Jakarta Mass Rapid Transit (Jakarta MRT) Project

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Abstract

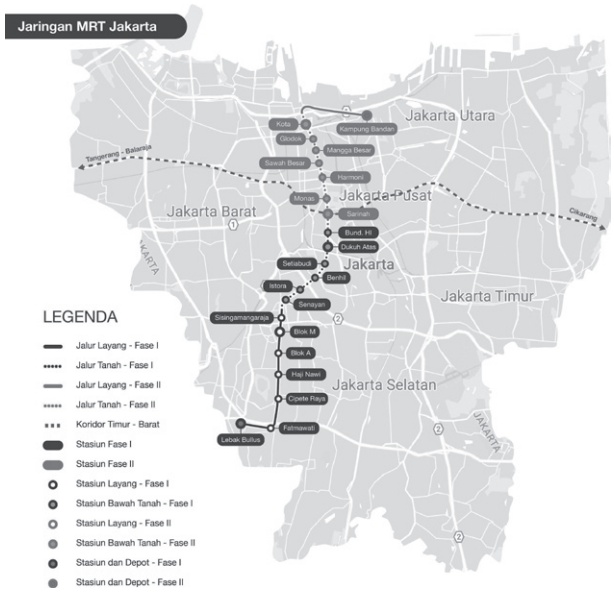
The Jakarta Mass Rapid Transit (Jakarta MRT) line in Phase 1 is a new north-south railway route connecting Bund. HI Station and Lebak Bullus Station in the metropolitan area of Jakarta. The total distance of this railway route in Phase 1 of the project is 15.7 km and there are 13 stations (6 underground and 7 elevated) in this route.

The Greater Jakarta area has attained remarkable development based mainly on its economic activities. Along with this development, however, chronic traffic jams tend to occur. The Jakarta MRT Project was set up for the purpose of alleviating such traffic.

In the new construction of the Jakarta MRT line, we delivered a complete set of electrical and monitoring facilities for intake, power feeding, and station servicing power supply facilities.

1 Preface

Jakarta is the capital of Indonesia, with outstanding development being the center of economic activities involving the surrounding Greater Jakarta areas. Consequently, people in Jakarta suffer from chronic traffic jams. To relieve such traffic, the Mass Rapid Transit (MRT) line was projected and constructed.



Source: Jakarta MRT website (https://jakartamrt.co.id/id)

Fig. 1 Diagram of Route

Location of the Jakarta MRT line and its stations are shown.

Fig. 1 shows a diagram of a route. The Jakarta MRT line in Phase 1 runs from north to south in the Greater Jakarta along a total distance of 15.7 km. There are 13 stations (6 underground and 7 elevated) and it takes about 30 minutes to travel between Bund. HI Station and Lebak Bullus Station. We delivered a complete set of power supply facilities and Supervisory Control And Data Acquisition (SCADA) in order to supply stable electric power to railway stations and MRT trains. This paper mainly introduces the features of Traction Substation (TSS) to feed electric power to MRT trains and those of Power SCADA equipment.

2 Outline of Power Supply Facilities

The electric power of the Jakarta MRT line is received at the Receiving Substation (RSS) from the Pondok Indah and CSW Substations of PT Perusahaan Listrik Negara (Persero) (PLN, in English: State Electricity Company). The intake system voltage is 150 kV. The receiving power voltage of 150 kV is stepped down to 20 kV and the received power is distributed to the TSS, Electric Room (ER), and a depot. The TSS rectifies the power to 1500 V DC and the rectified DC power is fed to MRT trains.

The ER makes voltage stepdown to 400 V to feed power to the ER inside and the TSS.

2.1 Intake System

Fig. 2 shows the overall power supply system including the 150 kV intake and 20 kV power distribution systems. The intake power from the PLN is received through a two-circuit line and the incoming voltage is stepped down to 20 kV at a main transformer of each circuit. Power from the main transformer is supplied to the 20 kV system. The main transformer is equipped with an on-load tap changer that controls the 20 kV distribution system voltage at a constant voltage level.

2.2 20 kV AC Power Distribution System

Power from the 20 kV distribution system is distributed to the TSS, ER, and depot through the respective power systems. At the ER, the incoming voltage is stepped down to 400 V so that the received power is supplied to inner facilities of the ER and the TSS.

2.3 1500 V DC Feeder System

Each TSS is equipped with two rectifier units. For rectifier transformers, the FR3 type of insulation oil is adopted because of its high incombustibility. Power to the overhead catenary is fed through the 4 traction power feeders. The traction power feeder is provided with a single circuit of spare feeder. This spare feeder is used in the case of feeder maintenance. In this setup, power can be fed to the required overhead catenary. Disconnecting switches for extension power supply are installed between traction power feeders.

