DELHIMETRORAILCORPORATIONLTD.

(A JOINT VENTURE OF GOVERNMENT OF INDIA AND GOVT. OF DELHI)

INDUSTRIAL TRAINING REPORT

ELECTRICALTRACTION DEPARTMENT

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DTU/2K16/EL/068

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank the training department of Delhi Metro Rail Corporation Limited, New Delhi for granting me this opportunity to be a part of this wonderful organization as an industrial trainee. I would sincerely like to thank AGM/E/AEL&L2, Traction for his constant assistant provided during the time of this training.

On the very outset of this report, I would like to extend my sincere & heartfelt obligation towards all the personages who have helped me in this endeavor. Without their active guidance, help, cooperation & encouragement, I would not have made headway in the project.

I am grateful to Mr. Pushpendra, Mr. SanjayYadav(OHE), Mr. Bhaskar(SCADA) for the inconstant guidance and enlightening words during the course of the training. I would be doing in justice if I forget to thank all the shift in-charges and engineering assistances who made me aware of the process undergoing in the organization. Last but not least, I would like to thank my parents and friends for the inconstant support and guidance.

ABOUT DMRC

The followings section contains the details of DMRC as an organization. Why it was created and how it has been maintained. Delhi, the national capital with the population of about 12 million, perhaps, the only city of its size in the world, which depends almost entirely on buses on it sole mode of mass transport. Bus services are inadequate and heavily over-crowded. This situation had led to proliferation of personalized vehicles, so much so that Delhi has more registered vehicle than the total number of vehicles in Mumbai, Calcutta and Chennai put together. Nearly 70% of these are two wheelers. The result of extreme congestion on the road, ever slowing speeds, increasing accident rate, fuel wastage and environmental pollution. Delhi has now become the fourth most populous cities in the world, with automobiles contributing more than two thirds of the total atmospheric pollution. Pollution related health problems are reaching disconcerting levels.

To meet forecast transport demand for the year 2001, the number of buses will have to beat least doubled and personalized vehicles will grow threefold. This sure to lead to further worsening of the levels of congesting and pollution, which had already crossed acceptable limits in many part of the city.

Immediate steps are, therefore, needed to improve both the quality and availability of mass transport service. This is possible only if a rail-based mass transit system, which is non-polluting, is introduced in the city without further delay.

DELHI MRTS PROJECT

With a view to reducing the problems of Delhi's commuter, the launching of an Integrated Multi Mode Mass Rapid Transport System for Delhi had long been under consideration. The first concrete step in this direction was, however, taken when a feasibility study for developing such a multi-modal MRTS system was commissioned by GNCTD (with support from GOI) in 1989 and completed by RITES in 1991. It is recommended a 198.5 km predominantly rail based network, with first phase to cover a length of 55.3 km, report was completed by RITES during 1995.

The present proposal of modified first phase of the Delhi MRTS project approved by the Union Cabinet will cost approximately Rs. 4860 crores (at April, 1996 prices) and will comprise a network of 11 km to underground (METRO) corridor alongwith 44.30 km of elevated/surface (RAIL) corridors. It will have 45 stations in all. The project will require the acquisition of about 340 ha of land, of which about 58% is government land, 39% is private agricultural land and 3% is private urban land . The project is been implemented through a joint venture company (viz., Delhi Metro Rail Corporation Ltd.) set up on 50:50 partnership basis by GOI and GNCTD in May, 1995 and will be completed within 10 years.

ECONOMIC BENEFITS

The Delhi MRTS is essentially a "social" sector project, whose benefits will pervade wide sections of economy. The modified first phase will generate substantial benefits to the economy by the way of:

- Time saving for commuters
- Reliable and safe journey
- Reduction in atmospheric pollution
- Reduction in accident
- Reduced fuel consumption
- Reduced vehicle operating costs

- Increase in the average speed of road vehicles
- Improvement in the quality of life
- More attractive city for economic investment and growth

Economic IRR of the project works out to 21.4%, even though the financial IRR is less than 3%

FINANCING PLAN

As urban MRT projects are mean to provide a safe, speedy and affordable mode of travel to the commuters, they have not generally been found to be financially viable in the most cities of the world, despite their large economic benefits. MRT fares cannot be fixed purely on the basis of commercial principles, without drastic decrease in ridership and defeating the very object of setting up such mass transit system. Hence, the city dwellers must necessarily supplement the contributions to be made by the system users to meet the costs of setting up. as well as running the system. Delhi being national capital and international city, the GOI and GNCTD must also contribute to meet part of these costs. It has accordingly been decided that the project will be financed by way of equity contributions from the GOI / GNCTD, soft loan from the OECF (Japan), property development revenue and certain decided levies / taxes on the city dwellers.

The loan will rapid partly from surpluses from the box revenue, partly through dedicated levies / taxes in the NCT.

The financial plan of the project has been approved by the GNCTD and GIO on 24.7.1996 and 17.9.19996 respectively.

Source of Fund	**Percentage of Total Cost**
1. Equity contribution from GOI & GNCTD	15% each
2. OECF (Japan) Loan	Approx. 56%
3. Revenue from Property Development	Approx. 6%

4. Subordinate Debt towards Cost and Land	Approx. 8%
The above financial plan is based on : • Debt Equity ratio 2:1 • Fare: Base rate rs. 5.00 (at April, 1995 prices) per passenger trip of 7.12 km.	

Status of the Project

Phase – I

With the opening of Dwarka Sub-city Extension Line on 31st March 2006, except for 2.81 km section from Barakhamba Road to Indraprastha, entire phase – I covering a total network of 62.15 kms has been opened for commercial operations. Originally, the phase-I of Delhi Metro Project was planned for a total network of 55.3 kms covering three lines. With the substitution of Subzimandi – Holambi Kalan section with Inderlok – Rithala section and Trinagar – Nangloi section with Barakhamba Road Dwarka line and also with the additional sections of Dwarka Sub – city Extension line and Indraprastha – Barakhamba Road section, the total route Kms in phase – I increased to 65.1. As against the original target of completion of 55.3 Kms of network in 10 years, your Company has achieved the target of implementing 62.15 Kms in 7 years and 3 months. The remaining section from Indraprastha – Barakhamba Road is nearing completion and is slated to be opened in November 2006

Phase - II

As you are aware, the Group of Ministers in its meeting held on 30th August 2005, had approved phase-II of Delhi Metro project comprising six corridors, aggregating in length to 50.14 kms.

The approved corridors are as under:

i. Vishwavidyalaya – Jahangir Puri: 6.36 Kms

ii. Central Secretariat – IIT : 7.99 Kms

iii. Indraprastha – New Ashok Nagar : 8.07 Kms

iv. Shahdara – Dilshad Garden : 3.09 Kms

v. Kirti Nagar – Mundka : 18.47 Kms

vi. Yamuna Bank Depot – Anand Vihar ISBT : 6.16 Kms

The Group of Ministers while approving the above corridors laid down a condition that proposal in respect of IIT – Qutub Minar portion (2.88 Kms) of the proposed Central Secretariat – Qutub Minar line would be reviewed again, mainly in the context of its impact on the Qutub Minar. Based on the study conducted and discussions held with Archeological Survey of India (ASI), out of 6 options, the Board of Directors has recently approved the underground alignment beyond Green Park with last station at Ambedkar Colony. This line will require additional funds to the tune of Rs. 558 crores.

