



**MAHATRANSCO**

Maharashtra State Electricity Transmission Company Limited

**COMPENDIUM OF  
GRID DISTURBANCES  
AND EVENTS – 2025**

**MAHARASHTRA POWER SYSTEM**



Prepared by

**MAHARASHTRA STATE LOAD DESPATCH CENTRE (MSLDC)**

January - December 2025

# Compendium of Grid Disturbances and Events – 2025, Maharashtra Power System

**Prepared By: Maharashtra state Load Despatch Centre  
January - December 2025**

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## **Preface**

Every grid disturbance or significant operational occurrence, irrespective of its magnitude, provides valuable insights into the behaviour of the power system under stressed conditions. Systematic analysis of such events helps identify latent vulnerabilities, assess the effectiveness of operational and protection practices, and draw lessons that are essential for strengthening grid reliability and preventing recurrence. This compendium is founded on the principle that institutional learning from real system events is central to resilient grid operations.

The Maharashtra State Load Dispatch Centre (MSLDC) has, for the first time, brought out a comprehensive Grid Disturbance Analysis Compendium documenting and analysing major grid disturbances and significant occurrences in the Maharashtra Power System. This initiative represents an important step towards structured documentation, objective analysis, and transparent dissemination of operational experience. The compendium consolidates insights drawn from SCADA data, disturbance and event records, protection system behaviour, PMU data where available, and field-level inputs, and is intended to serve as a common reference for management, regulators, utilities, and other stakeholders.

I take this opportunity to congratulate the SLDC team for this significant and pioneering effort. The preparation of such a document requires sustained technical diligence, coordination across multiple agencies, and a strong commitment to analytical rigor. The contribution of engineers involved in event reconstruction, protection analysis, and documentation has been commendable and reflects SLDC's evolving role as not only a system operator, but also an institutional knowledge centre for grid operations.

The analyses presented in this compendium highlight the increasing need for structured technical deliberations and coordination mechanisms, particularly through forums such as the Protection Coordination Committee (PCC). As the Maharashtra power system grows in complexity—with higher loading of transmission corridors, greater reliance on protection and automation, and increasing interdependencies among stakeholders—it is essential that disturbance findings and analytical feedback from SLDC are systematically discussed in such committees. Strengthening the role of PCC as a platform for examining protection performance, maintenance practices, and corrective actions will be critical for improving system robustness.



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The disturbances documented herein also underscore the critical importance of enhancing maintenance practices and protection audit regimes, especially in the context of ageing assets and stressed operating conditions. Equally, the need to improve communication systems, expand SCADA visibility, and enhance overall system observability—including wider and more effective deployment of PMUs—must be treated as top-most priorities for the Maharashtra Power System. Adequate real-time visibility and high-resolution measurements are fundamental to informed operational decision-making during disturbances and to meaningful post-event analysis.

Going forward, SLDC Maharashtra will continue to strengthen its analytical capabilities and institutional capacity to provide timely, objective, and technically grounded feedback and suggestions to utilities, system planners, and regulatory forums. As part of this effort, SLDC also intends to work towards the creation of a unified digital platform for submission of disturbance- and occurrence-related data, with the objective of improving data quality, timeliness, consistency, and efficiency of analysis.

This compendium reflects SLDC Maharashtra’s commitment to transparency, continuous learning, and improvement in grid operations, and it is hoped that the insights contained herein will contribute meaningfully to building a more secure, observable, and resilient Maharashtra Power System.



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- 1. The Western Region Power Committee (WRPC)**
- 2. The Western Region Load Despatch Centre (WRLDC)**
- 3. The ACI & P Department and all PAC circles of Maharashtra State Transmission Company Limited (MSETCL)**
- 4. All Intrastate Transmission Licensees in Maharashtra.**
- 5. Engineers from MSLDC associated with System Operations, Control rooms, Market operations and regulatory coordination**

## **Executive Summary**

The *Compendium of Grid Disturbances and Events – 2025, Maharashtra Power System* presents a structured and comprehensive account of important grid disturbances, incidences and events observed in the Maharashtra state Power System during the year 2025. The compendium is prepared by Maharashtra State Load Dispatch Centre (MSLDC) in its role as the State Load Dispatch Centre and grid operator, in compliance with the reporting and analysis requirements stipulated under the IEGC-2023 and the MEGC-2020.

As mandated under Clause 37(2) of IEGC, 2023, and Clause 29.6, 29.15, and 43.8 of MEGC, 2020, all grid disturbances, major incidents, protection operations, and abnormal system conditions affecting grid security, reliability, or continuity of supply are required to be reported, analyzed, and documented by the concerned Load Dispatch Centre. This compendium fulfils these regulatory obligations and serves as an institutional knowledge repository for system operators, utilities, and planners.

The compendium covers major grid disturbances in Maharashtra, including but not limited to:

- Widespread and localized undervoltage / Overvoltage events,
- 400 kV and 220 kV Busbar protection operations,
- 400 kV and 220 kV LBB (Local Breaker Backup) protection operations,
- Multi-circuit transmission line tripping, and
- Associated cascading or near-cascading system events.

Each disturbance has been analyzed from a grid operator's perspective, focusing on both pre-disturbance and post-disturbance system conditions. The analysis aims to identify root causes, contributing factors, system vulnerabilities, and the effectiveness of existing protection and operational practices.

For comprehensive and objective analysis, MSLDC has utilized multiple data sources, including:

- SCADA data,
- Field communications and operator logs,
- Detailed field investigation reports from utilities,
- Disturbance Recorder (DR) and Event Logger data,
- Phasor Measurement Unit (PMU) data for dynamic system behavior assessment, and
- Protection relay indications and sequence-of-events (SOE) records.



## Maharashtra State Load Despatch Centre

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In line with Clause 37(2) of IEGC, 2023, and Clause 29.6, 29.15, and 43.8 of MEGC, 2020, the compendium documents MSLDC's observations during each disturbance, highlighting operational challenges, coordination issues, and system response characteristics. Further, remedial measures and recommendations suggested by MSLDC are provided, covering aspects such as protection coordination, voltage control, system strengthening, operational procedures, and communication protocols, with the objective of preventing recurrence and enhancing grid resilience.

The *Compendium of Grid Disturbances and Events – 2025, Maharashtra Power System* is intended to support:

- Improvement in grid protections and reliability,
- Situational awareness and preparedness of system operators,
- Understanding the grid probable causes grid disturbances and measures to be adopted
- Better coordination among stakeholders, and
- Continuous learning and compliance with the grid code framework.

Overall, the compendium reflects MSLDC's commitment to transparent reporting, in depth technical analysis, and knowledge sharing in accordance with the provisions of IEGC 2023 and MEGC 2020, contributing to the safe, secure, and reliable operation of the Maharashtra Power System.



## Table of Contents

Contents	
<b>Disclaimer</b> .....	1
<b>Copyright Information</b> .....	2
<b>Preface</b> .....	3
<b>Contributors</b> .....	6
<b>Executive Summary</b> .....	7
<b>Table of Contents</b> .....	11
<b>List Of Tables</b> .....	14
<b>List Of figures</b> .....	15
<b>Chapter 1: Introduction</b> .....	19
1.1. Purpose of the Grid Disturbance Analysis Compendium - 2025.....	19
<b>Chapter 2: Regulatory Guidelines and Compliance Requirements</b> .....	21
2.1. The Indian Electricity Grid Code (IEGC)-2023 & MEGC State Grid Code Regulations, 2020 clauses .....	21
2.2. Definitions of Grid disturbance, Grid incident.and Grid Events: .....	21
2.3. Categorization of Grid Incidents & Disturbances .....	22
2.4. Event/Disturbance reporting procedure to SLDC by the User/Transmission Licensee.....	23
2.5. Role of SLDC .....	24
<b>Chapter 3. Grid Disturbance / Occurrence analysis Reports prepared by SLDC.</b> .....	25
3.1. Overview of major Grid Disturbance / Occurrences analyzed during – 2025.....	25
3.2. Detailed Grid Disturbance / Occurrences analysis Reports prepared by SLDC. ....	29
3.2.1. Report on Voltage Collapse on 12.03.2025 in Maharashtra. ....	29
Preface .....	30
Executive Summary.....	31
3.2.1.1. Event Description .....	33
3.2.1.2. Antecedent Conditions of the System.....	35
3.2.1.3. Details of LTS and UVLS schemes in the affected region .....	45
3.2.1.4. Sequence of Events (SoE) .....	46
3.2.1.5. Root Cause Analysis .....	64
3.2.1.6. Impact Assessment .....	91
3.2.1.7. Restoration Process .....	92
3.2.1.8. Recommendations & Mitigating measures .....	95
3.2.2. State Grid Alert Report: Pune Region.....	100

