SCADA
(Supervisory Control and Data Acquisition)
Introduction

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SCADA- PREAMBLE

This Power Point Presentation is primarily an introduction to the components which make up a SCADA System and does not include the communication channels used by these components of the system.
This presentation does not introduce the protocols which are used by the components to communicate with each other and to the Central Host Computer.
This presentation does not cover any of the specific application for which SCADA is well known. We do not address any of the weaknesses of the SCADA System itself.

SCADA- Introduction One

SCADA is an acronym for Supervisory Control and Data Acquisition.

- SCADA systems are very important in the monitoring and controlling of the ELECTRICAL INFRASTRUCTURE commonly referred as the GRID.
- SCADA systems are also used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation.
- These systems encompass the transfer of data between a SCADA central host computer and a number of **Remote Terminal Units** (RTUs), **Programmable Logic Controllers** (PLCs), **Intelligent Electronic Devices** (IEDs) **Phasor Measuring Unit** (PMUs), and the central host and the operator terminals.
- SCADA system are used to monitor and control all aspects of the production facilities, substations, transmission lines and distribution facilities.

SCADA- Introduction Two

- A SCADA system gathers information (such as where a leak on a pipeline has occurred), transfers the information back to a central site, then alerts the home station that a leak has occurred.
- Today many systems are monitored using the infrastructure of the corporate Local Area Network (LAN)/Wide Area Network (WAN).
- Wireless technologies are now being widely deployed for purposes of monitoring.

Example processes include industrial, infrastructure, and facility-based processes, as described below:

- Industrial processes include manufacturing, process control, power generation, fabrication, and refining, and may run in continuous, batch, repetitive, or discrete modes.
- Infrastructure processes may be public or private, and include water treatment and distribution, wastewater collection and treatment, oil and gas pipelines, electric power transmission and distribution, wind farms and Solar .

SCADA- Introduction Three

SCADA systems consist of:

- One or more field data interface devices, usually RTUs, or PLCs, which interface to field sensing devices and local control switchboxes and valve actuators
- A communications system used to transfer data between field data interface devices and control units and the computers in the SCADA central host. The system can be radio, telephone, cable, satellite, etc., or any combination of these.
- A central host computer server or servers (sometimes called a SCADA Center, master station, or Master Terminal Unit (MTU)
- A collection of standard and/or custom software [sometimes called Human Machine Interface (HMI) software or Man Machine Interface (MMI) software] systems used to provide the SCADA central host and operator terminal application, support the communications system, and monitor and control remotely located field data interface devices

SCADA FUNCTIONS

- Data acquisition
  - Analog and discrete values
- Event and alarm processing
  - Event and alarm
- Control
  - Tap changer
  - Shut capacitor/reactor
  - Switching devices
  - Generator excitation (AGC)
- Data storage, archiving and analysis

SCADA
Introduction Summary

Supervisory Control And Data Acquisition

- Collect measurements and status data from the process
- Remotely intervene in the process
- Centralized system platform
- Based on distributed I/O

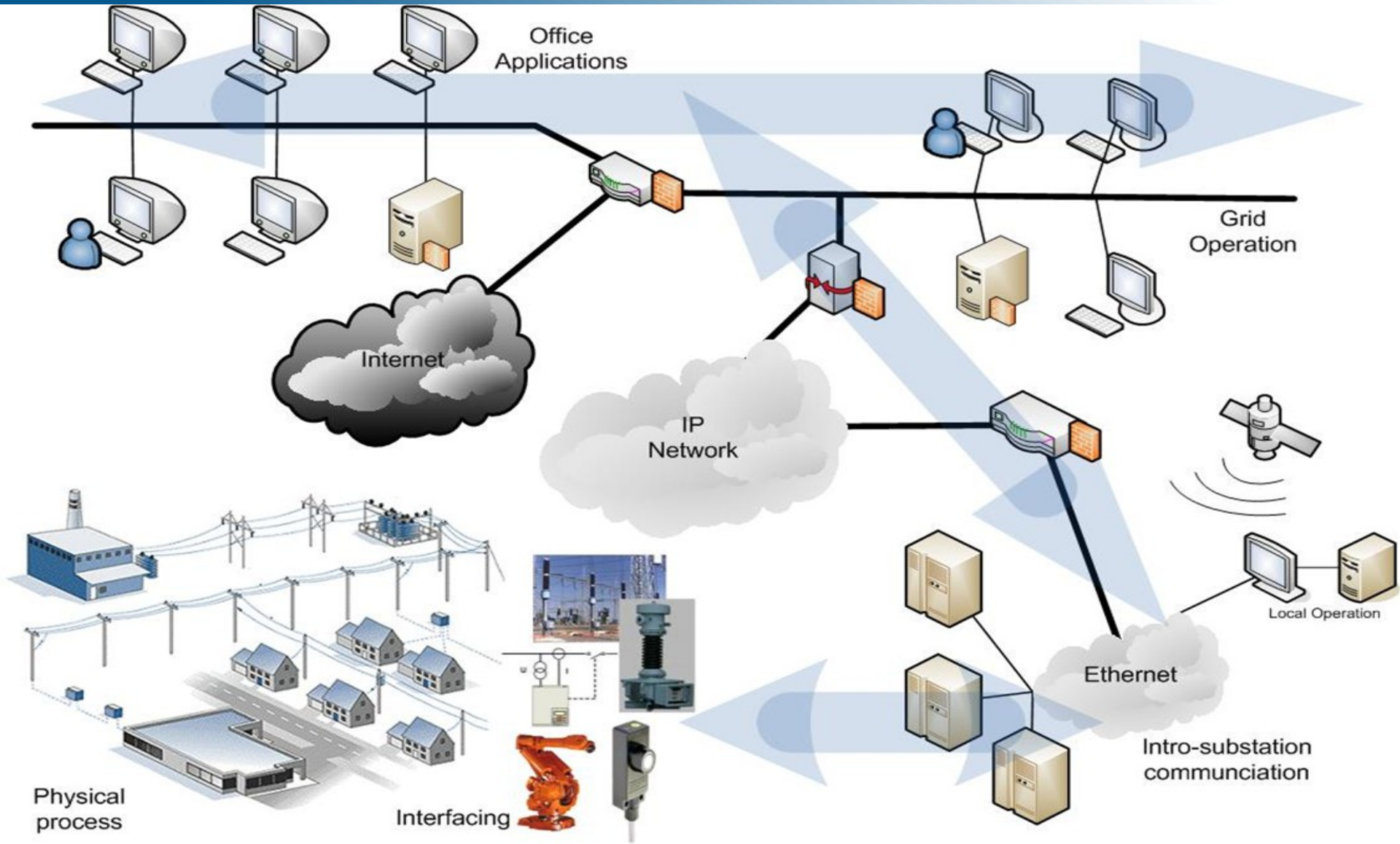
Applicable Processes

- Nuclear, Gas, Hydro generation plants
- Transmission System Operators (TSO)
- Transmission lines, substations, distribution station
- Oil or Gas production facilities
- Pipelines for gas, oils, chemicals or water.
- Railway/Transportation Process
- Sewer and water Infrastructure

EVOLUTION OF SCADA IN POWER SYSTEM

- Originally electrical power units used electro-mechanical automation
- Dial-up modems used for remote access
- In 1970s computer-based SCADA commenced
- Suppliers (e.g. IBM, Siemens, GE) supplied complete proprietary systems
- More advanced with client-server computers
- Advanced functions became common (e.g. EMS. DMS, load forecasting, dispatch, protection engineering, regulatory reporting, etc)
- Communication link evolved from noisy narrow bandwidth telephone lines to sonet, Microwave, radio, power line carrier, cellular networks