Extension of Delhi Metro to NOIDA

An agreement has been signed between DMRC and NOIDA Authority for extending Delhi Metro to NOIDA city. The extension of Delhi Metro into NOIDA will cover 7 Kms and will have six stations. The cost for the extension will be Rs. 736 crore, out of which the entire cost of land amounting to Rs. 32 crore will be borne by NOIDA Authority and Rs. 93 crores on account of rolling stock will be borne by DMRC. The balance amount of Rs. 611 crore will be funded by NOIDA and Central Government in 85: 15 ratios. An amount of Rs. 155 crores has already been handed over to DMRC by NOIDA authority. During the current financial year, the civil works on this extension will gain full momentum and, it is proposed to complete entire works on this section by June 2009.

Extension of Delhi Metro to Gurgaon

Central Secretariat – IIT metro corridor is proposed to be further extended to Ambedkar Colony. There is a proposal to take this line further to Gurgaon via Andheria Morh, for which Govt. of Haryana has conveyed their acceptance. Approval of the GOM is being taken for the extension. The total route length of this extension to Gurgaon will be 14.47 kms, out of which 7.42 kms will be in Delhi

Territory and remaining 7.05 kms will be in Haryana territory. The total completion cost for this extension line will amount to Rs. 1422 crores. The work on Haryana segment will be taken up as a deposit work on the lines of Metro work being undertaken by DMRC for UP government for extension of Delhi Metro to NOIDA city.

This section is planned to be opened for commercial operations by August 2010, before the commencement of Commonwealth Games.

Airport Link Express line

Government is seriously considering providing the city an express connection to the airport terminal. It is expected that approval of the Government to this proposal will shortly be accorded.

Commercial Operations

Barring a small section of 2.81 kms from Barakhamba Road to Indraprastha, the entire network of 62.15 Kms running across three lines is now operational. The year under review was very busy year as three different sections were inaugurated for commercial operations during the year. M-II section (Kashmere Gate – Central Secretariat) was inaugurated on 2nd July 2005 and entire Line –III (Dwarka – Barakhamba Road) was opened for commercial operations on 31st December 2005.

Dwarka Sub-city Extension line was also opened for commercial operations on April 1, 2006. With the opening of various sections, there has been steady increase in the ridership on Metro network. Presently, the average daily ridership is approximately 4, 60,000. During the year under review, out of 73 shortlisted feeder bus routes, 65 bus routes, which were found in accordance with existing policy of RTVs, were Approved by State Transport Authority (STA). On these approved routes, presently, 383 RTVs are running to provide feeder links to metro commuters. A high level Committee is considering to introduce special mini buses which will be equipped with better facilities, as " Metro Link " service. The punctuality status of Delhi Metro, which is running services on all three lines from 6 a.m. to 10 p.m. is over 99%. Punctuality in Delhi Metro is measured in seconds and every train which is 60 seconds behind schedule is considered late. Metro trains run more than 20, 000 kms everyday and the doors of the trains open and close 5.6 lakhs time each day, making Delhi Metro trains among the most heavily used metro system. To run these trains, services of 250 specially trained train

operators are used. These train operators are specially trained in handling all sophisticated computerized train operations. Besides that, they can attend to minor technical problems including door closing issues, fire fighting, night train operations etc. During the year under review, Metro train frequency has been brought down to 4 minutes on line –I and line – II , while 5 minute headway is being maintained on line –III. The headway will gradually be reduced to 3 minutes.

Special Provision for Handicap Passengers

Delhi Metro is committed to provide highest standard in commuter satisfaction. It has designed its trains and stations to cater the needs of handicap passengers. Some of the facilities are as under –

- Special ramps are provided at the stations for access to the lifts.
- Lifts and escalators are provided at all the stations for easy movement.

Moreover, lifts are designed so that they can be operated by visually

Impaired persons.

- Wheelchairs and stretchers are provided at all the stations.
- Tac tile path is there for visually impaired persons.
- Seats are reserved for handicap passengers.
- Extra space is designated in metro coaches for passengers with wheel chairs and in stretchers.
- Visual display and announcement system in each train for passenger convenience.

Consultancy Business

The success of the Delhi Metro has enthused several states of India to seek DMRC's help in building similar systems in their cities. DMRC has already prepared Detailed Project Reports (DPRs) for MRTS systems in Bangalore, Hyderabad, Ahmedabad, Mumbai, Kochi and a new line in Kolkata. Detailed Project Report for the cities of Thiruvananthapuram, Faridabad, Ghaziabad and Bahadurgarh are

under preparation. Even other countries have shown a great deal of interest, notably Pakistan, Bangladesh, Indonesia, Sri Lanka, Syria and Ireland. DMRC recognizes that its consultancy role can be an important source of revenue, which, in turn, will help keep fare structure on Delhi Metro system within the reach of the common man. A dedicated task force, therefore, has been identified within the DMRC team to render these services.

Delhi Metro changing urban scenario in Delhi

The Delhi Metro has come a long way since it was first visualized as a solution to Delhi's transport woes. Today, it is not longer a dream but a reality that lakhs of people are using Delhi Metro's services everyday. It has become a model of efficiency, which can be emulated in other spheres to make Delhi a global city. Not only Delhi Metro compare with the best in the world, it has also brought a sea change in the state of real estate in the city. With the promise of better connectivity, areas through which the Metro passes have seen an upswing in property prices in recent years. This became evident as on the completion of Phase-I area like Dwarka and Rohini, once shunned for their distance from the city center, have now become accessible. Consequently, prices of dwellings in these areas have gone up. With construction already under way for Phase-II of the Metro, similar changes in the real estate market prices of other areas are inevitable. Delhi Metro has, therefore, played a very vital role in enhancing the asset value of Delhi city, as a whole.

Environmental Management Plan

During execution of the project in phase – II of Delhi MRTS Project, Delhi Metro is preparing an Environmental Management Plan, which will include compensatory afforestation, control of noise pollution and vibration control. There are plans to plant over 31,000 saplings in an area of 26.30 hectares. The species recommended for plantation in the Detailed Project Report (DPR) of phase – II include Neem, Eucalyptus, Kikar, Ashok, Jamun and Sisso. Noise Pollution will be

controlled through automation, protection devices, noise barriers and sound proof compartments. In phase – II also, the Metro train tracks, when trains are in operation, will be supported by two layers of rubber pads to reduce track noise and ground vibrations. DMRC is committed to keep the environment clean from various kinds of atmospheric pollutions. Delhi Metro will monitor the noise levels, air and water quality and construction linked vibrations through sampling at

various stages of the construction in phase - II of the project. During execution of Phase – I of Delhi MRTS Project also, Delhi Metro maintained very high concern for environment related issues, in recognition of which, DMRC received ISO 14001 for Environmental protection OHSAS 18001 (Occupational Health and Safety Assessment Sequence) for organizational Health and Safety.

Human Resources Management

The Employer-Employee relationship continued to be cordial throughout the year. Your Directors wish to place on record their sincere appreciation for the highly committed services rendered by both project and O&M wings of the company. Through extraordinary work spirit exhibited by employees at all levels helped the Company to achieve all project targets and to run the operations smoothly safely and efficiently.

