KERETAPI TANAH MELAYU BERHAD

PRESENTATION TO

JKR

27 February 2019

KERETAPI TANAH MELAYU BERHAD

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Act. General Manager
Electrification System

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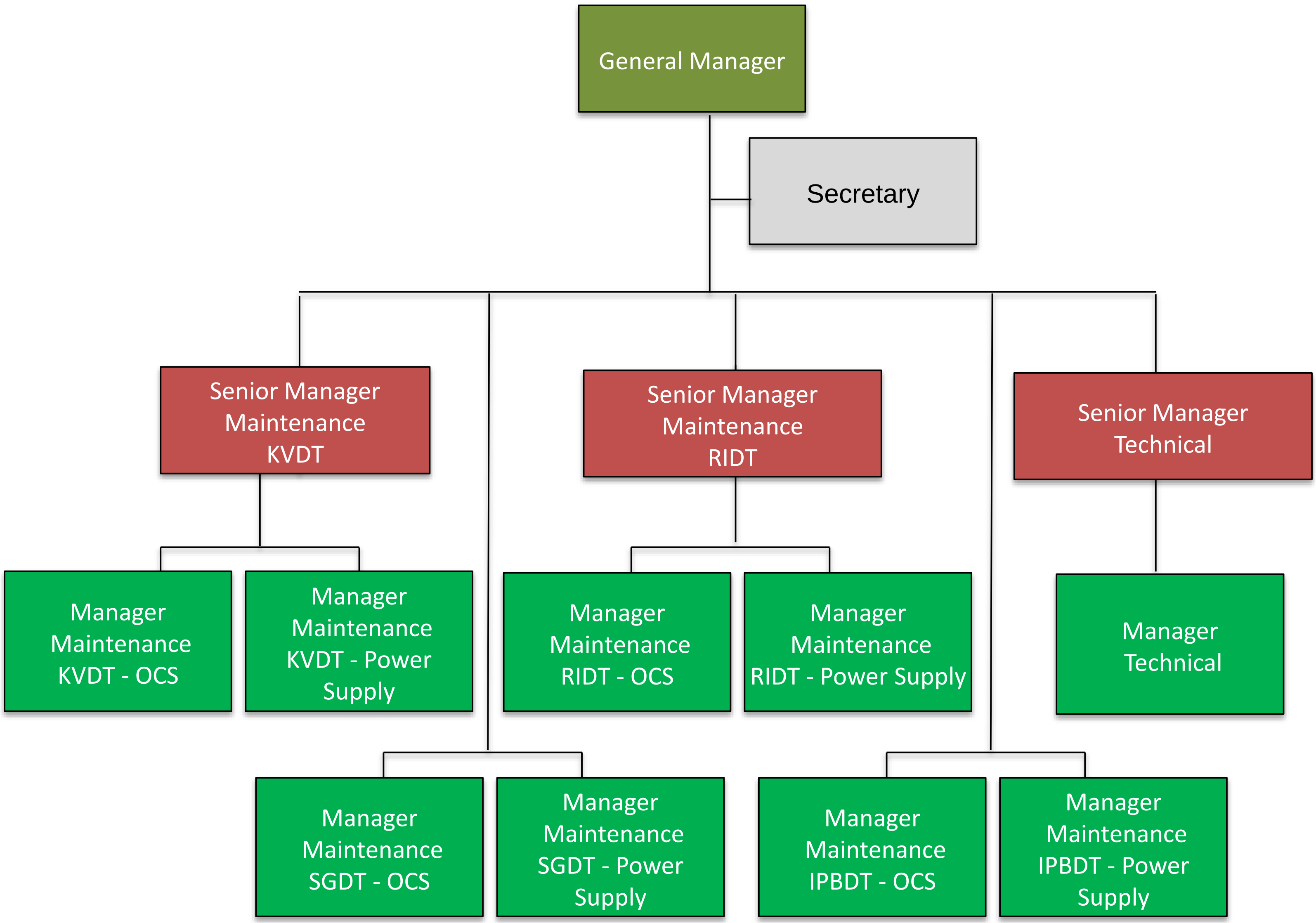
1.0 Organization Chart
Electrification Department



1.0 Organization Chart

Electrification Department>Function

ELECTRIFICATION SYSTEM

i. Responsible for the maintenance of Overhead Catenary System, Power Supply Infrastructure and SCADA System to ensure availability, reliability, safe, effective and cost efficient manner.
ii. To plan and provide reliable Electrification System to ensure safe & efficient electricity powered train operations throughout KTMB Electrification Network
iii. Responsible for monitoring and maintaining the continuity of the electrical supply in KTMB Electrification Network
iv. Provide efficient prevention and repair maintenance to service by controlling the operations of all maintenance activities to avoid operations disruption
v. Ensure that all Electrification System installation comply with statutory requirement of Energy Commission, Malaysian Communication and Multimedia Commission, and other regulatory bodies

OCS MAINTENANCE

i. To ensure that the Overhead Catenary System Infrastructure are maintained in good working condition, safe for operation and will not in any way endanger to the life of the persons who are working/operating the equipments
ii. Analyze the maintenance activity, implement alteration to maintenance schedule and procedures to improve the reliability of the equipment and systems
iii. Taking immediate action to deal with any incident or failure in accordance with the relevant instructions.

PS MAINTENANCE

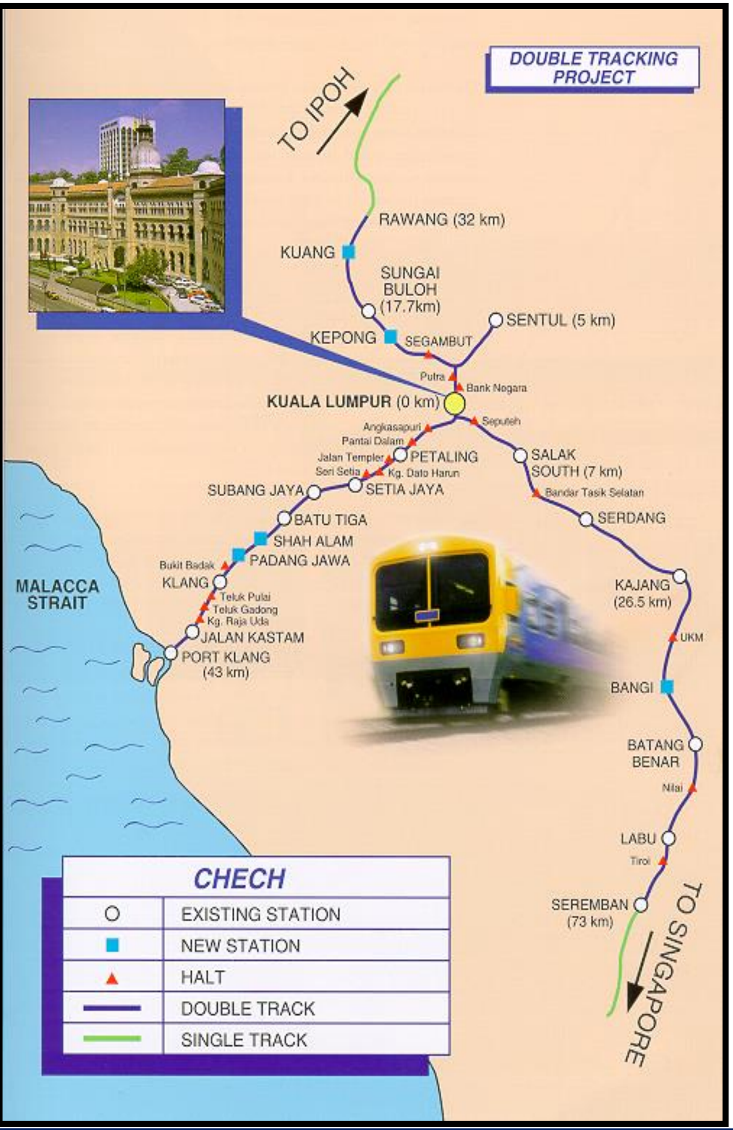
i. Carrying out, or authorizing for local control, all switching operations concerned with electricity supply or the services.
ii. Taking immediate action to deal with any incident or failure in accordance with the relevant instructions.
iii. Being a liason department to liase with Power Utility Provider (TNB) for any planned Maintenance Activity involving 132kV equipment and attend any emergency power outage of 132kV supply

TECHNICAL UNIT

i. Responsible for monitoring and maintaining the continuity of the electrical supply for all switching operations in the Electrification Systems and issuing instructions for the operation of the overhead line switches
ii. Provide a quality technical services for the Electrification System to meet KTMB requirements by making a safe, interruption free and realiable maintening power supply continuity throughout the system.
iii. Carrying out, or authorizing for local control, all switching operations concerned with electricity supply or the services which are normally under the jurisdiction of the Electrical Control Center.

2.0 Introduction

Electrification > KTMB Rail Network

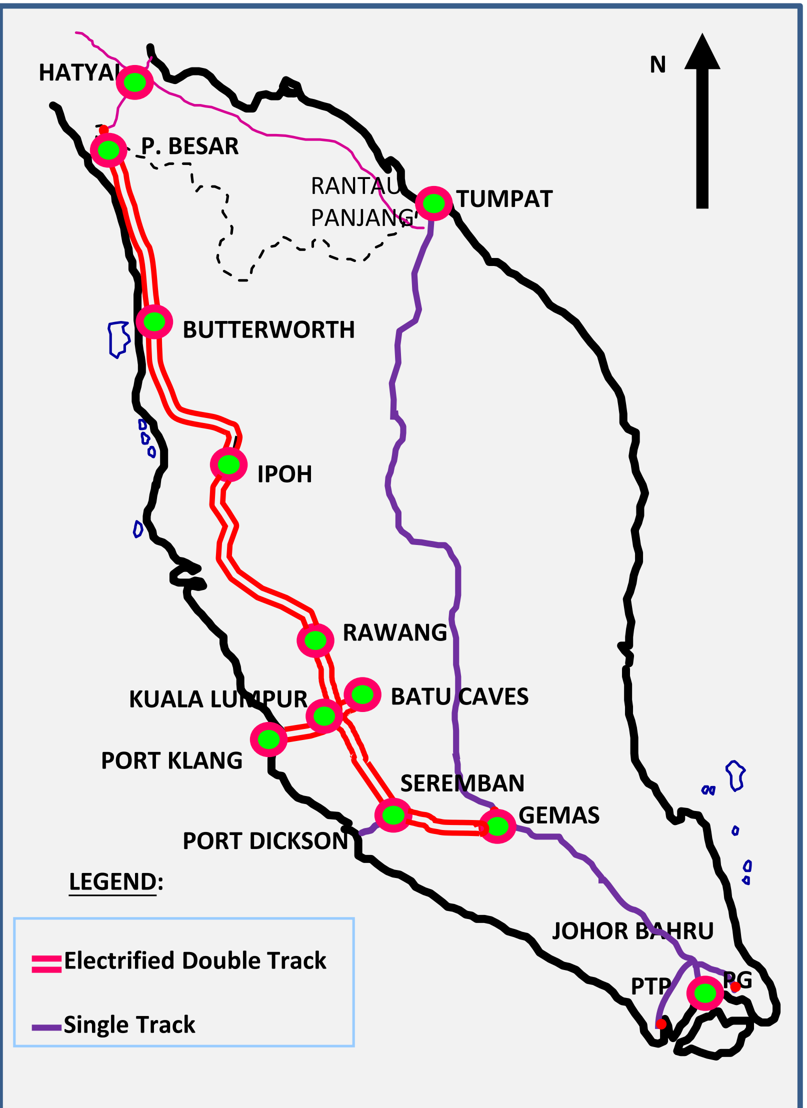


History Of The Railway Electrificaton In Malaysia

- Construction for 132/25kV Kuala Lumpur Electrified Commuter System was completed in November 1995.
- The first section of the system between Rawang and Sungai Buluh was energised on 28th December 1994.
- The last section between Bangi and Seremban was energised on 15th November 1995.
- It comprises approximately 400 single track kilometers of 25kV overhead wiring.
- At completion of Package F (1st. Electrification System package in Kuala lumpur, Malaysia), it has 3 single 132/25kV power transformer feeder stations, 1 double 132/25kV power transformer feeder station and 11 track sectioning locations (TSL).
- During Power System Upgrade Project to improve efficiency of the Commuter service, 2 single 132/25kV power transformer feeder stations were constructed and one of the existing single power transformer feeder station was upgraded to double power transformer feeder station.

2.0 Introduction

Electrification > KTMB Rail Network



- KTMB has introduced electrification system for train operations since 1995 upon completion of construction of 132/25kV system for Klang Valley Double Track (KVDT) Line (160km).

Klang Valley Double Track (KVDT)	1995	160 km

- Subsequently the electrification system has been expanded to the following sectors:

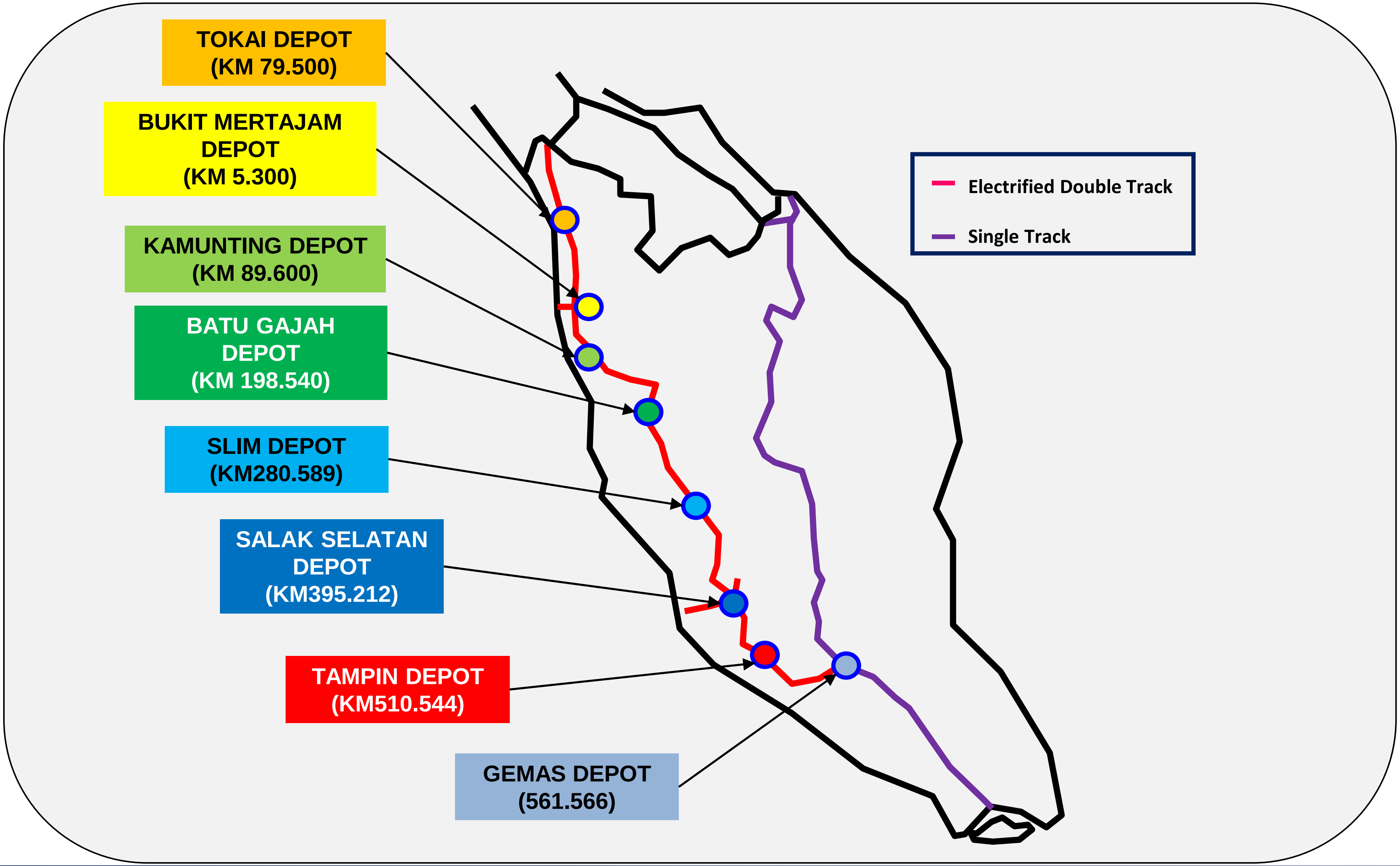
Rawang Ipoh Double Track (RIDT)	2008	178 km
Seremban Gemas Double Track (SGDT)	2013	102 km
Ipoh Padang Besar Double Track (IPBDT)	2014	337 km

- Current development project for electrification system expansion is between Gemas and Johor Bahru (197km) which is scheduled to be completed by October 2021.

Gemas Johor Baharu Double Track (IPBDT)	2021	197 km

2.0 Introduction

Electrification > Maintenance Depot



2.0 Introduction

Electrification > KTMB Electric Train

ETS Class 93

- Manufactured by CSR Zhuzhou, China in 2014-2015
- Design speed : 160km/h
- Operational speed : 140km/h
- Capacity : 312 seats
- Electric System: 25kV, 50Hz, AC Catenary

ETS Class 91

- Manufactured by Hyundai-Rotem Co. Korea in 2008-2009
- Design speed : 160km/h
- Operational speed : 140km/h
- Capacity : 350 seats
- Electric System: 25kV, 50Hz, AC Catenary

SCS Class 92

- Manufactured by CSR Zhuzhou, China in 2010-2012
- Design speed : 140km/h
- Operational speed : 120km/h
- Capacity : 1118 standing & seating
- Electric System: 25kV, 50Hz, AC Catenary

EMU Class 83

- Manufactured by Hyundai-Rotem Co. Korea in 1996
- Design speed : 140km/h
- Operational speed : 120km/h
- Capacity : 406 standing & seating
- Electric System: 25kV, 50Hz, AC Catenary

EMU Class 81

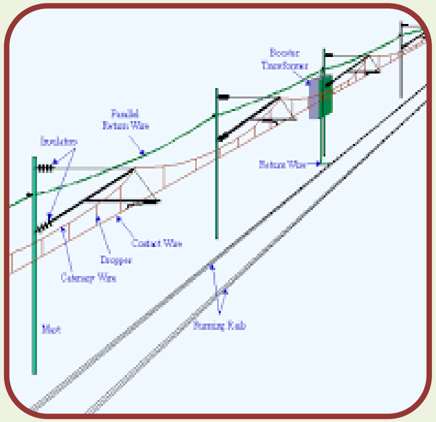
- Manufactured by Jenbacher Transport, Austria in 1995
- Design speed : 140km/h
- Operational speed : 120km/h
- Capacity : 414 standing & seating
- Electric System: 25kV, 50Hz, AC Catenary

2.0 Introduction

Electrification > Electrical Railway System Mainly Based on Following

Rolling Stock

Provides possibility to transport passengers and cargos on the Railway line.



Overhead Catenary System

Distribution of the electrical Power along the Railway line to the point of consumption.

Signalling System

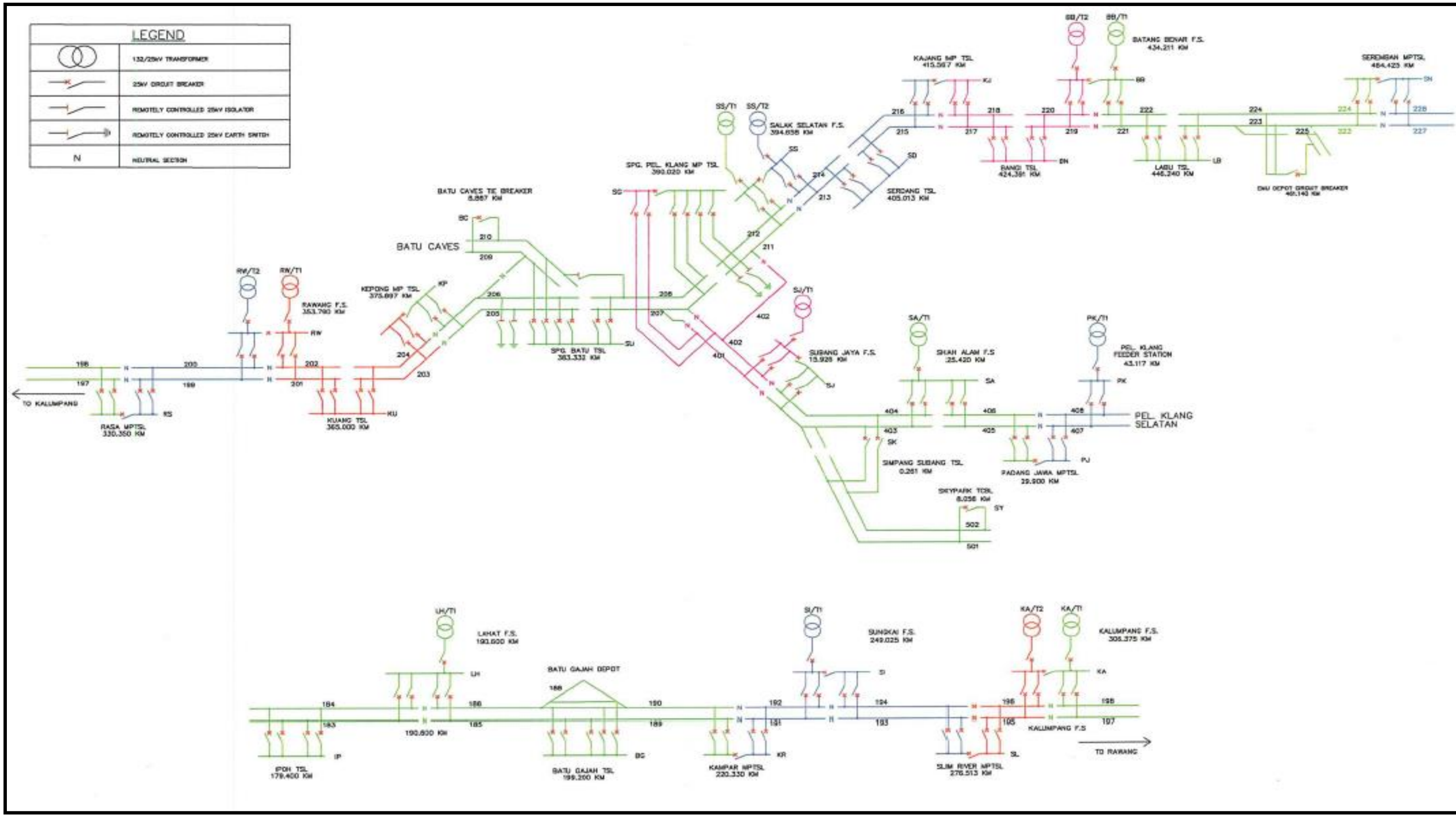
Provides safe train control and operation processes.