SCADA- Pictorial Overview



SCADA- Hardware and Firmware-One

Complex SCADA Systems such as those used in controlling the Electrical Generation and distribution systems contain essentially five levels in their hierarchies:

- Field level instrumentation and control devices
- Marshalling terminals and Remote Terminal Units (RTUs)
- Communication Systems
- Master Station
- The commercial data processing department computer system

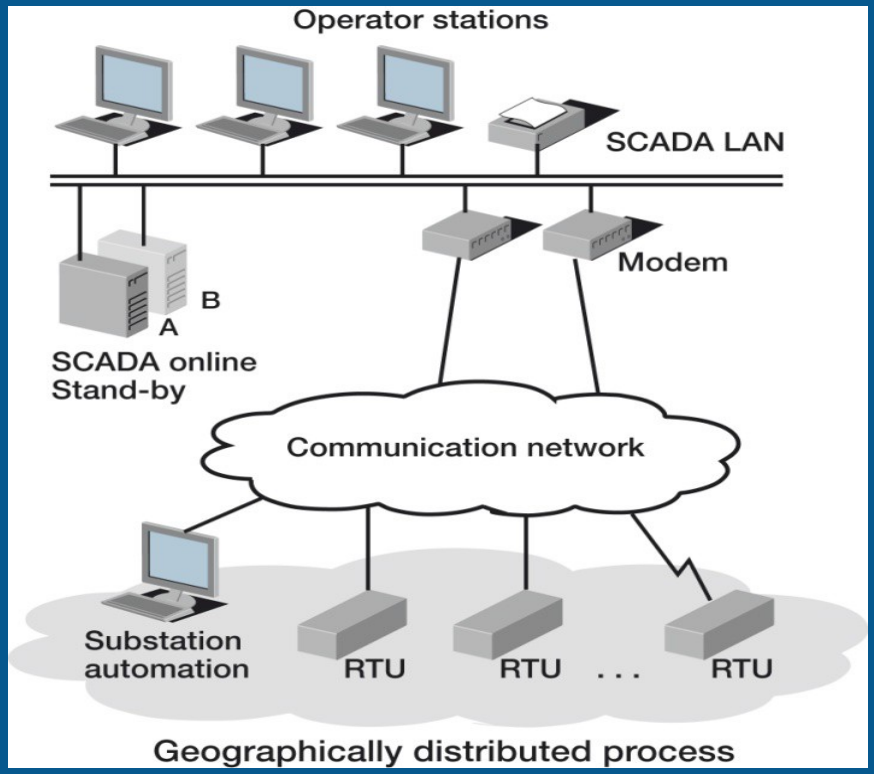
SCADA- Hardware and Firmware-Two

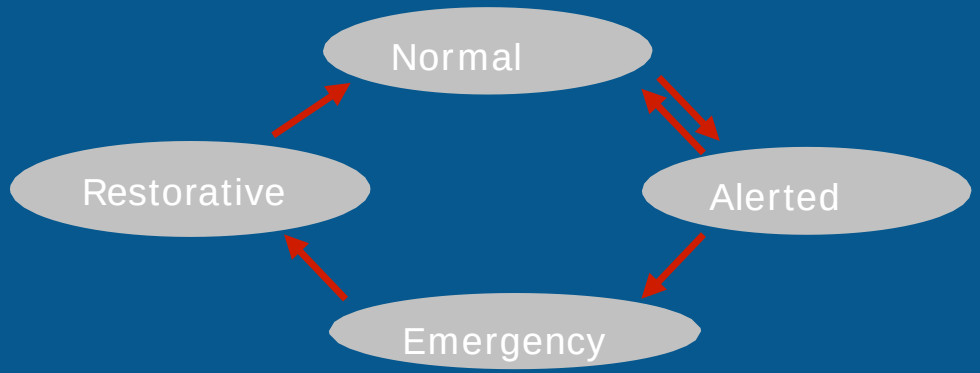
Complex SCADA Systems such as those used in controlling the Electrical Generation and distribution systems contain the following Subsystems:

- Remote Terminal Units (RTUs)
- Programmable Logic Controllers (PLCs)
- Intelligent Electronic Devices (IEDs)
- Phasor Measurement Units (PMUs)
- Communication Systems: Modern SCADA uses mostly the TCP/IP (Internet) Protocol
- Master Station AND Human Machine Interface (HMI)
- The commercial data processing department computer system

POWER SYSTEM OPERATION

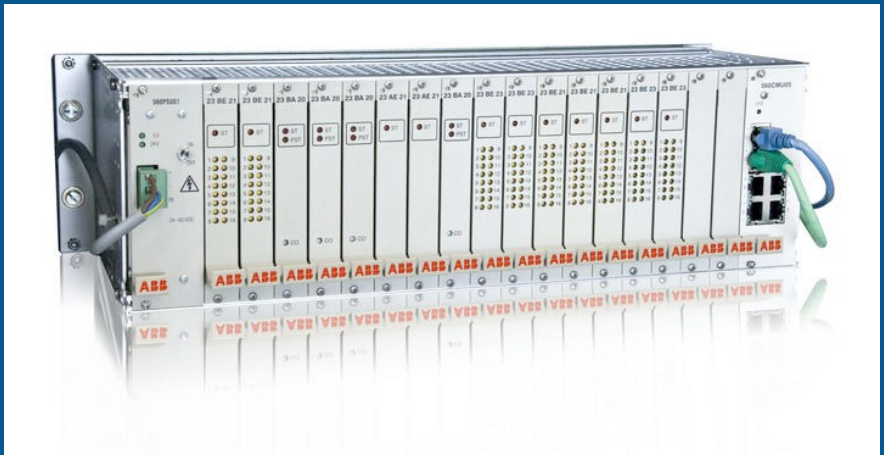
- System-wide monitoring, planning & optimisation for reliable and cost efficient operation of the power system
- Time scale: seconds to hours.





REMOTE TERMINAL UNIT

- A remote terminal unit (RTU) is a microprocessors- controlled electronic device that interfaces objects in the physical world to a distributed control systems or SCADA by transmitting telemetry data to the system, and by using messages from the supervisory system to control connected objects.