Women Workforce

The present strength of women employees in DMRC is 140. Out of which 53 are in Project Division and 87 in Operation and Maintenance Division. The enabling organization culture of DMRC and exposure to the latest technology of various fields is attracting more and more women candidates for employment in DMRC. Apart from various welfare schemes available in DMRC, a few facilities are available exclusively for women employees.

Particulars of Employees

There was no employee in the employment of the Company who was drawing salary of more than Rs.2,00,000/- per month, if employed for the part of the year and Rs.24,00,000/- per annum, if employed, for the full year, in whose respect information in accordance with the provisions of Section 217(2) A of the Companies Act, 1956, read with the Companies (Particulars of Employees) Rules, 1975, as amended, is required to be given.

Company's Website

The Company's Website is **www.delhimetrorail.com.** All major information pertaining to company, including project, contracts, job, recruitment process and results etc. are given on the website.

Overhead Equipment (OHE)

The electrical conductors over the track together with their associated fittings, insulators and other attachments by means of which they are suspended and registered in position.

All overhead electrical equipment, distribution lines, transmission lines, and feeder may be collectively referred to as overhead lines.

Auto Tensioning Device (ATD)

OHE with Automatic Tensioning Device (ATD), known as regulated OHE, is generally provided on all main lines, but for large depot/yards and unimportant lines ATD is dispensed with in the interest of economy and only unregulated OHE is used. However, in DMRC only regulated type of OHE is used, except in inspection pit area where one end is terminated with Fixed Terminal Anchoring (FTA) insulator and the other end is terminated through ATD.

Types of ATDs

4 types of ATDs are used:

i. **5 pulley blocks**: Maximum permissible half tension length for OHE on viaduct is 570 m with this type of pulley arrangement. With evolution of compact counter weight, half tension length of 650 m is also possible.
ii. **3 pulley blocks**: Maximum permissible length of OHE on viaduct has been kept as 650 m. This is suitable for multiple cantilever assemblies.
iii. **Gas type ATDs:** filled with pressurized Nitrogen gas to maintain required OHE tension.
iv. **Spring type ATDs**: There are two types of Spring ATD viz. - Helical and Spiral springs. Both gas & spring type ATDs are suitable for locations where there are space restrictions and full movement of counter weight of pulley type ATD is not possible.

Types Of Breakers In Used DMRC

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by excess current from an overload or short circuit. Its basic function is to interrupt current flow after a fault is detected. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset either manually or automatically to resume normal operation.

The circuit breaker must first detect a fault condition. Typically, the heating or magnetic effects of electric current are employed. Once a fault is detected, the circuit breaker contacts must open to interrupt the circuit; this is commonly done using mechanically stored energy contained within the breaker, such as a spring or compressed air to separate the contacts.

SF6 Circuit Breaker

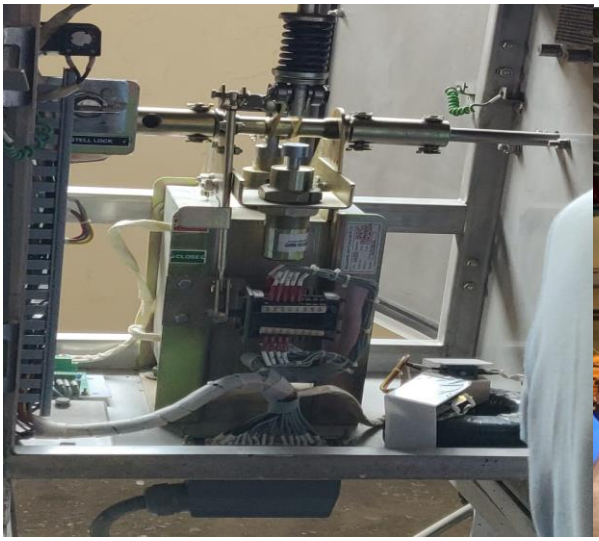
SF6 breakers or sulphur hexafluoride circuit breakers are used to protect larger power systems that is these are generally used for the protection of higher voltage power systems. These circuit breakers use SF6 gas to cool and quench the arc on opening.

Sulfur hexafluoride circuit breakers protect electrical power stations and distribution systems by interrupting electric currents, when tripped by a protective relay. Instead of oil, air, or a vacuum, a sulfur hexafluoride circuit breaker uses sulfur hexafluoride (SF6) gas to cool and quench the arc on opening a circuit. Advantages over other media include lower operating noise and no emission of hot gases, and relatively low maintenance.

SF6 gas is electronegative and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high-pressure flow of sulphur hexafluoride gas, and an arc is struck between them. The gas captures the conducting free electrons in the arc to form relatively immobile negative ions. This loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc.

Vacuum Circuit Breaker

A breaker which used vacuum as an arc extinction medium is called a vacuum circuit breaker. In this circuit breaker, the fixed and moving contact is enclosed in a permanently sealed vacuum interrupter. The arc is extinct as the contacts are separated in high vacuum. It is mainly used for medium voltage ranging from 11 KV to 33 KV.



The operation of opening and closing of current carrying contacts and associated arc interruption take place in a vacuum chamber in the breaker which is called vacuum interrupter. The vacuum interrupter consists of a steel arc chamber in the centre symmetrically arranged ceramic insulators. The vacuum pressure inside a vacuum interrupter is normally maintained at 10– 6 bar.

Air Circuit Breaker

Air Circuit Breaker (ACB) is an electrical device used to provide Overcurrent and short-circuit protection for electric circuits. Air circuit breaker is circuit operation breaker that operates in the air as an arc extinguishing medium, at a given atmospheric pressure.

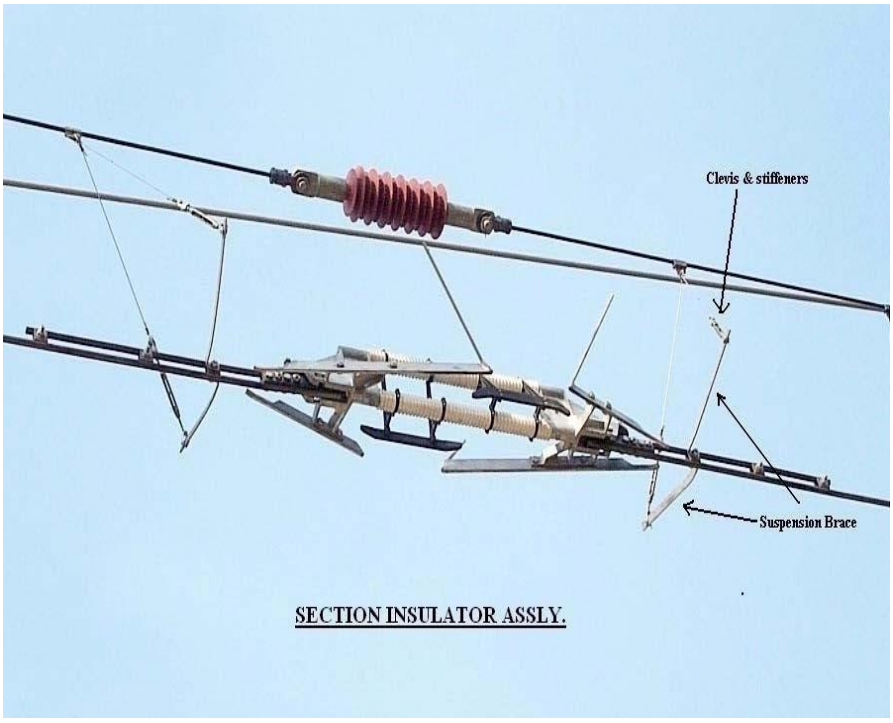
Air Circuit breakers generally have two pairs of contacts. The main pair of contacts (carries the current at normal load and these contacts are made of copper metal. The second pair is the arcing contact and is made of carbon. When the circuit breaker is being opened, the main contacts open first. When the main contacts opened the arcing contacts are still in touch with each other. As the current gets a parallel low resistive path through the arcing contact. During the opening of main contacts, there will not be any arcing in the main contact. The arcing is only initiated when finally the arcing contacts are separated. The each of the arc contacts is fitted with an arc runner which helps. The arc discharge to move upward due to both thermal and electromagnetic effects . As the arc is driven upward it enters in the arc chute, consisting of splatters.

