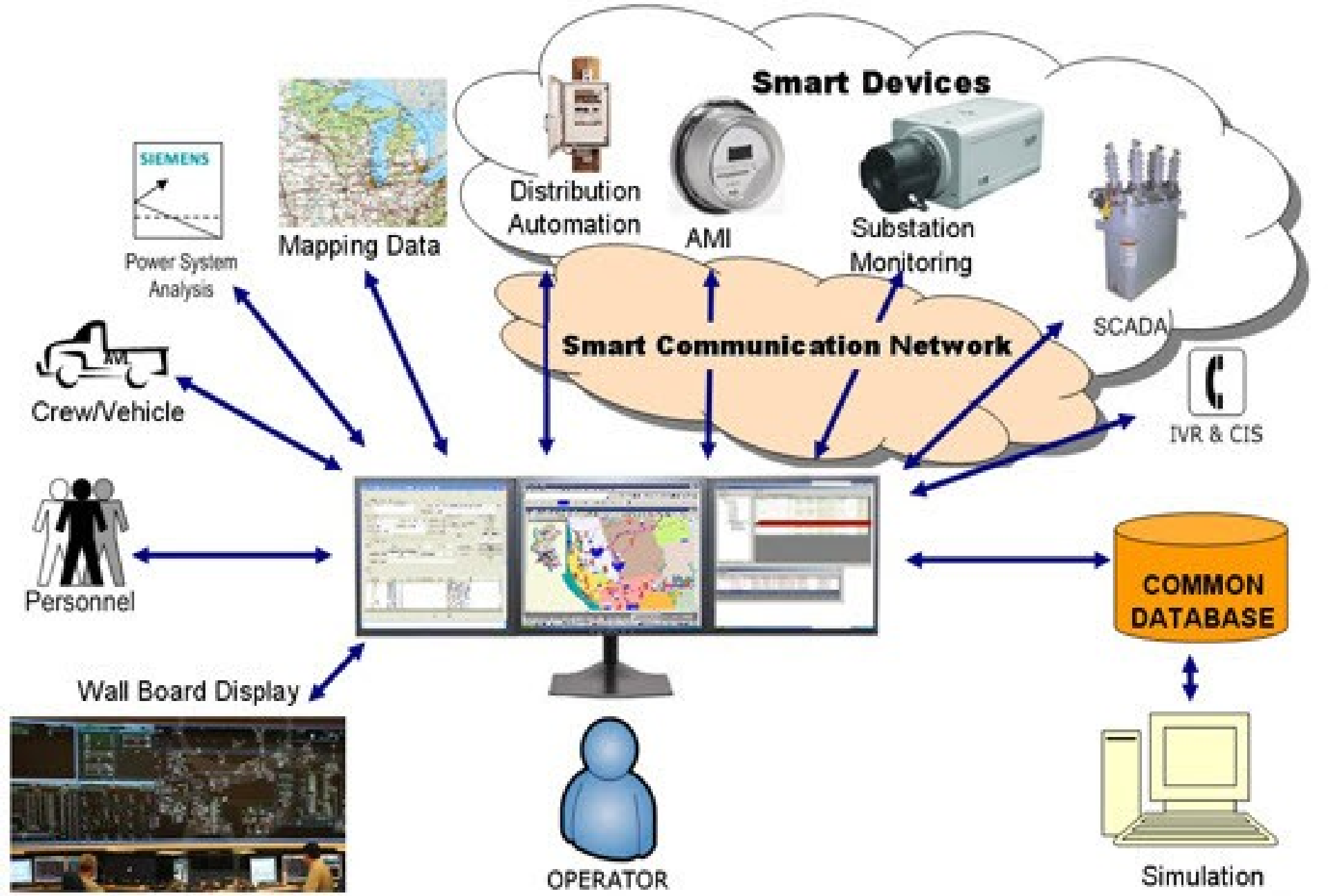
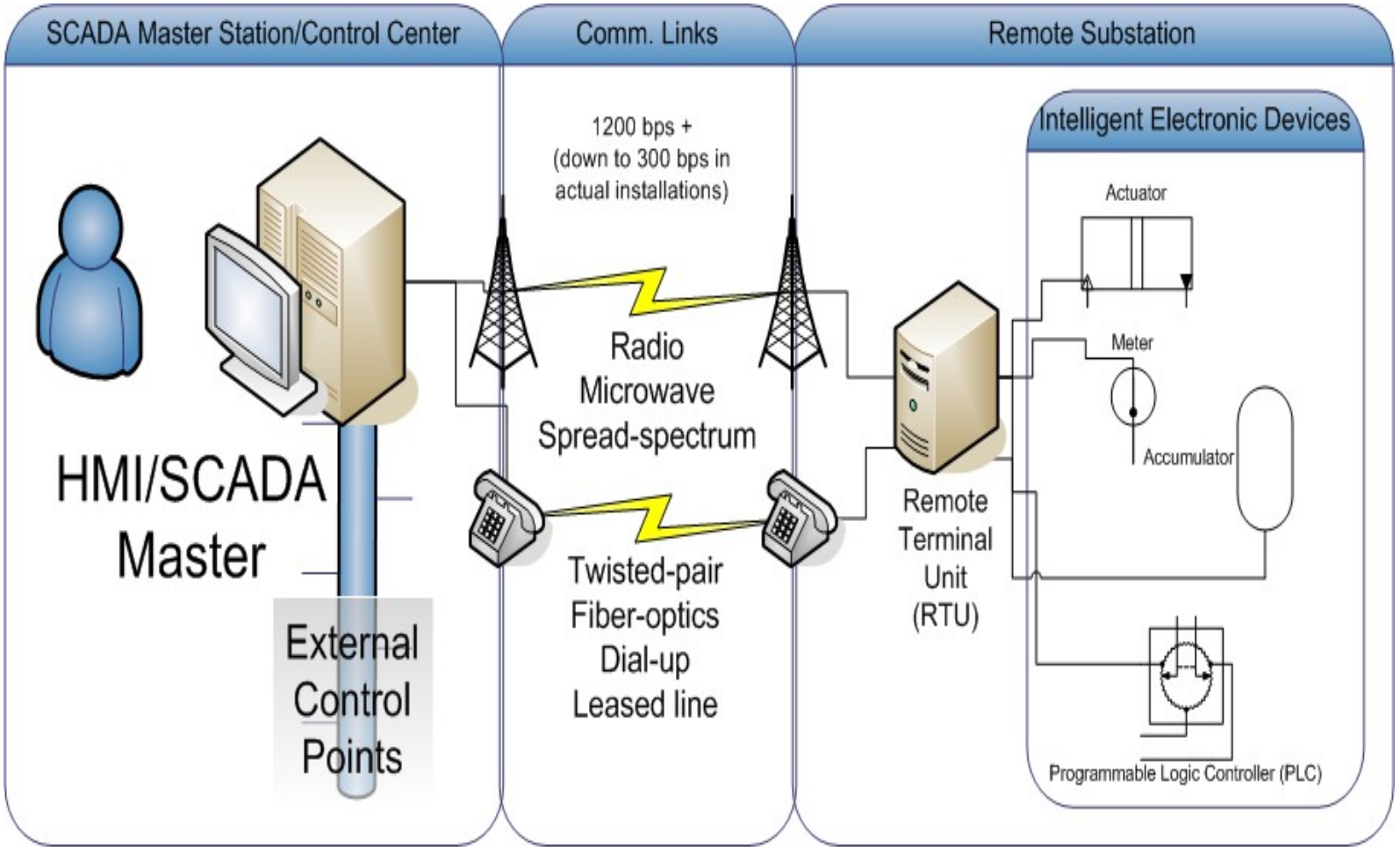

Smart Devices
Distribution Automation
AMI
Substation Monitoring
SCADA
Mapping Data
Power System Analysis
Smart Communication Network
Crew/Vehicle
IVR & CIS
Personnel
COMMON DATABASE
Wall Board Display
OPERATOR
Simulation


SCADA Master Station/Control Center
Comm. Links
Remote Substation
1200 bps +
(down to 300 bps in
actual installations)
Intelligent Electronic Devices
Actuator
Meter
Accumulator
Radio
Microwave
Spread-spectrum
HMI/SCADA
Master
Remote
Terminal
Unit
(RTU)
Twisted-pair
Fiber-optics
Dial-up
Leased line
External
Control
Points
Programmable Logic Controller (PLC)

Substation Automation(SAS)

- This Substation Automation System (SA) comprises full station and bay protection as well as control, monitoring and communication functions and provides all functions required for the safe and reliable operation of the substations.
- It shall enable local station control via a Personal Computer (PC) by means of a human machine interface (HMI) and control software package, which shall contain an extensive range of system control and data acquisition (SCADA) functions. It shall include communication gateway, interbay bus, intelligent electronic devices (IED) for bay control and protection.
- The communication gateway shall secure the information flow with Regional Control Centres. The interbay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

SCADA –Substation Functional Descrption

- Emergency Load shedding.
- Re-routing services for station maintenance. Automatic transfer schemes.
- Load sectionalizing.
- Custom, automatic reclosing schemes.
- Automatic service restoration.
- Circuit breaker control and interlocking.
- Feeder automation and fault recovery.

SCADA –Substation
Functional Description

- Protection and Control Circuit breaker lockout. Protective relay interface/interaction.
- Dynamic protective relay setting for dynamic station topology.
- Voltage Regulation Management Load Tap Changer (LTC) control.
- Voltage regulator control.
- Capacitor control.
- Transformer Management Parameter monitoring and alarming.
- Real-time modeling. Interface to existing transformer monitors.
- Automatic System Diagnostics Power apparatus health monitoring. LC and communications self monitoring. Report and alarm on IED self diagnostics.

SCADA –Substation Functional Description

- Maintenance „Lock-out/Tag-out management. Automatic circuit isolation control.
- Station MMIs – Graphical User Interface (GUI) Interface real-time single-line displays.
- Interactive real-time breaker and switch control display.
- On-line operation and maintenance logs. Sequence of events recording.
- IED detail displays. Parameter trending displays.

Advantages of SCADA system in power sector

- Increased reliability, lower costs. Forecasting accurate demand supply management. Faster restoration of power in case of a break down. Better active and reactive power management. Reduced maintenance cost, conditioning monitoring. Reduce human influence and errors. Assists operator for faster decision making. Automated meter reading.
- Analysis of information. Decision making. Optimized system operation (competitive environment). Equipment condition monitoring (ECM) Equipment parameters are automatically tracked to detect abnormalities.
- Timely action, extended life. ECM IEDs available.

Issues in Power System

1. **Reliability**
   - Continuity of power supply
   - Fault detection, isolation, service restoration after fault
2. **Quality**
   - Voltage, power factor, Harmonics, Frequency variations
3. **Efficiency**
   - Technical losses, commercial loss
4. **Unplanned Growth of Electric Power Network**
   - In Distribution; cause of difficulty in Management of the network
5. **Complexity**
   - Of network, Of technology
6. **Cost**
   - Implementation cost, maintenance cost
7. **Time**
   - To meet the requirement of customer within shortest time

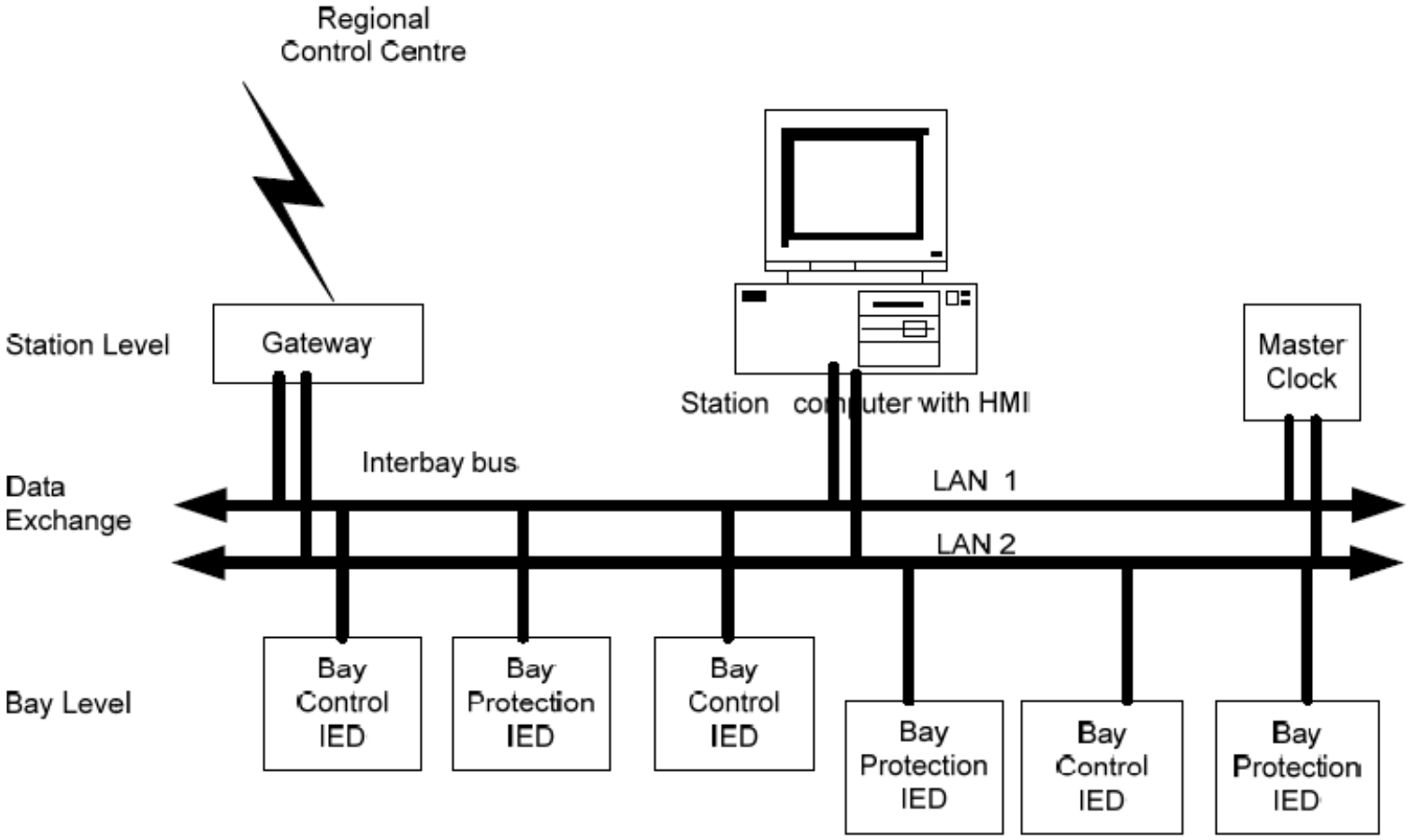
SCADA –Substation

- SCADA performs automatic monitoring, protecting and controlling of various equipments in distribution systems with the use of Intelligent Electronic Devices (or RTUs). It restores the power service during fault condition and also maintains the desired operating conditions.

- SCADA improves the reliability of supply by reducing duration of outages and also gives the cost-effective operation of distribution system. Therefore, distribution SCADA supervises the entire electrical distribution system.

The major functions of SCADA can be categorized into following types.

- Substation Control
- Feeder Control
- End User Load Control



System Architecture of Substation Automation

- At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.
- Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.
- The data exchange between the electronic devices on bay and station level shall take place via the interbay bus. The bus shall be realized using fibre-optic cables or Ethernet.
- At station level, the entire station shall be controlled and supervised from the station HMI. It shall be possible to control and monitor the bay from the bay level equipment, in the event that the communication link fails. The station wide interlocking shall also be available when the station computer fails.