REMOTE TERMINAL UNIT

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REMOTE TERMINAL UNIT

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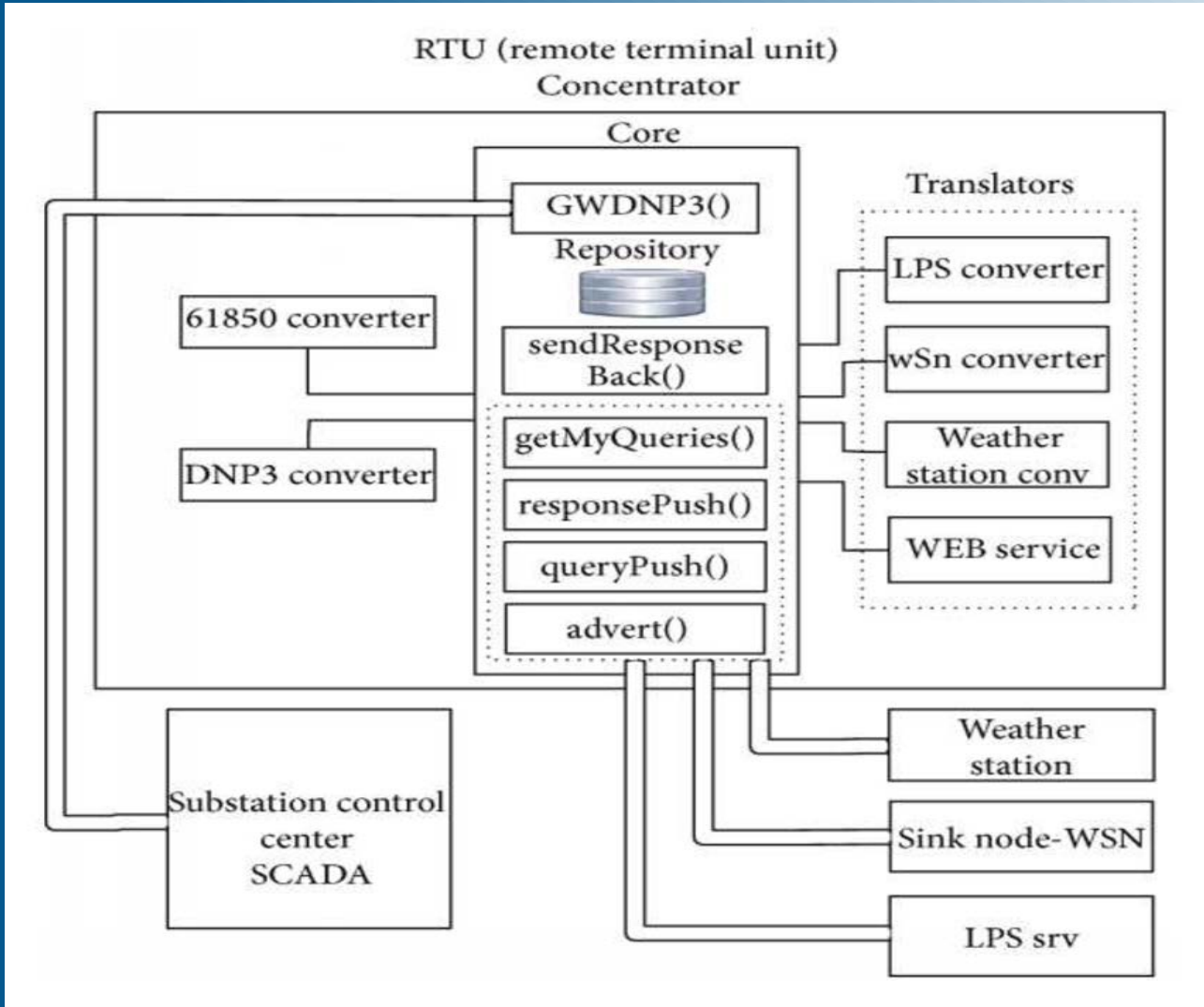
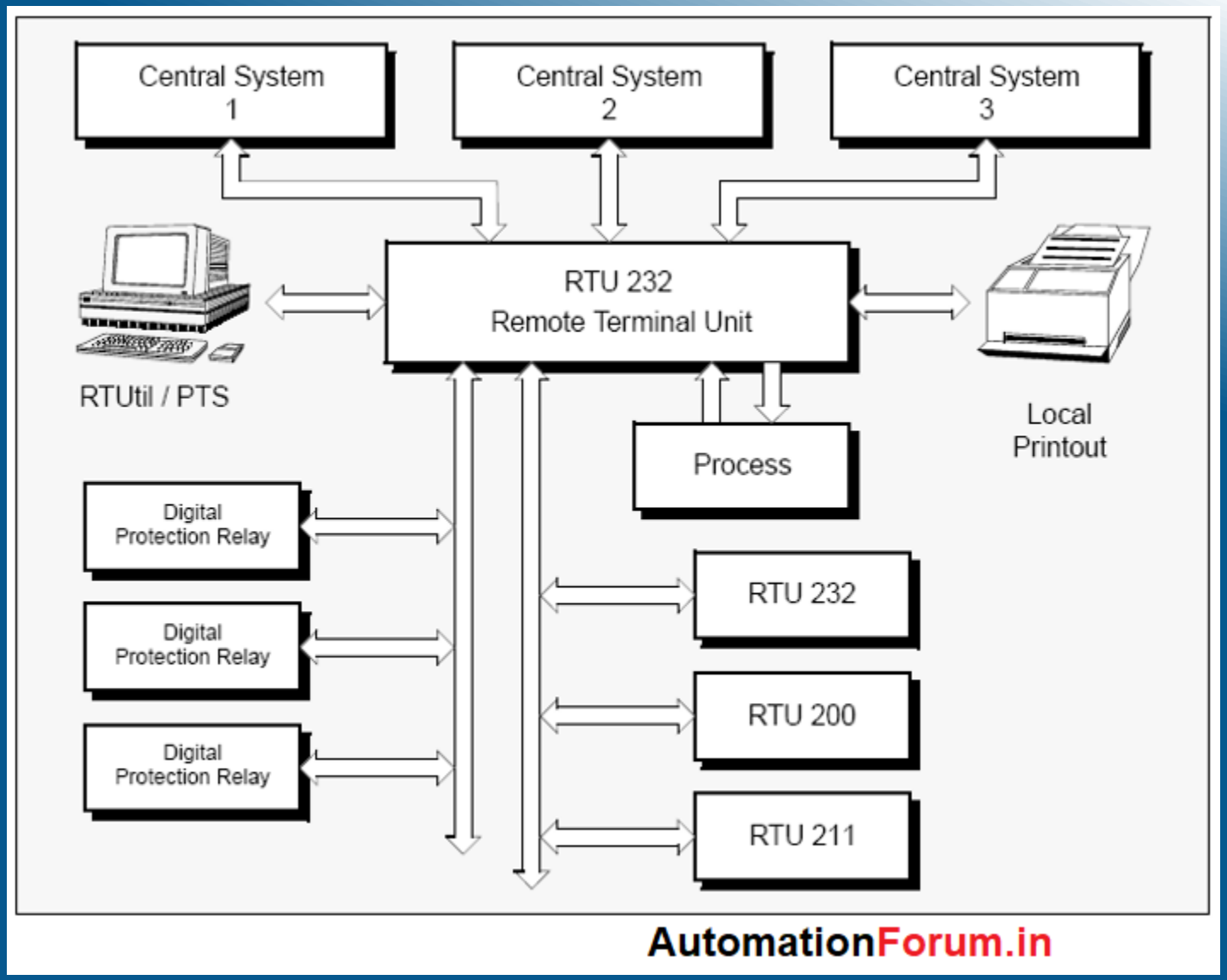
REMOTE TERMINAL UNIT: SCHEMATIC LAYOUT ONE



REMOTE TERMINAL UNIT: SCHEMATIC LAYOUT TWO



PROGRAMMABLE LOGIC CONTROLLER

A **programmable logic controller** (**PLC**) or **programmable controller** is an industrial computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, machines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis. The PLC provided several advantages over earlier automation systems. It tolerated the industrial environment better than computers and was more reliable, compact and required less maintenance than relay systems. It was easily extensible with additional I/O modules, while relay systems required complicated hardware changes in case of reconfiguration. This allowed for easier iteration over manufacturing process design.

