5. POWER SUPPLY, signaling & train control SYSTEM

5.1 INTRODUCTION

Existing Virar-Dahanu Road section is operational on 25 kv AC traction, therefore it is logical to adopt same system for proposed suburban corridor also. This chapter broadly covers the power supply system to meet the power requirement for various horizon years, designed loads, sources of supply, broad description about distribution network and major equipment etc.

5.2 EXISTING POWER SUPPLY ARRANGEMENT

As the proposed corridor is going to be fully integrated with the existing system therefore it is prudent that power supply arrangements of the proposed corridor are also integrated with existing arrangements so as to get economy of operation, ease of maintenance and keeping initial cost bare minimum. At present this section is equipped with following installations,

Traction Substations (TSS)				
Sr. No.	Name	Chainage	Rating	Present Maximum Demand
1	Plaghar	89/23-25	2*21.6 MVA	15 MVA
2	Gholwad *	133/30-32	2*21.6 MVA	15 MVA
• At Palghar, 3rd transformer is under commissioning. • Gholwad TSS is feeding for only 6 km out of a total feeding zone of 45 km and proportionate loading on Gholwad TSS due to an stretch of Vangaon-SP to Dahanu Road is only 2 MVA				

Sectioning Post (SP)			Sub Sectioning Post (SSP)		
Sr	Name	Chainage	Sr	Name	Chainage
1	Virar	63/17-18	1	Saphale	76/15-17
2	Vangaon	118/25-26	2	Boisar	101/15-17
			3	Dahanu Road	

5.3 ESTIMATION OF THE POWER DEMAND

The proposed corridor will be a predominantly a suburban corridor but it will also be available for goods operation and long distance mail express trains during margins available in the time table and also to meet any emergency situations. Suburban trains require more energy as compared to mail express or goods train. Therefore capacity of the power supply system shall be designed by assuming entire line

capacity is utilized for suburban services ie 12 car services with headway of 3.0 minutes. Specific energy consumption is the energy consumed for hauling 1000 tones of goods for a distance of one km, and specific energy consumption data of Siemens rakes for suburban operation is utilized to work out the number of traction substation and the capacity of transformers to be used. Average interstation distance in existing 63.77 km long section is 9.11 km and there are 7 stations between Virar and Dahanu Road section. Average interstation distance in existing 28 km long Borivli-Virar section is 4.34 km. For calculation of capacity of traction power, an SEC of 25.8 units for empty rake movement and 22.3 units for super dense crush load is taken. During field trials, it is observed that SEC of empty rake haulage is higher as compared to haulage of loaded trains. Demand in KVA is worked as per following formula

Demand in MVA = km*(SEC/1000)*Train wt.*(Trains/hr.)*2*1.05/p.f

Factor of 1.05 has been taken into account to consider requirement for station auxiliaries and S & T demand @ 3% and other losses in system @ 2%, similarly, power factor of 0.9 has been considered to convert energy (KWH) into demand (KVA).

5.4 POWER REQUIREMENT FOR DIFFERENT LEVEL OF SERVICES

Frequency of 12-Car Service	Year	Demand in MVA for entire Section		
		For Suburban service	For 2 goods and one M/E train per hour in each direction	Total
12 min	2021	13.39	13.4	26.79
6 min	2031	26.80	13.4	40.20
4 min	2041	40.22	-	40.22
3 min designed Capacity		53.65	-	53.65

Present demand of the existing corridor is 17 MVA and it is handling over 250 trains in both directions per day. There is hardly any scope for further increase in traffic in the existing corridor. Considering requirement of 50% additional demand on account of increase in the line capacity by haulage of heavy trains etc. total demand both corridors will be as under

Year	Demand in MVA		
	Existing Corridor	Proposed corridor	Total
2021	25.5	26.79	52.29
2031	25.5	40.20	65.70
2041	25.5	40.22	65.72
Designed	25.5	53.65	79.15

Above demand can be met by at least three TSS in suitably located in Virar-Dahanu Road section.