- To provide highest reliability the station HMI and the gateways shall work completely independent meaning retrieving the process data directly from the bay level devices. Additionally the gateway and the station HMI shall be configured fully redundant to ensure fullfunctionality in case of single point of failure.
- Clear control priorities shall prevent that operation of a single switch can be initiated at the same time from more than one of the various control levels, i.e. SCADA, station, bay level or apparatus level. The priority shall always be on the lowest enabled control level.
- The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

SAS main functional parts:

- A dedicated master clock for the synchronization of the entire system shall be provided. This master clock should be independent of the station computer and of the gateway, and should synchronize all devices via the interbay bus.
- Human Machine Interface (HMI) with process database
- Separate gateway for remote supervisory control via SCADA
- Master clock (e.g. GPS receiver)
- Collection of the relevant data concerning the substation and distribution of the data where needed
- Bay and station level devices for control, monitoring and protection
- Bay-oriented local control panels.

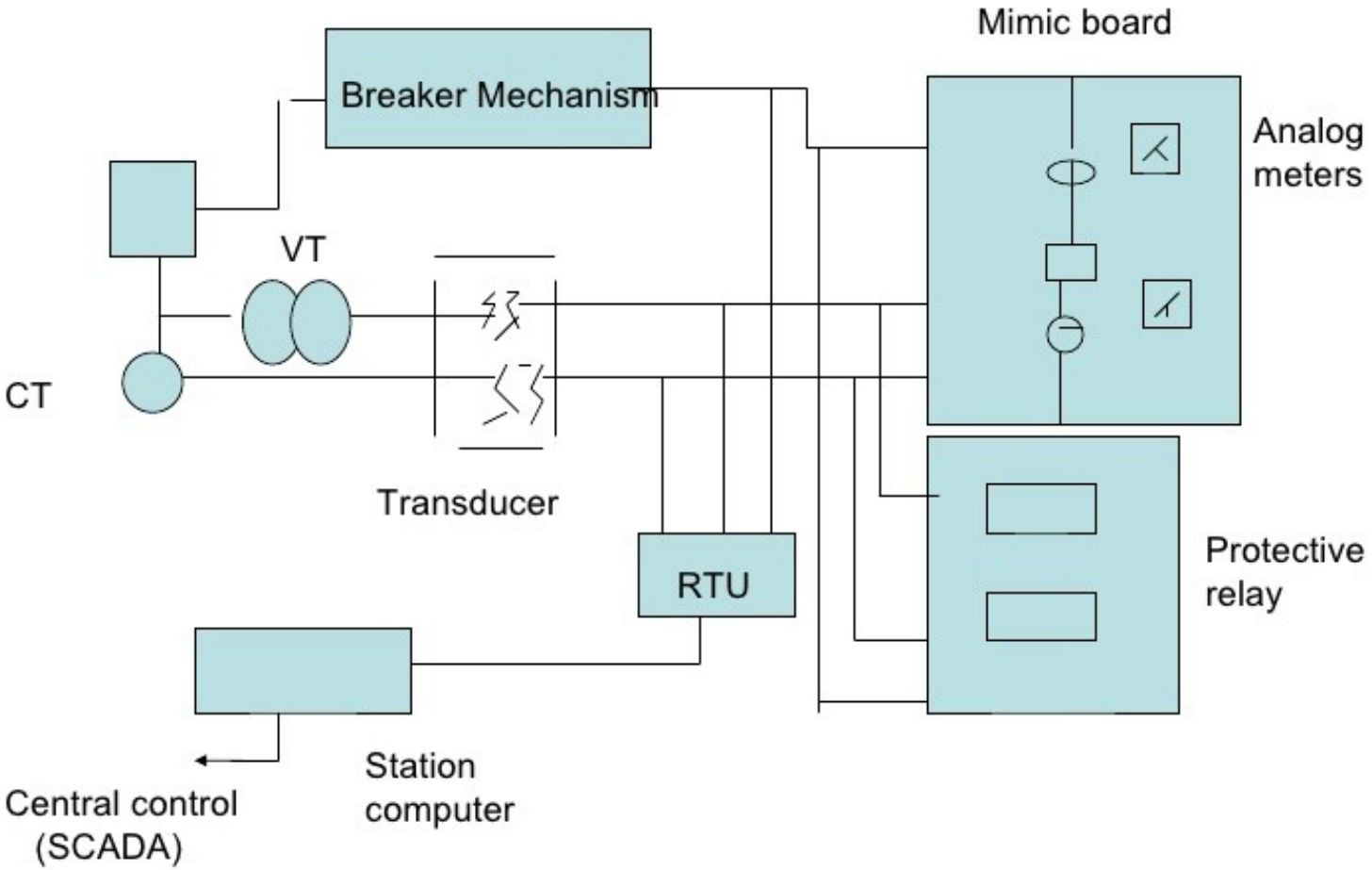
Signal List

Commands for all CBs and motorized switchgear
Status Indications
Alarms
Set Point Regulation
Measurands

Accumulators
The design shall include mapping of the Signal list from the supplier (as addressed & used in the HMI) to the requirements of the Regional Control Centre (supervisory level) signal requirements.
The design of the SCMS SA system shall include the following;
Control mode selection
Select-before-execute principle
Command supervision: Interlocking and blocking Double command
Autoreclosing
Monitoring pole discrepancy and trip function
Transformer tap changer control
Display of interlocking and blocking
Breaker position indication
Alarm annunciation
Measurement display
Local HMI (local guided, emergency mode)
Data storage for at least 200 events

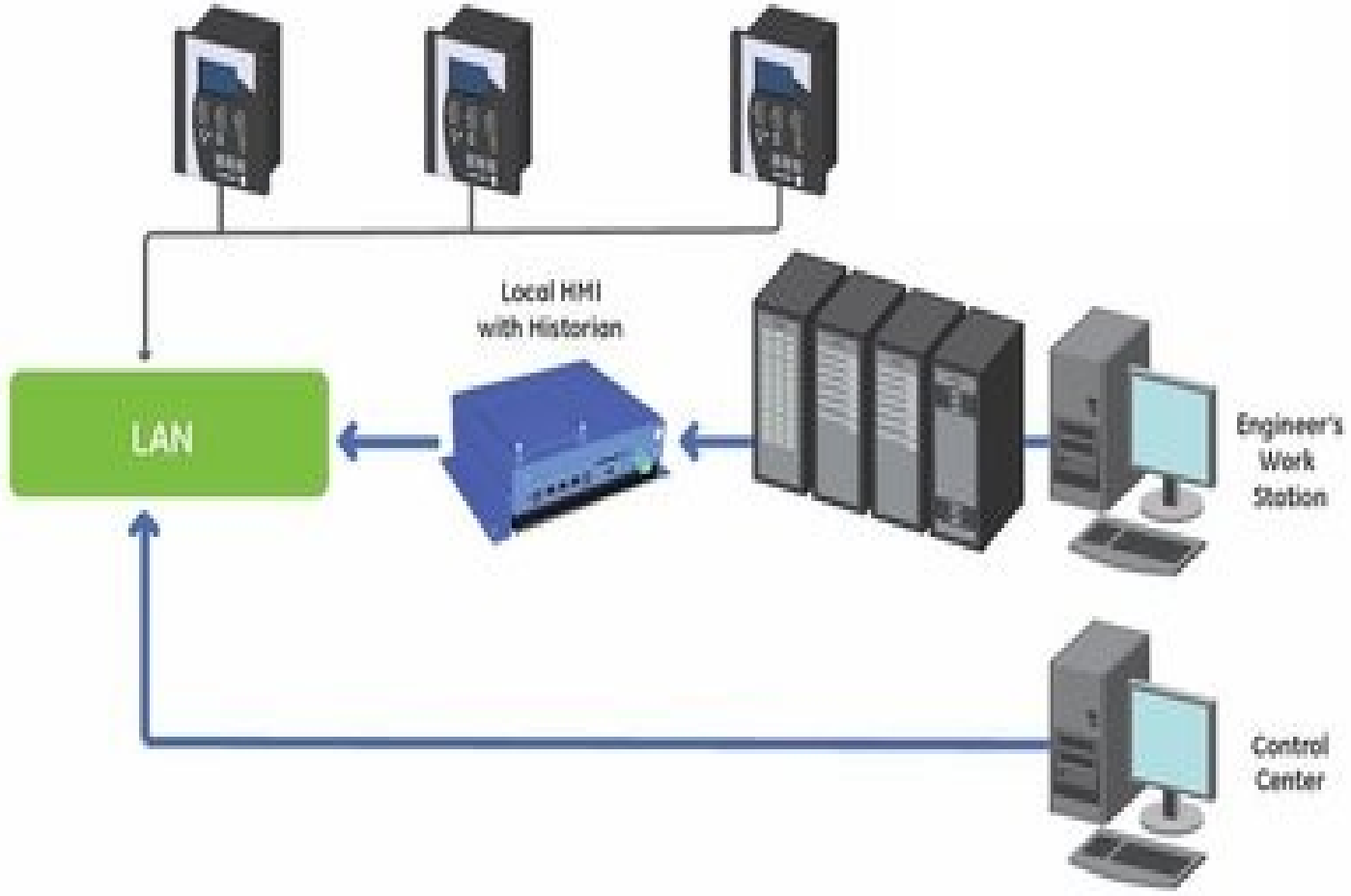
Substation Control using SCADA

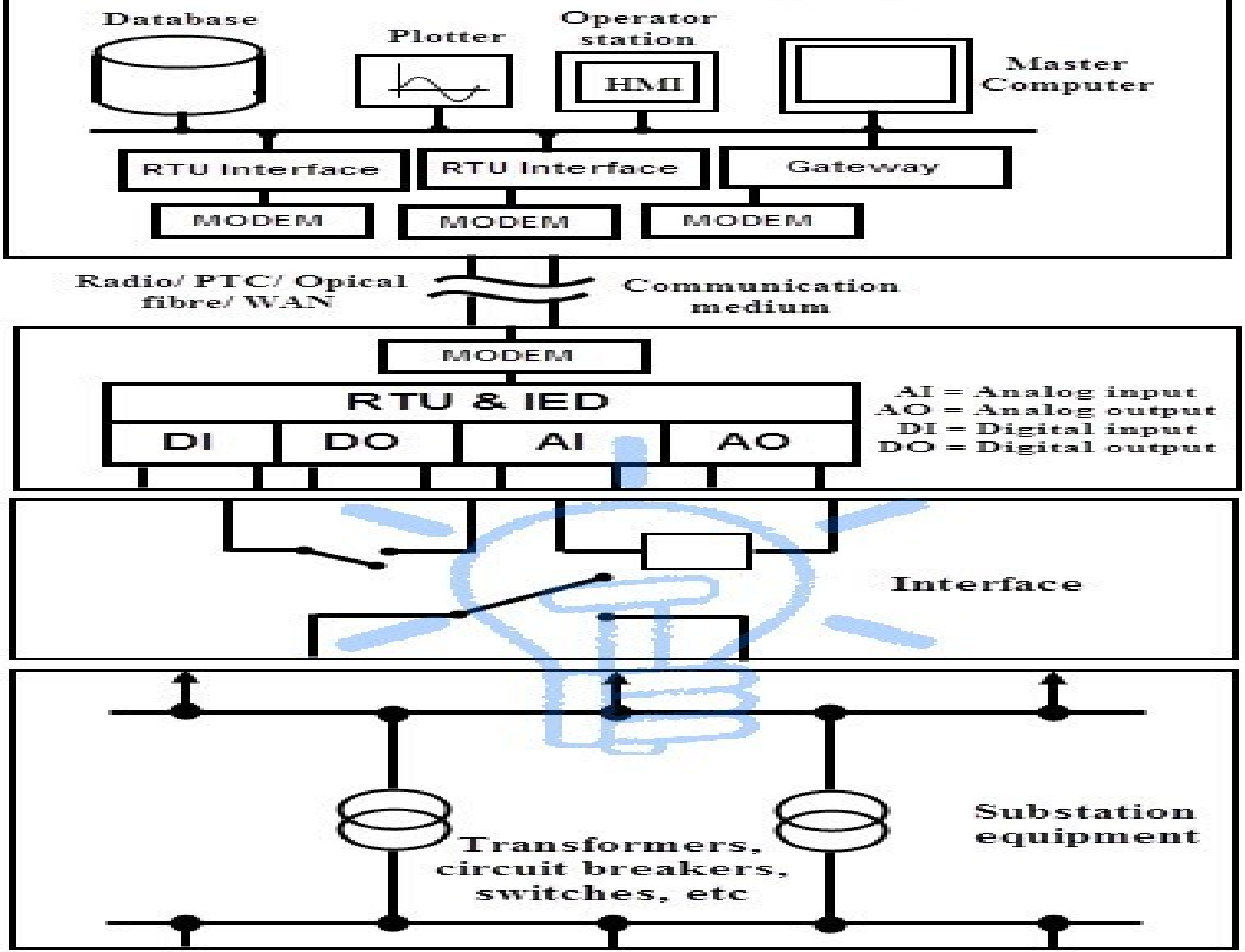
- In substation automation system, SCADA performs the operations like bus voltage control, bus load balancing, circulating current control, overload control, transformer fault protection, bus fault protection, etc.
- SCADA system continuously monitors the status of various equipments in substation and accordingly sends control signals to the remote control equipments. Also, it collects the historical data of the substation and generates the alarms in the event of electrical



Monitoring & Control of local system using RTU:

Automatic functions for local control performed by regulators, as well as sequence control performed by relays are integrated as software functions in the RTU.

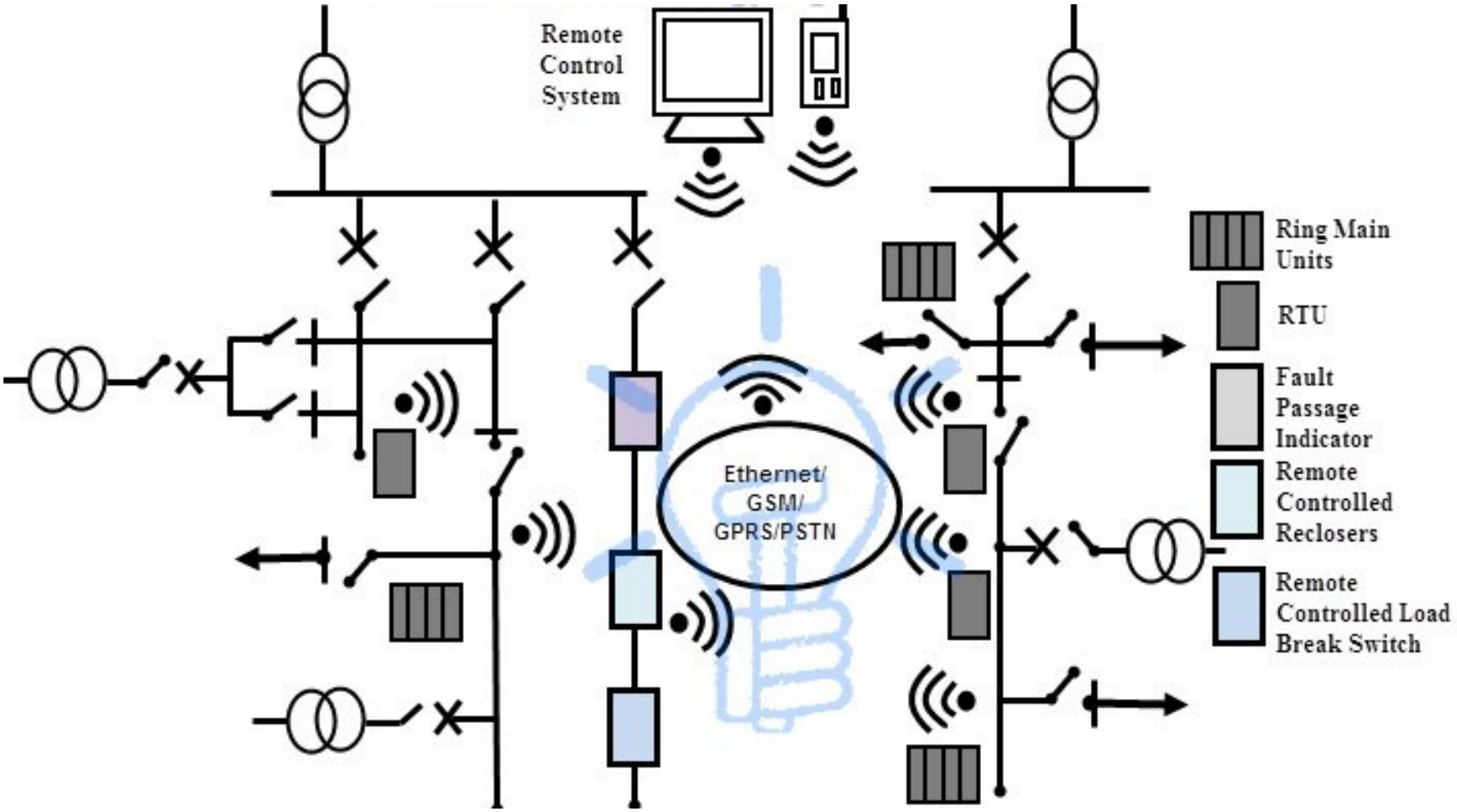

Local HMI
with Historian
LAN
Engineer's
Work
Station
Control
Center


Database
Plotter
Operator station
HMI
Master Computer
RTU Interface
RTU Interface
Gateway
MODEM
MODEM
MODEM
Radio/ PTC/ Opical fibre/ WAN
Communication medium
MODEM
RTU & IED
DI
DO
AI
AO
AI = Analog input
AO = Analog output
DI = Digital input
DO = Digital output
Interface
Transformers, circuit breakers, switches, etc
Substation equipment

