बिहार स्टेट पावर ट्रांसमिशन कंपनी लिमिटेड
(An ISO 27001 : 2013 Certified Company)
(रजिस्टर्ड ऑफिस : विद्युत भवन, बेली रोड, पटना)

Annexure-A

संचिका संख्या : ULDC/Electrical connection/ 42/2025 पृष्ठ सं० : 08

The matter is regarding Financial Concurrence of estimate for installation of 2 X 315 KVA DSS for providing new 150 KVA HT Power connection in Back up control Center, Gaya (Chandauti, Gaya).

The sanctioned estimate for installation of 2 X 315 KVA DSS for providing new 150 kVA HT power connection has been submitted by transmission circle, Gaya for Back up control Center, Gaya and is placed at C/14-21 via email on dated 20/Sept/2025 and 24/Sept/2025. The estimated amount of ₹ 17,69,994 (Rupees Seventeen Lakh Sixty Nine Thousand Nine Hundred Ninety Four Only) and ₹ 16,76,901 (Rupees Sixteen Lakh Seventy Six Thousand Nine Hundred One Only) may be sanctioned in SLDC head.

Accordingly, file may kindly be send to Accounts Department, BSPTCL for the Financial Concurrence of the same.

Put up for kind perusal & further needful.

Sd/- 24/Sept/2025
Khushboo Gupta
Assistant Executive Engineer
ULDC, BSPTCL, PATNA

EEE(ULDC)

Notes above

E.S.E TC Gaya has submitted estimate (technically sanctioned) for establishing electric connection for back up SLDC building, Chandauti Gaya under deposit head. Amounting ₹ 3,446,895/— (Thirty four lakh forty six thousand Eight hundred Ninety five) only for installation consisting of Two no. of 315 KVA D.S.S with extension of 11 KV line, connection load 150 KVA HT connection. Hence, estimate if sanctioned will be booked in SLDC O&M head, the same may be sent to Accounts

TC - 36 - Oriental - 1.50 Lac - 2024

wing for obtaining financial concurrence of amount of ₹ 3,446,895/- (Thirty four lakh forty six thousand eight hundred ninety five only) including GST.

Anupam Kamal 24/09/25
ANUPAM KAMAL
ELECTRICAL EXECUTIVE ENGINEER
ULDC

E.S.E ULDC

Notes above and from pre pages may kindly be seen.

ESE/TC/Gaya vide letter no. 614, dated 20.09.2025 has submitted sanction estimate for installation of 2x315 KVA DSS for providing new 150 KVA HT power connection in Back-up control centre, Gaya (Chandauti).

It is to be mention that both 315 KVA distribution transformer shall be connected separately.

1X315 MVA transformer will be connected through 80 meter ACSR Dog conductor from 11 KV DRC feeder while; another 1X315 MVA distribution transformer will be connected through 70 meter, 11 KV police line feeder.

The total estimated amount is ₹ 3,446,895/- including gst offered by concerned DISCOM including gst.

→ The estimated amount of 1x315 MVA distribution transformer is ₹ 17,64,994/-

बिहार स्टेट पावर ट्रांसमिशन कंपनी लिमिटेड

(An ISO 27001 : 2013 Certified Company)

(रजिस्टर्ड ऑफिस : विद्युत भवन, बेली रोड, पटना)

11.

संचिका संख्या : ULDC/ Electrical Connection/42/2025 पृष्ठ सं० :

File is put up for according F.C for Rs. 34,46,895=00 (Rupees Thirty Four lakh Forty six thousand Eight hundred ninety five) only for payment to SBPDCL (including GST) for said work.

GM(F&A)

25/09/25

ARUN KUMAR CHOUDHARY
CHIEF ENGINEER (SYSTEM OPRETION)
BSPTCL, PATNA

494/CE(SO)
25-09-25

SM(F&A)
25/9/25

AO(T)
25/09/25

Acctt
25/09/25

471/जाम(F&A)
25-09-2025

Accountant

Notes from pre-page and above may kindly be seen.

The Instant matter is related to F.C for installation of 2×315 KVA sub-station Transformer CSST 11/0.415kv with extension of 11 KV 2 (two) lines for providing stable and uninterrupted power supply of SLDC (main-II) at Chandauti (Gaya). C.E. (S.O) has sent the file for F.C amounting to Rs. 34,46,895=00.

In view of above facts and proposal of CE (SO) (at/above) F.C may be concur for amounting to Rs. 34,46,895=00 (Rupees Thirty four Lakh forty six thousand eight hundred ninety five) only under IRF (Capital) Plant & machinery Head. 'A'

Submitted

25-09-25

TC - 36 - Orientatal - 1.50 Lac - 2024
F. C. No. IRF (Capital) Plant & machinery Head/08
Date 25-09-25
Page of F.C. 12
Register 2025-26

हमारा आधार
उर्जस्वित बिहार

A.O(T)

Notes from prepage may kindly be seen.

In the light of prepage mark 'A', File may kindly be sent to CE (SO) for needful action. Submitted.

[signature] 25-09-25

[signature] 25/09/25

SM(F&A)

[signature] 25/09/25

GM(F&A)

CE(S.O)

[signature] 25/9/25

Notes on prepage and above.

- Instant matter is regarding installation of 2X315 KVA, 11/0.415 KV Sub Station Transformer with extension of nearby 11 KV 02 (two) separate line for providing reliable, stable and uninterrupted power supply to upcoming SLDC (Main-II) under SCADA Phase-III at Chandauti (Gaya).
- SBPDCL has submitted 02 (Two) separate estimate amounting to Rs. 16,76,901=00 for 1X315 KVA with 3 Nos.

C/15-14

बिहार स्टेट पावर ट्रांसमिशन कंपनी लिमिटेड

(An ISO 27001 : 2013 Certified Company)

(रजिस्टर्ड ऑफिस : विद्युत भवन, बेली रोड, पटना)

संचिका संख्या : पृष्ठ सं० :

poles and Rs. 17,69,994=00 for 1X315KVA SST and 4Nos. poles (C/17-16).

- Finance wing has accorded FC for amounting to Rs. 34,46,895=00 (Rupees Thirty four lakhs forty six thousand Eight hundred Ninty five) only. N/11-12.

'A' File is put up for kind perusal and according administrative approval for release of Rs. 34,46,895=00 to SBPDCL for installation of 2X 315KVA SST with extension of 11 KV HT line at Chandauti for SLDC (Main-II) Chandauti, Gaya.

Director (Operations)

25/09/25

ARUN KUMAR CHOUDHARY
CHIEF ENGINEER (SYSTEM OPRETION)
BSPTCL, PATNA

497/C.E.(S.O)
25-09-25

696/Dir(op)
26.09.25

Approval on 'A' above may kindly be considered.

29/9/25
A.K. Singh
Director (Operation)
BSPTCL

M.D. BSPTCL

Rahul Kumar

1337/MD(T)
26-09-25

CE (S.O.)

29/09/25
A.K. Singh
Director (Operation,
BSPTCL

ESE/ULDC

29/09/2025

EEE/ULDC

AEE, ULDC
29.09.2025

हमारा आधार
उर्जस्वित बिहार

TC - 36 - Oriental - 1501 pac - 2024

served vide estimate no. 412.

While 2nd 1x315 MVA distribution transformer the amount is ₹ 1676901/- served vide estimate no. including applicable GST.

In view of the financial concurrence of ₹ 3,446,895/- only including GST may be obtained from account dept. of BSPTCL to execute this work on priority basis.

File is being put-up for kind perusal and further needful.

Arvind Kumar
25.09.2025
ESE ULDC
BSPTCL

CE (S/S)

Notes from N/08 may kindly be perused.

- Instant matter is regarding installation of 2X315 KVA Sub-Station Transformer (SST 11/0.415KV) with extension of 11 KV 02(two) lines for providing stable and uninterrupted power supply of SLDC (Main-II) at Chandauti (Gaya).
- SBPDCL has sanctioned 02 (two) separate estimates amounting to Rs. 16,76,901=00 (C/15-14) and Rs. 17,69,994=00 (C/17-16). Total cost comes to Rs. 34,46,895=00 for installation of 2X315 KVA 11/0.45 KV SST at Chandauti GSS, Gaya for SLDC (Main-II).

Annexure-B

BIHAR STATE POWER TRANSMISSION COMPANY LTD., PATNA

A subsidiary company of Bihar State Power (Holding) Company Ltd., Patna

CIN – U74110BR2012SGC018889

[SAVE ENERGY FOR BENEFIT OF SELF AND NATION]

Head Office, Vidyut Bhawan, Bailey Road, Patna – 800021

Telephone No. 0612 – 2504655, E-mail address – so.dept@bsptcl.bihar.gov.in,

Fax No. 0612 – 2504655, Website- www.bsptcl.in

O.O. No. ....65............/

Dated....27-08-25

ULDC/electrical connection/42/2025

Office Order

In continuation of Letter No. 1917 dated 14.08.2025, regarding approval of payment of Rs. 30,41,809.00 (Excluding GST as applicable) towards installation of 11/0.433 KVA × 2 additional DT for providing 300 KVA HTS-I Connection under ESSD Board Colony, ESD New Capital, PESU (W), Patna, it is to state that an amount of Rs. 30,41,809.00 (Rupees Thirty Lakh Forty-One Thousand Eight Hundred Nine only) is to be deposited by the BSPTCL as the total estimated cost.

The payment shall be made **only through online transfer** in favour of:
Electrical Executive Engineer, New Capital Division, PESU (W)
A/c No.: 442920110000087
IFSC Code: BKID0004429
Bank: Bank of India, Secretariat Branch, Mangles Road, Patna

The aforesaid amount must be deposited **within three months from the date of sanction of estimate.**

This payment amounting to **Rs. 30,41,809.00 (Excluding GST as applicable)**, in reference to **Letter No. 1917**, will be transferred from the **Internal Resource Fund (IRF) of BSPTCL** to the **SBPDCL Deposit Work Account.**

The **approval of the competent authority** has been obtained for the said amount of **Rs. 30,41,809.00 (Rupees Thirty Lakh Forty-One Thousand Eight Hundred Nine only).**

Yours faithfully,

Sd/-
(A.K Chaudhary)
Chief Engineer (System operation)

Memo No.........571........../
Patna, Dated.......27-08-25.......

Copy forwarded to GM(F&A)/Sr. Manager (F&A),BSPTCL for information and further necessary action.

27/08/25

(A.K Chaudhary)
Chief Engineer (System operation)

BIHAR STATE POWER TRANSMISSION COMPANY LIMITED
(A Wholly Owned Subsidiary of Bihar State Power (Holding) Company Limited)
Registered Office : Vidyut Bhawan, Bailey Road, Patna-800021
(CIN : U74110BR2012SGC018889)

U.O.I. No. 46
BSPTCL/CS/2025-26/149

Patna, Dated: 18th July, 2025

SUBJECT: REGARDING APPROVAL OF IMPLEMENTATION OF PATNA ISLANDING SCHEME:

The Board of Directors of Bihar State Power Transmission Co. Ltd. in its 131st Meeting held on 17.07.2025 vide its Resolution No. 131- 06 took following decision:

"**RESOLVED THAT** Board of Directors of the company be and is herby accord its approval on following proposal:

i) Implementation of Patna Islanding Scheme with total estimated cost of Rs. 9,79,32,664., out of which ₹ 7,74,74,538 is eligible for PSDF Funding i.e. (90% of Rs. 8,60,82,820).

ii) To meet the rest 10% of the cost i.e ₹ 86,08,282 & Cost of civil and other items which are not covered in PSDF i.e 1,18,49,844 from BSPTCL Internal resources Fund."

Distribution to:

CE (SO), BSPTCL for information and issuance of needful executive order.

for and on behalf of Board of Directors of
Bihar State Power Transmission Company Limited

18/7/25

(Kriti Kiran)
Company Secretary

883/CE(S.O.)
18/07/25

BIHAR STATE POWER TRANSMISSION CO. LTD., PATNA

(Regd. Office – Vidyut Bhawan, Bailey Road, Patna) (Contact No– 0612-2504655,
M No- 7763817701, Fax No– 0612-2504655, Email ID – so.dept@bsptcl.bihar.gov.in)
(GST No. :- 10AAFCB2393H1Z1, CIN – U74110BR2012SGC018889)
(Department of System Operation of BSPTCL)

Tender Extension Notice for (NIT) NO.- 57/PR/BSPTCL/2025, PR.No. 013388 (B&C)2025-26

Due date for submission and opening of Online tenders for NIT No.57/PR/BSPTCL/2025 turnkey Contracts for "Appointment of agency for turn key contracts for Design, Supply, Erection, Testing and Commissioning for Implementation of Islanding scheme for the city of Patna" is extended as follows: -

Date of Pre-bid meeting	**On 11:00 Hrs. of 25.09.2025**
Bid submission End Date and Time	**Up to 17:00 Hrs. of 09.10.2025**
Last date of submission of EMD and hard copy of receipt of BSEDCL processing fees and tender cost	**Up to 18:00 Hrs. of 09.10.2025**
Date of opening of Techno-Commercial Bid (Part-I):	**After 16:00 Hrs. of 10.10.2025**

1. "Bid Processing Fee is mandatory to be paid through online mode i.e. Internet Payment Gateway (Credit/Debit Card), Net Banking, NEFT/RTGS".
2. Bidders are requested to submit Bid Security Declaration Form (in hard copy) to Chief Engineer (SO), BSPTCL, Vidyut Bhawan, Patna positively up to 18:00 Hrs. of 09.09.2025 failing which the tender shall be summarily rejected.
3. "Bid along with necessary online payments must be submitted through e-payment portal https://eproc2.bihar.gov.in/ before the date & time specified in the NIT. The department doesn't take responsibility for the delay/ Non submission of Tender/ Non-Reconciliation of online Payment caused due to Non-availability of Internet Connection, Network Traffic/ Holidays or any other reason".
4. Eligibility Criteria, tender documents along with General/Special condition, bids and any corrigendum/ addendum of the tender are available only at website **www.eproc2.bihar.gov.in**

Chief Engineer (System Operation)

E-tendering introduced in BSPTCL for tenders above Rs. 25 lacs. For registration log in to www.eproc2.bihar.gov.inand e-Procurement Help Desk Toll free No: 1800 572 6571 , Email Id: eproc2support@bihar.gov.in
Working Hours: 8AM to 7PM (All days in week except few selected state holidays).
While participating in e-tendering process, the contractor shall have to get them registered to get user ID, Passwords and digital signature. This will enable them to access the Website: www.eproc2.bihar.gov.in only.

" विवादों के निष्पादन के लिए लोक अदालत का लाभ उठायें, परस्पर सहमति से न्यायिक निर्णय प्राप्त करें, समय एवं खर्च की बचत करें।"

Sd/-
Chief Engineer (System Operation)

Memo No……………………………/ **Patna, dated …………………………. /**
Copy forwarded to GM (H.R/Adm.), BSPTCL, Patna for kind information.

Sd/-
Chief Engineer (System Operation)

Memo No……………………………../ **Patna, dated……………………………………/**
Copy forwarded to DBA, BSPTCL Patna for uploading the above tender notice on the websites.

Sd/-
Chief Engineer (System Operation)

Memo No……………………………../ **Patna, dated……………………………………/**
Copy submitted to Director (Operation), BSPTCL/ OSD to MD, BSPTCL for kind information.

Chief Engineer (System Operation)

VOLUME-II

DETAILED PROJECT REPORT

FOR

IMPLEMENTATION OF ISLANDING SCHEME FOR PATNA CITY, BIHAR

BIHAR STATE POWER TRANSMISSION COMPANY LIMITED

1. REQUIREMENT OF THE PROJECT

One of the key features of a resilient power system is robust islanding scheme. It allows a part of the System to continue functioning in case of blackout events or any large disturbance in the system. It ensures that essential loads continue to receive power during any major outage.

Ministry of Power (GoI) has directed that islanding schemes should be implemented for all major cities of the country considering all the strategic and essential loads. After deliberation with all stakeholders in different fora, it was decided that an islanding scheme would be implemented for capital city of Bihar, Patna.

Success of an islanding scheme depends on the design as well as implementation of the logic. Logic needs to be robust as well as simple for successful implementation and must have redundancies to ensure its successful operation. It also needs to be impervious to demand growth of the selected area and it should be successful in all possible scenarios.

Extensive studies are required to design an effective islanding scheme considering all possible scenarios. The dynamic behavior of islanding generator needs to be studied in detail while accurately modelling the generating unit coupled with network modelling and estimated load modelling of the island load.

Since Patna city is connected with the rest of the grid at multiple nodes, tripping of all tie lines is necessary for successful islanding of the grid from the grid. Therefore, it is required that the network chosen should be in such a way that minimum number of tie lines need to be disconnected to island the system. It is also required that maximum load selected for the islanding should not be more than 560-570 MW, apart from auxiliary requirement of islanding generator plant.

2. BACKGROUND

In a meeting held on 28th December 2020 and chaired by the Hon'ble Minister of State (IC), in the backdrop of Mumbai Grid disturbance that occurred on 12th October 2020, it was directed that islanding schemes should be implemented for all major cities of the country considering all the strategic and essential loads.

This was deliberated in a special meeting held by ERPC on 01.04.2021 through MS Teams to identify the major cities of Eastern Region for implementation of Islanding Schemes wherein it was decided that an islanding scheme for Patna city would be designed. The same was discussed in 10th NPC meeting held on 09.04.2021.

In another meeting held subsequently on 06.08.2021 by ERPC, it was decided that one unit of NPGCL (3*660 MW) will be taken as the participating generator for Patna islanding. The provision of island formation with one unit of NPGCL with corresponding logic need to be studied and its feasibility need to be checked. ERLDC was advised to conduct a preliminary study to check the feasibility of the Patna islanding with one unit of NPGCL. Bihar was advised to prepare a rough map/SLD of Patna Islanding Scheme with the all the substations and lines intended to form a successful island and submit the same to ERLDC.

Accordingly, a preliminary study was done by ERLDC to check the feasibility of Patna islanding with one unit (660 MW) of NPGCL after taking necessary inputs from Bihar and NPGCL (attached at Annexure-E). A tender was thereafter floated by Bihar for preparation of DPR, however it was cancelled due to no participation from vendors.

In 45th TCC Meeting held on 25.03.2022, a technical committee was formed comprising of the members from BSPTCL, SLDC Bihar, and NPGC, PowerGrid, ERLDC and ERPC for finalizing the Islanding Scheme. NPGCL was directed to conduct a detailed dynamic study of the islanding, which was conducted by M/s Solvina and the final report was submitted in May 2024 (attached at Annexure-F).

In 221st OCC Meeting held on 27.11.2024, ERLDC was advised to form a joint committee with SLDC Bihar, NTPC and Bihar DISCOMs for regular monitoring of implementation of Patna islanding scheme.

An online meeting was conducted on 05.12.2024 to expedite the implementation of Patna islanding scheme wherein SLDC Bihar was advised to submit load details (Maximum and minimum) of Patna Island in current scenario and the list of feeders to be tripped. NPGCL, NTPC was requested to communicate within a week via letter that NPGC unit is capable of islanding operation and there is no requirement of non-linearity test.

NTPC submitted that one limitation of machine as pointed out by M/s GE is that the maximum time limit for which the NSTPS turbine can be exposed to 103% overspend limit is 20 minutes for the complete lifecycle of turbine. The said condition is appearing for 5 seconds in one of the scenarios when generation is maximum and Patna load is minimum. NTPC consented for participation of NPGC Unit for islanding subject to the mentioned limitation.

In 222nd OCC meeting held on 23.12.2024, ERLDC was advised to finalize Patna islanding logic considering overspeed limitation of NPGC units. Bihar SLDC was advised to identify loads to be included in the islanding scheme.

Based on the feasibility study conducted by ERLDC, detailed dynamic study by M/s Solvina, necessary inputs from NPGCL, NTPC and network and load details from Bihar, a Detailed Project Report has for the islanding has been prepared in consultation with all the stakeholders.

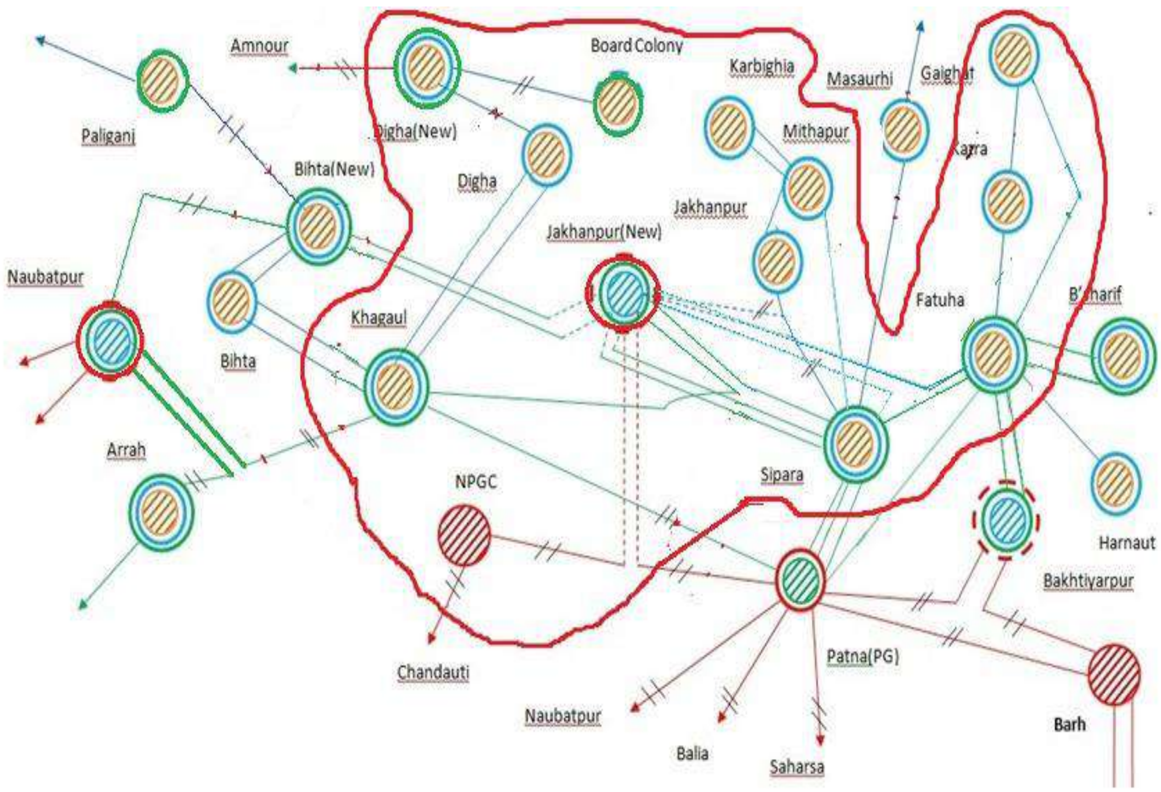
3. OBJECTIVES OF ISLANDING SCHEME OF PATNA:

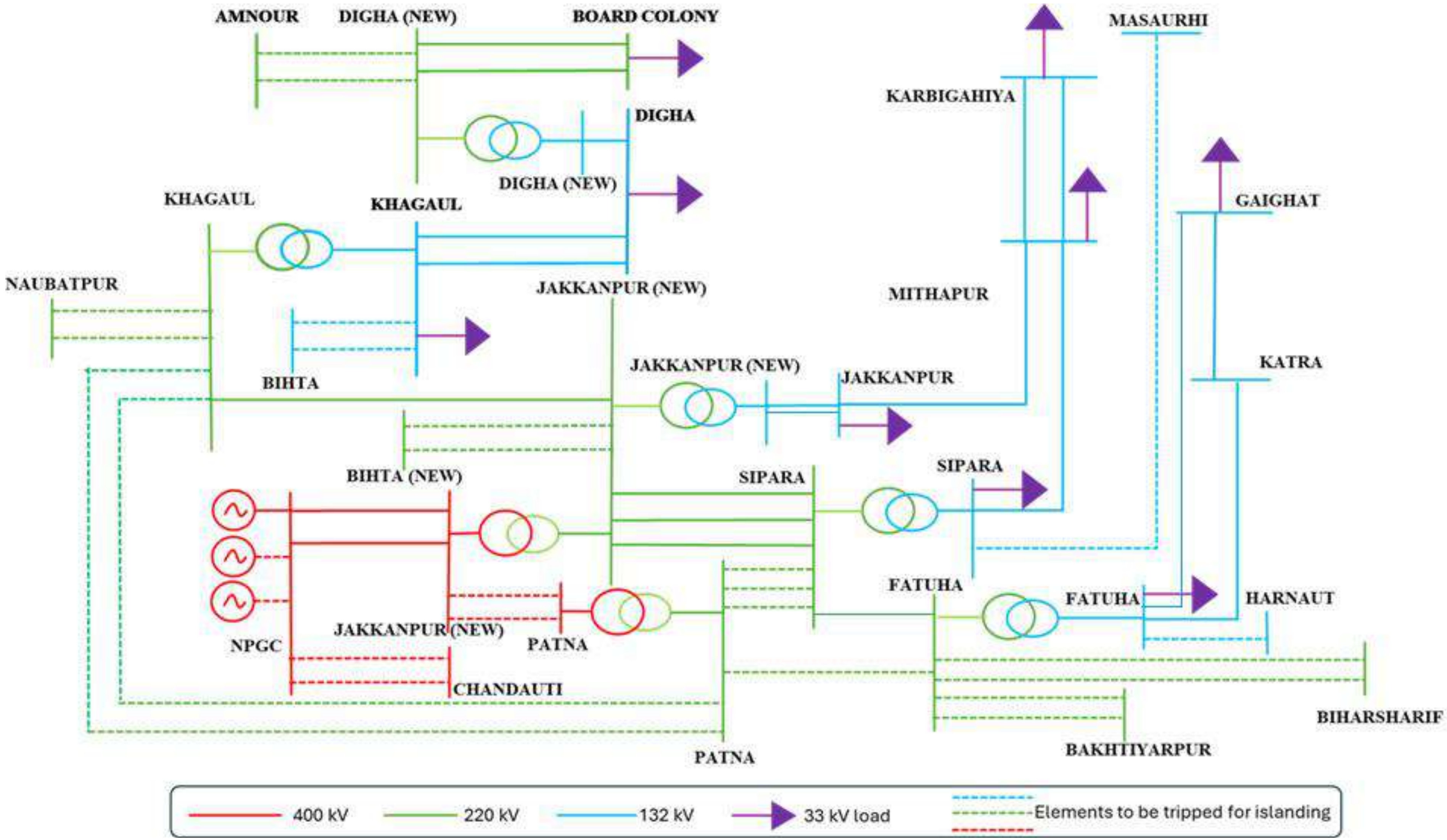
Objectives of the islanding scheme are:

- To isolate one running unit of NPGC (660 MW) with pre-identified load of Patna city and nearby areas.
- After isolation of selected loads and NPGC through the identified network, run the island in islanded mode to cater the city load.
- To extend start-up supply to generating stations in adjoining area to facilitate early restoration.

4. PATNA ISLANDING NETWORK:

Patna city and nearby loads will be islanded with one of the running units of NPGC (660 MW). NPGC is connected to the grid through 400 kV NPGC-Jakkanpur D/c and 400 KV NPGC-Chandauti D/c lines. For the islanding 400 kV NPGC-Jakkanpur D/c and at Jakkanpur through 400/220 kV ICTs, pre-identified 400, 220 and 132 kV feeders will be tripped to confirm the islanding of the Patna city load from the rest of the grid with one unit of NPGC.





SLD of Patna Island

ISLANDING SCHEME OVERVIEW

Pre-Islanding 48.4 < F < 48.6 Hz

- Load -generation balancing for smooth islanding by Optimizing load curtailment among **37 Nos** of Feeders based on priority.
- Tripping of pre identified tie lines (**20 Nos** of tie lines at 220 & 132 KV level) for getting prepared for smooth and reliable islanding.

Stage 1 – Islanding at 48.4 Hz

Tripping of Pre identified feeders/ tie lines with grid (**2 Nos** of 400 KV feeders) for island formation and isolation from rest of the Grid. Breaker tripping at NPGC for keeping 1 unit with Island.

Stage 2 – Post-Islanding

- **Stage 2A:** 80 MW (**5 Nos** of 33kv Feeders) at 48.2 Hz
- **Stage2B:** 40 MW (**2 Nos** of 33kv Feeders) at 48.0 Hz
- **Stage 2C:** 50 MW (**3 Nos** of 33kv Feeders) at 47.8 Hz

5. ARCHITECTURE OF THE ISLANDING SCHEME:

To safeguard the system from grid collapse, a robust Islanding system is required which will consist of numerical islanding controller having features of under frequency with Special Protection Schemes depending upon system conditions.

It is proposed to install a numerical controller on each sub-station depending upon number of feeders at the sub-station. Master Islanding Controller will be installed at SLDC Bihar which will have inputs of load and generation of identified islanding feeders and islanding unit of NPGC. The master controller will calculate load generation balance and will start minimizing the imbalance by tripping low priority feeders within the islanding network once frequency reaches a threshold (48.6 Hz) which is higher than the islanding frequency. The slave islanding controller will be installed at different sub-stations on the load side at 33 kV level. The Master islanding controller shall monitor the frequency of the bus and have a programmable feature to issue command based on different frequency stages or as per the output logic to minimize load generation imbalance. The output command will transmit through BSPTCL's OPGW network to trip different lines/ feeders as per logics through Slave islanding controller. Slave islanding controller will issue the trip command through auxiliary tripping relay and give feedback to the master controller.

After normalization of grid disturbance, the tripped lines/ distribution feeders may be restored after obtaining clearance from SLDC.

The status of all circuit breakers, Protection stages, operation of Auxiliary relay of islanded zone shall be monitored through OWS (Operating WorkStation) at SLDC Bihar. Sequence of event will be recorded with time stamping at master controller.

6. ISLANDING SCHEME AND LOGIC

As demand of identified feeders may increase/decrease with time, to maximize chance of survival, it is necessary to have a central logic system which will monitor load and generation balance and will trip feeders prior to islanding if frequency reaches below a certain point.

Since the islanding is being done with one unit of NPGC along with the critical loads of Patna city amounting 568 MW (Feeders mentioned in list of feeders priority wise) only needs to remain within the island at the time of island formation, rest other loads within Island should trip before the Island formation via UFR stage 3 & 4 and if required one additional UFR at 48.7

Hz with 100ms delay to be put in remaining feeders to ensure that only available list of priority feeder is only in service .

As the cities demand may further grow slowly on yearly basis, it is important to ensure that only the priority list /critical load feeder is there at the time of island formation.

So, if any additional feeder is coming in future, it should trip before Pre-islanding frequency (48.6 Hz), either by integrating in UFR stage 3 or 4 or by putting the additional stage at 48.7 Hz with 100 Ms delay so as to ensure that no other feeder is in service apart from the mentioned feeder list before pre-islanding stage (48.6 Hz).

