

TRANSMISSION AND DISTRIBUTION OF POWER FROM SWITCHYARD IN NLC TPS-II

Submitted in partial fulfilment of the requirements for the completion of

PROFESSIONAL TRAINING

By

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with grade "A++" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this INTERNSHIP Report is the bonafide work of **PRANAV RK (41140066)** who have done the Internship in NLC TPS-II who carried out the Internship entitled "**TRANSMISSION AND DISTRIBUTION OF POWER FROM SWITCHYARD IN TPS-II**" from **07/06/2023** to **16/06/2023**.

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Submitted for Viva voce Examination held on _____

Internal Examiner

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DECLARATION

I hereby declare that the Internship training titled **“TRANSMISSION AND DISTRIBUTION OF POWER FROM SWITCH YARD IN TPS-II”** IN **NLC INDIA LIMITED NEYVELI**, submitted to department of **ELECTICAL AND ELECTRONICS ENGINEERING** in **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for the degree of bachelor of Engineering in a reward of original work done by myself under the guidance of **Mr. SHRI. A.VELU**, DEE/E/TPS-II, NLC India Limited, Neyveli.

This internship report is for reference only and no part of the report will be published copied anywhere without the written permission from officials of NLCIL Neyveli.



Signature of the student

Date:

Place: Neyveli

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ABSTRACT

Power generation plays a pivotal and indispensable role in human life, permeating every facet of our daily existence. The availability and reliable supply of electricity have become the lifeblood of modern society, exerting a profound influence on our well-being, productivity, and overall quality of life. NLC India Limited, a stalwart in the power generation sector, stands as a beacon of power production, contributing significantly to the national grid. With a formidable power generation capacity of approximately 6061 MW, which includes energy harnessed from renewable sources, NLC India Limited powers homes, industries, and businesses across the country. In the realm of power generation, it's crucial to acknowledge that electricity, once generated, cannot be stored indefinitely. It demands instantaneous and continuous evacuation to reach the farthest corners of the grid, where it is harnessed to illuminate homes and drive the engines of progress. This intricate process is orchestrated and executed with precision in the switchyard—a critical component of any power station. Within the expansive landscape of Thermal Power Station Two, this process unfolds in two stages, with Stage 1 operating at 230 kV and Stage 2 at 400 kV. In this dynamic environment, the complete control and monitoring of the transmission and distribution of the generated power take place, making the switchyard a nerve center of power management. India's vision of "One Nation, One Grid, One Frequency" stands as a testament to the nation's commitment to efficient and synchronized power distribution. This visionary initiative seeks to harmonize and unify the diverse power grids that crisscross the country, resulting in a single, consistent frequency resonating across the entire nation. The benefits of this scheme are far-reaching, encompassing the seamless exchange and transfer of electricity across regions, enhanced grid stability, the judicious use of resources, and the optimal integration of renewable energy sources into the national energy matrix. Within the broader context of efficient power transmission and distribution, the concept of Availability-Based Tariff (ABT) assumes a pivotal role. ABT represents a pioneering pricing mechanism implemented in the power sector, revolutionizing the way electricity tariffs are determined. At its core, ABT hinges on the readiness and availability of power generators to supply electricity. This framework incentivizes power generators to maintain high levels of availability and operational efficiency, thereby ensuring a reliable power supply. The tariff structure, rooted in ABT, promotes efficiency, minimizes grid congestion, optimizes resource utilization, encourages the seamless integration of renewable energy sources, and enforces grid discipline through a judicious application of incentives and disincentives during unscheduled power interchange.

The study of the transmission and distribution of power within the switchyard emerges as the central theme of this internship training. It is a journey into the heart of the power generation process—a voyage through the labyrinthine switchyard that orchestrates the symphony of power flow. This internship report seeks to unravel the intricacies of switchyard operations, providing a comprehensive understanding of the critical role it plays in sustaining the nation's power grid. With a spotlight on the "One Nation, One Grid, One Frequency" scheme and the innovative ABT framework, this report serves as a testament to the significance and complexity of power transmission and distribution in modern India.

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LIST OF SYMBOLS AND ABBREVIATIONS

S.NO	SYMBOLS/SHORT FORM	ABBREVIATIONS
1	NLC	Neyveli Lignite Corporation
2	NTPS	Neyveli Thermal Power Station
3	NNTPS	New Neyveli Thermal Power Sation
4	NTPL	NLC Tamilnadu Power Limited
5	TPS-II	Thermal Power Station Two
6	TPS-I	Thermal Power Station One
7	MW	Mega watt
8	Kv	Kilo Volt
9	PGCIL	Power Grid Corporation of India
10	SRLDC	Southern Region Load Dispatch Centre
11	PLCC	Power line Carrier Communication
12	CT	Current Transformer
13	CVT	Capacitive Voltage Transformer
14	LA	Lightning Aresster
15	GT	Generator Transformer
16	MF	Mines Feeder
17	ST	Station Transformer
18	ICT	Inter connecting Transformer
19	ACB	Air Circuit breaker
20	OCB	Oil Circuit Breaker
21	VCM	Vacuum Circuit Breaker
22	SF6	Sulphur Hexafluoride
23	A	Amperes
24	RMS	Root Mean Square
25	MOV	Metal Oxide Varistor
26	GDT	Gas Discharge Tube
27	SAD	Silicon Avalanche Diode
28	TSP	Thyristor Surge Protector
29	SCR	Silicone controlled rectifiers
30	RF	Radio Frequency
31	AM	Amplitude Modulation
32	FM	Frequency Modulation
33	PSK	Phase shift Keying
34	PT	Potential Transformer
35	MVA	Mega Volt Ampere
36	LV	Low voltage
37	HV	High Voltage
38	SCADA	supervisory control and data acquisition
39	ABT	Availability based tariff
40	MWh	Mega watt Hour
41	RLDC	Regional Load dispatch centre
42	SEB	State electricity Board
43	CGS	Central generating station
44	UI	Unscheduled interchange
45	Hz	Hertz
46	MVAR	megavolt ampere of reactive power

OVERVIEW OF NLC INDIA LTD

Neyveli Lignite Corporation (NLC) is a prominent Indian public sector enterprise engaged in lignite mining and power generation. NLC's lignite-based power plants play a vital role in the Indian electricity grid by supplying a significant portion of the country's power demand. The corporation operates large-scale lignite mines in Neyveli, Tamil Nadu, which provide a reliable and indigenous source of fuel for its power plants. The lignite reserves owned by NLC ensure a stable supply of fuel, contributing to the overall energy security of the grid. The lignite-based power plants operated by NLC employ advanced technologies for efficient power generation. These plants utilize modern, high-efficiency combustion techniques to extract energy from lignite, resulting in improved thermal efficiency and reduced environmental impact compared to traditional coal-fired power plants. NLC's focus on technological innovation enables it to generate electricity with lower carbon emissions and reduced environmental pollutants. NLC's contribution to the grid extends beyond reliable and efficient power generation. The corporation actively participates in renewable energy initiatives, including the development of solar and wind power projects. By diversifying its energy portfolio, NLC helps promote a more sustainable and environmentally friendly grid. The integration of renewable energy sources alongside lignite-based power generation enables a balanced energy mix, reducing dependence on fossil fuels and mitigating greenhouse gas emissions. NLC operates thermal power plants primarily in Neyveli, Tamil Nadu, India. The corporation's thermal power plants are located in the Neyveli region, which is known for its abundant lignite reserves. Some of the major thermal power plants operated by NLC in Neyveli include the Neyveli Thermal Power Station (NTPS) and the Neyveli New Thermal Power Station (NNTPS). These plants contribute significantly to the power generation capacity of the region and play a crucial role in meeting the electricity demands of Tamil Nadu and neighboring states. Apart from this it owns coal based thermal power plant in Tuticorin, Solar power plants in Neyveli and Nicobar Islands, wind power plants in Tirunelveli

The following table illustrates the gross generation capacity of the plants owned by the company

POWER PLANT	CAPACITY (MW)
TPS-II	1470
TPS-II EXPANSION	500
TPS-1 EXPANSION	420
WIND POWER PLANT	51
SOLAR POWER PLANT	1370
NTPL	1000
NNTPP	1000
BARASINGSAR TPS	250
TOTAL	6061

The 1470 MW (7x210 MW) Neyveli Thermal Power Station II was built in two stages. At the first stage between March 1986 and March 1988 three units with capacity of 210 MW each were commissioned. Boilers were supplied by Ganz-Danubius and generators were supplied by Franco Tosi. At the second stage from March 1991 to June 1993 four units with the same capacity, supplied by Bharat Heavy Electricals Limited, were added.

Stage 1 consists of 3 units ,each units generator terminal voltage is 15kv , it is stepped up to 230kv.

Stage 2 consist of 4 units,each units generator terminal voltage is 15.75kv, it is stepped up to 400kv.

230kv feeders are relatively of lesser distance than 400kv feeders.

The standard auxiliary voltage is 6.6kv



Fig 1

NATURE OF WORK DONE

The nature of the job undertaken during the internship at NLC Neyveli Thermal Power Station Two encompassed a multifaceted and comprehensive exploration of the intricate processes involved in power generation, transmission, and distribution within the context of a thermal power station. Over the course of the 10-day internship, I was exposed to a diverse range of tasks and responsibilities that collectively constituted a holistic learning experience in the field of electrical engineering and power systems.

One of the central aspects of my internship involved acquiring an in-depth understanding of the entire power generation cycle. This entailed delving into the fundamentals of coal mining and its transportation from the mining site to the power station. I had the privilege of witnessing the transformative journey of coal as it was converted into electricity through the utilization of advanced technological processes. This included gaining insights into the operation and significance of critical components such as boilers, turbines, and generators, all of which are integral to the power generation process.

Furthermore, my internship provided a unique opportunity to acquaint myself with the auxiliary systems that play a pivotal role in the operational efficiency of a thermal power station. Notably, I gained valuable exposure to the operation of the water

desalination plant, an essential facility that ensures the availability of high-quality water for various processes, including steam generation.

Within the switchyard, I had the privilege of exploring the intricacies of the power transmission and distribution systems. This involved a comprehensive education on the basics of switchyard operations, the significance of Availability-Based Tariff (ABT) mechanisms, and the role of regional load dispatch centers such as the Southern Regional Load Dispatch Centre (SRLDC) in optimizing power flow and grid stability.

Hands-on experience was a fundamental aspect of my internship, with opportunities to engage in critical activities. I was actively involved in thermal imaging, a technique employed to assess the condition of contacts within the switchyard equipment. Through this task, I learned how to identify potential issues by detecting temperature variations, thereby contributing to the preventive maintenance efforts within the power station.

Monitoring and logging the data from various meters emerged as another pivotal responsibility. This task not only honed my skills in data management but also underscored the significance of accurate data collection in maintaining the efficient operation of the power station.

Additionally, my internship allowed me to collaborate closely with experienced technicians and staff members during the meticulous process of isolator operation. This practical experience offered insights into the critical safety protocols and procedures involved in managing a power station, particularly during crucial power-down and power-up sequences.

