

A Design Overview of Traction Power Supply System for the First High-speed Rail System in Hong Kong

Mr. William CHENG*, Mr. C. M. YEUNG*,
Mr. Samuel CHAN**, Mr. M. K. MAK**

Abstract:

A good high-speed railway system should provide reliable services and seamless interoperability with other railway systems. A reliable traction power supply system is the foundation of reliable operation of the railway. Due to different infrastructure requirements in different parts of the world, there are critical design issues that need to be addressed.

Hong Kong is building its first high-speed rail system, namely the Hong Kong section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL). High-speed trains operating at a speed up to 200km/h will run from the underground terminus in the city center through a 26km long twin-track tunnels to the boundary before entering into the Mainland. The XRL will then run further north connecting to the longest high-speed rail network in the world, the China's National High-speed Rail Network.

Electrical & Mechanical Services Department (EMSD) of the Hong Kong Special Administrative Region Government is responsible for conducting independent design review of the electrical & mechanical (E&M) systems of the XRL project.

This paper gives an overview of the design key features associated with the traction power supply system for the XRL.

Keywords: Express Rail Link, High-speed Rail Network, Interoperability, Traction Power Supply System.

1. INTRODUCTION

1.1 Background

The Hong Kong section of the Guangzhou – Shenzhen – Hong Kong Express Rail Link (XRL) is the first high-speed rail system with trains operating at a speed up to 200km/h from the West Kowloon Terminus (WKT) through about 26 km long tunnels to the Hong Kong / Mainland boundary at Huanggang.

The XRL will connect with the Mainland section of the Express Rail Link at Huanggang and the railway line runs a further 116km north to Guangzhou running at speed of up to 300km/h, with new stations at Futian, Shenzhen North, Humen and Guangzhou South. It will further connect the XRL to the high-speed rail network in China that is rapidly

expanding and is expected to reach 19,000km by the end of 2015.

The XRL has two types of train service, namely shuttle and long-haul train. Whilst the shuttle services run between Hong Kong and Shenzhen, Dongguan and Guangzhou; the long-haul train services run between Hong Kong and other Mainland major cities outside Pearl River Delta region, such as Wuhan, Beijing and Shanghai through connections with the future National High-speed Rail Network which has been designed to a maximum speed of up to 350km/h. The alignment of the Hong Kong section of the XRL is shown in Figure 1.

The project will reinforce Hong Kong as the southern gateway of the Mainland. It will play an unparalleled role in fostering closer social and economic ties between Hong Kong and the Mainland, injecting momentum and creating new opportunities for future development in the medium and longer term.

* Electrical and Mechanical Services Department (EMSD), Hong Kong SAR Government (www.emsd.gov.hk)

** The MTR Corporation Limited (www.mtr.com.hk)



Fig. 1. Alignment of the Hong Kong section of the Guangzhou – Shenzhen – Hong Kong Express Rail Link

1.2 Design Basis

The 25kV a.c. single phase 50Hz direct feed traction power supply system will be adopted for the XRL Hong Kong Section which is the same system as adopted in the Mainland section between the boundary and the Shenzhen North Traction Substation. This electrification system is currently a well-accepted international practice in supplying traction power for high-speed rail system with nominal length around 50km.

The traction power supply system will have adequate capacity to cater for 16 car long-haul trains running at 200km/h in 3 minutes ultimate headway in both directions under both normal and single traction transformer failure scenarios.

the running rails, aerial earth wire (AEW), along track earth strap and traction return cables back to the neutral of the traction transformer.

Feeder Stations (FS) will convert the 132kV infeed power from the nearest Grid Substation to 25kV a.c. single phase power by traction transformers for feeding traction power to the overhead line system. It is a substation equipped with the necessary equipment including circuit breakers for receiving the traction power supply from power utility (i.e. China Light & Power Co., Ltd.) network and distributing it via outgoing feeders to the Overhead Line System [1]. These transformers are specially designed to cater for the severe operating environment of traction which is characterized by frequent short-circuits and line faults.

2. SYSTEM DESCRIPTION

2.1 25kV Traction Power Supply System

The 25kV a.c. single phase direct feed traction power supply system will supply traction power to rolling stocks via the Overhead Line (OHL) system and traction return via

Two FS's will be located at Mong Kok West Ventilation Building (MKV) and Shek Kong Stabling Sidings (SSS) named Mong Kok West (MKW) FS and Shek Kong (SHK) FS respectively to supply traction power to the OHL system and receive traction return current.