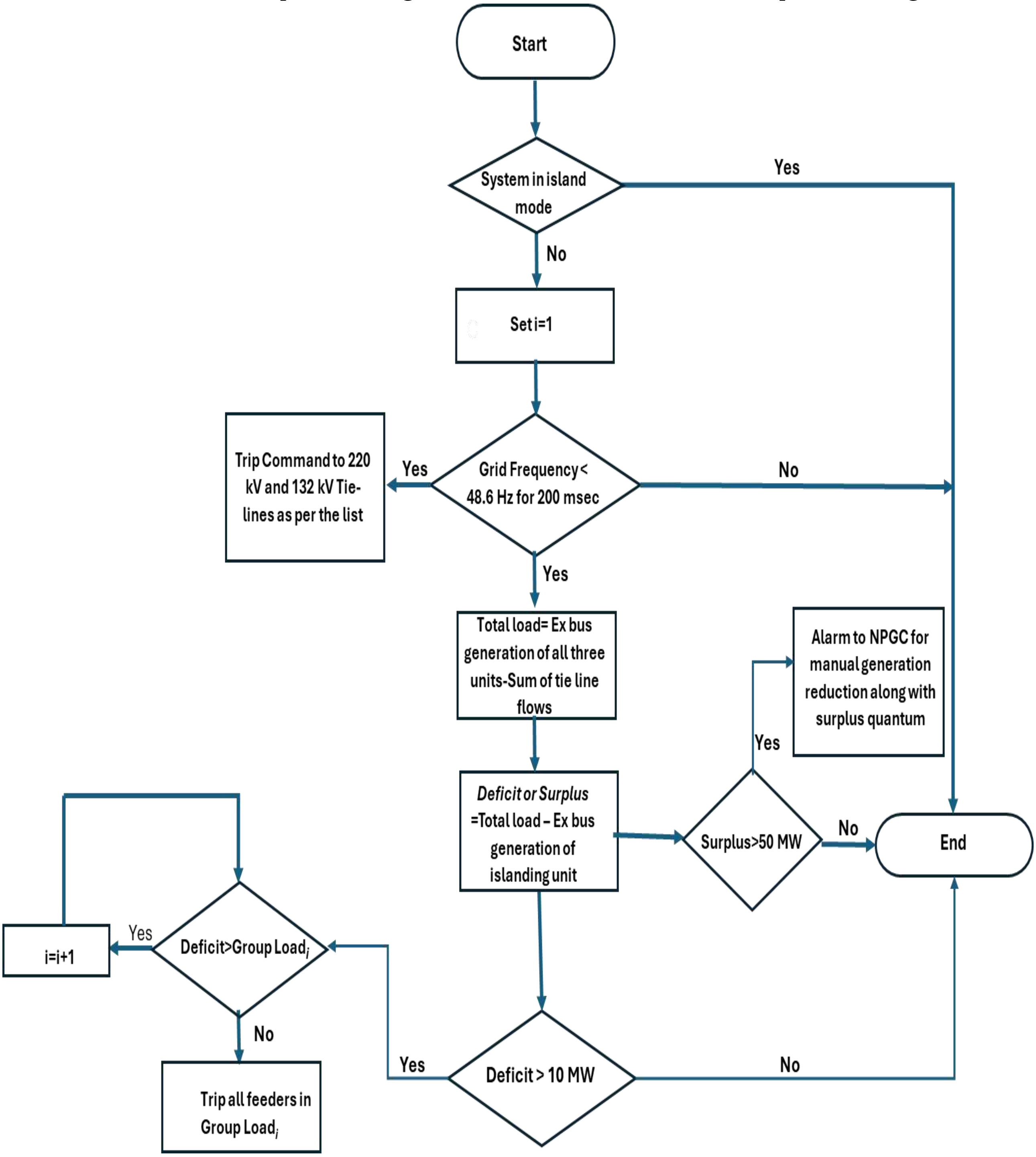
a. **Pre-islanding (Centralized Island Monitoring Unit):**
   - There will be a **Centralized Island monitoring and control unit** needs to be installed at SLDC Bihar for continuous monitoring of load and generation balance in the island. It is necessary to maintain the load generation balance within the island for island stability.
   - The control scheme will continuously monitor frequency, load generation imbalance and will trip identified feeders' priority wise if load generation imbalance goes beyond a certain limit and frequency reaches 48.6 Hz for 200 msec.

b. **Islanding (2 stages):**
   - When Frequency reaches 48.4 Hz, then with a delay of 500 msec, identified system will be islanded. For islanding, several tie lines need to be tripped to isolate the system from the grid. The command to trip the feeders will go from the Central master controller. As a back-up UFR relays may be installed in the identified feeders set at 48.4 Hz and 500 msec time delay.
   - After islanding, another stage of feeder disconnection is also to be done if island frequency decreases. Three sub-stages are set after islanding and UFR relays will be installed on the identified feeders to get the desired load relief.
     i. Stage 2A: 80 MW at 48.2 Hz
     ii. Stage 2B: 40 MW at 48.0 Hz
     iii. Stage 2C: 50 MW at 47.8 Hz

Logic schemes for each stage is detailed as below:

Pre-Islanding tie-lines and load disconnection at 48.6 Hz for smooth islanding through Central Master Controller

Load /Feeders selected for pre-islanding disconnection will be identified as per below logic:



Sum of flow all the tie-lines that will be tripped during islanding will be taken to calculate total load within the island. The list of tie lines is given in the islanding logic Stage-1. (Sign Convention for tie line flow: +Ve if flowing towards the grid, -Ve if flowing from the grid)

Group load will be calculated as sum of loads in individual feeders taking low priority feeders in following way:

Group Load$_1$=Low Priority_ 1
Group Load$_2$=Low Priority_ 1 + Low Priority_ 2

Group Load$_3$=Low Priority_ 1 + Low Priority_ 2 + Low Priority_ 3

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Group Load$_n$=Low Priority_1 + Low Priority_ 2 + Low Priority_ 3 +....... + Low Priority_ n

The list of feeders identified for tripping to maintain load generation balance are as follows:

Priority wise list of Feeders within the Island:

S.No	At S/s	Feeder	Peak Load (MW)	Priority
1	GAIGHAT GSS	33 KV BAHADURPUR (GAIGHAT)	19.4	Low Priority_1
2	JAKKANPUR GSS	33 KV URJA BHAWAN	18.0	Low Priority_2
3	JAKKANPUR GSS	33 KV PESU 8	14.8	Low Priority_3
4	KARBIGAHIYA GSS	33 KV RAILWAY	6.9	Low Priority_4
5	MITHAPUR GIS GSS	33 KV BAHADURPUR (MITHAPIUR GIS GSS)	18.0	Low Priority_5
6	KARBIGAHIYA GSS	33 KV PESU-4	17.0	Low Priority_6
7	KARBIGAHIYA GSS	33 KV PAHARI-2 & 33 KV PRESS CLUB	21.9	Low Priority_7
8	GAIGHAT GSS	33 KV MEENABAZAR	15.5	Low Priority_8
9	GAIGHAT GSS	33 KV MACHHUATOLLI	20.9	Low Priority_9
10	DIGHA GSS	33 KV Rajapur	21.1	Low Priority_10
11	MITHAPUR GIS GSS	33 KV IOCL	1.1	Low Priority_11
12	KHAGAUL GSS	33 KV KHAGAUL-5	19.0	Low Priority_12
13	KARBIGAHIYA GSS	33 KV PESU-5	12.3	Low Priority_13
14	MITHAPUR GIS GSS	33 KV MITHAPUR-3	6.0	Low Priority_14
15	KHAGAUL GSS	33 KV DANAPUR-2	20.0	Low Priority_15
16	DIGHA GSS	33 KV Excise -1	21.2	Low Priority_16
17	GAIGHAT GSS	33 KV SAIDPUR	19.3	Low Priority_17
18	KARBIGAHIYA GSS	33 KV PESU-2	21.1	Low Priority_18
19	JAKKANPUR GSS	33 KV URJASTADIUM	19.3	Low Priority_19
20	JAKKANPUR GSS	33 KV SACHIWALAY	8.6	Low Priority_20

21	JAKKANPUR GSS	33 KV PESU 9	21.0	Low Priority_21
22	DIGHA GSS	33 KV Patliputra	19.1	Low Priority_22
23	DIGHA GSS	33 KV NEW BOARD COLONY (DIGHA GSS)	23.0	Low Priority_23
24	BOARD COLONY GSS	33 KV NEW BOARD COLONY (BOARD COLONY GSS)	11.7	Low Priority_24
25	BOARD COLONY GSS	33 KV IGIMS-I	13.9	Low Priority_25
26	BOARD COLONY GSS	33 KV BOARD COLONY (BOARD COLONY GSS)	7.3	Low Priority_26
27	JAKKANPUR GSS	33 KV PESU 3	20.1	Low Priority_27
28	JAKKANPUR GSS	33 KV S K PURI	19.2	Low Priority_28
29	GAIGHAT GSS	33 KV GAIGHAT GIS	10.0	Low Priority_29
30	BOARD COLONY GSS	33 KV VETERINARY (BOARD COLONY GSS)	4.7	Low Priority_30
31	KARBIGAHIYA GSS	33 KV BAHADURPUR (KARBIGAHIYA)	10.4	Low Priority_31
32	GAIGHAT GSS	33 KV GAIGHAT	13.0	Low Priority_32
33	JAKKANPUR GSS	33 KV BSEB	18.1	Low Priority_33
34	BOARD COLONY GSS	33 KV IGIMS-II	11.7	Low Priority_34
35	MITHAPUR GIS GSS	33 KV TELECOM	14.0	Low Priority_35
36	KARBIGAHIYA GSS	33 KV S K MEMORIAL	16.1	Low Priority_36
37	JAKKANPUR GSS	33 KV SINCHAI BHAWAN	8.0	Low Priority_37
Total			**562.8 MW**	

Action in case of deficit in the island: The master controller will send tripping command to 33 kV feeders based on the output of the Pre-islanding logic and all the 33 kV feeders coming in the Group $Load_n$ will be tripped at once.

Action in case of surplus in the island: The master controller will send an alarm to NPGC for manual generation reduction in case surplus is more than 50 MW. As per the dynamic study (Ref. Annexure-E & F), in the scenario when generation is maximum and load is minimum, with a surplus of 140 MW, frequency is rising to 51.7 Hz. Hence if an alarm is received at NPGC for generation reduction then same may be immediately acted upon.

*NPGC will also have an OWS where the load and generation of the island will be displayed based on the data received from master controller.
For ensuring smooth islanding, stepwise isolation of network needs to be ensured so that at the time of final islanding minimum number of breakers need to be opened at 48.4Hz. All

interconnection points with grid at 220 and 132 KV level will be tripped except 400 KV at 48.6 Hz with 200 msec delay.
The master controller at SLDC Bihar will send the tripping command for breakers to the following feeders (When frequency is below 48.6Hz for 200 msec) for getting prepared to ensure smooth islanding.

List of Feeder tripping when frequency is less than 48.6Hz

Sr.No.	Name	Breaker to be opened at	CKts
1	220 KV Patna -Sipara-1,2&3	Sipara	3
2	132 KV Sipara-Masaurhi		1
3	220 KV Patna-Khagaul D/c	Khagaul	2
4	220 kV Khagaul-Naubatpur D/c		2
5	132 KV Khagaul-Bihta D/c		2
6	220 kV Patna-Fatuha S/c	Fatuha	1
7	220 KV Fatuah -Bakhtiyarpur D/c		2
8	132 KV Fatuha-Harnaut		1
9	220 KV Fatuah -Biharsharif D/c		2
10	220 KV Digha New -Amnour D/c	Digha New	2
11	220 KV Jakkanpur (New)-Bihta (New) D/c	Jakkanpur	2
	Total		**20**

As a backup, UFR will be installed/enabled in all the above tie-lines at the nodes inside the island at 48.6 Hz with 200 msec delay ensuring isolation of the island from the rest of the grid.

Islanding at 48.4 Hz

Stage-1:

Islanding would commence at 48.4 Hz due to following reasons:

- As Last stage of UFR(Stage-4) is at 48.8 Hz and when frequency is going below last stage there is no further mechanism to improve the frequency hence to safeguard the critical load of city, islanding would commence at 48.4 Hz keeping a margin of 0.4 Hz.
- Also, Island should commence at a stage that after islanding frequency of island should not fall below the under-frequency setting of Islanding unit (47.5 Hz) else unit will trip and island will collapse.
- Once the island is formed the inertia of islanded system will be very small and ROCOF (Rate of change of frequency) will be very high and even for a small load generation imbalance frequency will decline sharply and may lead to tripping of islanded unit on Under frequency (Ref. Annexure-E & F).
- So, keeping a margin and stage wise scope of corrective actions for frequency improvements island formation will occur at 48.4 Hz.

For islanding the isolation of entire islanding network needs to be ensured. The master controller at SLDC Bihar will send the tripping command for breakers to the following feeders to ensure islanding:

Sr.No	Name	Breaker to be opened at	CKts
1	400 KV Patna-Jakkanpur D/c	Jakkanpur	2

As a backup, UFR will be installed/enabled in all the above tie-lines at the nodes inside the island at 48.4 Hz with 500 msec delay ensuring isolation of the island from the rest of the grid.

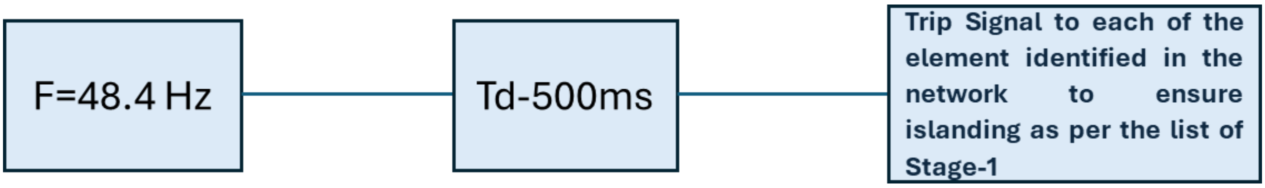
<u>At NPGC</u>

- **The selected unit will be islanded with 400 kV NPGC-Jakkanpur D/c and ICTs and will be isolated from the rest of the network.**
- **Through slave controller, specific breakers need to be tripped as per the pre-identified islanding unit to ensure that the unit alongwith 400 kV kV NPGC-Jakkanpur D/c and ICTs for meeting the auxiliary load comes within the island and rest other elements at NPGC are shifted to other bus on the grid side (Ref. NPGC SLDs in Annexure-D).**
- **As a backup, UFR will be enabled at NPGC to trip breakers corresponding to selected islanding unit at 48.4 Hz with 500 msec delay ensuring isolation of the selected unit for island formation, rest other elements at NPGC will be shifted to other bus.**
- **A signal from master controller at SLDC will be sent to NPGC also to run the islanding unit in speed control mode after islanding.**

- **If UFR operates, then also a signal must go to the islanding unit to run in speed control mode.**

Logic of implementation:

At SLDC Patna:



Whenever grid frequency reaches to 48.4 Hz, Master controller unit will initiate Trip signal to all the circuit breakers of the above-mentioned lines through respective slave controller unit.

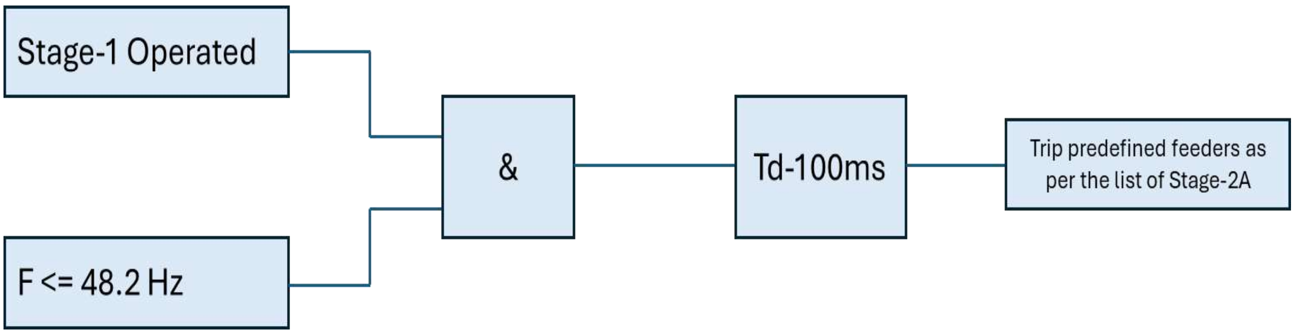
Stage-2:

After successful formation of the island in the first stage, frequency of the islanded network along with island voltage (at 220KV level) shall be monitored by the islanding panel. If the islanded system frequency again falls, then Stage -II islanding will be active. In Stage -II, tripping will be occurred in following three stages.

Under frequency load shedding inside the island is proposed to trigger at 48.2 Hz with 100 msec time delay. Load shedding of remote end feeders may be done accordingly via communication network established between the islanding panel and feeders in the islanded system.

Following logic may be used to implement under frequency load shedding in the islanded network.

Stage-2 A



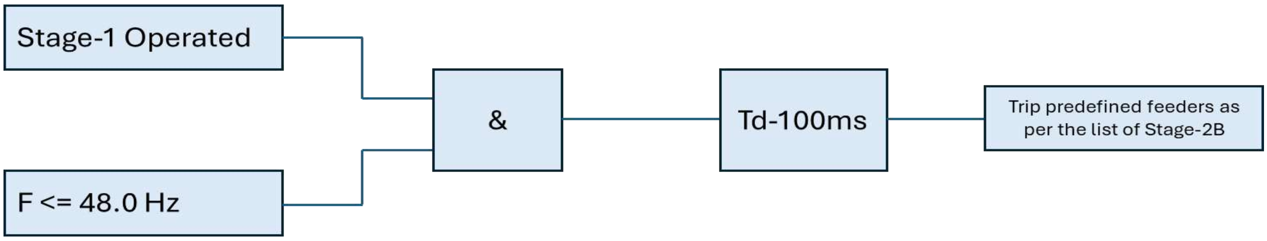
If frequency reaches 48.2 Hz, then around 80 MW will be disconnected. Following feeders* may be selected for UFR:

S.No.	At S/s	Feeder	Peak Load (MW)
1	KHAGAUL GSS	33 KV KHAGAUL-5	19.0
2	KARBIGAHIYA GSS	33 KV PESU-5	12.3
3	MITHAPUR GIS GSS	33 KV MITHAPUR-3	6.0

4	KHAGAUL GSS	33 KV DANAPUR-2	20.0
5	DIGHA GSS	33 KV Excise -1	21.2
Total			78.5 MW

*Considering a scenario of minimum generation and maximum load (350 MW minimum generation and 560 MW maximum load, 210 MW is kept for Central logic to disconnect pre-islanding. Feeders for UFR after islanding has been selected after that based on priority order submitted by SLDC Bihar.

Stage-2 B

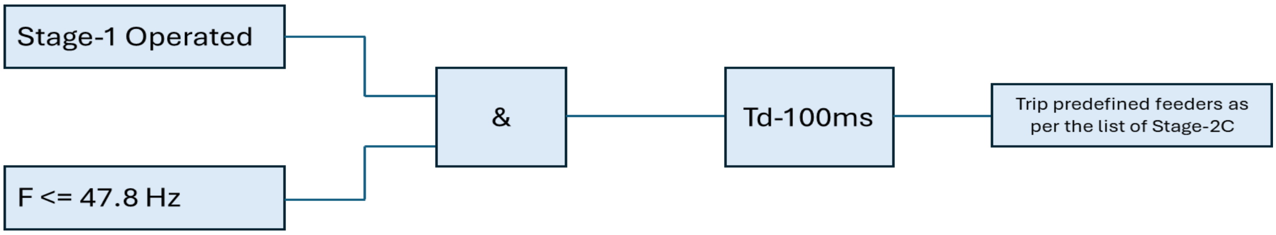


List of Feeders for stage-2B:

If frequency reaches 48.0 Hz, then around 40 MW will be disconnected. Following feeders may be selected for UFR:

S.No.	At S/s	Feeder	Peak Load (MW)
1	GAIGHAT GSS	33 KV SAIDPUR	19.3
2	KARBIGAHIYA GSS	33 KV PESU-2	21.1
Total			40.4 MW

Stage-2 C



List of Feeders for stage-2C:

If frequency reaches 47.8 Hz, then around 50 MW will be disconnected. Following feeders may be selected for UFR:

S.No.	At S/s	Feeder	Peak Load (MW)
1	JAKKANPUR GSS	33 KV URJASTADIUM	19.3
2	JAKKANPUR GSS	33 KV SACHIWALAY	8.6
3	JAKKANPUR GSS	33 KV PESU 9	21.0
Total			48.9 MW

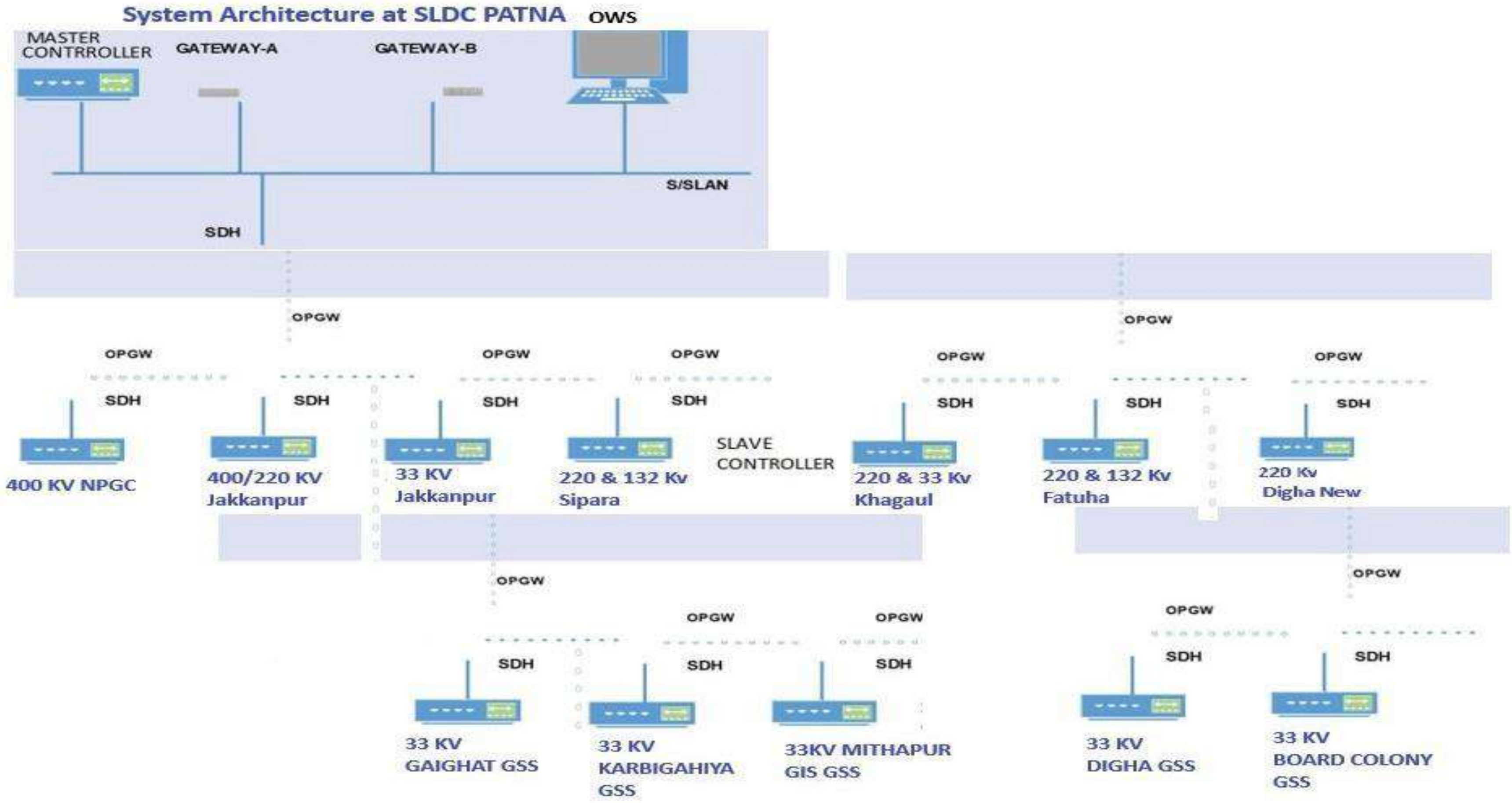
Points to be kept in consideration:

- Redundant communication from centralized unit control at SLDC Patna to all feeders needs to be ensured without any delay.
- The centralized scheme should have test mode along with arming and disarming mode to ensure that mock testing can be performed without actual breaker tripping by ensuring communication/command signals are reaching the last mile.
- Scheme should be using the existing relays capability to maximum and should have enough redundancy at each level to ensure its successful operation.
- Scheme design should be done also considering in case of any failure of one main control unit, the backup controller should be live and in armed condition.
- In case of high rate of change of frequency, it may happen that islanding stage reaches before pre-islanding loop gives tripping command to 33 kV feeders for load generation balance. The time taken to trip 33 kV feeders after running of logic need to be checked and time delay for islanding and pre-islanding need to be adjusted to avoid any race around. The same needs to be measured during testing and documented.
- NPGC to decide about the scheme regarding unit selection during islanding as it will require tripping of breakers to create island. This requires flexibility based on selection of units with one and half scheme bus arrangement. It should be noted that islanding should not be unit specific and should work even with one unit in service during actual conditions.
- The information regarding the unit selected for islanding should automatically reach to the Centralized unit at SLDC Bihar, generation of that unit will be used for disconnection during pre-islanding.
- NPGC must ensure that during islanding, islanded unit auxiliary or any AC connection between existing units and islanded units should not be there as it will create a loop with the grid.
- In case of surplus generation, care needs to be taken that maximum frequency does not go beyond overspeed setting of the unit. As per the study conducted by M/s Solvina, maximum frequency is expected to touch 51.83 Hz, the overspeed setting need to be modified accordingly.
- Islanding system of Patna need to be implemented by inviting tender with suitable vendors with proposed scope of work and scheme.
- Remarks / observations of vendors in respect to SLDC Patna's scope are to be checked.
- Necessary changes of DCS system at NPGC may be implemented by NPGC with necessary support from OEM.
- Suggestion for revision of Over Speed and Over Frequency setting of NPGC generating units are to be discussed with OEM and final recommendation of OEM is to be implemented.
- No feeder within the islanded zone should be covered under the existing ADMS/UFR scheme.
- Data visibility up to 33KV feeders need to be ensured and made available to Central Logic scheme.
- A display page in the Scada system of Islanded Zone is to be setup at SLDC Bihar and ERLDC.

System Description and Scope of Work

I. **System Description**

As per the requirement of the Islanding & Load Shedding System, Architecture of the system will be:



Slave controllers with identified actions

Sr. No	Substation	Action
1	400 KV NPGC	Breaker tripping for island formation and Governor status change
2	400/220/132 KV Jakkanpur	Feeder tripping for island formation
3	220/132/33 KV Sipara	Feeder tripping for island formation
4	220/132/33 KV Khagaul	Feeder tripping for island formation G Load disconnection
5	220/132/33 KV Fatuha	Feeder tripping for island formation
6	220/132/33 KV Digha New	Feeder tripping for island formation
7	132/ 33 KV Gaighat GSS	Load Disconnection
8	132/ 33 KV Karbigahiya GSS	Load Disconnection
G	132/ 33 KV Mithapur GIS GSS	Load Disconnection
10	132/ 33 KV Digha GSS	Load Disconnection
11	132/ 33 KV Board Colony GSS	Load Disconnection
12	132/33 KV Jakkanpur	Load Disconnection

II. Cost Estimate for the Project

The cost estimate for the complete project is around 9.79 Cr (Including taxes).

PRICE SCHEDULE-SUMMARY		
Implementation of Patna Islanding Scheme		
Sl. No.	Description	Amount (in Rs)
1.	Total Price of Supply of all materials and equipment including F&I and GST	7,55,27,903
2.	Total price for Erection, Testing & Commissioning Charges including GST.	1,06,58,791
3.	Total Price for Civil Works including GST	1,17,45,970
4.	Total price for the complete project (in figure)	9,79,32,664

II.Implementation Timeline

S. No.	Details	Tentative Timeline
1.	Tendering and Order	3 months
2.	Supply of materials and implementation	12 months
3.	Testing and commissioning & Training	3 months

III. Bill of Materials:

The items against ''Design, Engineering, Supply including transportation, storage of Islanding System'' is to be considered with following materials as a complete Lot as to be supplied by the successful bidder:

Sr.N	Description	SLDC Patna	400 kV NPGC	400/220/132 KV Jakkanpur (New)	132/33 KV Jakkan	220/132 /33 KV Sipara	220/1 32/33 KV	220/13 2/33 KV	220/132 /33 KV Digha	132/ 33 KV Gaighat	132/33 KV Karbigahi	132/33 KV Mithapu	132/33 KV Digha	132/ 33 KV Board
1	Master Controller / Master Remote Terminal Unit (RTU)	2	0	0	0	0	0	0	0	0	0	0	0	0
2	OWS(HMI)	2	1	0	0	0	0	0	0	0	0	0	0	0
3	Panel/Load Shedding Cabinet	1	1	1	1	1	1	1	1	1	1	1	1	1
4	LAN Switch	2	1	1	1	1	1	1	1	1	1	1	1	1
5	Slave Controller /Slave RTU	0	1	1	1	1	1	1	1	1	1	1	1	1
6	Auxiliary Relay (Heavy Duty Relay)	0	12	6	11	6	8	7	3	8	9	6	6	7
7	Supervision Relay	0	12	6	11	6	8	7	3	8	9	6	6	7
8	Multi Functional Meters	0	4	6	11	6	8	7	3	8	9	6	6	7
9	Annunciator	1	1	1	1	1	1	1	1	1	1	1	1	1
10	NIT Switch with Lock & Key	0	0	0	0	5	8	7	3	0	0	0	0	0
11	Contact Multiplication Relay	0	12	7	11	7	9	8	4	0	0	0	0	0
12	GPS System	1	0	0	0	0	0	0	0	0	0	0	0	0
13	Frequency Meter	2	0	0	0	0	0	0	0	0	0	0	0	0
14	Control Cable	Digital Input Cable: 12C X 1.5 mm2 Cu cable of length-3.5 KM Digital Output Cable: 4C X 2.5 mm2 Cu cable of length-5 KM												
15	Power Cable	4Cx 2.5 mm2 Cu. Cable of length, 1.2 KM												
16	6 core FOC without armour	1.5 KM												
17	Cat -6 Cable	1.5 KM												
18	LC/FC/PC) type 10	13 Nos												

IV. Brief Description of Scope of Work

A. SCOPE OF WORK:

The scope of work includes Design, engineering, manufacturing, testing, supply including transportation and insurance, storage, erection, testing and commissioning of Islanding System. The indicative Scope of work is as given:

1. Based on philosophy of the Islanding Scheme, the Master islanding panel is to be installed at SLDC Patna and will be used to install the Master Islanding Controller (02 nos.), redundant Gateway system, Lockout relays, Auxiliary relays& OWS PC hardware as shown in the system architecture above. The hardware would be further connected to the OPGW network through the SDH available at this location.

2. The OWS (operating workstation) will monitor the Status of SLDC Patna Islanding network and building up of logics.

3. The Slave load shedding controller (13 nos.) will be installed at the locations mentioned in above architecture respectively. The entire system would be connected through the existing OPGW network through SDH provided by SLDC Bihar/BSPTCL.

4. The load shedding Slave Controller at each location would be installed at different Substation along with transducer modules will get connected with the main gateway using any standard communication protocol and the MFMs will also be connected to the Slave /Master Controller using any standard communication protocol.
5. The slave controller at NPGC will be configured such that it will give tripping command to specific breakers at NPGC as per selected islanding unit (Out of three units). These units will be manually selected at NPGC end and generation data of that particular unit will be communicated to master controller for Pre-islanding calculation.

6. Slave Islanding Controller will be used for tripping different lines/ feeders through auxiliary relays at remote Substation/Switchyard, Monitoring of CB status (open/close, trip coil/healthy status/CB drive ready status etc.) of the feeders /bays which are to be included in this scheme. CB status of the feeders/bays for the future expansion of the system may also be wired to the input module of the slave Controller. The tripping path will be using the existing tripping path of the CB i.e the cables to be terminated from Load shedding Panels to existing Control Panels. If required Auxiliary Contactors may be used to check the CB Status (spare core is not available for the breaker status). Status of Trip Transfer Switch is to be taken care of for tripping the lines which are diverted through Bus coupler to be tripped during islanding mode. In Substations/PH, where there is no provision of NIT switches due to BUS side CT scheme, NIT switches with sufficient spare contacts must be installed and commissioned.

7. MFMs (Multifunction meters) are considered to monitor the MW & MVAR for the feeders at each S/S.

8. The Central processing Unit (CPU) or Master Islanding Controller will be interfaced with Slave Controllers at each location through OPGW network. Using the data collected from the SLAVE Controllers and the transducers and combination of the advanced automation applications, the Master Controller will send the control commands to the Slave Controllers in the field to achieve the desired sequential load shedding function. The details of the implementation of the logic in the Master Controller would be decided based on the implementation philosophy shared in the Architecture Islanding Scheme (Mentioned above section). The field Panel should have Annunciators to understand that islanding has taken place and tripping of feeder through islanding has been taking place.

9. Digital Outputs shall be provided in a dedicated spare terminal inside Slave Load Shedding panel at NPGC generating station, for GE input (to change characteristic Governors of pre identified Islanding unit to Speed control mode).

10. The restoration will be taking place manually as per instruction of SLDC Bihar But the required input from Line CVT may be taken whenever Grid to be synchronized.

11. The new GPS Clock has to be installed & commissioned at SLDC Patna for Time Synchronisation among the Master and Slave Controller of Islanded zone.

12. A replica of Islanded Zone i.e display page in SCADA shall have to be shown at SLDC, Patna and at ERLDC on real time basis.

13. Dismantling of Panels if required at site is to be carried out as per direction of Engineer- In-charge.

14. **Any modifications in configuration, including integration of additional Generating Units, Grid Substations (GSS), or other network elements. In such cases, the successful bidder shall undertake the necessary re-configuration, updating, and validation of the application software, Islanding logics, Master/Slave Controllers, and associated communication links to ensure sustained reliability and seamless operation of the Islanding Scheme.**
15. Prepare comprehensive SOPs for SLDC operators for pre-islanding, islanding, and post-restoration actions.

Note: There should be provision for integrating additional load feeder and for changing the feeder already integrated with the Master controller. Also, there should be scope of expansion for including new tie-lines if there is any change in network configuration.

V. Implicit in Scope

The following shall be considered as inherent in the scope of work:

a. Transportation, unloading and storing of all equipment and materials covered in the scope of supply.

b. Collection, loading, transportation, unloading and storing at site of the equipment and materials covered under Owner's scope of supply from any site store of BSPTCL or Unified Store.

c. Arrangement of insurance coverage & security for all equipment including those to be supplied by the Owner during transit, storing, erection and commissioning at site.

d. Preparation of temporary roads wherever required for approaches and transportation of heavy equipment.

e. Employment of the services of original equipment manufacturer's representative in the erection and adjustment of the equipment. The cost of the same shall be included in the quoted of the respective equipment.

The List of items for which manufacturer's commissioning supervision is must, are as follows:

1. The complete Islanding System.

Note: The installation, testing and commissioning of the equipment indicated above, in any case, shall be carried in presence of the employee of the Original Equipment Manufacturer only.

VI. Scope of Design

Design and drawing of all equipment, structures and foundation of the Islanding System needed for the substation as per Purchaser's requirement.

VII. Scope of Supply

The scope of supply is listed in the Schedule of prices for supply items. Supply of materials along with spares and accessories shall be made as indicated in the price schedule. The quantity against each item is indicated in the price schedule may vary during the detailed engineering stage. It shall be binding on the contractor to execute the order with any addition and /or deletion of item(s), and change of quantity, as required for the complete erection and commissioning, but not specifically covered in the price schedule, shall be supplied by the Contractor as per terms and conditions along with settled contractual rate and the rate shall be valid till successful commissioning of the project.

a. **Completeness of Supply**: Equipment shall be complete and operative in all aspects and shall conform to the highest standard of engineering, design and workmanship. Any material or accessory which may not have been specifically mentioned but is necessary or usual for satisfactory and trouble-free operation and maintenance of the equipment and for completion of the total job shall be supplied without extra cost.

b. **General Requirement:** All equipment and materials to be supplied shall conform to the following:

1. Specifications, codes, and standards indicated herein.

2. Equipment and materials conforming to any other standard, which ensures equal or better quality, may be accepted. In such case, copies of the English version of the Standard adopted shall be submitted along with the bid.

