



SUBSTATION FUNDAMENTALS

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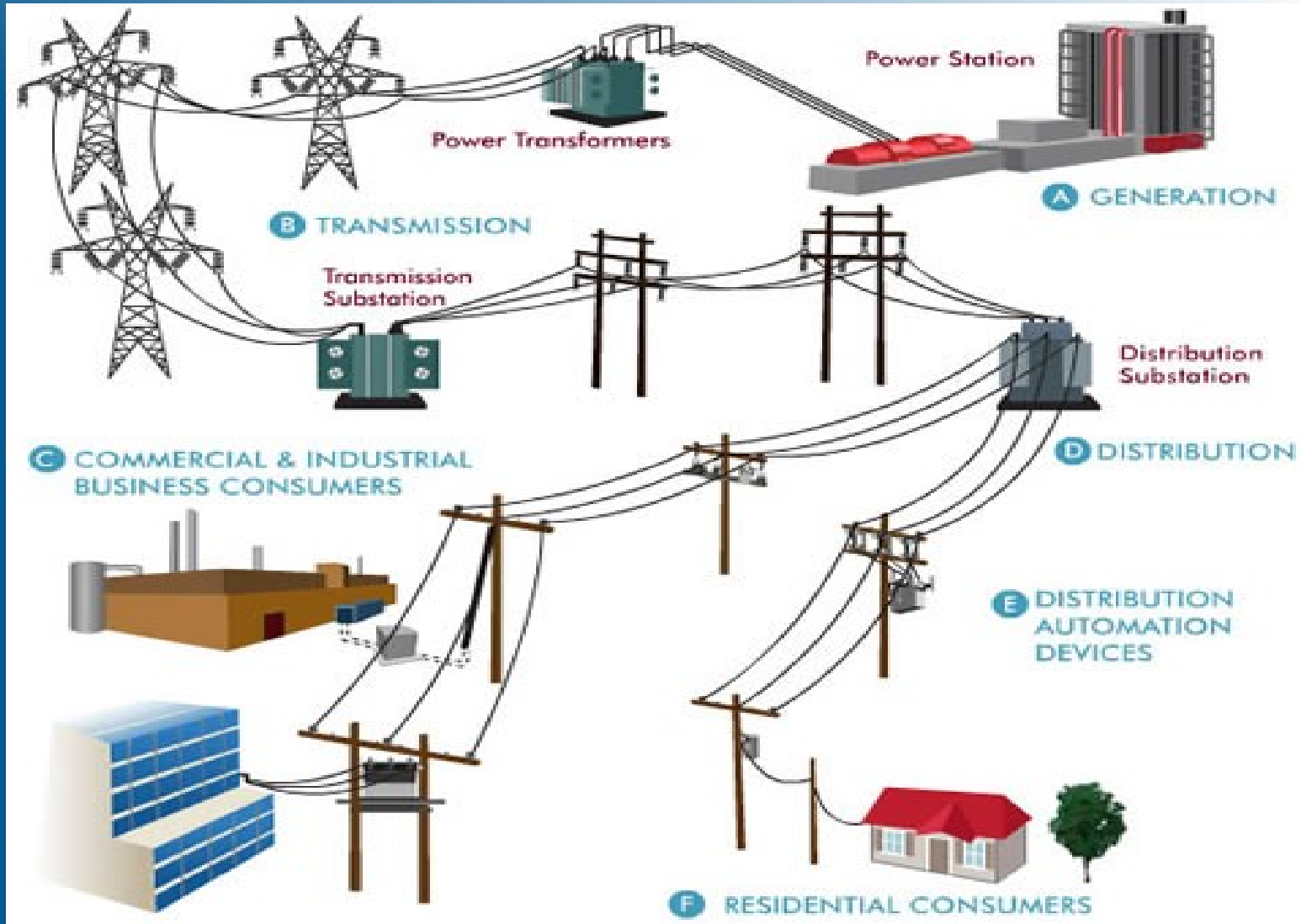
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POWER GRID

This presentation only applies to 60 Cycle, three phase Electrical Components of the Grid. The Electrical Grid is made up of the following components:

1. Generation Facilities
2. Power Transformers at generating center
3. High Voltage Transmission Lines
4. Transmission Substations
5. Distribution Substations
6. Low voltage distribution to residential and commercial customers

POWER GRID



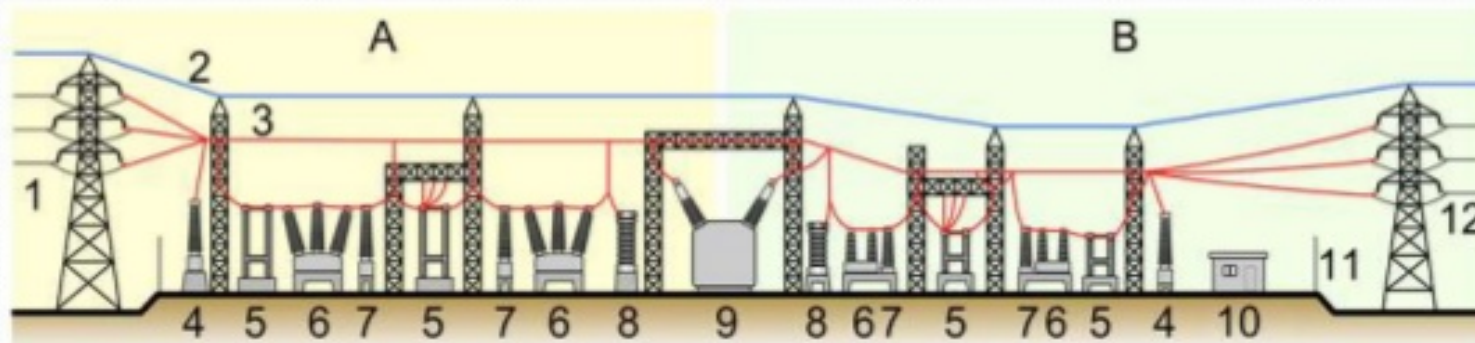
ELECTRICAL SUBSTATION



This presentation is an outline of the major component which make up the Electric Power Substation portion of the Power Grid. The main components of a substation are:

1. Power Transformers
2. Circuit Breakers
3. Grounding Switches
4. Current Transformers
5. Voltage Transformers
6. Main Busbar
7. SCADA (Supervisory Control and Data Acquisition)

Sub-station Layout



A: Primary power lines' side

1. Primary power lines
2. Ground wire
3. Overhead lines
4. Transformer for measurement of electric voltage
5. Disconnect switch
6. Circuit breaker
7. Current transformer
8. Lightning arrester

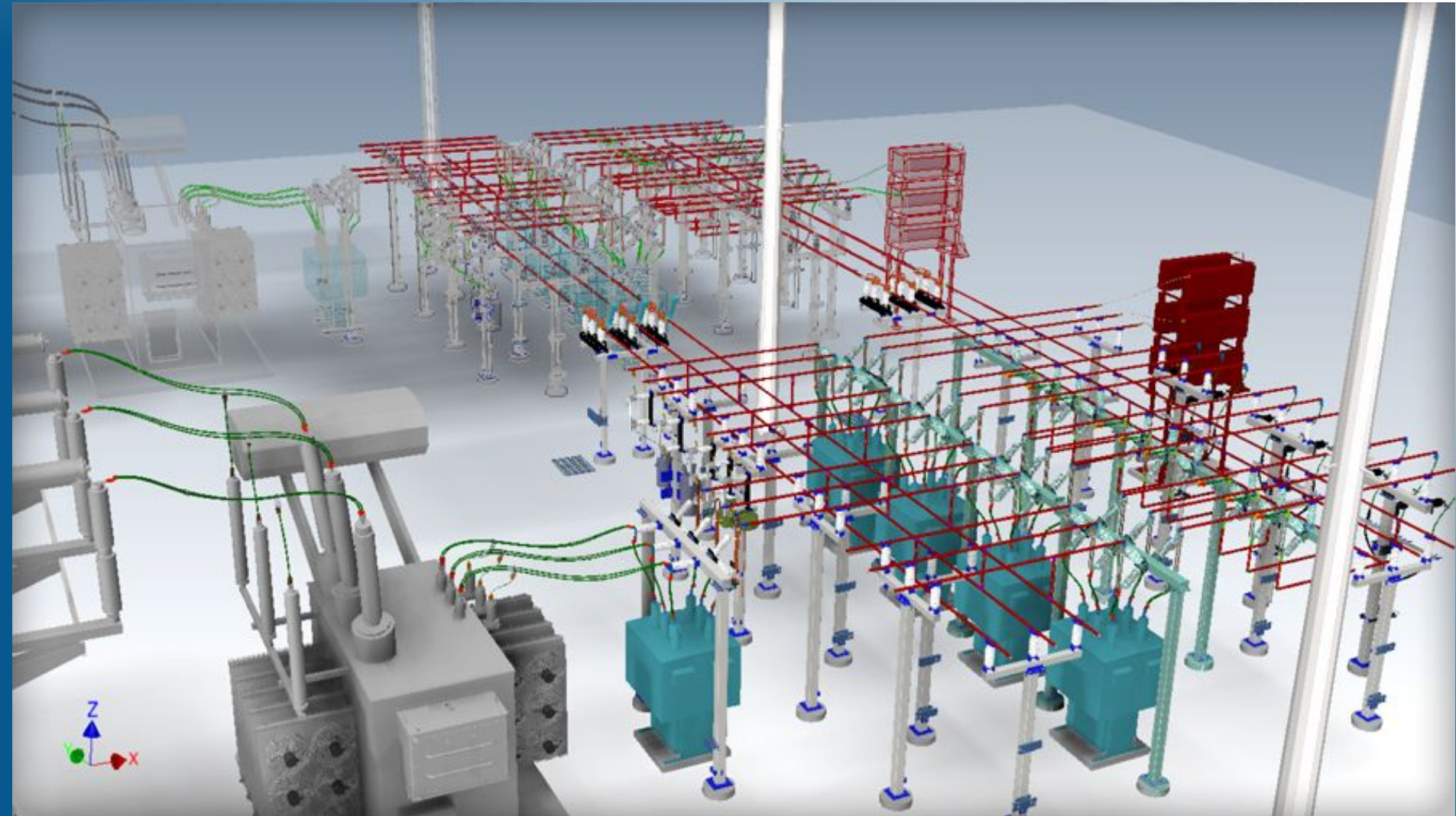
B: Secondary power lines' side

7. Current transformer
8. Lightning arrester
9. Main transformer
10. Control building
11. Security fence
12. Secondary power lines