# Maharashtra State Load Despatch Centre

---

3.2.3.	System disturbance due to Multiple line tripping at 400 kV Warora substation on 10.06.2025 .....	104
3.2.4.	Occurrence at 400 kV Karad substation due to non-operation of 220 kV RADSS make bus bar scheme on 29.06.2025.....	110
3.2.5.	Disturbance in MMR area (Dombivali, Ambarnath, Badlapur region) in view of tripping of 220 kV Padghe Pal Line on 04.07.2025. ....	118
3.2.6.	Long Duration Load Loss in Pune Region. ....	122
3.2.7.	State Grid Alert Report: Mumbai and MMR region dated 30.07.2025. ....	126
3.2.8.	State Grid Alert Report: Mumbai and MMR region dated 30-31.07.2025.....	130
3.2.9.	Occurrence of 220 kV busbar bar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.....	134
3.2.10.	Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025.....	140
3.2.11.	Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.....	146
3.2.12.	Occurrence of LBB protection operations at 100kV Padgha substation on 29.07.2025 and 13.08.2025. ....	155
3.2.13.	Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025. ....	163
3.2.14.	Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025 .....	172
3.2.15.	Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400kV Deep-nagar substation on 19.09.2025. ....	180
3.2.16.	Occurrence of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.....	189
3.2.17.	Report of multiple occurrences on 220 kV Busbar at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.....	202
<b>Chapter 4. Observations and Remarks / Remedial measures suggested by MSLDC. ..</b>		<b>215</b>
4.1.	MSLDC Observations during the Major grid occurrences .....	215
4.1.1.	Voltage Collapse event on 12.03.2025 in Maharashtra .....	215
4.1.2.	System disturbance at 400 kV Warora substation on 10.06.2025.....	215
4.1.3.	System disturbance at 400 kV Karad substation due to non-operation of 220 kV bus bar scheme on 29.06.2025 .....	216
4.1.4.	Occurrence of 220 kV busbar bar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.....	216
4.1.5.	Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025.....	217
4.1.6.	Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.....	217

# Maharashtra State Load Despatch Centre

---

4.1.7.	Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025. ....	218
4.1.8.	Occurrence at 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025 .....	218
4.1.9.	Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deepnagar substation on 19.09.2025.....	218
4.1.10.	Occurrence at 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.....	219
4.1.11.	Multiple occurrences on 220 kV Busbars at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025. ....	219
4.2.	MSLDC Remarks / Remedial measures during the Major grid occurrences .....	220
4.2.1.	Voltage Collapse event on 12.03.2025 in Maharashtra .....	220
4.2.2.	System disturbance at 400 kV Warora substation on 10.06.2025.....	224
4.2.3.	System disturbance at 400 kV Karad substation due to non-operation of 220 kV bus bar scheme on 29.06.2025 .....	224
4.2.4.	Disturbance in MMR area (Dombivali, Ambarnath, Badlapur region) in view of tripping of 220 kV Padghe Pal Line on 04.07.2025. & Long duration load loss in Pune region. ....	225
4.2.5.	Occurrence report of 220 kV busbar bar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.....	226
4.2.6.	Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.....	226
4.2.7.	Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping. ....	226
4.2.8.	Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025. ....	227
4.2.9.	Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025 .....	228
4.2.10.	Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deepnagar substation on 19.09.2025.....	228
4.2.11.	Occurrence at 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.....	229
4.2.12.	Multiple occurrences on 220 kV Busbars at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025. ....	229
<b>Chapter 5.</b>	<b>Common Challenges Encountered During Grid Disturbance Analysis.....</b>	<b>231</b>
5.1	Data Availability, Quality, and Timeliness .....	231
5.2	System Observability, SCADA Visibility, and Communication Constraints .....	231
5.3	Time Synchronisation and Event Reconstruction Challenges.....	232
5.4.	Complexity of Protection System Operations .....	232

# Maharashtra State Load Despatch Centre

5.5.	Legacy Systems and Heterogeneous Technology Environment.....	233
5.6.	Human Factors and Operational Preparedness .....	233
5.7.	Geographical Spread and Multi-Stakeholder Coordination.....	233
5.8.	Regulatory and Procedural Constraints .....	234
<b>Chapter 6.</b>	<b>Conclusion .....</b>	<b>235</b>

## List Of Tables

Table 1:	Categorization of grid incidents in increasing order of severity .....	22
Table 2:	Categorization of grid disturbance in increasing order of severity .....	22
Table 3	Overview of major Grid Disturbance / Occurrences analyzed during – 2025.....	25
Table 4	The voltage profile of various 400 kV Sub-stations .....	35
Table 5:	Intra state resource availability with resource margin.....	36
Table 6:	Interstate exchange before the event .....	36
Table 7:	Generating units under outage during the event .....	38
Table 8:	Transmission system Outages or maintenance activities .....	41
Table 9:	Bus reactor position in the State at 14:30 Hrs before the event .....	42
Table 10:	Capacitor position at 14:30 hrs before the event.....	42
Table 11:	List of elements not available.....	44
Table 12:	low voltages at multiple 400 kV locations.....	46
Table 13:	Sequence of Auto Defense Mechanism in Maharashtra.....	47
Table 14	Sequence of Events at 220 kV Nashik (OCR): .....	53
Table 15:	Trippings at Karjat Belwani & Pathardi ss Relays are not GPS sync.....	54
Table 16:	Abstract of affected substations under EHV O&M DIV Babbleshwar.....	55
Table 17:	Koyna Stage IV Generation as per SCADA (in MW).....	57
Table 18	TPCL Hydro Generation as per PSCC SCADA (in MW) .....	58
Table 19:	Koyna Stage I&II Generation as per SCADA (in MW) .....	59
Table 20:	Manual Load Curtailment instructed by MSLDC .....	61
Table 21:	lines already out in Gujrat .....	64
Table 22:	Generation loss in Gujrat/Maharashtra.....	64
Table 23	Possibility of load encroachment of Distance protection in Zone-3 .....	80
Table 24	Affected Areas .....	91
Table 25	load restoration at Kalwa circle.....	92
Table 26	load restoration at Panvel circle.....	92
Table 27	load restoration at Padghe circle .....	93
Table 28	load restoration at Pune Zone.....	93
Table 29	load restoration at Nashik Zone.....	93
Table 30	load restoration at TPCL area .....	93
Table 31	load restoration at AEML area.....	94
Table 32	Transmission Schemes proposed in MMR & Pune Area.....	95
Table 33	loading on Talegaon (PG)-Chakan and Talegaon-Lonikand line.....	101
Table 34	Substation wise load curtailment.....	102
Table 35	Transmission elements loading prior to event .....	105
Table 36	Sequence of Events on 10.06.2025: .....	106
Table 37	Transmission elements loading prior to event main bus 1.....	111
Table 38	Transmission elements loading prior to event main bus 2 .....	111
Table 39	Sequence of Events on 29.06.2025 .....	113
Table 40	Observations from PMU plots: .....	114
Table 41	load Loss during the event.....	124
Table 42	loadings of Major 400 kV Source lines to Mumbai before incident.....	127
Table 43	Changed loading on 400 kV source lines to Mumbai.....	128
Table 44	400 kV source lines to Mumbai are under forced outage / Breakdown.....	131

# Maharashtra State Load Despatch Centre

---

Table 45	Sequence of events subsequent to earlier grid alert report on 31.07.2025 .....	132
Table 46	Transmission elements loading prior to event.....	136
Table 47	Sequence of Events on 18.06.2025.....	137
Table 48	Tripping and Restoration details .....	137
Table 49	Transmission elements loading prior to event.....	142
Table 50	Sequence of Events on 16.07.2025.....	143
Table 51	Transmission elements loading prior to event .....	148
Table 52	Tripping and Restoration details.....	150
Table 53	Tripping and Restoration details.....	159
Table 54	Bays connected to 100kV Main-Bus section -1 and 100kV Main -Bussection-2 .....	160
Table 55	Tripping and Restoration details.....	166
Table 56	Load Power loss and /or generation (in MW) .....	167
Table 57	Transmission elements loading prior to event: At 400 kV Nagothane .....	174
Table 58	Tripping and Restoration details.....	175
Table 59	Tripping and Restoration details.....	183
Table 60	SOE (derived from DRs received from substation involved) .....	195
Table 61	Transmission elements loading prior to events.....	204
Table 62	Transmission elements loading prior to events .....	205
Table 63	Tripping and Restoration details.....	206
Table 64	Tripping and Restoration details on 14.11.2025.....	207
Table 65	Bus bar relay event log on 08.10.2025; 17:55 hrs.....	208

## List Of figures

Figure 1:	Root cause and action tree diagram.....	31
Figure 2:	Geographical Area Affected .....	33
Figure 3:	Resource Mix before the event .....	35
Figure 4:	400 kV Network Overview (SCADA).....	36
Figure 5:	Resource Overview of the State (SCADA).....	37
Figure 6:	DR 220 kV Nashik GCR – Babhleshwar ckt 1&2 – Overcurrent LTS.....	48
Figure 7:	DR 220 kV Nashik GCR – Babhleshwar ckt 1&2 – Overcurrent LTS .....	48
Figure 8:	DR 400 kV Babhleshwar – Under Voltage Stage-1 LTS.....	49
Figure 9:	The second operation of UVLS DR depicts low voltages at Babhleshwar .....	49
Figure 10:	DR 400 kV Padghe – Under Voltage Stage-1 LTS .....	50
Figure 11:	DR 400 kV Padghe – Under Voltage Stage-2 LTS .....	51
Figure 12	Area affected due to Trippings around Babhaleshwar substation .....	54
Figure 13:	Snap shot of 220 kV OCR substation loadings.....	56
Figure 14:	KOYNA STAGE IV RESPONSE ON 12-03-2025 .....	58
Figure 15:	TPCL HYDRO RESPONSE ON 12-03-2025 .....	59
Figure 16:	KOYNA STAGE I&II RESPONSE ON 12-03-2025 .....	60
Figure 17:	Padghe HVDC MW plot 12.03.2025.....	60
Figure 18:	SCADA Snapshots at 14:55 Hrs i.e. after initiation of incidence: .....	62
Figure 19:	Resource Overview of the State_After Incidence (SCADA).....	62
Figure 20:	400 kV Network Overview_After Incidence (SCADA).....	63
Figure 21:	Resource Overview of the State_After Incidence (SCADA).....	63
Figure 22:	The geographic area affected in Gujrat.....	65
Figure 23:	Frequency at 400 kV Padghe S/s. (PMU).....	67
Figure 24:	Voltage at 400 kV Padghe S/s. (SCADA).....	67
Figure 25:	Voltage at 400 kV Padghe S/s. (PMU) .....	67
Figure 26:	dv/dt plot at 400 kV Padghe S/s. (SCADA).....	68
Figure 27:	Reactive Power & Voltage plot of 400 kV Tarapur-Padghe-1 at Padghe end .....	68
Figure 28:	Active Power Flow on 400 kV Tarapur-Padghe-1 (SCADA).....	69
Figure 29:	Active Power Flow on 400 kV Tarapur-Padghe-1 (PMU) .....	69
Figure 30:	Active Power Flow on 400 kV Tarapur-Padghe-2 (PMU).....	69
Figure 31:	Active Power Flow on 400 kV Tarapur-Boisar (PG) (SCADA) .....	70
Figure 32:	Active Power Flow on 400 kV Tarapur-Boisar (PG) (PMU).....	70
Figure 33:	Active Power Flow on 400 kV Babhaleshwar-Padghe-1 (SCADA) .....	71