VIII. Scope of Erection

- Bidders may note that the job being on turn-key contract basis anything incidental not specifically mentioned in the item-descriptions in the Price Schedule but required for completion and safe & satisfactory operation of the Islanding System is covered under the scope of the contract. Supply of all bolts, nuts, and all other sundry materials as would be required for erection shall be provided by the contractor without any extra payment. Dismantling of Panels etc. if required shall be carried out as per the direction of Engineer-In-charge of the site. SLDC PATNA would take over the Complete Islanding System after satisfactory erection, testing and commissioning of the same. Erection shall conform to the relevant standard, safety rules and regulations and also to the recommendations of the equipment manufacturer. However, in case of any dispute, the decision of the Engineer-in-Charge shall be final and binding on the contractor.

- Pre-commissioning is to be conducted with representative of BSPTCL/SLDC PATNA. Any modification, if desired/ suggested by BSPTCL/SLDC PATNA representative during either stage shall have to be carried out by the contractor without any additional payment. Commissioning of the equipment shall be carried out as per BSPTCL/SLDC PATNA standards of commissioning of electrical equipment, which shall be indicated to the successful tenderer in due course of time.
- On completion of erection prior to pre-commissioning test the area should be reasonably cleaned.

Before pre-commissioning of the Islanding Panels, the entire area must be finally leveled and cleaned.

IX. Scope of documentation

(Preparation of drawings and handing over of drawings & manuals)

The Contractor must provide the number of copies of the documents specified in Contract Drawings with comments for correction must be re-submitted within two weeks of the date of comment.

1. Vendor drawings, GTP, manufacturing quality plan and inspection test schedule of each equipment/material to be supplied along with one copy of the manual and complete Type Test Report as specified.

2. Site preparation drawings.

3. Complete general electrical layout of the Panels and its accessories with incorporation of new foundation, structure, cable trenches, any other installation etc.

4. Complete Foundation Layout of the Islanding Panels with changes marked distinctly.

5. Complete Elevation Layout of the Islanding Panels with changes marked distinctly.

6. Complete Cable Trench Layout of the Islanding Panels and associated existing Panels with changes marked distinctly.

7. Preparation & Finalization of scheme drawing: complete electrical schematic diagram (A.C.

& D.C.) alongwith communication showing complete circuitry of all the equipment of the Islanding System including substation common auxiliaries integrated with the control, supervision/monitoring, protection, indication, alarm/annunciation (C & R panel) to implement the Islanding System complete in all respect.

8. One line diagram for switching.

9. One line diagram for functional relaying.

10. Complete Control and Relay panel disposition diagrams.

11. Complete electrical schematic diagrams, detailed wiring diagrams, interconnection diagrams for all equipment and panels of each feeder/ bay included in the islanding system.

12. Layout of panels/equipment in Control room etc.

13. Complete Bill of Material

14. Cable Schedule for each Bay, Metering Room, Control Room installation etc.

15. All vendor drawings of the equipment/materials under scope of supply.

16. Lighting scheme for both indoor and outdoor with design calculation, light fittings used and Lux contours.

17. Detailed drawings for all connectors, hardware and insulators.

18. Detailed drawings of all junction boxes.

19. List of all drawings submitted.

20. Any other drawings required for commissioning but not specifically mentioned herein.

21. Complete Scheme of the Islanding System.

Note:

As built drawings shall be submitted after pre-commissioning as specified above to the office of the BSPTCL/SLDC Patna, for onward distribution to concerned Departments and sites.

Drawings shall be submitted for approval in fully legible form and paper size shall be chosen accordingly. Size of fonts and symbols should be so selected that an optimum portion of the paper is utilised. However, if there is any difficulty in reading the drawing, the size of approved/final drawing to be submitted by the contractor shall be as per the decision of the dealing engineer of SLDC PATNA.

Each drawing including vendor/sub-vendor’s drawings shall bear the following:

- Each drawing including vendor/sub-vendor’s drawings shall bear the following:

- Purchaser’s Name
- Purchase Order No.
- Project name
- Relevant Purchase Order item no.
- Quantity of the respective item based on finalisation of layout.
- Revision detail
- Date
- Representative factor
- Co-ordinate system in border margin
- Direction arrows for layouts
- Exhaustive list of references associated with the drawing.
- Other relevant information the bidder felt required / necessary.

The scope of work is indicative and shall be guideline for the execution of the Contract as per other provisions/Specification/Scope of the Contract including BoQ, SCC etc. as well as site requirement and direction of the Engineer-in-Charge.

Please see Annexure – A & B for Specific Requirement of Controller/RTU with respect to electrical point of view and Communication point of view respectively.

For Communication Specification of Master Controller Unit & Slave Controller Unit, FO Cable, LAN Switch/Gateways, Multifunction Transducers, Contact Multiplier Relay, Cables, and for mode of communication please see Annexure-B.

Please also see (Annexure C) Specific Requirement for Design Standards for Controllers & Cables Construction, Type test and Acceptance Criteria.

ANNEXURE-A

B. TECHNICAL SPECIFICATION WITH RESPECT TO ELECTRICAL POINT OF VIEW

1. Master Controller/Master RTU- to be installed at SLDC PATNA

a. Shall be based on IEC61850 and PRP network based, and its communication based on IEC 60870-5-104 (Please See Communication Specification)

b. Must have adequate under frequency stages (minimum five)

c. Must have over frequency stages.

d. Each frequency stages must have timer for definite time delay setting.

e. must have adequate df/dt stage (small change in frequency with respect to time).

f. Each df/dt stage shall operate on change of frequency rate function +basic frequency setting.

g. Must have adequate MW comparators.

h. Must have adjustable under voltage blocking setting along with VT fuse failure protection.

i. Must have configurable overvoltage blocking setting.

j. Must have bay control functionality via interlock logics via suitable both way communication protocol message with sufficient Digital inputs and outputs.

k. Must have readable Human Machine Interface with LED display.

l. Each stage must have two binary output contact viz. one for trip and another for annunciation.

m. Must have adjustable pickup.

n. Must have flexible configuration of blocking inputs, protection stages and output relays.

o. Must have adequate (min.no. of BI/BO) binary inputs/outputs and one spare module of binary inputs & outputs to comply with IO List.

p. It should have RS 232 / RS 485 port for serial communication and Ethernet ports for connectivity to Master/Slave station on IEC-60870-5-104 and to relays on IEC 61850.

q. Must be supplied with all suitable original customized Licensed Software (CD may also have to be provided) & communication cable for local and remote communications, analysis of fault etc.

r. Must have continuous self-monitoring and diagnostic features.

s. Must have disturbance as well as event recording facility.

t. Must have its healthiness supervision.

2. Slave Controller /SLAVE RTU–to be installed at each substation in the islanded zone

a. Shall be based on IEC61850 and PRP network based, and its communication based on IEC 60870-5-104 (Please See Communication Specification).

b. Must have adequate binary inputs and binary outputs and one spare module.

c. Must have bay control functionality via interlock logics message with sufficient GOOSE inputs and outputs.

d. It should have RS232 /RS485 port for serial communication and Ethernet ports for connectivity to Master/Slave station on IEC-60870-5-104 and to relays on IEC 61850.

e. Must have disturbance as well as event recording facility.

f. Must have healthiness supervision.

g. Each stage must have two stage binary output contact viz. one for trip and another for annunciation.

3. Annunciator- As per Standard IS specification (3x6 Window)

4. NIT(Normal-Inter-Transfer) Switch- Stay Put type, 3 Position (Normal-Inter-Transfer),10ways, Pistol Grip & Lockable at all 3 positions.

5. Contact Multiplying Relay:

Contact multiplying relays (CMRs) are required to multiply the auxiliary contacts of breaker/isolators etc. The contacts of these relays shall be used to provide status input to the RTUs. The relays shall be of self-reset type. The relay shall have a minimum of two changeover contacts each with minimum current carrying capacity of 5A at 110V/220 V DC.

The relays shall conform to the following requirements:

a) Power frequency withstand voltage: 2 kV for 1 minute as per IEC standards.

b) Insulation resistance of 100 M ohms at 500 V DC.

c) 5 KV Impulse test as per IEC standards.

The CMRs shall be generally mounted in existing control & Relay panel but in case of non-availability of space, it shall be accommodated in the System Interface Cabinets (being supplied by the Contractor).

6. Multi-Function Transducers (MFTs):

The contractor shall provide the multi-function transducers for acquiring the real time analog inputs through 3 phase 4 wire CT/PTs circuits. The multi-function transducer shall be designed for nominal 110 V (Ph-Ph voltage) and 1A/5A (per phase current). The MFT shall be suitable for 20% continuous overload and shall be able to withstand 20 times the normal current rating for a period one second. The MFT shall be able to accept the input voltages up to 120% of the nominal voltage. The MFTs shall have low VA burden. These MFTs shall be mounted in the interface cabinet to be supplied by the contractor.

Multi-function transducers shall provide at least the following parameters as a minimum with the specified accuracies.

Sl. No.	Parameters	Accuracy
(i)	Voltage	±0.5%
(ii)	Current	±0.5%
(iii)	Frequency	±0.2%
(iv)	Active Power / Reactive Power	±0.5% / ±1%
(v)	Import & Export Energy (Active/Reactive)	±1% / ±2%
(vi)	Power Factor (Measuring range shall be 0.6 to 1.0 lag & lead	±1% / ±2%

The parameters to be acquired from multifunction transducers shall be selectable. MFT shall provide the 15-minute values (configurable 15 minute/1 hour) of Active Energy Import, Active Energy Export, Reactive Energy Import and Reactive Energy Export.

Multi-function transducers shall accept nominal -48 V DC (positive earthed) as auxiliary power supply. Multi-function transducer shall be provided with RS 485 interface to communicate with RTU over Modbus/103 protocol in multi-drop mode.

The MFTs shall be suitable for mounting on DIN rails. The MFT terminals shall accept up to two 2.5 mm2 / 4 mm2 for PT/CT circuit terminations as applicable**.**

7. Control & Power Cables

1.1 1100V (E) stranded plain (untinned) annealed high conductivity copper conductor, extruded PVC insulated, extruded PVC inner sheathed, Single layer GI round/ flat armoured, overall served with PVC suitably compounded to ensure specified fire retardant low smoke properties, heavy duty control cable conform to IS : 1554 (Pt. I) and also meeting type and special test requirements detailed herein.

1.2 Reference: IS 1554 (Pt. I); IS 8130; IS 5831; IS 3975, other applicable Standard and test requirement as subsequently specified.

8. As per the guidelines of ERPC, a separate SCADA display of the islanding region is to be set up at SLDC control room and the same should be extended to ERLDC for real-time monitoring of the generators and connected loads of the islanding region under concern. For reliable data transmission the new RTUs (to be commissioned for the purpose of implementation of the Islanding Scheme) are to be considered instead of existing SCADA RTUs. However, the detail requirement from communication point of view will be conveyed after finalisation of the display page by ERPC.

9. All special cables in the substations (other than those specified in the Bill of Materials) as required for connecting various supplied equipment's and up to BSPTCLs communication equipment's shall be deemed included in the scope of work. The scope shall cover supply, laying and termination of various cables including accessories as per scheme requirements.

10. The complete design and detailed engineering (unless specified otherwise in specification elsewhere) shall be done by the Contractor.

11. Any other items not specifically mentioned in the specification, but which are required for erection, testing and commissioning and satisfactory operation of the scheme are deemed to be included in the scope of the specification unless specifically excluded

For Communication related Specification of Master Controller Unit & Slave Controller Unit, FO Cable, LAN Switch/Gateways, Multifunction Transducers, Cables, and for mode of communication please see Annexure-B.

ANNEXURE-B

TECHNICAL SPECIFICATION WITH RESPECT TO COMMUNICATION POINT OF VIEW

1. **Remote Terminal Unit**

1A. General:

The Remote Terminal Unit (RTU)/Panel, shall be installed at Substations to acquire analogy data such as MW export, MW import, frequency, power factor, maximum demand, planned outage duration & numbers, forced outage duration & numbers, MVA, MVAR etc. & also digital data like status of isolators, circuit breakers etc. at each Sub-Station under this scope of work and transfer those information to workstation (PC based data monitoring system) at SLDC Patna as well as Islanding Control Panel.

Remote Terminal Unit shall also be used for control of station devices from Master station. Necessary data base creation at Remote Terminal Unit at each S/s for integration of RTU with Master Control Panel at SLDC PATNA is also included under this scope of work. Workstation PCs shall be used for acquisition, monitoring of various electrical parameters and generation of reports and log sheets in line with the requirements of the specification. The supplied RTUs shall be interfaced with the Control & Relay (C&R) panels, communication equipment, power supply distribution boards; for which all the interface cables shall be supplied by the Contractor.

This document describes the specifications for the Remote Terminal Unit (RTU). Contractor shall supply RTU, associated equipment such as transducers, relays, cabling etc. and required number of panels for housing of all the hardware envisaged for the RTU and system interface cubicle (SIC).

The contractor shall be responsible for supplying all hardware, software, installation, cabling, and field implementation for RTU as defined in this Specification. The contractor shall also provide complete documentation, training and testing to fully support the hardware and software provided. The RTU shall be used for real-time supervision and control of substation/ power plant through SCADA system. RTU configuration/ point count, transducer count is given in BoQ.

It is Employer’s intent that the Contractor uses as much standard hardware and software as possible; however, all of the functional requirements of this Specification must be satisfied. The use of the Contractor's standard hardware and software may cause the Contractor to conclude that there is a need for additional items not specifically mentioned in this Specification. The Contractor shall supply all such items and provide a complete RTU design that meets all of the Employer’s functional requirements defined in this Specification.

It is the responsibility of the bidder to configure the RTU to make it compatible with (i) Master Controller at SLDC Patna (ii) Slave Controller at 13 locations (400 KV NPGC , 400/220/132 KV Jakkanpur (New), 132/33 KV Jakkanpur, 220/132/33 KV Sipara, 220/132/33 KV Khagaul, 220/132/33 KV Fatuha, 220/132/33 KV Digha New, 132/ 33 KV Gaighat GSS, 132/33 KV Karbigahiya GSS, 132/33 KV Mithapur GIS GSS, 132/33 KV Digha GSS, 132/ 33 KV Board Colony GSS, 220/33 KV Bhusaula GSS (iii) Existing SDH equipment of BSPTCL.

1B. Design Standards:

The Remote Terminal Units shall be designed in accordance with applicable International Electro- technical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA) standards, unless otherwise specified in this technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.

1C. Remote Terminal Unit Functions:

All functional capability described herein shall be provided by the Contractor even if a function is not initially implemented. The term master station is used to denote the SCADA systems. As a minimum, the RTUs shall be capable of performing the following functions:

i. Collecting and processing the digital status inputs, antilog inputs, accumulated values and transmitting to master station.
ii. Receiving and processing digital & analog control commands from the master station.
iii. Accepting polling messages from master station simultaneously using separate logical databases.
iv. Communication simultaneously on all Communication ports and using multiple concurrent protocols, including the IEC 60870-5-104 & MODBUS/103 protocol.
v. RTU shall be compatible with protocol 61850 for communication with IEDs.
vi. RTU shall have the capability of automatic start-up and initialisation during power outage, without need of manual intervention. All restarts shall be reported to the connected master station.
vii. RTU shall support time synchronization through messages received from master station using IEC 60870-5-104 protocol.
viii. RTU shall support downloading of RTU database from the master station using the IEC 60870-5-104 protocol.
ix. RTU shall support SOE (Sequence of events) feature.
x. Acting as a data concentrator for acquiring data from Slave RTUs and exercising supervisory control on slave RTUs using IEC 60870-5-104 protocol.

1D. Communication Ports:

The RTUs shall support simultaneous communications with multiple independent master stations (SCADA system), maintenance and configuration terminal (Laptop/PC), a local logger (printer), multi-function transducers. The RTUs shall have communication ports as follows:

a) Two Ethernet ports for connectivity to Master Station on IEC 60870-5-104 and to relays on IEC 61850.
b) 1 RS232 ports –for communication with master stations on IEC60870-5-101.
c) One port for the RTU maintenance and configuration terminal.
d) One port for Local logger (printer).
e) Required number (minimum two) of RS 485 ports for polling Multi-function transducers using MODBUS/103 protocol in multi-drop mode

It shall be possible to increase the number of communication ports in the RTU by addition of cards, if required in future. The RTU shall respond to independent scans and commands from Master Station and Configuration & Maintenance Terminal simultaneously. The RTU shall support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port.

1E. Local logger /Printer Interface:

The RTU shall include the interface to support an optional local logger /printer. The interface shall provide easy access to allow employer to connect the logger at the RTU installed in the field.

1F. Communication Interface Between RTU & MFTs:

The RTU shall acquire data from the MFTs. The MFTs will act as slave to the RTU. The RTU shall have the ability of issuing retry scan to acquire data from the MFTs in case of communication failure between RTU and MFTs. All data from the devices connected on a single port shall be acquired within 5 seconds.

1G. Communication Protocol Between RTU &IEDs:

The RTU shall use the IEC 61850 protocol for communication with IEDs over Sub- station LAN. The RTU shall act as a Client and collect data from the IEDs.

The RTU shall store the data acquired from the MFTs & IEDs in its database and do processing like change detection/dead band processing on the data for optimizing its transmission to the Master Station (SCADA Control Centre). The processing shall include requirements of mapping of information from the protocol of MFT/IEDs to the protocol requirement for communication with Control Centre.

2. Master Station/Controller Communication Protocol:

The Contractor shall provide a communication protocol for communicating with SCADA master station/ controller using the IEC 60870-5-104 communication protocol standard. The communication protocol shall support all the requirements of this standard. The communication protocol shall be non-proprietary, and the Contractor shall provide complete description and documentation of the protocol to Owner.

The RTU shall perform as a slave to SCADA master station/controller. All communication shall be initiated by the SCADA master stations. RTU must notify the master stations of unusual conditions at the RTU (such as a power fail/restoration or RTU malfunction), the transfer of changed data etc. All the notifications shall be accomplished within the framework of the periodic data acquisition.

The RTU shall process the various messages/commands for communication to the Master station using the following priority.

a) Control command

b) Status data by exception

c) Analog data by exception

d) Analog data periodic

e) Status data integrity scan

The communication interface to the master station shall allow scanning and control of defined points within the RTU independently for each master station using a separate logical database in the RTU. It shall be possible to pick points from the RTU database randomly and assign it for reporting to a Master station. Further, the RTU shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each master station.

2A. Scan groups:

Analog and digital input points (including points reported by exception) shall be assignable to scan groups. A scan group shall be a specified set of data points within the RTU central database which will be communicated to a master station when requested by a specific (addressed) scan request. A scan group size shall only be limited by the communication protocol message length. Any RTU input point shall be assignable to any scan group. The RTUs shall support at least sixteen scan groups and all scan groups per communication port. The Contractor shall provide a convenient and flexible scheme for assigning points in the RTU to scan groups.

2B. Reporting of status points:

The RTU communication protocol shall be configured to report digital status changes by exception to master station. Digital status data shall have higher priority than the Analog data. All the digital status data shall also be assigned to scan groups for integrity check by Master stations at every 10 minutes.

2C. Reporting of Analog points:

The analog data shall be reported periodically to update all the values at the master station within 10 to 15 seconds. Analog data shall also be reported by exception if the analog value exceeds its previous value by more than 20%.

2D. Digital control commands:

The RTU shall follow the select-and-execute sequence for operation of digital control commands from the master station. The RTU shall reset its control logic upon any error in the sequence.

2E. Data Concentrator Communication Protocol:

The RTU shall act as a IEC 60870-5-104 protocol master and collect data and also perform supervisory control from/on the slave RTUs and communicate it to the Control Centre. The Master protocol implementation shall be such that the data polling requirements should be accomplished.

RTU as a Data concentrator shall be provided with at least One (1) IEC 101 and three (3) IEC 104 input ports/ cards and shall have capability to report to master station on IEC 104 interface. Data concentrator shall support at least 200 (two hundred) data points. The RTU as a Data Concentrator shall be supplied with GPS receiver system with antenna, cable etc. for time stamping of Data concentrator which in turn shall synchronize the IEC 104 protocol connected RTU/device. The RTU as a Data Concentrator shall come complete with built in monitoring mechanism to avoid loss of any data, especially the one reported by exception. The data concentrator shall have dual CPU and dual Power supply unit. The overall data update requirement from any Sub-RTU to Control centre should not affect the functionality defined elsewhere in the specification.

The Data concentrator shall have the provision for remote login from Control centre. The Master Controller computer system shall be able to configure and poll health of Data concentrator from remote on 104 connected interfaces after due authentication of the users. It shall support diagnostic & maintenance activities remotely. Individual RTU configuration shall be possible from Data Concentrator including accommodating devices from heterogeneous suppliers. The RTU as a Data Concentrator shall have following communication ports & support for protocols:

i. IEC 104 for Master Control Centre.

ii. IEC 104 for Sub-RTU.

3. Analog Inputs:

The RTU shall accommodate analog inputs which are unipolar or bipolar, 2-wire ungrounded differential signals. All analog inputs are of +4 to +20 mA. However, the RTU shall be capable of accepting other standard analog input ranges (0 to 5V, 0-10V, 0 to 10mA).

The RTU shall make all appropriate signal level conversion and conditioning to allow full utilization of analog inputs and meaningful reasonability checking. The analog-to- digital converter shall have a minimum resolution of 2048 counts (sign plus 11 data bits). Each type of analog input shall be converted with full resolution. The RTU shall monitor the drift in characteristics of its ADC and mark the analog points with a drift quality code if a drift is detected. This drift quality code shall be sent to the master station also.

The RTU accuracy, for analog input measurement, shall be 99.8% or better at 25 degree C ambient temperature. Mean accuracy shall drift no more than 0.002% per degree C within the temperature range of –5-to +55-degree C. Determination of accuracy shall be made while the analog multiplexer is operating at rated speed.

Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak) and overload. Loading upto 150% of the input value shall not sustain any failures to the RTU input. The total input impedance offered by the RTU shall not be greater than 250 (for +4 to +20 mA range).All analog inputs shall be scanned by the RTU from the field at least at 1 second periodicity.

4. Status Inputs:

RTU shall be capable of accepting isolated dry (potential free) contact status inputs. The RTU shall provide necessary sensing voltage, current, optical isolation and de- bounce filtering independently for each status input. The sensing voltage shall not exceed 48 Vdc. The sensing voltage source shall be isolated from that of the RTUs logic power so that any noise or a short circuit across the sensing supply of a digital status input terminals would not disrupt the RTU operation other than the shorted digital status input.

The RTU shall be set to capture contact operations of 20 ms or more duration. Operations of less than 20 ms duration shall be considered no change (contact bounce condition). The RTU shall accept two types of status inputs i.e., Single point status inputs and Double point status inputs. Single point status input will be from a normally-open (NO) or normally-closed (NC) contact which is represented by 1-bit in the protocol message. Double point status s input will be from two complementary contacts (one NO and one NC) which is represented by 2-bits in the protocol message. A switching device status is valid only when one contact is closed and the other contact is open. Invalid states shall be reported when both contacts are open or both contacts are closed. All status inputs shall be scanned by the RTU from the field at 1 millisecond periodicity.

4A. Momentary Change Detection:

Two-state status input points with momentary change detection shall be used by Employer for points where multiple operations (changes of state) can occur between scans from the master station (such as breakers with auto-reclosing devices that operate faster than the master station scan rate). The RTU shall capture and maintain all the momentary changes, up to 4 per MCD digital status point. The MCD status input points shall be set to capture operations of greater than 20 msec duration.

Alternatively, the RTU can store and report the multiple state changes of a digital input as discrete events. It shall be ensured that all the changes are reported to the Master station in the sequence in which they occur in the RTU.

4B. Sequence of Events (SOE) feature:

SOE is the time-stamped digital status data. SOEs will enable Employer's personnel to determine the sequential operation of digital status input devices for their state changes. The RTU shall timestamp the digital status data with a time resolution of one millisecond.

Initially, all breakers & protection contacts digital status input points in the RTU shall be configured as SOE points. However, it shall be possible to assign any digital status input data point in the RTU as SOE point. Each time a SOE status input point changes state, the RTU shall time-tag the change and send it to the Master station. The RTU shall maintain a SOE buffer within the RTU for communication delays and communication failure. SOE buffer shall be sized to store, as a minimum, of 600 events. The RTU shall transmit the SOE data stored in its buffer to master station. An acknowledgement of receipt by the master station shall be made prior to the loss of any data in the RTU SOE buffer. Data not received at the master station shall be retransmitted. The RTU shall send a message to the master station to indicate the RTU SOE data buffer overflow condition.

5. Control Outputs:

The RTU shall provide the capability for a master station to select and change the state of digital output points. Device control will be used by employer to control power system devices including:

(a) Two-state Devices: Circuit breakers

The RTUs shall have the capability for control outputs as described in the following sections.

5A. Two State Momentary Control

A pair of outputs shall be supplied for each two-state (open/close) control output point that drive control relays. One output shall be supplied for open, the other for close. Upon command from a master station using the check-before-execute sequence, the appropriate control output shall be operated for a preset (momentary) time period. The operation period shall be adjustable for each point from 0.1 to 2 seconds.

5B. Raise/Lower Pulse Output

A pair of outputs shall be supplied for each (raise/lower) control output point that drive control relays. One output shall be supplied for raise, the other for lower. When commanded from the master station, the appropriate raise or lower output shall be operated for the selected time interval. The closure time interval for raise/lower pulse output points shall be specified in the operate command from the master station. The raise/lower output for each point shall operate over a range of 0.1 to 4 seconds in a minimum of eight equal increments.

5C. Timed Supervisory Control

The RTU shall store Timed Supervisory control command received from the SCADA system. This supervisory control command from the SCADA system shall contain the ‘time’ up to a resolution of milliseconds and the type of control Operation.

The RTU shall then perform the supervisory control command at the specified time. The SCADA system shall be able to cancel this command prior to the occurrence of the specified Time of Operation.

5D. Control Output Interposing Relays (Double Contact Digital Output)

Control output interposing relays shall be supplied by the Contractor for each control output specified in appendix. Each control relay shall consist of two isolated single- pole double-throw contacts. The output contacts shall be rated to carry minimum current of 10 amps at 220 V DC and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC standards.

5E. Latching (Dummy Breaker) Relay

The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the RTU. The simulation relay shall accept the control signals to open and close from the RTU and shall provide the correct indication response through a single contact indication input point. This point is not included in the RTU point count.

5F. Control Security and Safety Requirements

The RTU shall include the following security and safety features as a minimum for control outputs:

a) Select-and-execute sequence for control output.

b) No more than one control point shall be selected at any given time.

c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.

d) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "operate" command is not the next received message and is not received within the set time period.

e) No control command shall be generated during power up or power down of RTU.

vii) Local/Remote selector switch

A manual Local/Remote selector switch shall be provided for each RTU to disable all control outputs by breaking the power supply connection to the control outputs. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of RTU without activating the control outputs to field devices. A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch. This point is not included in the RTU point count defined in Schedule of works.

6. Time facility:

The RTU shall have an internal clock with the stability. The RTU shall be synchronised through synchronisation message from master station at every 10 minutes using IEC 60870-5-104 protocol. The RTU shall support the calculation of the propagation delay dynamically by the Master station. However, all the RTUs shall have a suitable interface for receiving synchronization signals from a local GPS receiver.

The RTUs communicating over IEC-60870-5-104 shall be supplied with a GPS receiver for synchronization of RTU clock.

The RTU shall synchronize its internal clock with the master station system clock when time synchronization messages are available and shall mark all the time stamped information/data as invalid when the RTU clock is not synchronised with the Master station.

7. Diagnostic features:

The RTU design shall facilitate isolation and correction of all failures. The following features which promote rapid problem isolation and replacement of failed components shall be provided:

a) Self-diagnostic capabilities within each RTU which can be initiated at the RTU site. The diagnostic software shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

b) On-line error detection capabilities within the RTU and detailed reporting to the connected master station of detected errors. It shall be possible to choose the errors to be sent to the Master station within the framework of the communication protocol.

c) Local indication of major RTU failures.

d) A non-volatile event buffer that shall record all fatal errors/restarts/ faults.

8. Input DC Power Supply:

The RTU will be powered from a 48 V DC (+ve earthed) system. The RTU shall not place additional ground on the input power source. The characteristics of the input DC power supply shall be:

a) Nominal voltage of 48 Vdc with operation between 41 and 60 Vdc.

b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

The RTU shall have adequate protection against reversed polarity, over current and under voltage conditions, to prevent the RTU internal logic from being damaged and becoming unstable causing mal operation.

Environmental Requirements:

The RTU will be installed in control room buildings with no temperature or humidity control. The RTUs shall be capable of operating in ambient temperature from -5 to +55 degree C with rate of temperature change of 20 degree C/hour and relative humidity less than 95%, non-condensing. At some locations, environmental temperature may go below –5 degree C for which the contractor shall take suitable measures for successful operation of RTU.

Noise level:

The audible noise generated by the RTU equipment shall not exceed 50 dBA from one meter from the enclosure.

RTU Size and Expandability:

The software and the database shall be sized to accommodate growth within the ultimate sizing parameters as defined in this specification for the RTU without requiring software or database structure regeneration.

The point counts for the RTUs have been defined in the BoQ. The RTU shall have additional wired available reserve capacity of twenty percent (20%) for each type of points defined in the BOQ. This reserve capacity shall be used without any additional hardware such as I/O cards and terminal blocks.

The RTUs delivered shall have the capability to accommodate additional I/O modules to expand the overall point count of the RTU by a minimum of fifty percent (50%) i.e. 80% more than the actual point count defined in the BOQ. The I/O modules here means Status Input module, Analog input module and the Control output module. Other modules, such as processor module, racks etc. as required to meet the overall expandability requirement defined above shall also be supplied by the contractor.

9. RTU and SIC panels:

The Contractor shall provide RTU & System Interface Cabinet (SIC) panels. The SIC shall primarily house all MFTs, interposing control relays and interface terminal blocks. Generally, the SIC shall be mounted adjacent to the RTU panel. However, in some cases, the SIC may be mounted separately at a different location. All RTU signals shall be connected to the MFTs, interposing relays, and field signals in the interface cabinet. The panels shall meet the following requirements:

a. Shall be free-standing, floor mounted, and height shall not exceed 2315 mm from FFL.
b. Shall have maintenance access to the hardware and wiring through lock- able full height doors.
c. Shall have the provisions for bottom cable entry.
d. The safety ground shall be isolated from the signal ground and shall be connected to the ground network. Safety ground shall be a copper bus bar. The contractor shall connect the panel's safety ground of to the Employer's grounding network. Signal ground shall be connected to the communication equipment signal ground.
e. All panels shall be supplied with 230 Vac, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.
f. All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.
g. All panels shall be indoor, dust-proof with rodent protection, and meet IP41 class of protection.
h. There shall be no sharp corners or edges. All edges shall be rounded to prevent injury.
i. Document Holder shall be provided inside the cabinet to keep test report, drawing, maintenance register etc.
j. All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame-retardant material and shall not produce toxic gasses under fire conditions.

10. Interconnections:

All cabling between component units of the RTU, RTU to interface cabinet, RTU to MFTs and to the Employer control and relay panels (located in the substation control room) shall be supplied and installed by the Contractor and shall be shown on Contractor supplied drawings. Plug-type connectors with captive fasteners or compression type connectors shall be used for all internal interconnections. The connectors shall be polarized to prevent improper assembly. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable's terminations. This information shall match with the Contractor's drawings.

Adequate space and hardware shall be provided for routing of the field wiring within the enclosures. Contractor wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame. All internal interconnection wiring, and cables shall be routed separately from field wiring to the RTU terminals &power wiring. All wiring shall use copper conductors and have flame retardant insulation. Conductors in multi-conductor cables shall be individually colour coded.

The use of non-flammable, self-extinguishing, plastic wire troughs is permissible. Metal clamps must have insulating inserts between the clamps and the wiring. Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

11 Wiring/Cabling requirements:

Shielded (screened) cables shall be used for external Cabling from the RTU/ SIC panels. These external cables (except communication cables) shall have the following characteristics**:**

a. All cables as per IS 1554 shall have stranded copper conductor.
b. Minimum core cross-section of 2.5 mm2 for PT cables, 4 mm2 for CT cables and 2.5 mm2 for Power & Control outputs and 1.5mm2 for Digital Status inputs, transducer mA current output.
c. Rated voltage UO/U of 0.6/1.1KV.
d. External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test ..
e. Shielding, longitudinally laid with overlap.
f. Dielectric withstand 2.5 kV at 50 Hz for 5 minutes.
g. External marking with manufacture's name, type, core quantity, cross- section, and year of manufacture.
h. The Communication cable shall be of shielded, twisted pairs and of minimum 0.22sq mm size.

12. Terminal Blocks:

Terminal blocks shall be having provision for disconnection (isolation), with full depth insulating barriers made from moulded self-extinguishing material. Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and wire used. No more than two wires shall be connected to any terminal. Each analog input signal, digital status input and digital output signals shall require two terminals per point plus a common shield termination for each cable.

All terminal blocks shall be suitably arranged for easy identification of its usages such as CT circuits, PT circuits, analog inputs, status inputs, control outputs, auxiliary power supply circuits, communication signals etc.

Terminal Blocks for CT circuits shall have feature for CT shorting (on CT side) &disconnection (from load side) to facilitate testing by current injection. Similarly, TBs for PT circuit shall have feature for disconnection to facilitate voltage injection for testing.