X-Y Charts

With the increase or decrease in the conductor temperature, the conductor expands or contracts respectively, and as a result the movable pulley moves towards or away from the fixed pulley (i.e., towards or away from the anchor mast), causing the counter-weights to travel downwards or upwards. The extent of movement of counterweight depends upon the expansion or contraction of OHE conductors. It is very important to ensure that under the extreme conditions, the counterweight assembly maintains a predetermined minimum mechanical clearance, from the bottom muff or the top anchor point, as the case may be. This can be ensured by maintaining pre-determined clearance of bottom of counterweight assembly from the muff (designated Y) and pre-determined distance between the axes of fixed pulley and movable pulley (designated-X).

Section Insulator (SI)

It is a device installed in the contact wire for insulating two elementary electrical sections from each other while providing a continuous path for the pantograph without break of current. Whenever SI is used, catenary wire is also electrically insulated by providing a cut-in insulator.



SECTION INSULATOR ASSLY.

Use:

Due to non-availability of sufficient space to create insulated overlaps, light weight section insulators are provided to achieve necessary sectioning.

Location:

i. At location of section insulator, the axial distance between the catenary and contact wire shall not be less than 450 mm.

ii. The section insulator is to be located beyond the point where the centre distance between the two tracks is equal to or more than 1.65m.

iii. The stagger of the contact wire at the location of the section insulator should normally be zero, but in no case it should be beyond ± 100 mm.

iv. The preferred location of section insulator on main running track is 2 to 10 m from the support in the direction of traffic.

Neutral Section (NS)

Neutral sections in OHE are provided for separation of Power supply coming from two different RSS. This is provided at Sectioning & Paralleling post.

There are some basic requirements which should be fulfilled before deciding location of NeutralSection:

i. To be located on tangent track.
ii. To be located on level track.
iii. To be away from stop signals.
iv. S&T track circuit boundaries may be considered as stop signals.
v. Train operator is not supposed to stop the train in a NS area.
vi. Location of neutral section near river/open drains of polluted water/polluted zone should be avoided as far as possible.

Type of Neutral Section: Following types of neutral sections are installed at different locations in DMRC.

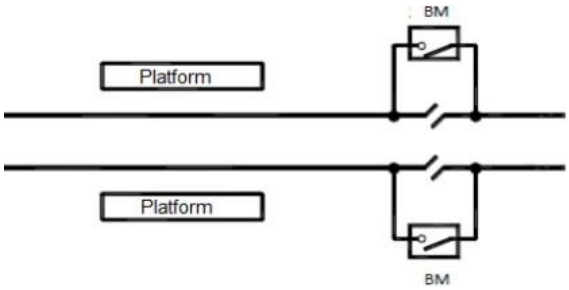
i. **Conventional Type Neutral Section:** This Neutral section comprises of three Section Insulators (SI) at a distance of 3 m and 27m. SI which are used in the neutral section is same as used for sectioning.

ii. **PTFE Type Neutral Section:** PTFE type Short Neutral Section comprises of two insulator assemblies. Mid-section of this Neutral Section is solidly earthed.

iii. **Neutral Section with Automatic Switching (PTFE insulated)**: These are modified Short Neutral Sections provided on experimental basis to provide safety to OHE against any eventuality of non-opening of train VCB. In case a train enters the neutral section with VCB in closed condition, flashing takes place inside the specially designed Vacuum bottle of ASNS. This saves external flashing and hence avoids damage to Neutral Section and pantograph. Tripping at main line is also avoided.

Sub-Sectioning Post (SS)

A supply control post where sectioning interrupters are provided. These are provided only occasionally. They are similar to SSPs with provision for sectioning of the OHE but not paralleling.

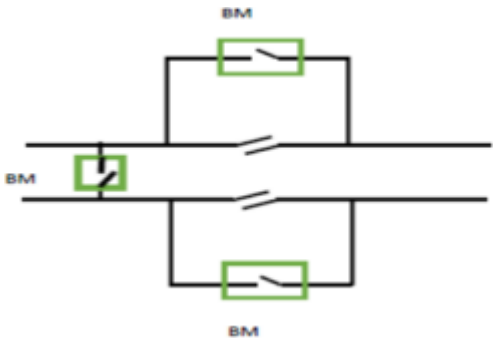


Sub Sectioning simplified Diagram

Sub-sectioning and paralleling post (SSP)

A supply control post wheresectioning and paralleling interrupters are provided. One or more SSPs are provided between each FP and adjacent SP depending upon the distance between them. Normally three interrupters are provided at each SSP i.e. two connecting the adjacent sub-sectors of up and down tracks and one for paralleling the up and down tracks.

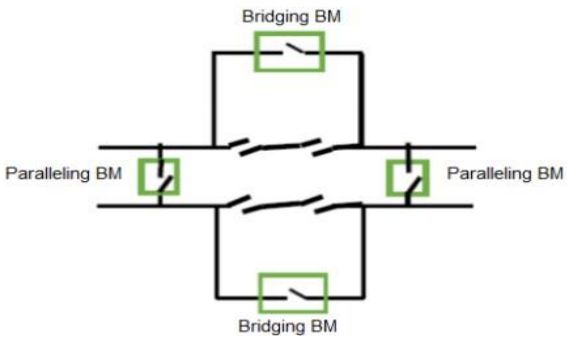
There are two type of control on these switches: Automatic opening of a paralleling interrupter (PIT) when the tracks are de-energised. This allows rapid trouble shooting by the power controller who does not have to open all PIT's one after the other to isolate tracks. Under these conditions, when resetting, it will be possible to locate the fault since tracks are electrically independent. Provision of automatic closing of paralleling interrupter is available in SCADA using group command. This command is executed by TPC after normalizing the traction supply in both lines. This function allows to rapidly restoring normal operating conditions.



Sub-Sectioning and Paralleling Post simplified diagram

Sectioning and Paralleling Post (SP)

A supply control post situated between two feeding posts at the neutral section and provided with bridging and paralleling interrupters. These posts are situated approximately midway between feeding posts and is demarcating point separating power supply of two adjacent sub-stations. Which may be on same or different phases at these posts, a neutral section is provided to make it impossible for the pantograph of an electric train to bridge the different phases of 25 kV supplies, while passing from the zone fed from one sub-station to the next one.



