SUMMER INTERNSHIP REPORT ON

400/220 KV SCADA CONTROLLED GIS BASED TRANSMISSION SUBSTATION

OPERATED BY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

Submitted in the Month of August, 2013 by
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As part of MBA (Power Management) Curriculum of

MAHARSHI DAYANAND UNIVERSITY, ROHTAK
(A State University established under Haryana Act No. XXV of 1975)
B++ Accredited University by NAAC
DECLARATION

I, Jayant Shekhar, Roll No. 36, Class MBA (Power Management) 2012 – 2014 of the National Power Training Institute, Faridabad hereby declare that the Summer Training Report entitled 400/220 kV GIS/SCADA BASED TRANSMISSION SUBSTATION is an original work and the same has not been submitted to any other institute for the award of any other degree. A seminar presentation of the Training Report was made on ______________ and the suggestion as approved by the faculty was duly incorporated.

Presentation In-charge (faculty)  Signature of the Candidate

Countersigned (Director of the Institute)
ACKNOWLEDGEMENT

"Gratitude is not a thing of expression; it is more a matter of feeling."

I would like to express my deep gratitude to Mr. Ramawtar Meena, Engineer and Mr. Kamal Kumar, Junior Engineer at PGCIL Gurgaon Substation for their active support and continuous guidance without which it would have been difficult for me to complete this project. They were generous enough to take time out of their regular work to lend a helping hand whenever I needed one and enabling me to complete this project.

I would also like to mention the generous guidance of Mr. H. H. Mahto, Chief Manager, Gurgaon Substation and Mr. Himanshu Garg, Engineer (IE), Regional Head Quarter, New Delhi together with my internal project guide Dr. Rohit Verma, Dy. Director, CAMPS whose guidance helped me settle down in the organization and successfully complete the project within the relatively short time frame of 8 weeks, from 10th June, 2013 to 2nd August, 2013. They were supporting enough to give me an opportunity to be a part of such a prestigious organization for 2 months and learn the day to day functioning.

Last but by no means the least, I am grateful to the Training and Placement Cell of my institute, headed by Mrs. Manju Mam for providing a quick turnaround time for all the requests.
Executive Summary

As a student of MBA – Power Management from the National Power Training Institute, Faridabad, I got a rare opportunity to do my summer internship in Powergrid Corporation of India Limited, India’s Central Transmission Utility.

Though my reporting office was the Regional Headquarters situated in New Delhi, the authorities were generous enough to allocate me a working project that dealt with the study of existing infrastructure at the 400/220 KV substation situated in Gurgaon which supplies power to Haryana. The initial part of the project consisted of a thorough study of the equipments used in the transmission substation. The study of existing infrastructure showed the advantages of having a Gas Insulated Substation (GIS) compared to the conventional one. It gives the advantage of housing the entire machinery indoors, which eases the task of regular inspection, repair and maintenance. Another big advantage is its easy compatibility with the Supervisory Control And Data Acquisition (SCADA) system which provide easy mechanism for access and control.

The next phase of the project was about proposing an expansion plan of the existing facility. The current system takes input at 400 KV and steps it down to 220 KV before transmitting it to the Haryana distribution substation. Owing to the ambitious capacity addition plans of the 12th five year plan, it has been decided to upgrade the existing transmission facilities. In order to reduce the losses it has been proposed that the transmission take place at 765 KV. A comparative study needed to be conducted to
ascertain whether there was a need to completely overhaul the existing facility or an upgrade would be enough.

The relevant study is still underway and it is expected to get over only by the end of this year. Conducting tests on existing equipments requires coordination from all the three vendors supplying the equipments, namely ABB, Samsung and Hayosung. From my 8 week stint at the substation, I could suggest the following measures:

- As the existing lines have been successfully charged at 765 KV, a complete overhaul isn’t needed.
- The protective equipments of the circuits are in the process of being tested at 800 KV. The ABB machines stood up to the tests hence don’t need replacement but the Hayosung equipments showed signs of instability during testing. Samsung manufactured equipments could not be tested.
- Since there is plenty of barren land available in the vicinity of the existing substation, there is no dearth of the space available for expansion. Thus, the ideal scenario would be going for a mix of the two approaches, i.e. a healthy mixture of expansion and up gradation.
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1. ELECTRICAL SUBSTATION

INTRODUCTION

An electrical Network comprises of the following systems:

- Generating Stations
- Transmission Systems
- Receiving Stations
- Distribution Systems
- Load Points

In all these systems, the power flow of electrical energy takes place through Electrical Substations. An Electrical Substation is an assemblage of electrical components including busbars, switchgear, power transformers, auxiliaries, etc. Basically an electrical substation consists of a number of incoming circuits and outgoing circuits connected to common busbar system. Busbars are conducting bars to which a number of incoming or outgoing circuits are connected. Each circuit has certain electrical components such as circuit-breakers, isolators, earthing switches, current transformers, voltage transformers, etc. These components are connected in a definite sequence such that a circuit can be switched off/on during normal operation by manual/remote command and also automatically during abnormal conditions such as short-circuits. A substation receives electrical power from generating station via incoming transmission lines and delivers electrical power via the outgoing transmission lines. Substations
are integral parts of a power system and form important links between the generating stations, transmission and distribution systems and the load points.

**Functions of a sub-station:**

An electricity supply undertaking generally aims at the following:

- Supply of required electrical power to all the consumers continuously at all times.
- Maximum possible coverage of the supply network over the given geographical area.
- Maximum security of supply.
- Shortest possible fault duration.
- Optimum efficiency of plants and the network.
- Supply of electrical power within targeted frequency limits.
- Supply of electrical power within specified voltage limits.
- Supply of electrical energy to the consumers at the lowest cost.
- As a result of these objectives, there are various tasks which are closely associated with the generation, transmission, distribution and utilization of the electrical energy. These tasks are performed by various, manual, semi-automatic and fully automatic devices located in generating stations and substations.

The tasks associated with a major substation in the transmission system include the following:

- Controlling the exchange of energy
- Protection of transmission system
• Ensuring steady state and transient stability
• Load shedding and prevention of loss of synchronism.
• Maintaining the system frequency within targeted limits
• Voltage control, reducing the reactive power flow by compensation of reactive power, tap-changing.
• Securing the supply by providing adequate line capacity and facility for changing the transmission paths.
• Data transmission via power line carrier for the purpose of network monitoring, control and protection.
• Determining the energy transfer through transmission lines and tie-lines.
• Fault analysis and pin-pointing the cause and subsequent improvements.
• Securing supply by feeding the network at various points.