For a protective factor, feeder lines employ multi-function relays that have functions of a current rate of rise and current step (ΔI) available at the time of DC Circuit-Breaker (CB) tripping. In addition, a transfer trip function is provided so that the fault section can be assuredly protected. Since there is a possibility of momentary recovery even in the case of a fault, a CB reclosing function is provided.

The Negative panel is provided with a DC earth fault relay (64P). This device is mainly intended for ground fault protection by measuring a potential difference between the rails and ground. If this voltage should exceed the relay's preset level, such a condition is identified as the occurrence of a ground fault and all CBs of the DC switchgear are tripped for protection.

The DC switchgear is also equipped with a frame leakage relay (64) for the purpose of protection against a DC ground fault. In this case, an earthing cable is directly connected to the casing so that 64 can detect a ground fault current. When this ground fault current exceeds the preset current level, all CBs of the DC switchgear are tripped for protection.

2.4 Power Control System (Power SCADA)

As a Power SCADA to be used for the remote control and monitoring of these power systems, the server and workstation are installed at the Operation Control Center (OCC). For the control and monitoring data exchange with the server, Remote Terminal Units (RTUs) are installed at the receiving substation, 4 traction substations, and 15 electric rooms. The OCC and each RTU are connected through a communication network of single-mode optical fiber cables configured in a loop state. The communication protocol is based on the International Standard IEC 60870-5-104. To configure in a loop state, the Ring Topology Protocol (RTP) is adopted so that a rapid route change is enabled in the case of a communication failure. Fig. 3 shows the Power SCADA system configuration.

The OCC workstation User Interface (UI) was designed with the "ease of use" in mind, along with a UI design guide that applies Human Centered Design (HCD). Fig. 4 shows a single line diagram screen.

In addition to the basic control and monitoring function, there are functions of command sequence control by which combined control of multiple units can be accomplished by a single action, and repetitive schedule control by which automatic execution of operation can be done at the preset time. By these functions, routines can be made efficient for dispatchers.

In addition to the power management server (SCADA Server) in a duplex configuration, there is a backup server available in the case of a system error. This backup server is provided with a training function and can be used for operation training for dispatchers. Fig. 5 shows the server panel.

3 Specifications of TSS and Power SCADA

Major specifications of TSS and Power SCADA are itemized below.