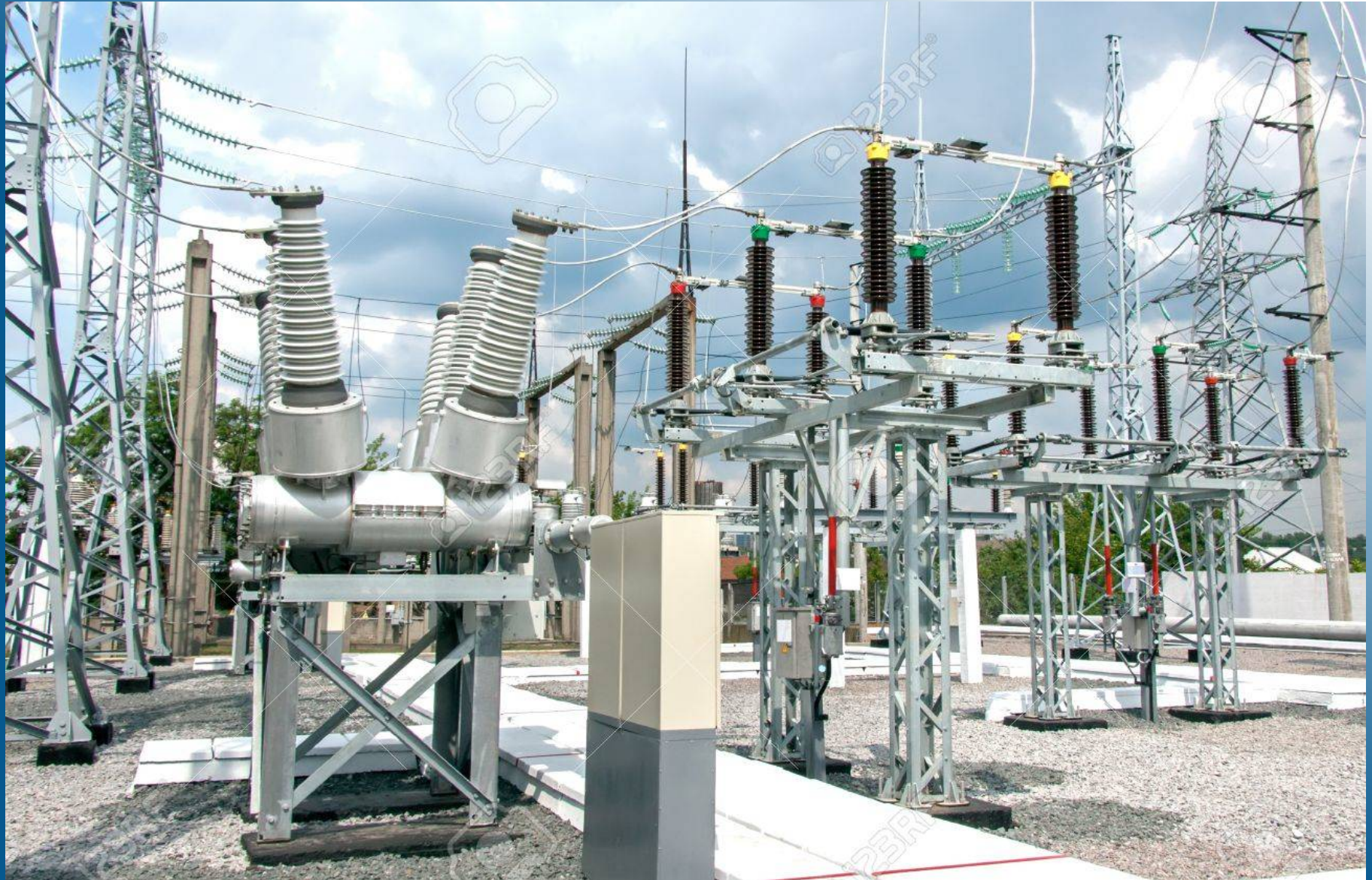
SUBSTATION LAYOUT (RENDERING)



SUBSTATION LAYOUT (RENDERING)



HIGH VOLTAGE SUBSTATION



DISTRIBUTION SUBSTATION



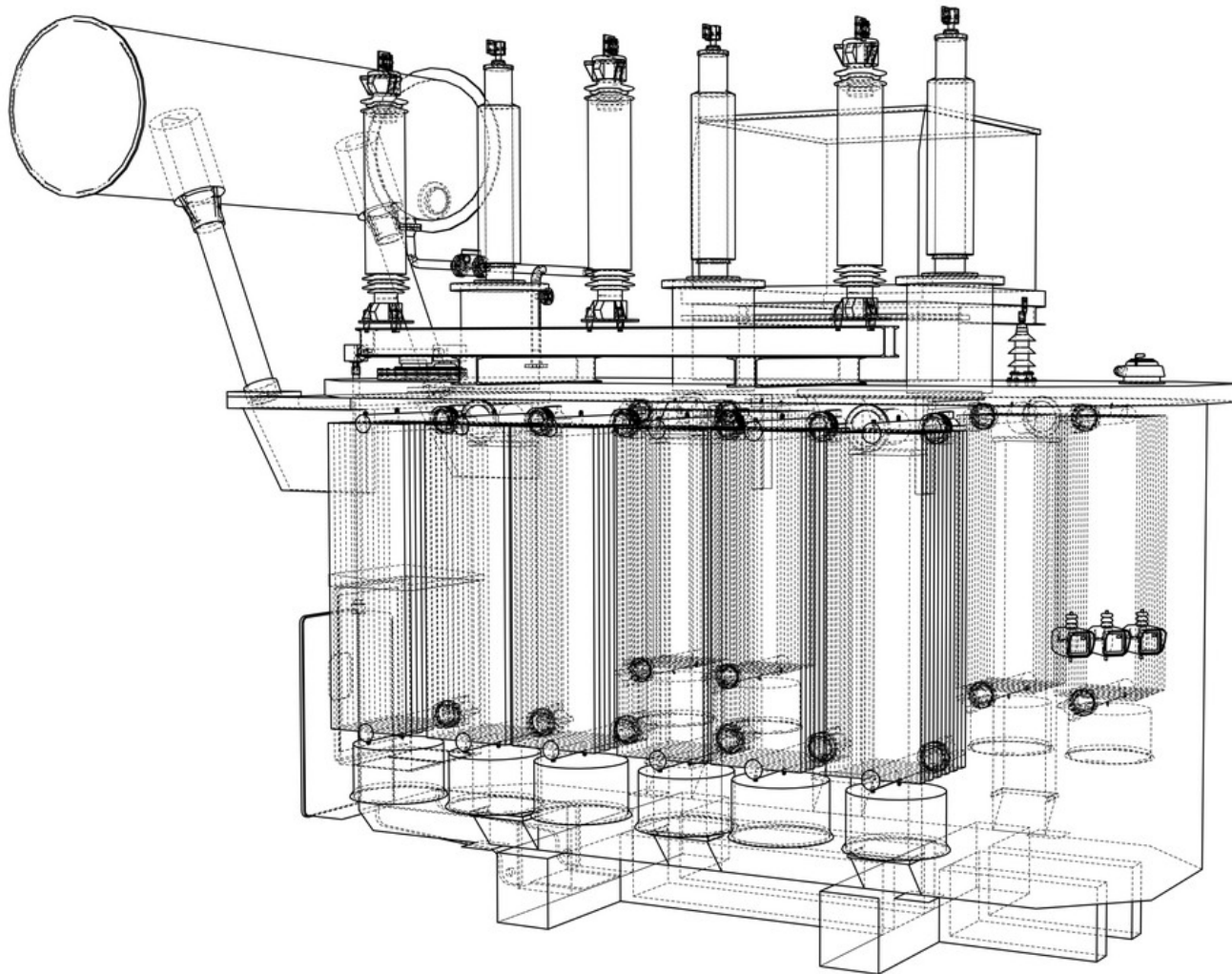
DISTRIBUTION SUBSTATION



1. POWER TRANSFORMERS

This portion of the presentation is concerned with the major components of any Substation. The Power Transformers are used to transform voltages from the line side to a different voltage on the load side. The Power Transformer is used at the Generating facility, at a Substation and at all distribution nodes.

1.1 SUBSTATION TRANSFORMER



1.2 SUBSTATION TRANSFORMER



1.3 SUBSTATION TRANSFORMER (EXTRA HIGH VOLTAGE)



1.4 SUBSTATION TRANSFORMER (EXTRA HIGH VOLTAGE)



1.5 SUBSTATION TRANSFORMER (EXTRA HIGH VOLTAGE)



1.6 SUBSTATION TRANSFORMER



1.7 DISTRIBUTION TRANSFORMERS



1.8 LOW VOLTAGE TRANSFORMERS



2. CIRCUIT BREAKERS

This portion of the presentation is an outline of the Circuit Interrupts used in substations and Distribution Stations. These disconnect facilities along with Substation Grounding and the use of Grounding Switches are used to protect the Power Transformers, the Current and Voltage Transformers. The Power Transformers and the switchgear are the main components of the Electric Substation.