13. Transducer Protection:

The input, output and auxiliary circuits shall be isolated from each other and earth ground. The transducer output shall be ungrounded and shall have short circuit and open circuit protection. The transducers shall comply to the following requirements, in addition to the requirement of IEC 60688, without damage to the transducer:

a) Electromagnetic Compatibility: IEC 61000-4-3, Level 1.
b) Electromagnetic Compatibility: IEC 61000-4-4, Level 1.
c) Shock Resistance: Minimum severity 50 A, IEC 68-2-27 requirements.
d) Vibration Strength: Minimum severity 55/05, IEC 68-2-6 requirements.
e) Input Circuit Consumption: Less than 0.5 VA for voltage and current circuits.

14 Portable Configuration and Maintenance Terminal (PCMT):

Contractor shall supply a Portable Configuration and maintenance Terminal (Laptop / PC) which shall provide followings capabilities:

(a) RTU Data base configuration &Maintenance

(b) Local Operator Interface & RTU Diagnostics

(c) Master Station and RTU simulator cum protocol analyser

15. RTU Data base configuration:

The RTU database Configuration software being supplied with the PCMT shall have the following features:

i. Full graphics windows User Interface.
ii. Standard editing capabilities e.g., cut, paste, copy, sorting etc.
iii. Capable of controlling revisions of various RTU database files and storing multiple versions of databases for all the RTUs.
iv. Capable of uploading database from the RTU and compare that with another version of database stored in the PCMT.
v. Provide standard template for database modelling required for I/O modules, MFTs & IEDs, communication setting.
vi. Provide mapping of the individual data points acquired from one protocol to another protocol for transmission.

The database configuration software shall use the same terminology for configuration of the various protocol parameters as specified in the communication protocol standard i.e., it shall be possible to define these parameters by the user discreetly. Also, it shall be possible to select an ASDU type to be used for transmission of a measurand e.g., measured value to be transmitted as ASDU 9 or ASDU 11.

16. Local Operator interface and RTU diagnostics

The Local Operator interface software shall support operator inquiries to demand current status and data values of various RTU points, or an overall substation snap- shot, or of the status change buffer.

The local operator interface software shall provide the following reports:

i. Status Reports: Display of all substation status indications, of all tele- metered values, and the RTU's status.
ii. Event Reports: Display all the stored events in the event buffer of the RTU.
iii. Print Requests: Provide user interface for requesting print out of the reports on the logger.

Successful bidder shall also install one no. Workstation along with administrative rights at SLDC Patna for SCADA display of this Islanding Scheme. Connectivity & SDH port for VLANing will be done by the Communication wing in consultation with bidder. Sufficient length of UTP patch cords along with laying will be included in the bidder scope of work.

One no. workstation shall also be installed at NPGC end with display of load and generation data of the island and will communicate with SLDC Patna through the Master-Slave controller. An alarm shall also be configured to reduce generation in case of surplus generation if pre-islanding condition is satisfied.

All special cables in the substations/power houses (other than those specified in the Bill of Materials) as required for connecting various supplied equipment’s and up to BSPTCLs communication equipment’s shall be deemed included in the scope of work. The scope shall cover design, supply, laying and termination of various cables including accessories as per scheme requirements.

The complete design and detailed engineering (unless specified otherwise in specification elsewhere) shall be done by the Contractor.

Any other items not specifically mentioned in the specification, but which are required for erection, testing and commissioning and satisfactory operation of the scheme are deemed to be included in the scope of the specification unless specifically excluded.

Annexure C

Design Standards:

A. Controllers covered by this specification shall conform to latest issues the following Standards:

- IS:3231 Electrical relays for power system protection.
- IEEE C37.90 IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE C37.90.1 IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE C37.90.2 Electrostatic Discharge Tests for Protective Relays
- IEC 60688 Electrical Measuring Transducers for converting a.c electrical quantities to analogue or digital signals.
- IEC 60255-5 Electrical Relays- Part 5: Insulation co-ordination for measuring relays and protection equipment- Requirements and tests
- IEC 60255-6 Electrical Relays-Part 6: Measuring Relays and protection equipment.
- IEC 60255-22-2 Electrical disturbance tests for measuring relays and protection equipment, Electrostatic Discharge Tests.
- IEC 60255-22-3 Electrical disturbance tests for measuring relays and protection equipment, Radiated Electromagnetic Field Disturbance Tests
- IEC 60255-22-4 Electrical disturbance tests for measuring relays and protection equipment, Fast Transient/burst immunity Tests.
- IEC 60255-22-6 Electrical disturbance tests for measuring relays and protection equipment - Immunity to conducted disturbances induced by radio frequency fields.
- IEC 60255-25 Electrical relays - Part 25: Electromagnetic emission tests for measuring relays and protection equipment.
- IEC 61850 Communication networks and Systems in Sub-station – all relevant latest versions and editions.
- IS:13703 Low voltage fuses.
- IS:694 PVC insulated cables for working voltages up to and including 1100V.
- IS:11353 Uniform system of marking and identification of conductors and apparatus terminals

The BOQ of the cables are indicative only but not exhaustive.

All bought out items shall be quality checked, tested at Bidder’s works and test reports of major items along with drawing /documents and name of manufacturer shall be submitted to the Purchaser’s for verification.

Where the equipment offered conforms to any other standard, the salient points of difference between the standards adopted and IEC recommendation shall be clearly indicated, and the English version of the proposed standard shall be furnished.

Construction Standards

A. Panel

• Type of Panel	Simplex type (as per requirement & to be finalized during detailed Engineering)
• Front Door	Swing frame glass door (For simplex type) (as per requirement & to be finalized during detailed Engineering)
• Rear Door	Leaf type door with handle lock (For Simplex) The access door for the simplex type of panel shall be at the back side and of 1900 mm height.
• Degree of protection(minimum)	IP-31
• Dimension(mm)	2200 (H) X 800(D) X 800(W) Simplex (or as per requirement of site and will be finalized during detailed engineering)
• Base frame(mm)	100
• Anti Vibration Pad above Base frame(mm)	15
• Sheet Material	CRCA Steel of thickness 3 mm
• Paint	Inside - Glossy white Outside– Shade 631(light grey) of IS:5, powder coated, mat finish; Base frame – Glossy black
• Wiring	Reference Standard - IS:694 Voltage Grade - 1100 V Insulation – PVC Number of strands – Minimum Seven (07) Conductor Material – Annealed copper Fire

Properties - FR/FRLS

Minimum size for different circuits shall not be less than those as specified below Current

Transformer Circuit	1 X 2.5 sq. mm. Copper
Voltage Transformer Circuit	1 X 2.5 sq. mm. Copper
Other Circuit including Control wires	1 X 1.5 sq. mm. Copper for fuse rating of 10 Amps or less

- Ferrule

Each wire shall be identified at both ends with wire numbers by means of PVC ferrules. Ferruling of wires shall be as per relevant IS.

All control wiring shall be enclosed in plastic trough

- ***Terminal Block***

Split type terminal blocks **of approved make** shall be provided for all CT terminals. The terminals screws shall be of the Washer type and long enough for connecting following type conductor on each side.

Each terminal block shall be capable of terminating the following no. of wires(minimum): CT

circuits	2 nos 10 mm sq. copper
PT/CVT circuits	2 nos 2.5 mm sq. copper
AC/DC supply circuits	2 nos 2.5 mm sq. copper
All other circuits	2 nos 2.5 mm sq. copper

Each terminal block of approved make shall be provided with a wire-marking strip and shall be shrouded by easily removable shrouds moulded of transparent dielectric material.

Provision shall be made on each pillar for holding 20% extra connections both for incoming and outgoing. The terminal blocks shall be suitable for 660 V,10 A rating.

There shall be a minimum clearance of 250 mm between the front row of terminal block and the associated cable gland plate on panel side wall. The clearance between two rows of terminals block edges shall be a minimum of 150 mm. Make of terminal block shall be Elmex/ Connectwel.

- All inter-panel wiring within each shipping section shall be the vendor's responsibility. Wiring between panels shall be routed through PVC sleeves. For wiring between shipping section, vendor shall provide terminal blocks on adjacent shipping sections and supply suitable jumpering wires.

- ***Earthing***

25mm X 6mm tinned copper earth bus shall be provided. Suitable arrangement shall be provided at the two ends for connection to the sub-station grounding system. Each panel and the equipment mounted on each panel shall be securely connected to the grounding bus. The main earth connection for each panel shall be brought out to terminals for connection to the station earthing system.

- ***MCB & MCCB***

Moulded Case Circuit Breaker (MCCB) shall confirm to Is:13947 and duty type AC4.Miniature Circuit breaker (MCB) shall conform to IS 8828.

All MCCB shall have short circuit and overcurrent protection.AC MCCB shall have interrupting capacity of 25 KA and DC MCCB shall have 15 KA of that.

- ***Fuses and Links***

H.R.C. Cartridge fuse and link of adequate current and voltage rating shall be provided inside the cubicle in an easily accessible location. The selection of the main and sub circuit fuse ratings shall be such as to ensure selective clearance of sub circuit faults. Fuse carriers and bases shall have imprints of rating, voltage and circuit designation.

- ***Push Button Switch***

Push button switches, provided where required, shall be of the monetary contact type wired back connected. They shall be semi flush mounted. They shall be provided with integral inscription plates engraved with their functions.

All push buttons shall be with a set of NO/NC contacts as required to fulfill the scheme requirement. The contact faces shall be silver plated and shall be able to make/break and carry the rated current appropriate to the duty of the desired function.

- ***Name and identity Plates***

All instruments, relays and other electrical devices mounted on the control panel shall be provided with identity plates bearing the Manufacturer's name, Serial number, Model number and the electrical rating data.

Ten (10) mm wide plastic plates bearing suitable identification marks shall be fixed in the interior of the switchboard, at the test blocks, at the fuse blocks and at the cable terminals. Similar plates shall be fixed to indicate functions of control switches, push buttons, indicating lamps, relays and other equipment not incorporated in the mimic diagram etc. Suitable identification marks shall be provided for other instruments as well.

Fifty (50) mm brass or plastic plates bearing respective circuit designation (which will be furnished later) etched in 30 mm letters and mounted suitably on the top of the front side and back side of each panel shall be supplied and fixed in such a way that these can be removed and refitted when required.

- ***DC Circuits (Panels)***

There shall be only two DC incomers (220V) as DC supply –1 and DC supply-2 for the entire Islanding panel fed from D.C. distribution board through individual 32Amp. Switch fuse unit/MCB provided there. Necessary arrangement for Supervision of the both the incoming DC supplies shall be made. One 16Amp.rating HRC fuse unit both at +ve and -ve side shall be provided for each D.C. incomer.

The above D.C. incoming buses of the Panel shall run continuously. Individual panel D.C. supply shall be teed off in each panel from the above two D.C. buses through set of MCB/links.

Indication circuit through 6A HRC fuse and link. Control

circuit through 10A HRC fuse and link.

D.C. emergency lamp circuit with 2A HRC fuse and link.

- ***AC Circuit***

230V, single phase 50Hz AC auxiliary supply to the islanding panel through separate 32Amp. switch fuse units/MCB provided there. The supply shall be provided in Bus coupler/Bus Transfer panel. A continuous AC bus shall be provided at the control, relay and protection panel board of each group wherefrom AC supply to each panel shall be teed off through a set of MCB/links. One 16Amp rated HRC fuse units shall be provided for a complete control, relay and protection panel board of each system voltage for the incoming AC supply. A set of fuse and link rated for 10Amps. for 3 pin plug circuit, cubicle lamp circuit, space heater circuit shall also be provided in each panel.

Door operated corridor illumination lamp ckt. of Simplex type panel shall be arranged from the above incoming AC bus through suitably rated fuse and link.

AC circuit for incoming DC Annunciation DC fail alarm scheme shall be provided in the Bus coupler panel of 400KV & 220 KV system and in the Bus Transfer / Bus Coupler (3 bus system)/ Common panel of 132KV and 33KV system. The above circuit shall be teed off from the above respective panel AC bus through fuse and link suitably rated.

One supervision relay for incoming AC fail with test P.B. and reverse flag indication shall be provided for monitoring of AC supply healthiness through D.C. operated facia annunciation of

Bus Coupler panel of 400KV & 220KV system and of the Bus Transfer/ Bus Coupler (3 bus system)/ Common panel of 132KV and 33KV system.

- ***Illumination & Space heaters***

Incandescent or fluorescent lamps working on 240V AC, operated by door switches shall be provided for internal panel illumination. A 240V, single phase, 5A, 3 pin socket shall be provided in the panel interior of each cubicle with on-off switch.

Panel space heaters shall operate on 240 V±10% AC and shall be supplied complete with on- off switch, fuse and thermostat.

The above AC auxiliary supply. in each panel shall be though HRC fuse and link protected.

- Annunciation System
- Incoming DC Fail Alarm

Panel shall have alarm scheme, as follows: -

In each panel, Protection for DC-1/DC-2 fail supervision shall be provided.

The "Incoming DC fail (DC – 1 and DC – 2) and operated from 230V single phase AC auxiliary supply for audible as well as visual alarm through lamp and bell arrangement. The scheme shall comprise of D.C. supervision relays with test push buttons for Incoming DC supply (DC – 1 and DC – 2) and AC operated alarm accept relays, indication lamps, AC operated hooter and push button for cancellation of audible alarm, as necessary.

In each panel, Annunciation DC Fail indication at Annunciator, which is fed by AC supply.

- ***Other Trip and Non-Trip Alarms***

Facia annunciation system shall be provided in each control panel by means of visual and audible alarm to draw attention of the operator to the abnormal operation or operation of the protective devices. The annunciation shall be divided into the following categories:

(i) Trip annunciation

(ii) Non-Trip annunciation

The annunciator shall be suitable for operation with the sub-station AC/DC voltage and potential free initiation contact is to be provided.

The visual facia window shall be flush mounted at a convenient position near top row of the control panel and necessary switching relays for the same shall be mounted inside the panel or at the relay side of the panel.
The annunciator facia shall be provided with translucent glass or plastic cover plates of white color with inscription in black color. The size of facia window shall be 70mm x 35mm in general and the size of the lettering shall not less than 5 mm. Alarm inscription shall be engraved not more than three lines of in each facia window and the same shall be prominently visible when facia light is ON. The cover plates of the facia window shall be easily removable to facilitate replacement of lamp when required. Annunciator of each Panel must have minimum 5-6nos. spare windows available.

The transparency of cover and wattage of the lamp provided in the facia window shall be adequate to ensure clear visibility of the inscription from the location of the operator's table in the control room having high illumination intensity. Each facia window shall be provided with two lamps to ensure safety against lamp failure. Long life lamp shall be used having resistor of adequate rating in series. Annunciator should have in-built Accept, Reset, and lamp Test push buttons for acknowledgment of alarm, reset of visual indication and for checking perfectness of the lamps shall be provided below the facia window in each panel. These push buttons shall be common for both trip and warning annunciation.

B. Cable:

i) Designation: 1100 V (E) grade, multi-core copper conductor, PVC insulated GI flat/round armoured, overall served with PVC suitably compounded to ensure specified fire-retardant low smoke properties heavy duty control cable.

ii) Conductor: Standard plain (untinned) annealed high conductivity copper conductor Class 2 table 2 of IS 8130.

iii) Insulation: PVC Type-A of IS 5831.

iv) Inner sheath and filler: PVC Type ST-1 of IS 5831. Inner sheath shall be extruded.

v) Outer sheath: PVC type ST-1 of IS 5831 suitably compounded for FRLS properties and with suitable additives to prevent attack by rodents and passing test requirements specified hereinafter.

vi) Armouring: GI Wire/strips to IS 3975 and IS 1554 (Pt. I).

viii) Factory test: As specified hereinafter.

- ***Identification Mark***

Throughout the length, cables served with FRLS PVC outer sheath shall be identified by surface marking by embossing/ machine printing giving:

1. Name of manufacturing and year of manufacture:
2. Cable description e.g., 1100 V 4C x 6.0 Sq. mm Cu PVC FRLS Type cable etc.
3. Name of customer e.g., CUSTOMER: SLDC PATNA
4. Embossed length measure in Meters at every meter interval.
5. Core identification shall be done by colours as per IS 1554 (Pt. I).

- ***Drumming, Reeling & Marking***:

The cables shall be supplied in non-returnable wooden drums in 500M ± 5%-reel lengths for power cables and 1000M ± 5% for control cables unless otherwise specified. However, actual drum length both for power & control cable will be finalized during detail Engineering stage. The cable drums shall be suitable for taking round spindle and shall be suitably logged with strong 5cm thick wooden battens to prevent damage to the cable. A minimum clearance of 15cm shall be allowed between the outer layer and the inside of logging. Cable ends shall be properly sealed and made watertight to prevent ingress of moisture during transit/storage in the open cable yard. The drums shall be suitably reinforced with hoop iron to withstand transit hazards. Each drum shall have a distinguishing number. On outside of the flange particulars of the cable viz. voltage class, length, cable description, project reference and order details, finished gross weight and net weight and direction of reeling shall be clearly stated on the flange of the drum. The wooden drum shall conform to latest IS.

Type test and Acceptance Criteria

Controllers:

Type Tests:

Complete Type Test Reports from NABL accredited laboratory / Equivalent laboratory abroad in respect of the following aspects shall be submitted with the offer.

The following type tests shall be conducted on the Controllers/ Protective relays.

A. High Voltage Withstand – As per IEC-60255-5

i) Dielectric Withstand

ii) Impulse withstand

iii) Insulation resistance

B. Electrical environment -

i) Auxiliary supply test, dc interruption- as per IEC 60255-11. The relay or its associated power supply is required to operate satisfactorily with a DC supply voltage range of 220V ± 20%.

The performance shall not be affected due to

- An interruption to the DC auxiliary supply of duration up to 10ms.
- AC component (ripple) in the DC auxiliary supply up to 5% of rated value.

ii) High frequency disturbance – as per IEC 60255-22-1

iii) Fast Transients – as per IEC 60255-22-4

iv) Conducted electromagnetic field disturbance– as per IEC 60255-22-6

v) Radiated electromagnetic field disturbance - as per IEC 60255-22-3

vi) Radiated emission – as per IEC 60255-25

vii) Conducted emission - as per IEC 60255-25

viii) Electrostatic discharge – as per IEC 60255-22-2, (Class III and IV)

ix) Surge immunity – as per relevant IEC

x) Power frequency magnetic field – as per IEC 61000-4-8

C. Atmospheric Environment

i) Temperature – as per IEC 60068-2-1-cold IEC 60068-2-2- dry heat

ii) Humidity – as per IEC 60068-2-3, IEC 60068-2-30

iii) Enclosure protection – as per IEC 60529

D. Mechanical environment

i) Vibration – as per IEC 60255-21-1

ii) Shock and bump- as per IEC 60255-21-2

iii) Seismic – as per IEC 60255-21-3

E. Relay characteristics, performance, and accuracy test as per IEC 60255
   i) Steady state Characteristics and operating time.
   ii) Dynamic Characteristics and operating time

F. Tests for rated burden as per IEC 60255-6

G. Conformance Testing as per IEC 61850

Routine Tests:

During fabrication, the panels shall be subject to inspection by the Purchaser to assess the progress of work as well as to ascertain that only quality raw material is used. Routine test as per relevant BSS/ISS/IEC shall be carried out on each equipment without any cost implication to the purchaser.

Following constitute Routine tests:

i) Visual inspection, dimensional, paint thickness checking etc,

ii) Checking of BOM and test certificate of all bought out items used in panel.

iii) Functional check of all equipment and scheme for control & protection purpose with all equipment placed in its proper position along with all inter panel wiring as per approved panel board formation layout.

iv) AC HV test for 1min duration on panel wiring circuit.

Acceptance Tests

Acceptance tests as per indicated IS/IEC/SLDC PATNA specification/Scheme requirement shall be carried out on each equipment, wiring in presence of the Purchaser's representative.

Acceptance test includes:

i) Visual inspection, dimensional, paint thickness checking etc,

ii) Checking of BOM and test certificate of all bought out items used in panel.

iii) Functional check of all equipment and scheme for control & protection purpose with all equipment placed in its proper position along with all inter panel wiring as per approved panel board formation layout.

iv) AC HV test for 1min duration on panel wiring circuit.

Minimum twenty-one (21) days advance intimation shall be given to the Purchaser for witnessing the acceptance tests of the complete equipment. The formal call for Acceptance tests must accompany the Routine Test Reports of the equipment. Testing and commissioning of the panels at site shall be carried out by the manufacturer at no extra cost.

Cables:

Complete Type Test Reports shall be submitted with the offer as per the indicated standards from an accredited laboratory. Accreditation shall be from the national accreditation of the country in which the laboratory is located. If the Type Tests reports are older than specified time limit (seven years) the Manufacturer/Bidder shall give undertaking to conduct all the following type tests free of costs to SLDC PATNA before Accordance of Mass Manufacturing Clearance.

Type Tests:

The test of one drum out of every 10 drums or less on each type and size of the cable shall be conducted as per IS: 10418.

a. Test on Conductor
    1. Tensile test (for Aluminium): As per IS 8130
    2. Annealing test (for copper): As per IS 8130
    3. Wrapping test (for Aluminium): As per IS 8130
    4. Conductor resistant test (for Aluminium and Copper): As per IS 8130

b. Test for armouring wires: As per IS 3975.
c. Test for thickness of insulation and sheath: As per IS 1554(Pt.I).
d. Physical test for insulation and outer sheath: As per IS 5831

1. Tensile strength and elongation at break
2. Ageing in air oven
3. Shrinkage Test
4. Hot deformation
5. Loss of mass in air oven
6. Heat Shock Test
7. Thermal Stability.
8. Cold Bend Test (for diameter
9. Cold Impact Test (for diameter > 12.5 mm)
10. Insulation resistance test: As per IS 5831
11. High voltage test (water immersion test): As per IS 1554(Pt.I)
12. High voltage test at room temperature: As per IS 1554(Pt.I)
13. Flammability Test: As per IS 1554(Pt.I)

Special Tests

These tests will be conducted on any two drums of each group as per Purchaser's choice.

1. Water absorption test for insulation as per IS 5831
2. Oxygen Index test as per ASTMD-2863. Minimum guaranteed value shall be 29.
3. Temperature Index test to ASTMD-2863. Minimum guarantee value shall be 250.0.
4. Acid gas generation test as per IEC 60754. Maximum guaranteed value should be 20.
5. Smoke density test as per UTTD test method F4 of ASTMD-2843.

Routine Tests

These tests will be conducted on each drum of FRLS cable.

1. Conductor resistance test
2. High voltage test at room temperature

Existence of facilities for carrying out all the routine tests in manufacturer's works shall be specifically confirmed. Dates of installation and commissioning and details of make, year of manufacture etc. for machines/test apparatus for carrying out ’special tests’ shall be furnished.

Acceptance Tests

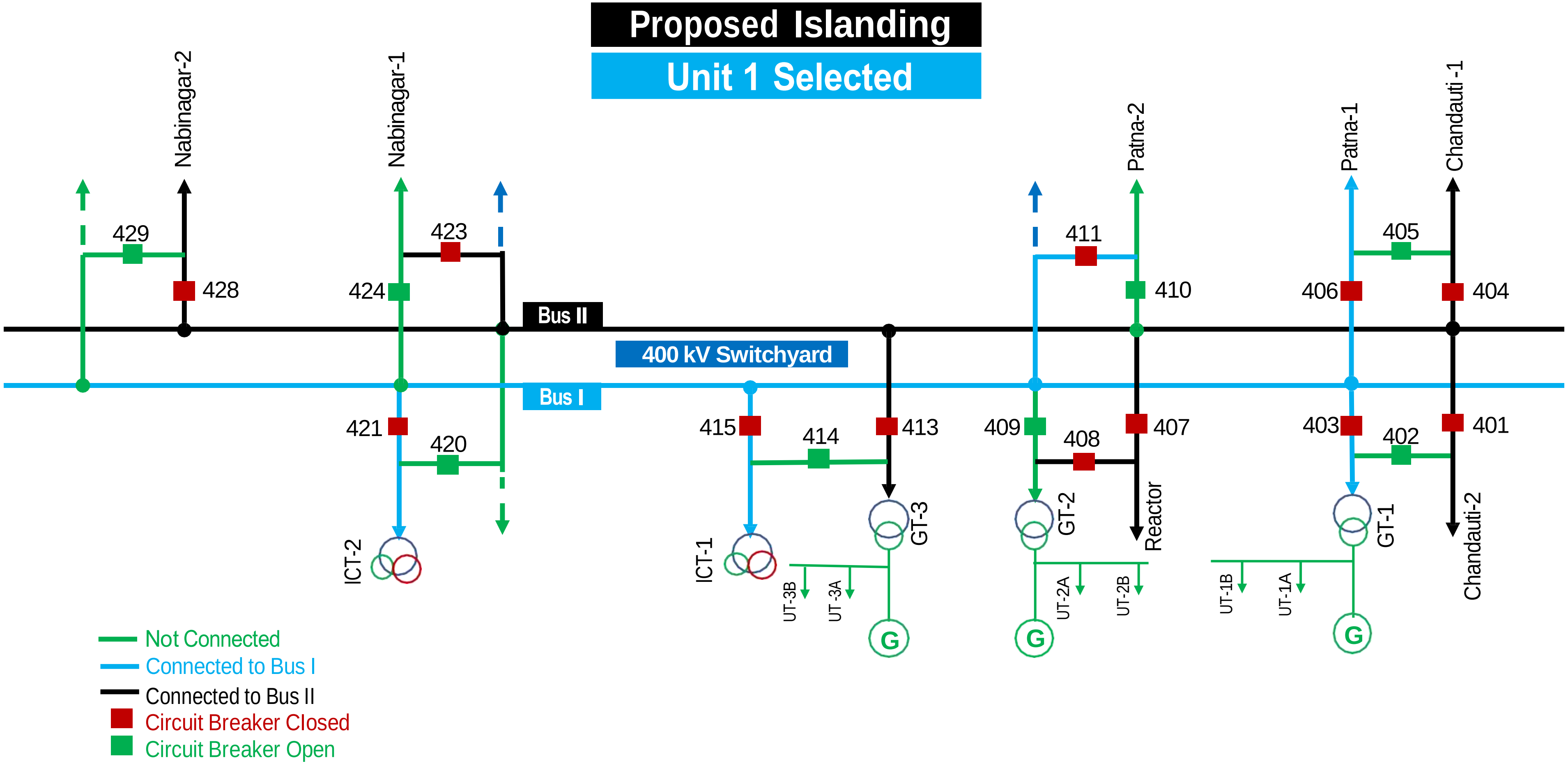
1. Tensile test (for aluminium)
2. Annealing test (for copper)
3. Wrapping test (for Aluminium)
4. Conductor resistance test
5. Test for thickness of insulation and sheath
6. Insulation resistance test
7. High voltage test at room temperature
8. Dimensional check.

Underarmour and overall diameters of cables (average values) shall be recorded on each Routine test certificates.

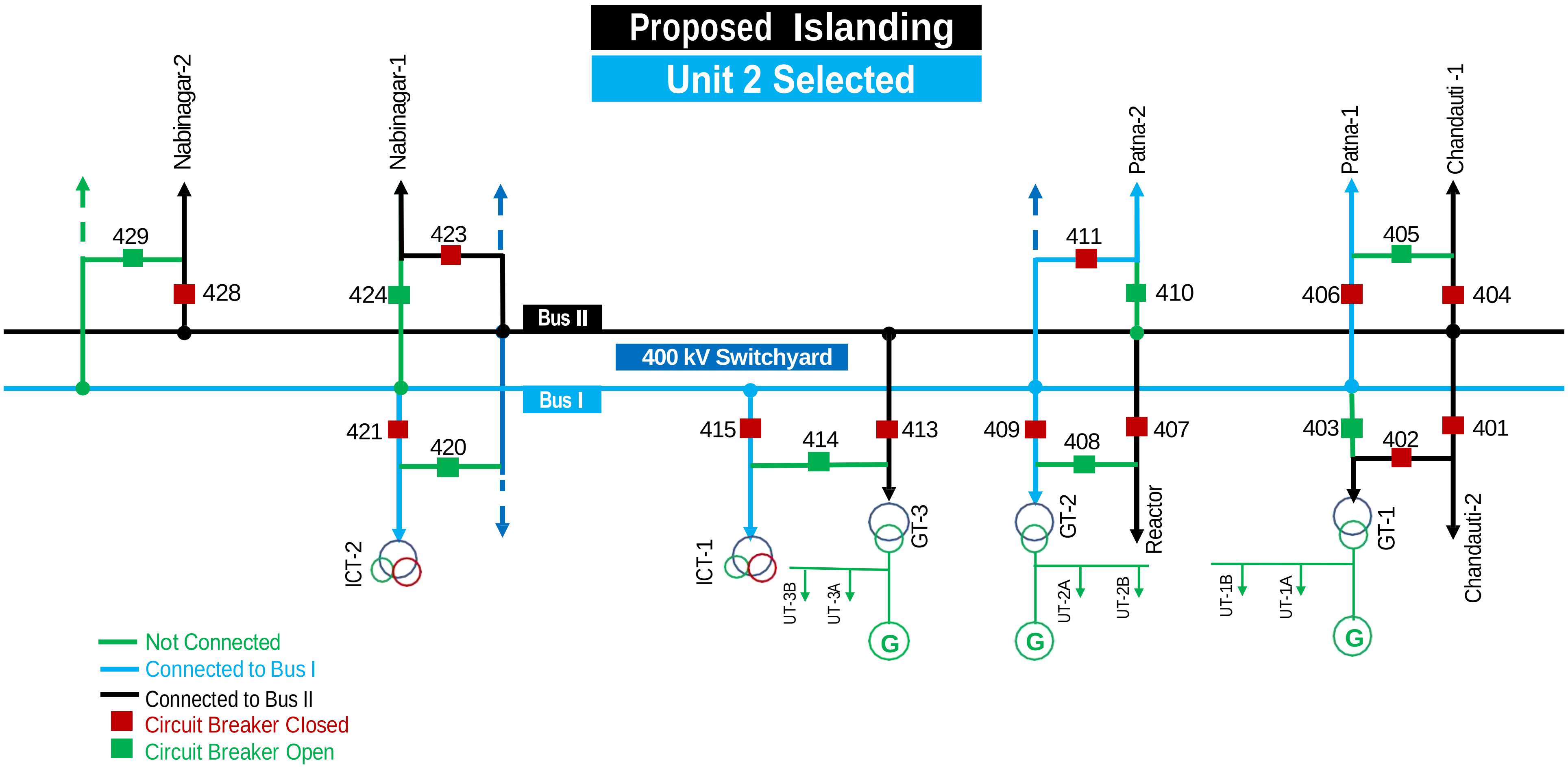
The Purchaser reserves the right to witness all tests, for which at least 3 weeks advance intimation for inspection, will be required.