In summary, the nature of the job during my internship at NLC Neyveli Thermal Power Station Two was multifaceted and encompassed a wide spectrum of tasks and responsibilities. From understanding the entire power generation cycle, auxiliary systems, and switchyard operations to participating in hands-on activities such as thermal imaging, meter data monitoring, and isolator operation, the internship provided an immersive learning experience that deepened my knowledge of power systems and electrical engineering. It was an invaluable opportunity to bridge the gap between theoretical knowledge and practical application, preparing me for a career in the dynamic and essential field of power generation and distribution.

KNOWLEDGE AND EXPERIENCE

The internship at NLC Neyveli Thermal Power Station Two was an educational journey that enriched my understanding of various aspects of power generation, transmission, and distribution. Over the course of the internship, I acquired a diverse range of knowledge that significantly expanded my insights into the complexities of the electrical engineering field and power systems. First and foremost, the internship provided me with a profound appreciation for the entire power generation process. I gained comprehensive knowledge about coal mining operations, including the extraction and transportation of coal from the mining site to the power station. Understanding the intricacies of this initial phase was essential to grasp the

foundational aspects of power generation. Moreover, I delved into the heart of power generation within the thermal power station, learning about the functioning of critical components such as boilers, turbines, and generators. This knowledge encompassed not only the theoretical aspects but also hands-on experience in observing and contributing to the operational aspects of these systems. Understanding the inner workings of these components was a cornerstone of my learning, as it illuminated the transformation of coal into electricity and the importance of process efficiency. In addition to the core power generation processes, I gained invaluable insights into auxiliary systems that play a pivotal role in ensuring operational efficiency. The water desalination plant, in particular, became a subject of deep understanding. I learned about its significance in providing high-quality water for steam generation and its crucial role in maintaining the integrity of the entire power generation process.

Within the switchyard, I accumulated knowledge regarding the complex realm of power transmission and distribution. This included a comprehensive grasp of the fundamental principles of switchyard operations and the role of Availability-Based Tariff (ABT) mechanisms in regulating power flow. Moreover, I developed an understanding of the operations conducted at the Southern Regional Load Dispatch Centre (SRLDC) and how it contributes to grid stability and power optimization.

Practical experience was a cornerstone of my internship, providing me with hands-on skills and insights. The task of thermal imaging, for instance, enhanced my knowledge of contact assessment within switchyard equipment. I learned to identify potential issues by detecting temperature variations, thus contributing to the maintenance efforts of the power station. Another vital dimension of my knowledge gain was related to data monitoring and logging. This responsibility underscored the importance of accurate data collection for power station efficiency and further honed my skills in data management and analysis. Furthermore, the internship allowed me to work closely with seasoned technicians and staff during isolator operations. This experience not only deepened my understanding of safety protocols but also illuminated the meticulous procedures required for managing a power station, especially during critical power-down and power-up sequences. In essence, the knowledge gained during my internship at NLC Neyveli Thermal Power Station Two was multifaceted and comprehensive. It encompassed not only theoretical understanding but also practical skills in power generation, auxiliary systems, switchyard operations, thermal imaging, data management, and safety protocols. This immersive learning experience has equipped me with a solid foundation in electrical engineering and power systems, preparing me for future endeavors in this dynamic and essential field.

I had the privilege of taking on an educational leadership role. I conducted educational sessions for college students who were visiting the power station for an industrial visit. These sessions focused on elucidating the intricate workings of the switchyard and its various components, offering a practical perspective that bridged the gap between theoretical classroom learning and real-world applications. By sharing my experiences and insights, I aimed to enhance the educational value of the industrial visit for my fellow students, providing them with practical insights and a deeper understanding of power systems and switchyard operations. This teaching experience not only solidified my own understanding but also highlighted my communication, presentation, and mentoring abilities, contributing to the collective knowledge-sharing within our academic community.

GRID

An electrical grid, also known as a power grid or an electric power system, is a network of interconnected power generation, transmission, and distribution infrastructure that delivers electricity from power plants to consumers. It is a complex network that enables the generation and distribution of electrical energy over large areas. The electrical grid operates in a synchronized manner, balancing electricity supply and demand in real-time. It is typically managed by grid operators and regulated by governmental entities to maintain the stability, reliability, and safety of the electrical supply.

In India, the electrical grid operates on a similar principle as in other countries. The Indian power system is known as the National Grid, which is responsible for the generation, transmission, and distribution of electricity across the country.

The Indian power grid comprises several regional grids that are interconnected to ensure the efficient transmission and exchange of electricity between states and regions. The five regional grids in India are:

- Northern Region Grid: Covers the states of Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Rajasthan, Uttar Pradesh, Uttarakhand, and Delhi.
- Eastern Region Grid: Covers the states of Bihar, Jharkhand, Odisha, West Bengal, Sikkim, and parts of Uttar Pradesh.
- Western Region Grid: Covers the states of Maharashtra, Gujarat, Madhya Pradesh, Goa, Chhattisgarh, and parts of Rajasthan.
- Southern Region Grid: Covers the states of Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu, and Puducherry.
- North-Eastern Region Grid: Covers the states of Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, and parts of West Bengal.

These regional grids are interconnected through high-voltage transmission lines, allowing for the transfer of surplus electricity from one region to another and ensuring a balanced and reliable power supply across the country. The Power Grid Corporation of India Limited (PGCIL) is the central transmission utility responsible for the operation and maintenance of the inter-state transmission system.

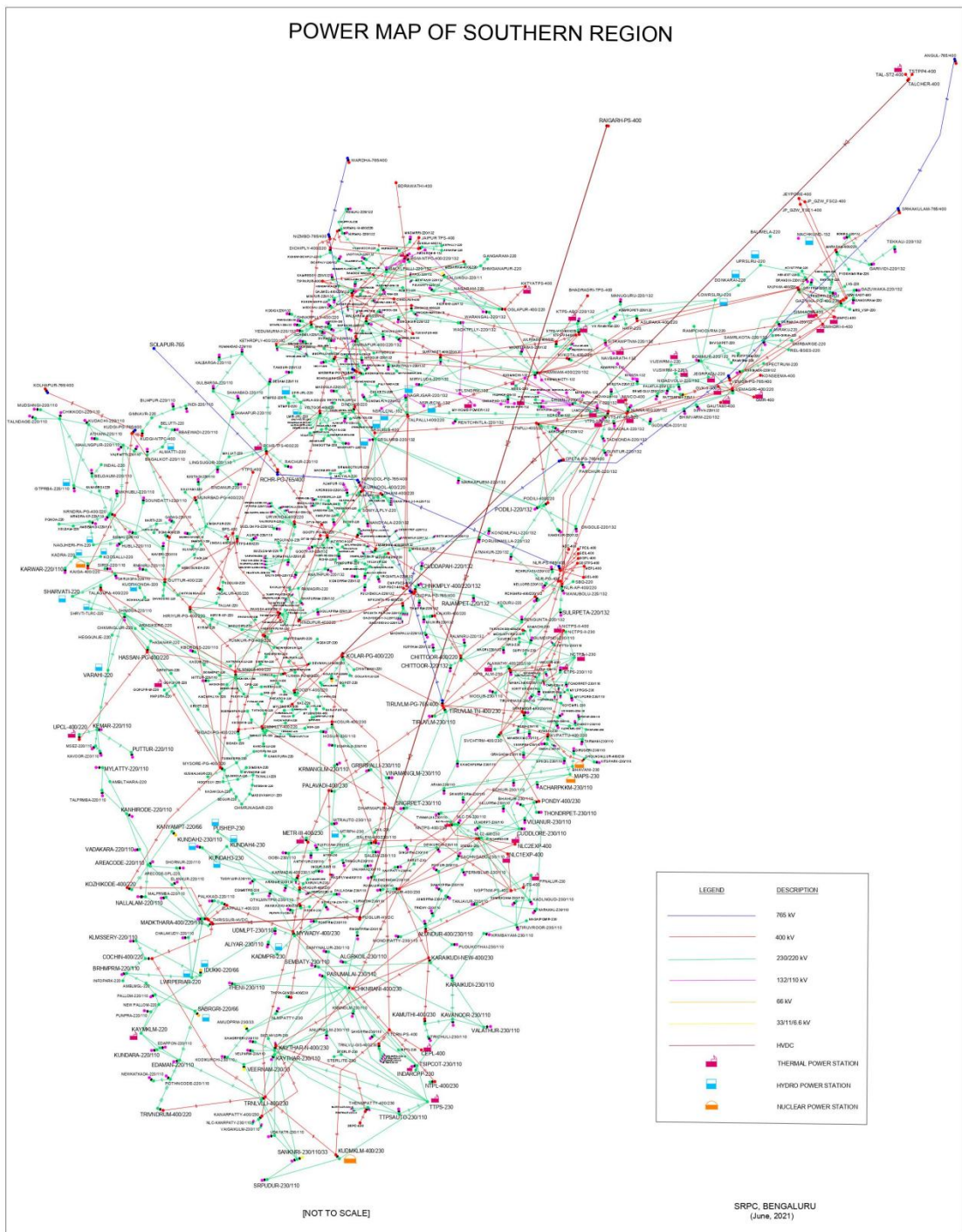


Fig 4

SRLDC stands for "Southern Regional Load Dispatch Center." It is one of the regional load dispatch centers in India responsible for the operation and coordination of the power system in the southern region of the country.

The Southern Regional Load Dispatch Center (SRLDC) monitors and controls the power generation, transmission, and distribution within the states of Andhra Pradesh, Telangana, Karnataka, Kerala, Tamil Nadu, and Puducherry. It ensures the reliable and secure operation of the power grid in the southern region.

The functions of the SRLDC include:

1. Load Forecasting and Dispatch: SRLDC forecasts the electricity demand in the southern region and coordinates the dispatch of power from various generation sources to meet the demand. It ensures that the generation and consumption of electricity are balanced.
2. Grid Operation and Control: SRLDC monitors the operation of the regional power grid, including the voltage, frequency, and power flows. It takes corrective actions to maintain grid stability within the desired limits and ensures the reliable operation of the transmission system.
3. Energy Accounting and Scheduling: SRLDC maintains records of energy transactions and schedules in the southern region. It coordinates with power generators, distribution utilities, and other stakeholders to optimize the utilization of available resources and manage the scheduling of power generation.
4. Outage Management: SRLDC manages planned and unplanned outages of power plants, transmission lines, and other grid elements in the southern region. It schedules maintenance activities and coordinates with other entities for power restoration during emergencies or contingencies.
5. Grid Security and Reliability: SRLDC works to ensure the security and reliability of the power grid in the southern region. It implements measures to prevent grid failures, manages grid disturbances, and restores the grid after blackouts or disruptions.

The SRLDC plays a crucial role in maintaining the stability and reliability of the power system in the southern region of India, ensuring uninterrupted power supply to the states within its jurisdiction.

SWITCH YARD

A switch yard, also known switching station, is a critical component of the power transmission and distribution system within a power plant. It serves as the interface between the power generation and the transmission/distribution networks.

