

Technical Specification Of Substation Protection & Control System with IEC 61850 - BHEL's Perspective

India Core Events 2008



September 24th 2008

Background



- **Stability & Reliability**
- **Data Storage**
- **Communication Facilities**

Numerical Relays



- Data Storage
- Communication Capabilities
- Instrumentation
- Programmable Logic
- Self Supervision
- Multiple Setting groups
- Multiple Characteristics

Changing Scenario



- Conventional Control & Protection
- RTU based SCADA with backup Mimic
- IEC 61850 based Substation Automation System



- Interoperability
- Free Allocation of Function to devices
- Insulation from Changes in Communication
- Peer to Peer Communication

Comparison Of Features



Function	Conventional Control Panel and Protection Panel	RTU based SCADA, Backup Mimic Board Panel and Conventional Protection Panel	IEC 61850 based Substation Automation System (Control & Protection)
Mimic	Central Control Panel	SCADA HMI and Backup Mimic Board	HMI of Substation Automation System (SAS)
Control	Breaker and Isolator Control Switch	SCADA HMI and Miniature Discrepancy Switches on Backup Mimic Board	SAS HMI and BCU
Circuit Breaker Synchronising	Synchronising Trolley with Synchroscope & Check Synchronising Relay	Check Synchronising Relay and Synchronising Trolley with Synchroscope on Mimic Panel	Check Synchronising Function in BCU. Hand held Synchroscope where BCU panel is in same room as

HMI

Comparison Of Features

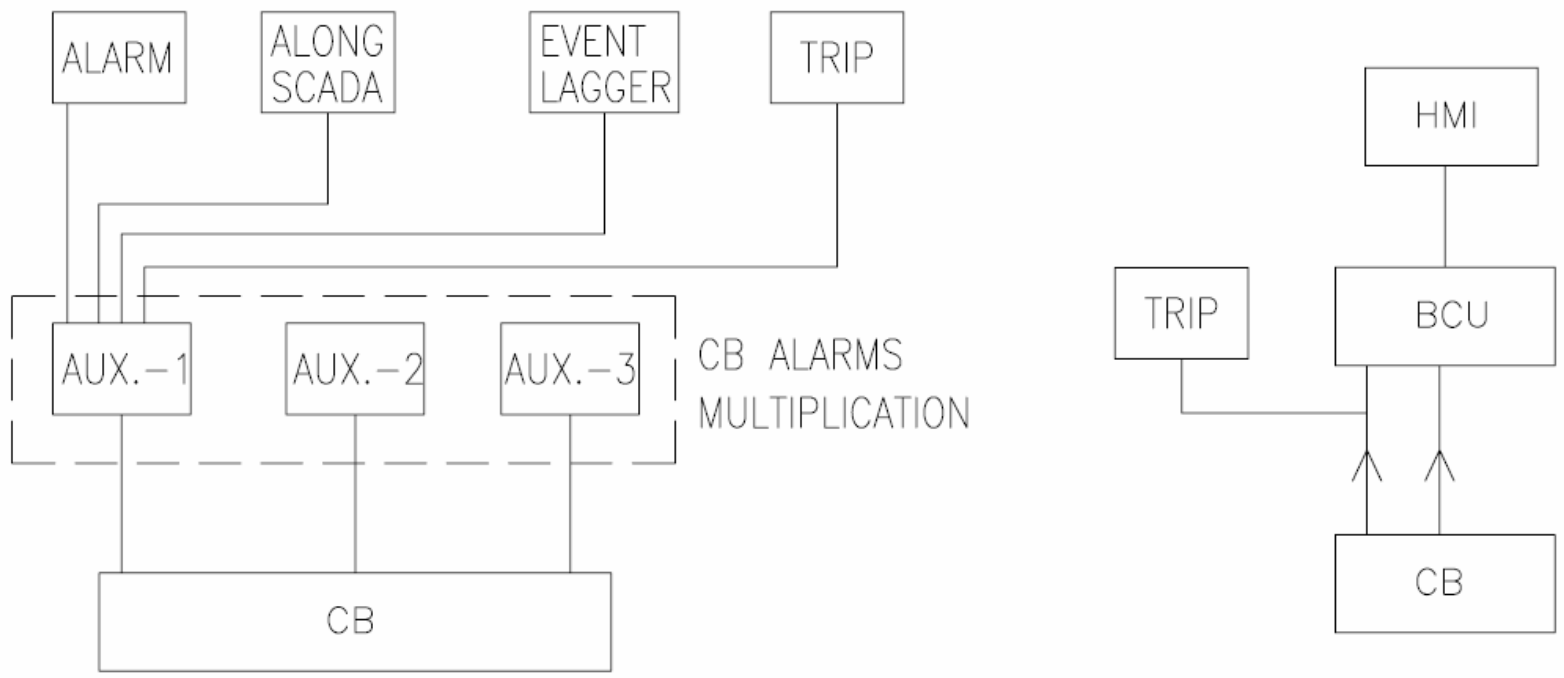


Function	Conventional	RTU	SAS
Indication	Semaphore and Indicating Lamp	SCADA HMI and Miniature Discrepancy Switches on Backup Mimic Board	SAS HMI and BCU
Indicating Metering	CT/VT or Transducer driven Indicating Meters	SCADA HMI and Multi-function meters	SAS HMI and BCU
Interlocking of Isolator, Earth Switches	Hardwired Interlocks	Software interlocking with Backup Hardwired Interlocks.	Software interlocking at BCU level using information from other BCUs through GOOSE Message.

Comparison Of Features



Function	Conventional	RTU	SAS
Alarm Management	Alarm Facia	SCADA HMI and Alarm Facia on Backup Mimic Board	SAS HMI
Event Logger	Independent Event Logger	SCADA HMI	SAS HMI
Disturbance Recorder	Independent Disturbance Recorder with own LAN	Independent Disturbance Recorder with own LAN. Engineering Work Station connected to BPU through dedicated network.	SAS Engineering Work Station connected to BPU through IEC 61850 LAN.
Protection	Single or Multiple functions in single device.	Multiple functions in single device.	Concept of Logical Device and Physical Device. Multiple functions in single device. Single functions in multiple device using GOOSE messaging.



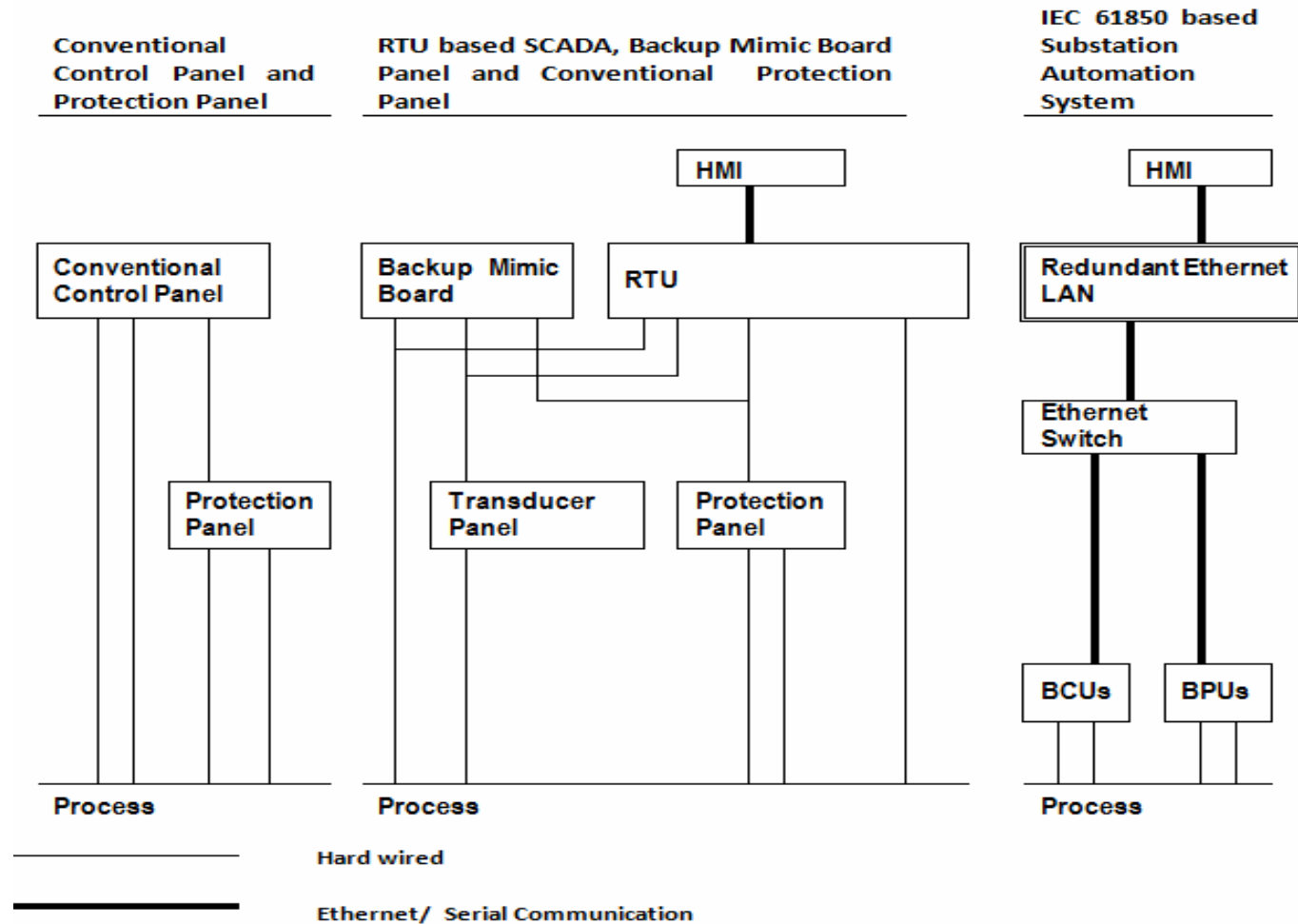
ALARM MANAGEMENT

Comparison Of Features



Function	Conventional	RTU	SAS
Historical Data Manangement, Analysis	NIL	SCADA	SAS
Remote interface with Load Dispatch Centre (LDC)	Communication with independent RTU	Communication with SCADA or RTU	Communication through Gateway
Power Plant Distributed Control System (DCS) Interface	Hardwired through potential free contacts and transducer outputs	Hardwired through potential free contacts and transducer outputs	Communication through Gateway

Comparison Of Features



Physical architecture showing the flow of signals

IEC 61850 Implementation in India



- PGCIL - 400kV Swyd 1¹/₂ CB scheme With remote comn
- NTPC - 400kV Swyd 1¹/₂ CB scheme with remote & DCS
- DVC - 400kV 2M+T Scheme with remote & DCS
- MSEB - 400kV Swyd 1¹/₂ CB scheme
- TNEB - 400kV Swyd 1¹/₂ CB scheme , 220kV- 2M
- Pragati Power Corp Ltd - 400kV Swyd 1¹/₂ CB scheme

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
Scope of BCUs	<ul style="list-style-type: none"> • EHV System • Electrical Auxiliary System (415 V ac and 220/48V dc System) • Mechanical Auxiliary system (Air-conditioning and 	<ul style="list-style-type: none"> • Control and monitoring is limited to EHV System. • It does not extend to Electrical or Mechanical Auxiliary System. Of switchyard
Physical Architecture	The BCU, BPU and PLCC Panels are located close to the process in Air-conditioned Kiosk. LAN extends to the switchyard.	The BCUs, BPU and PLCC Panels are located in the Centralised Control Room. LAN does not extend to the switchyard, Instead it extends to Main Plant Control Room.

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
Local Area Network (LAN)	Bay to Bay - Fibre Optic LAN	Bay to Bay - Fibre Optic LAN
	Sub-Station Network - Fibre Optic LAN	Sub-Station Network - Cat-5 Shielded UTP Cable or Fibre Optic. Fibre Optic LAN for distance >50m, between rooms and between buildings.
Redundancy	Communication shall be in 1+1 mode except link between IED to Ethernet switch, such that failure of one set of fibre shall not affect the normal operation	Communication shall be in dual redundancy configuration. No single failure of any component/module of SAS including communication link shall cause loss of functionality of more
	Redundant SAS HMI	Redundant bay HMI at switchyard and one HMI at Power Plant

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
HMI Specification	<ul style="list-style-type: none"> • 21" Visual Display Unit (VDU) – 	<ul style="list-style-type: none"> • Visual Display Unit (VDU) and • Rear Projection Display (2m x 1.5m)
Gateway for Remote Control & Monitoring	<ul style="list-style-type: none"> • Regional 280x1024 System Co-ordination Centre • Remote Control 	<ul style="list-style-type: none"> • Power Plant Distributed Control System (DCS) • Remote Load Dispatch Centre
No. Of BCUs	1 per Bay & Bay defined as CB.	1 per Bay.
I/O Requirement for BCUs	As per Actual Utilisation & 200 numbers spare inputs.	<u>Minimum I/O specified per bay</u> Binary Input - 64 Binary Output – 24 Analog Input – 16

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
Interlocking	All interlocks are software based using Goose. Station Level Interlocks are also Hardwired (e.g. Bus Earth Switch).	All interlocks are software based using Goose. Station Level Interlock are in two BCUs (e.g. Bus Isolator, Earth Switch, Bus Coupler)
Display Response Time	Not specified.	1.5 sec
Duty Cycle Time	Not specified	40% free time over 2 sec period 60% free time over 1 min period
Inter-bay bus and sub-station network spare duty	Not specified	50% free time over 2 sec period

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
Analog value updation	2 sec	Not specified
Alarm and Event Tag	1 milli-sec	Not specified
Auto-reclose (AR)	AR is a control function and can be a part of BCU. Auto-reclose function in BCU with Goose messaging from Distance relays offers an elegant solution for both Main and Tie CB. 220 & 132kV system –	AR is a protection function. 400 & 220 kV system – AR can be a part of both Main 1 & 2 BPU. Hardwired signals are preferred. 132kV system and below – AR can be a part of BPU AR for Tie CB, TBC CB has to be standalone.

AR can be a part of BPU

IEC 61850 Specs in India



Features	POWERGRID Specification	NTPC Specification
Busbar Protection	<p>Duplicated Busbar protection for 400kV system.</p> <p>220/132kV system - Check zone with different CT core is not specified. However, check function is implemented in main</p>	<p>Duplicated Busbar protection for each bus with different CT cores is provided in 400kV system.</p> <p>One main protection for each bus with common check zone for both buses with common check zone connected to different CT core for 220/132kV system.</p>
LBB Protection	<p>Generally protection feature of Busbar protection.</p> <p>Single standalone relay for Tie Breakers.</p>	<p>Generally inbuilt feature of Busbar protection.</p> <p>duplicated LBB scheme for all Breakers irrespective of inbuilt or standalone Relay</p>

BHEL RECOMMENDATIONS - Control Functionality



- Level 4 – Remote Control Centre (RLDC) – **Status Indication and Metering**
- Level 3 – Remote Control Centre (Remote Sub-station) – **Full Functionality**
- Level 2 – Substation Level (HMI of SAS)
- Level 1 – Bay Level (BCU, BPU)
- Level 0 – Equipment Level (CB, Isolator, Transformer)

BHEL RECOMMENDATIONS - Control Functionality



– BCU – Per Bay / Per Feeder Basis

Analog Inputs Clarity :

- VT Inputs (Metering) – 4

– CT inputs – 4

–VT Inputs (Synch) – 1

–Transducer Inputs – for WTI,OTI, Tap Position

– Transformer Monitoring Relay with Tap Changer Control, Tap Position Status , Automatic Voltage Control – Replace RTCC Panels

BHEL RECOMMENDATIONS - Control Functionality for Aux Systems

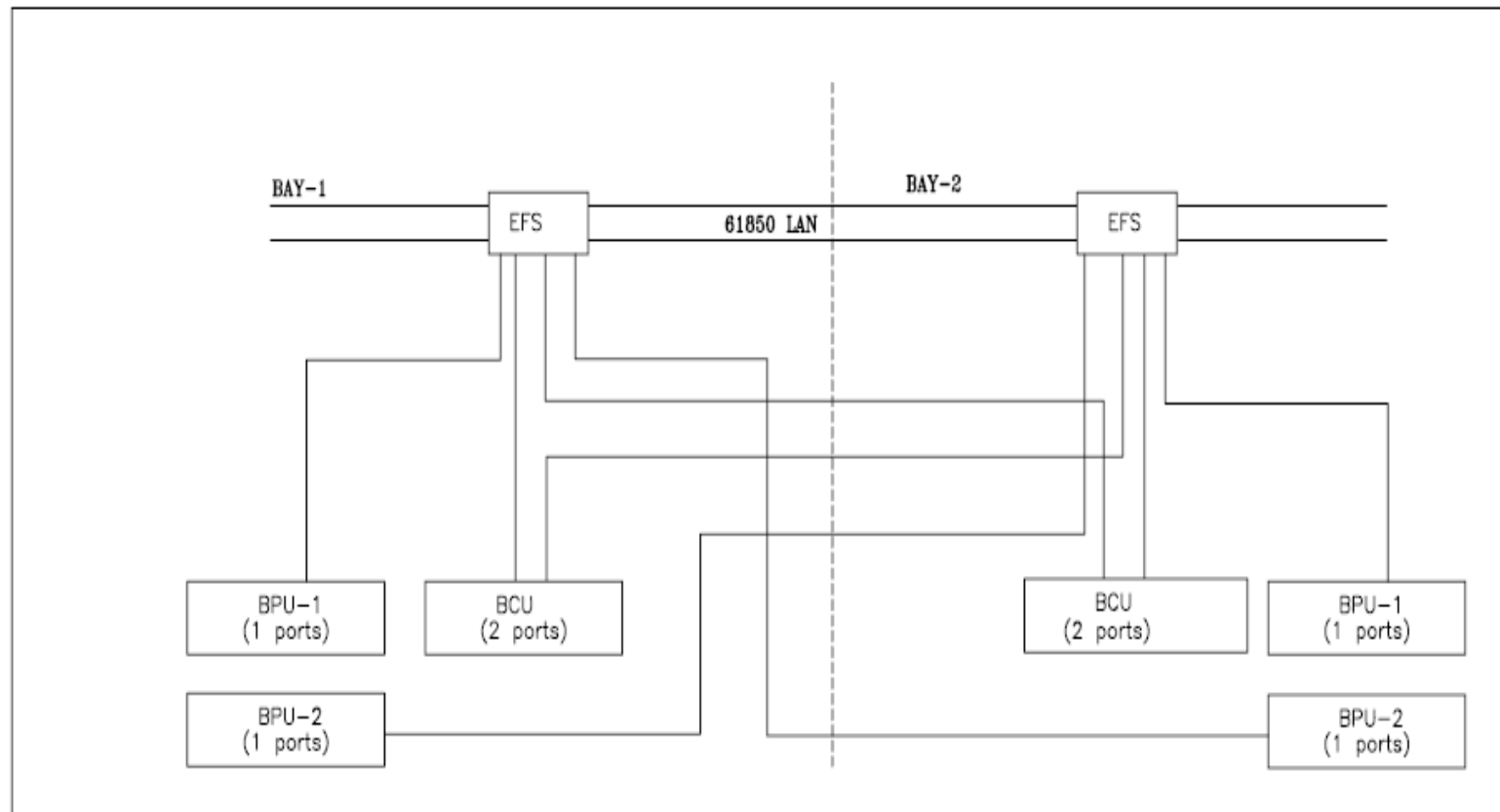


- **Aux BCU – For Station Aux System**

415 V AC, 220V DC & 48 V Dc

- **Remote Control for Incomers , Bus Sections & Bus Coupler**

BHEL RECOMMENDATIONS - Redundancy

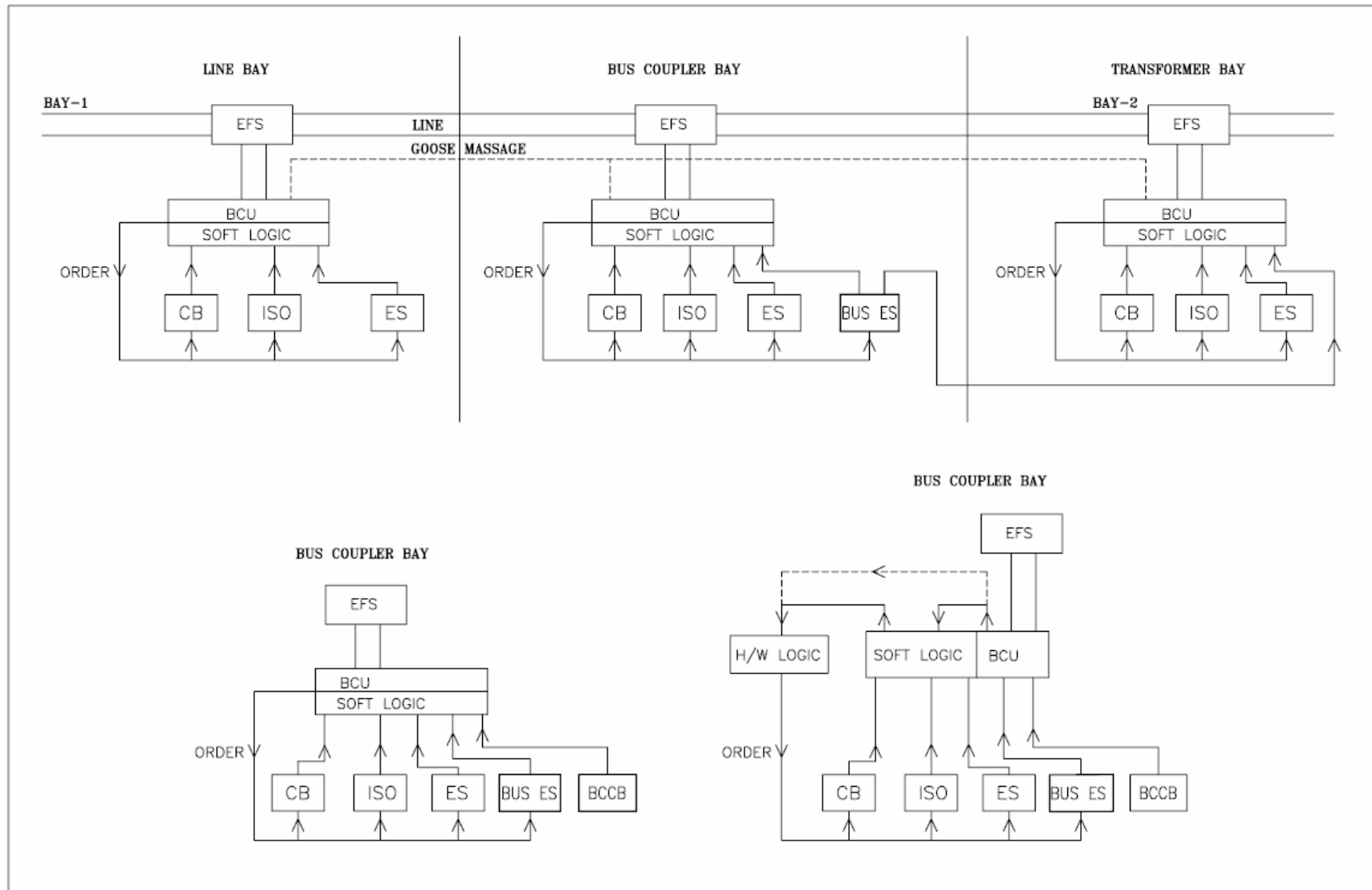


BHEL RECOMMENDATIONS - Interlocking



- **All Bay Level Interlocks to be in BCU**
- **Inter bay interlocks through GOOSE**
- **Station Level Interlocks in Redundant BCU**

BHEL RECOMMENDATIONS - Interlocking



BHEL RECOMMENDATIONS - Goose Implementation



Present Implementation by BHEL

- Alarms from BPU to BCU
- Isolator / ES interlocking
- CB Closing interlocking (86 & 96)
- Relay Supervision
- DR Triggering in M1 from M2

General Trend to Implement Goose in Control And Hardwiring for Protection.

Time to replace Faith in Wiring to Faith in LAN

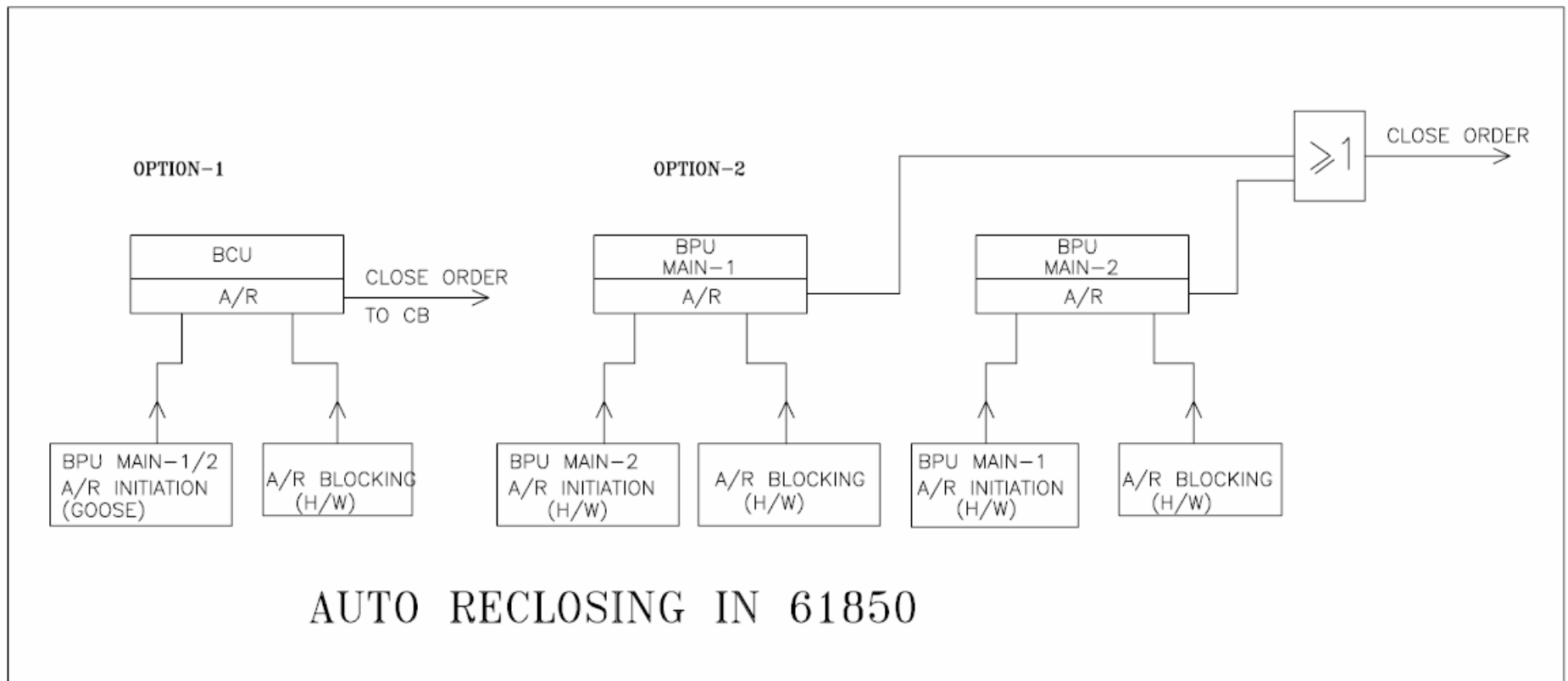
BHEL RECOMMENDATIONS - Goose Implementation



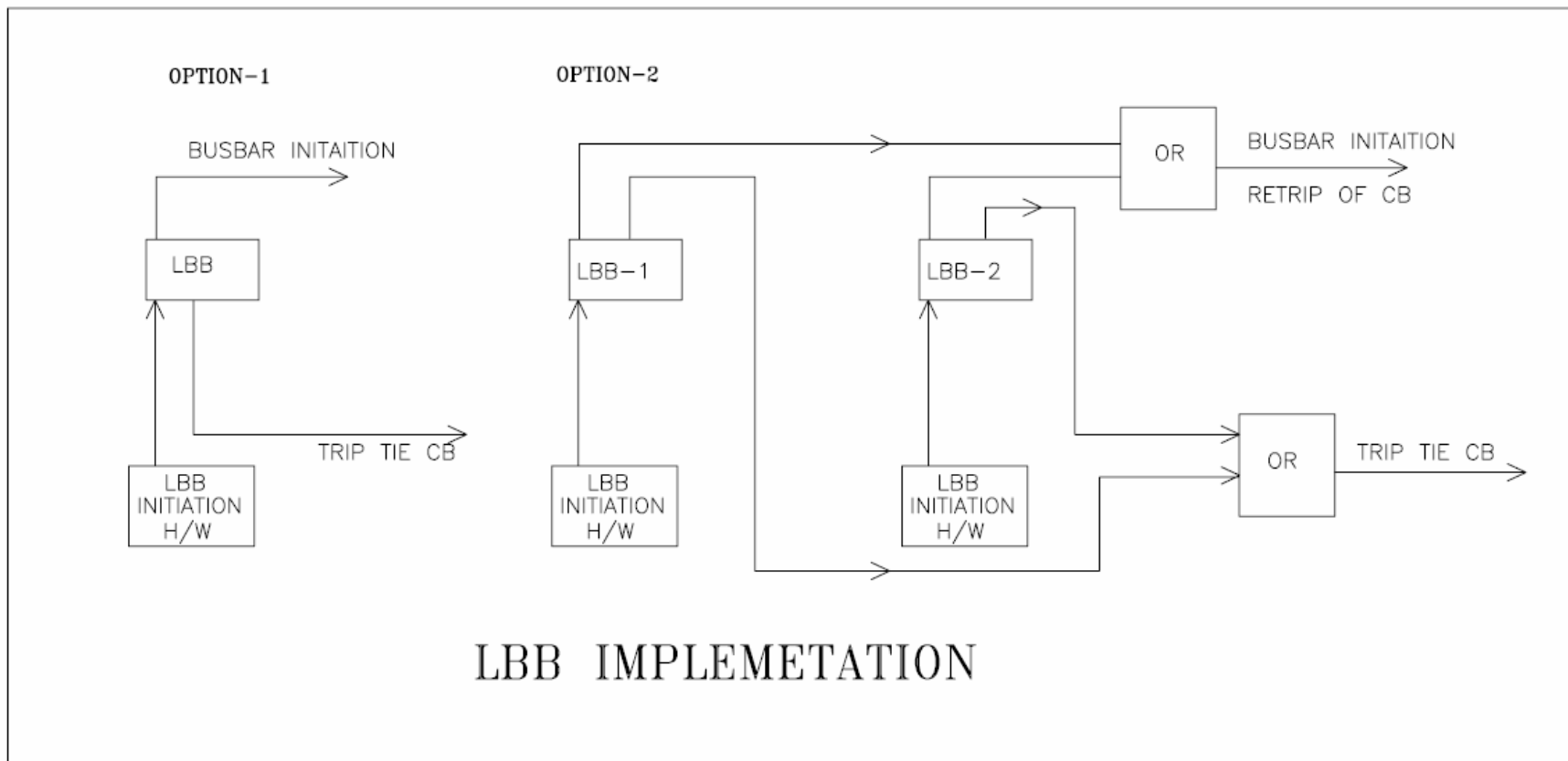
Some Suggestions

- **Auto – Reclose Initiation**
- **Voltage Selection for CB Synchronisation**
- **LBB Initiation**
- **Switchyard equipment status for DR**

BHEL RECOMMENDATIONS - Goose Implementation



BHEL RECOMMENDATIONS - Goose Implementation



BHEL RECOMMENDATIONS - Control Commands



- **Select before Operate (SBO) – For CB, ISO Operation**
 - ❖ **Selection**
 - ❖ **Execution**
 - De-selection Automatic**

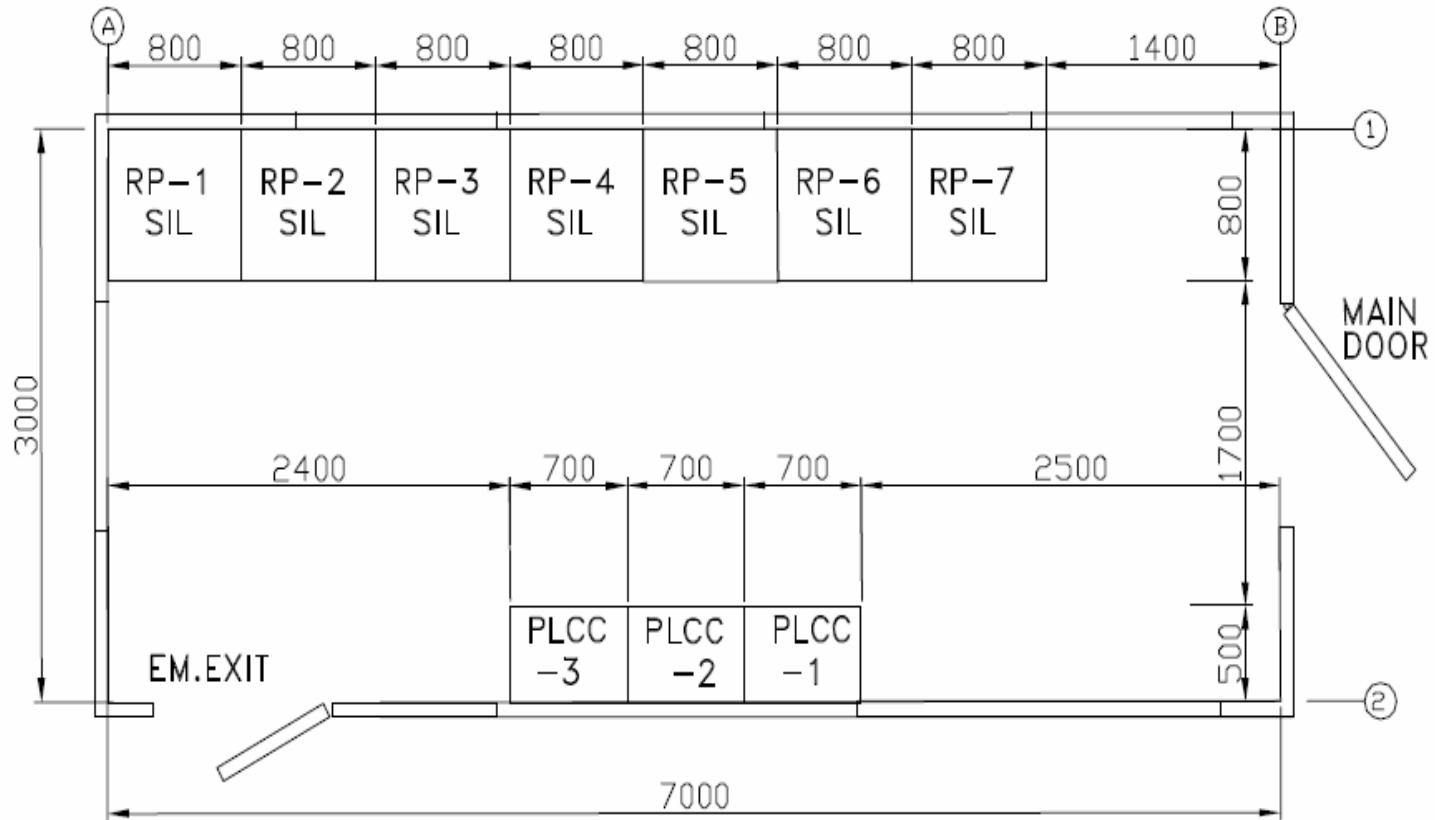
- **Select Before Operate Many (SMO many) – For Transformer tap change operation**
 - ❖ **Selection**
 - ❖ **Execution (repeatative)**
 - ❖ **De-selection**

- **Direct Execute Mode**
 - ❖ **Control Without any Selection (e.g. Trip Relay Reset)**

Future Developments - Process Bus



- **Currently, primary equipment data models are implemented in BCU as Logical Node**
- **XCBR for CB, TCTR for CT, TVTR for VT.**
- **In Future, SAS will interact with Merging Unit (MU) and Circuit Breaker Controller (CBC)**
- **Merging Unit works acts as digital interface between BCU/BPU and primary equipment (CT, CVT). Standards : IEC 60044-8, IEC 61850-9-1**
- **Controller acts as Digital Interface for Switchgear. Circuit Breaker Controller (CBC) & Disconnecter Controller (DSC)**



AC KIOSK - TYPE ACK1

System Architecture (POWERGRID)



TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM

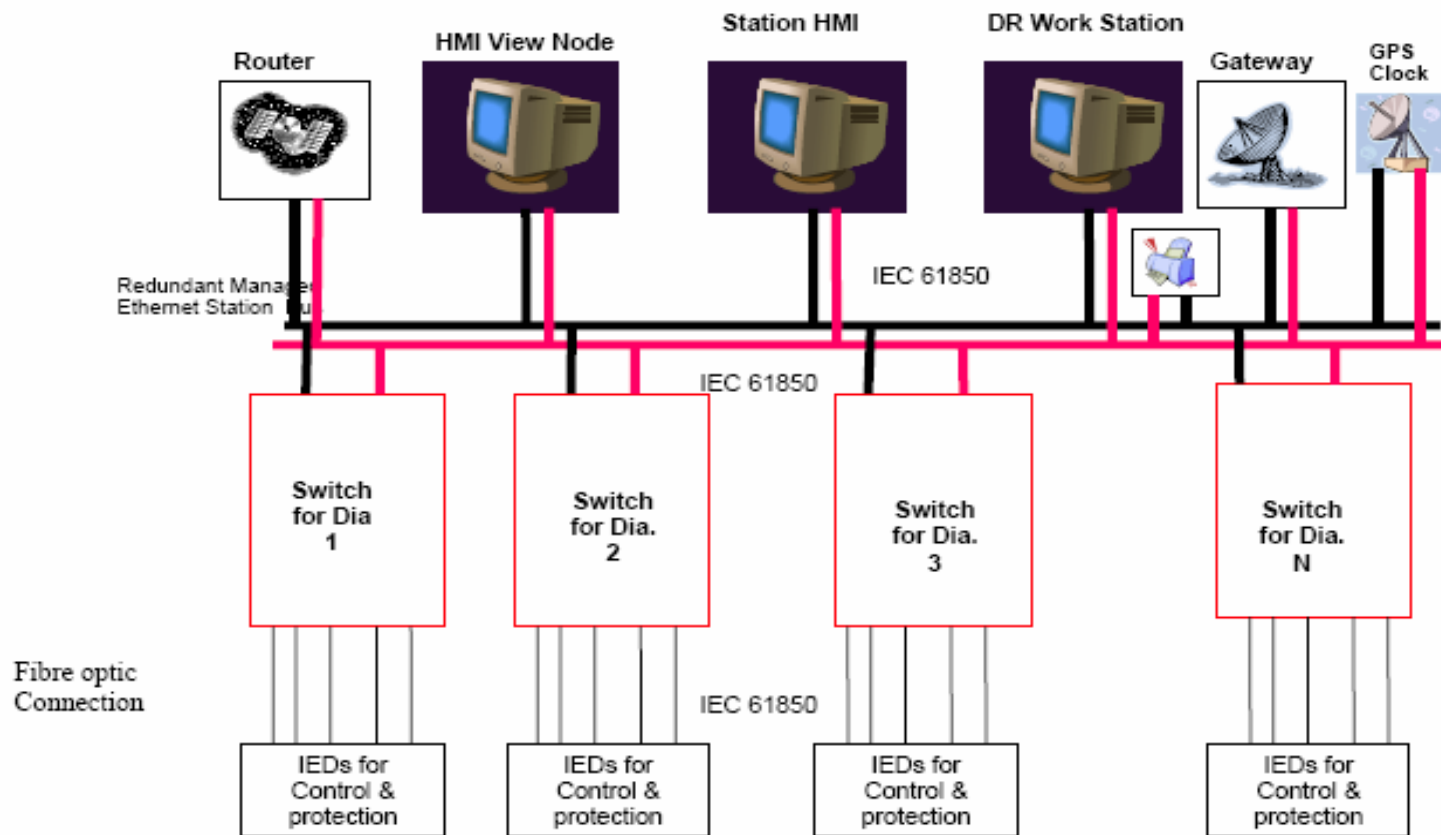
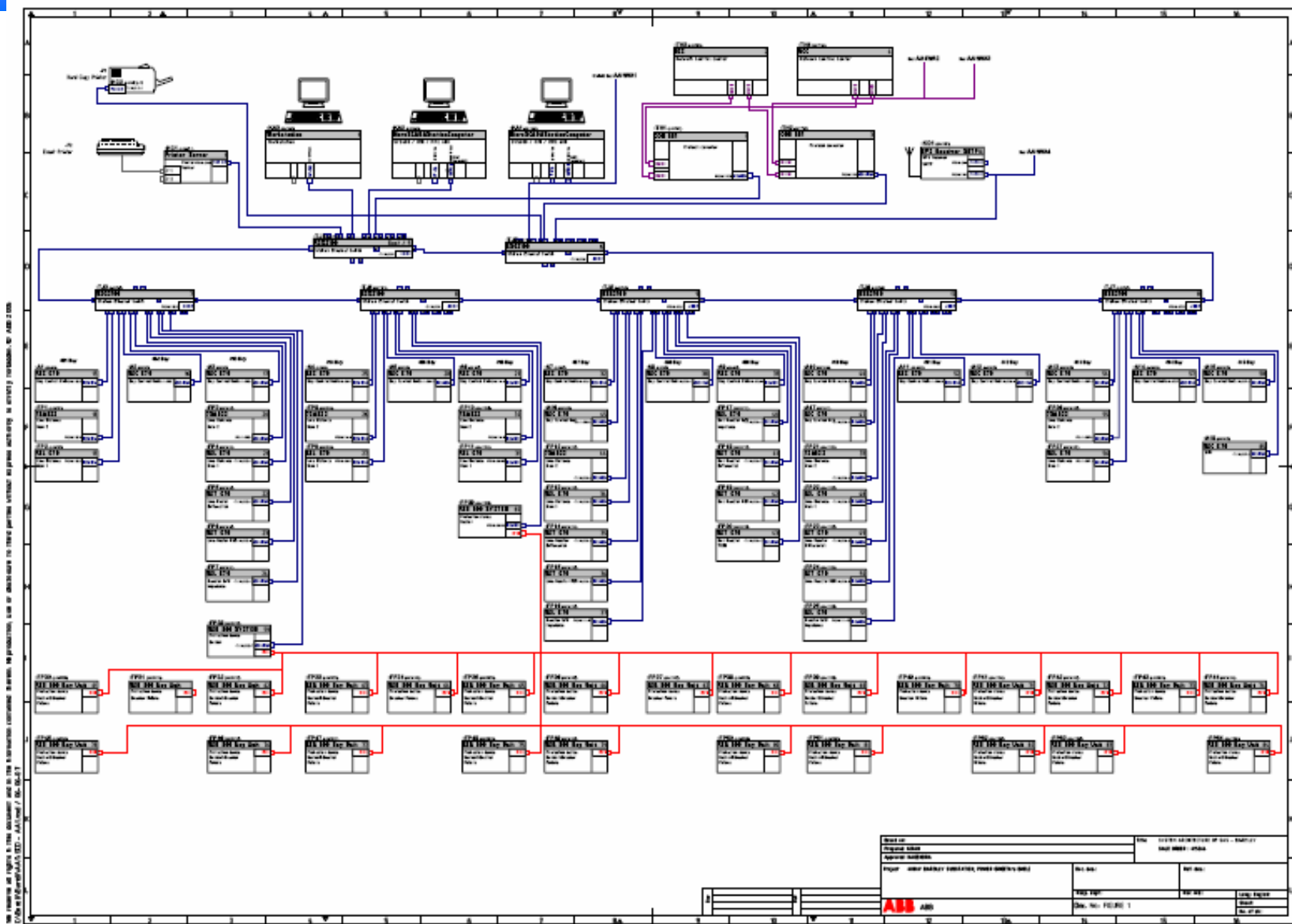
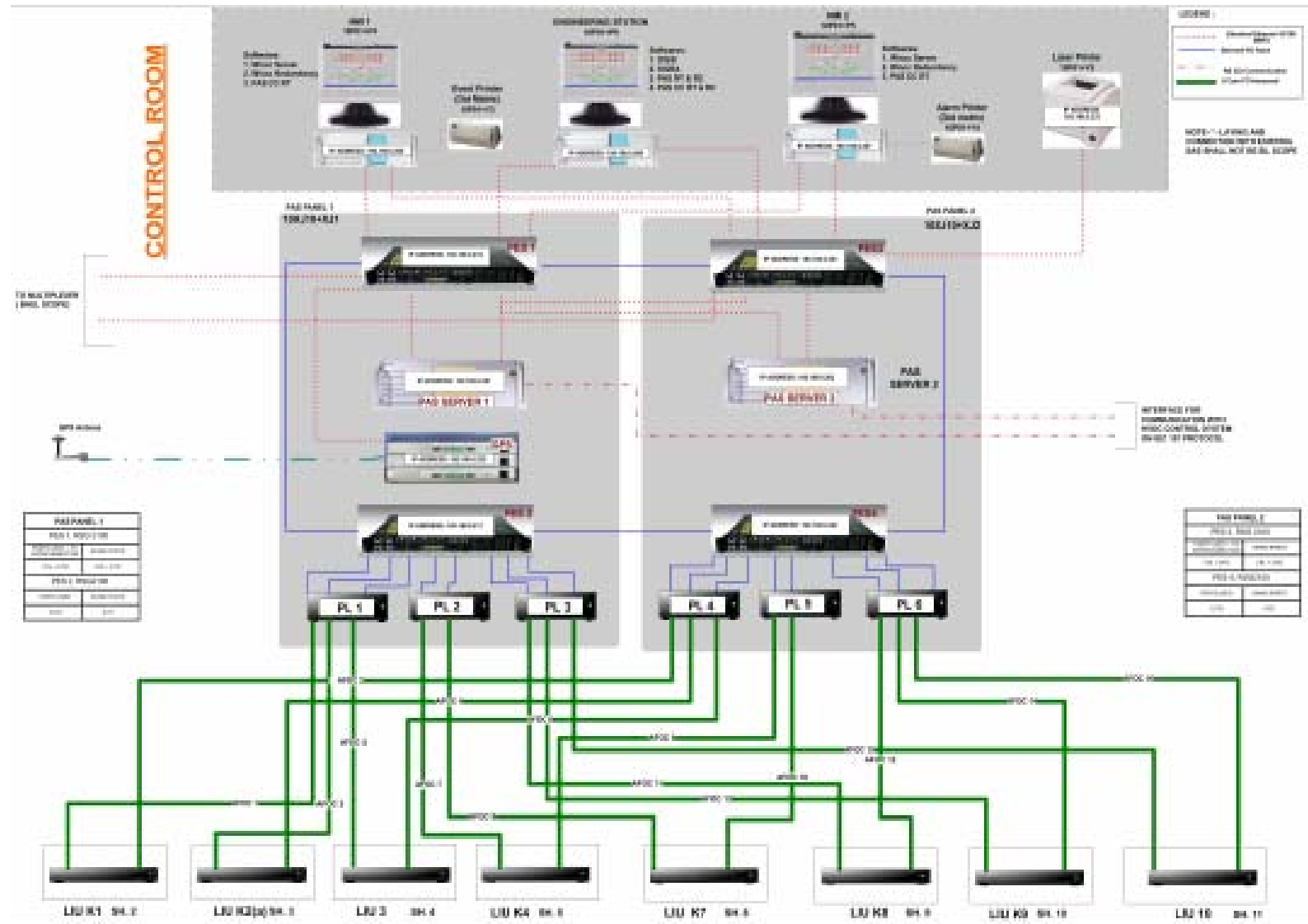
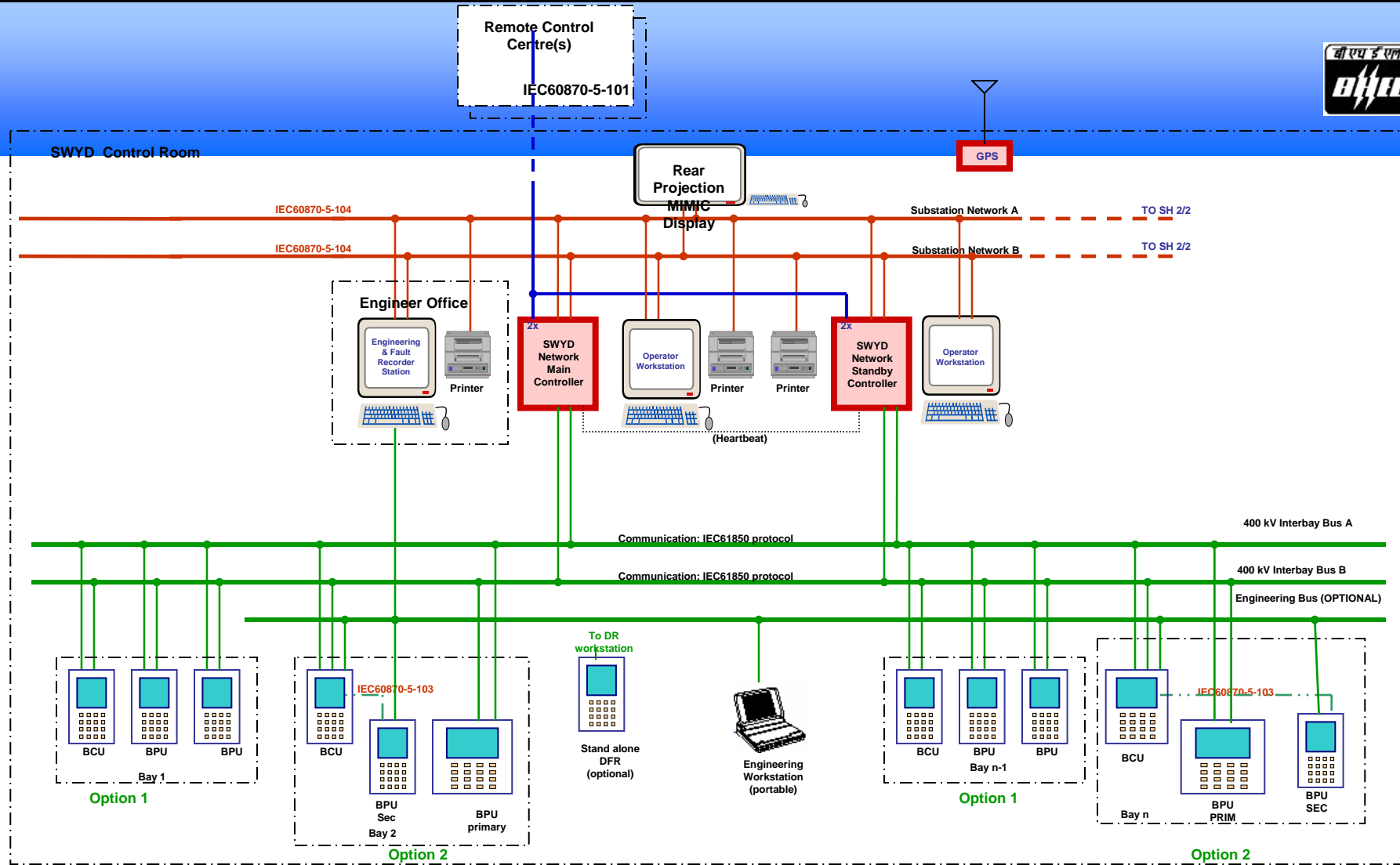


ABB IMPLEMENTATION



SIEMENS IMPLEMENTATION




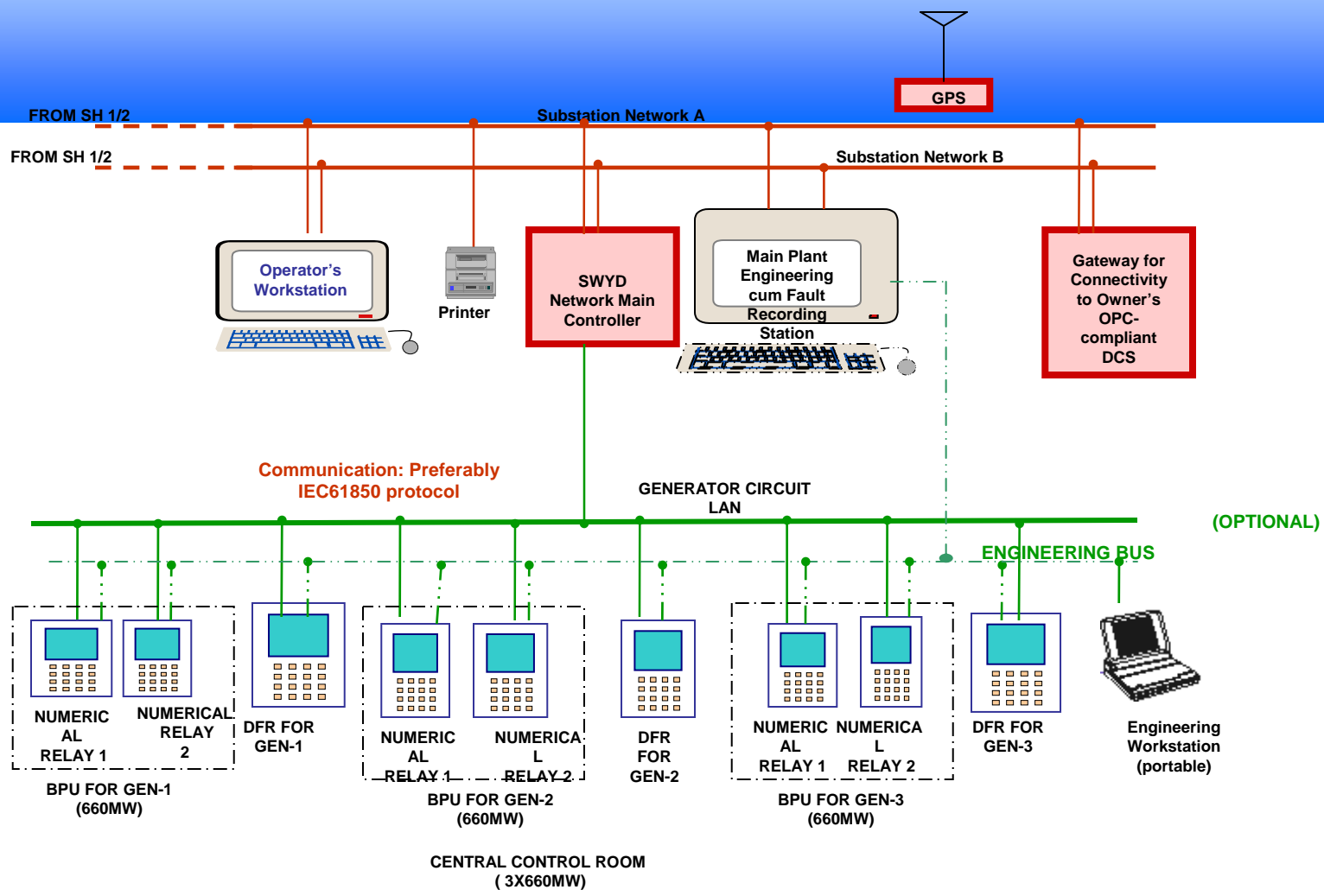


LEGEND: BCU Bay Control Unit
 BPU Bay Protection unit
 DFR DISTURBANCE Recorder


- Notes:**
1. The substation controllers and operator workstations are fully redundant
 2. The SWYD Interbay bus shall be a dual redundant, star or ring topology, fibre optic bus.
 3. All data connections between rooms or buildings shall be via fiber-optic.
 4. The BCU includes mimic display, analogue and status indications, alarm annunciation, local control, and inter-bay communication for local control with interlocking
 5. All BCU, BPU, Controllers, Workstations synchronized to GPS reference time
 6. Two IEC60870-5-101 ports shall be provided to interface to control centre(s)

FOR TENDER PURPOSE ONLY

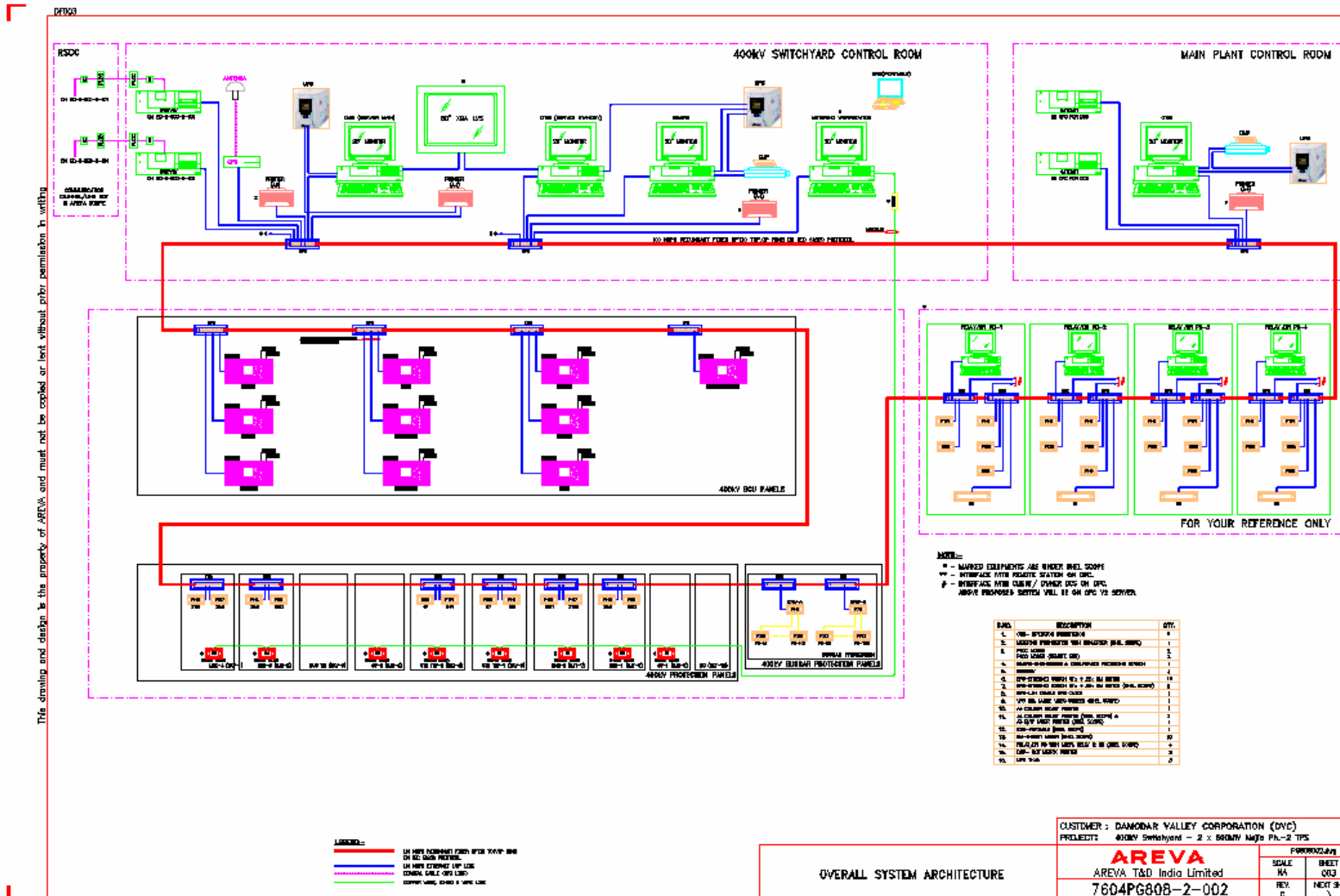
 नैशनल थर्मल पावर कारपोरेशन लिमिटेड NTPC National Thermal Power Corporation Ltd. (A GOVERNMENT OF INDIA ENTERPRISE)					PROJECT BARH STPP- SWITCHYARD	
					TITLE - SUBSTATION AUTOMATION SYSTEM ARCHITECTURE	
					DRG. NO. 9558 -572-POE-A-006- SH 1/2	
DRN	DGN	CHKD	APPD	DATE	REV. B 36	



