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SPECIAL ISSUE ON DESIGN AND ENGINEERING OF SWITCHYARD

May 2022

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DESIGN AND ANALYSIS OF SWITCHYARD IMPLEMENTATION

Dr. Rajiv Singh*

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the design and engineering of the switchyard and define the working of the switchyard and uses. Substations are power stations with components such as electrical buses, breakers, switches, potential or voltage transformers, current transformers, and so on. An electrical substation is a location where voltage is changed using transformers from high to low or the other way around as part of an energy generating, transmission, and distribution system. A utility often plans to add a new power substation to its electric system because consumer demand for electricity in the region has grown due to new development in enterprises, industries, residential areas, etc. The primary safety requirements and procedures in substation and switchyard design are the subject of this course on electrical substation and switchyard design. An electrical substation is a part of a power system that transforms voltages for power transmission, distribution, transformation, and switching. The internal and exterior connections, as well as the high voltage and low voltage enclosures and compartments, are shown on the mechanism drawings.

KEYWORD: *Electrical Substation, Power System, Power Transmission, Switchyard Design, Substation Switchyard.*

INTRODUCTION

Bureau of Indian Standards (BIS), Rural Electrical and Electronics Engineers, American Society of Mechanical Engineers (ASME), and others have published a number of standards, recommendations, and guides on the electrical and electromechanical components of moving machines and hydro power. The vast majority of them have been created with huge water resources/hydropower projects in mind. At this time, following the standards, guidelines, and manuals is optional. The development of small-scale hydropower projects must be done in a way that is both reliable and cost-effective. Hence, it was believed that standards and guidelines designed expressly for small-scale initiatives should be produced and made accessible. It is broken into two parts: the first section discusses switchyard design concerns; the second half gives a case study of a 33/220 kV transmission switchyard.

In this article, many switchyard design factors are covered, including location, voltage, and general architecture. An electrical substation is a location where voltage is changed using transformers from high to low or the other way around as part of an energy generating, transmission, and distribution system. Also, it acts as a connecting point for numerous power system components such transmission lines, transformers, generators, and loads. A substation that uses porcelain or composite insulators and/or bushings to isolate the main circuit potential from the ground using air is known as an air-insulated substation (AIS).Switchgear is made up of electrical disconnect switches, such as fuses or circuit breakers, which are used to control, protect, and isolate the electrical equipment. AIS is fully composed of air-insulated technology components, such as circuit breakers, disconnecting switches (disconnectors), surge arrestors, instrument transformers, power transformers, capacitors, bus bars, and so on. Switchgears are tools used for regulating, protecting, and switching electrical circuits show in figure 1.

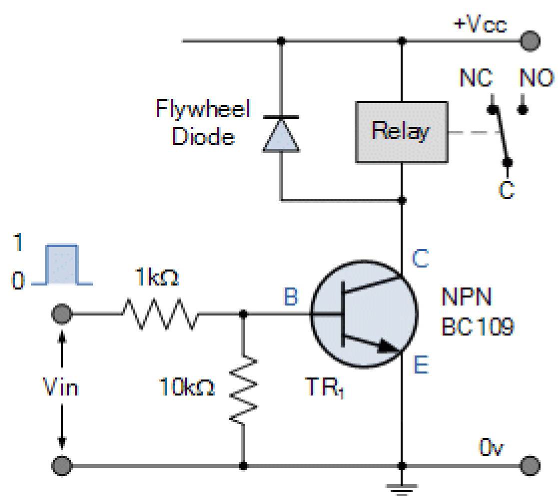

Figure 1 Switching electrical circuit [electronics-tutorials].

The primary safety requirements and procedures in the design of electrical substations and switchyards are the subject of this course. The part of a power system that transforms voltages for power transmission, distribution, transformation, and switching is called an electrical substation.A substation without transformers that runs at a single level of voltage is called a switchyard. As a result, these components' design and knowledge are crucial to the majority of modern power systems. The main components of these components are covered in this programme, along with the electrical, chemical, and human dangers that may be found in areas where substations and switchyards are present.

Why the Basics of Electrical Substation and Switchyard Design, Safety, and Maintenance course at Zoe is your best choice. You will be able to understand the fundamentals of electrical substations and switchyards at the conclusion of this course. This course also covers basic best practises for addressing potentially dangerous or dangerous situations, making students more careful and aware.The transmission of the electricity produced at a power plant is accomplished with the aid of a switchyard, which serves as a junction where the power transmission takes place, however switchgear may be a piece of equipment in a switchyard. In addition to helping with power transmission, switchyard may assist safeguard the power plant.An efficient and dependable power system is necessary for the switchyard's operations. Any switchyard system design, whether it is brand-new or an addition to an existing system, must be examined to make sure it is secure, dependable, achieves the current goal, and allows for future development.Electric power substations are often considered to be the most crucial component of a power utility's electric system, which is made up of power generating, transmission, and distribution systems.

Substations are power stations with components such as electrical buses, breakers, switches, potential or voltage transformers, current transformers, and so on. Depending on whether it is a producing substation or a transmission/distribution substation, a substation is a station that has a power transformer for either stepping up or stepping down the supply voltage. To distribute electricity over longer distances and with less power losses due to transmission line impedance, generating substations scale up the voltage from the generator's lower voltage to a higher voltage.Transmission substations prepare distribution systems for end-user consumers by stepping down the incoming higher voltage from transmission lines to a lower voltage potential transformer show in figure 2.

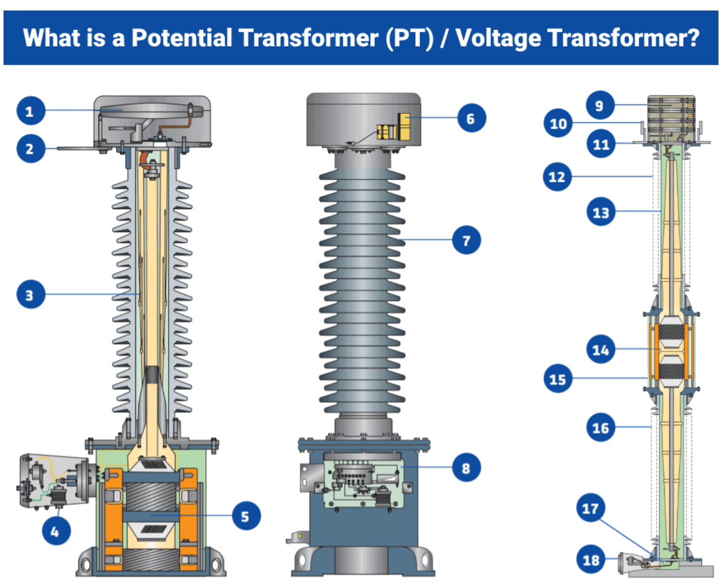

Figure 2 Potential transformer/voltage transformer [electricaltechnology]

Developing a New Electricity Substation

A utility often plans to add a new power substation to its electric system because consumer demand for electricity in the region has grown due to new development in enterprises, industries, residential areas, etc. The replacement of an aged, outmoded substation that has reached the end of its useful life is another rationale for building a new substation. The fundamental actions a utility may take in the development and construction of a new substation are:

1. Hold discussions to design the new power substation.
2. Carry out load flow power analyses.
3. Calculate the size of the substation and the overall footprint needed (including equipment), taking into account the transmission right of way (ROW).
4. Establish the substation's configuration (e.g., Single Bus, Main/Transfer Bus, Ring Bus, etc.).
5. Set aside the finances needed for the real estate acquisition, engineering, planning, building, implementation, etc.
6. Choose the region or location and buy the property, including the ROW.
7. Establish the substation project with its in-service date and planned milestones.
8. Assign internal team members, external personnel, or contractors, or contract the full project as an engineer-procure-construct (EPC) option, turnkey solution, etc.
9. Start working on the substation drawing package and deliverables' engineering and design.
10. Have a pre-construction meeting and a final design review meeting.
11. Finally, build, evaluate, and use a new substation.

LITERATURE REVIEW

Shantanu Abu-Siada, et.al explored international Electrotechnical Commission 61850, a communication protocol established by the International Electrotechnical Commission, has received significant attention in response to the global trend towards the digitalization of substation automation systems. Its goal is to ensure reliable communication and the integration of substation high-voltage primary plant assets, such as instrument transformers, circuit breakers, and power transformers, with various intelligent electronic devices at various hierarchical levels. Due to their fast-transient reaction across a broad bandwidth, main plant equipment in the switchyard such non-conventional instrument transformers and a secondary system with merging units are projected to play crucial roles throughout this transition [1].A non-traditional instrument transformer offers benefits over a conventional one, but for it to be fully implemented on a broad scale in utilities, businesses, smart grids, and digital substations, substantial and rigorous performance analysis and feasibility studies are still needed. In order to analyse the performance of an Ethernet-based network and to verify the overall process bus design need of a high-voltage non-conventional instrument transformer, this article moves this goal further by using an optimised network engineering tool. Also, a thorough simulation study is conducted to examine the effects of communication latency on the substation automation system during times of high traffic.

Urvashi H. Verma et.al investigated electricity consumption has risen steadily as a result of digitization and high-profile lifestyles. We must set up a new generating unit, extend our transmission and distribution network, and build a new EHV substation in order to fulfil the rising demand for electricity[2]. Large areas are needed for the construction of new EHV substations, yet in today's urbanised world, land is scarce and expensive. In such case, we would need to set up a new EHV substation that would be simpler to construct, operate reliably, and be simple to expand to meet future demand. Instead of using an air-insulated substation, we create hybrid systems and gas-insulated substations to meet these needs. The installation of a new substation with asset management throughout design engineering, procurement, construction, testing, and commissioning is discussed in this article for the switchyards of AIS, GIS, and HS.

E. A. Varganova et.al explored one of the stages of designing an electric substation that takes the longest is the outside switchyard. It necessitates that the designer be familiar with a wide range of design standards, switchgear safety requirements, and common design choices [3]. There is currently no CAD system that can automate the design of outdoor switchgear substation plans while taking into account their economic indicators and provide the designer with not only a technically viable solution but also carry out its economic assessment, allowing the designer to select the best layout option. The objective of this project is to establish the algorithmic foundation for CAD software for electric power substations. A design algorithm for an open switchyard layout and an economically sound strategy had been created. The algorithm enables the selection of a scheme, the selection of electrical components, and the creation of switchyard single-line diagrams and layouts. A sample form for the outcomes of an engineering and economic comparison had been provided. This suggests that the complex CAD system may be used to architect and engineer tasks.

Correa, J. Garcia, J. et.al discussed the basic and detailed design have been selected as having the largest potential to be reduced within the electric substation chain of value and taking into account the current environment, in which projects have shorter execution time [4]. Engineering businesses are under a lot of strain as a result of this circumstance since they must consistently fulfil scope change needs while ignoring due dates, final costs, and quality standards. HMV Engineers has created two complimentary tools for computer-based design: HMVTools and DISAC. These tools are based on the expertise and experience that have been gained over the course of 50 years in consulting, management, and design of High and Extra High voltage transmission systems. A platform called HMV Tools assists with the calculations necessary for electromechanical, structural, and civil designs. DISAC is an AutoCAD tool that enables the creation of 3-D models of substations with all essential elements, such as switchyard equipment, structures like as columns and beams, insulators, busbars, equipment connections, connectors, and building volumes, among others (foundations, grounding grid, drainages, cable trenches and ducts). These models make it possible to identify problems like interferences and clearance breaches while also producing the project's bill of materials. Both tools save the data in a single substation model, and the model is kept in a secure Internet cloud so that various work teams across the globe may access its distinctive layout (design criteria, data, calculations and 3-D model).

DISCUSSION

Construction of a New Electricity Substation

A scaled site plan will be made to identify the right of way (ROW) access for roads, transmission lines, distribution lines, and other utility access, including: water, sewer, gas, and telecommunications, once the substation planning has been completed, real estate has been acquired, and the project has begun. The site plan will also illustrate the whole footprint of the substation, along with the position of the main substation equipment, including the control house and cabins, if any. Before the site design can be finished, the substation layout configuration must be established. This will indicate if the substation will have a single bus arrangement, a main bus and transfer bus, a ring bus, a breaker-and-a-half system, etc.

The next step may be the need for an excavation plan, which will outline how to level off sloping soil in order to prepare it for foundations. The foundation design will display the concrete foundations (drawn to scale) necessary to support all significant apparatus, buildings, cabinets, and the control house. In order to safeguard against electrical problems, the grounding design must display the underground ground grid with grounding connections at all significant machinery, steel buildings, the control house, and numerous points along the substation fence. To verify that the appropriate copper conductor diameters, ground rods, and connections are used, a separate grounding analysis study will be needed. It will be necessary to conduct a separate shielding and lightning protection study to make sure that all equipment and wires are adequately protected from potential direct lightning strikes. The research will assist in deciding whether to use overhead shield wire (OHSW), lightning rod masts, or both, among other safety measures[5].

The precise layout of the substation yard's equipment, including connections to the transmission and distribution lines, must be shown on a general arrangement design. The control house, transformers, breakers, switches, electrical bus, foundations, cable trenching, etc. are all precisely oriented on this scaled design, along with the substation fence with access gates.The overall layout is divided into several sized equipment parts and detailed drawings as needed to show all significant yard equipment, buildings, fences, and control house. For building, connecting, operating, and maintaining, these parts and thorough schematics are required.

In most cases, manufacturers offer or produce drawings of equipment mechanisms based on vendor requirements. The internal and exterior connections, as well as the high voltage and low voltage enclosures and compartments, are shown on the mechanism drawings. The many details, mounting specifications, schematics, and wiring diagrams included in these drawings are necessary for the equipment's installation and functioning.Plans for conduits and lights are made to demonstrate all the underground and above-ground lighting requirements as well as the above-ground lighting needed to appropriately illuminate the yard equipment. Conduit and cable lists are made in combination with conduit plans to display all outdoor and indoor cables with labels that include the conduit, as well as information on the different kinds of cables and conduits, their diameters, the number of conductors in each cable, and other details[6].

Typically, the manufacturer or vendor chosen based on the substation size and housing specifications of the utilities provides the control house designs. Buildings made of concrete, masonry, or metal often make up control houses. With prefabricated metal structures that are supplied to the construction site and only need little assembly there, control homes are growing in popularity nowadays. According to the requirements of the utilities, prefabricated control houses can be delivered with electrical, lighting, HVAC, AC/DC distribution cabinets, control or command modules, protection & controls (P&C) modules, telecommunications modules, battery rooms, bath rooms, cable trays, relaying & controls panels, wiring terminal blocks, telecom racks, etc.On protection and controls drawings, including single line diagrams, AC & DC schematics, front and back views, wiring diagrams, bill of materials (BOM), etc. P&C Systems are discussed in further detail in the Significance of Protection & Controls and IEDs show in figure 3.

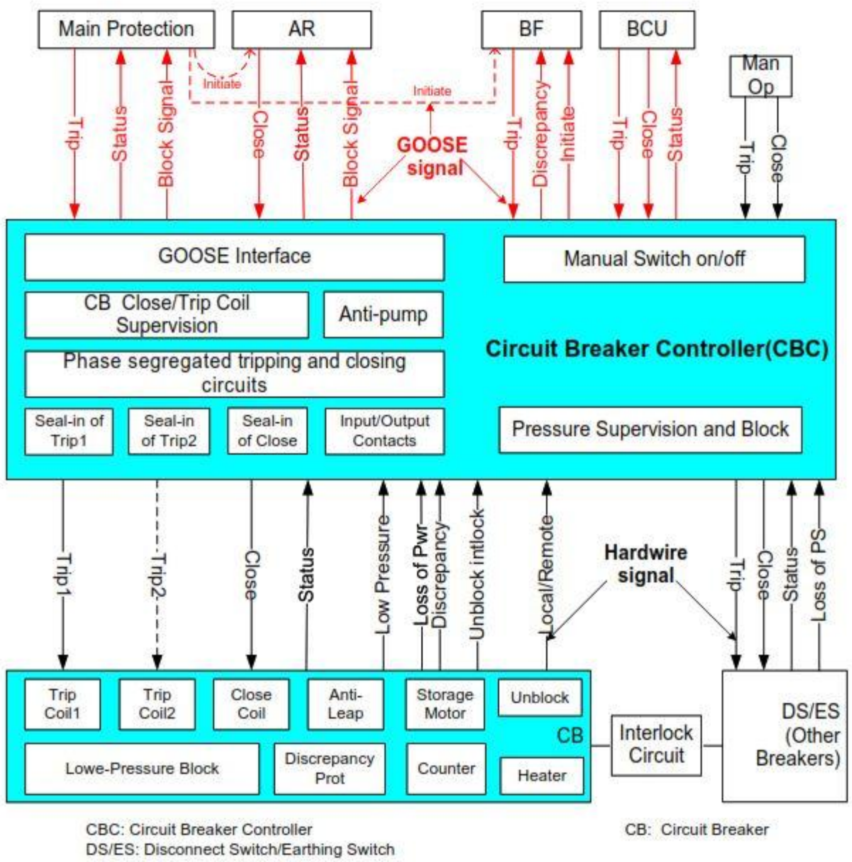

Figure 3 Control and IED [switchgearcontent].

The SCADA equipment drawings will be made to display all P&C and substation equipment's remote-control capabilities. Depending on the requirements of the utilities, either P&C drawings or Telecommunications drawings will illustrate the SCADA equipment. Typical components of these drawings include single lines, schematics, front and back views, connection and wiring diagrams, cable lists, SCADA point lists, etc. The communications drawings are made to demonstrate communications transport systems, including SCADA systems, and the route taken by communications as they return to the utilities' main or master dispatch control centre. The utility may own these communications transport networks, or a different telecommunications business may lease them.

In the control centre or another location, the telecom transport systems de-multiplex the individual communication circuits from the transport channel that they had multiplexed into while travelling through the substation. The transport systems may use a single or a combination of media, including fibre optics (FO), microwave radio (MW), 900 MHz radio, power line carrier (PLC), copper DS3, DS1, DSN, or twisted pair circuits, among others. Often seen in telecomm drawings are single line diagrams, schematics, front and back views, connection and wiring diagrams, cable lists, bill of materials (BOM), etc[7].In order to successfully complete a project, KNR provides efficient basic design and detail engineering services for EHV substations. These services also include planning for constructability, contracting, and equipment procurement.A team of post-graduate professionals from the electrical and civil & structural disciplines is available at KNR, and they are equipped with software tools like CYMGRD, STAAD, access to CDEGS, and a variety of user-developed programmes to carry out the full range of services for both electrical and civil & structural work in substations.

Voltage degree

With an increase in voltage levels, it becomes less and less advantageous to separate higher voltage class equipment from bus bars since transmission lines' capacity to transport power typically rises with the square of voltage. In earthquake-prone locations, high constructions are undesirable. It is crucial to build such substations with no more than two tiers of busbars, ideally, in order to achieve smaller structures and simplify maintenance.

Unit switching strategy

A "unit" switching system that only allows for high-voltage side outside switching of the generator and transformer bank as a unit. In power systems where the loss of large chunks of generation is difficult to accept, the unit scheme works effectively. In all other setups, the failure of a transformer or transmission line might result in the loss of several generating units.Tiny power systems may not be able to make up for the loss of many units, unlike alternative configurations that could be used. Maintenance outages are easier to schedule using the "unit" system.

Switchyard layout

A low-level switchyard configuration for the step-up station should be offered. According to the Central Board of Irrigation and Power's Substation Layout Manual for 36 kV and above, the layout of the switchyard may be typically created[8], [9].

Layout of a transformer

Being the biggest piece of equipment in a substation, the transformer's layout is studied since it is crucial for handling and station design.On the transformers are bi-directional rollers that are available for this use. Layout is also affected by the need to make arrangements for the removal of the transformer in the event of maintenance or repair. Transformers are equipped with soaking pits large enough to hold the whole amount of oil in order to lessen the likelihood of fire spreading.In certain cases, when it is practical, drainage systems are set up to drain the oil away from the transformers in the event of a fire. In addition, there are walls that divide the transformers from one another and from the roadways within the substation[10].

CONCLUSION

The primary safety requirements and procedures in substation and switchyard design are the subject of this study on electrical substation and switchyard design. An electrical substation is a part of a power system that transforms voltages for power transmission, distribution, transformation, and switching. A substation that uses just one level of voltage and no transformers is called a switchyard. As a result, the majority of modern power systems heavily rely on the design and knowledge of these components. The main components of these components are covered in this study, as well as the physical, chemical, and electrical dangers that might arise in substation and switchyard situations. What justifies the 'Fundamentals of Electrical Substation and Switchyard Design, safety and maintenance individual will be able to grasp electrical substations and switchyards fundamentals properly at the conclusion. As a result of this study's discussion of basic procedures for addressing potentially dangerous circumstances, participants become more watchful and aware.In this book chapter there is discussed about the design and engineering of the switchyard definition and the working of the switchyard and uses of the switchyard.

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EXPLORING ELECTRIC CLEARANCE OF THE SUB-STATION

Ms. Renuka Bhagwat*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

ABSTRACT:

In this book chapter there is discussed about the electric clearance of sub-station. A substation's single line diagram (SLD), which pertains to circuit layout, the number of bus bars, their kind, and other related equipment, serves as the basis for planning. When atmospheric or ambient conditions deviate from the norm, the proper correction factor should be used by determining the withstand voltage under such circumstances while performing the BIL test in the brand-new non-standard ambient or atmospheric condition. Two or more transmission lines are connected by a transmission substation. When all transmission lines have the same voltage, the situation is the simplest. When this occurs, the substation has high-voltage switches that enable the connection or isolation of lines for fault repair or maintenance. A substation that operates just at one voltage level and without transformers is referred to as a switching station. Collector and distribution stations may sometimes be found in switching stations.

KEYWORD: *Circuit Breaker, Line Diagram, Node Dissection, Remote Control, Single Line, Transmission Line.*

INTRODUCTION

EHA system planning

The single line diagram (SLD) of a substation, which refers to circuit layout, the number of bus bars and their kind, and other related equipment, serves as the starting point for substation planning. The layout of any substation, however, is the most crucial and important engineering from the perspective of erection and installation because the single line diagram and bus switching scheme must be translated into a layout of suitable bay widths, sections, and ground clearances in order to physically achieve the feeder switching required for ease of erection and maintenance.The main component of a substation layout is the arrangement of various switchgear parts in a systematic way that is determined by their purpose and the laws of spatial separation.

EHV AIS substation planning

A substation's single line diagram (SLD), which pertains to circuit layout, the number of bus bars, their kind, and other related equipment, serves as the basis for planning. The layout of any substation, however, is the most crucial and important engineering from the perspective of erection and installation because the single line diagram and bus switching scheme must be

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translated into a layout of suitable bay widths, sections, and ground clearances in order to physically achieve the feeder switching required for ease of erection and maintenance.

Planning an EHV AIS substation MUST take clearance criteria into consideration (on photo: High voltage transformation substation of the Kimanis Power, in Malaysia). The main component of a substation layout is the arrangement of various switchgear parts in a systematic way that is determined by their purpose and the laws of spatial separation.The following forms of separation are included in spatial separation:

1. Clearing the earth

2. Clearance of phases

3. Creep age

4. Floor clearance

5. Sectional safety working clearance, number (Will be outlined in Part Two)

Range of Creep age

Creep age (Leakage distance) is the distance along the surface of the insulation between two conducting components, or between a conductive portion and the equipment's enclosing surface. Protection against tracking, which results in a partly conducting, is provided by an appropriate and sufficient creep age distance [1].Insulators are supplied in the substation to stop any live electrical conductor leakage current from passing through supports and into the ground. A conducting layer is created when the air dust adheres to the surface of the insulator show in figure 1.

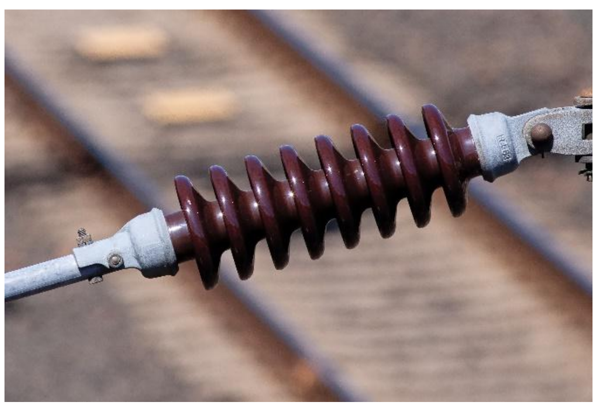

Figure 1 Illustrates the Insulator.

Via these surface layers, the leakage current travels from the live conductor to the soil. The length of the leakage route determines an insulator's leakage qualities at a substation. The leakage distance for insulators need should be met while constructing the insulator sheds.

Atmospheric humidity

Contaminant elements;

Corrosive substances.

The altitude at which the item will be used.

Clearance

A conductive component's clearancemeasured via airis the smallest distance between two conducting parts, or between a conductive part and the equipment's enclosing surface. Clearance space aids in preventing the ionisation of air from causing dielectric breakdown between electrodes. The degree of environmental pollution, temperature, and relative humidity all have an impact on the dielectric breakdown level [2].

Distance between dry arcs

The shortest distance outside the insulatoralong the air, not the insulator bodybetween the components that ordinarily have the working voltage between them is known as the dry arcing distance. Direct discharge distance is often referred to as dry arcing distance, also known as arc distance. Cree page distance and dry arcing distance: The latter refers to the shortest route through which the voltage may pierce the atmosphere outside the insulator. Cree page distance refers to the distance measured along the insulation's surface between two conductive elements clearance EHV AIS show in figure 2.

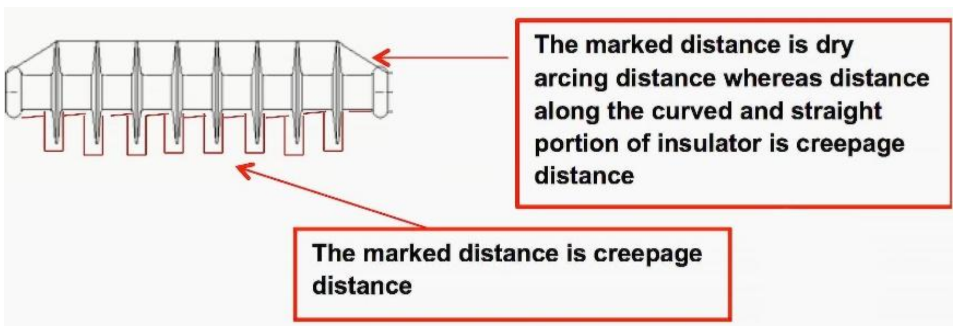

Figure 2 Illustrates the clearance EHV AIS [electrical-engineering-portal].

Ground clarification

The ground clearance of an outdoor substation is the distance between the ground and the bottom of any insulator. All voltage levels maintain a 2.5 metre clearance. The bottom of the equipment base, where it sits on the foundation pad, must be at least 2.5 metres vertically above the lowest porcelain section of the bushing, porcelain enclosures, or supporting insulators.This implies that the support structure should extend 2.5 metres from the plinth up to the bottom of the insulator or the top of the metallic earthed component of the equipment below the insulator. See the illustration of a CT and CVT placed on a support structure below.

The ground clearance for the equipment falling on both sides of the road must be increased in circumstances when trucks and cranes are permitted within a substation since their height is typically 3.5 metres. The minimum ground clearances at the substation between the live point and the ground for the various voltage classes are specified in rule no. 64 of the I.E. Regulation 1956, along with the bus height [3].When atmospheric or ambient conditions deviate from the norm, the proper correction factor should be used by determining the withstand voltage under such circumstances while performing the BIL test in the brand-new non-standard ambient or atmospheric condition. The necessary phase to phase and phase to earth clearance may then be computed depending on the dielectric strength of the air.

LITERATURE REVIEW

Xu Cao, et.al discussed the building plan for an HVDC grid with flexible overhead lines in terms of topology, important components, control, and security. The symmetrical monopole station network and the HVDC grid network are both squarely configured [4]. There are two options for sub-modules: fault self-clearance topology with rapid mechanical DC switch or half bridge topology incorporating HV heavy current DC breaker. Half bridge sub-module design is straightforward and established, but it requires a very quick protection device. A significant number of converter and line current-limiting reactors are required since DC breakers may not entirely protect all stations during breakdowns. The fault self-clearance sub-module technique does not need an extremely quick protection mechanism, although it will result in a brief station-wide blackout following a DC line failure. Key devices, control, and protection are currently not challenging issues for the overhead line flexible HVDC grid.

Sylvie etal. explored that people from Sub-Saharan Africa who had relocated to Hong Kong, Bangkok, Jakarta, and Kuala Lumpur's markets in the early 2000s migrated to Guangzhou and set up businesses on the top floors of structures in the Baiyun and Yuexiu Districts. They were close to the city's main train station and one of the two Canton fairs in the northwest of the city. In order to meet the demands of an African nomadic consumer, these dealers were eventually able to provide the conditions for hospitality by building neighbourhood eateries on higher floors, expanding the number of showrooms and offices, and adding services for freight and customs clearance. The article will first highlight the economic philosophies that have contributed to the establishment of African trading posts in China and describe their extension from the Middle East and from Asia based on interviews conducted between 2006 and 2009 in the People's Republic of China as well as in Hong Kong, Bangkok, Dubai, and West Africa. The second section will establish the relative contributions of immigrants and nomadic Sub-Saharan businesspeople before examining how these groups interacted with Chinese culture to establish these economic networks. Also, the effects of stricter immigration regulations will be examined[5]. The African trading posts' tenet of anchoring certain merchants in advantageous locations after negotiations with the host group permits both mobility and temporary habitation of numerous visitors. To meet the need of the nomadic traders, who in turn serve clients on other continents, the first established dealers buy goods produced in the hinterland [6].

Xiang An, etal.explored in this research to reduce operator pesticide toxicity while increasing the automation and intelligence of high-clearance sprayers. Hence, a high-clearance unmanned sprayer was created employing cutting-edge mechanical, electrical, hydraulic, and autonomous navigational technology. To act as the platform, a typical high-clearance booming sprayer was used. The driving control, navigation, remote control, spraying, and ground station were the five components that made up the sprayer's electrical system. Engine start/stop, four-wheel steering, throttle aperture, moving speed, spraying pump, and booming beams may all be automated with the use of electric devices. Data was processed using a PIC18F258 microcontroller with CAN and serial connections, and signals were then sent to relays and motor drivers, which served as the executors and turned DC motors. Moreover, a brushless motor, potentiometer, motor driver, and steering controller were created for an electric steering system[7].

The hydraulic steering unit's input shaft was directly linked to the output shaft of the brushless motor, which was utilised to generate the steering torque. To enable the real-time switching between two modes, such as remote control and autonomous navigation, a CAN-bus communication network was set up. The location and attitude data were gathered using a dual-antenna RTK-GNSS receiver and an Inertial Measurement Unit (IMU) as navigation sensors. To rectify positioning data tainted by the chassis tilt and precisely determine the sprayer's true location, an attitude-based correction was developed. The actual minimum turning radius during the headland turn was also calculated using the RTK-GNSS positioning data, taking into account kinematic characteristics in fields with varying soil conditions. In order to guarantee the explicit turning trajectory and precise route tracking after completing the headland turn, a straight path has to be designed in accordance with the turning radius. The reason for this was that, with a working width of 12 m, the distance between neighbouring working pathways was much greater than the turning radius.

For high-accuracy driving, an automated calibration was developed to establish the range of steering angle, steering angle in straight lines, and heading measurement shift. Moreover, the adjustment was required to account for the placement of the potentiometer and GNSS antennae on various fixing sites in relation to the machine body. As a result, a thorough validation of the autonomous operating mechanisms and CAN-bus network connectivity was obtained. The effectiveness of newly created unmanned high-clearance sprayers under remote control and autonomous navigation, in terms of automated operation in route tracking, was also evaluated via a series of trials. The results showed that the maximum values under remote control and autonomous navigation, respectively, were 20.81 and 8.84 cm, with average errors of 0.90 and 3.16 cm on the left and the maximum root mean square errors of 7.47 and 2.66 cm, indicating that the executing mechanisms responded to operation commands in a stable and quick manner. Driving performance during agricultural spraying when using autonomous navigation was much better than while using remote control [8].

Zejian Wang, et.al in clinical practise, laparoscopic radical gastrectomy for stomach cancer is often used, and its indications have been expanded from early to advanced gastric cancer. Because of the intricate anatomy, abundant blood supply, and extensive lymph node dissection, laparoscopic radical gastrectomy is considered to be technically difficult[9]. This paper's main goal is to describe a laparoscopic radical D2 gastrectomy for distal gastric cancer, including specifics on where the trocar was placed, the surgical techniques used, and the order in which the lymph nodes were removed. The Guangdong General Hospital's Department of General Surgery and Gastrointestinal Surgery handled all of the operations.

According to the research, a proper laparoscopic trocar placement is the key to having a clear operative field view. The surgical hole should typically be at the bilateral clavicle midline, and the observation hole should typically be about 2 cm below the umbilicus. Moreover, a successful laparoscopic radical D2 gastrectomy depends on the surgical technique, the order of lymph node dissection, and the guarantee of a thorough and safe dissection of lymph nodes. The surgical team at our facility adopts the following position: the surgeon stands to the patient's left, the laparoscope operator is positioned between the patient's knees, and the first assistant is positioned across from the surgeon on the patient's right side. The guidelines of sequential lymph node dissection, which are "from left to right," "from proximal to distal," and "from inferior to superior," are correlated with this location. Thus, it may effectively avoid subsidiary harm and is conducive to inferior and superior pylorus area dissection.

The procedure for lymph node dissection in our facility has been standardised. The initial step entails station 4sb dissection and greater gastric curvature clearance; next, the patient is shifted into a different position for the cleaning of the sub-pyloric lymph node region and the linear stapler cutting off of the duodenum; next, the inferior region of the pylorus and the upper margin of the pancreas are cleared; finally, the first and third groups of lymph While different surgical procedures and lymph node dissection sequences are used in various facilities, laparoscopic D2 radical gastrectomy for stomach cancer generally requires complex and cutting-edge technology. Surgery professionals should get acquainted with the architecture of the stomach peripheral vascular system and the features of lymph node drainage since radical lymph node dissection is challenging. Surgeons can standardise the entire surgical procedure, which ultimately reduces bleeding during surgery and shortens the operative time, by developing and putting into practise effective strategies, such as forming a regular team, positioning surgical team reasonably, changing a patient's posture during operation, selecting an appropriate surgical approach, and following a logically sequenced lymph node dissection.

Yuzhe Zhang et.al explored the benefits of both the line commutated converter (LCC) and the modular multi lever converter are combined in the hybrid high voltage direct current (HVDC) system (MMC). Yet, there are two major issues when it comes to large-capacity overhead line transmission: the maintenance of power transmission after an AC system defect on the rectifier side, and the self-clearance of DC side faults. These two issues may be resolved by the hybrid HVDC system, which uses hybrid MMCs in the inverter station and LCCs in the rectifier station. Initially, the hybrid MMC's working concept is presented, followed by a thorough explanation of the connection between the full-bridge sub module percentage and the DC operating range [10]. Next, a control approach and a workable DC fault clearing technique are presented for hybrid HVDC. Lastly, PSCAD/EMTDC is used to construct a bipolar hybrid DC transmission system. The simulation findings show that the suggested control technique can successfully address both rectifier side and DC side faults in an AC system [11].

DISCUSSION

Two or more transmission lines are connected by a transmission substation. When all transmission lines have the same voltage, the situation is the simplest. When this occurs, the substation has high-voltage switches that enable the connection or isolation of lines for fault repair or maintenance. Transformers to convert between two transmission voltages, voltage control/power factor correction devices like capacitors, reactors, or static VAR compensators, and machinery like phase shifting transformers to regulate power flow between two nearby power systems are all possible in a transmission station.Simple to complicated transmission substations are possible. It's possible that a modest "switching station" is little more than a bus and a few circuit breakers. The biggest transmission substations may cover a lot of ground (a few acres or hectares), have a lot of circuit breakers, and a lot of protection and control gear (voltage and current transformers, relays and SCADA systems). International standards like IEC Standard 61850 may be used to implement modern substations.

Substation for distribution

An area's distribution system receives electricity from the transmission system via a distribution substation. Unless they use huge quantities of power, it is not cost-effective to connect electricity users directly to the main transmission network, thus the distribution station lowers voltage to a level appropriate for local distribution power distribution show in figure 3.

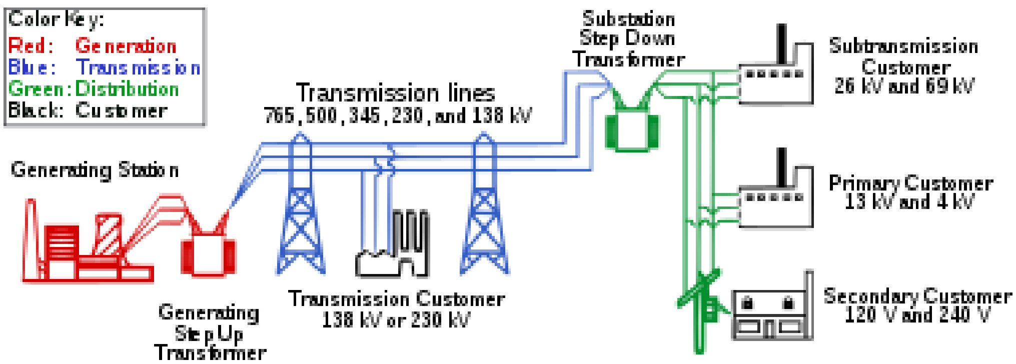

Figure 3 Power distribution [Wikipedia]

At least two transmission or sub-transmission lines are normally used as the input for a distribution substation. For instance, the input voltage may be 115 kV or another standard value for the region. There are many feeders as the output. In general, distribution voltages range from 2.4 kV to 33 kV, depending on the size of the serviced region and the utility's policies in the area. The feeders provide electricity to the distribution transformers at or near the client premises via roadways that are above (or, in certain circumstances, subterranean).

Distribution substations convert voltage and isolate faults in either the transmission or distribution networks. Voltage control equipment may also be put along lengthy distribution circuits (of many miles or kilometres) however distribution substations are primarily where voltage regulation happens.Many cities' central business districts are home to complex distribution substations with high-voltage switching, low-voltage switching, and backup systems. On the low-voltage side, more standard distribution substations feature a switch, one transformer, and few amenities.

Intake substation

A collector substation could be necessary in dispersed generating projects like a wind farm or solar power plant. While electricity flows in the other way, from several wind turbines or inverters up into the transmission grid, it resembles a distribution substation. While some collector systems are 12 kV, the collector system typically works at roughly 35 kV for construction efficiency, and the collector substation steps up voltage to a transmission level for the grid. Moreover, the collector substation can manage the wind farm and alter power factor as necessary. A collector substation may, in rare exceptional circumstances, also house an HVDC converter station.

There are also collector substations in locations with a number of nearby thermal or hydroelectric power plants with similar output power. These substations, which draw electricity from local lignite-fired power plants, include Brauweiler in Germany and Hradec in the Czech Republic. The substation is a switching station if no transformers are needed to raise the voltage to transmission level.

Substations for converters

Convertor substations might be linked to traction current, HVDC converter plants, or integrated non-synchronous networks. These stations have powerful electronic components that can modify the current's frequency or convert it from alternating to direct current or the other way around. In the past, rotary converters altered frequency to link two networks; these substations are now uncommon.

A switching points

A substation that operates just at one voltage level and without transformers is referred to as a switching station. Collector and distribution stations may sometimes be found in switching stations. They may also be used to parallelize circuits in the event of a breakdown or to divert the current to backup lines. The switching centres for the HVDC Inga-Shaba transmission line serve as an example.A switching station, sometimes referred to as a switchyard, is typically situated next to or next to a power plant. In this instance, the transmission lines get their power from a Feeder Bus on the other side of the yard while the generators from the power plant send their electricity into the yard onto the generator bus on one side.

Switching, or the connecting and unplugging of transmission lines or other system components, is a crucial task carried out by a substation. Events that switch might be planned or spontaneous. For maintenance or for new construction, such as the addition or removal of a transmission line or a transformer, it may be necessary to de-energize a component or a transmission line. Companies strive to keep the system up and operating while undertaking maintenance in order to preserve supply dependability. Anything that has to be done, from standard maintenance to constructing totally new substations, should be done while the system is still in operation.

Structure of a substation

Transformers, switching, protection, and control equipment are often found at substations. Circuit breakers are utilised in a big substation to stop any potential network short circuits or overload currents. Recloser circuit breakers or fuses may be used in smaller distribution stations to safeguard the distribution circuits. While a power plant may have a substation nearby, substations don't often contain generators. A substation may also house other components including reactors, voltage regulators, and capacitors.Substations may be found underground, on the surface in walled enclosures, or in specific purpose structures. Several interior substations may be present in high-rise structures. Urban locations often include inside substations to protect switchgear from harsh weather or pollution conditions, to improve aesthetics, or to lessen noise from the transformers.

Designing a grounding system is necessary. To safeguard bystanders in the event of a transmission system short circuit, it is necessary to compute the total ground potential increase and the gradients in potential during a fault (referred to as touch and step potentials). A spike in the ground potential might result from earth faults at a substation. Metal items may have a touch potential that is substantially higher than the earth under a person's feet because to currents flowing through the Earth's surface during a fault; this contact potential creates an electrocution risk. To shield people from this danger, every substation that contains a steel fence must be properly grounded.

Reliability and cost are the two fundamental problems a power engineer face. A good design tries to balance these two in order to obtain dependability without incurring too much expense. Also, the station should be able to expand as needed thanks to the architecture.Several considerations need to be taken into account while choosing a substation's site. For the installation of equipment with the requisite clearances for electrical safety and for access to maintain huge apparatus such as transformers, sufficient land space is needed.

Gas insulated switchgear may result in total cost savings in locations where land is expensive, such metropolitan regions. Substations near coastlines that experience floods and tropical storms may often need an elevated construction to protect surge-sensitive equipment from the elements. The site has to have capacity to expand in case the load increases or more transmission lines are added later. The substation's impacts on the environment, including as those on drainage, noise, and traffic, must be taken into account.The substation location must be somewhat central to the service area's distribution network. Both to prevent people from being hurt by electric shock or arcs and to prevent the electrical system from malfunctioning due to vandalism, the site has to be secured against intrusion by outsiders.

Design schematics

The creation of a one-line diagram, which depicts the necessary switching and protection arrangements in a simplified manner as well as the incoming supply lines and outbound feeders or transmission lines, is the initial stage in developing a substation layout. Several electrical utilities regularly generate one-line diagrams with the main components (lines, switches, circuit breakers, and transformers) organised on the page in a manner that mirrors how the equipment would be positioned in the real station.

Incoming lines often feature a circuit breaker and a disconnect switch. In certain circumstances, only one of the two devicesa switch or a circuit breakerwill be present on the lines. As a disconnect switch cannot stop load current, it is utilised to offer isolation. A circuit breaker may be used to turn loads on and off, to shut off a line when electricity is flowing in the "wrong" direction, and as a protective device to automatically interrupt fault currents. Current transformers are used to determine whether a significant fault current is flowing through the circuit breaker. The circuit breaker may be tripped using the current transformer's output power, which would disconnect the load it was feeding from the circuit break's feeding point. By doing this, the system's failure point is separated from the rest of it, minimising any negative effects on the remainder of the system's functionality. Switches and circuit breakers may both be controlled remotely from a supervisory control centre or locally.

Lightning and switching surge propagation over overhead transmission wires might result in insulation failures in substation machinery. Hence, line entry surge arrestors are utilised to safeguard substation equipment. To guarantee that equipment failure (and the resulting outages) is kept to a minimum, comprehensive Insulation Coordination studies are conducted.The lines of a certain voltage link to one or more buses after they have passed the switching components. Due to the widespread use of three-phase electrical power distribution worldwide, these are bus-bar sets that are often in multiples of three.The configuration of the utilised switches, breakers, and buses has an impact on the substation's price and dependability. A ring bus, double bus, or so-called "breaker and a half" design may be used for key substations to ensure that the failure of one circuit breaker does not disrupt power to adjacent circuits and to enable de-energizing of certain substation components for upkeep and repairs. In particular for small installations, substations supporting a single industrial load may have few switching facilities.

Transformers may be linked between the voltage levels after buses for the different voltage levels have been constructed. In the event that a transformer develops a fault, they will once again have a circuit breaker, similar to transmission lines (commonly called a "short circuit"). Also, a substation always contains the control circuitry required to instruct the different circuit breakers to open in the event of a component failure.

Automation

Early electrical substations needed human data collecting for load, energy consumption, and abnormal occurrences as well as manual switching or adjusting of equipment. It became economically important to automate substation monitoring and control from a centrally monitored location as distribution networks got more complicated in order to allow for overall coordination in case of crises and to save operating expenses. Early attempts to manage substations remotely required special communication lines that were often run alongside power circuits. SCADA for substations has been implemented using power-line carriers, microwave radio, fibre optic cables, as well as specialised wired remote-control circuits. The number of locations that could be inexpensively managed and monitored increased exponentially with the invention of the microprocessor. Many intelligent electronic devices may now interact with one another and supervisory control centres thanks to established communication protocols like DNP3, IEC 61850, and Modbus, to name a few. Substation distributed automated control is a component of the so-called smart grid.

CONCLUSION

Air-insulated bare wires strung on support structures may be used to link switches, circuit breakers, transformers, and other equipment. With system voltage and the lightning surge voltage rating, more air space is needed. Metal-enclosed switchgear may be used in medium-voltage distribution substations, and there shouldn't be any active conductors outside. Gas-insulated switchgear in a gas insulated substation (GIS) decreases the necessary area near active buses for greater voltages. Buses and equipment, like as switchgear, are constructed within pressurised tubular containers that are filled with sulphur hexafluoride (SF_6) or another gas, as opposed to naked conductors. The equipment may be smaller because of the gas's better insulation value compared to air. Other insulating materials, including as transformer oil, paper, porcelain, and polymer insulators, will be used by the equipment in addition to air or SF6 gas.In this book chapter we discuss about the electric clearance of sub-station and the distribution of the power system structure as well as switching of the points.

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INSULATION COORDINATE CALCULATION OF EQUIPMENT

Dr. Sreenivasappa Bhupasandra*

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the insulation coordinate calculation of equipment uses of the insulation in the transmission and the distribution process industrial as well domestic purpose. Depending on the distance from the arrester site, the steepness of the wave front, and other electrical characteristics, the voltages at various places in the sub-station may exceed the protective limit for steep fronted moving waves. The transformer, circuit breaker, and other equipment are often installed at certain distances from the surge arrester and linked through a short overhead line or cable. Whenever time an electrical power system experiences an overvoltage, there is a danger that its insulating system might fail. The weakest insulation point closest to the overvoltage source has a significant failure probability. This is the difference between the RMS phase to phase power frequency voltage that would have been attained at the chosen site in the absence of the fault and the greatest rms phase to earth power frequency voltage on a sound phase during the fault. Over the study of an electrical device's service life, it must endure various aberrant transient over voltage situations at various periods.

KEYWORD: *Electrical Power, Frequency Voltage, Over Voltage, Protection Level, Surge Arrester.*

INTRODUCTION

Depending on the distances involved and the positions of the arresters, the voltages at sub-stations for steep fronted lightning waves at Insulation Coordination of Substation and at various places on lines may be higher than the protected limit. In order to reduce costs overall, it is vital to choose the number of arrest places. Surge arresters are often installed between a transformer and its circuit breaker in high voltage sub-stations to protect the transformer against current hopping and the resulting overvoltage. Also, additional protection is provided by the arrester's proximity to the transformer and its circuit breaker show in figure 1.

Giving a margin of 30% to the surge arrester's protection level and choosing the next closest standard BIL are common methods for determining the fundamental insulation coordination of a substation. Tables 8.3 and 8.4 provide the standard values of BIL for system voltages ranging from 145 to 765 kV. The allowable margin is just 15% when a surge arrester is employed to provide switching surge protection as well. Separate insulation levels must be specified for lines and other equipment. This threshold is chosen for lines based on factors such the atmosphere, lightning activity, insulation contamination, and the line's tolerable outage or failure rate.

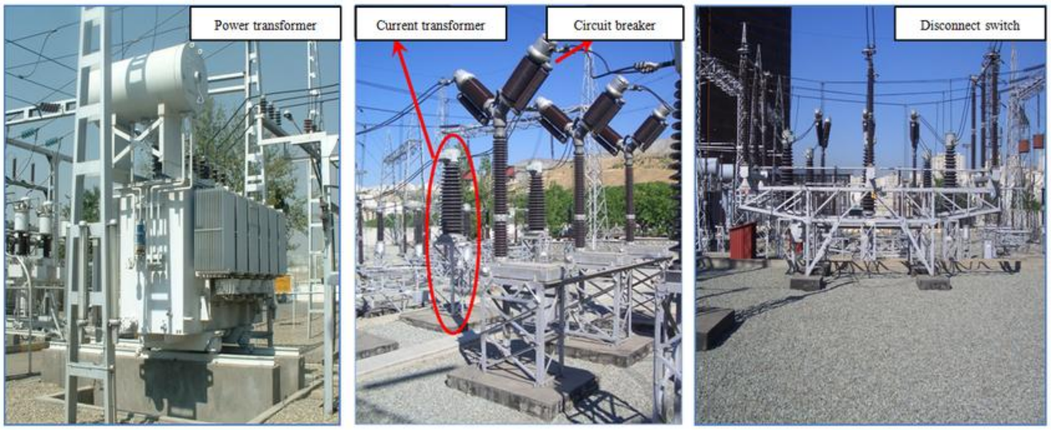

Figure 1 Transformer and its circuit breaker.

The location of the station, the amount of the arrester's protection, and the kind of line shielding being employed all affect the substation's insulation coordination's protective level. To prevent lightning over voltages from entering the sub-station, the insulation in the line's end spans close to the sub-station is often lowered. The bus bar insulation level is the greatest in an insulation coordination of substation to guarantee supply continuity. The next lower level is supplied to the circuit breakers, isolators, instrument, and relay transformers, etc. The power transformer has the lowest amount of insulation since it is the most expensive and delicate instrument.

If a rod gap is required to safeguard a transformer, the rod gap with a 440 kV negative spark over voltage (59 cm gap) may be used to provide a 25% safety margin. The protection is effective for surges with a front time of at least 2 s. Nevertheless, the switching surge spark over voltage, which is roughly 380 kV, is extremely close to the system's maximum switching surge and may thus lead to many outrages. The protection is questioned if a rod gap of 66 cm is employed since a 2 second front wave has an impulsive spar kover voltage of 600 kV.

Sub-station Insulation Levels with Protection Zones

Size and Characteristics of the Incoming Voltage Surges

As they large currents flowing through the surge arrester, direct strokes to phase conductors close to the station point are extremely hazardous. Because of the very high discharge voltages that are created across the arrester components, the arrester's risk being damaged. The stations are thus totally protected from direct hits. Sometimes the shielding is affected for up to 2 kilometers on each side of the station. The surges can only come from outside areas because to this protected zone. By assuming that the voltage magnitude at the start of the protected zone is equal to 1.3 times the negative critical flashover voltage of the line insulation, it is common practise to estimate the voltage wave at the station entry. Also, it is crucial for the surge arrester to function well that the point of the surge slopes off. Flashovers in the back are also crucial. In the event of back flashovers, there is a chance that a more catastrophic surge may occur. The likelihood of this happening relies on the speed and duration of the shielded zone's rearward flashover.

Degree of Equipment Insulation

Depending on the distance from the arrester site, the steepness of the wave front, and other electrical characteristics, the voltages at various places in the sub-station may exceed the protective limit for steep fronted moving waves. So, it is vital to choose the number of sites and the ratings of the surge arresters. This number must be kept to a minimum. Also, care must be taken to avoid damaging the transformer or the equipment next to the circuit breakers with switching over voltages caused by current chopping. Simple calculations show that the Basic Impulse Level (BIL) is 1.25 to 1.30 times the surge arrester's protective threshold. Generally, the next greater BIL value is picked from the list of values. For smaller stations and station ratings up to 220 kV, this is more than enough. When surge arresters are to be used for both SIL and larger stations, the "distance impact" addressed in the following section must be appropriately provided for; typically, a margin of 15 to 20% is permitted above the protective threshold. The impact of distance is minimal for long fronted switching surges show in figure 2.

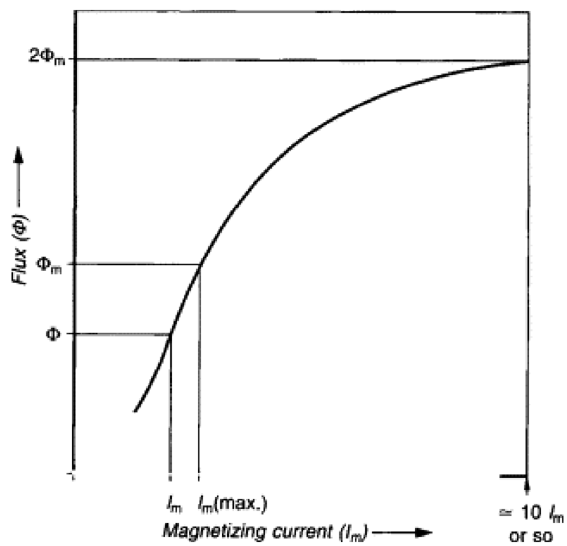

Figure 2 Switching surge [Science Direct].

The Impact of Distance

The transformer, circuit breaker, and other equipment are often installed at certain distances from the surge arrester and linked through a short overhead line or cable. Each piece of equipment is subjected to several reflections during a surge, which may result in significant over voltages (the travel time is usually less than a its). The voltage that may build up at a distance D from the surge arrester point when a surge arrester, breaker, and transformer are in line is given by V(D) = Vp + 2ST, where Vp is the spark over voltage/protective level, S is the steepness of the wave front, and T is the transit time =D/v. Given that the line stretches a considerable distance and does not experience any reflections at either end, v represents the velocity at which the wave travels in this case. At 2T=T0, the arrester's spark over time, the maximum value of V(D) is reached. The aforementioned straightforward formula demonstrates how high the transfer surge impedance is. The relationship between the protective level Vp and the transformer terminal voltage, VT, depends on (T/T0). Sometimes VT may even surpass 2 Vp for steep fronted waves.

It has been shown that, in a 330 kV sub-station, a 1.5/50 s, 1500 kV incoming wave may produce a surge at the bus terminals with a peak value of 1250 kV and a rise time of 2 s, while the protection level provided by the surge arrester at the transformer terminal is only 750 kV. A peak surge voltage of 930 kV may be applied to the transformer terminals. Computer estimates for a 1/50-second wave on a wire connecting to a 330 kV station have confirmed this.

Insulation coordination in power systems was developed to coordinate the electrical insulation levels of various electrical power system components, including the transmission network, in a way that, in the event that an insulator fails, the damage is contained to a small area that is simple to fix and replace and causes the least amount of disruption to the power supply.Whenever time an electrical power system experiences an overvoltage, there is a danger that its insulating system might fail. The weakest insulation point closest to the overvoltage source has a significant failure probability. The equipment and parts in the power system and transmission networks are equipped with insulation.

