Engineering Standard

SAES-P-126 25 January 2011

Power System Automation

Document Responsibility: Electrical Systems Designs and Automation Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This Standard prescribes the mandatory requirements for the design and installation of Power System Automation (**PSA**). The scope of this standard covers **high voltage** electrical system. If interface means are provided for **low voltage** electrical system, intelligent electronic devices (**IED**) shall be integrated with the **PSA**.

2 General

The Power System Automation (**PSA**) is used throughout the plant to provide protection control and monitoring of the power system. The Power Operation Department (POD) is responsible for maintaining and operating the **PSA**.

3 Conflicts and Deviations

3.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (**SAESs**), Materials System Specifications (**SAMSS**s), Standard Drawings (**SASD**s), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

4 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

4.1 Saudi Aramco References

The documents listed below, and any others attached to the requisition, apply when included in the requisition to the extent referenced herein or on the data sheets:

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-P-114	*Power System and Equipment Protection*
SAES-P-119	*Onshore Substations*
SAES-Z-004	*Supervisory Control & Data Acquisition (**SCADA**) System*
SAES-Z-010	*Process Automation Networks*

Saudi Aramco Materials System Specifications

16-SAMSS-502	*Low Voltage Switchgear*
16-SAMSS-504	*High Voltage Switchgear*
16-SAMSS-513	*Power System Automation Components*

Saudi Aramco Engineering Report

SAER-6114	*Process Automation Communication Networks Architecture*

4.2 Industry Codes and Standards

American National Standards Institute (ANSI) / Institute of Electrical and Electronics Engineers (IEEE) Standards

IEEE C37.1 - 1994	*Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control*
IEEE 730	*Standard for Software Quality Assurance Plans*
IEEE 828	*Standard for Software Configuration Management Plans*
IEEE 1588	*A Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*
IEEE 1613	*Standard Environmental Testing Requirements for Communications Networking Devices in Electronic Power Stations*

International Electrotechnical Commission (IEC) Standards

IEC 61000-4-3	*Testing and Measurement Techniques - Radiated, Radio frequency, Electromagnetic Field Immunity Tests*
IEC 61000-6-5	*Electromagnetic Compatibility (EMC) - Part 6-5: Generic Standards - Immunity for Power*

	Station and Substation Environments
IEC 61850	*Communication Networks and Systems in Substations*
IEC-61850-3	*Communication Networks and Systems in Substations - Part 3: General Requirements*

5 Definitions

Words in bold font throughout this standard are defined below.

AFD: Adjustable Frequency Drive.

Approval or Approved: Written approval of the **ESD Coordinator**.

Availability: The ratio of uptime to total time (total time = uptime plus downtime).

Client: The user point-of-entry for the required function in **client**/**server** computing. Normally, a desktop computer, workstation, or laptop computer.

Database: A group of related files (data tables).

Database Management: Special software to create and maintain a **database** and enable individual business and application to extract the data they need without having to create separate files or data definitions in their computer programs.

DCS: Distributed Control System.

EMC: The Electromagnetic Compatibility. **EMC** is a measure of equipment tolerance to external electromagnetic fields.

ESD Coordinator: Coordinator, Consulting Services Department/Electrical Systems Division, Saudi Aramco, Dhahran.

Ethernet: A link layer protocol using a shared channel to broadcast messages and used widely in Saudi Aramco **LAN**.

Expandability: The capability of a system to be increased in capacity or provided with additional functions.

Failover: The transfer of a function or functions to a backup device.

Graphical User Interface (**GUI**): Part of a software to display data and functions. Users use graphic icons and the computer mouse to issue commands and make selections.

GPS: Global Positioning System. The system provides time signal for time synchronization purposes.

HMI: Human machine interface.

High Voltage: Voltages 1000 V or greater unless otherwise designated in a specific MSAER or referenced international standard.

IED: Intelligent Electronic Device. See IEEE C37.1 - 1994.

LAN: Local Area Network, a computer network that is concentrated in a geographical area such as a building or a plant area. See IEEE C37.1 - 1994.

Low Voltage: Less than 1000 V.

Monitor: The metering device; a multifunctional metering **IED**.

MTBF: Mean time between failure.

PI: Process information system.

PSA: Power System Automation.

Response Time: The time between initiating some operation and obtaining results.

RTU: Remote Terminal Unit.

SAMSS: Saudi Aramco Materials System Specification.

SCADA: Supervisory Control and Data Acquisition. See IEEE C37.1 - 1994.

Scalability: The ability of a computer, product, or system to expand to serve a larger number of users without breaking down.

SEC: Saudi Electrical Company.

Server: Computer specifically optimized to provide software and other resources to other computers over a network.

SOE: Sequence of Events (time-tagged status points).

Substation: Per the definition within SAES-P-119.

Switchgear: Equipment manufactured to either 16-SAMSS-504 (High Voltage Switchgear) or 16-SAMSS-502 (Low Voltage Switchgear).

6 Scalability and Expandability Requirements

Table 1 specifies the **Expandability** requirements for the **PSA**.

Table 1 – Expandability Requirements for PSA

Item	Performance Parameter	Requirement
1	Future I/O growth (this is over and above the I/O growth considered during project execution)	20%
2	System processing and memory expansion capability	50%
3	Communications network node expansion capability	25%
4	Hardware expansion capability	25%
5	Fiber optic cable	100% spare fibers

The system **Scalability** and **Expandability** requirements specified in Table 1 shall be met while meeting the system performance requirements specified in Table 3 of this specification.