# Maharashtra State Load Despatch Centre

Figure 34 Active Power Flow on 400 kV Babhaleshwar-Padghe-1 (PMU) .....	71
Figure 35 Active Power Flow on 400 kV Babhaleshwar-Padghe-2 (SCADA) .....	72
Figure 36 Active Power Flow on 400 kV Babhaleshwar-Padghe-2 (PMU).....	72
Figure 37 Active Power Flow on 400 kV Padghe-Kalwa-1 (SCADA) .....	72
Figure 38 Active Power Flow on 400 kV Padghe-Kalwa-1 (PMU).....	73
Figure 39 Active Power Flow on 400 kV Padghe-Kalwa-2 (SCADA).....	73
Figure 40 Active Power Flow on 400 kV Padghe-Kalwa-2 (PMU) .....	73
Figure 41 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-1 (SCADA).....	74
Figure 42 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-1 (PMU) .....	74
Figure 43 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-2 (SCADA) .....	74
Figure 44 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-2 (PMU).....	75
Figure 45 Active Power flow on 400 kV Nagothane – Padghe-2 (SCADA) .....	75
Figure 46 Active Power flow on 400 kV Nagothane – Padghe-2 (PMU).....	75
Figure 47 Trombay Unit-5 (500 MW): P, Q & Gen Current (Source: TPCL).....	76
Figure 48 Trombay Unit-7 (180 MW): P, Q & Bus Voltage (Source: TPCL).....	76
Figure 49 Trombay Unit-8 (250 MW): P, Q & Gen Current (Source: TPCL) .....	77
Figure 50 Dahanu Unit-1 (250 MW): P, Q & Bus Voltage (Source: AEML) .....	77
Figure 51 Dahanu Unit-2 (250 MW): P, Q & Bus Voltage (Source: AEML).....	78
Figure 52 APML Unit-1 (660 MW): Active Power & Frequency (Source: APML) .....	78
Figure 53 APML Unit-2 (660 MW): Active Power & Frequency (Source: APML).....	78
Figure 54 APML Unit-3 (660 MW): Active Power & Frequency (Source: APML).....	79
Figure 55 APML Unit-4 (660 MW): Active Power & Frequency (Source: APML).....	79
Figure 56 APML Unit-5 (660 MW): Active Power & Frequency (Source: APML).....	79
Figure 57 Angular Difference before incidence (PMU).....	81
Figure 58 Angular Difference After incidence (PMU) .....	81
Figure 59 Snapshots of PMU Screen indicating Angular difference & df/dt: At 14:45:08 Hrs: (Before incidence).....	82
Figure 60 Snapshots of PMU Screen indicating Angular difference & df/dt: At 14:52:19 Hrs: (after incidence).....	83
Figure 61 Voltage Angle Plot (PMU) .....	83
Figure 62 frequency deviation during event 1.....	84
Figure 63 frequency deviation during event 2 .....	85
Figure 64 frequency deviation during event 3 .....	85
Figure 65 frequency deviation at 15:35:31:760 .....	86
Figure 66 Voltage at 400 kV Padghe S/s. (SCADA).....	87
Figure 67 Voltage at 400 kV Padghe S/s. (PMU).....	87
Figure 68 Voltage at 400 kV Vikhroli S/s. (SCADA) .....	88
Figure 69 Voltage at 400 kV Kolhapur S/s. (PMU) .....	88
Figure 70 Voltage at 400 kV Kalwa S/s. (PMU) .....	88
Figure 71 Voltage at 400 kV Chandrapur S/s. (PMU) .....	89
Figure 72 Phase to Ground Voltage plot at 400 kV Padghe (PMU).....	89
Figure 73 Export Active Power v/s Voltage plot at Padghe on all 400 kV lines (PMU).....	90
Figure 74 Export Reactive Power v/s Voltage plot at Padghe on all 400 kV lines (PMU).....	90
Figure 75 PMU Plot at 400 kV Chandrapur Bus voltages.....	107
Figure 76 PMU Plot at 400 kV Chandrapur Bus Frequency.....	107
Figure 77 System disturbance due to multiple line trippings at 400kV Warora substation on 10.06.2025 .....	109
Figure 78 PMU Plot Of 400 kV Solapur PG-Karad Line DF/DT .....	113
Figure 79 Sequence of operation from PMU Plots.....	114
Figure 80 Occurrence at 400 kV Karad substation due to non-operation of 220 kV RADSS make bus bar scheme on 29.06.2025. ....	117
Figure 81 220 kV Network around 220 kV Bhosari-1 ss. ....	135
Figure 82 Occurrence of 220 kV busbar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025. ....	139
Figure 83 Grid Location of 220 kV Nagothane Bus .....	141
Figure 84 Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025..	145

# Maharashtra State Load Despatch Centre

---

Figure 85 Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.....	154
Figure 87 Occurrence of LBB protection operations at 100kV Padgha substation on 29.07.2025 and 13.08.2025. ....	162
Figure 88 400 kV Network around 400 kV Chandrapur ss.....	164
Figure 89 Transmission elements loading prior to event: At 400 kV Chandrapur ss .....	165
Figure 90 400 kV Bus 2 Voltages PMU Plots of PMUs at 400 kV Chandrapur ss .....	167
Figure 91 400 kV Bus 1 Voltages PMU Plots of PMUs at 400 kV Chandrapur ss .....	167
Figure 92 400 kV Bus 1 Frequency .....	168
Figure 93 Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.....	171
Figure 94 EHV Network around 400 kV Nagothane ss .....	173
Figure 95 PMU Plots of PMUs at 400 kV Padhe ss Bus-1.....	175
Figure 96 PMU Plots of PMUs at 400 kV Padhe ss Bus-2 .....	176
Figure 97 PMU Plots of PMUs at 400 kV Padhe ss Bus-1.....	176
Figure 98 Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025.....	179
Figure 99 400 kV and 220 kV Network around 400 kV Deepnagar substation. ....	181
Figure 100 Physical location of Burst R ph CT of 400 kV Deepnagar Khadka -1 bay at 400 kV Deepnagar ss .....	183
Figure 101 PMU Plots of PMUs at 400 kV A`bad _PG ss .....	184
Figure 102 PMU Plots of PMUs at 400 kV A`bad _PG ss.....	184
Figure 103 Disturbance Recorder plots of 400 kV deepnagar- Khadka2 M1 relay.....	185
Figure 104 Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deep-nagar substation on 19.09.2025.....	188
Figure 105 400 kV Network around 400 kV Chandrapur-2 ss. ....	190
Figure 106 Bus configuration & load prior to occurrence .....	191
Figure 107 400 kV Bus 2 Voltages at Chandrapur .....	197
Figure 108 Occurrence of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping. ....	201
Figure 109 220 kV Network around 220 kV Uran substation .....	203
Figure 110 Bus bar relay DR on 09.09.2025; 03:24 hrs .....	208
Figure 111 Busbar relay DR On 14.11.2025 at 02:22 hrs, .....	209
Figure 112 SLD of occurrences on 220 kV Main Bus-I & II Busbars at 220KV Uran substation on 14.11.2025.....	213



## **Chapter 1: Introduction**

### 1.1. Purpose of the Grid Disturbance Analysis Compendium - 2025

The *Compendium of Grid Disturbances and Events – 2025, Maharashtra Power System* is prepared by Maharashtra State Load Dispatch Centre (MSLDC) to systematically document, analyze, and disseminate information on important grid disturbances, incidences and events that occurred in the Maharashtra Power System during the year 2025. The primary purpose of the compendium is to provide a structured, operator-centric analysis of major grid events such as under-voltage / over-voltage conditions, 400 kV and 220 kV busbar protection operations, LBB protection operations and multi-circuit transmission line tripping & to meet the reporting, analysis, and knowledge-sharing requirements prescribed under the Indian Electricity Grid Code (IEGC), 2023 and the Maharashtra Electricity Grid Code (MEGC), 2020, while strengthening transparency and accountability in grid operations.