2.1 CIRCUIT BREAKERS-SUBSTATION



2.2 CIRCUIT BREAKERS-SUBSTATION SF₆ CIRCUIT BREAKER



2.3 CIRCUIT BREAKERS MEDIUM VOLTAGE



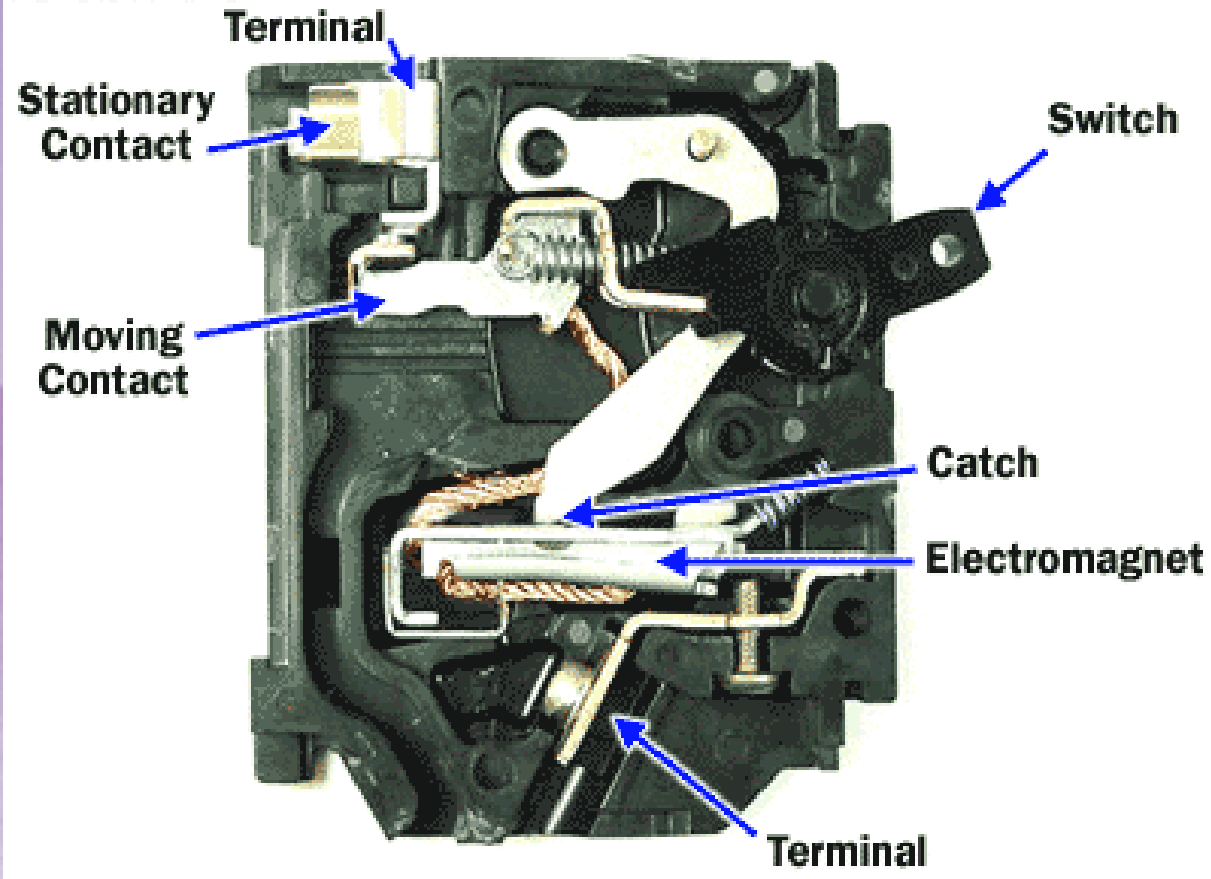
2.4 CIRCUIT BREAKERS: LOW VOLTAGE



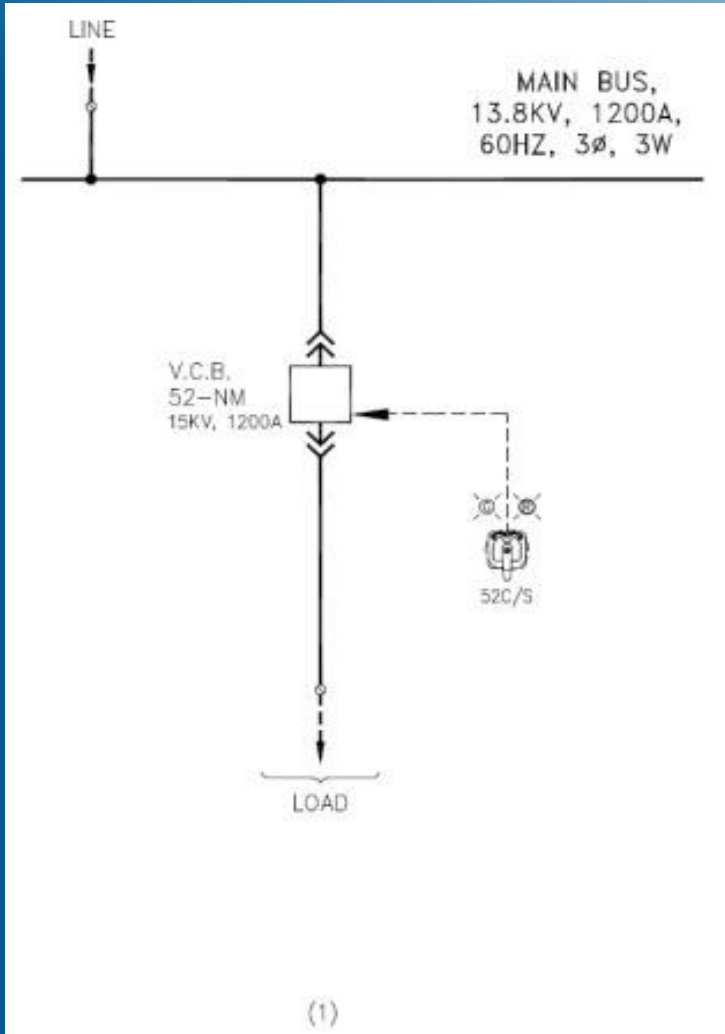
2.5 CIRCUIT BREAKERS LOW VOLTAGE



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2.6 BREAKER CONTROL

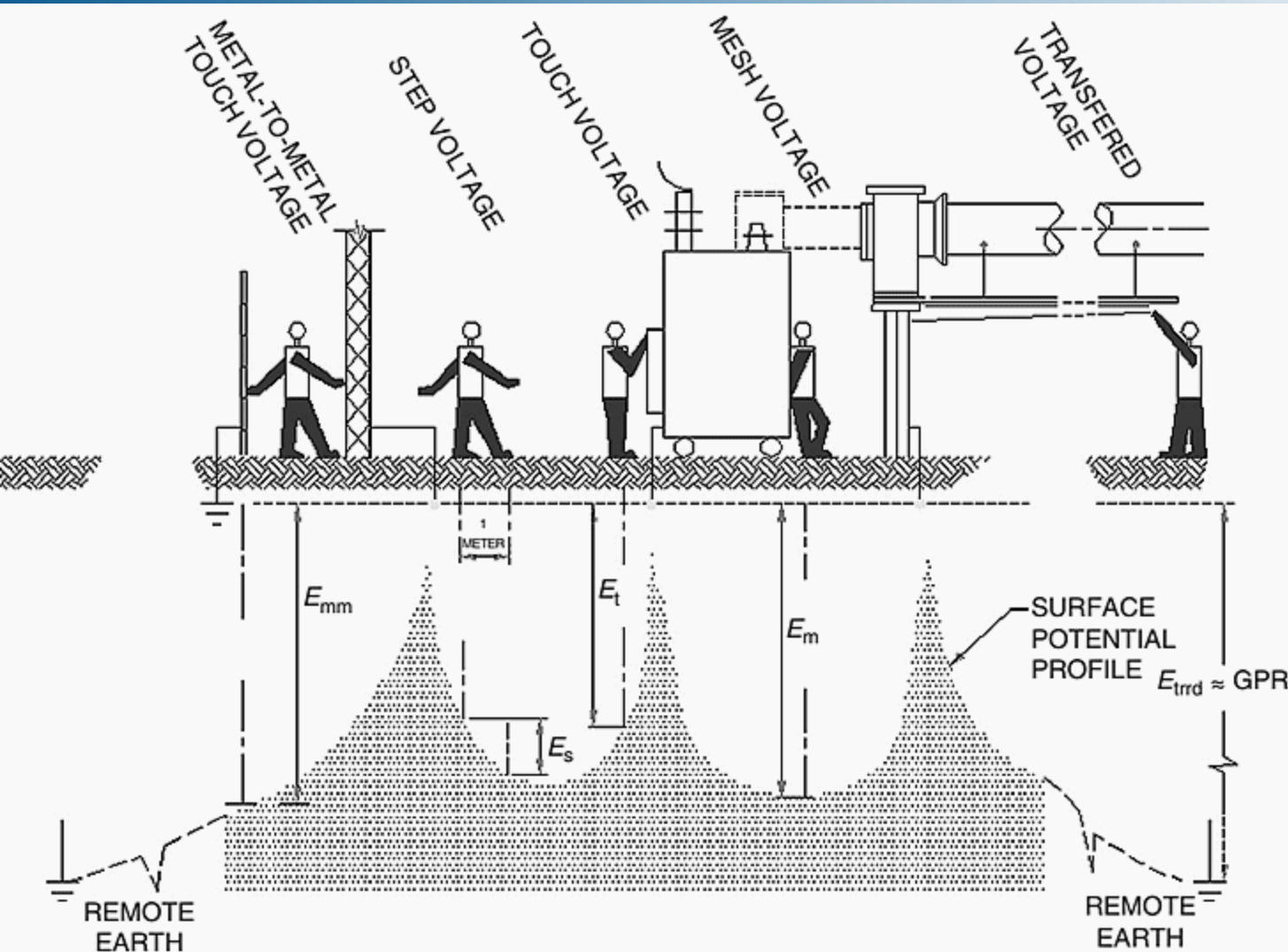


3. GROUNDING AND GROUND SWITCHING

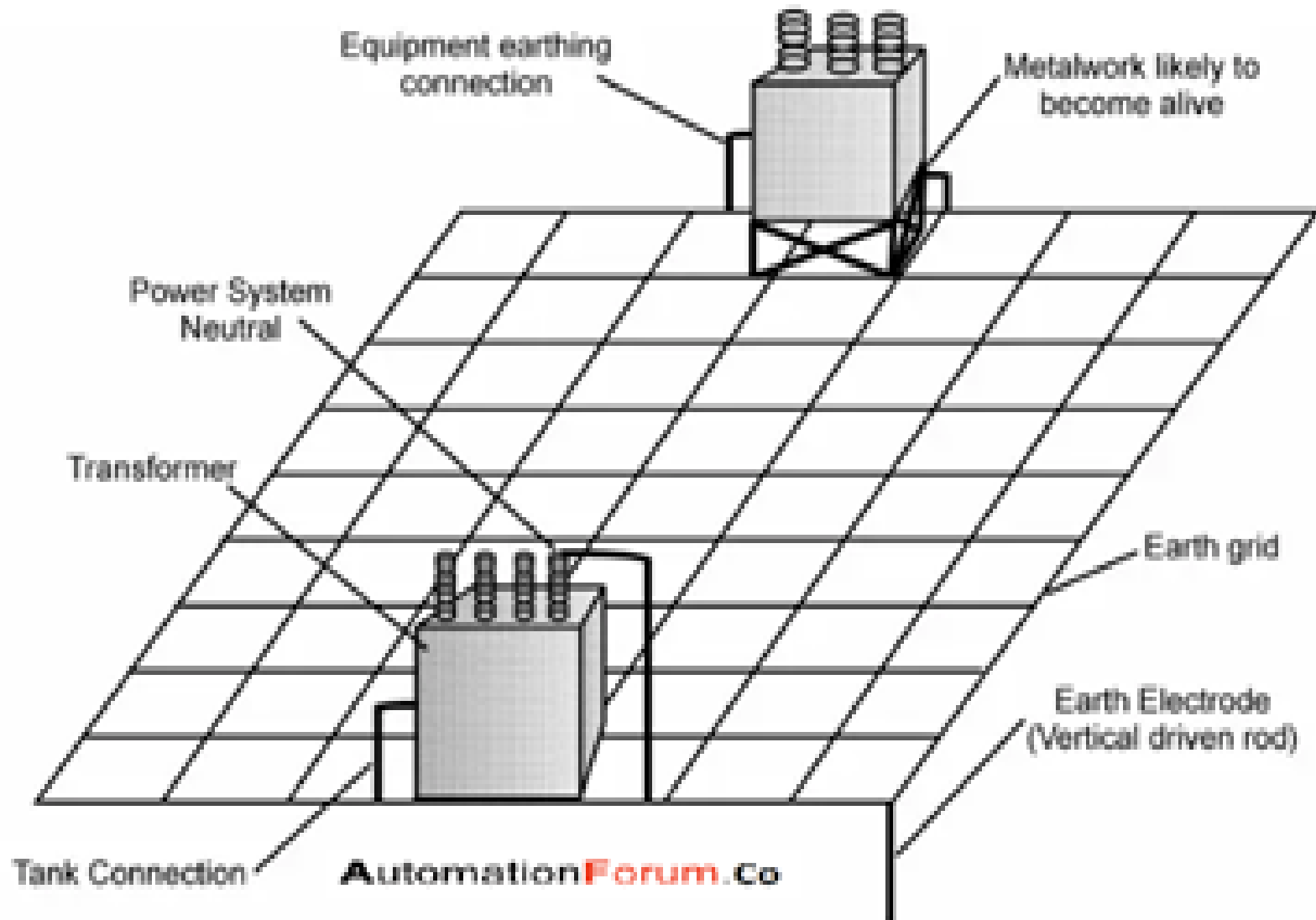


This portion of the presentation is concerned with Substation Grounding and the use of Grounding Switches