Power Supply System

Transfer of electrical Power from a High Voltage network to the Voltage level used in the electrical Railway System..

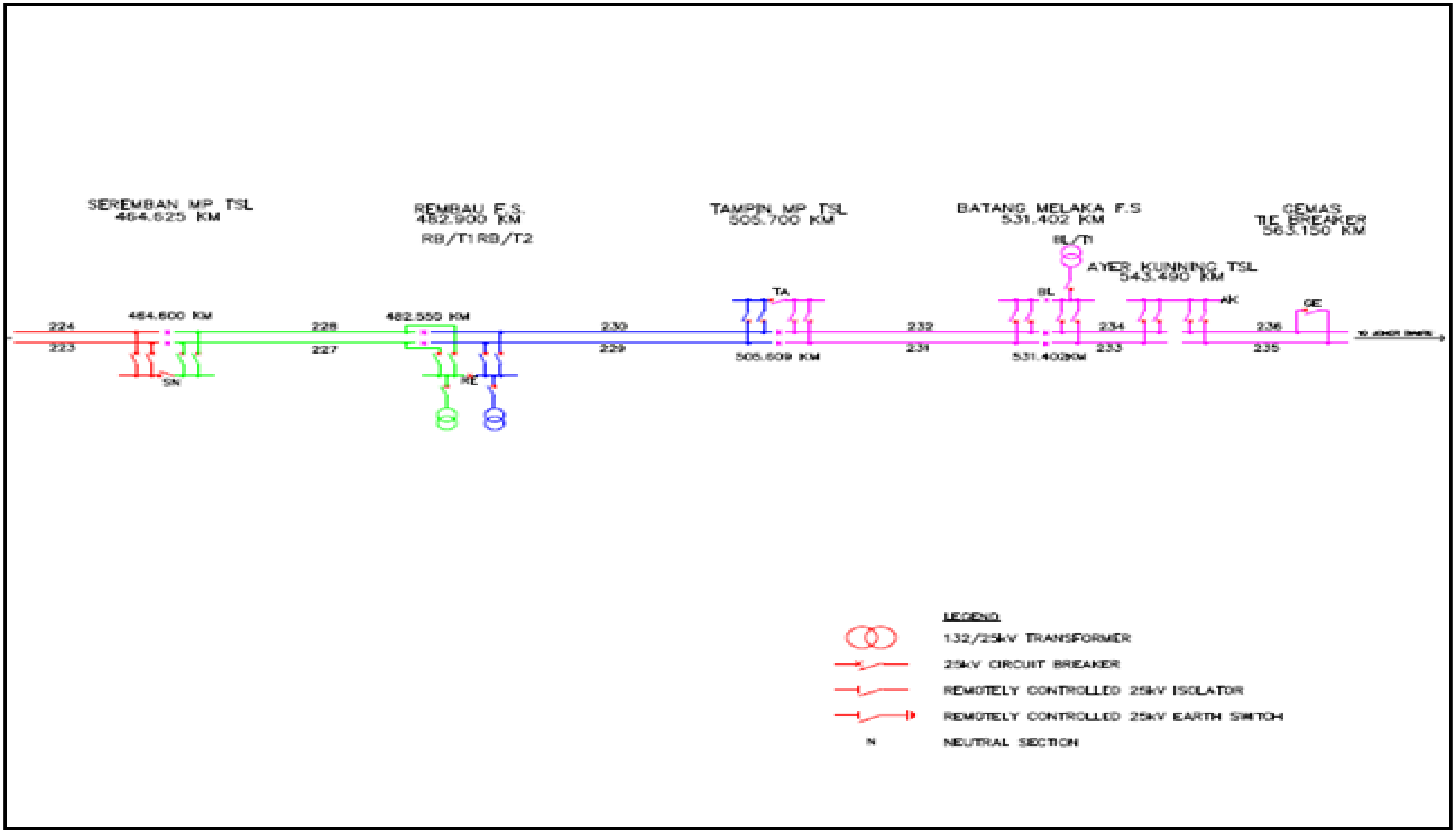
2.0 Introduction

Electrification > Major Feeding Diagram KVDT & RIDT



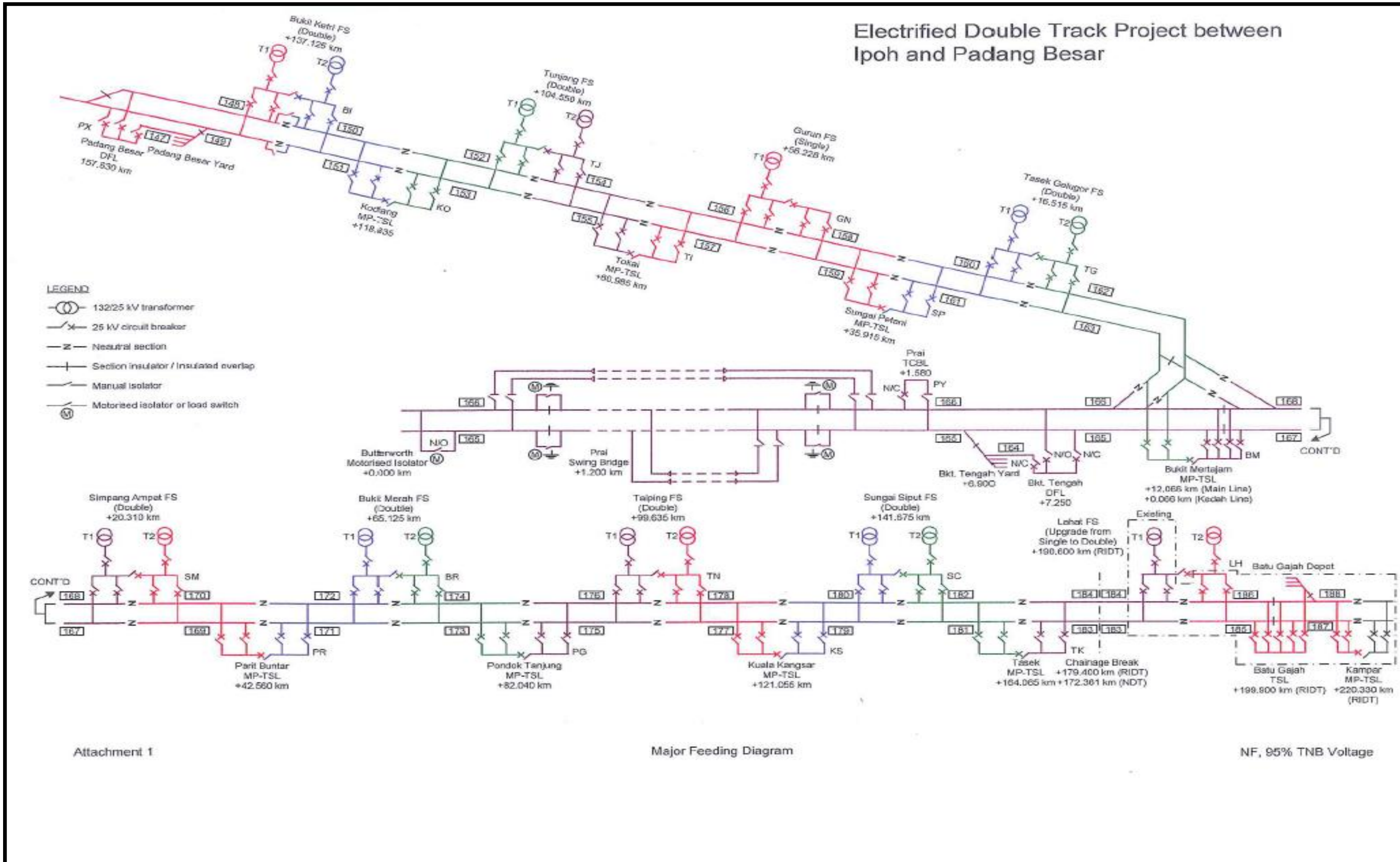
2.0 Introduction

Electrification > Major Feeding Diagram SGDT



2.0 Introduction

Electrification > Major Feeding Diagram IPBDT



3.0 Electrification System

Overview of KTMB Railway Electrification System>

Background

Power System chosen 25kV A.C, Single phase, 50Hz with railways lines from Padang Besar to Gemas (777KM) and on-going project from Gemas to Johor Bahru (197KM) are being electrified using overhead line conductors and a total length of about **974KM.**

Supply taken from 132kV TNB national grid network and transformed at the KTMB Feeder Stations to the 25KV required for railway purposes.

These system design allows transformers to be operated in an extended feed arrangement to adjacent sections which have no supply due to failures, shutdown (Outages) or faults.

The sufficient power will be available from these Feeder Stations to service a timetable which operate electric trains (ETS, SCS, EMU, E-LOCO) running during the peak period.

2.0 Electrification System

Overview of KTMB Railway Electrification System>

Advantages:

- Lower Initial Cost
- Lighter Overhead Equipment
- Minimum Interference with other electrical System nearby
- Environment friendly

All 25kV switch gear is under the control of an Electrical Control Operator (ECO) who is able by mean of a remote Supervisory Control And Data Acquisition (SCADA) system.

To operate all switches like the circuit breaker, motorised isolator including the incoming feeder circuit breakers at feeder stations, from an Electrical Control Center (ECC) at KL Sentral which is manned on a continuous basis.

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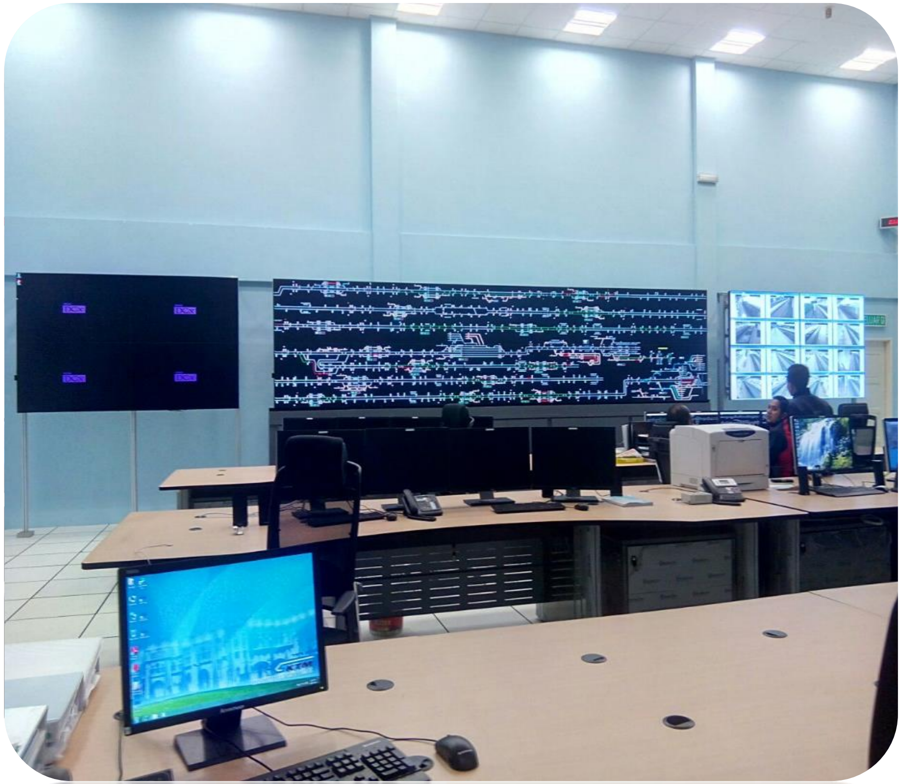
3.0 Electrification System

SCADA System>

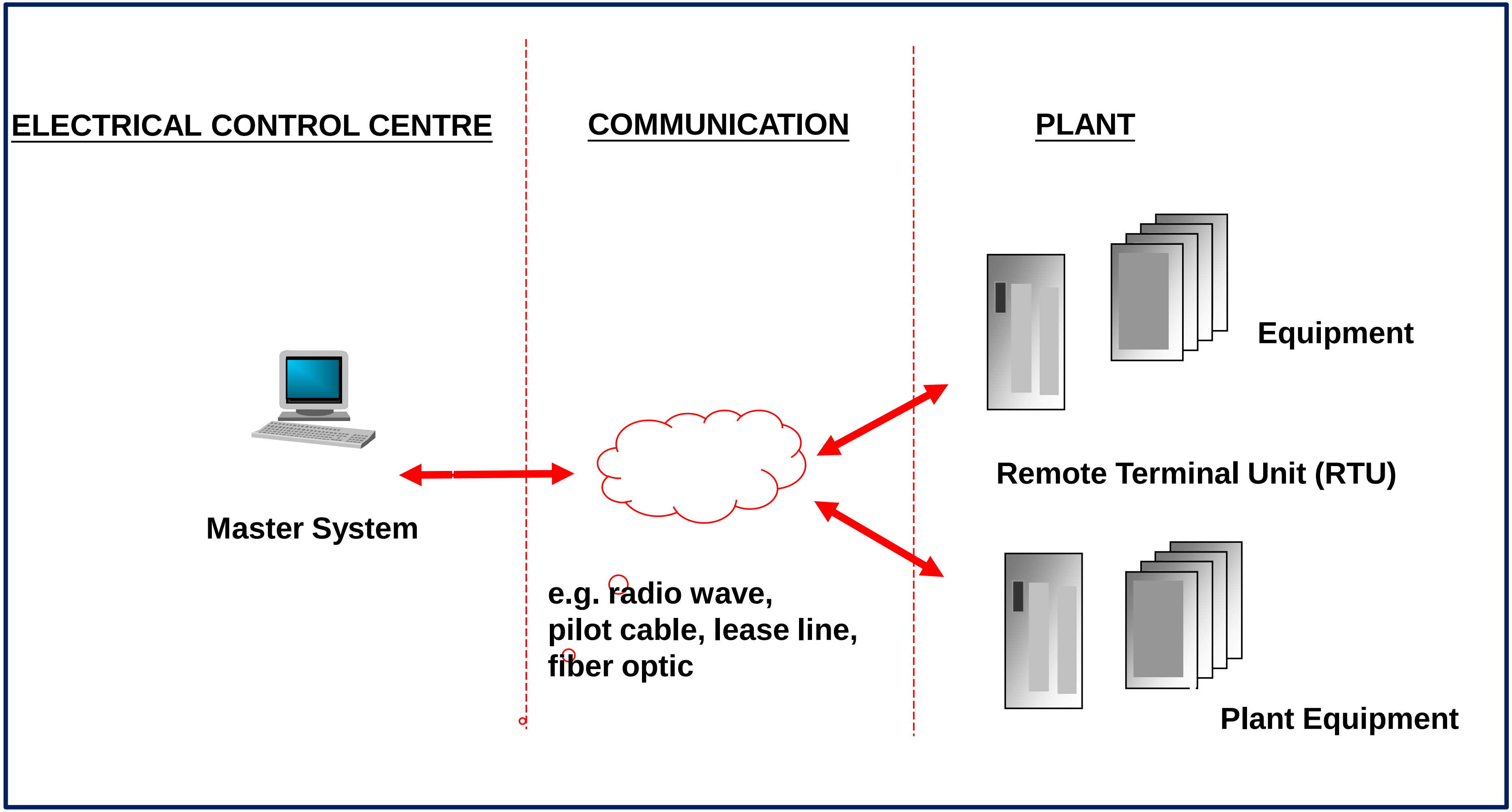
Kuala Lumpur Sentral



CTC North at Bukit Tengah

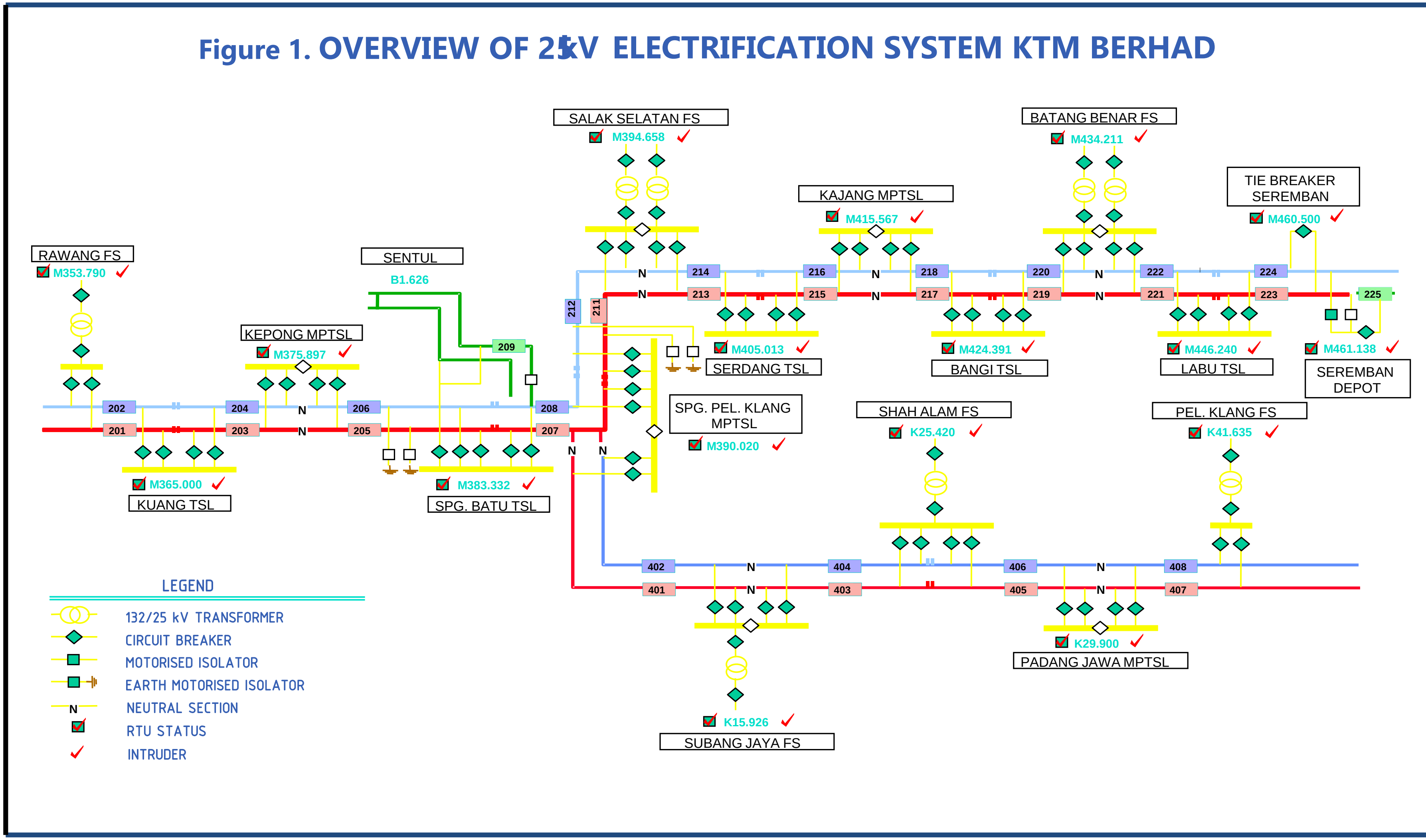
3.0 Electrification System

SCADA System>



3.0 Electrification System

SCADA System>



3.0 Electrification System

Traction Power Supply System>

Feeder Station (F.S)

- A building or compound containing electrical switch gear and equipment to which main 25 kV supplies from TNB are brought and from which the overhead line equipment is fed.
- Normally consist of 132 kV isolators, 132 kV Circuit Breakers, 25 kV bus section circuit breaker, a 25 kV bus bar, a number of 25 kV track feeder circuit breakers, 25 kV isolators together with all protection, control and auxiliary equipment .

Mid Point Track Sectioning Location (MPTSL)

- A building or compound containing electrical switch gear and equipment which is arranged to connect together a number of sections of line equipment and separate the feed from adjacent FS.
- Normally consist of a 25 kV bus section circuit breaker, a 25 kV bus bar, a number of 25 kV track feeder circuit breakers, 25 kV isolators together with all protection, control and auxiliary equipment.

3.0 Electrification System

Traction Power Supply System>

Track Sectioning Location (TSL)

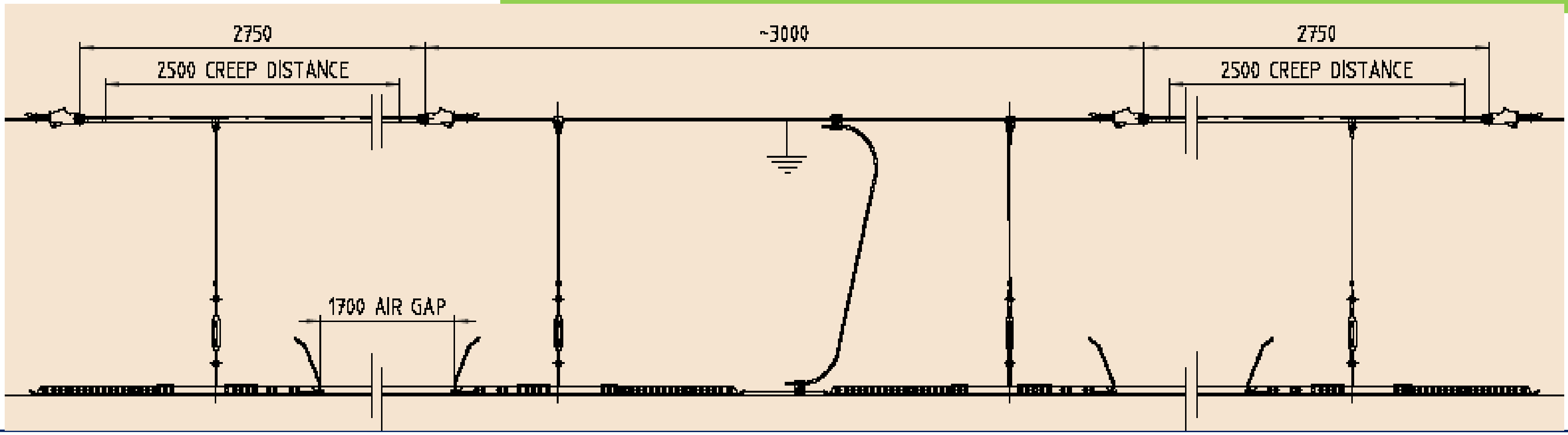
- A building or compound containing electrical switch gear and equipment to sectionalise the overhead line equipment for protection, operational or voltage drop considerations.
- Normally consist of a 25 kV track feeder circuit breaker, 25 kV isolators together with all protection, control and auxiliary equipment .