PROGRAMMABLE LOGIC CONTROLLER

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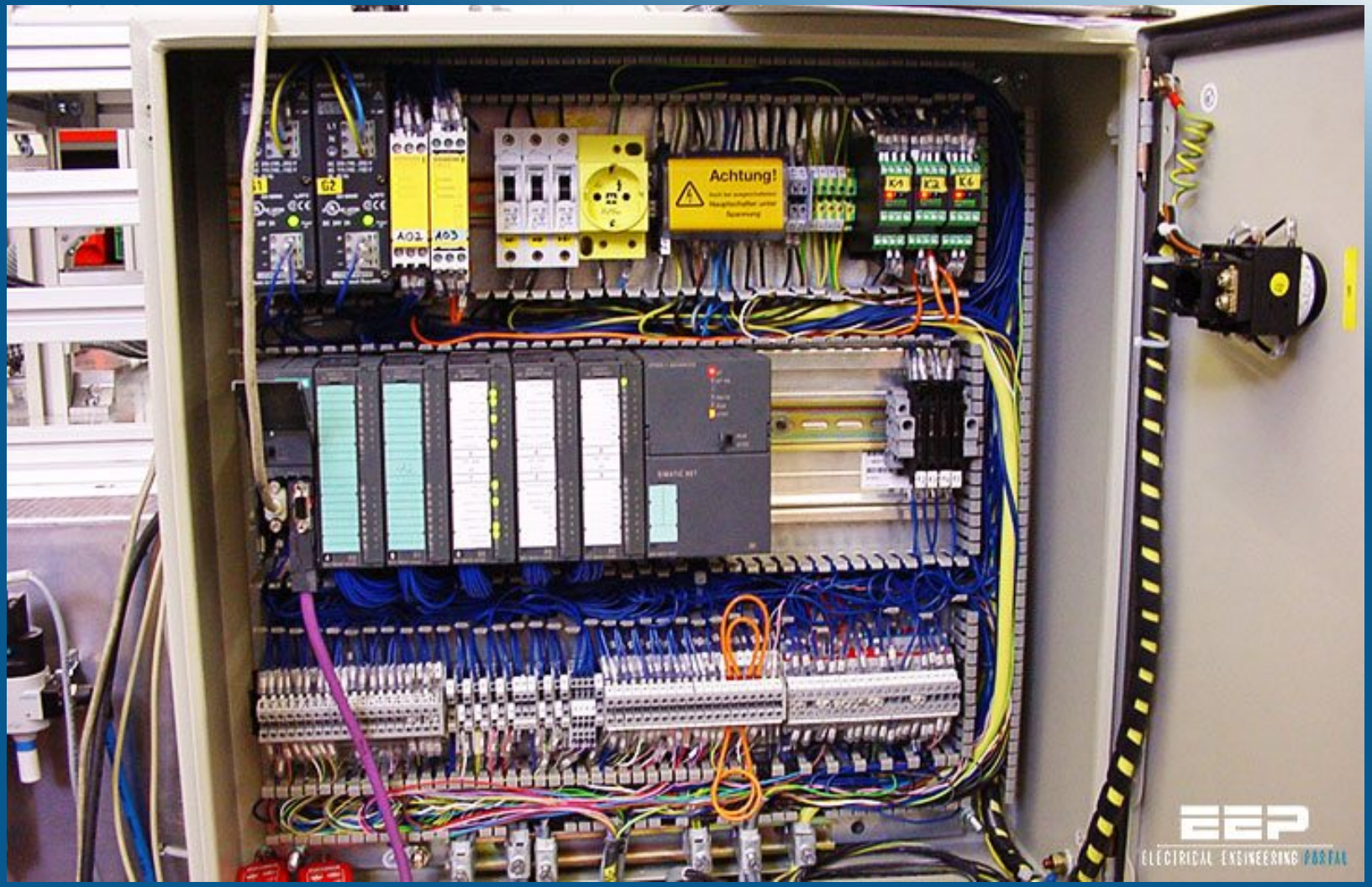

PROGRAMMABLE LOGIC CONTROLLER

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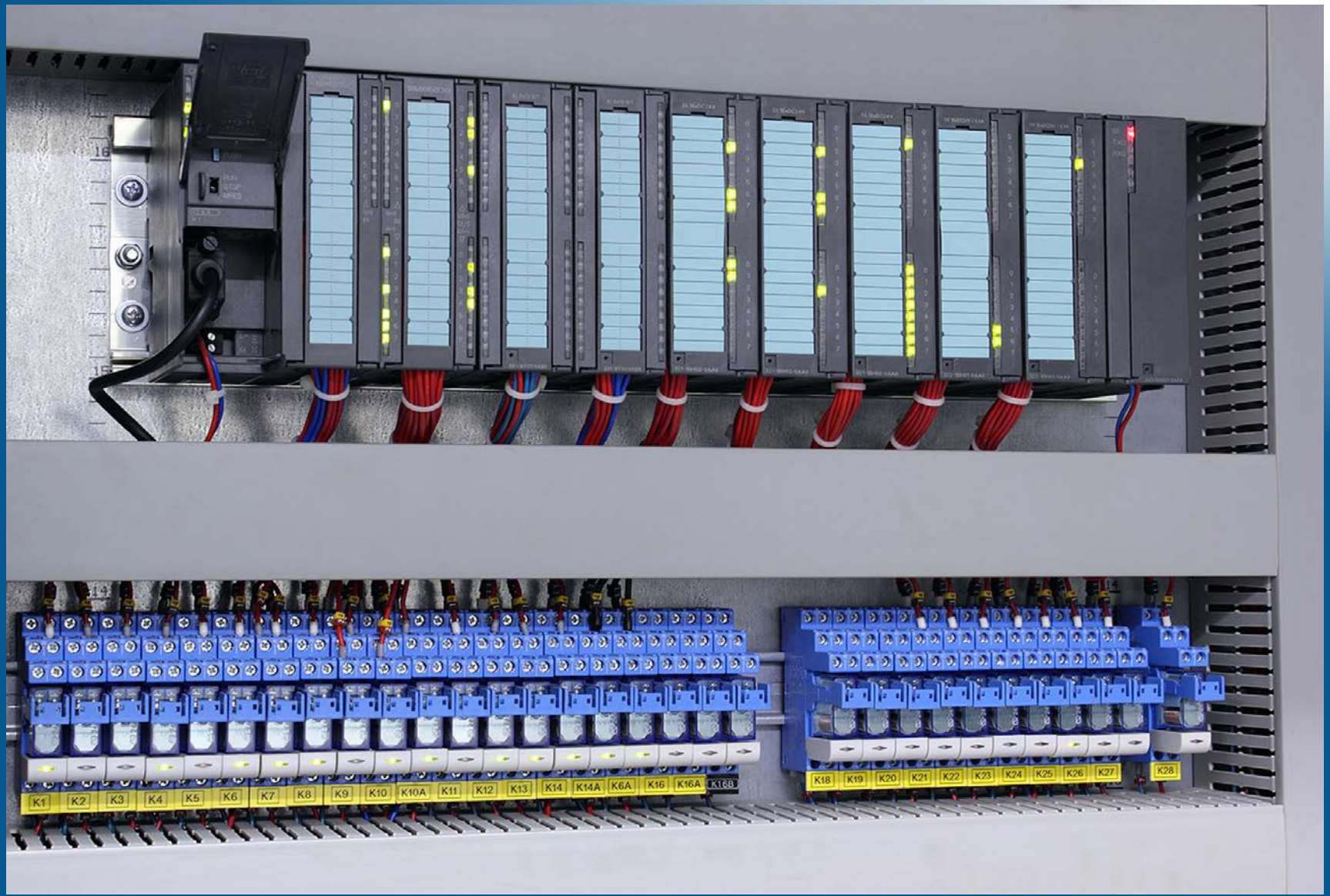
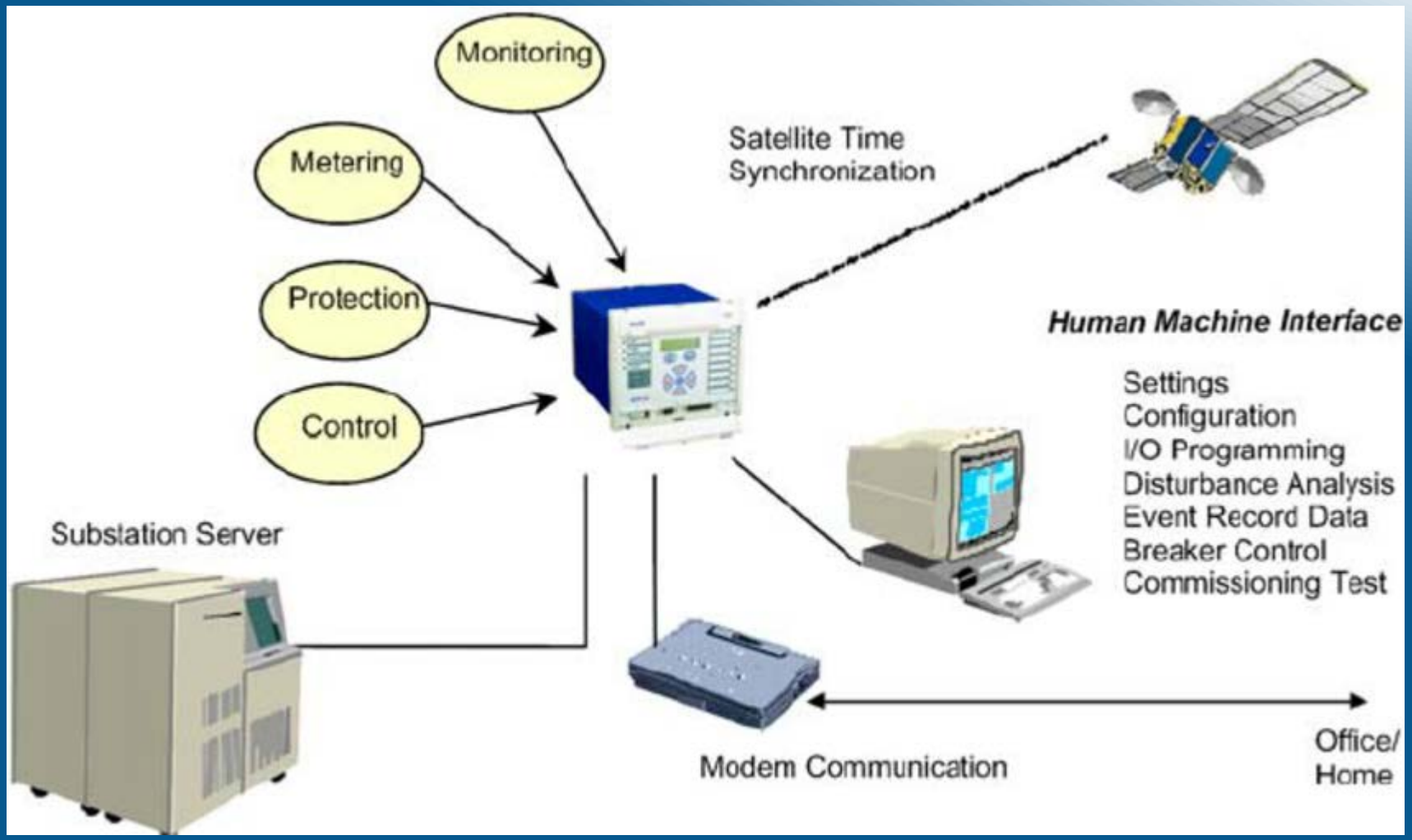