Annexure-D

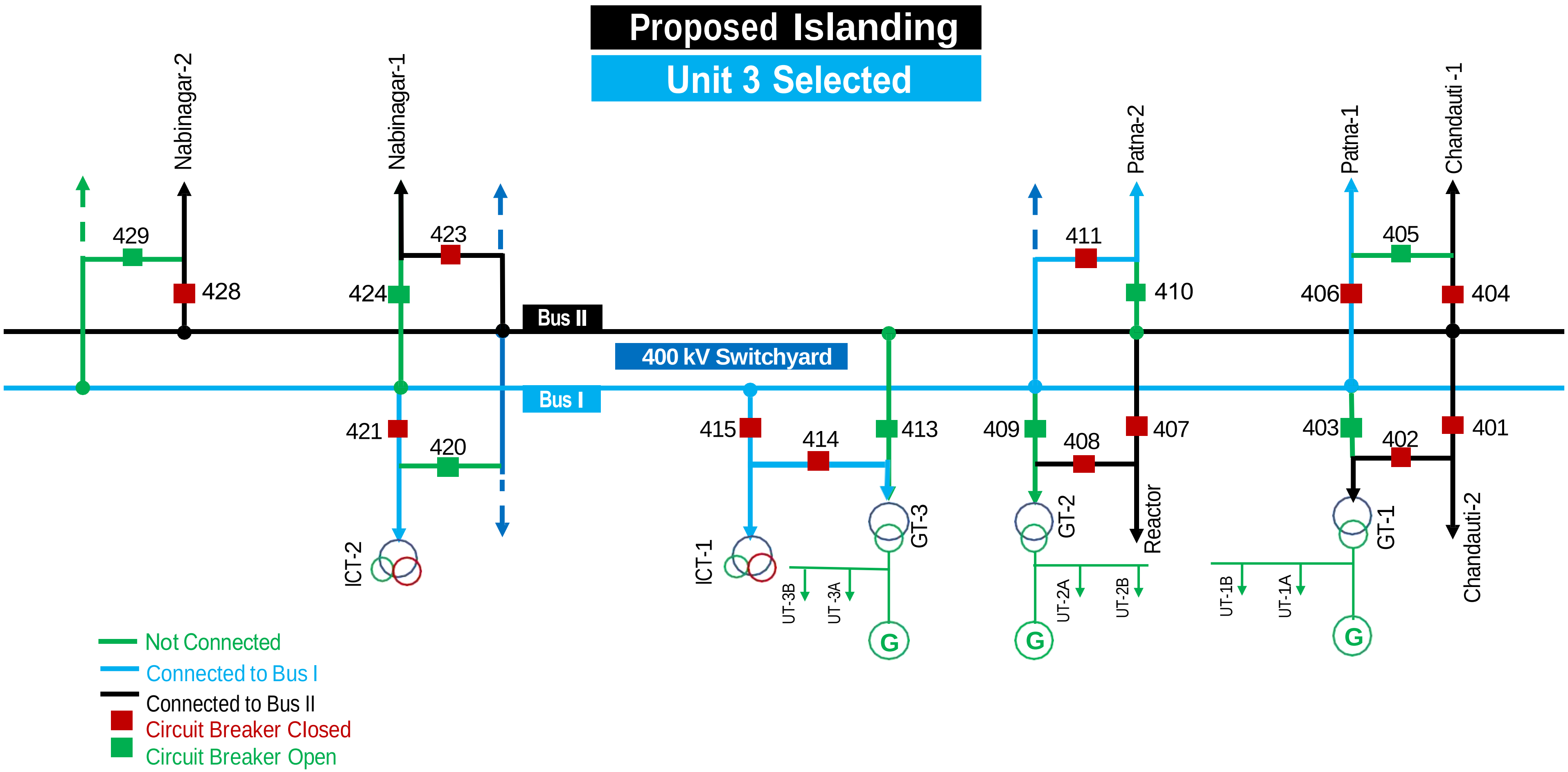
NPGC SLD for breakers to be opened for islanding of U#1



NPGC SLD for breakers to be opened for islanding of U#2



NPGC SLD for breakers to be opened for islanding of U#3



PATNA ISLANDING STUDY

Introduction:

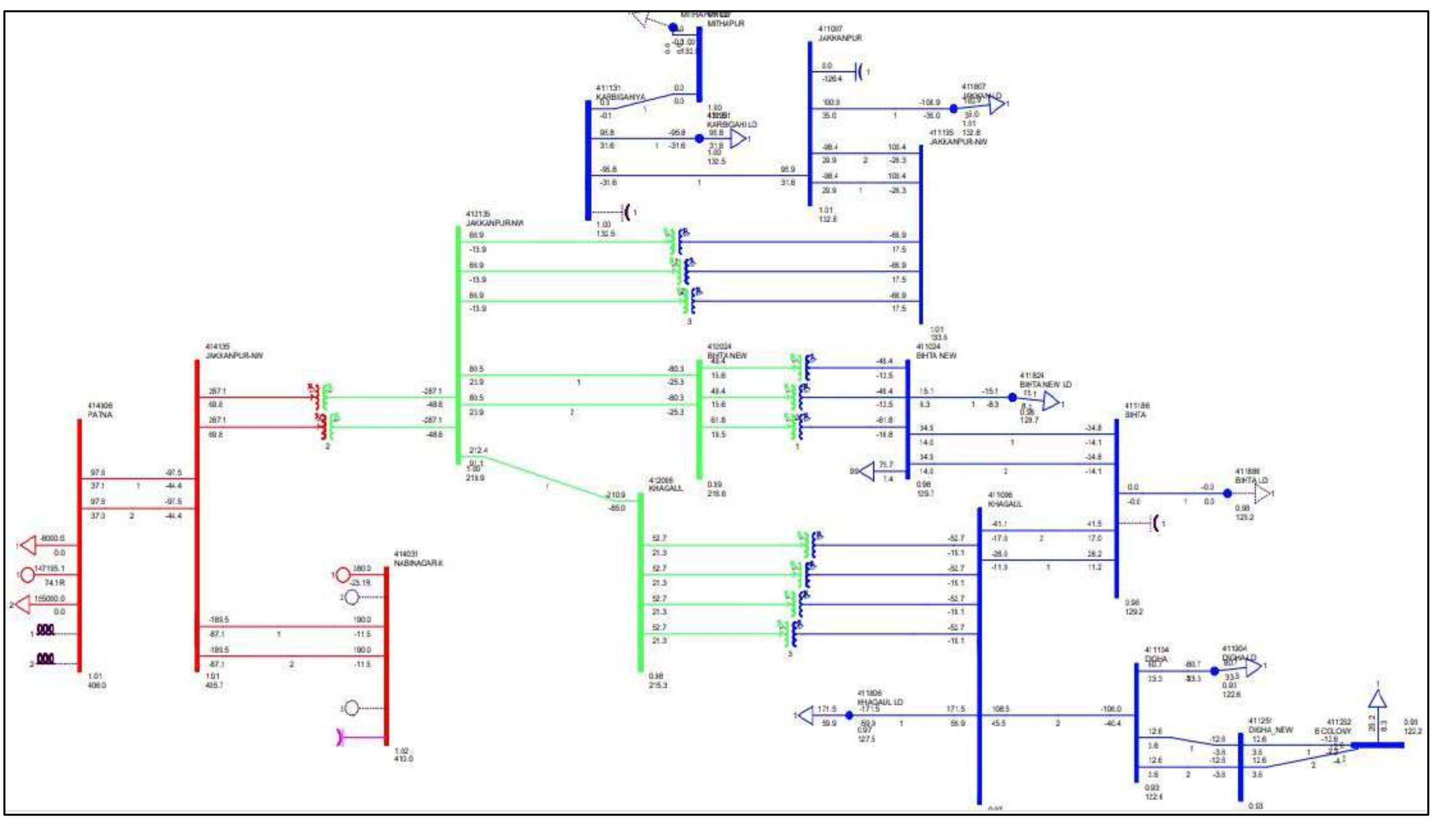
One of the key features of a resilient power system is robust islanding scheme. Success of an islanding scheme depends on the design as well as implementation of the logic. Logic needs to be robust as well as simple. Extensive study is required to design an effective islanding scheme. For PATNA islanding scheme design various preliminary studies are done and the results are discussed below. However, these studies are done based on certain assumption (which will be discussed below) and its purpose is to check the broader feasibility of an islanding scheme. Hence the final islanding logic must be finalized by the respective generating plants in consultation with their OEM.

1. Modeling:

A. Network:

Network modeling data is taken from latest PSSE base case as shared by BIHAR SLDC. Only the part of BIHAR network which corresponds to the Island to be formed, is taken into consideration. Rest of the grid is modeled as an equivalent generator or load.

In one of the equivalent generator bus (400 KV PATNA Bus) two loads are added: 1) Load 1 is a negative load and used for creating the frequency disturbance during the dynamic simulation. 2) Load 2 is All India load.



B. Generator:

NPGC generators are modeled as "GENROU" (cylindrical rotor synchronous machine) based on the OCC magnetization curve. The parameters of "GENROU" are populated based on the generator data sheet.

	Con Value	Con Description
1	5.2600	T'do (> 0)
2	0.0210	T"do (> 0)
3	0.6600	T'qo (> 0)
4	0.0330	T"qo (> 0)
5	2.6500	H, Inertia
6	0.0000	D, Speed Damping
7	2.0300	Xd
8	1.9800	Xq
9	0.3000	X'd
10	0.5000	X'q
11	0.2400	X"d = X"q
12	0.1500	Xl
13	0.0290	S(1.0)
14	0.1700	S(1.2)

Figure 1: NPGC generator parameters.

The equivalent generator representing the All-India grid is modeled by a simple classical cylindrical rotor **"GENCLS" model and its Inertia value** is used as per the inertia calculated during real frequency excursion event in the grid.

C. Exciter and PSS:

The NPGC excitation system is represented by ST7C model of PSSE library along with that PSS2B is used.

	Con Value	Con Description
1	0.0200	TR - regulator input filter time constant (s)
2	1.0000	TG - lead time constant of voltage input (s)
3	1.0000	TF - lag time constant of voltage input (s)
4	1.1000	VMAX - voltage reference maximum limit (p.u.)
5	0.9000	VMIN - voltage reference minimum limit (p.u.)
6	43.8400	KPA (>0) - voltage regulator gain (p.u.)
7	5.1580	VRMAX - voltage regulator maximum limit (p.u.)
8	-5.1580	VRMIN - voltage regulator minimum limit (p.u.)
9	0.0000	KH - feedback gain (p.u.)
10	1.0000	KL - feedback gain (p.u.)
11	1.0000	TC - lead time constant of voltage regulator (s)
12	1.0000	TB - lag time constant of voltage regulator (s)
13	1.0000	KIA (>0) - gain of the first order feedback block (p.u.)
14	3.0000	TIA (>0) - time constant of the first order feedback block
15	0.0000	TA (>0) - thyristor bridge firing control time constant (s)

Figure 2: NPGC exciter model

D. Governor model:

TGOV1 governor model is used and following parameters are considered in simulation:

	Con Value	Con Description
1	0.0500	R
2	0.1000	T1 (>0)(sec)
3	0.7847	V MAX
4	0.3000	V MIN
5	2.0000	T2 (sec)
6	8.0000	T3 (>0)(sec)
7	0.0000	Dt

Figure 3: NPGC governor Model

However, the above model doesn't take for the RGMO and maximum output limit is limited to 5% of current generation value for maximum governor output.

During few simulation the lower limit of the governor is not restricted to 5% of MCR , the reason is as follows:

We know that there is a speed controller in generator, which starts unloading the unit even beyond the 5% limit of RGMO when speed crosses some value and speed controller takes over the load controller. Also HP-LP bypass system is there for quick load reduction.

E. Load modeling:

Loads are modeled as below:

Real Power: 100% Constant Current

Reactive Power: 100% Constant Admittance

Frequency dependency of the load is not modeled.

2. Design logic:

Following points are considered in designing the islanding logic:

I. Frequency setting for last stage of the existing All-India UFLS scheme is 48.8 HZ; therefore island formation should happen below this frequency with sufficientmargin.
II. However, during few scenarios after the formation of the island, island may be generation deficit. To tackle such some UFLS scheme is designed forisland. Butthis UFLS schemestartsmuch belowthe gridside UFLSscheme.
III. Present frequency protection setting for NPGC units is as follows:

Under Frequency: 47.4 Hz, 2sec
Over frequency: 52 Hz, 2 sec Only Alarm No tripping, but mechanical side speed related tripping of turbine is there. (At what frequency corresponding to turbine speed ,tripping is there needs to be given by plant)

Based on the above inputs following islanding logic is proposed:

I. Islanding should commence before pick up of any of the under-frequency protection stage of units and that's why island formation will start at 48.4 Hz with a delay of as minimum as possible.
II. **Under frequency inside the island is proposed** to trigger at 48.2 Hz.

The details are as follows

- 48.2 HZ 500 ms 30 % of island load
- 48.0 Hz 500 ms 10% of Island load
- 47.8 Hz 500 ms 10 % of Island load

3. Load Generation Scenario:

GSS	Peak Load(MW)	Off peak load(MW)
Jakkanpur	100	75
Karbigahiya	80	45
Mithapur	60	50
Khagaul	170	150
Bihta(Old)	116	90
Bihta(New)	15.5	10
Digha	95	60
Jakkanpur(new)		
Digha(New)		
Board colony		
Total in MW	**636.5**	**480**
Mithapur AUFLS	50	50
After deducting AUFLS LOAD	**586.5**	430
Railway	11	5
After deducting RAILWAY LOAD	**575.5**	**425**
Additional margin for 220 Khagul line loading	20	5
Final island load	**555 (Max Load)**	**420 (Min load)**
Generation Of NPGC	**MAX Generation = 580 MW (660-80 MW) after deducting auxiliary and other necessary load of NPGC.**	**Min Generation = (380 MW) Tech Minimum**

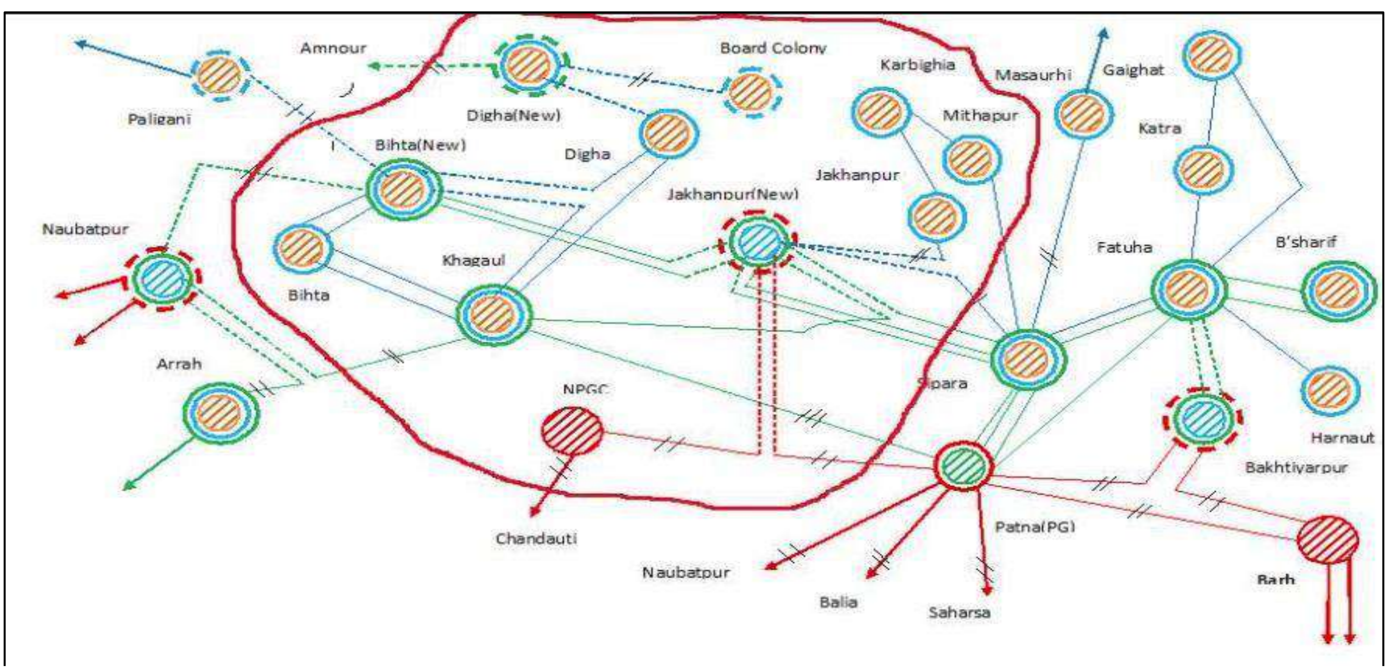


Figure (4) Geographically marked Islanded area

4 Simulation:

Different LGB scenario is studied in the simulation for checking the robustness of the proposed scheme. Details of different scenario are summarized as follows:

Scenario	Generation	Load	Surplus(+)/Deficit(-)
Scenario-1	580 MW (Max Generation)	560 MW (Max Load)	20 MW
Scenario-2	580 MW (Max Generation)	420 MW (Min Load)	160 MW
Scenario-3	380 MW (Min Generation)	420 MW (Min Load)	-40 MW
Scenario-4	380 MW (Min Generation)	560 MW (Max Load)	-180 MW

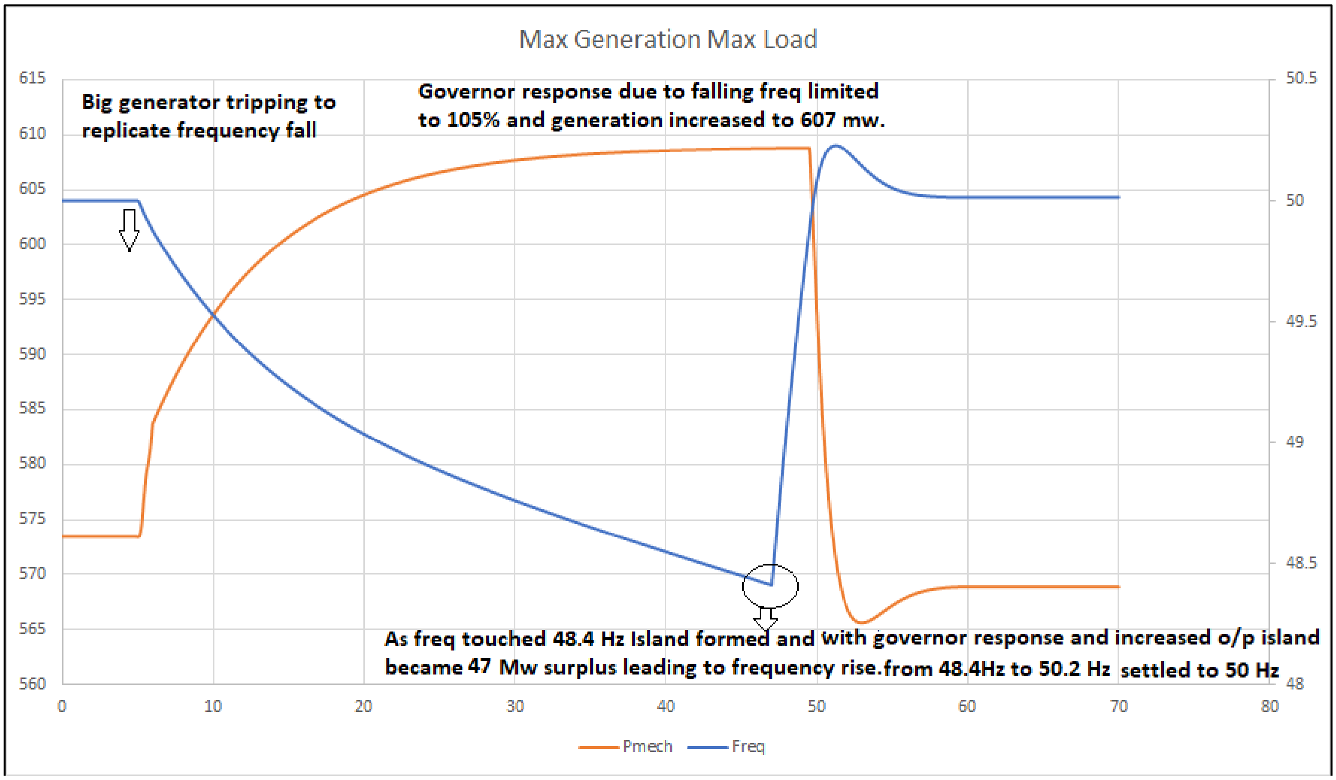
The above LGB is prepared based on input from SLDC.

With above islanding logic following steps are followed:

Step-1. First a grid disturbance is created by tripping 8000 MW generation (i.e. the negative load). This triggers the island formation logic in which the equivalent generator or load buses are tripped, as the frequency drops to 48.4 Hz Island is formed.

Step-2. After formation of island the simulation is further carried out for 60 sec to check stabilization of the island frequency with all generator protection and island UFLS in action.

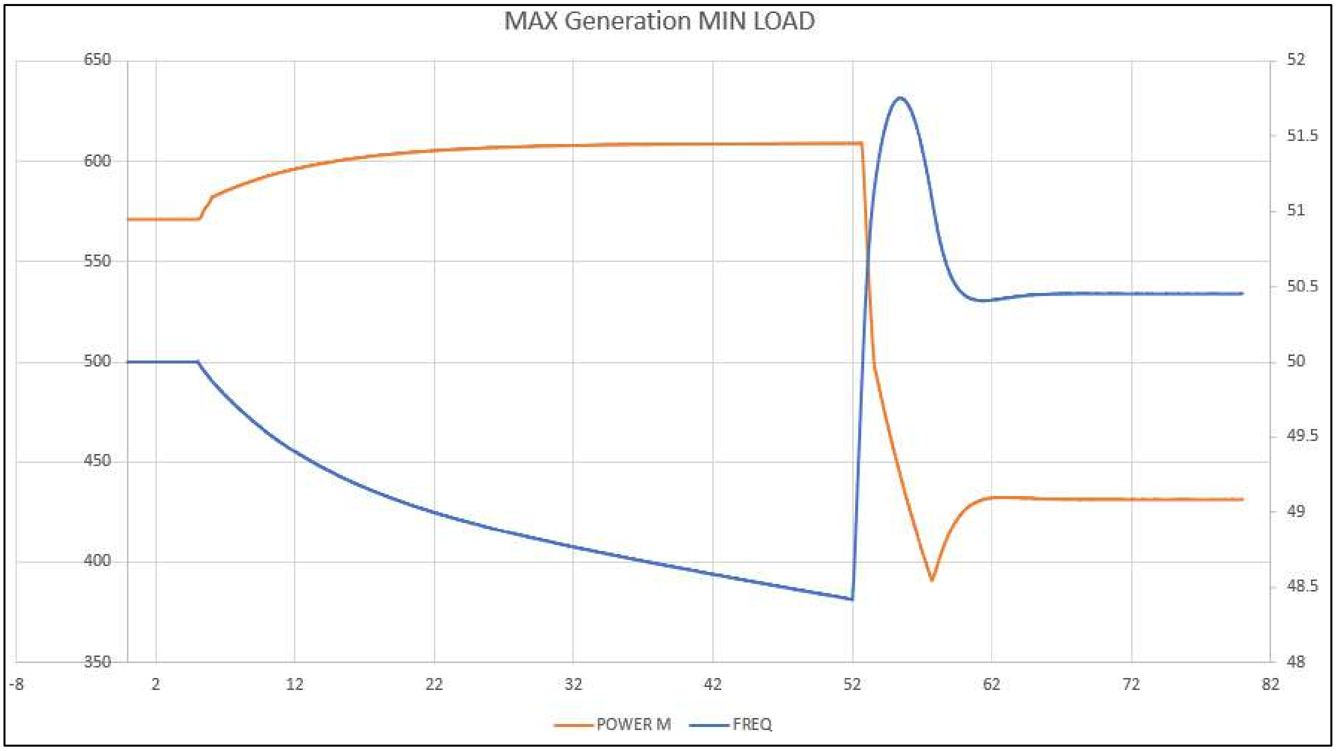
Scenario-1: Maximum generation & Maximum load



Discussion:

1. In max generation max load scenario there is 20 MW surplus generation inside the Island.
2. As the one big generator tripped to replicate frequency fall, Unit of NPGC will also respond to this frequency change and which is limited to 105% of the generation so generation increased till 607MW from 580 MW.
3. As the frequency touches 48.4 Hz and island is formed Island becomes 47 MW generation rich and sharply frequency rises from 48.4 HZ TO 50.2 Hz and settles to 50 Hz.

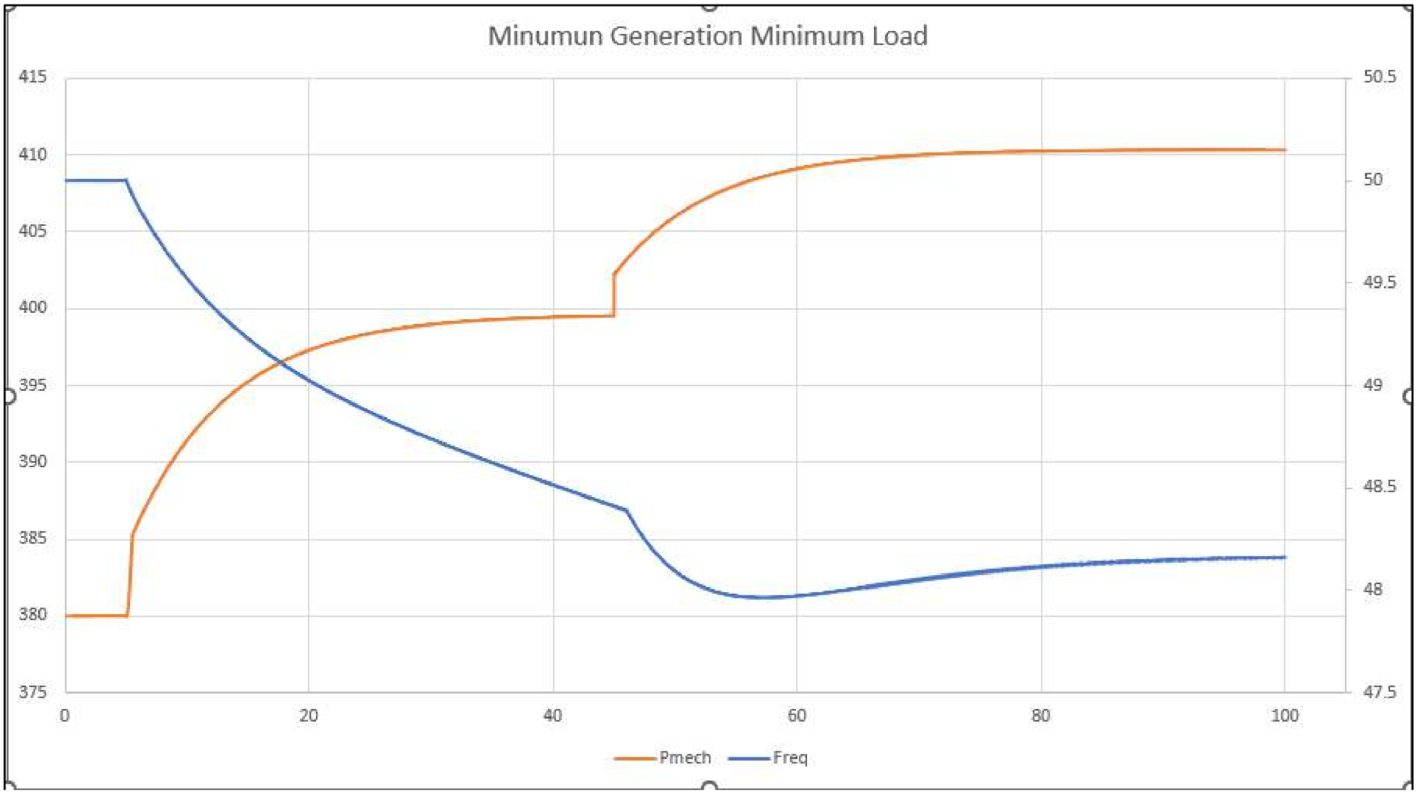
Scenario-2 : Maximum generation & Minimum load



Discussion:

1. In max generation min load scenario there is 140 MW surplus generation inside the Island.
2. As the one big generator tripped to replicate frequency fall, Unit of NPGC will also respond to this frequency change and which is limited to 105% of the generation so generation increased till 607MW from 580 MW.
3. As the frequency touches 48.4 Hz and island is formed Island becomes 187 Mw generation rich and sharply frequency rises from 48.4 HZ TO 51.7 Hz and settles to 50.5 Hz.
4. As per information received at 52 Hz -2 sec O/F alarm is only there no direct frequency based relay but , turbine speed related tripping is there .
5. **In respect to above Generator over frequency/Turbine speed related tripping may be kept upto 53 Hz if possible, to ensure sufficient margin and avoid unit tripping on over frequency.**

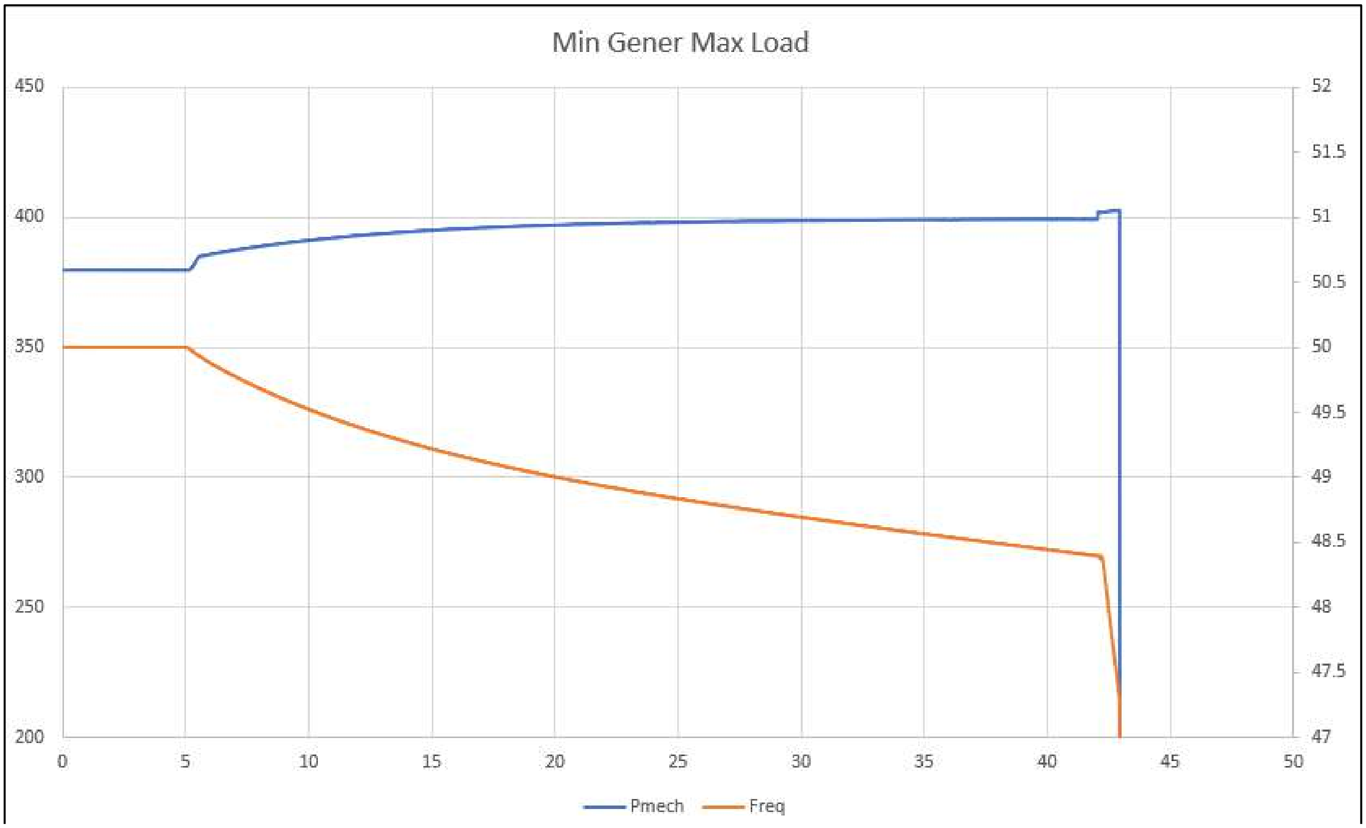
Scenario-3: Minimum generation & Minimum load



Discussion:

1. In min generation min load scenario, there is 40 MW generation deficit inside the Island.
2. As the one big generator tripped to replicate frequency fall, Unit of NPGC will also respond to this frequency change and which is limited to 105% of the generation so generation increased till 400MW from 380 MW.
3. As the frequency touches 48.4 Hz and island is formed Island becomes only 20 MW generation deficit and frequency further decreases from 48.4 HZ TO 48 Hz and settles to 48.15 Hz (in islanded mode **governor response is limited to 107% of current generation so 107*380 MW=406 MW**).
4. As per information received at 47.4 Hz -2 sec under frequency tripping is enabled.
5. **In respect to above it appears no under frequency tripping should occur still to create sufficient margin if Governor response can be limited to 105% of MCR would help in frequency support which is also mandated by new IEGC.**

Scenario-4: Minimum generation & Maximum load

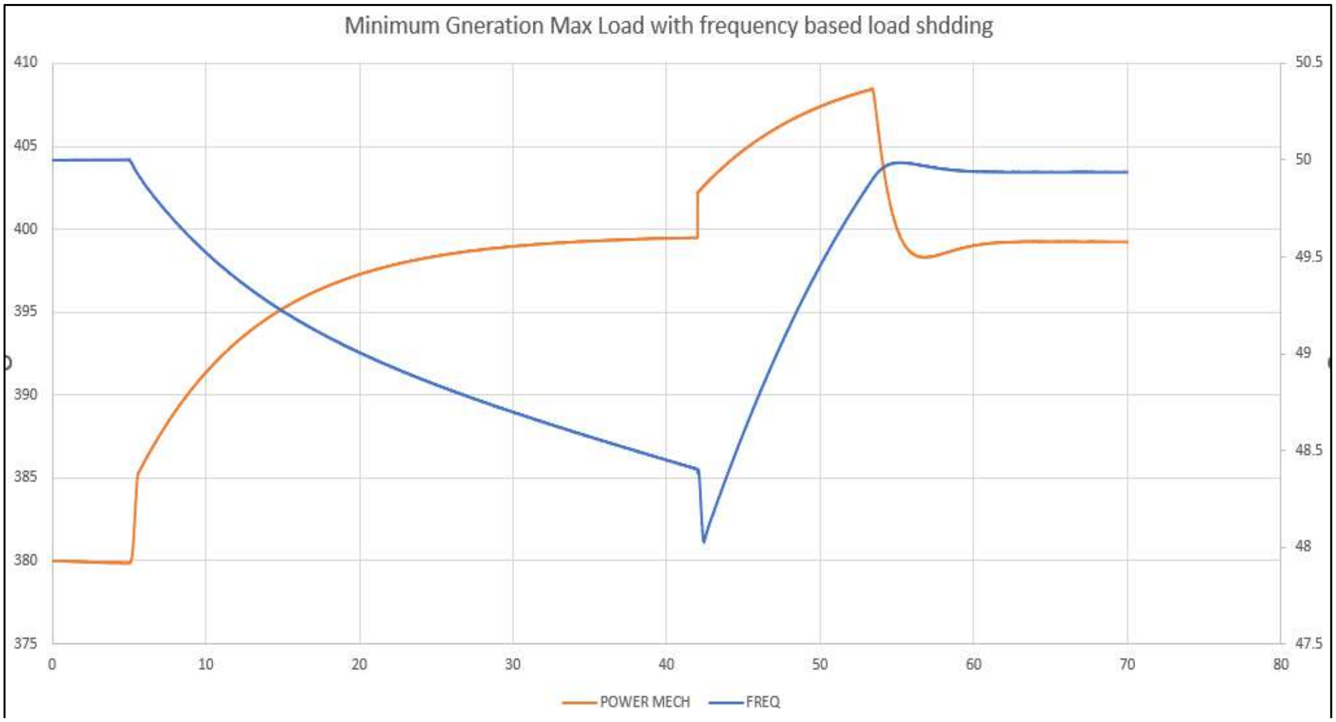


Under the Minimum generation and maximum load scenario after islanding, island is almost 160 MW generation deficit this will lead to sudden frequency fall and tripping of generating unit and island will not survive .

So to ensure survival under this condition automatic load shedding to be implemented inside the island.

Under frequency inside the island is proposed to trigger at
48.2 Hz. The details are as follows

- 48.2 HZ 500 ms 30 % of island load
- 48.0 Hz 500 ms 10% of Island load
- 47.8 Hz 500 ms 10 % of Island load



With the proposed UFLS scheme with 30% Load shedding at 48.2 Hz,(560*0.3=168 Mw) frequency improved to 50 Hz as total load inside the island became 392 MW WITH A Generation of same amount.