Whilst two 26.5MVA 132/25kV single phase traction transformers will be installed at MKW FS, three 26.5MVA 132/25kV single phase traction transformers will be installed at SHK FS. Each Feeder Station will accommodate 25kV infeed isolators, 25kV switchgear, neutral busbar cubicle, interface marshalling cubicle, and battery and charger.

One hot standby traction transformer will be provided at each feeder station. The 132/25kV traction transformers would be fed from different 132kV busbars of the 132kV substation. It will ensure no degradation of train services will occur in case of single contingency condition, such as, outage of any one traction transformer, the remaining transformer will be able to supply traction power to the railway mainline.

Two Track Section Cabin (TSC) will be installed at Mai Po Ventilation Building (MPV) and Shing Mun Ventilation Building (SMV) to enable adjacent Feeder Station to provide power supply feed to the electrical section connected to an entirely failed Feeder Station. Each TSC will accommodate 25kV switchgear, neutral busbar cubicle and battery and charger. Three separate 25kV feeders will be provided from 25kV switchboard at SHK FS to supply the traction power to the OHL system at SSS areas.

Figure 2 illustrates the 25kV a.c. traction supply system schematic for XRL.

A neutral section is a short section of insulated overhead line that separates the sections fed by two adjacent feeder stations which are normally connected to difference supply sources. It will be provided at the boundary as the demarcation of the traction power supply systems between Hong Kong and Mainland. Another two neutral sections will be provided along the XRL Hong Kong Section alignment near SMV and Emergency Rescue Siding (ERS) to segregate the electrical sections supplied by different traction transformers.

Neutral sections will be in the form of 6 spans, 2 overlaps arrangement as illustrated in Figure 3 [2]. The span length is the distance between the centre lines of the adjacent supporting masts for overhead line. Each span length will be 40m nominal and 50m maximum in the XRL.