5.5 POWER SUPPLY ARRANGEMENT PROPOSED

5.5.1 In the inception year of the service, a demand for each TSS is 17.43 MVA (21.9 MVA for 2031 and 20.91 MVA for year 2041) for both corridors. To meet this requirement, two new TSS are proposed at Saphale and Vangaon and at existing Palghar TSS, replacement of one of the existing units of 21.6 MVA rating with 30 MVA transformer. Details of TSS and sub sectioning and sectioning post are as under

Traction Substations (TSS) in the inception year			TSS Feeding Zone
Sr	Name	Chainage	
1	Virar (SP)	63.7	
2	Saphale (TSS) 2*30 MVA	75.7	12+5.5=17.5
3	Kelve (SP)	81.2	
4	Palghar (TSS) 2*30 +21.66 MVA	89.7	5.5+14.5=23
5	Boisar (SP)	104.2	
6	Vangaon (TSS) 2*30 MVA	112.3	8.1+14.4=22.5
7	Dahanu Road (SP)	126.7	

Existing SP's at Saphale and Vangaon will be replaced by new TSSs. Similarly, existing SSP's at Boisar and Dahanu Road will be converted into SP's and a new SP will also be added at Kalve Road. There is no need for any SSP in the section. It is also to be noted that with the proposed scheme, services of Gholwad TSS will not be required for Virar-Dahanu Road section.

5.5.2 Emergency feed arrangement will be as under

Year	Normal Demand			Demand during Outage of one TSS		
	Saphale	Palghar	Vangaon	Saphale	Palghar	Vangaon
2021	13.60	17.88	18.11	-----	33.19	19.10
	13.60	17.88	18.11	21.31	-----	30.98
	13.60	17.88	18.11	14.34	37.95	-----
2031	16.18	21.27	21.55	-----	41.71	23.99
	16.18	21.27	21.55	26.77	-----	38.93
	16.18	21.27	21.55	18.02	47.68	-----
2041	18.03	23.69	24.00	-----	41.72	24.00
	18.03	23.69	24.00	26.78	-----	36.94
	18.03	23.69	24.00	18.03	47.69	-----
Designed Capacity to 3 minutes service						
2041	21.71	28.53	28.91	-----	50.24	28.91
				32.26	-----	46.89
				21.71	57.44	-----

From above it clear that in the inception year, loading on Palghar TSS is 33.19 and 37.95 MVA in the event of outage of Saphale and Vangaon TSS respectively; and it is well within upgraded rating of 42 MVA by providing forced air cooling (ONAF). But by year 2031, at Palghar TSS, maximum demand of 47.68 is reached during the outage

of Vangaon TSS. Therefore around year 2031, 3rd transformer at Palghar TSS will require replacement with 30 MVA capacity transformer ie all three transformers at Palghar TSS should be off 30 MVA capacities. During outage of either Vangaon or Saphale TSS, Parallel operation of two transformer of 30 MVA capacity will be required.

5.5.3 With the proposed corridor, Virar-Dahanu Road section will become 4-line section similar to the present 4-line Borivli-Virar section. For Mumbai Suburban area, protection scheme as per RDSO specification no TI/SPC/PSI/PROTCT/3003 will have to be adopted, therefore all feeding post, sectioning post (SP) and sub-sectioning post (SSP) will be equipped with circuit breakers in place of interrupters used at present.

5.5.4 It is proposed to use latest state of switchgears ie gas insulated switchgears for TSS and switching post widely used in metros in our county to achieve its advantages of almost maintenance free, less requirement of space etc. Cost of GIS equipment's are declining with their use increasing day by day therefore its advantages will offset its initial higher cost in time to come. TSS's are planned within the available railway land by using gas insulated switchgears.

5.6 AUXILIARY SUPPLY ARRANGEMENTS

New corridor is proposed to be opened with existing stations ie Virar, Vaitarna, Saphale, Kelve Road, Palghar, Umroli, Boisar, Vangaon and Dahanu Road. Tapping HT supply from the nearest point of local supply undertaking will ensure reliable power supply for passenger amenity items and general power supply arrangement. Substation design shall be done in such a way that it meets not only the requirement of all passenger amenity items which will be introduced in the inception year and it shall also be upgradable to meet the requirement of items likely to be introduced later. Typical design of a substation is as under;

Table 5.4 : Summary of Loads (KW) for Typical Elevated/At Grade Station

S. No	Type of load	Elevated Stn.		
		Connected load	Diversity	Substation Load
1	Lighting load	40	1	40
2	Fan & other Misc small power load, power plugs etc.	50	0.5	25
3	Escalators (2Nos) @25Kw	50	1	50
4	Lifts (2Nos) @15Kw	30	1	30
5	Pumps	20	0.5	10
6	Signaling & Telecom	5	1	5
	Total Load (KW)			**160**

5.7 ELECTROMAGNETIC INTERFERENCE (EMI)

25kV ac traction currents produce alternating magnetic fields that cause induced voltages to be in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation for elevated section.

