

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning and Integration
with NLDC of 13 nos of new Grid Sub-Stations on Turnkey Basis.**

Volume 2 of 3

TABLE OF CONTENTS

Volume 1 of 3:

- Section 1 - Instruction to Bidders
- Section 2 - Bid Data Sheet
- Section 3 - Evaluation and Qualification Criteria
- Section 4 - Bid Forms
- Section 5 - Eligible Countries
- Section 6 - Employer's Requirements
- Section 7 - General Conditions of Contract
- Section 8 - Special Conditions of Contract
- Section 9 - Contract Forms

Volume 2 of 3:

- Section 1 - Scope of Work
- Section 2 – Fiber Optic Multiplexer Equipment of Communication & Teleprotection
- Section 3 – RTU & SCADA Integration
- Section 4 – Communications DC Power Supply Equipment

Volume 3 of 3:

- | | |
|------------|--|
| Schedule A | Introduction & Preamble to the Price & Technical Schedules |
| Schedule B | Price Schedule |
| Schedule C | Terms for Delivery & Completion |
| Schedule D | Manufacturers, Places of Manufacture and Testing |
| Schedule E | Technical Particulars and Guarantees |
| Schedule F | Departure from Specifications |
| Schedule G | Proposed Alternative Standards to which Equipment shall Provided |
| Schedule H | Proposed Contract and Site Organization |
| Schedule I | Drawings and Documents to be Submitted with Bid |
| Schedule J | Proposed Subcontractors |

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning and Integration with
NLDC of 13 nos of 132 KV new Grid Sub-Stations on Turnkey Basis.**

(Contract No.)

SECTION 1

SCOPE OF WORK

SECTION 1

SCOPE OF WORK

TABLE OF CLAUSES

1.1	SCOPE.....	1/3
1.2	Sub-Station List.....	1/4
1.3	Sub-Station Wise Required Main Equipment Details.....	1/5
1.4	Summery of BoQ.....	1/6
1.5	Detail Scope of Work.....	1/7
	1.5.1 RTU, MC & SIC.....	1/7.
	1.5.2 Telecom & Teleprotection	1/8
	1.5.3 SCADA/EMS Integration to NLDC (Master & Back-up Station)	1/10.
	1.5.4 Battery & Battery Charger	1/15.
1.6	Single Line Diagram of Sub-Stations.....	1/16

1.1 SCOPE

In order to provide the monitoring facilities of 13 Grid Sub- Station at the National Load Dispatch Center (NLDC), the following provisions shall be made under the contract:

All required electrical quantities digital and analog shall be transmitted to the NLDC through the SDH/PDH from Sub-Stations, Integrated database and tested.

All analog data and digital data of HV breakers, tap changer, Isolators, etc. shall be monitored from NLDC through the RTU and SDH/PDH using IEC 60870-5-104 or IEC 60870-5-101 protocol. Necessary cabling and interfacing between the Sub-Station and the RTU and the communication equipment are to be included in this contract.

Necessary modification in the software and hardware at NLDC master station and back up station at Biddyut Bhaban is also to be done under this contract to accommodate all the new system extended under this contract if necessary including the following:

- Modeling of RTU and communication model in the NLDC software. Creation of associate display and modification of existing displays wherever required.
- Performing point to point test to verify the data.
- Modeling of electrical network associated with the new RTUs/SAS to be included, parameterization of various power system devices like lines, transformers, units, 33 KV load shade feeders etc. at the NLDC software.
- Tuning of EMS applications at NLDC to be carried out.
- Updating of the DTS with the new network model.

Sl. No	<i>Sub-Station</i>	<i>Adjacent Sub-Station</i>	<i>Remarks</i>
1	Savar	Aminbazar	
2	Munshigonj	Madanganj	
3	Daudkandi	Sonargaon, Comilla North, Daudkandi p/s	
4	New Tongi	Tongi 230kV	
5	Sonargaon	Daudkandi, Haripur	
6	B. Baria	Ashugonj, Shahajibazar	
7	Panchagar	Thakurgaon	
8	Joypurhat	Naogaon	
9	Niamatpur	Naogaon	
10	Chuadanga	Jhenaidah	
11	Magura	Jhenaidah	
12	Gallamari GIS	Khulna South	
13	GK Project 132kv	Bheramara P/S	

1.2 List of Sub-Stations

1.3 Sub-Station Wise Required Main Equipment Details

Sl. No.	Name of Grid S/S	Telecom Equipment	RTU& MC	48v Charger	48v Battery	Remarks
1	Savar	-	1	-	-	
2	Munshigonj	-	1	-	-	
3	Daudkandi	-	1	-	-	
4	New Tongi	1	1	-	2	
5	Sonargaon	-	1	-	-	
6	B. Baria	-	1	-	-	
7	Panchagar	1	1	2	2	
8	Joypurhat	1	1	2	2	
9	Niamatpur	1	-	-	-	
10	Chuadanga	1	1	2	2	
11	Magura	1	1	2	2	
12	Gallamari GIS	1	-	2	2	
13	GK Project 132kv	1	1	2	2	
Total		8 Lots	11 Lots	12 Sets	14 Sets	

12.1

Sl. No.	Descriptions	Quantities	Remarks
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1.4 Summary of BoQ

1	Remote Terminal Unit (RTU) as per SLD with 20% spares capacity. RTU acquisition protocol –MOD Bus, Communication protocol IEC 60870-5-104 or IEC 60870-5-101 and communication parameter & as per signal list to be approved by PGCB. Supply of Sub-Stations SCADA adaptation materials (i.e. Transducer/MFT, Cables for CT/PT/control/signaling etc, GPS,MC/SIC, Multiplying relay and so on) also included. 03 (Three) load-shade feeder shall be considered for SCADA integration in each Sub-Station.	11 Lots	
2	Fiber Optic Telecommunication Equipment (SDH/PDH) for each Lot with following services: a) Voice Communication (IP Phone and 2-w phone) b) Data Communication (Both LAN & WAN), c) Tele-protection d) Different LAN services (CCTV, DFDR etc for central monitoring)	8 Lots	Proposed telecom equipment shall be communicated with remote station's telecom equipment. If supplier proposed different type of telecom equipment, they have to provide the same equipment to the remote station under the same lot. Contractor can re-arrange the telecom equipment of the existing with the new. Proposed equipment shall be integrated to NMS as well as the station's services.
3	Integration of RTU and Telecom equipment to Master & Back Up Station's SCADA EMS and Telecom NMS system.	12 Lots	Integration of RTU and Telecom equipment to Master & Back Up Station's SCADA EMS and NMS system is proprietary item for ALSTOM T&D. Alstom will do this work as per approved PGCB rate.
4	48 Volt DC Battery, 100Ahr, Alkaline.	14 Sets	
5	50 A, Charger for 48 Volt DC 100Ahr battery with DC distribution BOX suitable for 48V DC system of the SS.	12 Sets	

1.5 Detail Scope of Work .

1.5.1 RTU, MC & SIC

List of RTU & MC need to be supplied:

Sl. No.	Name of Grid S/S	RTU,MC& SIC	Remarks
1	Savar	1	
2	Munshigonj	1	
3	Daudkandi	1	
4	New Tongi	1	
5	Sonargaon	1	
6	B. Baria	1	
7	Ponchogor	1	
8	Joypurhat	1	
9	Niamotpur	-	
10	Chuadanga	1	
11	Magura	1	
12	Gallamari GIS	-	
13	GK Project 132kv	1	
Total		11 Lot	

RTU should be capable to operate analog and digital data as per the station wise Single Line Diagram (SLD) and attached standard Signal List provide by PGCB with 20% spare for every different type of data (like alarm, status, control, analog etc) or at least suitable for integration of 2 (two) feeders which is more. The following functions are included in the scope of works:

01. Site survey shall be done as per Single Line Diagram (SLD) and Standard Data List approved by PGCB SCADA division.
02. Collection of existing sub-stations drawing for adaptation of necessary signals, control and metering as required.
03. Preparation of necessary adaptation drawings for SCADA EMS and get approval from PGCB.
04. Adaptation works with required materials (i.e. supply of all control/status/data/LV power cables, multiplying relays, transducers, TBs etc).
05. Any modification, Fabrication, repair of civil/electrical work which is related to the installation of said works.
06. Arrangement for auxiliary AC & DC power supply from existing power source for supplied equipment (i.e. RTU & MC,).
07. For required data integration as per Data List existing control/relay/SIC panel can be used if not possible it has to be taken from of the Sub-Stations field.
08. Approval and arrangement of the necessary Shut down for performing testing and commissioning.
09. Testing and commissioning of subjected works as per PGCB standard.

10. All RTU shall be integrated to the master station (NLDC) & back station (Biddyut Bhaban) by IEC-60850-05-104 or IEC-60850-05-104 protocol. Any necessary up-gradation if required at NLDCs is contractor's scope.
11. Skilled/Experience Manpower need to be provided to perform the RTU adaptation work.
12. RTU have to be ALSTOM T&D or ABB Ltd. make of latest model & version.
13. 03 (Three) load-shade feeders shall be considered for SCADA integration in each Sub-Station.

1.5.2 Telecom & Teleprotection

List of Telecom Equipment need to be supplied:

Sl. No.	Name of Grid S/S	Telecom Equipment	Remarks
1	Savar	--	
2	Munshigonj	--	
3	Daudkandi	--	
4	New Tongi	1	
5	Sonargaon	--	
6	B. Baria	--	
7	Ponchogar	1	
8	Joypurhat	1	
9	Niamotpur	1	
10	Chuadanga	1	
11	Magura	1	
12	Gallamari GIS	1	
13	GK Project 132kv	1	
Total		8 Lots	

Information of Telecom equipment at remote S/S and No. of feeder to be protected:

Sl. No	Name of Sub-Station	Name of Remote Sub-Station	Name of the existing Telecom equipment of remote station	No. of line/feeder to be protected by Teleprotection	Remarks
1	Savar	Aminbazar	OSN-1500,FOX515	--	
2	Munshigonj	Madanganj	OSN 1500B, FOX515	--	
3	Daudkandi	Sonargaon,	FOX515),	02	
		Comilla North,	FOX515, OSN-1500		
		Daudkandi p/s	None		
4	New Tongi	Tongi 230kV	FOX515, OSN-1500	--	
5	Sonargaon	Daudkandi,	FOX515	04	
		Haripur,	FOX515, OSN-1500		
		IEL p/s	None		

6	B. Baria	Ashugonj,	FOX515, OSN-1500	--	
		Shahajibagar,	FOX515, OSN-1500		
		Narsindi	FOX615		
7	Ponchogar	Thakugaon	METRO	01	
8	Joypurhat	Naogaon	METRO	01	
9	Niamotpur	Naogaon	METRO	01	
10	Chuadanga	Jhenaidah	METRO	01	
11	Magura	Jhenaidah	METRO	01	
12	Gallamari GIS	Khulna South	FOX515, OSN-1500	--	
13	GK Project	Bheramara p/s	METRO	--	

N.B.: ETER1 shall be supplied for each of SAVAR, Munshiganj, Daudkandi, Sonargaon, B-Baria for Integration.

The following functions are included in the scope of works:

01. Site survey shall be done as per Single Line Diagram (SLD) supplied by PGCB.
02. Collection of existing/remote sub-stations telecommunication drawing for establishing of necessary data, voice, tele-protection, LAN/WAN as required.
03. Preparation of necessary working drawings for Telecom system and approved from PGCB.
04. Adaptation works with required materials (i.e. supply of all control/data/power cables, patch cord, ODF, FOAC, TBs etc).
05. Any modification, Fabrication, repair of civil/electrical work which is related to the installation of said works.
06. Supply of necessary cards/modules for LAN/WAN services of existing telecom equipment.
07. Arrangement of auxiliary AC & DC power supply from existing power source for supplied Telecom equipment from the existing source.
08. Each lot of telecom equipment should be a SDH&PDH or SDH+PDH.
09. Capacity of each telecom link shall be STM-4, any necessary modification of remote station required to be done to established said link capacity.
10. Reuse/Relocation of existing Telecom equipment at respective remote station is acceptable.
11. Tele-protection system for each circuit shall have 4 (four) input & 4 (four) output channel with G.703 protocol.
12. Every station shall have 1 (one) IP phone with license and 2(two) 2-wire phone for voice communication.
13. All Telecom system shall be integrated into the NMS system of NLDC master station, any necessary upgrade required to NLDC master station's NMS system should be done by the contractor.
14. Approval and arrangement of the necessary Shut down for performing testing and commissioning of Tele-protection.

15. Testing and commissioning of subjected works have to be as per PGCB standard.
16. Skilled/Experience Manpower is need to be provided to perform the telecom works.
17. Telecom equipment have to be ABB Ltd. or ALSTOM T&D make.
18. After commissioning all as-build document should be submitted before site acceptance test (SAT)

1.5.3 SCADA/EMS Integration to NLDC (Master & Back-up station)

All required electrical quantities shall be transmitted to the NLDC through Remote Terminal Unit (RTU)/Industrial gateway of the sub Station Automation system.

Remote Terminal Unit (RTU)/Industrial gateway of the sub Station Automation system shall be reported to master station at Rampura, Dhaka and backup station at Biddut Bhaban Dhaka at the same time using IEC 60870-5-104 Protocol.

RTU or Gateway shall be report to master station, Rampura through VLAN Network and backup station at Biddut Bhaban through routed Network. RTU or Gateway shall be configured according to provided signal list, mapping address, communication parameter, IP address and station address. IP and station address, communication parameter shall be provided at the time of execution.

Analogue data should be floating point with dead band of 1 %.

Frequency dead band will be 0%. Digital data should be time stamp at field.

Signal list

Analog Input

1. MW, MVAR, Amp, kV for Transformer (LV side) and Transmission Line, Generator (11 kV Side)
2. kV and Frequency for Bus bar
3. Tap Position Indication for Transformer

Digital Input (Single Point)

With Time tag at site

1. Remote/ Local Switch for Every Circuit Breaker, Tap Changer, Disconnecter
2. Bay Fault
3. Breaker Fault
4. Protection class -1

- 5 Protection class -2
6. Protection class -3
7. Voltage Status for Bus bar
8. Transformer Alarm
9. Transformer Trip.
10. Transformer Temperature Alarm
11. Transformer Temperature Trip
12. Tap Changer Alarm
13. Tap Changer Trip
14. NLDC/ Station Switch (Operation from NLDC or Sub-station)
15. Control/Control Disable
16. Auto reclose
17. Auto reclose block
18. Generator Trip
19. Generator Transformer Alarm
20. Generator Transformer Trip
21. DC Fail
22. RTU Fail

Digital Input (Double Point)

1. Circuit Breaker Open/ Close
2. Disconnecter Open/ Close
3. Earth Switch Open/ Close
4. Tap Changer SCADA/ Station Control

Digital Output (Double point)

1. Circuit Breaker Open/ Close

2. Motorized Isolator Open/ Close
3. Raise/ Lower for transformer

33 kV Load shed Feeder

1. CB Status (Double Point input)
2. CB Control (Double Point Output)
3. CB Ready Status (Single Point input)

Integrating RTU/ gateway with NLDC following work shall be done at master Station Rampura, Dhaka and Backup station at Biddut Bhaban Dhaka

1. SCADA Database Modelling

The following activities will be carried out based on the datalist & single line diagram

- .Preparation & Updation of COMTOP(Communication Topology)
- Preparation & Updation of RTUTOP(RTU Topology)
- Preparation & Updation of SUBTOP(Substation Topology)
- Preparation & Updation of System Calculation Database.

2. Substation Display

The following activities will be carried out to build single line diagram for stations configured in SCADA database

- Preparation & Updation of SCADA general display
- Preparation & Updation of SCADA online station display
- Preparation & Updation of Network application station online display
- Preparation & updation of NETWORK_MAP display
- Preparation & updation of all GENERATION display
- Preparation & updation of all LOAD display
- Preparation & updation of Area Control Centre's display

4. Network database Modeling

The following activities will be carried out

- Preparation & Updation of NETTOP(Network Topology)
- Preparation & Updation of NETPARAM(Parameter value of X-former, Lines, Unit)
- Preparation & Updation of NETTAB Topology

5. Generation Database Modeling

The following activities will be carried out

- Preparation & Updation of GENTOP(Generator Topology)
- Preparation & Updation of GENPARM (Heat rate curve, unit regulation, capability curve etc.)
- Preparation & Updation of GENTAB Topology

6. DTS Database Modeling

The following activities will be carried out

- Preparation & Updation of DTSTOP
- Preparation & Updation of DTSPARM
- Preparation & Updation of DTSAB Topology

7. Alarm database Modeling

The Following activities will be carried out

- Preparation & Updation of ALARM Topology
- Preparation & Updation of ALARM category, Priority, exception

8. Validation

- Cross validation of all databases and create update copy of those databases.
- On-lining of databases in DTS (Simulator) server
- Checking and modifying (if require) topology of Substations, Devices, Network etc.

10. Local Test

The following test will be carried out at site using e-terra control software

- Verification of all Analog Measurement and checking of Limit, Deadband , Polling Time
- Verification of Digital signals Status (OPEN, CLOSE, BETWEEN, INVALID)
- Verification of ALARMS, EVENTS etc.
- Control and Interlock

9. Database Update

The following activities will be carried out in Master NLDC and Backup NLDC after successful site test.

- On-lining of all databases in Running Servers
- IP/VLAN Configuration on Polling servers and switch
- Compilation & On-lining of all the displays on WEB servers

10. End to End Test

The following activities will be carried out in Master NLDC and Backup NLDC

- Verification of all Analog Measurement,
- Verification of Digital signals and Controls
- Verification of displays including Single line, Pop up, alarms etc.
- Verification of communication line for Redundancy

11. Tuning of Power System Application

- Tuning will be do required for all available Network and generation applications in SCADA/EMS server and DTS(Dispatcher Training Simulator)

Notes:

- Data communication path creation for both Main & Backup station is scope of Integration
- Collection of Network and generation data required for modeling network & Generation database is in contractor's scope of work
- Contractor will conduct necessary work for both at NLDC & Substation (if required)

Inspection:

The Contract Price shall include all costs of inspection of Employers engineer for the following:

- (a) Six(6) engineers nominated by the Employer shall participate in the inspection and witnessing of factory acceptance tests at manufacturers' works for RTUs, for Communication equipment and Battery & Battery Chargers (3 trips), each visit to be attended by two engineer of at least seven (7) days duration each.

The Contractor shall be responsible for bearing all costs for witnessing factory acceptance, including air fares, accommodation, meal, healthcare, transportation, visa fees etc. together with payment of a daily allowance of US\$ 100 for each of the Employer's engineer.

1.5.4 Battery & Battery Charger

List of Charger & Battery need to be supplied:

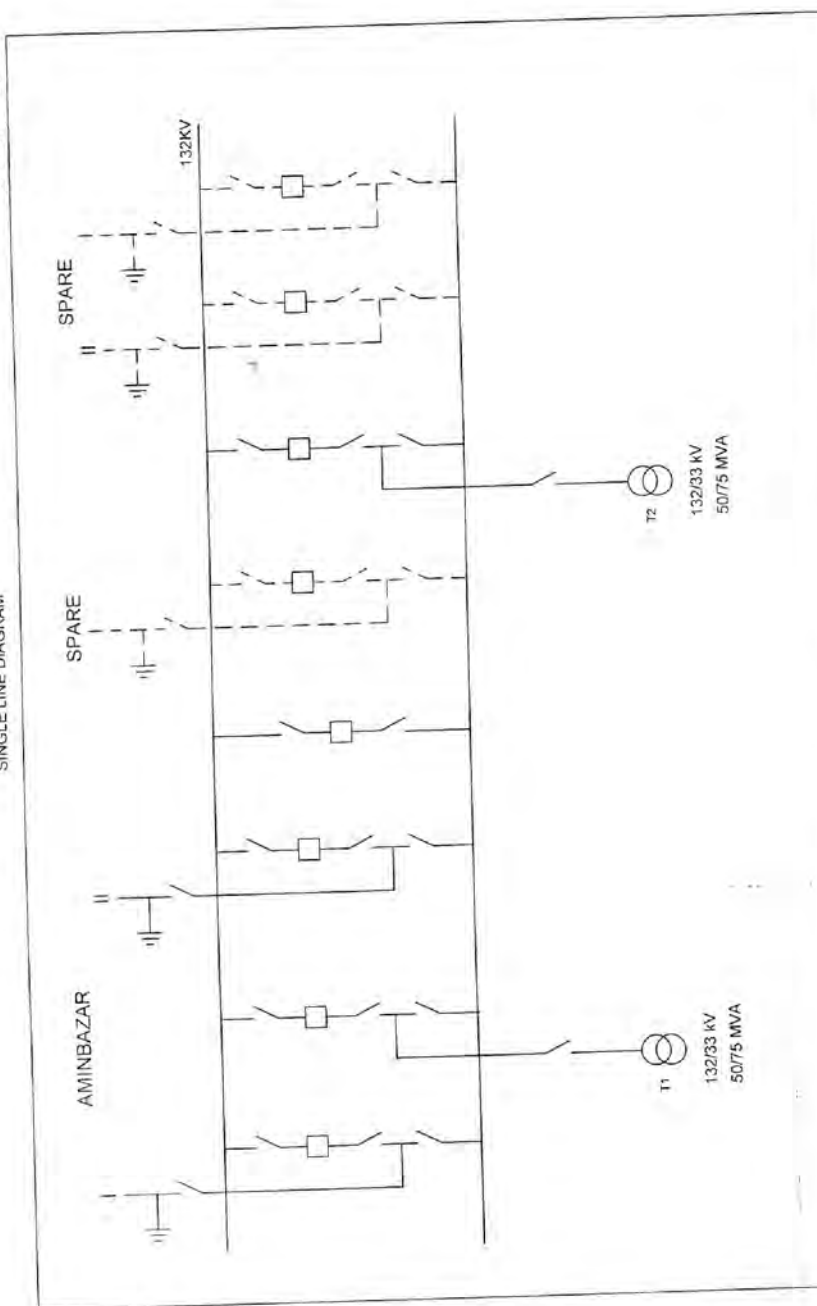
Sl. No.	Name of Grid S/S	48v Charger	48v Battery	Remarks
1	Savar	-	-	
2	Munshigonj	-	-	
3	Daudkandi	-	-	
4	New Tongi	-	2	
5	Sonargaon	-	-	
6	B. Baria	-	-	
7	Panchagar	2	2	
8	Joypurhat	2	2	
9	Niamotpur	-	-	
10	Chuadanga	2	2	
11	Magura	2	2	
12	Gallamari GIS	2	2	
13	GK Project 132kv	2	2	
Total		12 Set	14 Set	

01. Preparation of necessary adaptation drawings for 48 Volt DC systems and approved from PGCB.
02. Adaptation work with required materials (i.e. supply of all cables, LPD, TBs etc).
03. Any modification, fabrication, repairs of civil/electrical work which is related to the installation of said works.
04. Arrangement of auxiliary AC power supply for supplied charger from the existing source.
05. Each set of battery shall be Alkaline.
06. Capacity of each set of battery and charger shall be 100Ahr and 50A respectively.

07. Battery & Battery Charger's manufacturer shall be Saft Nife, Singapore/ HBL Nife , India/
Cloride, India, make

Single Line Diagram of Sub-Stations

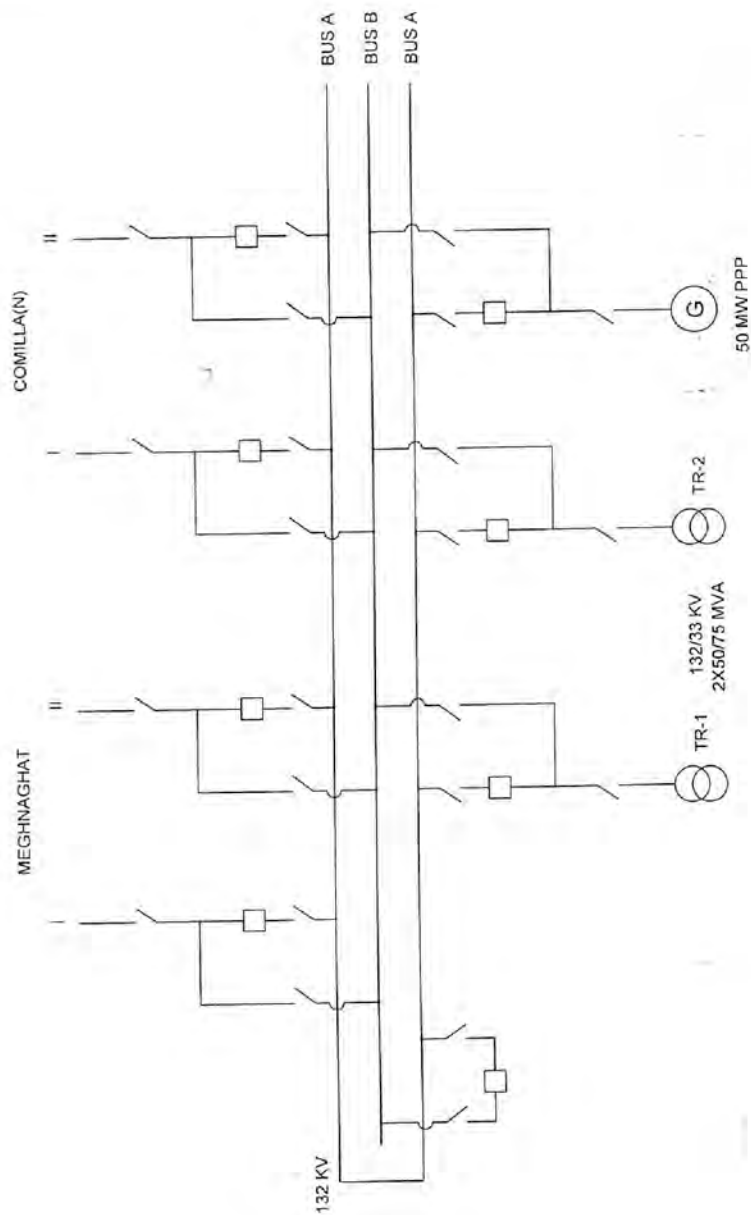
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JAN 2012	POWER GRID COMPANY OF BANGLADESH LTD.	SINGLE LINE DIAGRAM OF 132 KV S/S SAVAR
	ENERGY MANAGEMENT	

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

QF-SPL-23



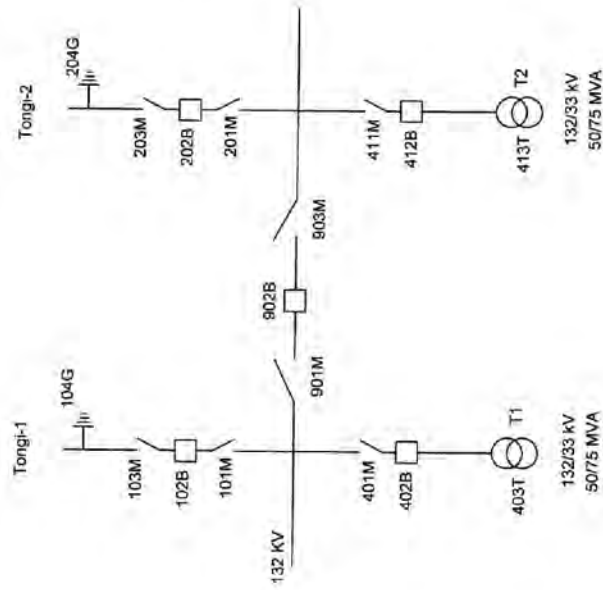
JAN 2012

POWER GRID COMPANY OF BANGLADESH LTD.
SYSTEM PLANNING / ENER MANAGEMENT, LDC

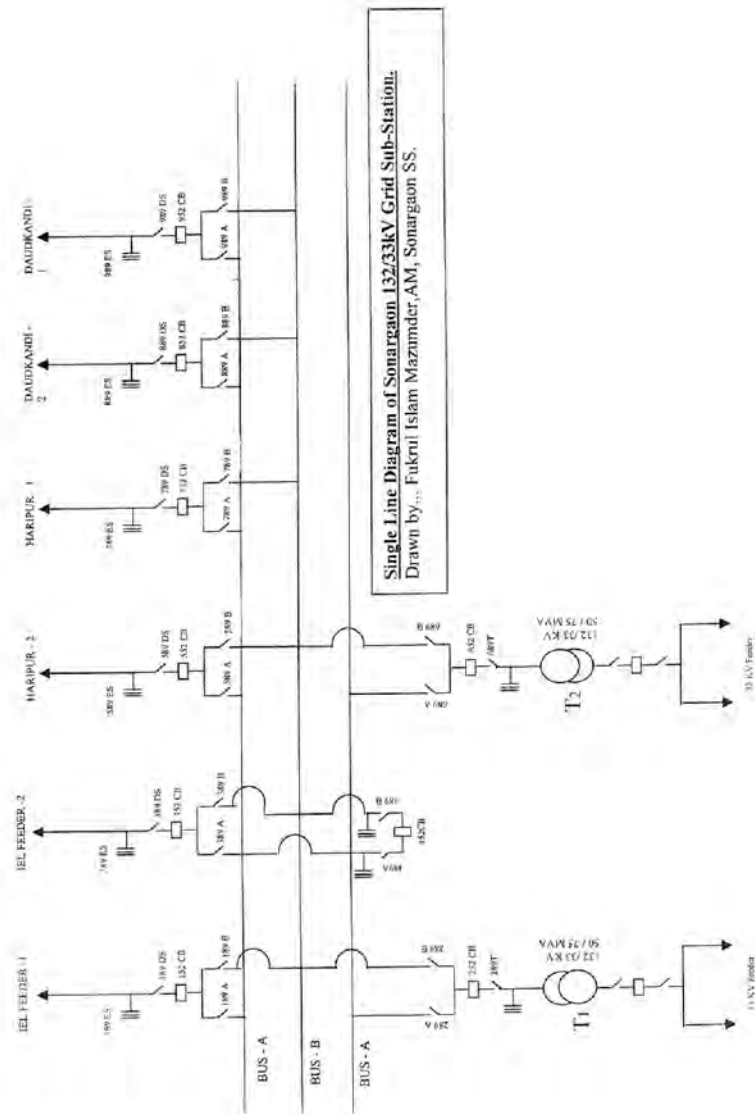
SINGLE LINE DIAGRAM OF 132 KV S/S
DAUDKANDI

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

QF-SPL-17

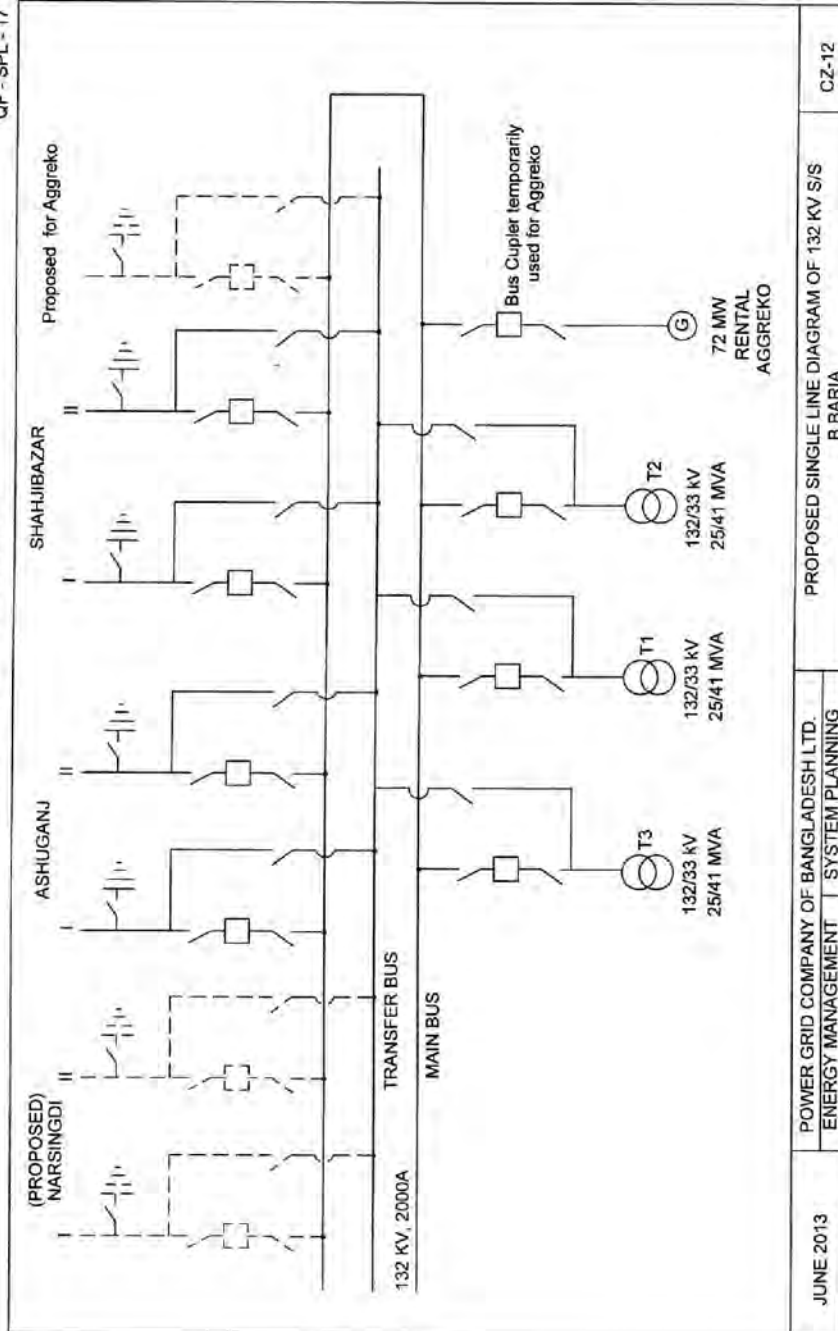


MARCH 2013	POWER GRID COMPANY OF BANGLADESH LTD.	SINGLE LINE DIAGRAM OF 132 KV S/S NEW TONGI	DS-27
DEPUTY MANAGER, SYSTEM PLANNING DATE:	ENERGY MANAGEMENT	MANAGER, SYSTEM PLANNING DATE:	



POWER GRID COMPANY OF BANGLADESH LTD.
SYSTEM PLANNING
PROPOSED SINGLE LINE DIAGRAM

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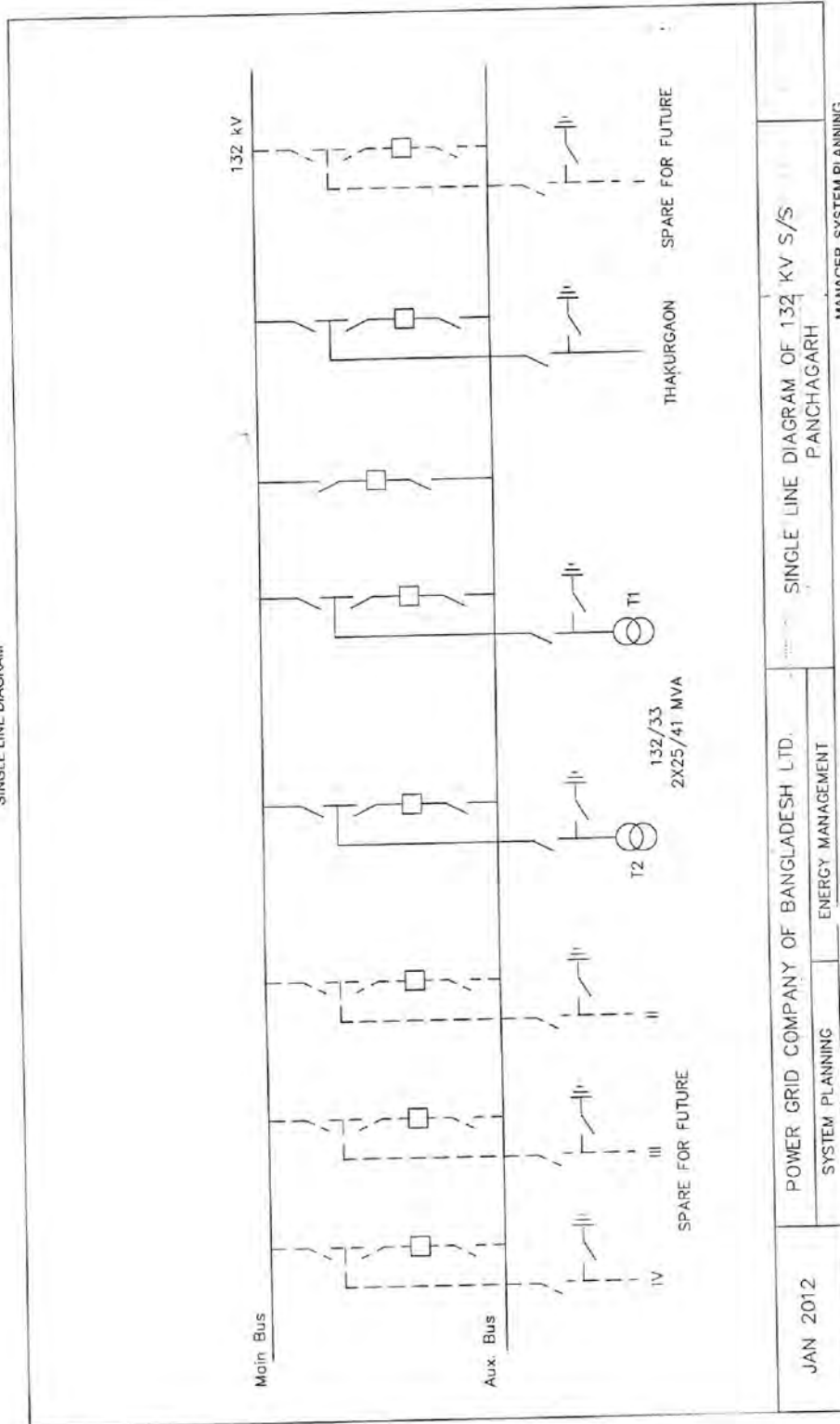


Dy. Manager, System Planning
 Date:

Manager, System Planning
 Date:

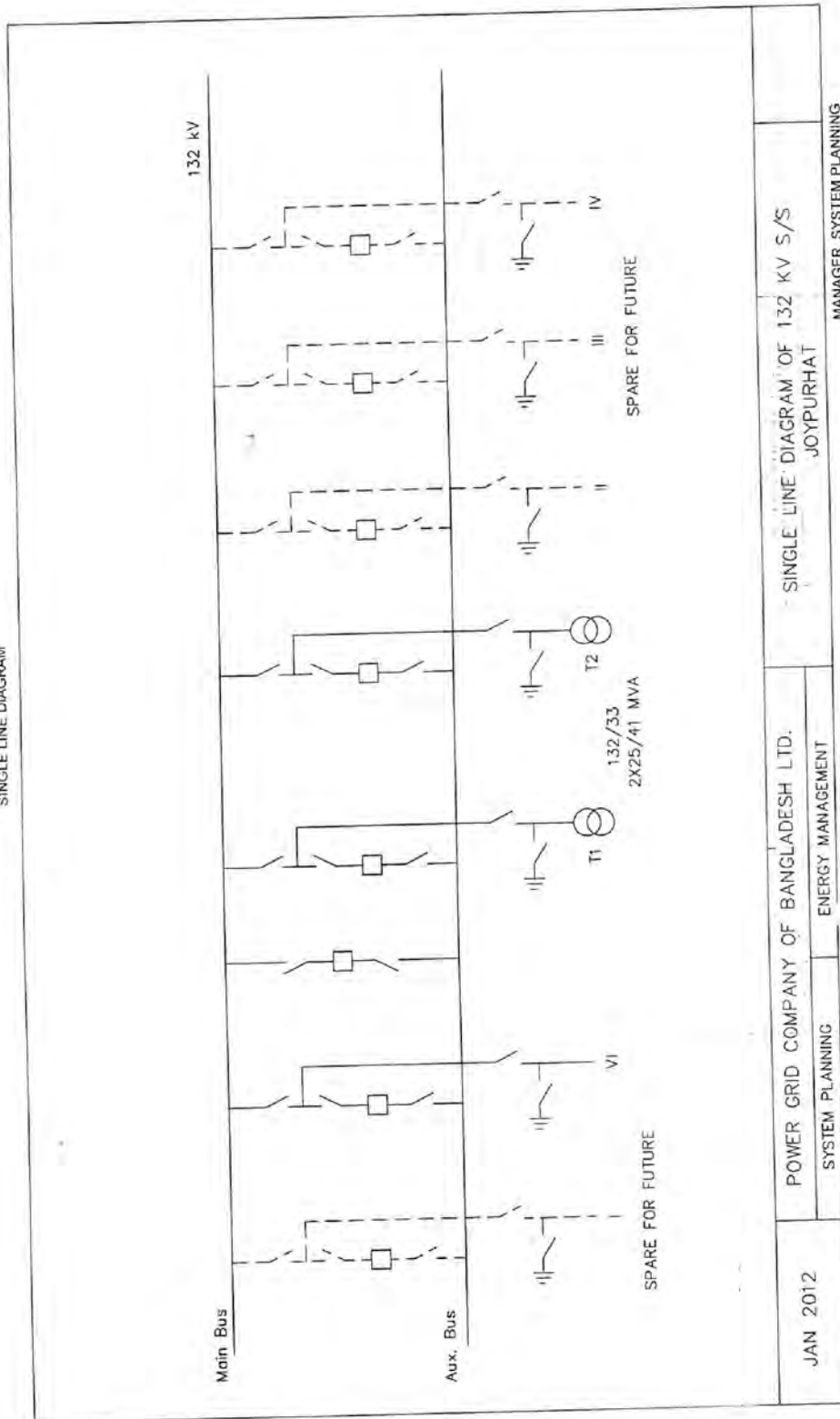
POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

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POWER GRID COMPANY OF BANGLADESH
 SYSTEM PLANNING
 SINGLE LINE DIAGRAM

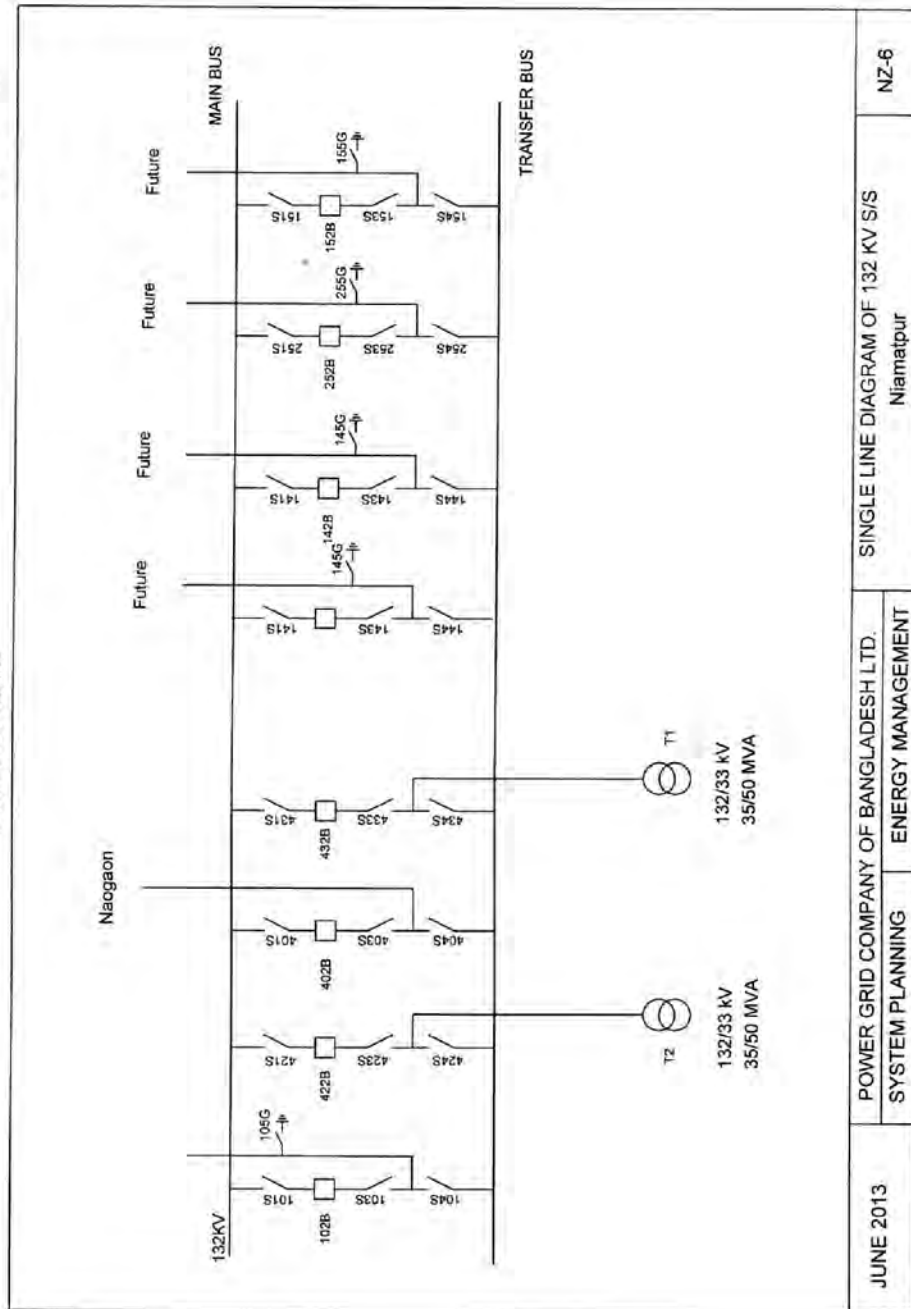
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JAN 2012	POWER GRID COMPANY OF BANGLADESH LTD.		SINGLE LINE DIAGRAM OF 132 KV S/S JOYPURHAT	
	SYSTEM PLANNING	ENERGY MANAGEMENT	MANAGER, SYSTEM PLANNING DATE:	

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

QF-SPL-17



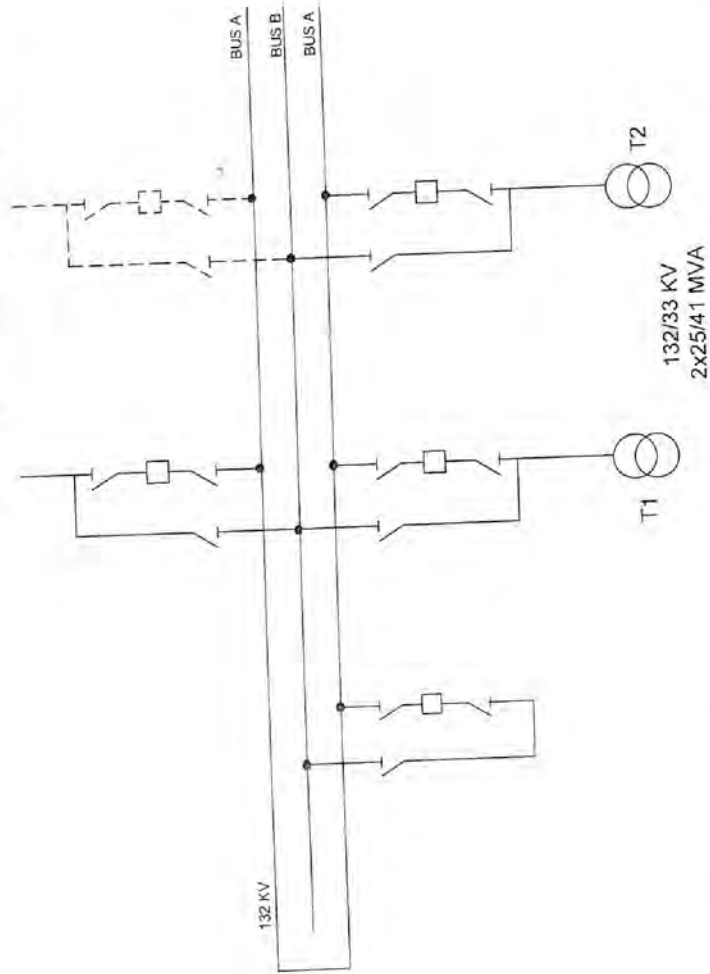
JUNE 2013	POWER GRID COMPANY OF BANGLADESH LTD.	SINGLE LINE DIAGRAM OF 132 KV S/S Niamatpur	NZ-6
	SYSTEM PLANNING		

Deputy Manager, System Planning
Manager, System Planning

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

QF-SPL-23

JHENAIIDHA SPARE FOR FUTURE



SINGLE LINE DIAGRAM OF 132 KV S/S

CHUADANGA

POWER GRID COMPANY OF BANGLADESH LTD.
SYSTEM PLANNING ENERGY MANAGEMENT

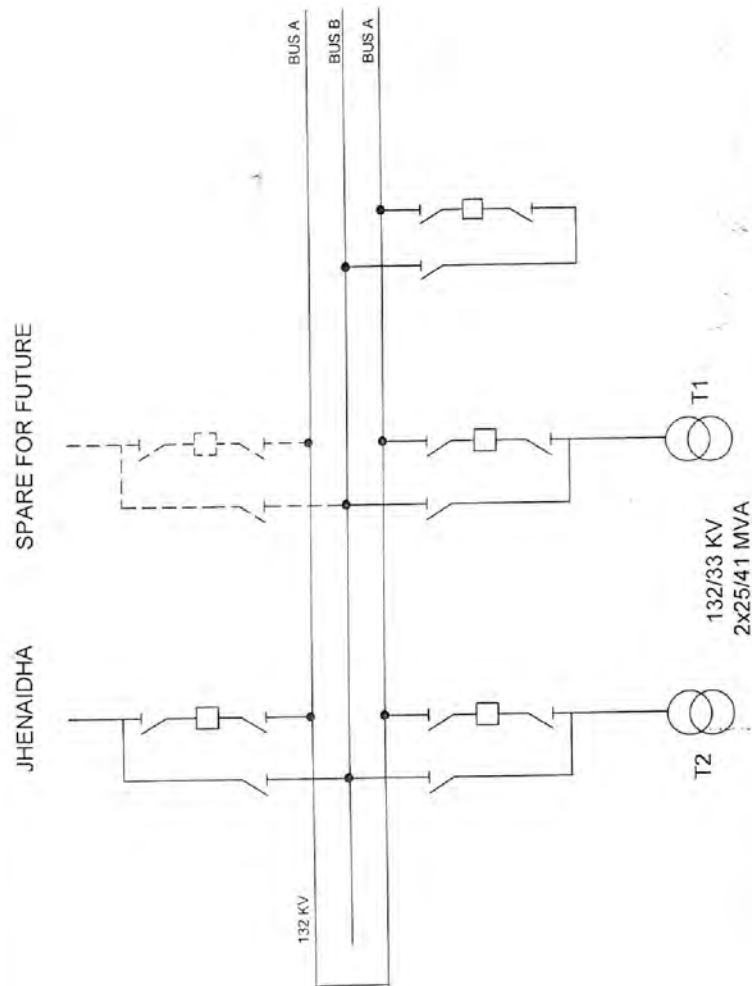
JAN 2012

MANAGER, SYSTEM PLANNING
DATE

PCDITY MANAGER SYSTEM PLANNING

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

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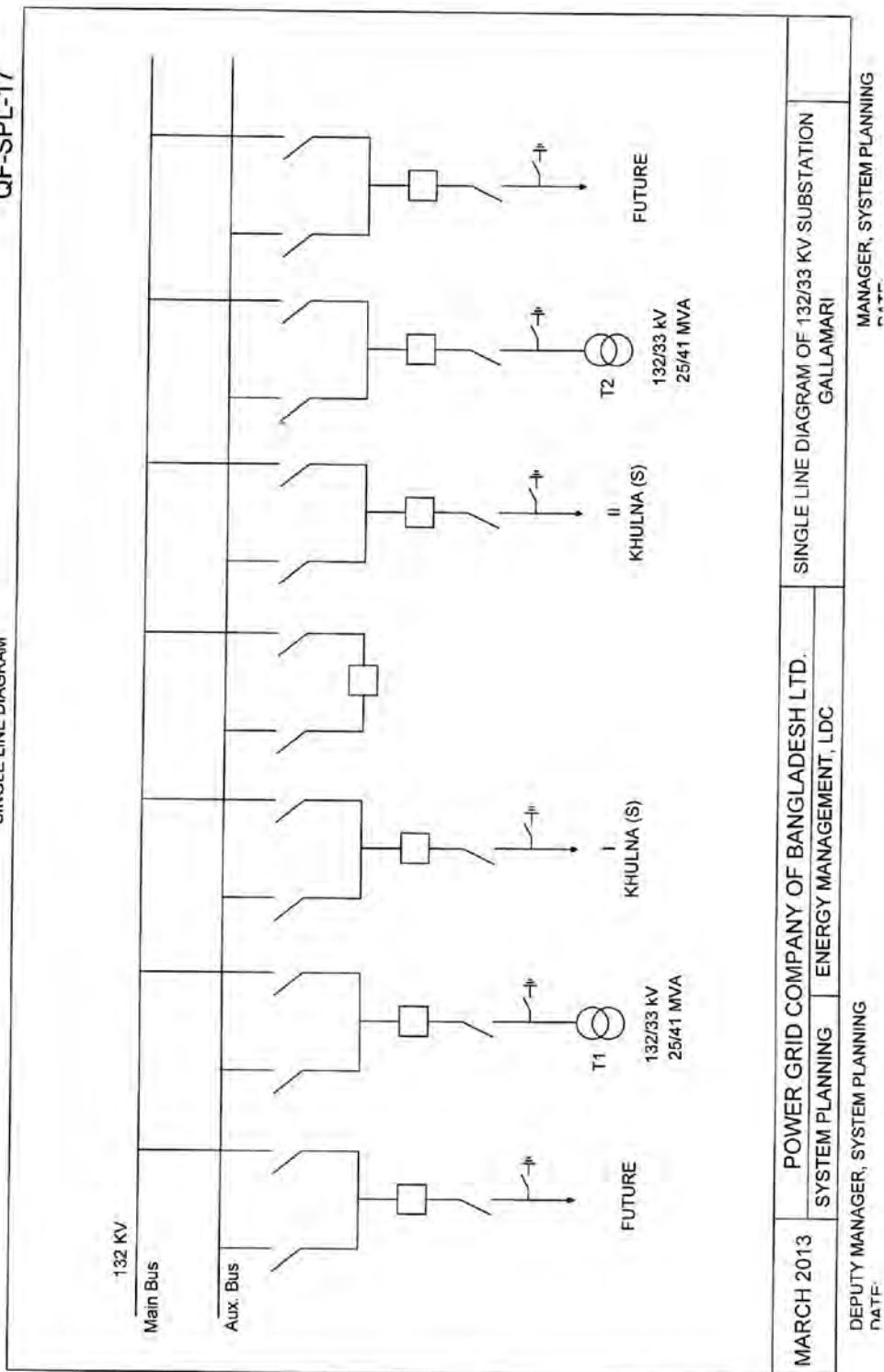
JAN 2012	POWER GRID COMPANY OF BANGLADESH LTD.	SINGLE LINE DIAGRAM OF 132 KV S/S	
	SYSTEM PLANNING	ENERGY MANAGEMENT	MAGURA

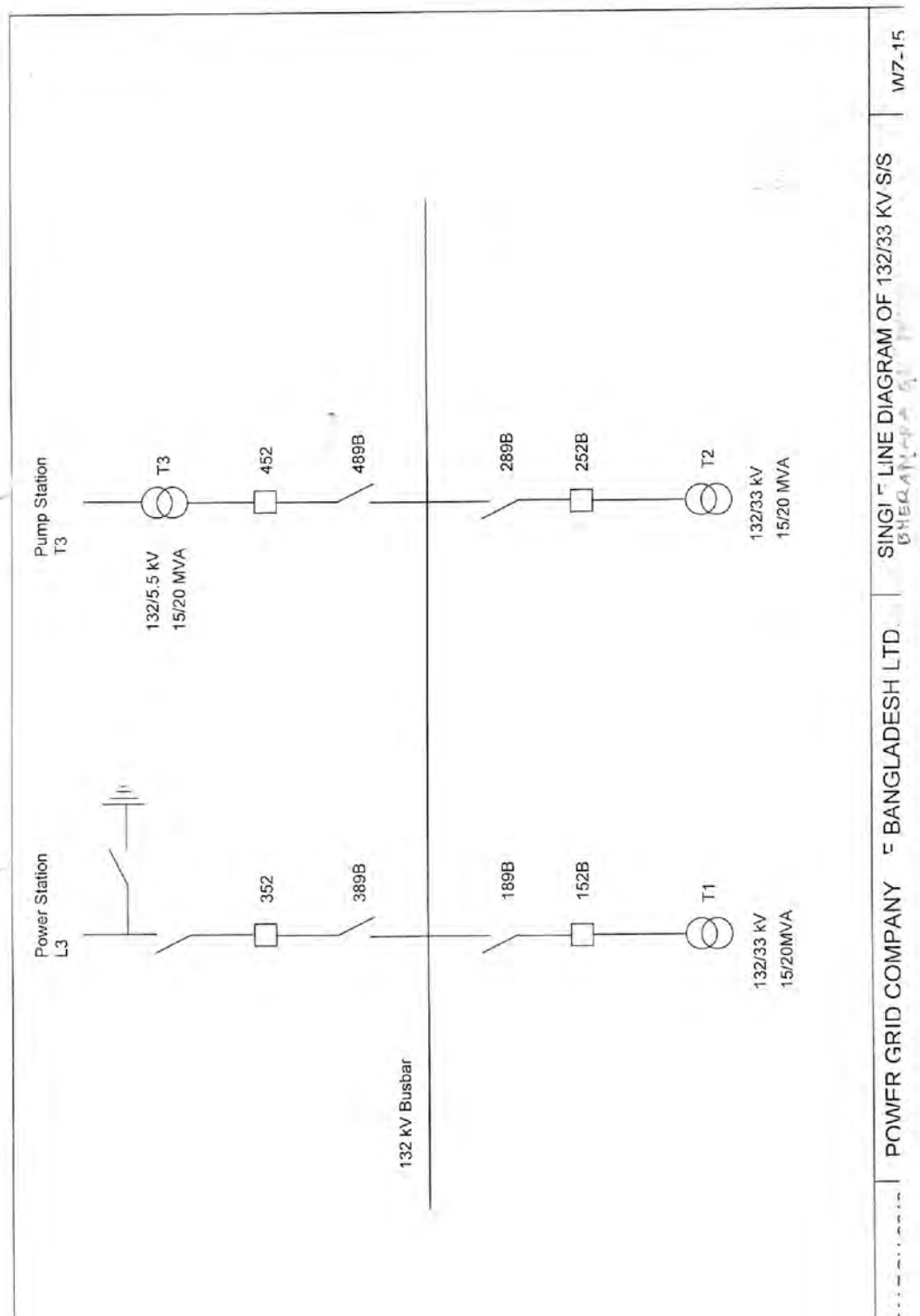
DESIGNER: MANAGER, SYSTEM PLANNING

DATE: MANAGER, SYSTEM PLANNING

POWER GRID COMPANY OF BANGLADESH
SYSTEM PLANNING
SINGLE LINE DIAGRAM

QF-SPL-17

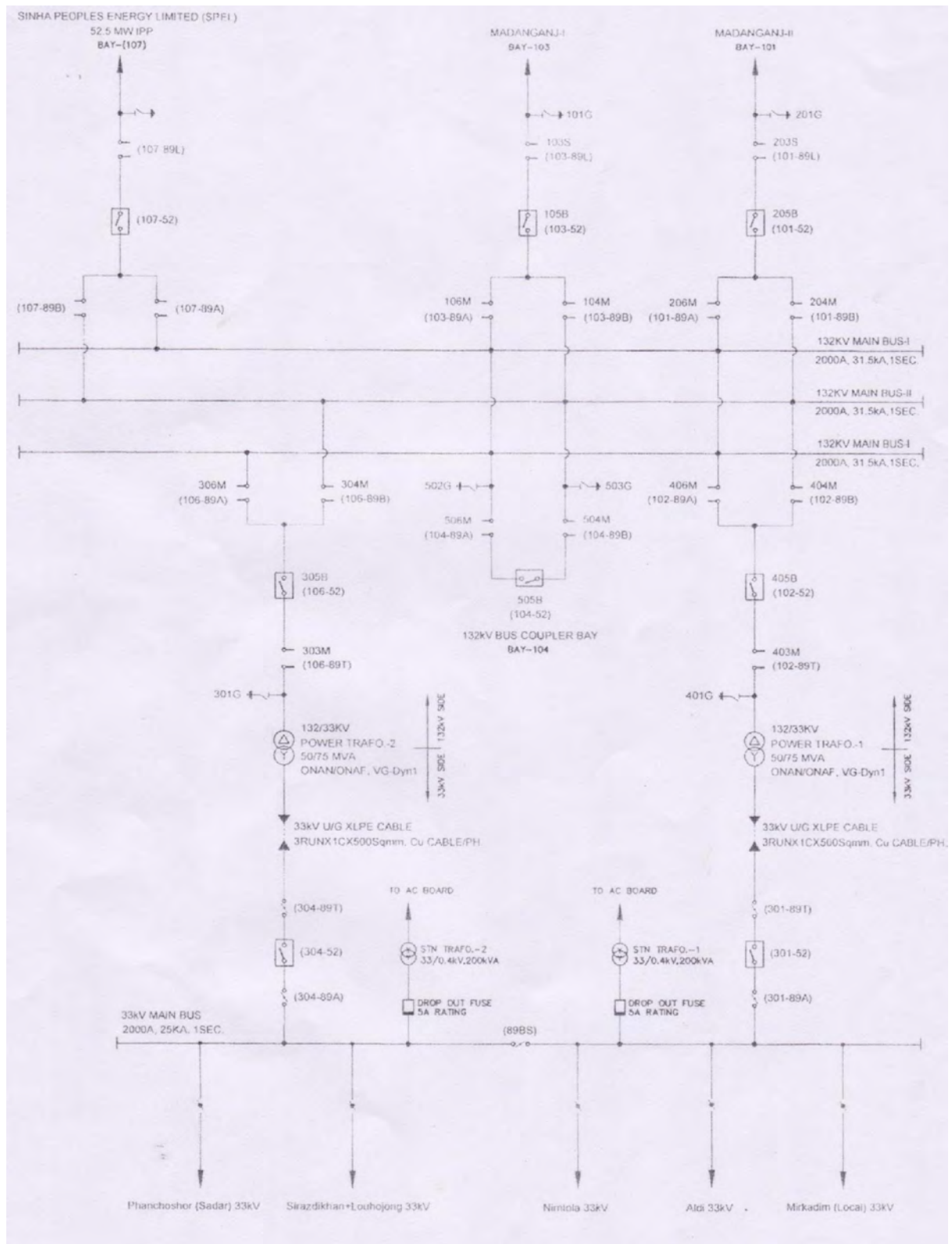




SINGI LINE DIAGRAM OF 132/33 KV S/S

POWER GRID COMPANY BANGLADESH LTD.

W7-15



Single Line Diagram of Munshiganj 132/33 KV Sub-Station

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning and Integration
with NLDC of 13 nos of 132 KV new Grid Sub-Stations on Turnkey
Basis.**

(Contract No.)

SECTION 2

**FIBER OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND
TELEPROTECTION.**

SECTION 2

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND TELEPROTECTION

TABLE OF CLAUSES

2.1	SCOPE.....	2/36
2.2	Summary of Standards.....	2/37
	2.2.1 The PDH interfaces shall conform to the following recommendations:.....	2/38
	2.2.2 The architecture of optical SDH interfaces shall conform to the following recommendations:	2/39
	2.2.3 The synchronisation and timing of optical SDH interfaces shall conform to the following recommendations:	2/39
2.3	Abbreviations	2/40
2.4	General requirements.....	2/41
2.5	General Conditions.....	2/43
	2.5.1 Channel capacity: Digital Cross Connection	2/43
	2.5.2 Redundant centralised functions.....	2/43
	2.5.3 Power Supply.....	2/43
	2.5.4 ITU Compliance	2/44
	2.5.5 Electromagnetic compatibility and safety regulations	2/44
	2.5.6 Ambient Conditions	2/44
	2.5.7 Mechanical construction	2/44
	2.5.8 Network management system	2/44
	2.5.9 1+1 Path protection.....	2/45
	2.5.10 1+1 Section protection	2/45
	2.5.11 Network Topology	2/46

2.5.12 Synchronisation	2/46
2.5.13 Alarms	2/46
2.5.14 Test Loops	2/46
2.5.15 Maintenance facilities	2/46
2.6 Requirements for Transport Level	2/47
2.6.1 SDH Aggregate Units	2/47
2.6.2 HDSL Aggregate Units	2/48
2.7 Tributary Units.....	2/49
2.7.1 4-Wire Interface (VF interface)	2/49
2.7.2 Analogue Subscriber Interface	2/50
2.7.3 Exchange Interface	2/51
2.7.4 Partyline Telephone System (Engineering Order Wire)	2/52
2.7.5 V. 24/V.28 RS232 Interface	2/52
2.7.6 V.11/X.24 Interface	2/52
2.7.7 V.35 Interface	2/53
2.7.8 V.36 / RS 449 Interface.....	2/53
2.7.9 64 kBit/s Codirectional Interface.....	2/53
2.7.10 LAN Interface.....	2/54
2.7.11 Alarm Interface.....	2/54
2.7.12 Teleprotection Interface	2/55
2.7.13 Optical Protection Relays Interface	2/57
2.7.14 Optical amplifier.....	2/57
2.7.15 Binary Contact Interface	2/57
2.7.16 2 Mbit/s G.703 / G.704 Interface.....	2/58
2.8 OPERATIONAL & ADMINISTRATIVE TELEPHONE	
SYSTEM.....	2/59

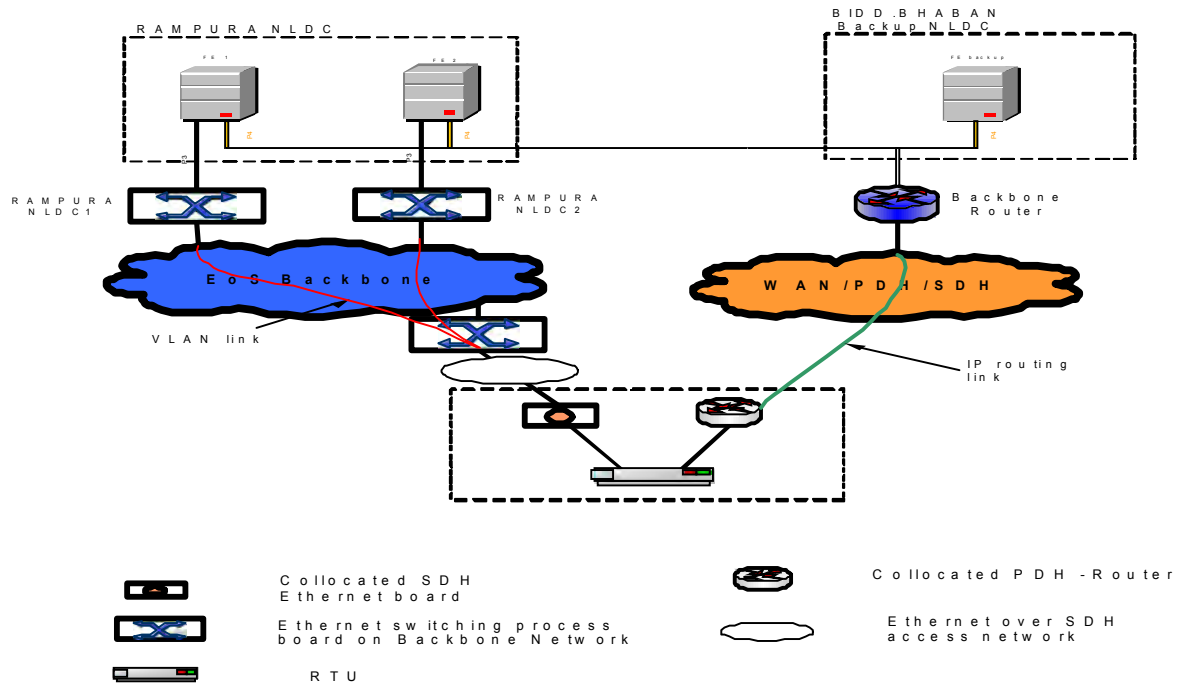
SECTION 2

FIBRE OPTIC MULTIPLEXER EQUIPMENT FOR COMMUNICATION AND TELEPROTECTION

2.1 SCOPE

This specification describes the communication requirements for the transport of DATA (SCADA & Diff. LAN Services), VOIP-IP Telephone (Operational Telephone) & 2-W Telephone (Administrative Telephone) signal from the new 13 Grid Sub-Stations to Main NLDC (Rampura) and Back-up NLDC (Biddyt Bhaban) through/upgrading existing communication Back-bone. It has also be transport of VOIP-IP Telephone (Operational Telephone) & 2-W Telephone (Administrative Telephone) signals and protection signals from the new sub-stations to their neighbor substations or power stations, including engineering, configuration, testing, installation and commissioning. The scope of work also includes extension of existing teleprotection equipment (AREVA, France make DIP 5000 type/ **ABB make**) and fibre optic multiplexer equipment (AREVA, France make MSE 5010 type/ABB, Switzerland make FOX515 type) at the counter sub-stations/power stations of new sub-stations for protection and communication (voice and data)

Drawing in this Specification shows the planned arrangements of fibre optic multiplexer equipment for communication and protection. All materials and equipment offered shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according the latest technological methods.



2.2 Summary of Standards

The Equipment shall comply with the latest ITU-T recommendations for the plesiochronuous and synchronuous hierarchies.

The equipment shall be independent type tested.

In particular the mentioned recommendations shall be covered:

2.2.1 The PDH interfaces shall conform to the following recommendations:

ITU

- ITU-T G.702: General aspects of digital transmission systems – Terminal equipment - Digital hierarchy bit rates
- ITU-T G.703: Digital transmission systems – Terminal equipment – General Physical/electrical characteristics of hierarchical digital interfaces
- ITU-T G.704: Digital transmission systems – Terminal equipment – General Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels
- ITU-T G.706: General aspects of digital transmission systems – Terminal equipment - Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in recommendation G.704
- ITU-T G.711: Pulse code modulation (PCM) of voice frequencies
- ITU-T G.712: Transmission performance characteristics of pulse code modulation channels
- ITU-T G.732: General aspects of digital transmission systems – Terminal equipment - Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s
- ITU-T G.735: Characteristics of primary multiplex equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
- ITU-T G.736: General aspects of digital transmission - Characteristics of a synchronous digital multiplex equipment operating at 2048 kbit/s
- ITU-T G.737: Characteristics of external access equipment operating at 2048 kbit/s and offering synchronous digital access at 384 kbit/s and/or 64 kbit/s
- ITU-T G.823: The control of jitter and wander within digital networks, which are based on the 2048 kbit/s hierarchy
- ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

2.2.2 The architecture of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

- ETS 300 147: Synchronous digital hierarchy multiplexing structure
- ETS 300 417: Transmission and Multiplexing (TM); Generic requirements of transport functionality of equipment
- ETS 300 417-1-1 / EN 300 417-1-1 V1.1.2: Generic Processes and Performance
- ETS 300 417-2-1 / EN 300 417-2-1 V1.1.2: SDH and PDH Physical Section Layer Functions
- ETS 300 417-3-1 / EN 300 417-3-1 V1.1.2 : STM-N Regenerator & Multiplex Section Layer Functions
- ETS 300 417-4-1 / EN 300 417-4-1 V1.1.2 : SDH Path Layer Functions

ITU

- ITU-T G.707: Network node interface for the synchronous digital hierarchy
- ITU-T G.783: Characteristics of synchronous digital hierarchy (SDH): equipment functional blocks
- ITU-T G.803: Architecture of transport networks based on the synchronous digital hierarchy (SDH)
- ITU-T G.805: Generic functional architecture of transport networks
- ITU-T G.826: Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate
- ITU-T G.841: Types and characteristics of synchronous digital hierarchy (SDH) network protection architectures
- ITU-T G.957: Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
- ITU-T G.958: Digital line systems based on the synchronous digital hierarchy for use on optical fibre cables
- ITU-T M.2101.1: Performance limits for bringing into service and maintenance of international SDH paths and multiplex section
- ITU-T T.50: International Reference Alphabet (IRA) - Information technology 7 bit coded character set for information interchange

2.2.3 The synchronisation and timing of optical SDH interfaces shall conform to the following recommendations:

ETS/EN

- ETS 300 417-6-1 / EN 300 417-6-1 V1.1.2: Synchronisation Layer Functions

- ETS 300 462-1 / EN 300 462-1-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 1: Definitions and terminology for synchronisation networks
- EN 300 462-4-1 V1.1.1: Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 4-1: Timing characteristics of slave clocks suitable for synchronisation supply to Synchronous Digital Hierarchy (SDH) and Plesiochronous Digital Hierarchy (PDH) equipment
- ETS 300 462-5 / EN 300 462-5-1 V1.1.2: Transmission and Multiplexing (TM); Generic requirements for synchronisation networks; Part 5: Timing characteristics of slave clocks suitable for operation in Synchronous Digital Hierarchy (SDH) equipment

ITU

- ITU-T G.813: Timing characteristics of synchronous digital hierarchy (SDH) equipment slave clocks (SEC)

2.3 Abbreviations

ADM	Add-drop multiplexed
ALS	Automatic Laser Shutdown
BIP	Bit Interleaved Parity
CAS	Channel Associated Signalling
CAP	Carrier-less Amplitude and Phase
CRC	Cyclic Redundancy Check
DTMF	Dual Tone Multi-Frequency
EN	European Norm
EOW	Engineering Order Wire
ETS	European Telecommunications Standards
GPS	Global
HDSL	High Density Subscriber Line
IEC	International Electrical Commission
ITU	International Telecommunication Union
IP	Internet Protocol

ISDN	Integrated Services Digital Network
MCMI	Multi Coded Mark Inversion
MS	Multiplex Section
NE	Network Element
NMS	Network Management System
LAN	Local Area Network
OS	Optical Section
OSPF	Open Shortest Path First
PDH	Plesiochronuous Digital Hierarchy
PPP	Point-to-Point Protocol
RS	Regenerator Section
SDH	Synchronuous Digital Hierarchy
SNMP	Simple Network Management Protocol
SOH	Section Overhead
STM	Synchronous Transport Module
TCP	Transmission Control Protocol
TTI	Trail Trace Identifier
VC	Virtual Container
VF	Voice Frequency

2.4 General requirements

The digital multiplex equipment shall be universal, software-controlled, and provide various interface cards to connect tributary interfaces signals such as voice, teleprotection and data to aggregate interfaces. On aggregate level 2 Mbit/s and 8 Mbit/s electrical interfaces complying with ITU-T recommendations G.703 / G.704 and 2 Mbit/s HDSL interfaces shall be available. In addition, optical STM-4 aggregate interfaces on 622 Mbit/s shall be available. All modules shall form an integrated part of a shelf.

The multiplexer shall provide means to drop and insert individual 64 kbit/s signals and allocate them to determined time slots in the 2 Mbit/s streams. Path protection on 64 kbit/s and 2 Mbit/s shall be supported.

It shall be suitable for operation in substation with harsh environment with high electromagnetic interference, be highly reliable and provide secure communication for real time signals such as voice, SCADA, teleprotection and status/control signals.

The equipment offered shall already be working successfully in telecommunication networks operated by power utilities. It shall comply to the latest ITU-T standards and be able to be interconnected with telecommunication equipment.

Any equipment in the network shall be manageable from a control centre and there shall be means to supervise external/existing equipment as well.

As a minimum modules for the following user signals shall be available as plug-in units for the digital multiplexer:

- Analogue subscriber interface: subscriber and exchange side
- 4-wire E&M voice interface
- G.703, 64 kbit/s data Interface
- X.24/V.11 (RS-422), Nx 64 kbit/s data interface
- V.24/V.28 (RS-232), data interface
- V.35, Nx 64 kbit/s data interface
- Data interface V.36 (RS-449), Nx 64 kbit/s data interface (V.10)
- Alarm collection interface
- Teleprotection command interface
- Binary signal (status and control) interface
- 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704.

Additionally, the equipment shall provide the following aggregate interfaces:

- STM-4 (622 Mbit/s) optical 1+1 interface for medium and long distances, with automatic laser shut down.
- STM-4 (622 Mbit/s) optical add-drop interface for medium and long distances, with automatic laser shut down
- STM-4 (622 Mbit/s) electrical interface
- 2 Mbit/s HDSL interface

The equipment shall be equipped with a ringing generator for analogue subscriber interfaces.

2.5 General Conditions

The same equipment shall be used as a terminal, for through connections (transit, repeater) and as add-drop multiplexer (ADM) with integrated optical line modules.

First order multiplexing (2048 Mbit/s), second order multiplexing STM-1 (155Mbps) and STM-4 (622 Mbps) multiplexer shall be integrated.

Conference for voice channels and point-multipoint function for data signals shall be possible.

The equipment shall be of fully modular design, based on a single shelf.

2.5.1 Channel capacity: Digital Cross Connection

The equipment shall be equipped with a redundant cross connection function with decentralised cross connection functions on each board.

The cross connect capacity shall be minimum 40x2 Mbit/s, or 200x64 kbit/s non-blocking.

2.5.2 Redundant centralised functions

The equipment shall be equipped with redundant circuits for all centralised functions.

2.5.3 Power Supply

The multiplex equipment shall operate at 48 VDC +/- 15%. Redundant power-supply shall be supported.

2.5.4 ITU Compliance

The Equipment shall comply to the latest ITU-T recommendations for the plesiochronuous and synchronous hierarchies, such as:

G.702-704, G.706, G.711-714, G.732, G.735-737, G.742, G.826, G.823, Q.552

2.5.5 Electromagnetic compatibility and safety regulations

The equipment shall comply with the EN50022, EN50082, IEC 801-2, IEC 801-6 and shall be conformant with CE.

2.5.6 Ambient Conditions

Storage and transport: -40 ... +70°C; 98% (no condensation)

Operation: -5 ... +45 °C, humidity of max. 95% (no condensation)

2.5.7 Mechanical construction

The equipment shall be of robust design. All tributary and aggregate units shall be integrated in the same shelf.

All connectors shall be accessible from the front.

2.5.8 Network management system

The equipment shall be software programmable, either by a local craft terminal - preferably notebook - or a centralised Network Management System (NMS).

Traffic through the multiplexer shall under no circumstances depend on Network Management System; i.e. the multiplexer has to operate without being connected to any management system.

The Network Management System shall be used to supervise the PDH and SDH network.

2.5.9 1+1 Path protection

The equipment shall provide means to protect 64 kBit/s channels. The protection shall be end to end from one interface (telephone or data) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm.

The switching shall be done within the multiplexer without using the Network Management System.

2.5.10 1+1 Section protection

The equipment shall provide means to protect 8 Mbit/s and 155 Mbit/s connections. It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed.

The switching shall be done within the multiplexer without using the Network Management System.

2.5.11 Network Topology

It shall be possible to build point to point - , linear-, ring-, T, and meshed networks.

2.5.12 Synchronisation

The equipment shall be synchronisable with an external clock, with connected 2048 Mbit/s signals and/ or with internal oscillator. The synchronisation shall be configurable and it shall be possible to distribute the synchronisation to other equipment as well.

The system shall have means to switch to select the synchronisation source as well as means to prevent the system from switching synchronisation loops. The equipment shall be capable select the synchronisation source by means of the SSM (Synchronisation Status Messaging) feature according to ITU-T G.704 or priority based.

2.5.13 Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS.

Each node shall be capable to collect up to 50 external alarms.

2.5.14 Test Loops

The equipment shall provide means to loop signals on 64 kBit/s level as well as on 2 Mbit/s level. It shall indicate an alarm if a loop is activated. It shall have the possibility to determine the time after which an activated loop is switched back.

2.5.15 Maintenance facilities

Every Network Element shall have a built-in Signal Generator and Analyser to analyse communication paths. It must be possible to cross connect the Generator and Analyser to transmission channels and terminate the signal in other Network Elements. The configuration must be possible locally with the craft access terminal and remotely with the NMS or the craft access terminal.

It must be possible to loop-back signals locally and remotely using the craft access terminal or the NMS.

2.6 Requirements for Transport Level

2.6.1 SDH Aggregate Units

The interface shall be designed for use on single mode fibre at 1310nm and 1550nm. The optical connectors shall be LC/PC.

The following main functions shall be supported:

- Termination of the OS-, RS-, MS- and VC-4 layer

- Extraction and insertion of the SOH communications information

- Through connections of VC-12 and VC-3

The following maintenance functions shall be supported:

- Status indications

- Loops

- Restart after ALS

- TTI monitoring

- BIP Error Insertion

The following SDH interfaces shall be available:

STM-1/4 (155/622 Mbit/s) optical 4-port interfaces
STM-1/4 (155/622 Mbit/s) electrical 2-port interfaces
STM-1 (155 Mbit/s) optical 2-port interfaces
STM-1 (155 Mbit/s) electrical 2-port interfaces

This interface shall provide Multiples Section Protection (MSP) and Sub-Network Connection Protocol (SNCP) both :

1+1 Section Protection

STM-1/4 (155/622 Mbit/s) electrical/optical 2-port interface

2.6.2 HDSL Aggregate Units

2 Mbit/s HDSL interface

The HDSL interface shall provide means to interconnect the multiplexer over two pairs of copper wire up to 12 km using CAP modulation (Carrier-less Amplitude and Phase). It shall communicate either with another interface of the same type or with a remote desktop terminal.

2 Mbit/s HDSL Desktop Terminal

This Terminal shall provide a HDSL interface to transmit 2 Mbit/s over two pairs of copper over a distance up to 12 km. It shall be housed in a metallic indoor case. The following interfaces shall be available:

- G.703, 2 Mbit/s, 75 ohm
- G.703, 2Mbit/s, 120 ohm
- X.21/V11, Nx 64 kBit/s (N = 1 .. 32)
- V.35, Nx 64 kBit/s (N = 1 .. 32)
- V.36 / RS449, Nx64 kBit/s (N = 1 .. 32)

LAN connection:

10/100 BaseT Ethernet connection for e.g. router supporting LAN protocols: IP, IPX; Routing Protocols: RIP, DHCP, OSPF; WAN protocols: HDLC, PPP, Frame Relay (including RFC 1490). It shall inter-operate with Cisco, Wellfleet, 3Com etc. and be manageable locally, remotely, and with Telnet and SNMP. Two such Desktop Terminals shall be connectable to provide a 2 Mbit/s link over two pairs of copper.

HDSL Repeater:

An HDSL repeater solution for distances longer than 12 km shall be offered including a remote powering solution.

HDSL Line Protection:

The HDSL equipment shall (where necessary) be protected against influences of induced voltages up to 10 kV.

2.7 Tributary Units

2.7.1 4-Wire Interface (VF interface)

This interface shall provide 8 voice channels with a bandwidth of 300 Hz .. 3.4 kHz and 2 signalling channels (M => E, M' => E') per voice channel.

Each interface shall be configurable to operate with or without CAS. With CAS it shall use the a and b bits for the two signalling channels.

The level shall be software adjustable within the following range:

Input: +7.5 .. -16 dBr

Output: +7.0 .. -16 dBr

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.2 Analogue Subscriber Interface

An interface with at least 10 subscribers as well as high-density analogue subscriber card with 60 subscribers shall be available. The ringing generator shall be integrated in the subscriber module interface. The ringer frequency shall be adjustable for 20 Hz, 25 Hz, and 50 Hz.

The following main functions shall be supported:

Downstream signalling:

 Ringing

 Metering

 Polarity reversal

 Reduced battery

 No battery

Upstream signalling:

 On/off-hook

 Pulse and DTMF dialling

 Flash impulse

 Earth key

General:

Constant current line feeding

Line test

Permanent line checks

CLIP (On-hook VF transmission)

Metering after on-hook

2.7.3 Exchange Interface

This interface shall provide 12 interfaces to connect remotely connected analogue subscribers to an exchange. It shall provide the following functions:

pulse dialling

tone dialling (DTMF)

earth key function

metering function(12 kHz or 16 kHz)

flash impulse

polarity reversal

indication of busy lines

The following parameters shall be configurable by software:

input voice level $-5 \dots +4$ dBr

output voice level $-7.5 \dots -1$ dBr

metering pulse enable/disable

signalling bit definition

loop back of voice to the telephone

2.7.4 Partyline Telephone System (Engineering Order Wire)

An engineering order wire (EOW) facility shall be provided at each multiplexer. The EOW shall be configured as a party line and use inband DTMF signalling to call another EOW-Terminal. The Terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (1..4 digits), and two group call numbers (1..4 digits each).

2.7.5 V. 24/V.28 RS232 Interface

It shall support the following bit rates:

0 .. 0.3 kbit/s transp. (V.110)

0.6 .. 38.4kbit/s synchronous / asynchronous (V.110).

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.6 V.11/X.24 Interface

This interface shall comply to the ITU-T X.24 recommendation for signal definition and to V.11 for electrical characteristics.

It shall support the following bit rates:

48, 56, Nx 64 kbit/s (N = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous (X.30)

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.7 V.35 Interface

This interface shall comply with the ITU-T V.35 and V.110 recommendations.

It shall support the following bitrates:

48, 56, Nx 64kbit/s (Nx = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.8 V.36 / RS 449 Interface

This interface shall comply with the ITU-T V.36 and V.110 recommendations.

It shall support the following bit rates:

48, 56, Nx 64kbit/s (N = 1 .. 30) synchronous

0.6 .. 38.4kbit/s synchronous / asynchronous

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.9 64 kBit/s Codirectional Interface

This interface shall comply with the ITU-T G.703 part 1.2.1 for codirectional data transfer.

A module shall have at least 8 interfaces.

Modules where each interface can be individually configured with 1+1 path protection shall be available.

2.7.10 LAN Interface

There shall be a 10/100 BaseT interface available with Router Bridge and FRAD Function available. The following specification shall be covered:

Ethernet connection:	10/100 BaseT
LAN protocols:	IP, IPX
Routing Protocols:	Static IP route, OSPF2 V2, DHCP
WAN protocols:	PPP, Frame Relay (including RFC 1490)

The interface shall be manageable locally, remotely, with the management system of the platform.

The LAN interface shall support linear-, ring- and star- configurations.

The WAN side shall support link capacities Nx64 kBit/s and 2 Mbit/s.

2.7.11 Alarm Interface

This interface shall provide means to collect various alarms, which will be displayed, on the Network Management System. It shall be used to manage non-PDH equipment with the PDH Network Management System.

It shall have at least 24 binary inputs and at least 4 outputs, which can be switched by the Network Management System.

It shall be possible to connect an input to an output so that if an alarm occurs, the output contact will be switched.

It shall be possible to label an alarm. The label-text shall be read from the interface module so that it can be indicated on the Network Management System as well as on the local craft terminal.

2.7.12 Teleprotection Interface

The protection of the lines shall be arranged as detailed in Section 5. Teleprotection equipment shall be provided for permissive tripping and direct tripping on the lines.

The permissive tripping signals are required to operate circuit breaker trip relays in conjunction with the distance protection and directional earth fault relays.

The direct tripping signals are required to operate remote circuit breaker tripping relays.

Technical Requirements:

This interface shall provide means to transmit four bi-directional command channels.

The signals shall be adjustable from 24 to 250 VDC by means of software.

All inputs and outputs shall be isolated and with EMC immunity for harsh environment.

Security, Dependability and Transmission speed shall be selectable and programmable.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between commands.

The interface shall support T-nodes.

The Teleprotection interface shall provide an integrated non volatile event-recorder which shall be synchronisable either internally or by GPS or a command counter which counts trip commands.

The teleprotection interface shall provide means for signal delay measurement.

1+1 protection must be available; the switching shall be done within less than 10ms.

The interface shall do automatic loop test every 60s.

Under no circumstances shall the interface cause trip-commands in case of power supply failure or when put in or out of service.

It shall be possible to synchronise all teleprotection interfaces with one GPS in one station. The GPS time shall be distributed over the teleprotection channel.

An 8-bit command addressing shall be used to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.

2.7.13 Optical Protection Relays Interface

This interface shall have an optical port to connect protection relays for teleprotection to the multiplexer. It shall operate on 1300 nm use MCMI line coding and be suitable for teleprotection relays.

2.7.14 Optical amplifier

In case of long distance communication, which can not be covered by standard a optical interface, optical amplifier shall be applied.

The amplifier shall

- provide a power budget of at least 48 dB
- for bit rates from 8 Mbit/s up to 622 Mbit/s
- on a pair of single-mode fibre
- for single wavelength (single channel)
- have no dispersion limits for STM-4 applications up to 250 km.

2.7.15 Binary Contact Interface

This interface shall provide means to transmit binary signals.

The inputs and outputs shall be isolated.

The inputs shall be suitable for 24VDC .. 60VDC.

Outputs shall be solid state relays.

The interface shall provide a 24VDC short circuit proofed auxiliary power supply.

It shall be able to drop and insert commands, transfer commands as a transit station, it shall be possible to have AND- and OR-connections between

commands,.

The Teleprotection interface shall provide an integrated event recorder, which shall be synchronisable either internally or by GPS.

2.7.16 2 Mbit/s G.703 / G.704 Interface

This interface shall comply with the ITU-T G.703 and G.704 recommendations.

The interface module shall have at least four interfaces to be activated individually. It shall be possible to have 128 interface modules a multiplexer.

In order to connect different equipment, the interfaces shall be available with the impedance of 120 ohms and 75 ohms.

The interface shall support CRC-4 multi-frame according to ITU-T G.704 (enabled and disabled by software).

The CAS signalling according to ITU-T G.704 table 9 shall be activated optionally.

The interface shall be able to extract the 2.048 MHz clock, which can be used to synchronise the multiplex equipment.

The interface module shall support 2 Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals.

2.8 OPERATIONAL & ADMINISTRATIVE TELEPHONE SYSTEM

2.8.1 Operational Subscriber

The PTNX (CISCO-Call Manager) of operational Telephony systems are located in Main NLDC, Rampura and Back-upNLDC . So contractor shall configure those PTNXs for the new Sub-stations and create a telecom path for operational telephony system from PTNXs to new sub-stations. This system will have interoperable with Administrative Telephony system.

2.8.2 Administrative Subscriber

Facility for minimum 10X2W of remote subscriber shall be provide and installed at the substation and the remote sbscribers shall be connect with the neasrest exisitng exchange of the exisitng telephone network. Necessary cards required at nearest exchange and its asscociated muliplexter shall be included in the contract price. This system will have no connection to the PSTN

2.8.3 Integration with Exsiting System

The trunk numbering plan shall be compatible with the present scheme in service in Bangladesh.

The telephone signalling (dialling) system shall be compatible with the present system.

An alarm system shall be provided to indicate traffic failure including blown fuses, loss of power supplies etc. In addition, contacts shall be provided to facilitate extension of the alarms to the telecontrol equipment.

Appendix 2.A.1

SCHEDULE OF REQUIREMENTS FOR MULTIPLEXER

SL.No.	DESCRIPTION	UNIT	REQUIRED
1.0	GENERAL:		

1.1	Type of multiplexer		SDH: ADM
1.2	Complying to ITU-T rec.		Yes
1.3	Transmission Capacity	Mbit/s	STM-4: 622
1.4	Access capacity on 64 kbit/s	channels	Minimum 200
1.5	Access capacity on 2 Mbit/s	channels	Minimum 40
1.6	Redundant central processor		Shall be available
1.7	Digital cross connect function		Fully non-blocking
2.0	Available AGGREGATES:		
2.1	Optical aggregates (ITU-T G.957)		L-4.1, L-4.2
3.0	Available TRUNK INTERFACES:		
3.1	HDB3, 2 Mbit/s interfaces per module	No.	Minimum 8
3.2	Complying to ITU-T rec.		G.703, transparent G.704, selectable
3.3	HDSL, 2Mbit/s interface: no of copper wires Capacity of Ca	No. ch ch / pair of wire	4 or 2 30 or 15 30 / 2 pairs 30 / 1 pair 15 / 1 pair
4.0	Available USER INTERFACES		
4.1	Voice interfaces for trunk lines:		

4.1.1	1 + 1 com path protection, available for all		yes
4.1.2	Analogue, 4wire with E&M: Input level Output level	dBr	+7.5 .. -16 +7.0 .. -16.5
4.1.3	Analogue, 2wire with E&M: Input level Output level	dBr	+6.5 .. -12.5 -1.0 .. -20
4.1.4	Digital, 2Mbit/s CAS or PRI		yes

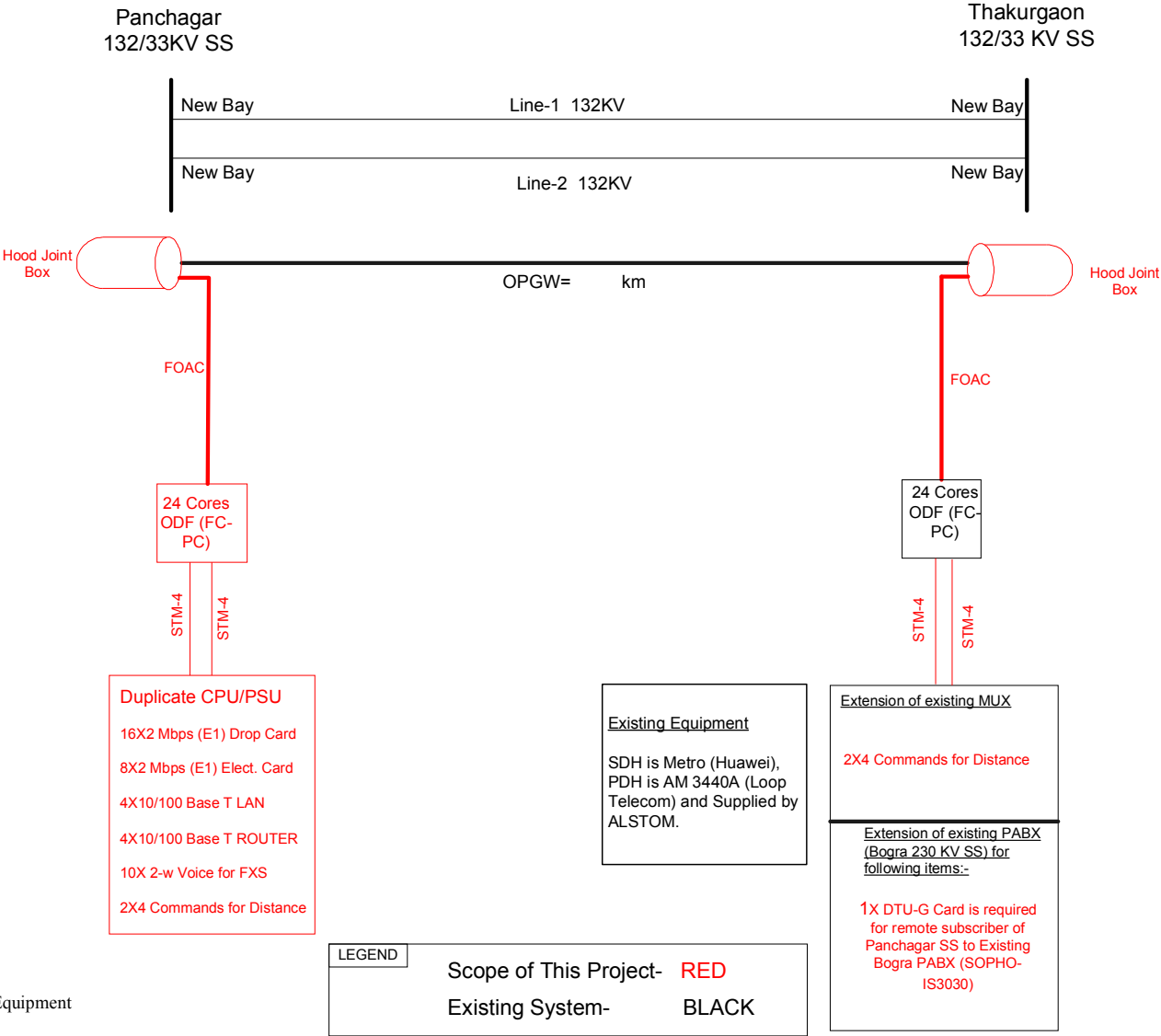
4.2	Voice interfaces for remote subscriber:		
4.2.1	2wire, subscriber side	dBr	-5 .. +4 / -7.5 .. -1
4.2.2	2wire, PABX side	dBr	-5 .. +4 / -7.5 .. -3
4.3	Integrated teleprotection		
4.3.1	Interface for Commands:		
4.3.1.1	Number of independent commands	No.	4
4.3.1.2	Transmission time max.	ms	6
4.3.1.3	Signal voltage	V _{peak}	250
4.3.1.4	1 + 1 com path protection		yes
4.3.2	Interface(s) for Differential Protection:		
4.3.2.1	Electrical interface: G.703	kbit/s	64
4.3.2.2	Optical Interface	kbit/s	Minimum 64
4.4	Data: channels per module		
4.4.1	1 + 1 com path protection, available for all		yes
4.4.2	V.24/V.28 (RS-232): up to 38.4kbit/s	No.	4
4.4.3	V.11/X.24 (RS-422): 64kbit/s	No.	4
4.4.4	V.35: 64kbit/s	No.	4

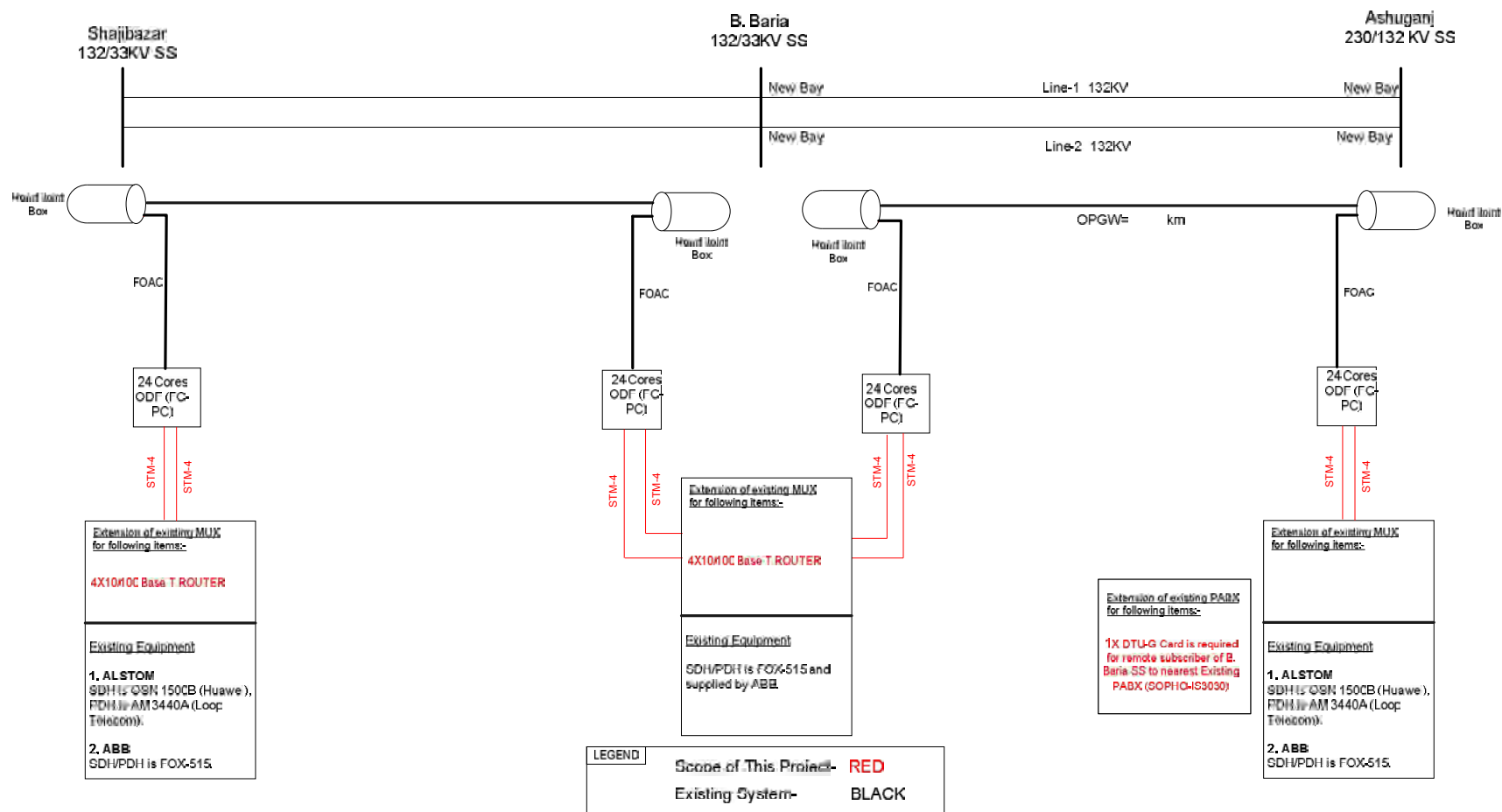
4.4.5	V.36 (RS-449): 64kbit/s	No.	2
4.4.6	G.703: 64kbit/s	No.	8
4.4.7	Ethernet: 10/100 BaseT WAN capacity Protocols	No. Mbit/s	Min: 2 Min: 2x 2Mbit/s Min.: IP
4.5	Integrated alarm gathering module:		

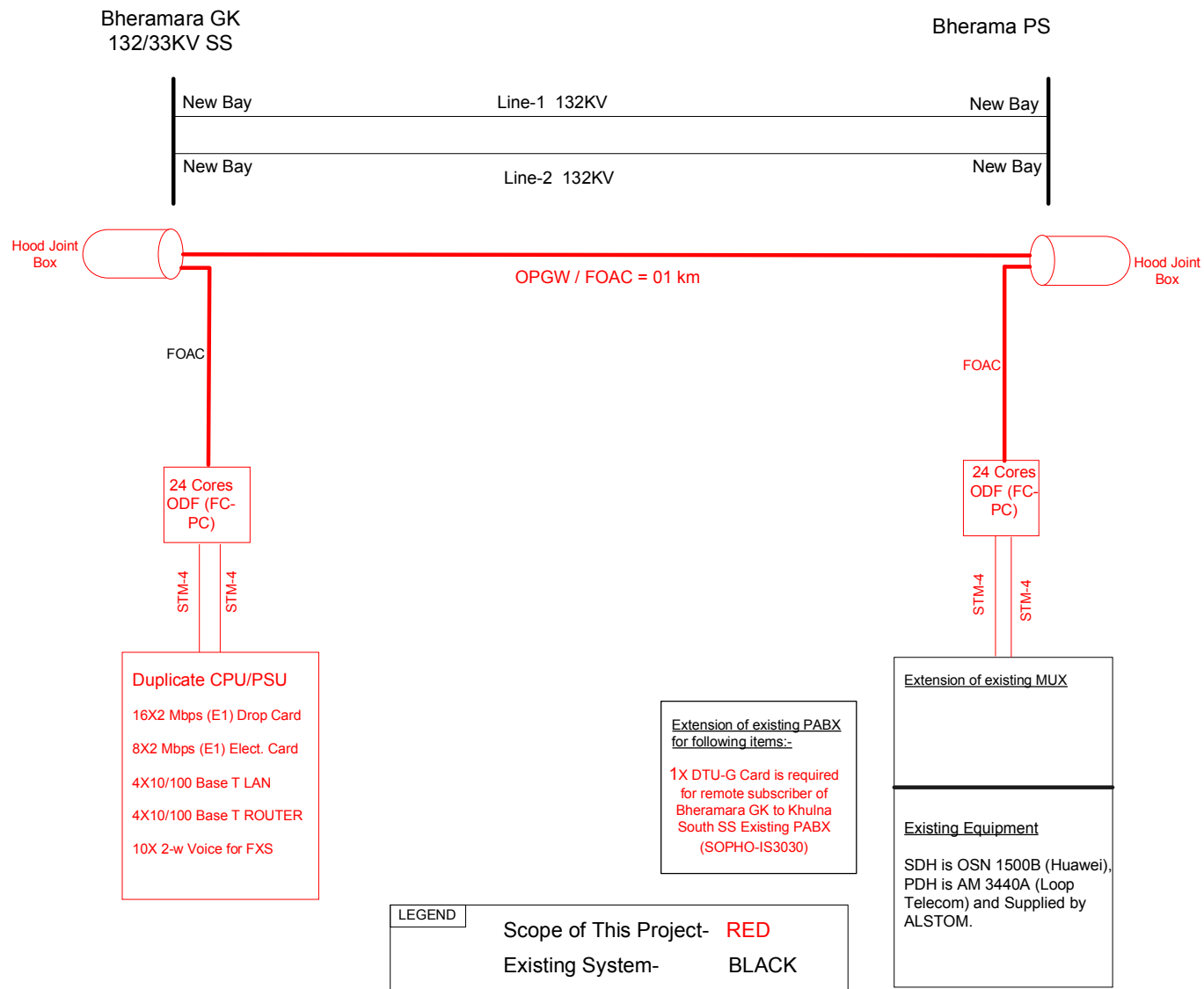
4.5.1	Number of external alarms per module	No.	Min. 20
4.5.2	Auxiliary power supply for ext. contacts		Yes
4.6	Network Management System		
4.6.1	Type/Name of configuration tool		
4.6.2	For fault / configuration management		Yes / yes
4.6.3	For local / remote operation		Yes / yes
4.6.4	Data communication network (DCN)		Ethernet / IP or Ethernet / OSI
4.7	Ambient Conditions:		
4.7.1	Storage: ETS 300 019-1-1, class 1.2	°C / % hum	-25 .. + 55 / class 1.2
4.7.2	Transport: ETS 300 019-1-2, class 2.2	°C / % hum	-25 .. + 70 / class 2.2
4.7.3	Operation: ETS 300 019-1-3, class 3.1E	°C / % hum	-5 .. +45 / class 3.1E
4.8	Power Supply		
4.8.1	Operation	VDC	48 / 60 (-15/+20%)
4.8.2	Fully redundant power supply		yes

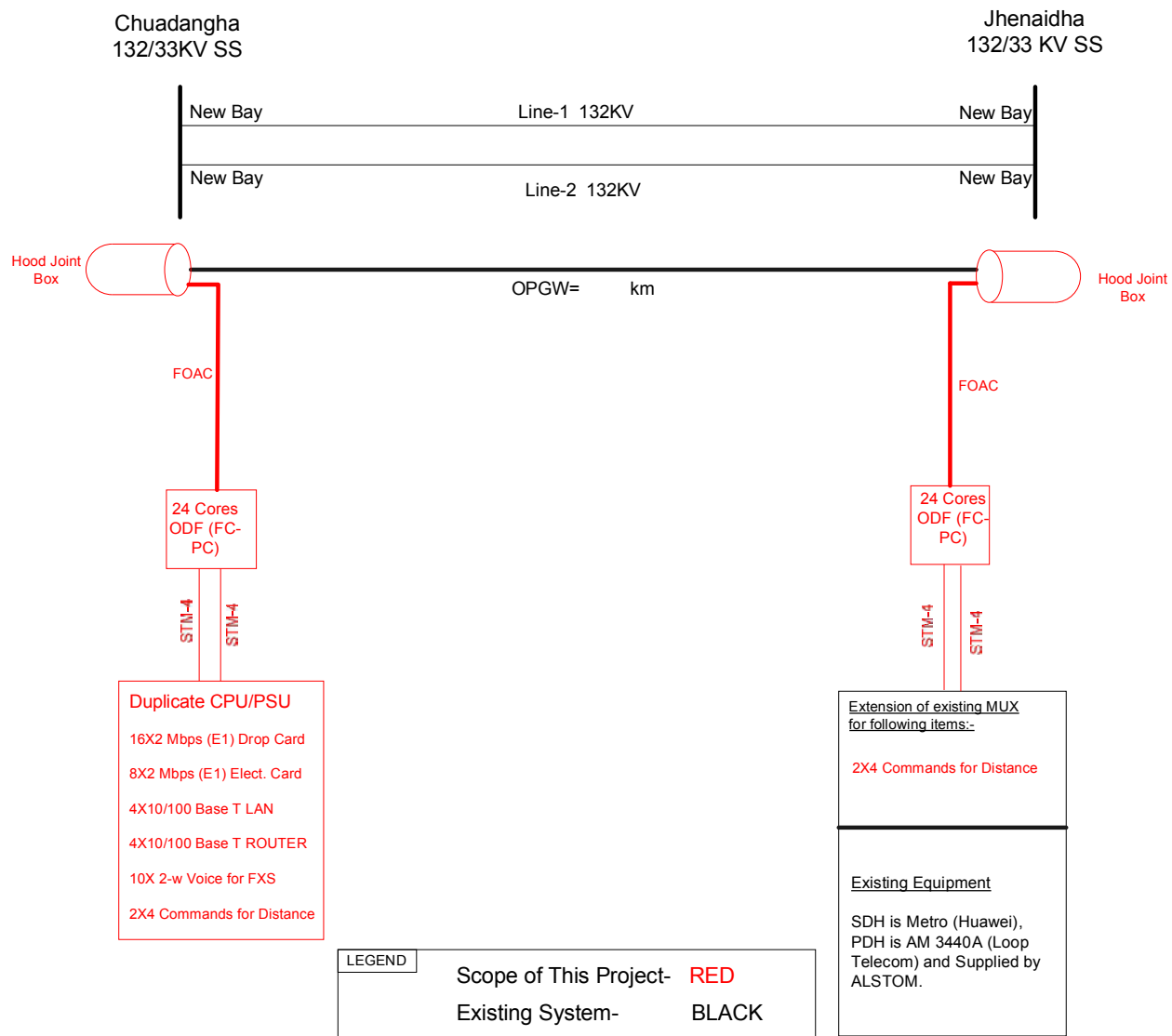
Appendix 2.A.2

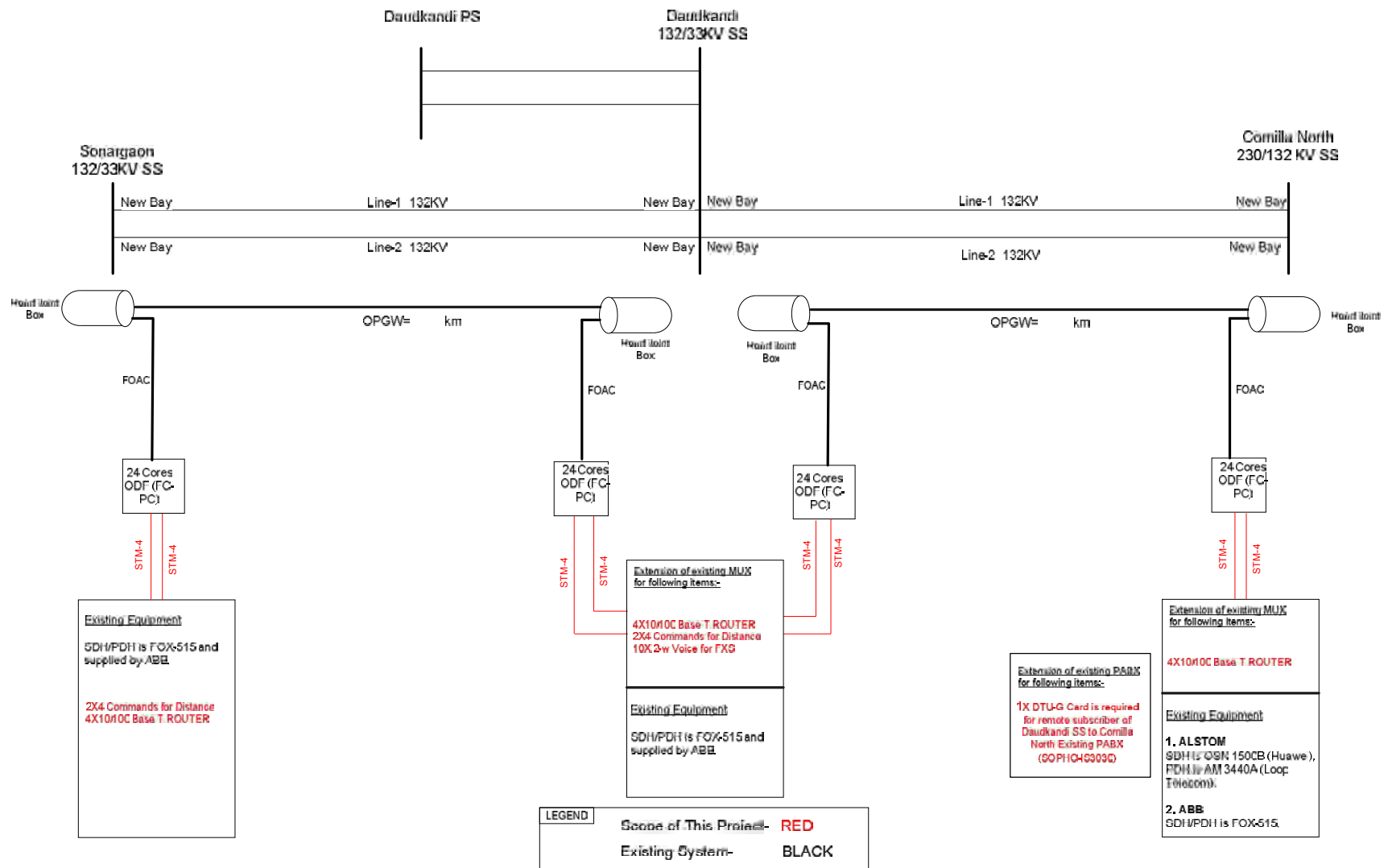
COMMUNICATION NETWORK WITH SERVICES TO BE TRANSMITTED

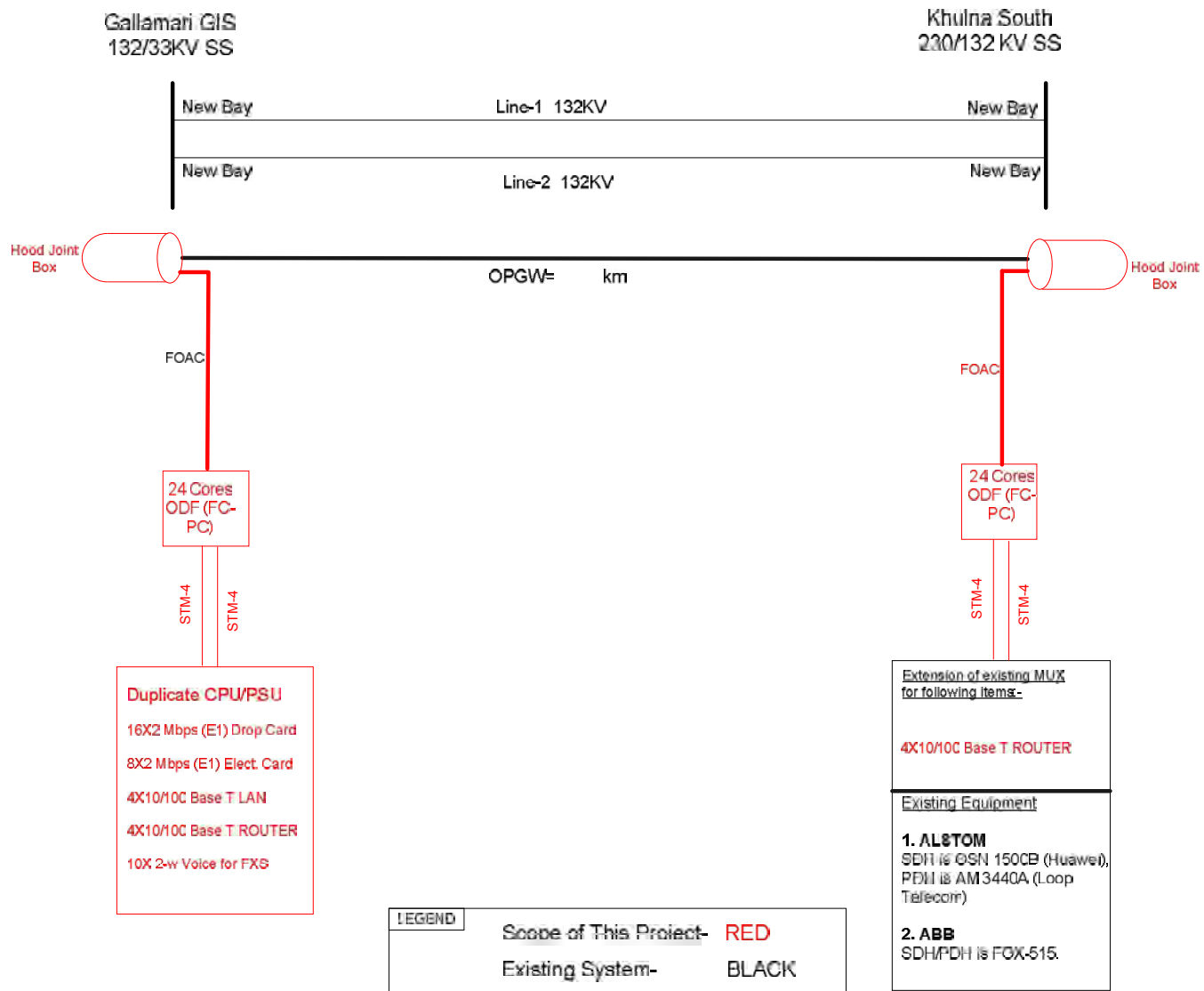


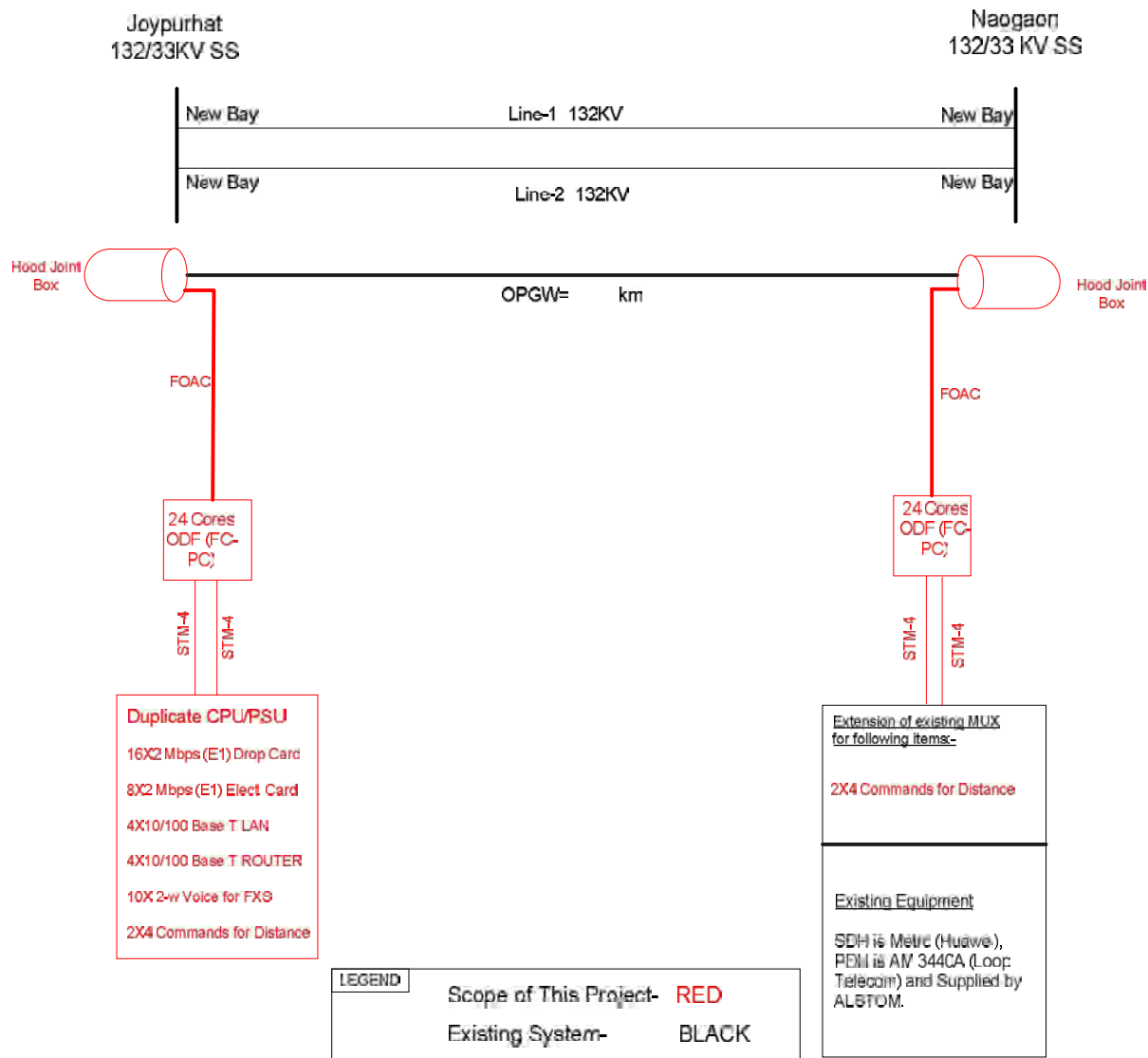


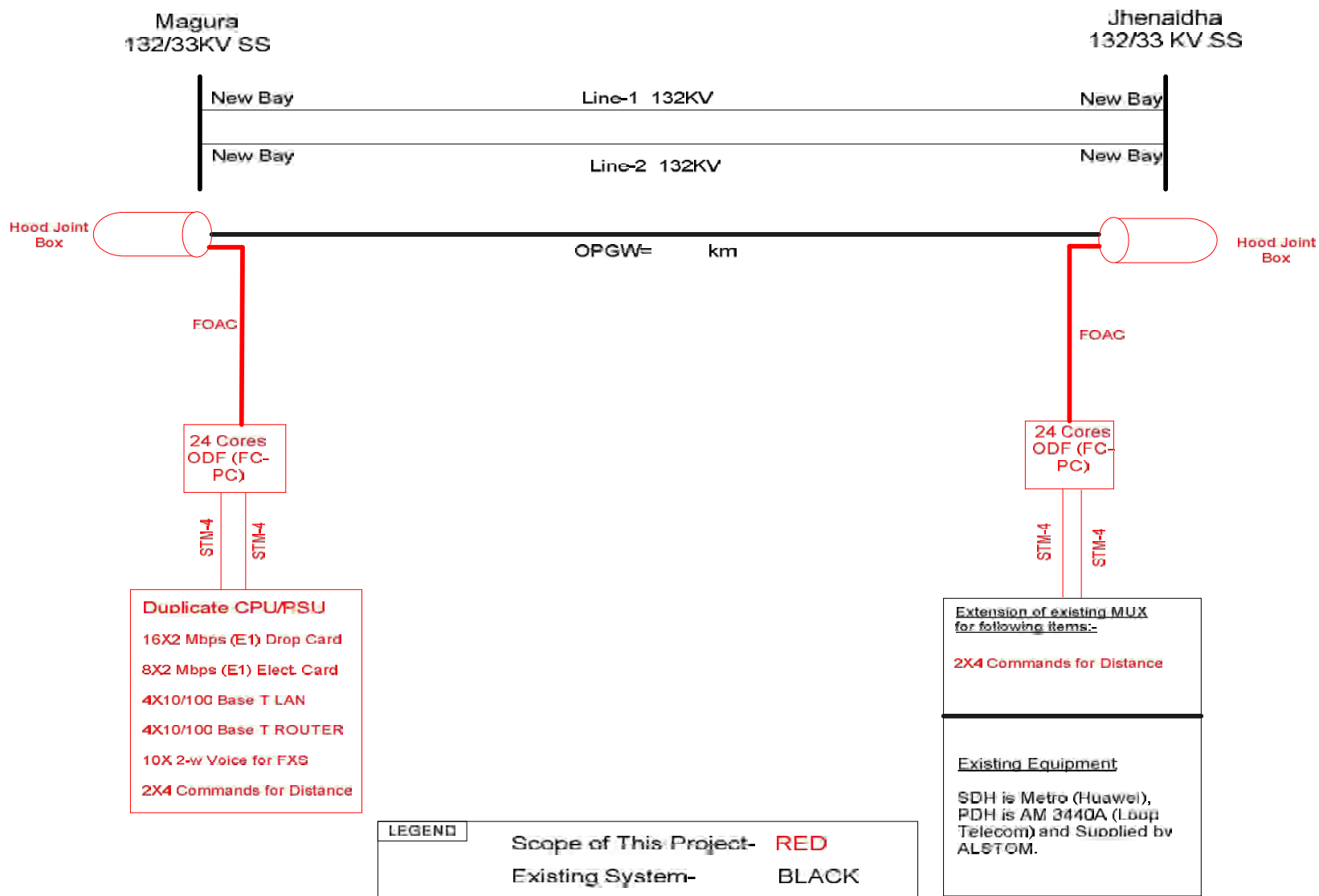


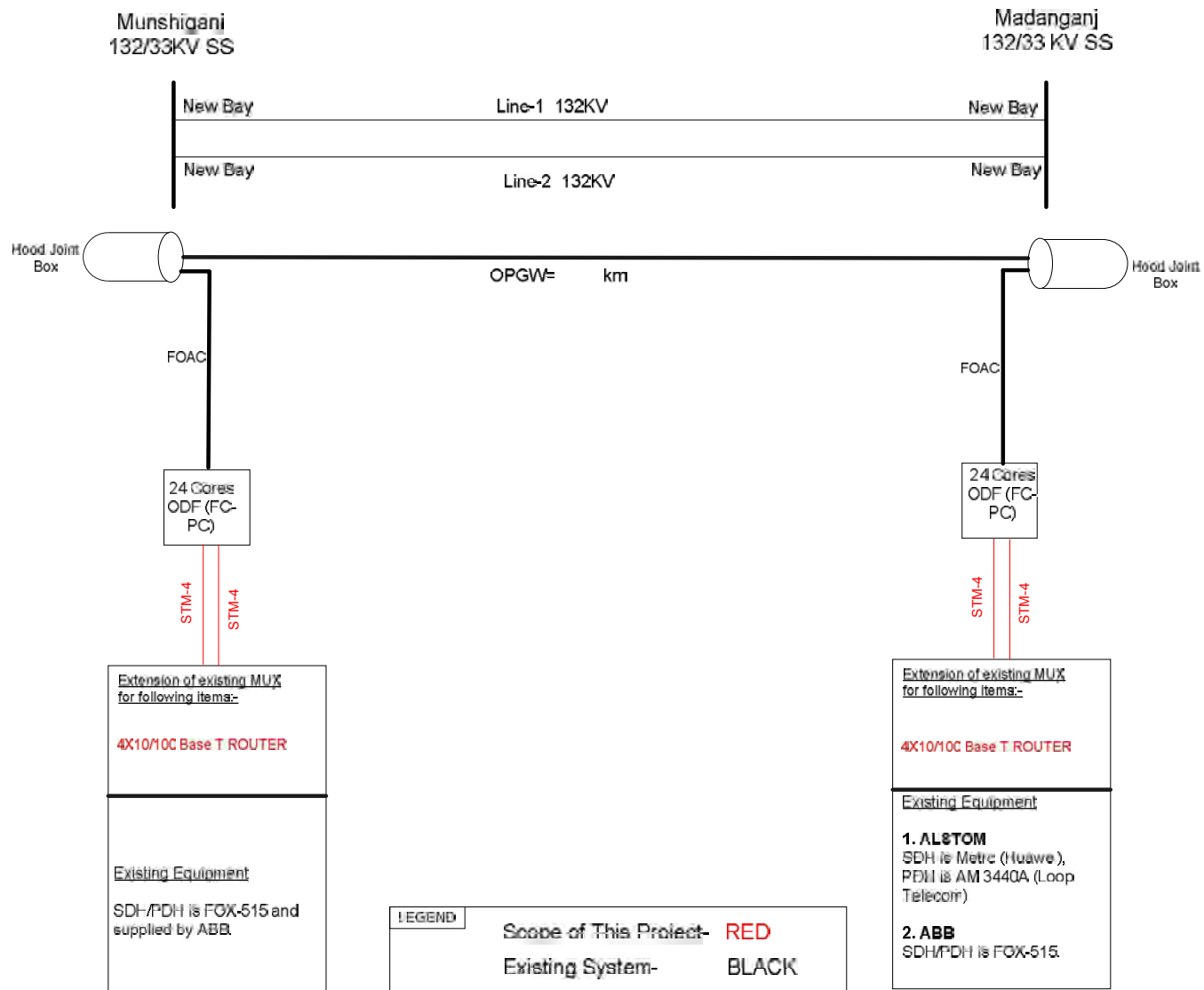


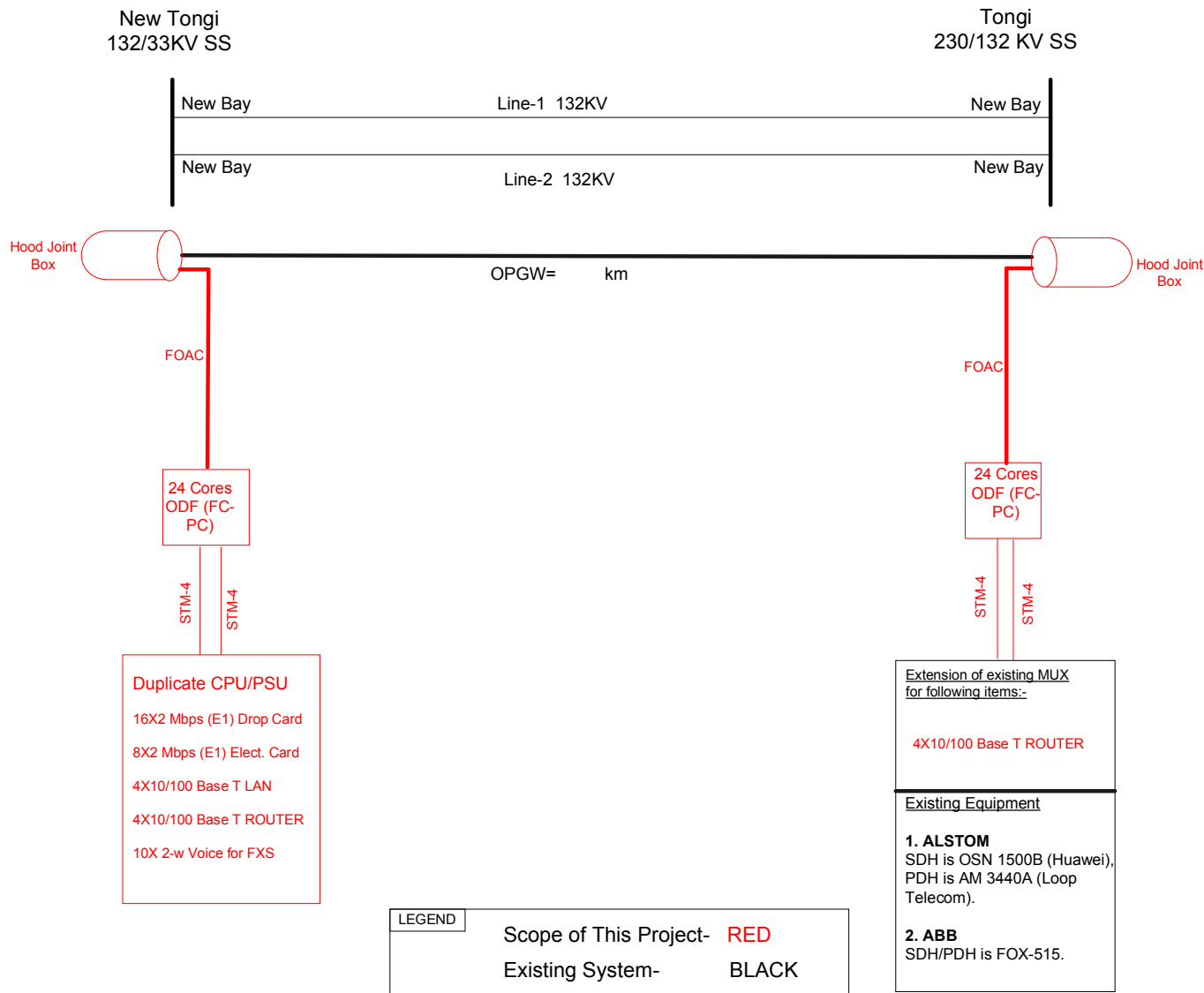


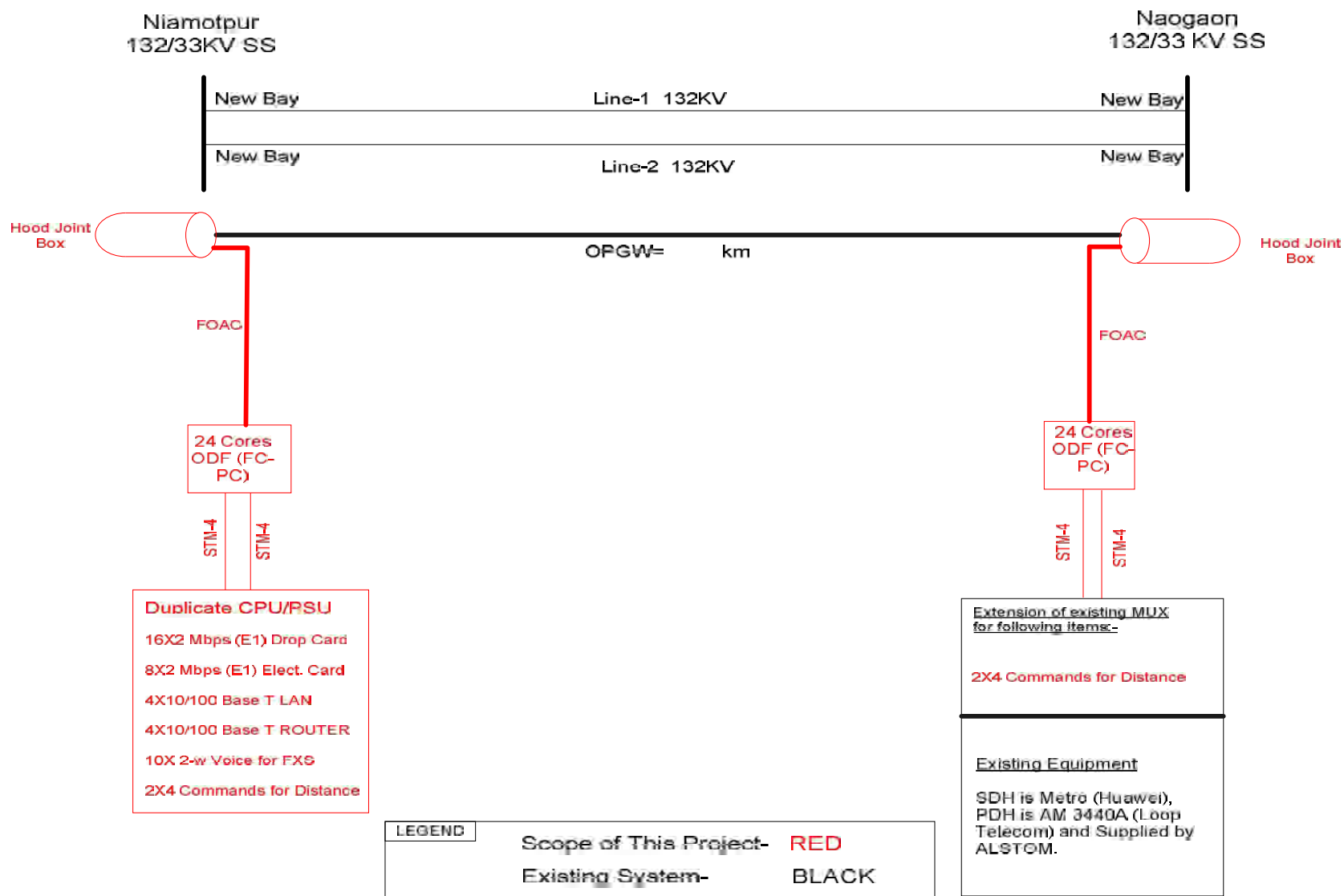


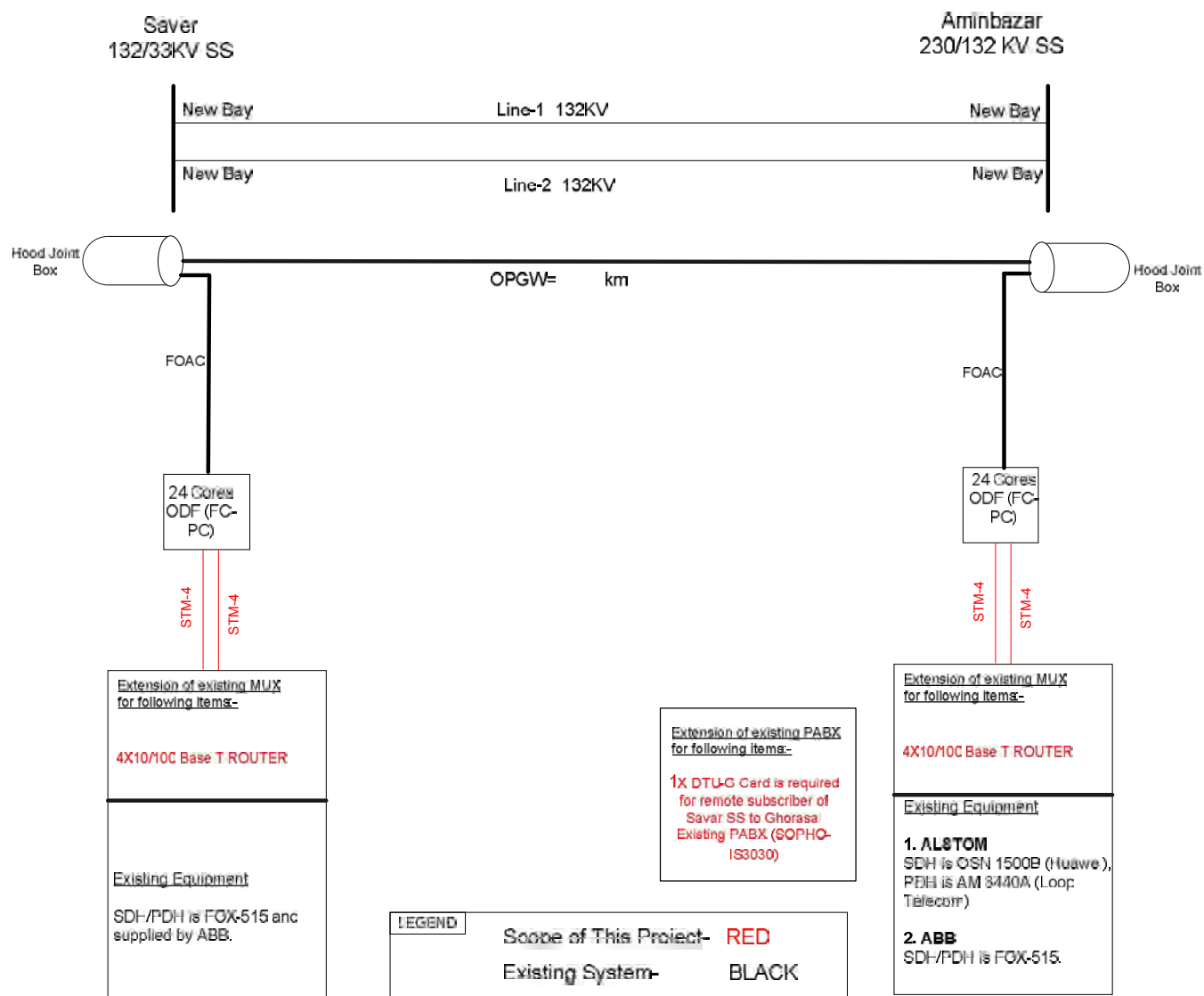


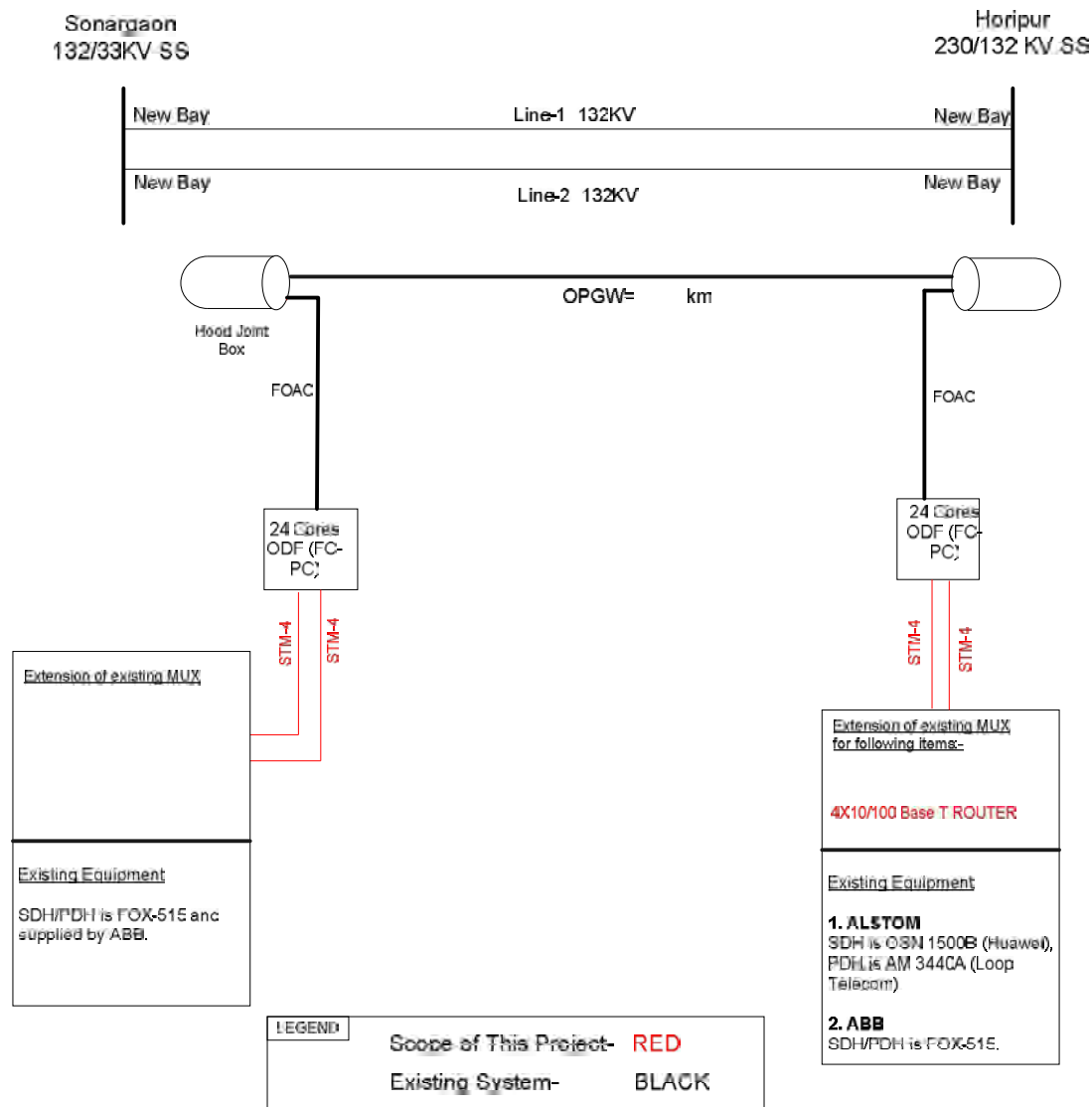












POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning and
Integration with NLDC of 13 nos of 132 KV new Grid Sub-
Stations on Turnkey Basis.**

(Contract No.)

SECTION 3

RTU & SCADA INTEGRATION

SECTION 3

RTU & SCADA INTEGRATION

TABLE OF CLAUSES

3.	HARDWARE	
REQUIREMENTS.....		3-1
3.1	GENERAL DESIGN REQUIREMENTS	
3-1		
3.1.1	Overview.....	
3-1		
3.1.2	System Design	
	Standards.....	3-1
3.2	MASTER STATION COMPUTER SYSTEM.....	
3-2		
3.2.1	Local Area Network (LAN).....	
		3-2
3.2.2	Operator Station Workstations Overview	
		3-2
3.2.3	Workstation and Server Characteristics	
		3-3
3.2.3.1	SCADA/EMS Workstations.....	
		3-3
3.2.3.2	Servers.....	
		3-3

3.2.3.3	Hardware Details.....	
	3-4	
3.2.3.4	Other Workstations on the WAN.....	
	3-5	
3.2.4	Portable	PCs 3-6
3.2.5	Printers.....	
	.. 3-6	
3.2.6	Communication Interface to RTUs.....	3-7
3.2.7	Operator Stations.....	3-7
3.2.8	Local Input/Output Subsystems.....	3-8
3.2.9	Projection Screen Display	3-8
	3.2.9.1 Size	3-8
	3.2.9.2 Display Modules and Projectors	3-8
	3.2.9.3 Image Controller/Display.....	3-9
	3.2.9.4 Spares and Consumables	
3.3	REMOTE TERMINAL UNIT (RTU)	3-9
3.3.1	General	3-9
3.3.2	Capabilities.....	
	 3-10	
3.3.3	General Arrangement	3-10
3.3.4	Standards	3-11
3.3.5	Functional Requirements	3-11
	3.3.5.1 I/O Isolation	3-11
	3.3.5.2 Interface to Field Devices	3-11
	3.3.5.3 RTU Capacity	3-12
	3.3.5.4 RTU Configuration System	3-12

3.3.5.5	Input/ Output Interface Specification.....	3-12
3.3.5.6	Communications Interface	3-12
3.3.5.7	Analogue Inputs	3-13
3.3.5.8	Digital Inputs	3-13
3.3.5.9	Control Outputs	3-14
3.3.5.10	Analogue Outputs.....	3-15
3.3.5.11	Digital Display Outputs.....	3-15
3.3.5.12	Transformer On Load Tap Changers	3-15
3.3.5.13	Dummy Control and Dummy Analogue	3-16
3.3.6	Disable Switch	3-16
3.3.7	Power Supply.....	3-16
3.3.8	Equipment	Protection 3-16
3.3.9	Environmental Specification.....	3-17
3.4	IT EQUIPMENT.....	3-17
3.4.1	Bridges, Hubs, Switches, Routers...	3-17
3.4.2	Firewalls.....	3-17

SECTION 3

RTU & SCADA INTEGRATION

3. HARDWARE REQUIREMENTS

All equipment to be supplied shall be new and of highest commercial production quality. Major equipment items requiring a significant amount of new design or development shall not be accepted. Similarly, any modules or printed circuit boards supplied as part of the system, as spare parts or as warranty replacements shall not bear any repair modifications or post-production alterations. All engineering and field changes shall be implemented prior to the factory performance tests.

3.1 GENERAL DESIGN REQUIREMENTS

12.2 3.1.1 Overview

The NLDC computer system shall be configured with sufficient resources and computational power to meet the specified performance requirements under the various loading conditions.

The system design shall ensure that no single points of failure exist which may significantly degrade the availability of any of the basic critical SCADA/EMS functions. That is, the failure of any one major system component shall not impair the ability of the system to meet its performance objectives.

The system shall be capable of future growth with minimal disruption to existing hardware and software structures, including the database. Hardware replacement due to age or technological obsolescence shall have no effect on the operating software system.

It is preferred that the computer hardware used is from world recognized vendors such as Hewlett Packard (including Compaq/DEC), Sun, IBM, Dell, Toshiba (for portable PCs) or Fujitsu.

12.3 3.1.2 System Design Standards

Particular emphasis shall be placed on configuring a system with non-proprietary hardware and an open software structure.

Wherever possible, generic industry standards shall be followed. For example, the Master Station components shall be linked on a non-proprietary industry-accepted Local Area Network (LAN) complying with the IEEE 802.3 standard.

Communications standards and protocols shall follow the relevant ITU-T Recommendations (ie Vseries modem standards, etc.).

The Information Technology (IT) components of the system provided shall adhere to modern accepted networking and inter-networking standards including applicable Internet “Requests for Comments” (RFC) documents.

The Bidder shall state what standards that the proposed system meets.

3.2 MASTER STATION COMPUTER SYSTEM

12.4 3.2.1 Local Area Network (LAN)

A modern Master Station shall be provided based on a LAN arrangement both at NLDC and at the Standby Master Station at Biddyut Bhaban.

The required hardware configuration for both SCADA/EMS Master Stations is shown on drawings 11001T and 11002T-1. The Contractor shall provide his own hardware configuration based on proven systems supplied for previous projects, but generally along the lines indicated in the hardware configuration diagrams. The configuration shall provide for secure real time control of the PGCB power network and have high functional availability in a vendor-independent hardware environment.

The NLDC SCADA LAN cable itself shall be duplicated for circuit redundancy. One break anywhere on the cable shall be tolerated with data taking the alternative cable path. If either one of the duplicated LANs fails, then an alarm shall be generated to alert the operator.

To maintain high levels of security on the SCADA LAN, only those devices deemed essential to the SCADA/EMS functions shall be attached. Workstations outside the immediate control centre area shall be bridged via secondary LAN cables and routers.

The operator shall have an active mimic to represent the LAN and attached computer systems.

12.5 3.2.2 Operator Station Workstations Overview

The console workstation comprises the major link between the Operators and the power network. This man-machine interface must:

- (a) Present information in a clear and well organized manner.

- (b) Highlight exceptional data and power network states.
- (c) Attract attention to abnormal conditions through alarm and event warnings.
- (d) Have logical interactive operating procedures with short response times.

The Operator desks at NLDC shall conform to current ergonomic standards. Gas-lift office chairs with arm rests and five-way casters shall be provided for the Operators.

Each operator desk and the supervisor desk shall accommodate a dual monitor (VDU), single computer workstation complete with alphanumeric keyboard and mouse.

With the exception of quantity of monitors, each workstation on the SCADA LAN shall be identical.

In operation, each workstation shall operate independently of the other but shall have access to all SCADA and EMS facilities.

The workstations generally will be utilized for power system control monitoring, and for network security and analysis functions, and Automatic Generation Control / ED as required.

Particular attention shall be focused on the Master/Reserve server switchover sequence. No data shall be lost during the switchover process. The operation shall be transparent to the Operator and should occur within 10 seconds. The Master/Reserve server status shall be indicated to the Operator.

12.6 3.2.3 Workstation and Server Characteristics

12.6.1.1 3.2.3.1 SCADA/EMS Workstations

Workstations on the SCADA LAN and workstations installed in future ACC substations shall be identical and shall include or be equipped with the following minimum features:

- (a) High speed 32-bit or 64-bit central processing units with processor clock speed of at least 1.5GHz, or if a RISC based processor is used, at least 700MHz
- (b) Minimum of 1GB main memory.
- (c) Minimum of 40GB Hard Disk Drive.
- (d) 3.5" Floppy Disk Drive.
- (e) CD Read/Write Drive.

- (f) Two x 10BaseT/100BaseTX Ethernet LAN interfaces.
- (g) Dual input power supply.
- (h) 101 key AT-type keyboard or equivalent, or VT200 type keyboard (i) Optical mouse with at least 2 buttons.
- (j) At least one RS232C serial port.
- (k) At least two USB ports.
- (l) Parallel port.
- (m) High performance graphic card supporting at least two monitors with resolution up to 1600 x 1200 and 16.7 million colors.
- (n) One or two LCD monitors (as specified) supporting up to 1600 x 1200 pixel resolution and 16.7 million colors. Each monitor shall have a viewable area measuring at least 20 inches on the diagonal.
- (o) Audio support and speakers.

12.6.1.2 3.2.3.2 Servers

All servers except the office server shall be identical and shall include or be equipped with the following minimum features:

- (a) High speed 32-bit or 64-bit central processing units with processor clock speed of at least 2.5GHz, or if a RISC based processor is used, at least 1GHz.
- (b) Support for 4 or more processors.
- (c) Minimum of 4GB main memory.
- (d) Minimum of 100GB high speed SCSI connected Hard Disk Drive.
- (e) 3.5" Floppy Disk Drive.
- (f) CD Read/Write Drive.
- (g) DVD Read/Write Drive (DVD-R/RW, DVD+R/RW, DVD+RW) (h) Two x 10BaseT/100BaseTX Ethernet LAN interfaces.
- (i) Dual input power supply.
- (j) 101 key AT-type keyboard or equivalent, or VT200 type keyboard (k) Optical mouse with at least 2 buttons.
- (l) At least one RS232C port.
- (m) Suitable graphics card and colour monitor.
- (n) At least two USB ports.
- (o) PC speaker.

The office server shall include or be equipped with the following minimum features:

- (a) High speed 32-bit central processing units with processor clock speed of at least 1.5GHz.
- (b) Minimum of 2GB main memory.
- (c) Minimum of 100GB high speed SCSI connected Hard Disk Drive.
- (d) 3.5" Floppy Disk Drive.
- (e) CD Read/Write Drive.
- (f) 10BaseT/100BaseTX Ethernet LAN interface.
- (g) 101 key AT-type keyboard or equivalent, or VT200 type keyboard (h) Optical mouse with at least 2 buttons.
- (i) At least one RS232C port.
- (j) Suitable graphics card and colour monitor.
- (k) At least two USB ports.
- (l) PC speaker.

12.6.1.3 3.2.3.3 Hardware Details

Power Supply

The workstations and servers on the NLDC SCADA LAN shall each accept two sources of AC power and shall be unaffected if one source of power fails. SCADA/EMS servers shall have dual hot swappable power supplies.

12.6.1.4 Hard Disk Drive Storage

Hard Disk Drive memory units shall be provided with each workstation and server suitably sized for their designated function. The Contractor shall size the Hard Disk Drive units to support initial requirements plus all specified future expansion requirements plus at least 100% spare capacity. The disks must include sufficient capacity to store all pictures, logs, database, historical archives, application source code etc.

12.6.1.5 VDU Screens

The visual display units (VDUs) shall be high-resolution Liquid Crystal Display (LCD) colour monitors designed for continuous use in an industrial control centre environment.

The VDU monitors connected to SCADA/EMS workstations shall have the following features:

- Active matrix, thin film transistor (TFT) LCD type display
- Screen diagonal length of at least 20 inch
- Resolution of up to 1,600 x 1200 pixels
- Palette of up to 16.7 million colours
- Dot pitch down to 0.255mm
- Brightness 200 cd/m² minimum
- Contrast ratio 250:1 minimum
- Wide viewing angle (at least +/- 80 degrees horizontal and vertical)
- Convenient access to all frequently used adjustments

12.6.1.6 Magnetic Tape Cartridge Units

Three identical industry standard tape backup units shall be provided, either separately connected to the network or installed in servers (two at NLDC and one at Biddyut Bhaban). The tape units shall have the following features:

- Capacity at least 24 Gbytes.
- Interface via high speed bus (e.g. SCSI, FireWire- IEEE1394) or via Ethernet if stand alone.
- Utilizes industry-standard digital audio tape (DAT) cartridges (4mm or 8mm tape)
- High speed data transfer rate of at least 2 Mbytes/second.
- Provided with Windows-based backup and restore software allowing multi-tasking operation for background file backup operation and unattended operation.

The system software shall allow the backup of any workstation or server on the network to the tape unit designated as the network backup facility. The system software shall provide for incremental backup of data.

The Contractor shall supply sixty (60) magnetic tape cartridges for use with these tape units.

12.6.1.7 Audible Alarm Devices

Each SCADA workstation shall have audio output via speakers to indicate that an alarm has arrived. A one-off multi-note chime shall be provided for urgent alarm message annunciation and a different sound for a non-urgent alarm. It shall be possible enable and disable the alarm sounds per terminal and to continuously vary the sound output level from zero to maximum.

12.6.1.8 3.2.3.4 Other Workstations on the WAN

Other workstations on the local LAN and WAN, as specified in Section 3.3 will be used for EMS, planning, protection, generation, communications, metering and management functions.

All other workstations shall be based on high performance desktop PC architecture with MS Windows XP or later operating system. At a minimum these PCs shall have a 1GHz speed processor, 512MB RAM, 20GB Hard Disk Drive, 3.5" Floppy Disk Drive, CD ROM Drive, 10BaseT/100BaseT Ethernet LAN interface, optical mouse, 101 key AT-type keyboard, one RS232C port, two USB ports, parallel printer port, high performance graphic card and 17" monitor with resolution up to 1280 x 1024 and 16.7 million colours, audio support and speakers.

Authorised users outside the main SCADA LAN shall be provided with access SCADA and EMS data that is appropriate to their job function. A router and firewall shall be used to provide a secure logical interface between the SCADA system and the PC network.

All equipment not connected to the main building UPS or situated off-site from the NLDC Building. i.e. PCs, laser printers, bridge/routers and associated network interface equipment shall be installed via a mains power regulator, and shall have a UPS capable of supplying power for 1 (one) hour after mains failure.

12.7 3.2.4 Portable PCs

The portable computers provided shall have the following minimum features:

- (a) Integrated PC, screen, keyboard, speakers and pointing device (i.e. a "Notebook" PC)
- (b) 32-bit processor with clock speed of at least 1GHz
- (c) 512MB main memory.
- (d) 30GB Hard Disk Drive.
- (e) 3.5" Floppy Disk Drive.
- (f) CD ROM Drive.
- (g) 14" TFT LCD color graphics screen with at least 1280 x 1024 pixel resolution.
- (h) 10BaseT Ethernet LAN interface.
- (i) At least one RS232C port.
- (j) At least one USB port.
- (k) Parallel printer port.
- (l) Built in V.90 modem.
- (m) MS Windows XP or later operating system

12.8 3.2.5 Printers

The printers provided on the SCADA LANs shall have the following capabilities:

- (a) Laser Printers (for the logging and report printing functions etc.)
 - Print speed at least 20 pages per minute
 - 3 paper trays including one for A3 paper
 - Input paper capacity minimum 850 sheets
 - 10BaseT/100BaseTX Ethernet interface capable of connecting to dual LAN
 - At least 128MB RAM
 - Hewlett Packard LaserJet 5100 or equivalent.
- (b) Color Laser Printers (for SLD printing, screen dumps etc.)
 - Print speed at least 20 pages per minute
 - 2 paper trays including one for A3 paper
 - Input paper capacity minimum 600 sheets
 - 10BaseT/100BaseTX Ethernet interface capable of connecting to dual LAN
 - At least 256MB RAM
 - Hewlett Packard color LaserJet 5500 or equivalent.

Printer alarms to the system shall be provided for "paper jam" and "out-of-paper".

Other printers provided under this Contract shall have the following capabilities:

- (c) Laser Printers (for the logging and report printing functions etc.)
 - Print speed at least 20 pages per minute
 - 2 paper trays
 - Input paper capacity minimum 350 sheets
 - 10BaseT/100BaseTX Ethernet interface
 - At least 64MB RAM
 - Hewlett Packard LaserJet 2300 or equivalent.

Printers shall utilise standard, plain, 80-gram photocopier paper stock, of A3 or A4 sizes.

12.9 3.2.6 Communication Interface to RTUs

Communications with RTUs that are located on the SDH network shall be via the MS/RTU protocol over TCP/IP, and for RTUs connected on Power Line Carrier shall be via the MS/RTU protocol over serial links. Communications concentrators/interfaces such as terminal servers, located at key substations, shall be used to translate routed messages to serial line messages for transport over PLC channels.

Terminal servers or equivalent shall be provided to interface the Mini-SCADA RTUs with the SDH network at those stations where they are installed.

Terminal servers will also be provided to interface other serial I/O peripheral devices such as the mimic controller at Biddyut Bhaban. Terminal servers shall support the common serial data rates being: 50, 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 baud.

The Bidder shall provide full details of the proposed communication system configuration and interfaces in their Bid.

The communication system interface equipment shall be designed to allow expansion, replacement or repair without disruption to normal services.

The Contractor shall provide modems where required. Modems shall comply with ITU-T Recommendations including V.24 for interchange circuits, V.42 for error correction, V.42bis and MNP5 for data compression and V.90 for signaling rates up to 56,000 bps.

The Contractor shall provide line isolation transformers for each circuit (if required) with impulse withstand capability to IEC Standard 60472 and 60255-4 (with at least 5 kV isolation).

The Contractor shall provide RTU communications test software, or a communications test set for monitoring RTU/Master Station communications. The test set/software shall be capable of emulating the Master Station or an RTU. The set/software shall be capable of continuously monitoring circuit traffic without interfering with normal operation, and shall be able to capture selected messages between RTUs and the Master Station, and decode, store and display the message contents on a dedicated display or VDU window.

12.10 3.2.7 Operator Stations

Each Operator Station shall consist of a workstation computer with associated LCD colour monitors, keyboards and telephone equipment located on an ergonomic designed desk for computer terminal equipment.

The desks shall have adequate space for a minimum of two computer-based workstations (each with dual screens), with independent screen and keyboard height adjustments. The height and location of the workstation VDUs shall not unduly obstruct the operator's view of the projection screen. A suitable desk for the use of the System Software Engineer shall be provided.

Provision shall be made for easy access storage, bookshelves and other surfaces for each Operator Station, Power System Supervisor Workstation and System Software Engineer.

Two gas-lift executive office chairs with side arms and five-way casters shall be provided at each workstation computer, including the Training/Maintenance Workstation. A single chair shall be provided for the System Software Engineer.

A suitable test/training table shall be provided in the Operator Training/Maintenance room to allow an unobstructed view of the workstation. The table shall have room to seat a minimum of 12 people. Two fire resistant cabinets shall be provided in the control room. These shall have adequate space to hold all Manufacturer's data, operations manuals, technical (hardware and software), manuals, PGCB's operations instructions, a copy of current software and on site backup tapes.

One fire proof cabinet to hold all current and previous software revisions and documentation. This will be situated in an area remote from the control room, and preferably off-site.

The Contractor shall provide full details of dimensions and installation requirements for control centre furniture and operator desks for approval during the implementation period.

12.11 3.2.8 Local Input/Output Subsystems

A local LAN based RTU shall be provided at NLDC as the interface to the control room digital displays, building services equipment and any other control centre instrumentation.

12.12 3.2.9 Projection Screen Display

12.12.1.1 3.2.9.1 Size

The display shall be a minimum of 3m high by 9m wide, and shall not be more than 1.5m deep. The individual screens shall be mounted within a rigid structure that is fixed to the floor. The overall screen area may be flat or slightly curved (concave). If it is curved, the angle between each screen in a row shall be equal. The seam width between the screens shall be a maximum of 0.5mm.

12.12.1.2 3.2.9.2 Display Modules and Projectors

The display modules and projectors shall have the following characteristics:

- (a) Resolution per display module shall be a minimum of 1280 x 1024 pixels (SXGA).

- (b) The displays shall be capable of displaying at least 16-bit colour/pixel.
- (c) The luminance of the display shall be at least 140 Cd/m².
- (d) The brightness uniformity shall be >95%. (e) The contrast ratio shall be at least 600:1.
- (f) The horizontal and vertical half-gain viewing angles shall be at least $\pm 45^\circ$.
- (g) The brightness and colour balance between the projection modules shall be adjustable during service operation and when replacing a light source.
- (h) The projection technology used shall be 3 panel PolySilicon LCD or digital micro mirrors.
- (i) Projectors shall have dual lamps with automatic switchover to the standby lamp if the primary lamp fails. The failed lamp shall be easily replaceable while the other lamp is operating, and no mechanical adjustment shall be required upon lamp replacement.
- (j) Lamp life shall be a minimum of 6000 hours and lamp failure shall be annunciated to the operator, preferably via SNMP.

12.12.1.3 3.2.9.3 Image Controller/Display

The video display system shall be controlled by the SCADA computers via an image controller / video processor which shall have the following characteristics:

- (a) The image controller shall be connected to the SCADA LAN (both main and backup LAN) and shall interact with the SCADA computers over the Ethernet network.
- (b) The image controller shall control each projector to produce a display over the complete video display area irrespective of boundaries between display modules.
- (c) The image controller shall accept video signals from other sources and shall be configurable to display a combination of analogue composite and s-video sources as well as digital SDI video signals on PAL and NTSC formats.
- (d) Any control room operator shall be able to control what is displayed on the large screen and have complete control over the format of the display using their local Graphical User Interface.
- (e) It shall be possible to display multiple Windows and/or images at once on the large display either next to each other, or overlapped.

12.12.1.4 3.2.9.4 Spares and Consumables

The following spare parts and consumable items shall be supplied:

- (a) A complete spare illumination unit including LCD and lens.
- (b) One of each of every different module, including power supply, used in the image controller.
- (c) Enough spare projector lamps to replace failed lamps for three years after the end of the Contract Period.

- (d) Enough spare dust filters and other such consumables items to last for three years after the end of the Contract Period.

3.3 REMOTE TERMINAL UNIT (RTU)

12.13 3.3.1 General

The Remote Terminal Units (RTUs) are the interface between the SCADA system and the power network equipment. Each RTU is wired to field devices via a Marshalling Cubicle (MC), which is the designated boundary between substation facilities and SCADA equipment.

The RTUs supplied shall be of a rugged industrial type suitable for installation in an electrically noisy environment as found in substations. RTUs incorporating office PC parts will not be accepted.

The PGCB “SCADA Standard” document included in Technical Appendix 1, Volume 3, gives the requirements for monitoring and control of each type of substation equipment. It lists the minimum basic quantities of Input and Output (I/O) points to be wired to the RTU for each station.

The RTU arrangement will be flexible to cater for the varying situations at substations. At some sites all I/O will be wired to the one RTU and at others, a separate RTU will be required for 132kV, 230kV and/or power stations because of the distances separating the control rooms. For intermediate situations, depending on the architecture supported by the RTU, remote I/O racks may be used. If remote I/O racks are located in a separate building from the main RTU then the remote rack shall be connected to the RTU via fibre optic cable.

Where one RTU covers multiple areas, the RTU shall be segregated into logical RTUs as defined in the “SCADA Standard”. This means the RTU is seen as separate RTUs from the Master Station.

The RTU shall be of modular construction with separate replaceable functional subsystems. An arrangement with plug in modules is preferred, either in a 19 inch rack or mounted on a gear plate.

12.14 3.3.2 Capabilities

The RTU maintains SCADA functions by scanning measured (telemeasurements) on a regular cyclic basis, by monitoring alarms and indications on a continuous basis and by executing plant control commands from the Master Station.

The RTU shall have the following characteristics:

- (a) Be capable of performing local data validity checks as well as simple arithmetic functions such as summation, subtraction, multiplication, division and averaging.
- (b) Be capable of time tagging system events (sequence of events) with resolution to 1mSec repeatable accuracy better than 2mSec for transmission to the Master Station.
- (c) Be capable of filtering contact bounce and suppressing chatter on digital inputs.
- (d) Be capable of picking up and processing fleeting alarms.
- (e) Be capable of local data acquisition and storage for a designated time period if communications circuits are unavailable. On recovery of communications, all accumulated data should be transferred to the Master Station.
- (f) Be capable of transferring data, including files, to or from intelligent field devices using a standard communications protocol. The RTU shall also be capable of file transfer to or from the Master Station.
- (g) Have the capability of being accessed by different Master Stations. The RTU shall be capable of transferring information to, and accepting commands from, more than one master station using different protocols. The RTU shall be capable of accepting commands from master stations at different levels of priority in the network hierarchy.
- (h) Be configurable to appear as two separate RTUs to a Master Station (support for logical RTUs).
- (i) Be capable of analogue processing and I/O requirements necessary for AGC.
- (j) Support at least dual Master Station communications paths.
- (k) Support dual power supplies. (l) Support remote I/O modules.
- (m) Internal failure detection and reporting including module failure, power supply failure, output fault and analogue fault.

The Bidder shall state if the RTU offered supports dual redundant CPUs in a hot-standby configuration, and advise on the improvement of reliability and the effect on system availability if dual CPUs are used.

12.15 3.3.3 General Arrangement

To perform the functions noted above, a microprocessor-based RTU is required.

The RTU shall operate under the control of a non-volatile memory based real-time executive program. RTU firmware shall be field upgradeable - preferably by updating Flash ROM. It shall be possible to add application specific custom software to RTUs (e.g. Sequence control,

Automatic Generation Control, gas calculations) via a programming mechanism easily configurable by users.

12.16 3.3.4 Standards

The RTU and its components shall meet the relevant requirements of the following IEC standards:

IEC 60255-3	Single Input energizing quantity measuring relays
IEC 60255-5	Insulation tests for electrical relays
IEC 60255-21	Vibration, shock, bump and seismic requirements
IEC 60255-22	Electrical Disturbance tests for measuring relays and protection equipment
IEC 60255-25	EMI emission tests
IEC 60870-2	Environmental conditions
IEC 60870-4	Performance requirements
IEC 61000-4	EMC immunity requirements
IEC 60529	Degrees of protection provided by Enclosures (IP code)
IEEE 802.3	Ethernet LAN

The Bidder shall detail the standards met by the RTU equipment offered, including the class rating where the standard allows for different classes.

12.17 3.3.5 Functional Requirements

12.17.1.1 3.3.5.1 I/O Isolation

The RTU system as a whole, including field input/output lines, power supply inputs, transducers and LAN connections shall provide electrical isolation and protection to meet or exceed the following standards:

Electrical Stress	IEC 60255-3
Insulation and Isolation	IEC 60255-5 (5kV impulse, 2 kV AC for one minute between all circuits and between each individual circuit to earth)
High Frequency Disturbance	IEC 60255-22-1 (1 MHz burst)
Electrostatic Discharge	IEC 61000-4-2 (8 kV Contact Discharge method)
RFI Susceptibility	IEC 61000-4-3 (10 V/m 50 kHz to 1000 MHz)
Fast Transient Burst	IEC 61000-4-4

Power supplies shall provide a minimum 2.5 kV isolation between equipment earth and electronic circuits.

12.17.1.2 3.3.5.2 Interface to Field Devices

The RTUs shall be wired to a Marshalling Cubicle (MC) located within 10 metres of the RTU cubicle. The general arrangement required for the I/O circuits is described in Section 10. The circuits shall be capable of being isolated at the MC and tested independently. The Bidder shall detail his proposed field interface arrangement.

All field or substation interface wiring is the responsibility of the Contractor. All inputs to the RTU will be simulated at the MC and verified at the Master Station. All inputs from the field to the MC will be by actual operation of the equipment. The MC and RTU panel terminal numbers shall be documented in the RTU I/O schedule.

Terminals for the different I/O types (digital, analogue, pulse etc.) shall be segregated from each other in both the RTU and the Marshalling Cubicle. The RTU I/O allocation for the logical RTU divisions shall be separated, with no single I/O module handling data for more than one logical RTU. Common points unrelated to a particular division, such as general alarms, shall be wired to the 230kV logical group.

All wiring from transducers, interposing relays, protection relay flags or optical coupled indication terminates at this point and is independently verified. The MC also serves as a signal commoning point as well as a power supply isolation point.

The estimated I/O point assignments for each RTU are given in Technical Appendix 2. The Contractor shall confirm the I/O point assignment after his initial site survey. In all cases the “PGCB SCADA Standard” Document will prevail as the basic requirements.

The Bidder shall provide full details of his proposed RTU architecture and subsystem.

12.17.1.3 3.3.5.3 RTU Capacity

Each RTU and marshalling cubicle shall be wired and equipped with a minimum of 25% spare capacity of each facility type (i.e. digital and pulse inputs, analogue inputs and outputs, and control outputs) over and above the indicated requirements itemised in the I/O Schedule as “To 2007+” in Technical Appendix 3.

The spare capacity shall be cabled to the Marshalling Cubicle (MC) and labeled as ‘Spare’.

The Bidder shall detail the expansion capabilities of the proposed RTU and itemize its limitations.

12.17.1.4 3.3.5.4 RTU Configuration System

The RTU will require a configuration system to assign and configure I/O, set point attributes and parameters, to map I/O points to protocol points, to set up custom logic and to set up communications parameters. The system provided shall be user friendly and be capable of operation from a remote location as well as from a locally connected PC.

A system that is integrated with the Master Station configuration tool is preferred so that points can be configured in a consistent manner from end to end.

The configuration system shall output RTU configuration information in printed and electronic form for documentation purposes.

12.18 3.3.5.5 Input/ Output Interface Specification

12.18.1.1 3.3.5.6 Communications Interface

For communications with the Master Stations, the RTU shall be equipped with dual ported communications interface circuits enabling multiple simultaneous operation on two independent communications channels.

The front end communications interface options that shall be provided are:

- (a) At stations serviced by two or more independent fibre optic circuits over transmission line links:
Two 10-MBit IEEE 802.3 (Ethernet) ports shall be fitted, with the option of adding a third asynchronous serial port. The Ethernet ports will generally be operating on a main/standby arrangement, although the RTU shall be capable of communicating simultaneously via both ports to provide increased throughput when traffic loadings are high. A mechanism shall be provided to periodically check that the alternative channel is operational.
- (b) At stations serviced by fibre optic link and a Power Line Carrier link:
One 10-MBit IEEE 802.3 (Ethernet) port shall be fitted and one asynchronous serial port. The Ethernet port will generally provide the main communications link and the asynchronous port will act as the standby link. A mechanism shall be provided to periodically check that the backup channel is operational.
- (c) At stations serviced by two Power Line Carrier links:
Two asynchronous serial ports shall be fitted. The serial ports will generally be operating on a main/standby arrangement and could be on one drop of a multi-drop (party line) arrangement. Both ports and communications facilities shall be identical and shall be periodically swapped to verify availability for service.

For communications with IEDs, the RTU shall be equipped with multiple serial communications interface circuits enabling multiple simultaneous operation on each communications channel, with the possibility of one or all of the channels connecting with devices arranged on a multi-drop basis. The RTU shall be capable of supporting eight or more serial ports, and shall be equipped as required to communicate with existing IEDs or IEDs added under this Contract. It is preferred that not more than four IEDs are connected via one multi-drop link.

The asynchronous serial ports shall support the common serial data rates such as: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 baud. They shall support the RS232 (V.24) interface, and the RS485 and RS422 interfaces either directly or via an external converter.

Asynchronous modems allowing operation in accordance with ITU-T Recommendation V.24 shall be provided. The modems shall be capable of being interfaced to two-wire or four-wire circuits.

12.18.1.2 3.3.5.7 Analogue Inputs

The RTU analogue input modules shall be capable of accepting the following floating (unearthed) unipolar and bipolar signals:

- 0 to 5V, 0 to 10V, -10 to +10mA, 0 to 10mA, 0 to 20mA, 4 to 20mA

The preferred analogue signal ranges, when transducers are being supplied under this Contract, are 0 to 10mA, or -10 to +10mA for bipolar signals.

Analogue input accuracy shall be 99.9% or better at 25°C ambient temperature.

Temperature drift shall be less than 0.002% per degree Celsius across the 0°C to the +60°C temperature range.

Common mode voltage effects on differential inputs shall be less than 0.1% of full scale when tested at a common mode voltage of 50V p-p at 50Hz.

Analogue to digital conversion shall have a resolution of at least 12 bits binary plus sign.

Over and under range analogue inputs shall be detected, and an “out of range” flag shall be telemetered along with the digitized value. An out of range condition shall set the ‘U’ (Unreliable) quality code flag for the point at the Master Station.

Contractor shall provide signal level conditioning and level conversion with input impedance for voltage inputs greater than 1 M ohms, or less than 5 k ohms for current inputs.

The RTU shall be able to provide the loop power supply for loop powered transducers and this shall be 24 or 48VDC.

12.18.1.3 3.3.5.8 Digital Inputs

The RTU shall accommodate the following discrete signals:

(a) Status inputs

Status input interface shall accept isolated (voltage-free) contact inputs. The RTU shall supply sensing voltage, current limiting, bounce filtering and optical isolation as signal conditioning. Maximum sensing voltage shall not exceed 48 VDC battery levels.

(b) Fleeting Change Detection

It shall be possible to designate discrete inputs as fleeting (or momentary) change detection (FCD) inputs. FCD points shall detect operations of 100 mSec or greater duration.

(c) Pulse Accumulation Inputs

The RTU shall have provision to define digital contact inputs as pulse accumulator inputs. Single or double (changeover) contact inputs shall be supported.

The pulse accumulator shall be incremented one count for each closure of an isolated normally open contact or change over of a N/O N/C contact pair. The RTU shall provide sensing voltage (at 48 VDC), current limiting, optical isolators and de-bounce filtering.

The pulse accumulator inputs shall be able to accept and correctly count pulse rates of up to ten (10) pulses per second. Pulse accumulator registers shall be large enough to count up to the maximum pulse accumulator value supported by the Master Station protocol chosen.

12.18.1.4 3.3.5.9 Control Outputs General

The RTU shall provide isolated contact outputs for control of field devices. Interposing relays shall be used if necessary to achieve the required switching capacity.

Each control output shall be operated via isolated changeover contact (Form C) capable of carrying at least 10 amps at 48VDC resistive or 5 amps at 240VAC, and 1 amp at 50VDC inductive. The contact shall include arc suppression for inductive loads.

All control relays shall be suitable for the voltages applied to them and shall have suitable duty rating appropriate to the connected load.

12.18.1.5 Two Stage Control

The RTU control output arrangement shall support a selection and check back scheme for two stage controls which are applicable to:

- Circuit breaker open/close
- Motorized isolator switch open/close
- Generator start/stop
- Tap changer raise/lower

At the first stage (select state), selection shall be confirmed as valid if only one output (the correct one) is detected as being primed for the required control, and no module faults are present. The select state shall cease if any one of the following conditions occurs:

- After the receipt of a control execute message,
- after a preset time if no control execute message is received,
- if a cancel command is received,
- if a module error is detected or
- if a second selection is detected.

At the second stage (execute), the appropriate output shall be activated when a trip or close command is received.

To provide the required switching capacity, common trip and close contactors may be used in conjunction with lower capacity selection relays that close before and open after the trip/close contactor.

The control output contact arrangement to the station equipment shall be as a minimum based on a 3wire scheme per pair of controls (i.e. Trip/Close/Common). A common field wire connected to more than one pair of controls will not be accepted.

12.18.1.6 Emergency Dump Control

If the Fast Response Emergency Dump is implemented via the RTU, then the RTU control output arrangement shall support this type of single stage control.

12.18.1.7 3.3.5.10 Analogue Outputs

The RTU shall have the capability of providing analogue outputs to field devices.

The digital to analogue converter shall be of the solid state type and shall have a resolution of 12 bits.

The analogue output module shall be capable of supporting varying output ranges, specifically 4 to 20mA, 0 to 10mA, 0 to 20mA and -10 to +10mA into a load resistance which can vary between 0 and 600 ohms.

The maximum error over the temperature range of 0 to 60 degree C shall be $\pm 0.25\%$ full scale for 4 to 20 mA and $\pm 0.1\%$ full scale for 0 to 10 mA and 0 to 20mA.

The loop power supply shall be provided by the Contractor and shall be 24 or 48VDC.

12.18.1.8 3.3.5.11 Digital Display Outputs

The RTU shall have the capability of providing output to a 4-digit digital display. The output format may be serial, or parallel BCD. This will be used to display required set points to operators of manually controlled power stations.

12.18.1.9 3.3.5.12 Transformer On Load Tap Changers

Remote indication of the position of the OLTC associated with all 230/132 kV and 132/33 kV transformers shall be provided at the Master Stations irrespective of how this indication is derived by individual transformer manufacturers.

Interfacing facilities shall be provided in parallel to the existing TPI equipment to provide tap position indication. In some cases a signal is available for each tap position and these may be fed into a special encoder module in the RTU that would convert the corresponding signal (relating to a particular tap position) into a number for transmittal to the Master Stations. In most cases however, tap position is indicated by an analogue voltage signal associated with a three-wire variable resistance system. This signal shall be fed into a standard RTU analogue input via a transducer and transmitted to the NLDC in analogue form (as a number). Depending on the variable resistance (linear or otherwise), the analogue signal shall be processed by the RTU software to provide the correct indication of tap position. Bidders shall be aware of the different methods used by transformer manufacturers and allow for this accordingly.

The position number shall be displayed at the NLDC in digital form as both tap position (1 to n) and a percentage of nominal voltage (e.g. -10% to +10%). Note a lower percentage equals a higher tap number equals a boost of voltage on the transformer secondary.

12.18.1.10 3.3.5.13 Dummy Control and Dummy Analogue

To permit testing of the control facilities at each RTU from the Master Stations, a dummy circuit breaker and dummy analogue reading of high stability and accuracy shall be provided at the RTU, which shall be allocated discrete addresses and operate as if they were real circuit breakers or analogues.

As an alternative method for a dummy analogue reading, the outstation could return a percentage calibration mark to show that the equipment is digitizing to 90%.

One dummy analogue shall be provided for each analogue-to-digital converter in an RTU and alarm limits shall be applied to advise the operator of calibration drift.

12.18.1.11 3.3.6 Disable Switch

A switch shall be provided within each RTU to enable/disable remote controls. All inputs, such as alarms and indications, shall not be affected by operation of this switch.

The switch should disable controls by disconnecting both positive and negative control supplies.

An indication of the position of this switch shall be transmitted back to the Master Stations and shall be annunciated as an urgent alarm.

12.19 3.3.7 Power Supply

The RTU shall be powered from the 48 volt DC battery system to be installed in each station as specified in Section 9. This system will also supply the communications equipment and is positive earthed.

12.20 3.3.8 Equipment Protection

(a) Analogue Over Voltage Protection

Input and output terminals shall not sustain any damage due to application of continuous overrange signals of up to 12 VDC (or 12 V peak AC at 50 Hz) between any terminal and equipment frame earth.

Overload on an analogue input shall not affect accuracy of adjacent analogue input circuits by more than 0.1% of full scale.

Recovery from terminal overload conditions shall occur in less than five (5) minutes from removal of overload.

(b) Surge Withstand Capability

The RTUs shall meet the requirements for high frequency electrical disturbance and impulse withstand capability as described in IEC Standard 60255-22 and IEC 61000-4.

(c) Power Supply Protection

Contractor shall provide all fuses, circuit-breakers, switches and surge protection necessary to protect the equipment supplied from power supply over voltage transients or abnormal conditions.

(d) Equipment Earthing Requirements

Each RTU enclosure shall provide separate signal and enclosure earth wiring in accordance with IEC recommendations. The equipment enclosure earth shall be isolated from signal earth and shall be connected to the power supply earth (AC power yellow/green earth wire) at an approved earth termination copper busbar or stud lug connection point.

The equipment frame earth shall be a dedicated copper busbar, braided wire or cable providing earth circuit continuity to all sub-assemblies and terminating at the power supply earth busbar. Use of cubicle frames, enclosures or rack assemblies for the earth network shall not be accepted.

The Contractor's cubicle earth wiring shall be subject to the Employer's approval.

12.21 3.3.9 Environmental Specification

The RTU's and MC's (including transducer cubicles and check synchronising relay cubicles as necessary) may be installed in substation equipment rooms without temperature or humidity control.

The RTU's shall be capable of normal operation throughout an ambient temperature range of - 10° to +50° Celsius and relative humidity from 10 to 97% non-condensing.

The Contractor shall provide a clear statement on how the temperature within each cubicle shall be maintained within these limits.

If a fan is used for forced cooling then an alarm shall be provided to indicate fan failure.

Acoustic noise levels generated by RTU equipment shall not exceed the values for the noise setting curve NR-45 from AS 1469-1983 or equivalent standard.

3.4 IT EQUIPMENT

12.22 3.4.1 Bridges, Hubs, Switches, Routers...

The size and capacity of all network interface hardware provided such as Bridges, Hubs, Switches and Routers shall be sufficient to support system expansion to the year 2015.

Bridges, Hubs, Switches and Routers shall have at least 4 spare ports. Network interface hardware shall have sufficient processing capacity and bandwidth to cater for peak throughput without slowing network traffic.

Network equipment installed in substations shall be capable of meeting the environmental specifications specified for the RTUs in section 6.3.9 above.

Equipment installed in substations shall obtain power from the DC battery system, either directly or via an inverter.

12.23 3.4.2 Firewalls

The firewalls provided shall be suitable for a mid-sized business and shall meet or exceed the following requirements:

- Packet throughput of at least 150 Mbps
- 3DES Encryption throughput of 20 Mbps
- Support for 200 VPNs

3.5 EQUIPMENT CONSTRUCTION STANDARDS

12.24 3.5.1 Enclosures

The Contractor shall indicate the type, size and weight of all equipment enclosures and their mounting requirements.

Mechanical and electrical packaging shall be in accordance with the Employer's Requirements - Technical Specification Volume 2, Section 2.

The RTU, MC and other necessary enclosures shall be floor-mounted cubicles or wall mounted as suits the Contractor's standard mounting method. Contractor may offer his standard size cubicles subject to approval by PGCB. All floor mounted cubicles shall be mounted on a channel section base frame and shall be fixed so as to comply with the seismic requirements specified in Section 2.

All enclosures of a size that allows a person to stand upright inside shall be fitted with an internal light, operated by door switch.

All electrical enclosures shall be fitted with anti-condensation heaters.

The RTU, MC and other enclosure hardware and wiring access shall be through lockable, full-height doors.

Provision shall be made for cable entry at bottom of all cubicles. Gland plates and cable glands shall be provided for all cables. Cable glands shall be subject to the Employer's approval.

Cooling air entry shall be through screened vents in the door of the RTU and MC cubicle with connection air exhaust at the top.

All enclosures shall be thoroughly cleaned and sanded to obtain a clear, smooth finish both inside and outside before being painted.

All enclosures that are offered for outside installation shall be weatherproof to IP55, vermin proof and shall be glanded for bottom entry.

All rack mounted equipment shall conform to the CEPT 19 inch rack mounting practice.

12.25 3.5.2 Labeling and Identification of Components

All cables and conductors shall be clearly labeled. The labels shall reference a drawing number with the correlation between cable core color code and signal definition.

Each end of each conductor shall have wire labels corresponding to the respective wiring diagram references.

All modules, sub-assemblies and printed circuit cards and the respective card slots shall be identified and cross-referenced to system drawing information.

Each terminal of a screen type terminal block shall bear the identification marking either on the body of the block or adjacent to it.

12.26 3.5.3 Construction

All equipment when delivered shall be new and the latest revision level as determined by the original equipment manufacturer.

All circuit modules should be configured on printed circuit cards. Back-plane wiring and wire wrap techniques are to be avoided.

All components and equipment shall be modular and designed to facilitate operation and maintenance.

The Contractor shall provide all interconnecting wires, cables, etc. for subsystem hardware and for the termination of electrical power supply.

12.27 3.5.4 Transport

The equipment shall be designed to withstand handling during shipment, installation and pre-commissioning and commissioning without sustaining damage.

All equipment shall be packaged for transport through 1 m wide doorways. The height of any cabinet shall not exceed 2m.

Maximum mass of any cabinet is not to exceed 1,000 kg.

12.28 3.5.5 Ergonomic Considerations

The system shall be designed using the latest human factors engineering techniques for modern control systems. Operating positions shall conform to current standards for VDU-based human machine interface facilities.

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning and Integration
with NLDC of 13 nos of 132 KV new Grid Sub-Stations on Turnkey
Basis.**

(Contract No.)

SECTION 4

COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

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COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

TABLE OF CLAUSES

4.1	COMMUNICATIONS DC POWER SUPPLY EQUIPMENT.....	4/3
	4.1.1 General.....	4/3
	4.1.2 Configuration.....	4/3
	4.1.3 Charger.....	4/4
	4.1.4 Battery.....	4/6
	4.1.5 D.C. Distribution and Instrumentation.....	4/7
	4.1.6 Housing.....	4/8
	APPENDIX 4.A.1 SCHEDULE OF REQUIREMENTS FOR DC SUPPLY SYSTEM	4/9

SECTION 3

COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

4.1 COMMUNICATIONS DC POWER SUPPLY EQUIPMENT

4.1.1 General

(a) Basis of Design

The equipment shall comply with IEC 146 and 478.

The charger shall be of either the thyristor controlled type or of the SMPS type. The battery shall be nickel cadmium type - as detailed in a separate section of this specification.

The design and selection of equipment and components shall be based on achieving a minimum lifetime of 20 years, when operating under the specified service conditions.

(b) Operating Principle

The output of the charger shall, during normal operation, continuously supply the power requirements of the load whilst simultaneously maintaining the battery charge in the float charge mode. In the event of an interruption in the a.c. mains supply to the charger, the battery shall supply the load requirements for not less than the specified standby time - whilst maintaining the output voltage within permissible limits.

Upon restoration of the a.c. mains supply, the rectifier shall automatically resume supply of the load requirements whilst simultaneously recharging the battery at the float voltage.

4.1.2 Configuration

The power supply installation shall comprise two batteries and two charging sources. Each charger shall be able to float charge both batteries as well as supplying the total load.

The total battery capacity shall be able to supply the total load (comprising the delivered load together with 20% spare for future use) for at least 10 hours in the event of failure of the a.c. mains supply.

The d.c. power supply equipment is required to limit the output voltage to the load within plus 15% and minus 15% of the nominal value, provided these values do not exceed the voltage guarantee of the load equipment. The power supply output positive shall be earthed.

4.2.2 Charger

(a) General

The charger shall operate according to the constant voltage current limiting principle and shall incorporate a soft start feature to gradually accept load on initial energising.

The charger shall restart automatically upon restoration of the a.c. mains supply following a mains supply interruption, and recharge the battery at the float voltage.

Internal cooling shall be by natural ventilation. Forced cooling is not acceptable.

The charger shall be suitable for operation in parallel with one or more chargers, and shall include a current sharing facility.

The charger shall be of sufficient output capacity for the application, parallel operation of chargers (where required) is for the purpose of redundancy and not to satisfy the output current requirements.

(b) Charger Output

The output characteristic shall provide an output voltage regulation of $\pm 1\%$, over the specified a.c. mains voltage and frequency range and for load changes 0-100%. The output voltage regulator shall be adjustable within limits approved by the Engineer and shall be so designed that special tools are not required for such adjustment. Compensation for battery temperature shall be provided.

The charger shall have protection against overloads or short circuits and shall limit the output current. Recovery to a constant voltage characteristic shall occur automatically at the end of the over current/short circuit.

(c) Boost Charging

Manual boost charging shall be provided. A boost timer shall be included to prevent overcharging.

Operation of boost charging shall disconnect the charger and battery from the load. It shall not be possible for both chargers to be selected to boost charging at the same time, or for the load to become disconnected from both batteries and chargers simultaneously.

If the a.c. mains supply fails during boost conditions the two batteries shall be automatically connected in parallel by “no volt” contactors to the load.

It shall not be possible to connect a “boosted” battery to the load until its terminal voltage has fallen below the load equipment upper voltage limit.

(d) Noise and Interference

To avoid unacceptable levels of electrical noise in the load equipment smoothing of the d.c. output is required. This shall achieve a psophometric noise level at the output, for loads between 0 and 100%, not exceeding the equivalent of 2 mV at a frequency of 800 Hz after weighting as specified by ITU-T (CCITT).

The relative harmonic content of the input current shall comply with the European Directive for EMC, the EN 60555-2 standard. In the case of SMPS chargers active power factor correction (i.e. boost for step up converter) shall be provided to control the power factor.

The production of radio frequency interference voltages shall not exceed the values of suppression grade “N”, as defined in EN 55014/55015 - for thyristor controlled type chargers, and suppression grade “B” as defined in EN 55022 for SMPS type chargers.

The performance of the d.c. power supply equipment unit shall not be affected, or in any way degraded, by the use of the following when the severity of the electromagnetic radiation environment corresponds to Class 3, in accordance with IEC 801-3:

- private mobile radio operating in designated or planned radio frequency bands
- current cellular radio equipment
- future cellular equipment
- mobile data equipment.

It is the Contractor’s responsibility to determine the radio frequency bands applicable in the locality.

(e) Efficiency/Rating

The charger efficiency shall not be less than 80%.

All chargers supplied shall preferably have the same rating, or be in fixed multiples, to limit the number of different charger ratings.

(f) Instruments, Controls and Alarms

The charger shall be equipped with the following

- a.c. mains input circuit breaker
- d.c. output circuit breaker
- charger output current meter
- charger output voltage meter
- alarms for charge fail, d.c. volts high etc.

Each alarm shall be provided with local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

4.1.4 Battery

(a) Type

Nickel cadmium cells shall be of the pocket plate type in accordance with IEC 623.

Cell containers shall be of the moulded plastic type, non flame propagating and mechanically shock resistant. They shall provide for the electrolyte level to be viewed through the container material.

Cells shall be permanently marked with the following information:

- manufacturer's reference number and code
- year and month of manufacture
- voltage and nominal capacity at the 10 hour rate
- cell number.

(b) Mounting

The batteries shall be mounted on metal stands, or racks, in a manner such that all the plates of each cell are visible for inspection, test and maintenance purposes. Stands or racks shall have a maximum of two tiers. In all cases adequate space must be left between the tiers for maintenance purposes and to permit the topping up of electrolyte. Stands or racks shall have a protective finish of not less than two coats of electrolyte resisting enamel or gloss paint. Alternatively, an epoxy resin sintered finish may be used.

At locations where the battery is not housed in a separate battery room the battery stand/rack shall be fitted with cladding. The cladding shall permit the free flow of air to the battery, and shall be removable for maintenance purposes.

Cell containers shall be accurately set up in alignment on the stand or rack with lead and/or rubber discs under the feet moulded on each container. Cell lids shall be so positioned that at least one topping up aperture is on the access gangway side of the cell and not obstructed by any inter-cell connecting arrangements.

(c) Battery Main Fuses

Bolted cartridge fuses shall be provided in both positive and negative leads and positioned as close to the battery as possible and shall be rated at five times the charger float output rated current. A cartridge fuse shall be provided in the charger input lead to the negative pole of the battery and rated at twice the charger float output rated current. These fuses shall be mounted preferably on the end of the battery stand or rack. These fuse links shall comply with BS 88.

Class DC 40 or equivalent and shall be mounted in fuse carriers with an insulated barrier between the poles.

The cable or busbar to the battery shall be firmly supported at a point near the cell terminal pillar. Where two cables are used they shall be terminated one to either side of the terminal pillar. These cables shall be arranged as to allow some flexibility and to avoid any forces being applied to the cell terminal pillar.

(d) Connections

The positive pole of each battery shall be connected to station earth via a single bolted link at the distribution cubicle. Low resistance inter cell connectors shall be used. Connections between tiers of cells and between end cells and fuses shall be made with insulated copper rod which shall be of equivalent cross-section to the distribution busbars.

Connections from the battery fuses to the chargers and distribution cubicles shall be made with insulated cable of equivalent cross-section to the distribution busbars. The positive and negative terminals of each cell shall be clearly indicated. The positive and negative terminals of the complete battery shall be indicated by red and black marking respectively.

(e) Capacity

The battery capacities shall be 100 ampere hours at the 10 hour rate.

4.1.5 D.C. Distribution and Instrumentation

(a) General

The distribution section shall be designed for incoming and outgoing d.c. supplies as follows:

- two independent supplies (including one for future use) incoming from the batteries and associated chargers. The battery negatives shall be connected to the distributed busbar through a single pole switch. The 48V battery positive shall be directly connected to the positive busbar.
- Each load equipment shall be connected to a distribution outlet. The use of teed supplies to more than one load equipment will not be permitted.
- Double pole miniature or moulded case circuit breakers to IEC 157 shall be supplied, fitted with auxiliary contacts which operate when the circuit breaker trips.

The MCBs shall be rated to meet the load requirements and shall be labelled with the destination of the load. Outgoing connections shall be brought to terminals, mounted in the cubicle, provided with strip connectors and cable lugs. The number of outlets shall cater for the quantity of load equipment items plus 50%, with a minimum of 10 outlets being provided, Space shall also be available for the installation of 10 extra outlets for future use.

(b) Instruments and Alarms

Instrumentation shall comprise

- battery ammeter (charge and discharge)
- battery voltage
- load current ammeter
- busbar voltage

An alarm indication shall be provided if the busbar voltage falls outside set limits.

The MCB auxiliary contacts and the high/low voltage alarm shall each provide local annunciation and two sets of potential free contacts, for connection to external alarm monitoring systems.

4.1.6 Housing

The above covers the mounting/housing for batteries.

A modular construction is preferred for the battery charger and d.c. distribution/instrumentation, with each unit comprising a single 19" or ETSI standard rack configuration, all mounted in a single cubicle.

The modular construction shall provide:

- simple plug in units for easy assembly and servicing
- individual battery charger unit removal in safety, without loss of output power to the load.
- expansion of capacity at a later date

In the case of Contractors who do not offer a modular construction, separate cubicles are required for each charger and the d.c. distribution/instrumentation.

Appendix 4.A.1

SCHEDULE OF REQUIREMENTS FOR DC SUPPLY SYSTEM

SL.No.	DESCRIPTION	UNIT	REQUIRED
4.8	Power Supply		
4.8.1	Operation	VDC	48 (-15/+20%)
4.8.2	Fully redundant power supply		yes

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR

**Design, Supply, Erection, Testing & Commissioning of Power Transformers
with associated switchgears on turnkey basis under Renovation, Extension,
Rehabilitation & Augmentation of Grid Substations**

SECTION 6

AUXILIARY POWER AND CONTROL CABLES

SECTION 6
AUXILIARY POWER AND CONTROL CABLES
TABLE OF CLAUSES

6.1	SCOPE	6/42
6.2	GENERAL DESCRIPTION OF INSTALLATION	6/42
6.3	STANDARDS	6/43
6.4	CABLE INSTALLATION	6/43
<u>6.4.1 General</u> <u>6/43</u>		
<u>6.4.2 Installation Criteria</u> <u>6/44</u>		
<u>6.4.3 Reduced Fire Propagation</u> <u>6/45</u>		
<u>6.4.4 Type Approval</u> <u>6/45</u>		
<u>6.4.5 Cable Sizing and Routing</u> <u>6/46</u>		
6.5	CABLE CONSTRUCTION	6/47
<u>6.5.1 Oversheaths</u> <u>6/48</u>		
<u>6.5.2 Armouring</u> <u>6/48</u>		
<u>6.5.3 Laying up</u> <u>6/49</u>		
<u>6.5.4 Cable Drums</u> <u>6/49</u>		
<u>6.5.5 Sealing and Drumming</u> <u>6/49</u>		
<u>6.5.6 Spare Cable</u> <u>6/49</u>		
<u>6.5.7 Jointing Accessories</u> <u>6/50</u>		
6.6	TYPES OF CABLE	6/51
<u>6.6.1 Low Voltage Cables</u> <u>6/51</u>		

6.6.2 Control Cables and Instrumentation Cables 6/51

6.7	STRAIGHT THROUGH JOINTS.....	6/54
6.8	GENERAL METHODS OF CABLE INSTALLATION.....	6/54
6.9	CABLES DRAWN INTO DUCTS	6/55
6.10	CABLES INSTALLED IN CONCRETE TRENCHES	6/56
6.11	CABLES SUPPORTED ON RACKS, TRAYS AND LADDERS.....	6/56
6.12	TERMINATIONS	6/59

6.12.1 General 6/59

6.12.2 Power Cables 6/60

6.12.3 Mineral Insulated Cables 6/60

6.13	TERMINATING AND JOINTING CONDUCTORS	6/61
6.14	CORE IDENTIFICATION.....	6/61
6.15	CABLE IDENTIFICATION AND SCHEDULES	6/62
6.16	INSPECTION AND TESTING.....	6/63

SECTION 6

AUXILIARY POWER AND CONTROL CABLES

6.1 SCOPE

A complete cabling system for the substation 415/230V auxiliary power requirements and the control and protection multicore cabling shall be designed, provided, installed and commissioned by the Contractor as specified in the Project Requirements and schedules. All ducts, cable racking and supports are to be supplied under the Contract. The Contractor shall, furnish satisfactory evidence as to the competence of the electricians and jointers he proposes to employ on the cable installation and jointing works.

6.2 GENERAL DESCRIPTION OF INSTALLATION

The complete cabling installation, including that associated with control and instrumentation, shall be managed by the Contractor, who shall be responsible for design, procurement, installation and works/site testing of the whole installation.

The Contractor shall employ a cabling computer program to facilitate the above and the Bidder shall describe in his Tender the cabling management procedures he will adopt. A cable scheduling system will be imposed by the Employer.

The Contractor shall provide an installation in accordance with the best modern practice and complete in every detail for continuous operation.

Cabling areas will include those which have natural ventilation. Cabling shall therefore be designed for the maximum ambient temperatures expected.

To cater for future requirements, adequate provision shall be made for the associated cables in respect of trench sizes, space for future racks or trays and numbers of cables permitted in areas or spaces required for future equipment.

The Contractor shall submit to the Employer drawings for approval showing the proposed cable routes, cross-sections of the trenches and arrangements of the cable racks and trays.

The Contractor shall prepare and provide all necessary cable schedules. The cable numbering system to be used shall be advised to the Contractor and this system shall be followed.

The Contractor shall provide all necessary power, multicore and communications cables required as required and specified in the Project Requirements.

6.3 STANDARDS

The cables shall comply with British Standards or International Electrotechnical Commission (IEC) Standards and Recommendations, or any other internationally recognised standards, subject to the approval and acceptance of the Employer.

6.4 CABLE INSTALLATION

6.4.1 General

The cabling system shall be designed to incorporate maximum practical security, to ensure that an incident such as fire causing loss of cable circuits in any one route would at worst result in the interruption in operation of one unit only. Cables with reduced fire propagation characteristics shall be provided.

Cables shall be satisfactory for operation under the atmospheric and climatic conditions prevailing at the site and under such variations of current, voltage and frequency as may be met under fault and surge conditions on the system.

Cables shall be derated to allow for the likely number of cables following a given route.

The methods of installation shall be as follows:

- (a) In concrete trenches
- (c) In ducts
- (d) On cable racks, trays or ladders

Control and instrumentation cables shall be screened/shielded to minimise interference, where necessary.

6.4.2 Installation Criteria

Specific requirements shall be as detailed in the Project Requirements.

System security shall be achieved by ensuring that cables are segregated or separated from each other as appropriate. Segregation shall be achieved by laying cables associated with any one high voltage circuit of a pair on separate trays or racks at least 600mm apart from the cables of the other of the pair with an airspace, but not necessarily a physical barrier, between them.

In general, to minimise interference, control cables and instrumentation cables shall be separated from power cables.

The following group classifications will be allocated for each cable:

- i) Group A: Single core power cables,
- ii) Group B: Multicore power cables,
- iii) Group C: Multicore control cables and protection cables,
- iv) Group D: multipair control and instrumentation or indication cables.

In general, single core (Group A) and multicore (Group B) power cables shall be allocated to separate racks. In a similar manner, multicore control (Group C) and multipair (Group D) instrumentation cables shall generally be allocated to separate trays.

There shall generally be a minimum separation of 600 mm between instrumentation cables (Group D) and power cables (Groups A and B), and a minimum separation of 300 mm between control cables (Group C) and power cables (Groups A and B). However, both these separation distances may be reduced where the two types of cable only run in parallel for a limited distance, provided the Contractor demonstrates that the level of interference resulting will not be detrimental to the operation of the equipment concerned.

6.4.3 Reduced Fire Propagation

A cable installation with reduced fire propagation characteristics shall be provided, utilising cables with organic compounds which are capable of extinguishing or considerably reducing the spread of flame along the cable.

Consideration shall also be given to ensuring that the minimum toxic or corrosive products are given off on combustion of any organic component used in cable construction.

6.4.4 Type Approval

Cables and accessories for use at all voltages shall have satisfactorily passed type approval tests equal to those required by the International Electrotechnical Commission or equivalent, and details for the cable designs offered shall be given in Schedule E of Particulars and Guarantees.

The Contractor is to certify that the cables and/or accessories offered will be identical in all essential particulars in respect of design, materials and workmanship with the cables and/or accessories for which type approval certificates are offered in support of his tender. The Contractor shall also ensure that all materials used will be subjected to and shall have satisfactorily withstood such tests as are customary in the manufacture of the types of cables specified. Records of such tests shall be available for inspection, if required by the Employer.

6.4.5 Cable Sizing and Routing

The Contractor shall be responsible for all cable sizing and routing design, procurement, installation and testing.

Proposals for the following aspects of cable design shall be submitted for approval:-

- Routing cables along the shortest route compatible with segregation /separation and capacity limitations
- Sizing cables in accordance with length grouping, ambient temperature and current rating
- Recording estimated lengths and later measured lengths for each cable
- Progressing the cable installation
- Producing and progressing cable schedules, cable termination schedules, and support steelwork schedules and drawings

All necessary de-rating factors shall be applied when sizing cables, to allow for maximum ambient temperatures, soil temperatures, values of thermal resistivity of soil, and grouping as necessary.

Due allowance shall be made for the method of installation, depth of laying, spacing and grouping factors.

All power cables shall be adequately rated to withstand the thermal and magnetic effects of short-circuit fault currents equivalent to the short circuit fault rating of the associated switchgear, except when advantage can be taken of the peak current limiting effects of MCCB's and fuses. Screens and/or outer sheaths shall be designed to carry the full ground fault current.

The short-time rating of all transformer and interconnector feeders shall correspond to the maximum short-circuit conditions and be based on the previous maximum continuous rating operating temperature, followed by the initial asymmetric peak current, followed by the thermal steady state r.m.s. fault current for the total duration

required for the associated main and back-up protection to operate and isolate the circuit. When protected by a circuit breaker which is not of the current limiting type, the cable shall withstand the maximum fault current, including asymmetric peak, for at least 3 seconds without damage.

For 415V motor supply cables the rating shall be based upon the duration of the let-through current of the associated main circuit breaker or fuse protection. The fault currents considered shall not include for the reduction due to the impedance of the cables concerned.

Maximum conductor temperatures permissible during the passage of short-circuit current shall be in accordance with cable manufacturer's recommendations and joints and terminations shall be designed to match the cable characteristics.

For all alarm, control, indication, instrumentation, metering and protection cables, the Contractor shall determine the impedances, load burdens and other requirements of the cabling and associated equipment and shall provide cabling for satisfactory operation. Particular attention shall be given to protection circuits and the Contractor shall ensure that satisfactory operation will be achieved under overload or short circuit conditions on the system.

The Contractor shall furnish copies of calculations and other details to show how the ratings and cross-section areas of all cables have been obtained and the de-rating factors for which allowance has been made. Where a cable is routed through differing types of installation conditions, the condition giving the lowest cable rating shall determine the cable size.

The sizes of all cables shall be submitted to the Employer for approval and the Employer may require the Contractor to increase the cross-sectional area of the conductor to ensure that the required current carrying capacity and performance is obtained. All such changes shall be made by the Contractor without extra cost.

6.5 CABLE CONSTRUCTION

6.5.1 Oversheaths

All cables shall have a black flame retardant low smoke PVC oversheath material, to meet the fire retardant characteristics of BS 4066 and IEC 60332.

PVC sheathing shall have flame retardant properties such that the Oxygen Index is not less than 30 when tested in accordance with A.S.T.M. D2863-77. Test certificates stating measurement values for sample drum lengths of cable shall be provided.

The external surface of the oversheath shall be embossed along two or more lines approximately equally spaced around the circumference with the words 'ELECTRIC CABLE' in English. Figures for the relevant voltage grade, together with manufacturer's name, shall be embossed on the oversheath.

The letters and figures shall be raised and shall consist of upright block characters. The maximum size of the character shall be 13 mm and the minimum size 15% of the approximate overall diameter of the cable. The gap between the end of one set of embossed characters and the beginning of the next shall not be greater than 150mm.

The minimum thickness of oversheath shall not fall below the manufacturer's stated value by more than 0.2mm plus 20 percent.

A means of identifying the manufacturer shall be provided throughout the length of the cable.

6.5.2 Armouring

All multicore cables shall be provided with galvanised steel wire armour. Single-core cables shall have copper or aluminium wire or tape armouring.

The armour shall be protected by an overall PVC or plastic sheath.

6.5.3 Laying up

The cores of multicore cables shall be laid up with a right hand direction of lay. Where necessary, non-hygroscopic fillers, which may be applied integrally with the bedding, shall be used to form a compact and circular cable.

6.5.4 Cable Drums

Cable drums shall be non-returnable and shall be made of timber, pressure impregnated against fungal and insect attack, or made of steel suitably protected against corrosion. They shall be lagged with closely fitting battens.

Each cable drum shall bear a distinguishing number on the outside of one flange. Particulars of the cable, i.e. voltage, conductor size and material, number of cores, type, length, gross and net weights shall also be clearly shown on one flange. The direction of rolling shall be indicated by an arrow on both flanges. The method of drum marking shall be to the Employer's approval.

Cable spare lengths shall be wound on to steel drums before they are handed over to the Employer's stores.

6.5.5 Sealing and Drumming

Immediately after the Works tests, both ends of each cable length shall be sealed by means of a shrinkable cap and the end projecting from the drum shall be adequately protected against mechanical damage during handling. The ends of each drum length of multicore cables shall be masked red and green in accordance with BS 6346 or BS 5467.

6.5.6 Spare Cable

Spare cable and accessories, as detailed in the schedules, are required to be included in the Contract.

6.5.7 Jointing Accessories

Cables shall be installed in continuous lengths and straight through jointing between shorter lengths will not be permitted.

Jointing accessories shall include all necessary internal and external fittings, insulating materials, soldering metal, glands, filling and drain plugs, armour clamps, earth bonding terminals and filling compounds as appropriate.

Mechanical glands for the termination of elastomeric or thermoplastic insulated cables into straight-through joints and termination accessories shall meet the requirements of BS 6121 and shall be correctly designed for the termination of the armouring. The gland shall not only adequately secure the armour to provide efficient electrical continuity but shall also provide a watertight seal between the oversheath and the inner extruded or taped bedding to prevent the ingress of moisture. All glands shall be fitted with a substantial earth bond terminal.

The armour clamping device shall be capable of clamping the cable armour so that the clamp withstands any short circuit current from the armour wires, through the gland body to the integral bonding connector.

Sealing end porcelains shall be free from defects and thoroughly vitrified so that the glaze is not depended upon for insulation. The glaze shall be smooth and hard, completely cover all exposed parts of the porcelain and for outdoor types shall be a uniform shade of brown.

Porcelains must not engage directly with hard metals and, where necessary, gaskets shall be interposed between the porcelain and the fittings. All porcelain clamping surfaces in contact with gaskets shall be accurately ground and free from glaze.

Sealing ends and fittings shall be unaffected by atmospheric conditions, proximity to the coast, fumes, ozone, acids, alkalis, dust or rapid changes of air temperature between 15°C and 65°C under working conditions.

6.6 TYPES OF CABLE

6.6.1 Low Voltage Cables

These cables shall be in accordance with IEC 60502 with a voltage rating of 0.6/1kV.

These cables shall have stranded copper conductors.

Insulation shall be XLPE with an operating temperature of 90°C.

6.6.2 Control Cables and Instrumentation Cables

6.6.2.1 General

Two types of cable shall be provided for the control and instrumentation cabling. The first is multicore cable with stranded (7/0.67mm wires) copper conductors of 2.5sq.mm. which is suitable for voltages up to 300V to ground a.c. or d.c. and currents up to 5A. These cables shall be used where a low impedance is essential i.e. the secondary wiring of current or voltage transformers and for circuit breaker or contactor controls.

The second type designated "signal cable" is defined as those cables carrying milliamp, analogue or digital signals at low voltage levels (50V d.c. maximum) used on instrument and Logic Transmission Systems. These cables shall be multiple twisted pairs, screened and PVC covered with conductors sized 0.5mm² minimum (1/0.8mm or 1/0.9mm diameter). The use of cable cores shall be such that each plant analogue signal is transmitted in a twisted pair. Under no circumstances shall the signal positive be in a different twisted pair to the negative. 20% spare capacity shall be included in all multiple twisted pair cables. The combinations of multiple twisted pair cables used throughout the Plant shall be restricted to 2, 5, 10, 20, 30, 50 and 100 pairs.

Inductive interference between primary and secondary cables due to load, switching or unbalanced fault conditions associated with the primary circuit shall be avoided. The more sensitive telephone, communication, analogue and digital circuit cables shall be spaced at least 600mm from power cables.

6.6.2.2 Multicore Control Cables

Cables shall comply with the construction hereabove and shall have cross-linked polyethylene (XLPE) insulation.

All cables shall be provided with a low smoke PVC oversheath.

Multicore control cables shall be generally in accordance with IEC 60502 with voltage rating 0.6/1 kV, except that 2.5 mm² copper conductors shall be stranded (7/0.67mm wires). Standard designs shall be for cables with 2, 3, 4, 7, 12, 19, 27 and 37 cores, and single strand conductors will be accepted at 1.5 mm²

All these cables shall have galvanised steel wire armouring.

These cables shall be used where a low impedance is essential, e.g. for the secondary wiring of current and voltage transformers and for circuit breaker and contactor control circuits.

6.6.2.3 Multipair Instrumentation Cables

Multipair instrumentation cables shall be provided in accordance with industry standards.

These cables shall have solid copper conductors, typically of 0.9 mm diameter laid in twisted pairs, triplets or quads. The cables shall be polyethylene or XLPE insulated. They shall have galvanised steel wire armouring.

Cables shall be provided with either an overall metallic tape screen or individual tape screens round each conductor bundle to reduce interference from adjacent circuits.

These cables shall be used for circuits with a voltage rating not exceeding 125 V to earth and a current rating not exceeding 20 mA, where considerations of interference and cross-talk are of great importance. Typical applications include communications, computer signals, transducer circuits and alarms.

6.6.2.4 Oversheaths

All the cable types above shall have a black flame-retardant low smoke PVC oversheath. In normally manned locations, especially the control building, cables shall have a low smoke, zero halogen oversheath, so as to minimise the generation of smoke and corrosive acid gases in the event of a fire.

6.6.2.5 Telephone Type Cables (TWPVC)

i) Construction

Multipair cables with 1/0.9mm tinned copper conductors complying with IEC 60228, PVC insulation, individual twisted pairs, PVC bedding, single wire armoured and low smoke PVC sheathed overall.

ii) Insulation

PVC insulation shall be "Hard Grade" to BS 6746 with a radial thickness of 0.7mm nominal 0.57mm minimum. Minimum insulation resistance per 1000 metres of conductor at 20°C shall be 10,000 Megohms.

iii) Laying Up

The insulated conductors shall be uniformly twisted together with a right hand lay to form a pair. The length of lay is not to exceed 150mm and the lays for each adjacent pair are to differ from one another in length. In any case, the length of lay of the pairs shall be such that any cross-talk from pair to pair is the least possible.

iv) Core Identification

The insulation of the cores shall be colour coded in accordance with IEC 60189-2 for 20 unique cabling elements (pairs) as described in Appendix A of IEC 60189-2.

6.6.2.6 Pilot Cable

Telephone type cable laid in the ground alongside HV power cables shall take into account the effects of induced voltages.

6.7 STRAIGHT THROUGH JOINTS

Each cable shall be run in one continuous length. Straight-through joints will not be permitted.

6.8 GENERAL METHODS OF CABLE INSTALLATION

The arrangement of cables and the methods of laying shall be approved by the Employer. Cables shall be installed by the following methods only: -

- In concrete trenches
- In ducts
- On cable racks, trays or ladders

Concrete trenches shall be provided in switchrooms. Cables shall be installed in a manner which permits the required ratings and with due regard to the number of cables following a given route, including future plant extensions.

All cables routed under roads and access ways usable by vehicular traffic shall be installed in ducts.

At all such crossings spare ducts shall be installed; the number of spare ducts shall be two, or 20% of the total number of ducts installed at each crossing, whichever is greater.

Mechanical protection to the Employer's approval shall be installed at all points where the cable is vulnerable to mechanical damage. Locations where this protection shall be installed shall include all points where cables pass through a wall, floor, side or top of a cable trench.

Cables shall be installed in such a manner as to avoid undue risk of damage during installation. The Contractor shall provide all necessary rollers and supports, and bending radii shall comply with the recommendations of cable specifications and be to the approval of the Employer.

Sunshields shall be provided in all locations where the cable would otherwise be subjected to direct sunlight.

6.9 CABLES DRAWN INTO DUCTS

Ducts and pipes 35mm minimum in excess of cable diameter, shall be supplied and installed by the Contractor in accordance with the building and civil works section.

Ducts shall be of rigid PVC and shall be surrounded by 150mm minimum thickness of concrete.

Before pulling cables through ducts, the Contractor shall remove any loose material from the ducts, and prove them by drawing through a mandrel of slightly less diameter than the duct. Any lubricant used shall have no deleterious effect on the cables.

Any ducts or pipes not used shall be sealed by plugs (detail subject to approval) supplied by the Contractor before back-filling.

The ducts shall be water and vermin proof sealed, after completion of cable installation.

6.10 CABLES INSTALLED IN CONCRETE TRENCHES

The cable trench system shall be designed by the Contractor to the approval of the Employer. It shall be complete with removable covers and shall comply with the building and civil works Section.

All cables routed in concrete trenches shall be suitably supported by means of cleats or racks and raised from the trench floor by means of suitable spacers. All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall not be acceptable without the prior approval of the Employer.

The Contractor shall be responsible for removing and replacing the trench covers free of charge during the execution of his work as directed by the Employer.

6.11 CABLES SUPPORTED ON RACKS, TRAYS AND LADDERS.

6.11.1 General

All single core and multicore main power cables shall be installed in cleats or saddles fixed at intervals. Multicore power cables shall be installed on trays, racks or ladders but segregated from other cables on the same tray by a space of 300 mm.

All control cables shall be installed on racks or trays with adequate clamps, cleats or ties to avoid excessive sagging. The Contractor shall include for the preparation and provision of single line cable routing drawings and detailed cable supporting steelwork drawings, necessary to enable the Employer to give his approval for all main and subsidiary routes before installation commences.

Ample allowance shall be made in the design for additional cabling for future extensions.

Racks and trays shall be secured to channel or similar inserts installed in accordance with Building and Civil works section.

All cables shall be run with a particular regard to neatness of appearance. Multiple runs shall be arranged so that cables entering or leaving the run do so in a logical manner.

Trays and supporting steelwork shall be securely bonded and grounded to the main earthing/grounding system. Bonding and grounding connections shall be adequate to carry prospective fault currents without exceeding thermal or voltage limits.

6.11.2 Supporting Steelwork

All supporting steelwork shall be hot dip galvanised after manufacture and shall be to the approval of the Employer.

Steelwork section shall not be less than 50 x 50 x 6 mm for steel channels and 50 x 50 x 5 mm for angles.

On all main cable runs, supporting structures shall be designed and drilled to accommodate additional cable racks or cleats to the extent of 20% of cables installed under the Contract and those required for known future extensions. The spacing between supporting structures shall be not greater than 1m unless otherwise approved by the Employer.

In cases where cables or their supports must be fixed to structural metal work, care shall be taken to avoid eccentric load transfer to beams or other structural metal. Also, local overloading or deformation of structures shall be avoided. The Contractor shall, if required, demonstrate that the loading resulting from the attachment of cabling steelwork has been taken into account in the steelwork design.

6.11.3 Cable Clamps, Cleats, Saddles and Ties

For single core cables carrying three phase alternating current, non-magnetic trefoil cleats shall be used and for other single core and three core cables claw type single or multicore unit cleats shall be used. The cleating arrangements for single core cables shall be adequate to withstand all short circuit forces.

Cable clamps shall be used at any change of direction of cable laying, but at agreed intervals on straight runs cable ties of approved design may be used.

Every non-flexible type cable shall be securely supported at a point not more than 1m from its terminal gland to prevent stressing the termination, and on vertical runs passing through floors, immediately above the floor.

6.11.4 Trays, Racks and Ladders

The Contractor shall provide all necessary trays, racks or ladders which shall be fixed at not more than 1m centres. On all main runs trays, racks or ladders shall be installed to accommodate additional cables to the extent of 50% of those installed under the Contract or known future requirements.

Cables shall be installed on trays, in general as follows:-

- (a) Up to 16mm² - double layer touching.
- (b) 25mm² to 70mm² - single layer touching.
- (c) Above 70mm² - single layer with 25mm (minimum) spacing.

All cable trays shall be perforated.

All trays, racks and ladders shall be galvanised to a thickness not less than 1.6 mm and shall be PVC coated in exposed areas. The erection of steelwork, trays, racks or ladders shall not proceed until the Employer's approval for such has been obtained.

Where cables are run on trays, racks or ladders, they shall be tied to the tray at 1 m intervals using materials approved by the Employer.

The cable tray system shall have minimum of 20% spare cable capacity throughout.

6.12 TERMINATIONS

6.12.1 General

The Contractor shall be responsible for making all terminations, checking and setting-to-work the completed installation. All cables provided as part of the Contract shall be terminated at both ends.

For control wiring the cable tails shall be so bound that each wire may be traced back to its associated cable without difficulty. Cores in twisted pairs or groups shall be kept together. Any spare cores shall be numbered and terminated in the spare terminals furthest away from the cable gland. All cables shall be long enough to permit a second termination if necessary at a future date to the remotest termination location in the panel.

Cable glands shall be used at all equipment to support the weight of cable from the terminations and to seal the cable to the equipment, unless otherwise approved by the Employer.

PVC, XLPE, silicone rubber and PTFE insulated cables shall be terminated via glands to BS 6121. Glands where water may impinge on cables shall be type EIU, with inner and outer seals and armour clamp. Unarmoured single core cables in these areas shall have type A2 glands.

Glands in indoor locations with the exceptions as noted above shall be type C for armoured cables and type A2 for unarmoured single core cables.

PVC shrouds shall be supplied and installed over each gland.

6.12.2 Power Cables

The Contractor shall ensure that the correct phase rotation and connections are achieved. Particular care shall be taken in the case of heavy cables, where subsequent correction may be difficult. Phase tests will be witnessed by the Employer and, if found necessary, the Contractor shall carry out the reversal of phase connections. Connections to electric motors shall be made as specified. Where motors have tails rather than bushings, a heat shrink or equivalent PVC tube for insulation of the crimp joint shall be provided.

Where insulated glands are provided, the Contractor shall ensure that the insulation is maintained after jointing the cable and shall, if required, demonstrate this to the satisfaction of the Employer.

The tails of two or three or four core cables in air insulated terminations shall be identified by a band of approved tape of appropriate colour over the self-sealing tape.

Single core cables shall be similarly identified by coloured tape over the cable beneath the gland.

6.12.3 Mineral Insulated Cables

The MICS cables shall be terminated with pot type seals in Universal ring type glands utilising cold plastic compound of an approved type. Accessories and methods of anchoring the extension sleeving shall be to the approval of the Employer. All MICS cable terminations shall be complete with high temperature neoprene sleeves of sufficient length over conductors and sundries. All MICS seals shall be tested not less than twenty-four hours after completion with a 1000V insulation resistance tester and a

reading of greater than 10 Mohms must be obtained before conductors are connected at any apparatus.

The Contractor shall provide the necessary compound of approved grade and necessary MICS cable glands. Where the ambient temperature is expected to exceed 50°C, special seals shall be used, details of which shall be approved by the Employer.

6.13 TERMINATING AND JOINTING CONDUCTORS

Compression (indentation) type cable lugs and ferrules shall be provided and all necessary tools, including dies and other materials for making compression joints, shall be provided by the Contractor, who shall comply with the recommendations of the supplier of cables and lugs in the preparation and execution of each termination.

For stud type terminals approved crimping lugs shall be used.

Where clamp type terminals are used, the conductor shall be terminated without lugs with the exception of flexible conductors having wires 0.3mm or smaller which shall be fitted with crimps. Not more than one conductor shall be terminated in each clamp.

6.14 CORE IDENTIFICATION

A uniform core identification system shall be used throughout the Station. The following clauses outline the broad requirements but the exact implementation shall be agreed with the Employer.

Approved numbered ferrules shall be supplied and fitted to every cable core of control and instrument cables at each termination. The ferrules or sleeves shall be of interlocking ring insulating materials such as plastic which shall be black engraved on yellow background and have a glossy finish. The ferrules or sleeves shall be unaffected by oil or damp. Identification marks on self-sticking cloth shall not be used. The ferrules shall be of "O" or "D" cross section. Ferrules of "C" type cross section shall not be used.

Single d.c. wires shall be identified by a red or blue coloured ring (positive or negative polarity) followed by the identification of the polarity concerned (instrumentation, klaxon, alarm, etc.).

Direct a.c. circuits shall be identified by a yellow end piece followed by an identification of the phase concerned.

Wiring for secondary circuits of voltage transformers shall be identified by a grey end piece and wires in current transformer secondary circuits shall be identified by a green end piece. This identification shall be completed by a terminal index.

All markings for terminal blocks, cables, cable conductors and wiring shall be located on the corresponding fault finding drawing.

Characters suitably marked 'TRIP' in white shall be fitted on all wires associated with trip circuits.

A common system of ferrule numbering shall be adopted such that ferrule numbers at terminations shall agree with ferrule numbers on the internal wiring of equipment.

6.15 CABLE IDENTIFICATION AND SCHEDULES

The Contractor shall prepare and submit computerised cable schedules, the content and style of which shall be to the general approval of the Employer. These shall include cable identification numbers for all cables except those provided for lighting and small power circuits and those which are connected to the load side of distribution boards for lighting and small power circuits.

The cable identification number system shall be such as to give a brief general indication of the type and function of individual cables and shall be approved by the Employer.

The Contractor may use a fully computerised system for rating, and routing of cables, but shall provide a system that readily permits the cables to be scheduled on the following basis in sequence of cable identification number:

- (a) By cable identification number only
- (b) By type and size of cables
- (c) By function of cable
- (d) By main LV ac and DC. Switchboard, actuator boards.
- (e) By agreed electrical and mechanical plant functional groups.

The Contractor shall provide copies of the cable schedule in an approved format. The Contractor shall provide a standard software package together with a suitable personal computer to permit the Employer to access, display, print and edit the schedules. The schedules shall be accessed by simple interactive dialogue using 'menu-selection' or other approved procedure.

In addition at agreed intervals the Contractor shall provide selected copies of the above schedules in a computer print-out form.

Each end of every cable, except those provided for lighting and small power circuits and which are connected to the load sides of distribution fuse boards, shall be identified with a separate cable reference number fitted in a suitable position under the cable termination.

Where cables enter and leave ducts or pipes, suitable identification markers shall be fitted.

The materials of the markers and fastenings shall be such as to avoid corrosion or deterioration due to incompatibility of materials and shall ensure permanent legibility.

6.16 INSPECTION AND TESTING

Inspection and testing during manufacture and after installation on site shall be in accordance with Section 15 of this Specification.