Intelligent Electronic Device

IEDs receive data from sensors and power equipment and can issue control commands, such as tripping circuit breakers if they sense voltage, current, or frequency anomalies, or raise/lower tap positions in order to maintain the desired voltage level. Common types of IEDs include protective relaying devices, tap changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators etc. This is generally controlled by a setting file. The testing of setting files is typically one of the most time-consuming roles of a protection tester.

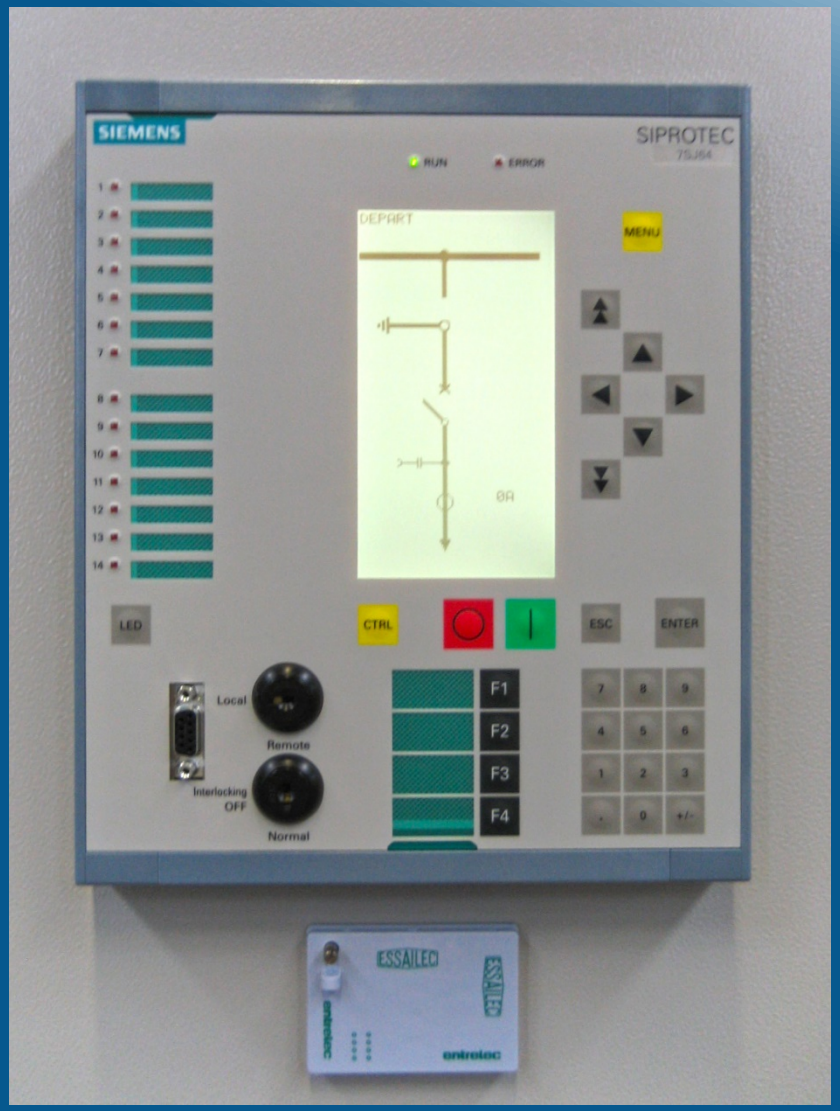
IEDs are used as a more modern alternative to, or a complement of, setup with traditional remote terminal units (RTUs). Unlike the RTUs, IEDs are integrated with the devices they control and offer a standardized set of measuring and control points that is easier to configure and require less wiring. Most IEDs have a communication port and built-in support for standard communication protocols (DNP3, IEC104 or IEC61850), so they can communicate directly with the SCADA system or a substation programmable logic controller. Alternatively, they can be connected to a substation RTU that acts as a gateway towards the SCADA server.[2]