Sectioning and Paralleling Post simplified diagram

Feeding Post (FP)

A supply post where the incoming 25 kV feeder lines from the substation are terminated, and connected to the overhead equipment through interrupters / isolators. Each feeder supplies power to OHE on one side of the feeding post. Traditionally as in Indian Railways, 25kV circuit breaker is connected to Up and Down line interrupters. The interrupters in turn feed 25 kV power to respective OHE. Since interrupters are not designed to trip on fault currents, fault in either of Up or Down line OHE causes opening of the common feeder circuit breaker leading to both the tracks becoming inoperative, till such time faulty section is isolated and healthy section re-charged.

Turn outs

The point at which one track separates/meets another track is called Turnout. From Flexible OHE point of view, turnouts are provided for smooth transition of pantograph during movement of train from main line to branch line or vice-versa.

Overlap (IOL/UIOL)

Where two OHE wire lengths are overlapped with each other with adequate horizontal separation (500 mm for IOL (insulated overlap) & 200 mm for UIOL (un-insulated overlap)) and suitable stagger is known as overlap. The overlap is so arranged that both OHE's are available to the pantograph for minimum 2 meter at the same level on either direction of central mast. Thereafter the OHE's are raised gradually by 500 mm and held at intermediate mast by RRA Clamp (Raised Register Arm).

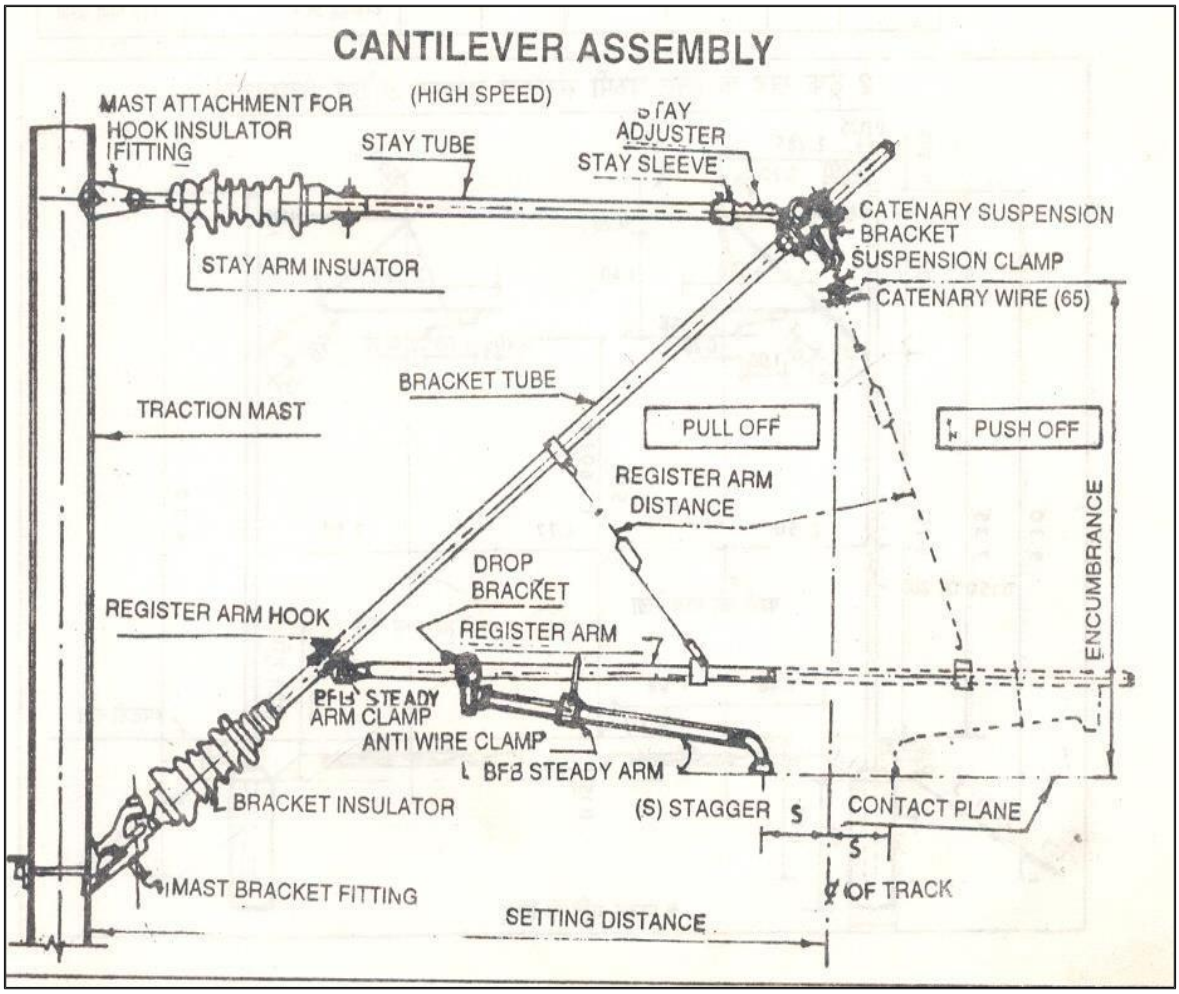
Booster Transformers

23.1 150 kVA/280 KVA Booster Transformer may be provided separately for each running tracks wherever necessary for suppression of inductive interference of P&T communication lines running in close vicinity and parallel to 25 kV OHE. The primary winding of the booster transformer is connected in series with the OHE at insulated overlaps. The Booster Transformers are located at an approximate spacing of 2.66km between each other.

Cantilever Assembly

It is an insulated swivelling type structural member, comprising of different sizes of steel/aluminium alloy tubes, to support and to keep the overhead catenary system in position so as to facilitate current collection by the pantograph at all speeds without infringing the structural members. It consists of the following structural members:

i. Adjustable Stay tube with an adjuster at the end to keep the Bracket tube in position. It is insulated from mast by stay arm insulator.
ii. Bracket tube is insulated by bracket insulator. Catenary is supported from this member by catenary suspension clamp.
iii. Register Arm tube is used to register the contact wire in the desired position with the help of steady arm.
iv. Steady arm tube is used to register the contact wire to the required stagger and to take the push up of contact wire. It is always in tension.



Power SupplyInstallation (PSI)

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SF6 Circuit Breaker

SF6 breakers or sulphur hexafluoride circuit breakers are used to protect larger power systems that is these are generally used for the protection of higher voltage power systems. These circuit breakers use SF6 gas to cool and quench the arc on opening.

Sulfur hexafluoride circuit breakers protect electrical power stations and distribution systems by interrupting electric currents, when tripped by a protective relay. Instead of oil, air, or a vacuum, a sulfur hexafluoride circuit breaker uses sulfur hexafluoride (SF6) gas to cool and quench the arc on opening a circuit. Advantages over other media include lower operating noise and no emission of hot gases, and relatively low maintenance.

SF6 gas is electronegative and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high-pressure flow of sulphur hexafluoride gas, and an arc is struck between them. The gas captures the conducting free electrons in the arc to form relatively immobile negative ions. This loss of conducting electrons in the arc quickly builds up enough insulation strength to extinguish the arc.