SCADA based substation control system

- Various input/output (I/O) modules connected to the substation equipment gathers the field parameters data, including status of switches, circuit breakers, transformers, capacitors and batteries, voltage and current magnitudes, etc. RTUs collect I/O data and transfers to remote master unit via network interface modules.
- The central control or master unit receives and logs the information, displays on HMI and generate the control actions based on received data. This central controller also responsible for generating trend analysis, centralized alarming, and reporting.
- The data historian, workstations, master terminal unit and communications servers are connected by LAN at the control center. A Wide Area Network (WAN) connection with standard protocol communication is used to transfer the information between field sites and central controller.
- Thus, by implementing SCADA for substation control eventually improves the reliability of the network and minimizes the downtime with high speed transfer of measurements and control commands.

Feeder Control using SCADA



Feeder Control using SCADA

- The automation includes feeder voltage or VAR control and feeder automatic switching. Feeder voltage control performs voltage regulation and capacitor placement operations while feeder switching deals with remote switching of various feeders, detection of faults, identifying fault location, isolating operation and restoration of service.
- In this system, **SCADA architecture** continuously checks the faults and their location by using wireless fault detector units deployed at various feeding stations. In addition, it facilitates the remote circuit switching and historical data collection of feeder parameters and their status. The figure below illustrates feeder automation using SCADA.

- different feeders (underground as well as overhead networks) are automated with modular and integrated devices in order to decrease the number and duration of outages. Underground and overhead fault detection devices provide accurate information about transient and permanent faults so that at the remote side preventive and corrective measures can be performed in order to reduce the fault repeatability.

- Ring main units and Remote Control Units (RTUs) of underground and overhead network responsible for maintenance and operational duties such as remote load switching, capacitor bank insertion and voltage regulation. The entire network is connected with a communication medium in order to facilitate remote energy management at the central monitoring station.

Circuit breaker control

- The Circuit breaker control function block can be used to integrate the circuit breaker control module with the station control system and to apply active scheme screens of the local HMI of the device.
- The Circuit breaker control function block receives remote commands from the SCADA system and local commands from the local HMI of the device, performs the prescribed checking and transmits the commands to the circuit breaker
- It processes the status signals received from the circuit breaker and offers them to the status display of the local HMI and to the SCADA system.

CBC

- The Circuit breaker control function block has binary input signals. The conditions are defined by the user applying the graphic equation editor.
- The signals of the circuit breaker control are seen in the binary input status list.

Main features-CBC

- Local HMI and Remote (SCADA) operation modes can be enabled or disabled individually.
- The signals and commands of the synchro check / synchro switch function block can be integrated into the operation of the function block.
- Interlocking functions can be programmed by the user applying the inputs (enabled trip command) and (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
- o Time limitation to execute a command
- o Command pulse duration
- o Filtering the intermediate state of the circuit breaker
- o Checking the synchro check and synchro switch times
- o Controlling the individual steps of the manual commands
- Sending trip and close commands to the circuit breaker (to be combined with the trip commands of the protection functions and with the close command of the automatic reclosing function; the protection functions and the automatic reclosing function directly gives commands to the CB). The combination is made graphically using the graphic equation editor
- Operation counter
- Event reporting

Timer parameters

Parameter name	Title	Unit	Min	Max	Step	Default
Timeout for signaling failed operation						
CB1Pol_TimOut_TPar_	Max.Operating time	msec	10	1000	1	200
Duration of the generated On and Off impulse						
CB1Pol_Pulse_TPar_,	Pulse length	msec	50	500	1	100
Waiting time, at expiry intermediate state of the CB is reported						
CB1Pol_MidPos_TPar_	Max.Intermediate time	msec	20	30000	1	100
Length of the time period to wait for the conditions of the synchron state. After expiry of this time, the synchro switch procedure is initiated (see synchro check/ synchro switch function block description)						
CB1Pol_SynTimOut_TPar_	Max.SynChk time	msec	10	5000	1	1000
Length of the time period to wait for the synchro switch impulse (see synchro check/ synchro switch function block description). After this time the function resets, no switching is performed						
CB1Pol_SynSWTimOut_ TPar_	Max.SynSW time*	msec	0	60000	1	0
Duration of the waiting time between object selection and command selection. At timeout no command is performed						
CB1Pol_SBOTimeout_ TPar_	SBO Timeout	msec	1000	20000	1	5000

Binary input status signals

Binary input status signal	Title	Explanation
CB1Pol_Local_GrO_	Local	If this input is active, the circuit breaker can be controlled using the local LCD of the device.
CB1Pol_Remote_GrO_	Remote	If this input is active, the circuit breaker can be remote-controlled via communication channels of the SCADA system.
CB1Pol_SynOK_GrO_	SynOK	This input indicates if the synchron state of the voltage vectors at both sides of the circuit breaker enables the closing command. This signal is usually generated by the synchro check/ synchro switch function. If this function is not available, set the input to logic true.
CB1Pol_EnaOff_GrO_	EnaOff	The active state of this input enables the opening of the circuit breaker. The state is usually generated by the interlocking conditions defined graphically by the user.
CB1Pol_EnaOn_GrO_	EnaOn	The active state of this input enables the closing of the circuit breaker. The state is usually generated by the interlocking conditions defined graphically by the user.
CB1Pol_BlkProc_GrO_	BlkProc	The active state of this input blocks the operation of the circuit breaker. The conditions are defined graphically by the user.
CB1Pol_stValOff_GrO_	stValOff	Off state of the circuit breaker.
CB1Pol_stValOn_GrO_	stValOn	On state of the circuit breaker.
CB1Pol_ExtTrip_GrO_	ExtTrip	External trip command for the circuit breaker (e.g. from protection). This signal is considered when evaluating unintended operation.

Binary output status signals

Binary output status signal	Title	Explanation
CB1Pol_CmdOff_Grl_	Off Command	Off command impulse, the duration of which is defined by the parameter “Pulse length”
CB1Pol_CmdOn_Grl_	On Command	On command impulse, the duration of which is defined by the parameter “Pulse length”
CB1Pol_StartSW_Grl_	Start Synchro-switch	If the synchro check/synchro switch function is applied and the synchron state conditions are not valid for the time defined by the parameter “Max.SynChk time”, then this output triggers the synchro switch function (see synchro check/ synchro switch function block description).
CB1Pol_Oper_Grl_	CB Operated	An impulse with a duration of 150 ms at any operation of the circuit breaker
CB1Pol_SelfOper_Grl_	Unintended Oper	This output is logic true if the status of the circuit breaker has changed without detected command from the SCADA system or on the input “Ext trip”
CB1Pol_Opened_Grl_	Opened	The filtered status signal for opened state of the circuit breaker
CB1Pol_Closed_Grl_	Closed	The filtered status signal for closed state of the circuit breaker

Isolator or Disconnector

- **Disconnector or Isolator** is an off-load device while, circuit breaker is an on-load device. **Isolator** is a switch operated manually, which separate the circuit from the power main and discharges the trapped charges in the circuit.
- Primarily isolators are used to **disconnect** a portion of the circuit from **source** for **maintenance**.
- **Isolators lack arc suppression capacity**. So they can only be employed when the current is already interrupted by another entity such as a circuit breaker.
- SCADA-Disconnector-Motrorised

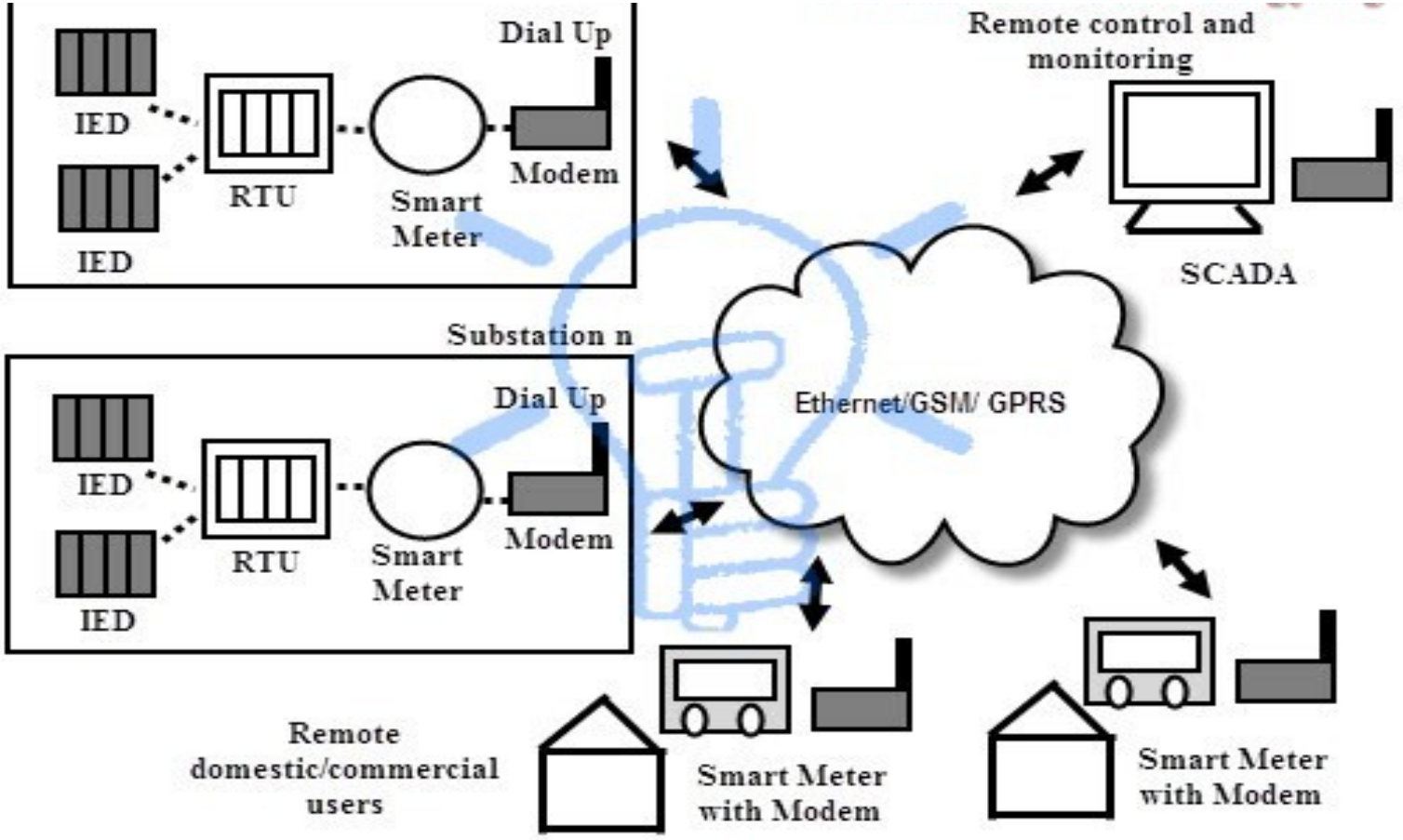
Disconnector control

- The Disconnector control function block receives remote commands from the SCADA system and local commands from the local HMI of the device, performs the prescribed checking and transmits the commands to the disconnector.
- It processes the status signals received from the disconnector and offers them to the status display of the local LCD and to the SCADA system.

Main features:
DCC

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” (enabled trip command) and “EnaOn” (enabled close command), using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
- o Time limitation to execute a command
- o Command pulse duration
- o Filtering the intermediate state of the disconnector
- o Controlling the individual steps of the manual commands
- Sending trip and close commands to the disconnector
- Operation counter
- Event reporting

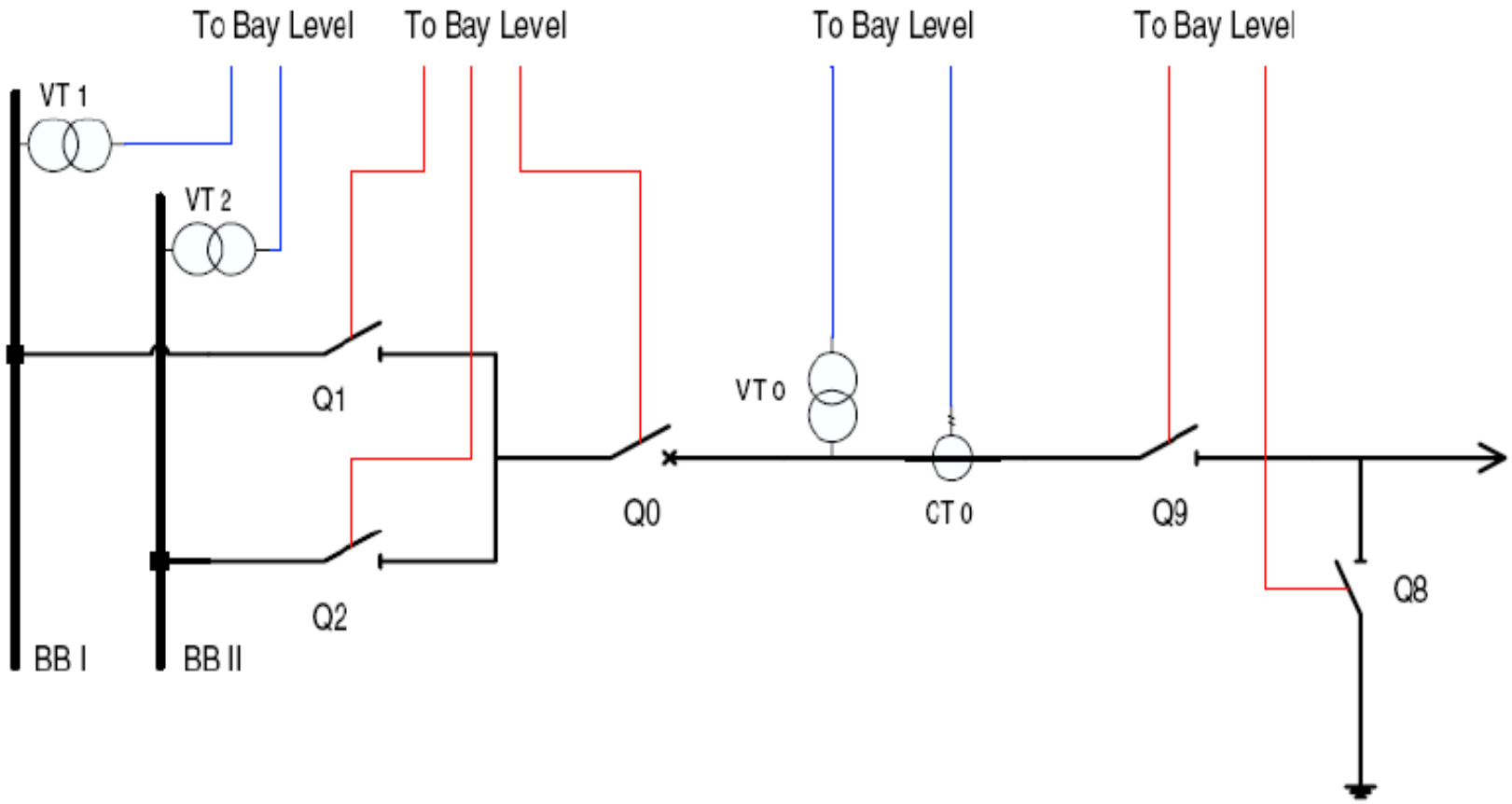
End User Load Control Automation by SCADA