7 PSA Reliability Requirements

Table 2 specifies reliability requirements for **PSA**. In the determination of the following requirements, system redundancy shall be considered, wherever provided with switchover / **failover** times.

Table 2 – Reliability Requirements for PSA

Item	Performance Parameter	Requirement
1	Overall system **availability** (Note-1)	99.7%
2	Hardware reliability	99.9%
3	Software reliability	Per Industry Standards IEEE 730, IEEE 828
4	GOOSE (Protection, interlocking, load shedding)	99.999% per EPRI report 1008688
5	Other critical information flow	99.99% per EPRI report 1008688
6	Loss of critical functions (Note 2)	Less than 5 minutes per year
7	Loss of non-critical functions (Note 2)	Less than 1 hour per year

Notes to Table 2:

1) During Site acceptance testing, higher level of reliability 99.9% shall be demonstrated due to short testing period.

2) Functions which impact operation of electrical system such as control functions shall be considered as critical functions. Functions related to monitoring and which do not lead to loss of data, shall be considered as non-critical functions.

7.1 Overall System MTBF of not less than 60,000 hours.

7.2 PSA within individual substations shall have a maintenance interval of not less than 45,000 hours.

Commentary:

*The intention of paragraph 9.2 is to ensure continuity of system operation for minimum of five years without a need for routine maintenance. Components such as built-in batteries or **database** storage media shall be sized for continuous operation for more than five years.*

8 PSA Redundancy Requirements

The **PSA** shall be designed based on one failure contingency scenario starting from the communication ports of **IED**s. Single failure occurrence on **IED** communication port or any component /segment upstream shall not result in loss of communication or any other **PSA** function. This shall include **Ethernet** switches/cables, power supplies, and computers.

9 PSA Architecture and Interfaces

9.1 All external interfaces to other subsystems (DCS, SCADA, PI, etc.) shall be based on native standard interface of the subsystem in question at the point of interconnection. Further processing of the interface inside the substation is part of the PSA standard.

9.2 The PSA shall interface with the following systems if available:

9.2.1 All IEDs installed in:

- Control and Protective Relay Panels.
- **High Voltage switchgear** & Controlgear.
- **Low Voltage switchgear** & Controlgear.

9.2.2 Equipment Monitoring & Control Systems that includes but not limited to the following:

- Power transformer condition based monitoring system.
- Load tap changer and automatic voltage regulator.
- Battery Monitoring, UPS, and DC Systems.
- Motor Partial Discharge, rotor flux monitoring systems, RTD, and other signals.
- **AFD**.

- Excitation systems of Synchronous machines.
- **Substation** Air-conditioning.

9.2.3 Plant power generation.

9.2.4 DCS and/or Process Information System.

9.2.5 SCADA system.

9.3 The PSA shall be implemented in three levels:

Figures and guidelines in Attachment 1 shall be used when designing **PSA** architecture with the following explanatory notes:

9.3.1 Level 1 shall consist of networks within switchgear, controlgear and other equipment/systems such as UPS & DC Systems. This may include devices located outside the substation.

9.3.2 Level 2 shall consist of networks within individual substations serving equipment at level 1 network. This may also include devices located outside the substation.

9.3.3 Level 3 shall consist of networks outside of individual substation and those located in the central control rooms. This includes links between Level 3 and the PCC (Power Control Center) network.

9.3.4 Each level shall be designed and implemented such that it can be independently installed, tested and commissioned.

9.4 PSA Network

9.4.1 The topology of PSA LANs shall be parallel redundant or bus-ring topology to provide fault-tolerant architecture. Engineering Report SAER-6114 may be used as design guide.

9.4.2 The network shall be stand alone and dedicated for PSA functions, i.e., the PSA LAN shall be physically and logically isolated from all other non PSA network traffic. This network is equivalent to process automation network prescribed in SAES-Z-010.

9.4.3 Connectivity alternatives for special cases such as remote/isolated sites, and interfaces with existing systems shall be reviewed and approved by Consulting Services Department.

Commentary:

The intention of paragraph 9.4.3 is to pay special consideration to cases like:

*1- Modification to existing **Substations**.*

*2- **Substations** added to existing facilities.*

3- Remote or isolated substations where extending the PSA network may introduce practical concerns.

9.4.4 SCADA communication link between the PSA and SCADA receiving end (power control center) shall be designed as per SAES-Z-004.

10 PSA Response Times and Performance

Table 3 specifies the performance requirements for **PSA**, unless indicated as "preferred" in:

Table 3 – Performance Requirements for PSA

Item	Performance Parameter	Response Time
1	**PSA** workstations power up	4 minute
2	Issuing a command in response to the operator's command	500 millisecond (Preferred) 1000 millisecond (Required)
3	Time critical **substation** events using GOOSE (e.g., circuit breaker opening & closing, protection operated, protection and interlocking signals etc)	4 millisecond (GOOSE or equivalent) + **Ethernet** switch propagation delay
4	Calling up new **HMI** screen	Not more than 2 second
5	Update of **HMI** screen after change in value (analog, digital, alarms, events, operational data)	Not more than 2 second
6	Time synchronization accuracy	1 millisecond
7	Time-stamped sequence of event resolution accuracy	1 millisecond
8	Automatic update of non-operational data	30 seconds
9	Update of non-operational data on request	10 second
10	System communication alarms & events	2 second

Notes to Table 3:

1) If required to achieve time synchronization accuracy per Table 1, open standard time synchronization methods may be used, such as, IEEE 1588 **Ethernet**-Based Precision Time Synchronization standard.

11 Functional Requirements

11.1 General

The functions to be implemented in **PSA** are identified in this section.

11.2 Power System Specific Functions

PSA Functions shall be as indicated in Table 4 below:

Table 4 – Power System Functions

Description	Local	Remote	Note
Power System and Equipment Protection	NA	NA	As per requirements prescribed in SAES-P-114 and other electrical equipment standards
Control of Circuit breakers: - Select to trip / close - Remote / local selection - Rack- in/ Rack-out	Y	Y	This include control of main incomer breakers through **SCADA** system *
ATS Control and interlocking	Y	Y	
Block auto-changeover	Y	Y	
Tap Changer Control including master / follower / independent, auto / manual, set point, raise/lower	Y (LTC Panel)	Y	This include control of main transformers through **SCADA** system
Load Shedding	Y	Y	
Synchronizing (where applicable)	Y	Y	*Cogen
Annunciation including signals from fire alarm HVAC systems	Y	Y	This function will replace classical enunciator panel with computer based system. Part of this is a touch screen and sound system to emulate classical enunciator.
Plant power Factor Control	Y	Y	Control of excitation panels of synchronous machines via the Adaptive Excitation Control or manually.
Condition Based Monitoring of Transformers, **AFD**, UPS & DC System, HVAC, etc.	Y	Y	This function is based on **availability** of interfaces to the systems outside and inside the **Substation**.
Power monitoring System	Y	Y	This includes basic electrical parameters, electrical demand & energy, events log and waveform capture. This function will replace classical meters, transducers, and fault recorders. Table 5 & 6 prescribes more details on data to be monitored.
GPS Clock Synchronization	NA	NA	Clocks of **PSA** components (**IED**s, and **server**s) shall have one time reference from the **GPS**.

11.3 Additional Operation Support Functions

Switching Function

PSA shall guide the operator in switching functions, by means of on-line step-by-step switching procedural help and interlocks. The **PSA** will ensure safe and error-free switching operations. **PSA** shall also guide the operator or automatically perform pre-defined sequential switching functions.

Tagging

PSA operator shall be able to place and remove soft tags from devices in the system. This shall allow operator to identify circuits and devices which are under maintenance and prevent closing of the related switching devices.

Intelligent Alarm Handling

All alarms shall be assigned priority to handle alarms intelligently and avoid avalanche of alarms being presented to the operator. The alarms shall be presented starting from the highest to the lowest priority.

12 Software, Database, and Servers

12.1 Ethernet switches, Computers, and computer peripherals hosting main software components shall be powered from the DC system in the substations or the UPS in the control room.

Commentary Note:

Ethernet switches located in subsations shall be powered from the 125 VDC system. Workstations are also recommended to be powered from the 125 VDC supply.

12.2 The PSA shall be based on Client – Server computing technology to allow users (clients) access the PSA remotely.

12.3 The security management tools of the PSA software shall be configured to allow for multiple access levels with different privileges. Administration tools for Authentication/authorization to perform PSA functions shall be based on specific users using user IDs or specific workstations located throughout the system.

12.4 An overall (simplified) diagram, on a single screen, of the plant or facility shall be developed with displays of plant total, real power, reactive power, apparent power, power factor, and system time.

12.5 One line diagram of monitored substations shall be configured with at least one screen for each substation displaying the following data:

i) Line voltage on each bus section

ii) Breaker/contactor status for each breaker/contactor.

iii) Average current, total real power and power factor on each feeder.

iv) An audible and visual alarming should immediately appear if a breaker/contactor trip. The alarm shall appear even if the screen is showing other healthy sites (screens). The alarm shall not be activated due to normal close/open operations.

12.6 Display(s) from each individual monitor shall be developed to show the following:

i) Phase voltages, line voltages, currents, and frequency.

ii) Per-phase and total of, real power, reactive power, apparent power and power factor.

Commentary Note:

*The requirement of per phase voltages is not applicable when the **monitors** are connected to an open delta PTs.*

iii) Links to the **database**/memory to retrieve historical data listed in Tables 1 and 2.

iv) Power quality related data such as harmonics, and phasor diagrams.

12.7 Diagram(s) for each plant process area (operating area) shall be developed with the following displays:

i) Electrical energy and the cost in US$ consumed for the previous two operating shifts.

ii) Electrical energy and the cost in US$ consumed for the previous day (yesterday).

iii) Electrical energy and the cost in US$ of the accumulating energy for the current operating shift.

iv) Electrical energy and the cost in US$ of the accumulating energy for the current day (today).

v) Link to retrieve historical energy data (the three shifts and the daily energy).

vi) Report by exception functionality shall be maximized to reduce network traffic, where possible.

12.8 The Database management system shall be provided with and configured to perform the following tasks:

12.8.1 All database element or tags shall be unique throughout the plant

12.8.2 All tags shall have a unique tag ID, descriptor, type and alarm requirement

12.8.3 Possible to add, modify or delete tags without restarting the system

12.8.4 All tags shall be searchable by tag ID, descriptor, point type, hardware address. All searches shall be capable of being sorted or filtered, printed or stored to media.

12.8.5 When **database** engine fails, real-time data to **HMI** and other applications shall not be affected.

12.8.6 Automatic Data back-up and archive tools.

12.8.7 Archive the data; data older than one year shall be automatically archived in a permanent storage media.

12.8.8 Maintain a minimum capacity of one (1) year worth of data to be always available in the online **database** (hard disk).

12.9 Data to be logged

12.9.1 Basic Parameters: See Table 5.

Table 5 – Basic Parameters

Parameter	Log Interval
Phase Voltages	6 Hours
Line Voltages	6 Hours
Line Currents	6 Hours
Frequency	6 Hours
Real Power (3 Phase)	6 Hours
Reactive Power (3 Phase)	6 Hours
Apparent Power (3 Phase)	6 Hours
Power Factor (3 Phase)	6 Hours
Max. Real Power (3 Phase), Time Stamped	Every operating Shift
Min. Real Power (3 Phase), Time Stamped	Every operating Shift

Parameter	Log Interval
Per Shift Energy	Every operating Shift
Daily Energy	Daily @ 24:00 Hours
Current THD (%)	6 Hours
Voltage THD (%)	6 Hours

12.9.2 Events & Waveforms: See Table 6.

Table 6 – Events and Waveforms

Parameter	When	Note
Breaker open / close	Occurrence	Time Stamped
Breaker tripped (86 operated) (Note-1)	Occurrence	Time Stamped
Protection operated	Occurrence	Time Stamped
Trip coil, closing coil, lockout, DC supply failure	Occurrence	Time Stamped
Local / Remote in Local position (**PSA** control is disabled)	Occurrence	Time Stamped
Alarm limit exceeded	Occurrence	Time Stamped
IED self check fail	Occurrence	Time Stamped
Auto-change over occurred	Occurrence	Time Stamped
Auto-change over failed	Occurrence	Time Stamped
Auto-change blocked	Occurrence	Time Stamped
Abnormal configuration	Occurrence	Time Stamped
Input or Output discrepancy (e.g., 52a & 52b inputs high)	Occurrence	Time Stamped
Any commands initiated by **PSA**, including blocking	Occurrence	Time Stamped
All operator actions	Occurrence	Time Stamped
Islanding, load shedding occurred	Occurrence	Time Stamped
Essential power system spinning reserve limits exceeded	Occurrence	Time Stamped
Protection settings changed	Occurrence	Time Stamped
IED Firmware changed	Occurrence	Time Stamped
Loss of communication with **IED**	Occurrence	Time Stamped
Loss of communication with **Ethernet** switch	Occurrence	Time Stamped
Loss of communication with **DCS**	Occurrence	Time Stamped
Loss of communication with other subsystems such as **AFD**, UPS, etc.	Occurrence	Time Stamped

Parameter	When	Note
Sag / swell detected	Occurrence	Time Stamped
Charger, UPS fail	Occurrence	Time Stamped
Substation air-conditioning fail	Occurrence	Time Stamped
Minimum 3 cycles of waveform pre-fault and 30 cycles of wave form post-fault (3-phase voltage and current and frequency)	Disturbance and Transient records	Set at voltage and current pick-up. Relays installed in **high Voltage** Incomer breakers and protection panels shall have a sampling rate of 64 sample/cycle or above. Note 1
Minimum 90 cycles of waveforms (3-phase voltages and currents and frequency), with 3 cycles of pre-event period at 64 samples/cycle.	Voltage sag/swell	Set at <85% or >125% of nominal voltage. On incomer circuit breakers only. Threshold values shall be adjustable.
13.2 kV and 4 kV motor start trending, RMS values of the 3-phase voltages and currents	Motor Start	To be triggered by breaker status. Record during motor acceleration period (0 to 100% RPM) with minimum resolution of 1 reading / 125 ms.

Note 1 on Table 6: The designer is responsible to provide an **IED** or a combination of **IED**s to achieve the required sampling rate.

13 Inspection and Testing

The following testing and inspection plan shall be implemented as a minimum:

13.1 Factory Acceptance Testing

PSA supplier shall perform the following factory acceptance tests:

1. Hardware integration testing
2. EMI testing (design / type test certificates are acceptable in lieu of testing if hardware is unmodified).
3. Hardware acceptance test
4. Protocol implementation test
5. **IED** integration test
6. **Switchgear** integration testing (at **switchgear** manufacturer's works)
7. Software testing
8. Software integration testing
9. **Database** testing
10. Functional testing
11. Performance testing

12. Final factory acceptance testing
13. Network reliability and performance testing

PSA supplier shall be present during **switchgear** FAT at manufacturer's works to check the **IED** settings and configuration and demonstrate integration with level-2 networks and performance requirements at level-2. **PSA** supplier shall provide the required PC with software, **Ethernet** switches and cables for interconnecting **IED** at the **switchgear** works which are required for testing of level-2 integration and performance requirements.

PSA supplier shall demonstrate during FAT all performance requirements specified in this specification.

13.2 Site Acceptance Testing

PSA supplier shall perform the following Site acceptance tests:

1. Installation check to verify correctness of installation
2. Power-up, commissioning checks and final settings
3. Site integration testing of **PSA**, including all sub-systems
4. Functional testing of **PSA**, including all sub-systems
5. Performance testing of **PSA**, including all sub-systems

13.3 Sustained Performance Testing

PSA supplier shall perform the Sustained Performance Testing to demonstrate compliance with reliability and **availability** requirements of this specification. **PSA** supplier shall perform a sustained performance test, after successful completion of site acceptance test for continuous period of sixty (60) days. The **availability** and reliability requirements shall meet or exceed the requirements of this specification.

14 Documentation Requirements

The following documentation shall be provided by the **PSA** supplier:

14.1 Documentation Required with the Quotation

1. Scope of supply for hardware and software with make, type and country of manufacture.
2. Scope of services
3. Nearest service center details

4. Project schedule and delivery
5. Project specific technical description of the system offered
6. Project specific management plan
7. Project specific quality assurance plan
8. Preliminary dimensions and weights of panels
9. Power supply requirements and heat loads
10. Completed data sheet
11. Completed compliance / deviation sheet
12. Documentation included in scope
13. List of training with descriptions
14. List of recommended spares
15. List of protocols to be implemented

14.2 Documentation after Receipt of Purchase Order

1. Project schedule and plan
2. Project management organization chart and plan
3. Project quality assurance plan
4. Functional Design Specification (FDS)
5. Protocol Implementation Document (PID) and Conformance statements
6. Detailed specification for software design
7. System design and integration documentation
8. Bill of materials
9. Hardware drawings, including internal component details, panel layouts with dimensions and weights, schematic and wiring diagrams, power supplies and heat loads
10. Termination drawings and diagrams
11. Cable specifications and cable schedule
12. Grounding arrangement and recommendations
13. Functional block diagrams and logic diagrams
14. **Database** documentation and drawings
15. Displays and hierarchy of displays

16. Factory acceptance test, Site acceptance test and Sustained performance test plan and forms
17. Final spares parts list
18. List special tools, devices and test equipment
19. Installation, operation and maintenance manuals (including all final **approved** drawings, documents, test results and certification)
20. Word processor or text files of all application software documentation shall be provided on CD's.
21. Three (3) backup copies shall be provided of all system software, application software, and system configuration post Sustained Performance Test. The format shall be such that they can be loaded directly into the system without additional translation or data manipulation.

All final drawings and documentation shall be provided in hard copies and in native format on CD's.

15 Warranty

The **PSA** shall be warranted for any defects in materials and workmanship for a minimum of 24 months from the date of initial start-up.

16 Interface Management

System Integrator (**PSA** supplier) shall consider the following while quoting and during project design and execution, as this may likely have impact on design, cost, schedule and manpower requirements:

1. Project execution may include multiple contractors executing various process units, offsite and utilities. These contractors may be located globally.
2. **PSA** system integrator(s) shall perform the integration and co-ordinate with contractors and manufacturers to ensure proper physical and engineering interfaces.

17 System Integrator

System Integrator (supplier) shall satisfy the requirements listed below:

1. Local Office: System integrator shall have permanent local office with adequate number of experienced engineers and management/sales staff for after sales supports.

2. Experience: the integrator shall provide evidence for previous installations of similar systems in the region supplemented with CVs of the key engineers who will manage and execute the project.

3. Certifications/ Qualifications: System Integrator shall be certified/qualified by the software firm. The qualification shall be in accordance with the certification scheme of the software firm.

4. Communication Qualification: For network installation and configuration, certifications such as BICSI RCDD or equivalent and CISCO Certified Network Associate (CCNA) or equivalent is highly recommended.

Revision Summary

3 October 2009	Major revision.
7 November 2009	Editorial revision.
25 January 2011	Editorial revision.

Attachment 1

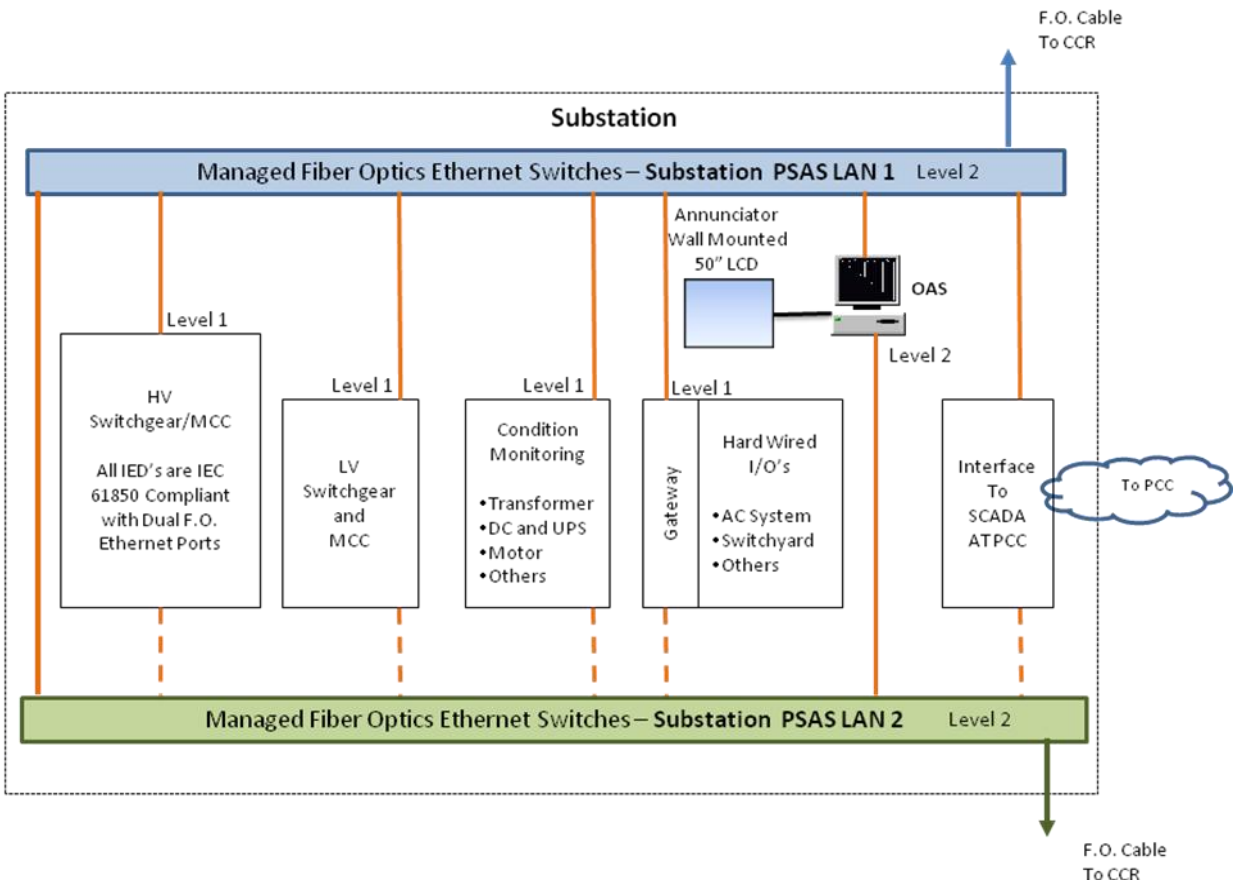

Figure 1 – Power System Automation (PSA) - *Substation Architecture*

Notes to Figure 1:

1. **PSA** Level 1 **LAN**
2. **PSA** Level 2 **LAN** (IEC 61850).
3. Connection media between the Gateway and the equipment side is determined by the equipment supplier.
4. All connections to Level 2 **LAN** shall be through F.O. media. Exceptions to this are connections to peripheral equipment such as printers, Laptops, etc.
5. **PSA** Level 3 **LAN**
6. **LAN** connection to SNTP/IEEE 1588 **Server** (running on EAS).
7. Optional Serial IRIG-B Time synchronization connection in case of SNTP broadcast absence.
8. Serial PC-LCD connection.
9. Operator Automation Station (OAS), for switching, control, and Annunciation
10. Engineering Automation Station (EAS), for **IED** setting, DFR, monitoring, and time synchronization.
11. Alternative redundant connection to level 1 network shall be provided for **IED**s that do not have readily available dual **Ethernet** ports which is shown in the dashed line in the figure.

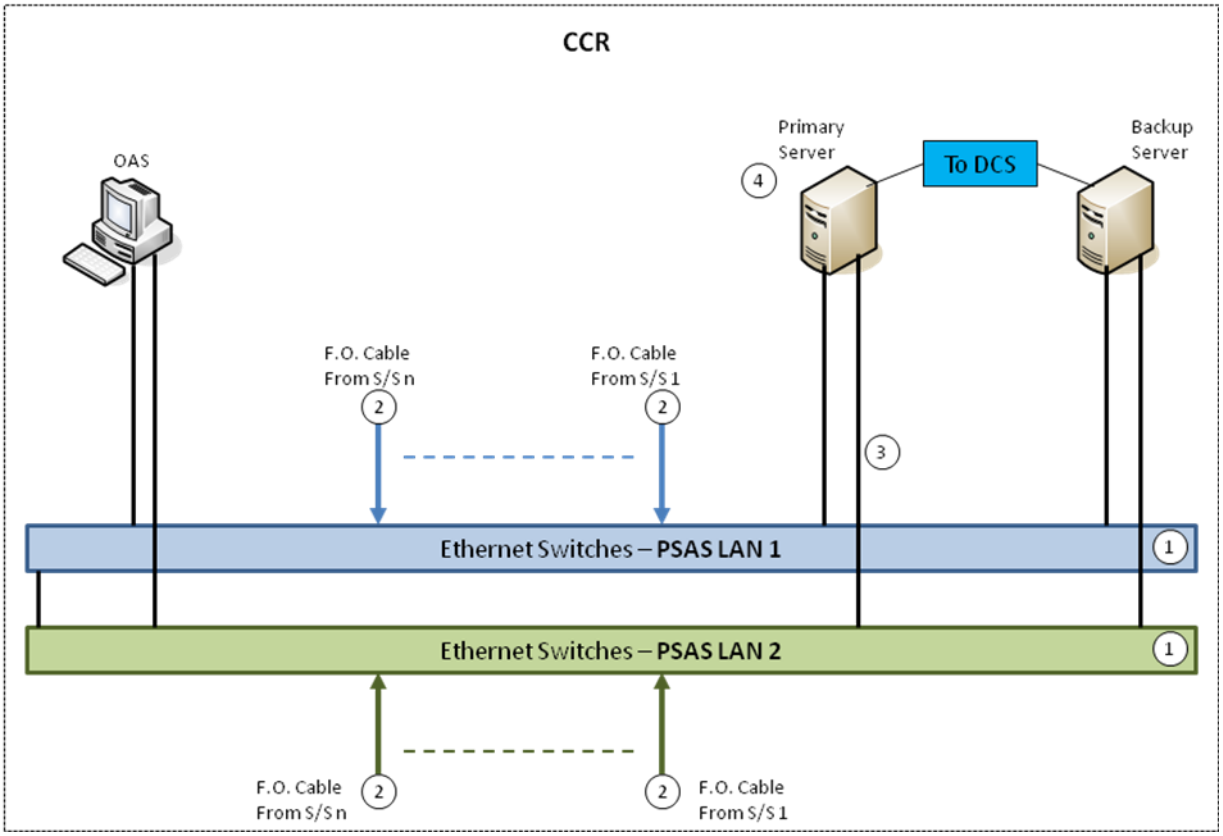

Figure 2 – Power System Automation (PSA) - *Central Control Room (CCR) Architecture*

Notes to Figure 2:

1. **PSA** Level 3 **LAN**.
2. **PSA** Level 2 **LAN** (inside substations)
3. CAT-5 or 6 **Ethernet** connections.
4. **LAN** connection to SNTP/IEEE 1588 **Server** (running on the **server**s).
5. **Server** functions shall include; but not limited to; IEC 61850 I/O **server**, Data Acquisition, Historian, Data Base, OPC, Time Synchronization **Server**, etc.