By examining pre-disturbance and post-disturbance system conditions using SCADA data, field reports, disturbance recorder and event logger records, PMU data, and relay indications, the document seeks to identify root causes, to deduce various observations and suggest remedial measures related to major grid occurrences / disturbances.



## Chapter 2: Regulatory Guidelines and Compliance Requirements

### 2.1. The Indian Electricity Grid Code (IEGC)-2023 & MEGC State Grid Code Regulations, 2020 clauses

The Indian Electricity Grid Code (IEGC)-2023 in its Operating Code-Regulation No. 37(2) mandates SLDC to prepare Flash report and detailed report on grid disturbance (post grid disturbance).

As per MEGC State Grid Code Regulations, 2020, clause 29.6, Any tripping, whether manual or automatic, of any of the elements of the InSTS, referred in Regulation 29.3, shall be precisely intimated by the concerned Transmission Licensee or User to the SLDC within one time block. The reason, to the extent determined, and likely time of restoration shall also be intimated. All reasonable attempts shall be made for the elements' restoration as soon as possible; provided that the information/data from disturbance recorder, sequential event logger outputs, etc., containing the sequence of tripping and restoration or any other information as asked, shall be sent to SLDC for the purpose of analysis; Provided further that such information/data may be directly made available at SLDC through suitable communication media for faster post fault analysis during grid disturbances.

The MEGC 2020, Clause 29.15 states that, All Users and Transmission Licensees shall send the requested information/data including disturbance recorder/sequential event recorder output, etc. within 24 hours to SLDC for the purpose of analysis of any grid disturbance/event.

Also, MEGC 2020, Clause 29.15 SLDC shall carry out the post-disturbance analysis of all major grid disturbances resulting into total or partial system blackout or system split and de-synchronism of any part of the State Grid. All Users shall coordinate and furnish the data pertaining to the system disturbance to enable SLDC to analyze the system disturbance and furnish a report to WRLDC in accordance with the provisions of IEGC, as amended from time to time.

### 2.2. Definitions of Grid disturbance, Grid incident, and Grid Events:

The terms “*Grid Disturbance*” and “*Grid Incident*” are not explicitly defined in the Maharashtra Electricity Grid Code (MEGC), 2020 and the Indian Electricity Grid Code (IEGC), 2020. However, these terms are used in operational and reporting contexts with reference to the Central Electricity Authority (Grid Standards) Regulations, 2010. In central electricity authority (Grid standards) regulations 2010 a Grid Disturbance is defined as “Grid disturbance- Grid disturbance means tripping of one or more power system elements of the grid like a generator, transmission line, transformer, shunt reactor, series capacitor and static VAR compensation, resulting in total failure of supply at a substation or loss of integrity of the grid, at the level of transmission system at 220kV and above.”

And a grid incident is defined as “Grid incident- means tripping of one or more power system elements of the grid like a generator, transmission line, transformer, shunt reactor, series

# Maharashtra State Load Despatch Centre

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capacitor and static VAR compensator which requires rescheduling of generation or load, without total loss of supply at a substation or loss of integrity of the grid at 220kV and above.”

In the **Maharashtra Electricity Grid Code (MEGC), 2020**, definition 2.1.38, “**Event**” means an unscheduled or unplanned occurrence on a Grid including faults, incidents, and breakdowns. Some of grid events are listed in Clauses 13.7, 46.1.1.

## 2.3. Categorization of Grid Incidents & Disturbances

### Categorization of grid incidents in increasing order of severity-

<i>Category GI-1</i>	<i>tripping of one or more power system elements of the grid like a generator, transmission line, transformer, shunt reactor, series capacitor and static VAR compensator which requires rescheduling of generation or load, without total loss of supply at a substation or loss of integrity of the grid at 220kV.</i>
<i>Category GI-2</i>	<i>tripping of one or more power system elements of the grid like a generator, transmission line, transformer, shunt reactor, series capacitor and static VAR compensator which requires rescheduling of generation or load, without total loss of supply at a substation or loss of integrity of the grid at 400kV and above.</i>

Table 1: Categorization of grid incidents in increasing order of severity

### Categorization of grid disturbance in increasing order of severity-

<i>Category GD-1</i>	<i>When less than ten per cent. of the antecedent generation or load in a regional grid is lost;</i>
<i>Category GD-2</i>	<i>When ten per cent. to less than twenty per cent. of the antecedent generation or load in a regional grid is lost.</i>
<i>Category GD-3</i>	<i>When twenty per cent. to less than thirty per cent. of the antecedent generation or load in a regional grid is lost;</i>
<i>Category GD-4</i>	<i>When thirty per cent. to less than forty per cent. of the antecedent generation or load in a regional grid is lost;</i>
<i>Category GD-5</i>	<i>When forty per cent. or more of the antecedent generation or load in a regional grid is lost.</i>

Table 2: Categorization of grid disturbance in increasing order of severity

# Maharashtra State Load Despatch Centre

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## 2.4. Event/Disturbance reporting procedure to SLDC by the User/Transmission Licensee

Any of the following events shall require reporting by the User/Transmission Licensee to SLDC or STU as the case may be: (The MEGC 2020, Clause. 46.1.1.)

- a) Blackout/partial system blackout;
- b) System islanding/system split;
- c) Grid indiscipline;
- d) Loss of major generating unit;
- e) Violation of security standards;
- f) Severe equipment problem relating to major circuit breaker, transformer, bus bar or EHV Transmission Tine tower collapsing;
- g) Non-compliance of SLDC's instructions;
- h) Protection failure on any element of InSTS;
- i) Power system instability;
- j) Tripping of any element of the State Grid;
- k) Major fire incidents;
- l) Force majeure conditions;
- m) Fatal or non-fatal accident of human;
- n) Sudden load rejection by any User;
- o) Exceptionally high or low system voltage;
- p) Any other event as stipulated by the Commission from time to time.

In line with MEGC 2020, Clause 46.2.1. after having initially reported about the event orally to the SLDC, User or Transmission Licensee, shall provide a written report within two days of the occurrence of the event to the SLDC in accordance with Regulation 46.1.1.

According to 46.2.3. A written report shall be sent to SLDC by Users/Transmission Licensees, and shall confirm the oral notification together with the following details of the event:

- i. Time and date of the event;
- ii. Location; Plant and/or Equipment directly involved;
- iii. Description and cause of event;
- iv. Antecedent conditions;
- v. Demand and/or Generation (in MW) interrupted and duration of interruption;
- vi. All relevant system data including copies of records of all recording Instruments including Disturbance Recorder,
- vii. Event Logger and Data Acquisition System;
- viii. Sequence of tripping with time;
- ix. Details of Relay Flags;
- x. Remedial measures;
- xi. Any other related information.

The standard reporting formats considering information mentioned in 46.1.1 and as approved by the GCC are circulated by office of The Chairperson, State PCC (Protection Coordination Committee) i.e. The Chief Engineer (ACI&P), MSETCL vide L. No. MSETCL/CO/CE (ACI&P)/WRPC/GI-GD Report/69 Date: 24.01.2025 with Subject: Reporting of Grid disturbance (GD/GI) and allied information to SLDC/ WRPC/WRLDC.

## 2.5. Role of SLDC

The State Load Dispatch Centre (SLDC) plays a central and statutory role in the management, analysis, and reporting of grid disturbances within the State Grid. In accordance with the provisions of the Indian Electricity Grid Code (IEGC), 2023 and the Maharashtra Electricity Grid Code (MEGC), 2020, SLDC is responsible for ensuring secure grid operation, effective coordination among stakeholders, and systematic learning from grid events.

SLDC is mandated to receive immediate intimation of any tripping, abnormal system condition, or grid disturbance from Users and Transmission Licensees. Upon occurrence of an event, SLDC prepares a flash report, captures the sequence of events, assesses the system conditions, and oversees prompt restoration of affected grid elements through coordinated operational instructions.

Transmission Licensees, generating stations, and other Users are required to furnish complete and accurate information to SLDC, including the cause of tripping, restoration status, disturbance recorder outputs, event logs, relay indications, and other relevant system data within the prescribed timelines. SLDC consolidates this information to carry out a detailed post-disturbance analysis, with the objective of identifying root causes, system impacts, protection performance, and operational challenges.

For major grid disturbances such as partial or total blackouts, system splits, or de-synchronisation events, SLDC is specifically mandated to conduct comprehensive post-event analyses and prepare detailed reports. These reports are communicated to WRLDC and other concerned agencies, thereby contributing to inter-control area coordination, regulatory compliance, and prevention of recurrence of similar events.

Through continuous real-time system supervision, coordination with transmission licensees, generating companies, distribution licensees, and regional entities, SLDC plays a critical role in enhancing grid reliability, operational preparedness, and resilience of the Maharashtra Power System.

# Maharashtra State Load Despatch Centre

## Chapter 3: Grid Disturbance / Occurrence analysis Reports prepared by SLDC.

This section presents an overview and detailed analysis of important grid disturbances and significant operational occurrences reported and analysed by Maharashtra SLDC during the year 2025. Each event has been examined with reference to system conditions, protection behaviour, operator actions, and restoration processes, in line with the Grid Code requirements.