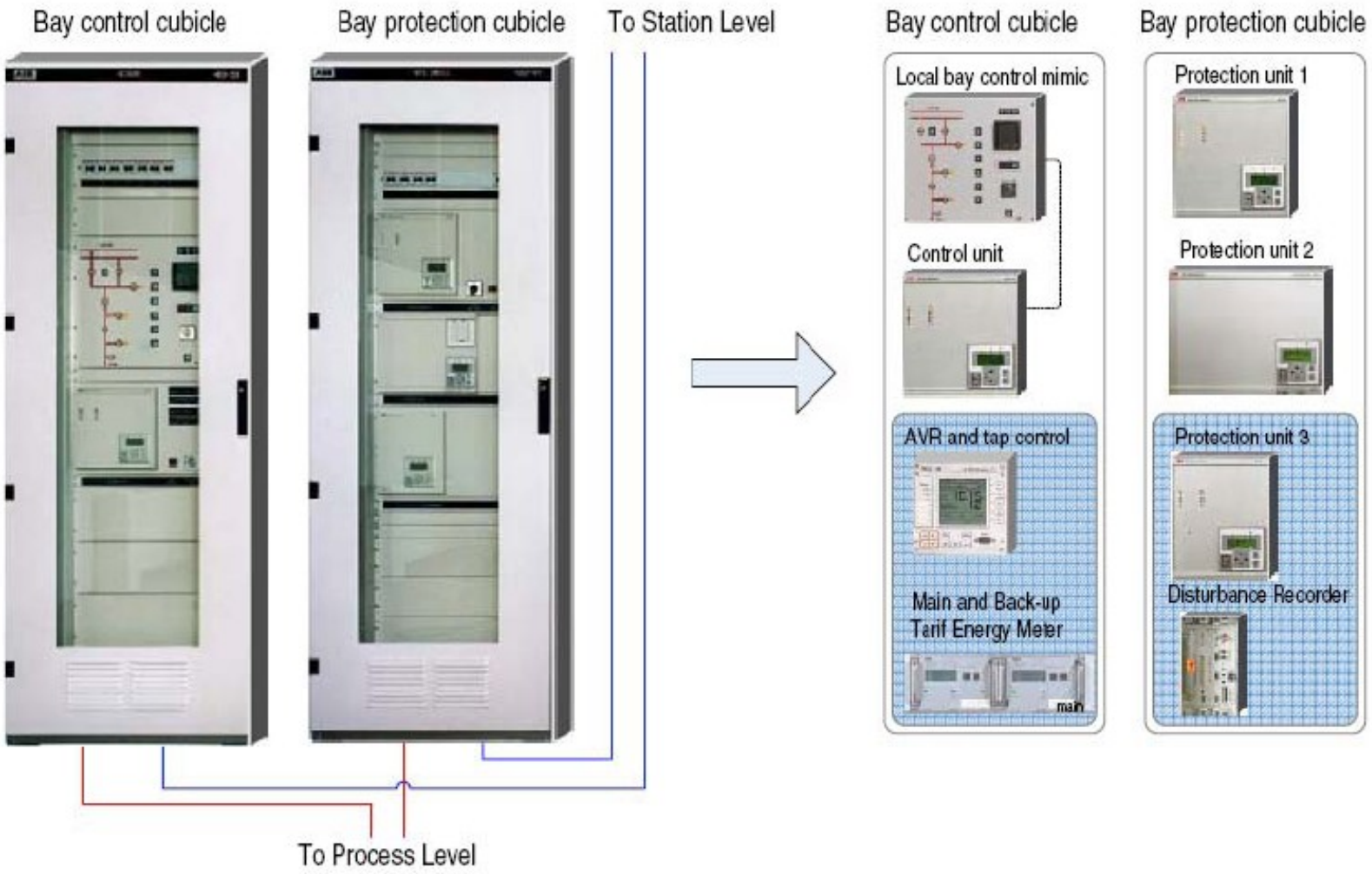
Meter data-management system using *SCADA*

- It is an easy and cost-effective solution for automating the energy meter data for billing purpose.
- In this, smart meters with a communication unit extract the energy consumption information and made it available to a central control room as well as local data storage unit. At the central control room, **AMR control unit** automatically retrieves, stores and converts all meter data.
- Modems or communication devices at each meter provide secure two-way communication between central control and monitoring room and remote sites

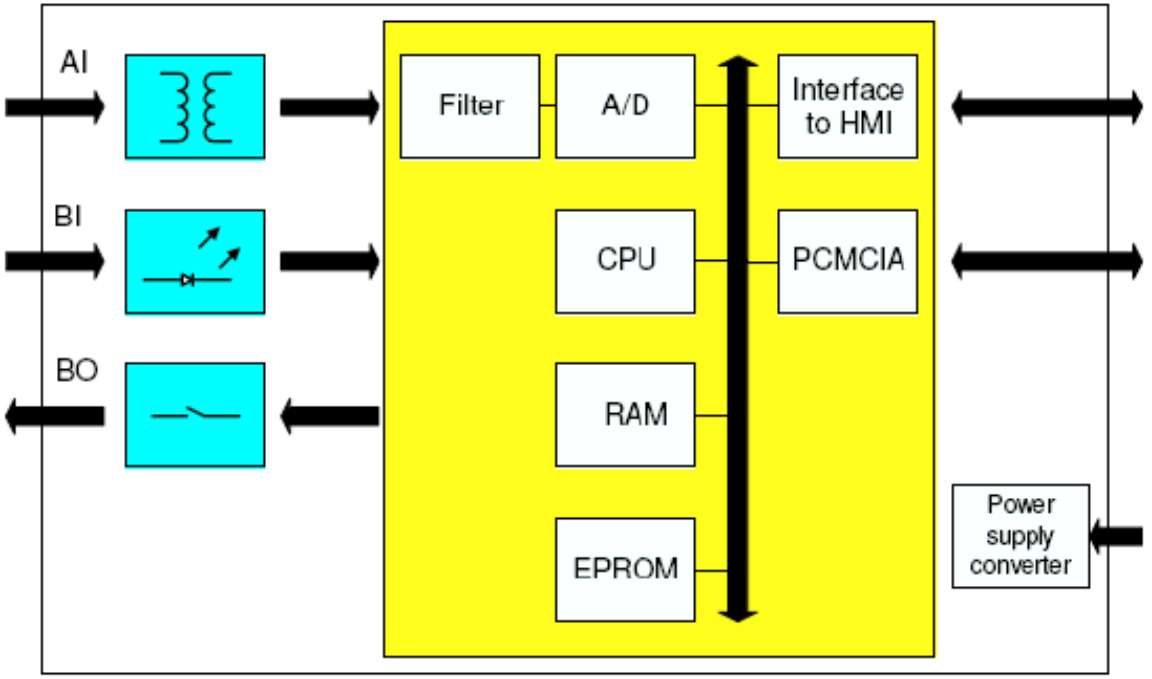
Process Level



Bay Level

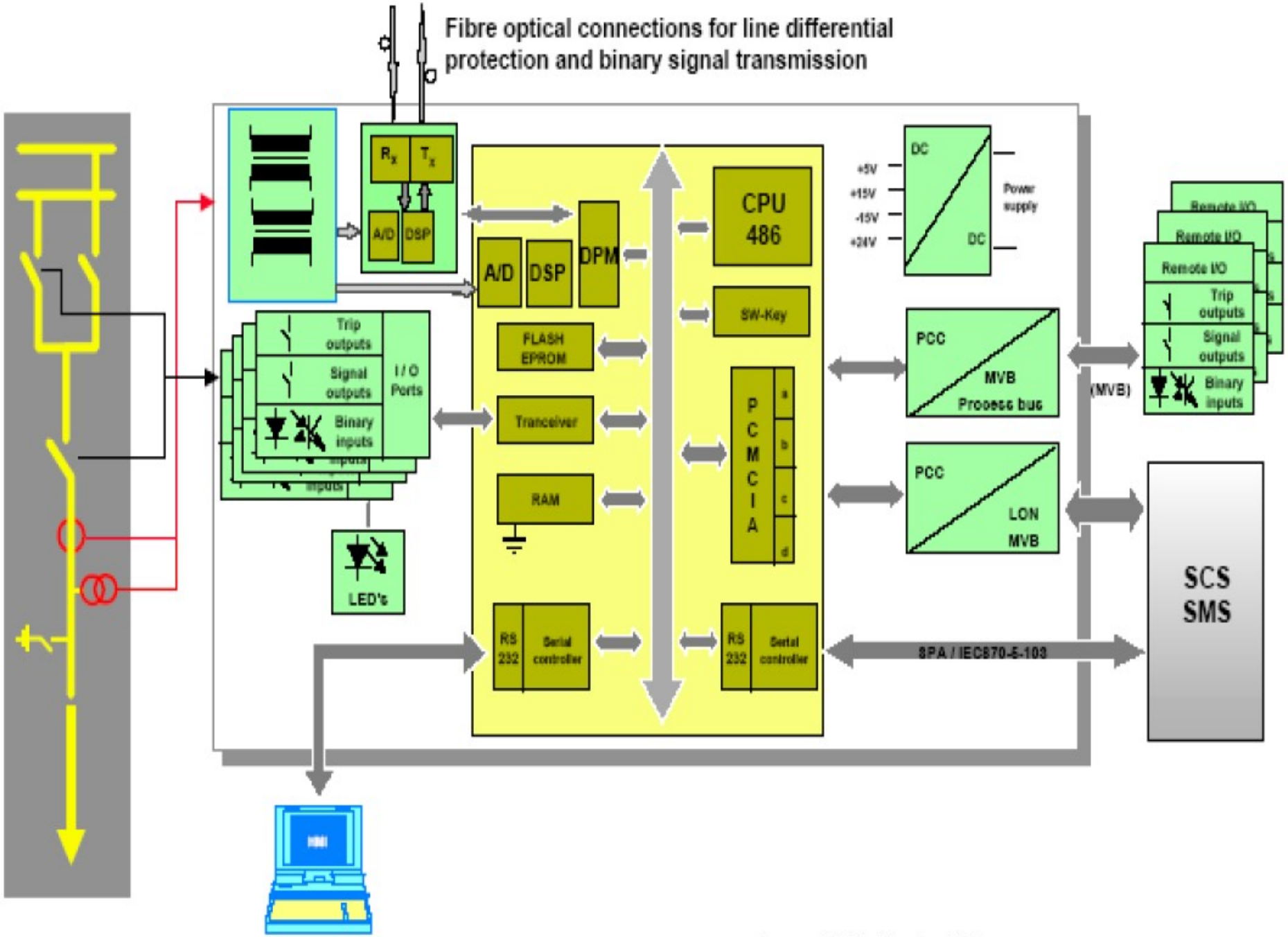

Bay control cubicle
Bay protection cubicle
To Station Level
To Process Level
Bay control cubicle
Bay protection cubicle
Local bay control mimic
Control unit
AVR and tap control
Main and Back-up
Tarif Energy Meter
main
Protection unit 1
Protection unit 2
Protection unit 3
Disturbance Recorder