Concrete structures are not good electrical earths and therefore, Earthing & Bonding of the power supply & traction system shall be designed in accordance with the standards adopted by railways etc.

5.8 25 KV FLEXIBLE OVERHEAD EQUIPMENT SYSTEM

25 kV ac regulated Flexible Overhead equipment system shall comprise of HD-copper contact wire of size 150 sq mm and 65sqmm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq mm cross section.

5.9 SPECIFICATION OF EQUIPMENTS/COMPONENTS TO BE USED

With addition of proposed new corridor, existing corridor will become four line corridor, therefore, protection scheme for PSI equipment suitable for Mumbai suburban system issued by RDSO is proposed to be implemented. Similarly for other items such as SCADA, PSI equipment, OHE items etc of latest RDSO specifications will be used. Rating of traction transformers, switchgear, cables, auxiliary transformer etc. have been worked out based on the conceptual design, however, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

5.10 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 200 kVA capacity at elevated/at grade stations to cater to the following essential services:

- Essential lighting
- Signaling & telecommunications
- Fire fighting system
- Lift/Esclators operation
- Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

5.11 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The entire system of power supply (traction & auxiliary supply) shall be monitored and controlled from a Centralized Control Centre through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre cables provided for telecommunications will be used as communication carrier for SCADA system.

5.12 ENERGY SAVING MEASURES

Energy charges will constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system for High Speed Metro corridor includes the following energy saving features:

i. Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25kV Overhead equipment system to be consumed by nearby trains ot\r to the grid.

iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (operation or maintenance hours etc) through SCADA.

iv. Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

v. The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) has been incorporated in the system design.

vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

5.13 ALTERNATE TRACTION SYSTEM PROPOSED

With conventional traction system, three TSS namely Saphale TSS (2*30 MVA), Palghar TSS (3*30 MVA) and Vangaon TSS (2*30 MVA) are required to meet the designed capacity. Alternatively, if 2x25 KV AT system is adopted in Virar-Dahanu section, only one TSS at Palghar, the mid point of the section, can achieve the designed capacity. This system will consist of one TSS with two numbers of three phase Scott connected transformers of 54 MVA rating, and SP/SSP at every 12-15 KM with autotransformer.

This system is operational in Bina-Katni-Annupur-Chirmiri Section of WCR and SECR railways since 1995. This system is considered energy efficient as compared to conventional system. Dedicated freight corridor has also adopted this system.

5.14 SIGNALLING AND TRAIN CONTROL SYSTEM

The signaling system will provide the means for an efficient train control, ensuring safety in train movements. It assists in optimization of rail infrastructure investment and running of an efficient train services on the network.

The adopted Train control & signaling system shall be for efficient, safe and quicker train movements. The proposed signaling system (for suburban corridor) shall be capable of supporting 15 car length trains and also flexible enough to accommodate the up-gradation in phased manner to achieve optimum train operation.
The communication system shall be provided for monitoring train operation, and provides relevant train running information to passengers and meeting the operational and administrative requirements of railway network.

5.14.1 SIGNALING SYSTEM DESIGN CRITERIA

The signaling system designs are based with following criteria

I. Signaling and Train Control systems shall be designed with fail-safe principles.

II. Safety critical systems shall be engineered for a Safety Integrity Level 4 (SIL 4)

III. The system is designed for the Train headway of 03 minutes in the year 2041.

IV. Automatic absolute working of trains

V. No trackside equipment (e.g. loop cables, beacons, etc) should affect passenger evacuation and maintenance activities. In addition, it shall not impose the tripping hazard to both passengers and maintenance staff.

VI. All Vehicle Position Detection devices (e.g. AFTC / HFTC /Digital axle counter) shall be AC-Immunized and shall not be interfered by other railway systems.

VII. All Signaling operations will be with a power backup of 4 hour and diesel generator/ solar power for operations during long power cuts.

VIII. The design life of all the electronic equipment and associated wayside equipment shall be 20 years and 30 years respectively.

IX. The Signaling systems shall be compatible with 25KV, 50 HZ AC traction.

X. Power supply for signaling systems will be available continuously with back up of generators to ensure train running even during long power cuts.

XI. Remote operations of Signals/ points from Haragebeya and Tadjourah port in possible for any station and especially crossing stations.