to protect the Power Transformers, the Current and Voltage Transformers which are the vital components of the Electric Substation.

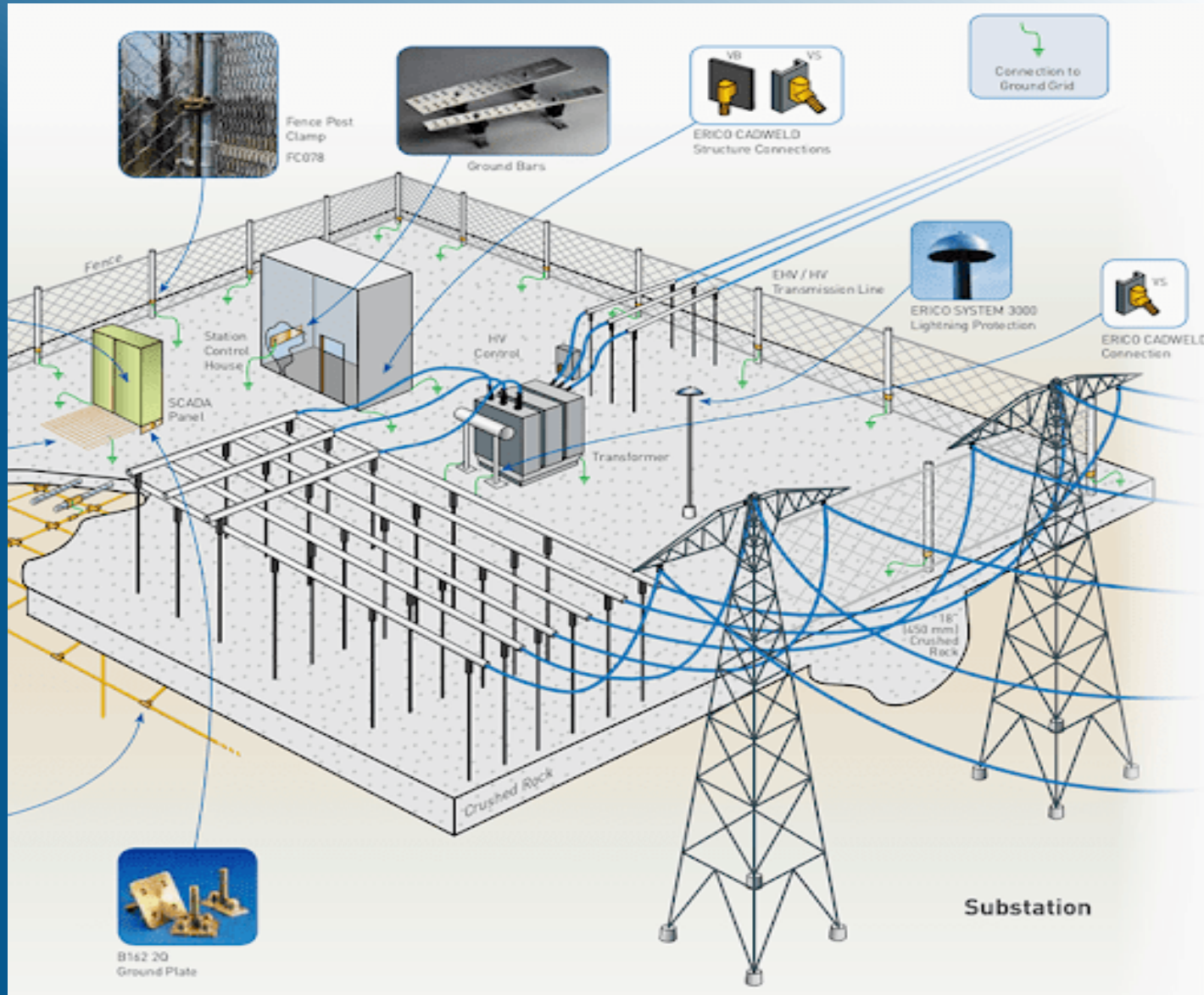
3.1 SURFACE POTENTIAL PROFILE



3.2 SUBSTATION GROUNDING: EARTH GRID



3.3 SUBSTATION LAYOUT



3.4 GROUNDING SWITCHES



3.5 GROUNDING SWITCHES



4. CURRENT TRANSFORMERS

This portion of the presentation is concerned with the Current Transformers.

The CT is the device in the Electric Power Substation which allows the measurement of the current on the line side or the load side of the Power Transformer.