Intelligent Electronic Device



Intelligent Electronic Device

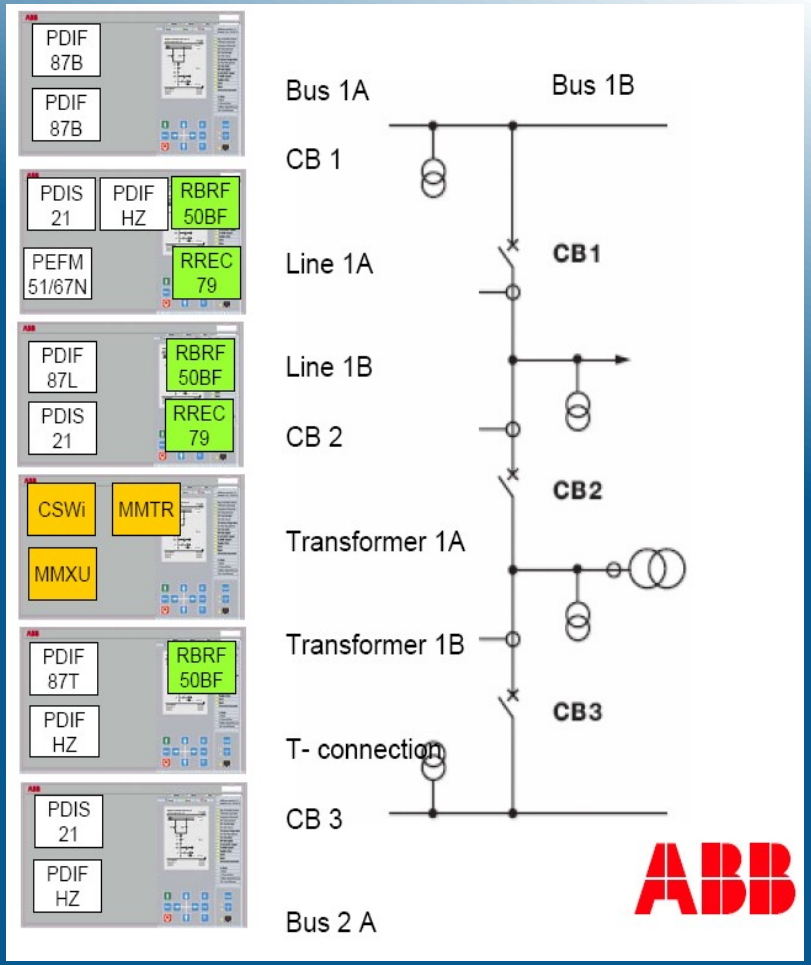
Intelligent Electronic Device



Intelligent Electronic Device

EXAMPLE – FAULT INITIATING EVENT

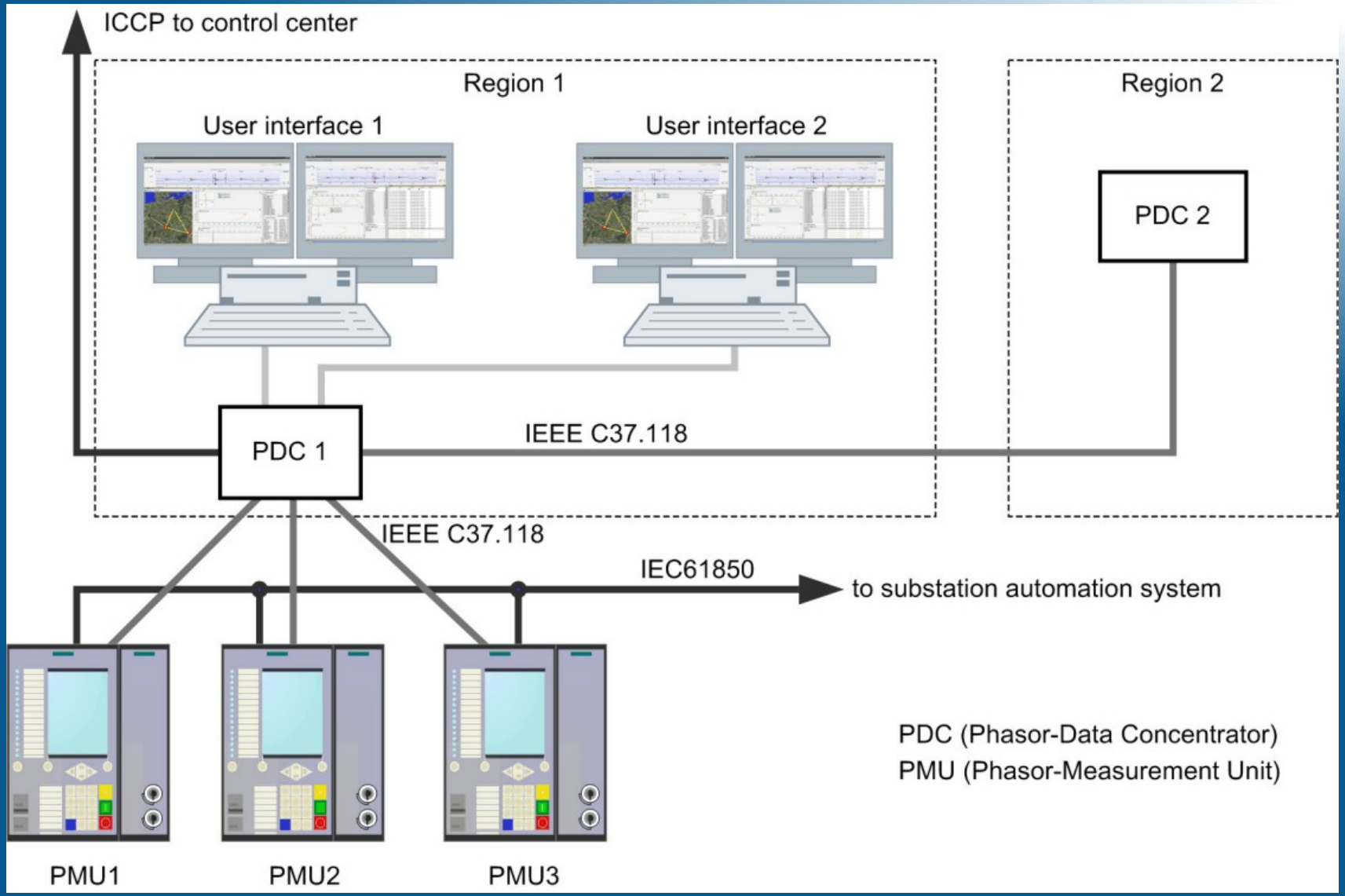
- Step-up transformer insulation fault
- Fault is detected by protection system
- Trip signal sent to breaker to disconnect generator