Summary:

SCENARIO	Generation	Load	Surplus/Deficit	Remarks
Scenario-1 (Max GEN& MAX LOAD)	580 MW	560 MW	20 MW	**In this scenario, island can survive.**
Scenario-2 (Max GEN& MIN LOAD)	580 MW	420 MW	160 MW	**In this scenario, island can survive. Generator over frequency/Turbine speed related tripping may be kept up to 53 Hz if possible to ensure sufficient margin and avoid unit tripping on over frequency.**
Scenario-3 (MIN GEN& MIN LOAD)	380 MW	420 MW	-40 MW	**In this scenario, island can survive. It appears no under frequency tripping should occur still to create sufficient margin if Governor response can be limited to 105% of MCR would help in frequency support which is also mandated by new IEGC.**
Scenario-4 (MIN GEN& MAX LOAD)	380 MW	560 MW	-180 MW	**In this scenario island cannot survive until, Automatic frequency-based load shedding is not implemented inside the island as mentioned.**

Based on the above study following islanding logic is proposed:

I. Islanding should happen before pick up of any of the frequency protection stage and that's why island formation will start at 48.4 Hz with a delay of 500 m sec.

II. Under frequency load shedding inside the island is proposed to trigger at 48.2 Hz. The details are as follows

48.2 HZ 500 ms 30 % of island load

48.0 Hz 500 ms 10% of Island load

47.8 Hz 500 ms 10 % of Island load

III. Generator over frequency/Turbine speed related tripping may be **kept at 53 Hz** if possible, to ensure sufficient margin and avoid unit tripping on over frequency.

IV. To create sufficient margin if Governor response can be limited to 105% of MCR would help in frequency support which is also mandated by new IEGC**.**

Limitation of the study:

1. In absence of any guideline for islanding study, we have applied a frequency disturbance in the grid and grid is simulated with closely matching inertia and Governor Response. However, it is well known that during such large disturbance lot of other protective control features of various generators, other equipment may come into picture. Also, UFLS of grid side impacts the frequency dynamics and the ROCOF. Those phenomena are difficult to consider in the study. Therefore, not considered here.
2. The exact governing behavior of the units has high impact on the island study, however those detailed model of a plant considering influences from speed and pressure control loop is not modeled here. Plants may consult OEM for the detailed study considering those control action.
3. Initial ROCOF has also has huge impact of island stability after separation, however this ROCOF depends on lot of things and very difficult to predict. Also, there is no guideline in Indian context what ROCOF should be considered during such study.
4. Therefor the above study is only showing a tentative frequency excursion of the island and helping in arriving a suitable starting logic for island formation and stability within the island.

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Distribution NTPC Nabinagar		

Executive Summary

This project report presents a comprehensive study of the feasibility and efficacy of the Patna Islanding Scheme, utilizing any one unit of 3x660MW at NTPC Nabinagar. The study aims to assess the potential for implementing an islanding scheme in Patna.

Based on the data received from NTPC Nabinagar for the elements within the island network, detailed model of Patna Island network has been developed in ETAP and Simpow software. The voltage and frequency control functions of generation sources are validated with the tests results shared by NTPC Nabinagar. Based on peak load and off-peak load data received, simulation scenarios are derived for assessing all possible conditions of transition to Island and stable Island operation after Island formation. The load handling capability of generator during islanded conditions are also studied. A total of 19 simulation cases are studied in this report. Based on the analysis of simulation results, it is observed that Island formation triggers under two conditions:

- When the frequency reaches 48.4 Hz.[1]
- When frequency reaches 49 Hz with a rate of change of frequency (ROCOF or df/dt) greater than or equal to +0.5 Hz/sec. (3.1.9)

It is observed that during the formation of island there is an overshoot in frequency with highest frequency amplitude reaching a value of 51.83 Hz (3.1.2) This gives the estimate of setting the over frequency protection value greater than 52 Hz with minimum delay.

In the simulated worst-case scenario (Case 4), where the generation is minimum (380 MW) and load condition is at maximum (640MW), load shedding was carried out in two stages and simulation gives a stable Island formation (3.1.4).

These simulation study results may change subjected to non-linear relationship between governor output and active power of the unit. The effect of deviation in main steam pressure may also alter the response. One such case (Case 19) is simulated (3.1.19) where a non-linearity between governor output and active power was introduced and simulation results with linear and non-linear response were compared. It was observed that Island operation was not stable, leading to tripping of the unit during the load variation through the non-linear zone. Hence, in order to know the true load handing capability of turbine and to validate the simulation study results we suggest performing a simulated online Island operation test.

In this report titled "**2023-10-06-1.0- Detailed Dynamic Study of Patna Islanding Scheme with One unit of 3x660MW at NTPC Nabinagar"** is structured as follows:

Section 1 introduces the *project overview* and outlines the *scope of work*. ***Section 2*** provides a detailed *model description* of the Patna Island network, including the grid boundary, governor, AVR, generator, loads of plant and the island network. ***Section 3*** elaborates on various *simulation scenarios* for island operation under different contingencies. ***Section 4*** delves into the islanding scheme resulting from the simulations in Section 3. ***Section 5*** presents *observations* from simulations regarding the operation of the unit during islanding. ***Section 6*** proposes *recommendations*, and ***Section 7*** lists the references used in the report.

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Revision record

Rev. No.	Date	Section	Change	Revised by	Distributed to
1.0	2024-05-08	All	Document created	Solvina	NTPC Nabinagar

1. Introduction

NTPC Nabinagar STPS is situated in Aurangabad District of Bihar having three units of 660MW each with M/s GE make Turbo generator and M/s BHEL make boiler. As per the direction of Ministry of Power, Islanding Schemes needs to be implemented in all major cities of the country. In line with that, Patna Islanding Scheme is to be implemented considering any one of the three units of NTPC Nabinagar (660MW) as participating generator and the corresponding load of Patna city.

A detailed dynamic study is carried out for successful formation of the Island and smooth running of the unit after Island formation with the following objectives:

1. To isolate Patna power system network from the national grid during the event of grid disturbance.
2. After isolation from the national grid, uninterrupted power to be supplied to the essential loads in the network by NTPC Nabinagar.

Under severe system disturbances the islanding scheme in place would result in isolating Patna system from the grid. It is crucial to assess the stability of the island once formed, because the resulting island could either be generation surplus or under-generated. Factors such as turbine-generator overspeed controls, under-frequency load shedding, and power plant controls all influence the stability of the island's operation. This includes aspects like damping power oscillations, minimizing peak overshoot, or limiting maximum frequency deviation when islands are formed. Thus, steady state and dynamic simulation study of islanded operation has been carried out under various operating scenarios to derive best operating strategy during the grid contingency situations and smooth Island operation.

The findings from such simulation will be of great help in identifying additional steps, if any, which need to be taken for enhancing success rate of proposed islanding. In this context M/s Solvina received a work order 5500043420-045-1019 dated 30.10.2023 from NTPC Nabinagar for carrying out dynamic simulation studies for Patna Islanding.

1.1. Project Overview

This study investigates how grid failure affects a range of power system parameters within Patna Island Network for successful islanding of the unit. To perform the dynamic studies Governor model and excitation system were developed along with loads within the plant and in island network are modelled in ETAP and Simpow simulation tools and their response were simulated. Several simulation cases were performed to understand the dynamic behavior of the unit undergoing islanding. Further, the effect of a linear and non-linear valve behavior was studied to develop the understanding of control loop interaction between boiler and turbine. To validate the results of simulation cases, it is suggested to perform the online island operation test.

1.2. Scope of Work

As outlined in the scope of work provided by NTPC Nabinagar in the document titled **"PO-Detailed Dynamic Study of Patna Islanding Scheme with one unit of 3x660 MW at NTPC Nabinagar"** Solvina attempted to address all points mentioned in the scope of work [2]. However, certain aspects of scope of work couldn't be addressed due to limitation in data provided from NTPC Nabinagar.

Below is the scope of work as shared by NTPC Nabinagar:

1. Carry out a detailed dynamic Study on the Capability and Feasibility of the Units for Island mode of operation considering actual models of Turbine governor and Excitation System.
2. Detailed modelling of the turbine, Governor, Boiler and Excitation System of the Synchronous Generator.
3. Study the impact of various control loop interactions (including influence from the boiler and turbine side) during the formation of the island and successful operation of the Unit in the Island.
4. Design and development of possible Islanding and Load shedding schemes using the detailed model for safe and smooth operation.
5. Study the impact of Island Operation on Generator Side relays and Unit Auxiliaries.
6. Study the impact of frequency dependent loads on island system performance and identify the worst-case scenarios.
7. Any other requirements/modifications required for the successful formation of the Island.
8. Equipment's/system Data required for the Study shall be arranged by NTPC.
9. It is suggested that Vendor shall visit the site before bidding for better understanding of the scheme and scope of the work.
10. Above mentioned scope of work is of indicative nature only and not exhaustive. Any additional study works necessary for completion of the Detailed Study shall also be deemed as part of work in vendor's scope.
11. All the Study tools/Software's required for the study shall be in Vendor's Scope.

2. Modeling Description

Based on data required for the study and provided by NTPC Nabinagar, an input data validation report [3] was shared with NTPC Nabinagar. The power system elements within Patna Island network are modelled in this section. Suitable assumptions are made wherever data is not provided.

2.1. Island Network

Figure 1 shows the indicative diagram of Patna Island network. The same has been modelled in ETAP and SIMPOW as shown in Figure 2. The Island network has been modelled from the grid boundary i.e. from 400 kV voltage level to 33kV. The rest of the network (grid) is modelled as equivalent generators with closely matching inertia as that of the Indian grid. [4]

Two loads are added to the generator bus (400kV Grid Bus) to represent all India load. A third generator is added to the grid bus which is used to create the frequency disturbance during the transient simulation.

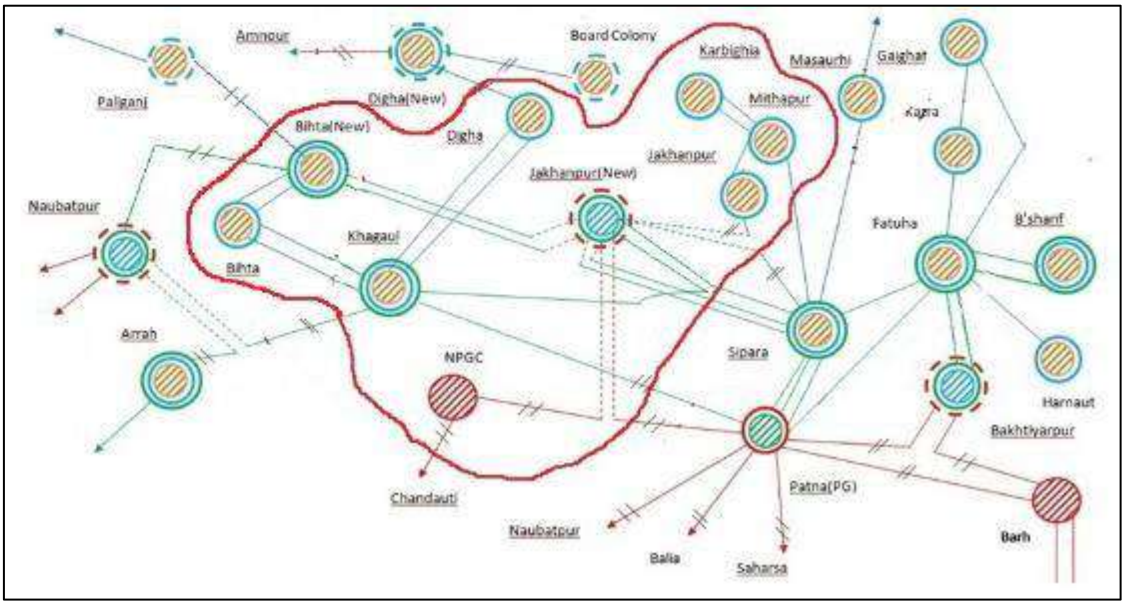

Figure 1: Indicative diagram of Patna Island Network

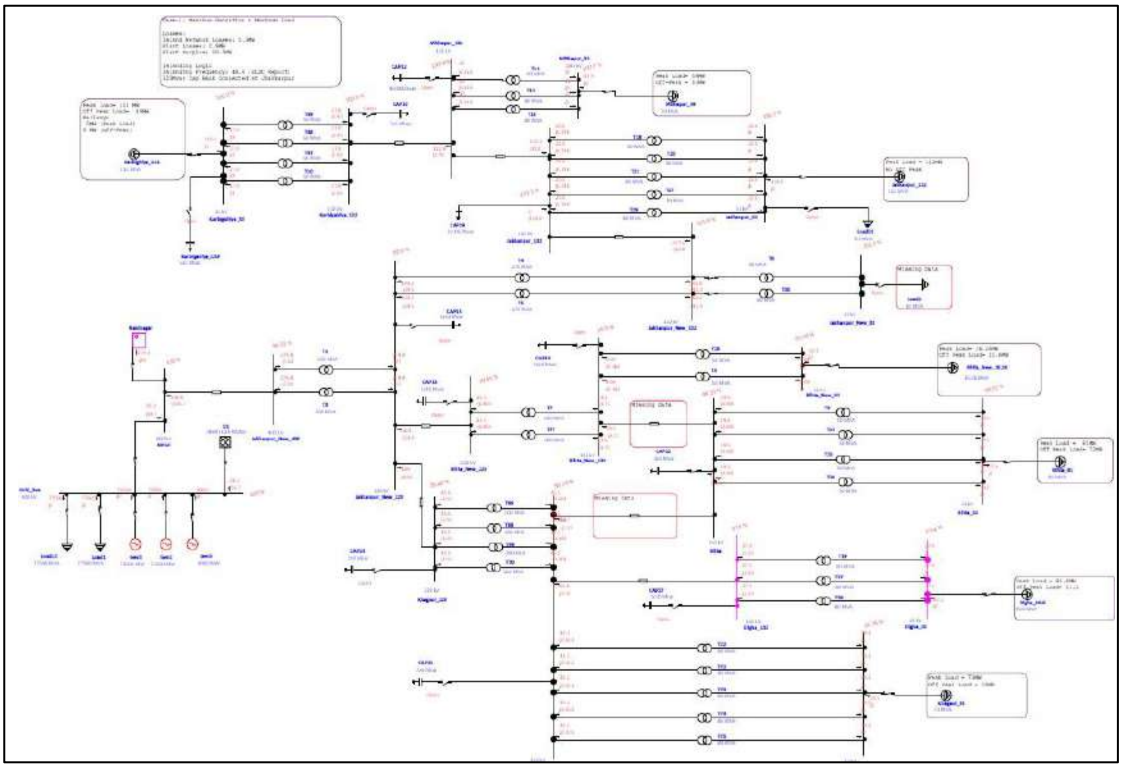

Figure 2: SLD of Patna Island network.

2.1.1. Island Load

The loads are modelled as per the data received form NTPC Nabinagar and tabulated in Table 1. All the loads in the Island network including the frequency dependent loads are modelled as static loads due to non-availability of the data from NTPC Nabinagar.

Table 1: Load description

GSS	**Peak load (MW)**	**Off peak load (MW)**
Jakkanpur	100	75
Karbigahiya	80	45
Mithapur	60	50
Khagaul	170	150
Bihta(Old)	116	90
Bihta(New)	15.5	10
Digha	95	60
Jakkanpur(new)		
Digha(New)		
Board colony		
Total in MW	636.5	480
Mithapur AUFLS	50	50
After deducting AUFLS LOAD	**586.5**	430

Railway	11	5
After deducting RAILWAY LOAD	**575.5**	**425**
Additional margin for 220 Khagaul line loading	20	5
Island load	**555 (Max Load)**	**420 (Min load)**
Final Island load with NPGC Load	**555+80=635 MW (80 MW is auxiliary and necessary load of NPGC**	**420+80= 500 MW**
Generation Of NPGC	**Max generation = 660**	**Min generation = 380 MW**

Note:

- No details of frequency dependent loads were provided, hence loads within island are assumed as static loads.
- Details of reactive power compensating elements were not provided; hence it is assumed that reactive power required by elements is supplied locally.

2.1.2. Island Transmission lines and cables

The transmission lines and cables are modelled as per the data provided by NTPC Nabinagar as shown in Table 2. Typical data for line impedances are used by assuming X/R ratio to be 10, due to non-availability of line impedance data from NTPC Nabinagar.

Table 2: Transmission lines and cables description

S.No	Transmission networks of Island	Conductor Type	Voltage level (kV)	Ckt length (km)
1	Jakkanpur New(BGCL) – Nabinagar (NPGC-02) Ckt - 01	Quad Moose	400	138.15
2	Jakkanpur New(BGCL) – Nabinagar (NPGC-02) Ckt - 02	Quad Moose	400	138.15
3	Jakkanpur New(BGCL) - Khagaul (BSPTCL)	ACSR Zebra	220	28.96
4	Jakkanpur New(BGCL) - Bihta New (BSPTCL) Ckt - 01	ACSR Zebra	220	44.31
5	Jakkanpur New(BGCL) - Bihta New (BSPTCL) Ckt - 02	ACSR Zebra	220	44.31
6	Jakkanpur New(BGCL) - Jakkanpur(BSPTCL) Old ckt-01	HTLS Panther	132	26.585
7	Jakkanpur New(BGCL) – Jakkanpur (BSPTCL) Old ckt-02	HTLS Panther	132	26.585
8	132 KV Mithapur-Sipara S/C T/L	HTLS Panther	132	14.00
9	132 KV Jakkanpur-Mithapur S/C T/L	HTLS Panther	132	1.20
10	132 KV Mithapur-Karbigahiya ckt 1	630 sq mm XLPE	132	1.80

S.No	Transmission networks of Island	Conductor Type	Voltage level (kV)	Ckt length (km)
11	132 KV Mithapur-Karbigahiya ckt 2	630 sq mm XLPE	132	1.80
12	132 kV Khagaul-Digha ckt1	630 sq mm XLPE+Overhead (Panther)	132	15.80
13	133 kV Khagaul-Digha ckt1	630 sq mm XLPE+Overhead (Panther)	132	15.80

2.1.3. Transformers within Island

The transformers within the island are modelled as per the data provided. However typical impedance (Z%) values are assumed as the required data is not provided and is listed in Table 3.

Table 3: Transformers description

S.No.	Transformers (kV)	MVA rating	Z% (assumed)
1.	400/220/132/33 GIS Jakkanpur New	500X2 160 X2 80 X2	15
2.	132/33 Jakkanpur	80	12.5
3.	132/33 Karbigahiya	50	12.5
4.	132/33 Mithapur	80	12.5
5.	220/132/33 Khagaul	200X4 80X5	12.5
6.	132/33 Digha	80	12.5
7.	220/132/33 Bihta New	160X2 50X2	12.5
8.	132/33 Bihta Old	50X4	12.5

2.2. Plant Network

NPGC station is connected to the grid at 400kV NPGC bus. The generating station is modelled as per the data received from NTPC Nabinagar [5] as shown in Figure 3.

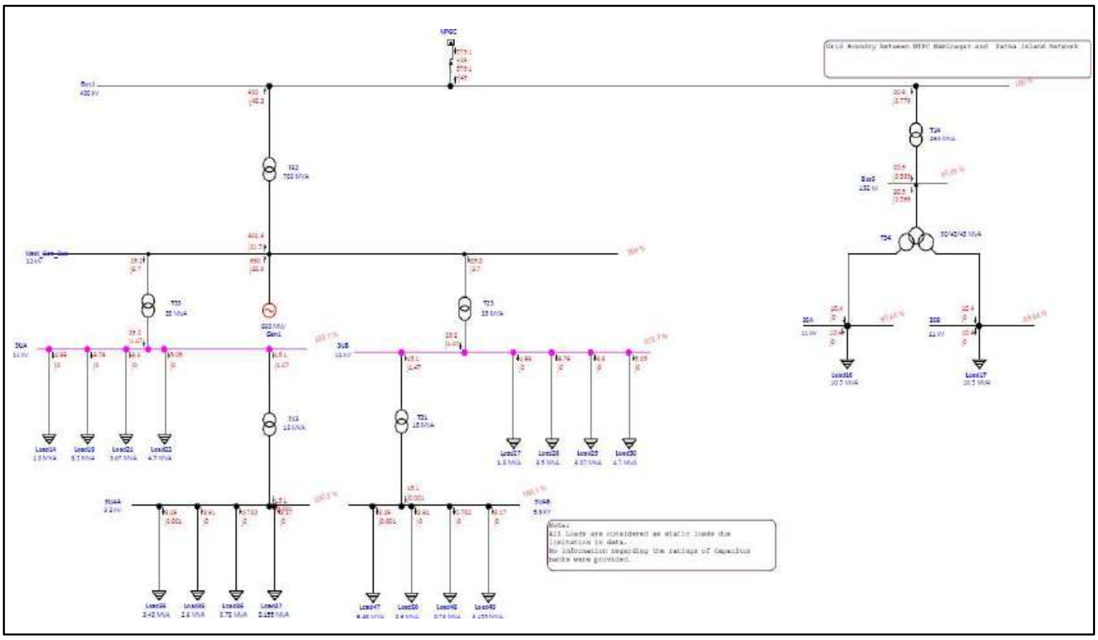

Figure 3: Single Line Diagram of one of the Unit at NTPC Nabinagar along with its auxiliaries.

2.3. Generator

The generator has been modelled as per the data received from NTPC Nabinagar [6].

The steam turbine generator (Gen 1) is a 3-phase, 2-pole, 776.5MVA, 22kV rated machine. The rated output of the generator is 660 MW at 0.85 pf lagging.

The parameters of Gen 1 used in the model are mentioned in the Table 4. The generator saturation curve is shown in Figure 4.

Table 4: Parameters of Steam Turbine Generator

Sl. No.	Parameters	Symbol/Abbreviation	Unit	Values
1.	Rated continuous output	Sn	MVA	776.5
2.	Rated terminal voltage	Un	kV	22
3.	Inertia constant (Generator)	H Gen	s	0.72
4.	Inertia constant (complete turbine)	H complete turbine	s	2.87
5.	Rated frequency	f	Hertz	50
6.	Direct axis synchronous reactance(unsaturated)	Xd	p.u.	2.03
7.	Quadrature axis synchronous reactance (unsaturated)	Xq	p.u.	1.98
8.	Direct axis transient reactance (unsaturated)	Xd’	p.u.	0.30

Sl. No.	Parameters	Symbol/Abbreviation	Unit	Values
9.	Quadrature axis transient reactance (unsaturated)	Xq’	p.u.	0.50
10.	Direct axis sub-transient reactance (unsaturated)	Xd”	p.u.	0.24
11.	Quadrature axis sub-transient reactance (unsaturated)	Xq”	p.u.	0.25
12.	Time Constant-Direct axis transient (unsaturated)	Td’	p.u.	5.26
13.	Time Constant-Quadrature axis transient (unsaturated)	Tq’	p.u.	0.021
14.	Time Constant-Direct axis sub-transient (unsaturated)	Td”	p.u.	0.66
15.	Time Constant-Quadrature axis sub-transient (unsaturated)	Tq”	p.u.	0.033

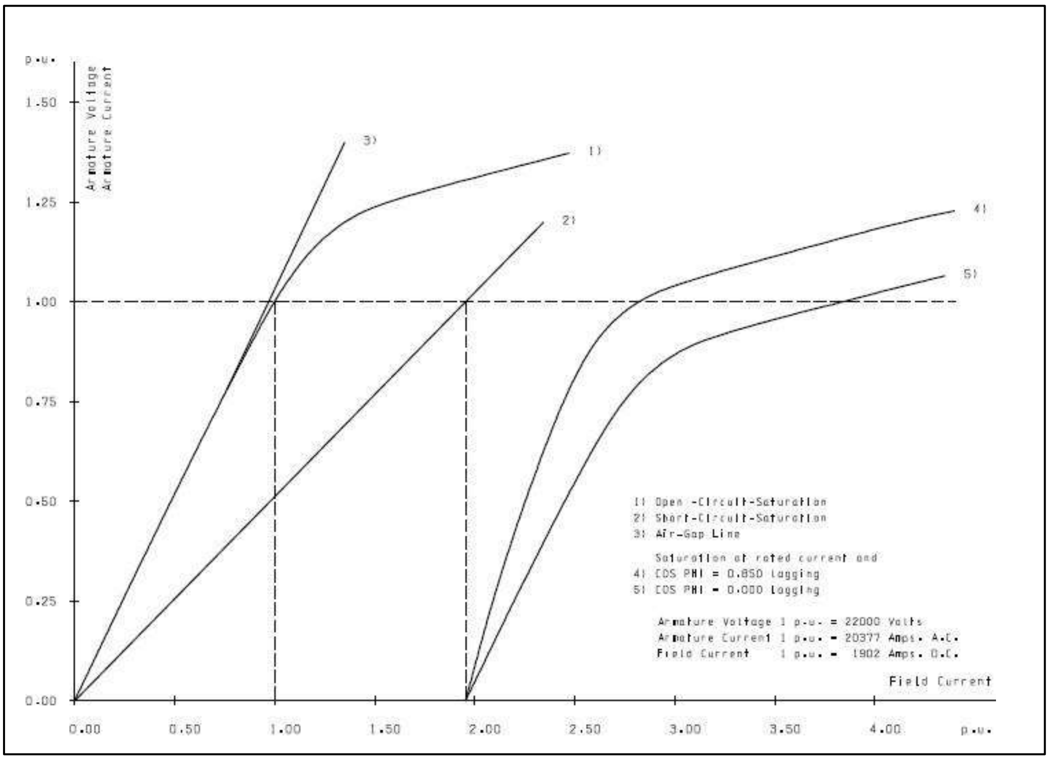

Figure 4: Saturation curve of generator.

2.3.1. Turbine and Governor

The turbine governor modelled is as per the data received from NTPC Nabinagar [7] as shown in Figure 5. The governor turbine parameters are tabulated in Table 5.

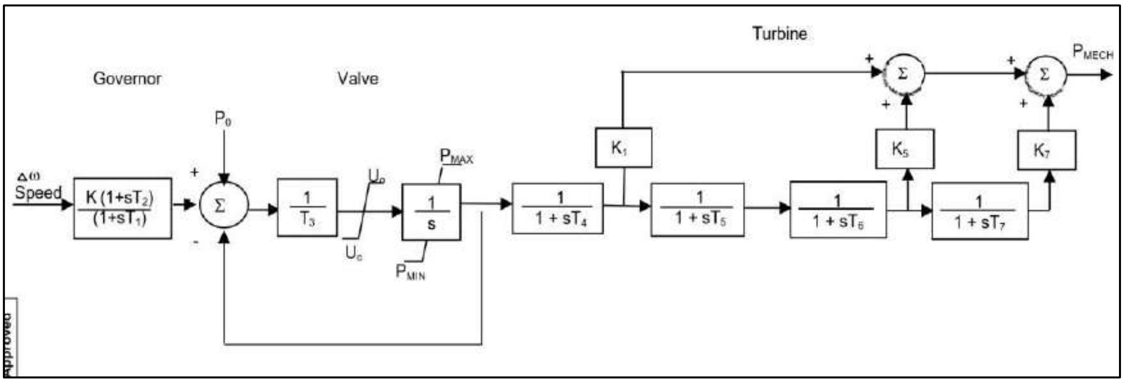

Figure 5: IEEEG1 turbine-governor model as shared by NTPC Nabinagar

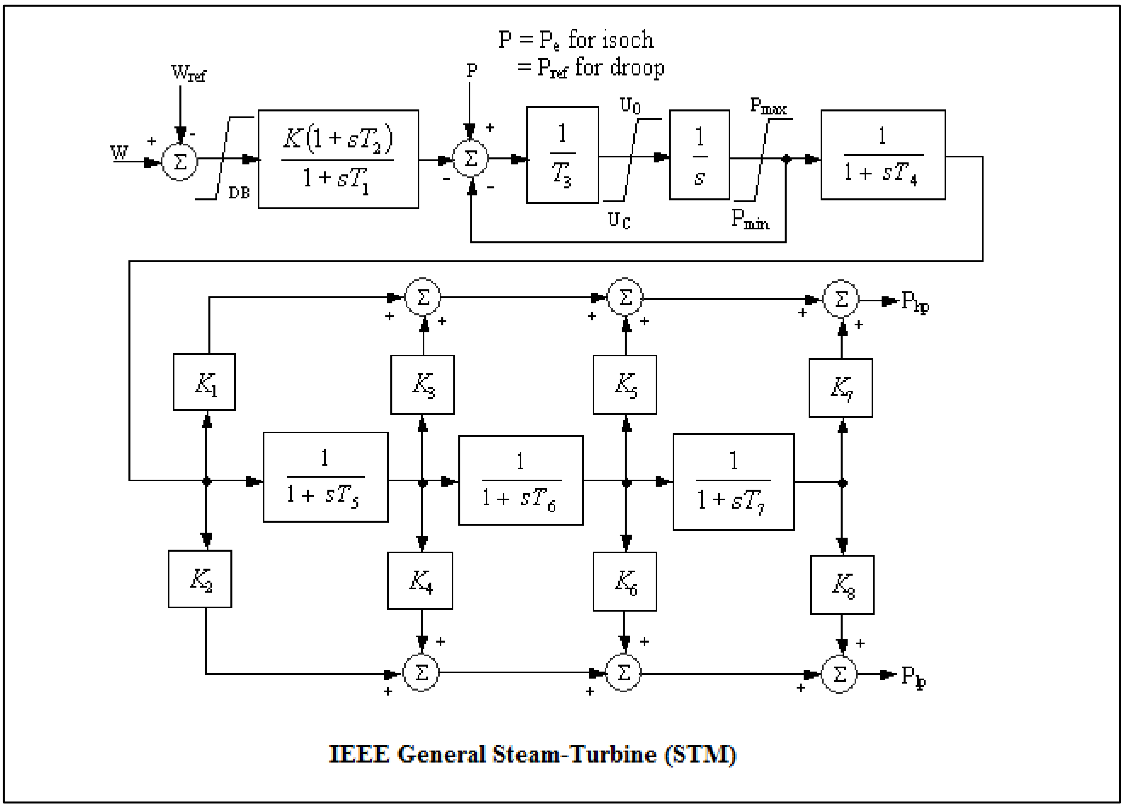

Figure 6: IEEE G1 turbine-governor modelled in ETAP

Table 5: Parameters for turbine-governor model

Sl No.	Parameters	Value	Description
1.	T1	0	Governor Lag (seconds)
2.	T2	0	Governor Lead Compensation (seconds)
3.	T3	0.004	Lag (>0) (seconds)
4.	T4	0.1	Delay due to HP-Turbine (seconds)
5.	T5	11	Expected reheater delay including hot and cold leads (seconds);
6.	T6	0.2	Delay due to IP-Turbine (seconds)
7.	T7	0.3	Delay due to LP-Turbine, cross-over pipes, and LP end hoods (seconds)
8.	K	20	1/Per Unit Regulation
9.	K1	0.289	Fraction HP-Turbine
10.	K5	0.489	Fraction IP-Turbine
11.	K7	0.289	Fraction LP-Turbine
12.	Uo	0.125	Valve opening time = 8 s (in connection with T3)
13.	Uc	-4	Valve closing time = 0.25 s (in connection with T3)
14.	PMAX	100	PMAX/%, Upper power limit
15.	PMIN	40	PMIN/%, Lower power limit of boiler based on TMCR

2.3.1.1. Validation of Turbine Governor system

Step response is simulated in turbine-governor model as shown in Figure 7. The turbine-governor model is validated by comparing simulation results and PFR test results as shown in Figure 8. The simulation result closely matches with the test results.

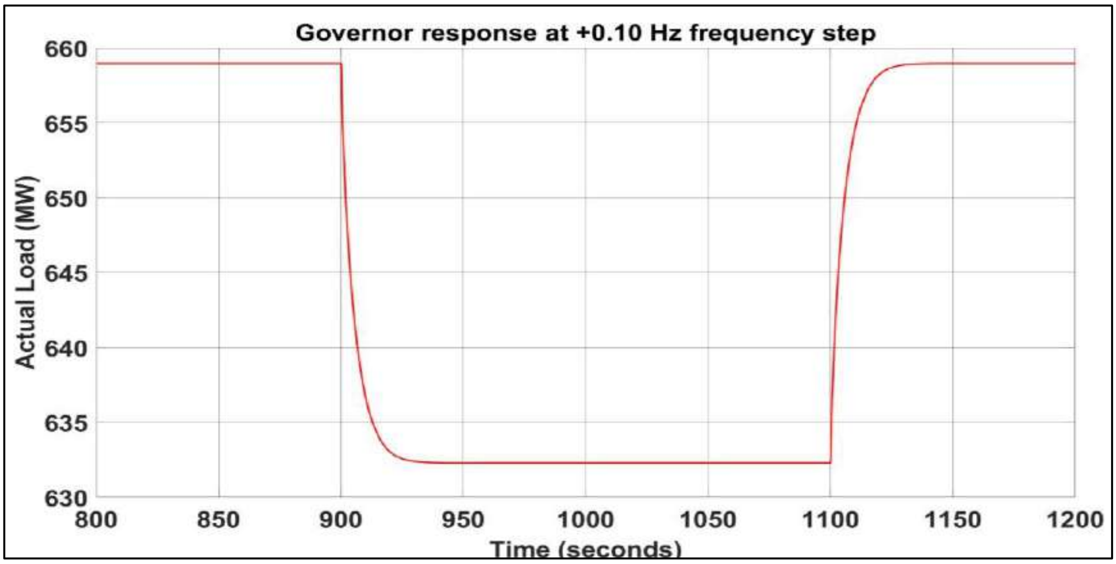

Figure 7: Step response simulation for ±0.10 Hz at 660 MW

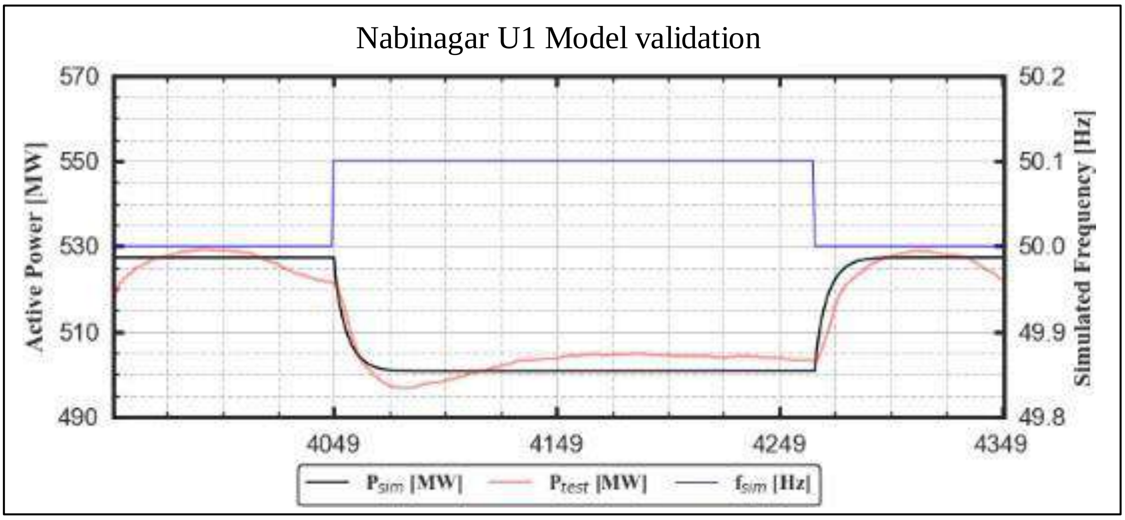

Figure 8: Turbine governor model- step response validation.