### 3.1. Overview of major Grid Disturbance / Occurrences analyzed during – 2025

The major grid disturbances and incidents analyzed by Maharashtra State Load Dispatch Centre (MSLDC) during the year 2025 are listed below:

Table 3 Overview of major Grid Disturbance / Occurrences analyzed during – 2025

Sr. No.	Date of Report	Substations / Area involved	Description	Date and Time of Event	Protection Operation / Primary Cause	Reason
1	<a href="#">26.03.25</a>	Mumbai, MMR, Pune, Nashik, Boisar, and Nagothane	Report on Voltage Collapse on 12.03.2025 in Maharashtra.	12.03.2025, 14:55	LTS and UVLS, Multiple Line/ ICTs Tripping, Load shading	Multiple transmission lines and generators tripping in South Gujarat led to excessive power flow from Maharashtra to Gujarat creating a severe undervoltage scenario in state grid.
2	<a href="#">13.05.25</a>	400 kV Talegaon PG (Pune AIS)	State Grid Alert Report: Pune Region;	06.05.2025, 16:30	Distance Protection, LTS	400 kV Talegaon PG (Pune AIS) - Lonikand1 Line tripped at Lonikand 1 end. Due to this tripping ICTS at 400 kV Chakan and 400 kV Chakan-Talegaon Line got overloaded resulting in operation of LTS schemes.
3	<a href="#">No.1272, 18.06.25</a>	400 kV Warora substation	System disturbance due to Multiple line tripping at 400 kV Warora substation on 10.06.2025;	10.06.2025, 00:25	Multiple line tripping	400 kV APML Ckt 2 CVT failure and Multiple line tripping at 400 kV Warora substation
4	<a href="#">No. 1475, 11.07.25</a>	400 kV Karad substation	Occurrence report at 400 kV Karad substation	29.06.2025, 05:25	Non operation of 220 kV	During Bus fault at 220 kV Oglewadi bay, 220 kV

## Maharashtra State Load Despatch Centre

			due to non-operation of 220 kV RADSS make bus bar scheme on 29.06.2025.		Busbar protection	Busbar protection failed to operate.
5	<a href="#">No. 1583;</a> <a href="#">23.07.25</a>	220 kV Padghe substation	Disturbance in MMR area (especially in Dombivali, Ambarnath, Badlapur region) in view of tripping of 220 kV Padghe Pal Line on 04.07.2025.	04.07.2025; 13:12	Distance Protection, LTS	220 kV Padghe Pal Line tripped on Rph -E due to EHV cable Failure and breakdown. Also, on 10.07.2025 at 18:54 hrs 220 kV Padghe - Jambhul line hand tripped due to heavy sparking observed.
6	<a href="#">07.07.25</a>	220 kV Pegasis - Infosys Line and 220 kV Pirangut - Hingewadi 2 Line	Long Duration Load Loss in Pune Region	02.07.2025 to 06.06.2025	Distance Protection	220 kV Pirangut - Hingewadi 2 Line and 220 kV Pegasis - Infosys Line tripped due to EHV cable Failure and breakdown.
7	<a href="#">30.07.25</a>	400 kV PadghaPG- Navi Mumbai PG line, 400 kV Padghe PG - Kharghar Line,	State Grid Alert Report: Mumbai and MMR region	30.07.2025	Distance Protection	400 kV PadghaPG- Navi Mumbai PG line, 400 kV Padghe PG - Kharghar Line tripped due failure of line insulators on 30.07.2025 pushing of Mumbai and MMR region grid in alert mode.
8	<a href="#">No. 1626;</a> <a href="#">31.07.25</a>	400 kV PadghaPG- Navi Mumbai PG line, 400 kV Padghe PG - Kharghar Line, 400 kV Navi MumbaiPG - Vikroli Line	State Grid Alert Report: Mumbai and MMR region	30.07.2025 and 31.07.2025	Distance Protection	400 kV PadghaPG- Navi Mumbai PG line, 400 kV Padghe PG - Kharghar Line, 400 kV Navi MumbaiPG - Vikroli Line line tripped due failure of line insulators on 30.07.2025 and 31.07.2025 increasing criticality of Mumbai and MMR region.
9	<a href="#">No. 1686;</a> <a href="#">31.07.25</a>	220 kV Bhosari substation	Occurrence report of 220 kV busbar bar protection operation at 220 kV Bhosari 1 ss during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.	18.06.2025, 20:04	Bus bar Protection	220 kV busbar bar protection operated at 220 kV Bhosari 1 ss during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.

## Maharashtra State Load Despatch Centre

10	<a href="#">No. 1775;</a> <a href="#">14.08.25</a>	400 kV Nagothane substation	Occurrence report of multiple line trippings at 400 kV nagothane ss on 16.06.2025	16.06.2025, 15:52	Simultaneous 220 kV Lines tripping while bay shifting operations (Bus1 to Bus 2)	PT selection scheme issues.
11	<a href="#">No. 2001;</a> <a href="#">19.09.25</a>	220 kV VIPL substation	Occurrence report of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.	15.08.2025, 19:00	LBB protection, Distance protection, BU protection, HT	Y ph pole stuck up of CB of 220 kV VIPL - ButiBori 1 ckt-4
12	<a href="#">No. 2002;</a> <a href="#">19.09.25</a>	400 kV Padghe substation	Occurrence report of LBB protection operations at 100kV Padgha ss on 29.07.2025 and 13.08.2025	29.07.2025 and 13.08.2025	LBB protection	100 kV CBs of 100 kV Bhiwandi-1 and 100 kV Bhiwandi-2 line failed to clear the line faults.
13	<a href="#">No. 2131;</a> <a href="#">07.10.25</a>	400KV GCR Chandrapur substation	Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.	06.09.2025 05:14	Busbar Protection	Failure of the Y-phase Current Transformer (CT) of the 400kV HVDC Circuit-2 Bay
14	<a href="#">No. 2233;</a> <a href="#">17.10.25</a>	400 kV Nagothane substation	Occurrence report of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025	10.09.2025; 23:36 Hrs	Busbar Protection	A failure and decapping of the extended B-phase bus insulator string
15	<a href="#">No. 2421;</a> <a href="#">10.11.25</a>	400 kV Deepnagar substation	Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deepnagar substation on 19.09.2025	19.09.2025; 04:25 Hrs	Busbar Protection	Bursting of R-ph line CT of 400 kV Deepnagar – Khadka Ckt-1.
16	<a href="#">2991;</a> <a href="#">10.12.25</a>	400kV Chandrapur-2 substation	Occurrence report of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and	21.10.2025; 20:02 hrs	Busbar Protection	400 kV Chandrapur (SW) Ckt-2's Y-phase IPS tube between the bus isolator and circuit breaker got detached from the Main Bus-1 isolator and came into the vicinity of the circuit breaker structure.

## Maharashtra State Load Despatch Centre

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			multi-line tripping.			
17	<a href="#">No. 2857;</a> <a href="#">30.12.25</a>	220 kV Uran substation	Report of multiple occurrences on 220 kV Busbars at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.	09.09.2025, 08.10.2025 & 14.11.2025.	Busbar Protection; LBB Protection.	On 09.09.2025, the R-phase pole of the GT Unit-8 circuit breaker got burst. On 08.10.2025, LBB command was initiated from GTPS end of Generation B0 unit bay. On 14.11.2025, R-phase CT of the 220 kV Bus-Coupler burst.

3.2. Detailed Grid Disturbance / Occurrences analysis Reports prepared by SLDC.

3.2.1. **Report on Voltage Collapse on 12.03.2025 in Maharashtra.**

# Maharashtra State Load Despatch Centre

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## Preface

The Maharashtra power system has evolved into one of the most complex and dynamic grids in the country, serving a diverse and rapidly growing consumer base. The **Maharashtra State Load Despatch Centre (MSLDC)** plays a pivotal role in ensuring the secure and reliable operation of this vast interconnected network by balancing demand and supply in real time, managing contingencies, and enforcing grid discipline.

The **voltage collapse event of 12th March 2025** posed a significant challenge to system operators, leading to widespread **load shedding across key urban Centres, including MMR, Pune, and Nashik**. While the event was mitigated through swift operator intervention, including **emergency generation ramp-ups, HVDC support, and load relief measures**, this report highlights the urgent need for **transmission system strengthening and advanced grid resilience mechanisms**.

**SLDC, Maharashtra** is making all efforts to ensure that Maharashtra's grid operates with reliability and resilience within available resources. This report presents a **comprehensive analysis** of the incident, examining its causes, impact, and the effectiveness of the mitigation strategies deployed. It also provides key **lessons learned** and **recommendations** for enhancing **grid stability through improved planning, automation, and coordination** between stakeholders, including **transmission utilities, generating stations and distribution utilities**.

I extend my sincere thanks and appreciation to the **SLDC team, WRLDC, transmission utilities, generation and distribution companies and all power system engineers and operators** who worked tirelessly to restore normalcy and minimize the impact of the disturbance. I am confident that the insights from this report will serve as a valuable reference for grid planners, policymakers, and system operators in shaping a more resilient Maharashtra power system.

**Shashank Jewalikar**  
**Executive Director, Maharashtra SLDC**  
**March 2025**

# Maharashtra State Load Despatch Centre

## Executive Summary

### Brief Overview of the Grid Disturbance in Maharashtra, on 12.03.2025

#### 1. Overview of the Disturbance

- A severe **voltage collapse** occurred in **Mumbai, MMR, Pune, Nashik, Boisar, and Nagothane** at **14:55 hrs on 12th March 2025**.
- The disturbance is classified as **Grid Disturbance (GD)-1** under IEGC, 2023.
- The event would have developed into a **near-blackout** scenario due to **critical voltage instability** which was **avoided** due to **automated operation of LTS and UVLS systems in Maharashtra, swift actions of SLDC and response from all the stakeholder transmission, generation and distribution licensees in Maharashtra**.

#### 2. Key Findings & Root Cause Analysis

- **Primary Cause:**
  - Multiple transmission lines and generators tripping in **South Gujarat** led to excessive power flow from Maharashtra to Gujarat.
  - Reversal of power flow on key **400 kV transmission corridors** (e.g., **Tarapur–Padghe, Boisar–Padghe**).
  - Severe voltage drops at multiple important 400 kV **substations** from **390 kV to ~350 kV or even less**.
- **Contributing Factors:**
  - Urban load concentration in Mumbai, MMR, Pune, with inadequate transmission infrastructure and less synchronous machine support in this area.
  - Lack of adequate reactive power compensation.
- Heavy pre-existing **line loadings and low system voltages**.

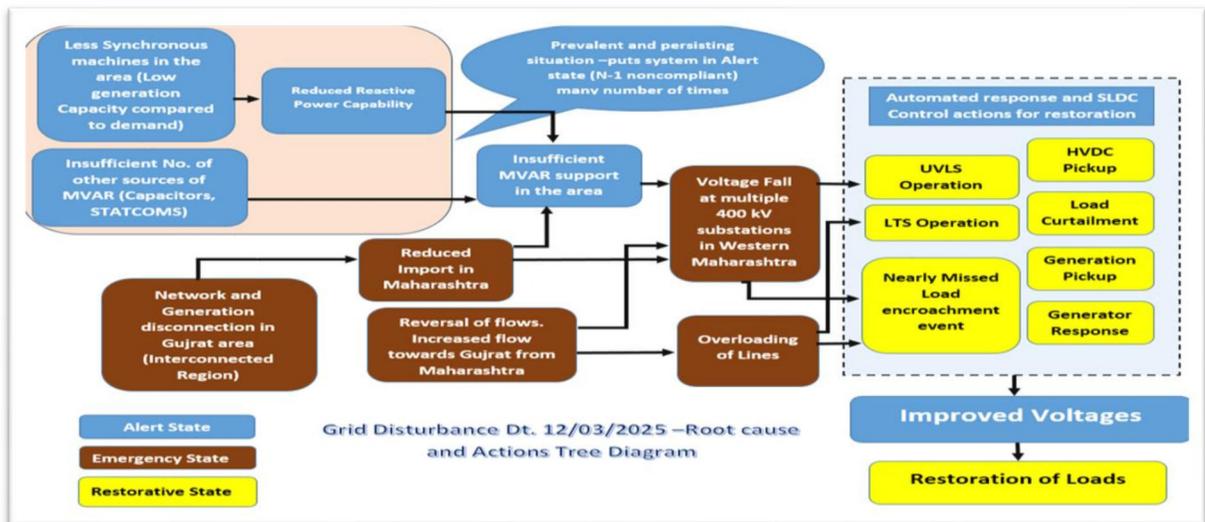


Figure 1: Root cause and action tree diagram

### 3. Impact on the Grid & Stakeholders

- **Load Shedding** of ~**3922 MW** across Maharashtra to stabilize the system.
- **Energy Not Served (ENS): 7.16 MUs** during the disturbance period (14:55 - 17:45 hrs).
- Significant **generator ramping up, HVDC flow ramp-ups** and **hydro generation pick-ups** for voltage support.

### 4. Restoration & Mitigation Measures

- **Restoration Time: 14:55 hrs - 17:58 hrs** (Full recovery in ~3 hours).
- **HVDC Support:** Chandrapur–Padghe HVDC ramped up from **950 MW to 1500 MW**.
- **Hydro Support:** **Koyna & Tata Power Hydro stations ramped up** to stabilize voltages.
- **Load Curtailment:** Manual shedding was implemented across key regions.

### 5. Lessons Learned & Recommendations

- **Short-Term Measures:**
  - Strengthening **load shedding schemes (LTS, UVLS)**.
  - Enhancing **real-time voltage monitoring & reactive power management**.
- **Long-Term Measures:**
  - Expanding **transmission capacity in urban load Centres**.
  - Deployment of adequate reactive compensation in this area.
  - Improvements in **grid automation, communication, and operator training**.

# Maharashtra State Load Despatch Centre

## 3.2.1.1. Event Description

### 1.1 Event Date & Time

The event of Voltage Collapse resulting in to large load shedding in Mumbai, MMR, Pune & Nashik area occurred on 12.03.2025 at 14:55 hrs.

### 1.2 Geographical Area Affected

In Western Maharashtra region, area affected was Mumbai, MMR, Pune, Nashik, Boisar & Nagothane.

This area was fed from 400kV Padghe, 400kV Babhaleshwar, 400kV Kalwa, 400kV Lonikand, 400kV Jejuri, 400kV Nagothane, 220kV Boisar & 220kV Nashik GCR-OCR Sub-stations.

Affected areas are marked in geographic map shown in Figure – 1 below:

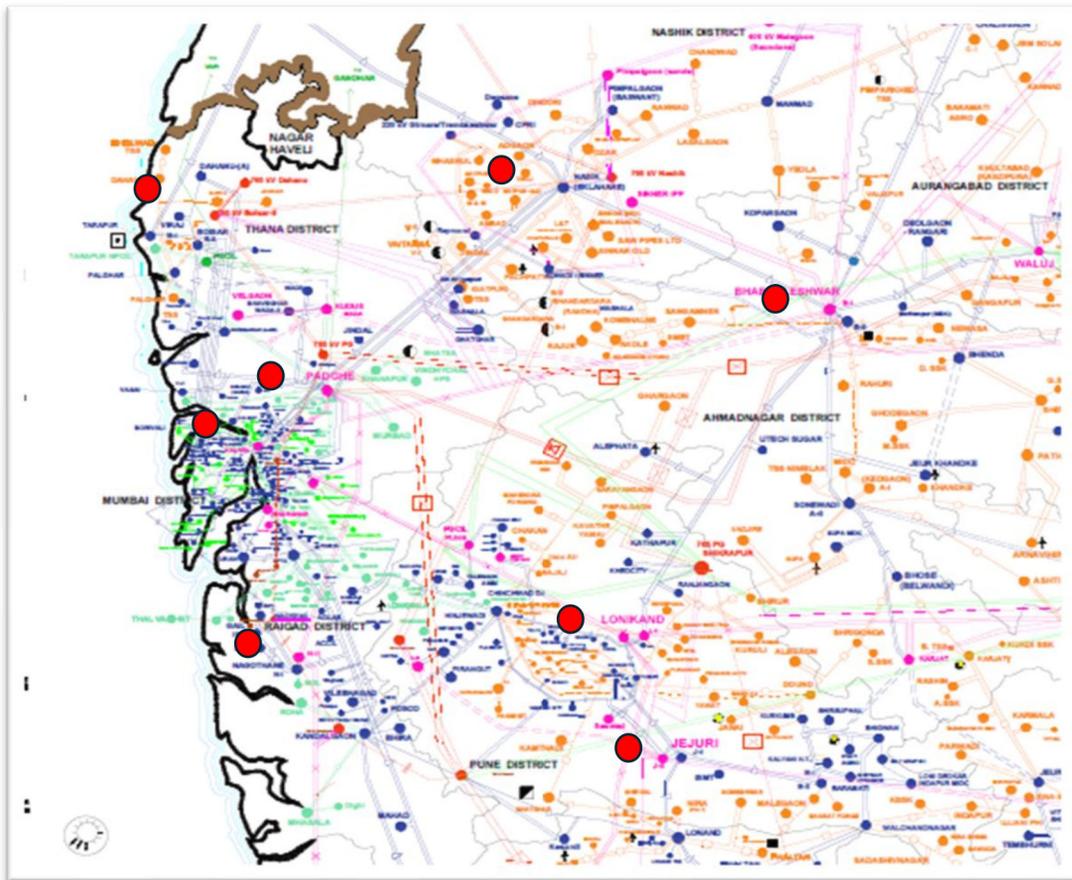


Figure 2: Geographical Area Affected

# Maharashtra State Load Despatch Centre

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## **1.3 Type of Disturbance**

In accordance with the IEGC, 2023, the event is categorized as Grid Disturbance (GD)-1.

This event was a near miss Blackout event due to severe Voltage Collapse in Western Maharashtra having concentrated loads.

## **1.4 Initial Observations**

- Maharashtra Power System was operating in condition as consistently observed during this season. The voltages of 400 kV Sub-stations in MMR & Pune area were in the range of 390-375 kV.
- At 14:50 Hrs, loading on 400kV Padghe – Babhaleshwar D/C reached up to 2000 MW (1000 MW each ckt). Also, voltage started decreasing drastically. This resulted in to LTS & UVLS operation at 400/220kV Padghe Sub-station.
- Normally, power is imported to 400 kV Padghe S/s from 400kV Tarapur – Padghe D/C and 400 kV Boisar (PG) – Padghe S/C lines.
- However, reversal of power flow from 217 MW (import) to 507 MW (export) was observed on each circuit of 400kV Tarapur – Padghe D/C lines. Also, reversal of power flow on 400 kV Boisar (PG) – Padghe S/C line from 570 MW (import) to 873 MW (export) was observed.
- LTS operation was also seen at 220 kV Nashik substation due to overloading of 220 kV Babhaleshwar Nashik D/C lines.
- UVLS operation was seen at 400 kV Babhaleshwar substation.
- 220 /132 kV ICTs tripped at 220 kV Nashik GCR. The 220kV Nashik – Navsari D/C tripped on Over-current protection at 220 kV Nashik OCR substation.
- Considering above scenarios, MSLDC Grid Operator immediately instructed Padghe Sub-Station to ramp-up HVDC to full capacity of 1500 MW, picked-up Koyna Generation and Tata Hydro generation. Load shedding was also instructed at multiple locations.
- It was informed by WRLDC that there are multiple trippings of Generating Units & Transmission Lines in South Gujrat, which has resulted into the severely low voltages in the Grid.

# Maharashtra State Load Despatch Centre

## 3.2.1.2. Antecedent Conditions of the System

### 2.1 Grid Demand & Generation Profile

- On 12<sup>th</sup> March 2025, before the grid disturbance, at 14:50 hrs, Maharashtra State Demand was 30,006 MW, State generation was 18308 MW and Receipt from central sector through Interstate lines was 11698 MW. The Resource mix is shown in the figure – 2.

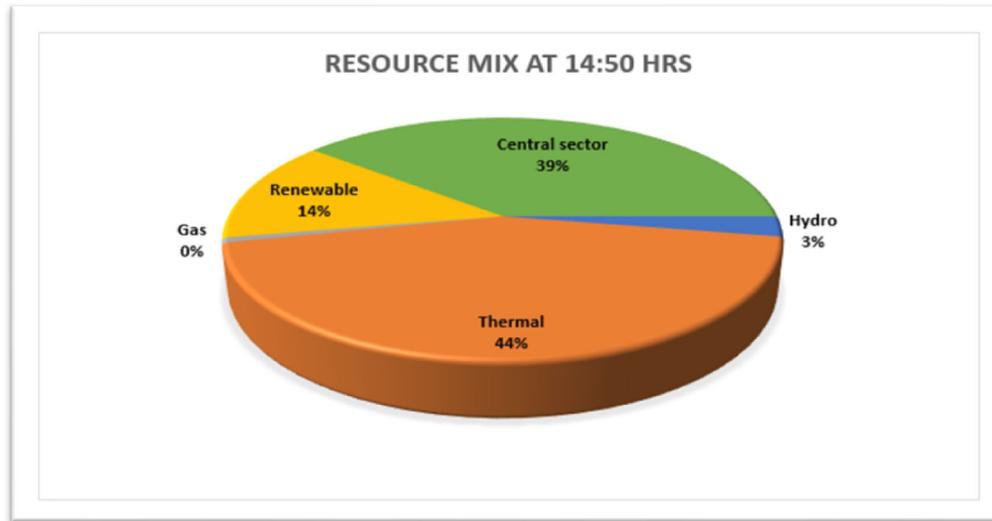


Figure 3: Resource Mix before the event

### 2.2 Voltage Profile

- The voltage profile of various 400 kV Sub-stations in the affected area at 14:49 Hrs are shown below:

Sr. No.	Name of Sub-station	Voltage (kV)
1	400 kV Babhaleshwar	383.2
2	400 kV Padghe	381.7
3	400kV Kalwa	384.7
4	400kV Nagothane	397.4
5	400kV Kharghar	398.3
6	400kV Vikhroli	380.1
7	400kV Lonikand I	373.4
8	400 kV Lonikand II	374.7
9	400 kV Chakan	375.3
10	400 kV Jejuri	376.4
11	400 kV Talegaon (PG)	381

Table 4 The voltage profile of various 400 kV Sub-stations

Source: (SCADA) Voltages of affected substations before the event

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## 2.3 Intrastate resource availability and schedules with resource margin

- The declared capacity (DC) of the Intra-State Thermal Generators was 14,185 MW & Schedule was 12,382 MW. Thus, up margin of 1,803 MW was available for Generation pick-up.

Block No.	Time Block	Declared Capacity (MW)	Schedule (MW)	Up margin (MW)
60	14:45-15:00	14,185	12,382	1,803

Table 5: Intra state resource availability with resource margin

## 2.4 Inter-state Exchange (OD/UD)

- Before the event, i.e. at 14:50 Hrs, share from the Central sector Generators was 11,430 MW and drawl was 11,698 MW. Thus, System was over-drawing 268 MW from Inter-State network.

State	Share (MW)	Drawl (MW)	Difference (MW)
Maharashtra	11,430	11,698	268 (Over-drawl)

Table 6: Interstate exchange before the event

## 2.5 SCADA Screenshots

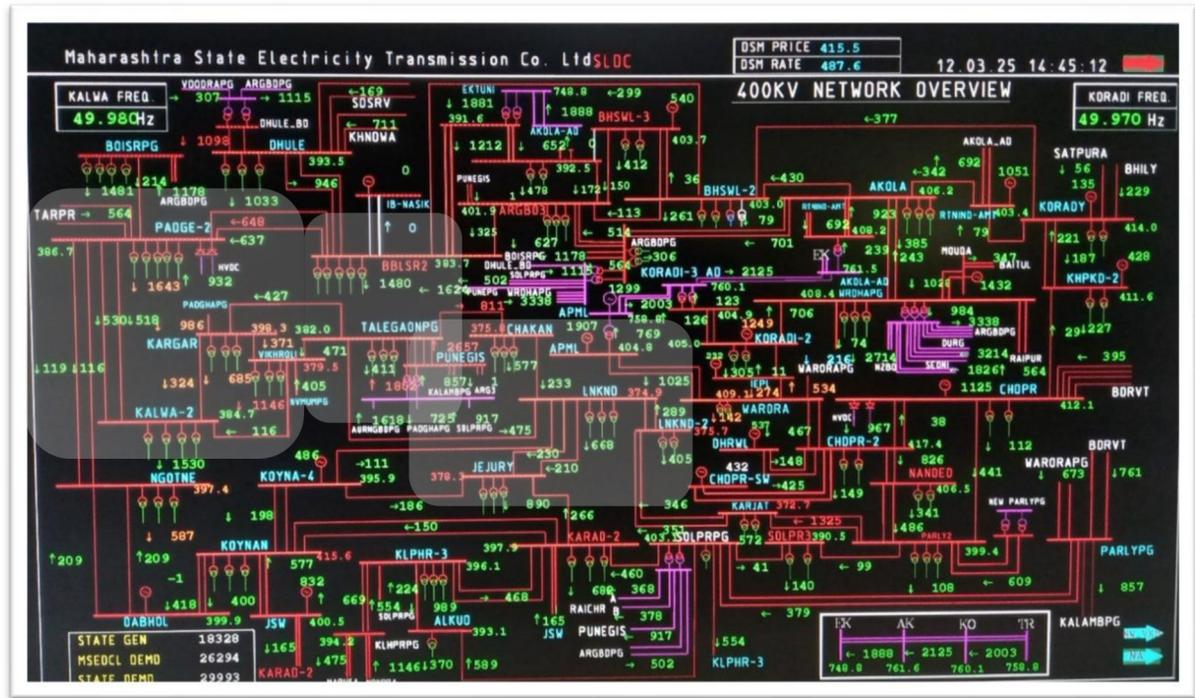


Figure 4: 400 kV Network Overview (SCADA)

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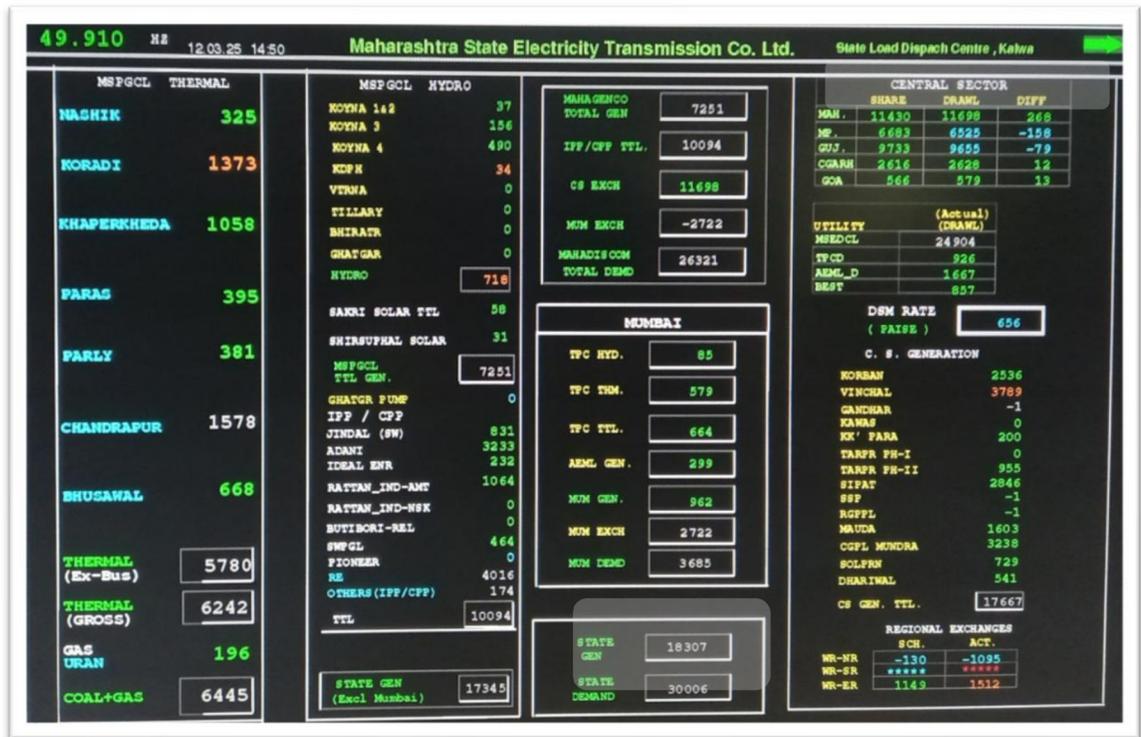


Figure 5: Resource Overview of the State (SCADA)

## 2.5.1 Generation & Transmission System Status

- During the event, total 2,851 MW generating capacity was not available. Out of this 2,851 MW capacity, 625 MW capacity is under long duration shutdown.