4.1 CURRENT TRANSFORMER



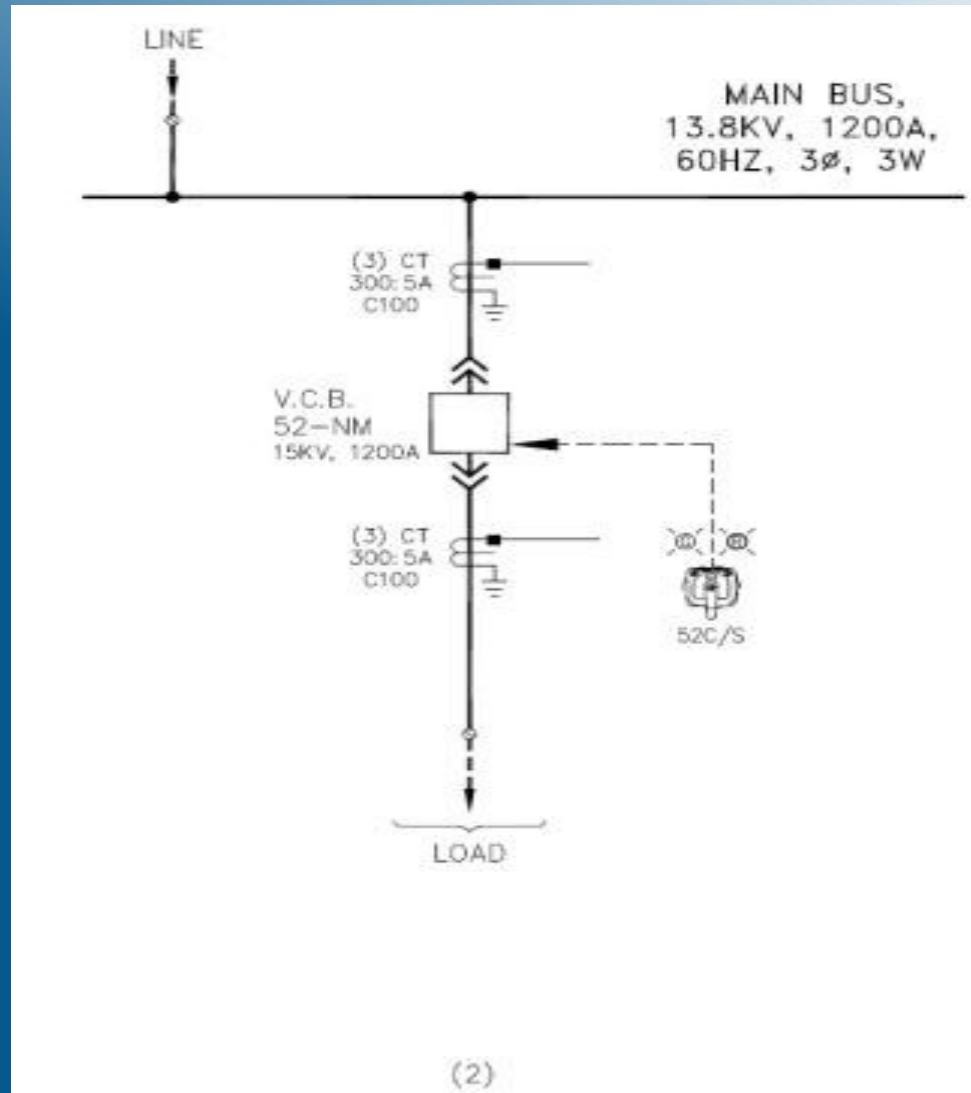
4.2 CURRENT TRANSFORMER



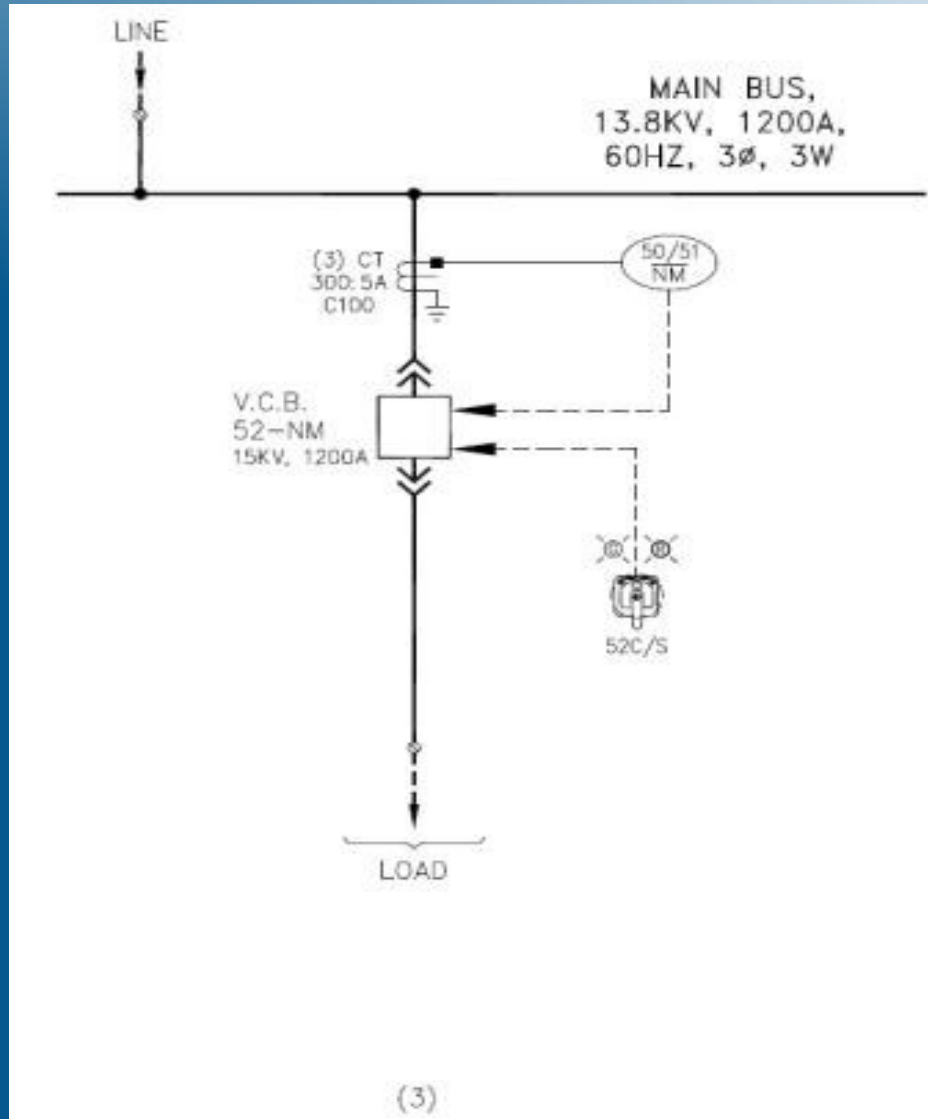
4.3 CURRENT TRANSFORMER



4.4 CURRENT MONITORING



4.4 OVER-CURRENT TRIP

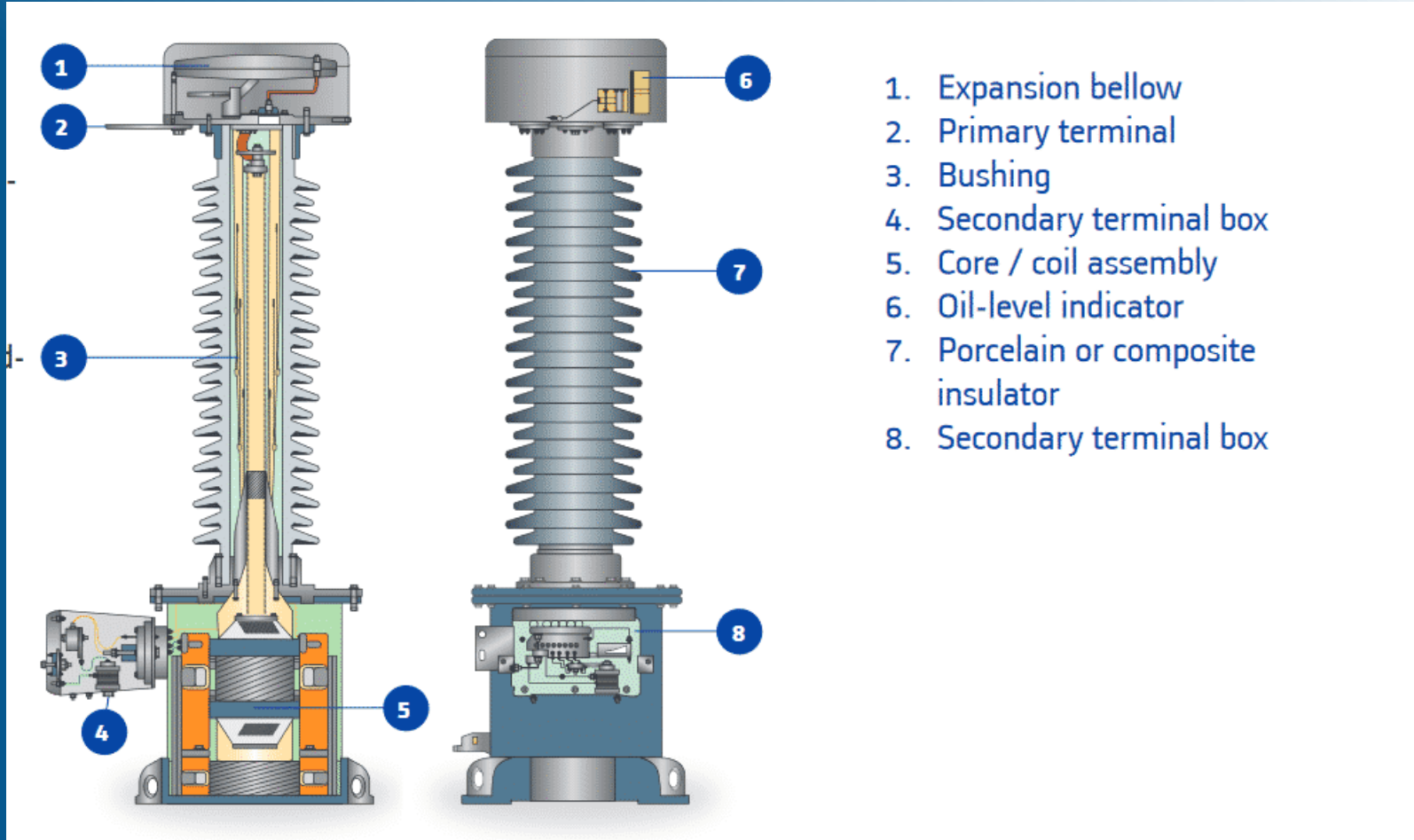


5. VOLTAGE TRANSFORMERS

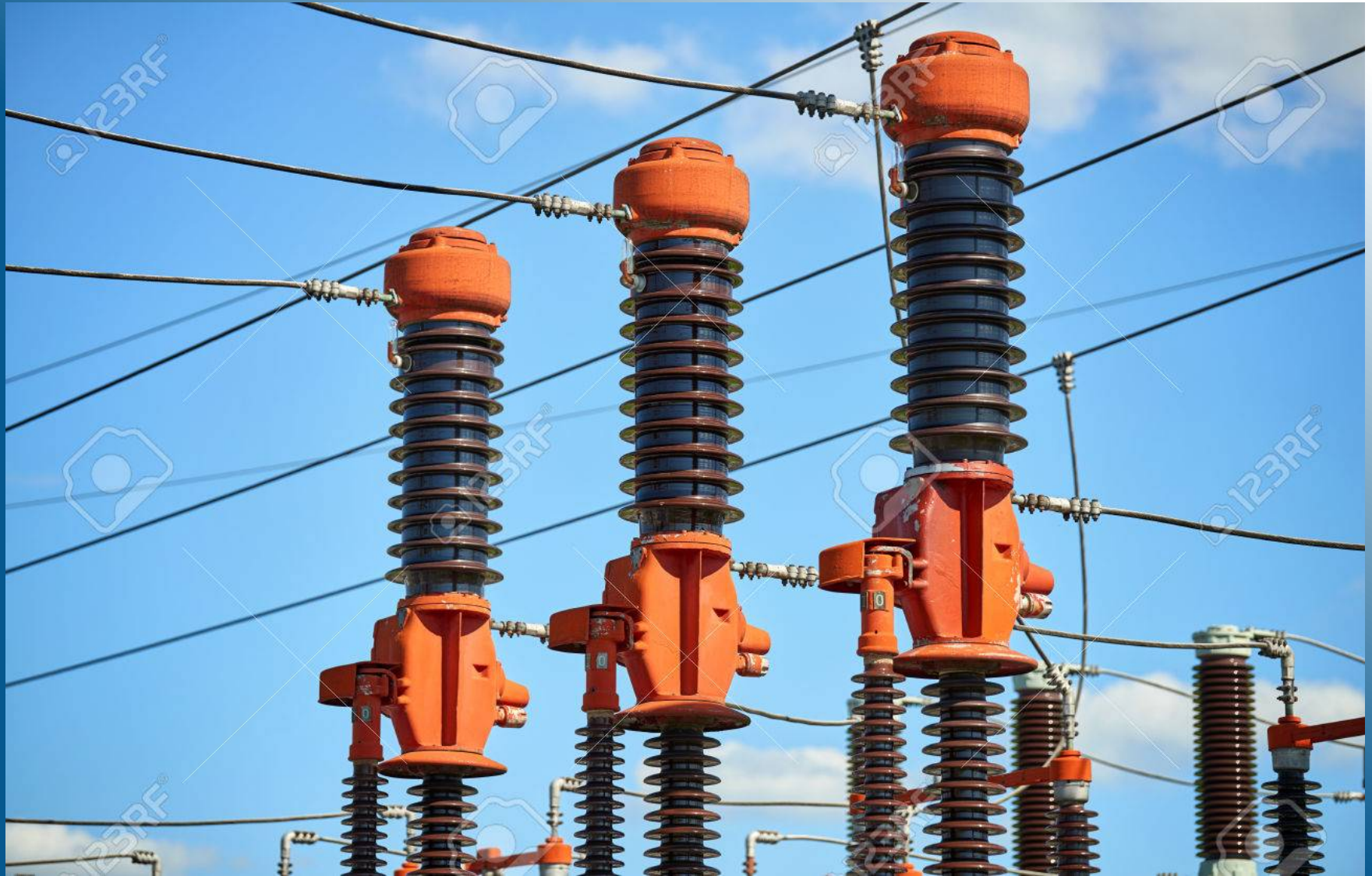
This portion of the presentation is concerned with the Voltage Transformers.