Vacuum Circuit Breaker

A breaker which used vacuum as an arc extinction medium is called a vacuum circuit breaker. In this circuit breaker, the fixed and moving contact is enclosed in a permanently sealed vacuum interrupter. The arc is extinct as the contacts are separated in high vacuum. It is mainly used for medium voltage ranging from 11 KV to 33 KV.

The operation of opening and closing of current carrying contacts and associated arc interruption take place in a vacuum chamber in the breaker which is called vacuum interrupter. The vacuum interrupter consists of a steel arc chamber in the centre symmetrically arranged ceramic insulators. The vacuum pressure inside a vacuum interrupter is normally maintained at 10– 6 bar.

Air Circuit Breaker

Air Circuit Breaker (ACB) is an electrical device used to provide Overcurrent and short-circuit protection for electric circuits. Air circuit breaker is circuit operation breaker that operates in the air as an arc extinguishing medium, at a given atmospheric pressure.

Air Circuit breakers generally have two pairs of contacts. The main pair of contacts (carries the current at normal load and these contacts are made of copper metal. The second pair is the arcing contact and is made of carbon. When the circuit breaker is being opened, the main contacts open first. When the main contacts opened the arcing contacts are still in touch with each other. As the current gets a parallel low resistive path through the arcing contact. During the opening of main contacts, there will not be any arcing in the main contact. The arcing is only initiated when finally the arcing contacts are separated. The each of the arc contacts is fitted with an arc runner which helps. The arc discharge to move upward due to both thermal and electromagnetic effects . As the arc is driven upward it enters in the arc chute, consisting of splatters.

Types Of Transformer Used In DMRC

A transformer is a passive electrical device that transfers electrical energy between two or more circuits. A varying current in one coil of the transformer produces a varying magnetic flux, which, in turn, induces a varying electromotive force across a second coil wound around the same core. Electrical energy can be transferred between the two coils, without a metallic connection between the two circuits.

Transformer

In DMRC both single phase and three phase transformers are used. The two transformers used are Traction transformers and Auxiliary transformers. These are denoted by TT and AT respectively. These Traction transformers and Auxiliary transformers are used in pairs. There Are usually two pair of TT and AT for the redundancy purpose. One is the main and the other is the standby which comes into use when a fault occurs in the main.

Traction Transformers

The traction transformers steps down the high incoming voltage to low voltages. The incoming voltage is 66KV and the traction transformer steps it down to 25KV. Higher voltage that is 27.5KV s preferred due to the losses in between the transmission.

Load balancing is an essential task therefore in a large network power is taken from all three phases either by three consecutive substations RY, YB, BR phase respectively. Other way is to feed substation of one line from YR, one from YB and other from RB. All are in star-star connections.

Auxiliary Transformer

The Auxiliary transformers steps down the high incoming voltage to low voltages. The incoming voltage is 66KV and the traction transformer steps it down to 33KV. This transformer is used for supplying power to the auxiliary system at the station.

The power required to operate a station is provided through this auxiliary transformer. The Equipments operated through this include AC, elevators, lights, escalators, lifts, passenger display board and other equipments.

The transformers are cooled using various methods which are as follows:

1. Using air as cooling agent. Natural air acts as a good cooling agent when it comes to lowervoltages.

2. By using Gas like Nitrogen Dioxide. It is an inert gas which cools down the transformer rapidly.

3. By using fans. Fans are used to cool down the transformer and these are automatic. These fans have a temperature sensing element which senses the temperature and when it exceeds it a particular value the fans start automatically. Below that temperature the fans are in an off state.

Their are various protection methods used for protection of transformers against a fault or failure.

For Traction Transformers:

1. Instantaneous Over currentprotection
2. Delayed Over currentprotection
3. Differential protection
4. Buchholz Protection
5. Oil temperature riseprotection

For Auxiliary Transformers:

1. Differential Protection
2. HVREF Protection
3. Secondary neutral protection
4. Delayed over currentprotection

Relays Used In DMRC

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

For protection of electrical apparatus and transmission lines, electromechanical relays with accurate operating characteristics were used to detect overload, short-circuits, and other faults. While many such relays remain in use, digital protective relays now provide equivalent and more complex protective functions.

IDMT stands for inverse definite minimum time relays. They are used on transmission lines to see to that the line current doesn't exceed safe values and if it does, triggers the circuit breaker. IDMT means inverse definite minimum time. So as the current keeps increases, the relay takes minimum time to trip the circuit.

Inverse means "higher the current value, lesser the time taken for the relay to trip the circuit". Current in the line and the time taken for the relay to trip the CB follow an inverse proportionality.

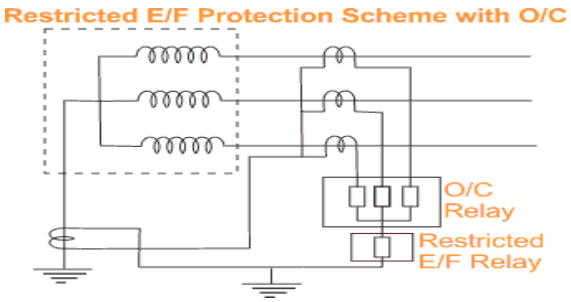
DMT Relay

DMT stands for definite minimum time relays. It is a type of over current relay. These are used to co-ordinate over other definite time, or instantaneous protection. Generally less sensitive (higher pickup) to prevent operating for load in rush. Generally they have a faster operating time.

REF Protection For Transformers

REF protection stands for Restricted Earth Fault Protection. Fault detection is confined to the zone between the two CTs hence the name 'Restricted Earth Fault'.

REF protection is fast and can isolate winding faults extremely quickly, thereby limiting damage and consequent repair costs. If CTs are located on the transformer terminals only the winding is protected. However, quite often the secondary CT is placed in the distribution switchboard, thereby extending the protection zone to include the main cable.