Intelligent Electronic Device

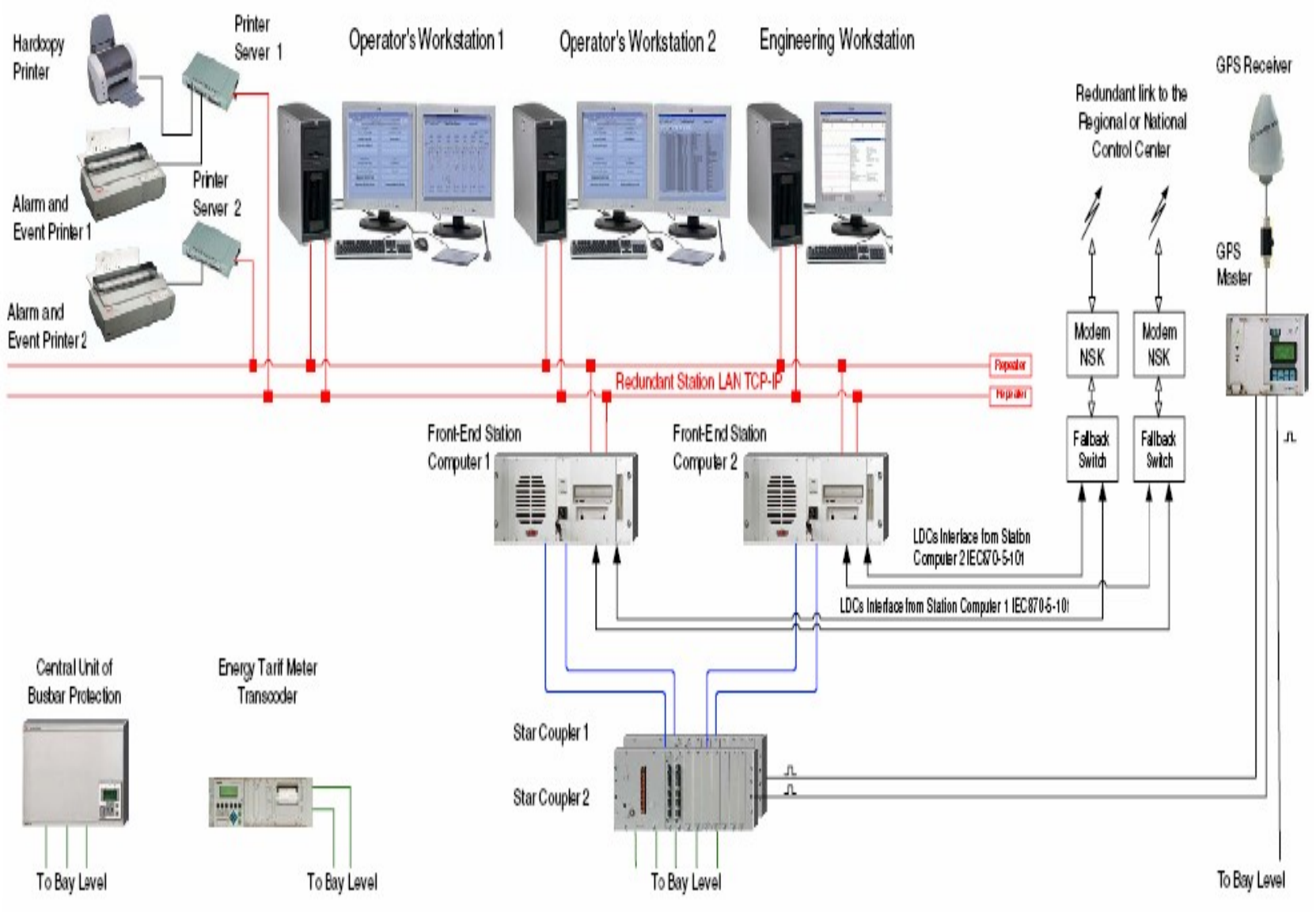


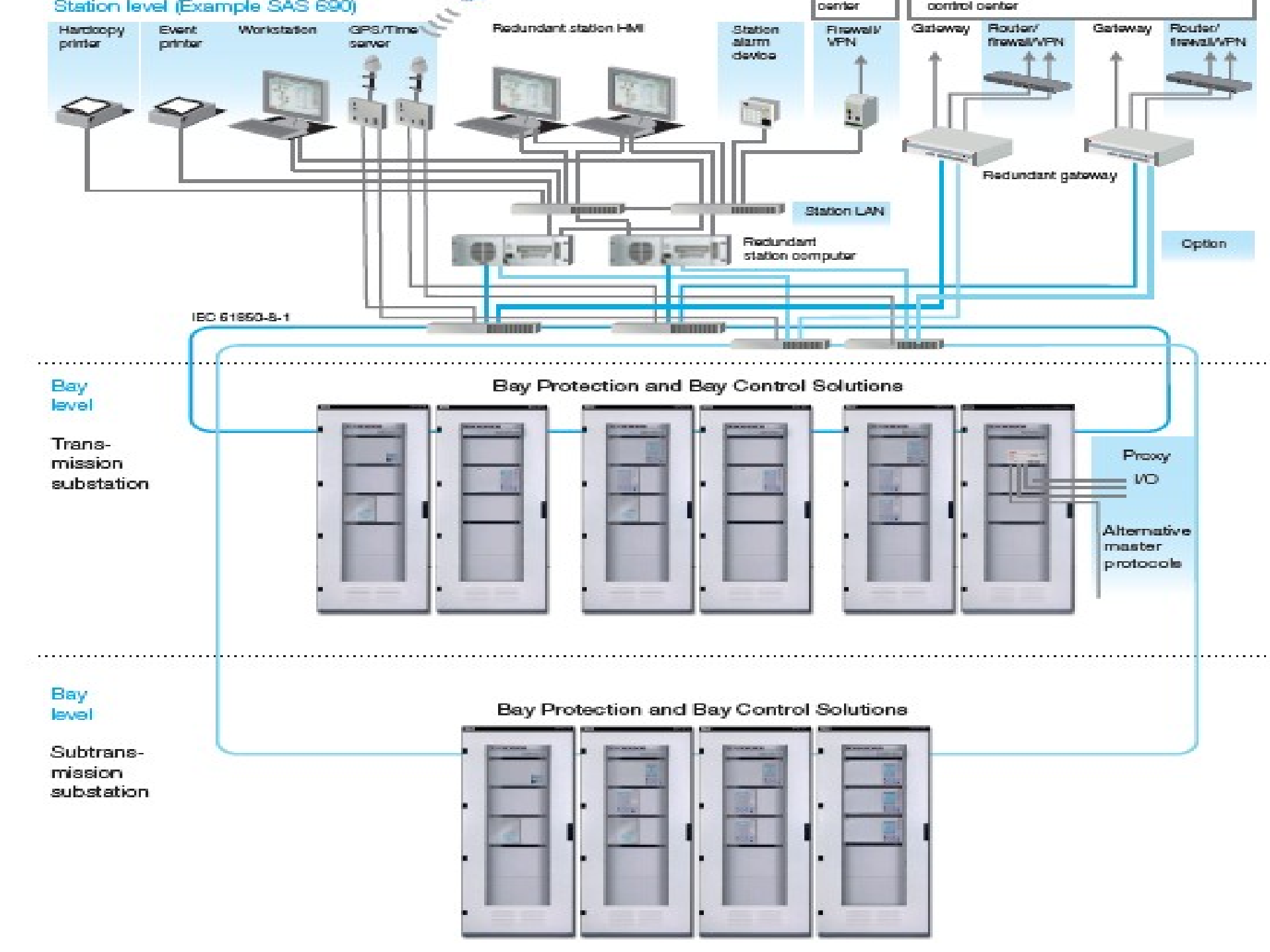
Bay Level Functions

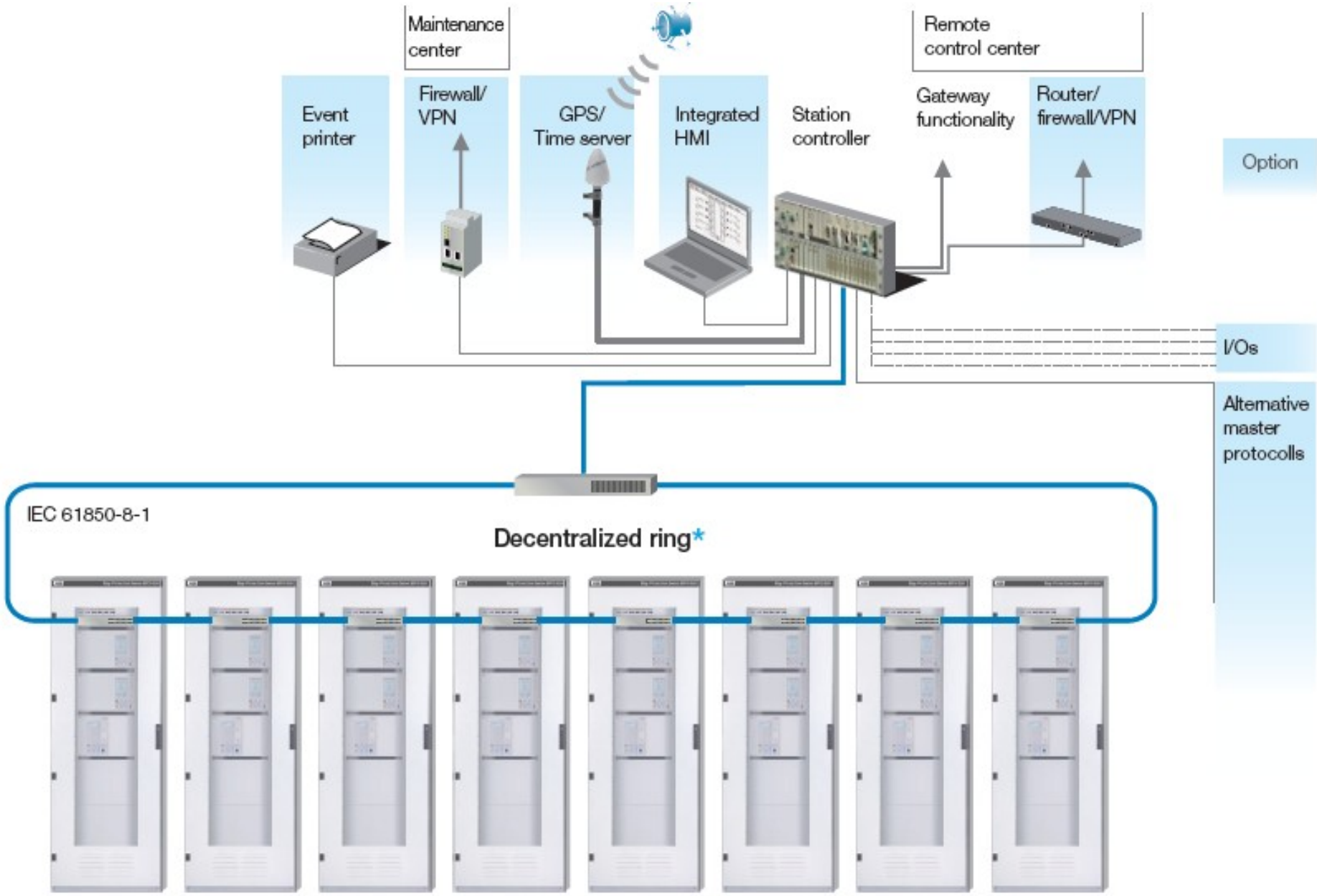
- Components protection:
  - Protection
  - Fault location, Autoreclosure and synchrocheck (for line protection)
- Data acquisition:
  - Rectification
  - A/D conversion
- Disturbance recording
- Control:
  - Switching operations (manual or automatic – initiated by protection): Sequencer and Interlocking
  - Tap-changer control

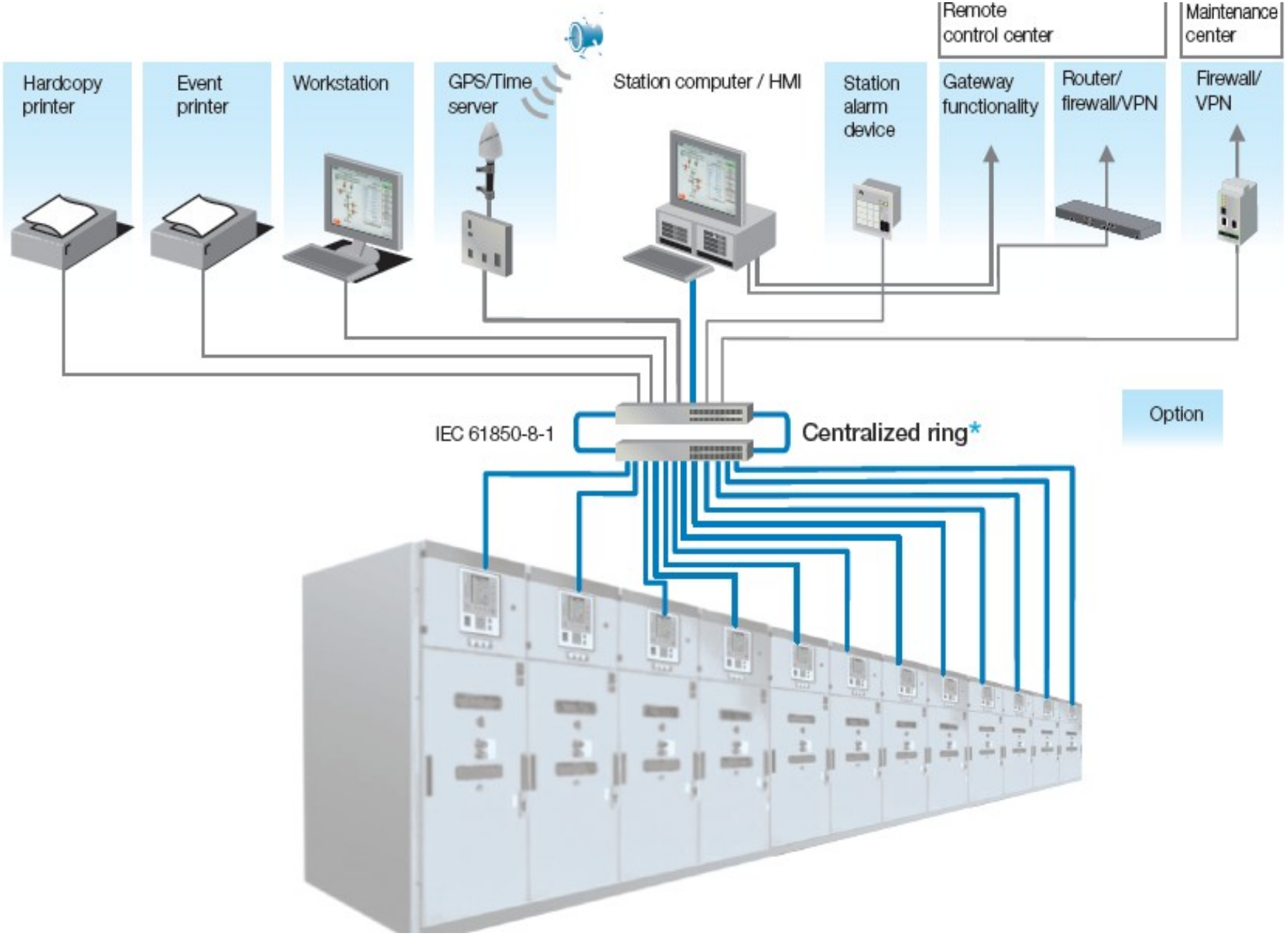


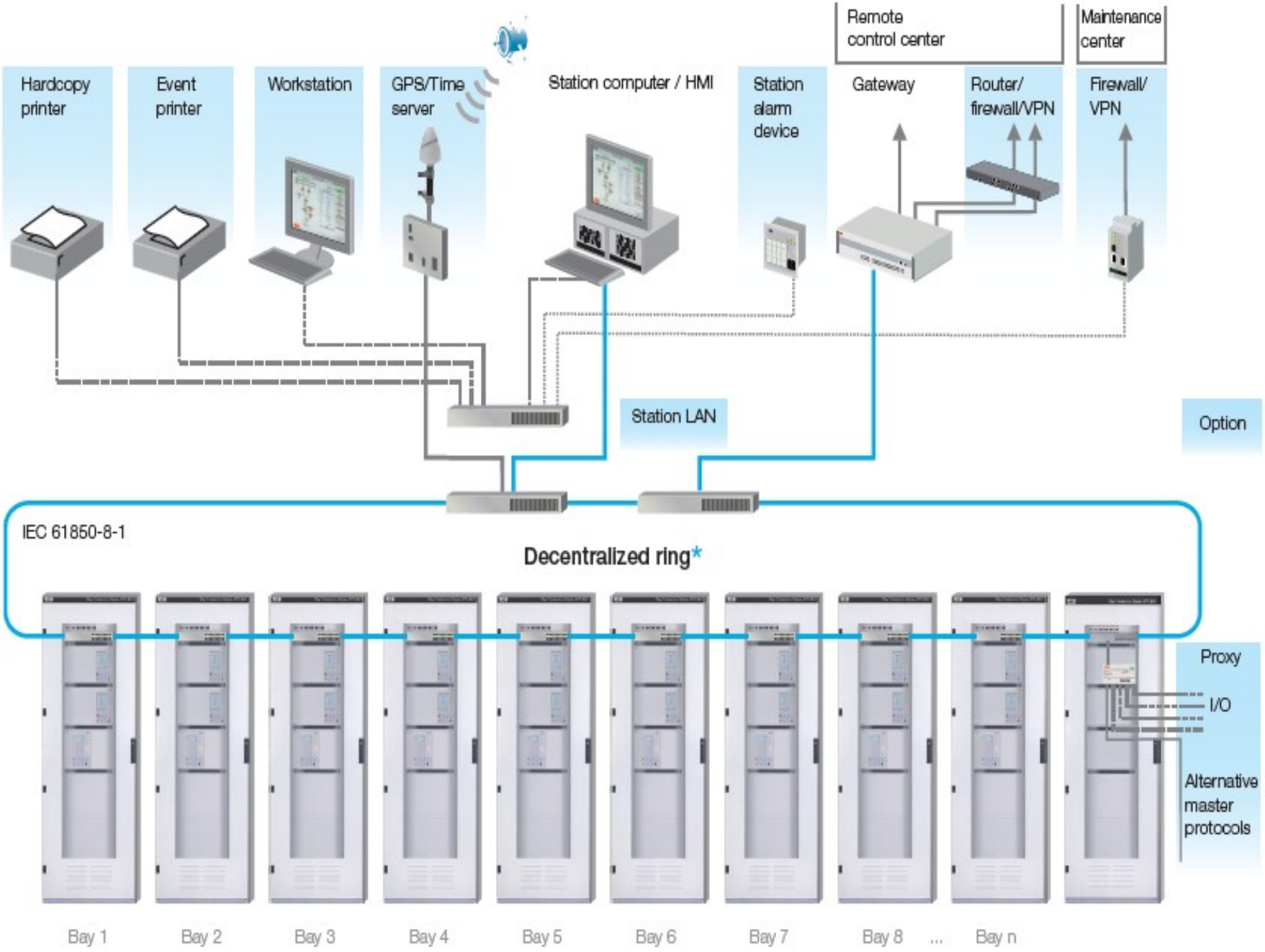
Source: ABB Switzerland Ltd.