The VT is the device in the Electric Power Substation which allows the measurement of the Voltage on the line side or the load side of the Power Transformer.

5.1 VOLTAGE TRANSFORMERS



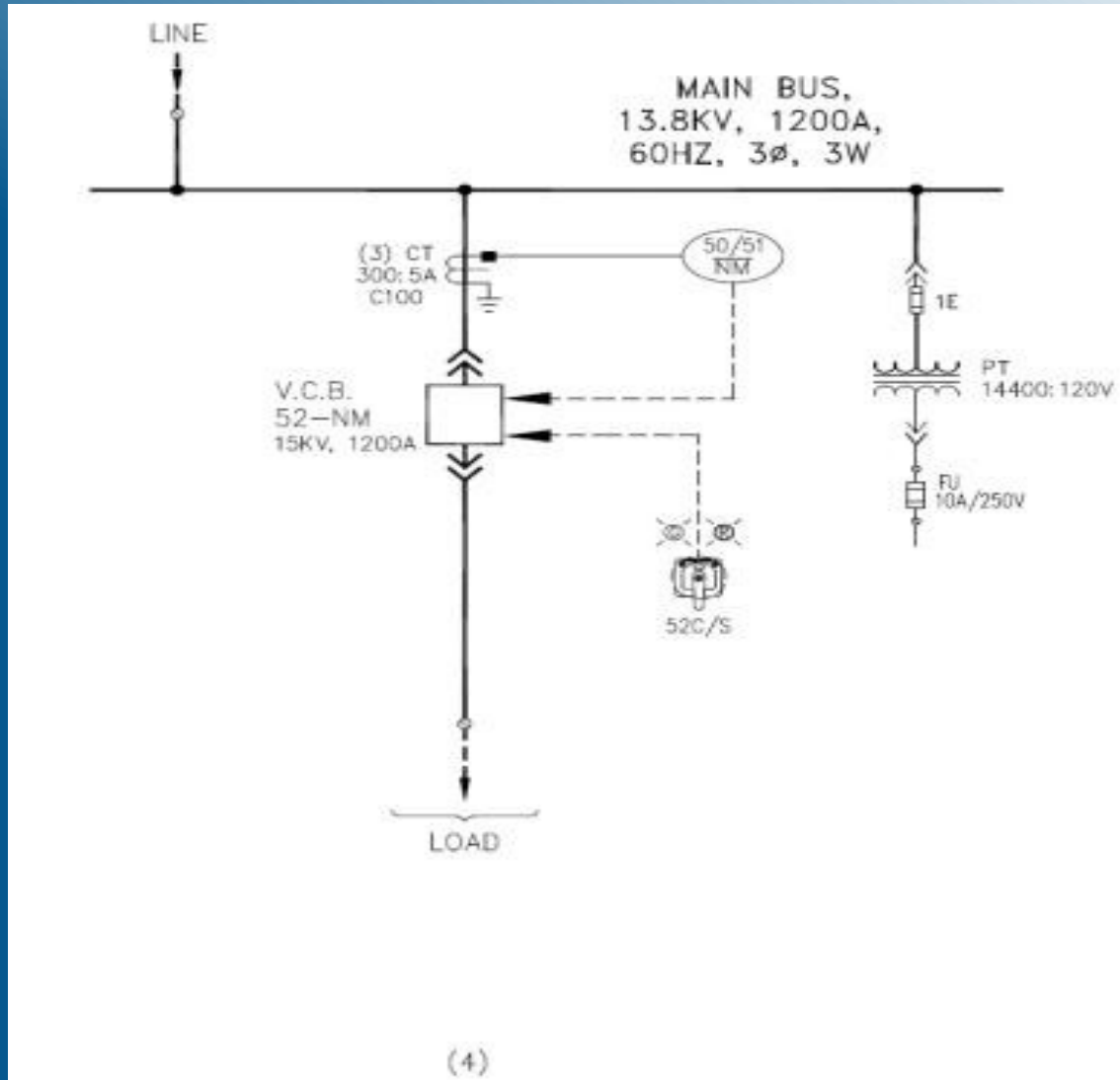
5.2 VOLTAGE TRANSFORMERS



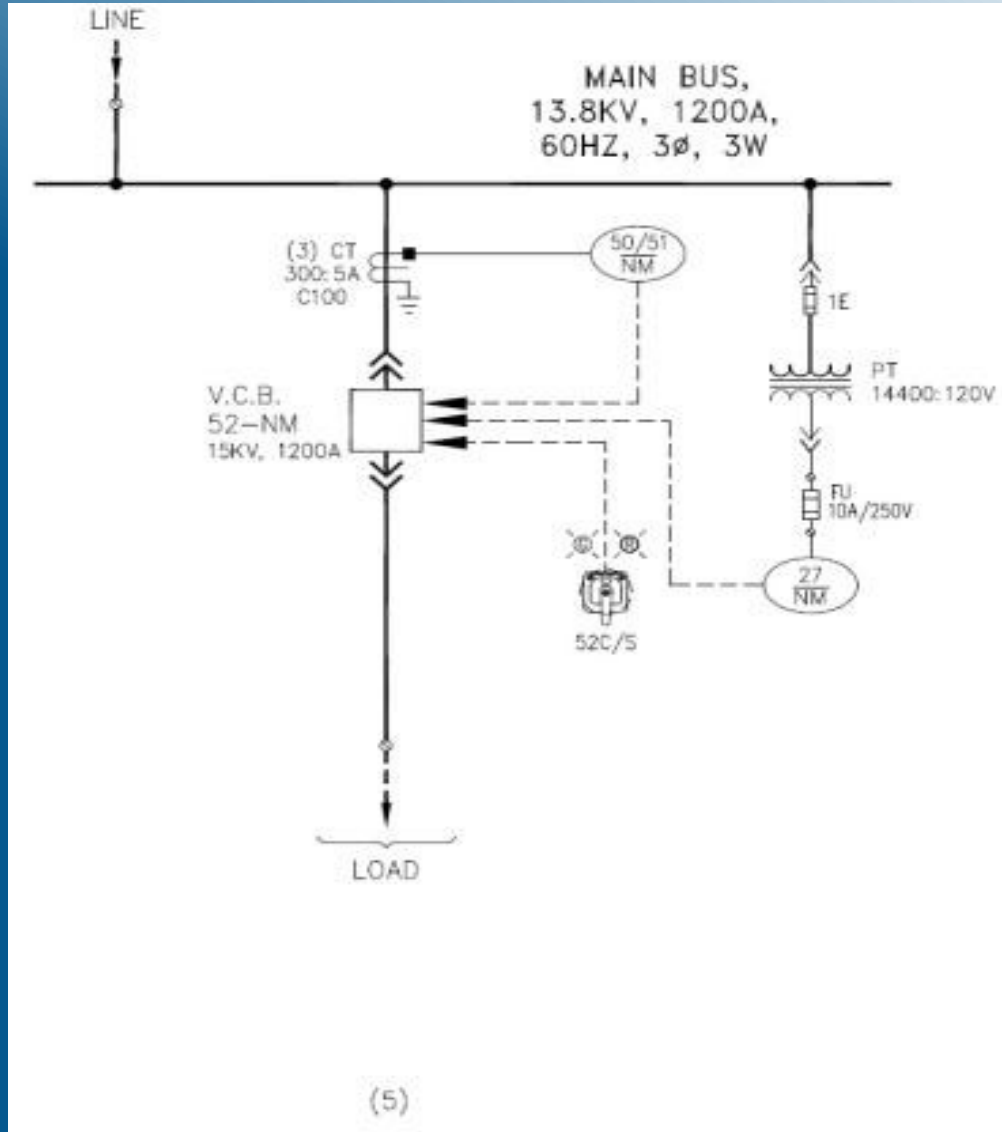
5.3 VOLTAGE TRANSFORMERS



5.4 VOLTAGE MONITORING



5.5 UNDERVOLTAGE TRIP

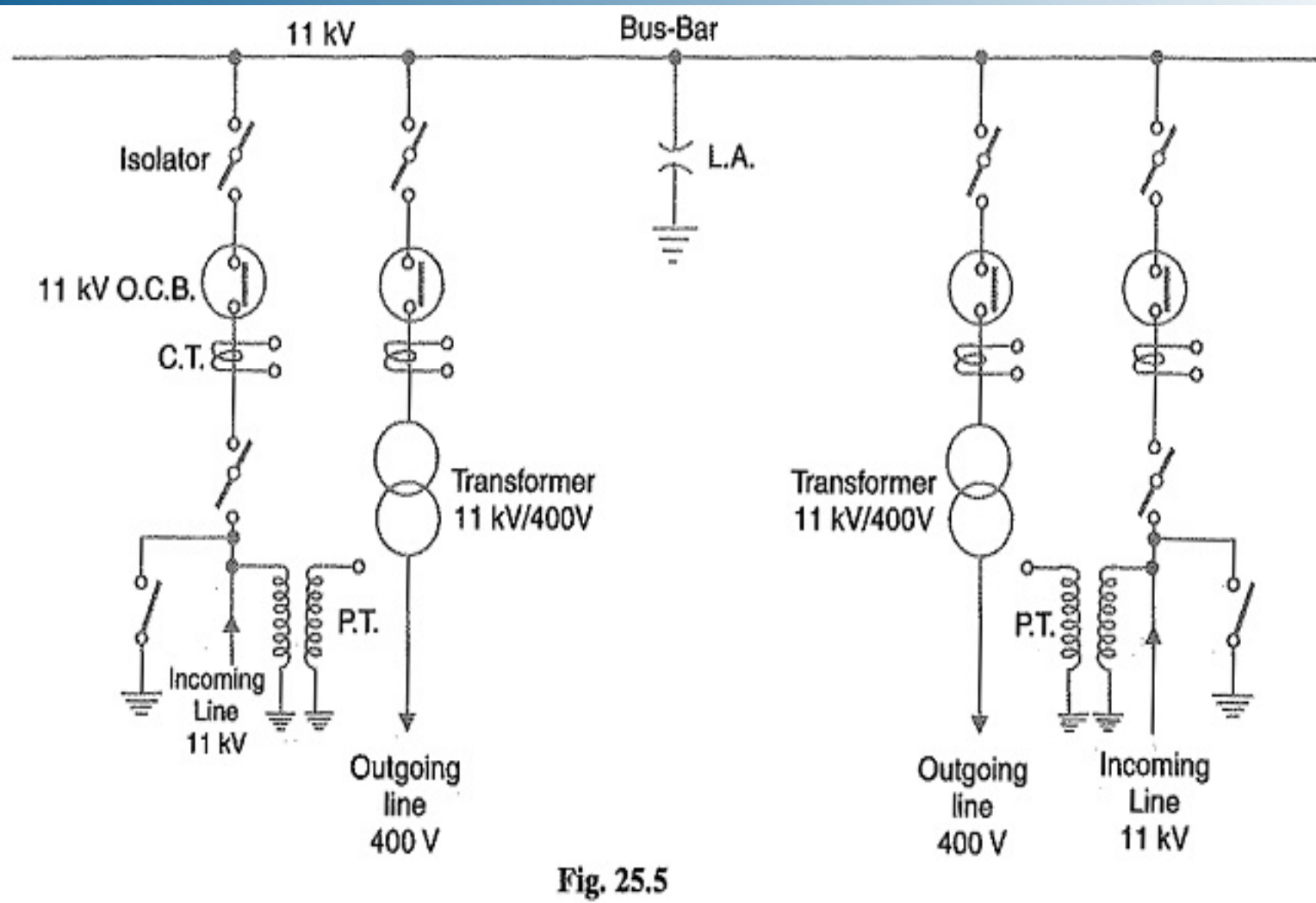


6. MAIN BUSBAR



This portion of the presentation is concerned with the MAIN BUSBAR portion of the Substation. The Main Busbar provides a common point of connection on the line side of the Electric Power Substation.

6.1 MAIN BUSBAR SINGLE LINE DIAGRAM



6.2 MAIN BUSBAR



6.3 MAIN BUSBAR



6.4 MAIN BUSBAR



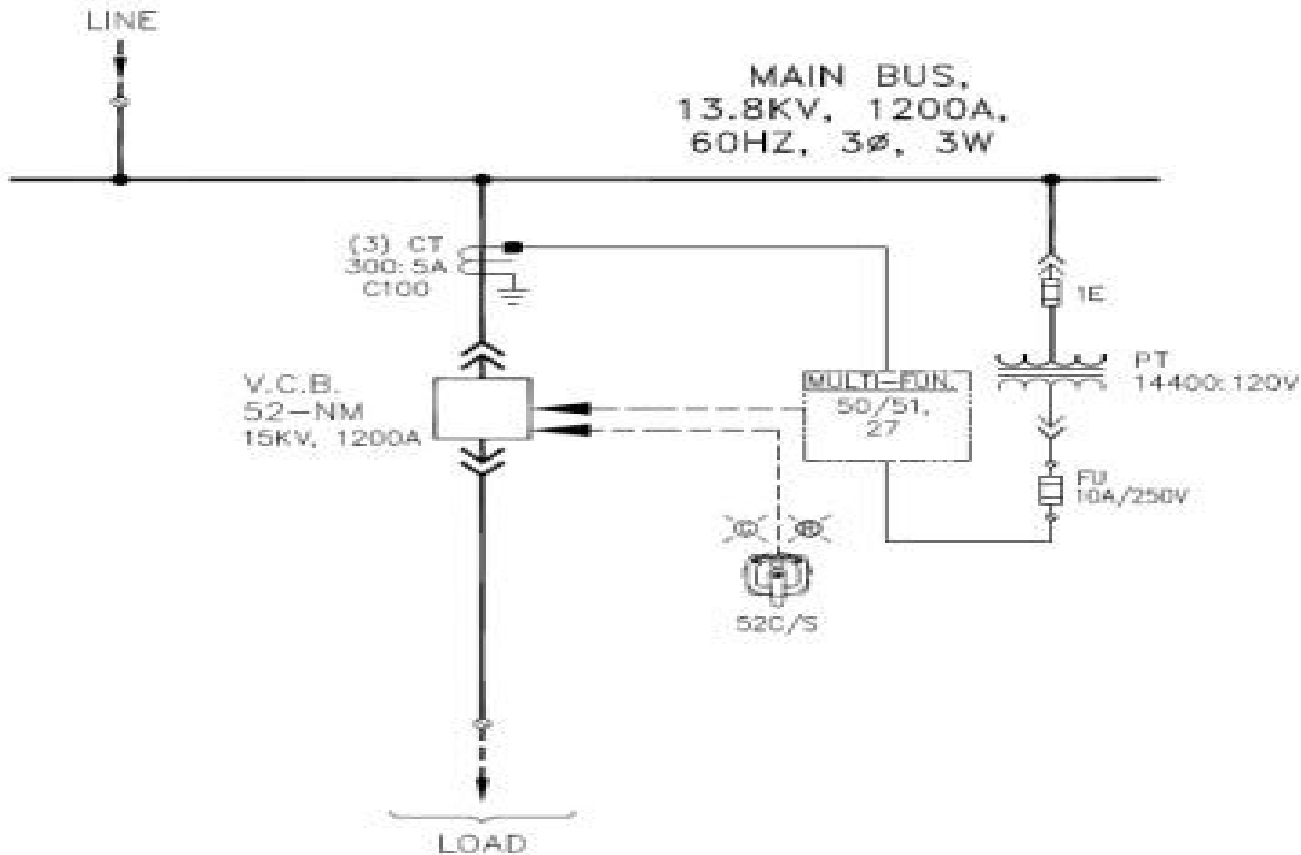
7. RELAYS AND SCADA SYSTEMS



This portion of the presentation is concerned with the SCADA (Supervisory Control and Data Acquisition) Systems. These system provide the control functions on the voltage and current on the line and load sides of the substation.

The relays are used to provide isolation in the event of the occurrence of a voltage or current fault.

7.1 MULTI-FUNCTION RELAY LINE DIAGRAM



7.2 MULTI-FUNCTION RELAY MODULE



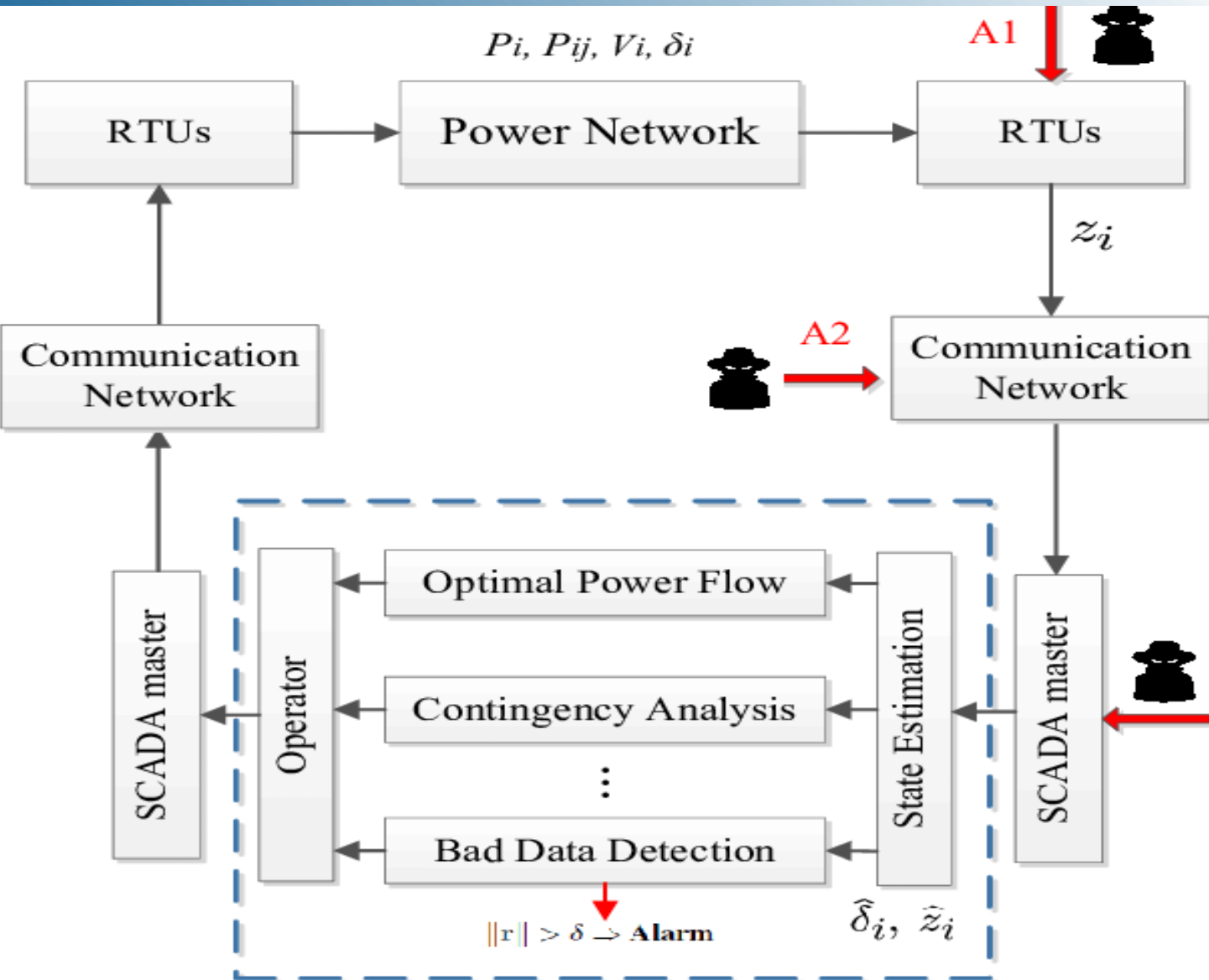
7.3 ELECTROMECHANICAL RELAY



7.4 POWER AND CURRENT MONITORING RACKS

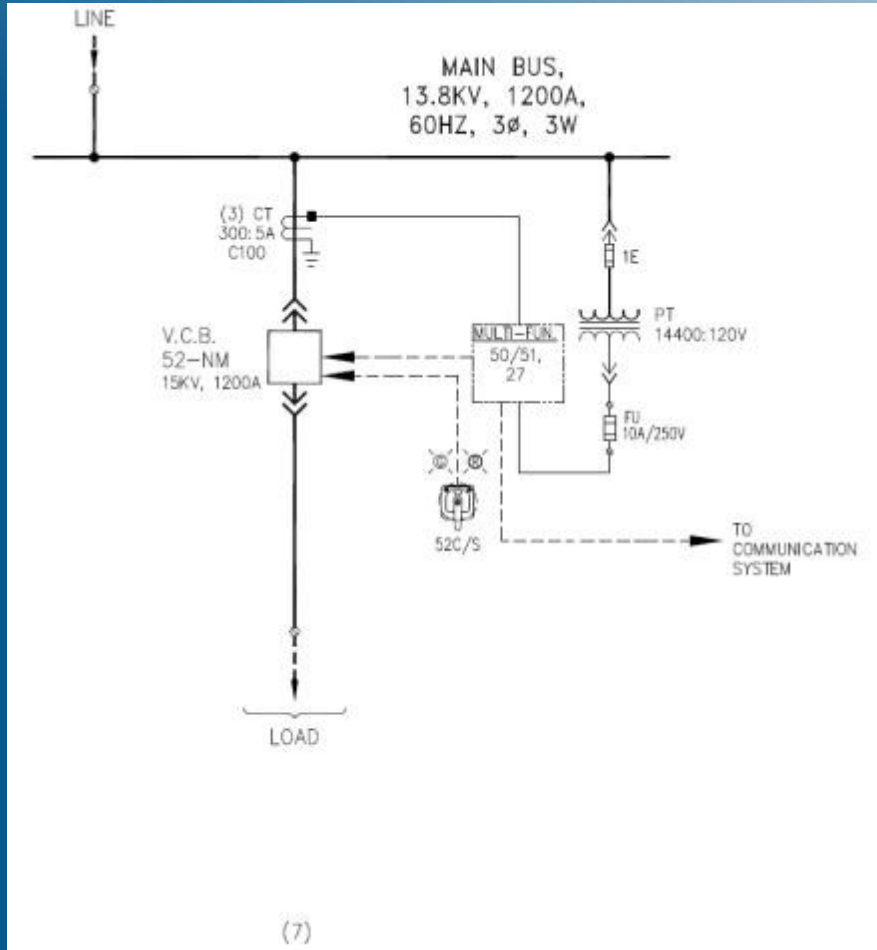


7.5 RELAYS AND SCADA SYSTEMS

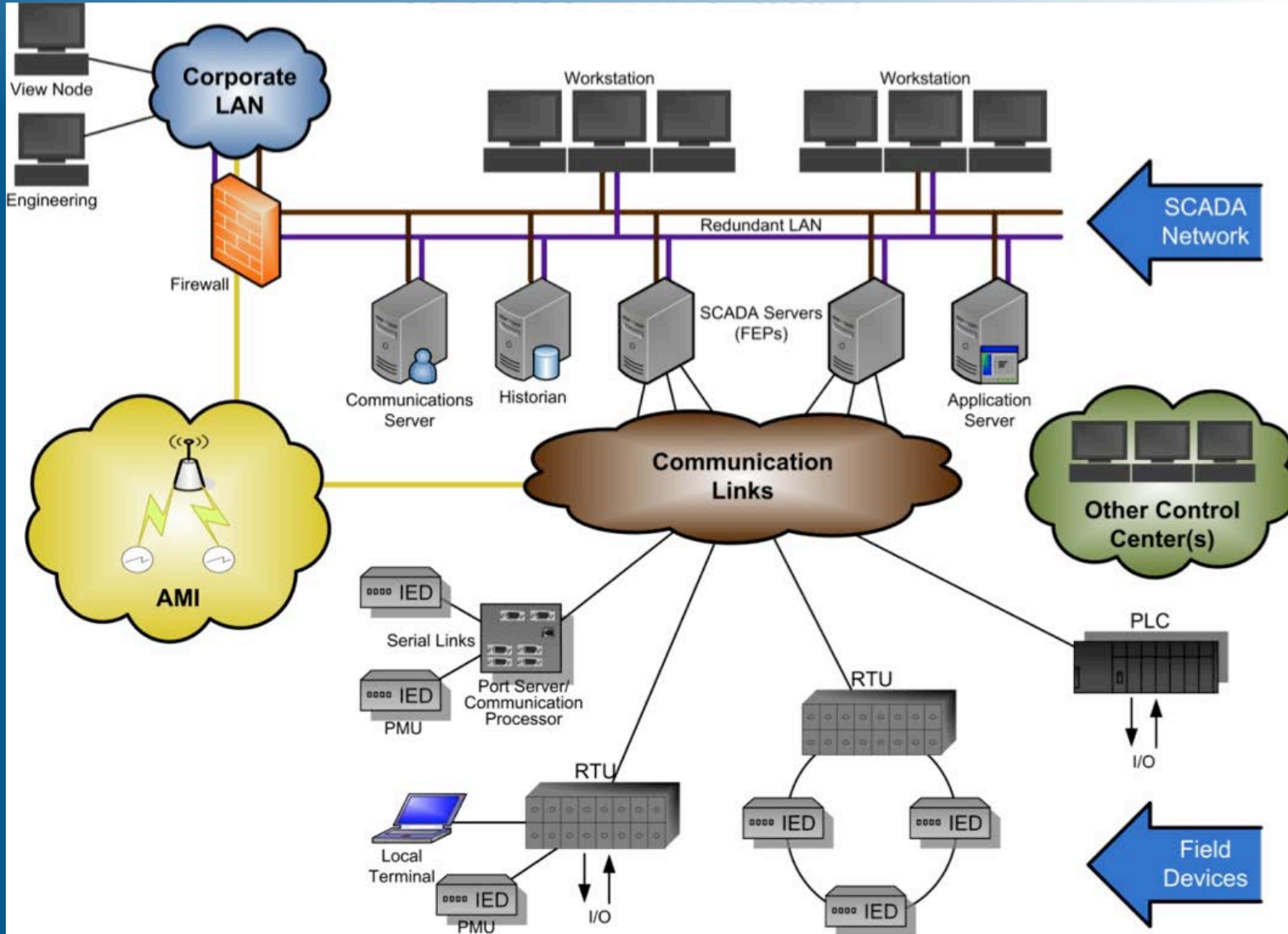


7.6 RELAYS AND SCADA SYSTEMS

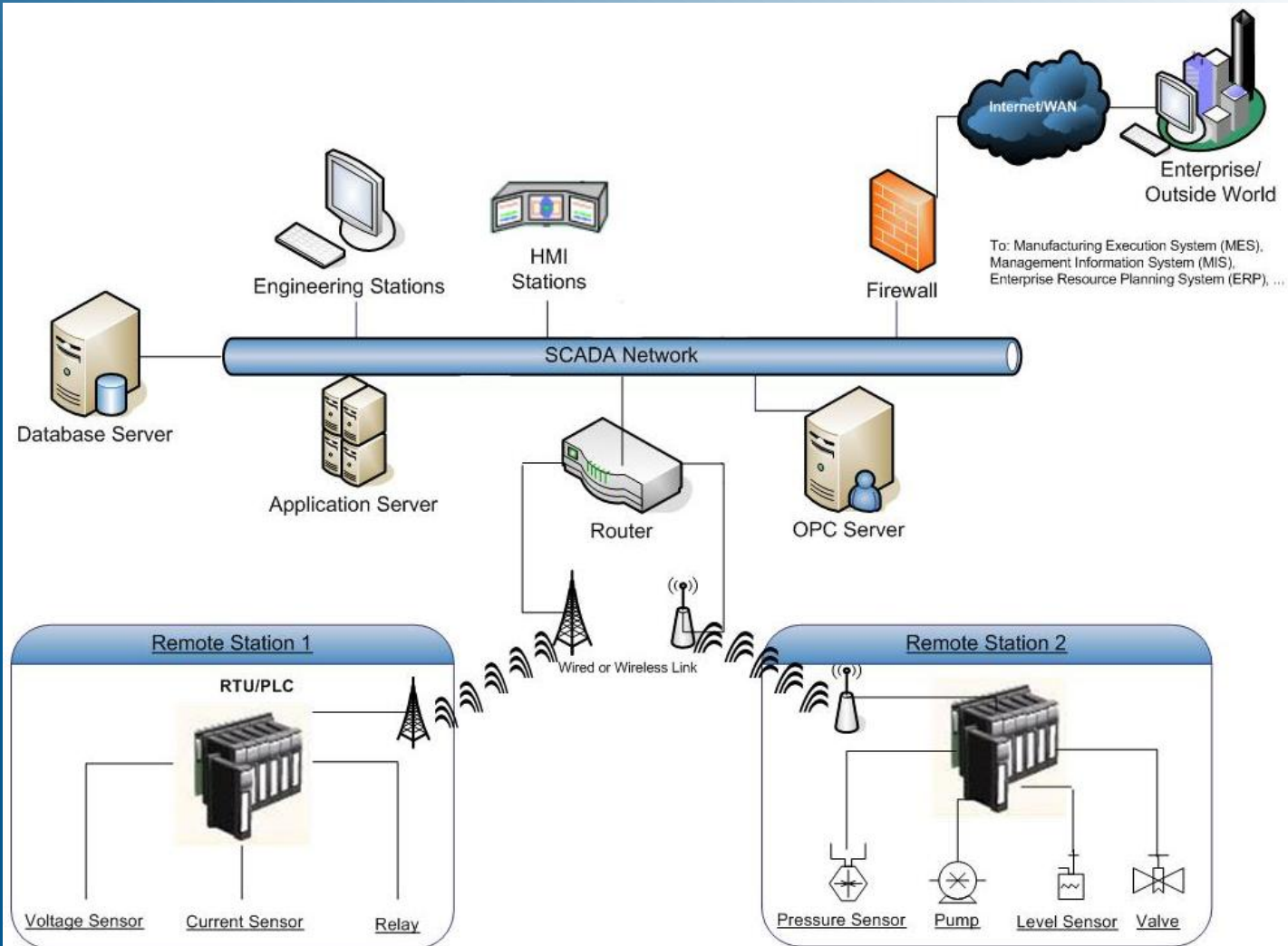
SINGLE LINE DIAGRAM



7.7 SCADA SYSTEM: LAYOUT



7.8 SUBSTATION SCADA SYSTEMS



OpenControl SCADA Network Architecture

7.9 REMOTE TERMINAL UNITS (RTU)



7.10 PLC FOR SUBSTATION SCADA SYSTEMS

Programmable Logic Controller



7.11 SUBSTATION PROGRAMMABLE LOGIC CONTROLLERS (RACK-MOUNTED)