Compared to other places, certain insulators are simple to replace and maintain. In certain places, insulation is difficult to replace and repair, and doing so might be very costly and necessitate a lengthy power outage. Moreover, insulator failure at these locations may render a larger portion of the electrical network inoperable. Thus, it is preferable that only the readily replaceable and repairable insulators fail in an insulator failure scenario. The ultimate goal of insulation coordination is to bring the expense and disruption brought on by insulation failure down to a level that is both financially feasible and operationally manageable. In the insulation coordination approach, the insulation of the different system components must be graded in such a way that, should flash over occur, it must do so at the desired spots. To properly grasp insulation coordination, it is necessary to first comprehend several fundamental terms used in the electrical power system. Let's have a conversation.

LITERATURE REVIEW

Nor Izzati Ali, et.al the impact of surge protection devices on a hybrid solar photovoltaic (PV)-battery energy storage system's lightning-induced voltage (SPD). Solar PV works by harnessing solar energy to produce electricity that is then sent to the client. Battery energy storage is used to meet the energy demand in order to guarantee consistency[1]. Due to the nature of the system's placement in open regions where the equipment may sustain catastrophic damage that might cause the operation to end suddenly, lightning has always been a significant problem for the nations situated at the Equator. Insulation coordination on the lightning protection system is required to reduce potential damages. In order to determine the performance of the system with a single installation of SPD Class II at the DC and AC sides, three case studieslightning current amplitude, lightning hit distance, and cable lengthare described in this work. Taking into account the quantified data gleaned from this work, the simulation results have helped to improve understanding of the significance of SPDs and the need to properly coordinate in accordance with the standard, thereby demonstrating the necessity of proper installation of SPD will provide better maintenance and extend the lifespan of the equipment.

Zhiguo Zhang etal. determined the compounds under study's HOMO-LUMO energy gaps, ionisation potentials (IP), and electron affinities (EA). The intrinsic reaction coordinate (IRC) theory yields the minimal energy path (MEP), and the QCISD (T) (single-point) technique further refines the energetic data. According to the potential energy surface analysis, the findings indicate that OCCHCN may be employed as an alternative to SF6 as an insulation gas in high voltage equipment. It is difficult to ionise and excite OCCHCN because the potential barriers for the isomerization and cleavage processes are lower than the Eg and IP values[2].

Pengfei Zhou etal.discussed that it is possible to evaluate insulation status effectively in air-insulated substations (AIS) by using partial discharge (PD) localization. The localization findings of earlier published techniques were presented as bearings or coordinates, and they revealed significant coordinate inaccuracy. If the problem is to be located, further investigation is needed. The non-metallic area of the source equipment, not a point, is where the PD ultrahigh frequency signal radiates from in this study[3]. A novel localization method based on directional antenna and multi-point measurement is proposed to increase the accuracy of the localization result and inform the possible error distribution. The bearing of the PD source is determined using single point measurement. A precise result and associated error distribution are made accessible with the multi-point measurement. A test was conducted on-site in a 220 kV testing AIS and compared to an existing procedure. The findings demonstrate that the suggested technique is more precise than the current method and that it is effective in locating defective equipment with extra knowledge on the error distribution.

Qi Chao Zhang etal.explored the acoustic signals produced by partial discharges allows for an efficient assessment of the insulation of power equipment (PD). PD acoustic signals may be recognised using Fabry-Perot (F-P) sensors. [4] Although though the frequency bandwidth of an F-P sensor is often associated with a traditional piezoelectric transducer (PZT) sensor, it remains uncertain to determine a suitable bandwidth for fibre sensors in PD signal detection. The frequency distribution of PD acoustic emission is researched in order to create an F-P sensor with a sufficient bandwidth, and an extrinsic F-P sensor is created to detect acoustic signals produced by PD. As potential bandwidth design guidelines for acoustic detection, F-P sensors are created with various inherent frequencies. These F-P sensors and PZT sensors detect PD acoustic impulses in the experimental system, which uses four conventional electrode types. In linear and semilogarithmic coordinates, the measured results of frequency performance are examined. The findings demonstrate that both wideband and narrowband F-P sensors are capable of reliably detecting PD acoustic emissions. Moreover, the narrowband mode increases the sensitivity of F-P sensors. We suggest that, in order to achieve optimal sensitivity, the intrinsic frequency of the F-P sensor should be constructed in the frequency range of 100-170 kHz.

Ramadan Fayez Wani, etal. explored the insulation of the medium voltage (MV) switchgear fails catastrophically as a result of the partial discharge (PD). In high voltage (HV) equipment, locating the PD source (fault) is crucial for both maintenance processes and identifying the underlying cause of PD production. In this study, a simulated MV switchgear model was utilised to capture defect-initiated PD signals using the transient earth voltage (TEV) detection approach. In order to collect the PD signals produced by the known location(s)/coordinates of the sharp needle type defect within the tank, an array of four TEV sensors was mounted on the surface walls outside an MV switchgear tank. Critical analysis was done on the time difference of arrival (TDOA) between the signals that the TEV sensor array captures. For precise defect localization, it is crucial to accurately estimate the TDOA between PD signals produced by PD sources at a particular location[5]. The onset time point of each TEV signal is calculated using the cumulative energy method (CEM). Based on the given coordinates of the PD source and TEV sensors, the calculated TDOA via the cumulative energy approach is compared to the actual and anticipated TDOA. For the purpose of evaluating the TEV method's accuracy for PD source localisation, experimental data are employed as the foundation. According to experimental findings, the average time difference error is 1.34 ns, or 0.4 metres of propagation distance.

DISCUSSION

Earthing Factor

This is the difference between the rms phase to phase power frequency voltage that would have been attained at the chosen site in the absence of the fault and the greatest rms phase to earth power frequency voltage on a sound phase during the fault. The earthing characteristics of a system as seen from the chosen fault point are often characterised by this ratio.

Efficacious Earthing System

If the earthing factor does not exceed 80%, a system is considered to be successfully earthed, and if it does, it is not. For an isolated neutral system, the factor of earthing is 100%, but for a system that is strongly earthed, it is 57.7% (1/3 = 0.577) [6].

Protection Level

Over the course of an electrical device's service life, it must endure various aberrant transient over voltage situations at various periods. It may be necessary for the equipment to endure switching impulses, lightning impulses, and/or brief power frequency overvoltage. The insulation level of a high voltage power system is established by the highest level of impulse voltages and short duration power frequency over voltages that one power system component can endure.The lightning impulse withstand voltage and short duration power frequency withstand voltage are taken into consideration when establishing the insulation level of the system with a rating of less than 300 KV. Switching impulse withstand voltage and short duration power frequency withstand voltage are taken into consideration for equipment rated at greater than or equal to 300 KV protection level show in figure 3.

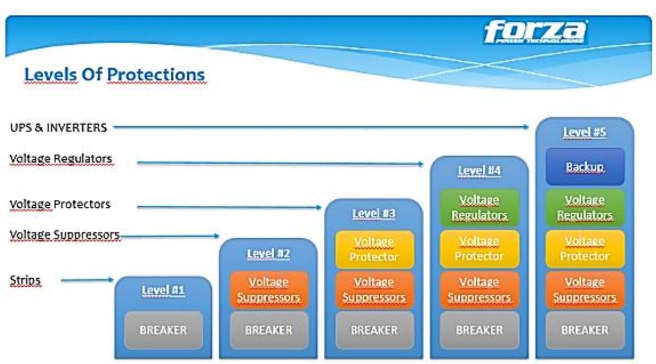

Figure 3 Protection level [Forzaups]

Thunderbolt Impulse Voltage

Three distinct fundamental wave forms may be used to illustrate the system disruptions caused by natural lightning. A lightning impulse voltage's wave form will resemble a complete wave if it travels some distance up the transmission line before it hits an insulator; this wave is known as a 1.2/50 wave [7]. If a lightning disturbance wave crosses an insulator while travelling and creates a flash, the wave's form changes to a chopped wave. When lightning strikes an insulator directly, the voltage of the lightning impulse may grow rapidly until it is alleviated by a flash over, which results in a swift, very steep drop in voltage. These three waves have quite distinct forms and lengths.

Changing Impulse

There may be unipolar voltage in the system during switching operation. Which might have an oscillating or periodically damped wave shape. The wave shape of a switching impulse features a sharp front and a lengthy, damped tail. Short duration Withstanding Power Frequency Voltage The rms value of the sinusoidal power frequency voltage that the electrical equipment must endure for a certain amount of time, often 60 seconds, is known as the short duration power frequency withstand voltage.

Voltage of Protective Device Protection Level

Surge arrestors and lightning arrestors are examples of over voltage protection devices that are designed to tolerate a specified level of transient over voltage before draining the surge energy to the ground and maintaining the amount of transient over voltage up to that level. Thus, transient excess voltage cannot go over that point. When switching impulses and lightning impulses are applied, the over voltage protective device's protection level is the greatest peak voltage value that should not be exceeded at the device's terminals voltage protection equipment show in figure 4 [8].

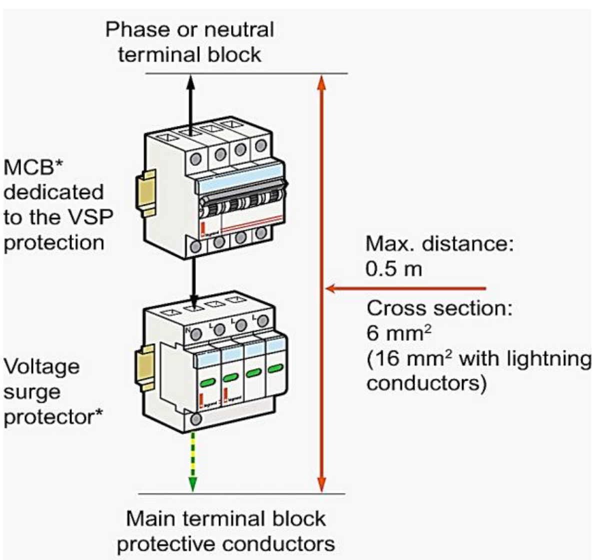

Figure 4 Voltage protection equipment [Zillions Buyer].

Utilizing Earth or Shield Wire

Direct lightning strikes on transmission lines above the ground might result in a lightning surge. It may be shielded by placing an earth wire or shield wire at an appropriate height from the transmission line's top conductor. Direct lightning strikes may be prevented from striking any conductors that are covered by the protective angle of an earth wire if the conducting shield wire is correctly attached to the transmission tower body and the tower is properly earthed. To guard against lightning strikes, an overhead shield wire, earth wire, or ground wire is also utilised above the electrical substation.

Traditional Insulation Coordination Method

As was mentioned above, an electrical power system component may experience varying degrees of transient voltage stressors, including switching impulse voltage and lightning impulse voltage. By including protective equipment like lightning arrestors into the system, the maximum amplitude of transient over voltages that can reach the components may be reduced. There should be no probability of insulation breakdown for any component if we keep the insulation level of every power system component above the protection level of protective devices. The amplitude of the surge protective devices will be equal to the protection level voltage and protection level voltage impulse insulation level of the components because the transient over voltage reaches the insulation after passing the surge protective devices. The impulse insulation level is often set at a voltage that is 15 to 25% higher than the protective level voltage of the protective devices[9][10].

CONCLUSION

The length of the insulator strings and the clearance in the air do not rise linearly with voltage at higher transmission voltages, but rather roughly to V1.6. The table below illustrates how many insulator discs are needed in a suspension string for certain over voltages. With the rise in the over voltage factor from 2 to 3.5, it can be noticed that the number of discs is only slightly increasing for 220 KV systems, while it is increasing quickly for 750 KV systems. Hence, having an over voltage factor of greater than roughly 2 to 2.5 on the higher voltage lines is clearly not economically viable, even if it may be possible to safeguard the lower voltage lines up to an over voltage factor of 3.5 (say). The switching over of voltages predominates in higher voltage systems. However, they could be managed with the right switching device design. In this book chapter we discuss about the Insulation coordinate calculation of equipment uses of the insulation in the transmission and the distribution process industrial as well domestic purpose can be uses of the insulation of the equipment.

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DESIGN AND ANALYSIS OF OUTDOOR SUBSTATION LAYOUT

Dr. Shilpa Mehta*

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

ABSTRACT:

In this book chapter there is discussed about the outdoor substation layout and the equipment use in the substation. These substations are used to support distribution transformers with a maximum 250 KVA capacity. These are the least expensive, most straightforward, and smallest distributions of transformers. The demand for electricity is rising quite quickly right now. The building of ever-larger power producing plants is necessary in the contemporary period to meet these enormous power needs. The mining sector needs a wide range of reliable transformers that are also secure. Satisfies the specific demands of the mining sector for high power density, compactness, and strong design, as well as forklift pockets for convenient site transfer. The temporary use of mobile substations for construction purposes makes them particularly special purpose substations as well. This substation provides the temporary electricity needed during construction for large construction purposes. Distribution substations transform voltage and isolate faults in either the transmission or distribution systems.

KEYWORD: *Circuit Breaker, Distribution Substation, High Voltage, Substation, Transmission Line,*

INTRODUCTION

Outside substations are substations that handle all voltage ranges from 55 KV to 765 KV. While it takes less time to build, this kind of substation takes up more room. Pole-mounted substations and foundation-mounted substations are the two primary categories for outdoor substations.For high tension transmission line protection, HT fuses are used. Low tension switches and fuses are provided for regulating low tension lines. To protect the transformers from surges, lightning arresters are installed over the high-tension line. Substations mounted on poles are earthed in two or more locations.

Substation Installed on a Pole

These substations are used to support distribution transformers with a maximum 250 KVA capacity. These are the least expensive, most straightforward, and smallest distributions of transformers. All of the equipment is outdoor-type and is supported by high tension distribution line supporting structures. The high tension transmission line is turned on and off using a triple pole mechanical switch [1].Transformers with capacities up to 125 KVA are put on double-pole structures, while transformers with capacities between 125 and 250 KVA are mounted on 4-pole structures with the appropriate platform. Such substation types are located in densely populated areas.Because of their low maintenance costs, it is desired to install the distributors more cheaply by using several substations in a town. Yet, as the number of transformers grows, so does the total KVA, the amount of no-load losses, and the price per KVA.

Substation Placed on the Foundation

In a substation that is installed on a foundation, all of the equipment is assembled, and for safety reasons, the substations are enclosed by a fence. Since the equipment needed for these substations is heavy, the location chosen for them must have a decent corridor for heavy transport.

Substation for electricity

The demand for electricity is rising quite quickly right now. The building of ever-larger power producing plants is necessary in the contemporary period to meet these enormous power needs. These power producing facilities might be thermal, atomic, or hydroelectric. These stations are built in various locations depending on the resources that are available. These locations may not be closer to the load centres where the real power consumption occurs.Thus, transmission of these enormous power blocks from the producing plant to the load centres is required. For this, extensive, high-voltage transmission networks are required. A relatively low voltage level is used to create power. High voltage electricity transmission is cost-effective. Electrical electricity is distributed at lower voltage levels based on user preferences. Between the producing station and consumer ends, a number of transformation and switching stations must be built in order to maintain certain voltage levels and to provide more stability. Electrical substations are the common name for this transformation and switching units. The substations may be categorised as follows depending on their purposes [2].

Boost Substation

Generating stations are connected to step-up substations. Because of the limits of spinning alternators, power generation is restricted to low voltage levels. To transmit electricity over great distances economically, these producing voltages must be increased. Thus, the producing station must be connected to a step-up substation boost substation show in figure 1.

Lower Step Substation

In the load centres, the stepped-up voltages must be stepped-down to various voltage levels for various uses. The step-down substations are further divided into other sub groups based on these uses.

Substation for primary step-down

Along the principal transmission lines, the primary step-down sub stations are built closer to the load centre. The voltages used for main transmission are stepped down in this case to various acceptable values for secondary transmission.

Figure 1 Boost substation [times of India].

Step-Down Secondary Substation

The secondary transmission voltages are further stepped down for primary distribution purposes at the load centre along the secondary transmission lines. In secondary step-down substations, secondary transmission voltages are stepped down to primary distribution levels [3].

Substation for Distribution

Distribution substations are located where the main voltages for distribution are stepped down to supply voltages for supplying the real customers via a distribution network.

Industrial Substation or Bulk Supply

While they are often distribution substations, bulk supply or industrial substations are exclusively intended for one customer. A big or medium supply group industrial customer may be referred to as a bulk supply consumer. These customers have a specialised step-down substation.

Substation for Mining

The mining sector needs a wide range of reliable transformers that are also secure. satisfies the specific demands of the mining sector for high power density, compactness, and strong design, as well as forklift pockets for convenient site transfer. Needless to add that products are trustworthy in harsh conditions. For mining applications, provides distribution class transformers with excellent performance values. In-depth industry requirements are gathered by, which has expertise building transformers specifically to meet needs throughout the continent, to keep us up to date on current industry requirements. Due to the additional safety measures required for the operation of the electric supply, mining substations are a particularly unique form of substation and need specific design and construction substation for mining show in figure 2.

Figure 2 Substation for mining [vantran].

Cellular Substation

The temporary use of mobile substations for construction purposes makes them particularly special purpose substations as well. This substation provides the temporary electricity needed during construction for large construction purposes. Following are some ways that substation types may be classified based on constructional features: Indoor/Outdoor Substation Construction of outdoor substations occurs outside. Almost all 132KV, 220KV, and 400KV substations are of the outdoor kind. A unique GIS (Gas Insulated Substation) is presently being built for extra high voltage systems, which are often located beneath roofs, despite this [4].

Household Substation

The substations that are built inside are known as indoor type substations. Typically, this sort of substation operates at 11 KV and, on occasion, 33 KV.

Subterranean substation

Underground substations are those that are located underground. One option for crowded areas where it is difficult to identify a location for a distribution substation is an underground substation plan.

Substation Installed on a Pole

Distribution substations built on buildings with two, four, or sometimes six or more poles are known as pole mounted substations. Electrical isolator switches and fuse-protected distribution transformers are installed on poles in this sort of substation.

DISCUSSION

An electrical generation, transmission, and distribution system includes a substation. Substations perform a number of other crucial tasks in addition to converting voltage from high to low or vice versa. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. Transformers may be used at a substation to adjust the voltage between high transmission voltages and lower distribution voltages or to link two distinct transmission voltages. There are 55,000 substations in the United States, making them a typical part of the infrastructure.Substations may be owned and operated by an electrical utility, or may be owned by a major industrial or commercial client. Substations are often unattended and depend on SCADA for remote monitoring and control.Before the distribution system was transformed into a grid, the term "substation" was used. Smaller producing plants were transformed into distribution stations as major generation stations grew in size, getting their energy supply from a bigger plant rather than utilising their own generators. The first substations were substations of a single power station that housed the generators and had a single connection to the outside world.

Transmission facility

Two or more transmission lines are connected by a transmission substation.

When all transmission lines have the same voltage, the situation is the simplest. When this occurs, the substation has high-voltage switches that enable the connection or isolation of lines for fault repair or maintenance. Transformers to convert between two transmission voltages, voltage control/power factor correction devices like capacitors, reactors, or static VAR compensators, and machinery like phase shifting transformers to regulate power flow between two nearby power systems are all possible in a transmission station.Simple to complicated transmission substations are possible. It's possible that a modest "switching station" is little more than a bus and a few circuit breakers. The biggest transmission substations may cover a lot of ground (a few acres or hectares), have a lot of circuit breakers, and a lot of protection and control gear (voltage and current transformers, relays and SCADA systems). International standards like IEC Standard 61850 may be used to implement modern substations.

Substation for Distribution

An area's distribution system receives power from the transmission system through a distribution substation. Unless they use huge quantities of power, it is not cost-effective to connect electricity users directly to the main transmission network, thus the distribution station lowers voltage to a level appropriate for local distribution.At least two transmission or sub-transmission lines are normally used as the input for a distribution substation. Input voltage may be, for example, 115 kV, or whatever is customary in the region. There are several feeders as the output. In general, distribution voltages range from 2.4 kV to 33 kV, depending on the size of the serviced area and the utility's policies in the area. The feeders supply power to the distribution transformers at or near the customer premises along streets that are overhead (or, in some cases, underground).Distribution substations transform voltage and isolate faults in either the transmission or distribution systems. Voltage regulation equipment may also be installed along long distribution circuits (of several miles or kilometres) but distribution substations are typically where voltage regulation happens [5].Large cities' central business districts are home to complex distribution substations with high-voltage switching, low-voltage switching, and backup systems. On the low-voltage side, more standard distribution substations have a switch, one transformer, and few facilities.

Collector substation

A collector substation could be necessary in dispersed generating projects like a wind farm or solar power plant. While electricity flows in the other way, from several wind turbines or inverters up into the transmission grid, it resembles a distribution substation. Although some collector systems are 12 kV, the collector system typically operates at around 35 kV for construction efficiency, and the collector substation steps up voltage to a transmission voltage for the grid. Additionally, the collector substation can manage the wind farm and correct power factor if necessary. A collector substation may, in rare exceptional circumstances, also house an HVDC converter station. There are also collector substations in locations with a number of nearby thermal or hydroelectric power plants with similar output power. Examples for such substations include Brauweiler in Germany and Hradec in the Czech Republic, where electricity is gathered from adjacent lignite-fired power plants. The substation is a switching station if no transformers are needed to raise the voltage to transmission level.

Substations for converters

Convertor substations might be linked to traction current, HVDC converter plants, or integrated non-synchronous networks. These stations have powerful electronic components that can change the current's frequency or convert it from alternating to direct current or the other way around. Previously rotary converters changed frequency to join two systems; presently such substations are uncommon.

Switching station

A substation that operates only at one voltage level and lacks transformers is referred to as a switching station. Switching stations are sometimes utilised as collection and distribution stations. They may also be used to parallelize circuits in the event of a breakdown or to divert the current to backup lines. An example is the switching stations for the HVDC Inga–Shaba transmission line.A switching station, sometimes referred to as a switchyard, is typically situated next to or next to a power plant. In this instance, the transmission lines get their power from a Feeder Bus on the other side of the yard while the generators from the power plant send their electricity into the yard onto the generator bus on one side.

Switching, or the connecting and unplugging of transmission lines or other system components, is a crucial task carried out by a substation. Switching events may be planned or unplanned. For maintenance or for new construction, such as the addition or removal of a transmission line or a transformer, it may be necessary to de-energize a component or a transmission line. To preserve dependability of supply, organisations aim at keeping the system up and operating while completing maintenance. All necessary work, including routine inspections and the addition of new substations, should be done while the system is still operational [6].

Structure of a substation

Transformers, switching, protection, and control equipment are often found at substations. Circuit breakers are utilised in a big substation to stop any potential network short circuits or overload currents. Reclose circuit breakers or fuses may be used in smaller distribution stations to protect the distribution circuits. While a power plant may have a substation nearby, substations don't often contain generators. A substation may also house other components including reactors, voltage regulators, and capacitors.Substations may be found underground, on the surface in walled enclosures, or in specific purpose structures. Multiple indoor substations may be present in high-rise structures. Urban areas frequently have indoor substations to protect switchgear from extreme weather or pollution conditions, to improve aesthetics, or to reduce noise from the transformers.

Designing a grounding system is necessary. To safeguard bystanders in the event of a transmission system short circuit, it is necessary to compute the total ground potential increase and the gradients in potential during a fault (referred to as touch and step potentials). A spike in the ground potential might result from earth faults at a substation. Metal items may have a touch potential that is substantially higher than the earth under a person's feet because to currents flowing through the Earth's surface during a fault; this contact potential creates an electrocution risk. To shield people from this danger, any substation that has a metallic fence must be properly grounded.Reliability and cost are the two fundamental problems a power engineer faces. A good design tries to balance these two in order to obtain dependability without incurring too much expense. The architecture should also facilitate extension of the station, as necessary.

Location choice

Several considerations need to be taken into account while choosing a substation's site. For the installation of equipment with the requisite clearances for electrical safety and for access to maintain huge apparatus such as transformers, sufficient land space is needed [7].Gas insulated switchgear may result in total cost savings in locations where land is expensive, such metropolitan regions. Substations near coastlines that experience floods and tropical storms may often need an elevated construction to protect surge-sensitive equipment from the elements [9]. The site has to have space to develop in response to increasing demand or anticipated transmission expansions. The substation's impacts on the environment, including as those on drainage, noise, and traffic, must be taken into account.

The substation location must be somewhat central to the service area's distribution network. Both to prevent people from being hurt by electric shock or arcs and to prevent the electrical system from malfunctioning due to vandalism, the site has to be secured against intrusion by outsiders.

Design schematics

The creation of a one-line diagram, which depicts the necessary switching and protection arrangements in a simplified manner as well as the incoming supply lines and outbound feeders or transmission lines, is the initial stage in developing a substation layout. Several electrical utilities regularly generate one-line diagrams with the main components (lines, switches, circuit breakers, and transformers) organised on the page in a manner that mirrors how the equipment would be positioned in the real station[8].

Outside Substation Benefits

The major benefits of outdoor substations

1. The outdoor substations have the following advantages:

2. The extension of the installation is simpler;
3. The time required for construction of such substations is reduced;
4. All the equipment is within view, making fault detection easier.
5. Concrete and steel are the two construction materials that are needed in the least quantity.

Construction work is quite little, and installing switchgear is also extremely inexpensive. Fixing is simple, and enough distance is supplied between the devices so that a problem at one place won't spread to another.

Issues with Outside Substation

1. The outside substations need more room.
2. Installation of protective equipment is necessary for the prevention of lightning surges.
3. The cost of the substation rises as a result of the lengthening of the control cables.
4. Equipment made for outdoor substations is more expensive because it needs extra protection from the elements, such as dust and grime[9].

CONCLUSION

Incoming lines often feature a circuit breaker and a disconnect switch. In some circumstances, only one of the two devicesa switch or a circuit breakerwill be present on the lines. As a disconnect switch cannot stop load current, it is utilised to offer isolation. A circuit breaker may be used to turn loads on and off, to shut off a line when electricity is flowing in the "wrong" direction, and as a protective device to automatically interrupt fault currents. Current transformers are used to determine whether a significant fault current is flowing through the circuit breaker. The circuit breaker may be tripped using the current transformer's output power, which would disconnect the load it was feeding from the circuit break's feeding point. By doing this, the system's failure point is separated from the rest of it, minimising any negative effects on the remainder of the system's functionality. Switches and circuit breakers may both be controlled remotely from a supervisory control centre or locally (inside the substation). Thisbook chapter discussed about the outdoor substation layout and the equipment use in the substation as well as types of the transformer use in the substation and any other equipment use in power system.

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TYPES OF BUS-BAR SUBSTATION

Mrs. Kamireddi Sunandana*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the Types of bus-bar substation uses of the bus-bar and the types of the bus bar. The benefit of this ring bus-bar arrangement is that there are always two parallel lines to the circuit, therefore the failure of one path does not entirely stop the service. The difference between the surface potential and ground potential increase at a location where a person is standing and simultaneously has a hand in contact with a ground structure. Mesh voltage is the difference in potential between metallic objects connected to the grid and the potential of the soil within the grid. Transformers are able to receive AC electricity at a single voltage and supply it at either a step-up or step-down voltage. They contribute to greater transformer efficiency while delivering power over longer distances in this manner. Simple electromagnetic induction serves as the transformer's fundamental operating principle. Three single phase transformers are used in a three-phase transformer, although the coil structure is somewhat different. Here, the main and secondary coils are arranged concentrically, and the three-phase transformer will employ two more of these windings.

KEYWORD: *Bus-Bar, Bar System, Circuit Breaker, High Voltage, Low Voltage, Magnetic Field.*

INTRODUCTION

The best option for moving and distributing energy in settings with high-capacity demands is bus bar trunking systems. These bus bars, which are made of aluminium or copper conductors, are less complicated to install and maintain than panel distribution and wiring. The enclosed architecture of the bus bar trunking system offers a high degree of safety and dependability even in the most demanding settings.The XTRA-compact (XCP) bus bar from Star line is a bus bar trunking system that is excellent for distributing and transporting energy in data centres. The high-power bus bar, which has an amp range of 630-6300, is distinguished by a clever, ultra-compact design, providing protection up to IP65. For the most demanding critical power applications, the XCP product family offers unmatched safety, performance, and flexibility.In a switchgear panel, a bus bar is a metallic bar that transmits electricity from entering feeders to departing feeders. Bus bars are electrical junctions where incoming and outgoing currents may interchange. Electrical Bus bar is made up of a number of lines that are powered by the same voltage and frequency. Bus bars are often built using copper or aluminium conducting material.

Goal of the Bus-bar

Bus bars are stacked in a variety of ways, and each configuration aims to offer the best possible operational flexibility, dependability, and cost-effectiveness. The placement of the circuit breakers maximises availability for plant operations [1].

Communication Network:

To reduce network losses and improve the amount of power that can flow through it, the transformers that scale down the 12000V generated at the power plant are 115Kv, 230KV, and 400KV. The energy is subsequently distributed through cables and overhead wires throughout the transmission network. Transmission voltages of 115 KV, 230 KV, and 400 KV are usual.Distribution network: Using a transformer, we now scale down the voltages so that they may be utilised by both industrial and residential users. Cables are often used to deliver electricity across the distribution network. Distribution voltages are typically 11 KV or 33 KV.

Configuration of the substation

1. **In the transmitting network, there are primarily two types**:

a. Switching post

b. Substation

Changing stations

A switching station just uses one voltage level and without a transformer. In order to link the power plants to the cities and other local centres, it is utilised to switch electrical energy along the transmission network.

Substation

Using a transformer, a substation steps down the energy from the transmission network to a lower voltage level. The importance of substations for the generating, transmission, and distribution systems [2].

a. Execute a number of crucial switching operations.

b. Before it reaches the client, the voltage level may be quite high. Depending on the customer's needs, whether they call for high or low voltage.

c. Owned and run by an electricity utility or a significant industrial or commercial client. This system is owned and will be operated by someone. For instance, the NTDCL runs the majority of the substations in Pakistan.

d. A SCADA system may be used for control and supervision.

Various bus bars

There are three types of bus-bar systems

a. Single bus-bar systems

b. double bus-bar systems

c. ring bus-bar systems

Single bus bar system

As the name suggests, this system only uses a single bus bar. Many incoming and outgoing lines are linked to the same bus-bar.As an example, consider connecting two 11 KV incoming lines with a circuit breaker and isolator. According to the above image, an isolator, circuit breaker, and step-down transformer link the single phase 230 V and three phase 440 V outgoing supply lines. As necessary, circuit breakers may be added to provide a single bus-bar sectionalized layout bus-bar show in figure 1 [3].

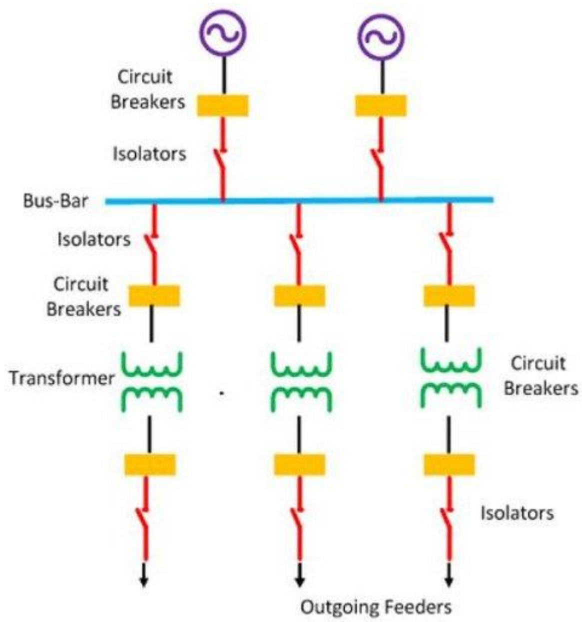

Figure 1 Illustrates the Bus-bar [Quora].

Benefits of a Single Bus-Bar System

a. One benefit of this system is that a failure in one bus-bar component does not result in a whole system shutdown.

b. It requires little upkeep.

Single bus-bar System Drawbacks Include

a. Complete shutdown is required before any expansion;

b. In the event of a malfunction, the whole system will be turned off.

Bus-bar Double System

Low voltage and high voltage bus-bars are replicated in a double bus-bar arrangement. Either one of the two bus-bar portions may be used as needed.

Benefits of the Double Bus bar System

a. With a twin bus-bar configuration, it is feasible to "activate" one bus-bar so that it is easy to do repairs on the other bus-bar as needed.

b. When a failure arises on the bus-bar, the undisrupted supply to the circuit may be maintained by moving it to another bus-bar, preserving the main bus-bar while testing feeder circuit breakers on a spare bus bar.

Cons of the Double Bus-bar System

a. The price of upkeep is expensive.

Bus-bar Ring System

With this configuration, two circuit breakers are used on a single line. For instance, CB1 and CB2 are on one line, while CB3, CB4, and other are on another line.The benefit of this ring bus-bar arrangement is that there are always two parallel lines to the circuit, therefore the failure of one path does not entirely stop the service. The ring bus-bar system includes multiple paths to the circuit, so failure of one segment does not fully disrupt service. It is also feasible to maintain any circuit breakers without affecting electricity.Within the substation, there are three different possible kinds to be found.

1) Touch Voltage

The difference between the surface potential and ground potential increase at a location where a person is standing and simultaneously has a hand in contact with a ground structure is known as touch voltage.

2) Step voltage

When a person crosses a 1 m distance with their foot across a variation in surface potential without touching any other ground objects.

3) Mesh Voltage

Mesh voltage is the difference in potential between metallic objects connected to the grid and the potential of the soil within the grid [4].

Configuration of the substation

Transformer

Transformers are able to receive AC electricity at a single voltage and supply it at either a step-up or step-down voltage. They contribute to greater transformer efficiency while delivering power over longer distances in this manner. Simple electromagnetic induction serves as the transformer's fundamental operating principle. According to this theory, a loop's fluctuating magnetic flux will cause an electromotive force to develop across it. A coil and alternating emf system may readily create such a fluctuating magnetic field. As electricity flows through it, a magnetic field is created everywhere around it. The coil generates a magnetic field, and since alternating current fluctuates, the magnetic field connected to the coil does too.

A ferromagnetic material core may be used to successfully connect this magnetic flux to a secondary winding. The secondary coils will experience an emf as a result of the fluctuating

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magnetic field due to electromagnetic induction. Because there is a sequence of turns. The total of the individual emf induced at each turn will make up the net emf throughout the winding. The emf per turn for both the main and secondary coils will be the same since the same magnetic flux is going through both coils. The input voltage for the main coil is affected by the EMF per turn. The secondary coil's induced EMF is thus stated as follows:

$$Es=(Ep/Np)Ns$$

The transformer will step up the voltage when the secondary winding has more turns than the primary winding, and it will step down the voltage when the secondary winding has less turns than the primary. Yet, since energy is conserved, the connection between the main and secondary currents must be observed [5].

$$EpIp = EsIs$$

Three single phase transformers are used in a three-phase transformer, although the coil structure is somewhat different. Here, the main and secondary coils are arranged concentrically, and the three-phase transformer will employ two more of these windings. The term "disc type winding" refers to a unique kind of winding used most often in transformers with high power ratings. When two independent disc windings are coupled together in series by an outer and an inner crossover. When coupled, the high voltage windings are in a star shape whereas the low voltage windings are in a delta configuration. Consequently, at the high voltage side, the line voltage increases by a further belt-3.5 time. This implies that we may draw four output lines, three phase power wires and one neutralfor a three-phase step-up transformer.

It needs high voltage bushing to release the electrical energy. Thin insulated steel laminations make up the transformer's core. Three phase limbs are created by stacking such steel laminations. Thin laminations help cut down on eddy current energy losses. Normally, the low voltage wind age is located close to the core. The transformer is submerged in cooling fluid for heat dissipation. The oil releases heat by natural convection. Oil in the transformer will take in the heat.

DISCUSSION

The circuit breaker

SF6 circuit breakers are often used in circuit breakers with ratings of 145 KV and above. The wires in the substation are typically linked at the top and bottom of the palm using a single pole circuit breaker. The circuit breakers SF6 gauge is used to keep track of the gas pressure. There are two major parts to the circuit breaker. Let's first examine one interrupter to discover how contacts are operated (closed and open) in order to drive a mechanism. Within the porcelain enclosure of this airtight container filled with SF6, we can observe two primary contacts: a moving male contact and a fixed female contact. If we look carefully, we can see two additional interactions that are comparatively smaller; these contacts are what we refer to as our contacts. This one is our fixed male contact, whereas this other one is our shifting female contact. This nozzle's purpose is to guide SF6 flows into the arcing zone to hasten quenching. It is built of a non-metallic insulating substance. In order to effectively quench SF6, pistons are utilized in the circuit breakers. The pistons are linked with an insulating rod that goes through the stack and is used to drive the piston rod, which is then used to move the contacts when the circuit breakers are in operation [6].

Since the distance between our contacts is less than the distance between the main contacts, while the interrupter is in the open position and a close instruction is sent to the circuit, the moving contact will move in the direction of the fixed contacts before the closing arc is created. Our contacts seem to think that SF6 gas builds up between the pistons and the main contact during this operation. This is how closed operation occurs within the interrupter: the arc and main contacts finally come near and the arc is quenched. We'll now examine how the circuit breakers' moving contacts respond to an open order to move away from a fixed contact in a closed state one strip. This is how open operation occurs inside the interrupter: first, the main contact opens, followed by our contact, causing an arc to form between our contacts. During this time, SF6 that has built up between the main contacts and pistons due to contact movement is pushed into the arc region through a nozzle, successfully quenching the arc.

Isolators

The isolator is a mechanical switch that, depending on the needs, separates a circuit from the system. Isolator is a mechanical switch that is manually manipulated and separates a portion of electric power. A motorized system may also be used to control the isolator. An isolator is a switch that is always opened or closed while the load is off.

Off load: the state of the circuit when current is not flowing

There are three different kinds of isolators:

a. Double break,

b. Single break,

c. Pantograph.

The isolator may be classified into the following groups depending on its location in the power system

Isolator on the bus side: This isolator has a direct connection to the bus.

Isolator on the line side: This isolator is placed on the line side of any feeder.

Isolator on the transfer side: This isolator is linked to the transfer bus directly.

A bus bars

Bus bar, also known as Bus bar, is a hub or node for several incoming and outgoing circuits. Let's start with different bus bar schemes or systems in electrical substation one single bus system this is the most basic and simple bus bar system as we can see in the diagram in this type all incoming and outgoing base such as lines transformer feeders are directly connected to single bus. As we know it is impractical to connect multiple conductors at one point so we use bus bar where these connection can be done spaciously conveniently [7].Just one bus Single bus sectionalized system: This single bus system has an extra circuit breaker and isolator, dividing it into two separate portions, therefore the name single bus sectionalized system. Due to the circuit breaker separating the two portions, a defect on one area does not impact the other.

Transform standardized main current into standardized secondary current using a current transformer. A current transformer is a current measuring device used for metering and protection that securely reproduces a low-level current that precisely reflects a larger current level. Since the ac currents converted in this manner are much smaller than the primary flowing currents, the connected protection, control, and measuring system can directly process them. Simple electromagnetic induction serves as the current transformer's fundamental operating mechanism. By using the Maxwell equations, and more especially the Amperes rule, we can state that if a magnetic field is integrated around a small wire loop, the value of that integral is equal to the net current contained within the loop. The magnetic core of the current transformer, which is a closed-loop device, is made up of secondary winding. The wire carrying the current we want to measure passes through the core of the CT's primary winding in the main loop. When winding wire, the primary winding, which carries the main current, is said to have a single loop. This single loop creates the magnetic field that drives the secondary winding, which serves as the potential transformer's output[8]–[10].

CONCLUSION

This transformer is used for both protection and measurement. The voltage is changed from high voltage to low voltage via a potential transformer. As a step-down transformer, the prospective transformer's main winding will have more turns than the secondary winding. It can be simply measured the voltage with a voltmeter since the secondary side has low voltage.High voltage measurements are done using a potential transformer. This is used to safeguard the lines against over- and under-voltage situations. The generator and line are synchronized using a potential transformer as well.This book chapter explores about the types of bus-bar substation uses of the bus-bar and the types of the bus bar along with working of the bus-bar in transmission and the distribution of the power in industrial as well as domestic process.

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ROLE OF SUBSTATION MAIN EQUIPMENT IN POWER SYSTEM

Dr. Rajiv Singh*

*Professor,
Department of Electronics And Communications Engineering, Presidency University, Bangalore, India,
Email Id-rajivranjansingh@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the substation main equipment define the equipment use in the substation and the types of the sub-station in power system. A high-voltage electric system facility is known as a substation. It is used to switch equipment, circuits, lines, and generators in and out of a system. Power transformers are used in generating stations to step up the voltage for transmission and in main step-down transformer substations to step down the voltage for further distribution. A current transformer transforms current by changing its value from one that is higher to one that is lower. A voltage transformer is a kind of instrument transformer that transforms voltage from one value to another, from higher to lower. When all transmission lines have the same voltage, the situation is the simplest. When this occurs, the substation has high-voltage switches that enable the connection or isolation of lines for fault repair or maintenance.

KEYWORD: *Circuit Breaker, Collector Substation, Main Equipment, Power Supply, Power System, Transmission Line.*

INTRODUCTION

A high-voltage electric system facility is known as a substation. It is used to switch equipment, circuits, lines, and generators in and out of a system. Moreover, it may convert alternating current to direct current or direct current to alternating current, as well as adjust AC voltages from one level to another. Some substations are tiny, consisting just only a transformer and any necessary switches. Some are quite massive and include several transformers, numerous switches, and other machinery.Several kinds of electrical equipment are needed for the transport of electrical power from producing units to distribution units. The electrical substation houses the equipment, such as bus bars, isolators, power transformers, etc., via which consumers get electrical supply. This is a detailed explanation of the key equipment needed for the substation installations[1]–[3].

Thunder Arrestor

The initial component of the electrical substations is the lightning arrestor. It controls the length and amplitude of the current flow as well as protects the substation equipment from sudden high voltage. The lightning arrestor is connected between the line and the ground, or in parallel with the substation equipment that is being protected. The lightning arrester prevents damage to the system's insulation and conductor by diverting the current from surges to the ground. The many varieties of lightning arresters are categorised according to the tasks they carry out Thunder Arrestor show in figure 1.

Figure 1 Thunder arrestor.

Power converter

Power transformers are used in generating stations to step up the voltage for transmission and in main step-down transformer substations to step down the voltage for further distribution. With ratings up to 10 MVA, type two winding, naturally cooled, three phase transformers are often utilised. Transformers with a rating greater than 10 MVA are often cooled by air blast. Force oil, water cooling, and air blast cooling may be employed for extremely high rating.When a transformer of this kind is operating at full load, it is unplugged. The banks of power transformers may be thrown in parallel with other devices. Thus, at full load, the power transformer's efficiency is highest.

Transformer for instruments

High voltages and currents are lowered using an instrument transformer to a safe and usable level that can be monitored with standard equipment (normally range is 1A or 5A for current and 110 V for voltage). The current and potential transformer is also used to deliver the current and voltage for activating the AC type protection relay. Instrument transformers go into one of two categories.

Current Transformer

A current transformer transforms current by changing its value from one that is higher to one that is lower. It is used in parallel with AC instruments, metres, or control equipment since it is not practical to make an instrument coil with enough current carrying capacity.

Instrument Transformer

A voltage transformer is a kind of instrument transformer that transforms voltage from one value to another, from higher to lower.

Bus-Bar

It is one of the most crucial components of a power substation. There are several connections made to this kind of conductor, which carries an electrical current. In other terms, a bus-bar is a form of electrical connection where electrical current flows both in and out bus bar show in figure 2.

Figure 2 Bus bar.

All of the circuit equipment linked to that piece of the bus bar must be completely isolated as soon as possible, say within 60 milliseconds, in order to prevent damage to the installation from conductor heating.

Surf Trapper

For the purpose of trapping the high-frequency wave, it is installed on incoming lines. The voltage and current waves are disrupted by the high-frequency wave that is emanating from the distant substation. The high-frequency waves are triggered by wave trappers and are directed to the telecom panel.

Isolator

This particular switch type is only used to isolate the circuit once the current has been briefly halted. The isolator, also known as unconnected switches, acts when there is no load. They don't have arc-quenching equipment. There is no known limit on their ability to produce or break current. It is sometimes used to stop the transmission line's charging current.

Breaker, a Circuit

When a defect occurs in the system, the circuit breaker is a sort of electrical switch that is used to open or close an electrical circuit. Two movable contacts that are typically closed make up this device. When a system problem occurs, the relay notifies the circuit breaker to trip, which causes their contacts to be pushed apart. it is now evident where the systemic error lies.Batteries The operation and automated control circuits, the protective relay system, as well as the emergency lighting circuits, are supplied by station batteries in electric power plants and high-capacity substations. Depending on the operating voltage of each DC circuit, the number of accumulator cells used to make up a station battery varies.Lead acid batteries and acid-alkaline batteries are the two kinds of storage batteries. As lead acid batteries have a high voltage and low cost, they are most often employed in power plants and substations.

Battery Bank

A capacitor bank is made up of capacitors that are either linked in series or parallel. Electrical charges were used to store the electrical energy. The power factor of the network and the system's capacity to transmit power both rise when a capacitor bank draws leading current.

Switchyard

Transformers, circuit breakers, and switches for connecting and disconnecting the transformers and circuit breakers are kept at the switch yards. Moreover, it features lightning arrestors to safeguard the power plant against lightning strikes.

Devices for indicating and measuring

Power factor metres, kWh metres, KVARH metres, and ammeters, voltmeters, and watt meters Substations are equipped with reactive volt-ampere metres to monitor and manage the current flowing through the circuits and the power loads.Insulator The bus bar systems are fixed and insulated in generating stations and substations using this material. They may be separated into two types: post and bushing. A post insulator's body is composed of porcelain, while its top is constructed of cast iron. It is fastened directly to the bus bars using bus-bar clamps. A bushing or through insulator is made comprised of a porcelain shell body, upper and lower locating washes, and a bus-bar or rod that is fixed in place within the shell.

Carrier-current Equipment

Several pieces of technology are put in the substations for supervisory control, telemetry, communication, and relay. The carrier room contains the equipment properly installed, linked to the high voltage power circuit, and housed Carrier-current Equipment show in Figure 3.Relay it safeguards the power system component against abnormal circumstances like malfunctions. The relay is a sensor device that first detects the problem, locates it, and then transmits orders to trip the circuit. After receiving the order from the relay, the circuit breaker disconnects the malfunctioning component. Relays guard against equipment breakdown and consequent dangers like fire. By eliminating the specifically faulty portion, the risk to life is decreased.

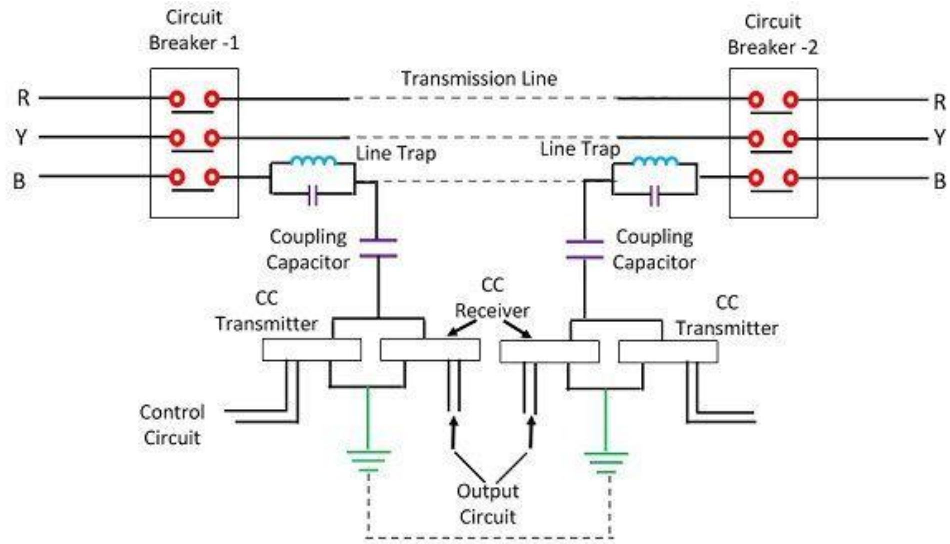

Figure 3 Carrier-current Equipment [Circuit Globe**]**.

LITERATURE REVIEW

I.G. Galyautdinova etal.explored a 35/6 (10) kV transformer substation's technical condition is the subject of an investigation and selection of the equipment required for monitoring and express analysis. The authors suggest diagnostic criteria for assessing the technical condition of a piece of equipment and an algorithm for calculating the coefficient of express analysis of a transformer substation, which ensures the process of remote monitoring, monitoring the condition of operating equipment, and anticipating changes in the technical condition. The equipment is kept in operable state by the system for monitoring and express analysis of the technical condition of the equipment that is currently being developed. This system permits online monitoring of changes in the monitored parameters. This monitoring system will allow for early fault detection, more efficient operation of the substation's energy equipment, and a thorough evaluation of the substation's technical state as a whole. The aforementioned fixes allow for the organisation of repairs to the primary machinery of the substation in accordance with its current condition, as well as an improvement in the dependability and calibre of energy transmission to customers[4]–[6].

Yuan Wang etal. explored an offering recommendations for the site selection of the substation and for the layout optimization within the substation, a precise analysis of the impact of the terrain environment of the plant boundary on noise transmission and attenuation can also serve as the foundation for the noise control of the operated substation. The noise characteristics of main transformers and shunt reactors as well as the noise distribution around the plant boundary are analysed in this paper, which leads to the conclusion that the noise at the plant boundary is primarily derived from the main equipment within the substation. Sound level metres are used to test the noise of the main equipment in the substation and around the plant boundary. The Zhebei UHV substation layout is used as an example, and the Sound PLAN software is used to simulate and calculate the noise attenuation law under seven different terrain conditions outside the plant boundary. The suggestion is made at the end that low-lying terrain and raised hilly terrain have the best blocking effects on the process of noise transmission. The findings of this article may serve as a guide for choosing new substation locations and optimising the terrain structure around active substations.

Mihaela Bitoleanu, etal. discussed in light of current worldwide concerns about lowering CO2 emissions by minimising energy consumption and energy loss, the study's main objective is to increase the energy efficiency of DC railway systems. In a thorough overview, the key developments in this difficult problem are summarised and analysed, with an emphasis on the application and implementation of the current solutions on real-world case studies. Every particular subtopic pertaining to energy efficiency is addressed, beginning with power quality conditioning and concluding with the recovery of braking energy, which is wasted in enormous quantities in traditional DC-traction substations. The solutions of on board and roadside energy storage devices are examined, contrasted, and provided real-world examples. The accomplishments in converting the current DC-traction substations into reversible substations with the ability to increase power quality are then thoroughly evaluated by presenting the key findings of recent studies on this subject. These consist of products that are on the market as well as solutions that have been approved via use on experimental models. The findings of this thorough evaluation serve as a valuable reference and support for the research and development aimed at creating energy-efficient traction systems.

Shi Ping Wang etal. discussed through the study of electrified railway traction substation power rapid switching technology, the problem of electrified railway traction substation main equipment maintenance or main transformer switch operation, which has low efficiency and overreliance on the maintenance "Window," can be resolved. This essay is a methodical introduction to the fundamental idea behind rapid switching power supply technology. The paper examines the engineering application of the fast-switching power supply device in the equipment maintenance and rotation working of the traction substation based on the practical application of the main electrical connection of the railway traction substation. It also analyses the outcomes of various programmes in order to promote the accumulation of experience. Power quick switching technology may achieve smooth switching of the traction substation's power supply and can maintain a continuous power supply throughout the main transformer's reversing operation, preventing station-wide power outages.Power quick switching technology increases the productivity of the traction substation's primary equipment and assures the dependability of the traction power supply. Power quick switching technology offers parallel and series switching modes, allowing for more flexible maintenance work arrangements for the primary electrical equipment at traction substations that are not constrained by maintenance "Window" time constraints. This technology may be extensively applied in the operation of the electrified railway traction substation with the enhancement of the hardware performance and the development of the software function.

Setiyo Silalahi etal. delivered the electrical energy produced by the power plant to the neighbourhood, the transmission line is often situated distant from the load centre. The substation is a collection of additional high voltage equipment that is a component of a distribution transmission line that serves as a control centre. The major piece of equipment at the substation, the power transformer, requires regular maintenance to ensure dependable operation.

The suggested approach for this study is to test the transformer when it is turned off to assess its condition, then calculate the transformer ratio and measure the Ray tech Transformer Turn Ratio measuring device to ascertain the transformer windings' condition. The ratio between the power transformer's winding input voltage of 20,000 volts and its output voltage of 400 volts is calculated in this study using the Ray tech Transformer Turn Ratio measuring tool. From the comparisons done, it is clear that at a voltage of 40VAC, the Ray tech Transformer Turn Ratio measuring instrument's test findings modify the ratio if the tolerance limit of 0.5% is exceeded. This is especially true for one of the coils. A voltage imbalance on one of the coils will occur if the transformer is not routinely inspected. Moreover, one of the phase-matched coils will enlarge and result in a voltage drop.

DISCUSSION

In order to deliver power to end users, a network of electrical devices is linked in a planned manner and referred to as an electricity substation. For the system to operate smoothly, there are several electrical substation components, such as incoming and outgoing circuits, each of which has its own circuit breakers, isolators, transformers, and bus bar system. The distribution, transmission, and generating systems are only a few of the components that make up the power system. Substations also play a crucial role in the functioning of the power system. The substations are the sources of the electricity that consumers use to power their loads, with the necessary power quality being provided to the customers via varying frequency, voltage levels, etc.

The designs for electrical substations solely depend on the requirements, such as a single bus or a complicated bus system, etc. The design is also influenced by the use, such as interior substations, generating substations, transmission substations, pole substations, outdoor substations, converter substations, and switching substations, among others. A collector substation is also required in big power producing systems, such as many linked thermal and hydropower facilities, in order to transport electricity from several co-located turbines to a single transmission unit.Two or more transmission lines are connected by a transmission substation.

When all transmission lines have the same voltage, the situation is the simplest. When this occurs, the substation has high-voltage switches that enable the connection or isolation of lines for fault repair or maintenance. Transformers to convert between two transmission voltages, voltage control/power factor correction devices like capacitors, reactors, or static VAR compensators, and machinery like phase shifting transformers to regulate power flow between two nearby power systems are all possible in a transmission station.

Simple to complicated transmission substations are possible. It's possible that a modest "switching station" is little more than a bus and a few circuit breakers. The biggest transmission substations may cover a lot of ground (a few acres or hectares), have a lot of circuit breakers, and a lot of protection and control gear (voltage and current transformers, relays and SCADA systems). International standards like IEC Standard 61850 may be used to implement modern substations.Substation for distribution an area's distribution system receives electricity from the transmission system via a distribution substation.Unless they use huge quantities of power, it is not cost-effective to connect electricity users directly to the main transmission network, thus the distribution station lowers voltage to a level appropriate for local distribution[7]–[9].

At least two transmission or sub-transmission lines are normally used as the input for a distribution substation. For instance, the input voltage may be 115 kV or another standard value for the region. There are many feeders as the output. In general, distribution voltages range from 2.4 kV to 33 kV, depending on the size of the serviced region and the utility's policies in the area. The feeders provide electricity to the distribution transformers at or near the client premises via roadways that are above (or, in certain circumstances, subterranean).Distribution substations convert voltage and isolate faults in either the transmission or distribution networks. Voltage control equipment may also be put along lengthy distribution circuits (of many miles or kilometres) however distribution substations are primarily where voltage regulation happens.Many cities' central business districts are home to complex distribution substations with high-voltage switching, low-voltage switching, and backup systems. On the low-voltage side, more standard distribution substations feature a switch, one transformer, and few amenities.

Intake substation

A collector substation could be necessary in dispersed generating projects like a wind farm or solar power plant. While electricity flows in the other way, from several wind turbines or inverters up into the transmission grid, it resembles a distribution substation. While some collector systems are 12 kV, the collector system typically works at roughly 35 kV for construction efficiency, and the collector substation steps up voltage to a transmission level for the grid. Moreover, the collector substation can manage the wind farm and alter power factor as necessary. A collector substation may, in rare exceptional circumstances, also house an HVDC converter station intake substation show in Figure 4.

Figure 4 Intake Substation [dreams time].

There are also collector substations in locations with a number of nearby thermal or hydroelectric power plants with similar output power. These substations, which draw electricity from local lignite-fired power plants, include Brauweiler in Germany and Hradec in the Czech Republic. The substation is a switching station if no transformers are needed to raise the voltage to transmission level.

Substations for converters

Convertor substations might be linked to traction current, HVDC converter plants, or integrated non-synchronous networks. These stations have powerful electronic components that can modify the current's frequency or convert it from alternating to direct current or the other way around. In the past, rotary converters altered frequency to link two networks; these substations are now uncommon.

A switching Point

A substation that operates just at one voltage level and without transformers is referred to as a switching station. Collector and distribution stations may sometimes be found in switching stations. They may also be used to parallelize circuits in the event of a breakdown or to divert the current to backup lines. The switching centres for the HVDC Inga-Shaba transmission line serve as an example.A switching station, sometimes referred to as a switchyard, is typically situated next to or next to a power plant. In this instance, the transmission lines get their power from a Feeder Bus on the other side of the yard while the generators from the power plant send their electricity into the yard onto the generator bus on one side.

Switching, or the connecting and unplugging of transmission lines or other system components, is a crucial task carried out by a substation. Events that switch might be planned or spontaneous. For maintenance or for new construction, such as the addition or removal of a transmission line or a transformer, it may be necessary to de-energize a component or a transmission line. Companies strive to keep the system up and operating while undertaking maintenance in order to preserve supply dependability. Anything that has to be done, from standard maintenance to constructing totally new substations, should be done while the system is still in operation.

Structure of a substation

Transformers, switching, protection, and control equipment are often found at substations. Circuit breakers are utilised in a big substation to stop any potential network short circuits or overload currents. Re closer circuit breakers or fuses may be used in smaller distribution stations to safeguard the distribution circuits. While a power plant may have a substation nearby, substations don't often contain generators. A substation may also house other components including reactors, voltage regulators, and capacitors.Substations may be found underground, on the surface in walled enclosures, or in specific purpose structures. Several interior substations may be present in high-rise structures. Urban locations often include inside substations to protect switchgear from harsh weather or pollution conditions, to improve aesthetics, or to lessen noise from the transformers.

Designing a grounding system is necessary. To safeguard bystanders in the event of a transmission system short circuit, it is necessary to compute the total ground potential increase and the gradients in potential during a fault (referred to as touch and step potentials). A spike in the ground potential might result from earth faults at a substation. Metal items may have a touch potential that is substantially higher than the earth under a person's feet because to currents flowing through the Earth's surface during a fault; this contact potential creates an electrocution risk. To shield people from this danger, every substation that contains a steel fence must be properly grounded.Reliability and cost are the two fundamental problems a power engineer face. A good design tries to balance these two in order to obtain dependability without incurring too much expense. Also, the station should be able to expand as needed thanks to the architecture.

Insulation

Air-insulated bare wires strung on support structures may be used to link switches, circuit breakers, transformers, and other equipment. With system voltage and the lightning surge voltage rating, more air space is needed. Metal-enclosed switchgear may be used in medium-voltage distribution substations, and there shouldn't be any active conductors outside. Gas-insulated switchgear in a gas insulated substation (GIS) decreases the necessary area near active buses for greater voltages. Buses and equipment, like as switchgear, are constructed within pressurised tubular containers that are filled with sulphur hexafluoride (SF6) or another gas, as opposed to naked conductors. The equipment may be smaller because of the gas's better insulation value compared to air. Other insulating materials, including as transformer oil, paper, porcelain, and polymer insulators, will be used by the equipment in addition to air or SF6 gas.

CONCLUSION

While there are various variations, outdoor, above-ground substation constructions typically consist of wood pole, lattice metal tower, and tubular metal structures. Steel lattice towers provide inexpensive supports for transmission lines and equipment in locations with plenty of available space and where the station's appearance is unimportant. In suburban regions where aesthetics is more important, low-profile substations may be provided. Indoor substations may employ metal-enclosed or metal-clad switchgear at lower voltages or gas insulated substations (GIS) (at high voltages, using gas insulated switchgear). Indoor substations in urban and suburban settings may have an exterior finish to match nearby structures.In this book chapter we discuss about the substation main equipment define the equipment use in the substation and the types of the sub-station in power system transmission and the distribution process.

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EXPLORING THE SIZE OF TRANSFORMER USED IN POWER SYSTEM

Ms. Renuka Bhagwat*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

ABSTRACT:

In this book chapter there is described the size of the different types of transformers used in the power system in transmission and the distribution of the power from industrial as well as domestic purpose. Different transformers are used in different way, the rated current, magnetising current, and kVA rating of transformers are all directly related to the frequency at which they are intended to operate. With single-phase transformers, the winding connections are unimportant. However, the choice of winding connection is important for three-phase transformers. Transformers of the dry kind utilise outside air to cool the core and windings. These transformers are often less costly in terms of materials and installation expenses while being bigger than liquid-filled transformers. These transformers must periodically have their oil analysed, although maintenance is thought to be less expensive. In the event of a spill, bio-based oils are less combustible and beneficial to the environment. If the transformers are located at grade level or on the roof at a position that provides sufficient separation from the transformers and guests, then room treatment may be unnecessary.

KEYWORD: *Single Phasetransformer, Distribution, Current, Power System.*

INTRODUCTION

The most fundamental form two copper loops of varying sizes, placed one within the other without making contact, may serve as an example of this idea. The terminals of the other loop experience an induced voltage if one of these loops has current flowing through it. The second loop's voltage and current are proportionate to those of the first loop's voltage and current. A range of working voltages may be produced by varying the number of loops or windings.In the HVAC business, we often employ Class 2 control transformers with a power rating of 100VA or less to decrease the voltage to 30 volts or less. As a result, low voltage wire may be routed outside of an enclosure without the need for electrical conduit.

The input voltage, often 120, 208, 240, or 460 volts, is known as the main voltage. The output voltage, also known as the secondary voltage, will often range between 24 and 30 volts. The main voltage's true value will determine the output voltage's actual value. By VA capability, the transformer power is rated. A high enough VA should be chosen because the VA must be big enough to meet the overall control power requirements.The main voltage must be chosen initially in order to appropriately size a transformer. Care must be taken to only connect to the 208V primary tap if the primary voltage is 208V. Care must be taken to only connect to the 240V primary tap if the main voltage is 240V. Low secondary voltage will occur when wiring 208V to the 240V tap. Low secondary voltage may result in failures or chattering of contactors and relays. When installing 208/240volt package equipment, this has to be verified power system equipment show in figure 1.

Figure 1 Power system equipment [electrical-engineering-portal].

Operational temperature

The rated current, magnetising current, and kVA rating of transformers are all directly related to the frequency at which they are intended to operate. The only frequency at which a transformer should work is that frequency. The input supply frequency and the operating frequency of the load should match the transformer's rated frequency.

Linkages in the wind

With single-phase transformers, the winding connections are unimportant. However the choice of winding connection is important for three-phase transformers. These are many main and secondary winding arrangements Copper or aluminium are used to make transformer windings. Since it is less costly and has comparable electrical properties to copper, aluminium is a popular choice. While it weighs less than copper, aluminium often has bigger physical dimensions.In the industry, power rating sizes for power distribution transformers are standardised. Three-phase delta primary to wye secondary step-down type transformers are the most popular use in a commercial building. 480 to 120/208 volt wye transformer sizes typically range from 15, 30, 45, 75, 112.5, 225, 300, and 500 kilovolt-amperes.

Moreover, single-phase 277- or 480-volt transformers in the 5, 7.5, 10, 15, 25, 37.5, 50, 75, and 100 kilovolt-ampere range are available. This is not an exhaustive list, but it does show the breadth and diversity of products that are commercially accessible.

In general, three-phase transformers are the most often chosen and used by electrical designers. Single-phase transformers are often utilised for specialised voltages or purposes. A item of equipment that expressly needs 240 volts single-phase but whose service voltage is 120/208 volts wye three-phase may be an example. It is typical to merely offer a single-phase transformer for the equipment in a specific scenario like this since it won't be serving many different loads. When a three-phase utility is utilised with a single-phase transformer for general distribution, phase imbalances may result. Alternatively, a single-phase transformer might be useful if a property is serviced by single-phase and a transformer is utilised

Every transformer must have a nameplate with the details indicated in NEC 450.11. The name of the manufacturer, the rated kilovolt-amperes, the frequency, the primary and secondary voltages, the impedance of transformers 25 kilovolt-amperes or larger, the necessary clearances for transformers with ventilating openings, the quantity and type of insulating liquid used, and the rated kilovolt-amperes are all included in this information. Temperature class for the insulating system in dry-type transformers.

Size of transformers

Finding the load that will be servedeither at the branch circuit, feeder, or service levelis the first step in sizing a transformer. Using NEC Article 220, estimate or calculate the demand load, and then apply any necessary demand factors are the first steps in this process. Demand considerations will lower the predicted load to establish the proper transformer size based on the kinds of loads serviced.The base load or starting point for sizing the transformer is represented by this computed design load. Depending on the kind of project, you will need to take a few factors into account after you have established the base load when estimating the transformer's ultimate size. Future adaptability, accessible physical area, pricing, and project kind are a few of these factors to take into account.One of the most important factors in choosing the right size for a property is its potential capacity or growth. This is crucial since both large and undersized transformers run at reduced efficiency and have the potential to gradually harm equipment. It is essential to comprehend how the facility will be used by the owner. In certain cases, the property is not expected to grow, therefore the owners may not need space for more equipment or loads in the future.

Nameplate for a transformer

A transformer's essential characteristics, such as its main and secondary voltages, KVA, winding connection, power factor, cooling techniques, winding conductor material, types, mounting configuration, efficiency, and frequency of operation, must be determined. The nameplate, a plate that is attached to the transformer, is where all of these specifications are listed. If a transformer is functioning properly, a well-fitting, comprehensive label including all of the required parameters will be visible.

Additional elements

In addition to the aforementioned factors, the selection process also takes into account a number of additional variables, including the transformer type (dry type or oil immersed), power factor, voltage regulation, operating temperature, mounting arrangements, cooling arrangements, and impulse withstand capacity of the transformer.

Literature review

De Caro, etal, explored step-up transformers, which are often sized solely based on the peak power of the PV plant, big PV plants are connected to the utility network. In the current research, a generic design technique is presented to choose these transformers' sizes optimum based on the site's statistical distribution of solar irradiation and the plant's mathematical model [1]. It is based on a probabilistic methodology that considers the so-called LPPP (Loss of Produced Power Probability) index as a basis for assessment. The suggested technique is used to determine the ideal transformer size for a grid-connected 2 MW PV plant that is situated in various geographical locations while taking whole life costs into consideration. Moreover, the impact of installing energy storage technologies in the PV plant is also assessed.

Ruikun Xu, etal, discussed the power battery string is in a long-period imbalanced discharge state due to the complexity of driving circumstances and the expansion of the driving range of electric two-wheelers and three-wheelers, which impacts power production and even poses certain safety issues. By sharing the main inductor with a boost discharger, a compact-size multi-winding transformer-based discharge equalisation is presented to address these issues and lessen the effect on the system volume. The boost converter's inductor generates a square wave voltage while it is powering a load, which is used to drive the multi-winding transformer equaliser, which creates many identical voltage levels to achieve voltage balance. As a result, each module just requires one winding and one diode to accomplish automated balancing. Four batteries were set up as part of an experimental prototype to confirm the viability of the suggested approach. Also, a quantitative comparison demonstrates that the suggested technique, in contrast to the conventional equalisation method based on the transformer, obtains a more compact-size equaliser since there is no need for a separate transformer.

Duk You Kim etal. explored a three-level converter with pulse-width modulation and a smaller filter that uses two transformers. The suggested converter offers a lot of benefits. All switches can only withstand 50 percent of the input voltage, and the output filter inductor may be decreased since the secondary rectified voltage has a three-level waveform[2]. High efficiency may be attained as a result of the transformer and lower output inductor sharing power. This study presents the operational theory, analysis, and design considerations of the proposed converter. The experimental findings from a prototype with a 600 W, 500-600 V input, and 60 V output validate the validity of this work.

Yotam Levi, etal. investigated current developments in the e-commerce fashion sector have prompted an investigation of creative strategies to improve the customer experience via more personalisation. This paper investigates a crucial customization challenge: recommending the right size for an item. Previous research in this area either concentrated on simulating explicit buyer fitting feedback or simply modelled one component of the issue (e.g., specific category, brand, etc.)[3]. The problem's content-based features are better accounted for in more recent publications that presented richer models, either content-based or sequence-based, or that more accurately modelled the online shopping experience of buyers. Unfortunately, both of these methods fall short in certain circumstances, such as when dealing with new users or previously unknown things (sequence-based models) (content-based models).

We suggest PreSizE, a unique deep learning architecture that makes use of Transformers for precise size prediction, to fill the aforementioned deficiencies. PreSizE simulates how the buyer's past purchases and content-based factors like brand and category affect her sizing choices. We show that PreSizE is capable of outperforming earlier state-of-the-art baselines in terms of prediction performance using a comprehensive series of tests on a large e-commerce dataset. PreSizE handles cold-start circumstances with unseen products and situations where buyers have limited prior purchase information better by encoding item properties. We provide a proof-of-concept that size estimates from PreSizE may be successfully included into an existing production recommender system, resulting in extremely useful features and noticeably better suggestions.

Zhuohan Wallace etal. explored deep learning model training often aims to optimise accuracy within the time and memory restrictions of training and inference since hardware resources are restricted. With an emphasis on Transformer models for NLP tasks such as self-supervised pretraining and high-resource machine translation, we examine the effects of model size in this context [4]. First, we demonstrate that broader and deeper Transformer models converge in noticeably fewer steps even if smaller Transformer models execute more quickly every iteration. Moreover, the increased computing burden caused by adopting bigger models is often outpaced by this acceleration in convergence. Hence, training tremendously big models but stopping after a limited number of iterations is the most computationally efficient training method. This causes what seems to be a trade-off between the effectiveness of tiny Transformer models for inference and the effectiveness of big Transformer models for training. We do, however, demonstrate that, compared to small models, big models are more resistant to compression methods like quantization and pruning. As a result, big, severely compressed models are more accurate than tiny, lightly compressed ones, giving users the best of both worlds.

DISCUSSION

Transformer types

Once a transformer's size has been established, take into account the uses and different kinds of loads it will handle. There are a few transformer types with the following features that are often used in commercial design. Transformers of the dry kind utilise outside air to cool the core and windings. These transformers are often less costly in terms of materials and installation expenses while being bigger than liquid-filled transformers.The two dry-type transformers that are most often used are enclosed and ventilated. For wash-down areas and corrosive, combustible, or other hazardous circumstances, non-ventilated or encased are totally enclosed with surface cooling. Ventilated dry-type transformers are bigger in size, employ different insulating materials, have an enclosure for the windings, and have air vents built into them. These features provide both workers and equipment with physical safety[5].

Transformers with liquid insulation employ the liquid to cool the cores and serve as an insulator. Mineral oil and bio-based oils are the most often utilised liquids. Better cooling is possible with liquid-insulated transformers, which results in a smaller transformer than with a dry kind.These transformers must periodically have their oil analysed, although maintenance is thought to be less expensive. In the event of a spill, bio-based oils are less combustible and beneficial to the environment. Liquids having a fire point of at least 300°C are thought to be less combustible. Utility transformers that are located on an outside pad are often filled with mineral oil and are regarded as flammable. Indoor installations for transformers under 35 kilovolts can just need a few things, such an automated sprinkler system or a liquid containment space without any combustibles kept there.The specifications for indoor and outdoor installations of these liquid-insulated kinds are covered by NEC 450.23. Also, under NEC 450.24, a transformer vault must be constructed inside for non-flammable fluid-insulated transformers that employ a non-flammable dielectric fluid. When used inside, oil-insulated transformers must be placed in a transformer vault in accordance with NEC 450.26.

Unique applications

For harmonic, nonlinear loads like computer/servers with switch-mode power supply, gambling slot machines, LED lights, motors, or variable frequency drives, K-rated and harmonic mitigating transformers are often utilised. Harmonic difficulties caused by nonlinear loads may be solved with HMTs.On the other hand, K-rated transformers enable a more resilient system to endure the harmonics rather than mitigating them. Transformer failure from harmonics is brought on by excessive and/or continuous overheating of the coils, which accelerates the deterioration of the insulation on the coils. Electrical systems with too many harmonics may deform the sinusoidal wave, which can lead to electronic component failure.

K-rated transformers are designed to withstand the stresses and strains of nonlinear loads depending on the level, which is the main distinction between them and HMTs. The physical design of HMTs prevents disruptive currents from passing electrically upstream of the transformer by reducing or mitigating harmonic currents from downstream devices.Switch mode power supply now power the majority of electronic devices. SMSPs use rectifiers and capacitors to transform sinusoidal alternating current to constant direct current, causing the original AC sinusoidal wave to change. As the wave has changed, it is now a nonlinear load with strange harmonics, which may damage the transformer by raising the current in the windings and producing too much heat in the transformer coils. These strange harmonics, especially the third harmonic, wich adds to the neutral conductor's effects, are suppressed or diminished by HMTs.

Considering the design of transformers

The transformer's actual placement must be taken into account. The surroundings or building type where the transformer is installed, as well as any nearby occupants or rooms, should be taken into account.For instance, spill containment sections that are normally more expensive are needed when an oil-insulated transformer is put inside. NEC Article 450.26 specifically states that a vault room is necessary for oil-insulated transformers unless one of six exceptions is fulfilled. Using a transformer vault has benefits and drawbacks that might vary based on a variety of factors, but they should be considered since they call for more care and can be expensive. Utility companies often utilise oil-insulated transformers, even though they are not subject to the same building design restrictions imposed by the NEC.

Also, take into account the transformer's actual placement inside the structure as well as the region it will be used to distribute electricity to. Due to voltage loss, a 277/480 volt-delta transformer is better suited for longer lines on medium-sized structures. Use a higher voltage to deliver electricity as necessary rather than designing bigger feeders for longer lines.At the branch circuit level, a 120/208 volt-wye is typical for non-industrial uses, but the lower voltage makes it inadequate for long-distance distribution. Power is transported throughout the site via medium-voltage properties, where the voltage-to-ground is 1,000 volts or greater.

Depending on the kind of building occupancy, noise should also be taken into account. The customer or tenants may hear an unpleasant hum due to the transformer's continuous oscillations. For instance, in a hotel tower occupation, sound-proofing or acoustical treatment may be required in the transformer rooms on the top floors, where the guestrooms are situated, to reduce noise from the electrical area.If the transformers are located at grade level or on the roof at a position that provides sufficient separation from the transformers and guests, then room treatment may be unnecessary. Offering vibration-isolation cushions that lower the loudness to a level the customer is comfortable with might be another option. It may be necessary to enlist the aid of an acoustical engineer or consultant to help with this noise reduction.

Construction of the space must adhere to NEC Article 450 Part II regulations. According to NEC 450.21, dry-type transformers placed inside must have at least 12 inches of space between them and flammable materials if their rating is less than 112.5 kilovolt-amperes. According to NEC 250.21, the room must have a fire-resistant structure of at least one hour for dry-type transformers greater than 112.5 kilovolt-amperes [6].There is, however, one rule that often applies: they do not have to be situated in one-hour rated rooms if they have Class 155 or above and are entirely enclosed with the exception of ventilation apertures. One of these transformers is therefore the room it is in doesn't need to have a one-hour fire-resistant rating[7].

CONCLUSION

The U.S. Department of Energy regulates dry-type distribution transformer energy efficiency. As a result, from January 1, 2017, complying transformers are marked with the DOE-2016 designation. With 35% of the nameplate-rated load, efficiencies vary from 97.0% to 98.9% depending on the transformer's capacity and number of phases. Several authorities with jurisdiction want transformers that are specifically stated to fulfil these standards in addition to the DOE's label requirement for commercially available transformers.This book chapter describes size of the transformer used in the power system in transmission and the distribution of the power from industrial as well as domestic purpose different transformer are used in different way of working while the use of the step up or step down the voltage[8], [9].

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AN ANALYSIS OF REACTIVE COMPENSATION EQUIPMENT

Dr. Sreenivasappa Bhupasandra*

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the Reactive compensation equipment use in the transmission line the power transfer long distance the reduce and losses the power. The installation of the new capacitor banks calls for 30 MVA rated power with an isolated neutral. Three conventional capacitor banks at most may be put in a substation. The losses in synchronous condensers, however, are far higher than those in the capacitor bank. Also, compared to capacitor bank, it provides equipment installation at a single fixed location. A synchronous motor may function as a synchronous condenser or capacitor by being excited above a certain level. Throughout the spectrum of its excitation, it is intended to provide dynamic power factor adjustment. Reactive power is absorbed at first when the synchronous motor is under excited since it has a trailing power factor. A low power factor number necessitates high reactive power, which impacts the voltage level.

KEYWORD: *Active Power, Power Factor, Power Transfer, Reactive Compensation, Synchronous Condenser, Synchronous Motor.*

INTRODUCTION

Devices that compensate for reactive power, such as capacitor banks, lessen the losses caused by reactive current flowing across the lines. Nevertheless, there is a current limit value for which, in the event of a significant load, the voltage decreases more quickly than the rising current required to keep the active power level constant. This event causes a voltage collapse and a reduction in transferred power. This value mostly relies on the network impedance and design; if a line trips due to a fault, it is important to make sure that the current is maintained within the new current limit value following the incident. This limit value may be raised by enabling shunt compensation. Blocking the transformers' load tap changers in the event of a significant voltage loss is also crucial since doing so would prevent them from trying to keep the voltage and subsequently the power constant, which would sustain or magnify the voltage drop. The possibility of a major voltage drop on the Brittany network was expected to occur in 2006–2007 if both a cold winter and line tripping occurred, according to voltage studies on the French network conducted by RTE in 2002 and 2003. It's crucial to remember that just 5% of Brittany's electrical needs are met by regional power plants, making this type of scenario still problematic.

Due to the retirement of many 250 MW thermal power reactors in the region as well as the removal of several capacitor banks contaminated with PCB from the Distribution grid, extremely low voltage levels may have been attained in the Parisian region in 2008. Instead of a voltage collapse in this instance, a line trip had the effect of drastically reducing the gap between the maximum transmittable active power and the load. The best method of compensating was determined by further stability network tests directed by RTE, which enabled an increase in the flowing active power limitations for each of these sectors. Brittany research It was determined that 840 Mvar would need to be installed, which would require twice the reactive power adjustment system now in place. The standard method of operating the shunt capacitor banks is to preventively turn on the required volume while taking line tripping into consideration. For each situation, the goal is to maintain a positive margin between active power capacity and load power consumption. Nevertheless, this method of running the network would in an excessive operating voltage under typical circumstances, such as when all the lines are in use, given the critical requirement for reactive power. it was decided to divide the 840 Mvar compensation between two capacitor banks (540 Mvar each) and two Static Var Compensators (SVC) with respective capacitances of 200 Mvar and 100 Mvar. When a problem occurs in the network, SVC may link extremely rapidly on voltage criteria since they are made of Thyristors Switching Capacitors. Tap-changer blockage is prevented by the SVC's quick reaction time.

SVC will also lessen the number of wind farms that may trip in the event of 400 kV or 225 kV network outages as compared to a simple approach using simply capacitor banks. In fact, the SVC will be able to swiftly restore voltage stability after the clearing of the fault and then prevent the functioning of the wind turbines' protection (over-speed or overvoltage protections). In such a scenario, the situation changes from simple pre-fault conditions with light load on the lines, high voltage profile, low thermal production, and low reactive compensation, to critical conditions with all loads imported from the lines, very high reactive power consumption (1 Mvar per MW imported), and insufficient time to start thermal production and adjust the reactive power for the region. This raises the danger of a voltage breakdown. Moreover, the SVC will aid in minimising power drops during faults, assisting in the reconnection of the wind farms. According to the research, the SVC should be able to absorb between 100 and 150 Mvar in order to manage the voltage during times of low demand or when there is a high level of distributed generation. In the end of 2003, it was agreed to commission the 2 SVC by the end of 2006 and the 540 Mvar shunt capacitors by the end of 2004.

French capacitor banks

The 63 kV and 90 kV networks were formerly linked by 30 Mvar capacitor banks that RTE had erected. When the capacitor bank is turned on and the short-circuit current (Scc) of the substation is low, 30 Mvar rated power corresponds to the ideal amount to minimise voltage variations. There is an isolated neutral in these capacitor banks. As the impedance of a 30 Mvar capacitor bank (about 130 ohms capacitive) is somewhat near to the equivalent zero impedance of a typical 63 kV substation of the South Brittany network, grounded neutral cannot be utilised for a 63 kV network (50 ohms inductive). The protection relay would observe a different impedance and different equivalent resistance of the fault depending on whether the neutral was connected to the ground or not.

If so, this can have a detrimental impact on the protection's selectivity for clearing faults. For these reasons, the installation of the new capacitor banks calls for 30 Mvar rated power with an isolated neutral. Three conventional capacitor banks at most may be put in a substation. When numerous capacitor banks are turned on back-to-back in the 1990s, a damping circuit (DAR) was created to reduce the frequency and amplitude of the voltage oscillations on the bus bar. Over voltages were being produced by these oscillations at the bus bar-connected dead-end line's extreme. In order to prevent this from happening, line circuit breakers stop the current within the first milliseconds of a fault being eliminated near the substation and to make sure that the transient recovery voltage does not exceed the defined gauge.

Also, this dampening circuit limits the discharge currents of the capacitor in the fault when the circuit breaker re-strikes in order to prevent high-frequency zero crossing of the current. The installation of the new capacitor banks must also take these dangers into consideration. Also, the danger of interfering with the signals used in France to adjust the customer's energy rate has grown with the introduction of 540 Mvar (18 capacitor banks). In the 20 kV network, these three phases of voltage (TCFM) at 175 Hz are connected in series. 2.3% of the voltage at 50 Hz makes up their amplitude. When the bus bar's Short Circuit current (Scc) is infinite, the whole 20 kV range of loads get this TCFM voltage. The produced voltage is split between the upstream network and the intended 20 kV loads, however, if the upstream network has a weak Scc. When simple capacitor banks are added on the 63kV network, this problem is magnified. As a general rule, we calculate that when the 10 Mvar capacitor bank is connected to the bus bar, the apparent Scc is decreased by around 100 MVA.

Banks of capacitors in the Paris area

It was required to plan for the building of 225 kV capacitor banks since the 63 kV and 90 kV substations in this area are cramped. This capacitor bank's defined rated reactive power is 80 Mvar at 225 kV, which limits the amplitude of voltage variations during switching to less than 3%. The short-circuit power in these substations ranges from 7 to 10 GVA, with a probable minimum of 3.5 GVA in N-1 design. The upstream network impedance is little changed when an 80 Mvar capacitor bank is installed, as can be observed from the 20 kV network where TCFM signals are produced. Also, as there are two stages involved in transforming between these two voltage levels, no special precautions were needed for the transmission of 175 Hz signals, in contrast to the 63 kV and 90 kV compensation. The impact of the 225 kV grounded-neutral shunt capacitor bank switching on the PX distance protection relay was also examined using EMTP simulations.

Calculations of the PX measurements using various connections (overhead line, single-phase cable, three-phase oil cable) between substations A, B, and C with and without capacitor banks placed in A and B were done using the schematic in Every time, we saw that the fault's upstream and downstream directions were unchanged and that the PX's performance did not significantly vary between setups with and without capacitor banks. We came to the conclusion that 80 Mvar/225kV capacitor banks with a grounded neutral and no filter structure tuned on 175 Hz were appropriate after taking into account everything said before. However prior harmonic voltage measurements taken in the substations as well as models illustrating the development of harmonic rate after the capacitor banks were implemented allowed for the detection of problems with the 5th harmonic voltage (H5). In fact, the rate was already greater than 2% in certain substations and would increase to 3.6% following the installation of conventional capacitor banks. Both before and after the installation of capacitor banks, the other harmonic voltage levels stayed below 1%. The decision was made to install filtered capacitor banks tuned to the fifth harmonic. The decision to utilise a damping type C filter, as was done in Brittany, was taken in order to filter higher-rank harmonics while avoiding the creation of any obvious anti-resonance below 250 Hz.

In order to create the maximum permissible harmonic voltages on the bus bar without the filtered capacitor banks attached, we thus modelled the harmonic impedance of the network feeding the bus bar when the capacitor banks were connected. After the identification of this source for each distinctive harmonic, we turned on the capacitor banks and gauged the amount of harmonic current entering the filter. The filter damping was related to this value. We selected R equal to 1000 ohms since it was the best value in terms of filtering performances for the harmonics with a rank equal to or greater than 5, without over-amplifying the third harmonic.

Reactive power correction required

Recently, we spoke about how reactive power is transferred back and forth from the supply to the reactor in such a manner that during the first quarter cycle of the AC signal, a capacitor stores the energy, and during the second quarter cycle, the energy returns to the AC source. Reactive power must be kept from bouncing back and forth between the source and the load reactive power compensation show in figure 1.

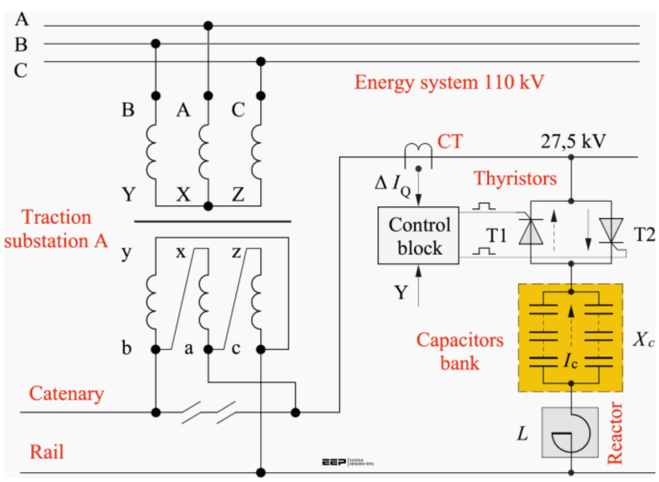

Figure 1 Reactive power compensation [electrical-engineering-portal].

Also, the loads in industrial equipment, such as induction motors, induction furnaces, and arc, run at low power factors, but fluorescent lights, fans, and other similar devices demand quite a bit of reactive power, lowering the voltage at the load terminals. Yet, such low voltage at the load terminal is not desired since this would cause their utility devices' performance to suffer. The system's power factor needs unavoidably be increased utilising certain particular techniques.Reactive power adjustment improves transmission efficiency. Moreover, the steady-state and transient overvoltage may be controlled, preventing devastating blackouts as a consequence.

LITERATURE REVIEW

Zhengpai Wang etal.discussed several dynamic reactive power compensation devices installed in its large-scale wind energy installations. The majority of the equipment, however, is not operating as well as it should since reactive power was not quickly adjusted to regulate the voltage of the wind power system. Performance of the dynamic reactive power compensation devices was examined using operational data from 2011 to 2014 of an actual large-scale wind power system in order to identify the issues with the dynamic reactive power compensation equipment and, therefore, to take appropriate solutions [1]. Low utilisation rates, poor operational dependability, sluggish dynamic reaction times, failure to meet nominal capacity, poor control methods, a lack of changeable reactive power margin, etc., might all be attributed to the equipment's issues. There have been suggestions made for enhancing the dynamic reactive compensation system's performance as well as the degree of safety at which it operates.

Zongchuan He, etal.explored power system expansion planning requires innovative strategies to balance the cost to meet ambitious renewable energy objectives while keeping a certain degree of flexibility and dependability in the face of uncertainty. Initially, a long-term stochastic co-optimization planning model is presented in this study, with the goal of reducing both the overall investment cost and operating costs [2]. To better handle renewable energy, a linearized AC power flow model that could properly preserve bus voltages, reactive power, and network losses is used. Capacitor banks and static Var compensators are included as reactive compensation equipment in addition to producing units and transmission lines. Moreover, the proposed model incorporates the probabilistic reliability criteria LOLE as constraints to provide reliable and cost-effective co-planning choices. The suggested model is then restated as a mixed-integer second order cone programming problem, which is easily solvable by commercial solvers that are available off the shelf. The usefulness of the suggested reliability-constrained co-optimization planning technique taking uncertainties into account is finally shown by numerical case studies.

Shuang Cui, etal. investigated distributed generator distribution networks have issues include incorrect power flow modelling, poor power communication, and trouble coordinating different reactive power compensation devices. The issues provide difficulties for distribution network's online reactive power optimization. This study suggests a deep reinforcement learning-based multi-time-scale online optimum operating methodology for the distribution network's reactive power (DRL) [3]. The method uses a Markov decision process to solve the issue of online distribution network reactive power optimization (MDP). Two-time scales are created to maximise the setup of the discrete adjustment equipment and the continuous adjustment equipment in light of the various reactive power compensation systems' varying adjustment speeds. This method does not depend on precise power flow models and can monitor the distribution network's condition in real time while also making judgements on reactive power regulation equipment optimization online. It works well for complicated, mutable, and difficult-to-communicate partial observable distribution networks. A numerical example concludes by confirming the potency and reliability of the suggested approach.

Zhang Xin etal. discovered the magnetic saturation-controlled reactor will undoubtedly become a necessary piece of reactive power compensation gear as the degree of automation of the power system rises and power electronic equipment develops. Yet there aren't many studies on it, either domestically or internationally. The magnetic saturation-controlled reactor examined in this article is a static dynamic reactive power compensation device in the power system with its better performance. It primarily employs trailing inductive reactive power to counter the leading capacitive reactive power. This research examines its structure and operation in depth, performs electromagnetic calculations and simulation analyses, and introduces a genetic approach to optimise it. To fill up the gaps in this approach, a full discussion is conducted from theory to practise.

DISCUSSION

Compensation for Reactive Power

A low power factor number necessitates high reactive power, which impacts the voltage level. Thus, the system's power factor has to be raised in order to make up for the reactive power. Hence, the techniques for reactive power compensation are just ways to enhance weak power components.

These are the techniques:

1. Using capacitor banks
2. Synchronous condensers
3. Static VAr compensators

1. Banks of capacitors:

A bank of capacitors creates a connection across the load using this technique. Given that the capacitor consumes the majority of the reactive power, this in a reduction in the amount of power drawn from the source. As a consequence, the system's power factor becomes more valuable. Other classifications include series and shunt compensation.As we have established in the beginning, the power factor value must be unity; thus, in order to accomplish this, the capacitor across the motor's terminals must be altered in accordance with the induction motor's load fluctuation. Dynamic power factor control is what this is since it compensates for reactive power by turning on or off the capacitors depending on the load[4].Many modest rating capacitors are necessary to maintain constant control of the system's pf. Before, mechanical switches were used to quickly switch static capacitors in and out, but nowadays, thyristors are employed instead, helping to manage reactive power voltage and flow by quickly switching the static capacitors.

2. Synchronous Condensers:

A synchronous motor may function as a synchronous condenser or capacitor by being excited above a certain level. Throughout the spectrum of its excitation, it is intended to provide dynamic power factor adjustment. Reactive power is absorbed at first when the synchronous motor is under excited since it has a trailing power factor. When a system is overexcited, the leading power factor kicks in and begins producing reactive power, acting as a capacitor synchronous condensers show in figure 2 [5]–[7].

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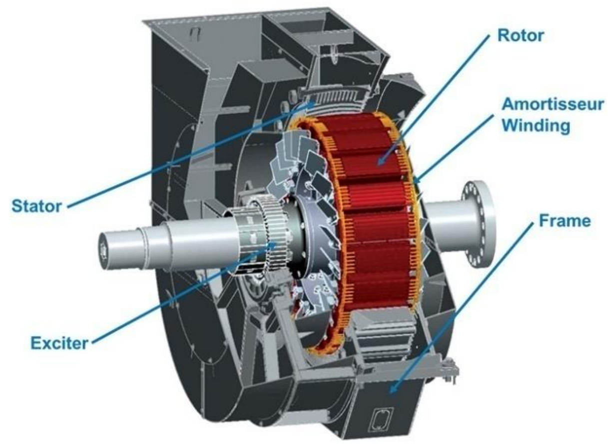

Figure 2 Synchronous condensers [pump sand systems].

Recently, we examined static capacitor banks, and it became clear that they provide discrete power factor management whereas synchronous condensers provide continuous power factor improvement and reactive power flow.The losses in synchronous condensers, however, are far higher than those in the capacitor bank. Also, compared to capacitor bank, it provides equipment installation at a single fixed location. This improves the synchronous condenser's efficiency. The synchronous condenser has a faster reaction time than the capacitor bank.

3. Static VAr Compensation Devices

Static VAr compensators are used in high voltage power systems. It is known as SVC and exhibits increased system stability, a decrease in line losses, and the maintenance of variance within bounds. Both shunt reactors and capacitors are present. Whereas static capacitors and thyristor switched capacitors are used to avoid the voltage sag during peak load situations, shunt reactors and thyristor-controlled reactors are used to restrict the voltage increase at no load or low load conditions [8].

CONCLUSION

Recent studies have shown that of the filter's reactor, TRV during a line fault clearing matched the capabilities of the 225 kV line circuit breaker. Nevertheless, the rated current for the component's design was affected by the tuning frequency for the filter, which was chosen to be on a distinctive harmonic of the network. It was unreasonable to require that the filter's terminals be exposed to the highest harmonic voltages permitted by the connection regulation, as was the case in Brittany. In fact, depending on the damping used, this concept would have caused the capacitor banks to be designed for a 5th harmonic current (H5) that is 3 or 4 times larger than the fundamental current (R value).In this book chapter we discuss about the Reactive compensation equipment use in the transmission line the power transfer long distance the reduce and losses the power when the transfer power for long distance the cable have as reactive compensation.

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ROLE OF SHUNT CAPACITOR IN POWER SYSTEM

Dr. Shilpa Mehta*

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

ABSTRACT:

This book chapter explores the key roles and application shunt capacitors in power system. Many shunt capacitor functions might sometimes alter depending on the application. To eliminate a lag between the voltage and current inside a power system, it is helpful in power stabilisation. A static capacitor is used in series or in close proximity to the system to apply the capacitor reactance. In terms of maintenance and installation, it is far more efficient to employ a bank of capacitor units rather than a single unit for each phase of the system. A series capacitor is efficient in lowering the power reactance. However, unlike shunt capacitors that permit voltage increase in lines, voltage rise is only allowed across terminals. For a distribution feeder application, the series-capacitor size is often chosen such that the capacitive reactance is lower than the inductive reactance of the feeder circuit. The load current has to have a lagging power factor in order to significantly reduce the voltage drop between the transmitting and receiving ends by using a series capacitor.

KEYWORDS: *Inductive Reactance, Power Factor, Power Transfer, Power Distribution, Series Capacitors, Shunt Capacitance.*

INTRODUCTION

A power system's shunt capacitors are essential because they aid in power factor adjustment. This device is the best choice for this operation since it may be installed anywhere in a circuit or a power network. Shunt capacitors are also comparatively less expensive and simpler to install than series capacitors. Electrical engineers install a connection in parallel across the transmission of a power distribution system. Shunt capacitor is the name of this device. Power transmission problems including poor dependability, low voltage regulation, and power factors are balanced by the shunt capacitor. It may also be divided into LV and HV capacitors. Many shunt capacitor functions might sometimes alter depending on the application. To eliminate a lag between the voltage and current inside a power system, it is helpful in power stabilisation. A capacitor bank is one of the most crucial pieces of hardware in an electrical power system. The load is the amount of energy needed to operate all the electrical appliances since useable energy is energetic energy. K W or MW are the units used to indicate active power. The inductive nature of the maximum load that may be linked to the electrical power system includes electrical transformers, induction motors, synchronous motors, electric furnaces, and fluorescent lights. In addition to this, the system's inductance is also contributed by the inductance of various lines.

The system current falls behind the system voltage as of these inductances. The system's power factor drops as the voltage-to-current lagging angle widens. With the same active power demand, the system draws more current from the source as the electrical power factor declines. Increased line losses due to more current reasons. Inadequate voltage regulation is a of low electrical power factor. So, the system's electrical power factor has to be enhanced to prevent these issues. Capacitive reactance may be utilised to neutralise the system's inductive reactance since a capacitor makes current lead voltage. The system's inductive reactance may be cancelled using the capacitor's reactance. Typically, a static capacitor is used in series or in close proximity to the system to apply the capacitor reactance. In terms of maintenance and installation, it is far more efficient to employ a bank of capacitor units rather than a single unit for each phase of the system. The term "capacitor bank" refers to this collection or bank of capacitor components. A drop in the electrical power factor brought on by a voltage and current lag raises the need for additional power from the source. Long-term effects of the cycle, also known as inductive reactance, include power spikes and line loss. Engineers may modify the system using a capacitive reactance to fix this problem. A dependable reactance against recurrent inductive reactance is produced by using several units as opposed to only one. A capacitor bank is the technical term for this collection of capacitor units. Power substations or other systems that provide electricity to local companies and households sometimes include capacitor banks. The benefits of an enhanced voltage profile include

Capacitors placed on electric poles

They are typically installed as permanent or switchable devices on electric poles. These modifications are helpful in supplying power demands ranging from 460V to 33kV. Typically, capacitor units installed on poles vary in voltage from 300 to 3000kVAR. Extra high voltage substations deliver electricity in bulk to load centres using EHV shunt capacitor banks. These wires often experience severe voltage drops while delivering high-point loads of electricity. As a, the EHV capacitors are used when needed to provide reactive power.

Substation capacitor banks

They are set up in substations to run voltages ranging from 2.4 to 765 kV. Before installation, the involved parties carefully examine the stability and load flow of the banks. Capacitors may also be positioned in additional places as needed. There are two possible connections: a delta connection and a star connection. A star connection has three points that come together to create a star-shaped network.

Moreover, the replaceable cable points are connected to one another. Inside the connection, there is a neutral or star point and a line current that is comparable to the phase current. This connection, which can handle up to 230V per curve, is often utilised in transmission networks.Considering that a delta connection includes a lot of turns, it utilises a phase voltage that is the same as the line voltage. Better still, this connection is more common in power distribution networks and each series gets a maximum of 414V. In order to protect this connection from the harmful effects of high-power voltages, it has to have substantial insulation.

Shunt capacitor and capacitor

Series and shunt capacitors vary in a number of ways, but the improvement in power load is the most important. When an inductive load is applied to a transmission line, a lag between the current and voltage may happen. Shunt capacitors assist reduce this lag. This makes this choice dependable for system stabilisation, power factor improvement, and line voltage enhancement.On the other hand, a series capacitor is efficient in lowering the power reactance. However, unlike shunt capacitors that permit voltage increase in lines, voltage rise is only allowed across terminals. Moreover, neither the power factor nor grid stability are impacted by this link.

LITERATURE REVIEW

Sangeeta Das etal. explored the distribution system's dispatch able DG and shunt capacitor arrangement and size. This work's goal is to reduce the feeder current that is pulled from the grid, as well as the yearly energy losses, actual power loss reduction, and voltage profile improvement. Considered is the load demand profile's typical hourly volatility[1]. The position of dispatch able DGs and shunt capacitors is determined using sensitivity analysis based on the voltage stability index. The GA optimization tool is used to optimise the size of the dispatch able DGs. To demonstrate the operation's economic advantages, annual cost reductions are determined. In a 33-node distribution network, the suggested methodology's effectiveness is shown. The s show how the suggested technique outperforms other ones that are currently used and documented in the literature.

Emad Ali El-Sehiemyetal. explored the performance of distribution systems is significantly impacted by controlling active/reactive power. The two most often used methods for enhancing the performance of the distribution system are the deployment of distributed generators (DGs) and shunt capacitors (SCs). In this vein, this study suggests an improved genetic algorithm (EGA) that combines the advantages of genetic algorithms with local search to determine the best position and capacity for the simultaneous allocation of DGs/SCs in radial systems. The search space capacity is improved and the rate of exploration for locating the global solution is increased by including local search scheme[2]. To improve the performance of the distribution system, the suggested approach attempts to reduce both the total actual power losses and the total voltage variation. Three industry-recognized test systemsIEEE 33 bus, IEEE 69 bus, and 119-bus test distribution networksare taken into account to demonstrate the effectiveness and scalability of the proposed approach. The simulations demonstrate that the suggested EGA outperforms other current algorithms in the literature and can efficiently search for the best answers to the issue. Also, a cost analysis with an economic foundation is given for light, shoulder, and severe loading levels. It has been shown that the suggested EGA s in significant advancements in both the technological and economic spheres.

Uchendu, Moses etal. explored to improving the voltage stability of the networks, this effort attempts to reduce active and reactive power loss in distribution networks. In order to install DG units and capacitor banks in networks that don't break any restrictions, optimal Distributed Generation (DG) placement and sizing is done in combination with shunt capacitor placement and sizing. The Cuckoo Search Optimization Algorithm was used to determine the best sizes for the DG units and capacitor banks, and the Voltage Stability Index was used to calculate the voltage stability (VSI) [3]. To determine the behaviour of the networks before and after their placements, the distribution networks were fitted with the determined optimum sizes of DG units and capacitors in both individual and simultaneous fashion. Power loss and voltage stability are taken into account as performance variables. Using IEEE 33 and 69 test buses, a comparison of these performance characteristics under separate and simultaneous deployment approach was shown. s indicate that power loss (active and reactive) decreased for 33 bus systems by 63.29% and 59.38%, respectively, and for 69 bus systems by 74.29% and 79.19%. As comparison to values obtained for the base case with the deployment of separate DG and shunt capacitors, voltage stability also enhanced for the 33 and 69 bus systems by 7.89% and 3.79%, respectively.

M. M. Jasmon, etal. INVESTIGATED Shunt capacitors are often used in distribution systems for the purpose of compensating reactive power. For the best shunt capacitor bank (SCB) location, many analytical, numerical programming, heuristic, and artificial intelligence-based strategies have been developed in the literature. The ideal SCB placement procedures will be covered in great depth in this article. Using four separate radial distribution test systems, six alternative methods for placing SCBs optimally based on minimising power losses, using the weakest voltage bus approach, and maximising system load ability will be used [4]. Power loss reduction, voltage profile improvement, system load ability maximisation, and the line limit limitation will be used to compare the outcomes.

Shuangting Wang, etal. investigated a good technique to reduce resonance created by a shunt capacitor is to add a damping unit to it. Damping systems, however, have problems with power loss. This flaw is accentuated much more in circumstances when resonance is unlikely to occur. In light of this, a technique of adaptive damping is suggested to enhance the current system. The dampening unit has the ability to reduce resonance and eliminate power loss when there is no resonance. The main concept behind the suggested method is the addition of a breaker, which will allow the damping unit to be turned on or off depending on whether resonance occurs. The suggested switchable damping unit's design and control mechanism are shown. For a real-world capacitor application example, the novel resonance mitigation scheme's effectiveness in terms of harmonic mitigation, loading, switching transient, and cost is confirmed.

DISCUSSION

The use of shunt capacitors

As was already noted, shunt capacitors may be employed in a variety of places, including power transformers, EHV and LV lines, electrical poles, and substations. Shunt capacitors are used in utilities to use reactive power to lower the current flowing through the distribution feeder. it reduces line loss and pointless power use. Shunt capacitors boost the transmission of power throughout the system in addition to redistributing voltages, all while stabilising the connection without introducing additional lines or conductors.Support is yet another crucial function of a shunt capacitor. When there is a peak in extra-high voltage transmission, it maintains the transmission system voltage and grants it complete access to the grid. Hence, anytime the system transmits a significant amount of power, you don't need to spend money on improvements.Moreover, in this instance, producing both reactive power and actual power does not put too much strain on the generators. The lines have higher capacity and have less system loss when less reactive electricity is flowing through them [5].

Where is Capacitor Bank

Theoretically, commissioning a capacitor bank closer to a reactive load is always preferred. This eliminates reactive KVARS transmission from a larger portion of the network. Also, if the load and capacitor are connected simultaneously, when the load is unplugged, the capacitor is likewise disconnected from the remainder of the circuit. As a, there is no issue with overcompensation. Yet from an economic standpoint, attaching the capacitor to each individual load is impractical. Since loads for various customers vary greatly in size. As a, different size capacitors are not always easily accessible. As a, adequate compensation is impossible at every loading point. Once again, every load is disconnected from the system for 24–7 hours. As a, the capacitor attached to the load cannot be used to its full potential capacitor bank show in figure 1.

Figure 1 Capacitor bank [cornerstone middle east].

Hence, a capacitor is not put at a tiny load. But a capacitor bank may be installed at the consumer's home or business for medium and high loads. Despite the fact that the inductive loads of medium and large bulk consumers are compensated, there would still be a significant amount of VAR demand coming from various associated uncompensated tiny loads. Inductance from the line and the transformer also adds to the system's VAR. Due to these issues, a huge capacitor bank is built at the main distribution sub-station or secondary grid sub-station in place of attaching capacitors to each load.

Shunt Capacitor Bank Connection

Either a delta or a star connection may be made between the capacitor bank and the system. Depending on the capacitor bank protection system used, the neutral point in a star connection may or may not be grounded. Sometimes the double star creation process is used to create the capacitor bank. Large capacitor banks are often linked in a star pattern in electrical substations.One particular benefit of the grounded star connected bank is a lower recovery voltage on the circuit breaker for typical repeating capacitor switching delays.

1. Improved surge defence.
2. A somewhat diminished over voltage phenomena.

3. Lower installation costs.
4. In a system with a solid ground, the voltage of a capacitor bank's three phases is constant and does not fluctuate even while it is operating in two phases.

Due to the fact that they are a more specialised sort of equipment with a narrower scope of use, series capacitors, or capacitors linked in series with lines, have only been employed to a very limited degree on distribution circuits. Also, a significant amount of specialised engineering analysis is necessary due to the unique issues connected with each application. A series capacitor may sometimes even be thought of as a voltage regulator, providing a boost in voltage proportionate to the size and power factor of the through current. A series capacitor offers a voltage rise that rises instantly and automatically as the load increases. Moreover, a series capacitor causes greater voltage drop than a shunt capacitor does when power factors are smaller. A series capacitor has minimal impact on the source current and improves the system power factor significantly less than a shunt capacitor.

Overcompensation

For a distribution feeder application, the series-capacitor size is often chosen such that the capacitive reactance is lower than the inductive reactance of the feeder circuit. The opposite, however, could be desirable in certain situations (when the feeder circuit's resistance is greater than its inductive reactance) to prevent the voltage drop.

Leading Power Factor

The load current has to have a lagging power factor in order to significantly reduce the voltage drop between the transmitting and receiving ends by using a series capacitor. Shows a voltage phasor diagram without series capacitors in the line that has a leading-load power factor as an example. Displays the final voltage phasor diagram, this time with series capacitors in the line and the same leading-load power factor. As observed in the image, the presence of series capacitors lowers the voltage at the receiving end.

Series and shunt capacitor effects

A capacitor, which consists of two metal plates separated by a dielectric insulating substance, seems to be a very uninteresting and simple device at first glance. It doesn't get much easier than that. The capacitor doesn't have any moving elements; instead, it works by being subjected to electric stress. Yet, a power capacitor is really working quite hard. The way series and shunt capacitors control voltage and reactive power flows differs [6].

Due to the use of very thin dielectric materials, severe electric stresses, and highly advanced production processes, the capacitor is a very technical and complicated device. Capacitors' primary purpose, whether they are deployed in series or shunt configurations, as a single unit or as a bank, is to control the voltage and reactive power flows where they are installed. The series capacitor accomplishes so by directly balancing the inductive reactance of the circuit to which it is attached, while the shunt capacitor does it through altering the power factor of the load.

Batteries in series

Due to the fact that they are a more specialised sort of equipment with a narrower scope of use, series capacitors, or capacitors linked in series with lines, have only been employed to a very limited degree on distribution circuits. Also, a significant amount of specialised engineering analysis is necessary due to the unique issues connected with each application[7]–[9].

Utilities generally usually hesitant to install series capacitors, particularly those of modest capacities. A series capacitor may sometimes even be thought of as a voltage regulator, providing a boost in voltage proportionate to the size and power factor of the through current.A series capacitor offers a voltage rise that rises instantly and automatically as the load increases. Moreover, a series capacitor causes greater voltage drop than a shunt capacitor does when power factors are smaller. A series capacitor has minimal impact on the source current and improves the system power factor significantly less than a shunt capacitor[10].

Issue with Overcompensation

For a distribution feeder application, the series-capacitor size is often chosen such that the capacitive reactance is lower than the inductive reactance of the feeder circuit. The contrary, however, may be preferable in certain situations (when the feeder circuit's resistance is greater than its inductive reactance), leading to a voltage drop that is particularly detrimental to lights (shortening their lifespan) and produces light flickering, which prompts complaints from customers.

CONCLUSION

The load current must have a lagging power factor in order to significantly reduce the voltage drop between the transmitting and receiving ends by the use of a series capacitor, for instance, displays a voltage phasor diagram without series capacitors in the line and a leading-load power factor. Displays the voltage phasor diagram that s, this time with series capacitors in the line and the same leading-load power factor. As observed in the image, the presence of series capacitors lowers the voltage at the receiving end.This book chapter investigates the key roles and applications of the shunt capacitors in power systems.

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WORKING OPERATION OF STATIC VAR SYSTEM

Mrs. Kamireddi Sunandana*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

ABSTRACT:

This book chapter investigates the static var system (SVC) working principal in a detailed manner. The SVC has fewer and smaller components, yet the conductors must be quite big to manage the higher currents brought on by the lower voltage. The reactor in the one-line version of the SVC may be a shifter internal to the circuit, and thus exhibits a continuously variable kind of VAR to the electrical system via the PAM type of modulation by the thyristors. Transformers may be needed to scale down transmission voltage levels since SVC devices generally cannot work at line voltage levels. The compensator will behave dynamically in a manner similar to how thyristors are coupled in series. Reactors that are controlled by AC thyristor switches make up one of the branches. For three-phase applications, the reactors are also coupled in a delta configuration. The absence of gate switching off capability in thyristors is a prerequisite for a static VAR compensator.

KEYWORD: *Control System, Capacitor Bank, Static Var, Thyristor Controlled, Var System.*

INTRODUCTION

A static VAR compensator is a parallel assembly of the fixed shunt capacitor and controlled reactor seen in the image below. The reactor is controlled by the thyristor switch assembly in the SVC. The voltage across the inductor, and therefore the current flowing through the inductor, are controlled by the thyristor's firing angle. The inductor's reactive power consumption may be managed in this manner.The SVC may step Lesly change reactive power over an infinite range without experiencing any delay. It raises the system's power factor and stability. The most popular SVC scheme.

1. A group of electrical components known as a static VAR compensator (SVC) is used in high-voltage electricity transmission networks to provide quick reactive power.
2. The flexible AC transmission system includes SVCs
3. Device family, controlling harmonics, power factor, voltage, and system stability. There are no substantial moving components in a static VAR compensator (other than internal switchgear). Power factor adjustment was previously only possible with huge spinning equipment like synchronous condensers or switching capacitor banks.
4. The SVC is an automatic impedance matching tool created to nudge the system's power factor closer to unity. SVCs are used in two primary circumstances

Attached to the power system and used to control transmission voltage ("transmission SVC") Linked to enhance electricity quality when close to big industrial loads ("industrial SVC") The SVC is used in transmission applications to control grid voltage. The SVC will employ thyristor-controlled reactors to consume VARs from the system, decreasing the system voltage, if the reactive load on the power system is capacitive (leading). The capacitor banks are automatically turned on when inductive (lagging) conditions exist, resulting in a greater system voltage. The continuous variable leading or lagging power is achieved by coupling the continuously variable thyristor-controlled reactor with a capacitor bank step.SVCs are often positioned next to heavy, quickly fluctuating loads, such arc furnaces, in industrial applications because they can calm flicker voltage.

Connection

The transmission voltage (for instance, 230 kV) is stepped down to a considerably lower level by a bank of transformers, instead of performing static VAR adjustment at line voltage (for example, 9.0 kV).The SVC has fewer and smaller components, yet the conductors must be quite big to manage the higher currents brought on by the lower voltage. When a medium-voltage bus bar is already existent, such as one at 33 kV or 34.5 kV, the static VAR compensator for industrial applications, such as electric arc furnaces, may be immediately attached to save the expense of the transformer.On the delta tertiary winding of Y-connected auto-transformers, which are used to link one transmission voltage to another voltage, is another typical connection location for SVC.

The use of thyristors coupled in series and inverse-parallel to create "thyristor valves" gives the SVC its dynamic aspect. The disc-shaped semiconductors are often housed inside in "valve houses" and have a diameter of several inches.The Compensator, which is utilised to regulate other systems, is the most important device in the control system. This is often controlled by altering the input or output of the control system. Basically, there are three different types of compensators: lead, lag, and lag-lead. Adjusting the control system in order to improve execution may have negative effects on performance, such as weak or imbalanced stability. So, it is more advised to reorganise the system and add a compensator, where this tool compensates for the real system's insufficient efficiency, in order to make it perform as planned. The Static Var Compensator, one of the most well-known kinds of compensators, is explained in length in this article. The Static Var Compensator show in figure 1.

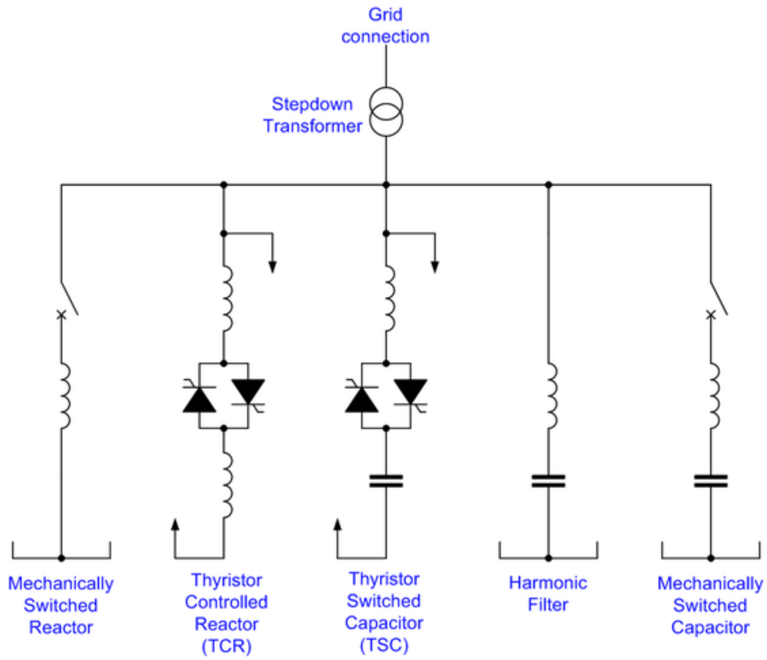

Figure 1 Static Var Compensator [Wikipedia].

This is a static, parallel-connected VAR absorber or generator whose output is adjusted to replace inductive or capacitive current and which controls or regulates relevant current factors, primarily the bus voltage factor. The absence of gate switching off capability in thyristors is a prerequisite for a static VAR compensator. The reactor in the device is regulated by the functionality and features of the thyristor switch assembly, and the firing angle is utilised to control the voltage and current values that flow through the inductor. In accordance with this, the reactive power of the inductor may be controlled.This technology has the capacity to eliminate reactive power regulation even across very long distances with no time delay. It improves the system's power factor and consistency.

The SVC adaptable reactive impedance is known to thyristors. The TCR and TSR, which are a thyristor-controlled capacitor and thyristor-controlled reactor, are the most important components of this device. When dealing with electrical transmission systems that use excessive voltage, the gadget also offers rapid functional reactive power. SVCs fall under the categories of voltage control, system stability, and adaptive AC transmission networks.

Design

The reactor in the one-line version of the SVC may be a shifter internal to the circuit, and thus exhibits a continuously variable kind of VAR to the electrical system via the PAM type of modulation by the thyristors. The capacitors manage high voltage levels in this mode, which is primarily recognised for its effective control. Thus, the TCR mode offers improved dependability and superior control. Moreover, thyristors may be controlled electronically.

Thyristors produce heat similarly to semiconductors, and deionized water is used to cool them. Here, reactive load slicing into the circuit introduces undesirable kinds of harmonics, and to prevent this, a wide variety of filters are often utilised to smooth out the wave. Since the filters have capacitive capability, they will propagate MVAR to the power circuit as well.

LITERATURE REVIEW

Pouyan Boström, etal. discussed a summary of modelling and application research pertaining to the installation of a contemporary static VAr system (SVS) in a utility grid[1]. The SVS uses a complex control system to combine a fully integrated static VAr compensator (SVC) and coordinated, automatically switched capacitor banks. Individual circuit breakers are used to switch the capacitor banks. For the application and design studies carried out for this device, descriptions are given for the SVC control technique and different degrees of modelling information. The stability model presented in this research extends a previously published work by including the coordinated/automatic capacitor switching, slow susceptance regulation, and appropriate protective mechanisms. A fresh perspective on how SVC controls affect the torsional damping of neighbouring generators is provided, along with information on how such interaction may be readily prevented with the right voltage regulator tuning.

Pouyan Sullivan, etal. explored use in simulations of power-flow and time-domain stability, the Western Electricity Coordinating Council's (WECC) SVC Task Group created three models to describe static Var systems (SVS). [2] The objective was to provide a collection of generic model structures that can be quickly customised to represent different SVS systems. When a model structure is said to be generic, it means that it is non-proprietary, public, and not particular to any one vendor or piece of technology. Some software providers have already used these approaches, and others may follow suit shortly. These models provide two things: 1) a suitable non-proprietary, non-vendor specific set of models that can be used to evaluate SVS solution options for planning studies, and 2) a way to stop the proliferation of user-written models that is making it difficult to manage in large interconnected power system models like the WECC. Power system planners and operators may get information about the newest SVS technologies and their use thanks to the distribution of the models and modelling documents.

Slaven Wan, etal. investigatedstatic VAR systems (SVS) that are needed by load centres for regulated voltage management; nevertheless, utilising several tiny, dispersed SVS at distribution buses is preferable than using a few big bulk SVS at transmission or sub-transmission buses[3]. The benefits include (i) less expensive high voltage transformers are no longer necessary because the SVS can be connected directly to the low voltage distribution buses, (ii) distribution-side voltage support is more effective, and (iii) the total MVAr requirement of the distributed SVS is lower. Standby to meet N-1 reliability criterion is one of the benefits. Studies using simulations have shown that the dispersed SVS units work well together.

K. R. Varma, etal. explored the use of the damping torque approach to test the effectiveness of different control signals for reactive power modulation of a midpoint placed Static Var System (SVS) in improving the capacity of power transfer of long transmission lines [4]. Calculated Internal Frequency (CIF), a brand-new auxiliary signal, is recommended for generating the internal voltage frequency of distant generators from electrical data at the SVS bus. It is shown that this signal fully utilises the network transmission capacity, making it significantly superior than other common auxiliary control signals. The eigenvalue analysis findings and the damping torque results are connected.

Ibrahim A. Seif etal. explored a tiny portion of the network, the performance of Egypt's electrical network is examined (Abu Hummus city). In the digital simulation and electrical network calculation (Dig SILENT power factory software), the transmission network of Abu Hummus city was developed for 66 kV, 11 kV, and 0.4 kV to analyse the voltage profiles [5]. To determine the voltage magnitudes at each bus bar, a load flow operational study was conducted. Due to overloading of the transmission lines, the voltage magnitudes in the 11 kV and 0.4 kV networks were 10% to 15% below the nominal value, while the voltage magnitudes in the 66 kV network were within allowable limits. In order to improve the voltage quality of the networks and achieve better voltage profiles on the low voltage side without much impact on the high voltage side under various operating conditions, this paper's main goal is to obtain the voltage profiles at each bus bar using an automatic tap-changing transformer or a static VAR system.

Narendra Dave, etal. suggested and shown to use a unique static var system (SVS) auxiliary controller application to dampen sub synchronous resonance in power systems. A series compensated long transmission line's SVS control system includes an SVS controller known as the combination reactive power and frequency (CRPF) auxiliary controller that has been created[6]. The system used in the experiments has a comparable distribution of torsional modes to the first IEEE benchmark model. Throughout a broad working range, the suggested SVS auxiliary controller stabilises all torsional modes. A nonlinear system model was used in a digital computer simulation research to demonstrate the efficiency of the suggested SVS auxiliary controller.

DISCUSSION

Operation of the Static VAR Compensator

Transformers may be needed to scale down transmission voltage levels since SVC devices generally cannot work at line voltage levels. Even if wires are needed to control the high amounts of currents linked to the minimum voltage, this reduces the equipment and size of the device needed for the compensator.In contrast, certain static VAR compensators used for commercial applications, such as electric furnaces, may have mid-range bus bars included. In order to save on the cost of the transformer, a static VAR compensator will have a direct connection in this case. The delta tertiary winding of Y-type autotransformers, which are used to link transmission voltages to various types of voltages, is the other typical point for connection in this compensator [7].The compensator will behave dynamically in a manner similar to how thyristors are coupled in series. The valve houses typically house the disc type SCs, which come in a wide variety of sizes.

Both positive and negative aspects

1. Static VAR compensators provide a number of benefits, including the capacity to improve the transmission lines' ability to transmit power.

2. One of the main benefits of using SVCs is that they are often used for regulating steady states and a wide range of voltages. They may also boost the system's transient strength.
3. SVC raises the load power rating, which reduces line losses and improves system efficiency.

The following are the static VAR compensator's drawbacks:

1. The device's size and weight are disadvantages, and it requires extra equipment to achieve surge impedance compensation since it lacks any novel components. It also has a deliberate dynamic response and cannot be used to regulate voltage changes due to furnace loads.
2. Benefits of SVC include a decrease in active energy losses through improved reactive power flow and harmonic filtering, an increase in system stability through load balancing, a decrease in flicker, better use of transmission and distribution systems, an improvement in supply quality, and a decrease in production costs in the iron and steel industry.
3. Transmission and distribution systems, the metal industry, railway transmission systems, the cement industry, the oil and gas industry, and grid code compliance solar and wind energy applications are some of the application areas.

Simple Operation

By regulating the amount of reactive power absorbed from or injected into the power supply, the static var compensator adjusts the voltage. For instance, when the system voltage is low or the loads are inductive, it switches the capacitor banks to provide reactive power. As a result, the SVC satisfies the trailing load's need for reactive power, relieving the distribution lines of that burden. This results in a lower voltage drop and an increase in voltage at the load terminals. In the same way, when the system voltage is high or the loads are capacitive, the static var compensator takes in reactive power. In this instance, the SVC lowers the system voltage by consuming the VARs from the system via the reactors [8].

Compensation for Static Var (SVC)

Devices called Static Var Compensators (SVCs) are capable of rapidly and accurately controlling line voltages. In regular steady state and emergency situations, an SVC will normally regulate and manage the voltage to the necessary set point, providing reactive power with a dynamic, quick reaction in the event of a system emergency (e.g., network short circuits, line and generator disconnections). An SVC may also improve transfer efficiency, lower losses, alleviate active power oscillations, and stop overvoltage during load loss over voltage migration method show in figure 2.

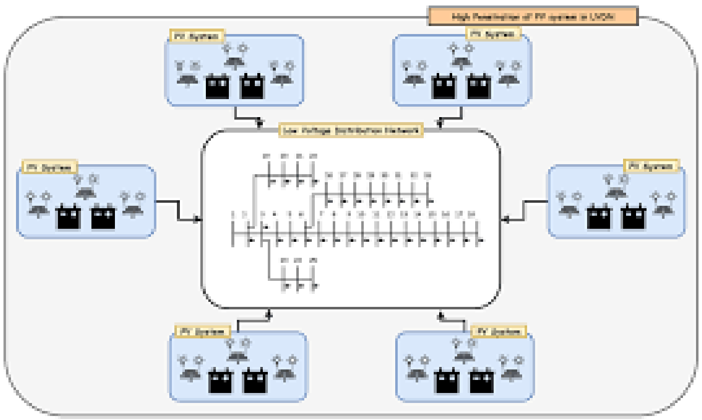

Figure 2 Over voltage migration method [online library].

Each customer's unique demands are taken into account while designing the SVC. The SVC is made up of a number of fixed or switched branches, at least one of which contains thyristors, and the arrangement of the branches may be greatly altered depending on the needs. Typically, an SVC consists of at least two of the following components (e.g., TCR/FC or TCR/TSC/FC):

Thyristor switched capacitor; Thyristor controlled reactor (TCR): (TSC)

Synchronization filter (FC)

The most popular SVC topologies are TCR/FC or TCR/TSC/FC. Reducing losses is the key benefit of employing a topology with TSC branch (es) (by reducing the filter size). The SVC control system from Hitachi Energy may be used to operate both new and old external shunt banks [9].

TCR/TSC stands for "thyristor-controlled reactors and thyristor switching capacitors".Essentially, this is the result of combining TCR and TSC. In this design, detecting the reactive load current at the time of voltage zero serves as the basis for controlling the static var compensator. The firing angle is then established using the observed current so that the SVC may inject or absorb the necessary amount of reactive power for compensation. Nevertheless, there is a delay between the firing instant and the instant at which the reactive component is measured (in one half-cycle) (the next half-cycle). One of its key drawbacks is the inherent latency in its operating mode[10].

Capacitors with thyristor switches (TSC)

The capacitor banks in this static var compensator system are linked phase to phase, with thyristors switching each part. As a result, only discrete variations in reactive power may be achieved rather than continuous changes like those seen in a TCR. Nonetheless, the necessary resolution of reactive power fluctuation for a single step may be accomplished by supplying an appropriately high number of tiny sections. The transients generally associated with capacitor switching are reduced by synchronising the switching and initial pre-charging of the capacitors. Reaction times for symmetrical operation often don't go beyond 20 ms capacitor or thyristor switch show in figure 2.

Figure 2 Capacitor or thyristor switch [India Mart].

CONCLUSION

Two parallel branches joined together on the secondary side of a coupling transformer make up this SVC arrangement. Reactors that are controlled by AC thyristor switches make up one of the branches. For three-phase applications, the reactors are also coupled in a delta configuration. Shunt filters or fixed capacitor banks might be used on the opposite branch. Controlling the thyristor's firing instants and, therefore, the current that flows via the reactance, allows for the adjustment of reactive power. This book chapter explores theworking operation of static var system as well as illustrates the key applications.

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EFFECTIVE DIMENSIONS OF VOLTAGE TRANSFORMER FOR SWITCHYARD

Dr. Rajiv Singh*

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the effective dimensions of voltage transformer for switchyard. There are several standard sizes and ratings for medium voltage transformers, with common values ranging from a few kVA to several MVA. Depending on a number of variables, including size, capacity, voltage rating, and manufacturer, the price range for medium voltage transformers might change. In general, bigger transformers cost more than smaller ones because to their greater capacity and voltage ratings. It is also crucial to remember that when buying medium voltage transformers, factors other than pricing should be taken into account. When we talk about medium voltage transformer protection, we're talking about the techniques and tools used to shield a medium voltage transformer from harm and failure brought on by electrical issues or overloading. A medium voltage transformer's protective system is created depending on the requirements, ratings, and electrical system it is put in. Aspects including the transformer's voltage rating, current rating, impedance, and location within the electrical system must be taken into account.

KEYWORD: *Electrical System, Kva Rating, Medium Voltage, Power, Transmission Line, Voltage Rating, Voltage Transformer.*

INTRODUCTION

Depending on the application and function for which they are designed, medium voltage transformers come in a range of sizes. They come in a variety of sizes, from compact models made for home or commercial usage to huge transformers used in industrial settings. The power rating of a medium voltage transformer, which is expressed in kilovolt-amperes (kVA) or megavolt-amperes (MVA), often determines the transformer's size (MVA). The greatest amount of power a transformer can provide to a load without going over its temperature limit determines its power rating.There are several standard sizes and ratings for medium voltage transformers, with common values ranging from a few kVA to several MVA. The precise usage and application of a transformer, together with the specifications of the regional electrical system, will determine its size and rating.

15 kVA, 30 kVA, 45 kVA, 75 kVA, 112.5 kVA, 150 kVA, 225 kVA, 300 kVA, 500 kVA, 750 kVA, 1000 kVA, and 1500 kVA are a few popular sizes for medium voltage transformers. Manufacturers may, however, also provide specialized services to fulfil the unique needs of their

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clients.The installation area that is available, the power needs of the load, and the voltage ranges of the nearby power grid should all be taken into account when choosing a medium voltage transformer. Although a transformer that is too big might result in inefficiencies and extra expenses, a transformer that is too small for the load can cause overload and damage to the transformer. It is shown in figure 1.

Figure 1 Damaged transformer [alineeds].

Depending on a number of variables, including size, capacity, voltage rating, and manufacturer, the price range for medium voltage transformers might change. In general, bigger transformers cost more than smaller ones because to their greater capacity and voltage ratings. Since medium voltage transformers are intricate pieces of bespoke electrical equipment, the cost might vary greatly depending on the demands of the client. Because of this, it is difficult to provide a precise pricing range for medium voltage transformers.But, by speaking with reputed producers like Daelim Belefic, clients may have a better sense of the pricing range. To meet varied client demands, Daelim Belefic provides a large selection of medium voltage transformers with varying specifications and ratings.It is also crucial to remember that when buying medium voltage transformers, factors other than pricing should be taken into account. In order to make sure that the transformer satisfies the necessary requirements and specifications, other variables like dependability, safety, and quality should also be taken into account.

Chart for sizing medium voltage transformers

The right size or capacity of a transformer for a particular application may be determined using a medium voltage transformer sizing chart, which is a tool. In addition to variables like load type, ambient temperature, and altitude, these characteristics may also include the system's voltage rating, current capacity, and power rating.Based on the input characteristics, the sizing chart generally displays the necessary transformer capacity in kVA (kilovolt-ampere). According to the main voltage, secondary voltage, and anticipated load current, for instance, a chart can indicate the necessary kVA rating.Using a trustworthy and precise sizing chart is crucial since choosing an inadequate transformer may lead to subpar performance and early failure, while choosing an oversized transformer can result in excessive expenses and inefficiencies.The majority of transformer manufacturers provide tools or sizing tables to assist clients in choosing the right transformer size for their application. These instruments could be accessible online or by contacting the manufacturer's customer care division. To guarantee correct size and installation, it is advised to speak with a certified engineer or electrician while choosing a transformer.

Protection for medium-voltage transformers

When we talk about medium voltage transformer protection, we're talking about the techniques and tools used to shield a medium voltage transformer from harm and failure brought on by electrical issues or overloading.Combinations of protective devices, such as fuses, circuit breakers, relays, and transformers, may be used to safeguard medium voltage transformers. These safety measures are intended to identify and isolate electrical system defects in order to stop them from spreading to the transformer.A medium voltage transformer's protective system is created depending on the requirements, ratings, and electrical system it is put in. Aspects including the transformer's voltage rating, current rating, impedance, and location within the electrical system must be taken into account.

Overcurrent protection, differential protection, and overvoltage protection are often used protection strategies for medium voltage transformers. Differential protection is conducted by comparing the currents on the main and secondary windings of the transformer, while overcurrent protection is normally handled using fuses or circuit breakers. Surge arresters, which guard the transformer from harm from high-voltage surges, are used to accomplish overvoltage protection.To maintain the safe and dependable functioning of the transformer and the electrical system in which it is mounted, adequate medium voltage transformer protection is essential. It helps to reduce downtime and related expenses, avoid transformer failure, and extend its lifetime.

LITERATURE REVIEW

Panayiotis Alizadeh-Mousavi etal. explored deregulation of the electrical market and the widespread use of distributed energy resources; real-time monitoring of distribution networks is now required. It often takes a significant expenditure and causes grid disturbances to monitor voltage and current at the sub-cycle level [1]. The waveforms of distribution transformers' medium voltage (MV) sides are calculated in real time in this study using measurements of the low voltage (LV) side of the transformers and a mathematical model of the transformer in question. This model is basically the MV side of the T/digital F's twin. The technique catches all harmonic content, is unaffected by asymmetrical loading, and locates the majority of system defects on the MV side of the T/F. It also calculates T/F MV waveforms of voltage and current, as well as active and reactive power, as precisely as an instrument T/F. The digital twin approach offers distribution T/F monitoring without the need of MV equipment, without sacrificing accuracy, and with the potential for quick deployment. Field information from a real MV-LV T/F is consistent with simulation findings, demonstrating the value of the digital twin approach.

Yizhe Siriburanon, etal. investigated a method for suppressing flicker phase noise (PN) across a large frequency range using a gate-drain phase shift in a complementary oscillator based on a transformer. We determine that the third-harmonic current entering the capacitive channel is now the primary source of the asymmetry in the rising and falling edges, resulting to the 1/f noise up conversion, after naturally neutralising its second-harmonic voltage by the complimentary operation itself. The complementary oscillator based on transformers is explored in detail using a

1/f 3 PN analysis. The flicker PN is decreased by adjusting the gate-drain capacitance ratio, which introduces a specified phase-shift range at the gate and drain nodes of the cross-coupled pair to counteract the negative impacts of misbehaving third-harmonic voltage. We present a brand-new triple-8-shaped transformer in an effort to further minimise the area and enhance the PN in the thermal zone. The prototype is made in 22-nm FDSOI and has a small footprint of 0.01mm2, achieving 1/f3 PN corner at 70kHz, PN of -110dBc/Hz at 1MHz offset, figure-of-merit (FoM) of -182dB at 9GHz, and 39% tuning range (TR). With a normalised TR and area (FoMTA) of -214dB at 1MHz offset, it produces the best FoM.

Feng Xie et.Al. explored the fly back micro inverter with pseudo-dc-link is a common architecture for photovoltaic applications, although it has a high transformer turns ratio and therefore high leakage inductance, which would reduce the converter efficiency. In order to address this problem, this work presented a hybrid boost-fly back/fly back (BF/F) micro inverter based on the non-isolated pseudo-dc-link topology. During the majority of a half grid cycle, this new topology is run in the BF mode, and for the remainder, in the F mode[2]. High voltage gain with minimal voltage stress is readily accessible in the BF mode with a reduced transformer turns ratio. The primary switch's turn-off voltage spike is also capped as a consequence of an intrinsic passive snubber in this mode, which also recycles the leakage energy. The F mode was created to control the output voltage even for values lower than the input voltage since the BF mode lacks a step-down capability. To ensure excellent power quality, the operation and characteristics of the hybrid BF/F micro inverter in boundary conduction mode are carefully examined. The mathematical expression of reference current is then theoretically constructed. A 240 W prototype was then put into use to verify the theoretical analysis and the advantages of the suggested topology.

Chao Chieh Yuan, etal. presented a class-F digitally controlled oscillator (DCO) with a DC-DC booster operating at 3.2-4 GHz for energy harvesting applications. To examine the impedance transformation and total loop gain of this multi-turn transformer is used. The DCO supply voltage of 0.2 V may be even lower than the threshold voltage of transistors without any performance deterioration because to the trifler coil's strong passive voltage loop gain[3]. This short achieves exceptionally low supply frequency pushing of 38 MHz/V thanks to the gate/drain isolation and reduced voltage-dependent capacitance in modern Fin FET technology. Due to source degeneration and impedance transformations, the switched capacitor located at the tertiary winding may achieve a very fine resolution of 1.3 kHz. With the help of a DC-DC converter with a switched-capacitor design and a ring-based non-overlapping clock generator, the bias and control voltages of almost zero power are produced.

An innovative on-line partial discharge (PD) monitoring system for power transformers that works by combining three unusual PD detection techniques, including high-frequency (HF), ultra-high frequency (UHF), and acoustic emission (AE). It is the first monitoring system using an active dielectric window (ADW), a hybrid PD sensor that uses both electromagnetic and ultrasonic signals. The article goes into great detail about how each hardware and software layer of the system was designed and constructed[4]. The PD sensors, such as the meandered planar inverted-F antenna (MPIFA), high-frequency current transformer (HFCT), and active dielectric window with ultrasonic transducer, which were designed to detect PDs in oil-paper insulation, received the most attention in this process. During an induced voltage test with partial discharge measurement on a 330 MVA big power transformer, the hybrid monitoring system prototype was first evaluated (IVPD). The device was then mounted on a 31.5 MVA substation power transformer and integrated, in accordance with IEC 61850 standards, with a SCADA (Supervisory Control and Data Acquisition) system to record the monitored unit's voltage, active power, and oil temperature.The acquired findings demonstrated the great sensitivity of the produced PD sensors, the benefits of using three PD detection methods simultaneously, and the potential for discharge parameter correlation with other power transformer characteristics.

Xiaoming Jin, etal. investigated a noise-circulating 12-GHz transformer feedback Class-F2,3 voltage-controlled oscillator (VCO). In order to provide Class-F2,3 resonant impedance control at the VCO output and tail current transistor input, transformer feedback is used in the proposed VCO. The tail current transistor's noise contribution is further reduced by partly recirculating some of its own noise. The proposed VCO has a 0.04-mm2 core area and is manufactured using a 40-nm CMOS technology[5]. According to experimental findings, the VCO's frequency tuning range is between 11.74 and 12.63 GHz. With a figure of merit (FoM) of 190.5 dBc/Hz and a FoM $_T$ of 187.8 dBc/Hz, the VCO achieves phase noise of -120.2 dBc/Hz at 1-MHz offset frequency at 12 GHz and uses 13.23 mW from a 1.1-V supply.

Mina Babies et al. suggested a technique to lessen voltage-biased RF oscillators' tendency to upconvert flicker (1/f) noise. A typical oscillation voltage waveform is noted to exhibit uneven rise and fall durations due to even-order current harmonics flowing into the capacitive component, since it provides the lowest impedance route, when excited by a harmonically rich tank current. The effective impulse sensitivity function of the asymmetric oscillation waveform has a nonzero dc value, which makes it easier for the 1/f noise to be upconverted into the oscillator's 1/f3 phase noise[6]. We show that the oscillation waveform would be symmetric and the flicker noise up conversion would be significantly inhibited if the 0 tank shows an auxiliary resonance at 2 0, forcing this current harmonic to flow into the equivalent resistance of the 2 0 resonance. By taking use of the various behaviours of inductors and transformers in differential- and common-mode excitations, the auxiliary resonance is accomplished in both inductor- and transformer-based tanks with no additional silicon area. While developing modified class-D and class-F oscillators for 40 nm CMOS technology, these tanks are finally used. The average flicker noise corner they display is less than 100 kHz.

Yizhe Siriburanon etal. explored complimentary oscillator built on a transformer in the form of a triple-8. It combines the advantages of both tank and ring oscillators and has a small area, broad tuning range (TR), electromagnetic compatibility (EMC), and low flicker phase noise (PN). We determine that the third-harmonic current entering the capacitive channel is now the primary source of the asymmetry in the rising and falling edges, resulting to the noise up conversion, after suppressing the second-harmonic voltage by the complimentary operation itself. The third-harmonic voltage is reduced and a particular gate-drain phase shift is introduced by adjusting the capacitance ratio between the switching transistors' gate and drain nodes, which also lowers the noise.

DISCUSSION

Protection of substations: This thesis's objectives were to familiarise readers with the theory behind instrument transformers in substations and to provide an Excel calculation template that would make calculating current transformers easier. Making many sheets for various protection functions was the method used to construct various computations so that they were print-ready for clients. The first section covers the fundamentals of instrument transformer theory before moving on to relay protection basics.The IEC standards for instrument transformers that are now in use are provided in the part on sizing, along with the various current transformer types that the IEC 61869 instrument transformer standard specifies.

Relay security

Protection function

The electrical grid is protected in various ways by various protection functions. The protective current transformer is required for a variety of protection purposes.One of the most common and crucial roles of high voltage transmission line protection is line distance protection. A transmission line's impedance increases with length. The distance protection feature will trigger if the observed transmission line impedance is less than the estimated transmission line impedance.Differential protection compares the current amplitude and/or -phase angle at both ends of the transmission line. Circuit breakers at both ends of the transmission line will trip if the measured value exceeds a predetermined threshold, isolating the problematic area of the network.

Reliable, high-quality transformers are crucial for maintaining operations in a variety of sectors, including healthcare, manufacturing, electrical contracting, higher education, and correctional. Big facilities and industrial operations need a lot of electricity, and they rely on reliable transformers to change the energy from the power plant into a form that can be used for their utilities and equipment.Transformers transform energy from a source into the power the load needs. Businesses need to know how much power their specific transformers can provide them in order to utilise them efficiently. Such information may be found in a transformer's rating.A main winding and a secondary winding make up the transformer's conventional two windings. Via the main winding, electricity is input. The power is subsequently converted by the secondary winding and sent to the load through its input lines. The rating, often known as size, of a transformer refers to its kilovolt-ampere output.The transformer is often to blame for faulty electrical equipment. In such scenario, you'll likely need to replace your transformer. When you do, be sure to get one with the right kVA rating for your requirements. If not, there is a chance that your priceless equipment may catch fire. It entails calculating your required kVA using a simple formula based on the current and voltage of your electrical load. We'll go through how to determine the necessary capacity kVA rating in more depth in the transformer kVA ratings guide that follows.

How to calculate the kVA Size

It helps to be familiar with the terms and acronyms before you start calculating kVA size. Transformers are occasionally measured in VA, particularly the smaller ones. Volt-amperes, or

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VA, stands for. For instance, a transformer with a 100 VA rating may manage 100 volts at one amp of current.Kilovolt-amperes, or 1,000 volt-amperes, are represented by the kVA unit. A transformer with a rating of 1.0 kVA can handle 100 volts at 10 amps of current and is equivalent to a transformer with a value of 1,000 VA.

Computation of kVA size

You must do a number of calculations using your electrical schematics to establish your kVA size. A certain input voltage, also known as the load voltage, is necessary for the electrical load that connects to the secondary winding. Give that voltage the letter V. You must be aware of this voltage; you may do so by consulting the electrical schematic. We may argue that the required voltage for an example load V is 150 volts.The specific current flow your electrical load demands must then be determined. You may also get this number by consulting the electrical schematic. If the necessary current flow cannot be found, it may be calculated by dividing the input voltage by the input resistance. Let's assume that the needed load phase current, abbreviated l, is 50 amps.

After you've found or computed these two numbers, you may use them to determine the load's kilowatt needs. To achieve so, multiply the necessary input voltage (V) by the necessary current load (l) in amps, then divide the result by 1,000: V * l / 1,000 multiplying 150 by 50 would result in a value of 7,500, which would then be divided by 1,000 to provide 7.5 kilowatts.The amount in kilowatts must then be changed to kilovolt-amperes as the last step. You must divide by 0.8, which corresponds to the normal power factor of a load, when you do so. Divide 7.5 by 0.8 in the previous example to obtain 9.375 kVA.

Nevertheless, you won't be able to locate a transformer with a rating of 9.375 kVA. The majority of kVA ratings are whole numbers, and manyparticularly those in higher rangescome in multiples of five or ten, for example, 15 kVA, 150 kVA, 1,000 kVA, and so on. Generally speaking, you should choose a transformer with a rating that is 10 or 15 kVA or somewhat greater than the kVA you estimated.You may also determine the amperage you can utilise by working backward from the known kVA of a transformer. When operating a 1.5 kVA transformer at 25 volts, multiply 1.5 by 1,000 to obtain 1,500, then divide that number by 25 to get 60. You may use up to 60 amps of electricity with your transformer to operate it.Charts may be used as an alternative to computations if they appear difficult or unpleasant while determining kVA. To make establishing the right kVA simpler, several manufacturers provide charts. If you're using a chart, identify the rows and columns where your system's voltage and amperage are stated, and then look for the kVA indicated there.

Considerations for the Start Factor and Specialties

In the aforementioned example, we divided by 0.8 to significantly raise the transformer's kVA.In general, a gadget needs more current to start than to operate. It's often good to include a start factor in your calculations to take into account this extra current demand. As a general guideline, double the voltage by the amperage and then by a start factor of an extra 125 percent. Of course, dividing by 0.8 is equivalent to multiplying by 1.25.But you can need a kVA much more than your estimated size if you activate your transformer often, such more than once every hour. Also, your kVA needs may vary significantly if you're dealing with specialty loads, including those associated with motors or medical equipment. You should certainly seek guidance on the appropriate kVA from a reputable transformer provider for unique applications.There are also a few minor differences in the equation for three-phase transformers, which we'll go over in more depth below. To ensure that your work is accurate while doing calculations using three-phase transformers, you must add a constant.

Calculate the Load Voltage

You must determine your load voltage, or the voltage needed to run the electrical load, before you can calculate the required kVA for your transformer. You may consult your electrical schematic to find out what voltage your load is at.Instead, you could already know your transformer's kVA and wish to determine the required voltage. You may then modify the equation we used before. We can solve for V to arrive at V = kVA * 1,000 / l because you already know that kVA = V * l / 1,000.In order to divide by amperage, first double your kVA rating by 1,000. You would enter 75 * 1,000 / 312.5 to get 240 volts if your transformer has a kVA rating of 75 and your amperage is 312.5.

Calculate the Secondary Voltage

The main and secondary circuits of the transformer wind around its magnetic core. The number of coils turns, together with the voltage and current of the main circuit, are some of the variables that affect secondary voltage.By dividing the voltage drops via the main and secondary circuits by the quantity of circuit coils around the magnetic component of the transformer, you may determine the voltage of the secondary circuit. We will apply the formula t1/t2 = V1/V2, where t1 denotes the number of turns in the main circuit's coil, t2 denotes the number of turns in the secondary circuit's coil, and V1 and V2 denote the voltage drops in each coil.Consider a transformer having 150 turns in the secondary coil and 300 turns in the main coil. Also, you are aware that the first coil's voltage loss is 10 volts. You can determine that t2, or the voltage drop through the secondary coil, is 5 volts by plugging these figures into the equation above, which gives the result 300/150 = 10/t2.

Calculate the primary voltage

The main and secondary sides of any transformer ought to be kept in mind. Calculating the main voltage, or the voltage that the transformer gets from a power source, is sometimes necessary.Using the current and voltage ratios from the main and secondary coils of the transformer, you can calculate the primary voltage. Maybe you are aware that the secondary coil of your transformer has a voltage drop of 10 volts and a current of 4 amps. Also, you are aware that the main coil of your transformer has a 6-amp current.Let the currents flowing through the two coils, i1 and i2, be equal. i1/i2 = V2/V1 is a formula that may be used. If you enter the values i1 = 6, i2 = 4, and V2 = 10 into the formula, you will receive 6/4 = 10/V1. The voltage drop across the main circuit should be 6.667 volts based on the result of the V1 equation, which is V1 = 10 * 4/6[7]–[9].

Ratings for Single-Phase kVA

A single-phase alternating current is used by a transformer. There are two alternating current (AC) power lines in it. These are a few typical types:

Encapsulated

Both indoor and outdoor general loads may benefit from a single-phase encapsulated transformer. These transformers are often used in commercial and industrial settings, including several lighting applications. Facilities may bank these units to build three-phase transformers if they so want. These transformers typically range in rating from 50 VA to 25 kVA, which is rather low.

CONCLUSION

Both indoor and outdoor single-phase loads might benefit from using a vented single-phase transformer. These transformers are often used in industrial and commercial lighting applications. They often have values between 25 and 100 kVA.Transformers that are completely enclosed but not vented might be single-phase or three-phase systems. They are perfect for settings where there is a lot of dirt and debris. Typically, their values fall between 25 and 500 kVA.This book chapter explores about the effective dimensions of voltage transformer for switchyard size. Also, the study investigates the optimum transformer ratings required in power system applications.

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INVESTIGATING THE DIMENSIONS OF CURRENT TRANSFORMER

Ms. Renuka Bhagwat*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

ABSTRACT:

This book chapter explores the required dimensions of current transformer in accordance with diverse applications. A current transformer, often known as a CT, is a kind of transformer that changes a high current and voltage value into a lower current and voltage value. Although the voltage quantity on the low-voltage side is lower, it is not linearly proportional, and the high voltage and low voltage current quantities are linearly proportional by the CT turns ratio under normal working circumstances. When sizing a current transformer for protection, maximum fault currents should be taken into account. There are several factors to take into account while discussing CT size, including the safety factor and the rated power. A current transformer is sometimes referred to as a series transformer because its primary coil is always wired in series with the main conductor. For convenience of measurement, the nominal secondary current is rated at 1A or 5A. The size of the load being measured, like its physical dimensions, is an important factor. The maximum load size that can be measured by a current transformer is specified by the current input range, also known as the amperage range.

KEYWORD: *Current Transformer,Low Voltage, Load Voltage, Power Transfer, Secondary Winding.*

INTRODUCTION

In single-phase or three-phase circuits, the Current Transformer (CT) measures the AC current. A single primary conductor travels through the core of the most fundamental instrument-grade current transformer.The secondary winding contains many turns and might provide a lower output current. This enables the metre to be placed far from the circuit with a high current. An ammeter, power metre, or energy metre may be connected to an instrumentation. CTs come in a range of shapes and sizes, with common aspect ratios ranging from 50:5 to 4000:5. Split core variants fit around existing wiring with ease. Models with solid cores are more affordable. Specifications for current transformers include size (VA rating), ratio, and accuracy. The maximum secondary impedance (burden) that may be driven at the claimed accuracy is determined by the VA rating[1]–[3].

The conventional analogue ammeter with a transformer rating moves at 5A AC (M). The input terminals' (t1 and t2) wires provide a little bit of extra series resistance. The ammeter load may be determined for operations at 50 or 60 Hz by measuring the resistance from t1 to t2. To get the whole CT load, add the two lead resistances. Some analogue metres use a tiny internal CT and an

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electronic circuit to power the movement in lieu of the 5A movement. The ammeter load in these devices is measured using the same technique.The analogue metre element (M) is often replaced in digital metres by a shunt resistor (usually 0.01) and an electronic measurement circuit. For isolation, certain digital metres may swap out the shunt resistor with an internal CT. The overall CT load and metre resistance measurements are same in both scenarios.

The maximum total lead wire length (Rlead1 + Rlead2) by VA rating for a CT with a 5A secondary is in the "Current Transformer Wire Length Chart" below. The total wire length for the chart is 20 feet if the distance from the metre is 10 feet. The values given are based on 50°C temperature, 0.02 metre resistance, and stranded wire. Lead resistance will increase as temperature rises (0.4%/°C for copper). Low resistance connections are anticipated since the current transformer's terminals also add to the CT load.

Voltage transformer

A current transformer, often known as a CT, is a kind of transformer that changes a high current and voltage value into a lower current and voltage value. Although the voltage quantity on the low-voltage side is lower, it is not linearly proportional, and the high voltage and low voltage current quantities are linearly proportional by the CT turns ratio under normal working circumstances. Hence, voltage and current are stepped down using potential and current transformers, respectively, while power is stepped down using a power transformer. Step up or step down are both possible. A step-down transformer is used in a very unique way with current transformers. The number of turns on the secondary side of the CT must be larger than the number of turns on the main side in order to have less current flowing through its voltage transformer show in figure 1.

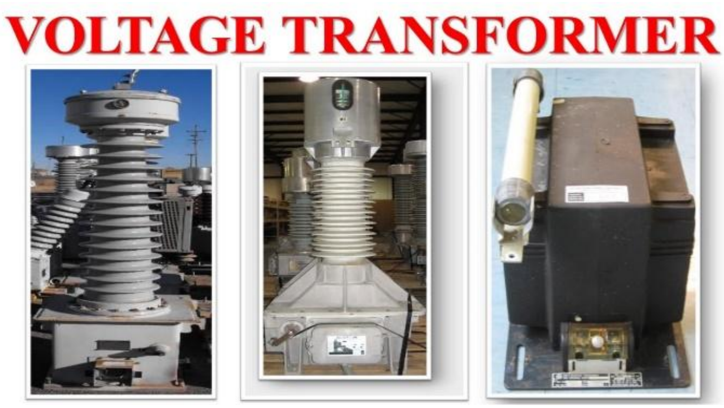

Figure 1 Voltage transformer [YouTube].

Assume a conductor is travelling through a CT. As the conductor goes through the window, there is only one primary turn. Yet, since this is an ideal transformer, there should be many more secondary turns. The ratio of primary current to secondary current should be the same as the sum of secondary turns over primary turns. As there is only one turn on the main side and four turns on the secondary, the transformer is a step-down transformer. Hence, if the main current is 100 amps and the CTR is 4, we should anticipate that the secondary current will be 100 divided by 4, or 25 amps.

LITERATURE REVIEW

Ehsan Mohiti, etal. explored the application of non-sinusoidal loads, such as Plug-in Hybrid Electric Vehicles (PHEVs), as well as the installation of a sizable number of distributed generators (DGs) in industrial plants and emerging smart distribution networks have significantly complicated the best practises for transformer sizing (OTS). In addition to significantly increasing transformer load losses, the harmonic currents produced in these novel conditions also induce anomalous winding temperature rise and excessive transformer life loss. Hence, while selecting the proper size of distribution transformers, the harmonic content of the load currents should be taken into consideration. This research presents a novel approach to resolve the OTS issue in such contexts in order to answer the utilities' concern. It accounts for the impact of harmonic currents on a transformer's excessive heat production and the transformer insulation's shortened lifespan as of these thermal stressors. In order to address the OTS issue, a novel dynamic programming (DP) paradigm is proposed in this research. While the suggested DP technique takes into account the transformer thermal equations, the subsequent stages of the proposed DP network are kept independent by adding a fresh variable called the depreciation cost. In order to tackle the OTS issue, the suggested DP technique does not need any additional heuristic algorithms. In answer, the suggested solution is quick and simple to use. The efficiency of the suggested algorithm is validated by in-depth research.

Ran Li, etal.discussed medium-voltage applications, a phase-shifted square wave modulation technique is suggested for modular multilevel converters (MMCs) and dc transformers. The suggested method may reduce the size of a cell capacitor without raising the total device rating (TDR) or impairing the capacity to manage dc current. The isolated modular multilevel dc-dc converter, which includes an MMC stage and is used as a dc transformer for medium-voltage dc grid, is used to demonstrate the working concept of the suggested technique. The TDR and passive component sizes are calculated, and they are contrasted with those obtained by employing various modulation techniques. The suggested modulation technique has now been validated using a hardware prototype that has been downscaled and tested[4]–[6].

Goh Teck Sugiyama, etal. explained three modulation strategies for a single-phase isolated matrix converter. The transformer integration and matrix converter work together to accomplish power decoupling control, which lowers the volume of capacitors and component parts. It's crucial to have a clear sinusoidal grid current waveform when modulating the matrix converter (MC) because of I direct alternating current (AC/AC) conversion and (ii) transformer integration. Control complexity, waveform quality, and the size of an inductive-capacitive-inductive (LCL) filter are evaluated across three different modulation techniques. There is a description of each method's primary control. The validity and efficacy of grid current regulation and power decoupling in the speaking circuit construction were finally evaluated using a prototype.

S. Essah etal.explored previous work on the energy consumption of commercial kitchens. Data on electricity usage was gathered from distribution board current transformers in a sample of fourteen pub-restaurants in the UK. This was put up to evaluate the overall energy consumption of these organisations as well as to discover appliance use trends. In comparison to existing literature estimates, the power usage in the chosen commercial kitchens was substantially greater [7]. The catering operation was responsible for 63% on average of the building's electrical use.

Refrigeration (70 kWh, 41% of the sample's average daily power use), fryers (11 kWh, 13%), combination ovens (35 kWh, 12%), bain maries (27 kWh, 9%), and grills (37 kWh, 12%) were to be the major contributors. Poor maintenance and behavioural variables were to be the primary causes of excessive power use, with potential savings of 70 and 45%, respectively. It is necessary to take steps to modify operator behaviour, including expanding the use of mandated energy labelling, improving feedback data, and launching behaviour change campaigns. Stricter maintenance procedures and better fridge size would be very beneficial for energy savings.

Douglas I. Law, etal. discussed large inrush currents may occur when power transformers are turned on. The severity of these currents depends on the intensity of the source, the transformer's leakage impedance and residual flux, and the angle at which the applied voltage is applied. Using a process known as "pre fluxing," which involves setting a single-phase transformer's residual flux to a known polarity after the transformer has been de-energized, and controlling the instant of transformer energization based on the flux polarity, a novel inrush current reduction strategy has been put into practise. The goal is to significantly reduce inrush current rather than completely eliminate it. Contrary to a common suggestion, this method doesn't call on previous knowledge of the transformer's flux. Pre fluxing equipment is straightforward in design and works at far lower voltage levels than the transformer's rated voltage. Even while taking into consideration common breaker variations, the proposed technique has been effectively applied to an 18 kVA laboratory transformer with inrush current levels dropped below the transformer's rated current. Inrush current reduction in three-phase transformers utilising a three-pole circuit breaker is described in this study along with the theory, device size, and execution of the reduction approach.

DISCUSSION

Let's start by defining CT accuracy. It may be thought of as the degree to which the current running through a current transformer's secondary side can accurately mimic the current flowing through the main side in real-world situations. When comparing the output current to the main winding's initial current, there will always be some inaccuracy present. The secondary branch's magnetization current is what's causing the issue. Let's think about the significance of CT accuracy for protection. If we consider a fault on a low voltage but in a three-phase system, we would require the connected CT to be able to operate effectively at the highest current level present on that particular bus. This is necessary because we want the CT to accurately recognize the fault level and deliver the signal to the relay connected to its secondary winding, which would then cause the circuit breaker to trip for protection. We need protection Class C Ts to saturate at a high value in order to allow the CT to appropriately recognize the high fault level signature for protective relays. CTS are required to transport the fault currents, which may be up to 10 times the rate at full load current. Class C T protection examples are the 5P20 and 10C400. Let's think about the usefulness of CT accuracy class for metering purposes. We would like metering Class CT's to properly measure the current flowing on the main side to the full load current and beyond. These CTS are intended to have a lower saturation value for this reason. Lower saturation restricts the maximum current that may pass through the core, preventing damage as a. These CTS are often used in instrumentation and energy metering applications. As metering applications depend critically on the accuracy class. Only percentage ratio errors that fall within a very narrow range, usually less than 1%, are acceptable. A few examples of metering Class C Ts include 0.15, 0.3, and 0.3s. These numbers provide information on the error percentage[8]–[10].

CT Sizing

There are several factors to take into account while discussing CT size, including the safety factor and the rated power. The accuracy class and CT load are essential considerations, but the CT ratiowhich was described aboveis the most crucial one. It is calculated by dividing the secondary number of turns by the main number of turns.

IP/Is = NS/NP CTR

In other terms, we can alternatively define it as the main winding current divided by the secondary winding current. Now let's look at an example circuit where a current transformer is connected to breaker B and 80 amps of current is flowing through it. We already know that the majority of CTS have either a one-arm or five-amp secondary current rating. Keep in mind that the secondary current generated does not exceed the maximum main load current. The CT total secondary circuit's continuous thermal current rating for each individual component in this situation. Let's use a 5-amp rating. If we enter at into the ratio calculation, the ant ratio is 16, which is 80 full load amps divided by the 5 amps of the secondary CT circuit's rated current.

IP/Is = 80/5 = 16 CTR

Practically speaking, a CT with a rating of 100 to 5 should be applicable because it has a ratio of 20 that is the closest to our calculated value. In our example, the 100 to 5 ratio means that we can expect 100 amps of full load current on the primary side and 5 amps of full load current on the secondary side. When sizing a current transformer for protection, maximum fault currents should be taken into account. When compared to the maximum symmetrical main fault current, the current transformer ratio has to be big enough to ensure that the CT secondary current does not exceed 20 times the rated current without going above the allowable error of 10%. For our example, let's suppose that the maximum fault current is at 10 times the rated load current. The ant is 80 times 10, or 800 amps. This is first a little tough to grasp, so let's rapidly break this statement down.

Using CT

While CT has many different applications, they are mostly employed for metering or protection. A current transformer may be Cond to provide certain current amounts to a protective relay in order to safeguard a distribution feeder. The main line current would rise in the event of an anomaly, changing its secondary values in the process. This increase in current would signify an abnormality, and the protective relay would trip a circuit breaker.

Ratio of transformation

The rating plate lists the transformation ratio as a simplified fraction and describes it as the proportion between the main and secondary rated currents.The most common transformers used are x/ 5 A current transformers. The greatest accuracy level for most measuring instruments is 5 A. Long measurement wire lengths are advised for x/ 1 A current transformers for both technical and financial reasons. Compared to 5-A transformers, line losses with 1-A transformers are just 4%. Yet, the measuring equipment used here typically displays a lower level of measurement precision.

RMS power

The rated load multiplied by the square of the secondary rated current yields the current transformer's rated power, which is expressed in VA. The standard values are 2.5, 5, 10, 15, and 30 VA. In accordance with the application situation, it is also acceptable to choose values more than 30 VA. The term "rated power" refers to a current transformer's ability to "drive" the secondary current through a load while staying within error bounds.It is vital to take into account the following factors while choosing the right power: measuring line length, line cross-section, and device power consumption (with connections made in series). The losses via the supply increase as line length and cross-section decrease, thus the nominal power of the CT must be chosen such that this is appropriately high.

The power usage ought to be quite close to the rated power of the transformer. In some conditions, if the power consumption is extremely low (under loading), the overcurrent factor will rise and the measuring devices won't be adequately protected in the case of a short circuit. Overloading, or excessive power consumption, has a detrimental effect on precision.In many cases, current transformers are built into an installation already and may be utilized if a measurement device has to be added later. In this situation, it is important to be aware of the transformer's nominal power: Is this enough power to operate the extra measurement equipment.

Comparing the protection current transformer and the measurement current transformer

Measurement current transformers, on the other hand, are designed to quickly reach saturation point once they exceed their operational current range (expressed by the overcurrent factor FS) in order to prevent an increase in the secondary current in the event of a fault (such as a short circuit) and to safeguard the connected devices. Saturation should be as far away from protective transformers as practicable.Along with the necessary switchgear, protection transformers are employed to safeguard the system. The 5P and 10P precision classes are the norm for protection transformers. Here, "P" stands for "protection." Just behind the identification of the protection class (in%) comes the notional overcurrent factor. For instance, 10P5 denotes that, with a five-fold nominal current, the negative secondary-side deviation from the expected value would, in accordance with the ratio, not exceed 10%.

Choose a current transformation

When making your decision on CTs, there are a few key factors you should take into account. The first factor is the current kind. A single-phase or three-phase CT can be your best option if you're seeking for a transformer that will let you monitor current in an area with just one phase or cable.A four-wire CT will probably be required if you wish to monitor a four-wire system or anything with more than three phases (such as a three-phase motor). While selecting a CT, you should also consider how much voltage it can withstand. Although some CTs can withstand high voltages like those on transmission lines, others are better suited to low voltage tasks like monitoring power lines.Before making any choices, check with your sales representative to see what voltage range your application fits inside. If necessary, our staff may propose current transforms from our collection and assist you with making the best choice.

Current transformers that are portable

Nowadays, a wide variety of specialized current transformer types are available. Clamp meters, as seen, are a common and portable variety that may be used to measure circuit loading.Without interrupting or opening the circuit, clamp meters encircle a current-carrying wire and measure its current by calculating the magnetic field around it. The reading is often on a digital display.Split core current transformers are an alternative to portable clamp-style CTs; they include a detachable end that eliminates the need to disconnect the load conductor or bus bar in order to install them. They have square window diameters ranging from 1 inch to over 12 inches, and they can measure currents from 100 amps to 5000 amps (25-to-300mm).In conclusion, a current transformer, also known as a CT, is an instrument transformer that transforms a primary current into a secondary current using a magnetic medium. A significantly lower current is then produced by its secondary winding, which may be utilized to identify overcurrent, undercurrent, peak current, or average current circumstances.

A current transformer is sometimes referred to as a series transformer because its primary coil is always wired in series with the main conductor. For convenience of measurement, the nominal secondary current is rated at 1A or 5A. Construction may consist of a several wound primaries turns, often for low current ratios, or a single primary turn, as in Toroidal, Doughnut, or Bar kinds.Transformers for current are designed to be utilized as proportional current equipment. Hence, just as a voltage transformer should never be run into a short circuit, a current transformer's secondary winding should never be operated into an open circuit.If the ammeter is removed or while a CT is not in use, the terminals must be short-circuited before turning on the system since opening the secondary circuit of an active current transformer would in very high voltages.In the next lesson on transformers, we'll examine what occurs when three separate transformers are connected in a star- or delta-shape to create a bigger power transformer known as a three-phase transformer, which is used to deliver three-phase supplies.

Conductor Size

The conductor's size is an important issue and might be a key determining factor when choosing a CT. The conductor you want to measure must physically fit around any CT that is utilized. The electrical panel may not have enough place for a big, stiff current transformer, therefore it might not be cost-effective or practical to oversize a CT in order to accommodate a tiny conductor. A flexible Rogowski coil may be a good compromise between a big window size and flexible functioning in this case since they can readily glide under huge bus bars in confined locations, making it simpler to measure in congested electrical panels or switchgear.

Load size

The size of the load being measured, like its physical dimensions, is an important factor. The maximum load size that can be measured by a current transformer is specified by the current input range, also known as the amperage range, of the device. A current transformer with a wide current sensing range, such a flexible Rogowski coil, might be useful if the load varies during the dayfor instance, when occupancy is low in the nighttime hours. Also, it's crucial to keep in mind that if a load exceeds the sensor's measurement range, the meter may not be able to detect it effectively. For this reason, you should always choose a sensor whose range corresponds to the load that you want to measure.

Accuracy rating

Choosing equipment with the best accuracy when it comes to tenant billing is crucial. In reality, power monitoring equipment must fulfil certain accuracy criteria in any application where "money changes hands" and is sometimes designated as "revenue grade" to indicate compliance with accuracy standards. What does accuracy in revenue grade mean? It is widely accepted to have an accuracy of at least 0.5% and preferably more than 1%. Be sure the accuracy class of the sensor you choose for your project fits the industry standards for accuracy before making your choice. IEC 60044-1 0.5 class is a widely used accuracy standard for revenue grades. On the other hand, you may not need to upgrade to a revenue grade model if all you're doing is gathering data on a facility's general consumption pattern.

Would a split-core or solid-core current transformer be preferable for my application is another way to phrase this. In spite of the fact that either sensor type can be used for any task, it is almost always simpler to use a split-core, or a Rogowski coil, current transformer for a retrofit application because it can be opened easily to fit around a conductor and does not require wire disconnection as part of the installation process. Instead, because facility shutdowns or wire disconnections are not yet disruptive, adding a solid-core CT does not involve much more labor when a facility is still being built. Cost is another thing to think about: While a solid core CT costs less up front, the initial savings are insignificant when compared to the installation cost, which must account for shutdowns and disconnections, increasing time and labor costs for the whole project.

A UL Listed current transformer has been put through a battery of tests to make sure it conforms to widely accepted safety regulations. A UL Listed sensor may be marketed as an end-user product and is meant to reduce installation risks like shock and fire, unlike a current sensor that is a UL Recognized Component, which signifies it is intended to be a component inside a whole system or product. To comply with safety code standards, it's possible that your application requires a current sensor that is UL listed. If this is the case, be sure to search for CTs that have the UL Listed designation, which indicates that they adhere to CSA C22.2 61010-1 and XOBA UL2808.

A CE mark is yet another important regulatory need. Products used in the European Economic Area (EEA), which includes nations including Germany, France, Spain, Italy, and others, must have this symbol. The CE stamp on a product signifies that it complies with European safety, health, and environmental requirements, in contrast to other quality certifications like UL. In product labels and paperwork, the CE mark should be discernible.You can come into a third legal need involving Measurement Canada clearance. Both a Measurement Canada-approved meter and current transformers may be needed for tenant billing applications in Canada, and both must adhere to strict standards for rating, design, accuracy, testing, and other factors. For instance, a few requirements for Measurement Canada-approved CTs are solid core construction, accuracy of 0.6% or greater, and either 5A, 80mA, or 100mA output capabilities. Examine the product labelling and paperwork to verify whether a sensor fits the regulatory standards, depending on the kind, scale, and location of your project[9], [11].

CONCLUSION

Rogowski coil current transformers have several benefits, including a big window size, wide amperage range, lightweight adaptability, and no saturation threshold. They are suitable for almost any project. Unfortunately, your power meter won't directly function with a Rogowski coil if it only takes 333mV, 5A, 1A, or another standard output. Thankfully, using an integrator is a straightforward solution to this problem. An integrator is a piece of electrical equipment that allows a Rogowski coil's output to be changed to a standard output, such as 333mV or 5A, so that it may communicate with a variety of power meters, protective relays, and other devices. An integrator is a straightforward way to resolve a frequent compatibility issue that spans the gap between Rogowski coils and industrial metering equipment by modifying the input ranges to meet practically any system. This book chapter exploresthe sizing of current transformer as well as key role and applications in different applications.

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EXPLORING THE METHODS OF EARTH'S RESISTANCE MEASUREMENT

Dr. Sreenivasappa Bhupasandra*

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

ABSTRACT:

In this book chapter we talk about how to measure the earth's and the soil's resistivity. An equilateral triangle with three test electrodes at each corner and an earthing system in the center is utilized in the star delta procedures. After an earth electrode system has been built and deployed, the earth resistance between the electrode and actual Earth must normally be measured and verified. From a safety standpoint, every piece of electrical equipment in the distribution system has to be properly earthed. The earth resistance is calculated using the potential fall method. The resistance area of the earth electrode is the area of the soil where a voltage gradient is measured using industrial equipment. It is uncertain since soil resistivity varies. Deeper soil levels are correlated with lower soil resistivity.

KEYWORD: *Earth System, Earth Resistance, Earth Electrode, Soil Resistivity, Test Electrodes, Test Stake.*

INTRODUCTION

To create earthing connections, the ground electrode is put into a variety of places. An earth electrode is a metal tube or conducting plate connected to the earth. The structure uses a variety of materials, including copper, aluminum, steel, and galvanized iron. Many factors, such as soil type, temperature, moisture content, and electrode depth, affect the earth resistance. A circuit may be properly earthed so that leakage current can connect to an automatic cutoff device and safely depart the circuit (which ensures power supply). Main earth terminals or bars, earth electrodes, earthing conductors, protective conductors, equipotential bonding conductors, electrically independent earth electrodes (for measurements), termination fittings, bonding, welding kits, and other materials are some of the components that make up an earthing system.

Calculating Earth Resistance

Methods

Many earth resistance testing methodologies are used, depending on the neutral system type, the installation type (residential, industrial, urban, or rural setting), and the ability to turn off the power supply. There are four elements that affect an earthing system's earth resistance, including:

1. Composition of the soil

2. The moisture content of the soil

3. The temperature of the soil

4. The depth of the electrode

The earth electrode's resistance is based on the soil's resistivity, which is where it is placed. As a consequence, resistivity measurements must be made while building any earthing systems.The resistance of the ground electrode that was measured while doing a resistance check is known as the earth resistance. Using other measurements, such as the voltage, the test electrode moved the original voltage electrode 10% closer to the earth system and 10% away from its original position.Several sites can calculate resistance by altering the voltage probe's location while being tested and current at regular intervals (each is comparable to 10% of the distance travelled). The digital earth tester's display indicates the resistance value. The earth resistance is determined using Ohm's equation R=V/I. In order to ensure that the (auxiliary test electrode) P lies distant from the earth electrode that is being tested and outside of both of the resistance zones of the earth electrode C.

Use the slope technique to determine the true resistance for large earthing systems, such as power plants. The star-delta technique is well suited for areas with vast systems or rough terrain where it would be difficult to locate test electrodes. An equilateral triangle with three test electrodes at each corner and an earthing system in the center is utilized in the star delta procedures. It is possible to assess the overall resistance between any two adjacent electrodes as well as between each electrode and the earthing system. The four potential techniques, also known as the Winner method, are similar to the Fall of the Potential method except from the fact that measurements are performed with the voltage electrode in different places and a series of equations are employed to determine the theoretical resistance of the system. Hence, different strategies are suitable depending on the circumstance.

The earthing testers are diagnostic tools that may aid with uptime maintenance. All ground and ground connections must be inspected at least once a year as part of a predictive maintenance strategy. In order to ensure a source-of-the-problem investigation and a remedy to reduce the resistance by replacing or adding ground rods to the ground system, the earth resistance would be increased by more than 20% during regular inspections. The Earth Resistance profile's range is 10 to 20 Ohms. Identification of the soil, earthing, and comprehensive field tests have shown that the soil resistivity values vary based on the kind of soil. To mitigate the damage of a lightning strike on rocky terrain, a network of underground counterpoise earth wire or (well-designed) earth mats may be used. For electrical systems to be efficiently earthed, soil resistivity must be acceptable.

The earth resistance of the earth electrode

After an earth electrode system has been built and deployed, the earth resistance between the electrode and "actual Earth" must normally be measured and verified. The most popular method for evaluating an earth electrode's earth resistance is the 3-point measurement approach. The three-point methodology, also known as the "fall of potential" method, consists of the Earth Electrode to be Monitored and two additional electrically independent test electrodes, often referred to as P (Potential) and C. (Current). Even if they are of inferior "quality," these test electrodes must be electrically isolated from the electrode being tested (greater earth resistance). The Slope Method and the Four Pole Method have been developed to address specific issues associated with this streamlined procedure. These methods are particularly useful for measurements of the resistance of large earthing systems or at locations where space for positioning the test electrodes is constrained electrode resistance show in Figure 1.

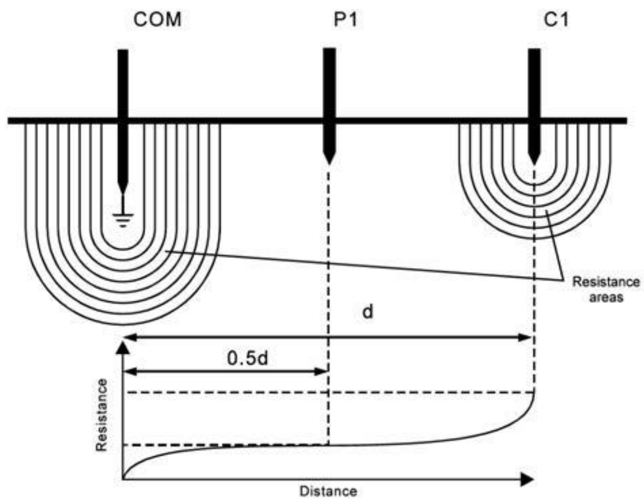

Figure 1 Electrode Resistance.

Loss of the forward-looking perspective

One of the most often used methods for determining earth resistance, it performs well with small systems that don't need to cover a wide area. It is simple to implement and requires minimal math. Due to the need for exceptionally long test lines and large stake separations in order to produce an accurate measurement. The outside test electrode, also known as the current test stake, is usually buried 30 to 50 metres from the earth system. Next, along a straight line between the current test stake and the earth electrode, the inner test electrode, also known as the voltage test stake, is pushed into the ground.

The Falling Potential and Earth Tester Method

It's essential to ground every piece of electrical equipment for both domestic and commercial usage. It is necessary to gauge the earth connection, earth plate, or earth electrode resistance for the reasons listed below.From a safety standpoint, every piece of electrical equipment in the distribution system has to be properly earthed. When an electrical device is linked to an earth electrode, all of its parts are at earth potential. In the body of the device, this provides a low resistance path for fault or leakage currents. As a consequence, it ensures that the individual will be safe from electric shock if they come into sudden touch with the machinery.Overvoltage brought into the circuit as a consequence of a lightning discharge, surges, or a rapid change in the voltage being utilised may cause damage to the equipment (voltage spikes). The equipment must be grounded in order to protect it from this dangerous overvoltage. To preserve the potential of other circuits, the neutral in three-phase circuits is earthed. The neutral grounding of the electrical system safeguards personnel and equipment.The resistance between the earth electrode and the ground underneath it must be carefully monitored. The resistance should be exceedingly low for optimal protection. Nevertheless, a variety of factors affect the resistance, including the electrode's size, shape, and material, its depth in the ground, and the specific resistance of the soil nearby, which is influenced by the moisture content.

LITERATURE REVIEW

Abhisek Field, etal. investigated the literature on iron melting and heat conductivity at Earth's core conditions is voluminous, and there are significant disagreements. The disparity could be explained by the wide variety of experimental procedures, each of which has certain flaws. The electrical resistance of both solid and liquid iron wires was measured in order to provide fresh information on the phase behaviour and resistivity of iron in the laser-heated diamond cell[1]. The most significant of them is the identification of the beginning of melting, which is one of the key defects that the experiment avoids. The resistivity findings indicate a tendency towards low thermal conductivity in the liquid outer core, and these observations support an earlier discovery of a shallow melting curve.

V. Rosakis, etal. explored to unzip fissures in the Earth's crust and unleash waves that produce damaging shaking, ruptures need friction. Yet, one of the major uncertainties in earthquake research is the development of dynamic friction. Here, we provide unique measurements of growing local friction made possible by our ultrahigh speed full-field imaging approach during laboratory mini-earthquakes that spontaneously developed. With a rupture speed range from sub-Rayleigh to supers hear, the approach captures the development of displacements, velocities, and stresses of dynamic ruptures[2]. The development of the friction that has been seen is complicated, with early velocity increasing followed by significant velocity decrease. Our results are in agreement with rate-and-state friction formulations with the addition of flash heating, but not with slip-weakening friction laws that are often utilised.As principles guiding the frictional resistance of faults are essential components in physically-based prediction models of the earthquake source, this work introduces a novel method for monitoring local development of dynamic friction and has significant implications for understanding earthquake hazard.

S. V. Galichenko, etal. investigated a tethered balloon with a measuring platform and a ground-based information-measuring complex of the Borok middle-latitude geophysical observatory, the electric condition of the near-surface atmosphere up to a height of 400 m is studied[3]. In order to estimate the average values and variability of the space charge density and conduction current in the atmosphere, measurements were made for the first time for vertical profiles of the atmospheric electric field, polar electrical conductivities, size distribution of aerosol particles, and volume activity of radon. Under various situations of temperature stratification, the near-surface air column's electrical resistance and the height dependence of the electric potential with regard to the Earth's surface are examined.

Shaxby, J. H. explored the commutated inductor magnetometer is mainly intended for field operations, particularly in hilly or other challenging terrain. It is set up to measure both the vertical intensity and the dip. For the first measurement, the instrument's horizontal coil field, which is supplied with a variable current from a small secondary cell, neutralises the Earth's vertical component. For the second measurement, the instrument is tilted through an angle theta until the component field, which is normal to the base of the instrument in the tilted position, is once again neutralised [4]. The complement of 1/2; is then used to determine the dip. So, the essential two elementssetting in the meridian, levelling, changing a resistance, and measuring an angleare measured with the least amount of manipulation possible.

DISCUSSION

Earth resistance calculation

The earth resistance is calculated using the potential fall method. The resistance area of the earth electrode is the area of the soil where a voltage gradient is measured using industrial equipment. In the image below, a stand for a second earth electrode that is positioned such that two resistance zones do not intersect, and E stands for the earth electrode that is at rest. Between electrodes E and A is the second auxiliary electrode, designated B. A steady-state alternating current flows through the earth from E to A, and the difference in voltage between E and B is measured.The electrode B is relocated from places B1 and B2, respectively, to avoid the resistance area overlapping. If the resistance values discovered are almost the same in all three situations, the earth resistance of the earth electrode may be determined by taking the mean of the three observations.When attaching the auxiliary earth electrode at a location farther from E, the aforementioned test must be performed again until the set of three readings obtained are in perfect agreement [5].

An alternating current source is used to eliminate the electrolytic effect

As shown in the picture above, a double wound transformer, coupled with a voltmeter, an ammeter, and an earth tester, may be used to provide current at power frequency for the test. An unusual kind of Merger known as an "earth tester" transmits DC via the measuring device and AC through the ground. On it, there are four terminals. The earth electrode under test has a connection to a common point formed by the shorting of two terminals. The other two terminals are each connected to one of the auxiliary electrodes A or B. The instrument shows the value of the earth resistance right away when the handle is rotated continuously.

Making Use of an Earth Tester an instrument used to measure the earth's or soil's resistance is called an earth tester. It is similar to a megger, which is used for high electrodes, and has additional properties (one earth electrode and two auxiliary electrodes). When the generator on the earth tester is running at rated speed. The potential and current coils of the earth tester carry the voltage and current, respectively, depending on the earth resistance. As a result, the pointer deflects and symbolizes the earth resistance, which is based on the relationship between the current coil current and potential coil voltage.

The soil's conductivity, also known as resistance to electric current, is quantified. This is a crucial factor to take into account when developing systems that rely on current flowing through the Earth's surface. As the earth often serves as a counterpale for low-frequency radio stations (VLF, LF, MF, and lower shortwave), it is an important consideration for choosing the best location for a transmitter. Understanding soil resistivity and how it varies with depth in the soil is essential for designing the grounding system in an electrical substation or for lightning conductors. It is important for the design of grounding (earthing) electrodes for substations and high-voltage direct current transmission systems. In the past, it was essential for earth-return telegraphy. In agriculture, it might potentially be used as a substitute for a moisture content measurement [6].

It is crucial to measure earth resistance

The level of the permanent water table and the ground's subsurface layers both affect how much moisture is present at any one time. Soil and water are often more stable at deeper levels. The ground rods are thus placed as deeply as they can, preferably at the water table, into the soil. Moreover, ground rod installation must be completed below the frost line and at a consistent temperature. If the system is designed to withstand the worst-case scenario, it is considered to be a successful grounding system.The length and depth of the ground electrode are:

It is uncertain since soil resistivity varies. Deeper soil levels are correlated with lower soil resistivity. So, by driving ground electrodes deeper, ground resistance may be reduced.The diameter of the ground electrode is as the diameter of the ground electrode is expanded, its resistance decreases.Counting the ground electrodes, it may be possible to lower the ground resistance by using extra ground electrodes. Many electrodes are connected in parallel and buried in the ground to lower the resistance.

Making a ground system design

A simple grounding method involves pushing one electrode into the earth. This is the most frequent technique for grounding. Complex grounding is a term used to describe grounding systems that include several ground rods, connected mesh or grid networks, ground plates, and ground loops. The optimal sites for these systems are close to power generating substations, central offices, and mobile phone towers.

Loss of potential

The current test stake, or outside test electrode, is sunk 30 to 50 meters from the ground system. The next step is to drive the inner electrode, also known as the voltage test stake, into the ground in a straight line, midway (50 percent distance) between the earth electrode and the current test stake. The size of the system being evaluated will determine this distance, as shown in the table below. This method includes confirming that the test electrodes are indeed spaced apart sufficiently to get an accurate result. The voltage test electrode (P) should be moved away from the earth system by 10% of the initial voltage electrodes-earth separation for the first measurement, then brought closer by 10% of that separation for the second measurement in order to get a corrected measurement [7]–[9].

The slope strategy

It is not feasible to measure the earth resistance for a large system utilizing fall of potential methods because of the electrode constraints. The earth at a power substation is an example of a large earthing system that may be employed with the slope technique. This method comprises a number of resistance measurements at various earth systems to voltage electrode separations, much like the fall of potential approach. It is important to build a graph of the resistance variation between the earth and the current after measurement in order to establish the optimum resistance.

The star-delta method

It is more difficult to position test electrodes, especially in a straight line across a vast distance, in large systems in inhabited areas or on rough terrain. With this method, an equilateral triangle with three electrodes at each of its four corners is produced, with the earth system in its center. Both the overall resistance between adjacent electrodes and the resistance between each electrode and the earthing system are considered when measuring star-delta method show in figure 2.

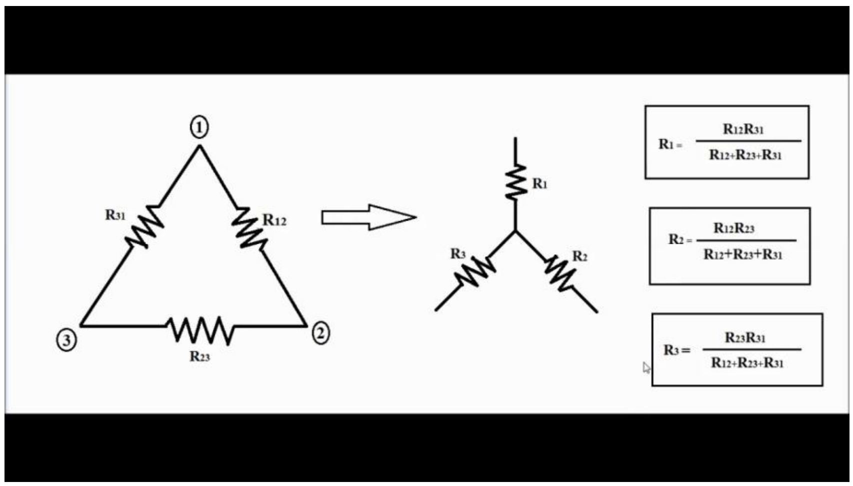

Figure 2 Star-delta method.

CONCLUSION

Soil ohmic resistance must be taken into account when constructing a grounding system for new installations (Greenfield applications) in order to choose a location with the least amount of resistance and so meet the ground resistance standards. Nevertheless, more sophisticated grounding systems may make up for poor soil conditions. The soil composition, moisture content, and temperature all have an impact on the soil resistivity. It is unexpected because soil resistivity is not constant and might change regionally and at different soil depths. Using this technique, four electrodes are put into the ground in a line, each one uniformly spaced at a distance "an" apart using the four-potential approach (Wenner method). The two outside electrodes (E and H) are connected together by a generator to create a current "I" that is then measured. The potential V between the two center electrodes is then measured using a voltmeter (S and ES).In this book chapter, the measurement of earth resistivity and soil resistivity are discussed along with the system requirements and applications of earth resistivity.

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INVESTIGATION OF OPTIMAL PLACEMENT OF POWER SOURCE IN POWER SYSTEMS

Dr. Shilpa Mehta*

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

ABSTRACT:

In this book chapter we explore the electrical power source placement in the power system and the site installation conditions. The majority of electrical installations are the product of the initial installations plus several modifications and improvements performed over time to meet site growth or new business needs. An electrical system that comprises cabling and related components including switches, distribution boards, sockets, and lighting fixtures is referred to as having electrical wiring. Wiring must follow all installation and design requirements for safety. In industrial environments, electrical switchboards are utilized to provide power to specific equipment. Together with ensuring worker safety, they safeguard electrical infrastructure from overload, fire, and electric shock. Large numbers of manufacturing units may sometimes be found in industrial areas, and these units need a consistent energy supply from the appropriate industrial electrical panel.

KEYWORD: *Power Source, Power Systems, Distribution Board, Energy Management, Site Installation.*

INTRODUCTION

The bulk of electrical installations in commercial and industrial buildings are the product of undocumented additions made in response to shifting demands and requirements over time. Every electrical installation has a special set of tiny surprises that come with it that you often don't learn about until the project plans and payment arrangements have been accepted and signed off, i.e., after it's too late. Hence, every monitoring and targeting project must begin with a thorough site inspection in order to describe the scope of work for the project proposal and prevent having to pay for a costly electrical installation.The majority of electrical installations are the product of the initial installations plus several modifications and improvements performed over time to meet site growth or new business needs. Electrical wiring as a consequence is often not rational or ideal, and more critically, it is rarely adequately recorded. After some kind of introduction from your client using carefully constructed queries, more technological checks should be conducted to provide you the most recent data. Get the site electrician to describe the electrical wiring diagram to you once you have it in your hands and to highlight any recent changes.

Visit the main switch room, which is where all of the smaller distribution boards are supplied from and where the building receives its electricity from the grid. The circuits on the sub-boards should be compared to those on the wiring diagram, and any discrepancies should be noted. A high-level overview of the building's power distribution is provided by this activity. The goal is to prevent you from overlooking a crucial extension circuit that is not shown on the design, about which you were not informed and which might in expensive electrical wiring costs.Not least among the most crucial elements for a good installation is labelling. Your bottom line might be significantly impacted by incorrect or absent circuit labelling. It is unclear how electrical loads relate to the circuits being examined if there is no labelling. Your energy management platform's KPIs are deceptive if labels are missing, wrong, or irrelevant. Customers will expect you to identify circuits at no additional expense, which is time-consuming and difficult, if you don't see improper labelling at the project proposal stage. This will lead to the installation being delayed, rescheduled, or cancelled.

Establish a deployment strategy for your energy monitoring system

Where is the meter (DIN rail/panel mount) located Will an additional enclosure be necessary to access the cable chambers on the meter, where should the CT leads go it's also important to consider whether or not the installation calls for the installation of a neutral and an extra microcircuit breaker (MCB). Can they still be posted there after the board has been closed for the day Are wall outlets for a laptop's electricity accessible during installation Is it feasible to connect the monitoring system to the Internet using the customer network infrastructure Is there a wired Internet access point that might be utilized nearby If necessary, would the IT department make it possible for you to monitor the strength of the GSM signal on your phone or using a signal tester in order to avoid needing a GPRS/3G router

For instance, several distribution boards may be needed on a manufacturing line to feed different components of the same machine, necessitating the deployment of metering equipment at various places. Metering equipment must be moved to a lower level in order to be closer to the machine of interest since a circuit feed numerous unit. Circuit breakers and current sensors must be installed prior to installation or during predetermined times, such as the weekend, since circuits may only be turned off during certain shutdown hours. Due to the lack of labels or the difficulty in seeing them, you must go through the painstaking process of labelling. For instance, broken current pulse meters that are unable to produce pulses must be repaired because the electrical wiring of third-party devices is not functioning as it should.

Effort level needed to interact with other parties

The effort required in interacting with all the different organizations throughout the project must be kept in mind, even if the electrical wiring is now fairly evident and you have an idea of how you're going to handle the metering part of your installation. Due to the requirement to visit the site and communicate with several individuals in order to acquire the information you want; project management might sometimes take a long time. Consider the following components, then go through them with your clients.

Several offloads

Can circuits or equipment be turned off if a representative of authority is present during installation, etc. Who may authorize you to attach loggers to utility meters or contact the energy provider for data when integrating third-party systems technical information may not always be accessible, and communication with local authorities and energy suppliers can be hard and time-consuming and determining the applicable taxes and levies and if the tariff system is uniform.

Hardware specifications Just 1 to 10, or a very small number, of different kinds of smart meters and sensor, are supported by many energy management systems. The Wattics Energy Analytics system can transport data in 200 different file formats through 200 different channels, including FTP, HTTP, and API. Before the required hardware is acquired, Wattics works with its partners to ensure that the appropriate data transmission method is chosen in line with their specifications.

Data format standards

Any pertinent factors that may have an impact on energy consumption, such as production, temperature, and air quality data, must be taken into account in order to conduct high-quality research. Verifying that the chosen unit will fit on the energy management platform is essential. The Wattics platform supports all numerical data, including the previously mentioned Plus weather, production statistics, square feet, visitor count, and more. Just temperature, water, and gas data are available on other platforms.

Data reading frequency and level of detail. 15 or 30 minutes are the most typical granularity/meter readings for business software systems. If you desire more frequent readings, the platform should be able to show meter readings. A smart metre should be able to record measurements as frequently as necessary (some industrial facilities need readings every minute, while others demand 5-minute granularity). It is advisable to discuss the ideal monitoring interval with the customer and determine if daily updates or real-time data would be sufficient.Costs for each user and access find out in advance how many users your customer will need if you're utilizing software that has a per-user cost to avoid losses later. Not every software platform has this expense. Partners are permitted an unlimited number of users with Wattics. Make sure your offer includes exclusive services or features when outlining the specifics of your advanced energy management system to a client to avoid future customer churn and cutting out the middlemen.Wattics partners have the flexibility to restrict client access to certain tools. Their customer relationship is sustainable, and the end user can easily monitor and analyses their energy use.

LITERATURE REVIEW

Fernando Álvarez Albarracín-Sánchez Partial etal. explored the measurement of discharges (PD) offers useful data for assessing the insulation state of high-voltage (HV) electrical systems. Many PD sensors and measuring methods have been created during the last three decades to conduct precise diagnoses when PD measurements are performed on-site and online. The electrical service remains uninterrupted after the sensors are put in the grid, which is one of on-line measures' most appealing features for utilities, and electrical systems are assessed under actual working circumstances [1]. Within metal-clad switchgears is one of the crucial locations where an insulation fault may develop in medium-voltage (MV) and high-voltage (HV) systems (including the cable terminals connected to them). As a result, this sort of equipment is increasingly being monitored so that appropriate maintenance may be performed depending on their state. The use of various electromagnetic measurement methods and the use of appropriate sensors allow for the assessment of the insulation state, primarily in MV switchgears. The primary goal is to provide a broad overview of the appropriate kinds of electromagnetic measuring techniques and sensors that should be used, while taking into account the level of precision and thoroughness in the diagnosis and the unique fail-save specifications of the electrical installations where the switchgears are located.

Ahmed Hamouda, et al. explored the various mono-crystalline and poly-crystalline silicon failures that may be detected in the URERMS fields of renewable energy in the Desert. This study aims to examine and evaluate PV module flaws in newer and older installations in a desert setting and under actual operating circumstances[2]. The visual inspection test used for the analysis and evaluation of 608 PV modules inside the URERMS site and in a remote solar installation (Melouka) reveals the following failures and degradation modes: delamination, encapsulant discoloration, corrosion and discoloration of the metallization (gridlines, bus bar, cell interconnect ribbon and string interconnect), solar cell cracks, broken glass, deterioration of the antireflection coating, snail trails, In order to provide a link between the visual flaws and the electrical performance of certain evaluated modules.

Hamed You sefi, etal.explored a method for evaluating photovoltaic solar energy's potential for utility-scale installations. The framework includes spatial planning and performance modelling of solar power plants in the potential evaluation process to accomplish this goal. Birjand County was chosen as the case study because of its favourable climatic conditions for the implementation of solar systems. Solar power plant installation, as a subset of infrastructure facilities, should adhere to land-use planning criteria. The first phase was defining the collection of variables (27 criteria) determining the location of solar power plants. By using Boolean logic, inappropriate locations were found and then removed from the county map. Using various fuzzy membership functions, the remaining places were assessed based on the technological, socioeconomic, and environmental criteria. These graded places were mapped after that[3]. The maps were fuzzified and then the fuzzy gamma operator was used to discover the best locations for grid-connected solar systems. The completed map's pixels were then divided into five groups based on their fuzzy value. The findings reveal that 0.5 percent (or 2005 hectares) of Birjand's land area is suitable for the building of solar power plants. Using satellite imagery, the geospatial modelling outcomes of this thesis were validated. A 46.2 kW-solar system was developed, and its performance and energy output were simulated under the climatic and geographic circumstances of Birjand in order to evaluate the capability of electricity generation from photovoltaic power plants. In addition to meeting the electrical needs of Southern Khorasan Province, the estimated energy output of photovoltaic power plants in Birjand County's best locations (1781.6 GW h/year) also allows for the export of excess electricity to other provinces and nearby nations like Pakistan and Afghanistan.

Xunhe Xu, etal.explored the world's fast use of photovoltaic (PV) power plants has generated discussion over their effects on the environment and climate. In this work, we used the thermal infrared remote sensing approach to evaluate the impacts of PV power plants on surface temperature using 23 of the biggest PV power plants in the globe. Our research revealed that the installation of the PV power plants had greatly lowered the daily mean surface temperature by 0.53 °C in the PV power plant locations[4]. The surface temperature decreased by 0.81 °C and 0.24 °C, respectively, during the daytime, when the cooling impact of the PV power plant installation was significantly higher than at night. Its cooling impact also relied on the power plants' capacity, with cooling rates of 0.32, 0.48, and 0.14 °C/TWh for the daily mean, midday temperature, and midnight temperature, respectively. We also discovered that while the effective albedo (surface albedo plus electricity conversion) increased significantly from 0.22 to 0.244 following the construction of the power plants, the surface albedo decreased significantly from 0.22 to 0.184. This suggests that the conversion of solar energy to electrical energy is a significant factor in the observed surface cooling. Our further studies revealed that the latitude and elevation of the power plants as well as the annual mean temperature, precipitation, solar radiation, and normalised differential vegetation index were all strongly connected with the power plants' night time cooling (NDVI). This indicates that the area topography, climate, and vegetation conditions influenced how the PV power plants affected the local temperature. The choice of locations for PV power plants in the future may be guided by this discovery.

DISCUSSION

When referring to an electrical system, the word "electrical wiring" refers to the cabling and related switches, distribution boards, sockets, and lighting fixtures. Safety installation and design requirements must be followed during wiring. Following the operating voltage and electric current capacity of the circuit, the acceptable wire and cable types and sizes are specified along with further limitations on the environmental conditions, such as the range of ambient temperature, moisture levels, exposure to sunlight and chemicals, and the permissible amounts of each. Voltage, current, and functional criteria need to be adhered to while installing relevant circuit protection, control, and distribution equipment in a building. At the municipal, state, and federal levels, there may be different laws controlling wire safety. In spite of the International Electro technical Commission's (IEC) attempts to harmonies wire standards across its member nations, there are still substantial variances in design and installation requirements.

Electric installations

Certain industrial settings have a lot of manufacturing units, and these units need a consistent energy supply from the appropriate industrial electrical panel. The most common method for this is to use electrical lines. The appropriate electrical installation materials, including the necessary troughs and apertures, installation pipes, cable clamps, cable grills, and cable ducts, are placed along their courses based on the characteristics of the individual sections. Electrical designers for specific locations choose the technological solutions.

Alerts for emergencies and fire alarms

Two distinct systems, one that detects the onset of a fire and the other that delivers voice evacuation orders, safeguard people's safety and reduce product damage in the case of a fire. The property is outfitted with the necessary fire detectors, emergency loudspeakers, electrical panel interlocks, etc. in every room. The two systems' independent control panels may interact with one another. The designer chooses the kind and location of the devices as well as the specifications for the control panels.

Methods for preventing lightning and earthling

The current earthing system is made up of an organized collection of earthing devices, boxes, earthing loops in the rooms, and arrestor electrical panels. The system in the electrical panels is linked to it to guarantee that it functions properly, safeguarding people's lives and averting fires. It is crucial for safeguarding delicate electronics in equipment from electric shocks. The installation for lightning protection may be linked to the present earthing system on the property or it may have a separate earthing system.

Alternative power source

Alternatives to backup power supplies are offered for industrial operations since their disruption might in significant financial losses. Planning should start early in the process, at the design phase, when the electrical designer develops the specification, to ensure that the solution requirements are correct. In addition to providing a higher category of external power supply through a second 20kV power line with an automated switching system built into the transformer substation or the site's substation, other alternatives include diesel generators, UPS systems, or a combination of both.

Electric installations

In industrial settings, a range of machinery with varying power levels is used. An industrial electrical panel must provide electricity to all equipment on a regular basis. Electricity lines must be built in order to do this. The technical project has to specify the specifications, routes, and installation techniques for these power lines. Sometimes, busbar construction may provide manufacturing equipment or electrical panels.

Switchboards for commercial electricity

Electricity is delivered to specific equipment in industrial environments via electrical switchboards. In addition to ensuring the security of human workers, they safeguard electrical infrastructure from overload, fire, and electric shock. The electrical designer for the site selects the switchboard's features and circuits. A common of problems with the industrial switchboards are the interruption of the manufacturing process. So, prior to considering craftsmanship, it is necessary to hunt for top-tier technological solutions at the design level.

Beautiful lighting

Industrial lighting helps workers to work productively and healthily. The electrical design engineer calculates the installation and specification requirements for the lighting system. Prior to the site's construction, the kind of lighting fixture chosen has an impact on the cost of maintenance as well as the amount of power that will be used. For occasions that are more upscale, intelligent lighting solutions are envisioned[5].

Items for bus bars

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Bus bar systems are built from sturdy, mechanically sound pieces that are appropriately integrated to transport and distribute energy across a site or building. Compared to wires, they provide far superior mechanical protection and are easier and faster to install. Busbar systems, as opposed to cables, which have a bend diameter, may readily overcome non-linear installation routes employing slanted components. Each user's bus bar has a junction box with circuit breakers located among them [6].

Periodic electrical system inspections are necessary

All electrics, wires, and systems gradually deteriorate with usage and time. It is advisable to examine and test them often to make sure they are always in excellent, secure functioning shape. The majority of electrical fires are brought on by faulty and outdated wiring, sockets, and appliances. For problem-solving and frying prevention, being aware of the typical causes of these electric fires can be helpful. These electric fires resulted in 440 fatalities and $1.3 billion in direct property damage, according to the National Fire Protection Association (NFPA). The US Fire Administration Agency reports that there are around 45,000 electrical fires in the country each year. Electric-only facilities must go through regular inspections and evaluations. To determine what, if anything, needs to be done to keep the installation in a safe and functional state, inspections and testing should be done at the proper intervals. Your organization's usage of energy is safe and appropriate, according to the EICR[7], [8].

Electrical Installation Condition Report (EICR) services

Electrical inspection for risk assessment

1. Thermography and visual inspection
2. electrical safety testing
3. thermography analysis
4. study of short circuits
5. study of relay coordination
6. analysis of load flow
7. investigation of power quality
8. harmonic evaluation
9. energy analysis
10. And analysis of arc flashes.

CONCLUSION

Many flaws and risks are not immediately obvious and are only discovered after extensive inspection and testing. These periodic checks should be performed by technicians with the necessary electrical knowledge and proficiency. An analysis of the electrical system will be done by engineers and technicians on our team, and a report will be given in compliance with the standards and laws.Care Laboratories advises having a periodic Electrical Installation Condition Report (EICR) as needed by law and having the repair done as recommended in order for the property to be electrically safe and to minimize electrical dangers at work as efficiently as possible.Care Labs offers reports for a variety of market participants, such as companies, producers, retailers, state and federal governments, NGOs, and countless other buyers and sellers on international marketplaces. In addition to New York, Pennsylvania, Texas, New Mexico, Michigan, and Florida, Care Laboratories offers its services in every state in the US. In this chapter of the book, we discuss about the diverse electrical installation conditions at the site, adding a power source to the power system, expanding the bus bar and adding commercial lighting.

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METHODS OF MEASURING EARTH LOOP IMPEDANCE

Mrs. Kamireddi Sunandana*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

ABSTRACT:

In this book chapter we discovered the keymethods and challenges regarding the earth loop impedance measurement. It is possible to utilise the distribution board measurement of the earth loop impedance where a distribution circuit or final circuit starts. As the earth-fault loop test will pull current from the phase that returns via the protective device, a circuit protected by an RCD will need to be handled with extra care. Using earth fault loop impedance testing, one may verify that overall ground connection is sufficient, has a low residual resistance, and is electrically safe. As the earth-fault loop test will pull current from the phase that returns via the protective device, a circuit protected by an RCD will need to be handled with extra care. To ensure that the actual loop impedance does not exceed the limit set for the relevant protection device, each circuit must be examined. It is crucial to have your electrical installations and power points evaluated for earth fault loop impedance due to the danger of contacting an electrical fault.

KEYWORD: *Distribution Board, Earth Loop, Earth Fault, Fault Loop, Impedance Test, Protective Device, Protective Device.*

INTRODUCTION

As the system hasn't been put into action yet, earth loop impedance testing for new installations should go smoothly during the initial verification stage. If an unexpected interruption of supply occurs during the test, s1uch as when RCDs accidentally operate, there might be major repercussions for the user if, for instance, computer data is lost or a home life support system is switched off.If an RCD trips during an earth fault loop impedance test, a circuit, group of circuits, distribution board, or even the whole system might be mistakenly disconnected. Due to the fact that numerous techniques have been created to reduce the possibility of an RCD activating during such a test.One such technique is explained in the next section. Another approach is to use a loop test setup to assess the earth loop impedance. The test current has to be kept below 15 mA in order to avoid triggering the RCD.

The estimation of earth loop impedance

According to regulation, methods other than measurement may be used to assess earth loop impedance. Consequently, the equation Zs = Ze + (R1 + R2) may be used to calculate the loop impedance of a circuit. If the external earth loop impedance (Ze) and the loop resistance of the line and protection conductors (R1 + R2) are measured correctly, this is accurate.Nevertheless, employing a Ze value that has already been measured or established by contact with the electrical distributor does not guarantee that the required earthing methods are accessible and have the required low ohmic values. Ze can only be computed with an instrument for measuring loop impedance. Only after the installation has been taken off the electrical grid and the methods of earthing have been detached from the installation's safety bonding wires can this assurance be achieved.In bigger, more sophisticated systems, Ze may be replaced by the measurement of the earth loop impedance taken at the distribution board where a distribution circuit or final circuit originates (Zdb).RCDs protecting the impacted circuit during the loop test are on the supply side, therefore they shouldn't typically activate while Ze or Zdb measurements are being collected. Anybody using this technique, however, has to confirm that there isn't another RCD upstream of the circuit being examined, such as one guarding a sub-main circuit.

Prudent precautions

When doing high or low current loop impedance testing, which often necessitates the use of test probes and partial disassembly, it is advised to utilise specialised plug-in adaptors (for example, to test lighting circuits in domestic premises). Electric shock danger might rise when probes are used for live testing.No person should do any job activity on or so near any live conductor unless it is permitted to do so and appropriate measures have been made to avoid harm from electric shock, according to Regulation 14 of the Electricity at Work Rules of 1989. Electrical testing is included in the definition of "work," which includes all job responsibilities and is not only limited to electrical labour.

Impedance of the earth loop in the final circuits

Group provides the longest times for final and distribution circuits in TN and TT systems with 230 V as the nominal voltage to earth that may be unplugged. Each final circuit and distribution circuit must have its line-earth loop impedance (Zs) value verified to ensure that, in the event of an earth failure, the automatic supply disconnection to the circuit will occur within the appropriate maximum time specified in Regulation (U0). The specifications of the protective device used for automatic disconnection must be taken into consideration when determining if the value of Zs is low enough to accomplish disconnection within the indicated maximum time impedance of the circuit.

This is often done by making sure that the measured value of Zs at the circuit's electrically furthest component does not exceed 80% of the appropriate maximum value for widely used overcurrent devices. The manufacturer's data or another trustworthy source of information on the limiting values of Zs should be reviewed for overcurrent devices not covered by those.

The highest value of Zs may be determined when the protective device is a non-delayed RCD. While they were developed for a TT system, the Zs values in the table may be used with a TN system. These Zs values satisfy the criteria RA as well as the disconnection time specifications of BS 7671. For a TT system, in 50 V as described in Regulation (ii). (RA is the result of adding the resistances of the earth electrode to Earth and the shielding conductor to the exposed conductive component.

Verify the Earth Fault Loop's impedance

To ensure that the actual loop impedance does not exceed the limit set for the relevant protection device, each circuit must be examined. It is crucial to have your electrical installations and power points evaluated for earth fault loop impedance due to the danger of contacting an electrical fault. For the longevity and productivity of your company, it is essential to maintain the circuitry in your systems. Most houses have an earthing circuit with automated switches in the interior electrical circuits to provide basic shock protection. The electricity to an earthing circuit is instantly switched off when a problem arises and the touch voltage increases beyond the permissible threshold earthing system.

You must carry out a loop impedance test on your property in accordance with the most recent national safety regulations in order to guarantee the safety of all visitors and staff. To find any issues with your electrical circuit, you must verify the electrical earth of all your electrical installations and power points. A functioning earth return circuit makes it easier to identify circuit problems and makes it easier for your MCB to respond (miniature circuit breaker). If the resistance level in your earth return circuit is too high or too low for the circuit breaker to operate properly, a Care labs specialist will test it and let you know. By contracting Care labs to examine your electrical wiring, you ensure both the safety of your workers and your responsibility. To avoid facing severe fines, it's essential to comply with national legislation.

Depending on the installation type (TN/TT, etc.) and the kind of protection, such as a micro circuit breaker (MCB), cartridge fuse, or re-wireable fuse, for instance, the needed values of impedance and duration will change. It is crucial to check the loop impedance of each circuit since the fault current may be in either the line-neutral or line-earth circuit. The impedance can be expected to be sufficiently low under earth fault conditions to meet the relevant limit specified in BS 7671 and for the protective device to automatically disconnect within the time specified if the measured earth fault loop impedance of a circuit is not greater than 80% of the relevant limit specified in BS 7671.

The TT wiring system is in operation when the following equation is true: Ra x Ia 50, where "Ra" is the total resistance of the earth bars and protective conductors and "Ia" is the maximum current of the protection system, provides an adequate defence against the hazards of electric shock. The greatest voltage that a person may be exposed to during an earth fault should not exceed 50 V when Ra and Ia are multiplied.

For fault loop impedance, the distance between the active conductor and the ground is examined. Our expert will measure the loop impedance using an earth loop impedance tester hooked into the power outlet (GPO). All around the country, our highly skilled team of professionals provides earth loop impedance test services.

A test for Earth Fault Loop Impedance

The External Earth Loop Impedance (Ze) test is the ideal place to start. With this distribution board test, the loop impedance of the circuit is estimated without taking the installation into account. The next step of fault loop impedance testing is the system loop impedance test (Zs), which includes both the installation resistance and the circuit that was examined in the Ze test earth fault loop impedance show in Figure 1.

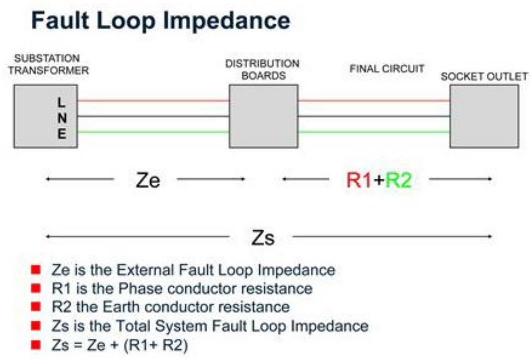

Figure 1 Earth fault loop impedance [carelabz].

In order to account for the possibility that an electrical circuit's AC impedance might vary from its DC resistance, especially for circuits rated at more than 100 A, the fault loop impedance is measured at the same frequency as the nominal mains frequency (50 Hz).On the supply side of the distribution board, at the primary earthing point, with the main switch open and all circuits isolated, the Ze earth fault loop impedance is measured. During the test, the earthing apparatus won't be connected to the installation's earthing system (earth rods). The earth fault loop impedance being equal to the total of the resistances will be confirmed by the Ze measurement.

LITERATURE REVIEW

Liviu Neamt etal. discusses the challenges and uncertainties surrounding the measurement of earth fault loop impedance. The flaws and faults associated with the measuring process are emphasised based on how the test equipment's measurement approach is presented (using diagrams and measured amounts, respectively, to interpret findings) [1]. As will be seen, the switching of loads at the consumer sides and/or the occurrence of fault regimes during measurements can cause the most serious impairment of the accuracy in the impedance assessment. Other significant sources of error include the position in the power system, the influence of power transformers, and the use of effective quantities rather than phasors. In a specialised programme called Eaton x Spider, which enables the thorough and intricate analysis of numerous scenarios, it is possible to clarify these aspects by modelling and simulating TN low-voltage electrical distribution networks as well as by starting with equivalent diagrams of the measurement circuits and the analytical interpretation of the phenomena associated with the measurements. As a result, key findings about the severity of mistakes and their causes were reached, and the study produced solutions that could be applied to the measurement methods of the devices in use.

Czapp, Stanis ław etal.explored earth fault loop impedance is measured as part of the electrical safety verification process in low-voltage power systems. The purpose of this assessment is to confirm the efficacy of indirect contact protection[2]. The widely used traditional techniques and metres employ a relatively high measuring current value (520) A, which causes them to be a source of annoying residual current device tripping (RCDs). The metres designed for circuits with RCDs often utilise a very low amount of current (less than 15 mA), which is frequently unacceptably inaccurate for measurement. The technique for measuring earth fault loop impedance in 3-phase circuits without annoying RCD tripping is presented in this study, along with the measurement idea, metre construction, and experimental validation. Although using measuring current values that are several times more than the rated residual current of RCDs, the nuisance tripping is avoided. The key benefit of the suggested approach is the ability to generate current measurement values across a very broad range, which is crucial for the measurement's accuracy.

Ryszard Musial, etal. discovered earth fault loop impedance (EFLI) measurement is the foundation for evaluating the efficacy of automated supply cut off in low-voltage networks. A TN low-voltage network in particular uses this measurement during startup and frequent verification [3]. These tests are challenging in many circuits nowadays because to the extensive usage of residual current devices (RCDs), which are active throughout the test. In this study, a technique for measuring EFLI without unintentionally tripping RCDs is suggested. With the use of this technique, EFLI may be measured while employing a substantial amount of full-wave testing current. In terms of measuring precision, it is advised.

Jacek Olesz, et.al uncertainty in fault loop impedance (FLI) measurements in circuits supplied by uninterruptible power supplies (UPS) is a serious issue (double-conversion AC-DC-AC)[4]. One of the most crucial factors that determines whether an electrical system and its receivers are approved for operation is the accurately established value of this impedance, which is connected to the short-circuit current disconnection time and to the reference value. Several hundred measurements of the short-circuit loop impedance in the circuits fed by the UPS were made to define the principles of FLI measurement. These measurements were done in various UPS operation modes and with various FLI instruments, allowing for the definition of measurement rules that reduce error in determining the efficacy of protection against electric shock by automatic supply disconnection. A unique technique for figuring out the short-circuit loop impedance has been suggested based on the analysis of voltage and current waveforms captured during the actual short-circuit testing in the circuit supplied by the UPS.

Czapp, S. etal. explored the precision of measuring earth fault loop impedance in a network with active loads. In a network with operational loads that may exceed allowed levels, the conventional measuring techniques and metres utilised in practise result in measurement inaccuracies[5]. Negative errors are the most hazardous because, like in the case of a line-to-earth fault, an automated supply cut off may not take place and an electrocution risk occurs. With the novel technique, errors brought on by operational loads may be minimised. The new method's analysis of the measurement errors is explained. According to the analysis's findings, the operational load's impact is negated. In low-voltage systems, the new earth fault loop impedance metres may be used extensively.

DISCUSSION

To ensure that the fault current in an electrical circuit will be powerful enough to activate the circuit protection, an earth loop impedance test is performed. Circuits might overheat and catch fire if a problem current is not identified in time. Electricity travels to the earth via the route that has the least resistance. Building electrical wiring systems are often grounded. We are talking about an earth return circuit right now. During a short circuit, electrical current may travel via the grounding wire [6].

Resistance serves as a barometer for the influence a current's course has on it. Low resistance is required in the grounding wire for the fault current to be able to go into the ground without damaging the system. The fault current may be too low to be noticed if the earth return circuit resistance is too high, in which case a short circuit may continue to loop through the main circuit. When it notices activity along the ground line, the circuit protection recognises it and activates. The circuit protection might malfunction if the resistance is too high. Why are impedance tests so crucial? It is crucial if the continued quality of the circuitry in your building worries you. The loop impedance has to be kept at a certain level to avoid overheating and fires. Regular testing is the only way to keep this level operating at its best.

As a method for measuring loop impedance, the 2-wire high current test

The conventional loop impedance test looks like this. It is by far the quickest and most accurate test now accessible on a daily basis, with a test current of up to 20 a and a simple 2-wire connection. This sort of test will be provided by the most widely used loop impedance testers. Because to the relatively large test current, readings are often unaffected by external variables and produce consistent, steady results in the majority of circumstances.

Test of dc saturation with "No-Trip" on two wires

The circuit was evaluated with a DC test current before doing a typical 2 wire high current test. The goal of this DC test was to completely saturate the RCD's monitoring coil in order to go on to the high current AC test. Despite the increased availability of electronic RCDs, this approach only has a few specific uses.

Test of "No-Trip" wire

By the use of a low current Line-Earth test current and a degree of accuracy, this test technique was able to get beyond even the most sophisticated electronic security measures. Time was saved since the RCD/RCBO did not need to be bypassed. By connecting to Line, Neutral, and Earth, the testers were also able to establish the existence of all three and identify whether reverse polarity was present at the test site. Also, the MCB could be activated without any problems since the test current was controlled.Most RCDs and RCBOs can be examined with these without needing to be bypassed. They no longer alert to a missing neutral or indicate reverse polarity, but they continue to function as real 2-handed devices without the need for a neutral connection. The physical test is faster than the 3-wire approach, but since the RCD cannot be manipulated, it is still more accurate [7].

Impedance measurement on a 4-wire grid

The accuracy of the test is increased by using a four-wire Kelvin connection, which eliminates internal lead and contact resistance. With test currents up to 1000 A, measurements down to 10 MOhm may be effectively performed. The test procedure has no "No-Trip" option. In order to get precise data for specialised applications like measurement in sub-station or switch room settings, the test engineer may utilise this tester.

As the earth-fault loop test will pull current from the phase that returns via the protective device, a circuit protected by an RCD will need to be handled with extra care. It has been challenging for instrument makers to provide tests for RCD-protected circuits that are equal to tests for non-RCD protected circuits without turning on the RCDs. During earth-fault loop testing, any RCDs must be short-circuited in order to be bypassed. Hence, it is crucial to ensure that these connections are broken after testing.Carelabs use an earth loop impedence tester to prevent the circuits under test's RCD from activating. All testing and inspections will be carried out by our professionals in accordance with the most recent safety regulations. For everyone's safety at work, testing is required. To secure the security of your employment, get tested as soon as you can. We can help you fulfil all of your compliance obligations.

Due to the fact that the test result depends on the provided voltage, even little changes will have an impact. In order to get valid results, the test should be done numerous times. Everyone on the premises must avoid shock hazards when making contact and performing the test. Request a distribution board to take measurements of Ze and Zs.To ensure that an electrical system complies with BS 7671 (IET Wiring Rules) addressing fault avoidance, it must undergo earth fault loop impedance testing. Impedance testing and recording for Earth Fault Loops. Deflection value. This testing is often carried out as follows: with a test current of roughly 23A for circuits protected merely by overcurrent devices like fuses or circuit breakers, or with a test current of approximately 15mA for circuits protected by 30mA or other RCDs to avoid accidental tripping.The resolution of the test results for high current (23A) testing is typically 0.01 and ranges from 0.1 to 1.0. They are also quite trustworthy. The resolution was 0.1 while testing at low current (15mA), but efforts to lower this to 0.01 have often fallen short [8].

One of the top instrument manufacturers in the UK recently conducted an investigation using equipment from seven different manufacturers under controlled circumstances and discovered considerable variations in the instrument. A further look into the matter indicated that the low-test currents seemed to be the root of the issue, and that fluctuations in the quality of the power supply brought on by changes in the voltage's amplitude, transients, harmonics, etc. were the major culprits. More trustworthy results were obtained from similar experiments utilising a stabilised power source and a pure 50Hz waveform. It must be emphasised, however, that these variances, which often fall within the range of 1.0 or less, have minimal impact on how well an RCD functions.

We will provide you a date for a retest that complies with national requirements when testing is complete (for your subsequent earth loop impedance test). You'll be informed by a member of our staff when it's time for the retest. Each customer will get a thorough report with an outline. It will either pass or fail to grade your equipment. This document will be kept on file in case you need to subsequently consult it to confirm compliance. In order to safeguard your whole organisation in a single visit, we offer customers a comprehensive variety of inspection and testing services. We may be able to provide you with further inspection services after your impedance test. You don't need to go elsewhere for your safety testing needs since we provide such a broad range of services [9], [10].

CONCLUSION

Using earth fault loop impedance testing, individual may verify that ground connection is sufficient, has a low residual resistance, and is electrically safe. Checking the earth loop impedance is crucial because, should a live wire unintentionally come into contact with a malfunctioning device or circuit's earth conductor, the short-circuit current to earth might easily be high enough to inflict electric shock or generate enough heat to ignite a fire. It is possible that an installation flaw may result in inadequate real short-circuit current, delaying the activation of the protective mechanism. Generally, the fuse will blow or the circuit protection device will trigger. Delays might have catastrophic effects for both people and property. To ensure that any installed protective device will function within a safe time frame, it is vital to determine if the impedance of the route that any fault current would travel is low enough to enable appropriate current to flow in the case of a failure.This book chapter explore about the earth loop impedance measurement methods in details.

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MAINTENANCE AND REACTION SOLUTIONS FOR TRANSMISSION LINES

Dr. Rajiv Singh*

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

ABSTRACT:

In this book chapter on transmission line maintenance, we go in-depth on the term's reaction solution and transmission line maintenance. The second kind of line inspection, which does not involve shutting down the line, requires the use of technology. Technicians use these tools, together with ultrasonic detectors, infrared and ultraviolet light cameras, to gather data locally or remotely. Major utilities are reviewing their operating and planning processes in order to solve these problems as well as considering their economic impact. Towers were constructed over an extended period of time, with location and other factors having a significant impact. As a result, it is essential to develop a complete evaluation and repair system that would allow transmission utility engineers to use their resources as efficiently as possible. This inspection will include a thorough internal and exterior inspection of every wood pole structure.

KEYWORD: *Reaction Solution,Line Maintenance, Transmission Line, Power.*

INTRODUCTION

Maintenance, which is a crucial aspect of a transmission line's functioning but is made more urgent by the structure's outside location. This kind of maintenance work requires highly qualified electrical professionals and mechanics with the great physical and mental endurance necessary to penetrate the often extremely impenetrable regions where these facilities are situated, extending the lifetime of a transmission line by 50 years [1].This characteristic expose transmission lines to a range of external factors that might damage their structures, parts, and components, such as corrosive chemicals, ice, wind, and UV radiation. Lines must thus get regular maintenance in order to extend their useful life by 30 to 50 years (on average). Nevertheless, engineers must first develop a diagnostic test before the actual repair is made. There are two ways they might go about doing this. The traditional strategy is planning several trips to the line. This includes dispatching a team of two to three people, often including mechanics and electrical experts, to the tower's base. The second kind of line inspection, which does not involve shutting down the line, requires the use of technology. Technicians use these tools, together with ultrasonic detectors, infrared and ultraviolet light cameras, to gather data locally or remotely [2]. The data is sent to a control center in the latter case via cellular networks and ultrasonic detectors.

After getting the diagnostic assessment, they may decide on a date for cleaning the line and, if required, fixing it. During maintenance, time may pass for hours, days, or even weeks. This mostly depends on their ability to reach the towers and the size and complexity of the restoration effort. For instance, in certain situations, access to the towers may be through paved or unpaved roads. On the other hand, in some situations, such in Peru, technicians must walk for hours and climb peaks higher than 4,000 meters.Regular transmission line maintenance includes cleaning the insulators, which are the parts at the top of the tower that hold the wires that transport power (conductors). To remove accumulated dust and other airborne debris, operators spray them with demineralized water at high pressure using a hose. They must first position themselves in front of them by climbing the 35- to 50-metre-high tower construction or ascending in a crane. To repair broken components, this operation sometimes also necessitates purchasing new ones transmission line maintenance show in figure 1 [3].

Figure 1 Transmission line maintenance.

Similar to visual inspection, maintenance may be carried out either while the line is active (hot-line maintenance) or not (cold-line maintenance). The first option is the most common choice worldwide and is a far more ambitious plan of action than cold-line maintenance. Specialists must be very careful and thorough while conducting moves, especially when dealing with extra-high-voltage lines, which are those that transfer the greatest energy. In fact, there are international standards and laws, such as those established by the Institute of Electrical and Electronics Engineers (IEEE), which outline details like the safe and secure distance the technical expert must keep when cleaning insulators.

Deterioration of the tower stubs for ground patrolling, many techniques are utilized, including line inspection, walk-down surveys, and thorough patrolling by climbing up the tower through the internal body of the tower and observing the line components while maintaining safe body clearance. Thermo-scanning, component digital photography, and Daycor camera corona detection are performed after visual assessment.Already a familiar sight in our landscapes, transmission lines traverse a broad range of environments, climates, and topographies, leaving behind permanent traces. Their longevity may be credited with at least some of their ubiquity. Most of the current huge systems come from the 1960s and 1970s, with lines often being installed around the turn of the century. Due to the relatively old age of this infrastructure, the majority of utilities that own and operate high-voltage transmission lines have the same types of maintenance problems.

Research and development on transmission lines is concentrated on upholding dependability, extending the life of the lines, improving electrical energy transmission capabilities, preventing failures, and guaranteeing worker and public safety. Wooden cross arms need extra caution since they are often quite climate-sensitive. Climate has a significant impact on the structural integrity of towers because air corrosion affects the steel's galvanization.Unexpected disasters that utilities must deal with include the failure of electrical protection systems, tree-induced cascade line failures, substantial storm damage, and other component failures. As was the case during the 2003 blackout and the 1998 ice storm, the loss of a significant transmission line emphasizes how dependent our society is on a steady supply of electric energy. It also highlights the need for utility engineers and managers to find workable solutions to prevent such occurrences by electrical system protection mechanism [4].

Major utilities are reviewing their operating and planning processes in order to solve these problems as well as considering their economic impact. Many are also heavily involved in the creation of equipment protection standards and regulatory guidelines in order to accomplish the ultimate goal of minimizing the combined cost of supply and consumption of energy by getting a high degree of transmission dependability.To assist with these endeavors, CEA Technologies Inc. (CEATI) has formed a Transmission Lines Asset Management Interest Group (TLAMIG). In order to improve the management of transmission line system assets, it brings together electrical utilities from all over the globe to exchange information and assist the development of new technologies.

One of the transmission grid's weakest links is the wood cross arm. For for over a century, these structures have supported electric transmission lines. Continually exposed to a range of humidity and temperature conditions are cross arms that are in use. If moisture becomes trapped in the wood, a substantial portion of its structural strength may be lost. The available quantitative methods are inadequate for determining how long wood cross arms will retain their strength. Due to this unpredictability, those cross arms that need maintenance may need to be replaced before they should and their upkeep put off. This makes it possible that utilities may distribute funds inadvertently.

Wood cross arms must be regularly inspected and repaired in order to ensure the reliability of customers' electric supply. However, it is difficult to assess the structural integrity of wood cross arms from the ground; thus, aerial inspections are sometimes necessary to offer a qualitative assessment. Using these visual assessments, conditions may be assessed on a scale of 1 to 5 for various factors. Even if this method is very arbitrary, it is still challenging to estimate how much power and service life a cross arm has remaining.

To improve condition assessment and service life prediction for in-service H-frame cross arms by correlating the visual grading scale with the findings of in-depth structural analysis and experimental evaluation of cross arms is investigated. Using hydraulic actuators and pressure points, the structural analysis will identify the critical areas and potential failure mechanisms of a cross arm structure. This will also lead to the development of "end of life" criteria, which will be an assessment of the level of wood deterioration needed to determine how much life is left. The ultimate goal is to develop an inspection-free visual grading system that will reduce the inherent uncertainties of the existing method [5].

Maintenance Schedule for Above-Ground Protective Coatings on Galvanized Steel Transmission Towers

Several electrical transmission tower constructions in North America have reached an age where the effects of air corrosion on the above-ground components have required significant increases in maintenance demands in order to continue operating safely.The degradation of the galvanizing is causing corrosion of the underlying steel, which is reducing the structural strength of the towers and might eventually lead to structural collapse if left unchecked.Towers were constructed over a long period of time, greatly influenced by location and other circumstances, so when rates of atmospheric corrosion change, it is necessary to design an extensive review and repair method that will allow transmission utility engineers to use their funding as efficiently as possible.

A tower coating survey has been started by CEA Technologies with the goal of identifying industry best practices and gathering information on the current practices used by electrical transmission organizations worldwide for maintaining the above-ground components of galvanized or coated steel transmission buildings.The second part of the project will also involve the tower coating test programme and a qualitative assessment of the inspection tools available for determining the state and remaining service life of towers. The test programme will assess each coating's physical characteristics, corrosion resistance, and weather resistance of the coated panels. Also, it will assess how well each sort of paint applies.

The development of cost analysis techniques to determine the exact cost of tower painting work will take place in the third phase. Environmental laws, preparation and travel costs, paint costs, the quantity of coating treatments necessary, labor costs, and drying times are just a few of the important aspects that this software will evaluate while doing its calculations. With the assistance of this application, utilities may manage their resources and budgets.

Controlling flora in public spaces

There are many different kinds of terrain and climates where transmission line rights of way may be found, from tropical to arctic. These circumstances have a considerable impact on the flora's ability to establish itself on the ground underneath transmission line conductors. Transmission lines are designed, developed, and erected with sufficient clearances between conductors and any below-ground activities. Clearance regulations take into account conductor sags (induced by electric loads or ice) and other live loads, such as those from linemen, encountered during maintenance. But, if the ground vegetation is not kept in good condition, an arc might eventually form between the electric wire and the vegetation below [6].

DISCUSSION

Line Condition Index Quantification

Understanding the condition of the transmission lines is crucial for making decisions on maintenance plans. The condition index of a transmission line offers a numerical illustration of the line's technical condition. Which information sources should be considered and how this information should be processed to get relevant knowledge from it are the two main considerations in developing this index. Plenty of data may be used to assess this index. Nonetheless, it is necessary to consider the most crucial elements, sometimes referred to as condition indicators, or CIs.

According to the advice of maintenance experts and the available data, this research focused on eleven CIs to establish the condition indices of transmission lines. To determine the indicators and their weighting factors in the process of calculating the conditions index, a questionnaire was created and distributed to experts who are members of the preventive maintenance teams of the province of Khorasan and have years of experience in the field of preventive maintenance of transmission lines. The weighted average of the expert assessments was then used to determine the weighting factor and scores for each condition indicator [7].

Among the condition indications are service age, insulator type, bundle type, and tower type, as shown in Moreover, since the network under investigation covers a significant region, a number of topographical and metrological factors must be taken into account by the transmission lines. The quantity of snow, the speed of the wind, the amount of dust in the air, the kind of weather, and the location are therefore additional indicators of condition. The yearly failure average and the incidence of theft of transmission line components are factors that go into creating the condition index.

Line Significance Index Quantification

The relevance of each transmission line is assessed by the potential impact of its failure on the reliability indices of the network. In truth, this score is greatly influenced by where the network's lines are located. This research created this index by taking into account the two steps that are described below.

Failed States Evaluation

The importance index for each transmission line reflects the threat that a transmission line failure presents to the electrical system. While evaluating the system risk in this research, the projected energy not served (EENS) is taken into account. The contingency states of the network that might result from first-stage transmission line failures must thus be modelled. Moreover, while most networks can withstand the breakdown of a single component, this study looks at three-way contingencies, such as the simultaneous failure of one to three lines and one or two generating units.The optimal power flow is solved for each failure occurrence in order to reduce load curtailment and potential line overloading. The generating units are rescheduled where possible, or the overall load that load buses can carry is increased.

Priorities for maintaining transmission lines

The significance and condition indices may be used to determine where each overhead transmission line is located on a two-dimensional image. Based on statistical analysis and talks with maintenance experts, importance and condition indices may be divided into three categories, including low, medium, and high value. As a result, 9 portions will be created in light of the information [8], [9].

Understanding Why Transmission Systems Are Necessary

System Voltage Ratings

The suitable insulator, conductor, hardware, and work practise characteristics will be determined by the system voltage ratings.

Every Kind of Structures

Understanding these types of structures is necessary to comprehend how people, machinery, and tools will connect to the transmission structures. The weather, topography, and distance have a big impact on accessibility, whereas terrain and climate slopes change strain values.

Access, Resources, and Work Methods

No project ever begins without a clear understanding of where it is headed, what will be used, and how it will be finished.

Measurements separating MAD and MAID

In a busy workplace, the distance between MAD and MAID is essential for guaranteeing worker safety.

The Rigging's Security

To lessen the likelihood of overloading equipment and suffering catastrophic accidents, an adequate safety factor should be scrupulously adhered to.

Maximum Strain per Conductor figures

Maximum strain tension values per conductor must be established in order to ensure that the load-bearing equipment being utilised has the appropriate rated working load to handle the stresses involved.

The option chosen for Transmission Live-Line Maintenance

When these crucial details, as well as detailed system and hardware designs, have been supplied, a thorough and accurate list of tools may be advised. Also, our outstanding CHANCE Tool Demonstration Team is available to come to your site and train your staff on how to do the necessary tasks your unique system requires in a proper, efficient, and SAFE way. Our renowned Tool Demonstrators are journeyman linemen who have been practising teaching Transmission Maintenance, a service that CHANCE has been providing all over the globe since the 1930s.

Terminal Guarding

Each structure, the cables and conductors that link them, as well as the vegetation along the line, are immediately visually examined during these patrols. While conducting ground patrols from the road, binoculars may be utilised to clearly see the houses and assess any vegetation problems. As one of their top aims is the growth of certain plants, these patrols must be conducted between the conclusion of the Fall Air Patrol one year and the start of the growing season the following year.

Cleaning insulation

We'll use a helicopter to use contaminants, such as dirt and road salt, off of insulators on electrical transmission lines. When a transmission line is too close to a dwelling, ground workers will complete the washing. Without the use of any extra chemicals or cleaning agents, the insulator will only be washed in distilled water.As the transmission lines won't need to be shut down for this repair, residents shouldn't notice any changes in their energy. If activities must be conducted on private property, we will contact you in advance to discuss the exact days and times we will require access to your property.

CONCLUSION

This inspection will include a thorough internal and exterior inspection of every wood pole structure. A small crew will do the inspection, and depending on the region and the time of year, the patrol may be carried out by snowmobile, light truck, or off-road vehicle (quad).After the soil has thawed, inspections of the poles are normally done in the spring through the fall. Infrastructure connected to wetlands will be examined in the winter after freeze-up.This book chapter we discuss about the comprehensively the maintenance of the transmission line, including the technique used to maintain the transmission line and the kind of transmission line.

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THE OVERHEAD LIGHTING FOR TRANSMISSION LINES

Ms. Renuka Bhagwat*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

ABSTRACT:

In this book chapter we talk about the overhead transmission line illumination computation. An approach to evaluate an overhead wire's lightning performance might include the stages below. To forecast the location of the return stroke, use an incidence model. The transmission lines were discussed by the electric power providers in the Murmansk region. 200 full transmission lines with various voltage classes make up the data collection. Ground wires shield transmission lines from lightning strikes. The likelihood of the insulation collapsing after a back flashover is particularly high in areas with high ground resistance. The ability of a power system to consistently meet short-term system operation limits and measurements of power user load needs while operating in real-time and in an outside environment is referred to as power grid dependability.

KEYWORD: *Lightning Strikes, Lightning Density, Lightning Protection, Overhead Transmission, Overhead Line, Power Line, Transmission Line.*

INTRODUCTION

Power lines need to be strengthened to be more resilient to the effects of lightning overvoltage if the consumer's power supply is to stay steady. While choosing the diameters of electrical wires, several environmental factors must be taken into consideration, most notably the strength of the lightning. According to the "Electrical Installation Regulations" regulation, lightning effect restrictions on power lines are presently determined in Russia. It displays maps of the lightning density made more than 30 years ago using actual lightning and thunder measurements. The instrumental method has also produced accurate maps of lightning density and thunderstorm days that have been utilized for a very long time in international practice. The authors of employ lightning data acquired by NASA satellite-based equipment OTD and LIS in addition to ground-based lightning detection devices CIGRE-500 and CGR3. A network of lightning location and protection sensors that detect lightning using the direction finder method was used for the studies, and it was controlled by. suggested, for example, counting the number of discharges each day in cells of 20 km, which roughly resembles the region of a normal downpour as well as the range of human perception for hearing and seeing lightning and thunder. Yet, modern techniques are being used by Russian researchers to study lightning activity [1]. Thunderstorms are monitored by the Vaisala LS8000 network, which is situated in the North Caucasus. The Global Wide Lightning Location Network was used to investigate the storm activity in Yakutat. A Boltek LD-250 single-point lightning detector was employed when lightning was seen over the southeast of Western Siberia. Unfortunately, "The Electrical Installation Rules," the primary regulatory guideline controlling electrical installations, has not been changed despite the available lightning evidence Electrical Installation show in figure 1.

Figure 1 Electrical Installation [zoe talent solutions].

A buffer zone or a corridor may sometimes be used to forecast the effects of lightning on overhead electrical wires (OHTLs). The corridor's width typically ranges from a few hundred meters to a few kilometers. For illustration, a map plot with a 9 km-long corridor on each side of the line was made. It suggests that beyond this range, OHTL is no longer impacted by lightning discharges. It is also shown that the corridor width, which seems to be too large for the lightning detecting system (LDS), correlates with the margin of error in the data the LDS provides. Moreover, the square cells used by the built-in corridor seem to be bigger than 20 km by 20 km. A technique for creating an overhead line route lightning density map is offered during long-term lightning registration. The size of the 5 km 5 km cells in the research region is determined by the accumulation of the requisite number of discharges (100-150) in the cell throughout a five-year observation period. Grid cells that cross the overhead line route and are situated close to it at a distance of less than 1/5 of the grid cell side are used to calculate the lightning density in the OHTL region [2].

We don't go into details about the flash incidence of certain power line sections and towers but instead estimate the predicted effect on the power line based on the density of the strokes. For instance, various cell sizes ranging from 5 km to more than 20 km are employed, despite the fact that the transmission towers of the high voltage class overhead wires are frequently just a few hundred metres apart. The buffer distance may also be calculated using uncoordinated distances. Electrical linemen employed by energy and utility firms need information on lightning strikes throughout the whole length of power lines to identify places that need special management. As a result, there is presently no easy way to determine the extent of lightning's impact on OHTLs throughout their whole length.

We aim to develop a measure of the average annual lightning impact intensity along the entire length of the overhead line, taking into account the lightning discharges that actually occurred over a long period of time, despite the importance of lightning density maps for estimating lightning incidence to power lines generally. The research used the transmission tower coordinates with the raw LDS data to achieve this.The Murmansk area of the Russian Federation is used as an example in this research to provide a straightforward approach for determining the effect of lightning on overhead power lines over their whole length. By using this technique, you can understand how crucial the buffer zone is for determining the amount of a lightning strike throughout a power line's whole length. On 200 OHTLs in the Kola Peninsula in the Russian Federation's Arctic Zone, the suggested procedure has been tried. The bulk of overhead wires are situated in the most often impacted regions [3].

An approach to evaluate an overhead wire's lightning performance might include the stages below. Computing the overvoltage brought on by each stroke based on where it will occur, using an incidence model to anticipate where the return stroke would occur, and determining the flashover rate. Generating random integers to arrive at the randomly generated lightning stroke and overhead line characteristics. Limitations and uncertainties must be considered while utilizing the method; for instance, our understanding of the lightning parameters is often lacking. By carrying out parametric research that may indicate the parameters for which precise information is necessary, these restrictions could be partially mitigated. Investigating the flaws in the overhead transmission line model used in lightning calculations is the goal of this work. This work describes a sensitivity assessment that tries to identify any potential impacts on the flashover rate of the model and parameters used for modelling the essential components of a transmission line. Investigated are the effects of the models for the tower, the footing impedance, and the insulator strings. The format of the document is as follows. Modeling rules are introduced in Section II. The process for calculating a transmission line's flashover rate is outlined in. Despite the fact that this line is carefully inspected, the configuration of the test line is supplied.

Information for energy lines

The transmission lines were discussed by the electric power providers in the Murmansk region. 200 full transmission lines with various voltage classes make up the data collection. As they include service information, some of these data will be given in this study anonymously and without the proper dereferencing. Even with this knowledge, we will be able to show how to calculate the lightning intensity on electrical lines across their whole length.

To send real-time information on flash incidence to power lines above the ground and to mimic the circumstances of the Kola power system, the approach and findings of this study's processing setup were used. The R programming language's "sf" and "plotly" packages were used to carry out the calculations.

The Method for Genuine Power Lines

It is crucial to look at the procedure on actual overhead lines, especially for electricity providers. Moreover, it's critical to identify the electrical line segments that have been hit by lightning the most quickly. The technique may sometimes be useful for persons choosing the best path for electrical transmission lines, depending on lightning density (least number of lightning hits). You must first compile the initial data before trying the method on actual local overhead wires. They include the locations of overhead line towers, the proximity of lightning strikes, and the size of the power line buffer. If the coordinates are straightforward enough, figuring out the buffer size is necessary. The OHTLs buffer is selected for this inquiry to be inside the LDN error limit. Using each flash's maximum deviation span (MDS) metric, this error may be calculated [4].

Ground wires shield transmission lines from lightning strikes. In areas with significant ground resistance, there is a very high likelihood that the insulation will fail after a back flashover (BF). Also, there is a chance that the shielding might break down and result in a flashover (SF). Hence, the back flashover rate (BFR) and the flashover rate caused by shielding failure are both equivalent to the lightning flashover rate (LFOR) of a transmission line (SFFOR). In order to distinguish between strokes to shield wires from those to phase conductors and those to ground, an incidence model is needed to get both amounts. In order to assess lightning stress, a Monte Carlo method may contain the following steps. Using an incidence model to identify the point of impact of each lightning strike, calculating the overvoltage produced by each strike depending on the point of impact, and calculating the flashover rate.

Generating random numbers to create parameters for the overhead line and lightning strikes of a random nature. In this study, flashover rates for both vertical and non-vertical strokes are estimated, and lightning performance is assessed. The innovative technique was developed in MATLAB and integrated with an EMTP/ATP sketch tool to run network simulations right away. An insulator string is represented by a leader progression model, and a transmission tower is represented by a multistory model because proper component modelling makes it possible to gather statistical data from networks.Characteristics and statistical distribution of stroke parameters. This article compiles the techniques used to estimate lightning's impact, including both vertical and non-vertical strokes. The key elements of the Monte Carlo method are explained. A list of modelling needs is provided. We present and analyses the simulation findings to demonstrate the link between the flashover rate and various transmission line parameters and return stroke current factors.

To prevent back-flashovers, the earthing resistance of the tower has to be reduced. Tower construction is not practicable nor possible in locations with poor soil and difficult terrain. Using asymmetrical or better line insulation is another method for lowering back-flashover. Nevertheless, this option is uneconomical since it would need more insulator discs, which would require changing the tower. The installation of Transmission Line Arresters (TLA) at certain tower sites is the most practical and cost-effective method of preventing back-flashovers. Nevertheless, installing TLAs also necessitates either unique cross arm configurations or unique conductor installation techniques. This study's major goal is to determine if using MCIA Strings instead of traditional Insulator Strings is feasible.

The Multi Chamber System (MCS) is the foundational architecture of the MCIA. The device is made up of several electrodes attached along a piece of silicon rubber. Little gas discharge chambers are created by the holes that have been drilled into the electrodes along their length. A lightning overvoltage impulse obliterates the gaps between the electrodes when it is applied to the arrester. Into very tiny chambers, electrode discharges can place. The tremendous pressure that results pushes the electrode channels in the spark discharge paths, increasing the overall resistance of all channels (i.e., that of the arrester), which reduces the lightning overvoltage impulsive current. Arc-quenching multi-chamber systems have enabled the creation of new 10-35 kV multi-chamber arresters (MCA) and a ground-breaking device known as the "Multi Chamber Insulator Arrester (MCIA)" that combines the features and capabilities of a bit insulator and an arrester (MCS) [5].

LITERATURE REVIEW

Olga Myasnikova, et.al the dependability of overhead transmission lines in Russia and the impact of climatic conditions were addressed. The potential effects of climate change are reviewed. Several reliability objectives related to the effects of weather events were estimated using the example of an electric grid provider in the Republic of Bashkortostan, including the quantity of power outages, the failure rate of 1 km of overhead transmission lines, and the duration of outages. These objectives are at a high level, especially for 6-10 kV overhead transmission lines, according to the estimates. Climate elements like wind and a lightning storm contribute the most. There is a significant association between these qualities, as shown by an examination of the outages of the overhead transmission lines as a function of the number of wind instances with a certain speed. Predictive data indicates that in the area under consideration in 2025, there will be 1.5 times as many power disruptions.

K. T.M.U. Gnana Swathika, etal. explored the dependability of a country's power supply system is significantly impacted by the functioning of transmission lines. It is well acknowledged that one of the main reasons for transmission line outages is the impact of lightning back flashover. his work focuses on transient modelling and subsequent simulation of a chosen transmission line to investigate the impact of Multi Chamber Insulator Arresters (MCIA) on lightning back flashover. For this research, the 132 kVMatugama-Kukule transmission line is modelled and simulated using the Power System CAD (PSCAD) software package. To assess the gains in lightning return flashover performance after installing MCIAs in this transmission line, simulation of the constructed transmission line model is done both with and without MCIA. The Sri Lankan electrical power system's dependability will be improved by this investigation.

Lamia El-Shennawy etal.explored burning fossil fuels to provide the heat required to run steam turbines, electricity production accounts for around 40% of all worldwide CO2 emissions. Carbon dioxide (CO2), the main heat-trapping "greenhouse gas" responsible for global warming, is produced when these fuels are burned. Using smart grid technology may help to cut CO2 emissions. The three main sectors of the electric grid are generating, transmission and distribution, and consumption. Renewable energy sources are used in smart generating (wind, solar, or hydropower). In order to ensure that new producing capacity are kept to a minimum, smart transmission and distribution depends on maximising the assets already in place, such as overhead transmission lines, underground cables, transformers, and substations. Using more efficient tools, such as energy-saving lighting fixtures, will enable smart houses and hybrid plug-in electric car technologies, which in turn will rely on smart consumption. The Egyptian case study is given particular attention. The ability to produce power from wind and solar energy as well as Egypt's strategic position, which makes it the ideal hub for integrating electrical networks from the Nile basin, North Africa, the Gulf, and Europe, are the country's main potential. The lack of investments, the lack of political will, the deterioration of the transmission and distribution infrastructure, and the ignorance of consumers about power use are all problems.

L. Iu Ermolenko etal. explored the equipment of systems for transmitting resonance-based electricity. Frequency conversion devices, power transmission lines, and devices for the reverse transformation of electrical energy to the voltage needed by the consumer are all components of resonant systems for electrical energy transmission by single-wire cable or overhead lines at increased frequency. Resonant systems operate at a higher frequency of 5–15 kHz and a higher line voltage of 1–10 kV than conventional electrical power transmission systems. Resonant transformers are used in this situation. The resonant transmitting transformer and the wideband step-down receiving transformer determine the frequency of the power transmission system. A power resonant circuit and a step-up/step-down winding make up the majority of the resonant transmitting transformer. The voltage applied to the circuit, the circuit voltage, the circuit capacitance, the frequency, and other factors all affect the converter's maximum output power. For example, in lighting systems, altering the transmission frequency might alter the transmitted power. They are more effective than single wire ground return lines running at constant current and alternating current of commercial frequency because resonant power transmission systems operating at increased frequency are less demanding on the grounding quality.

Jufeng Qu,In etal.investigated an air-blast arc-quenching gap based on the "scatter" idea of lightning protection is built in reference to the critical circumstance that the faults produced by lightning stroke commonly occur in 35 kV overhead transmission lines in portion of South China. When lightning hits an overhead transmission line, the planned air-blast arc-quenching gap may flashover before the insulator string does, quenching the power frequency after flow as the lightning current flows into the earth via the gap. Building a PSCAD model of the designed gap from testing data from small-current arc-quenching property tests and simulation results reveals that installing the designed gap on 35 kV overhead transmission lines can effectively suppress lightning overvoltage[6].

DISCUSSION

The lightning stroke process is briefly investigated using the concept of the full wave process. The actual wave process of the transmission and transformation system, grounding device, and subsurface grounding system is taken into consideration in the interim. While lighting a direct stroke on the pinnacle of the tower, the efficiency of the line back strike. There is application of the eigenvalue and characteristic vector theories of matrices. Using the matrix similarity transformation, the wave process on multiple conductor lines with mutual electromagnetic contact is condensed into n mutually independent moduli, which are equivalent to the wave process on a single conductor. The simulation employs a multi-wave impedance model for the tower. The tower stands between a main support and auxiliary supports. It is assumed that each component is distributed evenly. The wave impedance is computed using their own dimension and geometry function. For the lightning current model, both the current source model and the bi-exponent pulse are used and 300 is the impedance size.

Failure Transmission line shielding research

The underlying premise of the leader progression model is that the field intensity of the ground and ground objects constantly rises as illumination develops downward. Lightning strikes occur during relative development when the ascending and descending leads come into contact with the breakdown scenario, which occurs when the field strength is increased to a particular degree on the ground objects. When a lightning leader model is used to analysis the features of line shielding failure, the four parts of the modelhead-on leader starting criteria, upward leader model, and final breakdown criterionhave the most influence on the calculation outcome. The expansion direction of the lightning channel is quite unexpected since it is descending. A lightning channel, however, always forms in the direction with the strongest electric field, as shown by statistical laws. The electric field is regarded as the main parameter for defining the development direction of lightning in lightning fractal modelling. According to the article Lightning strikes, the lightning leader is believed to always develop in the direction with the strongest electric field failure of the transmission line show in figure 2.

Figure 2 Failure of the transmission line [power protection resource].

Computation of This Manner of Tripping Out of Lightning Strikes

The performance of line lightning protection is impacted by elements such as line back-striking trip-out rate, shielding failure trip-out rate, line lightning stroke trip-out rate, line tower types, dielectric strength, ground resistance, as well as topography and lightning activity along the line. Each base tower has a unique tower type, size, dielectric strength, geography, and grounding conditions. The level of lightning protection also varies from base tower to base tower. Yet since there are so many towers in the actual line, each base tower must conduct a time-consuming tri pout rate assessment on its own. So, it is necessary to assess the overall success of the lightning protection for the lines using the useful method provided below: According to statistical rules for all variables impacting the efficiency of line lightning protection, the lines are divided into a number of categories. The weighted sum technique is used to calculate the line's overall lightning protection efficiency based on the calculated line lightning stroke trip-out rate in the reach category [7].

Trustworthy Power Girds

The ability of a power system to consistently meet short-term system operation limits and measurements of power user load needs while operating in real-time and in an outside environment is referred to as power grid dependability. To assess the dependability of the power producing and transmission systems, a quantitative reliability index is utilized. The indexes generally include PLC (Probability of Load Curtailments), EFLC (Expected Frequency of Load

Curtailments), EDLC (Expected Duration of Load Curtailments), ADLC (Average Duration of Load Curtailments), ELC (Expected Load Curtailments), EENS (Expected Energy Not Supplied), BPII (Bulk Power Interruption Index), BPECI (Bulk Power Energy Curtailment Index) and SI (Severity Index), etc.

A Common Transmission Line Common Line Evaluation Basic Parameters

One 500 kV, one 220 kV, and one 110 kV line in Jinmen with more lightning strike trip out events per line are each selected in order to analyses and assess the lightning protection performance of the three typical lines.The standard DL/T 620-1997, overvoltage protection and insulation coordination of AC electrical equipment, which stipulates a typical value, should be followed when selecting the sag. The insulator parameters are established using the line's typical value, and U50% is converted in accordance with standard DL/T 620-1997. It is determined which tower models in each line either depict tower qualities the most accurately or have the highest percentage[8]. Single-circuit erection is utilized for 500 kV lines, and the most popular kinds of towers are angled and straight-line cup types. Two typical tower structures with the following measurements are used in the research. There are three different configurations for 110 kV line erection modes: double-circuit, three-circuit, and four-circuit. The towers that have been employed include two-circuit straight line towers, two-circuit angled towers, three-circuit straight line towers (1 base), and four-circuit straight line towers.

CONCLUSION

The anticipated SFR for an overhead transmission line from the lightning crest current distribution impact equation takes into account both the lightning attachment model and the dispersion of the lightning crest current. The statistical characteristics of different lightning crest current distributions are reported in the literature. Measurements taken in the field in Austria and Japan, respectively, were used to calculate the distributions. Adopting the suggests utilizing distribution for SFR calculations since the two are seen as being equivalent. An equation was used to demonstrate how lightning peak current distributions impact the SFR of conventional transmission lines. The lightning attachment model and overhead transmission line geometry both indicate that SFR is much greater for lightning crest current distributions that are both low and large. According to statistical and electro geometric models, this is more visible for relatively low-height lines, and according to Eriksson's and general models, for taller lines.In this book chapter we discussed about the overhead transmission line overhead line calculations for sag and tension of the line, and calculations for the cost and high cost of the transmission line.

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AN ANALYSIS OF CIRCUIT BREAKER SELECTION AND SIZING

Dr. Sreenivasappa Bhupasandra*

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about the Ht/lt circuit breaker selection and sizing of the circuit breaker and the type of the circuit breaker. A "Circuit Breaker" is an electrical device that has the capacity to safeguard the circuit in the event of a failure and to correct the fault state. An MCB is an electrical switch that operates automatically. Tiny circuit breakers are designed to guard against overcurrent damage to an electrical circuit. It is important for system designers and installers to comprehend the workings of moulded case circuit breakers and the significance of their ratings as installed system capacity in the Australian PV market keeps growing. In electrical systems with high Earth impedance, a safety device called an earth-leakage circuit breaker (ELCB) is employed to guard against shock. It monitors electrical equipment's metal enclosures for minute stray voltages and shuts off the circuit if a harmful voltage is found. The temperature-sensitive component of the MCCB uses overload protection. This part is basically a bimetallic contact, which a contact is made of two metals that expand at different rates when heated.

KEYWORD: *Circuit Breaker, Dc Circuit, Guard Against, Hybrid Dc, Oil Circuit, Residual Current, Short Circuit, Solid State.*

INTRODUCTION

Switchgear plays a significant part in the operation of a power system by switching, managing, and safeguarding the electrical circuits. One of the switchgear devices among them is the circuit breaker. The fundamental purpose of a circuit breaker is to safeguard an electric system, such as those found in power plants, transmission and distribution lines, distributors, lighting circuits, etc. A "Circuit Breaker" is an electrical device that has the capacity to safeguard the circuit in the event of a failure and to correct the fault state.

Considering the intense tension

Several categories of circuit breakers fall under the power system protection. It is primarily separated into five major components based on arc extinction or quenching medium.

1. A circuit breaker for air blast
2. A circuit breaker for oil
3. A vacuum circuit interrupter

4. A circuit breaker for sulphur hexafluoride

Circuit breakers employ air, oil, sulphur hexafluoride gas, or compressed air as the medium for arc extinction.

A circuit breaker for air

Low- and medium-voltage safeguards are developed for air circuit breakers (ACBs). With an air circuit breaker, compressed air or gas serves as the circuit-breaking medium. Lighting systems, distribution systems, and motor circuits all employ this circuit breaker. It may be utilised to sustain indoor applications in AC or DC circuits[1]–[3].

Air Blast Circuit Breaker

For the purpose of interrupting current at high-pressure or high-voltage installations, the air-blast circuit breaker is required. High pressure (or other gases including hydrogen, nitrogen, and carbon dioxide) is employed as the arc quenching medium in this circuit breaker. The air blast circuit breaker is divided into three groups along the arc route. Axial and cross air-blast circuit breakers are available. Circuit breaker with radial air blast in industrial operations, it is mostly utilised for the primary power transmission and distribution air blast circuit breakershown in figure 1.

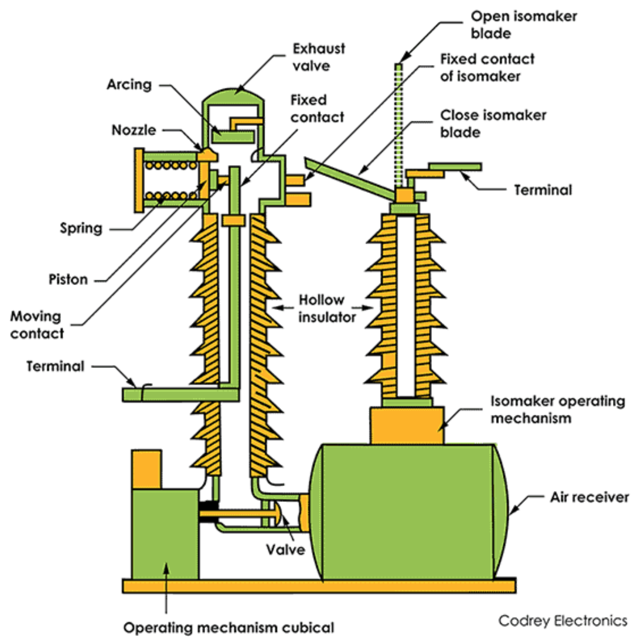

Figure 1 Air circuit breaker.

Circuit Breaker for Oil

Insulating oils (like transformer oil) are utilised as the arc quenching medium for the oil circuit breaker. It is the most traditional kind of circuit breaker that offers many features including high dependability, straightforward design, and reasonable cost.

Generally speaking, this circuit breaker may be divided into two pieces

1. Simple break oil circuit breaker, self-generated pressure oil circuit breaker, impulse oil circuit breaker, bulk oil circuit breaker (BOCB),
2. Circuit breaker for low oil (MOCB)

A vacuum circuit interrupter

Compared to air and oil circuit breakers, the vacuum circuit breaker (VCB) has a fairly simple structure. Vacuum provides a strong insulating strength in this circuit breaker between 10-7 and 10-5 torr. The structure may be divided into two categories. Vacuum circuit breakers come in two varieties: fixed and moving. For medium-voltage ratings, VCB is used (like 11KV and 33KV). It is often used in substations to prevent against overload or excessive current. Moreover, it is used in the switching of transformers, reactors, capacitor banks, etc.

Circuit Breaker for Sulphur Hexafluoride

In place of oil, air, or a vacuum, sulphur hexafluoride (SF6) gas is employed as an arc quenching medium. High and extra-high voltage are served by it. The three varieties of SF6 circuit breakers are typically separated based on their operating principles. Circuit breakers include single puffer piston, double puffer piston, and non-puffer piston models. In power plants, transmission and distribution networks, electrical grids, and other infrastructure, the SF6 circuit breaker is often employed. The electrical power transmission networks are protected and under the supervision of these high voltage breakers sulphur hexafluoride circuit breaker show in figure 2.

Figure 2Sulphur Hexafluoride Circuit Breaker

LITERATURE REVIEW

Liang Nian, etal.explored mesh-type DC micro grids, the circuit breaker (CB) and fault current limiter (FCL) are two important fault protection components. In order to create a CB and FCL configuration scheme that is both dependable and affordable for use in mesh-type DC micro grids, this research suggests a technique for parameter selection. Three optimisation factors in an evaluation model are chosen: the inductance of FCL, the notional breaking current of CB, and the breaking time of CB. It is important to precisely calculate the post-fault line current because the reliability of the fault prevention system relies on whether the nominal breaking current of the CB is larger than the line current at the CB's breaking moment. This research presents an accurate transient DC micro grid model based on this. The parameters of CBs and FCLs are then promptly configured using an upgraded non-dominated sorting genetic algorithm II (NSGA-II). Moreover, a case study on a six-terminal DC micro grid test system demonstrates that the suggested technique can successfully determine the parameters for CBs and FCLs as well as acquire an accurate post-fault line current.

Xiaoqing Peng et.al explored the creation of a hybrid dc circuit breaker with a 10 kV and 200 A rating that can safeguard electric ship dc power systems. The Thompson coil-based ultrafast mechanical switch (MS) and two additional solid-state power devices are used in the proposed hybrid dc circuit breaker. To achieve the zero current turn-off of the MS, a low-voltage (80 V) commutating switch (CS) based on metal-oxide-semiconductor field-effect transistors (MOSFETs) is series coupled with the MS. By doing this, the MS's arcing problem is prevented. To stop the fault current, a 15 kV SiC emitter turn-off thyristor-based main breaker (MB) is parallel coupled with the MS and CS branch. To clamp the voltage across the hybrid dc circuit breaker during interruption, a stack of MOVs is utilised in parallel with the MB. A companion article will explain the fast-acting MS's theory of operation as well as the hybrid dc circuit breaker's overall functioning while this study concentrates on the electrical components of the device. This article describes the design and selection of the high-voltage and low-voltage electronic components used in the hybrid dc circuit breaker. Experimental testing of the MB's turn-off functionality demonstrates that it is suitable for use as a hybrid dc circuit breaker both with and without a snubber circuit. Up to 200 A is evaluated for the CSs' conduction ability, and its current commutating during fault current interruption is also examined. Eventually, a quick current interruption at 7 kV and 100 A was shown using the hybrid dc circuit breaker in less than 2 ms[4]–[6].

Saurabh Santosoetal. explored the idea behind and effectiveness of a unique direct current fault interruption system that connects a reactor, a controlled rectifier, and a traditional AC circuit breaker in series. The DC filter capacitor's capacitive discharge current is restricted by the series reactor when it is present at the phase-controlled rectifier's output terminals. Moreover, a series RLC circuit formed by the reactor in series and the filter capacitor causes the fault current to fluctuate about zero. Then, a typical AC circuit breaker may be used to stop this artificial alternating current. Also, the overcurrent protection and series reactor selection criteria are discussed. As an example of the suggested method, a DC fault current of 56 kA is lowered to 14 kA, and the interruption duration is decreased from 44 ms to 25 ms.

Maurizio Shulman et.al examined the evidence for networks of brain regions that perform various attentional tasks in partly segregated ways. Goal-directed (top-down) selection for stimuli and responses is prepared and applied by one system, which comprises portions of the superior frontal cortex and intraparietal cortex. The recognition of stimuli also modulates this system. The other system, which is predominantly lateralized to the right hemisphere and consists of the inferior frontal cortex and temporoparietal cortex, is not engaged in top-down selection. Instead, this system is designed for the detection of stimuli that are salient or unexpected and that are behaviourally significant. As a "circuit breaker" for the dorsal system, this ventral front parietal network draws attention to important occurrences. During typical vision, both attentional systems cooperate, and unilateral spatial neglect impairs both of them.

Gustavo Celeita, etal. explored the proper design, size, and selection of protective devices in a power system, the multiplication factor (MF) is essential. The X/R ratio at the failure point affects this factor. According to engineering norms, the standards create an equal MF for the X/R ratios for both three-phase and single-phase fault. X/R ratios for single-phase faults, however, do not take into account the contribution of the positive-sequence or zero-sequence X/R ratio to the overall X/R ratio. This study shows that the overall X/R ratio at the failure point is not the sole element that influences the changing multiplicative factor. The findings show that it is also important to construct the MF taking into account the changes of the X/R ratios of each sequence, as shown by dynamic short-circuit simulations using EMTP-ATP Draw. This article suggests an approach that is complimentary to the standards and enables determining the multiplication factor using the X/R ratios of the positive and zero sequences independently in order to assist the engineering designer in making the right choice of the protective device. The findings demonstrate that, in some instances, disregarding the zero sequence may lead to both oversized and undersized design issues.

Ying Sun, etal. investigated the performance of hybrid dc breakers and the fault response in multi terminal dc (MTdc) grids are calculated using a time-domain technique. The suggested methodology, based on travelling waves, proposes a novel way to estimate reflection coefficients, gives an approximation of the worst-case fault site, and 1) provides a sound representation of fault performance by taking into account all formed travelling waves. Then, using multi objective optimisation, three parameters of the hybrid dc circuit breakercurrent limiting reactor, arrester rated voltage, and time delayare chosen in the best way possible based on the analytical results in terms of maximum overcurrent, maximum overvoltage, fault clearance time, and energy absorption in arresters. Time-domain simulation studies employing frequency-dependent models in the setting of power systems computer-aided design (PSCAD)/electromagnetic transients including DC (EMTDC) analyse and verify the accuracy and performance of the suggested technique.

DISCUSSION

Additional Circuit Breaker Classifications

The low tension indicates

In general, characteristics like voltage rating, operating principle, current carrying capacity, size, etc. are used to categorise circuit breakers.

1. A little circuit breaker (MCB)
2. Circuit breakers with moulded cases (MCCB)
3. Circuit breaker using solid-state (digital) technology
4. A residual current circuit interrupter (RCCB)
5. A circuit breaker for earth leaking (ELCB)

The top 10 kinds of circuit breakers used for switching or tripping mechanisms under abnormal circumstances are listed below. This technique requires less labour time (near about 30 ms and 150 ms). According to their requirements, there are several varieties of circuit breakers, and each type has pros and cons of its own. It will be briefly described each low tension (LT) circuit breaker along with its construction, operating principle, and other parameters in a subsequent post.

Circuit Breaker in Miniature

Work of a Little Circuit Breaker

An MCB is an electrical switch that operates automatically. Tiny circuit breakers are designed to guard against overcurrent damage to an electrical circuit. To guard against electrical problems and equipment failure, they are built to trip when an overload or short circuit.Tiny circuit breakers employ a moderately robust mechanical mechanism to reduce failures and false alarms. They are activated by overcurrent, which is electrical current that exceeds a predefined safe current.The bimetallic strip within the MCB heats up, bends, and trips as a result of excessive current. When a switch is released, the electrical contact points are moved apart to contain the arc (electrical discharge). The arc chute is an insulated metal strip that divides and cools the arc. After the problem has been remedied and the MCBs have been reset, the contacts shut once again.

Both overloading and short-circuiting are protected against by an MCB. They are identified in various ways using various procedures. The bimetallic strip uses thermal action to guard against overload, while the tripping coil uses electro-magnetic operation to protect against short circuits. The MCB will trip (activate) extremely quickly—within one-tenth of a second—if the discharge is very high. The component will react more slowly when the overcurrent approaches the safety limits.

Circuit breaker with a moulded casing (MCCB)

It is important for system designers and installers to comprehend the workings of moulded case circuit breakers and the significance of their ratings as installed system capacity in the Australian PV market keeps growing.An electrical protection device known as a moulded case circuit breaker (MCCB) is used to safeguard an electrical circuit against excessive current, which may result in overload or short circuit. MCCBs have changeable trip settings and a current rating of up to 2500A, making them suitable for a variety of voltages and frequencies. For system isolation and protection, these breakers are utilised in place of tiny circuit breakers (MCBs) in large-scale PV systems.

Protection against overload

The temperature-sensitive component of the MCCB uses overload protection. This part is basically a bimetallic contact, which a contact is made of two metals that expand at different rates when heated. The bimetallic contact will enable electric current to pass through the MCCB under typical working circumstances. Due to the various thermal rates of heat expansion inside the contact, the bimetallic contact will begin to heat up and bend away when the current reaches the trip threshold. The contact will eventually bend to the point where it physically pushes the

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trip bar and unlatches the contacts, interrupting the circuit.In order to accommodate a brief period of overcurrent that is often seen during the operation of particular devices, such as inrush currents experienced while starting motors, the thermal protection of the MCCB will generally incorporate a time delay. Due to the time delay, the circuit is able to function normally under these conditions without triggering the MCCB[8]–[10].

Protection against electrical short circuit currents

Based on the electromagnetic principle, MCCBs respond instantly to a short circuit problem. As electricity flows through the MCCB, a solenoid coil within the device produces a modest electromagnetic field. The electromagnetic field produced by the solenoid coil is hardly noticeable when it is functioning normally. A short circuit failure in the circuit, however, causes a significant current to start flowing through the solenoid. As a consequence, a powerful electromagnetic field is created, drawing the trip bar and opening the contacts.

Digital solid-state circuit breaker

The solid-state breaker idea uses semiconductors and cutting-edge software algorithms to replace the conventional moving elements of an electromechanical circuit breaker so that it can manage power and interrupt severe currents more quickly than ever before Digital solid-state circuit breaker show in figure 3.

Figure 3Digital solid-state circuit breaker [ABB**].**

In a matter of microseconds, solid-state technology ensures a very quick interruption and fixes a defect. A mechanical circuit breaker with the same frame size operates only a few milliseconds, by contrast. A mechanical circuit breaker cannot detect or react to a short circuit fault 100 times as quickly as a solid-state circuit breaker can. The downtime in the event of an internal malfunction has a significant impact on electrical grid services for energy storage systems and their accompanying systems. An abrupt disconnect of the faulty zone might stop the system from shutting down. The likelihood of a harmful arc flash developing is essentially non-existent since there is no energy released during current interruption. All electrical systems, particularly those using islanded networks like ships with an on-board DC grid, must be energy efficient. Solid-state circuit breakers promise 70% reduced power losses during the conduction phase compared to conventional semiconductor technologies.

Circuit breaker for residual current (RCCB)

Despite the fact that electricity has become an essential part of our lives, it is true that it poses risks to both human life and property. Due to the two main threats linked with electricityelectrocution and fireone cannot afford to be careless when it comes to insulating equipment.When it comes to safeguarding electrical circuits, a Residual Current Circuit Breaker (RCCB) is a crucial component. It is a current detecting device, and anytime a defect develops in the linked circuit or the current exceeds the rated sensitivity, it may automatically measure and terminate the connection. Designed to shield a person from the danger of electric shocks, electrocution, and flames, RCCB is especially useful in situations of rapid earth fault. Due to the RCCB's existence, the circuit will trip promptly in such circumstances, protecting the victim from receiving an electric shock.

Underlying idea of RCCB

Kirchhoff's law, which specifies that an electrical circuit's incoming and outgoing currents must be equal, serves as the foundation for RCCB. RCCB compares the current levels that vary between live and neutral wires in this manner. The current going through the neutral wire should be equal to the current entering into the circuit from the live wire. The difference between the two currents, known as residual current, is decreased in the event of a fault. The RCCB is activated to shut off the circuit when it detects a residual current.

CONCLUSION

In electrical systems with high Earth impedance, a safety device called an earth-leakage circuit breaker (ELCB) is employed to guard against shock. It monitors electrical equipment's metal enclosures for minute stray voltages and shuts off the circuit if a harmful voltage is found. While they were formerly frequently employed, residual-current devices (RCDs, RCCBs, or GFCIs) are now utilised in more modern installations since they directly detect leakage current.In this book chapter it is discussed about the Ht/lt circuit breaker selection and sizing of the circuit breaker and the type of the circuit breaker and the uses of the circuit breaker.

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INVESTIGATING THE ROLES OF CONTROL AND RELAY PANEL

Dr. Shilpa Mehta*

*Professor,
Department of Electronics & Communication (Communication System Engineering), Presidency University, Bangalore, India,
Email Id-shilpamehta@presidencyuniversity.in

ABSTRACT:

This book chapter investigates about the control and relay panel as well as types of the relay and the panel of the system. These panels have two feeder circuits each. In that there will be an extra feeder circuit in lieu of the transformer circuit, these panels are an identical reproduction of the multi-circuit, one transformer, and one feeder panel. Lighting and accessories for the control and relay board panels are as follows: Each cubicle interior unit (both the control and relay panel) should be lighted by LEDs linked to 230V single phase AC via an individual switch for duplex type panels and a door switch for simplex type panels. To avoid condensation of moisture, a tubular space heater appropriate for connection to the single-phase AC supply in each panel (both the control and relay panel in the case of a duplex type), complete with switches and a thermostat positioned in a convenient location, must be supplied. All control switches must be rotary and come with escutcheon plates that are clearly indicated with the switch's state. Just the switch front plate and working handle should protrude from the mounting surface. All such control switches must be available for the remote control of circuit breakers and isolators.

KEYWORDS: *Control Relay, Control Switch, Control System, Circuit Breaker, Feeder Circuit, Solar Panel, Transformer Circuit.*

INTRODUCTION

In different 11KV and 33KV zonal substations, a control and relay panel are intended to regulate the connected line or transformer using external switchgear. With all main and auxiliary relays, annunciation relay, fuses, connections, switches, wiring, labels, terminal blocks, earthing terminals, base frame, foundation bolts, lighting, cable glands, etc., the control and relay panels are complete in and of themselves. These panels are used to monitor and control electrical equipment including circuit breakers, transformers, and generators. The IDMT Numerical relay, Master Trip Relay, Trip Circuit Supervision Relay, Indicators & Meters, etc. are all included in the indoor control panel for the outside VCB. Depending on the needs of the client, these control & relay panels are offered in a variety of single circuit and multi-circuit configurations.

In different 11KV and 33KV zonal substations, a control and relay panel is intended to regulate the connected line or transformer using external switchgear. With all main and auxiliary relays, annunciation relay, fuses, connections, switches, wiring, labels, terminal blocks, earthing terminals, base frame, foundation bolts, lighting, cable glands, etc., the control and relay panels are complete in and of themselves. Transformers, generators, and circuit breakers are just a few examples of the electrical equipment that is controlled and monitored by these panels. The numerical relay, master trip relay, trip circuit supervision relay, indications & metres, etc. are all included in the indoor control panel for the outside VCB. Depending on the needs of the client, these control & relay panels are offered in a variety of single circuit and multi-circuit configurations.

Offering specialised solutions for distribution networks in the utility, industrial, and infrastructure sectors. In a main distribution substation, a Control & Relay Panel (CRP) solution is intended to regulate a number of feeders using medium and high voltage interior and outdoor switchgear. It is often used when the related switchgear cannot fulfil the substation's demands for protection, control, and monitoring. A separate control room is not necessary if the CRP solution is expanded to include substation HMI, time synchronisation, metering, and networking functions at the substation. The safety of the substation engineer is also improved by the use of CRP solutions since exposure to live switchgear is reduced. So, it is created and tailored to perfectly meet the needs of a certain client site.

Individual Circuit Panels

Feeder Panels

An 11KV or 33KV switchgear feeder panel design comprises of feeder circuits. These panels are offered as two O/C and one E/F element over current and Earth fault relays. For producing the alarm during a fault state as well as for annunciating the kind of faults and breaker status information, a single point annunciator is offered feeder panel show in Figure 1.

Figure 1 Feeder Panel.

Transformer Panels

An 11KV or 33KV switchgear transformer circuit is part of a transformer panel arrangement. At 11 kV and 33 kV ratings, these panels are provided as over current & Earth fault relays with two O/C and one E/F element each. As well as annunciation to identify the kind of faults and breaker status information, single point annunciators are supplied for triggering the alarm during different sorts of transformer fault conditions.

Several Circuit Panels

One Transformer and One Feeder Panels

These panels are designed for either 11KV or 33KV switchgear or combine a transformer and a feeder circuit in a single panel.The transformer circuit must be the same as in a transformer panel with a single circuit. Similar to a single circuit feeder panel, the feeder circuit must be the same.

Multicircuit two feeder panels with two feeder circuits each

These panels have two feeder circuits each. In that there will be an extra feeder circuit in lieu of the transformer circuit, these panels are an identical reproduction of the multi-circuit, one transformer, and one feeder panel.Two transformer circuits are included in a single panel by a two-transformer control & relay panel. In that there will be an extra transformer circuit in lieu of the feeder circuit, these panels are an identical clone of multi-circuit, one transformer, and one feeder panels.

LITERATURE REVIEW

Achmad Jamaaluddin, etal. explored the panel system power distribution is made up of various components, including a 20 KV Cubicle, a 20 KV step-down transformer for 380 V, and a novel panel for the user called the LVMDP (Low Voltage Main Distribution Panel)[1]. Please be aware that the power factor is adjusted using a capacitor bank before distribution to consumers. A capacitor bank with a worse power factor experiences an inductive load that causes the bank to operate at high temperatures and eventually blow up. This paper suggests a safety panel automation power distribution control system employing a microcontroller to circumvent this problem. Microcontroller (Arduino Nano), Light sensor (LDR), Temperature sensor (LM35DZ), LCD 16x2 I2C, Actuators (Fan, Buzzer, Relay Switch Breaker Network Three Phase), Switch (Relay 5 VDC), and ADC as Input Data make up the control system microcontrollers for safety panel power distribution. According to the LM35DZ microcontroller's operating principle, the fan will flash if the sensor detects a high temperature, and the buzzer will ring as a warning of the hazards and the power network will be stopped if the LDR sensor detects sparks. It is possible to avoid fire breakouts at power distribution panels from being caused by high temperatures or sparks, as well as through the design of a safety gadget.

Tolga Oğuz etal. explored control algorithms for the energy flow of a hybrid energy generating system made up of various solar panel types (monocrystalline, polycrystalline, and thin film) and a fuel cell were performed, it was practise for efficient and effective energy utilisation. In order to utilise the energy produced efficiently and effectively in hybrid power producing systems, which include solar panels, battery packs, fuel cells, and direct current and alternating current loads, an Arduino microcontroller-based control system was developed. Relays were used to route the energy, and a computer application called LabVIEW was used to monitor and save data related to the energy producing system as well as manually operate some of the relays[2]. The control system created for controlling energy flow kept track of the electrical energy generated by each solar panel, the energy requirement of the load, and the charge-discharge state of the batteries. The performance of these three control methods was compared after data analysis. Which of these three distinct control algorithms used the least amount of energy was shown to be the most effective.

Arief Nugraha, etal. explored how to forecast the Buchholz relay's performance using traditional approaches. The conventional approaches simulate a fault by injecting a phenomenon into an oil-immersed transformer.The functioning mechanism of the Buchholz relay, a kind of mechanical relay, is affected by the tendency of oil and gas in the transformer tank to migrate into the expansion tank via the connecting pipework[3]. An essential element of the oil-immersed transformer protection theory is this device. The method for simulating alarm or trip situations was an electronic circuit-based simulator that is combined with a circuit breaker operation control panel. For creating an alert and trip, the performance measurement offers simulated fault situations. the ability to mimic problems by briefly pushing a push button to create the appearance of an alert situation. In such situation, the CB's control panel does not function; instead, an alert signal is sent. Thus, the status check trip is still normal or "no lock-out," and the buzzer rings. The control panel marks the two CBs (side of 150 kV and 20 kV side) as being open and simulates trip circumstances on the Buchholz relay by applying full pressure. The alarm signal designation also takes place with the buzzer blaring. By monitoring pressure changes in the transformer oil or local heating, the Buchholz relay may detect the presence of gas. The performance of the Buccholz relay is known when all the requirements have been stated.

Hoon Gi Huh, etal. explored the variations in the global energy markets have had a significant impact on the Republic of Korea's (ROK) demand and supply for energy. A scenario like this has given rise to the need for facility upgrades at power plants. In order to increase transient stability, automated generator voltage control systems in large-scale power plants are using a rapid-response static excitation technique. The 1000 MW-class nuclear power station is now operating a large-scale, triple-redundant excitation system that was developed domestically and commercially, and its effectiveness has been confirmed at the same location [4]. A dependable and inexpensive redundant digital excitation control system was created and implemented in this research to address the cost issue, since such a system is too expensive for smaller power plants. With dual (redundant) design, the system's stability and dependability have both increased. After being applied to the gas turbine utilised in a thermal power plant, a number of control function tests were performed to evaluate the system's performance. Each component of this research was verified as a consequence of the construction of system hardware, simulations, and on-site trials. The paper also analyses and supports the technique utilised to replace the protective relays at the Papua New Guinea-based Kanudi power station. In the current power plant, protective relays 27 and 81 needed to be replaced because they weren't working correctly. After disconnecting the power supply from the old panel, new relays were fitted. As prior protective relays only enabled monitoring without releasing the contents, the individual power output portions of new relays were linked in parallel with the operational relays already in place. As a result, the new protection system was created so that both new and current relays could perform the detecting function. The effectiveness of the replacement was confirmed. The new system with the new relays is operating as intended, safeguarding its power generator and averting more mishaps.

R Radhakrishnan, etal. explored an effective MPPT DC-DC (Buck-Boost) converter is used in a hybrid PV-AC system, and a control approach for managing power flow is described. The suggested system uses a microcontroller coupled to a hybrid supply via a relay to meet load demand, eliminate power outages, regulate the flow of power from various sources, and inject extra power from the grid to charge the battery when electricity from the PV panel is not being gathered[5]. Although electricity from the PV is harnessed together with control over battery charging and discharging and is linked to a relay, power from the AC grid is done so using a transformer-coupled bridge converter. When the energy from the solar panel is gathered, the relay operates as an open circuit; otherwise, it operates as a closed circuit. The rectifier is utilised to draw electricity from the AC grid while the relay is closed-circuit. The performance of the suggested control method for managing power flow is shown by simulation results acquired using MATLAB/Simulink in a variety of operating modes. In-depth experimental tests are used to confirm the effectiveness of the proposed system and the simulation model. This allows MATLAB/Simulink and the hardware model to show how the system can operate in a variety of modes.

Wen Kamezaki, etal. explored the subsurface facilities must undergo regular inspections to ensure their long-term safety. Many mobile inspection systems are in use, however owing to intermittent wireless connectivity and cable limits in complicated facilities, certain significant issues with the short inspection distance still persist. We suggest a wheeled robot chain control system (RCCS) for inspecting subterranean facilities based on visible light communication (VLC) and solar panel receivers to address these issues. The RCCS comprises of a leader and follower robot and uses specialised "optical signal relay" technology to increase the inspection range. In comparison to traditional radio communication in intricate subterranean facilities, VLC may provide not just light for inspection but also reduced attenuation, greater information security, and stronger ant electromagnetic interference capacity. As comparison to traditional photodiode (PD) receivers, using solar panels may enhance the reception area of optical signals, environmental adaptability, and system resilience. Moreover, we create an optical signal relay mechanism and an attenuation control module to enable longer and more reliable connection. To assess the signal waveform, communication quality, effective communication area, and cooperative movement, we carried out a number of studies. The findings suggested that the proposed system, as opposed to a VLC-based system with PD receivers, might increase the inspection range while maintaining improved communication quality and environmental flexibility.

Iyere Aniebiet Idim, etal. explored to overstate the value of automated irrigation control systems in agriculture. The project demonstrates the design and execution of a "Solar Powered Automatic Sprinkler Irrigation System" that automatically turns on a DC water pump to irrigate a field depending on the set-time and time interval specified into the microcontroller. In order to save water, energy, and time, the developed system substitutes the traditional manual method used in sprinkler watering with an automation approach[6]. The project's goal is to reduce human operator participation in agricultural irrigation operations while improving water management in the process. The system's design used a number of different parts, including an AT89C51 microcontroller, a DC water pump, a relay, an LCD, and other electrical parts. The AT89c51 microcontroller served as the foundation for the whole system. Assembly language was used to programme the microcontroller. The microprocessor activates a 12-volt relay that automatically powers the DC water pump for three minutes after the predetermined time has passed. Every day at 7 a.m. and 7 p.m., irrigation is conducted to get the desired outcome. With the keypad, the microcontroller receives input in the form of time. The microcontroller and LCD are interfaced to show the system status. The system's whole energy needs are met by the 12v, 130watt Mon crystalline solar panel and the 60AH deep cycle (solar) battery linked to it. The system has shown to be a respectable improvement in irrigation technology.

DISCUSSION

Relays for protection with several uses

Protection, control, measurement, and automation features are all included in one device with SIPROTEC 4 and 5. SIPROTEC 4 and 5 earns high recognition among users all over the globe because of its homogeneous system platform, distinctive DIGSI 4 and 5 engineering programme, and substantial experience of more than a million effectively working devices in the field. In all sectors of application, SIPROTEC 4 and 5 is the industry standard for digital protection technology today.Setting the standard for cutting-edge, ecologically friendly technology is RELISERV SOLUTION. With an internal dedicated R&D facility and software development staff, RELISERV SOLUTION is a multi-specialist in power protection, encompassing everything from Design to Maintenance. With regards to control and relay panels, realiser solution has more than ten years of expertise.

For a broad range of energy sources including solar, thermal, hydro, nuclear, and wind, reliserv solution provides a comprehensive suite of protection solutions ranging from single components to entire Turnkey Integrated Smart Grid Solutions and related services.Lighting and accessories for the control and relay board panels are as follows: Each cubicle interior unit (both the control and relay panel) should be lighted by LEDs linked to 230V single phase AC via an individual switch for duplex type panels and a door switch for simplex type panels. The inside lighting must not cast hand shadows and must be intended to prevent any strain or tiredness on the wireman that might be brought on by poor or uneven illumination. Moreover, one emergency D.C. light (LED) with the appropriate identifying symbol must be supplied for each panel with a separate switch.The duplex type control and relay board formation's corridor should be adequately lit by a sufficient number of AC-operated LEDs through the door-operated push-button switch that is supplied on each side.One 15 Amp 3 pin power socket outlet and plug pins must be supplied in each panel at a suitable location, with markings at the bottom for receiving an AC supply wherever it is needed.

Space Heaters

To avoid condensation of moisture, a tubular space heater appropriate for connection to the single-phase AC supply in each panel (both the control and relay panel in the case of a duplex type), complete with switches and a thermostat positioned in a convenient location, must be supplied. The heater's watt loss per unit surface temperature must be low enough to maintain surface temperatures considerably below the permitted heat. In order to maintain 10 degrees Celsius above the typical ambient temperature during the rainy season, the heater's wattage must be such that it does not in any way harm the insulation around the panel's wiring.

Security Earthing

A secure ground bus must be attached to every panel, and the inner base of every panel must reach the full length of the C&R board formation. The earth bus bar must be copper and measure 25 mm by 6 mm in size. If any additional nearby panels need to be added in the future, provisions must be provided for extending the earth bus bars into those panels. At the end panels, a connection point to the system earth grid mat must be provided.

1. Earthingcurrent-free metallic components or metallic bodies of the switchboard's equipment must be done using a soft drawn conductor with a minimum cross-sectional area of 2.5 sq. mm.
2. Instrument transformers' neutral points on the star-connected LV winding and one corner of the open delta-connected LV side must both be earthed to the switchboard earthing system's main earth bar.

Links and fuses

There must be a readily accessible H.R.C. Cartridge fuse and connection with an appropriate current and voltage rating within the cubicle. The main and sub circuit fuse ratings must be chosen in such a way as to guarantee the selective clearing of sub circuit faults. Fuses must have operational indications to show when a fuse is blown. Rating, voltage, and circuit identification imprints must be visible on fuse carriers and bases.These lights must be of the LED kind and able to run on S/S D.C. voltage, AC voltage, or P.T. secondary supply as and when necessary. Each lamp must have a rear terminal connection, be interchangeable, and allow for simple replacement from the front of the panel. Lamps must have transparent lamp covers that are either clear white, red, green, amber, or blue in order to spread light. The lamp cover must be made of heat-resistant material, fastened in place, and unbreakable. On a continuous basis, the indicator lights with resistors must tolerate 120% of the specified voltage.

Management switches

All control switches must be rotary and come with escutcheon plates that are clearly indicated with the switch's state. Just the switch front plate and working handle should protrude from the mounting surface. All such control switches must be available for the remote control of circuit breakers and isolators.The wiring for all control switches must be connected at the rear. The contact mechanism must be actuated by a cam. The contacts must have a silver front and be made for a generous rating of the relevant duty. A detachable, dust- and vermin-proof protective cover must be supplied for the contacts. The protective cover should ideally be constructed of moulded dielectric material that is transparent and inflammable. Springs that will be included in the switch are not to be utilised as components that transport electricity. The switch's given contacts must be adequate for quick installation and disassembly during contact replacement. Strong control switch springs are necessary to guard against accidental activation brought on by a gentle touch on the handle[7]–[10].

Control switches for 400 kilovolt, 220 kilovolt, and 132 kilovolt circuit breakers must be of the discrepancy type with built-in pilot lights and two maintained contact positions for "ON" and "OFF" positions as well as two momentary contact positions for "ON" and "OFF" impulse.

When the control switch is in alignment with the related circuit breaker, the built-in pilot bulb must provide a constant light. When the control switch's position differs from the location of the associated circuit breaker owing to manual operation or automated circuit breaker tripping, the same bulb must provide a flickering light.

CONCLUSION

The contractor must make the necessary arrangements to provide the flickering voltage for the aforementioned function. The aforementioned built-in bulbs attached to the control switches must be connected via a switch to prevent continuous burning. The circuit should be designed such that changing the position of the appropriate control switch will not alter the lamp's winking regardless of the position of the aforementioned switch. At a certain amount of time, which is changeable between 0 and 10 seconds, the control switch pilot bulb must blink, then an alert announcement must occur. Switches with all necessary attachments for the aforementioned function must be provided. Control switches for 400KV, 220KV, and 132KV isolators, as well as 33KV circuit breakers, must have a pistol-grip operating handle with an "ON and OFF" monetary operational position and an automatic return to the neutral position upon release from operated positions.This book chapter explores about the control and relay panel, types of the relay and the panel of the system uses of the relay.

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STANDARD PROTECTION SCHEME FOR SUB-STATION AND TRANSMISSION LINE

Mrs. Kamireddi Sunandana*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

ABSTRACT:

This book chapter explored about the standard protection scheme for sub-station and transmission line when the fault causes in the transmission and the distribution line the effect the power system. Protection mechanisms serve their goal by separating a defective area from the rest of the functioning system, enabling it to function without interruption. Every protection strategy protects a specific region known as a protection zone. Each piece of electricity equipment is enclosed by a protective zone. Just the circuit breaker in that zone trips when a fault occurs in any of the zones. Circuit breakers and fuses are utilised to separate the system from the defective area, while relays are used to detect faults. Breakers serve the dual purpose of isolating the problem and detecting it in low voltage systems. The absence of any deliberate temporal lag is instantaneous. An instantaneous relay has a millisecond operation time. A relay of this kind has simply a pick-up setting and no time setting.

KEYWORD: *Circuit Breaker, Electrical Power, Ground Fault, Line Ground, Power System, System Protection, Transmission Line.*

INTRODUCTION

Systems for Electrical Power System Protection

A lot of money is invested in the electrical power system. The necessity to preserve electricity increases as we strive for more dependable power. To prevent equipment and workers from being damaged in any way by an electrical imbalance or fault state, protection is crucial. Continue reading as we discuss the goals of power system protection, various protective mechanisms, and methods designed to provide an electrical power system total safety.Protection mechanisms serve their goal by separating a defective area from the rest of the functioning system, enabling it to function without interruption. As its name indicates, a protection system's purpose is not to avoid problems; rather, since it only responds after a defect has already occurred, it lowers repair costs as it detects errors. In this article, many protection strategies are presented. But first, why is safeguarding the electricity grid so important

Power system protection's goals

The major goals of power system protection are to prevent equipment damage and to ensure the dependability of the functioning power system. Two things are kept in mind to accomplish reliability: only the defective component of the system is entirely isolated in a short amount of time so that the other parts of the system continue to function correctly; and in the event of normal circumstances, there should be no nuisance tripping.Circuit breakers and fuses are utilised to separate the system from the defective area, while relays are used to detect faults. Breakers serve the dual purpose of isolating the problem and detecting it in low voltage systems.

Zones of Protection in the Electricity System

Every protection strategy protects a specific region known as a protection zone. Each piece of electricity equipment is enclosed by a protective zone. Just the circuit breaker in that zone trips when a fault occurs in any of the zones. As a result, just the problematic component is unplugged, leaving the rest of the system unaffected.We use the idea of selective coordination in this case since a system may support up to six different sorts of protective zones.

1. Power plants, including generator-transformer units.
2. Transformers
3. Buses and lines (transmission, sub-transmission, and distribution)
4. Making use of equipment (motors, static loads, or other)
5. Banks of capacitors or reactors (when separately protected).

LITERATURE REVIEW

Ing Xiao,etal.explored flexible HVDC transmission line protection techniques now in use often fail to quickly and accurately identify the problem site. A prototype protection mechanism based on modulus power is suggested in relation to this issue. The expression of converter station dc voltage taking into consideration the effect of ac system is developed by examining the dynamic switching process of sub-modules in flexible dc converter station. On this foundation, the modulus power calculation model is developed using just dc components, and the modulus voltage and modulus current are computed using the phase-modulus transformation. Subsequently, a protection criterion based on the modulus power's polarity difference features is constructed after deriving the expressions of modulus power in various fault circumstances. Finally, a flexible dc system model is constructed using rt-lab for simulation verification. The outcomes of simulation testing show that the suggested protection strategy can identify fault lines and fault poles quickly and correctly, with no need for communication synchronisation and simple threshold setting. Moreover, it is unaffected by the unique boundary conditions of the current-limiting reactor as well as the fault resistance.

M. M. Ali, Nasser etal. explored how to include intermittent renewable energy production is one of the main problems that future energy transmission systems must deal with. The integration of multi-terminal transmission and sub-transmission systems into a single grid is the other issue. Although tapping a line is a cost-effective way to avoid constructing new stations, it also poses operational and security risks[1]. Future problems for the defence of contemporary power systems include the aforementioned restrictions. In this work, the communication component is heavily emphasised, and the theory and advantages of novel protection strategies applied to power systems are explicitly stated. A novel idea for employing coordination logic to safeguard several zones is called "w-protection," which uses wireless "wimax" technology. In order to accurately detect the faulty zone utilising wireless networks, such as ieee 802.16-based wimax technology, w-protection develops novel protection solutions. The real-time polling service (rtps) and unsolicited grant service (ugs) scheduling services of the ieee 802.16 standard, as well as the application models that map them over them, are thoroughly investigated. It is also detailed how ieds and the master protection center "mpc" may communicate via wimax's rtps-qos scheduling service and ugs. To assess the effectiveness of the rtps and usg scheduling services in the event of latency, a discrete event model using the opnet simulation package is employed. The first findings suggested that the ieee 802.16 network can accommodate the delay needs of security applications.

N. A. Halim, et.al discussed a lightning strike mitigation strategy for the Kedah paddy field area transmission line tower. The ATP Draw programme creates a schematic representation of a transmission tower hit by lightning and an incoming main intake sub-station. Graphs are then created by simulating various soil resistance levels and soil conditions. Between negatively charged thunderclouds and a positively charged steel transmission tower, a static eliminator lessens the electrostatic force[2]. It demonstrates how a static eliminator causes a transmission line to behave imperceptibly in a lightning path. This protection level decreases the risk of damaging the surge arrestor by preventing surge current from transmitting in the transmission line.

Satish Barik et.al explored about increasing the transmission line capacity between sub-stations allows for the transfer of more electrical power, which is rising day by day as we all know. Long transmission line systems sometimes experience problems including single line to ground faults (L-G), double line to ground faults (2L-G), triple line to ground faults (3LG), and line to line faults (L-L)[3]. These fault types damage the equipment and components of the electrical power system that are connected to the EHV transmission line. Long transmission lines often have (L-G) single line to ground faults, which are dangerous for the electrical equipment. In order to analyse and locate the faults, a suggested model for a 300km/440kv EHV transmission line is simulated in the MATLAB programme. The fault block was obtained from the collection of sim-power system blocks. This study presents the proposed work's whole modelling and simulation of various operational and diverse situations of fault on EHV transmission line, including the faults L-G fault, 2L-G fault, 3L-G fault, and three-line short circuit. Many forms of faults may occur in electrical power systems, which leads to the analysis and detection of transmission line faults as well as the calculation of bus voltage and line current. Bus voltage and bus current are crucial when discussing a lengthy transmission connection with the electrical power system. In lengthy transmission lines of power systems, three phase balance faults and three phase unbalance faults are the two types of problems that often occur in three phase electrical power systems. Line to ground faults, double line to ground faults, and triple line to ground faults are three different kinds of faults. The ability to identify faults in EHV transmission lines aids in the development of stronger protective measures. Circuit breakers are used to safeguard lengthy transmission lines, and their ratings are determined by L-L-L faults. The triple line fault current is much higher than other fault currents, which is their justification. As a result, we were able to readily identify and analyse the EHV transmission line issue using MATLAB simulation on a computer. This paper's primary goal is to examine common fault types, such as balance and imbalance faults of long transmission lines in the electrical power system. We must conduct detection and analysis as well as collect results for a number of different parameters, including current and voltage.

P. Sundaravaradan, etal. discussed comprehend, and analyse frequency domains since transmission lines constitute the key connection between producing stations and distribution substations. This makes them an almost important instrument in contemporary research. Wavelet analysis may be used to get information about the sub-band frequencies. We employ a mother wavelet to carry out the wavelet multiresolution analysis (MRA) [4]. The choice of the mother wavelet has a significant impact on the ability to identify and analyse transmission line defects. An essential part of power system protection is isolating the defective line(s), which also safeguards the equipment and extends its usable life while preventing a catastrophic catastrophe. Due to its many applications, transient signal analysis in the frequency domain has gained popularity recently. The analysis provides a great deal of data on the frequency content of the signals. A well-known technique for converting time-domain data into frequency-domain signals is the wavelet transform.

DISCUSSION

Power System Protection Devices

Let's go over some fundamental parts of the power protection system before we talk more about protection schemes: Batteries, a fuse, an instrument transformer, a relay, a circuit breaker, a surge protection device.

Fuse

The self-destructing gadget is called Fuse. It continuously moves the current through a power circuit and makes a sacrifice by blowing itself up in unusual circumstances. Unlike a circuit breaker, which always needs the help of other components, they are autonomous protection components in an electrical system.

Transformer for instruments

Without accurately assessing a system's normal and abnormal circumstances, accurate protection cannot be provided. In electrical systems, instrument transformers serve as a transducer. Voltage and current measurements provide information about the state of a system. These fundamental characteristics are measured using voltage transformers and current transformers instrument transformer show in figure 1.

Figure 1 Instrument transformer

The current transformer is responsible for two tasks. Secondly, it reduces the current to levels that the relay current coil can manage with ease. The relay circuitry is isolated from the high voltage of the high voltage system, secondly. The line in which current is to be measured is connected to a CT primary in series.The voltage transformer reduces the line's high voltage to a level that is safe for both workers and the relaying system's pressure coil to manage. If a measurement is required, a PT primary is connected in parallel.

Relay

Relays function as sensors. These relays are known as the brains of power systems because they are capable of making judgements on fault recognition. Relays work by monitoring voltage and current readings, translating them into digital and/or analogue signals, and then opening the problematic circuits to isolate the circuits they are operating on. The relays typically have two purposes: to trip and to warn whenever an irregularity is detected.The relays' capabilities and size were very constrained in past years. Nevertheless, relays now monitor a variety of factors as a result of advancements in digital technology, providing the whole history of a system [5].

Consider reading Power System Protection Basics. We briefly covered "Types of protective relays & design requirements" in this course. We began with an overview of the construction and operation of a relay, which is based on a protective system. The examination of the variables to be taken into account while constructing a relay-based protection strategy then continued. Next, we created distance or impedance relays, directional relays, and overcurrent relays. Details about relays and reverse power flow relays.

Circuit Breaker

The circuit breaker is an electrically powered switch that may open and close circuits in a secure manner. The associated relay's output drives the circuit breaker. The closing spring's tension keeps the contacts of the circuit breaker closed while it is in the closed state. When the trip coil is activated, a latch is released, releasing the closing spring's stored energy to quickly open the door.It takes some time to open defective circuits. These fault currents may be carried by the circuit breakers, which are employed to isolate the defective circuits, until the fault currents are cleared circuit breaker show in figure 3.

Figure 3 Circuit breaker [Wikipedia]

According to many design factors, such as arc quenching medium, operating mechanisms, voltage levels, etc., circuit breakers may be categorised.

Batteries

Batteries, which are needed to provide continuous power to relays and breaker coils, are the other essential part of a protective system. Relays and breakers need power sources to function, and those power sources must be fault-free[6].

Gadget for ESD Protection

The electrical components are shielded from electrostatic discharge by an ESD protection device. The accumulation of charges known as electrostatic discharge may harm protective circuitry and result in malfunction.

Gadget for surge protection

A surge protector is a tool for electrical equipment protection that reduces voltage spikes. By ensuring that it stays below a safe threshold, this device makes an effort to restrict the provided voltage to an electrical equipment. Every protective system that uses the aforementioned components significantly must carefully consider and choose them for optimal performance.

Protective Programs

Since power system development leads to new issues for protection engineers, a number of protective methods are developed throughout time. We'll talk about the most fundamental ones here.

Overcurrent Protection System

The most evident concept of protection is an over-current protection method because it may identify a rapid increase in current magnitude that is thought to be a fault effect. Yet, the kind of problem and the source impedance both affect how much fault current there is. The source impedance fluctuates depending on the number of producing units that are running at any particular moment. As a result, the operating duration of over-current protection as well as the set point for separating the amount of the fault current from the normal current fluctuate from fault to fault. Protection engineers have now considered other tenets as a result[7]–[9].

Automatic Overcurrent Relay

The absence of any deliberate temporal lag is instantaneous. An instantaneous relay has a millisecond operation time. A relay of this kind has simply a pick-up setting and no time setting.

Relay for Definite Time Overcurrent

An adjustable fixed period of time after it picks up is the time at which a fixed time overcurrent relay may be set to deliver a trip output. As a result, it has pick-up and time-setting adjustments[10].

Relay for Inverse Time Overcurrent

The inverse time characteristic is consistent with the rule that, in order to prevent damage to the equipment, a problem should be fixed as quickly as possible the more serious it is.

Differential Protection Plan

The premise of differential protection is that the current entering and exiting a protected region must be equal. A defect is present if there is a discrepancy between the two ends of a single segment. As a result, we may contrast the two currents' phase, magnitude, or both.

If the two ends of a device are located relatively near to one another physically, this approach of defect finding is quite common. In the event of an external fault or through-fault that is outside of its protective zone, it should stay stable and should only trip if the problem is internal. This protection's stability is determined by its capacity to distinguish between internal and external flaws. Nevertheless, since the endpoints of a transmission line are so far apart, it is impractical to employ this approach because it is impossible to equal information.

Distance Protection Program

The voltage and the current are related at the same end in a distance protection system. This method determines the impedance between the fault site and the protection location. To decide whether to go on the trip, it then compares it to a predetermined value.Due to the simple series model, it is possible to immediately relate the impedance of a transmission line to the distance of the fault in a line, which aids in pinpointing the site of the problem. Distance protection or under-impedance protection are two terms used to describe this form of defence. In actual use, the phrase "under" is deleted, and impedance protection is now the only term used.

CONCLUSION

When a defect is supplied from both ends, such as in a double-end feed system, parallel lines, or ring main system, a directional protection method becomes effective. This sort of protection is sensitive enough to identify the fault power flow's direction from the standpoint of selection. Such circumstances may call for the adoption of a directed system to control overcurrent schemes. Only utilise directional protection devices when absolutely necessary since they are substantially more expensive and need the installation of power transformers.In this book chapter we discuss about the standard protection scheme for sub-station and transmission line when the fault causes in the transmission and the distribution line the effect the power system and damage the equipment in the power system.

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ANALYSIS OF TRANSMISSION LINE WITH A 220 KV RATING

Dr. Rajiv Singh*

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

ABSTRACT:

This book chapter, provides a detailed analysis of the transmission line with a 220 KV rating in power systems settings. When the surrounding ground is in such poor condition that there is a possibility of an accident from it collapsing, pits will be backed up with shuttering. Design, engineering, manufacturing, supply, fabrication, galvanizing, prototyping, assembly, and testing, as well as inspection prior to delivery, are all covered by this standard. When analyzing illumination flashover rates, the tower footings' resistance is a key factor. Unfortunately, it is a statistical variable whose size depends on both geography and non-linear conduction physics in the ground. The design of tension towers, d-shackles, extension links, etc., must have a minimum electromechanical strength or ultimate tensile strength as specified when used with single and double tension strings to achieve needed clearances.

KEYWORDS: *Earth Wire, Extension Links***,** *Power Line, Steel Pole, Transmission Line.*

INTRODUCTION

For all of the tower sites, it is advisable to test the soil, and results should be received on the sub-soil water the kind of soil that was identified, its bearing capacity, the likelihood of submersion, and other soil attributes necessary for the accurate casting of foundation casing. Testing for soil resistance has to be done during the dry season, and the findings need to be well documented together with a map showing the layout of the route. After a soil analysis along the alignment of the line, the final quantities of different foundation types should be calculated. These foundations should only be cast and laid after the necessary inspection and approval.

Unless specifically indicated differently, all footing excavation should follow the lines and grades of the foundation. The excavation walls must be vertical and the pit dimensions must be such that they provide a clearance of no more than to maintain a clean sub-grade until the foundation is installed, employing, where necessary, timbering, shoring, or casing. Any sand, mud, silt, or other undesirable materials that may have accumulated in the excavation hole must be taken out before pouring concrete.

To build a skyscraper, under classified dirt must be mined

Typical dirt soil types found in broad plains and black cotton soil that may be removed with regular pick axes, shovels, and spades.Wet soil is described as soil that has a subsoil water that is within the range of the foundation depth, soil that is below the water, and soil in locations where surface water is present and water pumping or bailing out is required.Decomposed rock, hard gravel, kan kar, lime stone, laterite, and other soils of a similar kind are examples of soft rocks that are easily excavated with a pick axe or shovel.

Drilling, blasting, or chiselling are required for hard rocks

If rock is found, drilling the holes for the tower footings is preferred; however, if blasting must be utilised to save money, it must be done with the utmost care to minimise the need for concrete to fill the blasted area. You must take all necessary precautions in order to use and handle blasting materials safely. With the engineer's approval, the stubs may be suitably shortened if drilling is done.Pits are shored with shuttering when the soil quality is so bad that there is a risk of an accident caused by the surrounding earth falling. Depending on the conditions at the site, the supervising engineer will decide whether or not pits need to be shored up with shuttering. Depending on the calibre of the water in the pits, one of the following dewatering methods will be utilised.

Manual

In this instance, men use buckets and other instruments to manually dewater the area.

Mechanical

Dewatering the area using a hand pump

Power driven

When dewatering pumps with a power input of at least half HP are driven by engines or electricity.

The stub has to be correctly established in accordance with accepted procedures, at the precise levels, in the proper location, alignment, and alignment. Use the stub setup templates to build up stubs properly. Stubs must be set in the presence of an experienced junior engineer or assistant engineer. Before the foundations can be erected, the designs and drawings must be approved by the Engineer. The work's scope should not be expanded upon unless very unusual circumstances need the Supervising Engineer's prior approval. Stub installations at each location need approval from the Assistant Engineer or Executive Engineer.

The thickness has been designed in accordance with the guidelines given below. The minimum section of chimney would be 300 mm square because the concrete in the tower footing's chimney component would be thick enough to provide a minimum cover of at least 100 mm from any portion of the stub angle to the nearest outside surface of the concrete with reference to all dry areas. The chimney should have a minimum square size of 450 mm and should be placed 150 mm away from the tub angle in all wet regions. The coping must reach the lowest joint level between the bottom lattices and the main corner leg of the tower, which must be at least 225 mm above the ground.

Any concrete slabs or pyramids should not have a vertical spread more than 45 degrees. A pad at least 50 mm thick and the same size as the bases of the pyramid with its side vertical will be provided below the pyramid to account for the unevenness of soils and impurities that are likely to be mixed with concrete due to direct contact of wet concrete with earth and to allow stone aggregate reaching up to corner edges. This pad will also be accessible when pyramids are built on top of concrete slabs.

In the case of a foundation of the entirely submerged type, one base slab with a thickness of at least 200 mm has been provided. In the case of dry locations, the minimum distance between the lowest edge of the stubs angle and the bottom surface of concrete footings shall not be less than 100 mm or more than 150 mm, and in the case of wet locations, not less than 150 mm or more than 200 mm. The portion of the stub in the pyramid has been provided with cleats.

Earthing

When all towers have been put up but before earth wire has been stretched, their footing resistance has to be assessed in dry weather. Where required, pipe type earthing or counterpoise earthing must be done in accordance with this specification if the tower footing resistance is more than 10 ohms.

Pipe ionisation

The process of grounding involves digging a pit that is approximately 300 mm in diameter and 3750 mm in depth, not less than 3650 mm away from the stubs. The pit is then filled with salt mixed with finely broken coke with granules no larger than 25 mm, making sure that the top edge of the pipe is at least 600 mm below the surface. The G.S. strip has to be buried at least 600 mm Pipe ionisation show in figure 1.

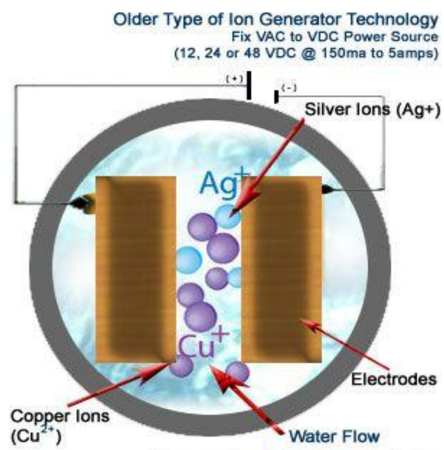

Figure 1 Pipe ionization

In opposition earthing

Counterpoise earth, a special earthing mechanism, must be utilised in place of high resistivity soil in order to lower the tower foundation resistance to 10 ohms. The counterpoise earth must be constructed of 7/9 SWG. Galvanized steel wire with the proper G.S. lugs soldered or compressed at one end is required, together with 16mm dia. bolts and nuts, to connect the earthing to the tower end. The counterpoise has to be buried radially out from the tower base at a depth of 600 mm. It is preferable to bury the lug in the foundation's chimney area to avoid theft. Receptivity of the soil and the tower footing's resistance

The tower footing resistance is an important consideration when estimating lighting flashover rates. Regrettably, it is an unstable statistical variable, and non-linear conduction determines its magnitude. Earth's physics and geography are also involved. It may fluctuate by a factor of two or more due to fluctuations in stroke current, and even with constant current, it will change with time.The earth's resistance is anything from constant, even locally. We may be able to infer the general order of soil receptivity at a specific location based on the kind of soil, temperature, seasonal variations, etc. There is no way to estimate with any degree of precision the expected resistivity of the electrode resistance in a particular place. It is always necessary to do an actual measurement in order to determine the earth resistivity in a certain situation. The results indicate that the four electrode approach is the most efficient, with a significant electrode spacing of around 50 metres.

Four-Element Approach

The well-known Earth Receptivity Tester makes it simple to undertake the four-electrode resistivity measurement method. It has a generator that produces DC at 500 or 1000 volts using current coils connected in series. The potential coil has a unique inclination out to four different terminals, and the current coil and potential coil are connected to the same shaft (C1, C2, and P1, P2, respectively). While the generator is running, both the potential and current coils have a propensity to rotate anticlockwise to one another in the field of a permanent magnet. When the instrument is connected to a test earth and the generator is switched on, the position of the combined current-potential coil will be proportional to the V/I ratio, or the mutual resistance between the current and potential circuits. At the region where the soil resistivity is to be measured, four equivalent electrodes are put into the ground at equal intervals of 50 metres. There are four terminals named P1, P2, C1, and D1 on the Earth Resistively Tester (should be driven about 1 metre depth). If these electrodes are labelled as A, B, and C, the extreme electrodes A and D should be connected to C1 of the Earth Tester. Connect P1 and P2 with the electrodes B and C, respectively. By continuously spinning the Earth Tester Handle at one speed, we can read the electrode resistance, or "R," on the Earth Tester scale.

The following are covered by this specification: design, engineering, manufacturing, supply, fabrication, galvanising, prototyping, assembly, and testing; inspection before dispatch; delivery of different types of steel pole structures for transmission lines (as specified by the utility) at the site; design of foundations; laying of foundations along with supply of complete foundation material; and erection of steel pole structures with accessories for conductor & earthier/OPGW and Also, a thorough site survey, profiling, tower/steel pole structure spotting and tower position optimisation, soil resistivity testing, and geotechnical research should be part of the bidder's scope. All raw materials, such as steel, zinc for galvanising, reinforcement steel and cement for the tower foundation, coke and salt for the tower earthing, anchor bolts & their templates, bolts, nuts, washers, D-shackles, hangers, links, danger plates, phase plates, number plates, circuit plates, anti-climbing devices, Bird Guard, etc., that are required for the creation and erection of tower/pole structures are included in the scope of supply for the bidder. The source(s) from which the bidder expects to get the components and raw materials must be explicitly stated in his offer. Throughout, conductor and earth wire must be linked together using approved stringing methods.

Basic Information

The steel pole structures must be used for the entire line, a section of the line, or just a few locations along the line, and they may be single circuit, multiple circuit (indicate the number of circuits & voltage level), multiple circuit & multi-voltage (indicate the number of circuits at each voltage level), or any other configuration (indicate the configuration). The number of poles (dual or multiple poles) should be selected based on the voltage level, the number of conductors per phase, the number of circuits, etc. The stem Self-supporting polygonal steel pole structures that are designed to handle line conductors with the proper insulators, earth wires or OPGW, and all fittings under all loading conditions are preferred. The pole construction has to be fully galvanised. The best quality of structural steel and plates must be used to create a tower/pole structure and base at the lowest cost achievable. The most current national and international standards must be followed when choosing the kind and grade of mild steel. Moreover, cross arms must be constructed from polygonal sections[1]–[3].

DISCUSSION

Common Design Span Routes for transmission lines (66 kV and higher voltage levels) must be clearly marked as regular sections without restrictions, sections through forests, sections through cities or other heavily populated areas, and sections that approach substations. The typical design span for different transmission line voltage levels, must be used in each of these parts.Airflow Range the wind span is created by adding the two half spans close to the support under consideration. This is equivalent to the horizontal ruling span. A maximum wind span that is 1.1 times the normal rule span must be considered in tower design. The weight span is the horizontal distance between the lowest points of the conductors on the two spans near to the pole structure. In structural design, the maximum weight span constraints are employed.

Ground Protection

Conductors are required to maintain a minimum ground clearance in accordance with the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations. Therefore, maintaining electrostatic & electromagnetic interference, radio interference voltage, audible noise, etc. within acceptable limits becomes a controlling requirement for transmission lines of 400 kV and higher voltage class. The minimum ground clearance from the bottom conductor is required under maximum sag circumstances that is, at the highest temperature for standard ACSR/AAAC conductors or at the highest temperature allowed for High Temperature Low Sag (HTLS) conductors in still air ground protection show in figure 2.

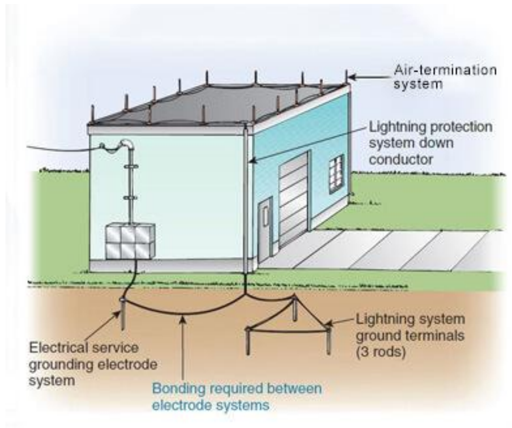

Figure 2 Ground protection

From Phase-to-Phase Clearance

The minimum phase to phase vertical and horizontal clearance will be determined by the minimum live metal clearances required for different insulator swing angles, as well as the tower design and geometrical arrangement.

The clearance at mid-span

The vertical clearance in the usual ruling span, including still air conditioning, between the earth-wire/OPGW and the closest conductor. Between the earth-wire/OPGW and the closest power conductor, there must be a minimum vertical mid-span clearance that is more than those values. Also, the earth-wire and power conductor tensions need to be balanced such that the sag of the earth-wires and OPGW is at least 10% lower than that of the power conductors in all temperature loading scenarios.

Train Overpass

Every railroad crossing that crosses the transmission line must be noted by the Contractor, and all guidelines issued by the Railway Authority must be followed. The railroad authorities' consent must be obtained before starting work on a railway crossing.

Power lines crossing

When one power line must cross another power line, poles with enough extensions may be used, depending on the condition of the existing site scenario. When a power line of 400 kV or above in voltage class, large angle poles with deviation angles of 30 to 60 degrees that are meant for dead end scenarios and have the requisite body extension must be utilised on both sides. Electricity lines of the voltage classes 110 kV, 132 kV, 220 kV, and 230 kV must be crossed using tension poles with the appropriate body extension, whereas power lines of the voltage class 66 kV may be crossed using any kind of pole (suspension or tension) with the required body extension. According to the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, the space between lines that cross each other must be maintained, and in cases of tension pole crossings, proper guying must be installed to allow for the stringing of the power line crossing sections separately after obtaining line shutdowns. To reduce the height of the crossing towers, it may be preferable to cut the ground wire of the line to be crossed (if this is possible and permitted by the owner of the line to be crossed)

Telecommunication line crossings

When crossing telecommunication wires, one must adhere to the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations and PTCC (Power and Telecommunication Co-ordination Committee) Guidelines. Angles at crossings must be as near to 90 degrees as is practical. But, under really difficult conditions, a deviation of up to 30 degrees can be permitted. When the necessary angle of crossing is less than 60 degrees, the problem will be notified to the entity in control of the telecommunications system. At the Contractor's request, the Employer may submit a request for authorization to the telecom authority. Moreover, power line support will be positioned as near to the telecommunication line as is practical in the crossing span to increase the vertical clearance between the wires.

Connecting a Road and a River

The tower must generally be equipped with a normal tension insulator at all significant road crossings, but the ground clearance at the roads must be such that, even in the event that the conductor in the adjacent span breaks, the ground clearance of the conductor from the road surfaces will not fall below the minimum ground clearances specified in the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations. All national and state roadways must use tension type towers (with deviation angles of 30-60 deg.) with tension insulator strings, unless a wider span is permitted by the national roads authority in the case of a highway with more lanes. Rules set out by highway authorities must be followed.

River Bridges

If there is a substantial river crossing, there must be river crossing towers of the suspension type as well as anchor towers of the tension type on each side of the main river crossing (with a deviation angle of 30-60 degrees). Due to costs and/or site/execution constraints, the crossing of rivers using conventional extended angle towers must be taken into account. Rivers that may be navigated must have the proper authorization from the navigation authority. Rivers that cannot be traversed must have clearance determined using the greatest flood stage (HFL). A minimum of two sets of long rod insulators or two sets of disc insulator strings per phase shall be used at power line crossings (66kV or higher), railways, or road crossings (express way, national highway, and state highway).The bidder shall use the same cross arm design where the jumper extends outside of the cross arm for the PD/DPD/MCPD/MVPD type tower that will be used as a dead end angle tower.

Arrangement of an earth wire and a conductor a single earth wire must be used for transmission lines up to 220 kV, whereas transmission lines 400 kV and higher voltage classes need the use of two earth wires. On 66 kV voltage class lines, OPGW, galvanised stranded steel (GSS), or aluminium alloy conductor steel reinforced (AACSR) type earth wire must be used. An OPGW earth wire must be used for lines with a voltage class of 110 kV or higher; for lines with a voltage class of 400 kV or higher, at least one of the two earth wires must be an OPGW, and the second earth wire must either be of the galvanised stranded steel (GSS) conductor type or of the aluminium alloy conductor steel reinforced (AACSR) conductor type[4]–[6].

Earth wire insulation strings and clamps Attachments

(a) The contractor shall use insulating components that have been approved by the customer for suspension and tension pole constructions.

(b) In order to get the required clearances under the different swinging conditions of the strings, a properly sized swinging hanger on the pole must be supplied if necessary for the attachment of suspension insulator strings. The pole's hanger, extension links, D-shackles, and other components must have a strength equal to or greater than the insulator string's corresponding electromechanical strength or ultimate tensile strength. D-shackles, extension links, and hangers must all be designed and delivered by the contractor[7]–[10].

CONCLUSION

Strain plates with the appropriate size should be installed at tension pole structures to accept the hooks or D-shackles of the tension insulator strings or, as necessary, the earth-wire tension clamps. These plates should be placed at the top of the earth-wire peak and on the bottom of each cross-arm tip. The contractor must provide a thorough description of the attachments for the employer's approval before mass manufacture may start.In order to meet required clearances when utilised with single and double tension strings, the design of tension towers, D-shackles, extension links, etc., must have a minimum electromechanical strength or ultimate tensile strength as specified. These D-shackles and extension links must also be supplied by the contractor.In this book chapter we discuss about the transmission line with a 220 KV rating equipment use to transmission the 220KV rating in power system and the types of the tower uses the transmission the power of the industries as well as domestic purpose.

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AN EVALUATION ON CHOICE OF CABLE TRANSMISSION LINE

Ms. Renuka Bhagwat*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

ABSTRACT:

In this book chapter there is defined the choice of cable transmission line to boost cable strength with affordable transmission. When choosing a cable, the electrical cable size chart facilitates more informed choice-making. To determine the size of cable needed for your application, utilize these tables. Three crucial factors to consider while choosing wires or cables are their physical performance, functional performance, and supportability. While selecting a wire or cable, performance under temperature, fluid exposure, installation, and abrasion at operating temperature are the most crucial physical characteristics to take into account. Depending on the installation needs, single-core and multi-core cables may be used, which will also affect how much current they can carry. A single core cable may carry greater current because it can dissipate heat more effectively than a multi-core wire.

KEYWORDS: *Cable Length, Cable Size, Electrical Cable, Transmission Line, Voltage Drop, Wire Cables.*

INTRODUCTION

The market offers a wide range of cables in different sizes. But you need an electrical cable size calculator to figure out which size is best for your application. It assists you in selecting the size that best suits your needs. Its calculation uses British and IEC standards. The 230V and 415V Voltage Drop KW Cable Size Calculator use a power factor of 0.8.Divide the required current by the cable's voltage in order to get the appropriate cable size. Divide the voltage current of your wire, which is 150 volts, by the desired aim of 30, for instance, to get the required target resistance of 5. When conducting extensive calculations concerning cable size, an electrical cable size calculator is handy.

1.5mm or 1mm cables are often used when purchasing wiring for household lighting in a home. Typically, electrical wires with a diameter of 1 mm are sufficient. Employ 1.5 only when the cable length is long and you need to handle voltage dips as well as supply and demand changes. When choosing a cable, the electrical cable size chart facilitates more informed choice-making. To determine the size of cable needed for your application, utilise these tables. For instance, if a small-sized cable is utilised, the higher current flow might cause it to melt. A cable sizing chart may aid with size and diameter estimation. Thermal resistance causes the diameter to shrink as energy flow resistance rises static electricity show in figure 1.

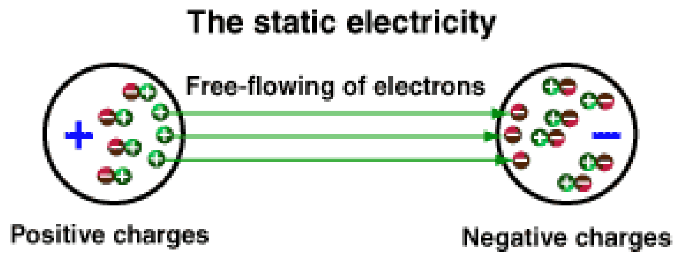

Figure 1 Static Electricity

Due of their intricate connections, they need precise cutting. They could inappropriately explode and harm people or property. The idea of Mv Cable Size was developed as a consequence of the growth in voltage specifications. The categorisation altered as demand increased. These days, both extra low and extra high categories are offered.This and the previous instance were identical. Exact same, since that the formula for determining electrical cable size is time-consuming and complex, we provide you the most straightforward method to determine the size that is appropriate for your application. The British Specification for Current Carrying Capacity of Single Core Armoured.It's crucial to choose the right conductor type, size, cross-section area, and diameter for the application when picking a cable. Understanding the importance of cable size and selection is first required. The selection criteria will then be reviewed while taking into account all of the potential issues that might lower cable capacity. It will also be discussed in this context since Kelvin's law is crucial to the conductors' economic scalability.

Various conductor kinds will also be explored in addition to conductor size. At the finish, we'll talk about the insulation and shielding of the wires.To locate around 250 papers on various aspects of aircraft wire systems and lifespan, explore publications from Lectromec. This volume of information can be too much for some people. The creation of a dependable and fault-tolerant electrical wiring interconnection system (EWIS) could be achieved by picking the appropriate components, installing them correctly, and carrying out the required system level analysis, though if these articles were reduced to their most fundamental elements, it would be clear how to do so. And Lectromec has always sought to do that.It is true that choosing the appropriate components is the first and most difficult stage. Sometimes it could be challenging to show that "not all wires are the same". As in 2004 (when it was mentioned in Lectromec's original essay), it is still applicable today. The selection of wires and cables is once again covered in this article, along with the factors that should be considered.

Three crucial factors to consider while choosing wires or cables are their physical performance, functional performance, and supportability. The overall design's physical performance displays its capacity to withstand stresses from the environment, including abrasion, temperature changes, installation, and contact with fluids and pollutants. The functional qualities take into account signal attenuation and how effectively wires and cables withstand electrical current surges without generating a smoke or fire danger. Supportability also evaluates how human variables and equipment's long-term maintenance demands effect the complete maintenance cycle.

Mathematical Foundations

While selecting a wire or cable, performance under temperature, fluid exposure, installation, and abrasion at operating temperature are the most crucial physical characteristics to take into account. Insulation and conductor restrictions must be taken into account when it comes to temperature. If the cable is shielded, the shield plating should be regarded as a limiting factor. As a conductor overheats, the plating may quickly deteriorate, resulting in decreased electrical conductivity, reduced signal quality, and increased electrical conductivity for corrosion.

Even though many of the insulation materials used for aviation wire and cable are chemically resistant when exposed to liquids, this should be taken into account for the application. The materials compatibility should be assessed if unusual chemicals are utilised throughout any stage of manufacture or platform maintenance. Recent instances of fleets using cutting-edge cleaning or dicing products only to visibly degrade electrical components are many. Test results are used to assess the degree to which fluid exposure causes wires and cables to deteriorate.At operational temperature, abrasion resistance testing must be conducted. Temperature, from ambient temperature to high temperatures, affects how well a wire insulation performs. With a rise of merely 10°C, the efficiency of some insulating materials can reduce by as much as 50%. These performance changes may occur at temperatures as low as 50 to 60 °C; they don't necessarily occur at temperatures of 140 °C or higher. It is advised to choose a component with exceptional abrasion resistance performance if the installation zone is exposed to frequent maintenance traffic or has significant levels of vibration.

LITERATURE REVIEW

Sonia Ghorbal, etal. explored a study of DC bus voltage levels for freestanding residential DC nano grid is presented in the. In a DC nano grid application, the DC bus that connects scattered generators and loads is often selected based on prior knowledge and use[1]. Despite the fact that certain organisations work on creating these standards, there is a discrepancy in voltage levels documented in the literature as a result of this lack of uniformity. From this perspective, this paper suggests outlining the factors to consider when selecting an appropriate voltage level for a particular application. This selection has to guarantee user safety, effectiveness, and cost savings. As a result, requirements for power consumption, application deployment area, cable size, and line transmission losses are taken into account. The method is used to a small size laboratory system with minimal power consumption and led to the choice of 48 V DC bus.

Steffen Marian, et al. explored long, high-power transmission lines are needed because the proportion of renewable energy in the European system is increasing. With significant energy and installation area savings, superconducting cables are a desirable solution for these connections [2]. The MgB2 superconductor may be an attractive option because of its inexpensive cost, however it must be used at very low temperatures. The major dimensions of a four-wall cryogenic envelope surrounding a high-power MgB2 cable and the practical distance between two cooling stations are quickly assessed using a simple thermo-hydraulic model developed in this research. The budgetary cost of such a connection, including the cryostat's parts and the required cooling stations, is then provided using an enlarged version of this model.

At a transferred power of 6.4 GW, a considerable cost savings may be realised as compared to a resistive connection. More reductions are achieved by examining various optimisations.

R. B. Araújo, etal. explored to evaluate the factors that contributed to a AAAC 900 MCM conductor's early fatigue failure on a 230 kV transmission line in Brazil's Center-West. Each line phase featured a double cable design, with vertical stiff spacer clamps between each pair of cables. At two separate points along the span, vibration recorders were mounted on the spacer clamps, and fatigue tests on the cable were performed as part of the investigation. When Miner's rule was used, it was calculated that the cable had more than 33 years left in it[3]. The use of rigid spacer clamps between the two conductors, the selection of a AAAC conductor (whose fatigue resistance proved to be significantly less than that of an ACSR), and the presence of a high frequency laminar wind regime were all factors that together contributed to the cable's actual life being much shorter than the estimated one. The hard spacer clamps were removed in order to prevent more failures. As a result of this procedure, the line's vibration was significantly decreased, and life projections rose for more than 100 years.

Rafael Rodrigues Fidel Miguel, etal.discussed the process for transmission line tower topology optimisation. This method divides the structure into primary modules, each of which may adopt a distinct pre-established topology (templates). Furthermore included is a generic template construction guideline that is based on design best practises and the viability of prototype testing[4]. They so enable the best solution to have the crucial quality of direct industrial applicability. Also, the structure's size and form are optimised together with the topology selection throughout the optimisation phase. Two structures were evaluated for the sake of numerical examples. The first one was examined at CIGRÉ and is a transmission line tower (2009). We looked at eight distinct load situations. A single circuit, self-supported 115 kV transmission line tower makes up the second structure. The structure was exposed to a cable conductor rupture scenario and a wind load hypothesis. The ASCE 10-97 (2000) limitations were used in both instances. The optimisation was carried out using the Firefly Algorithm (FA) and the Backtracking Search Algorithm (BSA), two contemporary heuristic algorithms, since the issue was non-convex and there were discrete variables included in the process. The findings for the size, size and shape, and size, shape and topology optimisation are provided and analysed, as well as an examination of the performance of the methods. As compared to a traditional size optimisation approach on original constructions, it is shown that the suggested technique is capable of reducing the structural weight by up to 6.4%.

G. C. Davis, etal. explored parallel wire transmission lines with lengths ranging from 0.125 to 1 m were put vertically at three locations in a cornfield during planting time for the purpose of measuring the water content using TDR. At one of the locations, vertical transmission lines with electrical impedance discontinuities were erected alongside horizontal transmission lines for comparison [5]. During the growth season, measurements of water content were conducted using a portable TDR cable tester. Comparisons of water contents by TDR with those from gravimetric samples indicated that typically both were the same results. When measured sites were the same, standard deviations of variances between TDR and gravimetric values were 0.02, but, when measured locations were different, they rose to 0.06 nrhn'3. During the course of the season, measurements taken repeatedly at the same spot were significantly associated with one another.

Analysis of variance indicated that all trans- mission line types were generating equal results and that the horizontal transmission lines produced the least standard error of the mean. Water content profiles were obtained from data from transmission lines with impedance discontinuities based on a single measurement, however the TDR data curves' analyses were more involved than for lines without impedance discontinuities. The range of transmission line designs available for TDR measurement provides for a great deal of application-specific options.

DISCUSSION

The ability of your cable to carry the necessary current load at your installation location without causing an excessive voltage drop from your supply voltage should be your criterion for selecting the appropriate cable size. These are some factors that may influence the final cable size you choose after you are aware of the weight the cable can support (in Amperes). You can come to a different conclusion about the optimum conductor size after taking into account the following criteria. The most important thing to remember is that the minimum conductor size you choose must at the very least be the smallest permitted cable size that can accommodate all the different scenarios you have investigated.

Installation Technique

We begin here since a cable's placement and installation immediately determine whether it could be overloaded (e.g. in conduit, on cable tray, in free air, grouping, and spacing, trefoil, laid flat). Generally speaking, the greater cable size you may need to make sure it can resist the current and allow for efficient heat dissipation is the more constrained the installation of the wires will be (for example, in conduit vs. open air) [6].

Structure of Cable

The maximum working temperature of your cable is directly influenced by the extruded layer known as the cable insulation material, which comes next after the conductor and is important for cable size. In the manual, common insulating materials including PVC, XLPE, and EPR are included for your reference.PVC, XLPE, and EPR are common cable materials with maximum working temperatures of 70°C, 90°C, and 90°C, respectively. You may be wondering why, given PVC's lower maximum working temperature, we would choose it over XLPE. This is tied to other material features that can be more suitable for your installation circumstance. For instance, PVC is much more flexible than XLPE and could be a better option when the wire has to bend in constrained areas.Depending on the installation needs, you may pick between single-core and multi-core cables, which will also affect the cable's ability to carry electricity. A single core cable may carry greater current because it can dissipate heat more effectively than a multi-core wire. But you are free to stick with the multi-core cable since it can be simpler to connect all the necessary conductors at once.

Sized cables

To calculate voltage, drop, sometimes referred to as the drop in electrical potential along your cable run, we need to know how long the cable is. Singapore adheres to the SS638 (formerly known as CP5) wiring standards, which state that a cable run's voltage loss cannot be more than 4%. For example, if the supply voltage is 415V, the maximum permitted voltage drop is limited to 4% of 415V, or 16.6V cable size.The size and length of a cable line have a big impact on the voltage drop of a circuit. The voltage loss increases with the given cable size or cable length, whichever is larger for your circuit. You would need to upgrade the cable if you discovered that the circuit's voltage loss had beyond the advised 4%.

Outside temperature

Our estimations are based on an ambient temperature of 30 °C in the open air or 15 °C at a depth of 0.5 m. It is crucial to bear in mind that the installation conditions must be taken into account throughout the whole length of the cable inserted since cable routing and ventilation will directly affect the ambient temperature. You would need to alter the current load that your cable is intended to take if the temperature deviated from the norm. You may need to increase the size of your cable if the temperature in your environment deviates even farther from the norm in order to support the necessary weight.

The number of circuits

Our tables assume the installation of a single single-phase or three-phase circuit. Using a cable grouping correction factor might help you choose the right cable size if you want to group circuits together in your installation to avoid overheating problems. It is difficult to disperse heat when you connect more circuits, thus you may need to increase the cable size proportionately.We hope that this article has helped you fully understand some of the most important things to consider while deciding on the lowest allowable cable size. To restate, in order to prevent the cable from being overloaded, you must choose the lowest economic size that satisfies all of the parameters you have considered. Please use the free advice provided below when determining the size of your wires. It provides suggestions for cable size that you may use in your own calculations and walks you step-by-step through a sample measurement for a circuit design.

Technical cables

In contrast to the rather robust wire, you would find within the walls of your house, the wire used in car electrical systems is incredibly flexible. This is because copper, although having considerable ductility, may "work harden" under mechanical stress and vibration, as it does when it is put in a vehicle. A stiff, solid conductor may fracture and break over time due to this work hardening as the metal gets more brittle[7].To solve this issue and reach the required cross-sectional area, the core is constructed from a number of strands of copper wire with very tiny diameters. Since it is far more flexible and has a greater resistance to work hardening, this kind of cable, which is (unsurprisingly) called "stranded" cable, is better suited for use in cars.

The current carrying capacity

As each object or component connected to a circuit requires a certain amount of current to operate, the cable delivering power to these devices must be able to carry at least the normal amount of current plus a safety buffer. The cable will surely heat up and perhaps catch fire if it fails. The cable must have a sufficient rating to avoid overheating even if fuses are placed in the circuit to protect it from damage.Studying our article on the fundamentals of electrical circuits, which includes the example below demonstrating how to utilise the formula $I = P/V$

50W/12V = 4.17A would be required to power a light bulb with a known power rating, according to the equation I = P/V. This means that a cable rated at 4.17A or more is acceptable. Nonetheless, it's advised to avoid designing a circuit that utilises all of the cable's capacity, therefore choose a cable with some extra capacity. In this case, a 0.5mm2 (11A) cable would be suitable.

Loss of voltage

The resistance of each element of an electrical circuit, including the cable itself, results in a voltage drop over the whole length of the cable. A copper conductor has resistance and will convert part of the energy it carries, resulting in a voltage drop, much as how a bulb transforms electrical energy into heat and light owing to its resistance. The voltage drop across a light bulb (or other load) is significant since it is what causes it to operate, in contrast to the undesirable voltage drop along cables and other passive circuit components that doesn't result in a meaningful energy conversion.

Cable length may significantly affect voltage loss in low voltage systems. Even a small cable length may create substantial voltage dips when utilising conductors with a narrow cross-section. This issue is clearly present in many cars that have headlights that are not as bright as they should be. If you test the voltage at the bulb connections and the lights aren't getting the full 12V from the circuit, you may discover that the conductor size is inadequate for the length of the cable run. Some owners choose to change their headlight circuit, allowing the circuit to provide the bulbs with their full power and often leading to extremely noticeable gains in lighting brightness. This modification involves employing wire with a bigger conductor across a shorter distance.Both above and below ground, cables may be utilised to distribute or transfer electricity. Most cables are created to satisfy a given demand. The distribution and transmission of energy are the primary functions of power cables. It is a grouping of one or more electrical conductors that have been individually insulated and are often kept together by an overall sheath. The component is used for the transmission and distribution of electrical power [8][9].

CONCLUSION

Electrical power cables may be placed as permanent wire, ran inside or outside of structures, or buried in the ground. It uses mobile tools, flexible power lines, and portable equipment. They are created and produced in line with the client's specified requirements for the voltage, current, operating environment, and application. We double-Armor the wire to increase its mechanical toughness for mining. We create in accordance with client specifications since wind power plant customers often need flexible, UV-protected cable with a mechanically robust sheath. Underground wires provide many benefits, including a smaller voltage drop, fewer faults, cheaper maintenance costs, and a better overall look. Moreover, they are less vulnerable to lightning and storm damage.This book's chapter discusses about the ways to choose a cable transmission line to boost cable strength while using less costly transmission methods for more expensive cables and wires, as well as what kind of cable to use for transmission to minimise transmission line losses.

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SELECTION OF CABLE THROUGH CURRENT RATING

Dr. Sreenivasappa Bhupasandra*

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

ABSTRACT:

In this book chapter we discuss about choosing a cable using the most recent ratings. Moreover, the study describes in detail how to control the cable and how to utilize it in a home. A rubber-sheathed cable is black in color and contains several rubber conductors within. It provides a waterproof electric covering for safeguarding the internal electric line. Fire resistant wire has a low smoke generation rate, a low hazardous level, and a little flame spread. Fire retardant cable has a high fire integrity and is resistant to combustion. Estimating the amount of current that will be required by the machinery or load attached to the receiving end of the cable is necessary to determine the current carrying capability. As each object or component connected to a circuit requires a certain amount of current to operate, the cable delivering power to these devices must be able to carry at least the normal amount of current plus a safety buffer.

KEYWORDS: *Current Rating, Cable Size, Carrying Capacity, Fire Resistance, Low Smoke, Short Circuit, Voltage Loss.*

INTRODUCTION

Cable insulation existed before PVC or PE were invented. As rubber is a poor conductor of electricity, it was sometimes employed to insulate them. Rubber Cable was initially covered with natural rubber, but now synthetic rubber has replaced it. All Rubber Wires do not melt or soften when heated since they are made of thermoset materials instead. These characteristics may be maintained by this vulcanized rubber cable because the vulcanization process causes the material to be cross-linked.The qualities of rubber-coated electrical wire may be altered by adding various components to the base. They are made up of accelerators, fillers, vulcanizing agents, antiozonants, and antioxidants. They are very water absorbing and flexible throughout a broad variety of temperatures. Rubber Insulated Cables are suitable for usage in adverse environments because of their superior absorption qualities, resistance to weathering, and resistance to abrasion.

A black wire with several rubber conductors inside is covered in a rubber sheath. It provides a waterproof electric covering for safeguarding the internal electric line. The mechanical forces that affect flexible rubber cables include bending, friction, torsion, and others. As they are used outside, they are also resistant to moisture, UV ageing, and grease.A variety of cables of various sizes are available on the market. But, in order to identify which size is ideal for your application, you need an electrical cable size calculator. It helps you choose the best fit size for your requirements. British and IEC standards are used in its computation. Voltage Drop Calculator for 230V and 415V Cables utilize a 0.8 power factor.

To determine the cable size, divide the needed current by the voltage that is passing through the cable. For instance, if your cable has a voltage-current of 150 volts and your target is 30, split 150 by 30. You now possess the required target resistance of 5. For large computations and cable sizing, an electrical cable size calculator is helpful.While shopping for wiring for domestic lights in your home, 1.5mm or 1mm cables are often used. Electrical cables with a 1 mm diameter are usually enough. Use 1.5 only when the cable length is considerable and you need to cope with voltage dips as well as fluctuations in supply and demand.

The electrical cable size chart helps with better informed decision-making when selecting a cable. These tables may be used to calculate the size of cable that is required for your application. If a small-sized cable is used, for example, the increased current flow might melt it. In order to estimate size and diameter, a cable sizing chart is helpful. The diameter decreases with increasing energy flow resistance.The range of medium voltage cables' voltage ratings is 1KV to 100 VK. They need accurate cutting due to their complex connections. They might detonate improperly and cause damage to persons or property. The increase in voltage requirements gave birth to the concept of Mv Cable Sizing. With the expansion of demand, the categorization changed. These days, super low and extra high categories of medium voltage drop are also available.

While cables with different degrees of electrical resistance are used in various applications, the Power Cable Size Calculator aids in determining the size of the cable required to avoid any mishaps. Given that the formula for calculating electrical cable size is laborious and complicated, we provide you the easiest way to calculate the size that is suitable for your application. Size is calculated in accordance with the British Standard for the Current Carrying Capacity of Single Core Armoured XLPE Insulated Copper Cable, Cable Size.The current carrying rating is influenced by the cable's thermal heating and conductor size. The cable spacing, use, and insulation types all affect how this heat is dissipated. Voltage control is often not a problem in electrical power networks that are correctly planned, but it is crucial to consider the voltage drop brought on by too long cable lengths. The National Wiring Regulations provide guidance on estimating voltage drops as well as suggestions for choosing the right cable size for various temperature ratings and wiring procedures.

The cable's maximum ability to withstand current in a short circuit is used to determine short circuit ratings. The cable should be able to carry this current without incurring thermal degradation as long as the fault condition can be brought to safety using a tool like a circuit breaker or fuse. To determine the size of cables based on British Standard and International Standards, use our Cable Calculator. Instead, give our experts at The Cable Lab a call at the technical hotline to get assistance choosing the appropriate cable size for your application's short circuit rating.When choosing a cable, it's critical to choose the appropriate conductor type, size, cross-section area, and diameter for the application. It is first necessary to comprehend the significance of cable size and selection. The debate will next turn to the selection criteria while accounting for any derating factors that might reduce cable capacity. As Kelvin's law is essential to the conductors' economic scaling, it will also be examined in this context. Several conductor types will also be studied in addition to conductor size. We'll discuss the insulation and shielding of the wires towards the end.

Flammable Cable:

The quality of the various cables available on the market varies. Some are insulated with rubber, while others are insulated with plastic, depending on their intended use. Just a small percentage of these cables, dubbed "Fire Resistant Cable," deter fire and prevent it from spreading to other areas. Fire rated power cable was created in order to maintain circuit integrity and operation for a set period of time under particular conditions.Fire resistant wire has a low smoke generation rate, a low hazardous level, and a little flame spread. Fire retardant cable has a high fire integrity and is resistant to combustion. Other subcategories of these wires are Low smoke and fume (LSF) cables and Low smoke and halogen-free (LSHF) cables. The phrase "life cable" is not used in the industry. Depending on the business, they are referred to as LSZH Cables or Low Smoke Halogen-Free Cables. These wires have zero halogen and minimal smoke halogen free cable show in figure 1.

Figure 1 Halogen Free Cable [sab cable].

The hydrogen chloride in PVC cables normally combines with air to create hydrochloric acid. This endangers living things and could corrode surfaces made of metal, electricity, and buildings. While Lszh Wire produces black smoke that facilitates exit. Also, these Lszh Power Cable reduce the chance of choking-risky vapors. Also, it reduces the chance that acid gas may damage electronic devices. Even though these Xlpe Lszh Cable don't produce a lot of smoke, some Fp200 Cable is made by modifying PVC. This causes certain Fire Rated Cable to burn with an obvious amount of dense smoke and hydrogen chloride gas.

When compared, the main differential between resistant cables is that, while flame-retardant cable prevents the spread of fire, fire-rated wire maintains the integrity of the circuit. Use of fire-resistant wire is essential in both indoor and outdoor housing construction. Due to its high temperature resistance, Fire Survival Cable may be used in these circumstances.Even after they have broken loose, some of these various flame-resistant wires could still work and endure fire. One of them has a 2-hour fire rating and is cable. They may remain active for two hours after the fire begins. They are specifically used to build enormous buildings, complexes, and skyscrapers. In case of an emergency, 2 Hour Fire Rated wires are used as a backup. This flame-resistant cable may support both the evacuation and maintaining the functionality of the elevators.

LITERATURE REVIEW

Thomas V.M. Jakobsen, etal. explored the design stage to identify the optimal cross-sectional area for a high voltage alternating current (HVAC) undersea cable[1]. The thermal behaviour at the conductor's centre, the cable's hot spot, was examined using the thermal ladder network technique (LNM). This article suggests a technique for a dynamic rating of submarine cables based on estimated cable characteristics and a thermal cable analysis of transient circumstances applied by a step function with a time length higher than 1 h. Iterative steps are used to create the dynamic rating. The methodology was evaluated in contrast to a finite element method (FEM)-based strategy and tested using a MATLAB simulation.

Mohamad Li, etal. investigated to transmit more power via a cable than its nominal power capacity, without jeopardising its dependability, in order to avoid installing expensive new underground cable connections in regions where peak demand exceeds current cable capacity[2]. A strategy that is often used to temporarily surpass the nominal cable capacity is dynamic current rating of cables. This research introduces a novel dynamic voltage rating-based strategy for increasing cable capacity. If multilevel converters are built at both ends of the line, as will become increasingly typical in the future as an inverter-rich power system is achieved, the approach may be used. This research examines the impact of a trapezoidal voltage waveform on the distribution of the electric field within wire insulation. The findings demonstrate that a more homogenous field distribution may be achieved within the cable insulation by employing a trapezoidal waveform. This makes it possible for the insulating system to be used more effectively, increasing the capacity for continuous power transmission.

Peter van Deursen, etal. explored the propagation properties of transient signals are impacted by temperature change caused by dynamic cable loading. Investigated are how temperature affects the distortion of modal signal components in a three-phase medium-voltage wire. The complicated insulating permittivity, which has a non-linear relationship with temperature, is primarily responsible for the temperature impact. The propagation velocity rises by 0.56% per degree centigrade near the cross-linked polyethylene insulation's maximum working temperature, while it is much less sensitive at room temperature. The modelling findings in this study account for the time-varying temperature distribution in the cable cross-section and are based on cable impedance and admittance matrices generated from electromagnetic field simulation. By using Rayleigh-Schrödinger perturbation analysis, the findings are confirmed. As the modal propagation velocities vary due to cable loading, signal patterns alter in the time domain. Moreover, when an imbalanced current flows through the cable phase conductors, degenerate modes separate. The potential uses of signal propagation temperature dependence for identifying cable flaws and for dynamic rating of underground power cables are highlighted.

Chong H. Parker etal. in[3]explored the top of the tower's nacelle typically houses an onshore horizontal axis wind turbine, generator, and converter, while the bottom houses the grid step-up transformer. Flexible cables with high current ratings are used to transport electricity downhill; these cables are costly and subject to significant I2 R loss. The step-up transformer must typically be installed in the nacelle of an offshore wind turbine. Although while new designs strive to lower the size and weight of the transformer, this greatly increases the mechanical strain on the tower. In either scenario, an appealing solution for big wind turbines would be a transformer-free, high voltage, high reliability generating unit for nacelle installation. In this work, a permanent magnet generator design-based power electronic solution is presented. A high sinusoidal output voltage may be created by developing a multilayer cascaded voltage source converter. Rectifiers supplied from separated generator coils balance the inverter modules' dc link voltages, and the inverter switching method balances the modules' power distribution. The dc link capacitors' size is limited by the switching strategy's reduction of the low order harmonics. It takes into consideration the modulating influence between the inverter's ac and dc sides. This article presents the generator-converter configuration, examines the impacts of inverter switching, and provides a switching strategy that is validated by simulation and laboratory testing.

Enric Prieto-Araujo, etal. explored modular multilevel converters (MMCs) utilised in high-voltage direct current (HVDC) applications are the subject of a control structure study. In specifically, this work considers an energy-based scheme (also known as closed loop or energy controlled) for the MMC, which means that the converter's internal energy is explicitly regulated, for the situation of a point-to-point connection with master-slave control[4]. In this way, the MMC's internal energy may be regulated independently of the energy of the HVDC connection, and the cable length affects the capacitance at the dc terminal rather than the MMC's internal capacitance, which is reliant on the rating of the converter. As a result, many options for the external control structure (internal energy and dc voltage) present themselves, each of which has a distinct impact on the dynamics as a whole. Although the traditional control structures should work well for long connections, the transient performance may not be acceptable for shorter links, in which case additional approaches must be adopted. In this study, several control structures are introduced, assessed, and verified by small-signal and frequency-domain analysis, time-domain simulation, and MATLAB Sims cape Power Systems.

DISCUSSION

It's crucial to choose the right conductor type, size, cross-section area, and diameter for the application when picking a cable. Understanding the importance of cable size and selection is first required. The topic of discussion will next shift to the selection criteria while taking into consideration any derating variables that might lower cable capacity. It will also be discussed in this context since Kelvin's law is crucial to the conductors' economic scalability. In addition to conductor size, several conductor kinds will be researched as well. At the finish, we'll talk about the insulation and shielding of the wires.

The Benefits of Choosing the Correct Cable Type and Size

For the following reasons, selecting the proper cable type and size is crucial

1. If the current flows faster than the cable can support, the cable will heat up and eventually break. Choose a cable size that will allow it to resist the entire load current as well as any potential short circuit current.
2. The cost of the cable will rise as its cross-section area increases because more materials will be needed to make it. As a result, it will be challenging to keep cable costs in line with customer demand.

3. A load must get a voltage that is either acceptable or has the minimum voltage drop. Lower diameter cables will experience more resistance. Moreover, the voltage loss throughout the cable will grow. It is crucial to choose a cable that results in the least amount of voltage loss because of this.
4. It is essential to choose the optimum cable type for the application since various conductor types have variable thermal conductivity, resistance, and other properties.

The cable's size is decided using the selection criteria listed below

Estimating the amount of current that will be required by the machinery or load attached to the receiving end of the cable is necessary to determine the current carrying capability. It also has a safety gap for overload current.

Voltage Drop

Power losses due to the cable's resistance result in a certain amount of voltage loss. In addition, voltage loss fluctuates with temperature in the same way that temperature affects resistance. The formula V=I*R may be used to calculate the voltage drop across a cable if we know its resistance and the current flowing across its voltage drop. Short Circuit Rate this has to do with a cable's capacity to endure a short circuit current for a certain period of time until the problem has been safely addressed.

Derating Factors

The current rating or cable capacity of a cable may change as a consequence of disruptions from the outside world. It is crucial in these cases to raise existing ratings by including a few relevant elements known as derating factors. As there are several types of derating factors, the average value is produced by multiplying all of the derating factor values. The key derating elements that need to be considered while choosing a cable size are as follows [5].According to the temperature derating factor, cables should be positioned to provide them the least amount of space possible for dissipating heat from their surroundings (CT). This variable is utilized in cable size calculations to take into consideration how the cable should be laid out to reduce heat losses and increase cable capacity.Grouping Factor for Conductors (CG) An electromagnetic field is produced while a current passes through a group of conductors, reducing the cable's capacity. The conductor grouping factor is taken into account as a result.

The temperature around the wires is around 40 °C because of the thermal resistance of the soil (CR). However burying cables in soil raises the temperature around the wires, reducing cable capacity. The thermal resistance of the soil is taken into account in the calculations to account for the temperature increase.The burial depth derating factor (CD) is determined by how deeply the conductor will be buried. The derating factor will rise when the wire is buried deeper in the soil.

Defined input standards

Power (V)

Typically, 230 V for single-phase supplies and 400 V for three-phase supplies are the supply voltages that are measured by this. You may choose from a single-phase, three-phase, two-phase, or DC phase configuration [6].Enter the load's value, expressed in amps, kilowatts, kilovolts, or horsepower. Remember that under a three-phase load, the phase that is experiencing the most strain should be associated with this current. Maximum voltage drops (%). The cable is sized automatically to satisfy the maximum voltage drop requirement. For further information on our article's restrictions on voltage drop for low voltage installations. Insert the power factor of the load here (assumed lagging). This calculator's more precise voltage drop calculation takes the power factor into consideration. The distance between the supply point and the load is represented by the cable's length in meters. In the "cores" section, specify how many cores the cable will have (2 or 3/4, depending on the phase choices). The right conductor material must be chosen since it may impact both the voltage drop and the current carrying capability.

Insulation

The kind of insulation that influences the current rating and the maximum operating temperature. Depending on the kind of insulation, cables with a greater permissible temperature will have a higher current rating.

Installation

Choose the cable circuit installation technique that best suits your system. Keep in mind to choose the worst scenario (resulting in the lowest possible current rating) for the whole length if the installation technique varies along the path [7], [8].

Capacity

As each object or component connected to a circuit requires a certain amount of current to operate, the cable delivering power to these devices must be able to carry at least the normal amount of current plus a safety buffer. The cable will surely heat up and perhaps catch fire if it fails. Even if the cable is protected by fuses in the circuit, it still has to have a proper rating to avoid overheating in typical situations.Studying our article on the fundamentals of electrical circuits, which includes the example below using the formula I = P/V, may be helpful to you. I = P/V states that 50W/12V = 4.17A is required to operate a light bulb with a known power rating. Based on this information, you may utilize a cable with a rating of 4.17A or higher. Nonetheless, it's excellent practices to avoid establishing a circuit that consumes the cable's entire capacity, so select a cable with some spare capacity. In this case, a 0.5mm2 (11A) cable would be suitable.

Voltage drop Due to the resistance of each element in an electrical circuit, including the cable itself, energy is lost in the form of a voltage drop throughout the whole length of an electrical cable. A copper conductor has resistance and will convert part of the energy it carries, resulting in a voltage drop, much as how a bulb transforms electrical energy into heat and light owing to its resistance. The voltage drops over a light bulb (or other load) is significant since it is what causes it to run voltage drop, but the voltage drop along cables and other passive circuit components is undesirable because it does not result in efficient energy conversion.

Cable length may significantly affect voltage loss in low-voltage systems. When utilizing conductors with a small cross-section, even a short cable length may result in noticeable voltage dips. When the headlights are not as bright as they should be, this issue occurs in certain automobiles. If you test the voltage at the bulb connections and the lights aren't getting the full 12V from the circuit, you may discover that the conductor size is inadequate for the length of the cable run. Some owners choose to change their headlight circuit, allowing the circuit to provide the bulbs with their full power and often leading to extremely noticeable gains in lighting brightness. This modification involves employing wire with a bigger conductor across a shorter distance.

CONCLUSION

To ensure that the voltage loss won't lead to issues, we must choose a cable. What therefore qualifies as proper conduct, and how do we determine the proper cable size? We may use V = IR (see Electrical Circuit Fundamentals) to get the voltage drop for a cable if we know the current consumed by the load and the resistance of the cable per meter. A voltage loss of between 3 and 4 percent is often acceptable for DC circuits.In this book chapter we discuss about choosing cable based on current ratings. This book chapter provides a detailed explanation of how to manage the cable, how to utilize it in a domestic context, and how to calculate voltage loss and short circuits at home.

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EXPLORING DESIGN APPROACH OF THE SUBSTATION AUTOMATION

Dr. Shilpa Mehta*

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

ABSTRACT:

In this book chapter the substation automation design control methods have been investigated. Automation on substation is continually being enhanced along with the progressive growth of automation in distribution networks. Power distribution businesses are able to learn more about a greater portion of the network, from the substation to the end customer, thanks to these expenditures. With the first introduction of digital devices, digital control and protection technology has been developing. The number of duties that tended to be moved from humans to machines increased as the gadgets' intelligence and capability increased. Modern substation devices may keep data in their internal storage for a certain amount of time and send it to outside applications for further research and analysis, in addition to having higher processing power. System administrators now have the luxury of polling progressively more operational and non-operational data points from their substations because to the quick development of communication and process technology.

KEYWORDS: *Automation Design, Control System, Electrical System, Power Management, Substation Automation.*

INTRODUCTION

It is a capability for converting medium voltage to low voltage for end-user requirements. For various categories of end users, the low voltage level is separated into distinct branches. Secondary substations (SS) may be designed in a variety of ways, such as a cabinet and transformer mounted on a pole, metal container, concrete skeleton, or subterranean implementation in already-existing structures. SS may be of the node, loop, or end types depending on where it is in the network.A smarter, more reliable electrical grid is being created via substation automation, a term that has lately gained popularity. While technology is evolving quickly, maintaining the security of the electricity system has become essential. Nobody anticipates what will happen in the next minute, and as a result, the strong constant estimation has already occurred. The SCADA system is also quickly becoming a thing of the past, and synchro phaser technology is gradually taking its place by adding PMUs (Phasor Measuring Units) for counting important substation and line limits. The term "substation automation" refers to the utilisation of data from clever intelligent electronic devices (IEDs), control and robotization capabilities within the substation, and control instructions from remote users to regulate power system equipment.

This asset necessitated the use of IEDs such RTUs, re-closers, PLCs, V metres, video for security or equipment status assessment, metering, exchanging, volt/VAR, wave structure, event information, the executives, and so on. The programmed control of interlocks, global and local warning and alarm, finding the location of distribution system faults, and equipment diagnostics are a few of the major advantages of substation automation. By equipping main equipment with current sensors and digitizing routine copper-based basic communication with secure, reliable, open-source fibre optic correspondence, substation digitization will significantly reduce costs, enhance operations, and increase safety. So, substation automation is essential for getting more reliable power grids and moving towards innovation and new technologies to improve our daily lives.

Situational description

Automation on SS is continually being enhanced along with the progressive growth of automation in distribution networks. Power distribution businesses are able to learn more about a greater portion of the network, from the substation to the end customer, thanks to these expenditures. The LV level is also monitored after early investments in the automation of the main sides of the SS (MV level). The development of Smart Grids and the connection of more renewable energy sources are primarily responsible for the breakthrough. Power quality metering, smart metres for monitoring distant power use and production, and self-healing grids, which utilise automation features to automatically reconfigure networks when lines fail to effect fewer customers, are additional emerging fields.

On the MV level, the power lines may be overhead wires or cables buried in the ground. It is advised to monitor both voltage and current in the case of overhead power lines, which are more environmentally sensitive, in order to assess any line defects. As it is believed that the voltage in cable networks is a fairly steady variable, problems on lines can only be found by current measurements. Due to the high cost of voltage sensors, this technique is much less costly. When the SS is in a strategic position, the voltage measurement on the MV level is also employed for the purpose of directional fault detection. This is beneficial when renewable energy sources are connected to the network or when the distribution node or loop may be powered from many directions. Another option is to monitor the voltage on the bus ones for all outlets and the currents at each outlet, which is a potential middle ground. This solution calls for a system that allows for the distribution of voltage data for the estimation of power (active, reactive, and apparent) at specific outlets.

Control history for substations

Conventional substations (mechanical relays, restricted sight, first RTUs with IO) An electrical firm has always placed a premium on an electrical substation's high availability and continuous functioning. Increased defects result in more service interruptions for customers, which reduces income and is undesirable for any organization. Engineers and operators have been interested in gathering useful information on various devices in a substation since the beginning of electrical systems so they can better assess the health of their system, anticipate potential issues, and, in the event of a fault, analyses and troubleshoot the issue as soon as possible to protect their high-value assets and to improve their continuous service to their clients.

Early substations were made comprised of mechanical relays and meters that could hardly be used for recording and had no communication capabilities. Reading and evaluating the information from fault recorders was a difficult procedure since the majority of the information was being recorded on paper charts.Any repair or troubleshooting made expensive and time-consuming since people had to be sent to substations that were sometimes remote and challenging to access.

LITERATURE REVIEW

Chen Wei Dubinin, etal. explored a process for automatically creating software for smart-grid automation systems using requirements that include physical system architecture and functional "recipes" for certain domains. The created software is organised into components and employs a decentralised method of controlling the smart grid, which lessens the difficulty of designing and modifying automation systems [1]. The suggested approach is based on the convergence of two industrial standards, IEC 61850 and IEC 61499, which are used to represent, respectively, a portion of the specification and the generated software model. The production of the specification model is therefore based on ontology transformation, and it takes the form of an ontology. For the suggested technique to facilitate the modification of an ontology axioms set for the purpose of ontology transformation, the Semantic Web Rule Language (SWRL) must be extended. Extended SWRL, the proposed transformation language, is presented and shown in action. When used as an example in a case study system for power distribution, the outcome demonstrates the potential of eSWRL as an ontology transformation language.

Padilla, Evelio et al. investigated the goal of substation automation systems. Design and implementation is to fill the vacuum left by rapidly evolving technologies that have an influence on a number of long-standing concepts relating to the design and implementation of substation secondary systems[2]. While also adhering to the most recent standards for best practises in the industry, it is meant to assist those who must define and apply SAS. Approaching all practical aspects of SAS design and project development in a project-oriented manner. Using cutting-edge communication technology and IEDs, it focuses only on the constantly evolving control part of substation architecture (Intelligent Electronic Devices). Instead of focusing just on intelligent electronic devices and communication networks, covers the whole chain of SAS components and associated equipment. Auxiliary power system control and monitoring facilities are included. Contributes considerably to the knowledge of IEC 61850, a standard that many experts throughout the globe still consider to be a "black box." This article explains the IEC 61850 standard, which supports all new systems that are networked to carry out control, monitoring, automation, metering, and protection activities. For professionals working in the many SAS project phases, such as the specification process, contracting process, design and engineering process, integration process, testing process, and operation and maintenance process, this book is an invaluable resource.

Yu P. Trofimov etal. explored the design database created as part of a computer-aided design of secondary switching circuits (CAD CVC), the principles of the creation and usage of the "digital twin" of a digital substation automation system are taken into consideration. It allows integrated work with circuit diagrams, installation documentation, and digital exchange models in compliance with IEC 61850[3]. The structure of the design database and the information model are described. An information search interface is shown. The "digital twin" is intended to be used throughout the whole life cycle of the item, including design, installation, commissioning, and operation.

Andrea Kulmala etal. explored the augmentation of distributed energy resources such as tiny solar plants or micro cogeneration systems, along with the development of electric cars linked to the grid, is presenting new problems to distribution system operators (DSOs) [4]. This study suggests a novel approach based on a framework for the deployment of substation automation units to assist DSOs in addressing such new difficulties. The development of smart distribution system solutions is supported by this framework.In comparison to conventional methods, the monitoring and control features of the proposed solution are decentralised and, therefore, closer to the related field equipment. By minimising the concentration of data in a single location, the suggested technique enables us to improve performance and decrease system complexity. An automation unit for distribution network automation that is installed in the electrical substation is suggested and described. Several outcomes of the suggested approach will be shown by test results in both lab and real-world settings.

Mini S. Kotharietal. explored the need to introduce graduate and undergraduate students to the most recent advancements in hardware, software, and associated protocols for power automation since the automation of power systems is gaining pace globally[5]. The design, construction, and commissioning of an automation lab are discussed in this study in order to better understand substation automation (SA). Relay intelligent electronic devices (IEDs) that support the IEC 61850 protocol, a universal secondary test kit for testing the relays, a programmable protocol converter that can handle many different power automation protocols, a Global Positioning System (GPS) clock for time synchronisation, and all necessary software are all present in the lab. This document shows how to retrofit the most recent relay IEDs with the current control centre software. The SA laboratory's experimental setup and commissioning procedure have also been discussed. The learning experience is assisting students in better comprehending the theory and improving their job chances in power automation, according to a post-training review. Research and teaching in this developing subject are heavily reliant on the SA laboratory, which showcases all facets of substation automation.

Jack Choietal. explored by addressing the subject of substation automation, a group of writers with backgrounds in academia and industry want to close a knowledge gap. Understanding substation automation concepts and real-world solutions necessitates expertise in a wide range of fields, including primary and secondary equipment, computers, communications, fibre optic sensors, signal processing, and general information technology, all of which are taught separately from power curricula[6]. Utility practise also governs the organisation and implementation of substation automation designs. To develop such a system, one also has to be familiar with current data interchange standards and test methodologies for solution assessment. The goal of this book is to satisfy the educational requirements of power majors in undergraduate and graduate programmes. It also serves as a reference for professionals who need to be familiar with substation automation due to the rapidly evolving technology required for their line of work. The book covers a variety of substation automation-related topics to accommodate a broad range of interests and demands, giving educators the freedom to combine chapters in the most effective way to suit their students' individual learning objectives.

DISCUSSION

Contemporary substations

Digital protection and control devices gained intelligence with the development of microprocessor technology. Modern intelligent electronic devices (IEDs) may gather and store data on a variety of system characteristics, evaluate that data in a split second using complicated logic, and then decide if a condition is abnormal and send orders to switches and breakers to fix the problem switch and circuit breaker show in figure 1.

Figure 1 Switch and Circuit Breaker

Modern substation devices may keep data in their internal storage for a certain amount of time and send it to outside applications for further research and analysis, in addition to having higher processing power. IEDs may now communicate information to a local or distant user using a variety of methods. In order to ensure a quick recovery period after a substation disruption, this allows operators additional freedom in how and when to handle the information.New supervisory systems were created to simplify the work of a system administrator in the control center as more information became remotely accessible. A Supervisory Control and Data Acquisition (SCADA) system can gather data from various IEDs in an electrical system using a variety of communication channels, control and monitor them using a variety of visualizing technologies, and even automate the supervision process using predefined parameters and algorithms.In order to provide operators the local control and monitoring capabilities often required during the setup, installation, or maintenance of the substation, a Human Machine Interface (HMI) is installed in each substation[7].

Standards, auto configuration, and digital substation

With the first introduction of digital devices, digital control and protection technology has been developing. The number of duties that tended to be moved from humans to machines increased as the gadgets' intelligence and capability increased. New technologies allow users to focus more on high-level aspects of the system architecture by taking care of the laborious task of defining every single detail in the system configuration, as opposed to early digital technologies, where an operator had to work with bits and bytes on a primitive user interface to define every parameter of the system and make sure all elements of the system are correctly configured to make the processing and communication work.

Each manufacturer had a unique method for interpreting and implementing various components in an intelligent system at the dawn of the digital age. Vendor dependence and lack of interoperability were the results of these diverse methods. To guarantee that devices from various suppliers would operate in the same prescribed manner, new standards have been devised. Users now have greater freedom and flexibility to choose the features that work best for them without having to pay close attention to the manufacturer.While remote information access gives operators significantly more system visibility, it also raises new issues and difficulties. Cyber security is one of the most crucial factors in any system deployment since it involves information exchanges with distant organizations, often through shared media.

Non-Operational Data Processing and Big Data

Few data points were accessible on each device in the early days of digital technology, and it was impracticable to get a large quantity of data from each substation due to the high cost of connectivity and the sluggish data exchange rate. Communication lines were carefully configured to save bandwidth and communication costs, and only essential operational data was transferred to control centers.System administrators now have the luxury of polling progressively more operational and non-operational data points from their substations because to the quick development of communication and process technology. Using various software programmers, this data may now be processed in a number of ways to more effectively monitor an electrical system. The advancement in technology allows for a clearer view of overall health as well as helpful data for other applications like condition-based maintenance and asset monitoring.

System for automating substations

For local and remote monitoring and management of an electrical system, a substation automation system combines hardware and software components. To increase the system's overall productivity and efficiency, a substation automation system may automate processes that are repetitive, time-consuming, and prone to errors.Modern intelligent electronic devices (IEDs) may collect and store data on different system characteristics, analyses that data quickly using complex logic, and then determine if a state is abnormal and send commands to switches and breakers to correct the issue. Substation automation's (EEP) stated goals are to increase the effectiveness of operation and maintenance while also optimizing the management of capital assets.

System for managing power

The Power Management System (PMS), a crucial component of substation automation that regulates electrical generators, switchboards, and key users, is typically included into the IAS. The major duty of the power management system is to guarantee that power capacity is always per vessel and power demand.The fundamental duty of the power management system is to make sure that power capacity constantly matches vessel power demand. Moreover, it ensures that your electrical distribution systems and any linked assets run safely, effectively, efficiently, and in compliance with all regulations.

RTUs and a controller

RTU is a microprocessor-based device that connects to SCADA (supervisory control and data acquisition) or plant control systems while monitoring field equipment. It is sometimes referred to as remote telemetry or remote-control unit.An RTU solution, which is a framework for substation automation that is asset-compelled, gives your insight over remote sites that are crucial to your business. They work in a variety of fields, including as communications, utilities, and public safety. Remote control of industrial activities, including factory assembly-line machines, is possible with the use of electronic instruments like RTU and controllers.

System of communication

For local and remote monitoring and management of an electrical system, a substation automation system combines hardware and software components. Substation automation is the most sophisticated electrical engineering approach. It requires having a sophisticated, interactive electrical distribution network.Updates to substation automation provide the opportunity to reduce management and maintenance costs, increase plant production using enhanced schemes, and assess the condition of circuit breakers, power transformers, etc. Ethernet switches, one of the substation automation communication components that Schneider Electric offers, are simple to install and can be quickly incorporated into a broad range of electronic equipment.

Visual user interface

Using symbols, visual metaphors, and pointing devices, individuals may communicate with machines using a graphical user interface. The GUI interface, which is a component of substation automation, enables people to communicate with electronics like computers and mobile phones. GUIs show information and associated user controls visually, in contrast to text-based interfaces, which only display data and instructions as text.

SCADA and EMS gateway

Both EMS and SCADA are widely acknowledged as crucial strategic resources in the utilities business environment of today. Computers, networked data communications, and graphical user interfaces are used in a substation automation control system called SCADA to monitor equipment and procedures.It also comprises programmable logic controllers and other devices, such as sensors, that are connected to equipment or manufacturing facilities. Electricity conservation is the aim of typical industrial process automation [8]–[10].

Customized, Economical Solutions

A solution that satisfies your particular needs and maintains the long-term health of your substation systems will be designed and implemented by our experts with extensive industry expertise. The planning, administration, and execution of the project are all done in accordance with sequential, phased design decision processes and project procedures, which guarantee that we comprehend your system and what you want from it and that we are responsible to you at all times.Also, we provide very affordable, preconfigured system solutions for many common applications. These solutions were created using knowledge gained from more than 35 years of engineering innovation and field testing. They are adaptable to enable future expansion and work with a broad range of equipment interfaces. Substation HMIs and SCADA Integration HMIs are crucial parts of an automated substation because they provide operators access to crucial data and let them monitor and manage equipment and substation operations. At every size, from small substations to commercial buildings and large-scale grid operations, SEL Engineering Services develops and implements HMI, SCADA, and data integration systems.

Our experts will put in place a cost-effective, high-quality monitoring and control system for your substation that satisfies your particular operating needs. We can construct and commission whole SCADA systems that incorporate both new and old equipment, as well as integrate device-based solutions into already-existing systems. SEL automation controllers, which provide versatile RTU functionality with greater dependability, expanded I/O connections, and enhanced automation and control functionalities, may also replace old and noncompliant RTUs.

1. View and operate substation systems both locally and remotely using SEL SCADA integration, HMI installation, and automation controller solutions.
2. Use a Sequential Events Recorder to capture crucial data for root-cause investigation and advanced diagnostics (SER).

a. Improve grid stability and efficiency by employing synchrophasors and phasor measurement unit (PMU) data to assess and react to faults and failures and avoid future issues.

b. Control data reporting at the local and enterprise system levels.

System Control and Visualization

SEL creates reliable HMI systems that interface with IED settings for protection and control plans, monitor the status of communications lines and logic controllers, display power system data (such as real power, reactive power, voltage, and current), and incorporate alarm management and annunciation.To aid in troubleshooting and event analysis, Sequence of Events (SOE) reports and other nonoperational data may also be shown.

Network Operations

In addition to integrating new substation automation technologies with current SCADA systems, SEL Engineering Services installs SCADA for transmission and distribution networks.Additionally, we are skilled at creating and putting into practise special protection schemes (SPSs) and remedial action schemes (RASs), which assist transmission networks in enhancing their stability margins and overcoming the difficulties associated with integrating large renewable generation sources.

Automatic Control and Protection

At the substation level, the system and process level, and the grid operations level, SEL offers automated protection and control solutions. These technologies may be completely linked with SCADA systems and provide remotely accessible, secure monitoring.We use SEL technology to build rapid bus transfer and other high-speed automated transfer topologies, improving substation equipment protection and reducing the possibility of important loads losing power. We also use integrated arc-flash mitigation with SEL relays and high- and low-impedance bus differential protection techniques to ensure secure fault clearing.These solutions enable operators to handle a whole facility's power system, including end devices, from a single HMI screen in industrial substations by seamlessly integrating with our MOTORMAX protection and control system, SEL POWERMAX power management, and power plant control systems.

Asset Tracking and Predictive Upkeep

Modern substation IEDs may already be able to provide the data required for asset monitoring and preventive maintenance, and some of your primary equipment may even have been delivered from the vendor packaged with a CBM system.

CONCLUSION

By combining CBM systems from different manufacturers into a single, complete asset monitoring and predictive maintenance system, we use tried-and-true techniques. This system is driven by the sophisticated data recording and processing capabilities of SEL automation controllers. These systems continually check the health and condition of switchgear and transformers used in substations, decreasing the likelihood of unexpected failures and allowing you to do maintenance exactly when and where it is required. They also provide information that may be used to risk assessment studies, capital asset management, efficiency improvement initiatives, and root cause failure mode analysis.In this book chapter we discuss about the substation automation design control the system through automation.Moreover, the working operation principal of the automation substation is explored.

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THE CABLE'S CAPACITY TO HANDLE HIGH CONDUCTOR TEMPERATURES

Mrs. Kamireddi Sunandana*

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

ABSTRACT:

In this book chapter there is describedthe conductor temperature tolerance using cable. Since conductor resistance increases with temperature, a conductor carrying a certain current produces more heat. When determining the maximum working temperature for a cable tie or its attachments, it is not necessary to match the specified temperature rating of the insulated conductor or cable. Since their thermal conductivity is substantially higher than that of the other insulating materials, the three metal layers that make up the three-core cablethe cable core, the metal shielding layer, and the armoured layerare selected as the temperature node in the thermal circuit model. For a certain ambient temperature, the conductor's rated continuous current carrying capacity, allowable temperature rise, shape, and installation are all determined.

KEYWORDS: *Conductor Temperature, Operating Temperature, High Voltage, Thermal Circuit, Circuit Model, Short Circuit, Thermal Stress.*

INTRODUCTION

It is often required to choose a conductor size for a particular task. The ability of a cable to carry current depends on a number of factors, including the electrical resistance of the conductor, the thermal resistance of the layers surrounding the conductor, the environment in which the cable is installed, and the available temperature rise between the conductor's maximum operating temperature and the ambient temperature of the surrounding medium, such as air or soil.A cable with a 110 °C maximum conducting temperature rating may carry more current than a cable of the same size with a 90 °C maximum operating temperature due to the bigger heat rise parameter, 110 °C minus 40 °C (70 °C rise) against 90 °C minus 40 °C (50 °C rise). When selecting cables that are 110°C approved, this often leads designers and installers to choose a cable with a smaller conductor size in an effort to seem to save money in comparison to utilising a cable with a higher size conductor. Based on a 40°C maximum ambient temperature and the assumption that wires would be installed outdoors [1].

Since conductor resistance increases with temperature, a conductor carrying a certain current produces more heat. If the installer or designer further chooses to employ a smaller conductor size with 110°C insulation, the effect is magnified. The additional losses in this case may exceed 30% when using a cable rated for 110°C. Even with the reduced cost of installing the smaller-size cable, the total cost of losses plus cable costs is often less in the first year of operation. As the cost savings grow with each year of operation, this "payback" for installing the larger conductor size makes a strong justification for adopting it. To ensure the security of people and machinery, an electrical system's design involves testing for thermal stresses in cables and conductors. Here, we discuss the fundamentals of calculating thermal stresses as well as the most common types of thermal restrictions.

The two characteristics that are essential for defining the size of a cable or conductor are the maximum temperature of the core in a steady state, which defines capacity, and the maximum temperature of the core in a short circuit, which is the temperature at which the insulation begins to deteriorate.For most cables, these values are required by a standard; for cables insulated with EPR/XLPE, for example, the values are 90°C and 250°C, respectively. It is crucial to prevent short-circuit current (Ik) from overheating the cable's core when it is disconnected (t) [2].

A cable is said to be "adiabatic" when it heats up in less than five seconds after being removed, indicating the heat created stays in the conductor's core and does not have time to dissipate to other parts of the cable. The cross-section of the conductor in mm2 and k, a factor that takes into account the resistivity, temperature coefficient, and resistance to heating of the conductor's material, as well as the initial (maximum core temperature in steady state for a charged conductor or a PE integrated into the cable or ambient temperature for a separate PE) and final (maximum temperature of the PE) temperatures, determine the thermal stress experienced by the conductors. As a result, it has to be verified that the connection is in every short-circuit circumstance. Simpler techniques for measuring thermal stresses

In order to ease measurements of thermal stresses in cables, Trace Software's Elec Calc tool determines the maximum let-through energy in conductors and compares it to their thermal withstand value after k2S2. A thermal stress error is shown if the criterion is not met. Phases, neutral, and PE are all subject to this verification. When a thermal stress problem occurs, the conductor's cross-section may be expanded to raise the acceptable thermal stress. Nevertheless, there are several approaches that may be used to do this without extending the cross-section, such as: Fuse melting times are sometimes much shorter than circuit breaker operating times when applying fuses with high short circuit currents. Hence, the let-through energy has a constraint built right in. Nonetheless, it should be remembered that maximal energy may occur during the shortest short circuit duration, even if the melting time may be longer in the case of fuse protection. Considering that it's crucial to evaluate the cable's resistance to various short-circuit currents [3].

Using circuit breakers with restrictions: In order to prevent fault currents, several pieces of equipment are designed to only let a certain amount of current. Manufacturers provide restriction curves that demonstrate how well a circuit breaker performs when subjected to cable load.The graph displays the limited let-through energy value as a function of the rms value of the potential fault current's alternating component. The curve displays the restricted current's peak value as a function of the expected fault current's alternating component's rms value. It is necessary to compare this limited value to the conductor's permitted thermal stress.When a reference with a limitation is coupled to a protection device, the software may determine the limited let-through energy associated to the possible short circuit current. The multi-manufacturer catalogue provides restriction curves for various kinds of protection. It should be noted that most microcircuit breakers include limiting features that enable the resolution of thermal stress problems in small-section cables, which are particularly sensitive to such problems.

DISCUSSION

In electrical systems, cable ties are often used to bundle or fasten collections of insulated electrical conductors, cables, or conductors. Also, it is specified what temperatures are appropriate for insulated electrical conductors and cables. These ratings indicate what temperature range the conductor insulation or cable insulation can withstand while still maintaining its mechanical strength and electrical insulating properties, or dielectric strength. It goes without saying that the flow of electrical current via these conductors generates heat. The resistance in the circuit used by the conductor(s) and the installation environment are two factors that affect how much heat is produced. Moreover, when insulated conductors are placed near together, electromagnetic induction may result in the production of heat. Electrical codes include complex calculations to take into consideration the effects of potential excessive conductor heating based on system design and installation circumstances. As a result of these modifications, the circuit ampacity is often drastically lowered or de-rated (current carrying capacity) [4]. A conductor or cable's listed temperature rating does not correspond to the conductor or cable's anticipated or recommended continuous operating temperature.

A three-core cable thermal circuit model

Since their thermal conductivity is substantially higher than that of the other insulating materials, the three metal layers that make up the three-core cablethe cable core, the metal shielding layer, and the armoured layerare selected as the temperature node in the thermal circuit model. The consistency of the metal's temperature is evident. The cable's outer surface is also thought of as a temperature node core round cable owing to the ability of the surface to be treated as an isothermal surface due to the armour layer's and the outer sheath's uniform temperature distribution three core cable shown in Figure 1.

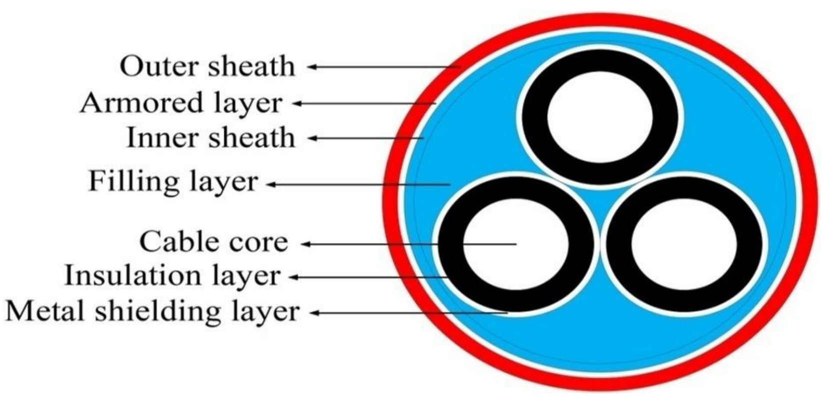

Figure 1 Three-core cable [IET researchOnline library].

Each layer of the cable's thermal properties may be described by its thermal resistance and heat capacity, and the heat source is utilised to indicate the associated loss. Since metallic materials have a very high thermal conductivity and the thermal resistance is disregarded, the transient thermal circuit model of three core cable may be expressed as follows: where Q c and Q d are the conductor loss and insulator dielectric loss; The temperatures of the cable core, metal shield layer, and armour layer are and respectively; the temperature of the outer sheath, which is equivalent to that of a hot press, is 0; and the thermal resistances of the insulation, filling layer, inner sheath, and outer sheath are and respectively. The loss factors for the metal shield layer and armouring layer are 1 and 2, respectively. The letters C1 to C6 stand for the heat capacities of the conductor, insulation layer, matching metal shielding layer, filler layer, inner sheath, armoured layer, and outer sheath. The steady-state thermal circuit model and the analogous transient thermal circuit model both lack heat capacity [5].

The same temperature

The experimental data from the area where the experimental cable model is employed is used to confirm that the thermal circuit model is accurate. The carrying capacity of three-core cables under a continuous cable trench load is investigated in this experiment[6]. In five separate scenarios, the six loops have been tested twice. The conductor temperature and surface temperature experiment results are average values after deleting specific data. As a common illustration of a multi-loop system, think of a loop. As shown in contrast to the form factor methodology, the temperature field method has a superior accuracy when estimating thermal resistance. The thermal circuit model utilises the surface temperature to derive the conductor temperature[7].

City Amp

For a certain ambient temperature, the conductor's rated continuous current carrying capacity, allowable temperature rise, shape, and installation are all taken into consideration. For exposed overhead wires, the typical ambient air temperature is 40 °C. The typical ambient soil temperature for buried, insulated power cables is 20°C. The baseline capacity is then modified using temperature correction factors for various ambient temperature ranges. The insulation temperature design limits will be surpassed if a cable is continually loaded over its rated capacity. If an overhead conductor is continuously loaded over its rated capacity, it starts to lose mechanical strength. A shorter mechanical life is the result of this abrupt failure overhead wire show in Figure 2.

Figure 2 Overhead Wires

CONCLUSION

When determining the maximum working temperature for a cable tie or its attachments, it is not necessary to match the specified temperature rating of the insulated conductor or cable. Consider the greatest temperature allowed in the installation area when selecting a cable tie product. The present product standards do not evaluate cable ties' insulating capabilities, if any, since they shouldn't be considered conductors or cable insulation.The highest and lowest operating temperature ranges for cable ties and their accessories (fixing devices) are based on the harsh conditions in the environment where the products are expected to be used and continue to perform as intended.This book chapter defines the temperature impact on the cable and the performance of the cable in this scenario.

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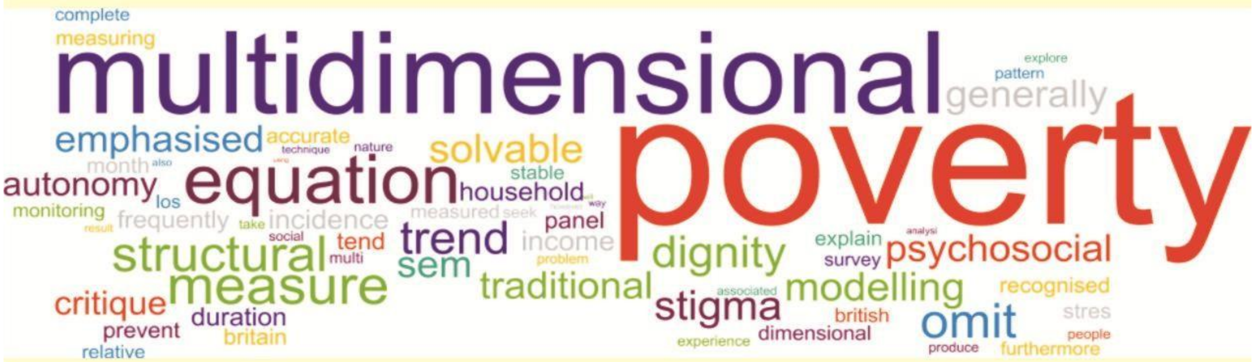

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