Hardcopy Printer
Printer Server 1
Operator's Workstation 1
Operator's Workstation 2
Engineering Workstation
GPS Receiver
Redundant link to the Regional or National Control Center
Printer Server 2
Alarm and Event Printer 1
Alarm and Event Printer 2
GPS Master
Modem NSK
Modem NSK
Redundant Station LAN TCP-IP
Front-End Station Computer 1
Front-End Station Computer 2
Fallback Switch
Fallback Switch
LDCs Interface from Station Computer 2 IEC870-5-101
LDCs Interface from Station Computer 1 IEC870-5-101
Central Unit of Busbar Protection
Energy Tarif Meter Transcoder
Star Coupler 1
Star Coupler 2
To Bay Level
To Bay Level
To Bay Level
To Bay Level


Station level (Example SAS 690)
Hardcopy printer
Event printer
Workstation
GPS/Time server
Redundant station HMI
Station alarm device
Firewall/ VPN
Gateway
Router/ firewall/VPN
Gateway
Router/ firewall/VPN
Redundant gateway
Station LAN
Redundant station computer
Option
IEC 61850-8-1
Bay level
Trans- mission substation
Bay Protection and Bay Control Solutions
Proxy
I/O
Alternative master protocols
Bay level
Subtrans- mission substation
Bay Protection and Bay Control Solutions


Maintenance center
Remote control center
Event printer
Firewall/ VPN
GPS/ Time server
Integrated HMI
Station controller
Gateway functionality
Router/ firewall/VPN
Option
I/Os
Alternative master protocolls
IEC 61850-8-1
Decentralized ring*


Remote control center
Maintenance center
Hardcopy printer
Event printer
Workstation
GPS/Time server
Station computer / HMI
Station alarm device
Gateway functionality
Router/ firewall/VPN
Firewall/ VPN
IEC 61850-8-1
Centralized ring*
Option


Remote control center
Maintenance center
Hardcopy printer
Event printer
Workstation
GPS/Time server
Station computer / HMI
Station alarm device
Gateway
Router/ firewall/VPN
Firewall/ VPN
Station LAN
Option
IEC 61850-8-1
Decentralized ring*
Proxy
I/O
Alternative master protocols
Bay 1
Bay 2
Bay 3
Bay 4
Bay 5
Bay 6
Bay 7
Bay 8
...
Bay n

Advantages of Implementing SCADA systems for Substation

- Due to timely recognition of faults, equipment damage can be avoided
- Continuous monitoring and control of distribution network is performed from remote locations
- Saves labor cost by eliminating manual operation of distribution equipment
- Reduce the outage time by a system-wide monitoring and generating alarms so as to address problems quickly
- Improves the continuity of service by restoring service after the occurrence of faults (temporary)
- Automatically improves the voltage profile by power factor correction and VAR control
- Facilitates the view of historian data in various ways
- Reduces the labor cost by reducing the staff required for meter reading

Alarm management

An Alarm is an important event that the operator needs to be informed of immediately so that prompt corrective action may be implemented to ensure the operational safety and integrity of Power Supply .High priority visual and audible warnings appear on the current operator work station and an acknowledgement request is made to ensure that the operator has received the alarm information. Alarm may result from field information changes or from processing of field information, operator and system actions. Alarms may be configured as major and minor alarms

The SCADA system shall be able to handle various types of alarms, typically:

- Alarm generated due to change in field information.
- Alarm generated due to fault in SCADA system equipment and communication link.

Alarm procedure

The purpose of the alarm procedure is to draw the operator's attention and ensure that the information is taken into consideration, whatever activity being performed when the procedure is initiated. The alarm procedure shall generate a specific visual effect and audible warning on the operator work station. The activation of the audible warning shall be configurable for major alarms. It shall be possible to disable the audible alarms. Alarm procedures may be generated in the following cases:

- Alarm appearance
- Alarm disappearance

Alarm appearance procedure:
Any change from "normal" to "alarm" value of a alarm shall be considered as an alarm appearance event and shall generate an alarm procedure.
Alarm disappearance procedure:
Any change from "alarm" to "normal" value of a alarm shall be considered as an alarm disappearance.

Alarm list

All alarm appearance events shall generate a record in the alarm list. The alarms can be removed from the Alarm List if

- Alarm is not present any more,
- Alarm has been acknowledged by the operator.

Alarm disappearance events, which generate an alarm procedure, shall also generate a record in the alarm list. This record shall only be erased by the SCADA system when the concerned operator has acknowledged the alarm disappearance. All alarms which appear in the SCADA screen shall be logged in the Log mode and shall not be erasable.

Audible warning cancellation

The possibility of implementing an "audible warning cancellation" facility shall be provided. When an alarm procedure has been initialised, this facility shall allow the operator to stop the audible warning prior to alarm acknowledgement. The audible warning cancellation shall have no other consequence on the alarm procedure (the visual warning shall remain until alarm acknowledgement) and shall not interfere with the management of the alarm list.

Any new alarm procedure after the audible warning cancellation shall reset the audible warning.

Display of Alarms and Events

- The digital inputs signals being monitored by various RTU shall be categorised as
- P0, P1, P2 & P3 categories. The method of configuration for these alarms shall be as below:
- **P0 (events)**
- P0 category signals are non severe signals that need not be configured as alarms.
- These are to be stamped in event list only.
- **P1 (Alarms and events)**
- P1 category signals also fall under non severe category but which requires attention of operator from the process point of view.The same shall be configured as visual alarms.
- **P2 (Alarms & Events)**
- P2 alarms are used for major and critical alarms that require acknowledgement
- from the operators and shall be attended so that the system can operate / function
- smoothly. These are to be configured as alarms & events. Audible alarms are
- required to be configured for this category signals.

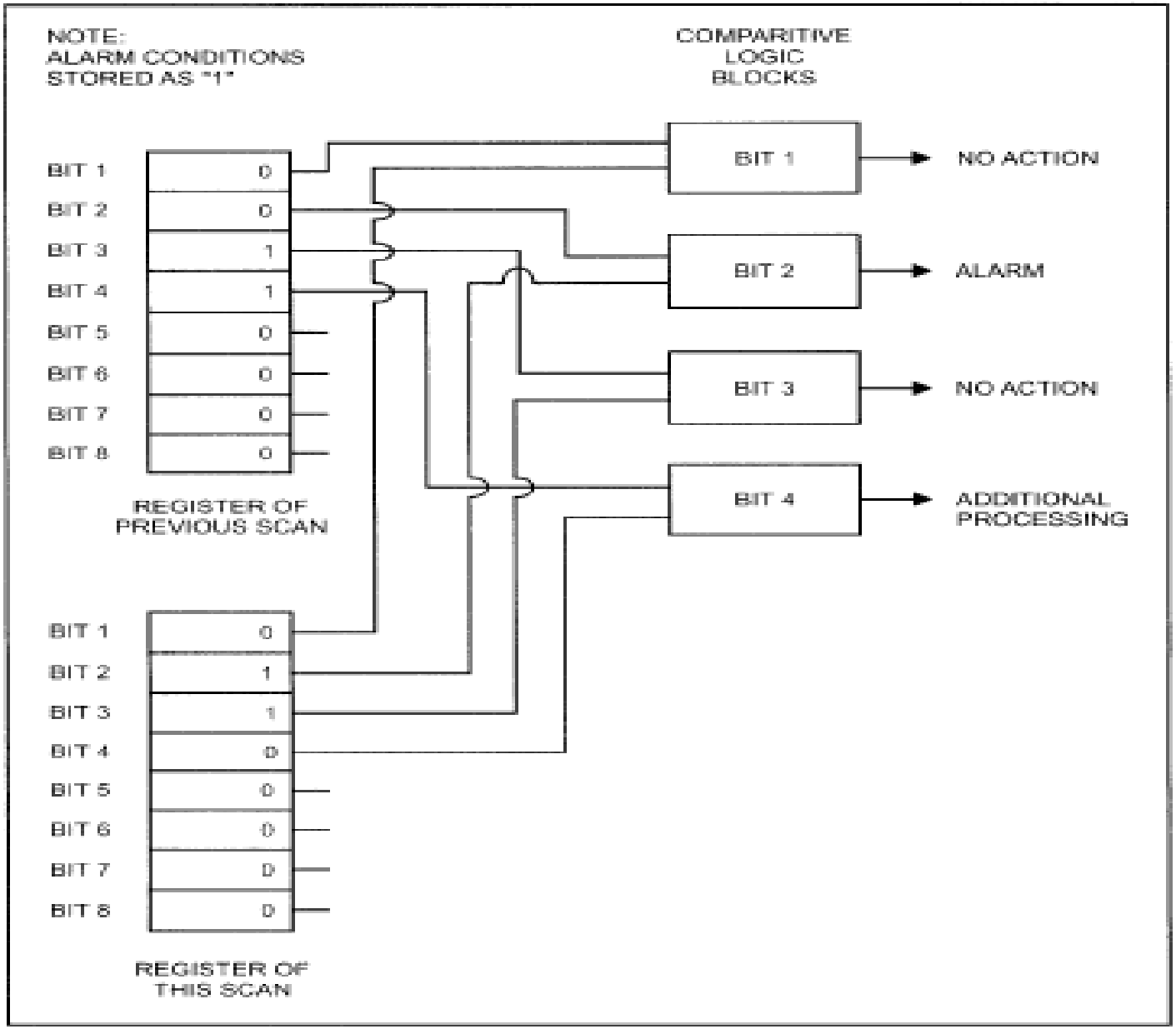


Figure 12-2. Checking for New Alarms

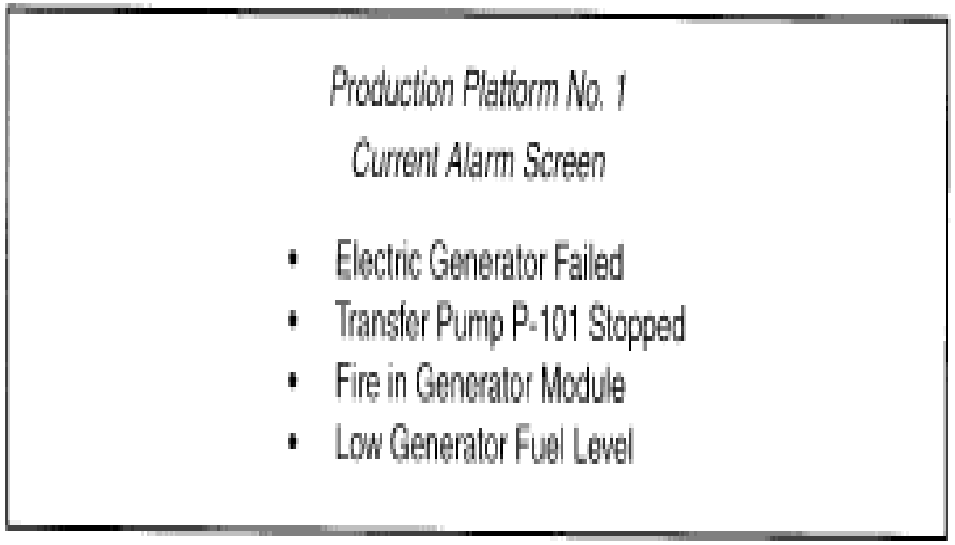


Figure 12-3. Four Possible Alarm Conditions for Unmanned Oil Production Platform

Alarm Priority	SCADA System Reaction
1.	Print on "Alarm Screen" Print on "Alarm Log" Flash "Alarm" on any active screen Sound audible alarm
2.	Print on "Alarm Screen" Print on "Alarm Log" Flash "Alarm" on any active screen
3.	Print on "Alarm Screen" Print on "Alarm Log"

Figure 12-4. Effects of Various Priority Alarms

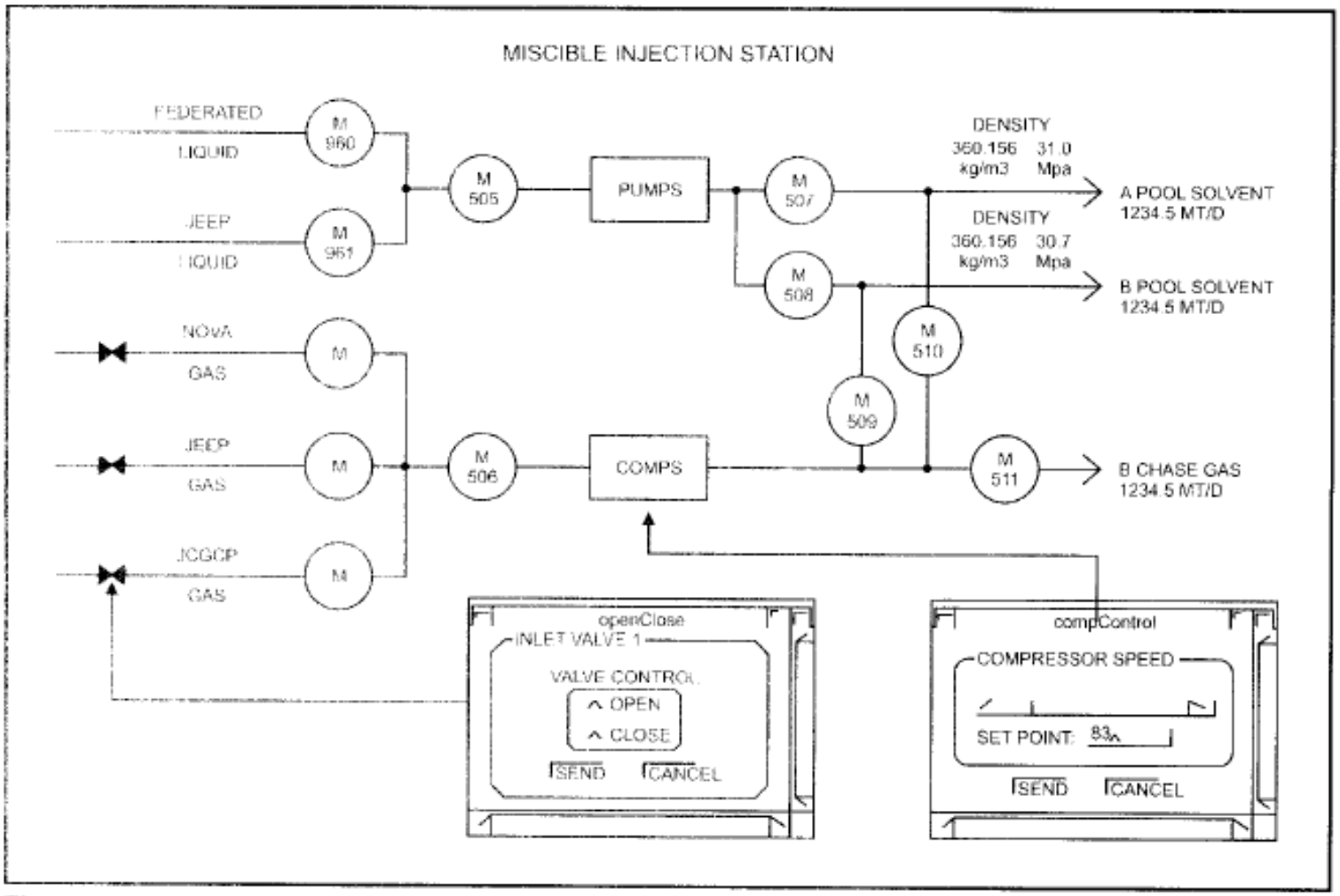
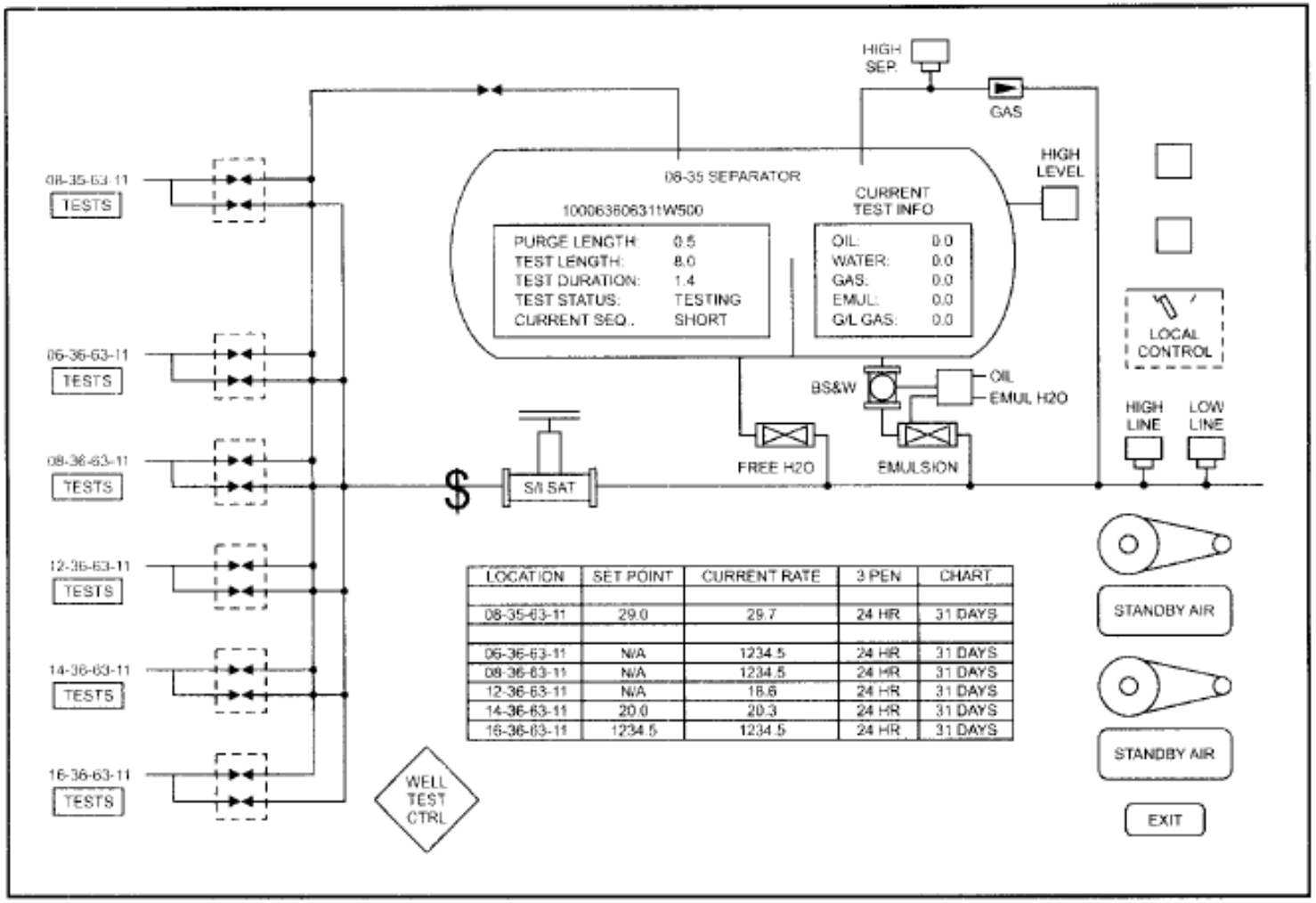