All these tasks are performed by the team work of load-control centre and control rooms of substations. The substations perform several important tasks and are integral part of the power system.

CLASSIFICATIONS OF SUBSTATIONS

Based ON Nature Of Duties:

Step up or primary Electrical Power substation:

Primary substations are associated with the power generating plants where the voltage is stepped up from low voltage (3.3, 6.6, 11, 33kV) to 220kV or 400kV for transmitting the power so that huge amount of power can be transmitted over a large distance to load centers.
Primary Grid Electrical Power Substation:

Such substations are located at suitable load centers along with the primary transmission lines. At primary Grid Power Substations the primary transmission voltage (220kV or 400kV) is stepped down to secondary transmission voltages (110kV). This Secondary transmission lines are carried over to Secondary Power Substations situated at the load centers where the voltage is further stepped down to Sub transmission Voltage or Primary Distribution Voltages (11kV or 33kV).

Step Down or Distribution Electrical Power Substations:

Such Power Substations are located at the load centers. Here the Sub transmission Voltages of Distribution Voltages (11kV or 33kV) are stepped down to Secondary Distribution Voltages (400kV or 230kV). From these Substations power will be fed to the consumers to their terminals.

**Basis Of Service Rendered:**

**Transformer Substation:**

Transformers are installed on such Substations to transform the power from one voltage level to other voltage level.

**Switching Substation:**

Switching substations are meant for switching operation of power lines without transforming the voltages. At these Substations different connections are made between various transmission
Different Switching Schemes are employed depending on the application to transmit the power in a more reliable manner in a network.

**Converting Substation:**

Such Substations are located where AC to DC conversion is required. In HVDC transmission, Converting Substations are employed on both sides of HVDC link for converting AC to DC and then converting back from DC to AC. Converting Power Substations are also employed where frequency is to be converted from higher to lower and lower to higher. This type of frequency conversion is required in connecting to Grid Systems.

**Based on Operation Voltage:**

**High Voltage Electrical Power Substation:**

This type of Substation is associated with operating voltages between 11kV and 66kV.

**Extra High Voltage Electrical Power Substation:**

This type of Substation is associated with operating voltages between 132kV and 400kV.

**Ultra High Voltage Electrical Power Substation:**

Substations where operating voltages are above 400kV are called Ultra High Voltage Substation.
Based On Substation Design:

Outdoor Electrical Power Substations:

In Outdoor Power Substations, the various electrical equipments are installed in the switchyard below the sky. Electrical equipment are mounted on support structures to obtain sufficient ground clearance.

Indoor Electrical Power Substation:

In Indoor Power Substations the apparatus is installed within the substation building. Such substations are usually for the rating of 66kV. Indoor Substations are preferred in heavily polluted areas and Power Substations situated near the seas (saline atmosphere causes Insulator Failures results in Flashovers)

Based on Design Configuration:

Air Insulated Electrical Power Substation:

In Air Insulated Power Substations busbars and connectors are visible. In this Power Substations Circuit Breakers and Isolators, Transformers, Current Transformers, Potential Transformers etc are installed in the outdoor. Busbars are supported on the post Insulators or Strain Insulators. Substations have galvanized Steel Structures for Supporting the equipment, insulators and incoming and outgoing lines. Clearances are the primary criteria for these substations and occupy a large area for installation.
Gas Insulated Electrical Power Substation:

In Gas Insulated Substation Various Power Substation equipments like Circuit Breakers, Current Transformers, Voltage Transformers, Busbars, Earth Switches, Surge Arresters, Isolators etc are in the form of metal enclosed SF6 gas modules. The modules are assembled in accordance with the required Configuration. The various Live parts are enclosed in the metal enclosures (modules) containing SF6 gas at high pressure. Thus the size of Power Substation reduces to 8% to 10% of the Air Insulated Power Substation.

Hybrid Electrical Power Substation:

Hybrid Substations are the combination of both Conventional Substation and Gas Insulated Substation. Some bays in a Power Substation are Gas Insulated Type and some are Air Insulated Type. The design is based on convenience, Local Conditions available, area available and Cost.

Boundary conditions

The following boundary conditions influence the design concept and measures to be considered for different parts of substation installations.
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Sub-station site selection

The aspects necessary to be considered for site selection are:

- Fairly level ground
- Right of way around the substation yard for incoming & outgoing transmission & distribution lines.
- Preferably of soil strata having low earth resistance values
- Easy approach & accessibility from main roads for Heavy equipment transportation and routine O & M of substation.
- Economy / Cost

Substation parts and equipment:

Outdoor Switchyard - Incoming & outgoing lines
- Busbars
- Transformers
- Insulators
- Substation Equipment such as Circuit breakers, Isolators, Earthing, Switches, Surge Arresters, CTs, VTs/CVTs
- Neutral Grounding Equipment
- Station Earthing system comprising ground mat, risers, earthing strips, earthing spikes.
- Overhead earthwire shielding against lightning strokes, or, lightning masts.
- Galvanised steel structures for towers, gantries, equipment supports
- PLCC Equipment including line trap, tuning unit, coupling capacitor, etc.
- Power cables
- Control cables for protection and control
- Roads, Railway track, cable trenches
- Station lighting system

11/ 33 kV Switchgear  - 33 kV Outdoor Switchgear
-11 kV Indoor Switchgear
LT Panels  - Low voltage AC. Switchgear
- Control Panels, Protection Panels.
Battery room - DC Battery system and charging equipment distribution system.

Mechanical, Electrical - Fire fighting system Oil purification system and other auxiliaries

Substation parts and equipment:
- Cooling water system
- Telephone system
- Workshop; stores etc.

Protection system - CTs, CVTs
- Protective Relays
- Circuit breakers

SCADA - Computer/Microprocessors, Data collection system, Data processing system
- Man-machine interface
- Expert system etc.

**SUBSTATION PROTECTION**

1. **Substation Grounding/ Earthing**

The sole purpose of substation grounding/earthing is to protect the equipment from surges and lightning strikes and to protect the operating persons in the substation. Hence intentional earthing
system is created by laying earthing rod of mild steel in the soil of substation area. All equipments/structures which are not meant to carry the currents for normal operating system are connected with main earth mat. The substation earthing system is necessary for connecting neutral points of transformers and generators to ground and also for connecting the non current carrying metal parts such as structures, overhead shielding wires, tanks, frames, etc to earth. Earthing of surge arresters is through the earthing system. The function of substation earthing system is to provide a grounding mat below the earth surface in and around the substation which will have uniformly zero potential with respect to ground and low earth resistance.