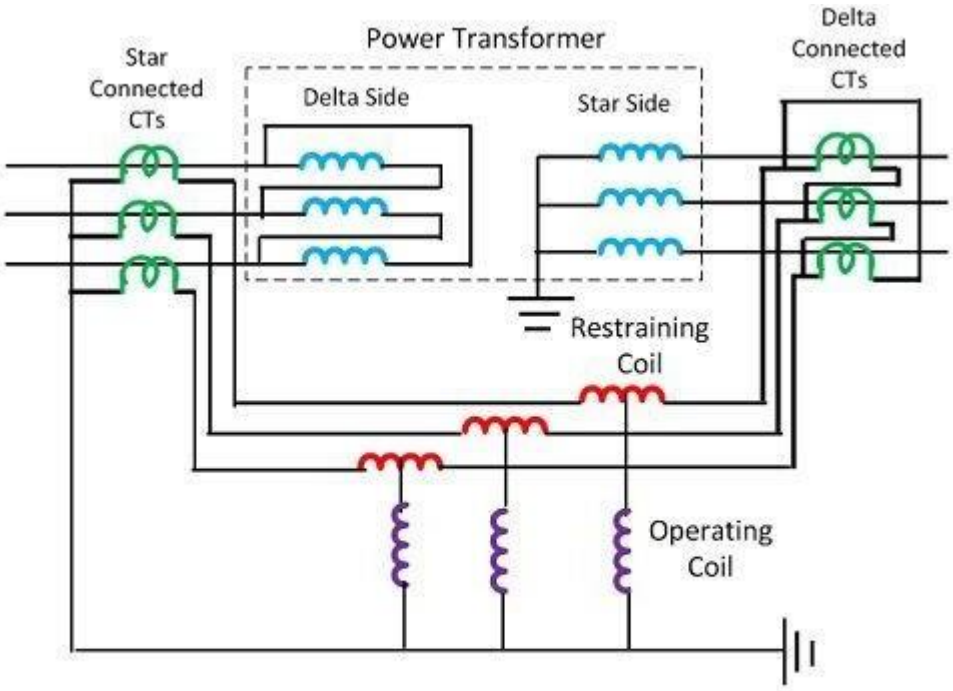


REF protection scheme

Differential Protection of a Transformer

The fault occurs on the transformer is mainly divided into two type external faults and internal fault. External fault is cleared by the relay system outside the transformer within the shortest possible time in order to avoid any danger to the transformer due to these faults. The protection for internal fault in such type of transformer is to be provided by using differential protection system.

Differential protection schemes are mainly used for protection against phase-to- phase fault and phase to earth faults.The differential protection used for power transformers is based on Merz-Prize circulating current principle.

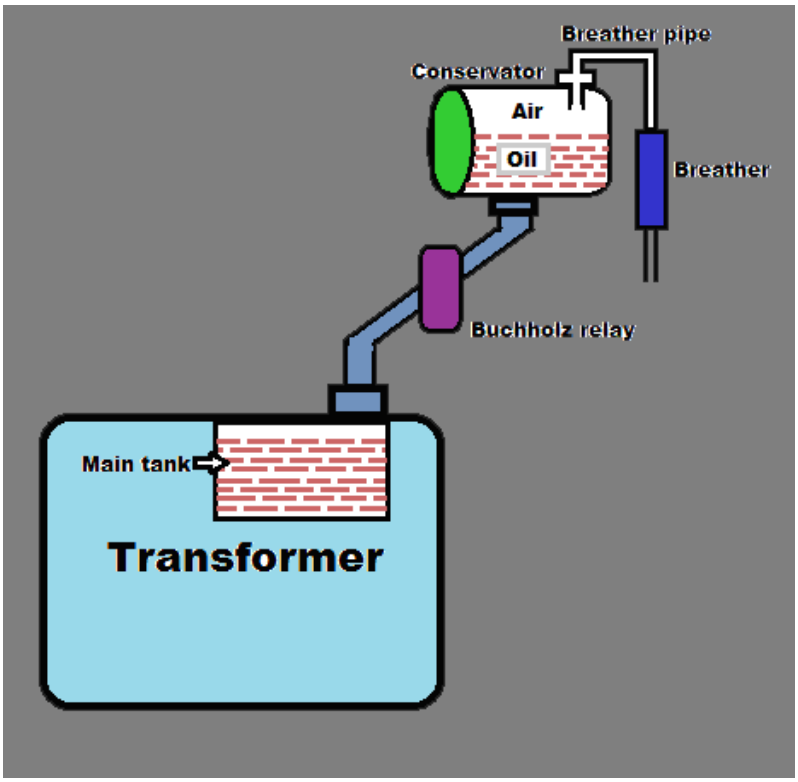


Buchholz Relay

Buchholz relay is a type of oil and gas actuated protection relay universally used on all oil immersed transformers having rating more than 500 kVA. Buchholz relay is not provided in relays having rating below 500 kVA from the point of view of economic considerations.

Buchholz relay is used for the protection of transformers from the faults occurring inside the transformer. Short circuit faults such as inter turn faults, incipient winding faults, and core faults may occur due to the impulse breakdown of the

insulating oil or simply the transformer oil. Buchholz relay will sense such faults and closes the alarm circuit.



Buchholz relay

Buchholz relay relies on the fact that an electrical fault inside the transformer tank is accompanied by the generation of gas and if the fault is high enough it will be accompanied by a surge of oil from the tank to the conservator

1. Buchholz relay indicates inter turn faults and faults due to heating of core and helps in the avoidance of severe faults.

2. Nature and severity of fault can be determined without dismantling the transformer by testing the air samples.

Weight Monitoring System

This system is established in RSS where all the control panels are installed. It is used to detect any spark within the system. The cylinders contain the CO2 required to protect the largest single hazard. On large hazards where several cylinders are required, a manifold is used to connect each cylinder by means of flexible hoses and check valves. Cylinder valves control the CO2 flow to the hazard through properly sized pipe, terminating in nozzles that apply the CO2. Flow rate is controlled by nozzle orifices as well as pipe sizes.

Whenever a fault occurs the Co2 lines placed under the system are opened and the co2 is used to extinguish any case of fire which may occur. Co2 is constantly monitored as a preventive measure.

For CO2 system it is always necessary to monitor the gas quantity by measuring the weight. Measuring the pressure through pressure gauge to ascertain the quantity of CO2 gas may not be a proper method since CO2 gas exists in the container both in liquid as well as in vapour form.

GIS Substation

GIS stands for Gas Insulated Substation. It is a high voltage substation in which the major structures are contained in a sea The clearance required for phase to phase and phase to ground for all equipment is much lower than that required in an air insulated substation; the total space required for a GIS is 10% of that needed for a conventional substation led environment with sulphur hexafluoride gas as the insulating medium.

Gas insulated substations offer other advantages in addition to the reduced space requirements. Because the substation is enclosed in a building, a GIS is less sensitive to pollution, as well as salt, sand or large amounts of snow. Although the initial cost of building a GIS is higher than building an air insulated substation, the operation and maintenance costs of a GIS are less.

AIS Substation

AIS stands for Air Insulated Substation. The AIS uses air as the primary dielectric from phase to phase, and phase to ground insulation. They have been in use for years before the introduction of GIS.

Actually, most substations across all regions are AIS. They are in extensive use in areas where space, weather conditions, seismic occurrences, and environmental concerns are not an issue such as rural areas, and favourable offsite terrain.

The indoor AIS version is only used in highly polluted areas, and saline conditions, as the air quality is compromised.

AIS substation

Earthing Requirements

Earthing is a major part of any power system. It is the basis of protection not only for the system but as well as the employees working there.

In an electrical installation, an earthing system or grounding system connects specific parts of that installation with the Earth's conductive surface for safety and functional purposes. The point of reference is the Earth's conductive surface. The choice of earthing system can affect the safety and electromagnetic compatibility of the installation. Regulations for earthing systems vary considerably among countries, though most follow the recommendations of the International Electrotechnical Commission. Regulations may identify special cases for earthing in mines, in patient care areas, or in hazardous areas of industrial plants.

Earth Mat

Earth Mat is a solid metallic plate or a system of closely spaced bare conductors that are connected to and often placed in shallow depths above a ground grid or elsewhere at the earth surface, in order to obtain an extra protective measures minimizing the danger of the exposure to high step or touch voltages in a critical operating area or places that are frequently used by people.

Earth Mat

Earth Pit

In electrical system, an Earth pit refers to a pit, dug in earth with some standard filling. Primarily Earth pits are used for SAFETY towards SHORT CIRCUITS. It also acts as the reference point for different electric power sources. As Earth Pits are easy to make and maintain so since starting of commercialized Electricity, Earth pits are used as reference points.