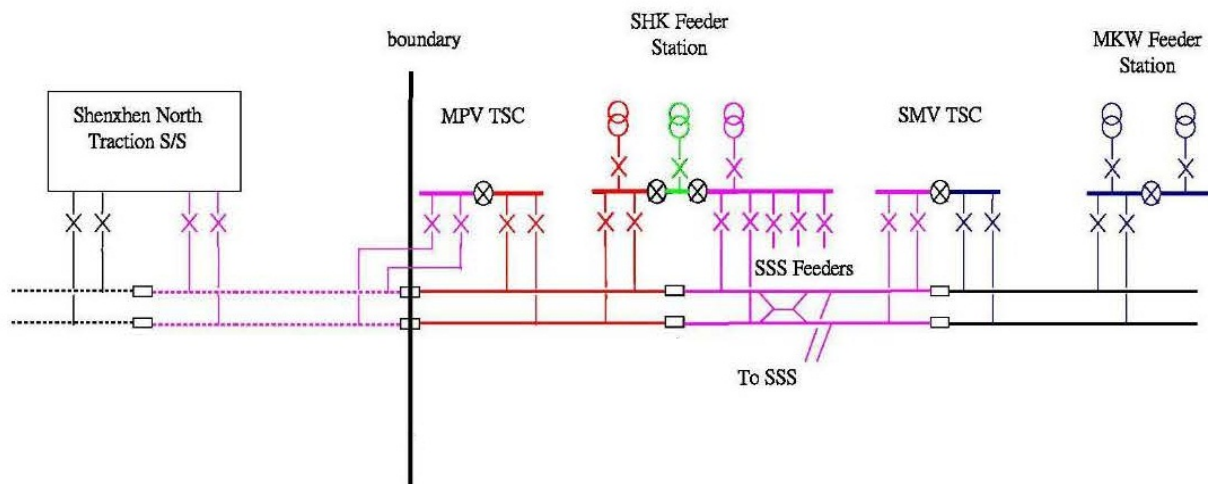


Fig. 2. The 25kV a.c. traction supply system schematic for XRL

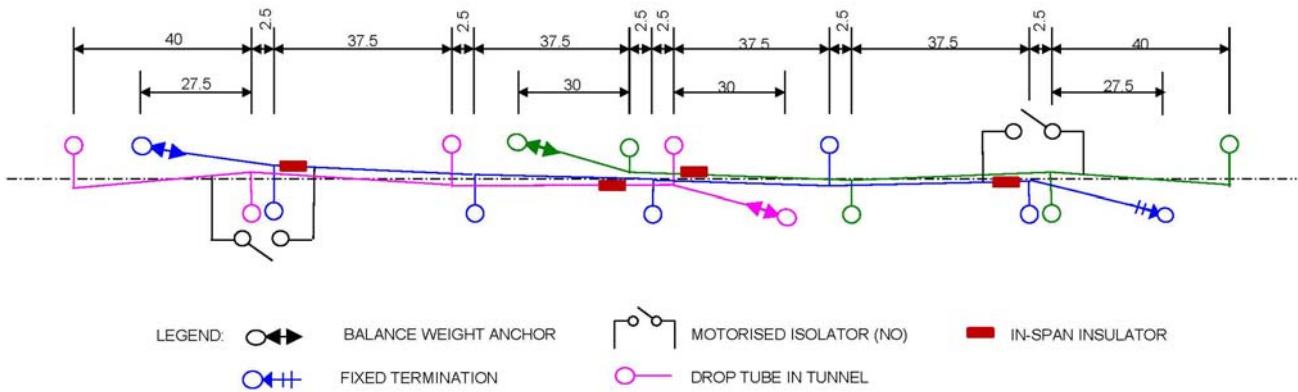


Fig. 3. Arrangement of typical neutral section of the XRL

Apart from the neutral sections, electrical sectioning by means of insulated overlaps and section insulators will be used as the isolation device for traction power supplies that are on the same power supply phase. In this arrangement, the two adjacent OHL sections will get temporarily shorted by the passage of pantograph below it. Among the insulated overlaps and section insulators, insulated overlap will be used wherever practicable in main line in order to allow smooth passage of pantographs underneath.

Hardwired electrical interlock will be provided at each Feeder Station and TSC 25kV switchboard to avoid paralleling of any two traction transformers. Software interlock will be provided to prevent the infeed transformers in the same Feeder Station or different Feeder Station from being paralleled. Electrical interlock will be provided between the infeed isolator and corresponding circuit breaker to ensure that the isolator status could not change unless the breaker has been opened.

The whole 25kV traction power supply system will be under the remote control and monitoring from Hong Kong Operation Control Centre.

2.2 System Voltage

The traction power supply system will operate in such a way to ensure the pantograph voltage will comply with the following requirements:

Nominal voltage, U_n :	25kV
Non-permanent maximum voltage, U_{max2} :	29kV
Normal maximum voltage, U_{max1} :	27.5kV
Normal minimum voltage, U_{min1} :	20kV
Non-permanent minimum voltage, U_{min2} : (under outage conditions)	17.5kV
Mean useful voltage:	22.5kV

The duration of voltage between U_{min1} and U_{min2} shall not exceed 2 minutes. The duration of voltage between U_{max1} and U_{max2} shall not exceed 5 minutes.

2.3 Traction Power Simulation

Traction power simulations have been carried out in system design stage to verify the capacity of 25kV traction power supply system can cater for 16-car trains running at 3 minutes headway under normal and single traction transformer failure scenarios.

The 16-car train used in the simulation model is CRH3 high speed train. The computer simulation model includes the 25kV traction supply network and alignment for the Hong Kong section including the section between Shenzhen North Substation and the Boundary. The simulation results of 30 minutes rms power demand for each traction transformer and minimum pantograph voltage for 16-car train services at 3 minutes headway are summarized as below:

30 Minutes RMS Power Demand:	
(a) MKW Traction Transformer:	22MVA
(b) SHK Traction Transformer: (SHK – SMV TSC)	17MVA
(c) SHK Traction Transformer: (SHK – Boundary)	12MVA
Minimum Pantograph Voltage:	22kV

The traction power demand profile for each traction transformer resulted from the traction power simulations is shown in Fig. 4 (a) – (c).

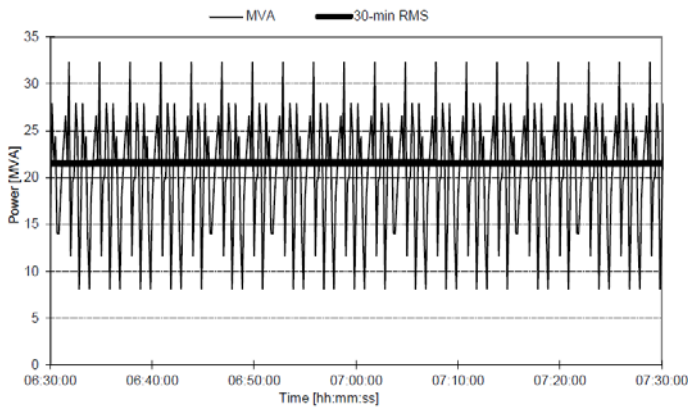


Fig. 4 (a) MKW Traction Transformer Power Demand Profile

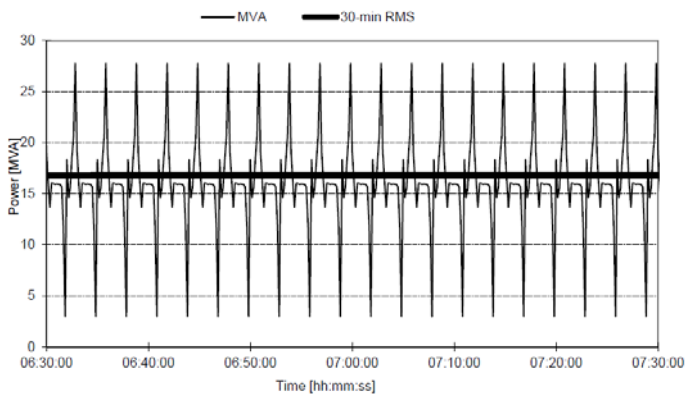


Fig. 4 (b) SHK Traction Transformer (SHK – SMV TSC) Power Demand Profile

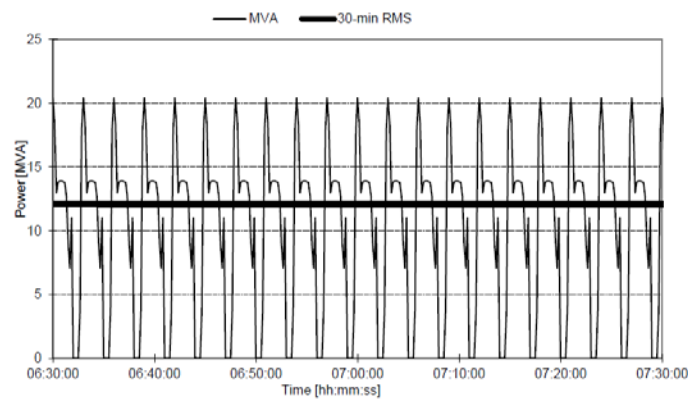


Fig. 4 (c) SHK Traction Transformer (SHK – Boundary) Power Demand Profile

The simulation results indicate that the capacity of the traction transformer in each Feeder Station and the pantograph voltage of trains are compliance with the requirements.

2.4 Overhead Catenary System in Main Line

The Overhead Catenary System (OCS) will be composed of 1 x 120mm² bronze messenger wire and 1 x 150mm² silver copper contact wires with 1x185mm² aluminum steel core aerial earth wire running in parallel. The contact wire height will be set at 5.3m in the mainline and the system height is 1.1m. The maximum length for a tension run will be 1,500m long and balance weights will be provided on both ends of messenger and contact wire to maintain constant tensions on the wires. The tensions applied on messenger wire and contact wire will both be 20kN and the maximum tension for aerial earth wire will be 14kN.

Fixed anchor will be installed in the middle of a tension length for preventing unidirectional creeping due to temperature changes. Overlaps will be installed between tension lengths to allow smooth passage of pantographs underneath and continuity of feeding current. Insulated overlaps will be used for electrical sectioning in the main line. Section insulators with remote control OHL isolators will be positioned at WKT north platform ends and turnouts for isolating OHL section.

2.5 Interface with Mainland Traction Power Supply System

The interface between Mainland and Hong Kong 25kV traction power supply system will be at the bus section breaker of the MPV TSC or the OHL bypass isolator at the boundary neutral section. There is no cross boundary traction power supply feed under normal operation.

3. CONCLUSION

This paper describes briefly the traction power supply system of the XRL. It is the first high-speed rail system in Hong Kong that connects with the high-speed rail network in the Mainland. The system is being installed and is targeted for completion in 2015. An overview of the traction power supply system has been presented in the preceding sections.

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References

- [1] MTR Corporation Limited, Express Rail Link, *Power Supply System Scheme Design Report*, May 2010
- [2] MTR Corporation Limited, Express Rail Link, *Overhead Line System Scheme Design Report*, May 2010

Mr. William CHENG is the Senior Electrical and Mechanical Engineer in EMSD responsible for conducting design review of the E&M Systems of the XRL Project. Before joining the Government in 1993, Mr. Cheng had worked in the power supply utility sector for 13 years.

Mr. Samuel CHAN is the construction manager in MTR responsible for the E&M design, system integration and commissioning of the high-speed rail project for the Hong Kong section linking the mainland network.

Mr. M. K. MAK is the senior engineer in MTR responsible for the power supply system and overhead line design for new railway extensions.

Mr. C. M. YEUNG is the Electronics Engineer in EMSD responsible for conducting design review of the E&M Systems of the XRL Project. Before joining the Government in 2007, Mr. Yeung had worked in a power supply utility in Hong Kong for 10 years.