Supplement A

Power System SCADA Requirements

A.1 **SCADA** shall be installed in **substation**s meeting the following criteria:

Power receiving **substation**s: any **substation** that will interface with **SEC** network or independent power generation supplies.

Transmission and sub transmission **substation**s: any **substation** that is supplied by 69 kV or above transmission lines.

A.2 **SCADA** point requirements shall be implemented as per the following Tables.

Table A.1 – SCADA Standard Point List

Equipment	Status	SOE	ACC	ANALOG	CONTROL
Line (from Line PTs)	Primary Relay (94P)Set Supply Lost 2nry Relay (94S)Set Supply Lost	Primary Relay Set (94P) operated 2nry Relay Set (94S) operated		K. Volts M. Watts M. VARS Frequency	
Line Incoming Breaker (from bus PTs)	Trip coil monitoring relay 74TC1 & TC2 Closing coil monitoring relay 74CC. Local / Remote Urgent Alarm Non-Urg. Alarm 86 Dc supply lost (7486)	Open/ Closed 86-Operated 94 Relay Operated		MW MVAR	Open Close
Line Incoming Circuit Switcher HV disconnect Switch HV grounding switch	Urgent Alarm Non-Urg. Alarm 86 Dc supply lost Open/Closed Open/Closed	Open/ Closed 86-Operated			
Power Transformer	Local / Remote **SCADA** Auto/ Manual Master Follower Independent Urgent Alarm Non-Urg. Alarm 86 Coil supply lost AVR Auto / manual	86-T Operated	MWH	MW MVAR Tap-Changer Position	**SCADA** Auto **SCADA** Manual Master Follower Independent Raise Lower

Equipment	Status	SOE	ACC	ANALOG	CONTROL
Bus Incoming Circuit Breaker	Local / Remote Urgent Alarm Non-Urg. Alarm 86 Dc supply lost Selected to trip	Open/ Closed 86-Operated 94 Relay Operated			Open Close Select to trip Select to trip reset
Bus Tie Breaker	Local / Remote Auto / Manual Urgent Alarm Non-Urg. Alarm 86 Dc supply lost ATS Auto/ manual Selected to trip	Open/ Closed 86-Operated			Open Close ATS **SCADA** Auto ATS **SCADA** manual Select to trip Select to trip reset
Bus				KV Frequency (Optional)	
Motor Feeder Breakers 5000 hp & above	Open / Closed Tripping Relay 94 (Optional) Dc supply lost	Motor protection package Operated (Optional) 94 Relay Operated			
Express Feeder Breaker	94 DC supply lost 86 DC supply lost Local / Remote Urgent Alarm Non-Urg. Alarm	Open / Closed 86-Operated Tripping relay (94) Operated		MW MVAR	Open Close
Station Service Transformer Feeder Breaker		Open / Close			
Feeder Breaker Less than 5000 hp	Open / Close (optional) Tripping Relay 94 (Optional) 86 Dc supply lost	Open/ Closed Motor protection package Operated (Optional) 94 Relay Operated			
Station	Abnormal		Revenue Meter (KWH)		
Battery & Battery Charger	Abnormal				

Table A.2 – SCADA Analog Description

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• K. Volts	• Line • Bus	**SCADA** shall have provisions to be interfaced to the **PSA** Level 2 **LAN** directly to provide the required point.
• M. Watts • M. Vars	• Power Transformer • Line • Express feeders	**SCADA** shall have provisions to be interfaced to the **PSA** Level 2 **LAN** directly to provide the required point.
• Tap Position	• Transformer equipped with AOLTC (Automatic On Load Tap Changer)	AOLTC shall be equipped with two resistor banks. One resistor bank will transmit tap position to local transformer control panel inside the **substation** building, while the second will transmit tap position to **SCADA**. The size of the resistor bank to be used for **SCADA** shall be 2000.00 ohm, all resistors must have equal size and connected between the tap positions, the resistor rating is ¼ watt. The DC supply (0-5VDC) is from **RTU** power supply module.

Table A.3 – SCADA Control Point Description

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• Open • Close	• Line Incoming, Bus Incoming, Tie Circuit Breakers express feeders and CP O/H lines breakers.	Each individual circuit breaker must be equipped with a Local/Remote switch; each close or open command must go through a dedicated Remote contact from a dedicated Local/ Remote switch. Amber light must not illuminate when breaker is opened via **SCADA**.
• Select to trip • Select to trip reset	• Bus incoming & tie circuit breakers	Central Dispatchers are able to select a breaker to be opened first before attempting to parallel the scheme by closing the third breaker. The selected breaker will be opened automatically, after time delay, when the third breaker is closed. The scheme shall be reset to normal by a separate control command
• **SCADA** Manual • **SCADA** Auto • Raise • Lower	• Transformer equipped with AOLTC (Automatic On Load Tap Changer)	Central Dispatchers are able to raise or lower transformer Tap position only when they disable transformer Automatic Voltage Regulator (AVR) with the manual command. An auxiliary relay is required for this function, which will be disabled through an Auto command.
• **SCADA** Manual • **SCADA** Auto	• Automatic Transfer Scheme (ATS)	Central Dispatchers are able to disable **substation** ATS scheme, with the Manual command. An auxiliary relay is required for this function, which will be disabled through an Auto command.
• Master • Independent	• Transformers which are operated in parallel as a master/follower (usually in normally closed bus tie SWGR set-up)	Master/ Follower/ Independent indication points must show actual status of Local/Remote operation modes.