2.3.2. AVR and Excitation system

The AVR/exciter model is IEEE ST7B type based on the document provided by NTPC Nabinagar [8] as shown in Figure 10. The excitation system is modelled in ETAP and Simpow as shown in Figure 10. The corresponding parameters are shown in Table 6.

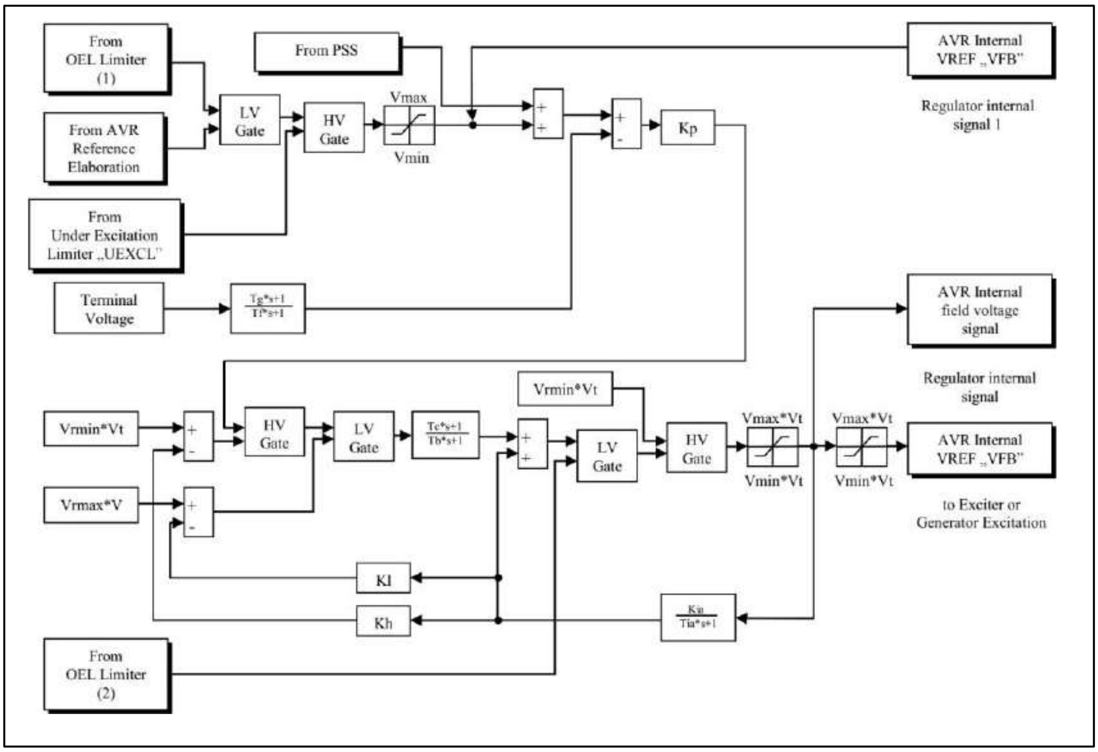

Figure 9: Potential-source excitation system ST7B.

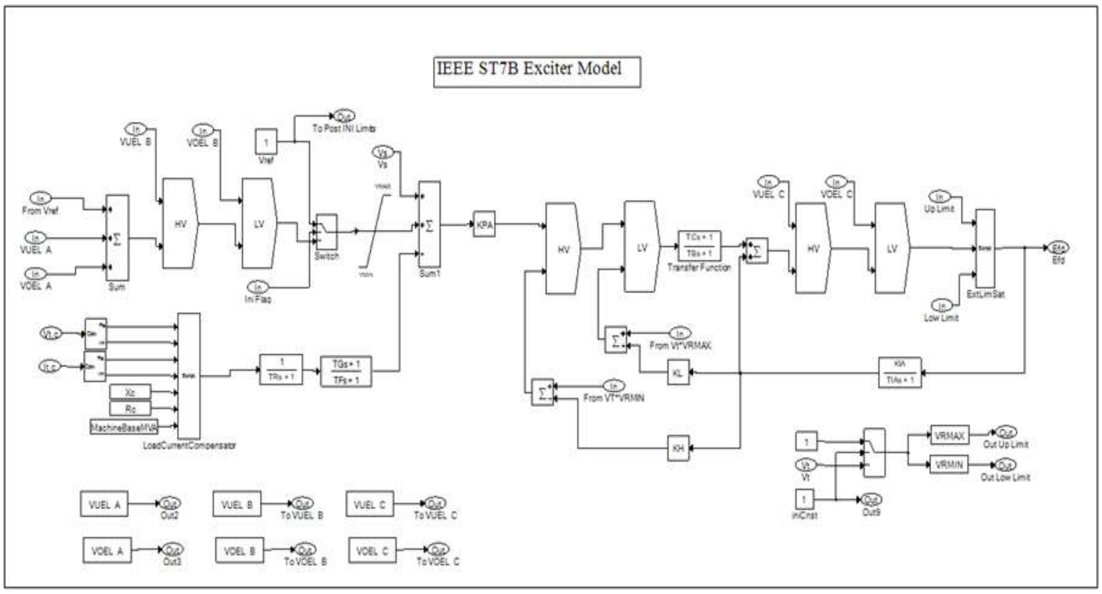

Figure 10*:* **IEEE ST7B exciter model developed in ETAP.**

Table 6: Parameters for AVR-ST7B as shared by NTPC Nabinagar

Sl No.	Parameters	Value	Description
1.	Kpa	43.84	Voltage regulator proportional gain (pu)
2.	Tia	3	Voltage regulator Integral time constant (s)
3.	Tc	1	Lead/lag filter numerator time constant (s)
4.	Tb	1	Lead/lag filter denominator time constant (s)
5.	Tg	1	Voltage feedback numerator time constant (s)
6.	Tf	1	Voltage feedback denominator time constant (s)
7.	Vmax	1.05	Positive limit of internal voltage reference (pu)
8.	Vmin	0.95	Negative limit of internal voltage reference (pu)
9.	Kl	1	Integral term validation for inner positive limitation
10.	Kh	0	Integral term validation for inner negative limitation
11.	Vrmax	5.158	Positive ceiling voltage with nominal generator voltage (pu)
12.	Vrmin	-5.158	Negative ceiling voltage with nominal generator voltage (pu)

2.3.2.1. Validation of excitation system

The excitation system model built in ETAP and Simpow is validated by comparing simulation results with the AVR step response tests results in no load and on load conditions shared by NTPC Nabinagar.

No load step test

When the generator is operating at no load, a step disturbance of 5% was introduced into the AVR reference which results in the change in generator voltage and excitation voltage as shown in Figure 11 and Figure 12. The settling time for the generator voltage subjected to the step change in AVR reference of 5% resulted in the settling of generator voltage within 0.304s. Figure 13 shows the test results shared by NTPC Nabinagar.

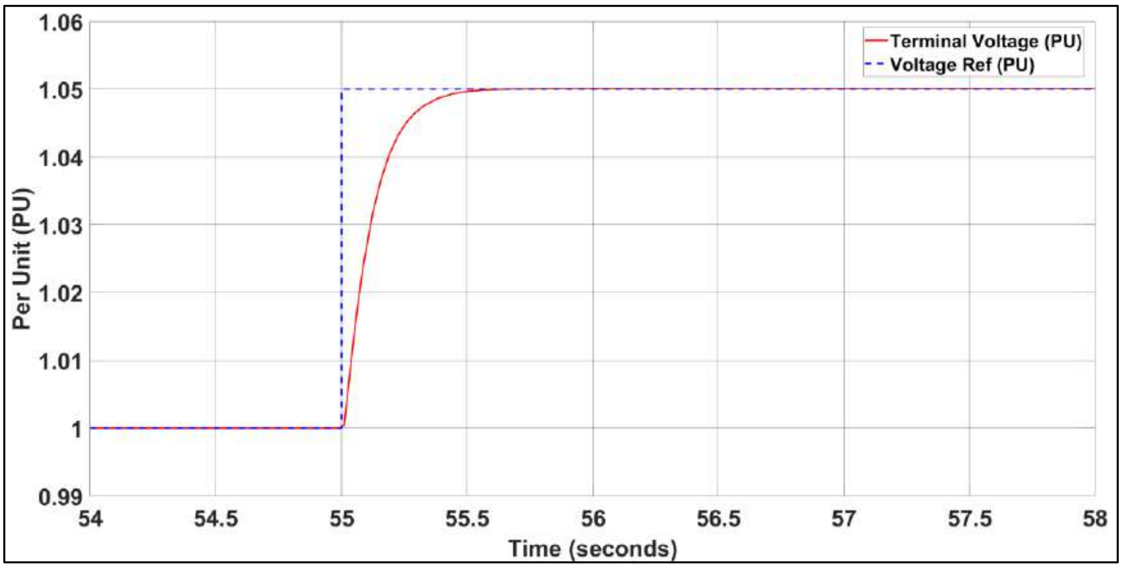

Figure 11: Generator voltage with 5% step disturbance at no load condition.

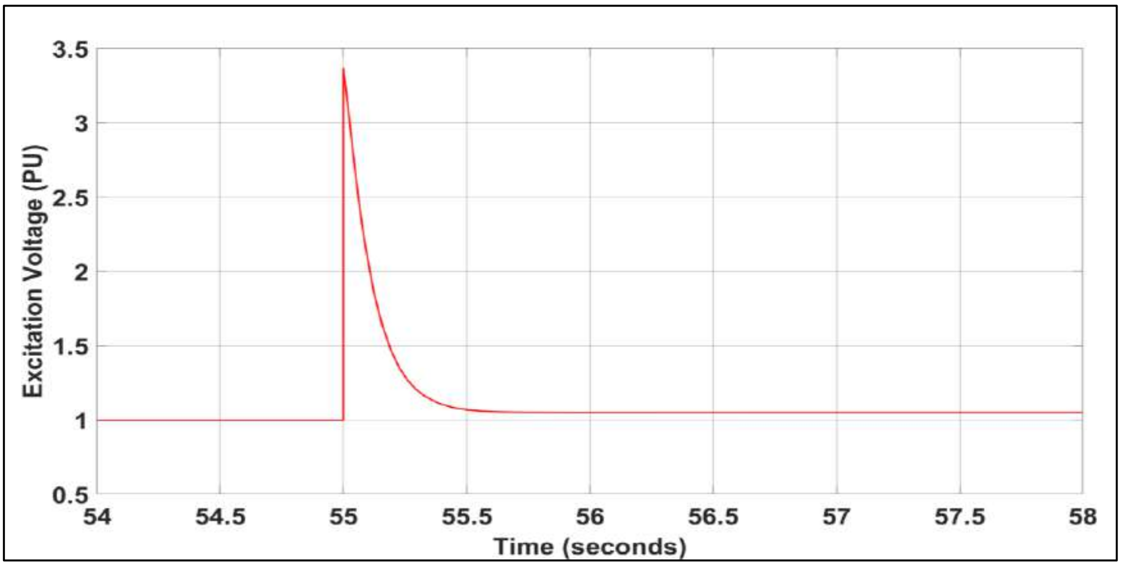

Figure 12: Excitation voltage with 5% step disturbance.

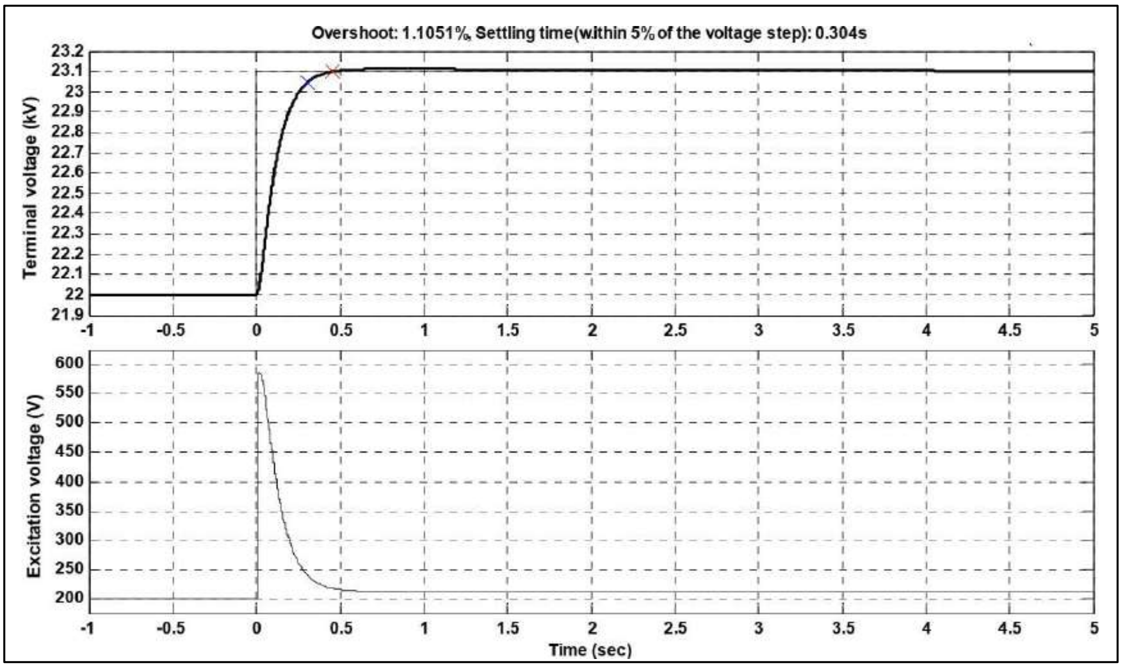

Figure 13: Simulation results of AVR at no load provided by NTPC Nabinagar [2].

On Load Step Test

Figure 14-Figure 17Figure 18 shows the simulation results of the AVR step response which has been validated with data received from NTPC Nabinagar [8].

During step disturbance simulation on AVR in loaded condition, the change in terminal voltage response, is shown in Figure 14.

The active power output of the generator experiences oscillations due to changes in excitation voltage and system dynamics, as shown in Figure 16.

Figure 18 show the results shared by NTPC Nabinagar. It can be seen from the figures below that simulated response matches with the response shared by NTPC Nabinagar to step disturbance in AVR in loaded condition.

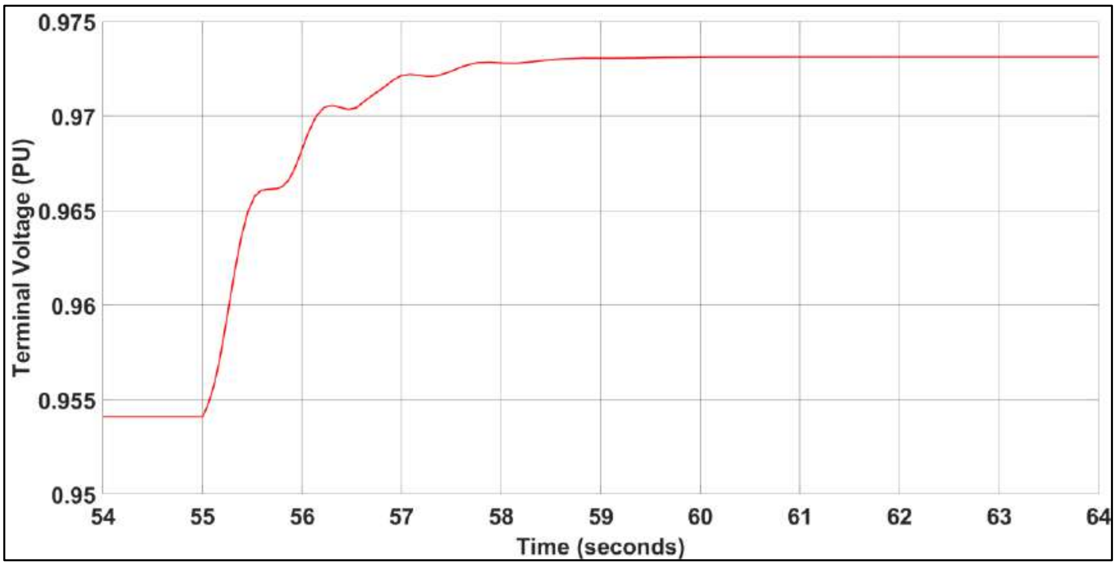

Figure 14: Generator unit terminal voltage with step disturbance.

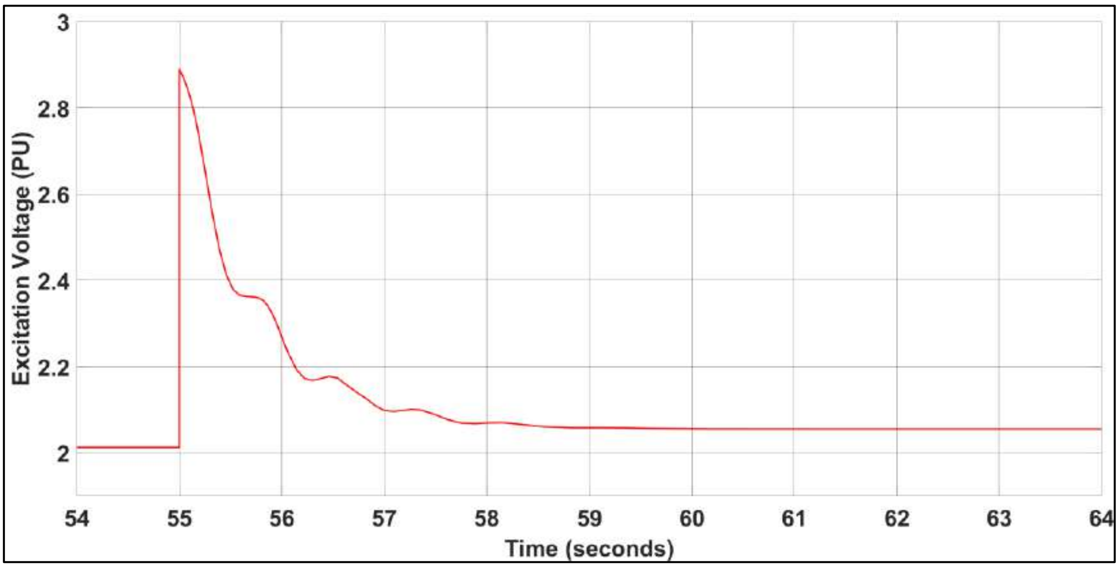

Figure 15: Field voltage with step disturbance.

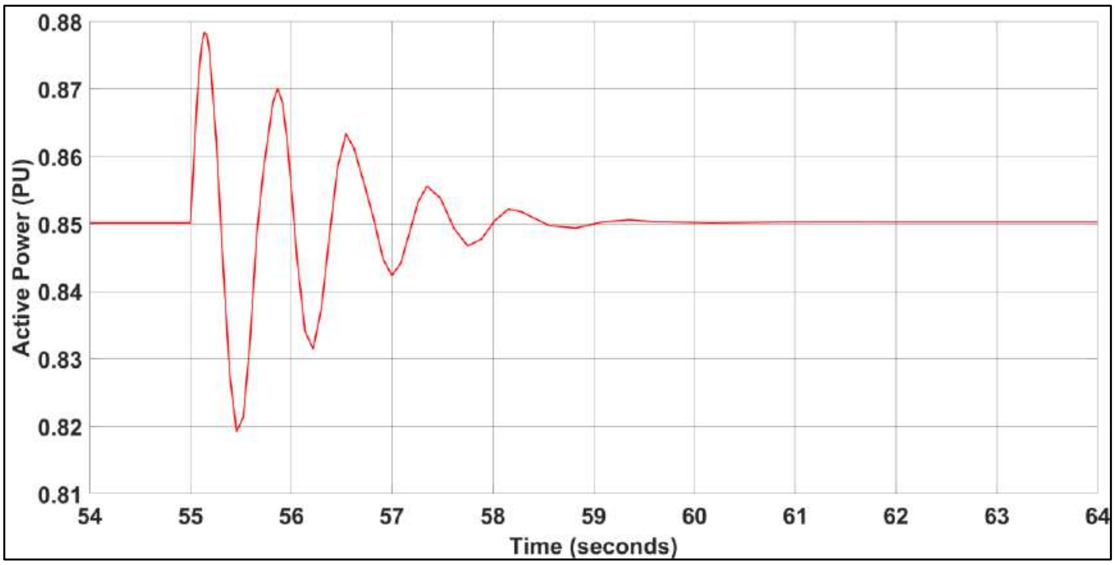

Figure 16: Active Power with step disturbance.

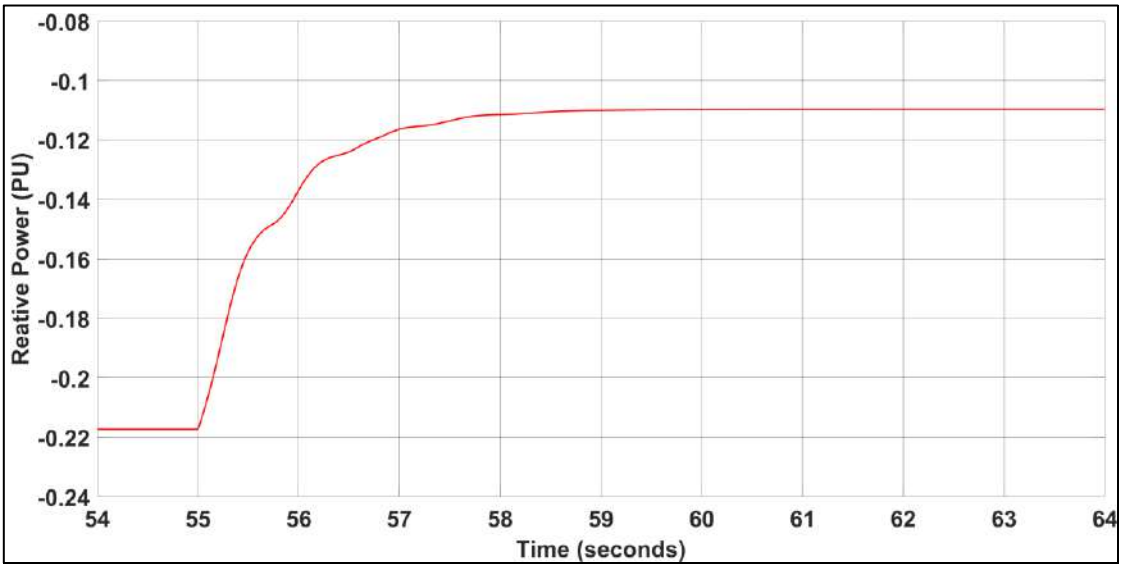

Figure 17: Reactive Power with step disturbance.

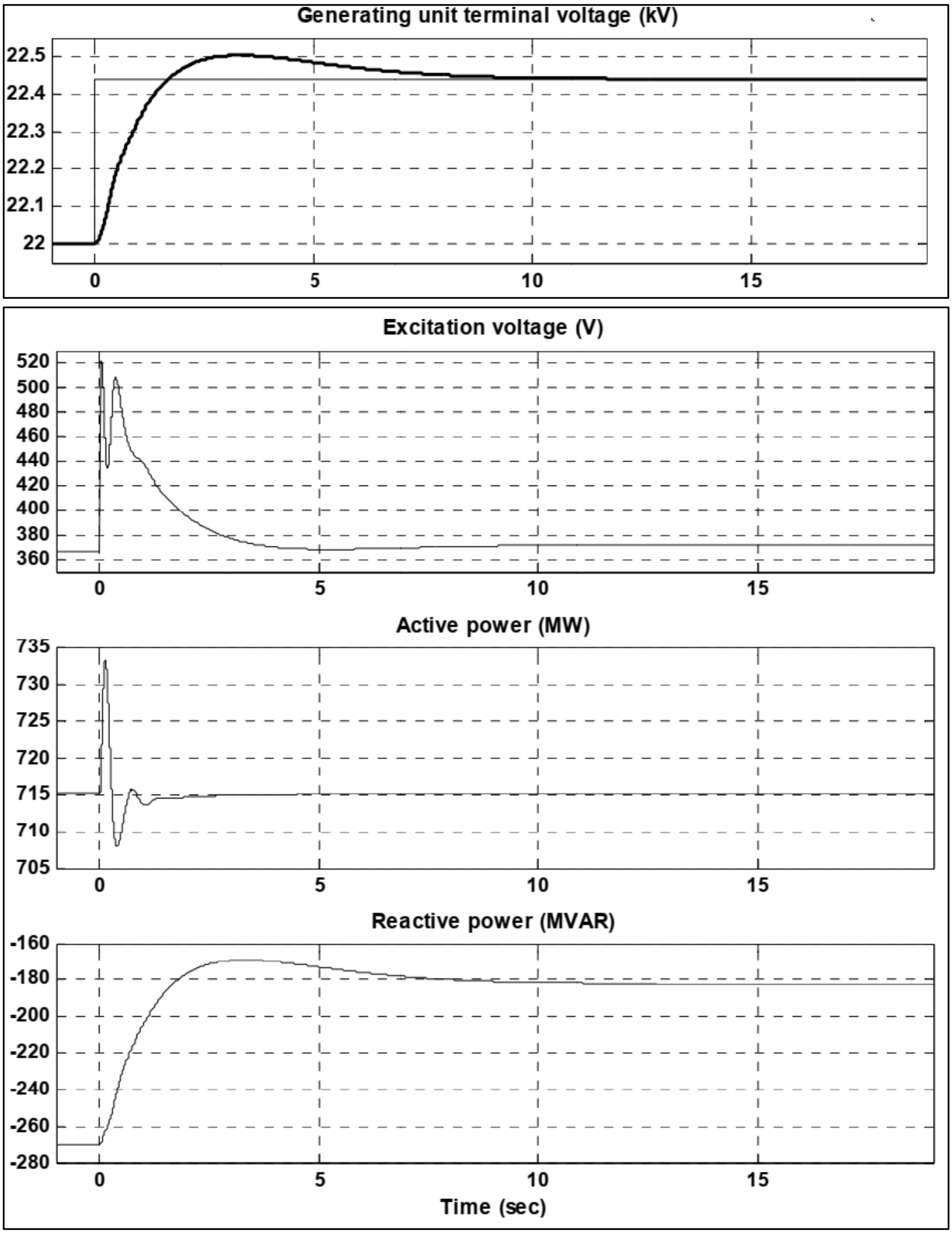

Figure 18: On load AVR step response results provided by NTPC Nabinagar

2.3.3. Plant loads

This section describes the loads within NTPC Nabinagar. All induction motors are considered as static loads as the motor modelling parameters were not provided. Other loads whose data has not been provided are also considered static loads. The plant load input data received and assumed parameters used for the modelling are tabulated in Table 7.

Table 7: Details of Load within plant received from NTPC Nabinagar

S.No.	Electrical Loads	Rating
1.	Line resistances and reactance	X/R =10 (assumed)
2.	All mills loads taken as one static load	3.48 MW
3.	BCW Pump +IA Compressor +PA Compressor + Station Aux. Cooling water pump+ Chemical Cleaning pump + Raw water pump	2.415 MW
4.	CE Pump	2.600 MW
5.	Ash handling pump	8.430 MW
6.	CHP Motors	5.290 MW
7.	AWRS Pump	430 KW
8.	MDBF Pump	2 x 10.5MW
9.	ID Fan	2 x 4.7MW
10.	CW Pump	2 x 3.07MW
11.	PA Fan	2 x 3.5MW
12.	FD Fan	2 x1.8MW
13.	Other loads	10MW
14.	Total Plant Load	≈ 80MW

Note:

- The sum of total plant loads shown in SLD is close to 70MW. An assumption of 10MW has been done to make the total plant load near to 80MW.
- Information regarding boiler loads is not clearly mentioned.
- Motors in ash handling package/ coal handling package which are connected at 3.3kV are modelled as static load.
- All induction motors are modelled as static load as the motor modelling parameters are not provided.

2.3.4. Transformers within generating station

Transformers from voltage level 400 kV to 0.433 kV are modelled as per the information received from NTPC Nabinagar. This also includes modelling of all three and two - winding transformers. The tap setting of transformers is not included in the modelling for reducing the modelling complexities. All the modelling parameters are tabulated in Table 8.

Table 8:Transformer type & parameters used for modelling in ETAP:

Sl. No.	Transformer Type	MVA Rating	LV Side kV	HV Side kV	Z%	R(pu) [Assumed]	X(pu) [Assumed]
1.	IBT #3	200	132	400	12.5	0.00278	0.12497
2.	GT # 3R	260	22	420/√3	15	0.033	0.15
3.	UT # 3A and #3B	35	22	11.5	9	0.0002	0.0089
4.	UAT #3A and #3B	16	3.45	11	12.5	0.000624	0.12497
5.	ESPT #3A, #3B & #3C	1.6	0.433	11	9	0.001315	0.00789
6.	UST #3C & 3D	2.5	0.433	11	12.5	0.001315	0.00789
7.	AET #3A & #3B	1	0.433	11	5	0.001315	0.00789
8.	CHP	2	0.433	11	10	0.001315	0.00789
9.	ST#3	90/45/45	11.5/11.5	132	ZHV-LV1=Z HV-LV2=21 LV1-LV2=37	R12=0.00278 R13=0.00278 R23= 0.00278	X12=0.125 X13=0.125 X23=0.125

3. Simulation Results

Several simulations cases were performed to develop the understanding of the dynamic behavior of the unit undergoing islanding. Respective cases and their simulation studies are described below.

3.1. Simulation Cases

Cases	Scenario	Description
Case 1	Maximum generation (660 MW) and Maximum load (640 MW)	There is a surplus of 20MW being fed to the grid, and simulation studies have been conducted at the island formation (48.4Hz).
Case 2	Maximum generation (660 MW) and Minimum load (500 MW)	There is a surplus of 160MW being supplied to the grid, and simulation studies have been conducted at the island formation (48.4Hz).
Case 3	Minimum generation (380MW) and Minimum Load (500MW)	Due to a deficit of 120MW in generation, simulation studies w.r.t suitable load shed has carried out taking unit stability and tripping limits into consideration.
Case 4	Minimum generation (380MW) and Maximum load (640MW)	Deficit of 260MW is being withdrawn from the grid, and simulation studies have been conducted at the island formation (48.4Hz).
Case 5	Calculations of Critical clearing time	A three phase to ground fault is simulated at the grid bus and the variation in power and load angle and system voltage has been studied. Worst fault clearing time is estimated.
Case 6	Load increment of 33.25MW (5.2% of island load) after island formation.	Referring case 1, after the formation of island network, load of 33.25MW is added and the dynamic behavior of the unit has been studied.
Case 7	Load increment of 42.75MW (6.67% of island load) after island formation	Referring case 1, after the formation of island network, load of 42.75MW is added and the dynamic behavior of the unit has been studied.
Case 8	Load increment of 52.25MW (8.2% of total island load) after island formation	Referring case 1, after the formation of island network, load of 52.25MW is added and the dynamic behavior of the unit has been studied.
Case 9	Rate of change of frequency (ROCOF) 0.5Hz/s Island formation (49Hz)	Referring case 1, simulation studies has been carried out with a rate of change of frequency of 0.5Hz/sec where island network is formed at 49Hz.

Cases	Scenario	Description
Case 10	Rate of change of frequency (ROCOF) 0.5Hz/s Island formation (48.4Hz)	Referring case 1, simulation studies has been carried out with a rate of change of frequency of 0.5Hz/sec where island network is formed at 48.4Hz.
Case 11	Island formation at 48.4Hz with a Rate of Frequency Change of 0.25Hz/s	Referring case 1, simulation studies has been carried out with a rate of change of frequency of 0.25Hz/sec where island network is formed at 48.4Hz.
Case 12	Optimal load reduction during island formation	Referring to case 3, during island formation a lesser load of 68MW is being shed in comparison to 74MW and comparative dynamic study has been performed for this case.
Case 13	Load increment of 12.5MW (2.5% of island load) after island formation	Referring case 3, after the island network formation, a load of 12.5MW is added and the dynamic behavior of the unit has been studied.
Case 14	Load increment of 20MW (4% of island load) after island formation	Referring case 3, after the island network formation, a load of 20MW is added and the dynamic behavior of the unit has been studied.
Case 15	Load increment of 22MW (4.4% of island load) after island formation	Referring case 3, after the island network formation, a load of 22MW is added and the dynamic behavior of the unit has been studied.
Case 16	Load shed with time delay	Load shedding was delayed compared to Case 3, and its dynamic study was performed to compare its effects.
Case 17	Island Formation (49Hz) with Rate of Change 0.5Hz/s	Referring case 3, simulation studies has been carried out with a rate of change of frequency of 0.5Hz/sec where island network is formed at 49Hz.
Case 18	Island Formation (48.4Hz) with Rate of Change 0.5Hz/s	Referring case 3, simulation studies has been carried out with a rate of change of frequency of 0.5Hz/sec where island network is formed at 48.4Hz.
Case 19	Effect of Linear and Non-Linear valve behavior in Active Power.	In this case, the effect of linearity and non-linearity in the governor output, and its effect on the dynamic studies is performed.