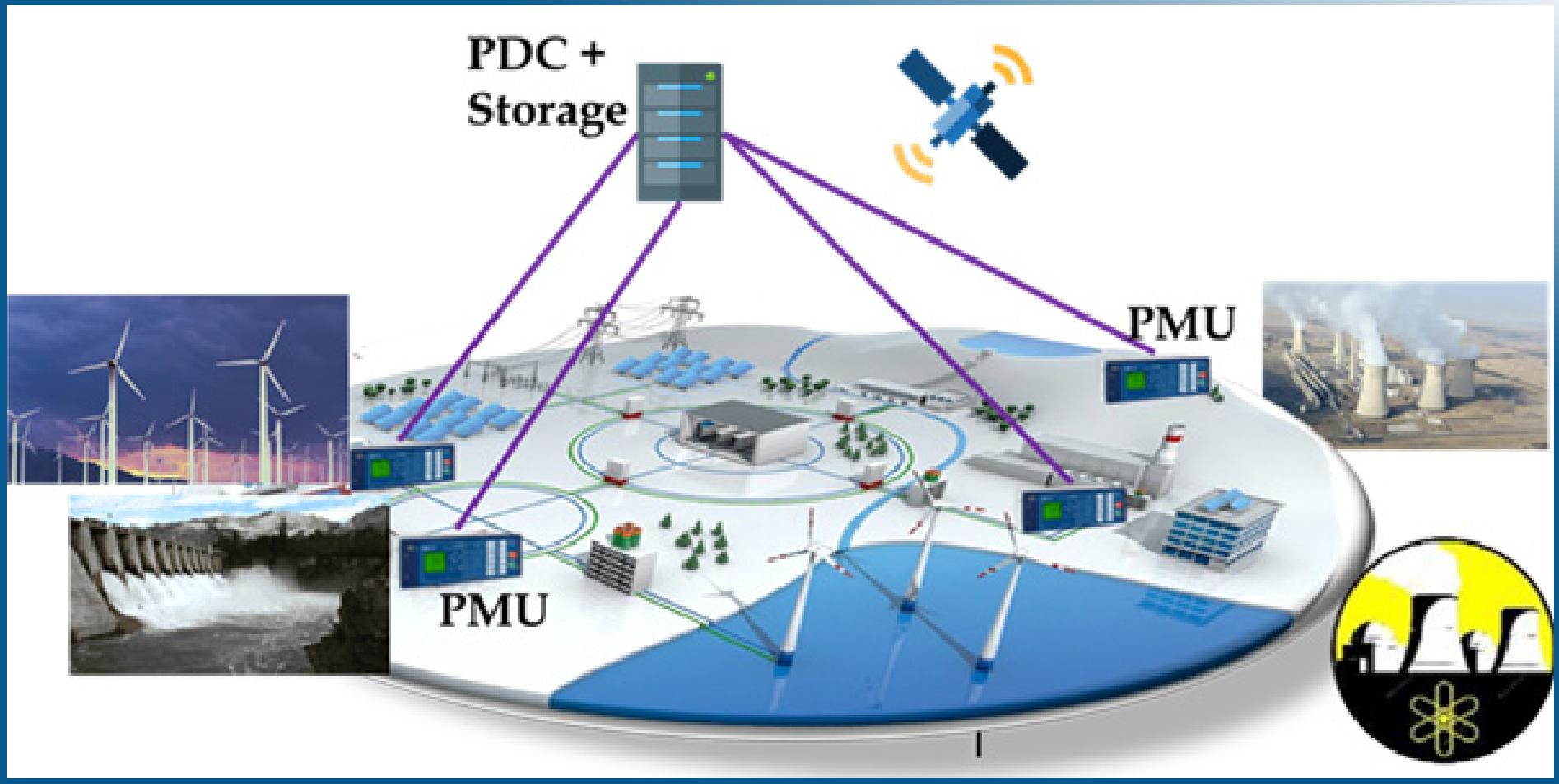
PHASOR MEASUREMENT UNIT

A **phasor measurement unit** (PMU) is a device used to estimate the magnitude and phase angle of an electrical phasor quantity (such as voltage or current) in the electricity grid using a common time source for synchronization. Time synchronization is usually provided by GPS or IEEE 1588 Precision Time Protocol, which allows synchronized real-time measurements of multiple remote points on the grid. PMUs are capable of capturing samples from a waveform in quick succession and reconstructing the phasor quantity, made up of an angle measurement and a magnitude measurement. The resulting measurement is known as a **synchrophasor**

PHASOR MEASUREMENT UNIT



PHASOR MEASUREMENT UNIT



PHASOR MEASUREMENT UNIT

PHASOR MEASUREMENT UNIT

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CENTRAL HOST COMPUTER

The supervisory computer is the core of the SCADA system, gathering data on the process and sending control commands to the field connected devices. It refers to the computer and software responsible for communicating with the field connection controllers, which are RTUs and PLCs, and includes the HMI software running on operator workstations. In smaller SCADA systems, the supervisory computer may be composed of a single PC, in which case the HMI is a part of this computer. In larger SCADA systems, the master station may include several HMIs hosted on client computers, multiple servers for data acquisition, distributed software applications, and disaster recovery sites. To increase the integrity of the system the multiple servers will often be configured in a dual-redundant or hot-standby formation providing continuous control and monitoring in the event of a server malfunction or breakdown.

APPLICATION SERVERS

- Application servers provide the computing platform for the SCADA System, included servers are:
  - Real-time database
  - Historical database
  - Energy Management applications
    - State Estimation
    - Optimal/Dispatcher Powerflow
    - Voltage Stability Assessment
    - Etc….
  - Geographic Information Systems
    - Distribution Management

APPLICATION SERVERS

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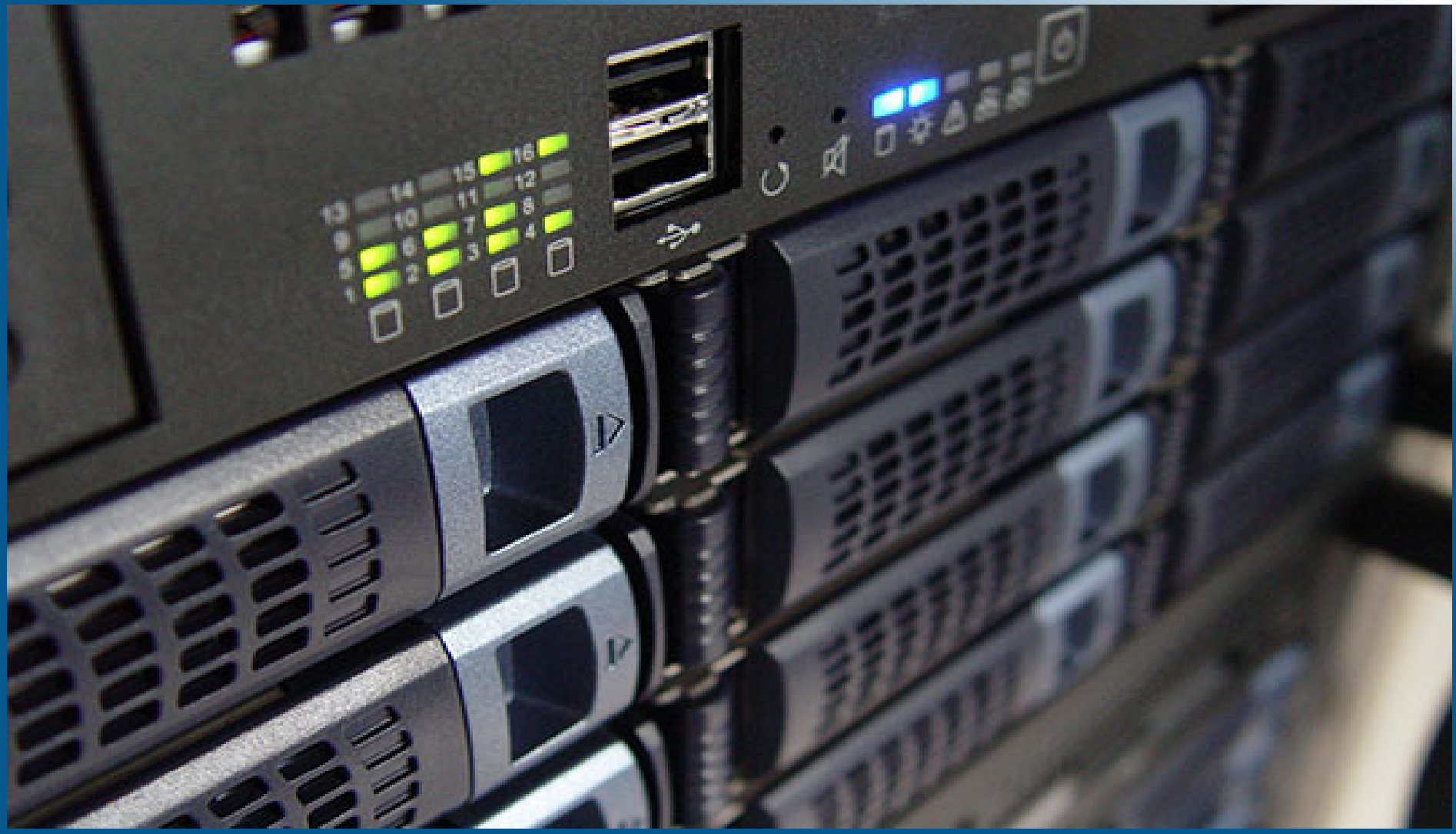