Table A.4 – SCADA ACC Point Description

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• Revenue readings (KWH)	• **Substation**	**SCADA** shall have provisions to be interfaced to the **substation** revenue meter
• M. Watt-Hours	• Line • Power Transformers	**SCADA** shall have provisions to be interfaced to the Metering system directly to provide the required point.

Table A.5 – SCADA SOE Point Description

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• 86 (lockout) Operated • Protection Relay Operated	• Transformers • Circuit Breakers • Circuit Switchers • Buses	
• Open/Closed	• H. V. breakers, cir-switchers, Incoming & Tie Cir. Breakers. • CP O/H breakers • Express Feeder • Motor Feeder breakers for motors > 5000 HP	

Table A.6 – SCADA Status Point Description

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• Local /Remote (Supervisory)	• Line Circuit Breakers • Bus Incoming & Tie Circuit Breakers • Power Transformers • CP O/H breakers • Express feeders	Each equipment must be equipped with a Local / Remote switch to disable **SCADA** control operations when equipment is operated locally at the station. One remote dry contact from each individual equipment must be wired to **SCADA** for indication.
Urgent Alarms: 1) For each individual Circuit Breaker & Switcher, the following summary alarms must be paralleled: • Loss of tripping circuit DC supply • Loss of protection DC supply • Circuit Breaker Trip coil • Loss of motor operating supply • Loss of air or SF6 gas pressure • SF6 Gas Blocking • SF6 Gas Refilling, and Pump Motor Running • Microprocessor-based relay failure (for breakers) 20 For each individual Power transformer, the following summary alarms must be paralleled: • Combustible gases present • Pressure relief • Buchholz relay operated • Sudden pressure • High winding temperature	Line Circuit Breakers & Switchers Bus Incoming & Tie Circuit Breakers Power Transformers **Substation**	All urgent alarms shall be segregated and indicated as urgent.

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
Non-Urgent Alarm 1) For each individual Circuit Breaker & Switcher, the following summary alarms must be paralleled: • Loss of closing circuit supply • Circuit breaker Closing coil • Loss of air or SF6 gas pump supply 2) For each individual Power transformer, the following summary alarms must be paralleled: • Loss of referential potential on AVR • Loss of cooling fans supply • Low transformer oil • High oil temperature • Low/High tap Changer oil level • Loss of tap changer motor operating supply • Loss of tap changer control supply • Tap Changer failure • Intrusion	Line Circuit Breakers & Switchers Bus Incoming & Tie Circuit Breakers Power Transformers **Substation**	
• Auto/Manual	• Power Transformer ALTC • Bus Automatic Transformer Schemes	• Auto contact of Auto / Manual switch or relay must be wired to **SCADA** for indication. Cases where Auto/ Manual switch and Auto/ Manual Relay are implemented for an individual control circuit, Auto contacts must be wired in parallel.
• Master • Follower • Independent	• Power Transformer ALTC • (Applicable in **substation** where planned or being operated with a normally closed Bus Tie Circuit Breakers)	• Each indication point must indicate actual (Master, Follower, or Independent) operating mode regardless of Local/ Remote switch position.

POINT DESCRIPTION	EQUIPMENT	END DEVICE REQUIREMENTS
• Open/ Close	• Outgoing & Station Service Transformers Breakers feeders • Less than 5000 hp motor feeder circuit breakers (Optional) • HV disconnected switch • HV grounding switch	
• Abnormal	• **Substation** • Battery Charger	1) The following **substation** alarms must be communicated to **SCADA** as a summary alarm point: • **Switchgear** Bldg. High Temperature • Fire or Smoke Detector 2) The following Battery Charger alarms must be communicated to **SCADA** as a summary alarm point: • Loss of AC Supply • Low DC Voltage • Low Charging Rate • Ground on DC System

A.3 A minimum of 20% spare point's of control, analog, **SOE** shall be provided to accommodate future operational field additions.

A.4 **SCADA** drawings shall be prepared and submitted for review before finalizing. Drawings shall be of 28" X 20" size. One complete package shall have the following:

A.4.1 Table of Contents: This will list all the **SCADA** design drawings by sheet number. Presently, all the drawings of any one package have the same drawing number with identification by sheet number.

A.4.2 Standard Symbols and Details: These drawings are a summary of legends describing the symbols used in the **SCADA** drawings.

A.4.3 Remote Station Function Tabulation: These sheets list the **SCADA** points by absolute point number. Each category (Status, **SOE**, Accumulator, Analog, and control) is given a separate sheet.

A.4.4 **SCADA** Function Diagram: This is a simplified one-line diagram for the station showing each piece of equipment connected to the **SCADA** system. Details on this drawing shall include those listed below:

a) Electrical Equipment Numbers obtained from **PDD** Chief Dispatcher.

b) CT and P.T. ratios and their connection to **SCADA** and synchronizing circuits. Information supplied shall be complete and allow the calculation of scale factors.

c) **SCADA** functions at each device defined by symbols.

d) Transformer tap details

In a general way represent the **SCADA** interface within the **substation**.

A.5 **SCADA** setup, pre-commission and commission shall be coordinated with **PDD** Planning & Technical Services Division.