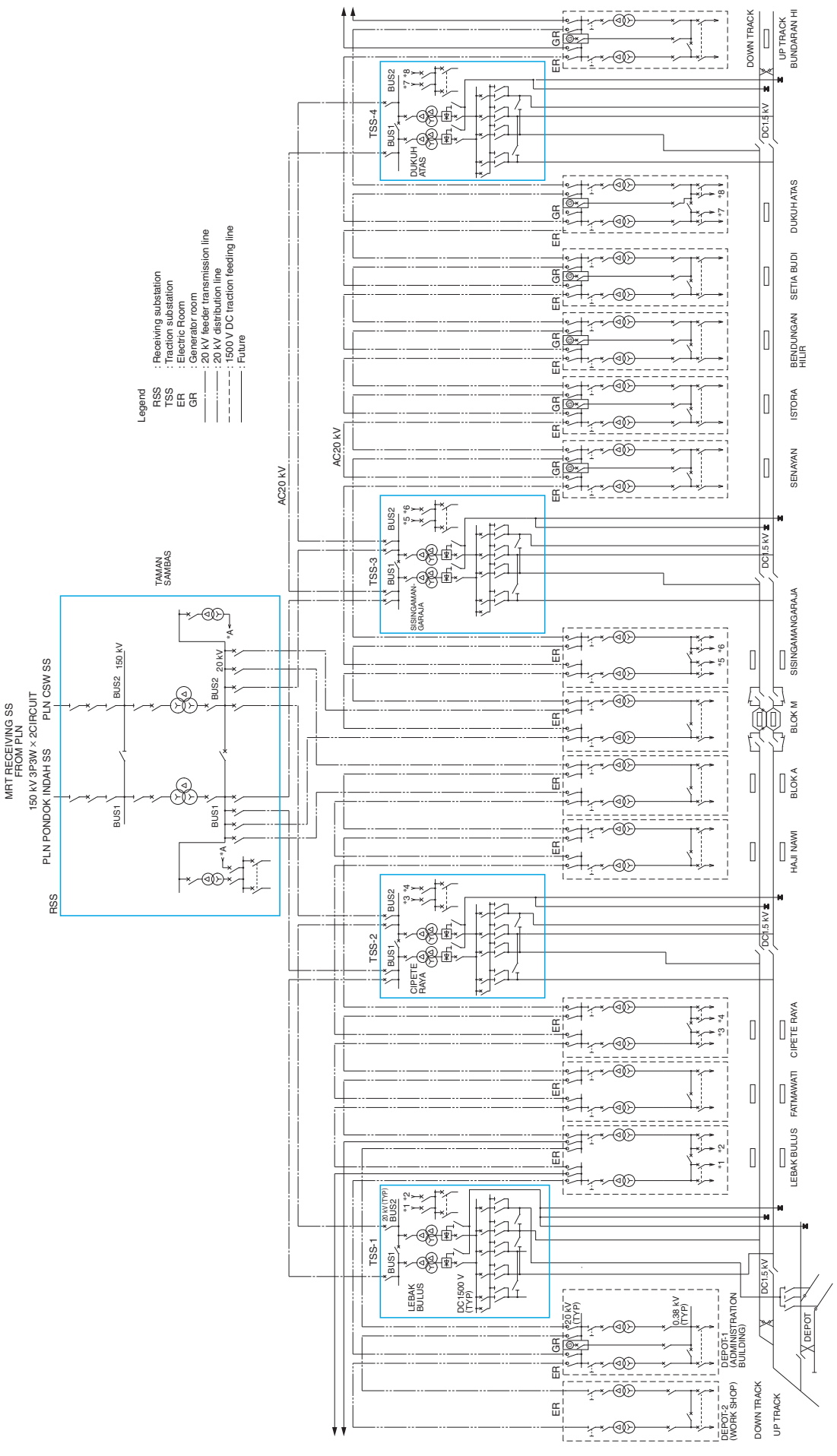


Fig. 2 **Overall Power Supply System**

Overall power supply system of the Jakarta MRT line is shown.

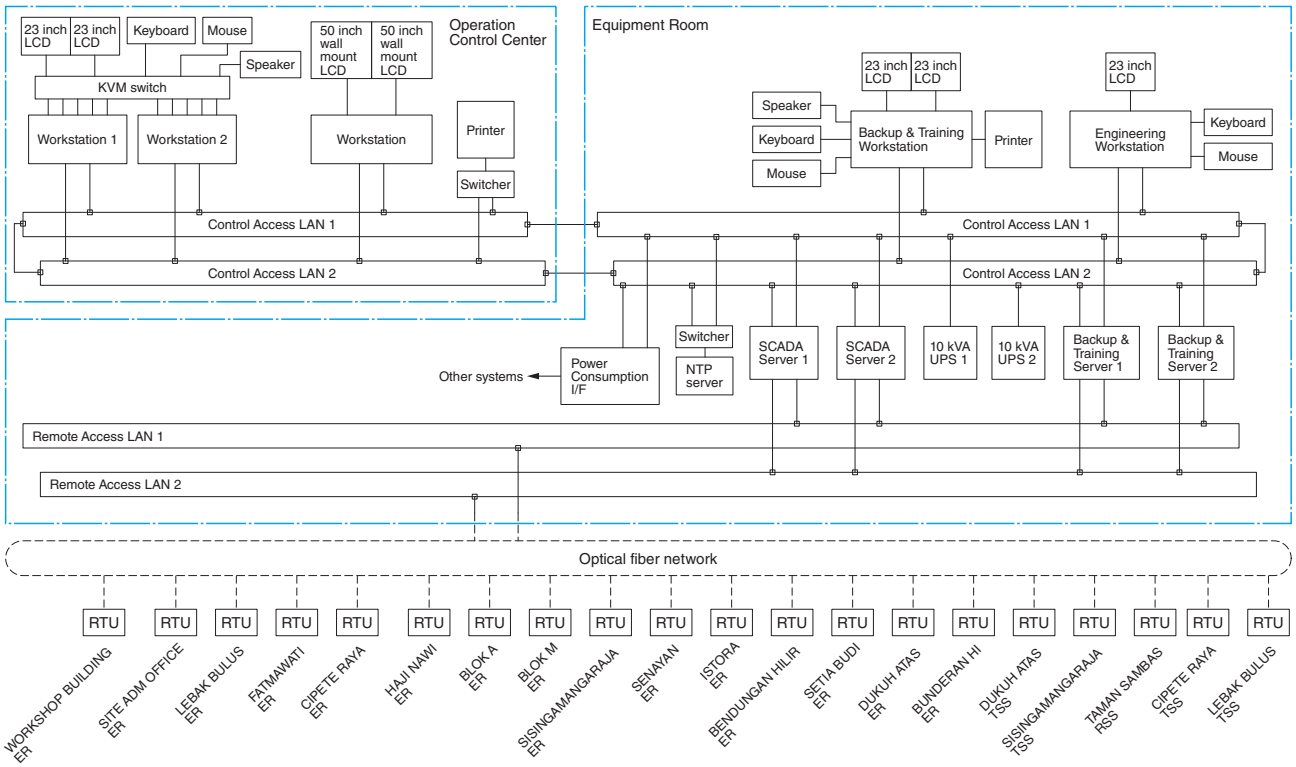


Fig. 3 **Power SCADA System Configuration**

An overall configuration of the Power SCADA System is shown.

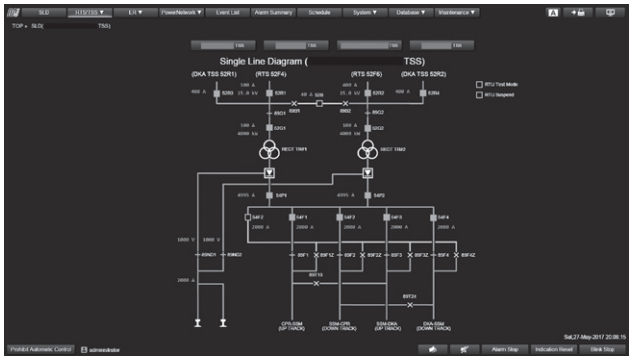


Fig. 4 **Single Line Diagram Screen**

A good contrast with symbol allocation is secured in consideration of optimal visibility.

Fig. 5 **Server Panel**

This is a natural air-cooling system where a punched metallic plate is adopted.

3.1 TSS

(1) 20 kV Gas Insulated Switchgear (GIS)

Standard: IEC 62271

Type: Indoor type

Ratings: Rated voltage 20 kV

Rated breaking current: 25 kA

Rated current: 1250 A

Fig. 6 shows an external appearance of a 20 kV GIS.

(2) Rectifier transformer

Standard: IEC 60146

Type: Indoor type oil-immersed transformer (FR3)

Ratings: 4850/2500/2500 kVA

20/1.18 kV 50 Hz

Connection Dy11d0

Fig. 7 shows an external appearance of a rectifier transformer.

Fig. 6 20 kV GIS

The GIS for 20 kV power distribution is shown.

Fig. 7 Rectifier Transformer

A transformer to be connected with rectifier unit is shown.

(3) Rectifier unit
Standard: IEC 60146
Type: Indoor natural cooling
Ratings: Rated voltage 1800 V DC
Rated capacity: 4500 kW (12-phase rectification)
Overload duty: 150% for 2 hours, 300% for 1 minute

Fig. 8 Rectifier Unit

The rectifier unit used to convert the AC power into DC power is shown.

Fig. 9 1500 V DC Switchgear

Equipment to feed traction power to MRT train and to protect them is shown.

Fig. 8 shows an external appearance of a rectifier unit.

(4) 1500 V DC switchgear
Standard: IEC 61992
Type: Indoor type
Ratings: Rated voltage 1800 V DC
Rated breaking current: 180 kA peak
Rated current: 6000/4000 A

Fig. 9 shows an external appearance of a 1500 V DC Switchgear.

Fig. 10 **1500 V Negative Panel**

A negative panel is shown.

(5) 1500 V negative panel
Type: Indoor type
Ratings: Rated voltage 1800 V DC
Rated current: 5000 A

Fig. 10 shows an external appearance of a 1500 V negative panel.

The other facilities in the traction substation are composed of low-voltage switchgears and a 110 V DC battery and charger panels.

3.2 Power SCADA

(1) Equipment installed at the OCC
Environmental conditions: Ambient temperature 15 ~ 30℃, relative humidity 40 ~ 70%
Equipment power source: 220 V AC, 50 Hz, single-phase 2-wire system
Withstand voltage: Server power source block, input-ground 1500 V (1 minute)
Server: 1U rack mount type server
Workstation: Mini-tower type
LC monitor: Model 23, Resolution 1920 × 1080px
Wall mounted monitor: Model 50, Resolution 1920 × 1080px
Switching hub: 24 ports (2 ports for SFP slot and combo port), SFP slot 1000BASE-LX, and single-mode optical fiber 2-core LC connector 2 ports
(2) RTU
Environmental conditions: Ambient temperature 0 ~ 40℃, relative humidity 30 ~ 90%
Equipment power source: 110 V DC
Withstand voltage: Power source Input-ground 1500 V (1 minute)
Dimensions: W700 × H2300 × D1000 mm
Digital output: 100 V DC Non-voltage contact
Digital input: 100/24 V DC Non-voltage contact 20 ms or more
Analog input: 4-20 mA DC, 250 Ω
Switching hub: 8 ports (2 ports for SFP slot and combo port), SFP slot 1000BASE-LX, Single-mode optical fiber 2-core LC connector 2 ports
Communication protocol with host: IEC60870-5-104

4 Postscript

The Jakarta MRT line started commercial operation on April 1, 2019 and continues to operate stably. Furthermore, the Jakarta MRT line is expected to extend the operation section to the north in the future. We hope that many residents will appreciate the necessity and convenience of the MRT trains.

Finally, we would like to express our gratitude to all parties concerned for their guidance and great cooperation in this construction.