Figure 12-5. Control Screen (Courtesy: TesserNet Systems Inc.)

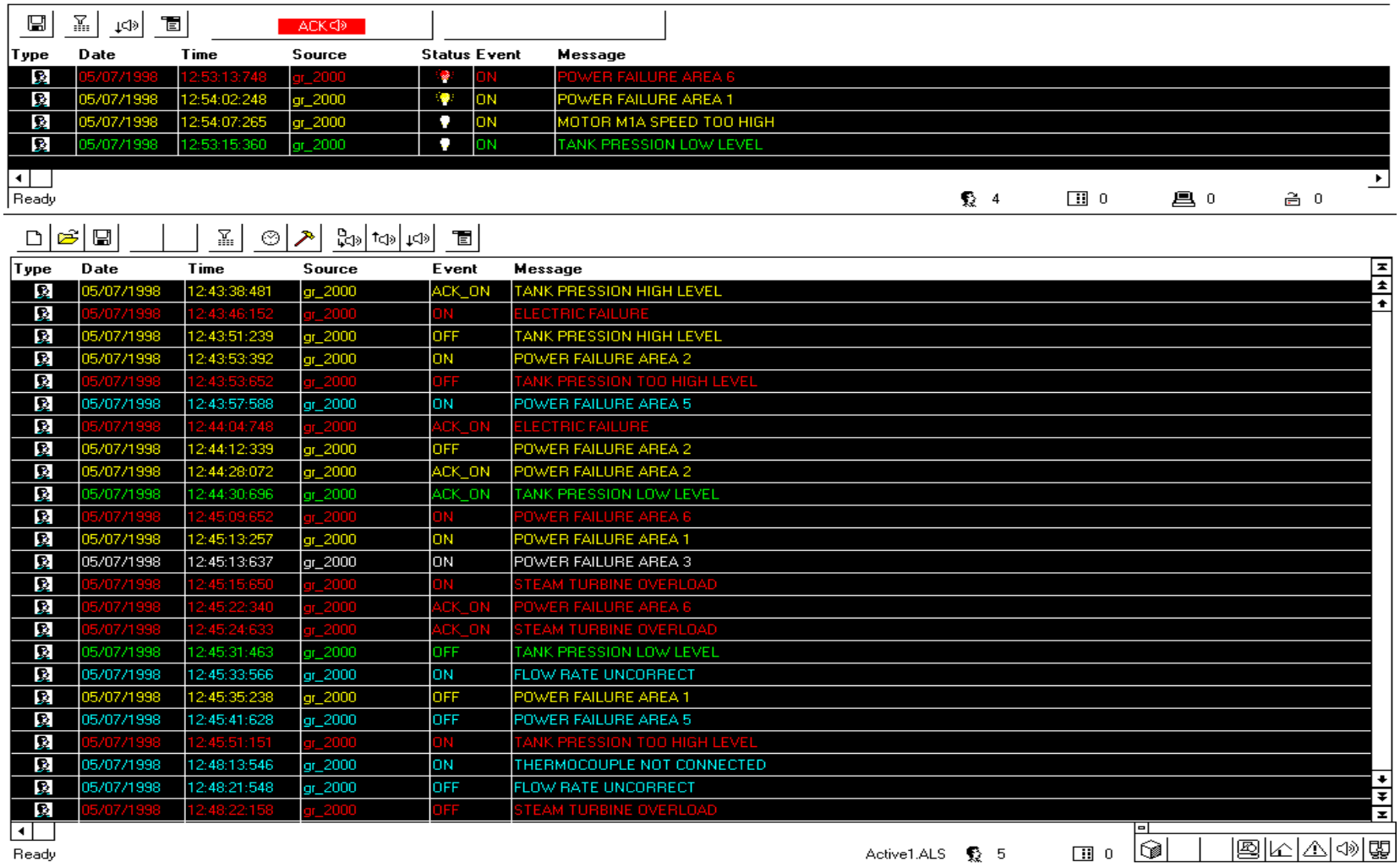


LOCATION	SET POINT	CURRENT RATE	3 PEN	CHART
08-35-63-11	29.0	29.7	24 HR	31 DAYS
06-36-63-11	N/A	1234.5	24 HR	31 DAYS
08-36-63-11	N/A	1234.5	24 HR	31 DAYS
12-36-63-11	N/A	18.6	24 HR	31 DAYS
14-36-63-11	20.0	20.3	24 HR	31 DAYS
16-36-63-11	1234.5	1234.5	24 HR	31 DAYS

Figure 12-6. Status Screen (Courtesy: TesserNet Systems Inc.)

- Alarm Handling
  - Based on limit and status checking *
  - More complicated expressions developed by creating derived parameters *
  - Alarms are time stamped and logically centralised *
  - Notifications (audible, visual, Email, GSM)
  - Multiple alarm priority levels
  - Grouping of alarms and handling of groups is possible
  - Suppression and masking of alarms either individually or as a complete group
  - Filtering of alarms is possible

Alarm Handling



Logics & Interlocking

- Control of paralleling switches (PIT) or Bridging Interrupters Automatic opening of a PIT (ring opening) when the tracks are de-energised. This allows rapid troubleshooting by the power operator who does not have to open all PITs one after the other to isolate tracks. Under these conditions, when resetting, it will be possible to locate the fault since the tracks are electrically independent.

Interlocking scheme

For safer operation interlocking has to be implemented in SCADA system.

The following interlocks mainly to be provided.

a) Breaker-Isolator interlocking – It should not be possible to operate Isolator when the corresponding breaker is in Close condition and breaker operation should not be possible when isolator is in open condition.

b) 33 KV Network Inter Loop-interlocking: - When Potential Transformer of adjacent loops is showing voltage, Extending power from one loop to other should not be possible.

c) Interlocking at SPs: - When Potential Transformers on both sides of SP is showing voltage, Extending power from one section to other should not be possible.

d) **(N-1)** interlocking in a 33 KV Network Loop .

Reporting

The SCADA software shall support configuration of time related measurement reports Measurement Report is used within SCADA's library applications for various types of time related reports, such as hourly, daily, weekly, monthly and yearly reports. The reports shall be based on time-related follow-ups of process, metered, entered or calculated data. The data for the reports shall be stored in real time. Report data is collected and calculated cyclically or triggered by events. The most common method is to fetch raw data from the process, and thereafter to scale and store it in the report database. All the events/reports are shall be automatically written in text files and stored on hard disk in the reports folder of the application. Periodic back ups of reports shall be possible

The Measurement Reports supports the following time related reports:

- Hourly report (time resolution: 3 minutes)
- Daily report (time resolution: 15 minutes)
- Daily report (time resolution: 30 minutes)
- Weekly report (time resolution: 1 day)
- Monthly report (time resolution: 1 day)
- Yearly report (time resolution: 1 month)

Printers that are connected to the Master Stations shall be used for printing of reports. Automatic periodic printing of reports can be configured for the Master. On demand printing of reports shall also be possible.

- Trends are something where you can view the industrial process data in real time and can save that data and view it in future. Trends plays a very important role in our Automation Industry. A Operator can see the trend and can tell about the whole production of the company. Trends are generally of 2 types viz. Real Time Trend and Historical Trend

Trends

- The SCADA shall support trends for performing time related follow up of process data. The trends shall be possible for both digital as well as analogue parameters.
- The trends shall be possible in both graphical and tabular forms which shall share the same database.

Types of Trends in SCADA System

- 1.**Real Time Trends**

  Real-time trends are dynamic i nature. They are updated continuously during run time and you can see the real time data of your Tags which you have configured. Real time trend help us in seeing actual data that is of the process. Like you have make a tag of Water Level in a Sewage Treatment plant and you want to see the the present value of Water level with respect to the time. Then you will use Real Time Trend which can be configured in seconds, Mili-seconds, minutes and hours.

  2.**Historical Trends**

  Historical trends as the name indicates are used to view past values of the Tag and you can configure them to see any past date Data. They can be configured in Days, Months, Years etc. You can view your tag value any time.

- Real-time 2D and 3D trending for WinForm and WPF applications. Free development and unlimited trend windows to each licensed OPC Systems Service. Communicate trend data over your company network and Internet to unlimited remote clients worldwide.
- Trend control that can be used with Visual Studio 2010, 2008, and 2005 to create WPF and Windows applications.
- There is no data loss in the OPC Trend.NET component if it losses a remote network connection to other OPC Systems Services.
- No programming required.
- No Client Licensing required
- Supports runtime modification for all properties.
- Includes:
- X-Y Plot
- Multiple Y-Axis
- History combined with the product SCADA Database.
- Free connectivity to OPC Servers.
- Efficient high speed communications for remote connectivity.
- Calculation engine for real-time math equations.
- Free programmatic interface for all configurations.
- CSV Import and Export methods for all configurations.
- Free user security to restrict data access and configurations.
- Tracking for individual events for time on and counts.
- Unlimited number of remote clients.
- All 100% managed .NET components.
- Extremely fast data update with very low CPU usage

Trends

- The x- axis and y-axis of the graphs shall be configurable in scale. It shall be possible to have different scan time variable in single display.
- The trend display shall support the following features:

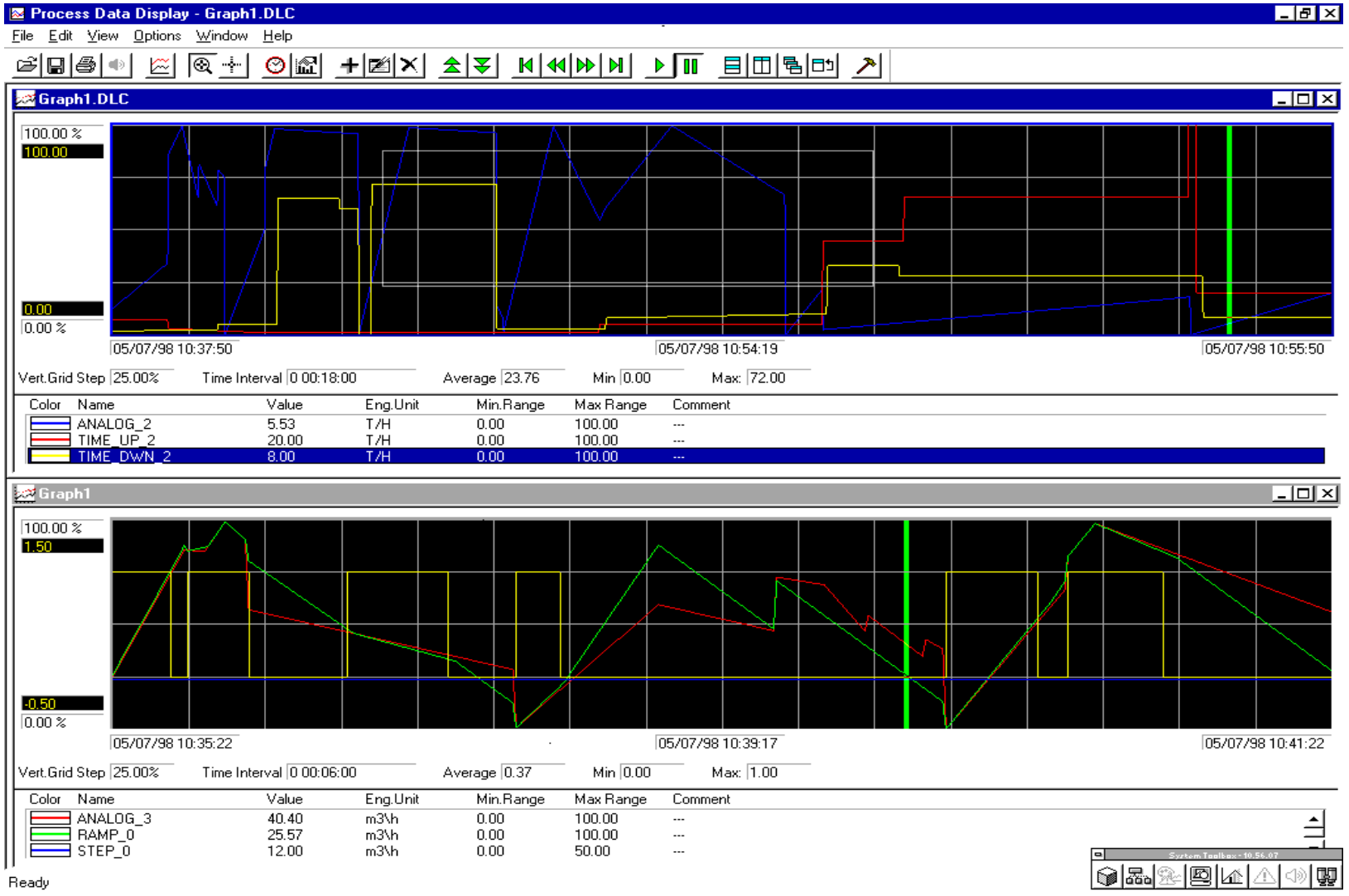
- Support of Graphical or tabular view modes with zooming facility
- Shall support Scrolling with scroll bars and panning
- Configurable axes, line properties and legend
- Update interval options from 30 seconds to 10 minutes