If a machine or equipment is properly grounded into the earth, it has less chances to get damaged. In case of short circuit or any other accident, the current will rush to the lowest resistance path i.e. into the earth. And a OCR(over current relay) will sense the high current and will cut off the supply.

NICKEL CADMIUM BATTERY

SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

SCADA stands for Supervisory Control and Data Acquisition. As the name indicates, it is not a full control system, but rather focuses on the supervisory level. As such, it is a purely software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules.

Supervision:

Supervision of the traction and auxiliary power system interactively with schematic pictures which illustrate the real time status of CB, Isolators, PT etc. and direct the operator to make correct decisions.

Control:

The operator performs control operations like open or close the CB, isolators, interrupters etc.

Data acquisition:

Process information is stored on a process database and a report database in the form of event list,energy reports and graphs.

TheSCADASystemperforms03maintasks:

i. Remote Monitoring(RM)
The status of various equipments such as circuit breaker,isolator etc. of all sub-stations can be monitored will be shown to the operator in the mimic diagram of the Operator station.

ii. Remote Control(RC)
TPC can open or close the CB,Interrupters,isolators and tap changers This function is needed while giving power block, supply change-over or isolation of faulty equipment and sections and may return them back to service on the establishment of normalcy.

iii. Tele Measuring

Various analog measurements like voltage,Current,Energy consumption,MD etc can be monitored by the SCADA software.

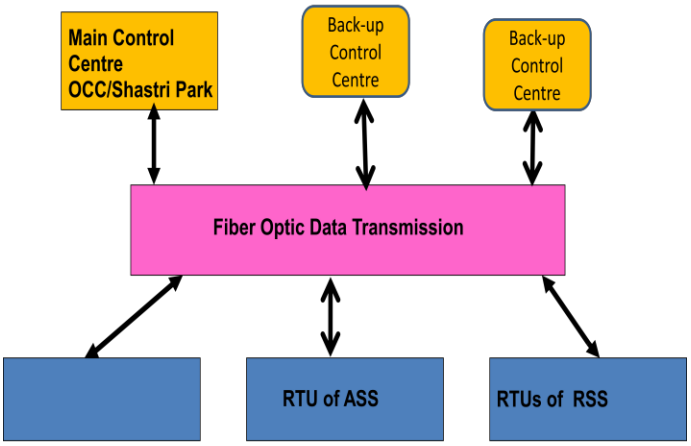
Working of SCADA

RTUs are installed for all the RSS, TSS, AMS, ASS, SP, SSP locations. The SCADA system installed at the Operator Control Centre continuously receives the data from all the RTUs over a combination of electrical RS485 & a Fibre Optic Network.

At operator control centre, there are servers which process the data received from RTUs. The software, MicroSCADA offers powerful and convenient tools for the operator for maintaining healthiness in the power supply system. The MMI provided on the operator workstations help the operator to get an overall view of the status, close/open operation of circuit breakers, Isolators etc, recording the events, alarms, trends and energy reports.

SCADA system is mainly divided into three parts :

- Remote Terminal unit.
- Communication system.
- The software/hardware part at Operation control centre.



SCADA System Functional Diagram

RTU (REMOTE TERMINAL UNIT)

The brains of a SCADA system are performed by the Remote Terminal Units (sometimes referred to as the RTU). IT is the most important part of the SCADA. RTU'S are located at every station, through RTU we can see the status of the field equipment or we can send the control signal to them.

The RTU consists of cabinets, main CPU, I/O modules, relays and terminal blocks. It collects data from the power supply equipments such as circuit breaker, transformer, protection relay etc. and transmits the same through the communication unit to the base system.

RTU cabinets will be used depending on the number of I /Os at different stations. The number of DI modules of the cabinets will vary according to I/O signal to be cabled. RTU cabinets are floor mounting and individual components of the RTUs are interchangable between RTUs at different sites.

The HARDWARE modules for RTU used in the DMRC are as follows.

- Central Control Unit 23ZG21
- Power supply Unit 23NG20
- Basic Module Rack 23ET22
- Extension Rack 23ET23
- Digital Input Module 23BE21
- Digital Output Module 23BA20
- Analog Input Module 23AE21

CENTRAL PROCESSING UNIT

The Central Control Unit 23ZG21 is the 32 bit CPU board of the RTU. The essential tasks of 23ZG21 are :

- Managing and controlling of the I/O – boards of the RTU peripheral bus.
- Reading process events from the input boards.
- Writing commands to the output boards.
- Serial communication with central systems
- Managing the time base for the RTU station and synchronizing the I/o boards and sub-systems.
- Handling the dialogue with the utilities RTUtil or PTS installed on a PC.

- Running the LAF (Local Automation Function) user application progarm

POWER SUPPLY UNIT

The power supply unit generates the two supply voltages (5V DC and 24 V DC) for the RTU boards. The output power is sufficient to supply a RTU sub rack with typical configurations.

The input voltage can be between 24 V DC and 60 V DC, so that only one version is necessary for all typical DC supplies. For the DMRC project, the input voltage will be set as 48 V DC.

Two light emitting diodes for displaying output voltages U1 and U2 Power on/off switch on the front panel.

DIGITAL INPUT MODULE (DI Card)

This card is used to collect the status of the sub-station equipments e.g. close/open status, SF6 gas status, Local/Remote status, Protection relay status etc. The binary input board 23BE21 is used for the isolated input of up to 16 binary process signals. Scanning and processing of the inputs are executed with the high time resolution of 1 Ms. The board allows process signal voltages from 24 to 60V DC. LEDs are organised in two columns on the front plate, The LED follows directly the input.

- 16 binary inputs pulse counters
- only one type of module for all digital input signal types single and double indication digital measurand
- Inputs potentially isolated
- Input voltage + 24 ..... + 60 V DC
- 16 LED's indicating the input states

DIGITAL OUTPUT MODULE (DO CARD)

This card is used to execute close/open command to the circuit breakers, isolators etc. The binary output board 23BA20 can be used for the potentially isolated

output of up to 16 binary signals to the process. The assignment of an output to a number of processing functions can be freely undertaken within the scope of the configuration rules. The 23BA20 can be used for the following types of signal.

- Object commands with 1 or 2 pole output without (1 out of n) check
- Set – point messages
- General output messages.

The 16 outputs are combined into two groups. Each 8 outputs have a common return. The groups are potentially isolated from one another as well as from other logic.

ST : common malfunction information of the board

PST : command output fault condition display the monitoring system responds CO

: Command output display during output time.

ANALOG INPUT MODULE (AI CARD)

This card is used to measure analog values such as voltage, current, frequency etc.Generally a Transducer is provided which takes the input from CT or PT and gives the output to analog input card in to analog data form e.g. 4-20 ma.The 23AE21 board records up to eight analog measured values. The 23AE21 board allows it to connect all typical measured value ranges as per the output of transducer. It can be configured for the Following measured ranges by Simple switches and jumpers.

Ranges are:

- V±2 mA
- V±5 mA
- V ± 10mA
- V ± 20 mA
- V±40mA
- V±2 V DC
- V – 0 to +20 V DC

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