Tie Breaker (TB)

- A building or compound containing electrical switch gear and equipment to connect one electrical section to another at the end of line.
- Normally consist of a 25 kV track feeder circuit breaker, 25 kV isolators together with all protection, control and auxiliary equipment .

Neutral Section

- An arrangement of insulators in the overhead line equipment and designed in such a way to ensure that two adjacent electrical sections which must not be connected electrically are kept separate even during the passage of the pantograph of an electric train.
- Neutral sections are situated at intervals(typically 20 km) along the electrified lines.
- Signs are located on the lines side indicating the locations of the neutral section



3.0 Electrification System

Traction Power Supply System>Typical Arrangement at Feeder Station

- Electricity supplies are taken from TNB' s 132kV grid Network.

- Two phases of the 132KV network are tapped for each feed and then fed via isolators to a 132kV two pole circuit breaker.

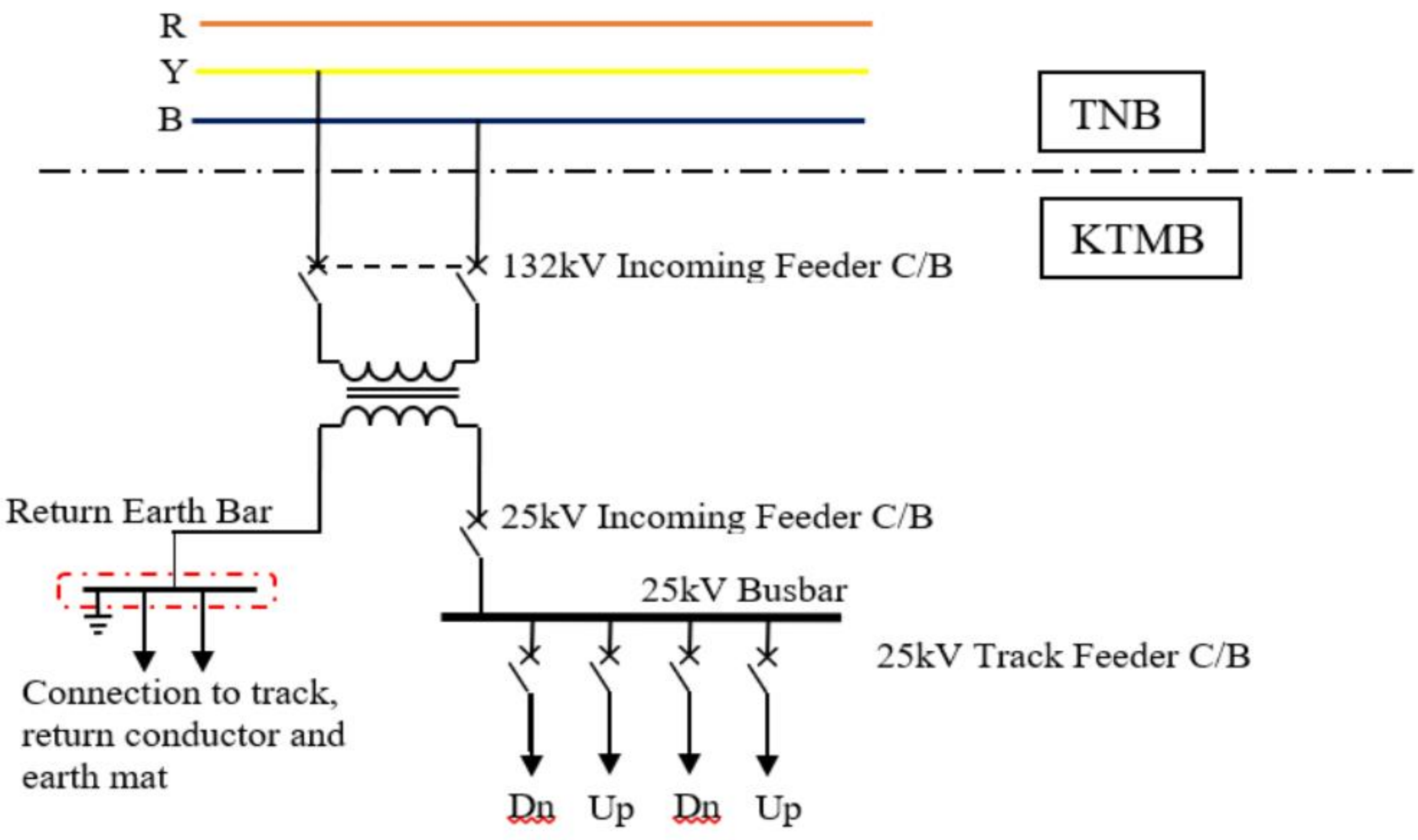
- From the 132KV circuit breaker the feed is then taken to the primary winding of a 132kV to 25kV single phase transformer. One side of the 25kV winding is then taken through a 25KV incoming circuit breaker and then onto a 25kV bus bar.

- The other side of the 25kV winding is taken directly to return current bus bar which is held by means of connections to the track and overhead line structures (which constitute a multiple earth electrode system at 0 volts).

- From the 25kV bus bar the overhead line equipment is fed via 25KV track circuit breaker. Each track is kept electrically separate such that should a fault develop a fault develop on one track the other track can be kept alive.

3.0 Electrification System

Traction Power Supply System>Typical Arrangement at Feeder Station



3.0 Electrification System

Traction Power Supply System>Typical Arrangement at Feeder Station

Incoming Supply taken from TNB 132 kV Grid Network Supply at F.S Salak South

3.0 Electrification System

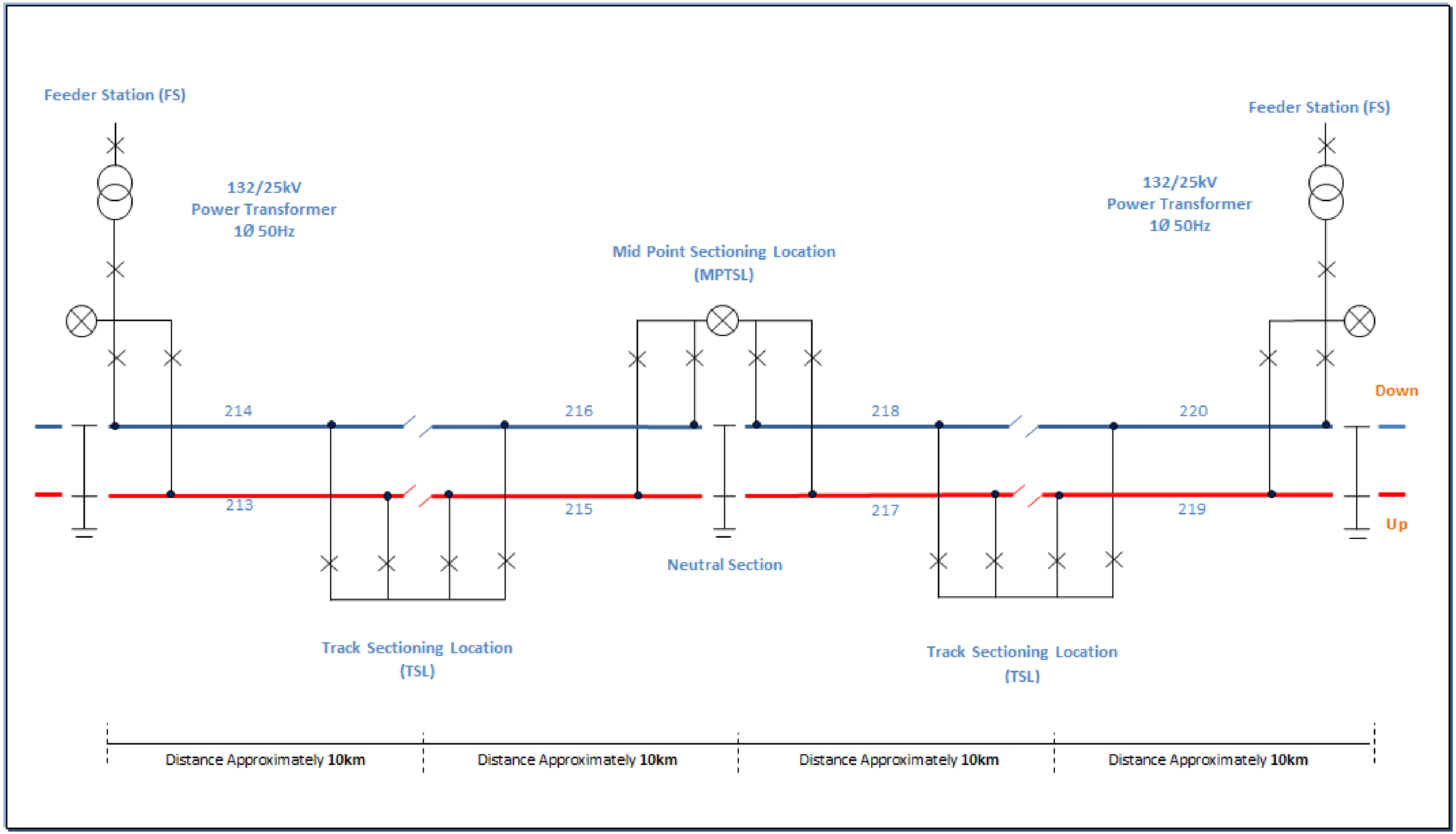
Traction Power Supply System>Typical Feeding Arrangement and sectioning

An addition substation or substations is usually provided between FS and the MPTSL are known as a TSL.

- To limit the voltage drop along the OCS.
- To minimize the extent of line affected by a fault on the OCS.

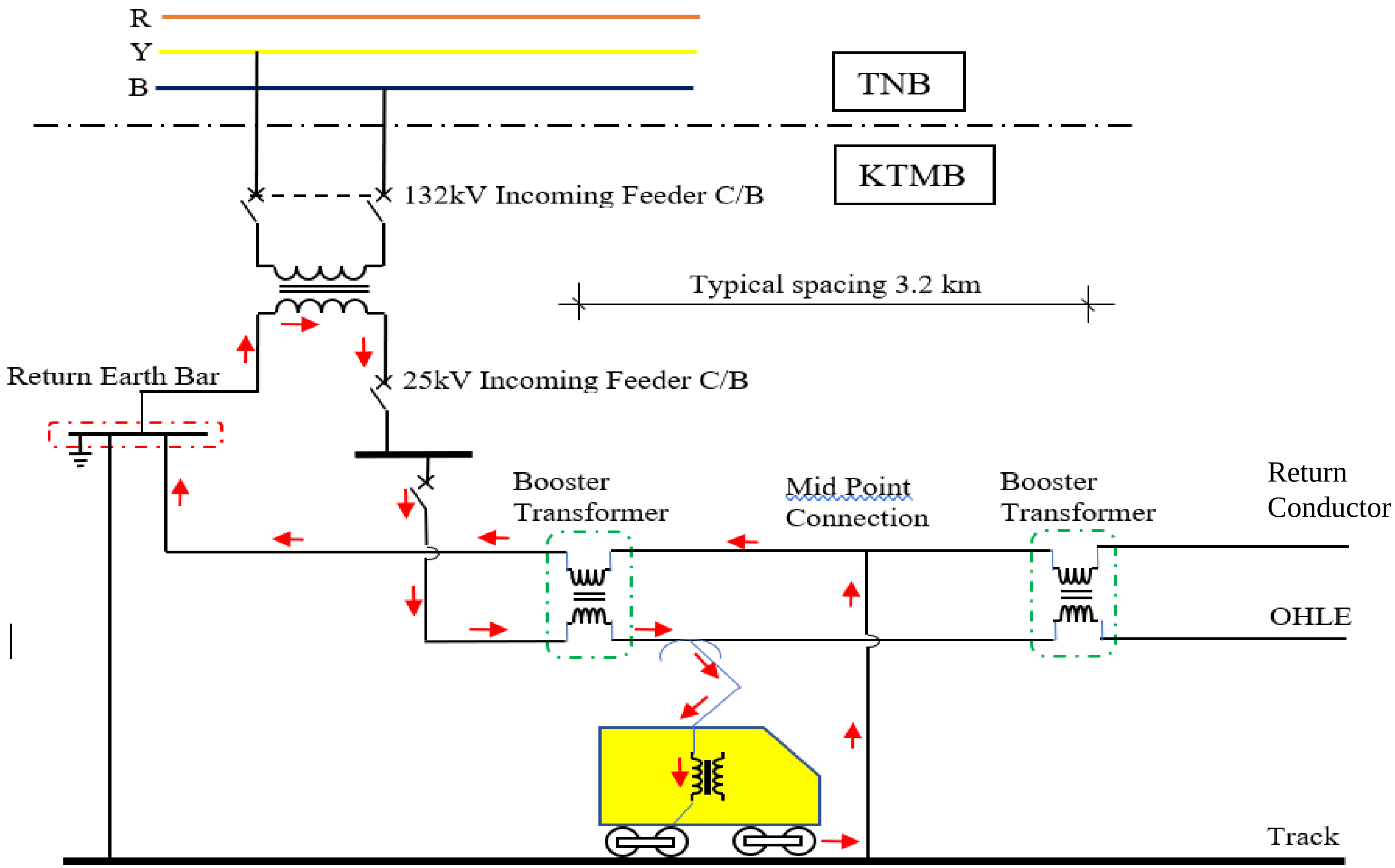
3.0 Electrification System

Traction Power Supply System> Typical Feeding Arrangement and sectioning



3.0 Electrification System

Traction Power System> Booster Transformer And Return Conductors System



NOTE: **A Booster Transformer is a transformer with 1:1 ratio so that current flowing in return conductor is equal in opposite direction to that on O.H.L**

3.0 Electrification System

Traction Power Supply System>Basic Railway Electrification Protection System

Reasons

- Protect damage to the equipment that is in the vicinity of the fault due to heavy currents, unbalanced currents or low voltages produced by the short circuit.

Basic Principles

- Any fault on the system should be detected and the fault cleared by tripping of a circuit breaker somewhere in the system.
- The area affected by a fault should be kept to a minimum to ensure as much possible of the railway can be left operational.

Protection Relay

Protection Used

- Track Feeder Circuit Breaker ie. Distance Impedance Protection, Thermal Over Current Protection.
- Transformer Protection. ie Buchholz Gas Relay, Differential Relay.

3.0 Electrification System

Traction Power Supply System> Distance Impedance Protection Coverage

- Primary Protection for the OCS and measures the impedance of the line by measuring the voltage at the substation and the current through the Circuit Breaker.

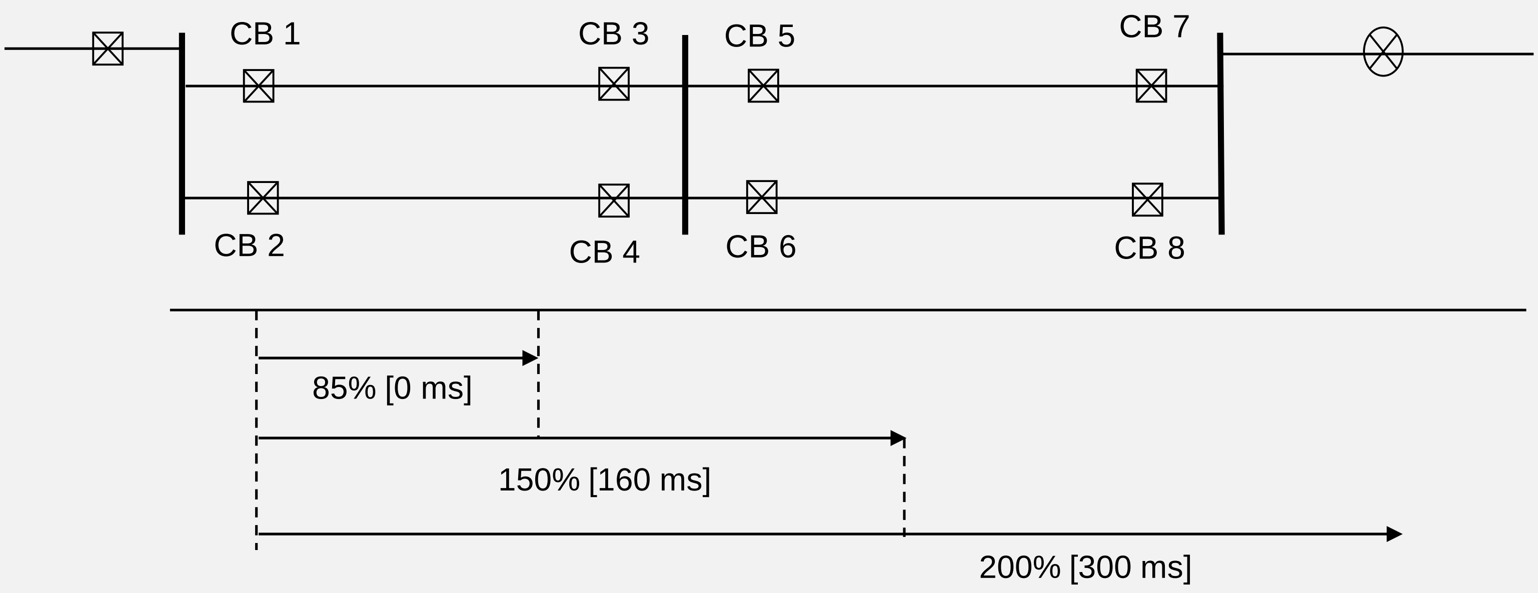
- Impedance fall below a set value the relay will trip circuit breaker

- Relays has 3 zones and can be set at 3 impedance value.

    i. Z1 sees faults in the protected section and operates instantaneously. It was set 85% s of the protected section such that it will not see a fault beyond the next bus bar.
    ii. Z2 is set to see just beyond the next bus bar and operates after approximately 160 ms thus giving another Circuit Breaker within the system to operate on Z1 for a fault beyond a bus bar. It was set 150%
    iii. Z3 is set to see to the following bus bar and round the ‘hairpin” looking back to its own busbar. This zone is normally set to operate after 300 ms. It was set 200%

3.0 Electrification System

Traction Power Supply System> Distance Impedance Protection Coverage



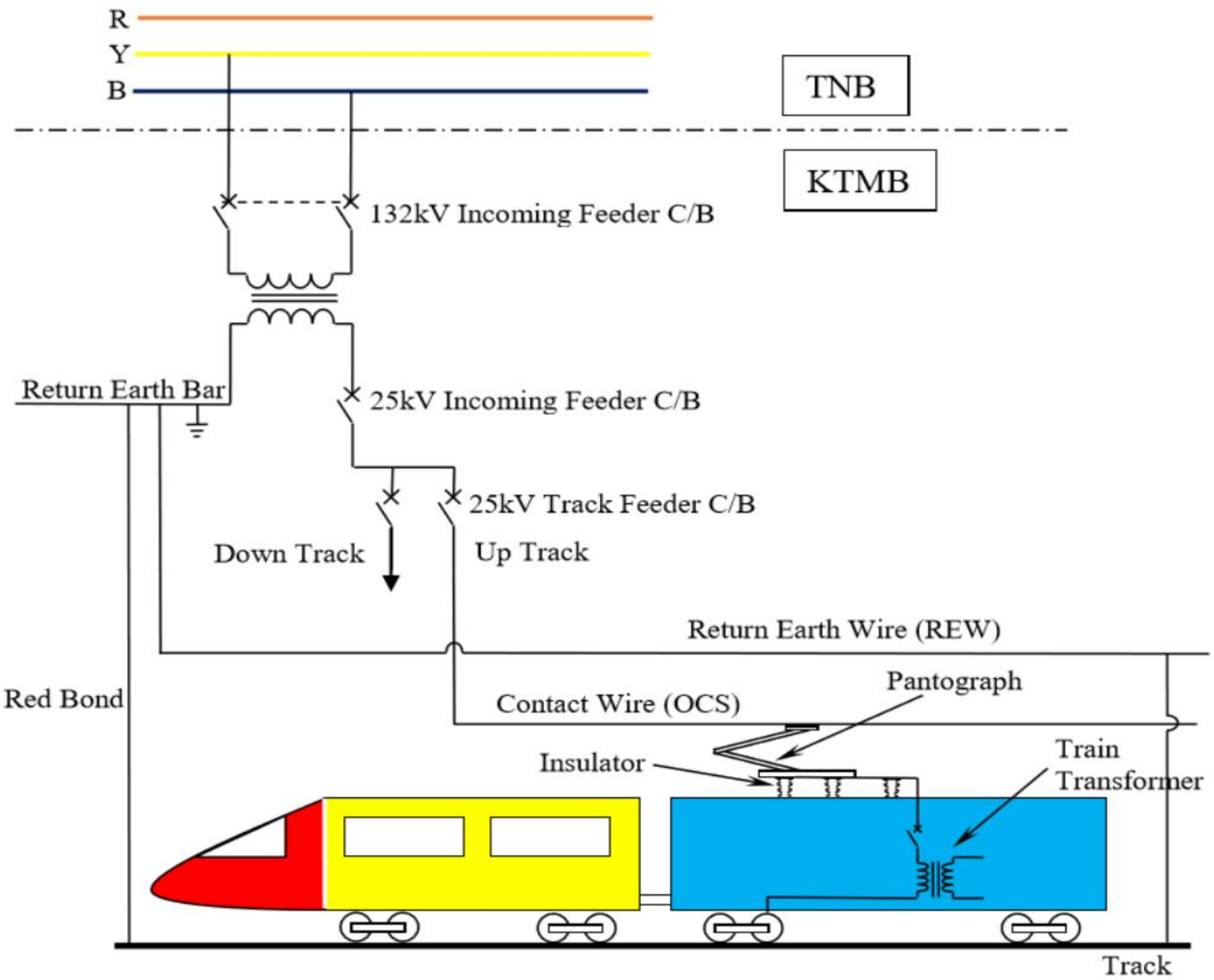
3.0 Electrification System

Traction Power Supply System> Power Supply System For Electrical Multiple Unit (EMU)

- Basically the Electric Train or Electric Multiple Unit (EMU) is empowered by electricity derived from TNB National Grid via Traction Power Supply and Overhead Catenary System (OCS).
- The intake from TNB is at 132kV AC 50Hz and stepped down to 25kV Single Phase at Feeder Station
- Electricity will then be sent to Electric Train through a Catenary and Contact Wire.
- By pushing up the pantograph which is located at its roof and it is mounted on the insulator, the carbon brush will touch underside of contact wire (apart of OCS) then transmit the power into the train through the train transformer for their distribution and traction. `
- The return current from the main train transformer will be through the rail and return earth wire going back to the Feeder Station power transformer.

3.0 Electrification System

Traction Power System> Power Supply System For Electrical Multiple Unit (EMU)



3.0 Electrification System

Overhead Catenary System (OCS)>Overview

When designing the Overhead line, it should:

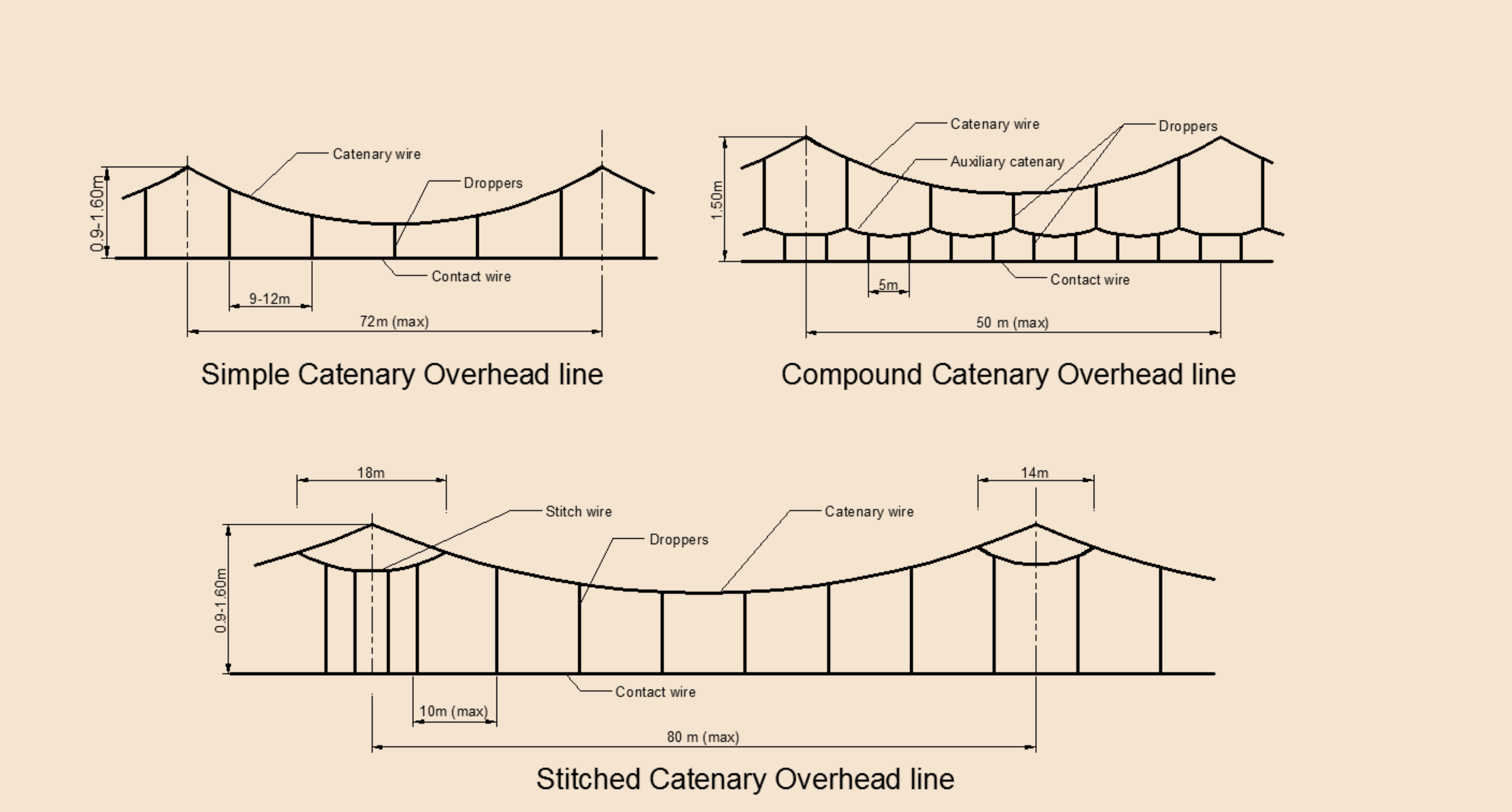
- Meet train speed and current requirement.
- Be at uniform level height to optimize pantograph power collection.
- Have minimum vibration and motion to ensure smooth pantograph passage.
- Be able to withstand vibration, corrosion, heat etc. with reliability and operating life span.

The pantograph on the electric locomotive is in constant contact with the overhead line (contact wire) located appx. 5m above the rails.

The overhead line must always be located within the pantograph range and the pantograph must always maintain contact with the overhead line to supply uninterrupted power at all times.

3.0 Electrification System

Overhead Catenary System (OCS)>Type of OCS Design



3.0 Electrification System

Overhead Catenary System (OCS)>Comparison Different Type of OCS

1. **SIMPLE OVERHEAD CATENARY(SEMI OR FULLY AUTO-TENSIONED EQUIPMENT**)

- Simple Economical design.
- wire independent of temperature.
- Contact Spans up to 75m are possible
- Current carrying capacity can be adapted by selecting suitable contact and catenary wire cross sections
- Large variation of elasticity between mid-span and support.
- Large vertical motion of the pantograph is compensated by pre-sag.
- Economical design for speeds up to 160kmph

3.0 Electrification System

Overhead Catenary System (OCS)>Comparison Different Type of OCS

2. STITCHED CATENARY(AUTO-TENSIONED EQUIPMENT)

- Complex design with extra stitch wire inserted between catenary and contact wire to compensate contact wire height difference between mid-span and supports.
- Constant tension in Contact wire independent of temperature.
- Higher span lengths up to 80m.
- Higher current carrying capacity.
- Lower elasticity difference between mid span and support.
- Vertical motion of pantograph is suppressed by pre-sag.
- Suitable for speeds up to 250kmph.
- Suitable for High speed Main line Railways with high electrical loadings.

3.0 Electrification System

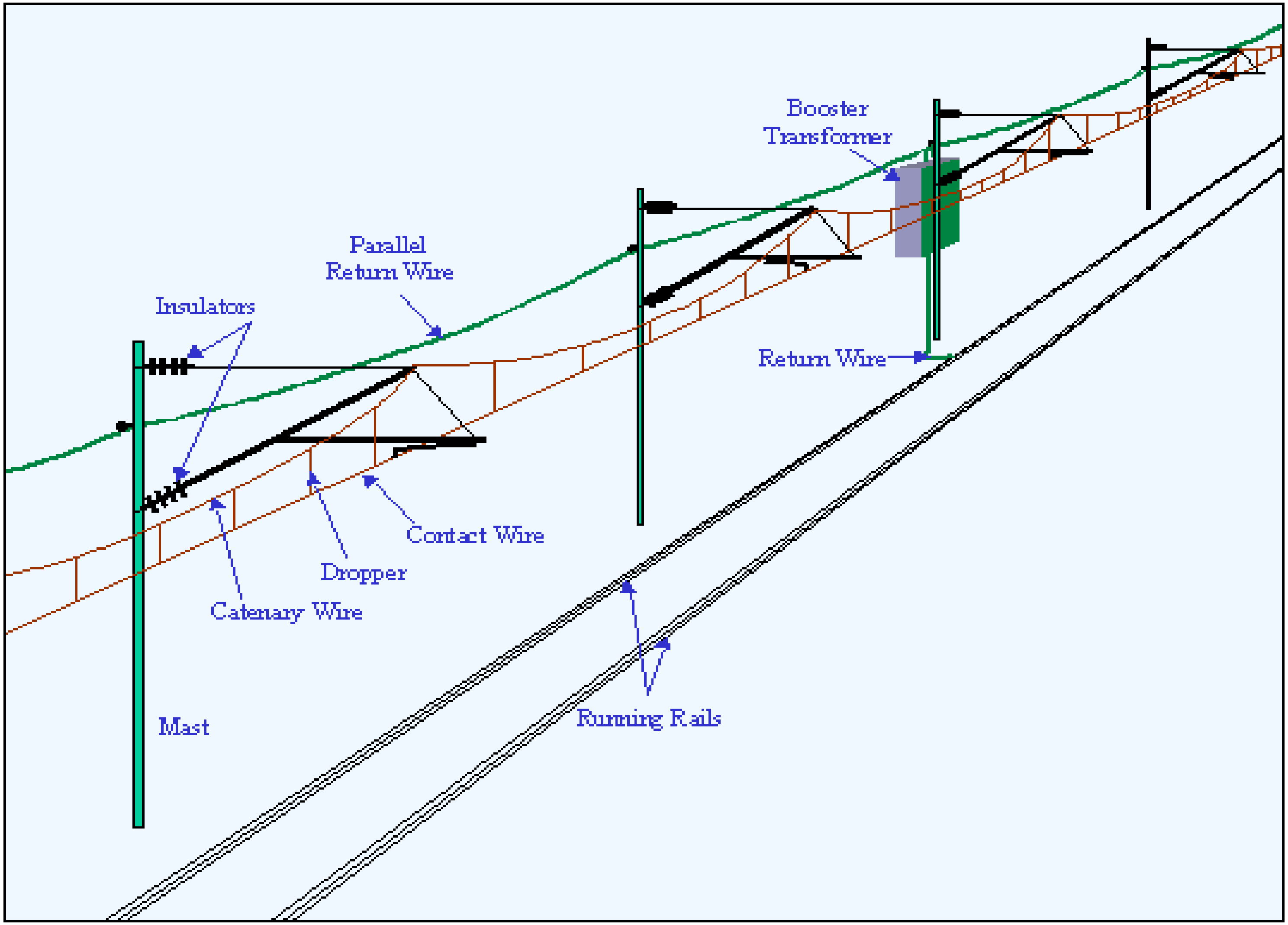
Overhead Catenary System (OCS)>Comparison Different Type of OCS

3 COMPOUND CATENARY EQUIPMENT (FULLY AUTO TENSIONED)

- More complex design with an additional catenary introduced between main catenary wire and contact wire.
- No variation of elasticity difference between mid span and support.
- Larger current capacity
- Effectively less pantograph vertical motion.
- Higher span lengths up to 80m.
- Requires a large number of components and higher installation efforts.
- Suitable for Main line electrification with very high speeds and very high electrical loadings.

3.0 Electrification System

Overhead Catenary System (OCS)>3-D View of A Typical OCS

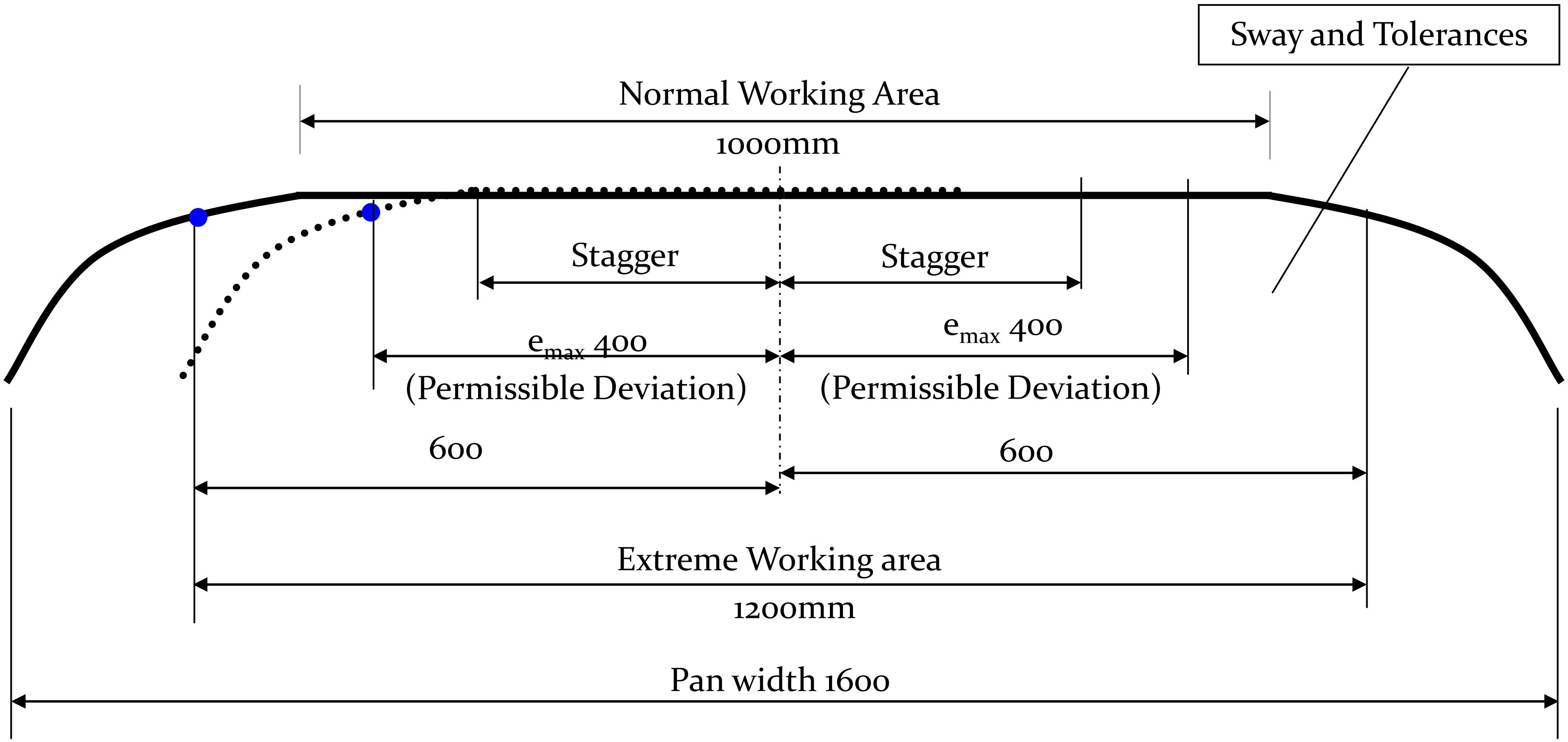


3.0 Electrification System

Overhead Catenary System (OCS)>A View of OCS

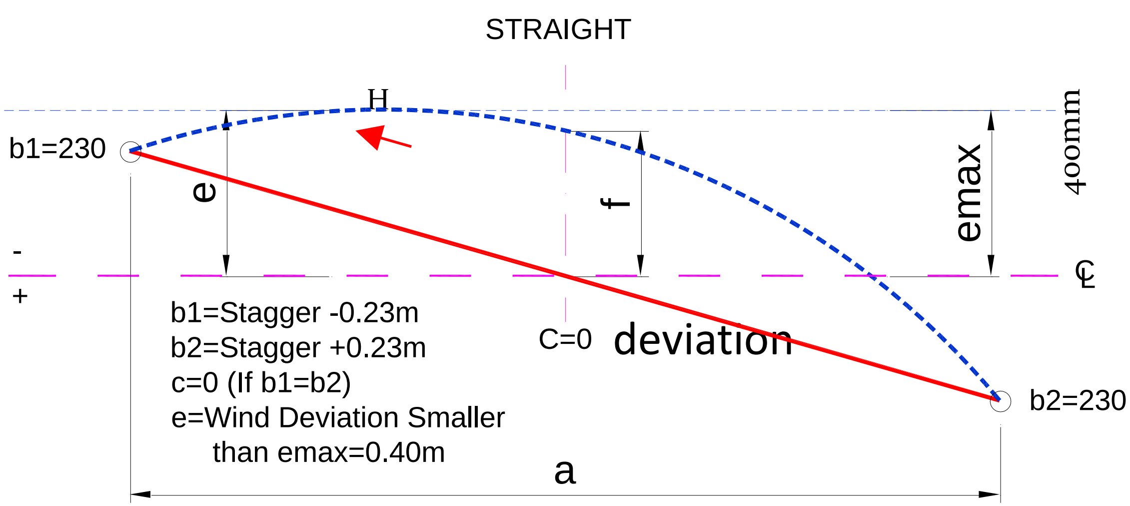
3.0 Electrification System

Overhead Catenary System (OCS)>Panthograph Design Philosophy



3.0 Electrification System

Overhead Catenary System (OCS)>Wind Deviation And Displacement of Contact Wire



ABBREVIATIONS

a =Span Length
b1 =Stagger at First Support
b2 =Stagger at second support
h =Stagger Difference
c =Static Offset at mid span
e =Wind Deviation
emax=Max. Permissible wind

sk =Stagger Effect
f =Blow Off
H =Horizontal Tension Force
s =Versine

3.0 Electrification System

Overhead Catenary System (OCS)>Wind Deviation And Displacement of Contact Wire

WIND DEVIATION

Wind Deviation “e” – The Wind deviation is the distance between centre line of track and contact wire in any point between two adjacent supports when it is deviated by the wind. It is to be calculated on each side of track and must be smaller than emax.

Maximum Permissible Wind Deviation “emax” – The maximum permissible wind deviation of contact wire due to wind is the maximum permissible distance between centre line of track and deviated contact wire in any point between two adjacent supports.

Wind Deviation should be equal to or less than maximum permissible wind deviation for any given span.

In case of increased height of contact wire, the *Maximum Permissible Wind Deviation “emax”* must be reduced by 4mm for each 0.10m height increase.

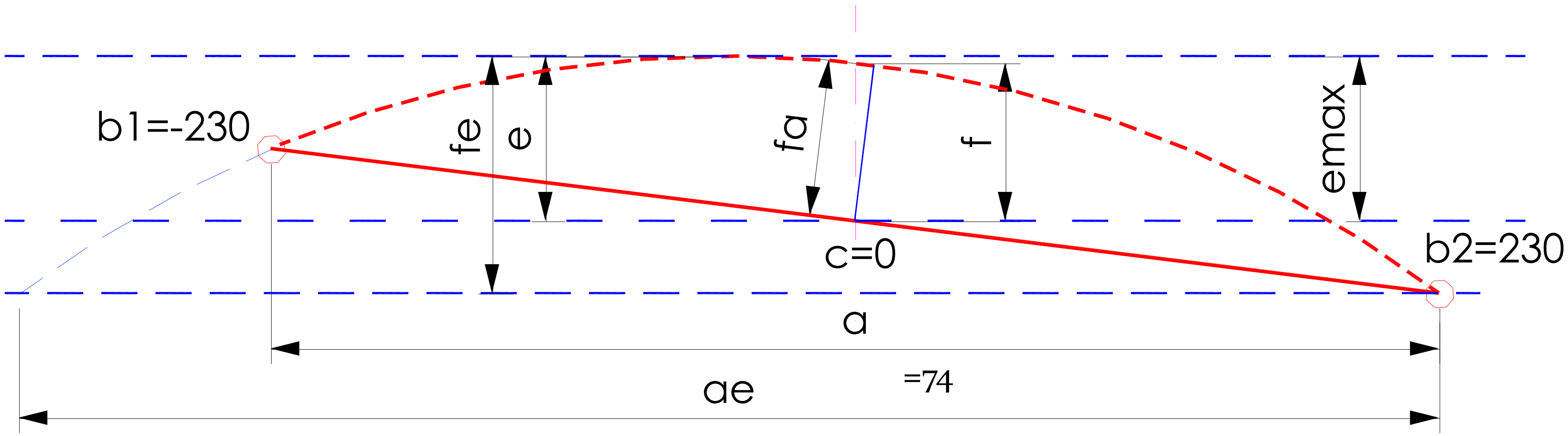
e.g. For a contact wire height of 5.20m the value of emax will be calculated as shown below-

5.20-4.60=0.60m

emax = 400-((0.60/0.10)*4)=376mm

3.0 Electrification System

Overhead Catenary System (OCS)>Wind Deviation Calculation (Straight Track)



$e = fe - b2$

- $fe = ae^2 * w / 8 * (H_{cat} + H_{cw})$
  - $ae = a * h / (4 * fa) + a$
    - $h = |b1| + |b2|$
    - $fa = a^2 * w / 8 * (H_{cat} + H_{cw})$

H_{cat} = Catenary Tension 12 kN

H_{cw} = Contact Wire Tension 12 kN

w = Wind Load 12.3N/m (v=26m/s)

a = Span m

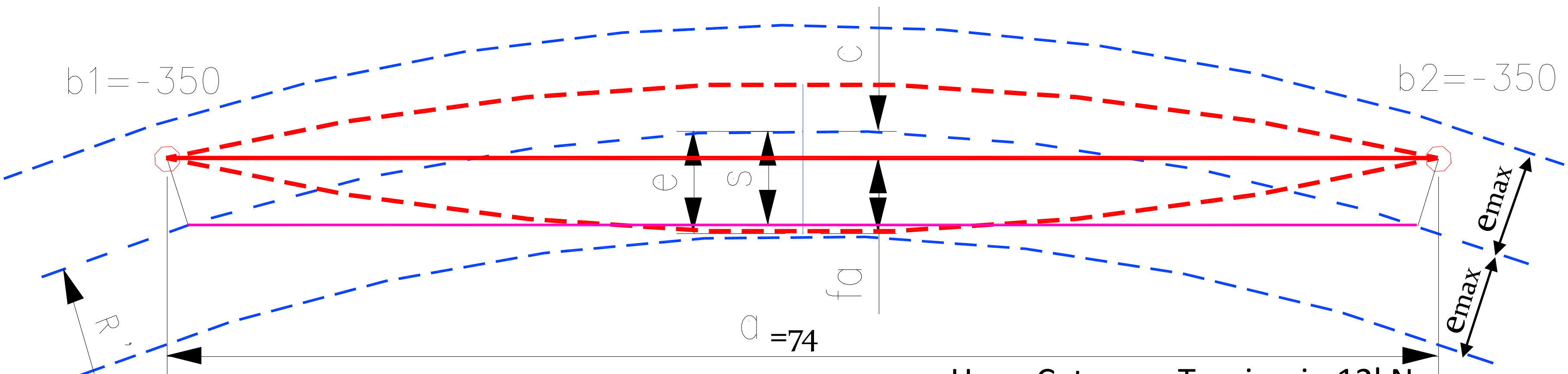
b1 = Stagger in m

b2 = Stagger in m

CWH= Contact wire height= 5m

3.0 Electrification System

Overhead Catenary System (OCS)>Wind Deviation Calculation (Curve Track)



e = fa + b – s (When stagger on same side and out side of curve)

- $fa = a^2 * w / 8 * (H_{cat} + H_{cw})$
- $s = a^2 / 8 * r$
- $c = a^2 / 8 * r + b$

H_{cat} = Catenary Tension in 12kN

H_{cw} = Contact Wire Tension in 12kN

w = Wind Load 12.3N/m (v=26m/s)

a = Span m

b1 = Stagger m

b2 = Stagger m

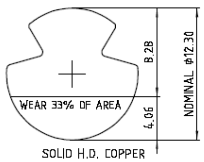
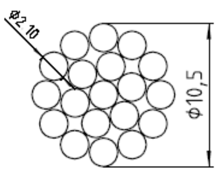
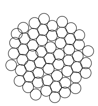
r = Radius of Curvature 2200m

b = b1-b2

3.0 Electrification System

Overhead Catenary System (OCS)>Main Conductor Details

<u>**Conductor -**</u> OCS is designed for a current rating of 600 A, The following main conductors are used to achieve this rating -

Figure	X-Sectional area/Material	Conductivity	Copper x-sec
 SOLID H.D. COPPER	107 Sq-mm Hard Drawn Grooved Copper ***CONTACT WIRE***	98%	104.86 Sq-mm
 19/2.10 BRONZE STRANDED BZ II	65.81 Sq-mm 19/2.10 Bronze Stranded ***CATENARY WIRE*** ***& Cross span wires***	60%	39 Sq-mm
	9.6 Sq-mm 7/7/0.50mm Copper Flexible Conductor ***DROPPER WIRE***	64%	6.14 Sq-mm
	Overall x-sectional area of copper 1 Sq-mm of Copper carries 4 Amps. Current So, 150 Sq-mm size is suitable for the OCS		**150 Sq-mm**

3.0 Electrification System

Overhead Catenary System (OCS)>Ancillary Conductors

Ancillary Conductors - In addition to main conductors some ancillary conductors are also used in the system for different purposes -

Specification	Area of X-Section/Diameter	Name	Usage
19/4.22mm AAC	265.3 Sq-mm/21.1mm	Return Conductor	For Return conductor, Feeder wire
19/4.22mm AAC PVC Sheathed wire	265.3 Sq-mm/24.4mm	Insulated Return Conductor	For Insulated Return conductor at station platforms, near signals
7/3.40mm AAC	63.6 Sq-mm/10.2mm	Earth wire	For System earth wire and bonding
37/2.50mm Hard Drawn Copper wire	181.5 Sq-mm/17.5mm	Switching Wire	For Isolators, Boosters Transformers jumper and cross feeder arrangement
19/7/0.70mm Copper wire	51.2 sq-mm/10.50mm	Jumper Wire	For all type of jumpers-Potential Equalizing and Full Current
19/1.625mm Stainless steel wire	40.4 sq-mm/8.4mm	Head-span Wire	For Head Span Wire
19/3.25mm AAC PVC Sheathed cable	157.5 sq-mm/19.6mm	Bonding Cable	Bonding, MPC connections

3.0 Electrification System

Overhead Catenary System (OCS)>Erection Tension & Sag

Sag – When a wire/cable is stretched between two points of support, sag is produced. It is defined as the max. offset of the lowest point of wire/cable from the chord connecting two supports. In case of contact wire, pre-sag is provided deliberately to better pantograph passage and current collection. In RI project it is normally 1‰ of span length.

Erection Tension – The initial tension of wires, given at the time of installation is known as erection tension.

In case of regulated OCS, tensions in both catenary and contact wire is kept constant at all temperatures by using regulating equipment.

In case of unregulated wires like Return Conductors, Earth Wires and Feeders, tension varies with the change in temperature and wind blow off.

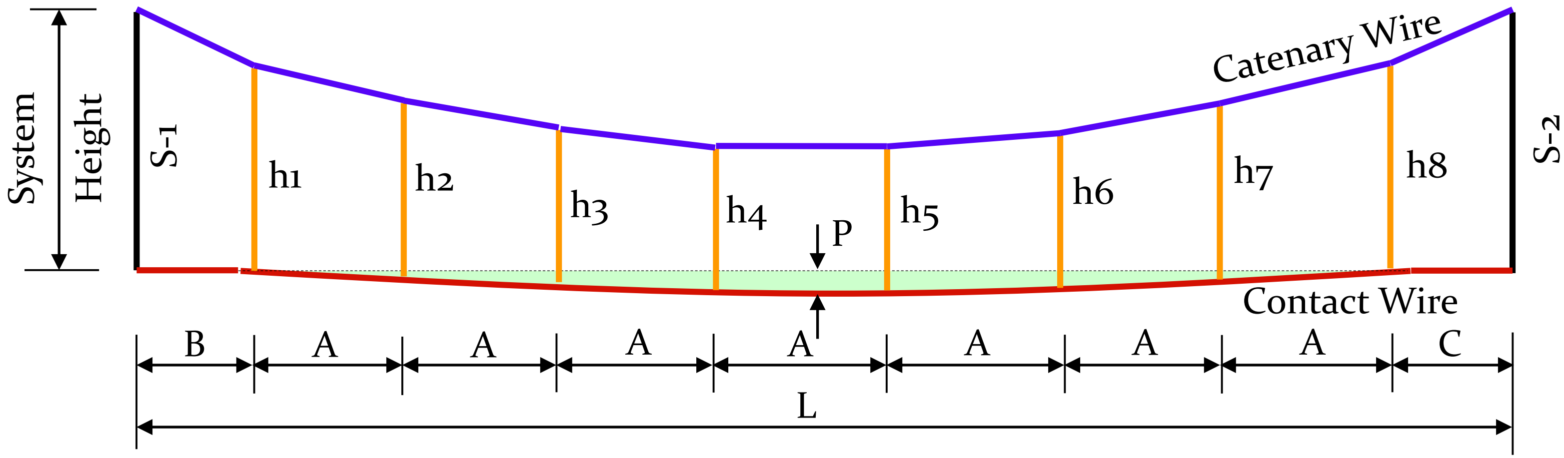
To achieve calculated sag for all spans and to maintain it within permissible limits, we need to install wire with some initial tension, so that, in increased temperature conditions the sag of wire remains in permissible limits and in decreased temperature conditions the tension in wire remain within breaking load limits.

S=Sag of Cable T=Wire Tension
W=Weight of Cable *S=(W*L^2)/8/T*
L=Span Length

Equivalent Span= SQRT $\left| \frac{(L1 + L2 + \ldots Ln)}{L1_3 + L2_3 + \ldots Ln_3} \right|$

3.0 Electrification System

Overhead Catenary System (OCS)>Typical Span & Dropper



S. No.	Symbol	Description
1.	L	Span Length. Generally between 20m min. to 74m Max.
2.	SH	System Height. Normal 1.2m, 1.6m is the maximum (1.0 – 1.6).
3.	A	Dropper Spacing. Min. 2m and Max. 12m (refer b1/001/119)
4.	h1 to h8	Dropper Nos., Min no. of droppers are 2, Max 8. Possibly the number of droppers is “even”. (refer b1/001/119)
5.	P	Pre Sag (1‰). For all spans with 4 or more droppers.
6.	Special dropper spacing and length apply to overlap and anchor spans	
5.	Value of Spacing “B” and “C” depends upon Radial Load at Supports	

3.0 Electrification System

Overhead Catenary System (OCS)>Typical Span & Dropper

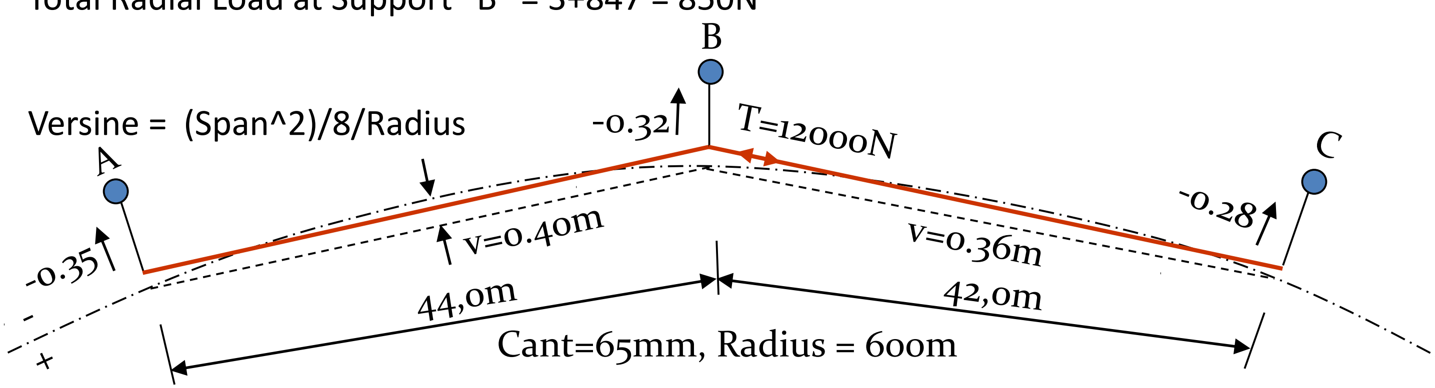
Tension in Steady Arm	To 110N	To 150N	To 200N	To 240N	To 400N	To 650N	To 850N	To 1000N	To 1100N	To 1200N
B and C	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m
For radial loads/tensions more than 1200N, the maximum spacing of 12m is to be used.										

Calculation of Radial Load – Calculation shown under is for radial load on Contact Wire

Radial Load due to Stagger= $\left[\frac{(-0.35-(-0.32))}{44} + \frac{(-0.28-(-0.32))}{42}\right] \times 12000 = 3N$

Radial Load due to Versin = $\left[\frac{(4*0.4)}{44} + \frac{(4*0.36)}{42}\right] \times 12000 = 847N$

Total Radial Load at Support “B” = 3+847 = 850N



3.0 Electrification System

Overhead Catenary System (OCS)>Span Length and Stagger

<u>Span</u> – The distance between the centre line of the adjacent supporting structures for the OCS is known as Span. The main consideration of span is that the contact wire should be within the current collection zone of the pantograph. Factors which effect the determination of span of OCS are-

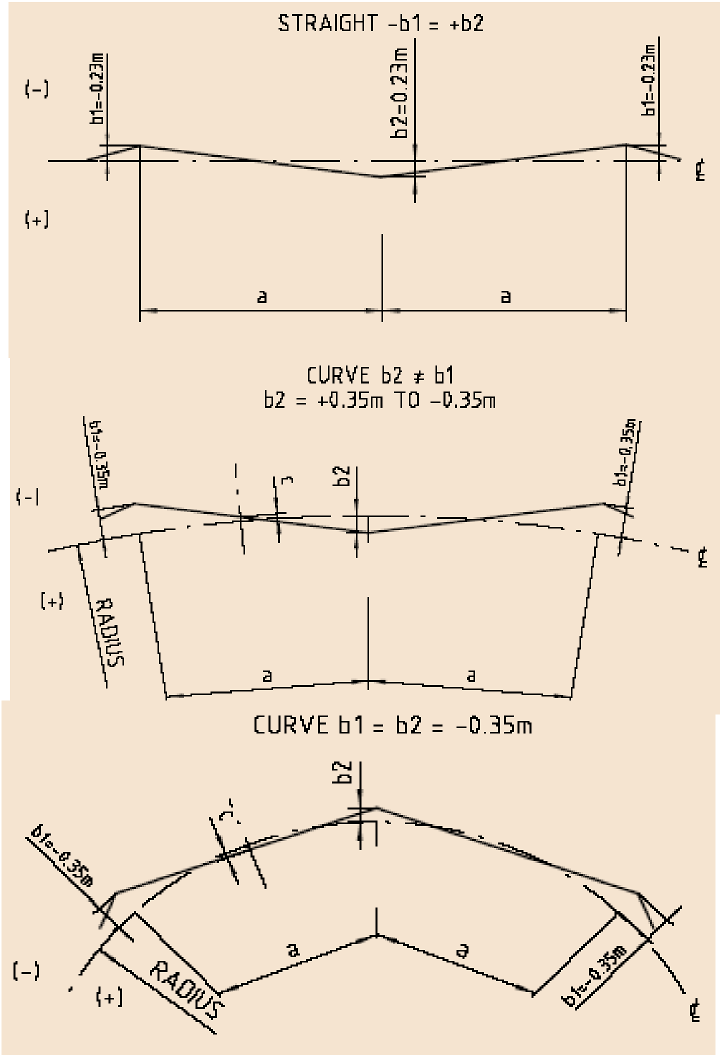
- Blow off
- Stagger of Contact wire
- Track Radius
- Pantograph Oscillation
- Displacement of OCS caused by mast deflection due to wind
- Span differential (max 15m)

<u>Stagger</u> – The horizontal distance of the contact wire from the vertical plane through the centre of pantograph pan at the contact surface is known as *Stagger.*

- *On tangent track, the contact wire is normally given a stagger of 230mm*
- *On curved track, the stagger of contact wire is governed by the versine, stagger at support is given in such a way that contact wire is very near to pantograph axis at mid span. The maximum permissible stagger at curved track is 350mm*
- *The stagger for contact wire height above 4.60m to be reduced by 40mm/metre from this value.*

3.0 Electrification System

Overhead Catenary System (OCS)>Span Length and Stagger at Catenary



b – Value at Straight

b1 = -230mm

b2 = +230mm

On Straight track, Maximum Span length is depending on wind speed. Table below shows the span limitations with regard to wind speed-

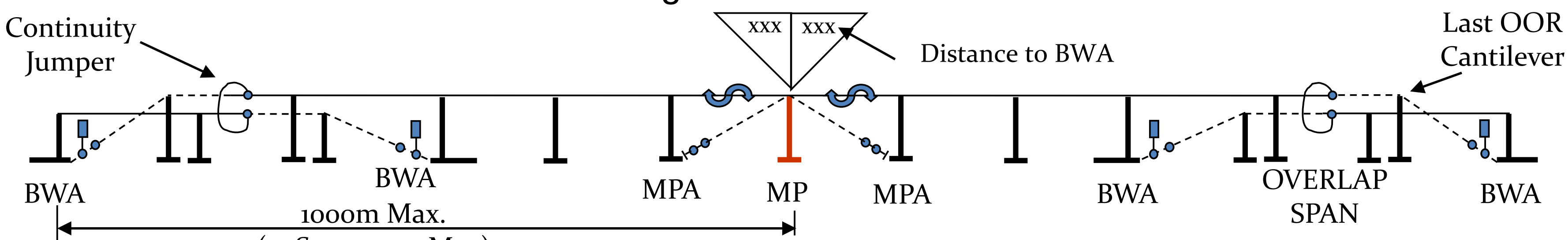
Wind Velocity	Span
22 m/s	a ≤ 74m
26 m/s	a ≤ 74m
30 m/s	a ≤ 65m
32 m/s	a ≤ 61m
36 m/s	a ≤ 54m
40 m/s	a ≤ 51m

3.0 Electrification System

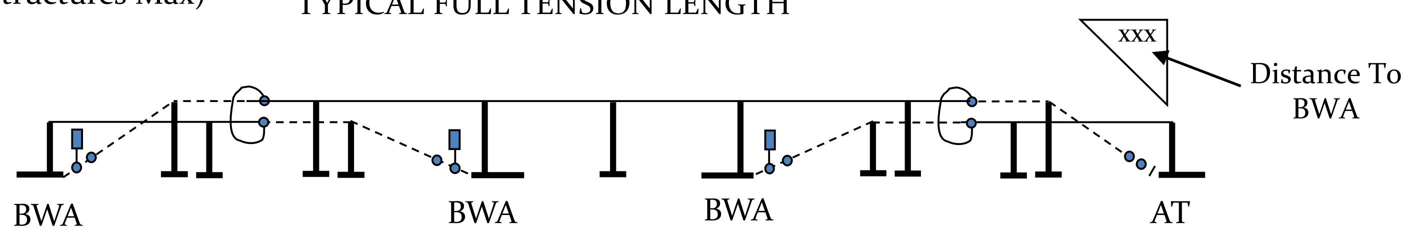
Overhead Catenary System (OCS)>Typical Tension Length

<u>Tension Length</u> – The distance between two anchoring structures where contact and catenary wire of a single wire run are terminated. There are two types of tension lengths we use in our system-

- **Full Tension Length** – Shall comprise a single length of Contact and catenary wire between Balance Weight anchors. The catenary system shall be restrained at or near its mid point to permit Along Track Movement towards each balance weight anchors. Maximum full tension length is 2000m as per specification.
- **Half Tension Length** - If the tension length of catenary equipment is less than 1000m, mid point restraints shall net be fitted and a fixed termination shall replace balance weight anchor at one end of the tension length.



TYPICAL FULL TENSION LENGTH

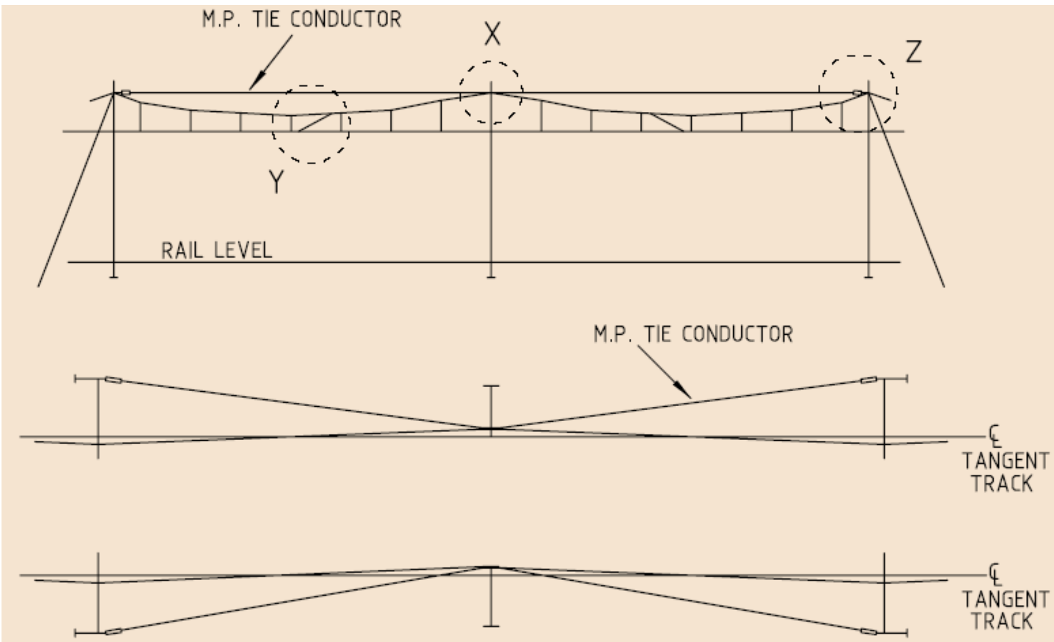


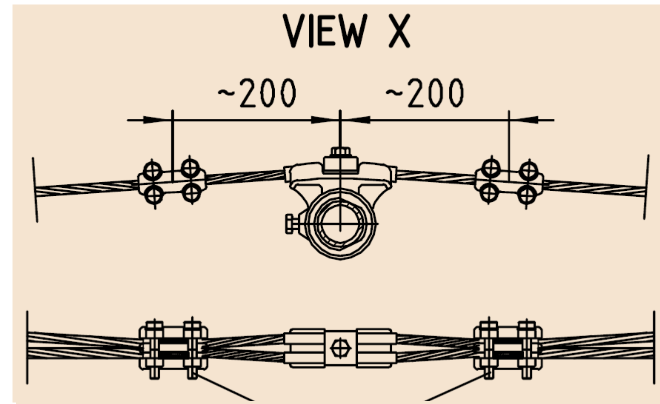
TYPICAL HALF TENSION LENGTH

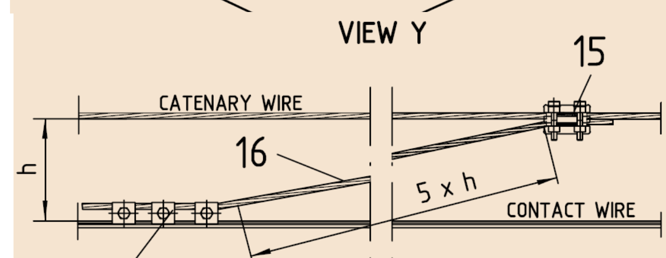
3.0 Electrification System

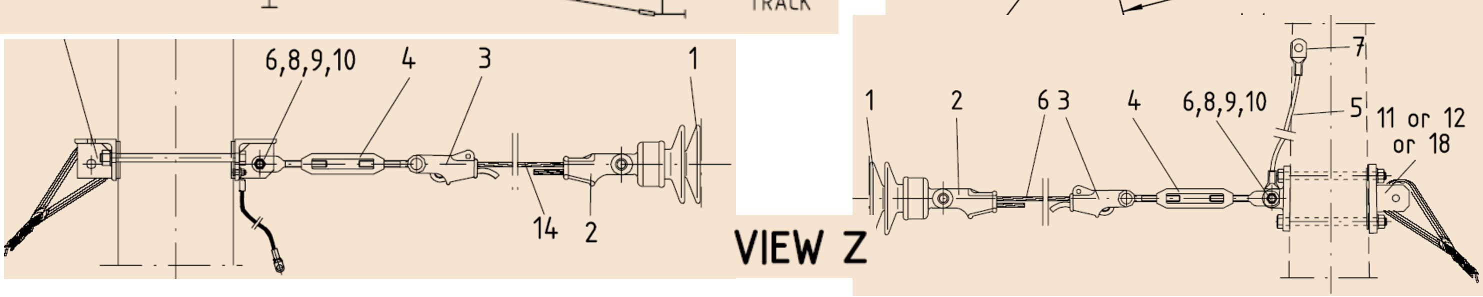
Overhead Catenary System (OCS)>Mid Point Arrangement

In Full Tension Length arrangement, the catenary system shall be restrained at or near its midpoint to permit Along Track Movement towards each balance weight anchors. The arrangement at mid point is shown below-



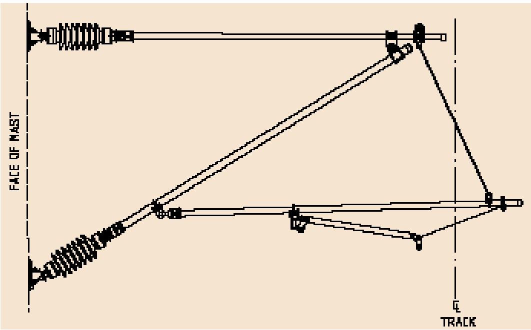


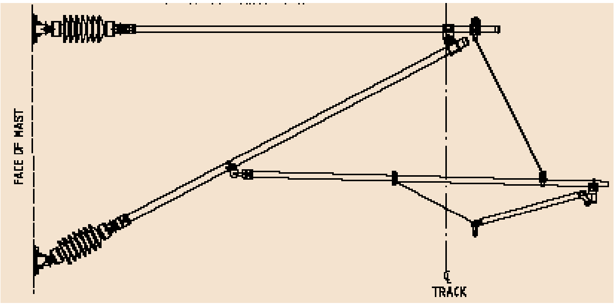




3.0 Electrification System

Overhead Catenary System (OCS)>Cantilever

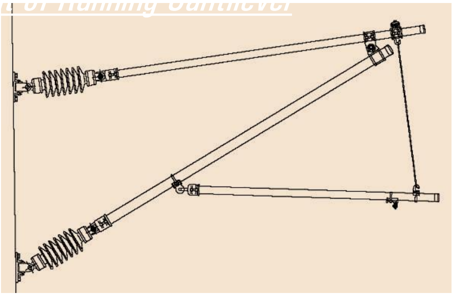


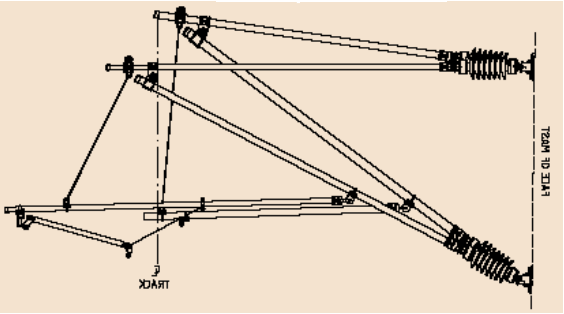


Cantilever Assembly –

It is an insulated swiveling type structural member, comprising of different sizes of aluminum tubes, to support and to keep overhead catenary system in position to facilitate current collection by the pantograph at all speeds without infringement. The minimum offset (distance between centre line of track and face of support) is 2.0m and maximum 5.0m. Based on usages these cantilevers can be divided in to the following categories –

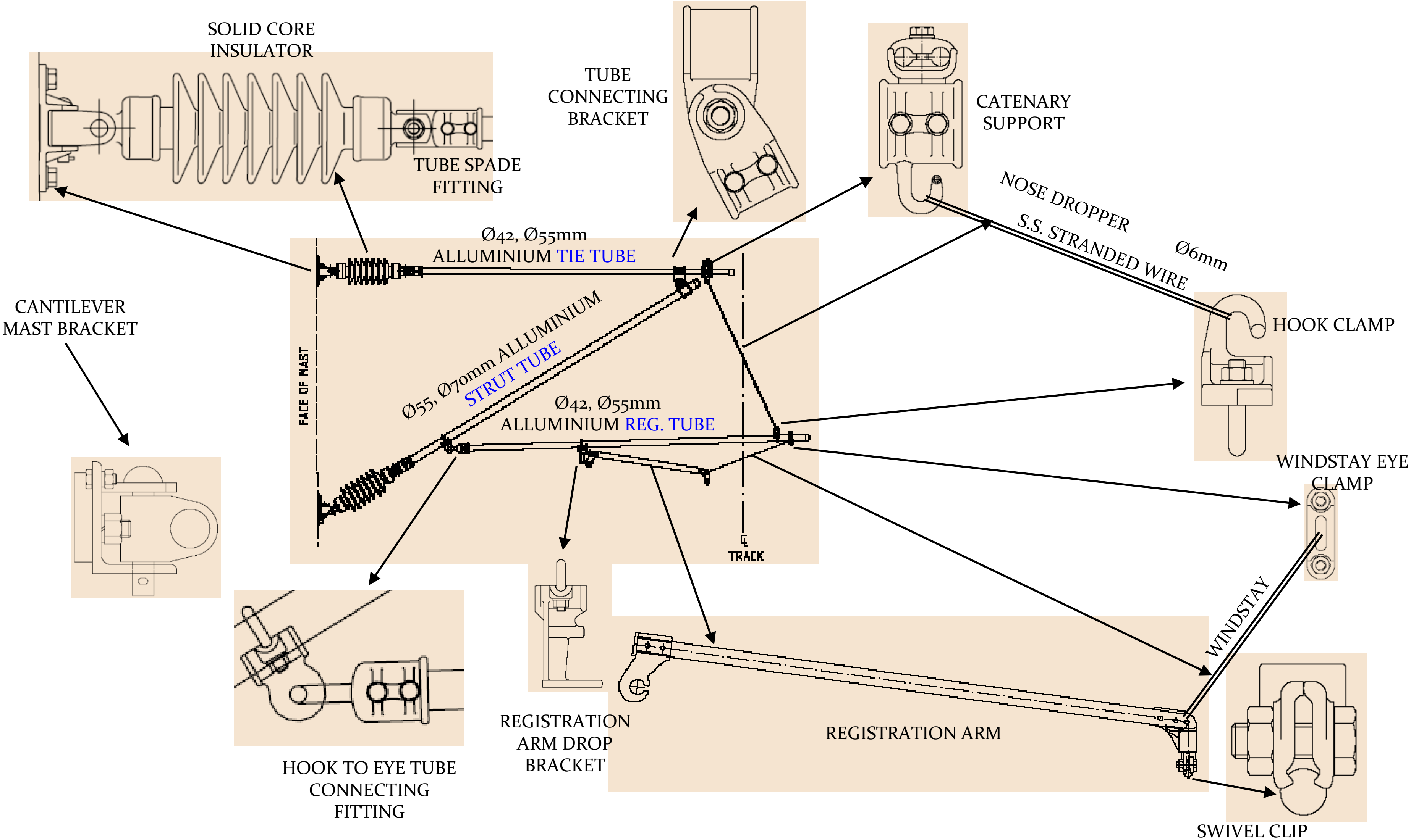
- ➢ Pull off cantilever
- ➢ Push off cantilever
- ➢ Out of Running cantilever





3.0 Electrification System

Overhead Catenary System (OCS)>Cantilever Component

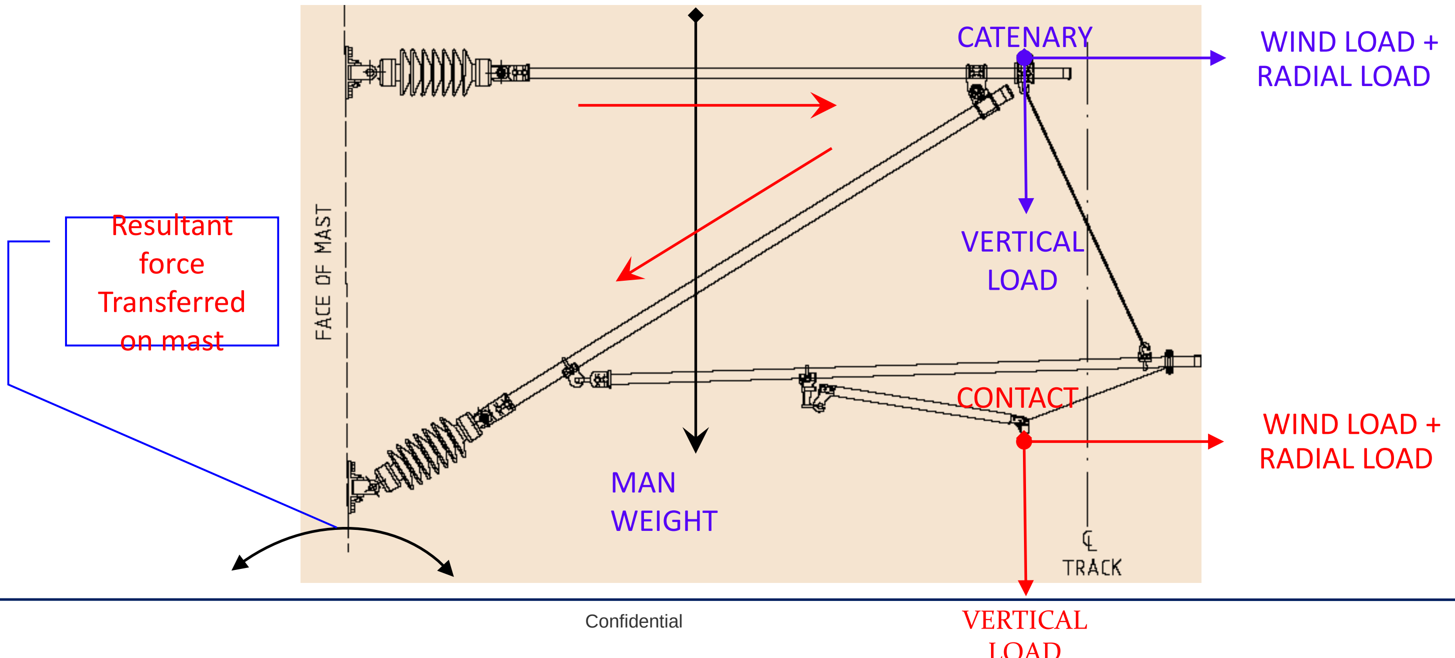


3.0 Electrification System

Overhead Catenary System (OCS)>Cantilever Arrangement

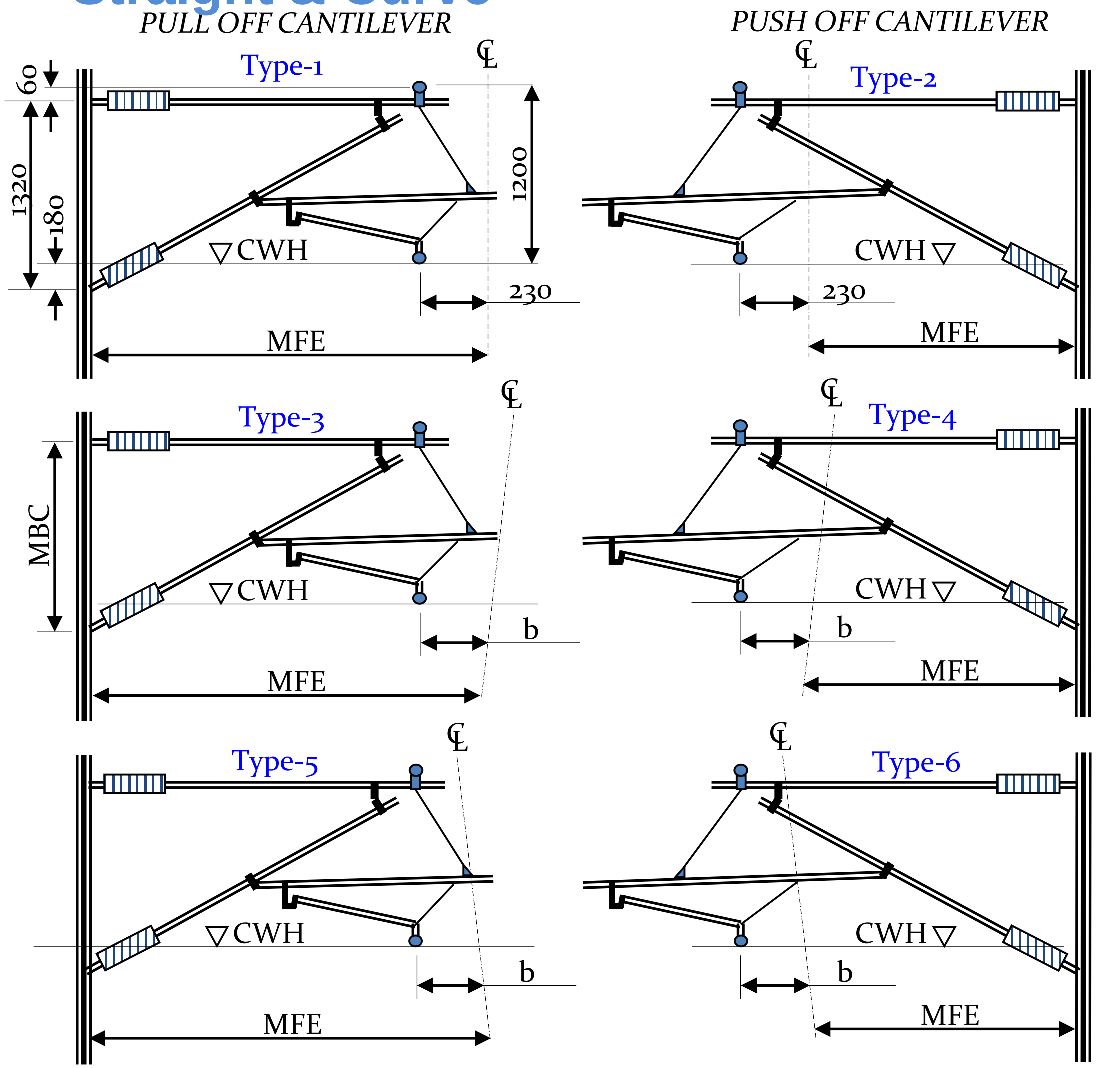
Forces acting on Cantilever - Following forces acts on the cantilever tubes–

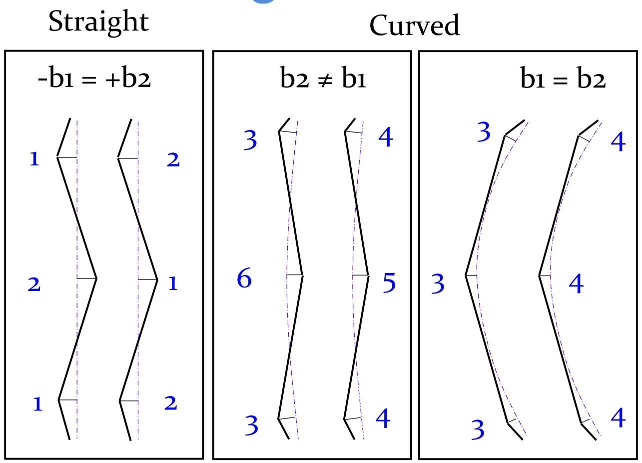
- Vertical Load- Vertical load of catenary, contact and droppers. In some cases weight of Section Insulator/Neutral Section and jumpers also acts on cantilever
- Wind Load- Wind force acting on wires transferred to cantilever.
- Radial Load- Radial load is generated due to the stagger of OCS, track curvature and Super elevation
- Man Weight- For design of Cantilever one man weight (standing on OCS) is also considered.



3.0 Electrification System

Overhead Catenary System (OCS)>Cantilever Arrangement – Straight & Curve





Allocation of Tube Diameter

MFC or Cantilever Type	Tube Ø (mm) Strut	Tie	Registration	Diagonal	Mast Bracket Centers (m)
2.60m-3.06m	55	42	42	-	1.32
3.06m-3.60m	70	42	42	-	1.32
3.61m-5.00m	70	55	55	42	1.80
Out Of Running	70	55	55	-	1.32
Mid Point	70	55	55	-	1.32
Neutral Section	70	42	42	-	1.32

MFE = Mast Face to centre line of Track

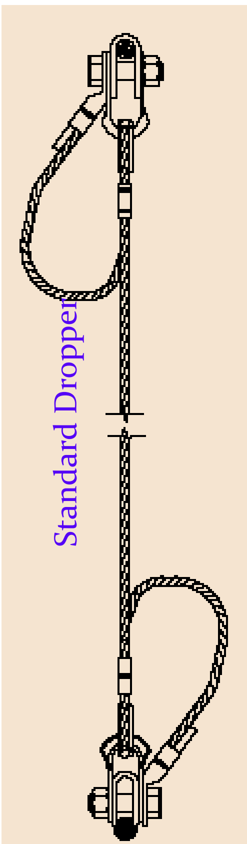
3.0 Electrification System

Overhead Catenary System (OCS)>Dropper

Dropper -

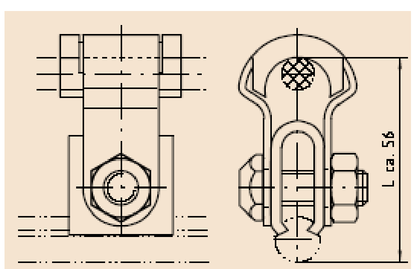
Droppers form an important part of OCS. They transfer the weight of contact wire to the catenary and transfer/equalize current between contact and catenary wires. In Rawang-Ipoh project, all droppers are current carrying type and made of 7/7/0.50mm, ø4.5mm stranded flexible copper conductor. In RIDT project mainly four type of Droppers used –

- Standard Catenary wire dropper (minimum length 500mm)
- Sliding droppers for low encumbrances (length 500mm to 50mm)
- “Z” dropper at Mid Point Location
- Cross dropper at cross over locations

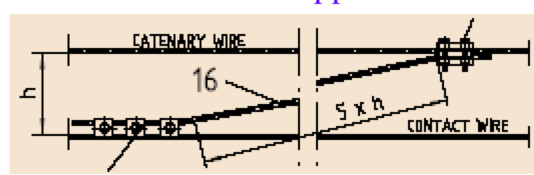


Standard Dropper

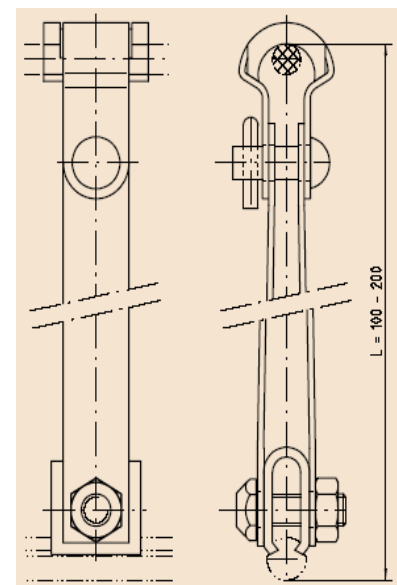
Sliding Dropper



“Z” Dropper

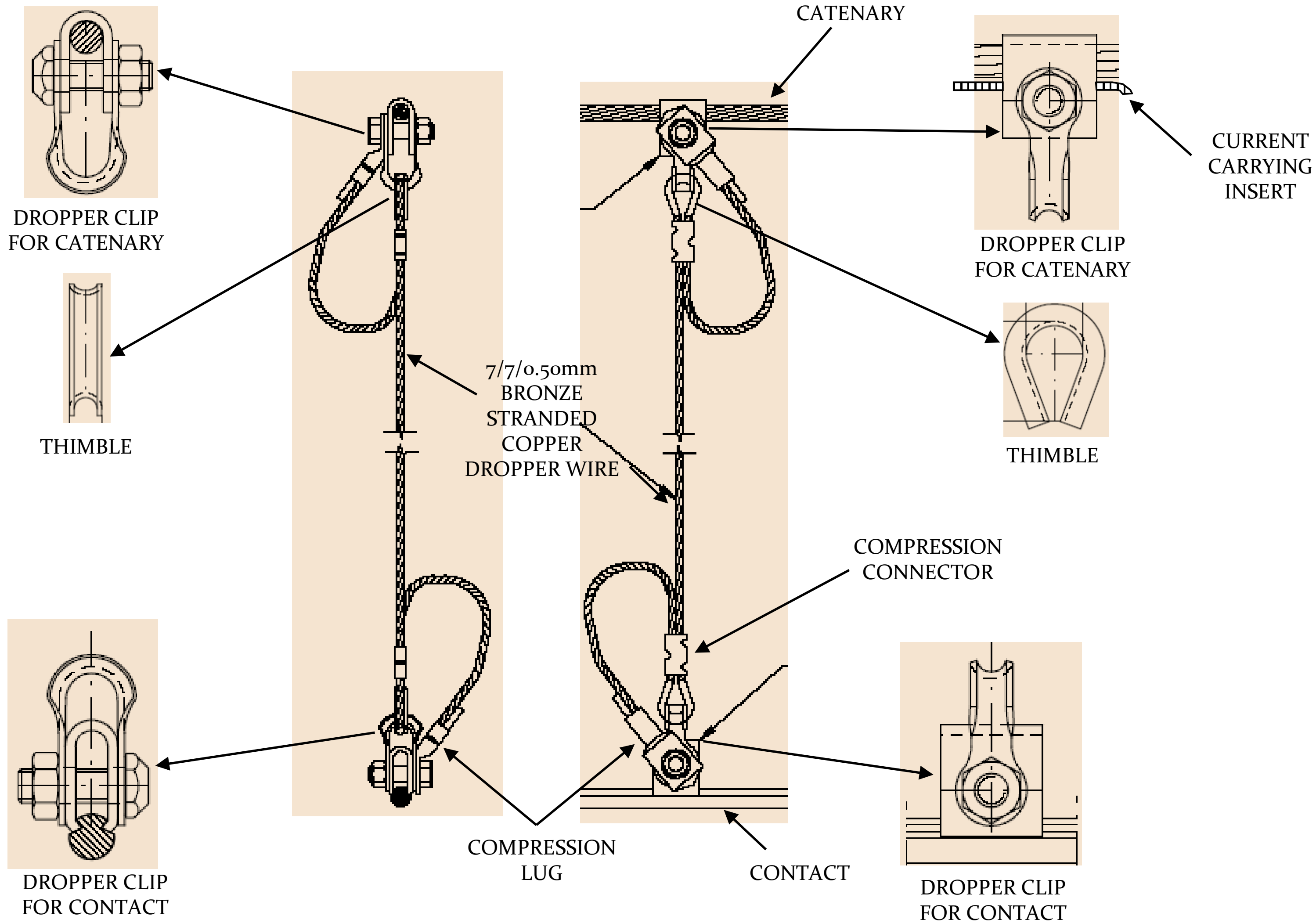


Sliding Dropper



3.0 Electrification System

Overhead Catenary System (OCS)>Dropper Arrangement



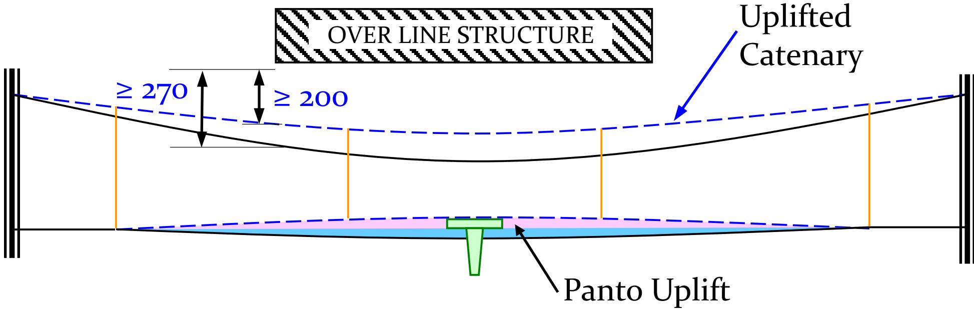
3.0 Electrification System

Overhead Catenary System (OCS)>Electrical Clearance

Normally air acts as an insulating medium between a live conductor and earthed body in its vicinity. Higher the Voltage, higher is the air gap required to be provided for adequate insulation. If the required clearance is not maintained in between the live and earthed body, flash over takes place. In order to prevent flash over, a specific clearance is required to be maintained between earthed body and live conductor, which is known as **electrical clearance**. Electrical clearance can be classified into two categories –