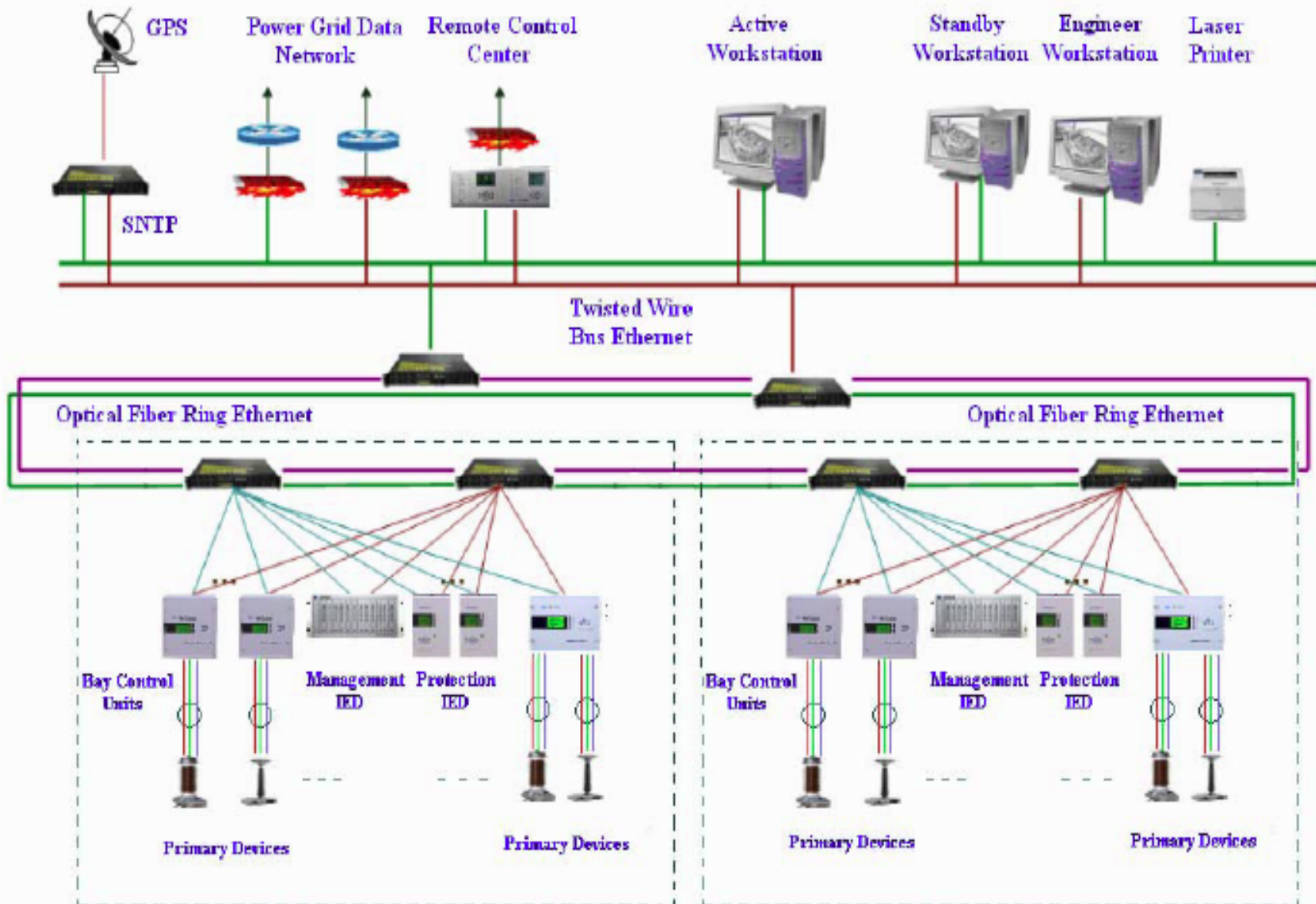
FOR TENDER PURPOSE ONLY

 नैशनल थर्मल पावर कारपोरेशन लिमिटेड National Thermal Power Corporation Ltd. (A GOVERNMENT OF INDIA ENTERPRISE)				
PROJECT				
BARH STPP- 400/132 kV SWITCHYARD				
TITLE - SUBSTATION AUTOMATION SYSTEM ARCHITECTURE				
DRN	DGN	CHKD	APPD	DATE
DRG. NO.				REV.
9558-572 - POE-A- 006 SH 2/2				A 37

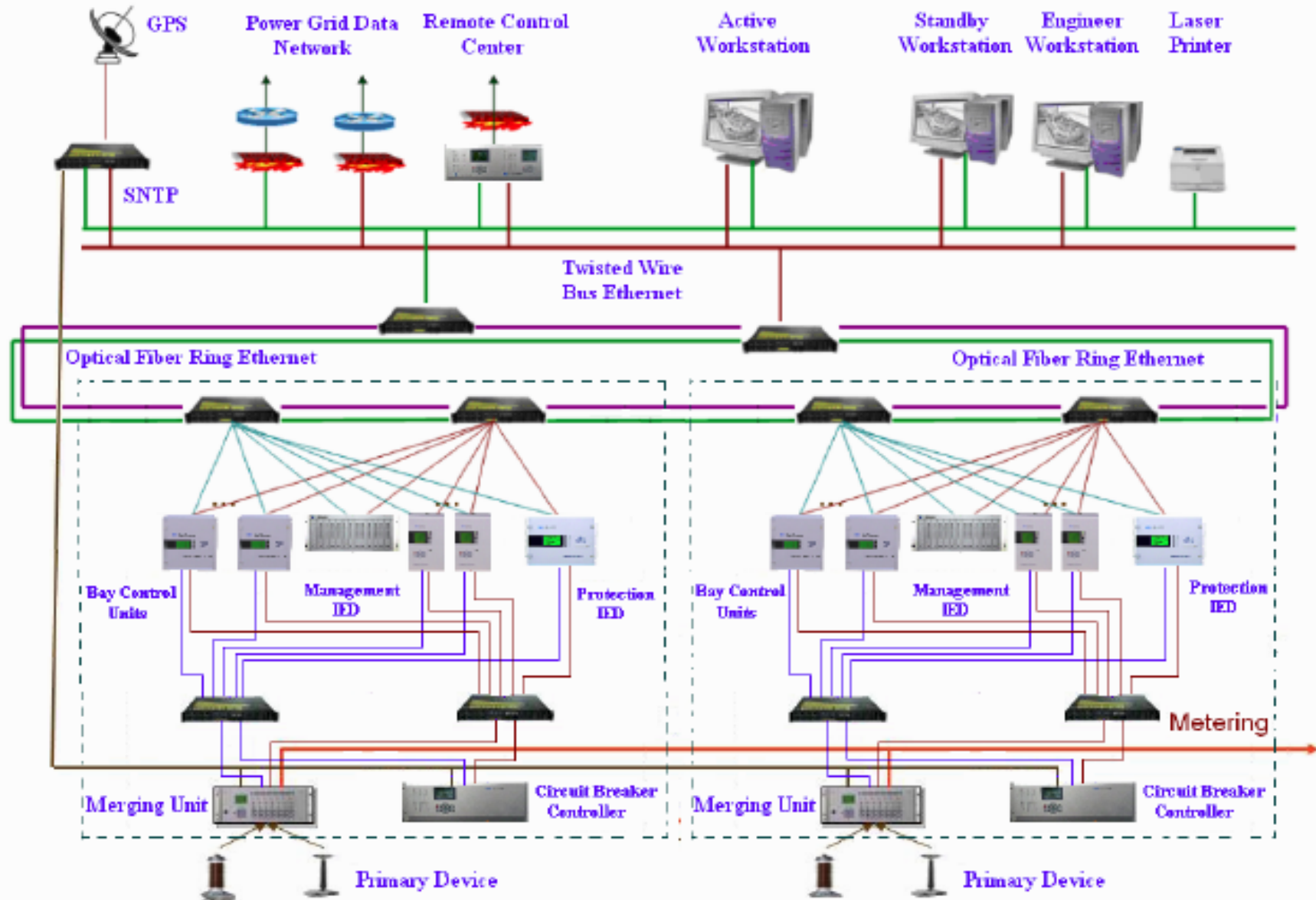
Areva Implementation



System without Process Bus



System with Process Bus



Cost Impact of IEC 61850 Implementation For SAS



	Conventional System	IEC 61850 System
Control Building (with AC Kiosk)	X	X- 35Lakhs
Illumination & ACVS	X	X-35 Lakhs
Control System	X	X + 125 Lakhs
Cable Trenchs	X	X-7 Lakhs
Cables	X	X- 95 Lakhs

THANK YOU