**The earthing system in a substation:**

- Protects the life and property from over-voltage.
- To limit step & touch potential to the working staff in substation.
- Provides low impedance path to fault currents to ensure prompt and consistent operation of protective device.
- Stabilizes the circuit potentials with respect to ground and limit the overall potential rise.
- Keeps the maximum voltage gradients within safe limit during ground fault condition inside and around substation.

**Earth Resistance:**

Earth Resistance is the resistance offered by the earth electrode to the flow of current in to the ground. To provide a sufficiently low resistance path to the earth to minimize the rise in earth potential with respect to a remote earth fault. Persons touching any of the non current carrying
grounded parts shall not receive a dangerous shock during an earth fault. Each structure, transformer tank, body of equipment, etc, should be connected to earthing mat by their own earth connection.

Generally lower earth resistance is preferable but for certain applications following earth resistance are satisfactory

- Large Power Stations – 0.5 Ohm
- Major Power Stations - 1.0 Ohm
- Small Substation – 2.0 Ohm
- In all Other Cases – 8.0 Ohm

**Step Potential and Touch Potential**

Grounding system in a electrical system is designed to achieve low earth resistance and also to achieve safe ‘Step Potential ‘and ‘Touch Potential’.

**Step Potential:**

Step potential is the potential difference between the feet of a person standing on the floor of the substation, with 0.5 m spacing between the feet (one step), through the flow of earth fault current through the grounding system.
**Touch Potential:**

Touch potential is a potential difference between the fingers of raised hand touching the faulted structure and the feet of the person standing on the substation floor. The person should not get a shock even if the grounded structure is carrying fault current, i.e, The Touch Potential should be very small.

Usually, In a substation a surface layer of 150 mm of rock (Gravel) of 15 mm to 20 mm size shall be used for the following reasons:

- To provide high resistivity for working personnel.
- To minimize hazards from reptiles.
- To discourage growth of weed.
- To maintain the resistivity of soil at lower value by retaining moisture in the under laying soil.
- To prevent substation surface muddy and water logged.
FORMATION OF SUBSTATION EARTHING:

The main earth mat shall be laid horizontally at a regular spacing in both X & Y direction (9m) based upon soil resistivity value and substation layout arrangement. The main earth mat shall be laid at a depth of 600 mm from ground. The earth mat shall be connected to the following in substation:

i. Lightning down conductor, peak of lightning mast

ii. Earth point of S A, CVT

iii. Neutral point of power Transformer and Reactor

iv. Equipment framework and other non-current carrying parts.
v. Metallic frames not associated with equipments

vi. Cable racks, cable trays and cable armour.

**Equipment and Structure Earthing in Substation**

i) Earthing pads are provided for the apparatus/equipments at accessible position. The connection between earthing pads and the earthing grid is made by two short earthing leads (one direct and another through the support structure) free from kinks and splices by 75 mm x 12 mm GS earth flat. The GS earth flat is welded to a MS Rod riser which is connected to the earth mat in ground.

ii) All steel/RCC columns, metallic stairs etc. are connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity is ensured by bonding different sections of rails and metallic stairs.

iii) Metallic pipes, conduits and cable tray sections for cable installation are bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points are also connected to earthing system.

iv) A separate earthing conductor should be provided for earthing the lighting fixtures, receptacles, switches, junction boxes, lighting conduits etc.
v) A continuous ground conductor of 16 SWG GI wire is run all along each conduit run and bonded at every 600 mm by not less than two turns of the same size of wires. The Conductor is connected to each panel ground bus, all junction boxes, receptacles, lighting fixtures etc.

vi) Railway tracks within switchyard are earthed at a spacing of 30 m and also at both ends.

vii) 50 mm x 6 mm MS (or of specified size) flat runs on the top tier and all along the cable trenches and the same is welded to each of the racks. Further this flat is earthed at both ends at an interval of 30 mtrs. The M.S. flat is finally painted with two coats or Red oxide primer and two coats of Post Office red enamel paint or of specified material.

viii) In isolator the base frame is connected to the earth mat.
Pipe earth electrode

Water should be poured in the earth pits at regular intervals to maintain the required earth resistance.

**LIGHTNING PROTECTION**

The protection from the lightning is done with the help of shield wire and lightning mast (high lattice structure with a spike on top).
• Shield wire

Shield wire lightning protection system will be generally used in smaller sub stations of:
Lower voltage class, where number of bays is less, area of the substation is small, & height of
the main structures is of normal height. The major disadvantage of shield wire type lightning
protection is, that it causes short circuit in the substation or may even damage the costly
equipments in case of its failure (snapping ).

• Lightning masts (LM)

This type of protection will be generally used in large, extra high voltage sub stations where
number of bays is more. It has the following advantages:
- It reduces the height of main structures, as peaks for shield wire are not required
- It removes the possibility of any back flashover with the near by equipments/structure,
  etc during discharge of lightning strokes
- Provides facility for holding the lightning fixtures in the substation for illumination purposes
- Aesthetic look.
Zone of protection for single lightning mask

**SELECTION OF LM HEIGHT**

The factors to be considered are:

- The height of the LM will be decided, depending upon the height of equipment to be protected
- The protection zone or coverage area of LM increases with the increase of its height. Hence LM’s height depends upon the height of equipment to be protected
- The protection zone of same LM would be more if the equipment height to be protected is less.
- The numbers of lightning masts in substation can be reduced by increasing the height of LM, but this will cause increase in cost of structure and civil foundations.
- The detailed analysis and experience revealed that 30mtr. LM height is economical proposition & hence to be limited to this height.
The installed LM in the substation covers an area of 44.96m dia circle. It has 2.5m high spike.

- **Earth wire**

Overhead power lines are often equipped with a ground conductor (shield wire or overhead earth wire). A ground conductor is a conductor that is usually grounded (earthed) at the top of the supporting structure to minimize the likelihood of direct lightning strikes to the phase conductors. The ground wire is also a parallel path with the earth for fault currents in earthed neutral circuits. Very high-voltage transmission lines may have two ground conductors. These are either at the outermost ends of the highest cross beam, at two V-shaped mast points, or at a separate cross arm. By protecting the line from lightning, the design of apparatus in substations is simplified due to lower stress on insulation. Shield wires on transmission lines may include optical fibers (OPGW), used for communication and control of the power system.

7/3.66 mm wire is used for providing earthing in lightning mast and towers.

The main function of Earthwire/ Groundwire is to provide protection against direct lightening strokes to the line conductors or towers. In addition Groundwire reduces the induced voltage on parallel telecom lines under fault condition.

Groundwire must meet the following requirements:

- It must be able to carry the maximum lightening current without undue overheating.
- It must be strong mechanically.
- It must be high enough to afford protection to all the line conductors. This function is called shielding.
- It must have enough clearance above the line conductors at mid-span to prevent a side flashover to a line conductor.

Tower footing resistance should be low.
2. **AN OVERVIEW OF 400/220KV GIS SUBSTATION GURGAON**

**BRIEF ABOUT PROJECT**

This project is made to overcome the electricity crises and to meet the power demand of Gurgaon region at Haryana. As the Gurgaon region is upcoming with multi industrial, financial sectors, commercial & residential complexes, offices, clubs and an improved infrastructure, there is a huge demand of electricity in this region which cannot be met by the existing structure of power supply. To meet the requirement a 400/220kV GIS project is set up which is in its completion stage.

This project is associated with Northern Region Strengthening Scheme-VI (NRSS-VI) as agreed during the 18th Standing committee meeting of Northern Regional Transmission Planning held on 6th June 2005.

Mainly three types of contract have been issued

a) Off-Shore Equipment – Includes Circuit Breaker, Isolators, Earth Switch etc. contract given to HYOSUNG Corp., Korea

b) On-Shore Supply – Includes lightning arrestor, CVT, Wave Trap, Cables, Transformer, C&R Panel. Under LOA the contract has been given to ABB, BHEL, BPL, GSW, etc.

c) On-Shore Services – Installation of all Equipment including testing, commissioning and handover.
This project is fed by LILO of existing 400kV Ballabhgarh- Bhiwadi transmission line through double circuit. Major towers in this line used are multi circuit on which four circuits at a time can be used to deliver power. Due to the major commercial & residential hub in this region the cost of land is very high and keeping in view the future hike in land prices these multi circuit tower are installed. The other two circuits in these multi circuit towers can be used by accommodating two circuits of 400/220kV GIS substation at Manesar.

Presently this project consists of 2 x 315MVA, 400/220kV Transformers which will deliver power of approximately > 550MW. The supply is step downed by two nos. of 315MVA Transformer from 400kV to 220kV & is fed to Haryana Vidyut Parashan Nigam Limited (HVPNL) by four outgoing feeders.

This project is equipped with latest technology of GIS System, **GIS** stands for **Gas Insulated Switchgear** in which switchgear assemblies (CB, DS, ES, CT, PT etc.) are enclosed in a metal enclosed chamber which in filled with gas( SF₆ gas) and the enclosure is earthed. The total land used in this project is 9.5 acres.

This project describes the 400kV GIS system of POWERGRID, Gurgaon substation. There is total no. of five bays in 400 kV systems and seven nos. of bays in 220kV systems which are:-
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<td>Bhiwadi Line feeder</td>
<td>ICT-2</td>
</tr>
<tr>
<td>3</td>
<td>ICT-1</td>
<td>HVPNL-1</td>
</tr>
<tr>
<td>4</td>
<td>ICT-2</td>
<td>HVPNL-2</td>
</tr>
<tr>
<td>5</td>
<td>Bus-Coupler and VT</td>
<td>Bus-Coupler and VT</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Outgoing Line-1</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Outgoing Line-2</td>
</tr>
</tbody>
</table>

In this substation double bus single Breaker scheme has been used.

The metal enclosure is made of non-corrosive aluminium. Due to light weight of aluminium, costly foundations are no longer required.
3. **INTRODUCTION TO GAS INSULATED SUBSTATION**

**What is GIS?**

A gas insulated substation is an electrical substation in which the major structures are contained in a sealed environment with sulfur hexafluoride gas (SF6) as the insulating medium. Gas insulated substations originated in Japan where there was a major need to develop technology that would allow substations to be made as compact as possible.

**Where and why Gas Insulated Substations are used?**

Gas Insulated Substations are used where there is space for providing the substation is expensive in large cities and towns. In normal substation the clearances between the phase to phase and phase to ground is very large. Due to this, large space is required for the normal or Air Insulated Substation (AIS). But the dielectric strength of SF6 gas is higher compared to the air, the clearances required for phase to phase and phase to ground for all equipments are quite lower. Hence, the overall size of each equipment and the complete substation is reduced to about 10% of the conventional **air insulated substation**
ADVANTAGES OF GIS TECHNOLOGY

1- Compactness.

The space occupied by SF6 installation is only about 8 to 10% of that a conventional outdoor substation. High cost is partly compensated by saving in cost of space.

2- Choice of Mounting Site.

Modular SF6 GIS can be tailor made to suit the particular site requirements. This results in saving of otherwise expensive civil-foundation work. SF6 GIS can be suitably mounted indoor on any floor or basement and SF6 Insulated Cables (GIC) can be taken through walls and terminated through SF6 bushing or power cables.

3- Reduced Installation Time.
The principle of building block construction (modular construction) reduces the installation time to a few weeks. Each conventional substation requires several months for installation.

In SF6 substations, the time-consuming high cost galvanized steel structures are eliminated. Heavy foundations for galvanized steel structures, Equipment support structures etc are eliminated. This results in economy and reduced project execution time. Modules are factory assembled, tested and dispatched with nominal SF6 gas. Site erection time is reduced to final assembly of modules.

4- **Protection from pollution.**

The external moisture. Atmospheric Pollution, snow dust etc. have little influence on SF6 insulated substation. All live parts are hermetically enclosed in the gas chamber & are, thus, independent from environmental influences like rusting, ageing, atmospheric faults etc.

However, to facilitate installation and maintenance, the substations are generally housed inside a small building.

5- **Increased Safety.**

As the enclosures are at earth potential there is no possibility of accidental contact by service personnel to live parts. Also continuous & robust mechanical interlocking systems ensure maximum operating stability & operator safety.

6- **Explosion-proof and Fire-proof installation.**

Oil Circuit Breakers and oil filled equipment are prone to explosion. SF6 breakers and SF6 filled equipment are explosion proof and fire-proof
7- **Easy operation and long life**

Operation of GIS is simple, user friendly and through safe mechanism.

As all GIS is enclosed in sealed chamber it provides long service life and low maintenance cost.
3. **COMPONENTS OF SUBSTATION**

1. **LIGHTNING ARRESTER**

   It is the first equipment in a substation. Substation design involves more than one installing apparatus, protective devices and equipment. The significant momentary investment and required reliable continuous operation of the facility requires detailed attention to preventing surges from entering the substation facility. The effects of disturbances with limiting in a power system, which if allowed to persist, may damage plant and interrupt the supply of electrical energy. Lightning is one of the most serious causes of over voltage. If the power equipment especially at outdoor substation is not protected, the over-voltage will cause burning of insulation. Thus it results into complete shutdown of the power and the loss may run into cores of kyat. Electrical equipment can be damaged due to over-voltage such as switching surge over-voltage, Lightning surge over-voltage, transient recovery voltage and power frequency temporary over-voltage in transmission line and receiving end of substation. It is important to protect power equipment against them wherever possible. Lightning Arrester can protect the damages of electrical equipments. So, Lightning Arrester must be installed at the terminal end of the transmission line, substation, high voltage transformers and low voltage transformer. The analysis of electromagnetic transient is depended on operating voltage, lengths of the lines and contactor configuration. So, it can be chosen correctly the technical specifications of the apparatus of Lightning Arrester base on the amounts of receiving overvoltage. Generally arresters are connected in parallel with the equipment to be protected, typically between phase and earth for three phase installations.
Lightning arresters are the most effective means of protecting an electrical apparatus against traveling voltage waves caused by lightning and switching. Lightning arresters are connected across and apparatus to provide a Low resistance path to ground, thus limiting the transient voltages below the Basic Impulse Level of the apparatus. There are four different classes of arrester.

1. Station
2. Intermediate
3. Distribution, and
4. Secondary

The functions of a lightning arrester are

1. To act like an open circuit during the normal operation of the system i.e., to hold off the system voltage,
2. To limit the transient voltage to a safe level with the minimum delay and fitter, and
3. To bring the system back to its normal operation mode as soon as the transient voltage is suppressed, i.e., to interrupt the power-follow current and to reseal itself.

The normal operation or operational mode includes the system under faulted condition. Under several types of system faults, such as the single line-to-ground faults, the voltage to ground across the healthy phases will rise above the normal voltage level. The arrester must not go into conduction during this fault condition. It should also be able to interrupt the power-follow
current and reseal itself under system fault conditions when the power-frequency voltage across it rises.

The active elements (blocks) of surge arresters are manufactured using a highly non-linear ceramic resistor material composed for the most part of ZnO mixed with other metal oxide. The resistor blocks in the surge arrester offers low resistance to high voltage surge to ground. Surge Arrester discharges current impulse surge to earth and dissipates energy in the form of heat. After discharging the impulse wave to earth, the resistor blocks in the surge arrester offers a very high resistance to the normal power frequency voltage and acts as open circuit.

There are 2 types of designs available for EHV Surge-Arrester. These are Conventional gapped Surge-Arrester (Value Type) and Metal Oxide Surge-Arrester.

**CAPACITOR VOLTAGE TRANSFORMER**
A capacitor voltage transformer consists of a Capacitor Voltage Divider (CVD) and an inductive Intermediate Voltage Transformer (IVT). The IVT voltage level of capacitor voltage transformers is about $22/\sqrt{3}$ kV, and the rated voltage of the complete capacitor voltage transformer determines the ratio at the capacitor voltage divider.

It is more convenient to make an Inductive voltage transformer for lower voltage levels and let the CVD take care of the high voltage.

The ratio of the capacitive divider is

$$K_1 = \frac{C_1 + C_2}{C_1} = \frac{E_1}{E_2}$$

The ratio of the intermediate voltage transformer is

$$K_2 = \frac{E_2}{E_3}$$

The total ratio factor is therefore

$$K = K_1 \times K_2$$

$K1$ is normally chosen to give $E_2 = 22/\sqrt{3}$ kV.

Thus for different primary voltages, only $C1$ differs and a standard intermediate transformer can be used for all primary voltages. The intermediate voltage transformer (IVT) also contains reactors for compensation of the capacitive voltage regulation.

The capacitor voltage transformer has a double function, one for metering/protection and one for power line communications (PLC).
CVT quality depends on formula:

\[ Q = U_m^2 \times C_e > 10 \]

\[ C_e = C_1 + C_2 \ \text{[μF]} \]

\[ U_m = U_n / \sqrt{3} \times (cap - ratio) \ \text{[kV]} \]

**CVTs as coupling capacitors**

It is possible to combine the CVTs as coupling capacitors for line carrier transmission and as a voltage transformer. The “L” terminal in the terminal box gives access to the CVTs capacitor.
voltage divider. Power line carrier equipment and accessories including drain coil and spark gap protection are available in the terminal box. For external connection of the power line equipment the insulation of the wires must withstand 10 kV RMS test voltage. It's further described under PLCC.

3. WAVE TRAP

Figure 7.1
Principle diagram for a capacitor voltage transformer
It is also called "LINE trap". It is connected in series with the power line. It blocks the high frequency carrier waves (24 kHz to 500 kHz) and let power waves (50 Hz - 60 Hz) to pass through. It is basically an inductor of rating in milli henry.

**GANTRY**

The incoming or outgoing electrical circuit terminates on gantry.

**GIS COMPONENTS**

The essential parts of a GIS are:

- Conductors which conduct the main circuit current and transfer power these are of copper or aluminum tubes.
- Conductors need insulation above grounded enclosures. Conductors also need phase to phase insulation, In SF6 GIS these insulation requirements are met by cast resin insulators and SF6 gas insulation.
- Gas filled modules have nonmagnetic enclosures. Enclosures are of aluminum alloy or stainless steel. Adjacent modules are joined by means of multi-bolts tightened on flanges. Suitable neoprene rubber “O” ring gaskets are provided for ensuring Gas-tight sealing joints.
- Various circuit components in main circuit are: CB, Isolator, Earthing Switches for conductors, CTs, VTs, cable-ends, Bushing-ends and Bus-Bars. Each of these main components has its own gas -filled metal enclosed module.
- Gas filling, monitoring system.
• Auxiliary LV DC and LV AC supply system, control, protection and Monitoring system. This is air-insulated like in conventional sub-station.

The Bus-Bars are conducting bars to which various incoming and outgoing bays are connected. In SF6 GIS the Bus-Bars are laid longitudinally in GIS hall. The bays are connected to Bus-Bars cross-wise. Bus-Bars are either with a three-phase enclosure or single phase enclosure.

Configuration of GIS:

The GIS installations are assembled from a variety of standard modules. Which are joined together by flange connections and plug contacts on the Conductors. So as to easily permit subsequent disassembly of individual components. Gas-tight barrier insulators in the Switchgear sections prevent neighboring Switchgear parts from being affected by overhauls. Any maintenance and overhaul work on Switch contacts can be done without removing the enclosure.

With GIS installations, all basic substation Bus-Bar schemes used, in conventional plant constructions can be realized. Installations with single or multiple Bus-Bar—also alternatively with a bypass bus—can be made with the standard modules, including Bus-Bar sectionalizing with disconnects and Breakers, and Bus-Bar coupling. The two-breaker, one and-a-half circuit breaker and ring-bus systems can also be realized economically. The various switching schemes have been discussed below.

Switching schemes:

• The factors considered for selection of switching schemes
• Reliability factor
• Availability of the space
• Economics (project cost)
• There can be several combinations in which the equipments, busbars, structures etc. can be arranged to achieve a particular switching scheme.
• The switching schemes can be made more flexible by making minor modifications like providing sectionalizers using by-pass path etc.
• The various types of switching schemes are:

  Single sectionalized bus

  Main and transfer bus

  Sectionalized Main bus with transfer bus

  Sectionalized double main and transfer bus

  Double Bus Scheme

  Ring bus

  One and a half breaker

  Double bus, double breaker
THE VARIOUS COMPONENTS OF GIS

CONDUCTOR AND CONTACT PLUG

Conductor is made of aluminium and in the shape of hollow pipe which has diameter of 180mm (outer) with having thickness of 5mm. There is silver plating on the both ends of conductor.
The contact plug is also called SPRING CONTACTS because of making the contact with the help of spring mounted on it. The Bus Bar conductors are interconnected by means of contact plugs in any standard connecting piece. Length variation due to temperature gradients, e.g. between the enclosure and the individual conductors, are compensated in plugs and will not cause any mechanical stress on the insulators.
INSULATORS

Barrier insulator

Support insulator
**Barrier insulator:** The GIS is sectionalized into individual gas compartments by means of gas-tight barrier insulators. By this, the impact of extension or internal faults on the overall installation is reduced to a minimum, and control, supervision and maintenance are greatly eased. All flange connections are sealed by means of age-resistant O-rings. Due to the gas tight design of the insulators no leakage between components can occur.

**Support insulator:** Support insulators are used to mechanically support the conductors. They mainly used for long SF₆ bus duct connection.

**CIRCUIT BREAKER**
CIRCUIT BREAKER

The circuit breaker operates as a single pressure puffer breaker with two interrupting chambers for each pole. For short circuit interruption the puffer breaker utilizes the drive energy in combination with the arc energy to generate the arc quenching gas flow.

Two interrupting unit is fitted in each of the three single-phase aluminum enclosures. The breaker is provided with a hydraulic spring operating mechanism for each phase. It is normally mounted horizontally on a steel bay structure.

The high-current connections from the interrupting unit to the flanges are designed as knife contact (at the drive side) and as plug contact (at the fixed contact side). This allows the interrupting unit to be pulled out of the tank through the drive side flange without removing the connections.

The operating mechanism combines the advantage of mechanical energy storage in plate-shaped springs with the advantages of a hydraulic energy transmission. The plate-shaped springs feature long-time stability, very high reliability and are independent from temperature changes. The hydraulic cylinder is based on existing and well proven design elements for hydraulic drives. The overall number of sealing points has been reduced to an absolute minimum. Sliding seals under pressure are arranged so the leaking oil is kept in the low pressure hydraulic system.

Each circuit breaker is fitted with a pressure relief device for pressure relief in case of overpressure inside the tank.

The circuit breaker gas compartment is isolated from components by barrier insulator 7. The interrupting chamber 3 is arranged horizontally and connected to the barrier insulator 7 through
the outgoing conductors. It is hold in place by the support insulator and the connector at the fixed contact side and is mounted or dismounted through the flange at the drive side.

The motion produced in the operating mechanism in transmitted to the inside of the gas compartment through a shaft bushing and to the chamber by the operating rod5.

The connector at the drive side is a formed as a knife-contact to allow dismounting of the interrupter without removing the barrier insulator.

The circuit breaker is provided with four identical flanges. The two of them on top are used for direct connection of other GIS modules. In standard layouts, these flanges will be connected to current transformer or connecting pieces.

1 – Enclosure
2 – SF6 gas
3 – Interrupting chamber
4 – Grading capacitor
5 – Operating rod
6 – Pressure relief device
7 – Barrier insulator
8 – Disk spring column
9 – Travel stroke switch
10 – Position indicator
11 – Power pack
12 – Auxiliary switches
CIRCUIT BREAKER OPERATION

CLOSING Operation:

During the closing operation, the circuit breaker operating mechanism causes the operating rod and, as a consequence, the moving parts of the two mechanical coupled interrupting chambers, such as the insulating nozzles, the auxiliary nozzles and the blast cylinders to move in the direction of the contacts, contacts is first established through pre-arcing between the arcing contacts, which subsequently enables the main contacts to engage at almost zero current.

OPENING Operation:

Opening is affected by withdrawing the moving contacts in the opposite direction. In this process, the main contacts are separated prior to the disengagement of the arcing contacts, resulting in the commutation of the current to the arcing contacts.

The energy of the arcs and the drive motion causes a pressure increase in the puffers. During the separation of the arcing contacts, a radial gas blast is released through the auxiliary and insulating nozzles, cooling down the arcs and finally extinguishing them at current zero.

The diagrammatic representation in following fig. shows the working principle of a single interrupting chamber following the puffing piston principle. View A shows the initial position of the interrupting chamber in the rest position of switch position ON. Contact ring 4 and the
contact figure 2 form a single conducting unit. During a break movement (view B) the contact ring 4 separates from the contact fingers 2. The gas volume in the puffing cylinder 7, which is traveling backwards, is continually reduced through the stationary puffing piston 8 and the pressure of the enclosed gas is thereby increased until the arcing finger contact 6 also separates from contact pin 1.

As a result of the separation (view C), an electric arc is drawn out, which creates a further pressure increase of the gas in the puffing cylinder 7 due to the effect of local heating from the short circuit current. Due to the increased pressure, the compressed gas flows along the electric arc through the insulating nozzle 3, or in the other direction through the auxiliary nozzle 5. The flow and the heat conducting ability of the SF₆ gas drain the energy from the electric arc, and thereby cause it to extinguish at the current zero transition. View D show the interrupting chamber in the rest position of the off switch position.
Puffer Piston Principle

1 – Contact pin
2 – Contact finger
3 – Insulating nozzle
4 – Contact ring
5 – Auxiliary nozzle
6 – Finger contacts
7 – Puffer cylinder
8 – Stationary puffer piston
9 – Exhaust
## Rating of Circuit Breaker

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Dimension</th>
<th>Unit</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated power frequency withstand voltage</td>
<td>KV</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>- Phase to earth</td>
<td>KV</td>
<td>800</td>
</tr>
<tr>
<td>2</td>
<td>Rated switching impulse withstand voltage</td>
<td>KV</td>
<td>1050+345</td>
</tr>
<tr>
<td></td>
<td>- Phase to earth</td>
<td>KV</td>
<td>1050</td>
</tr>
<tr>
<td>3</td>
<td>Rated lightning impulse withstand voltage</td>
<td>KV</td>
<td>1425+240</td>
</tr>
<tr>
<td></td>
<td>- Phase to earth</td>
<td>KV</td>
<td>1425</td>
</tr>
<tr>
<td>4</td>
<td>Rated normal current</td>
<td>A</td>
<td>4000</td>
</tr>
<tr>
<td>5</td>
<td>Rated short circuit breaking current</td>
<td>KA</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Rated making current</td>
<td>KA</td>
<td>125</td>
</tr>
<tr>
<td>7</td>
<td>Numbers of break per pole</td>
<td></td>
<td>2</td>
</tr>
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</table>
CIRCUIT BREAKER OPERATION MECHANISM

All the three poles of the circuit breaker are operated individually by a hydraulic spring operating mechanism. This hydraulic spring operating mechanism combines a hydraulic drive with mechanical energy storage in a set of a heavy-duty disk springs. The disk springs are hydraulically charged to store the drive energy. The contacts of the circuit breaker are switched on respectively off by means of a hydraulic cylinder. The hydraulic block features a closed loop for the hydraulic oil. Thus, it has no operating mechanism external hydraulic piping.
The different modules in the hydraulic drive are:

- Charging module
- Storage module
- Working module
- Control module
- Monitoring module

The technical concept of the hydraulic spring operating mechanism is achieved a compact design by combining the mechanical energy storage in disc spring and the hydraulic operating and control pipes.

The force given off the disc spring assembly acts on three storage pistons. On the storage piston, the mechanical energy values spring force and spring travel are converted to the hydraulic energy values pressure and volume. The hydraulic power transmission (oil column) between the high-pressure store and operating cylinder serves as quickly switching changeover variator for the
CLOSE and OPEN operation and enables besides it a simple setting of the switching speeds by means of the throttle screws.

The operating mechanism control and the energy transmission are based on the field-proven structural elements of the hydraulic operating technology such as the high-pressure hydraulic pump, storage piston, pilot and changeover valves as well as one operating piston with an integrated hydraulic end position damping.

Schematic view of operating drive

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disc spring assembly HMB-4</td>
</tr>
<tr>
<td>2</td>
<td>Manual operation of pressure release valve</td>
</tr>
<tr>
<td>3</td>
<td>Filling connector</td>
</tr>
<tr>
<td>4</td>
<td>Piston rod</td>
</tr>
<tr>
<td>5</td>
<td>Low pressure tank</td>
</tr>
<tr>
<td>6</td>
<td>Oil gauge glass</td>
</tr>
<tr>
<td>7</td>
<td>Disc spring assembly HMB-8</td>
</tr>
<tr>
<td>8</td>
<td>Charging module</td>
</tr>
<tr>
<td>9</td>
<td>Pump motor</td>
</tr>
<tr>
<td>10</td>
<td>Coal brushes</td>
</tr>
<tr>
<td>11</td>
<td>Storage module</td>
</tr>
<tr>
<td>12</td>
<td>Monitoring module</td>
</tr>
<tr>
<td>13</td>
<td>Pilot valve OPEN II</td>
</tr>
<tr>
<td>14</td>
<td>Pilot valve OPEN I</td>
</tr>
<tr>
<td>15</td>
<td>Pilot valve CLOSE</td>
</tr>
<tr>
<td>16</td>
<td>Control module</td>
</tr>
</tbody>
</table>
Advantage of the operating mechanism:

- Compact design
- High dependability
- Maintenance-free
- Extremely low rate of wear
- Internal hydraulic damping
- No temperature influence

DISCONNECTOR SWITCH
DISCONNECTOR SWITCH

A Disconnecter switch is incorporated between a busbar module and a circuit breaker at the exit side of the bay. The Disconnecter ELK-TV3 and ELK-TE3 provides disconnecting function in GIS substation.

The design of the disconnecter is based on a linear contact movement. The moving contact is operated by a motor drive via a spindle or a rack-drive. The conductors are mounted to a gas tight barrier insulator or a support insulator.

The disconnecter fixed contact is mounted on opposite side of the moving contact.

The ELK-TV3 and ELK-TE3 disconnecter switch can be added with an earthing switch with its own drive, or with a pressure relief device.

---

Disconnector ELK-TV3
Disconnector ELK-TE3

Components of Disconnector: The different components of the Disconnector switch are shown in following fig.
Assembly of Disconnector switch’s components

- Guide pins
- Insulating shaft
- Adjustment gauge
- Moving contact
- Upper screen
- Fixing screws 4xM5
- Lower screen
**Rating of Disconnectors**

<table>
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<th>Dimension</th>
<th>Unit</th>
<th>value</th>
</tr>
</thead>
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<td>Rated power frequency withstand voltage</td>
<td>KV</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>-Phase to earth</td>
<td>KV</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td>-Across open contacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Rated switching impulse withstand voltage</td>
<td>KV</td>
<td>1050</td>
</tr>
<tr>
<td></td>
<td>-Phase to earth</td>
<td>KV</td>
<td>1050+345</td>
</tr>
<tr>
<td></td>
<td>-Across open contacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Rated lightning impulse withstand voltage</td>
<td>KV</td>
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<td>1425+240</td>
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<tr>
<td></td>
<td>-Across open contacts</td>
<td></td>
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<tr>
<td></td>
<td>Description</td>
<td>Unit</td>
<td>Value</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>4</td>
<td>Rated normal current</td>
<td>A</td>
<td>4000</td>
</tr>
<tr>
<td>5</td>
<td>Switching of bus charging current (capacitive current)</td>
<td>A</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>Opening time (time until contact separation)</td>
<td>s</td>
<td>Approx. 0.6</td>
</tr>
<tr>
<td>7</td>
<td>Closing time (time until contact touch)</td>
<td>s</td>
<td>Approx. 1.2</td>
</tr>
</tbody>
</table>

**EARTH SWITCH**
EARTH SWITCH

The Earthing switch provides the earthing function in gas insulated switchgear substation.

1 - Earthed enclosure
2 - SF₆ gas
3 - Earthing switch ELK-EM3
4 - Operating mechanism ELK-DH3
5 - Moving contact
6 - Earthing fixed contact
7 - Insulator
8 - Earth connection

Moving contact

Fixed contact
**Insulating earth connection:** The earthing switch provides the possibility to apply low voltage measurement signals to the active parts. This function is usually referred to as an “insulating earthing switch”. The insulating earth connection is used for various measurements, e.g. switching time of circuit breakers or resistance of the current path.

The moving contact of the earthing switch is insulated from earthing housing 1 by an insulator 4. The earth connection is accomplished outside of the earthing housing by an earth connection 5. When removing this earth connection a measurement of no voltage and PD can be accomplished.

The earthing switch provides an insulated electrode 6 around the moving contact. This electrode is connected to the outside standard BNC connector to electrode 7. This connection can be used for on-site PD measurement and as a no voltage indicator.
The fast acting earth switch is a switching device for connecting active parts and enclosure of a GIS to accomplish earthing and short-circuiting of active parts.
The fast acting earth switch is composed of the drive and the earth switch. The drive includes the motor drive 13, a spring loaded assembly 12 for energy storage and a gear leverage 11, an insulated earth connection 9 and a BNC connector 14 for voltage and PD measurement. The drive is partly pressurized with SF$_6$ gas 5 of the primary apparatus. The earthing switch includes the moving contact 7. The fixed contact 6 is mounted in a different houses normally.

The position indicator 15 and the auxiliary switches are mechanically coupled to the moving contact and are thus performing the corresponding movement.

When starting the motor for the fast acting making operation, the compression helical spring charging, the contact system does not move. Upon triggering of the snap mechanism, the moving contact is rapidly moved to the ON position by the spring force. Thus, earthing switch accomplishes a fast acting making operation and the spring is released.
When starting the motor for an opening operation, it directly moves the contact system. Thus, the spring is not charged and the contact system performs a slow and continuous opening operation. Opening is not fast acting.
Rating of Fast acting earth switch

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Dimension</th>
<th>Unit</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated short circuit making current (peak)</td>
<td>KA</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>Rated induced inductive current at 25KV</td>
<td>A</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Rated induced capacitive current at 25KV</td>
<td>A</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>Rated normal current</td>
<td>A</td>
<td>4000</td>
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<tr>
<td>5</td>
<td>Switching of bus charging current(capacitive current)</td>
<td>A</td>
<td>0.5</td>
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<tr>
<td>6</td>
<td>Opening time</td>
<td>S</td>
<td>1.3</td>
</tr>
<tr>
<td>7</td>
<td>Closing time</td>
<td>Ms</td>
<td>≤50</td>
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</table>
**Transformer and its Auxiliaries:**

Apart from the equipments described so far, a substation uses many more equipments for safety and protection purposes. They are:

- Disconnector and Earth Switches
- Current Transformer
- Voltage Transformer
- Dismantling Unit
- Parallel Compensator
- Insulators
- Surge Arrester
- Density Monitor
- Pressure Relief Device
- Fire Fighting and Protection System
- Protective Relays
- PLCC – Power Line Carrier Communication
- SCADA Systems
- Transmission Lines
- Testing Equipments

Supervisory Control And Data Acquisition systems, popularly known as SCADA, are comparatively new in the power sector. The last section of this report contains an introduction about SCADA based systems, their benefits and drawbacks.
4. **Supervisory Control And Data Acquisition (SCADA)**

The task of supervision of machinery and industrial processes on a routine basis can be an excruciatingly tiresome job. Always being by the side a machine or being on a 24x7 patrol duty around the assembly line equipment checking the temperature levels, water levels, oil level and performing other checks would be considered a wastage of the expertise of the technician on trivial tasks. But, to get rid of this burdensome task, the engineers devised equipments and sensors that would prevent or at least reduce the frequency of these routine checks. As a result of that, control systems and it’s various off springs like **SCADA systems** were formed. **Supervisory Control and Data Acquisition (SCADA)** offers the ease of monitoring of sensors placed at distances, from one central location.

SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. A SCADA system gathers information, such as where a leak on a pipeline has occurred, transfers the information back to a central site, alerting the home station that the leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. SCADA systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or incredibly complex, such as a system that monitors all the activity in a nuclear power plant or the activity of a municipal water system.

SCADA systems were first used in the 1960s.
Parts of a SCADA System

There are many parts of a working SCADA system. A SCADA system includes signal hardware (input and output), controllers, networks, user interface (HMI), communications equipment and software. All together, the term SCADA refers to the entire central system. The central system monitors data from various sensors that are either in close proximity or off site (sometimes miles away).

For the most part, the brains of a SCADA system are performed by the Remote Terminal Units (sometimes referred to as the RTU). The Remote Terminal Units consists of a programmable logic controller. The RTU are set to specific requirements, however, most RTU allow human intervention, for instance, in a factory setting, the RTU might control the setting of a conveyer belt, and the speed can be changed or overridden at any time by human intervention. In addition, any changes or errors are automatically logged for and/or displayed. Most often, a SCADA system will monitor and make slight changes to function optimally; SCADA systems are considered closed loop systems and run with relatively little human intervention.

One of key processes of SCADA is the ability to monitor an entire system in real time. This is facilitated by data acquisitions including meter reading, checking statuses of sensors, etc that are communicated at regular intervals depending on the system. Besides the data being used by the RTU, it is also displayed to a human that is able to interface with the system to override settings or make changes when necessary.

SCADA can be seen as a system with many data elements called points. Each point is a monitor or sensor. Points can be either hard or soft. A hard data point can be an actual monitor; a soft
point can be seen as an application or software calculation. Data elements from hard and soft points are always recorded and logged to create a time stamp or history.

SCADA system includes a user interface, called **Human Machine Interface (HMI)**. The HMI of a SCADA system is where data is processed and presented to be viewed and monitored by a human operator. This interface controls where the individual can interface with the SCADA system.

HMI's are an easy way to standardize the facilitation of monitoring multiple RTU's or PLC's (programmable logic controllers). RTU's or PLC's will run a pre programmed process, but monitoring each of them individually can be difficult, because they are spread out over the system. Because RTU's and PLC's historically had no standardized method to display or present data to an operator, the SCADA system communicates with PLC's throughout the system network and processes information that is easily disseminated by the HMI.

HMI's can also be linked to a database, which can use data gathered from PLC's or RTU's to provide graphs on trends, logistic info, schematics for a specific sensor or machine or even make troubleshooting guides accessible. In the last decade, practically all SCADA systems include an integrated HMI and PLC device making it extremely easy to run and monitor a SCADA system.