Passing Clearance – It is that minimum clearance at which, if an charged body is brought momentarily near an earthed body or vice versa, there will not be any flashover. The minimum value of this clearance for 25kV 50Hz AC is **200mm.**

Static Clearance – If in the above case, the charged body is kept for some time near an earthed body, flash over will take place due to ionization of the air (insulating medium) in between charged and earthed body. In order to prevent this flash over, there should be a definite clearance when both are in static condition. This clearance is known as static clearance. The minimum value of this clearance is 270mm.



3.0 Electrification System

Overhead Catenary System (OCS)>Encumbrance

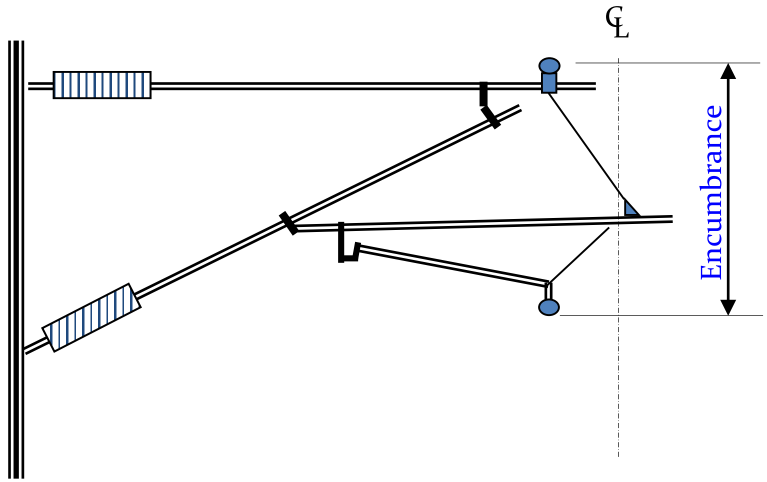
Encumbrance is the axial distance on vertical plane between centre of catenary and under side of contact wire at OCS support.

The encumbrance shall normally be 1.2m at single cantilever structure.

In case of **overlaps,** encumbrances of 1.2m and 1.35m, 1.6m and 0.95m have to be adopted to obtain adequate mechanical and electrical clearances.

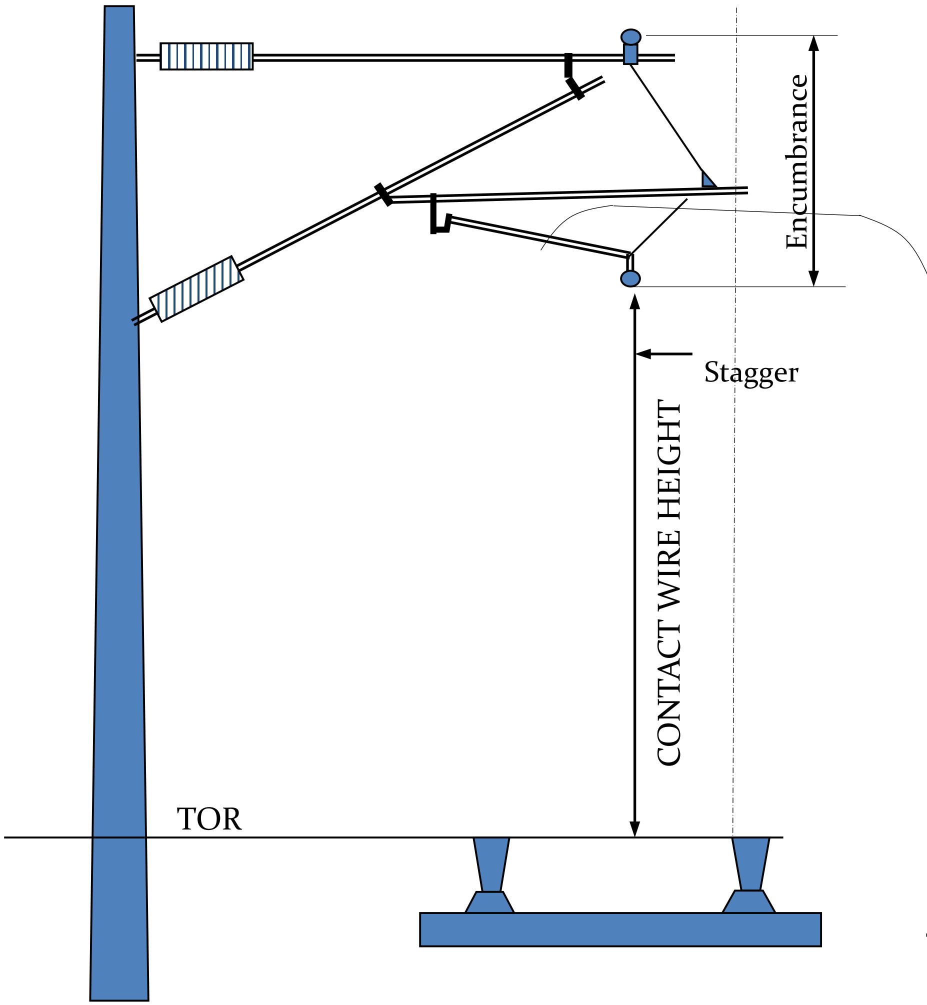
At **turnout structures**, it is a general practice to give encumbrance of 1.6m to turnout cantilever and 1.2m to the main line OCS. But in some cases it can be reversed considering the direction of staggers.

Under over line structures and in adjacent spans lower values of encumbrance may have to be adopted to grade catenary and contact wires as well as to get adequate electrical clearances.



3.0 Electrification System

Overhead Catenary System (OCS)>CW Height & Stagger



Height of Contact Wire -The distance from rail level to the underside of the contact wire along pantograph axis. The contact wire height shall normally be **4.60m- 5.0m,** this height can be reduced where OCS has to pass under an over line structure with low head room. A separate clearance study has to be prepared to calculate the minimum contact wire height and encumbrance to achieve the clearances mentioned above. For Grading of contact wire the a gradient of 1:500 and relative gradient of 1:800 shall be maintained.

Stagger of Contact Wire -Stagger of the contact wire is the horizontal distance of the contact wire from the vertical plane through the centre of pantograph pan at the contact surface. The nominal values of staggers are as follows-

Tangent Track – **230mm (max)**

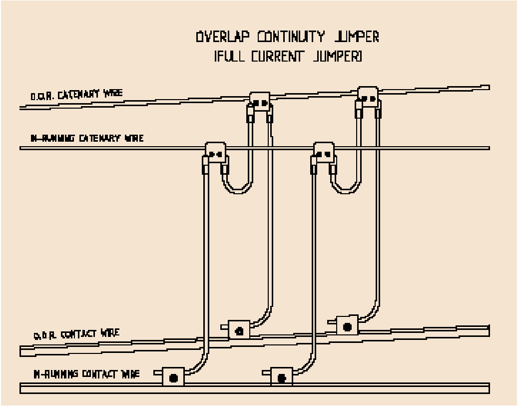
Curved Track – **350mm (max)**

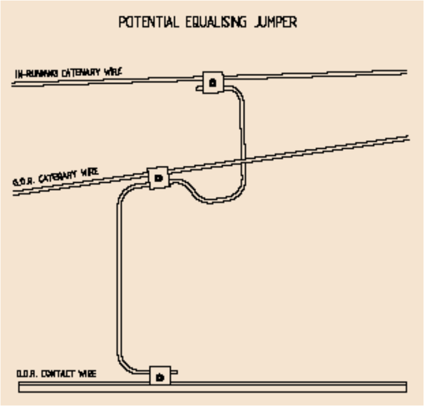
3.0 Electrification System

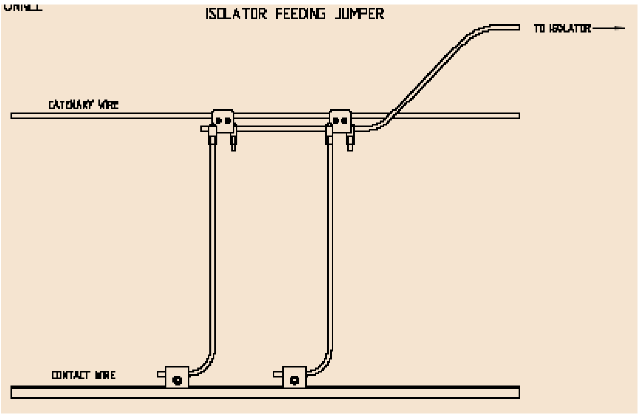
Overhead Catenary System (OCS)>Jumper

A conductor or an arrangement of conductors for **electrical continuity** not under tension, which forms electrical connection between two conductors or equipments.

- Full Current Jumper
- Potential Equalizing Jumper
- Switch Feeding Jumper







Full Current Jumper

Usage – Un-insulated overlaps, Turnouts, Cross-over

Potential Equalizing Jumper

Usage – Insulated overlaps, Crossing Anchors

Switch Feeding Jumper

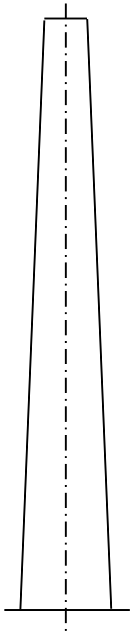
Usage – Isolators, Booster Transformers

3.0 Electrification System

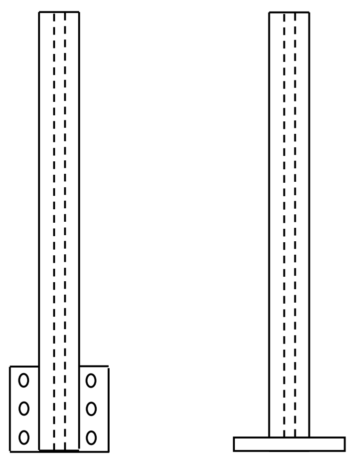
Overhead Catenary System (OCS)>OCS Support

Different types of supports are used to hold over head catenary system with or without cantilever assembly. In RIDT project the following types of supports are being used –

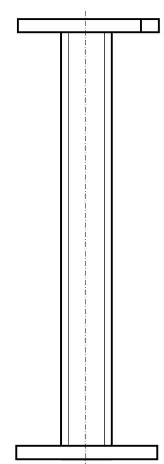
- Spun Concrete Mast Support (General Use & at head span supports)
- Steel Mast Support (At bridges & at portal uprights)
- Drop Tube (At station canopy and pedestrian bridge)



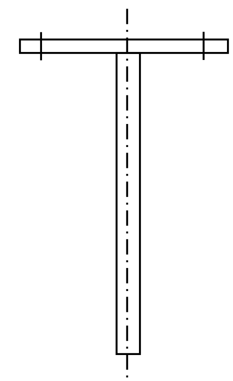
Length	Diameter
9.00m	190-310mm
9.50m	220-347mm
11.50m	300-453mm
12.50m	300-467mm
Usage	See Schedule



Length	Dimension
Varies	254x254x107kg/m
Usage	At bridges



Length	Dimension
Varies	305x305x118kg/m
Usage	Portal upright mast



Length	Dimension
2.60m	125x125x6 SHS
Usage	At station canopy

Overhead Catenary System (OCS)>OCS Support

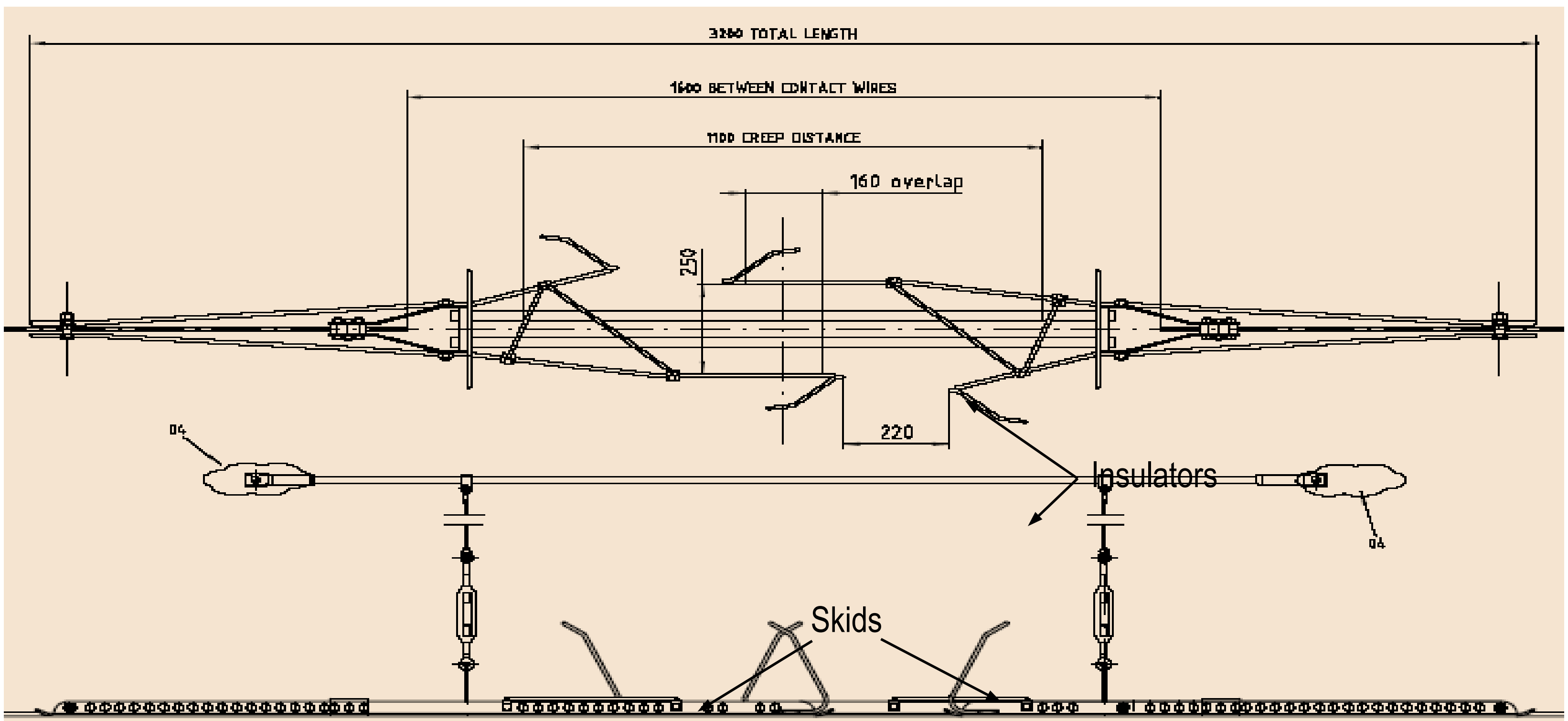
Employment schedule of concrete structures -

Type of Mast	Length (m)	Minimum Embedment (m)	Bending Moment kNm		Usage
			Nominal	Maximum	
9/001/101	9.0 m	1.10 m	40 kNm	50 kNm	Single OCS
9/001/102 B	9.0 m	1.10 m	75 kNm	91 kNm	Back to Back OCS
9/001/104	9.5 m	1.10 m	50 kNm	61 kNm	MPA, Isolator & BT locations
9/001/105	9.0 m	1.10 m	75 kNm	91 kNm	OOR OCS, Anchors and deep curves
9/001/106	12.5 m	1.50 m	160 kNm	178 kNm	Head Span and for cross track feeders
9/001/107	11.5 m	1.50 m	150 kNm	164 kNm	Two track head spans at stations

3.0 Electrification System

Overhead Catenary System (OCS)>Section Insulator

A device installed in the contact and catenary wire for isolating two elementary electrical sections from each other while providing a continuous path for the pantograph without break of current. This device consist of insulators, skids over which pantograph travels, strain clamps for contact wires and suspension arrangement. Only high speed section insulators are used in RIDT project. Ideally the stagger at SI should be zero, in any condition it must be less than 50mm.



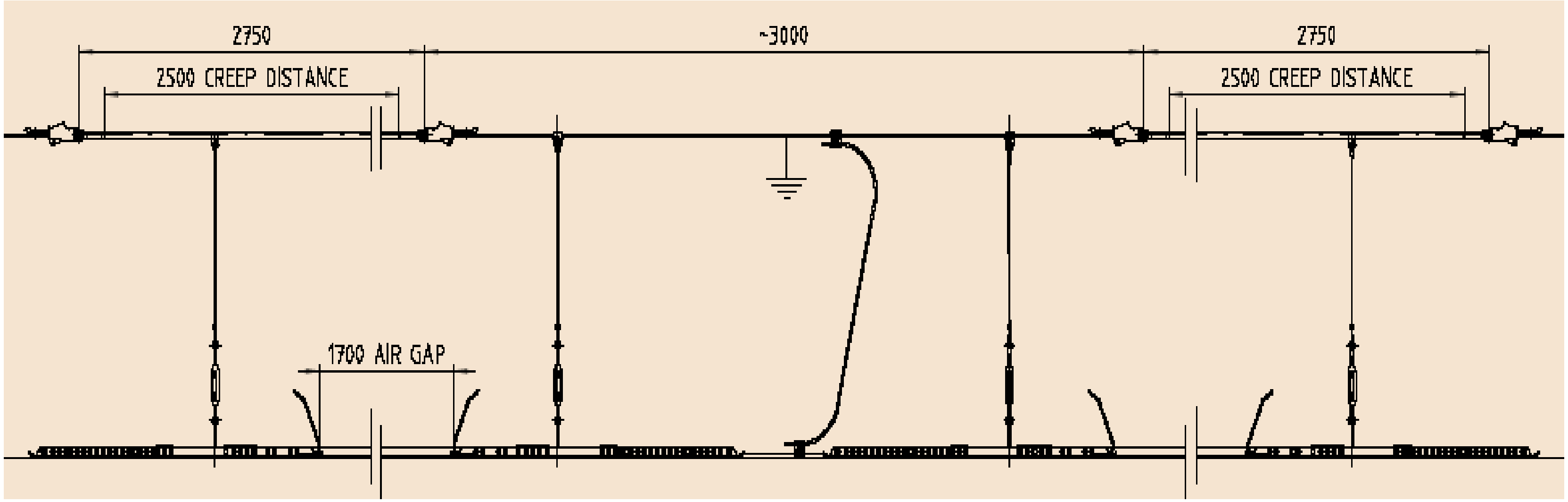
3.0 Electrification System

Overhead Catenary System (OCS)>Neutral Section

A short section of insulated (dead) over head equipment which separates the two electrical sections. Arthur Flurry type Neutral Sections are installed to improve dynamic behavior of OCS and spark less current collection at NS.

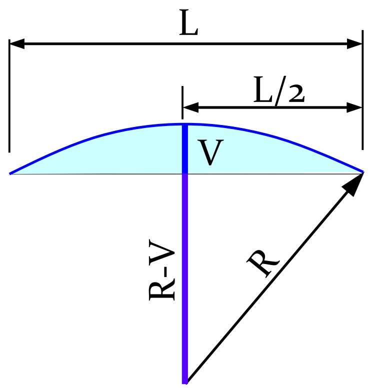
Neutral section are located taking in to account the signal locations, the gradient of the section, curvature etc. so as to reduce the likelihood of electric locomotive coming to stop in the dead section.

Preferably the stagger at NS should be zero, in any condition it must be less than 50mm.



3.0 Electrification System

Overhead Catenary System (OCS)>Track Parameter



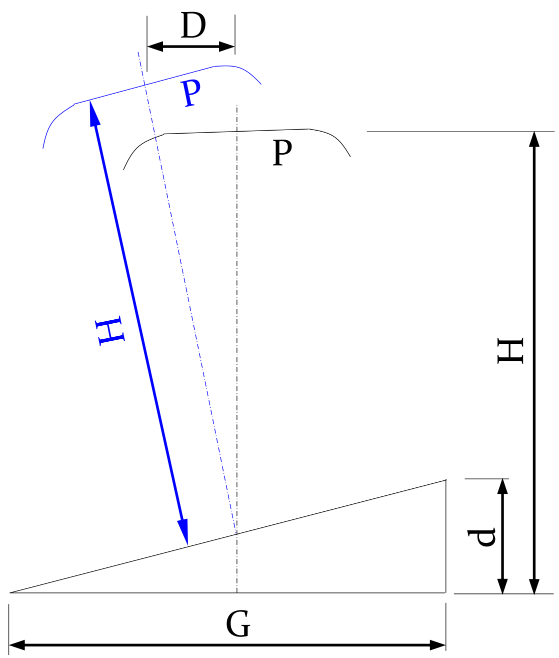
Versine –

The maximum offset of the inner edge of the outer rail from the chord connecting two points, also on the inner edge of the outer rail, opposite to location of structures.

Formula for the calculation of Versine is-

$$V= \frac{L^2}{8*R}$$

L=Span between two structures (m)
R=Radius of Curvature (m)



Cant and displacement of Pantograph axis –

Cant can be defined as the rise of one rail of a track to counteract centrifugal force developed during the motion of train on a curved track. Due to this effect the pantograph axis is displaced from its vertical position (normally at curved track).

Formula for the calculation of Pantograph displacement is –

$$D= \frac{d*H}{G}$$

H=Contact wire height (m)

G=Gauge of track (m)

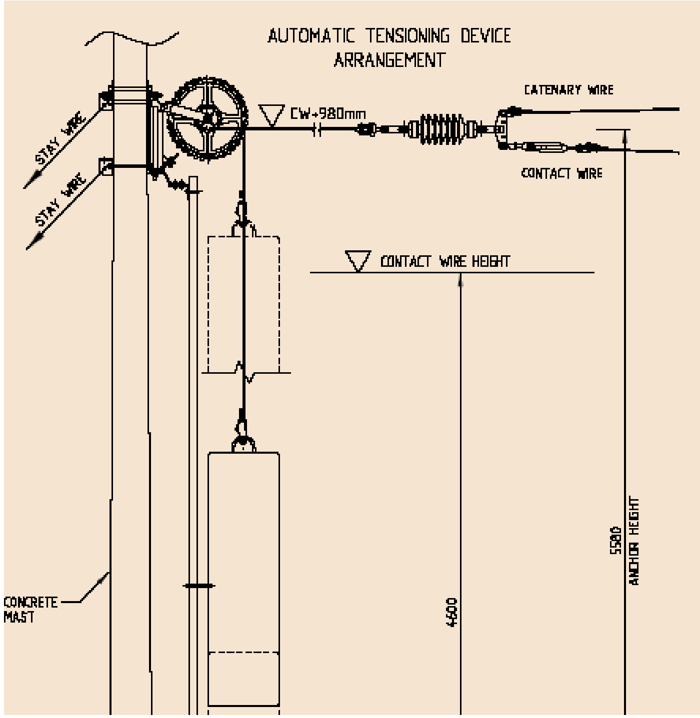
d=Cant of Track (m)

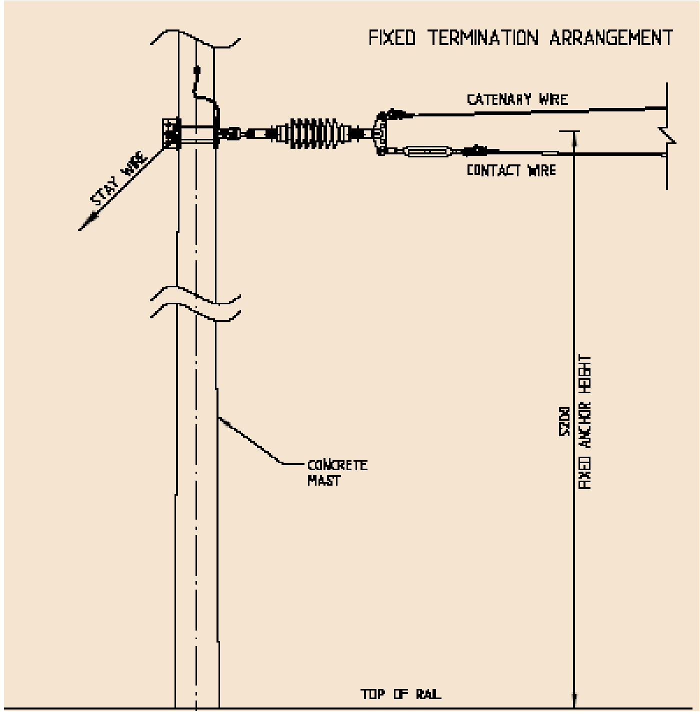
3.0 Electrification System

Overhead Catenary System (OCS)>Terminations

The conductors (Contact and Catenary wires) are terminated at the end of each tension length. This termination is classified into two types-

- **Fixed Termination** – Conductors are terminated to mast as fixed point.
- **Automatically Tensioned Equipment** – Conductors are terminated to the mast using a regulating device which maintains a constant tension in OCS conductors under all ambient temperature condition.





3.0 Electrification System

Overhead Catenary System (OCS>Terminations

Anchor Height -Anchor height shall be the standard one to get the regulation of overhead catenary within the limit travel zone of counter weight (Balance weight) assembly.

Anchor near Signals and Buildings – No live anchor or equipment shall be installed near or over any hut or building. If the anchor is provided near signal, the OCS equipment should be isolated by providing cut-in-insulation and earthed by connecting it metallically to the anchor mast without providing the insulator in the anchor assembly.

Standard Anchor Height – In RIDT project some standard anchor heights are adopted. Standard Balance Weight Anchor height is 5.58m, it can be reduced to 4.95m after taking the anchor span length into consideration. Standard Fixed Termination height is 5.42m, it can be lowered if anchor span is short.

Guy Anchor –In normal case, the anchor mast is guyed to save mast against excessive bending moments (caused by the tension force of anchoring wires acting on mast) about Y-Y axis. In RIDT project, two types of guy anchors are used –

a) Single Guy Anchor – Only one guy rope is used.

Usage: AT, MPA, EWA, RCA

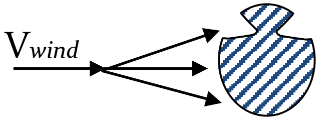
b) Double Guy Anchor – Two guy ropes are used.

Usage: BWA, RCA+RCA, AT/BWA+EWA, AT/BWA+MPA,AT/BWA+RCA,

3.0 Electrification System

Overhead Catenary System (OCS)>Wind Effect

As we know wind contains a lot of energy in itself. For the design of OCS we need to consider its effect on loadings and blow offs. In the calculation of wind drift, the catenary is seen as one complete system. The following wind loads form the basis of calculation-



Topographical Condition	Wind Speed in m/s (V*wind*)	Dynamic pressure in N/m² (q)	Wind Load per meter of catenary in N/m (p)
Region I	22 m/s	303 N/m²	8.6 N/m
Region II	26 m/s	423 N/m²	12.0 N/m
Region III	32 m/s	640 N/m²	18.2 N/m
Region IV	36 m/s	810 N/m²	22.0 N/m

The dynamic pressure is calculated from the wind speed as : $q = V^2_{Wind}/1.6$

The factor of 1.6 represents the density of air and, under extreme conditions (at high altitudes), can be assumed to be higher.

The wind load is calculated from the wind speed as : p = WCW + WCT + WD + (V*wind* / 30)

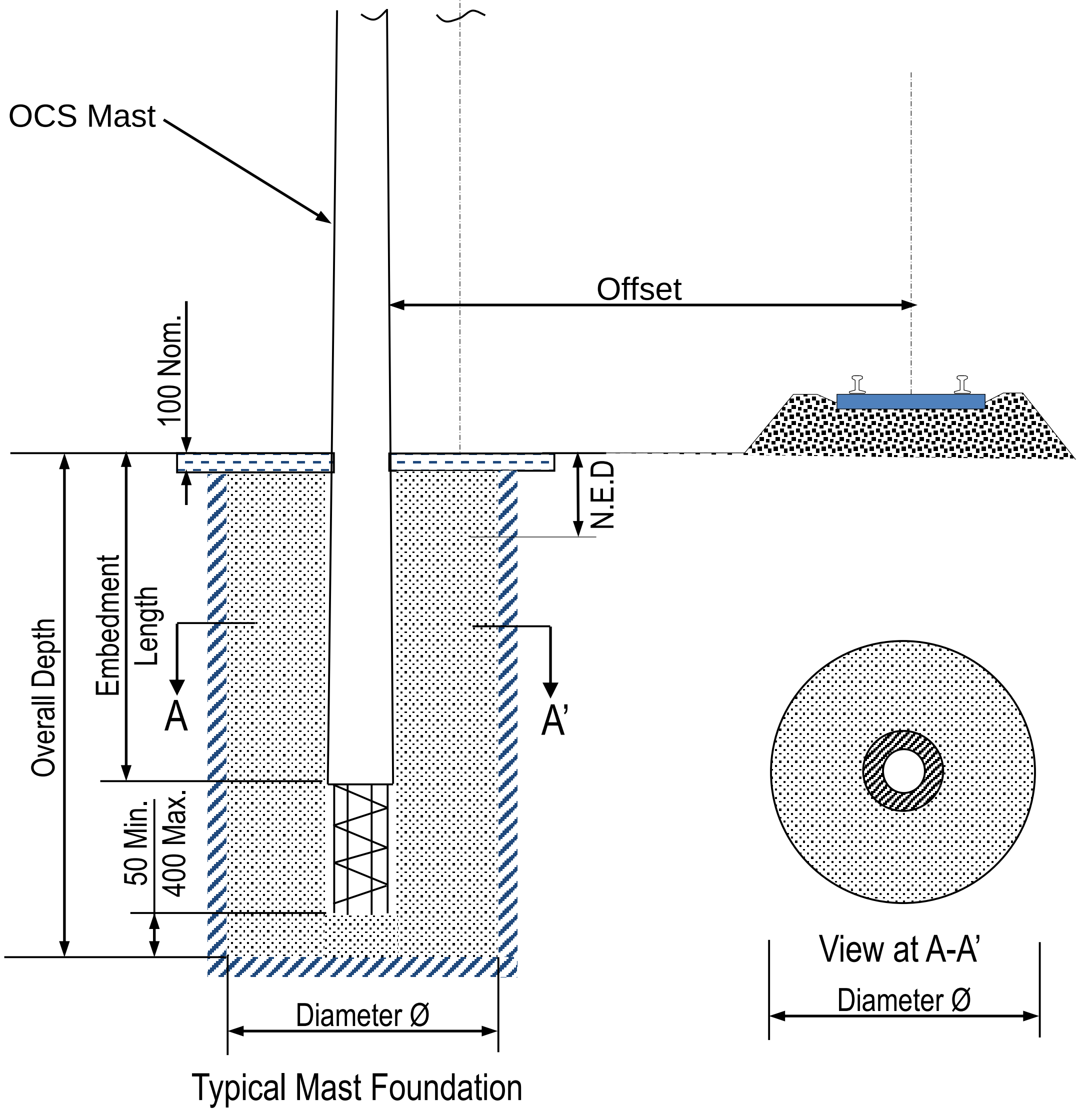
Where wind load on Contact = WCW = q*contact wire diameter*1.1 in N/m (Ø CW = 12.3mm)

Where wind load on Catenary = WCT = q*catenary wire diameter*1.2 in N/m (Ø CT = 10.5mm)

Where wind load on Droppers = WCT = 0.400 N/m

3.0 Electrification System

Overhead Catenary System (OCS)>Foundation



Foundation - for OCS structures, unlike normal foundations, are subjected to very heavy turning moments and very little vertical loads. Foundation are designed on the basis of bearing capacity of parent soil where it is to be cast. The exact location where the foundations are to be cast is obtained from the layout plan, which is prepared after making a detailed survey. In RIDT project circular foundations are adopted for all locations.

3.0 Electrification System

Overhead Catenary System (OCS)>Foundation

Drawing No.-- Mast Type	Length (m) / Weight (kg)	Maximum Capacity (kNm)	Standard Usage	Diameter Ø mm	Maximum Embedment Length (m)	Additional Reinforcing	
						Load Range kNm	Reinforce-ment
9/001/101	9.00 / 960	50	Single Cantilever	600	1100	0 - 50	None
9/001/102	9.00 / 1520	90.9	Back to Back Cantilever All anchors	700	1100	0 - 85	None
						86 – 90.9	4-Y12 Bars
9/001/104	9.50 / 1120	61.2	Switching & Overlap MPA anchors	700	1100	0-61.2	None
9/001/105	9.00 / 1520	90.9	Cantilever, Overlap OOR All Anchors	700	1100	0 - 85	None
						86 – 90.9	4-Y12 Bars
9/001/106	12.5 / 2470	178	Head Span, Switching & Overlap	900	1500	0 - 85	8-Y12 Bars
						86 – 178	10-Y16 Bars
9/001/107	11.5 / 2460	164	Head Span at Station Platforms	900	1500	0 - 150	None
						150 – 164	4-Y12 Bars
9/001/108	13.5 / 3090	198	Head Span and Switching (Not used)	900	1500	0 – 85	8-Y12 Bars
						85 – 198	12-Y16 Bars

3.0 Electrification System

Overhead Catenary System (OCS)>Foundation

Allocation Philosophy

9/ ___ ___ ___ / ___ ___ ___

Structure Type
2-Concrete Mast
5-Guy Anchor
7-Steel Mast

Concrete Mast
1-9/001/108
2-9/001/109
3-9/001/110
4-9/001/111
5-9/001/112
6-9/001/113

Guy Anchor
1-1 Guy Rope
2-2 Guy Rope

Steel Mast
1-9/800/105
2-9/800/104
3-9/800/106

Foundation Diameter Ø

Depth of Hole To nearest 0.1m

Concrete Mast
1-Bored-Normal Soil
2-Rock
3-Bored Exten. Column 0.3m
4-Bored Exten. Column 1.0m
5-Piled
6-Shored

Guy Anchor
1 Bored - Normal soil Non Bouyancy
2 Bored – Normal Soil Bouyancy
3 Mass Concrete – Gravity
4 Piled

Steel Mast
1-Block Foundation Normal Soil
2-Step Foundation Normal Soil

Example : Type 9/001/108,in normal soil, Ø600 x 2.3m Deep

=9/211/623

4.0 KTMB Competent Personnel for Electrification Systems

132kV Competent Engineer –

The person appointed by the Energy Commission who is responsible for all aspects of the electric traction system including the provision of power supplies from Tenaga Nasional Berhad, all switchgear and transformers at Feeder Stations and Track Sectioning Locations and all overhead line equipment

Nominated Person (NP) –

An "Authorised Person" over 21 years of age who holds a certificate of competency (issued by KTMB) which authorises him to issue and cancel Permits to Work for particular equipment and / or to carry out isolation and earthing procedures at locations where "Local Isolation" is permitted

Electrical Control Operator (ECO) –

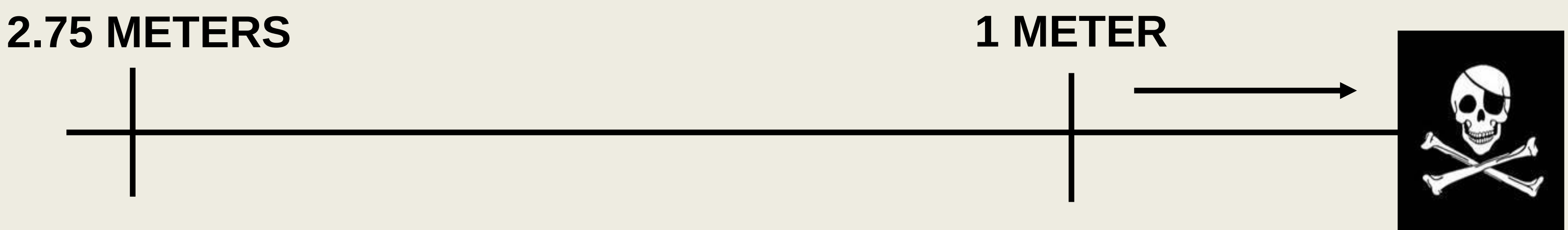
The person having control of the power supply to the electric traction system and who is responsible for all switching operations and isolations of that electrical equipment

Authorised Person (AP) –

A competent person, over 18 years of age possessing sufficient knowledge to carry out specific work on KTMB systems or equipment and appointed and certified to do so

5.0 Safety

Safety Distance>



NO ADVISE

ALL WORK TO OBTAIN APPROVAL OF ELECTRIFICATION

MANTENANCE MANAGER

MANDATORY

ISOLATION

5.0 Safety

Safety Distance>

BE CAREFUL

IF YOU OR ANY MATERIAL OR ANY PLANT CAN COME WITHIN

2.75 METERS

FROM LIVE TRACTION EQUIPMENT, WORK MUST NOT PROCEED WITHOUT THE PERMISSION OF THE ELECTRIFICATION MANAGER

Danger of Live Equipment>

HOW AND WHY DANGER FROM OCS LIVE EQUIPMENT

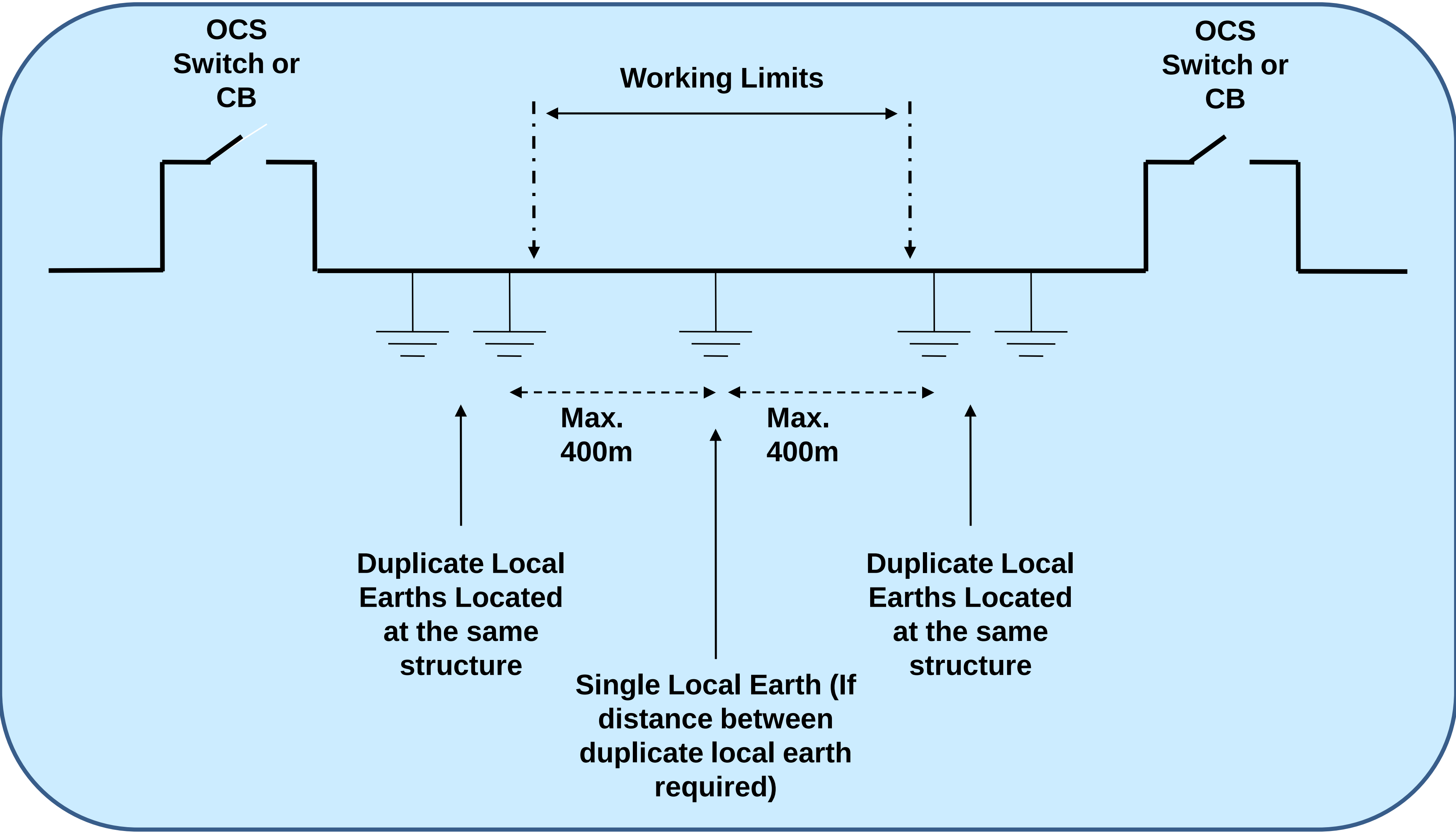
HIGH VOLTAGE – 25,000 V (25kV)

BARE CABLE

LIVE AT ALL TIMES

5.0 Safety

Safety Distance>



5.0 Safety

Personal Protective Equipment (PPE)>

PERSONAL PROTECTIVE EQUIPMENT MUST BE WORN

6.0 Conclusion

- To provide a detailed description of the Basic Design traction Power Supply System, SCADA System, and Overhead Catenary System used by KTMB.

- Traction Power Supply System used in KTMB is environmentally friendly system which is not polluting the nature.

- Electric train offers substantially better energy efficiency, lower emissions and operating cost.

KERETAPI TANAH MELAYU BERHAD

THANK YOU