APPLICATION SERVERS

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HUMAN MACHINE INTERFACE - HMI

The human-machine interface (HMI) is the operator window of the supervisory system. It presents grid status information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of those subsystems of the GRID being controlled, and alarm and event logging pages. The HMI is linked to the SCADA supervisory computer to provide live data to drive the mimic diagrams, alarm displays and trending graphs. In many installations the HMI is the graphical user interface for the operator, collects all data from external devices, creates reports, performs alarming, sends notifications, etc. Mimic diagrams consist of line graphics and schematic symbols to represent process elements, or may consist of digital photographs of the process equipment overlain with animated symbols.

Supervisory operation of the SYSTEM is by means of the HMI, with operators issuing commands using mouse pointers, keyboards and touch screens. For example, a symbol of a pump can show the operator that the pump is running, and a flow meter symbol can show how much fluid it is pumping through the pipe. The operator can switch the pump off from the mimic by a mouse click or screen touch. The HMI will show the flow rate of the fluid in the pipe decrease in real time.

HUMAN MACHINE INTERFACE - HMI

play the motor status, tripe & warning alert information is shown in fig 1.

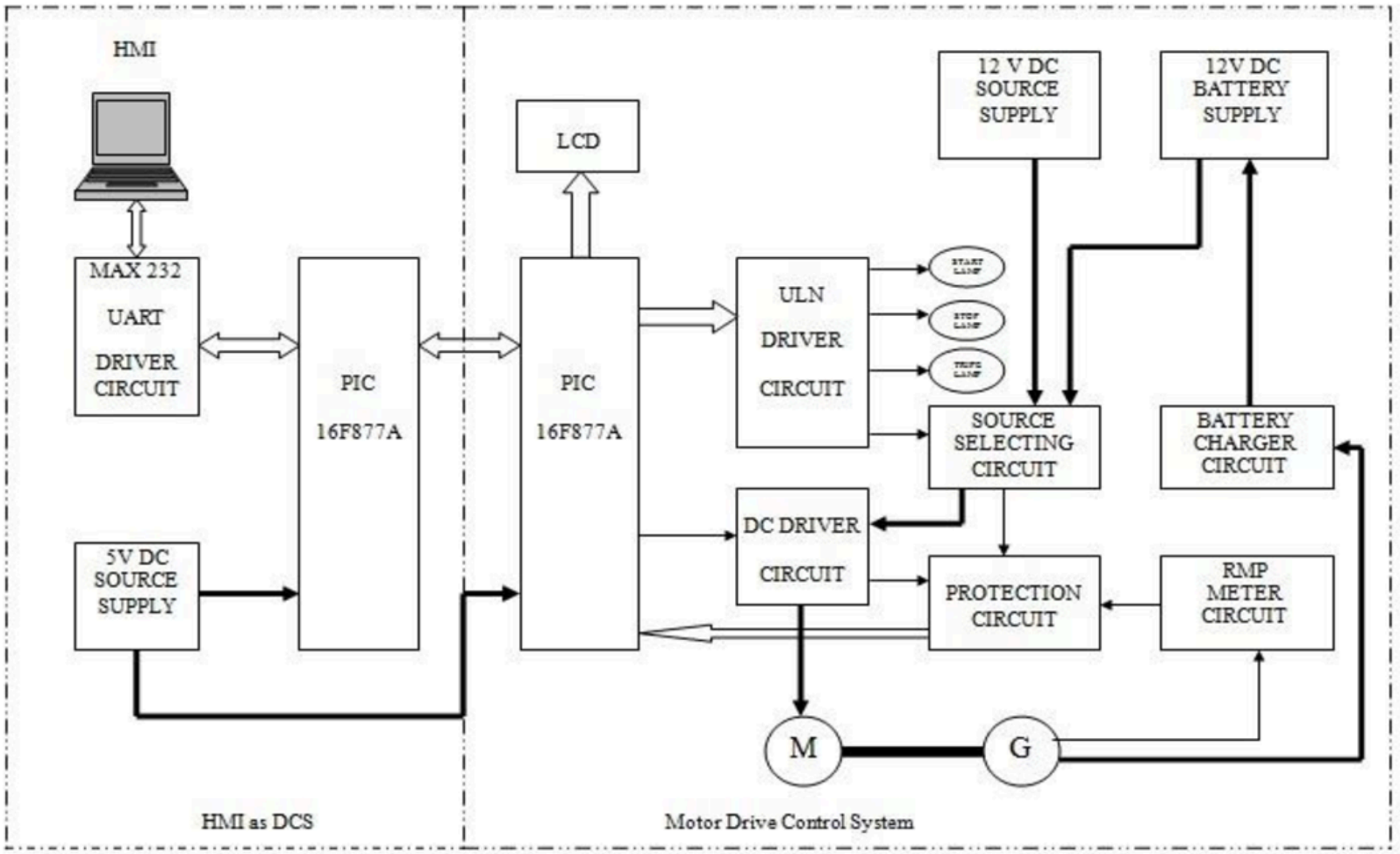
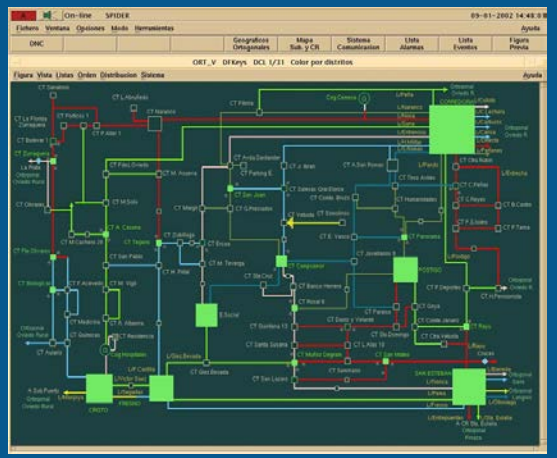


Fig. 1: Block diagram of Human Machine Interface

6F 877A MCU:

HUMAN MACHINE INTERFACE - HMI

- Communication between operator and machine
- Input
  - Mouse, keyboard, touch screen
- Output
  - Screen, audio, print-outs or mimic board
- A weak link
  - Information overload/misinterpretation



HUMAN MACHINE INTERFACE - HMI

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