- - Trends for Calculation formulas; direct, mean, sum and difference shall be possible

- Shall have Printout option
- Depiction of Update/Frozen modes
- Facility to Copy to clipboard and export to CSV File

- Trending
  - Multiple trending charts
  - Charts are pre-defined or configured on-line
  - Charts contain multiple pens,
  - Zooming, scrolling, panning, ‘Hairline’
  - Real-time and historical trending

Trending


Process Data Display - Graph1.DLC
File Edit View Options Window Help
Graph1.DLC
100.00 %
100.00
0.00
0.00 %
05/07/98 10:37:50
05/07/98 10:54:19
05/07/98 10:55:50
Vert.Grid Step 25.00% Time Interval 0 00:18:00 Average 23.76 Min 0.00 Max: 72.00
Color Name Value Eng.Unit Min.Range Max Range Comment
ANALOG_2 5.53 T/H 0.00 100.00 ---
TIME_UP_2 20.00 T/H 0.00 100.00 ---
TIME_DWN_2 8.00 T/H 0.00 100.00 ---
Graph1
100.00 %
1.50
-0.50
0.00 %
05/07/98 10:35:22
05/07/98 10:39:17
05/07/98 10:41:22
Vert.Grid Step 25.00% Time Interval 0 00:06:00 Average 0.37 Min 0.00 Max: 1.00
Color Name Value Eng.Unit Min.Range Max Range Comment
ANALOG_3 40.40 m3\h 0.00 100.00 ---
RAMP_0 25.57 m3\h 0.00 100.00 ---
STEP_0 12.00 m3\h 0.00 50.00 ---
Ready

Event Disturbance Recording

- Recording devices have existed for many years, from the first ink chart recorders, often referred to as perturbographs, to the digital recording equipment available today. Modern digital equipment has the capability to monitor a larger number of analog and binary inputs that could not be monitored in the earlier disturbance recording devices. The introduction of microprocessor relays provided another method of disturbance recording. The increased capability of disturbance recording devices and microprocessor relays with disturbance recording capability, have created analysis challenges for the engineer.

The three primary types of recording are:

- •High-speed disturbance recording
- • Low-speed disturbance recording
- • Steady State (continuous) recording

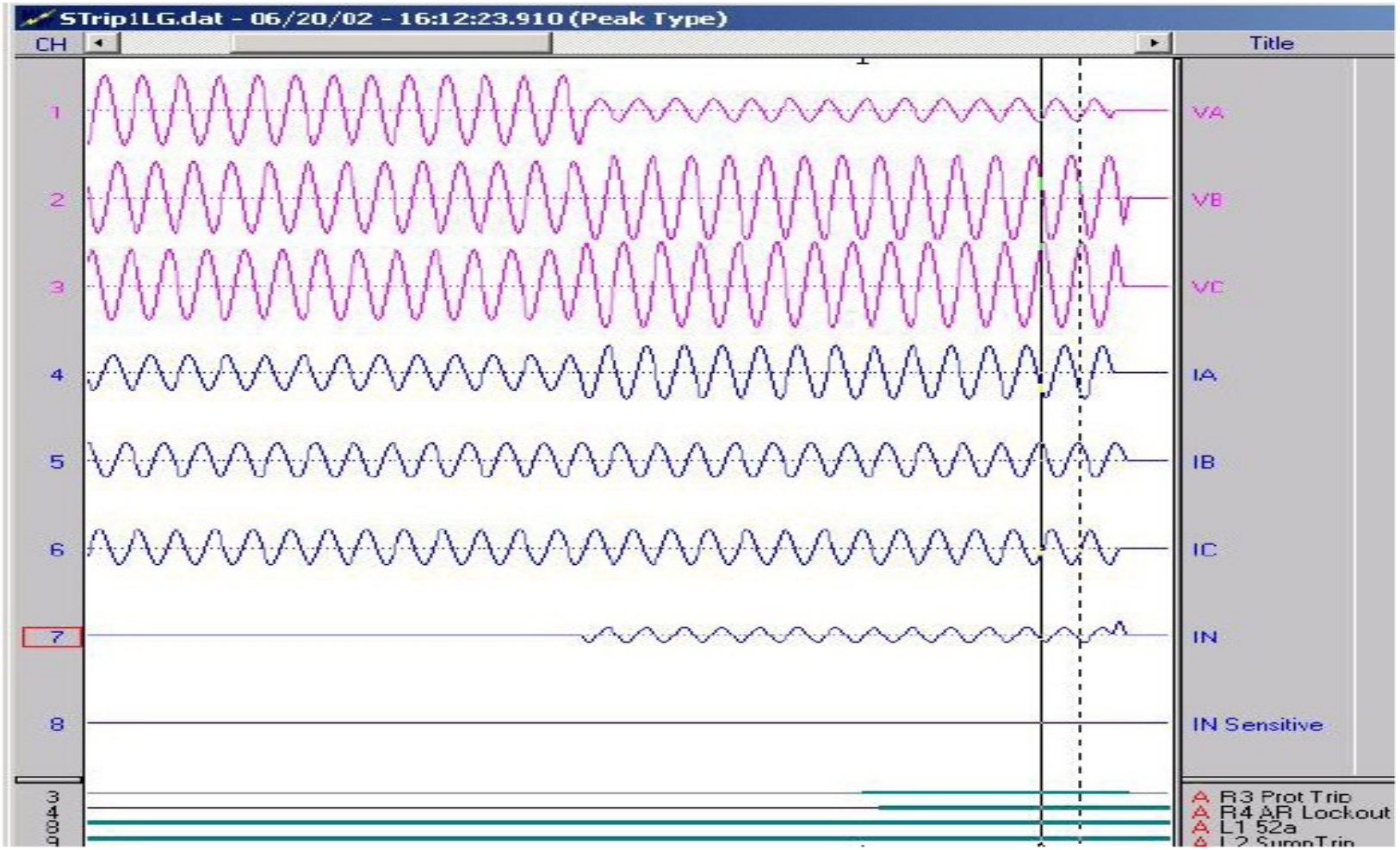


Figure 2 Transient record including binary state change information

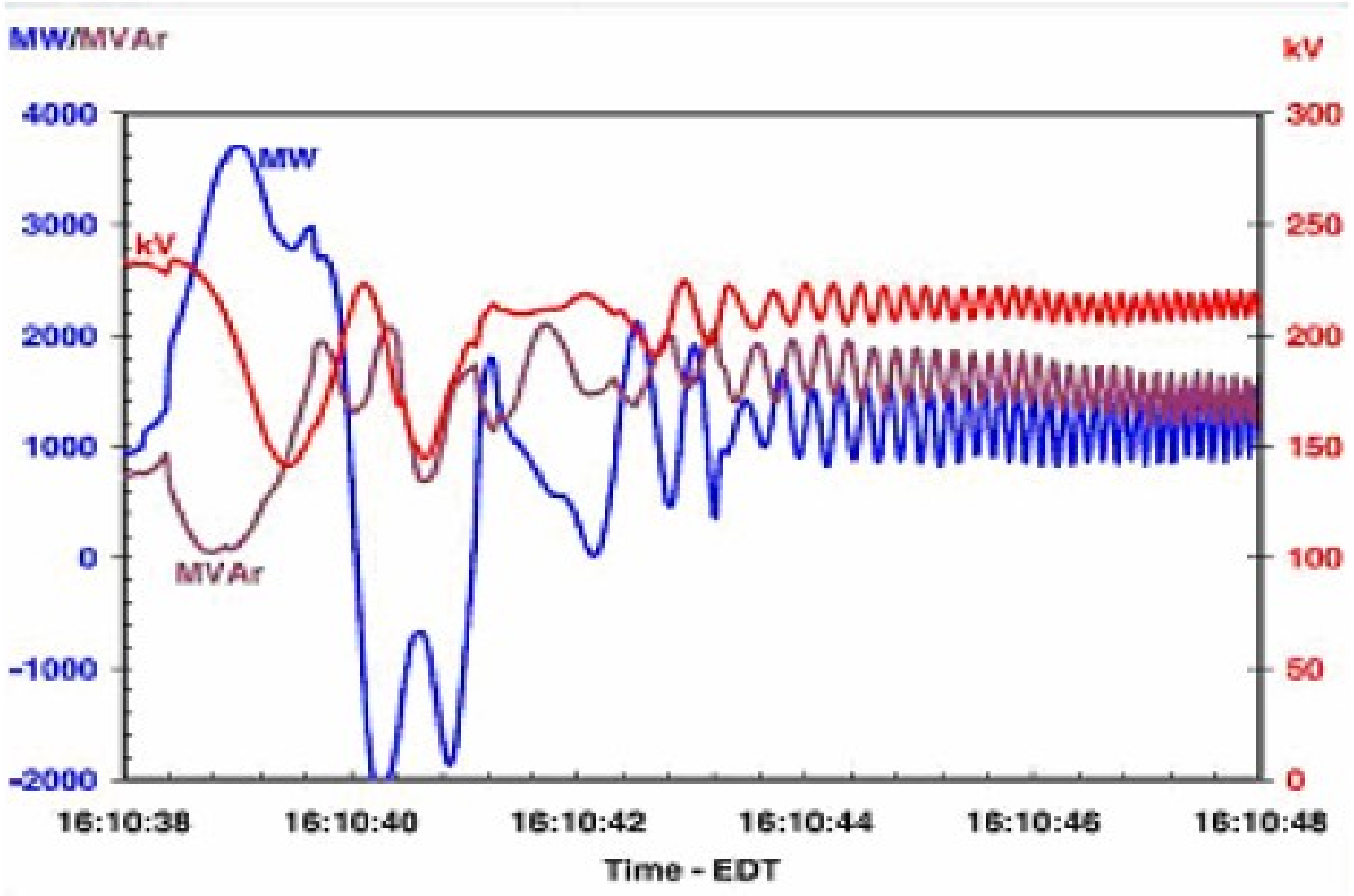
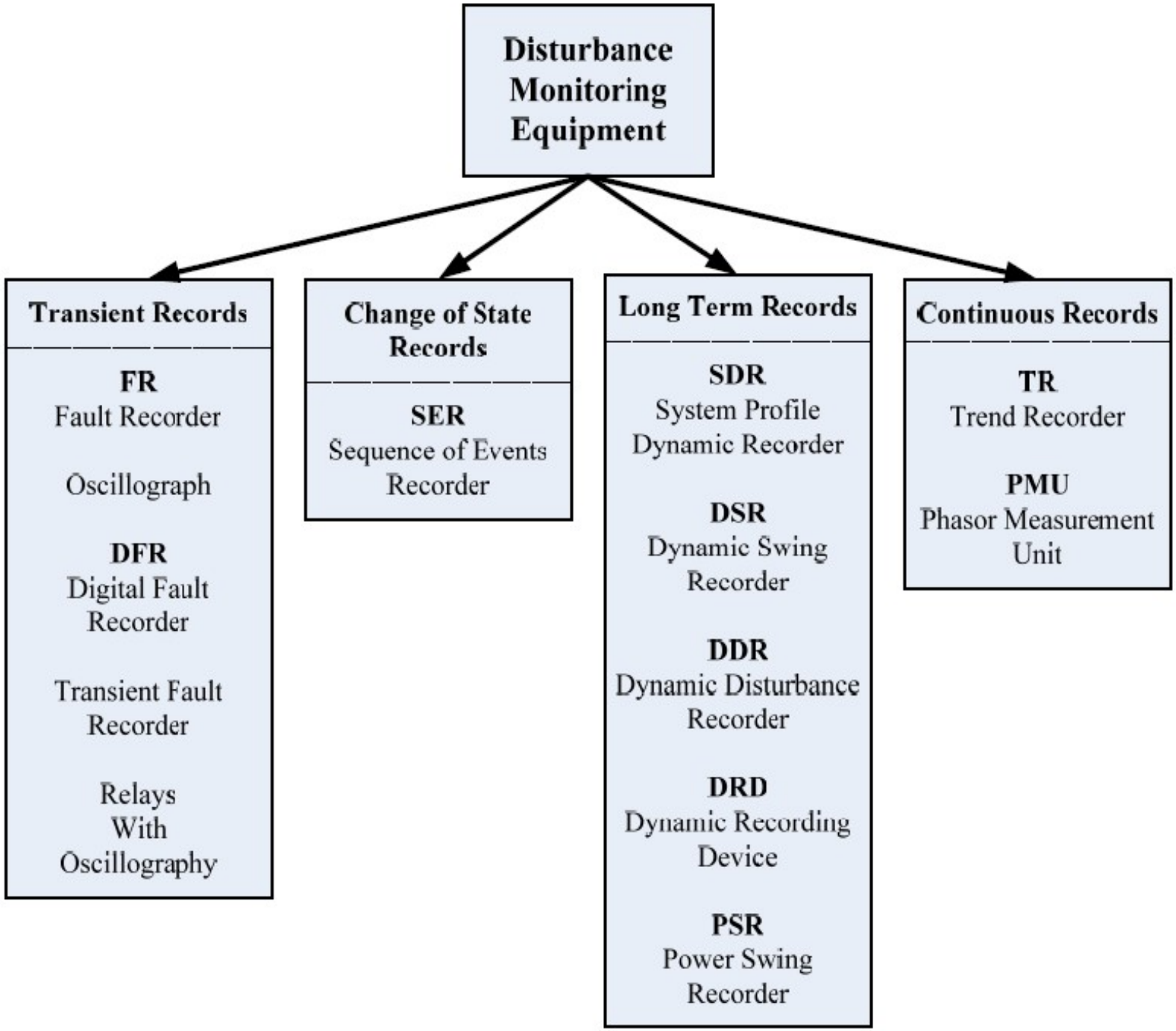


Figure 3 Low-speed disturbance record, short duration


Disturbance Monitoring Equipment
Transient Records
FR
Fault Recorder
Oscillograph
DFR
Digital Fault Recorder
Transient Fault Recorder
Relays With Oscillography
Change of State Records
SER
Sequence of Events Recorder
Long Term Records
SDR
System Profile Dynamic Recorder
DSR
Dynamic Swing Recorder
DDR
Dynamic Disturbance Recorder
DRD
Dynamic Recording Device
PSR
Power Swing Recorder
Continuous Records
TR
Trend Recorder
PMU
Phasor Measurement Unit

Disturbance recording

Issues relating to the application of disturbance recording equipment are:

- The specific event to capture
- The available data sources; analog and binary
- Characteristics of sensing equipment
- Required sampling rate to capture desired events
- Application of triggers necessary to capture the desired event
- The storage capacity of each device.
- Communication method associated with each recording device.
- Frequency of record retrieval necessary to minimize losing records.

Blocking List

- The operators shall be able to inhibit /block the control from SCADA system.
- This blocking action shall be available in the blocking list.
- The control inhibition/ control blocking shall be possible individually for each equipment being processed.
- The operator shall be possible to cancel the blocking also.
- The user performing the blocking / deblocking shall be logged in the event list.
- The blocking and deblocking actions shall be available in the SCADA system in the form of blocking list: