Power Facilities for the Purple Line, The Kingdom of Thailand

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Abstract

The Purple Line is an elevated railway that runs 23km. This line starts from the Khlong Bang Phai Station situated in Nonthaburi Province in the suburbs of Bangkok and joins the Tao Poon Station connected with the MRT Blue Line (subway) in the north of Bangkok. This line has been constructed to decrease the number of private passenger cars running from Nonthaburi Province to Bangkok to eliminate traffic congestion. We supplied one complete set of facilities for power receiving, traction power feeding, and power distribution to the Purple Line. In addition, we completed related equipment installation work.

1 Preface

In Bangkok, the capital of The Kingdom of Thailand, there are many on-going and future plans for railway network update and expansion to ease traffic congestion. In relation to part of these on-going plans, we have taken part in the Purple Line Project since 2014.

Fig. 1 shows the route map of the Purple Line. This line links the Tao Poon Station in the north of Bangkok and the Khlong Phai Station in about 30 minutes. The route length is about 23km and there are 16 stations for this line. This paper introduces our supplied power facilities and related electrical construction work under the supplied system, electric power is fed to the station facilities and trains.

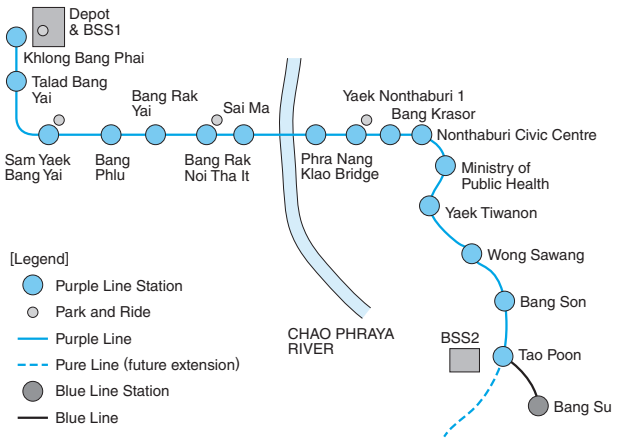

Fig. 1 Route Map of Purple Line

Position of the purple line and the number of stations are shown.

2 Outline of Power Supply System

Electric power for the Purple Line is received from two Bulk Substations (BSSs) and each BSS has a different receiving voltage level. These Bulk Substations are connected to the power transmission network of the Metropolitan Electricity Authority (MEA). BSS1 receives power at 115kV while BSS2 at 69kV. Voltages of electric power for Traction Substations (TSS), Service Substations (SSS), and the depot are stepped down at the main transformer of the BSS so that the incoming power is received at 22.8kV. The TSS supplies the rectified power at 750V DC to train cars. Part of the electric power is stepped down at 400V AC and fed to station facilities. Power facilities under the 400V power network are equipped with an Uninterruptible Power System (UPS) as a backup power for the power supply of mission-critical facilities.

2.1 Power Receiving Power Network System

Fig. 2 shows an overall power network system including the 115/69kV power receiving and transmission and 22.8kV loop power distribution facilities. The 115/69kV power network system at the incoming power substation is designed according to the MEA Specifications. The main power transformer of 50/75MVA ONAN/ONAF is equipped with an on-load tap changer and it conducts constant voltage control at 22.8kV. The main transformer capacity is designed to provide stable power supply even in a situation when train cars are changed

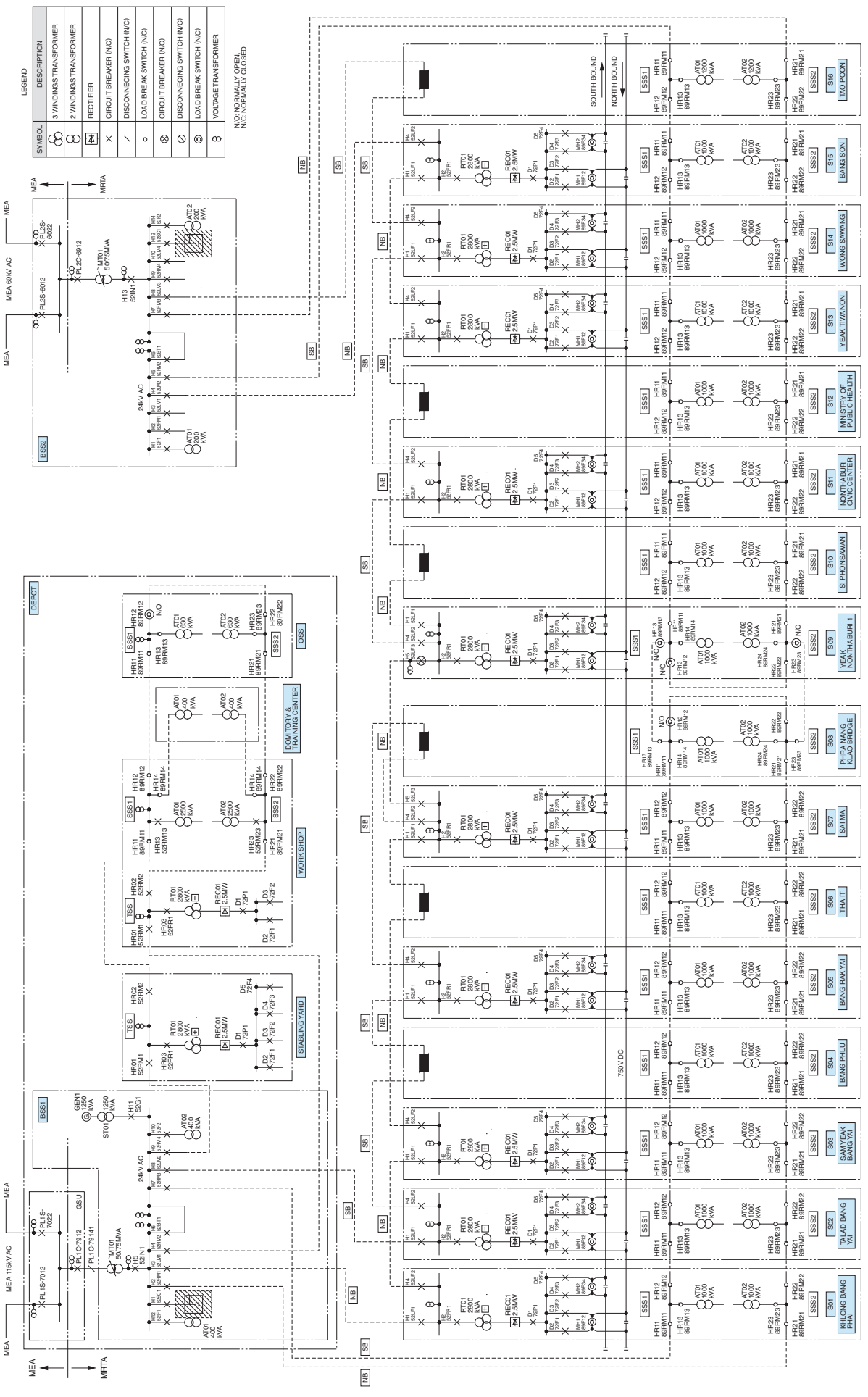

Fig. 2 **Purple Line Power Supply Overall System Diagram**

Purple Line Power Supply Overall System Diagram is shown.

from 3-car train to 6-car train.

2.2 22.8kV AC Power Distribution System

As shown in Fig. 2, the TSS works on a 22.8kV loop network system while the SSS and depot belong to a 22.8kV ring network system.

For loop network system between TSS and another TSS, the protection of sections is covered by directional overcurrent and earth fault protection. Each SSS has enough capacity to maintain a station service even if there is a failure in one of the dual power transmission lines. If there is a power outage in one of the dual transmission lines connecting a BSS, the power system is designed to control an automatic power supply extension using the other healthy transmission line connected to other BSS. For this purpose, the Programmable Logic Controller (PLC) is installed. By using this equipment, power network's power outage time is reduced to a minimum. By using this PLC, recovery operation of the power network system is automatically carried out to return the power supply in the normal mode.

When both power receiving network systems of 115kV and 69kV face a power failure, an emergency power generator installed at the BSS1 is used to feed power to the operation command facility located inside the depot.

2.3 750V DC Traction Power System

As shown in Fig. 2, each TSS is equipped with a rectifier unit. At each substation, a 12-phase rectifier transformer is installed. The phase of the delta winding on the primary side is shifted by ±7.5 degrees. By using each transformer between the two different substations, it synthesizes two 12-pulse outputs with different phase (±7.5° shifted) into a 24-pulse output. By this method, we aimed to reduce the amount of harmonics flow-out. The rectifier capacity is specified to eliminate any adverse influence upon train operations even in the event of an out of order TSS.

The 750V traction feeder line is provided with a direct acting function on a DC Circuit-Breaker (CB). In addition, multi-function protection relays are used. These relays come with the functions of measuring the current changing rate (rate of rise) and the current increase range (ΔI). Further, the DC feeder is an equipped function of a transfer trip. This function is a de-energized fault zone.

In the DC traction system, system restoration is possible even though an electric accident may occur. For this reason, a DC system is a provided function of a CB reclosure. In addition, since a load measuring function is additionally provided, it is possible to identify the presence of any short-circuit failure in the line. This function is effective in measuring the external line voltage and resistance by trial line charging through current limited resistance. If measuring the value under the setting, this function will cancel the HSCB closing command.

The negative panel is equipped with a Voltage Limiting Device (VLD) together with a function of leakage current measurement. The VLD is used to detect the presence of overvoltage between the negative and the earth. When an overvoltage is sensed, a magnetic contactor is instantly turned on to short-circuit the section between the negative and the earth. This operation protects passengers from any electric shock at the station by using a potential difference between the car body (negative pole) and the platform.

For the measurement of leakage current, a mesh earth to collect the stray current recovery is connected to the negative panel and the panel measures the current value of the leakage.

Meanwhile, protection against a DC ground fault is conducted by the frame leakage relay. With a ground wire connected directly to the panel frame, the frame leakage relay detects the ground fault current. The rectifiers and DC CB panels are, therefore, installed on the insulated floor.

2.4 Electrical Construction Work

We conducted installation work and cabling works for our electrical facilities. The electrical facilities include a variety of large and small equipment and units. According to the equipment structure and size, we planned and implemented safe equipment carry-in and solid installation work. When 24kV power cables were laid, we used a work train and the total length of cables amounted to approximately 400km. Fig. 3 shows a view of cable laying work.

3 Specifications of Incoming Power Substation Facilities

Under the Purple Line, it is designed so that even a single failure will not affect the entire system operation. The basic system configuration for the power facilities is such that all facilities are made

Fig. 3 View of Cable Laying Work

View of cable laying work is shown.

Fig. 4 69kV GIS

External appearance of GIS for receiving power from a power utility's 69kV electric power network system is shown.

redundant or it uses backup facilities. Major equipment specifications are as follows:

3.1 Incoming Bulk Substation

(1) 115kV Gas Insulated Switchgear (GIS) (BSS1)/69kV GIS (BSS2)
Standard: IEC62271
Type: Indoor GIS

Fig. 5 112/22.8kV Main Power Transformer

Main power transformer for stepping down from 112kV to 22.8kV is shown.

Ratings: Rated voltage: 115kV (BSS1)/69kV (BSS2)
Rated breaking current: 40kA
Rated current: 2000A

Fig. 4 shows an external appearance of the 69kV GIS.

(2) 112/22.8kV (BSS1) 67/22.8kV (BSS2) main power transformers
Standard: IEC60076
Type: Outdoor oil-immersed self-cooled/forced air cooled type
Ratings: 50/75MVA
112/22.8kV (BSS1) 50Hz with OLTC
67/22.8kV (BSS2) 50Hz with OLTC
Percent impedance: 12.5%
Connections: Dyn1

Fig. 5 shows an external appearance of the 112/22.8kV main power transformer.

(3) 22.8kV GIS
Standard: IEC60298
Type: Indoor GIS
Ratings: Rated voltage: 24kV
Rated breaking current: 25kA
Rated current: 2000/1250A

Fig. 6 shows an external appearance of the 22.8kV GIS.

(4) Emergency generator (BSS1)
Standard: IEC60034-1
Type: Diesel engine generator
Ratings: Rated capacity: 1250kV
Rated voltage: 416/240V 50Hz
Rated current: 2000/1250A

Fig. 7 shows an external appearance of the emergency generator.

Fig. 6 22.8kV GIS

External appearance of 22.8kV system distribution GIS is shown.

Fig. 7 Emergency Generator

External appearance of emergency generator is shown.

In addition, the BSS is composed of the protective relay panels to MEA Specifications, on-load tap changer control panels for main power transformers, main transformer secondary side grounding resistors (NGR), 22.8kV step-up cast resin molded transformers for emergency generators, local transformers, 110V DC source panels, UPS, and others.

Fig. 8 Rectifier Transformer

External appearance of transformer to be connected to the rectifier.

3.2 TSS

(1) 22.8kV GIS
Standard: IEC60298
Type: Indoor GIS
Ratings: Rated voltage: 22.8kV
Rated breaking current: 25kA
Rated current: 1250A

(2) Rectifier transformer
Standard: IEC60076
Type: Indoor cast resin mold
Ratings: 2800/1400/1400kVA
22.8/0.585kV 50Hz
Percent impedance: 8.0%
Connections: D (+7.5 or −7.5) d0y11

Fig. 8 shows an external appearance of the rectifier transformer.

(3) Auxiliary transformer
Standard: IEC60076
Type: Indoor cast resin mold
Ratings: 2500/1200/1000/630/400/200kVA
22.8/0.416kV 50Hz
Percent impedance: 6%
Connections: Dyn1

(4) Rectifiers
Standard: IEC60146
Type: Indoor self-cooled
Ratings: Rated voltage: 900V DC
Rated capacity: 2500kW (12-phase rectification)
Overload capacity: 150% for 2 hours, 300% for 1 minute

Fig. 9 shows an external appearance of rectifiers.

Fig. 9 Rectifiers

Device for converting AC electricity into DC electricity.

Fig. 10 750V DC CB Panel

Direct current CB board that protects 750V DC to the vehicle is shown.

(5) 750V DC CB panel
Standard: IEC61992
Type: Indoor DC CB panel
Ratings: Rated voltage: 900V DC
Rated breaking current: 180kA peak
Rated current: 4000A

Fig. 10 shows an external appearance of the 750V DC CB panel.

(6) 750V DC bypass LBS panel
Standard: IEC61992
Type: Indoor DC CB panel
Ratings: Rated voltage: 900V DC
Rated breaking current: 180kA peak
Rated current: 4000A

Fig. 11 750V DC Bypass LBS Panel

Bypass board that extends power supply in case of emergency is shown.

Fig. 12 VLD (Left) and Cathode Panel (Right)

VLD and Cathode Panel are shown.

Fig. 11 shows an external appearance of the 750V DC bypass LBS panel.

(7) 750V negative panel
Type: Indoor DC cathode panel
Ratings: Rated voltage: 900V DC
Rated current: 6000A

(8) VLD
Standard: EN50122-1
Ratings: Rated voltage: 900V DC
Rated current: 500A

Fig. 12 shows an external appearance of the VLD and cathode panel.

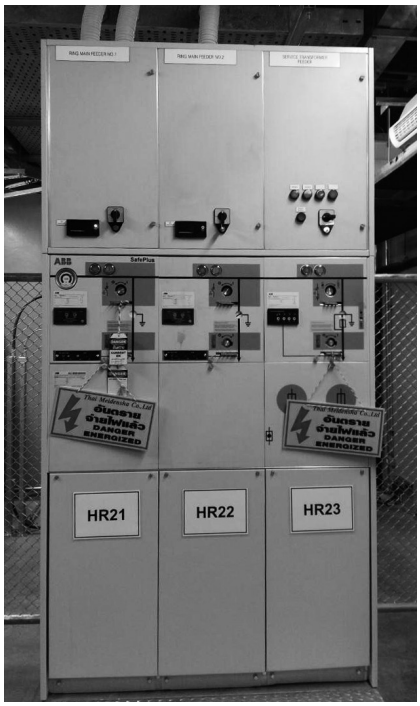

Fig. 13 RMU

RMU for 22.8kV distribution is shown.

Local facilities in TSS are composed mainly of 110V DC source panels and UPS.

3.3 SSS

The equipment for each SSS comes in the 24kV Ring Main Unit (RMU), local transformer, 110V DC source panel, and UPS. Equipment specifications are as shown below.

(1) 22.8kV RMU

Standard: IEC62271

Type: Indoor GIS

Ratings: Rated voltage: 24kV

Rated current: 630A

Fig. 13 shows an external appearance of the RMU.

3.4 Depot Substation

Equipment of the depot substation is the same as that of a TSS.

4 Postscript

The Purple Line commenced its business operation on August 6, 2016. Since then, stable operation has been maintained. We expect that the Purple Line will be popular and be used by many people in the future whereby improving connectivity and transit. We sincerely believe that this project could not be completed successfully in such a short period of time without the sound advices and cooperation from project-related people.

Lastly, we would like to express our gratitude to the project-related people.