The main functions of a switch yard in a power plant include:

1. **Switching and Control:** The switch yard contains various electrical switches, circuit breakers, and disconnectors to control and isolate the power flow. These devices allow the connection or disconnection of different power sources, transmission lines, or distribution feeders.
2. **Protection and Safety:** The switch yard incorporates protective relays and devices to detect faults, such as short circuits or overloads, and isolate the affected sections of the network. This helps prevent damage to the equipment and ensures the safety of personnel.
3. **Monitoring and Metering:** The switch yard is equipped with instruments and meters to monitor important parameters like voltage, current, power factor, and energy flow. This data is essential for system operation, maintenance, and billing purposes.
4. **Grounding and Lightning Protection:** Adequate grounding and lightning protection measures are implemented in the switch yard to ensure the safety of personnel and equipment from electrical surges, including lightning strikes.
5. **Interface with Transmission and Distribution Networks:** The switch yard provides the connection point between the power plant and the transmission or distribution network. It may have multiple incoming and outgoing transmission lines or feeders to transfer power to the grid or distribute it to local consumers.

Overall, the switch yard plays a crucial role in power system operation by enabling the safe and efficient transfer of power between the power generation and the transmission/distribution systems. It ensures that the generated electricity is appropriately controlled, transformed, and delivered to end-users while maintaining the reliability and stability of the power supply.



Fig 5.1



Fig 5.2

Switch yard consist of 2 stages, stage 1(230kv) and stage 2(400kv).
230kv yard consist of 22 bays and 400kv yard consist of 17 bays.

230 yard is connected top the following :

- Karaikal
- TANTRANSCO 1&2(TNEB)
- Villianur
- Ulundurpet
- TAQA
- Kadalangudi
- Mines feeder 3&4
- Station transformer 1,2,3&4
- Inter connecting transformer 1&2
- 230kV bus coupler
- Generator transformer 1,2&3
- 230kv transfer bus

400kV yard is connected to the following feeders:

- Salem 1
- Nagapattinam pooling station
- Pugalur
- TS-I Expansion Tie Line-3
- NNTPP Tie Line-5
- Inter connecting transformer- 1&2
- Reactors 1&2
- Generator transformer 4,5,6&7
- 400kV transfer bus
- 400kV bus coupler
- TS-II Expansion Tie Line 4

Apart from the above mentioned, the requirements of ther intra-plant are satisfied

- **Bus reactor:** A bus reactor, or shunt reactor, plays a crucial role in power systems by regulating voltage levels and providing reactive power support. It helps maintain a stable voltage profile, compensates for voltage drops, and improves power factor. Additionally, it dampens system oscillations, limits overvoltages, and acts as a harmonic filter. Overall, bus reactors contribute to voltage control, stability, and efficiency in transmission and distribution networks.
- **Bus coupler:** A bus coupler is an electrical component used to interconnect two or more parallel power sources or busbars within a power system. It acts as a bridge, enabling the smooth transfer of power between these sources or busbars while maintaining system stability and reliability. By synchronizing the voltage and frequency of the connected buses, a bus coupler ensures the coordinated

operation and sharing of electrical loads, enhancing the overall flexibility and efficiency of the power system.

- **Bus transfer:** A transfer bus is an electrical busbar that facilitates the transfer of power between independent power systems or substations, ensuring continuity of power supply and enabling efficient coordination and backup capabilities.

The 230kV and the 400kv are paralalled by using an auto transformer type inter-connecting transformer. There are two main Busses namely bus 1 and bus 2 and one transfer bus available for feeders.

Each bay consist of the following elements

- 1st bus isolator-89A
- 2nd bus isolator-89B
- Line isolator-89C
- Transfer bus isolator -89D
- Circuit breaker-52 series
- Current transformer
- Capacitive voltage transformer
- Lightning arrester
- Breaker earth bus side-89E1
- Breaker earth line side-89E2
- Earth switch-89E3

Wave traps and PLCC equipment's are available for VLCC purposes



Fig 5.3



Fig 5.4



Fig 5.5

400KV SWITCHYARD LAYOUT

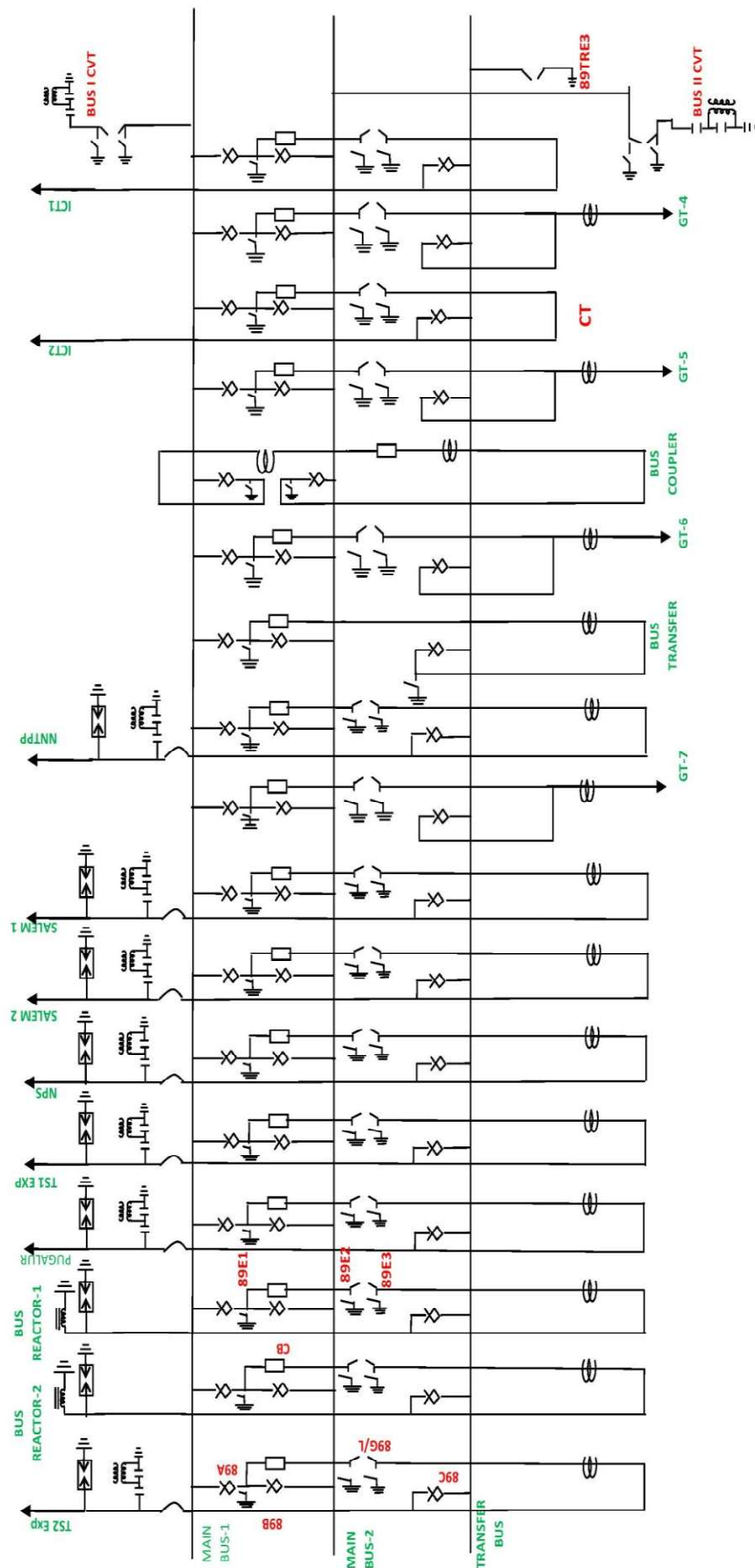


Fig 5.6

230KV SWITCHYARD LAYOUT

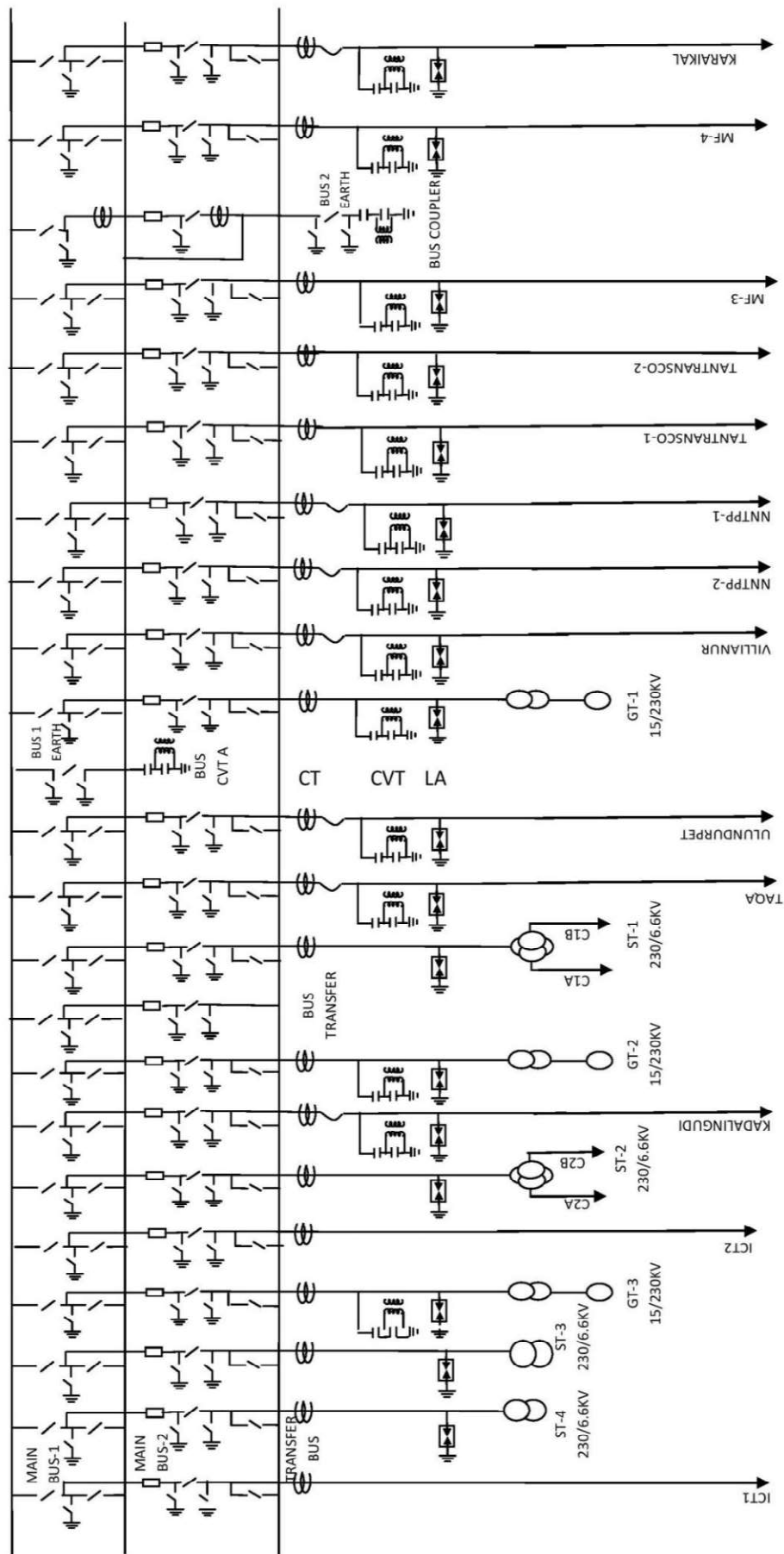


Fig 5.7

COMPONENTS:

ISOLATOR:

An isolator, also known as a disconnect switch or isolating switch, is an electrical device used to physically isolate a circuit or equipment from the power source. Its main purpose is to provide a visible break in the electrical circuit for maintenance, repair, or safety purposes. Here's a concise definition of an isolator:

An isolator is an electrical switch designed to disconnect a circuit or equipment from the power source. It creates a visible gap in the circuit, physically isolating the equipment for maintenance, repair, or safety reasons. Isolators are used to ensure the safety of personnel and protect electrical equipment from accidental energization during maintenance or when it is necessary to work on the isolated circuit. It is an off-load device.