3.1.1. Case 1: Maximum Generation and Maximum Load

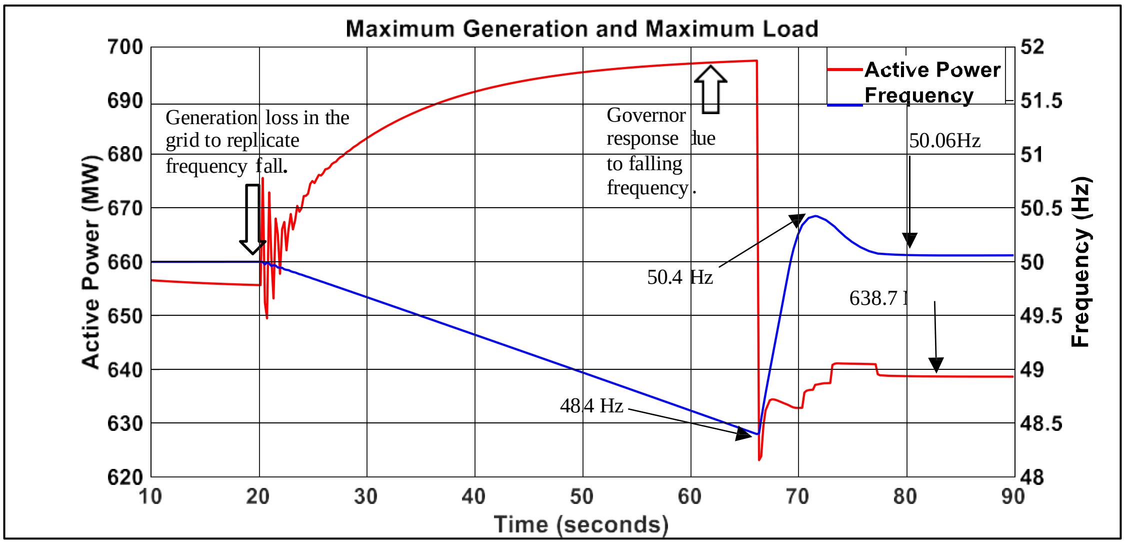

Figure 19: Variation in active power and frequency vs time during islanding.

For maximum generation and maximum load, unit generation is 660MW, island load demand is 640MW, there is surplus of 20MW from generation side which is fed to the grid.

A grid event (frequency fall) was created by tripping a large generator at the grid at 20th seconds, which resulted in an increase of electrical power of the unit undergoing islanding. Generator power increases during the frequency fall due to droop control in the governor. Unit was islanded from the network as soon as the system frequency reached 48.4 Hz. As there was surplus generation at the time of islanding, frequency rises after islanding. Governor action was able to stabilize the frequency after islanding without any load shedding as shown in Figure 19.

Simulation results for this scenario indicate a frequency fall at the rate of 0.035 Hz/sec when initiating an event of grid disturbance, followed by a frequency increase post islanding. Within 12 seconds the frequency stabilizes to its final value of 50.06 Hz, and the unit stabilizes to its final value of 638.7 MW. A sudden increase in frequency of 50.4 Hz was observed at the instant of island formation. Island frequency and voltages are well stabilized by the voltage and frequency control functions of the generator.

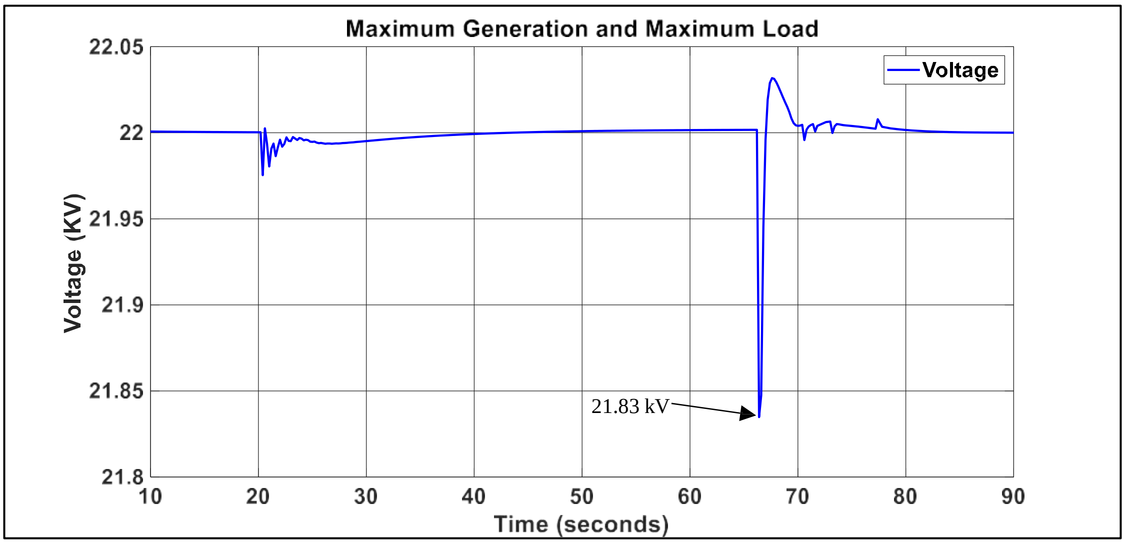

Figure 20:Variation in voltage vs time during islanding.

Generation is at 22kV, when the island is formed, the voltage initially experienced a sudden dip from 22kV to 21.83kV (0.91%) which further stabilized around 22kV.

3.1.2. Case 2: Maximum Generation and Minimum Load

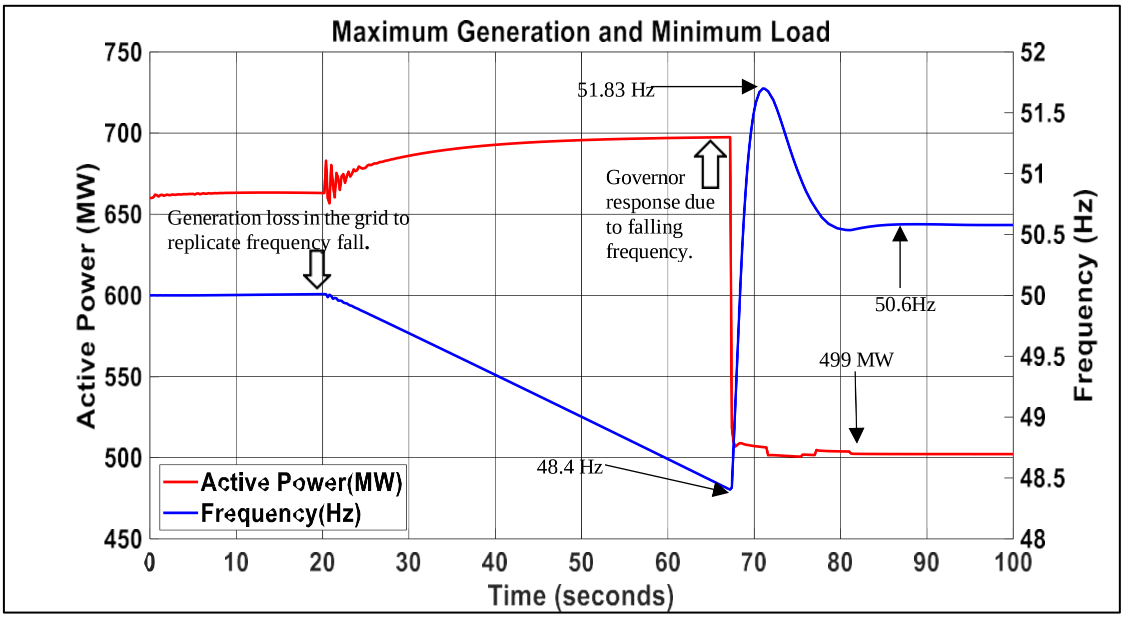

Figure 21: Variation in active power and frequency vs time during islanding.

For maximum generation and minimum load, unit generation was 660 MW and island load demand was 500 MW, thus there was surplus of 160 MW surplus inside the island.

A grid event (frequency fall) was created by tripping a large generator at the grid at 20th seconds, which resulted in an increase of electrical power of the unit undergoing islanding. Generator power increases during the frequency fall due to droop control in the governor. Unit was islanded from the network as soon as the system frequency reached 48.4 Hz. As there is surplus generation at the time of islanding, frequency rises after islanding. Governor action was able to stabilize the frequency after islanding without any load shedding as shown in Figure 21 results for this scenario indicate a frequency decrease of 0.035 Hz/sec when initiating islanding, followed by a frequency increase post islanding. Within 17.4 seconds the frequency stabilizes to its final value of 50.6Hz and the unit stabilizes to its final value of 499 MW. A sudden increase in frequency of 51.83Hz was observed at the instant of island formation.

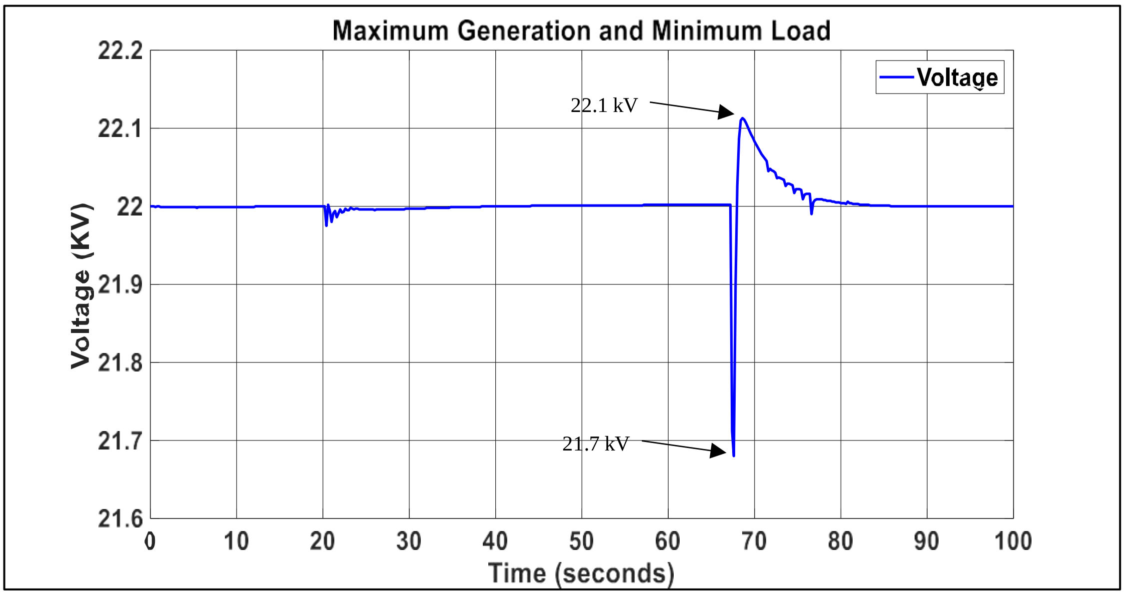

Figure 22: **Variation in voltage vs time during islanding.**

Generation is at 22kV, when the island was formed, the voltage initially experienced a sudden dip from 22kV to 21.7kV (1.3%) which further stabilized around 22kV. An overshoot of 22.1 kV was observed, while frequency was improving towards 50 Hz.

3.1.3. Case 3: Minimum Generation and Minimum Load

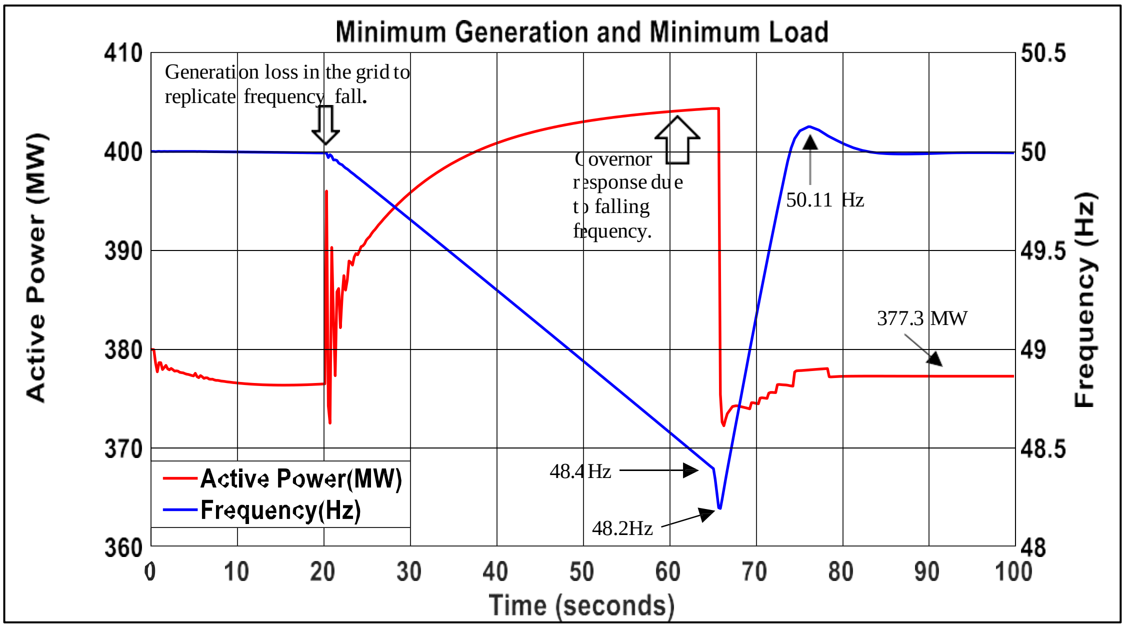

Figure 23: Variation in active power and frequency vs time during islanding.

For minimum generation and minimum load, unit generation was 380MW, island load demand was 500MW, thus there was deficit of 120MW from generation side which was being fed by the grid. In the event of a grid disturbance requiring unit islanding, strategic load shedding was necessary based on the criticality of the load to prevent the unit from tripping.

A grid event (frequency fall) was created by tripping a large generator in the grid at 20th seconds, generator power increases during frequency fall due to droop control in the governor however due to deficit in generation a load shed of 50MW (500-50=450) was initiated at 48.4 Hz, Since the generation was 380MW, shortfall persists, an additional island load shed of 74MW (450-74=376MW) was performed at 48.2Hz frequency. At 48.2Hz as generation was in surplus than Island load demand, thus frequency increased after islanding and stabilized at 49.99 Hz. To prevent the tripping of the unit by operation of under frequency relay, i.e., the island reaching a frequency of 47.4Hz, it was required to shed an additional load of 74MW at 48.2Hz.

Simulation results for this scenario indicate a frequency decrease of 0.035Hz/sec before initiating islanding, followed by a frequency increase post-load shedding. Frequency stabilizes to its final value of 49.99 Hz within 19.6 seconds corresponding to generation settling to of 377.3 MW. A sudden increase in frequency of 50.125Hz was observed at the instant of island formation.

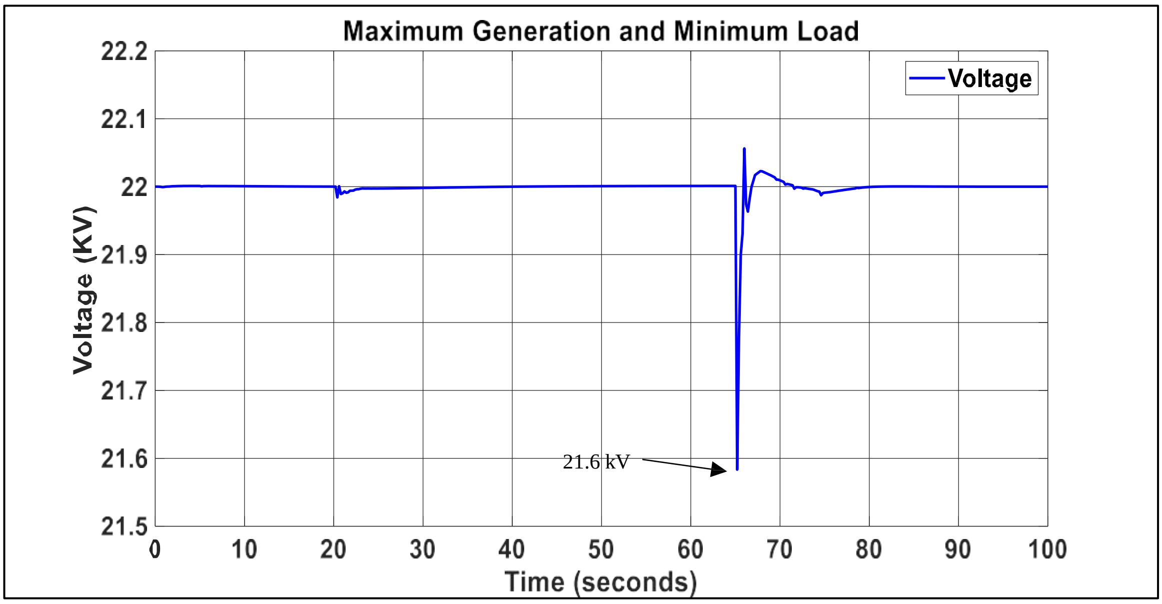

Figure 24: Variation in voltage vs time during islanding.

Generation is at 22kV, when the island formed, the voltage initially experienced a sudden rise from 22kV to 21.6kV (i.e., 1.81%) which further stabilized around 22kV.

3.1.4. Case 4: Minimum Generation and Maximum Load

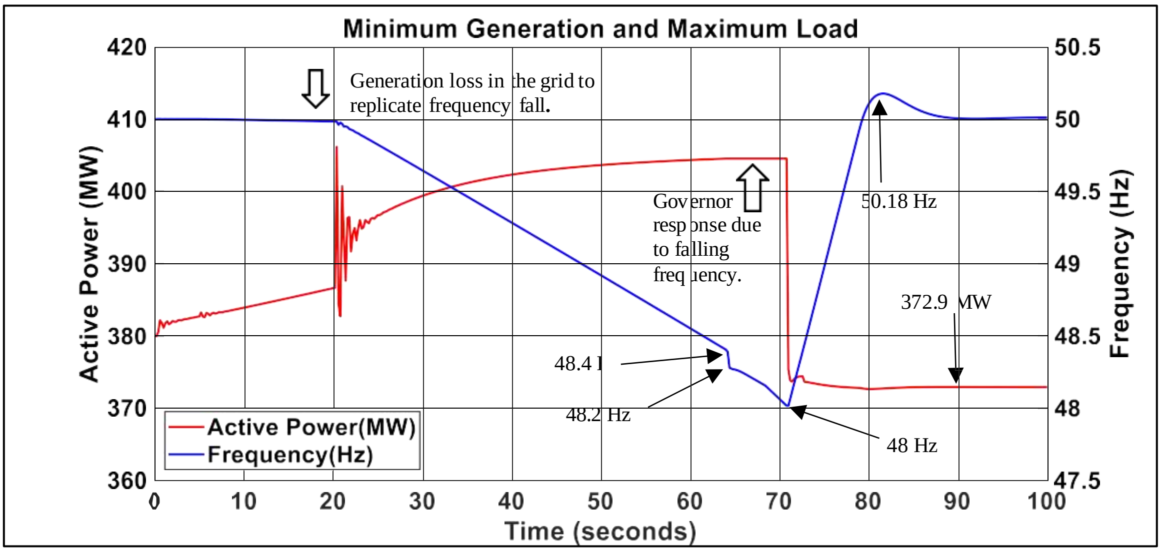

Figure 25: Variation in active power and frequency vs time during islanding.

For minimum generation and maximum load, unit generation was 380MW, island load demand was 640MW, thus there was a deficit of 260MW from generation side which was being fed by the grid. In the event of a grid disturbance requiring unit islanding, strategic load shedding was necessary based on the criticality of the load to prevent the unit from tripping.

A grid event (frequency fall) was created by tripping a large generator at the grid at 20th seconds, which resulted in an increase of electrical power of the unit undergoing islanding. When the frequency reaches 48.4 Hz, at the point of islanding, generation was 380MW and island load demand was 640 MW. Hence the generation was 260MW deficit inside the island. Thus, to limit the rate of fast frequency fall an additional load of 150 MW was shed at the instant of island formation i.e. 48.4 Hz.

The total island load was 640 MW which includes unit essential load of 80MW, hence the available load to shed was 640-80 = 560 MW. At the instant of island formation even after load shed from the total island load was 410MW (560-150 = 410 MW) a short fall in generation persists. At further frequency of 48.2 Hz, 20% of the remaining island load i.e. 0.2*410 = 82 MW was tripped and the total island load was 408MW (328MW (island load) + 80MW (NPGC essential load) = 408 MW) which was still more than the generation, so an additional load shed was required till the load and generation are balanced.

A further load shed of 10 % of the remaining island load i.e. 0.1*328 = 32.8 MW was tripped at 48.0 Hz, and the total island load would become 375.2MW (295.2MW (island load) + 80 MW (Unit essential load) = 375.2 MW) which was less than the generation (380MW), hence the island was generation rich with 4.8 MW and the unit stabilizes to 50.01 Hz in 18.4 seconds with a peak frequency of 50.18 Hz.

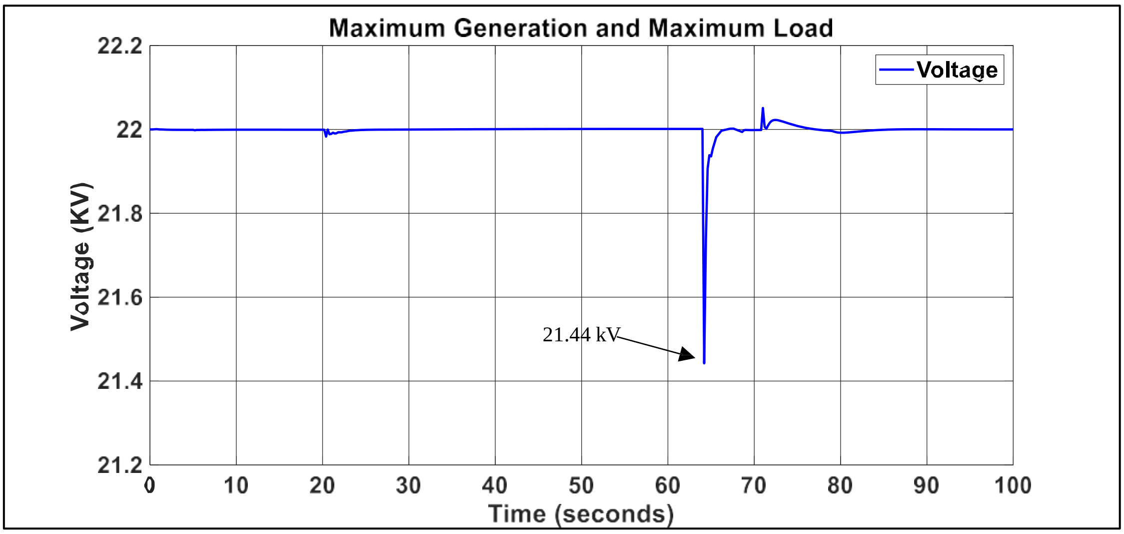

Figure 26: Variation in voltage vs time during islanding.

It can be observed from Figure 26 that at the instant of island formation voltage decreases from 22kV to 21.44 kV (2.54%) for a very short duration of about 0.5 second and finally stabilizes to 22 kV.

3.1.5. Case 5: Critical Clearing Time

In order to determine the critical clearing time a three phase to ground fault was simulated at grid bus, and it was observed that the critical clearing time was 220 milliseconds. The power-delta curve is shown in Figure 27 and variation in generator voltage is shown in Figure 28.

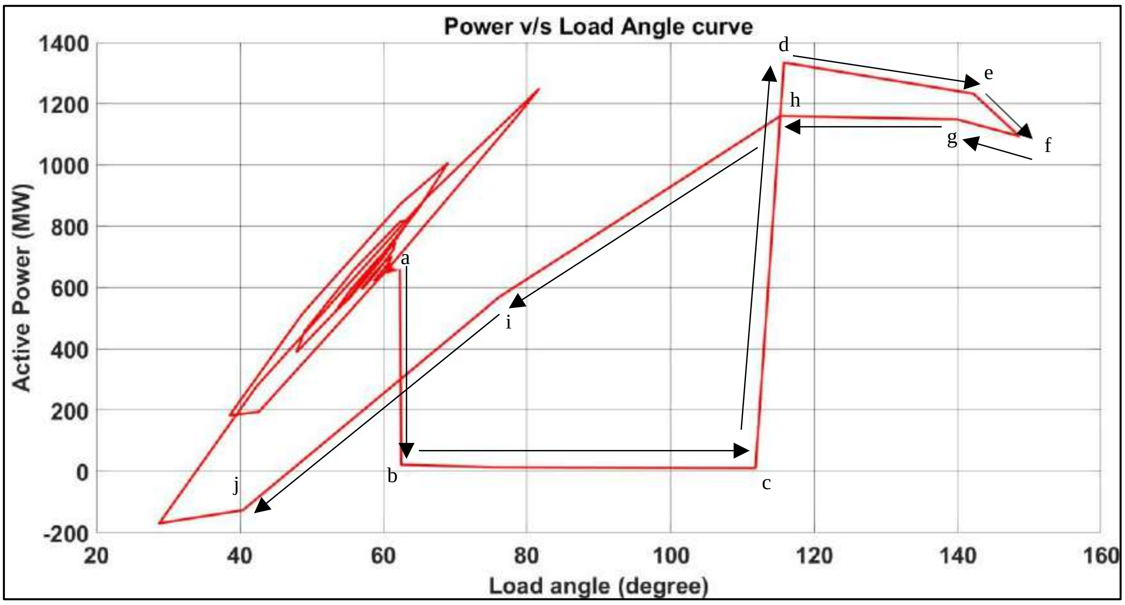

Figure 27: Critical clearing time for the unit in response to a three-phase to ground fault occurring in the grid was determined to be 220 milliseconds, before the unit loses its synchronism.

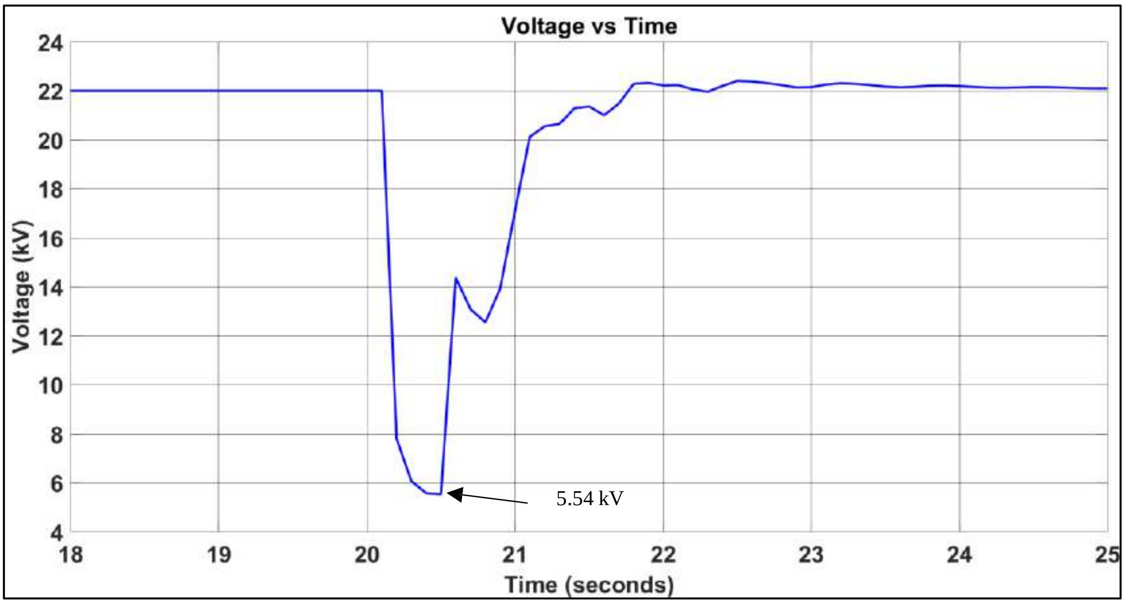

Figure 28: Voltage variation in response to the occurrence of three phase to ground fault and clearing the fault before the unit losses its synchronism.

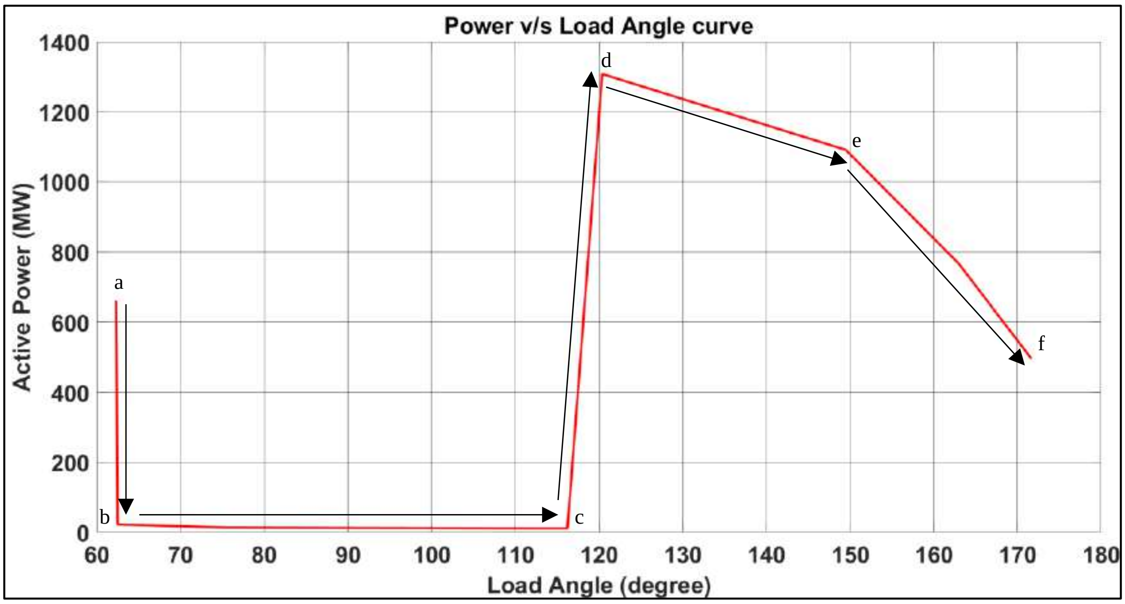

Figure 29: Loss of synchronism of the unit in response to the occurrence of three phase to ground fault at grid and clearing it in 221 milliseconds, load angle reaching close to 180 degree is indicative of Unstable operation of the unit.

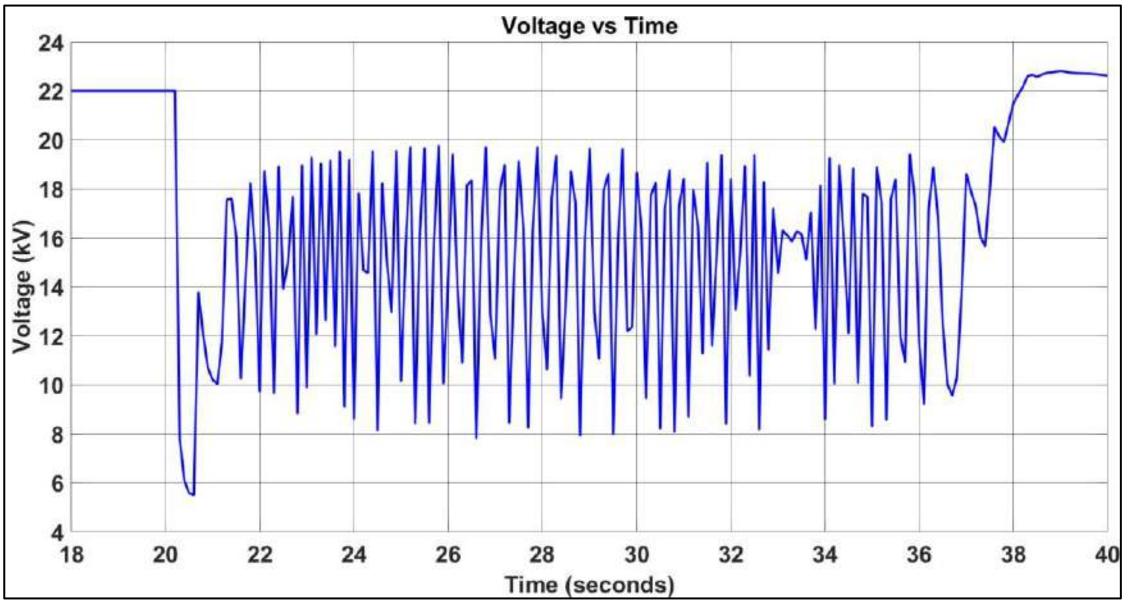

Figure 30: Voltage variation for the unstable operation of the unit, indicating unit loses its synchronism if fault was cleared beyond the critical clearing time of 220 milliseconds.