5.14.2 PROPOSED SIGNALING & TRAIN CONTROL SYSTEM

The Signaling system shall be designed to meet passenger traffic requirement and it can satisfactorily be managed by operating 15 cars EMU Train services at an interval of 3 minutes (head way) to meet the increased traffic demand in the course of time i.e. in year 2041.

The Signaling and Train Control system shall be of following types:

I. Interlocking: Electronic Interlocking

II. Point Operation: Electrical

III. System of working – Automatic absolute block working

IV. Signals: Multiple aspect colour light signals (MACLS)

V. Signal lighting: LED

VI. Operation: Train Management System

VII. Track vacancy detection: AFTC / HFTC/ Digital Axle counter.

VIII. Design Suitable for 25 KV AC traction systems

IX. Isolation : Standard III isolation will be provided at all running yards,

X. Safety Standard : Safety Integrity Level 4 CENELEC (SIL 4),

- Stations provided with points and crossings will have a Computer based Electronic (Solid State) Interlocking arrangement for operation of points / crossings & setting of routes.
- Facilities for setting of the route and clearing of the signals will be provided from SSI /RRI/Panel Cabin located at stations with points and crossings.
- For train detection AFTC /HFTC Track Circuits will be provided.

- Presence of Train on the track will be detected with the help of Digital Axle Counters (DAC) with Double detection system.
- All Signals working in automatic mode will be equipped with Auxiliary Warning System.
- The Signaling and Train Control system and its Sub-system/Components will conform to international standards like CENELEC, IEC, BS, IS, ITU-T, IRS etc:
- The new Suburban corridor injunction with existing lines shall form an integrated system to provide smooth, uninterrupted traffic flow. It is presumed that by the time the proposed corridor becomes functional, this would have been equipped with Automatic Signaling.
- This will enable running of optimum train services, meeting traffic requirements in the most efficient and cost effective way.

5.15 TELECOMMUNICATION SYSTEM

The purpose of Telecommunication System is to serve the Operative and Administrative communication requirement of Railway Organization. Telecommunication System also acts as a backbone for Railway signaling System.

The telecommunication facilities proposed are helpful in meeting the requirements for:

I. Supplementing the Signaling system for efficient train operation.

II. Exchange of managerial information

III. Crisis management during emergencies

IV. Passenger Information System

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Passenger Announcement System within the station and from Central Control to each station or station itself. .
- Centralized synchronous Clock System

- Passenger Display Information
- Data Channels for Signaling, SCADA for Traction & non Traction supply System etc.

Table: 5.1 Telecommunication Requirements and the proposed solutions

Telecommunication Requirements	**Telecommunication System**
Traffic Control Communication	Optical Fiber Communication system / Quad copper cable System
Emergency Control Communication	Optical Fiber Communication system and Quad copper cable System
Administrative voice and data communication	Optical Fiber Communication system/Digital Microwave System
Operational voice and data communication	Optical Fiber Communication system / Quad copper cable System
Interactive Voice Response System-IVRS	Computer Network based System
Pre recorded Announcements	Computer Network based System
Coach Guidance system	Local / Centralized Computer based System
Public Announcement and Clocks	Local / Centralized Computer based Master-Slave GPRS Clock System
Telephone Exchange System	TDMA, PBX Exchange System / Centralized IP based New Generation Exchange System
Passenger Reservation System	TDMA Circuit switched / IP based Packet switching computer network
Surveillance of fixed and movable assets	Close circuit TV and SCADA
Yard communication in big Marshaling yards	Paging Talkback System / Voice Group call or

5.15.1 Optical Fiber Cable - Main telecommunication bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fiber cable system. Considering the channel requirement and keeping in view the future expansion requirements 24 fibre, Optical Fiber Cable is proposed to be laid in ring configuration with path diversity. This medium shall be utilized to carry video/audio signals and SCADA related information.

5.15.2 Public Address System

The public Address System shall be capable of digitized voice announcements and will generally operate in automatic mode providing information of time and destination of the next schedule train, special upcoming event, safety and security announcement at pre determined intervals and general information to enhance the travel experience for all users. There will be over ridding facility for manual announcement in case of an emergency.

5.15.3 Clock System

The GPS enabled Clock System shall provide synchronized time for the whole Rail system. The time source shall be the Global Positioning System (GPS).

5.15.4 Passenger Information display

Passenger Information Display screens shall be fitted to provide passenger information on train movements and next train indication

5.15.5 Passenger Information System

At all stations, suitable Electronic Passenger Information Display Boards (Flat Panel) will be provided with facility for manual inputs from the local station.