There are several types of isolators used in electrical systems. The main types include:

- Center Break/single break Isolator
- Double-Break Isolator
- Pantograph Isolator

1. Center Break/single break Isolator:

A center break isolator, also known as a center break disconnect switch, is a type of isolator that features a vertical or horizontal rotating mechanism to create an air gap in the center of the switch. This design allows for the complete isolation of the electrical circuit or equipment.

Only one break point is available. one arm consist the male contact and the other consist the female contact.

Design: Center break isolators typically consist of two sets of contacts, which are separated by rotating the mechanism. When the isolator is in the closed position, the contacts are aligned and allow the flow of electrical current. When it is rotated to the open position, the contacts separate, creating an air gap and interrupting the current flow.

Center break isolators are commonly used in high-voltage applications, where safety and maintenance procedures are crucial. The center break design provides a clear and visible separation point, allowing personnel to easily identify and confirm that the circuit is safely disconnected for maintenance or repair work.

2. Double-Break Isolator:

It is designed to provide an extra layer of safety and reliability by incorporating two sets of contacts.

Double Isolation Points: The isolator has two sets of contacts, creating two separate air gaps when in the open position. This design ensures a higher level of isolation, minimizing the risk of unintentional contact and providing added protection for personnel and equipment.

Visible Disconnection: When the double break isolator is open, both sets of contacts visibly separate, creating a clear and noticeable gap. This visible break allows maintenance and repair personnel to easily identify and confirm that the circuit or equipment is safely disconnected.

Enhanced Reliability: The presence of two contact sets in the isolator contributes to increased reliability. In the event of a fault or failure in one set of contacts, the other set can still provide a reliable disconnection, ensuring continuous operation and minimizing downtime.

Operation and Control: Double break isolators can be operated manually through a mechanical lever or remotely using control systems. They are often integrated with protective devices and automation systems to facilitate coordinated switching and ensure safe and reliable operation.

Maintenance and Safety: Double break isolators are crucial for maintenance activities as they allow for the safe disconnection of circuits or equipment. They provide a physical barrier, preventing the flow of current during maintenance or repair work, and reducing the risk of electrical accidents.

A central insulator of three insulators mounted on the post has the rotating male part and the other mounted with two female contacts. When actuated, the male part rotates and makes contacts with the female parts, hence closing the isolator

3. Pantograph Isolator:

A pantograph isolator, also known as a pantograph disconnect switch, is a specialized type of isolator commonly used in overhead transmission lines and substations. Its design consists of two parallel conductors that can be vertically moved to create an air gap.

Vertical Movement: The main feature of a pantograph isolator is its ability to vertically move the conductors. This movement allows for the creation of an air gap between the conductors, enabling the disconnection of the electrical circuit.

Overhead Transmission Lines: Pantograph isolators are primarily used in overhead transmission lines where the conductors are suspended on towers. They provide a

means to isolate and disconnect specific sections of the transmission line for maintenance, repair, or safety purposes.

Flexible Adjustment: Pantograph isolators offer flexibility in adjusting the distance between the conductors, allowing for different air gap lengths as needed. This adjustability is useful for accommodating various operational and maintenance requirements.

Visible Disconnection: When the pantograph isolator is in the open position, the vertical gap between the conductors is clearly visible. This visual confirmation ensures that the circuit is safely disconnected and provides a clear indication for maintenance personnel.

Safe Maintenance: Pantograph isolators play a crucial role in ensuring the safety of maintenance workers. By creating a visible gap and preventing the flow of electrical current, they allow personnel to work on the isolated section of the transmission line without the risk of electric shock.

Coordination with Circuit Breakers: Pantograph isolators are often used in conjunction with circuit breakers to provide additional safety measures. The circuit breaker is used to interrupt the current flow before the pantograph isolator is operated, ensuring safe disconnection and reconnection of the circuit.

The 230kv yard uses gang operated double break isolator and 400kV yard uses single break and pantograph isolator.



Fig 5.8

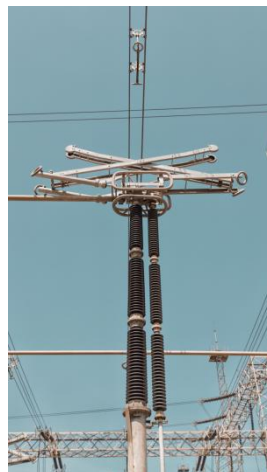


Fig 5.9

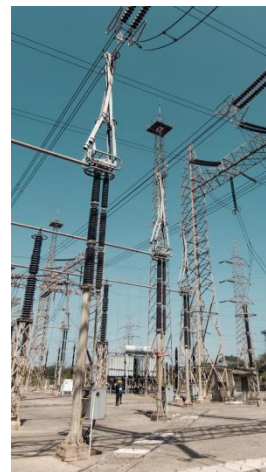


Fig 5.10

CIRCUIT BREAKER:

A circuit breaker is an electrical switching device that automatically interrupts or breaks the flow of electric current in a circuit when it detects abnormal conditions, such as overcurrent, short circuit, or electrical faults. Its main function is to protect electrical systems and equipment from damage due to excessive current or faults.

Overcurrent Protection: Circuit breakers are designed to detect and respond to excessive current flowing through a circuit. When the current exceeds a predetermined threshold, the circuit breaker trips and interrupts the flow of current, preventing damage to the circuit and connected devices.

Short Circuit Protection: In the event of a short circuit, where a low-resistance path is formed, circuit breakers quickly detect the excessive current and trip to isolate the fault. This protects the wiring, equipment, and individuals from the high levels of current that can cause fire hazards and damage.

Fault Protection: Circuit breakers are capable of detecting electrical faults, such as ground faults and phase faults. These faults occur when a live conductor comes into contact with a ground or an unintended path, resulting in an abnormal flow of current. The circuit breaker responds by tripping to isolate the faulted section and prevent further damage.

Manual and Automatic Operation: Circuit breakers can be operated manually to control the flow of current or automatically through protective relays that sense abnormal conditions. Automatic operation ensures swift response and protection in the event of a fault.

Different Types: There are various types of circuit breakers, including thermal, magnetic, and hybrid types. Thermal circuit breakers respond to overcurrent conditions, while magnetic circuit breakers detect and trip under short circuit conditions. Hybrid circuit breakers combine both thermal and magnetic technologies for comprehensive protection.

Resettable: Unlike fuses, which need to be replaced after they trip, circuit breakers are resettable. Once the fault or abnormal condition is resolved, the circuit breaker can be manually reset to restore the flow of current.

Circuit breakers are essential components in electrical systems, providing reliable protection against overcurrent, short circuits, and electrical faults. They help ensure the safety of personnel, prevent damage to equipment, and maintain the integrity and reliability of electrical installations.

A circuit breaker is considered an "on-load" device because it is designed to interrupt the flow of electric current while the circuit is energized or "loaded." Unlike certain isolators or disconnect switches that are primarily intended for opening or closing a circuit when it is de-energized, circuit breakers can interrupt the current flow while the circuit is actively supplying power.

The on-load capability of a circuit breaker is made possible by its internal mechanism, which includes an arc extinguishing system. When the circuit breaker trips due to abnormal conditions like overcurrent or short circuit, it quickly creates a gap between its contacts. At the same time, an arc is formed between the contacts as the current tries to continue flowing. The circuit breaker's arc extinguishing system works to safely extinguish the arc and prevent re-ignition when the contacts separate.

By interrupting the current under load, circuit breakers offer significant advantages in terms of their ability to provide protection and control in real-time situations. They can quickly respond to faults and abnormal conditions, minimizing damage to equipment and ensuring the safety of personnel. The on-load capability of circuit breakers enables them to function effectively in various electrical systems, including power generation, transmission, distribution, and industrial applications.

There are several types of circuit breakers commonly used in electrical systems. Some of the main types are:

Air Circuit Breakers (ACBs): ACBs are used in medium-voltage applications. They utilize air as the arc-quenching medium and can handle larger currents. ACBs are commonly found in power distribution networks.

Oil Circuit Breakers (OCBs): OCBs were widely used in the past but are now being phased out. They utilize oil as the arc-quenching medium and are suitable for high-voltage applications.

Vacuum Circuit Breakers (VCBs): VCBs use a vacuum as the arc-quenching medium. They provide reliable and efficient interruption of current and are used in medium to high-voltage applications.

SF6 Circuit Breakers: SF6 circuit breakers use sulfur hexafluoride gas as the arc-quenching medium. They are highly reliable and commonly used in high-voltage applications.

Based on interrupters present, the circuit breakers can be differentiated as:

- Single interrupted
- Double interrupted

1. Single interrupted :

A single interrupted circuit breaker is a type of circuit breaker that features a single interruption point for the electrical current flow. It is designed to open and interrupt the circuit by separating its contacts when an abnormal condition or fault is detected.

Interruption Mechanism: The interruption mechanism in a single interrupted circuit breaker operates by physically separating the contacts to create a gap and disrupt the current flow. This interruption occurs when a fault, such as overcurrent or short circuit, is detected.

Single Interruption Point: Unlike some other circuit breakers that may have multiple interruption points or stages, a single interrupted circuit breaker has a single point of interruption. This simplifies the design and operation of the circuit breaker.

Compact Design: Single interrupted circuit breakers are typically compact in size due to their simplified interruption mechanism. This makes them suitable for applications where space is limited.

Fast Operation: Single interrupted circuit breakers are known for their fast operation. They can quickly respond to faults and interrupt the current flow to protect the electrical system and connected equipment.

2. double interrupted:

A double interrupter circuit breaker is a type of circuit breaker that features two interruption points for the electrical current flow. It is designed to open and interrupt the circuit by separating its contacts at two distinct locations when an abnormal condition or fault is detected.

Dual Interruption Mechanism: The double interrupter circuit breaker has two separate mechanisms for interrupting the electrical current flow. Each interruption point operates independently to break the circuit and extinguish the arc.

Improved Interruption Performance: With two interruption points, the double interrupter circuit breaker provides enhanced interruption performance compared to single interrupter circuit breakers. The additional interruption points help ensure reliable interruption of the electrical current, even under demanding fault conditions.

Higher Breaking Capacity: Double interrupter circuit breakers are typically designed for higher breaking capacities. They can handle larger fault currents and provide effective protection for electrical systems operating at higher voltage levels.

Increased Safety and Reliability: The presence of two interruption points enhances the safety and reliability of the circuit breaker. It helps minimize the chances of re-ignition and ensures effective fault clearing, reducing the risk of damage to the electrical system and connected equipment.

Double interrupter circuit breakers provide reliable and efficient interruption of electrical currents, offering enhanced protection for electrical systems operating at medium to high voltage levels. Their dual interruption points improve the performance, safety, and reliability of the circuit breaker, making them suitable for demanding applications where higher breaking capacities are required.

SF6

SF6 (sulfur hexafluoride) gas is used in circuit breakers for its unique properties:

1. **Dielectric Strength:** SF6 has a high dielectric strength, making it an effective insulating medium in high-voltage electrical equipment. It can withstand high electric field intensities without ionizing, enabling efficient insulation and reducing the size of electrical equipment.
2. **Thermal Stability:** SF6 exhibits excellent thermal stability, maintaining its chemical and physical properties even at elevated temperatures. This ensures reliable insulation performance in a wide range of temperature environments.
3. **Arc Quenching:** SF6 has exceptional arc quenching properties, extinguishing electrical arcs rapidly and effectively. When exposed to an electrical arc, SF6 gas absorbs free electrons and dissociates into sulfur and fluorine atoms. These atoms quickly recombine to form stable byproducts, such as sulfur dioxide (SO₂) and fluorine compounds, extinguishing the arc and preventing re-ignition.
4. **High Density:** SF6 gas has a high density, contributing to better heat dissipation in electrical equipment. It minimizes the risk of electrical discharges and corona formation, maintaining insulation integrity.
5. **Chemical Stability:** SF6 is chemically stable and non-reactive under normal conditions. It does not react with common materials used in electrical equipment, ensuring long-term integrity and reliability.
6. **Environmental Considerations:** Despite its technical advantages, SF6 is a potent greenhouse gas with a high global warming potential. Efforts are being made to minimize its release and usage, promoting the development of alternative gases and technologies.

In circuit breakers, SF6 gas is used for its superior arc quenching performance. It can rapidly absorb free electrons and extinguish electrical arcs, ensuring reliable interruption of current flow. Additionally, SF6's high dielectric strength, thermal stability, and chemical inertness make it an ideal choice for interrupting and isolating electrical circuits in various voltage levels, from medium to extra-high voltage systems.



Fig 5.11



Fig 5.12



Fig 5.13



Fig 5.14

CURRENT TRANSFORMER(CT):

A current transformer (CT) is an instrument transformer used in electrical power systems to measure or monitor electrical currents. It is designed to transform high currents in the primary circuit into proportional and manageable currents in the secondary circuit, which can be safely measured by instruments or used for control and protection purposes.

Current Measurement: The primary function of a current transformer is to accurately measure the current flowing through the primary circuit. It provides a reduced current output that is proportional to the primary current, enabling easy monitoring and measurement.

Step-down Ratio: Current transformers operate on the principle of electromagnetic induction. They have a specific step-down ratio, which determines the reduction factor between the primary current and the secondary current. Common ratios are 100:5, 200:5, and 1000:5, among others.

Isolation and Safety: Current transformers provide electrical isolation between the primary circuit and the secondary circuit, ensuring safety for personnel and equipment. The primary circuit, typically carrying high currents, remains isolated from the secondary circuit, making it safer for instruments and control devices.

Protection and Control: Current transformers play a crucial role in protection and control schemes. They are extensively used in relays, protective devices, and circuit breakers to sense overcurrents, short circuits, and other abnormal conditions. By accurately measuring the current, they help initiate the appropriate protective actions.

Accuracy and Precision: Current transformers are designed to provide accurate and precise current measurements. Their accuracy class defines the maximum permissible error in the secondary current with respect to the primary current. Common accuracy classes include 0.1, 0.2, 0.5, 1, and 3, with lower accuracy classes offering higher precision.

Secondary Circuit: The secondary circuit of a current transformer typically consists of a few turns of wire wound around a magnetic core. This secondary winding generates a proportional current in response to the primary current, which can be connected to measuring instruments, relays, or other devices.

Current transformers (CTs) are used for several reasons in electrical power systems:

Current Measurement: CTs provide a means to accurately measure the current flowing through a conductor. They transform high currents into proportional and manageable currents in the secondary circuit, allowing for easy measurement using instruments such as ammeters and energy meters. This enables monitoring and analysis of power consumption, load balancing, and power quality assessment.

Protection and Fault Detection: CTs play a vital role in protection schemes by sensing overcurrents, short circuits, and other abnormal current conditions. They are extensively used in relays and protective devices to detect faults and initiate appropriate actions, such as tripping circuit breakers to isolate the faulty section of the system. CTs help prevent damage to equipment, minimize downtime, and enhance system safety.

Energy Management: CTs are used in energy management systems to measure and monitor the power consumption of individual circuits, equipment, or specific areas of a facility. This information is crucial for load profiling, energy audits, demand management, and optimizing energy usage.

Billing and Revenue Allocation: CTs are employed to measure current in specific feeders or sections of a power distribution system. This enables accurate measurement of energy consumption for billing purposes or revenue allocation in multi-tenant buildings, industrial complexes, or shared energy infrastructure.

Safety and Isolation: CTs provide electrical isolation between the high-current primary circuit and the lower-current secondary circuit. This isolation ensures the safety of personnel and equipment by preventing direct contact with high currents. It also allows for the use of low-voltage instruments and control devices in the secondary circuit, enhancing safety during maintenance and testing procedures.

TYPES:

1. Based on the type of primary winding

- **Bard type** - consists of a bar type primary.
- **Wound type** - has more than one primary turn.
- **Window type** - No primary winding present ,secondary wound over primary.

2. Based on function

- **Measuring CT** - used along with measureing devices.
- **Protective CT** - used along protective devices such as trip coil relays etc..

Technical details:

	230kV	400kV
No.of secondary core	5	5
Current	1600A	2000A
Withstand voltage	105kv	1425 peak
Frequency-withstand voltage	460kv RMS for 1 min	603kv RMS for 1 min
Creepage distance	5700mm	10000mm
ISI	185/IS270r1992	185/IS270r1992
Insulation class	A	A
Accuracy	0.5 for metering	0.5 for metering



Fig 5.15

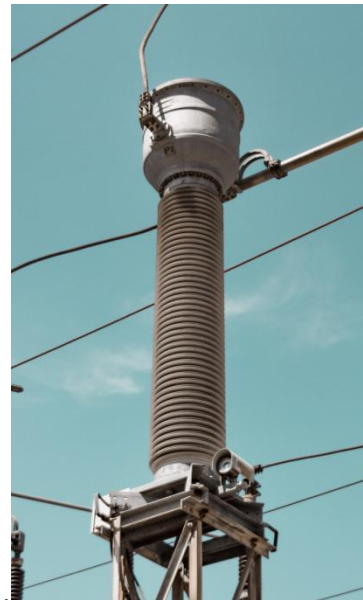


Fig 5.16

CAPACITANCE VOLTAGE TRANSFORMER:

A Capacitive Voltage Transformer (CVT) is an instrument transformer used for voltage measurement and protection in high-voltage switchyards and substations. It operates based on the principle of capacitive voltage division and is specifically designed to accurately measure high voltages.

Voltage Measurement: CVTs are primarily used for precise voltage measurement in high-voltage switchyards. They step down the high voltage to a lower, measurable level that can be used by meters, relays, and other monitoring devices. CVTs provide accurate voltage readings, enabling operators to monitor the voltage levels in the switchyard.

Protection and Control: CVTs play a crucial role in the protection and control schemes of switchyards. They provide voltage inputs to protective relays, which monitor the voltage levels and detect abnormal conditions such as overvoltage or undervoltage. Based on these measurements, the protective relays can initiate appropriate actions to safeguard the equipment and the switchyard.

Insulation Coordination: Switchyards deal with high voltages, and insulation coordination is essential to ensure safe and reliable operation. CVTs help in maintaining proper insulation levels by providing accurate voltage measurements. This information is crucial for designing and maintaining the insulation systems, ensuring they can withstand the voltage stresses within the switchyard.

Power Quality Monitoring: CVTs allow for the monitoring of power quality parameters in switchyards. By measuring the voltage levels accurately, CVTs provide data that can be used to analyze power quality issues such as voltage sags, swells, harmonics, and transients. This information helps in diagnosing and resolving power quality problems, ensuring the smooth operation of equipment.

Capacitive Coupling Compensation: CVTs also help compensate for the capacitive coupling effects that occur in high-voltage systems. Due to the presence of capacitance between phases and between conductors and ground, voltages can induce errors in voltage measurements. CVTs mitigate these errors by providing an accurate and isolated voltage reference.

	230kV	400kV
	Single phase	Single phase
	230kV-245kv	400kV-420kV
Withstand voltage	1050kV peak voltage	1425kv peak voltage
Current	400kV RMS for 1 min	630Kv RMS for 1 min
Voltage rating	230kv/ $\sqrt{3}$ 115kv/ $\sqrt{3}$	400kv/ $\sqrt{3}$ 115kv/ $\sqrt{3}$
Secondary winding	3	3
Creepage distance	5700mm	1000mm

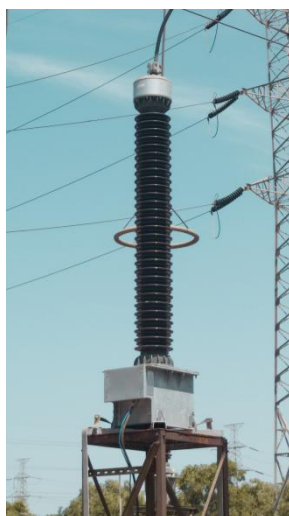


Fig 5.17



Fig 5.18

ARRESTERS:

A lightning arrester and a surge arrester are both devices used to protect electrical systems and equipment from voltage surges, but they are designed to handle different types of surges.

Lightning Arrester: A lightning arrester, also known as a lightning rod or a lightning diverter, is specifically designed to protect electrical systems from the damaging effects of lightning strikes. Lightning strikes can produce extremely high voltage surges that can cause severe damage to equipment and disrupt power systems. Lightning arresters provide a path of least resistance for the lightning current to follow, diverting it safely to the ground and away from sensitive equipment. They are typically installed on structures such as buildings, power poles, or transmission towers to capture and dissipate the lightning energy.

Surge Arrester: A surge arrester, also called a surge protector or transient voltage suppressor, is a device designed to protect electrical systems from transient voltage surges that can occur due to various reasons, including switching operations, fault conditions, or external disturbances. Surge arresters are capable of limiting and diverting high voltage surges away from sensitive equipment, preventing damage and ensuring the system's uninterrupted operation. They are typically installed at different points within electrical systems, such as at the entrance of buildings, substations, or near sensitive equipment, to suppress and absorb voltage spikes.

There are different types of lightning arresters available, each with its own design and application. The three common types of lightning arresters are as follows:

- **Rod Type Lightning Arrester:** This is the most commonly used type of lightning arrester. It consists of a vertical rod or rods made of a conducting material, such as copper or aluminum, mounted on a grounded structure. The rod type arrester provides a direct path for the lightning current to follow, diverting it safely to the ground.
- **Horn Gap Arrester:** This type of lightning arrester consists of a series of metallic horn-shaped elements. When a lightning surge occurs, the voltage rises and causes a gap to form between the horns. The surge current passes through the ionized air gap, diverting the energy away from the protected equipment and towards the ground.
- **Metal Oxide Varistor (MOV) Arrester:** MOV arresters are based on the principle of metal oxide varistors. These arresters contain metal oxide discs or blocks sandwiched between electrodes. During normal operating conditions, the MOV arrester presents a high impedance. However, when a surge voltage exceeds a certain threshold, the MOV's resistance drops significantly, allowing it to divert the surge current to the ground.

There are different types of surge arresters available, designed to provide protection against transient voltage surges in electrical systems. Here are some common types of surge arresters:

- **Metal Oxide Varistor (MOV) Arrester:** MOV surge arresters are widely used due to their high energy absorption capability. They consist of metal oxide discs or blocks sandwiched between electrodes. During normal operation, the MOV presents a high impedance. However, when a surge voltage exceeds a certain threshold, the MOV's resistance drops significantly, allowing it to divert the surge current to the ground.
- **Gas Discharge Tube (GDT) Arrester:** GDT surge arresters use a small gas-filled tube to provide protection against voltage surges. When a surge occurs, the gas in the tube ionizes, creating a low-resistance path for the surge current to bypass sensitive equipment. GDT arresters are characterized by their fast response time and ability to handle high surge currents.
- **Silicon Avalanche Diode (SAD) Arrester:** SAD surge arresters utilize silicon avalanche diodes to provide surge protection. These diodes have a breakdown voltage that triggers avalanche breakdown when the surge voltage exceeds a certain threshold. This causes the diode to conduct and divert the surge current away from the protected equipment.
- **Carbon Gap Arrester:** Carbon gap surge arresters consist of two carbon electrodes separated by a small air gap. Under normal operating conditions, the carbon gap presents a high resistance. However, when a surge voltage exceeds a certain level, the air gap breaks down, allowing the surge current to discharge through the carbon electrodes and to the ground.
- **Thyristor Surge Protector (TSP):** TSP surge arresters use thyristors or silicon-controlled rectifiers (SCRs) to provide surge protection. Thyristors are typically in a high-impedance state during normal operation. When a surge occurs, the thyristor switches into a low-impedance state, diverting the surge current away from the protected equipment.

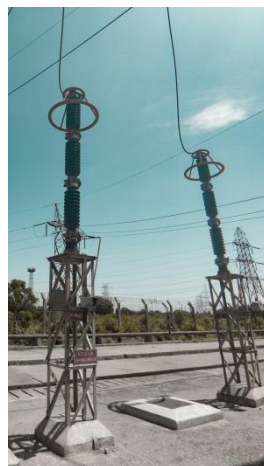


Fig 5.19



Fig 5.20

INSULATOR:

In a switchyard, insulators are used to provide electrical insulation and support for conductive components such as power transmission lines, busbars, and other equipment.

Insulators are utilized in switchyard by the following methods:

- **Overhead Line Insulators:** Switchyards often include overhead power transmission or distribution lines. Insulators are installed at regular intervals along these lines to support the conductors and provide electrical insulation. These insulators prevent the flow of current to the supporting structures and the ground, maintaining the desired electrical isolation.
- **Busbar Insulators:** Busbars are conductive bars or systems used to distribute electrical power within a switchyard. Insulators are placed at specific points along the busbars to prevent electrical contact with supporting structures or other conductive components. They help maintain the electrical separation between different sections of the busbar system.
- **Insulator Strings:** Insulator strings are arrangements of insulators connected in series to provide higher electrical insulation levels. These strings are commonly used in switchyards to support high-voltage power lines or busbars. They ensure that the high voltage is isolated from the structures and other equipment, preventing electrical leakage or short circuits.
- **Equipment Insulators:** Insulators are also used in switchyard equipment such as circuit breakers, disconnect switches, and surge arresters. They provide electrical insulation and support for the internal conductive components of these devices, preventing unintended current flow and ensuring proper operation.

various types of insulators are used to provide electrical insulation and mechanical support. some common types are

- **Pin Insulators:** Used for supporting overhead power transmission or distribution lines.
- **Suspension Insulators:** Suspended in strings to support high-voltage overhead transmission lines.
- **Post Insulators:** Provide insulation and support for busbars and equipment.
- **Composite Insulators:** Made of lightweight and high-strength materials like fiberglass-reinforced polymer (FRP) or silicone rubber.

- **Surge Arrester Insulators:** Designed to withstand high voltage and current associated with surge events.
- **Strain Insulators:** Used to support conductors under tension, such as overhead transmission lines or cables.
- **Shackle Insulators:** Provide insulation and support for conductive hardware like shackles or clamps.
- **Stay Insulators:** Used to support guy wires or stays that help support structures.
- **Bushing Insulators:** Provide insulation and support for bushings, which allow conductors to pass through grounded barriers.



Fig 5.21

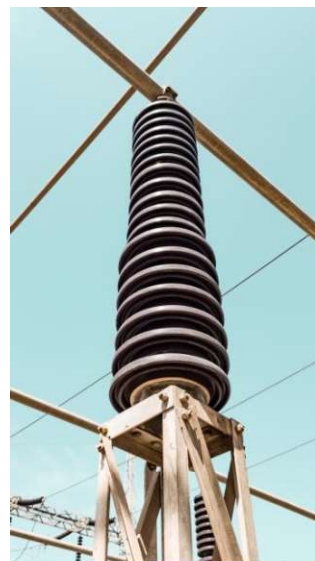


Fig 5.22

WAVE TRAP :

A wave trap, also known as a line trap, is a specialized device used in switchyards and electrical substations. Its primary purpose is to provide a high impedance to high-frequency signals while allowing the flow of power frequency signals. Wave traps are used in switchyards for the following reasons:

- **Blocking High-Frequency Signals:** Switchyards are often located in areas with high levels of electromagnetic interference, such as near communication towers or industrial facilities. High-frequency signals, such as radio frequency (RF) or carrier signals, can interfere with the operation of protective relays, communication systems, and other sensitive equipment. Wave traps are installed at strategic points in the switchyard to block these unwanted high-frequency signals from entering or leaving the switchyard, preventing interference and maintaining the reliability of control and communication systems.

- **Power Line Carrier Communication:** Power line carrier (PLC) communication is a method of transmitting signals over the power transmission lines for various purposes, such as remote control, monitoring, and protection. Wave traps are utilized to separate the communication signals from the power frequency signals. They allow the PLC signals to pass through while blocking the power frequency signals, ensuring efficient and reliable communication without interference from the power system.
- **Filter for Harmonic Mitigation:** Switchyards may have equipment or systems that generate harmonics, which are unwanted frequency components that can affect the power quality. Wave traps with specific filter characteristics can be used to attenuate or filter out these harmonics, reducing their impact on the power system and maintaining a stable and efficient operation.
- **Protection Against Transient Signals:** Wave traps can provide a level of protection against transient signals, such as voltage surges or voltage spikes caused by lightning strikes or switching operations. By offering high impedance to these transient signals, wave traps help to limit their propagation and prevent damage to sensitive equipment in the switchyard.

Wave traps are typically composed of a series of inductive and capacitive elements that create the desired impedance characteristics for high-frequency signals. They are designed and tuned to specific frequencies and applications. The proper installation and configuration of wave traps in switchyards are crucial to ensure effective blocking of unwanted signals, reliable communication, and protection against disturbances, thereby maintaining the overall performance and integrity of the switchyard.



Fig 5.23

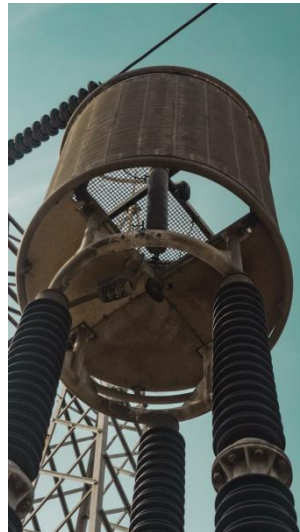


Fig 5.24



Fig 5.25

PLCC:

PLCC stands for Power Line Carrier Communication. It is a method of communication that utilizes the existing power transmission lines to transmit signals for various purposes, such as remote control, monitoring, and protection of electrical systems.

- **Communication over Power Lines:** PLCC involves sending data signals through the power lines that are already used for transmitting electrical power. It eliminates the need for separate communication cables, reducing infrastructure costs and simplifying installation.
- **Carrier Frequency:** PLCC typically operates at higher frequencies (in the kilohertz or megahertz range) than the power frequency (50 or 60 Hz) to avoid interference with the power transmission. By using carrier frequencies, the communication signals can be separated from the power frequency signals.
- **Modulation Techniques:** Various modulation techniques are used in PLCC, including amplitude modulation (AM), frequency modulation (FM), and phase shift keying (PSK). These techniques allow the encoded data to be transmitted over the power lines.
- **Applications:** PLCC is used in power systems for a wide range of applications, such as remote control of switches and circuit breakers, monitoring of system parameters (voltage, current, temperature), protection coordination, fault detection, and control of power system equipment.
- **Benefits:** PLCC offers several advantages, including cost-effectiveness, as it utilizes the existing power infrastructure; reliable communication over long distances without the need for additional cables; and less vulnerability to external interference since the power lines act as a shield.
- However, PLCC has some limitations, such as the attenuation of the communication signals with distance, the possibility of signal interference due to electrical noise, and the need for proper filtering and signal conditioning to ensure reliable communication.
- PLCC provides a convenient and efficient means of communication in power systems, enabling control, monitoring, and protection functions without the need for separate communication infrastructure.

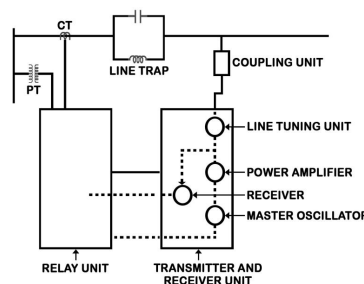


Fig 5.26

INTERCONNECTING TRANSFORMER(ICT):

An interconnecting transformer, also known as an intertie transformer or interconnection transformer, is a specialized transformer used to connect two or more electrical systems or grids together. Its primary purpose is to facilitate the transfer of power between the interconnected systems.

An interconnecting transformer that connects a 230 kV system and a 400 kV system in a switchyard is a specialized transformer(Autotransformer)designed to facilitate the transfer of power between these two voltage levels.

An interconnecting transformer that connects a 230 kV system and a 400 kV system in a switchyard is a specialized transformer(Autotransformer)designed to facilitate the transfer of power between these two voltage levels.

Voltage Conversion: The interconnecting transformer steps up the voltage from the 230 kV system to the higher voltage of the 400 kV system. This voltage conversion allows for the transfer of power from the lower voltage system to the higher voltage system.

Power Transfer Capacity: The interconnecting transformer is designed to handle the power transfer between the two systems. It is rated for a specific power capacity, typically in megavolt-amperes (MVA), to ensure that it can handle the required power flow without exceeding its thermal and electrical limits.

Impedance Matching: The interconnecting transformer ensures impedance matching between the two systems. Impedance matching helps to minimize voltage drops and losses during power transfer, ensuring efficient and reliable transmission of electrical energy.

Tap Changers: The interconnecting transformer may be equipped with tap changers, which allow for voltage adjustment and fine-tuning of the transformer's turns ratio. Tap changers provide flexibility in matching the voltage levels of the 230 kV and 400 kV systems, considering load variations and system conditions.

Cooling Systems: Due to the high power handling capacity, interconnecting transformers typically incorporate efficient cooling systems. This helps dissipate the heat generated during operation and ensures the transformer operates within its specified temperature limits.

Protective Devices: Interconnecting transformers are equipped with protective devices, such as Buchholz relays, temperature sensors, and overcurrent relays. These devices monitor and protect the transformer against faults, such as internal faults, overloads, or short circuits, to safeguard its operation and prevent damage.

Insulation: The interconnecting transformer is designed with suitable insulation systems to withstand the high voltages involved. It employs insulation materials and configurations that can handle the electrical stress and provide sufficient dielectric strength for safe and reliable operation.

Grid Stability and Power Quality: The interconnecting transformer plays a crucial role in maintaining grid stability and power quality between the 230 kV and 400 kV systems. It helps ensure synchronized operation, proper voltage regulation, and control of reactive power flow to maintain stable voltage levels and efficient power transfer.

Interconnecting transformers of this nature are typically large and complex, requiring careful design, installation, and maintenance. They are installed in dedicated bays within the switchyard, with appropriate protection and monitoring systems in place to ensure the reliable and safe operation of the interconnected systems.



Fig 5.27

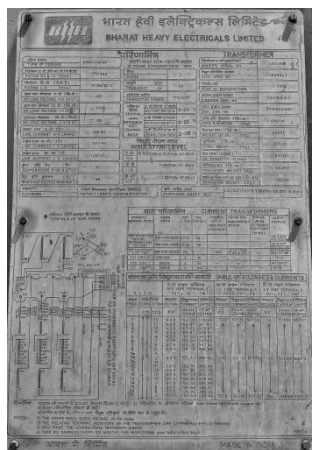


Fig 5.28



Fig 5.29

BUS BAR:

In a switchyard, a bus bar refers to a conductor or a set of conductors that acts as a common electrical connection point for various components within the switchyard. It serves as a backbone for the distribution of electrical power within the switchyard and facilitates the interconnection of various electrical devices and equipment.

- **Conductor Material:** Bus bars are typically made of highly conductive materials such as copper or aluminum. These materials have low resistance to the flow of electrical current, allowing efficient transmission of power.
- **Structural Support:** Bus bars are designed to provide mechanical support to the connected components. They are often mounted on insulators or support structures to maintain their position and prevent sagging or deformation.
- **Main Electrical Junction:** Bus bars serve as the main junction point where power from different sources, such as generators, transformers, or transmission lines, is

combined. They provide a central point for the interconnection of these power sources.

- **Distribution of Power:** The bus bars distribute the electrical power to various components in the switchyard, such as circuit breakers, transformers, disconnect switches, and other equipment. They ensure that power is routed efficiently and reliably to the intended destinations.
- **Voltage Levels:** Bus bars in a switchyard can handle various voltage levels depending on the design and purpose of the switchyard. They can range from low voltage (LV) levels of a few hundred volts to high voltage (HV) levels of several kilovolts (kV) or even higher.
- **Bus Configuration:** Bus bars can be configured in different ways based on the requirements of the switchyard. Common configurations include single bus, double bus, ring bus, breaker-and-a-half, or mesh bus configurations. These configurations determine the flexibility, redundancy, and fault tolerance of the switchyard.
- **Bus Couplers:** Bus bars may include bus couplers or bus tie arrangements that allow the interconnection of multiple bus sections. Bus couplers enable the transfer of power between different sections of the switchyard, providing flexibility, redundancy, and the ability to isolate or synchronize sections as needed.

Technical details:

230kV	400kV
● Aluminium pipe 4'' ● Grade - 63401wp ● IS - 508L ● Conductor type - ACSR - moose ● Diameter 3.53mm ● Voltage - 230kV ● Short time rating - 40kA for 3 seconds ● Current - 1600A ● Withstand Current - 100kAmps	● Rated voltage - 400kV ● Current - 2000A ● Short time rating - 40kA for 3 seconds ● Withstand current - 100kA ● Main bus bar - Quadrapole moose ● Bus bay conductor - 4'' Aluminium Tube ● IS standard - 398 IS 508L

Transfer bus bar

In a switchyard, a transfer bus bar, also known as a transfer bus, is a specialized type of bus bar that is used to facilitate the transfer of electrical power between different sections or zones within the switchyard. It acts as an intermediary connection point that allows for the seamless transfer of power from one bus section to another.

Interconnecting Zones: A switchyard may be divided into multiple sections or zones for various reasons, such as redundancy, maintenance, or load management. Each zone may have its own dedicated bus bar system. The transfer bus bar provides the means to interconnect these zones and transfer power between them when necessary.

Power Transfer: The transfer bus bar serves as a bridge or link between the separate bus bar systems. It enables the transfer of electrical power from one zone to another, allowing for flexibility in power distribution and load balancing within the switchyard.

Switching Operations: During switching operations, such as maintenance or repair work, it may be necessary to isolate a particular zone from the main bus bar system. The transfer bus bar allows for the safe and controlled transfer of power away from the isolated zone to other zones that are still in operation.

Redundancy and Backup: Transfer bus bars can also be used to provide redundancy and backup capabilities in a switchyard. In the event of a fault or failure in one zone, power can be transferred to an alternate zone via the transfer bus bar, ensuring continuity of power supply.

Protection and Control: Transfer bus bars are equipped with protective devices, such as circuit breakers or isolators, to ensure safe and reliable operation. These devices provide control over the transfer of power and help protect the switchyard equipment from overloads, faults, or abnormal conditions.

Monitoring and Control Systems: Transfer bus bars are typically monitored and controlled through supervisory control and data acquisition (SCADA) systems or other monitoring systems. This allows operators to monitor the power flow, voltage levels, and other parameters associated with the transfer bus bar operation.

Transfer bus bars are designed to handle the electrical load and voltage levels specific to the switchyard configuration. They are an integral part of the switchyard infrastructure, enabling efficient power transfer, load management, and maintenance operations while ensuring the reliability and safety of the electrical system.

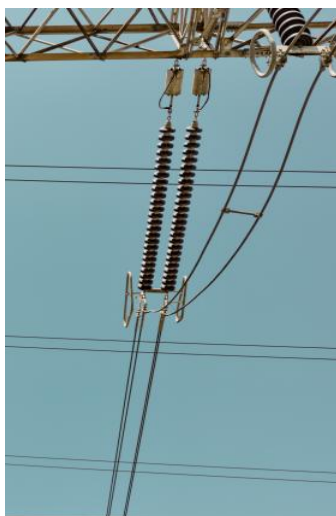


Fig 5.30

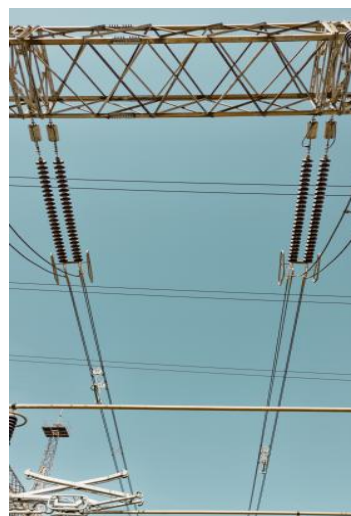


Fig 5.31

BUS REACTOR:

In a switchyard, a bus reactor, also known as a shunt reactor or line reactor, is a device used to regulate voltage levels and compensate for reactive power in the electrical system. It is connected in parallel with the bus bars or transmission lines within the switchyard.

Voltage Regulation: Bus reactors are essential for voltage regulation in the electrical system. They provide inductive reactance, which helps absorb excess reactive power and stabilize voltage levels. By adjusting the inductive reactance, bus reactors ensure that voltage remains within acceptable limits, even during varying load conditions or system dynamics.

Reactive Power Compensation: Reactive power compensation is a key function of bus reactors. They balance out the capacitive reactance in the system by providing inductive reactance. This helps improve the power factor, which is the ratio of real power to apparent power, resulting in reduced voltage drops and enhanced system efficiency. By compensating for reactive power, bus reactors optimize the power flow and reduce wastage.

Fault Current Limitation: During a fault or short circuit, high currents flow through the system. Bus reactors limit the magnitude of these fault currents by introducing impedance. This impedance restricts the flow of current, protecting the system equipment from damage. By limiting fault currents, bus reactors contribute to system reliability and prevent excessive stress on the system components.

Damping Oscillations: Power system oscillations can occur due to switching operations, sudden load changes, or transient disturbances. Bus reactors help dampen these oscillations by providing additional inductive reactance. The inductive reactance helps absorb and dissipate the oscillation energy, thereby stabilizing the system and preventing any adverse effects on equipment and power quality.

Voltage Transient Suppression: Voltage transients or surges, such as those caused by lightning strikes or switching operations, can pose a risk to the electrical system. Bus reactors play a crucial role in suppressing these transients. Their inductive nature allows them to absorb and dissipate the transient energy, protecting the system equipment from voltage spikes and ensuring the integrity of the system.

Harmonic Filtering: Nonlinear loads, such as electronic devices, can introduce harmonics into the electrical system. Harmonics are unwanted frequencies that can distort the power waveform and affect power quality. Bus reactors, to some extent, act as harmonic filters by introducing impedance to high-frequency harmonics. This helps reduce harmonic distortion and maintain a cleaner power supply.

System Resonance Mitigation: Resonance conditions can occur when the inherent capacitance of the system interacts with its inductive elements. Bus reactors help mitigate system resonance issues by introducing additional inductive reactance. This alters the resonance frequency and prevents excessive voltage or current amplification, which could lead to instability or equipment damage.

These functions make bus reactors indispensable in power systems, as they contribute to voltage stability, reactive power compensation, fault current limitation, oscillation damping, transient suppression, harmonic filtering, and system resonance mitigation.



Fig 5.32



Fig 5.33

Bus reactors, encompassing various types like shunt reactors, line reactors, neutral grounding reactors, and resonance reactors, hold a critical role in electrical power systems. These reactors are strategically connected either in parallel with transmission lines and bus bars or in series with specific equipment to address multiple operational challenges. They are instrumental in maintaining voltage stability by providing inductive reactance, compensating for reactive power to enhance the power factor and diminish voltage fluctuations, and limiting fault currents during short circuits, thus safeguarding essential equipment. Furthermore, they play a crucial role in damping power system oscillations, suppressing voltage transients caused by factors like lightning strikes, acting as partial harmonic filters to mitigate harmonic distortion from nonlinear loads, and mitigating resonance issues in the power system. Modern bus reactors may integrate advanced monitoring and control systems, facilitating real-time data analysis for predictive maintenance and seamless integration into smart grid configurations. Environmental considerations are also taken into account in their design and operation. Overall, bus reactors are indispensable for optimizing system reliability, efficiency, and power quality within electrical power systems.

AVAILABILITY BASED TARRIF(ABT)

INTRODUCTION

Availability Based Tariff (ABT) is a frequency based pricing mechanism applicable in India for unscheduled electric power transactions. The ABT falls under electricity market mechanisms to charge and regulate power to achieve short term and long term network stability as well as incentives and dis-incentives to grid participants against deviations in committed supplies.

- The main objective of ABT is to incentivize power generators and transmission companies to ensure higher availability and reliability of their assets, thereby enhancing the overall power system performance.
- Payment Structure: Under ABT, generators and transmission companies are paid based on their availability rather than the actual energy generated or transmitted. The availability of power plants and transmission lines is measured and quantified, and payments are made accordingly.
- Availability Calculation: Availability is typically calculated as a percentage by dividing the actual available capacity by the total capacity of the power plant or transmission line. It considers factors such as scheduled outages, forced outages, and maintenance periods.
- Penalties and Incentives: ABT incorporates penalties for non-availability or underperformance, while providing incentives for higher availability. Generators and transmission companies are motivated to maintain their assets in good condition and minimize downtime to avoid financial losses and earn additional revenue.
- Market Efficiency: ABT promotes market efficiency by aligning economic incentives with system reliability. It encourages generators to optimize their operations and maintenance practices, reducing the likelihood of breakdowns and improving overall system stability.
- Grid Discipline: ABT fosters grid discipline by enforcing strict adherence to scheduling and dispatch protocols. It ensures that generators and transmission companies adhere to their commitments, reducing congestion and optimizing the utilization of transmission infrastructure.
- Open Access: ABT is often implemented in conjunction with open access regulations, allowing multiple generators to access the transmission network. It promotes competition and facilitates the efficient utilization of generation resources.

OPERATION

1. Each day of 24 hrs starting from 00.00 hours be divided into 96 time blocks of 15 minutes each.
2. Each generating station is to make advance declaration of its capacity for generation in terms of MWh delivery ex-bus for each time block of the next day. In addition, the total ex-bus MWh which can actually be delivered during the day will also be declared in case of hydro stations. These shall constitute the basis of generation scheduling.
3. While declaring the capability, the generator should ensure that the capability during peak hours is not less than that during other hours.
4. The Scheduling as referred to above should be in accordance with the operating procedures in force.
5. Based on the above declaration, the Regional Load Dispatch Centre (RLDC) shall communicate to the various beneficiaries their respective shares of the available capability.
6. After the beneficiaries give their requisition for power based on the generation schedules, the RLDC shall prepare the generation schedules and drawal schedules for each time block after taking into account technical limitations and transmission constraints.
7. The schedule of actual generation shall be quantified on ex-bus basis, whereas for beneficiaries, scheduled drawals shall be quantified at their respective receiving points.
8. For calculating the drawal schedule for beneficiaries, the transmission losses shall be apportioned in proportion to their drawals.
9. In case of any forced outage of a unit, or in case of any transmission bottleneck, RLDC will revise the schedules. The revised schedules will become effective from the 4th time block, counting the time block in which the revision is advised by the generator, to be the 1st one.
10. It is also permissible for the generators and the beneficiaries to revise their schedules during a day, but any such revisions shall be effective only from the 6th time block reckoned in the manner as already stated.

Mode of operation scheduling times for CGS

- 10 00 hours CGS declares EX bus MW availability for the next day.
- 11 00 hours SRLDC advises SEBs on declared availabilities.
- 15 00 hours SEBs give their requirement to SRLDC.
- 17 00 hours SRLDC advises next day's schedule to CGS and SEBs.
- 22 00 hours CGS confirms earlier declaration or gives revised availability declaration.
- 23 00 hours SRLDC advises final schedule to CGS with SEBs revised requisition in case of change.
- 00 00 hours to 24 00 CGS generation starts as per final schedule.

DEFINITION OF UNSCHEDULED INTERCHANGE(UI)

UI is the difference between actual export and scheduled export for a given period of time.

C=ACTUAL ENERGY-SCHEDULED ENERGY

If UI is positive ----incentive

If UI is negative ----penalty

FREQUENCY IN Hz	UI RATE PAISE/KW hr
50.2<	0.0P
>50.2 upto 49.7 in steps of 0.02Hz	At the rate of 15.5P
49.7 to 49.5 Hz	At the rate of 73P
49.5 to 49.2 Hz	483.6P/units
>49.2 Hz	564.2P/units

NECESSITY

Availability Based Tariff (ABT) is necessary in the power sector for several reasons:

1. **System Stability:** ABT promotes system stability by incentivizing power generators and transmission companies to maintain high availability of their assets. This reduces the risk of blackouts, voltage fluctuations, and other disruptions in the power grid.
2. **Reliability of Supply:** ABT ensures a reliable and uninterrupted power supply to consumers by encouraging power generators and transmission companies to optimize their operations and maintenance practices. This leads to reduced downtime, fewer outages, and improved service quality.
3. **Efficient Resource Utilization:** ABT encourages efficient utilization of generation resources by rewarding power generators based on their availability. It motivates them to maintain their assets in good condition, optimize their scheduling, and minimize breakdowns. This helps extract maximum value from existing power generation capacity.
4. **Grid Discipline:** ABT enforces grid discipline by requiring power generators and transmission companies to adhere to their commitments and scheduling protocols. It promotes coordination and cooperation among market participants, reducing congestion and ensuring smooth power flow in the transmission network.
5. **Cost Efficiency:** By incentivizing higher availability, ABT encourages power generators and transmission companies to minimize downtime and optimize their operations. This leads to cost savings by reducing maintenance costs, fuel wastage, and potential penalties for non-availability.
6. **Market Transparency and Competition:** ABT is often implemented alongside open access regulations, allowing multiple generators to access the transmission network. This promotes competition, market transparency, and equal opportunities for participation. It fosters a level playing field for all market participants, driving efficiency and innovation.

7. Revenue Generation: ABT provides a revenue stream for power generators and transmission companies based on their availability, which helps in covering their operational and maintenance costs. It provides a financial incentive for them to invest in asset maintenance and upgrade, ensuring long-term sustainability of the power sector.

Overall, ABT is necessary to ensure the stability, reliability, and efficiency of the power system. It incentivizes availability, promotes grid discipline, encourages efficient resource utilization, and fosters a competitive market environment. These factors contribute to a robust and resilient power sector that can meet the growing energy demands of consumers.

FREQUENCY		UI RATE		FREQUENCY		UI RATE	
	50.2		0	49.8	49.78		325.5
50.2	50.18		15.5	49.78	49.76		341
50.18	50.16		31	49.76	49.74		356.5
50.16	50.14		46.5	49.74	49.72		372
50.14	50.12		62	49.72	49.7		387.5
50.12	50.1		77.5	49.7	49.68		403
50.1	50.08		93	49.68	49.66		450
50.08	50.06		108.5	49.66	49.64		497
50.06	50.04		124	49.64	49.62		544
50.04	50.02		139.5	49.62	49.6		591
50.02	50		155	49.6	49.58		638
50	49.98		170.5	49.58	49.56		685
49.98	49.96		186	49.56	49.54		732
49.96	49.94		201.5	49.54	49.52		779
49.94	49.92		217	49.52	49.5		826
49.92	49.9		232.5	49.5	49.48		873
49.9	49.88		248				920
49.88	49.86		263.5	GENs payment	<49.2		964.2
49.86	49.84		279		<49.5		1222.2
49.84	49.82		294.5	EBsPayment	<49.2		1746
49.82	49.8		310				

Fig 6.1

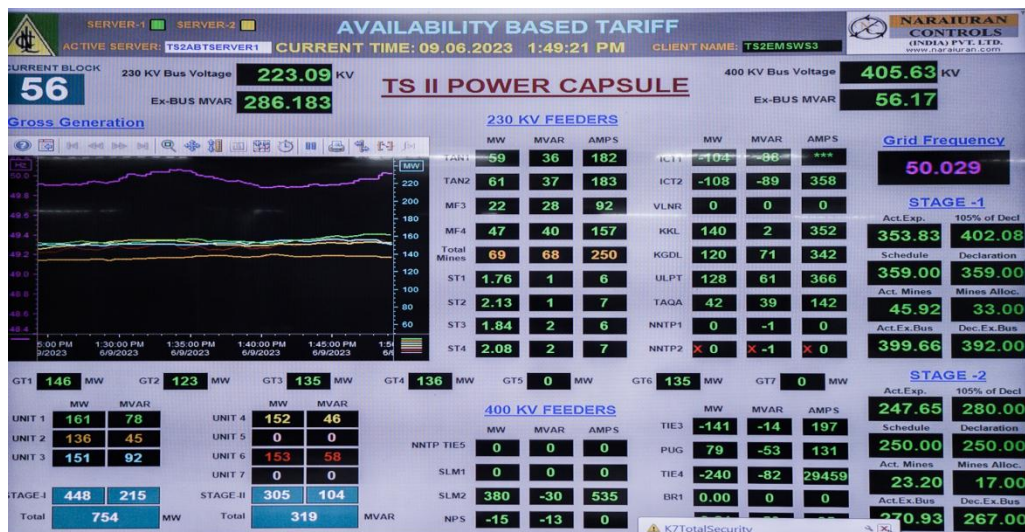


Fig 6.2

CONCLUSION

In conclusion, the internship report on the transmission and distribution of power from the switchyard in a thermal power station has provided valuable insights into the intricate workings of the power transmission and distribution system. Through this internship, I have gained practical knowledge and hands-on experience in the operation and maintenance of various components within the switchyard.

The switchyard serves as a crucial hub for receiving, transforming, and transmitting electrical power generated in the thermal power station. It encompasses a range of equipment such as transformers, circuit breakers, isolators, bus bars, surge arresters, and other protective devices. These components work together to ensure the efficient and reliable transmission of electrical power to the grid and various distribution networks.

During the internship, I have learned about the different types of equipment used in the switchyard and their specific functions. This includes the understanding of transformers for voltage transformation, circuit breakers for interruption of fault currents, isolators for disconnecting and isolating circuits, and surge arresters for protection against transient voltage surges.

I have also gained insights into the significance of safety measures, maintenance procedures, and grid discipline in the switchyard. Adherence to proper maintenance practices, periodic inspections, and adherence to safety protocols are essential to ensure the smooth operation of the switchyard and mitigate the risks associated with electrical hazards.

Furthermore, I have become familiar with the concept of availability-based tariff (ABT), which incentivizes power generators and transmission companies to maintain high availability and reliability of their assets. ABT, coupled with open access regulations, promotes competition, market efficiency, and ensures a reliable supply of electricity to consumers.

Overall, this internship has provided a comprehensive understanding of the transmission and distribution of power from the switchyard in a thermal power station. It has equipped me with practical skills, technical knowledge, and a deep appreciation for the critical role played by the switchyard in the power sector.

APPENDIX