### 2.5.1.1 Generating units under outage during the event

Name of Unit	Capacity (MW)	Date Trip	Time Trip	Date Sync	Time Sync	Outage Type	Reason
Ghatghar Unit-2	125	26-05-24	13:17		Continued	FORCE D	Stator Earth Fault
Chandrapur Unit 9	500	11-01-25	18:55		Continued	FORCE D	Generator Protection operated
Uran Unit 7	108	04-03-25	14:15		Continued	FORCE D	Turbine bearing vibration high
Bhusawal Unit 6	660	05-03-25	0:04	15-03-25	6:14	FORCE D	PG TEST preparation
Uran Unit A0	120	10-03-25	3:09	16-03-25	5:27	FORCE D	Turbine Vibration
Uran Unit 5	108	11-03-25	20:00	12-03-25	15:49	ZEROSC H / RSD	Emergency Pick Up Given due to grid occurrence

## Maharashtra State Load Despatch Centre

RPL(AMT) U-4	270	11-03-25	21:00	13-03-25	21:13	FORCE D	Bottom Ash evacuation problem
Koradi Unit-10	660	12-03-25	13:21	12-03-25	20:48	FORCE D	Governing Valve Oil Leakage of Main Turbine.
JSW (J) U1	300	12-03-25	14:30		Continued	FORCED	Turbine Vibration
<b>Total Capacity</b>	<b>2851</b>						

Table 7: Generating units under outage during the event

### 2.5.1.2 Transmission system Outages or maintenance activities

Name of Line	IsTs / InsTs	Tripped Date	Tripped Time	Sync. Date	Sync. Time	Outage Type	Reason of Outage
<b>400 KV element Outages/Trippings</b>							
400/11.5 KV 110MVA STN T/F 6A @ DEEPNAGAR	InterState	08-03-2025	10:44			T	WINDING TEMP TRIPPED, MTR OPTD.
MAIN BAY (410) OF ICT-2 @ KUDUS	IntraState	12-03-2025	14:24	12-03-2025	17:12	PO	Annual Maintenance of bays equipment & Diagnostics Testing Work
CHANDRAPUR 2 - DHARIWAL CKT – 2	IntraState	12-03-2025	06:02	12-03-2025	17:08	PO	Line & its Bay Equipment PM & Testing work
DEEPNAGAR - THAPTI TANDA	IntraState	12-03-2025	07:16	12-03-2025	16:59	PO	To increase the ground clearance at span 202-203 and other maintenance work like disc replacement and nut-bolt tightening work
400KV 125MVAR BUS REACTOR @ CHANDRAPUR 2	InterState	12-03-2025	09:36	13-03-2025	00:16	PO	Diagnostic testing and allied bay maintenance work
BUS REACTOR (80 MVAR) - 1 @ TIRORA	IntraState	10-03-2025	09:38		Continued.	PO	Dia Equipment Maintenance
<b>220 KV element Outages/Trippings</b>							
PRINT HOUSE - NAVI MUMBAI (PG)	InterState	05-12-2024	23:09			EO	1) For bunching at TL no 678/1 with 220kV Kalwa-Panchanand line to provide 2nd source to Panchanand & Taloja s/stn. 2) For opening

## Maharashtra State Load Despatch Centre

							jumpers at TL no 678/1.
220KV YAWATMAL- WARDHA(DEOLI) PG CKT 1	InterState	12-03- 2025	14:31	12-03- 2025	18:49	EO	For attending Hot glow on Line Isolator Rph Pad towards CB (Temp - 180°C) Nut Bolt
220 kV-Wardha(PG)- Yawatmal Ckt-1	InterState	12-03- 2025	14:31	12-03- 2025	18:49	EO	Attending Hot glow on line isolator R-ph pad towards CB temp-180 deg nut bolt.
PUSAD - WARDHA (PG)	IntraState	08-03- 2025	20:26		Conti nued.	PO	1)Shifting of Line on ERS for Erection & Conductor Stringing of Inline Towers under ORC work for the work of Diversion of 220kV Deoli - Pusad Line at Loc. No. 181-182 by considering Monopole Tower for Wardha - Yavatmal - Nanded Railway Line Crossing. 2) ORC WORK - Diversion of 220KV Deoli PG-Pusad line at loc 250-251 due to four lanning of NH-361 (Butibori-Tuljapur)- shifting of line on ERS thereof. 3)ORC WORK -Diversion of 220KV Deoli PG-Pusad line at loc 250-251 due to four lanning of NH-361 (Butibori-Tuljapur)- shifting of line from ERS to newly erected tower thereof.
PUSAD-GHATODI	IntraState	10-03- 2025	19:47			HT	IN VIEW OF OUTAGE ON PUSAD-WARDHA PG-CKT.

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KHAPARKHEDA-BUTIBORI	IntraState	12-03-2025	09:38	12-03-2025	16:25	PO	Replacement of Y-ph CT due to ageing and CB timing
GOREGAON - VERSOVA CKT – 1	IntraState	12-03-2025	09:45	12-03-2025	17:13	PO	Annual Maintenance of Circuit Breaker
220KV KURUNDA - GIRWALI CKT	IntraState	12-03-2025	12:01	12-03-2025	13:31	EO	Attend Hotspot at R-ph CT P1 side.
THEUR-PHURSUNGI CKT II	IntraState	12-03-2025	12:29	12-03-2025	18:57	EO	Replacement of flashover SSN string Rph at loc. no. 37 and chemical washing of disc insulator
LAMBOTI - TULJAPUR CKT – 2	IntraState	12-03-2025	12:49	12-03-2025	20:35	PO	Outage is required for Replacement of string at Loc. No. 28, 41, & cold washing of Insulator String.
MALINAGAR - TEMBHURNI	IntraState	12-03-2025	12:53	12-03-2025	19:50	PO	Outage is required for Quarterly Maintenance
PEDHAMBE ONI LINE	IntraState	12-03-2025	13:02	12-03-2025	18:42	PO	For replacement of damaged rusted jump nut bolt at loc no- 202, 223, 227.
OSMANABAD – BARSHI	IntraState	12-03-2025	14:38	12-03-2025	17:37	PO	Outage is required for Quarterly Maintenance
220/132 KV 80 MVA ICT 1 @ HINGANGHAT	IntraState	19-02-2025	12:45			HT	H/T Due to end of expected life of paper insulation of ICT
220/33 KV, 50MVA, PTR NO 2 @ ALEPHATA	IntraState	10-03-2025	11:02	13-03-2025	19:57	PO	ABB make HV CB pole overhauling work & HV CB testing by agency
220/132KV 200MVA ICT 4 @ EKLAHARE (OCR)	IntraState	12-03-2025	08:23	12-03-2025	23:16	PO	Shifting of LA & CT of ICT 4 LV side from RCC structure to Lattice structure
220/132 KV 200 MVA ICT 1@ BALE(SOLAPUR)	IntraState	12-03-2025	08:51	12-03-2025	15:55	PO	Outage is required for Tandelta Testing of Bushing & Winding & SFRA Test By MTU, Pune
220/132 KV 100MVA ICT - 1 @ MANMAD	IntraState	12-03-2025	14:07	12-03-2025	17:25	PO	SFRA & DFR measurement &

# Maharashtra State Load Despatch Centre

							Quarterly Bay maintenance work.
132 KV element Outages/Trippings							
132 KV PATHRI-MAJALGAON CKT	IntraState	06-01-2025	13:05			HT	After completion of outage on 132kv patri parbhani ckt
HT : Hand Tripping, T : Tripping, PO : Planned Outage, EO : Emergency Outage							

Table 8: Transmission system Outages or maintenance activities

Note: Elements in the affected area are highlighted.

### 2.5.1.3 Reactor and capacitor positions Pune, Nashik, MMR: Bus reactor position in the State at 14:30 Hrs before the event

Sr. No.	Voltage level	Name of substation	Reactor in Service (In MVAR)	Reactor out of Service (In MVAR)
1	765kV	Akola 2	--	240
2	765kV	Ektuni	--	240
3	765kV	Koradi 3	--	240
4	765kV	Tiroda	--	240
5	400kV	Akola	--	125
6	400kV	Alkud	--	125
7	400kV	Babhaleshwar	--	205
8	400kV	Khadka	--	50
9	400kV	Chandrapur 2	--	125
10	400kV	Deepnagar	--	125
11	400kV	Dhule	--	125
12	400kV	Jaigad	--	100
13	400kV	Karjat	--	125
14	400kV	Karad	--	205
15	400kV	Kalwa	--	125
16	400kV	Khaperkheda	--	125
17	400kV	Kharghar	--	80
18	400kV	Koradi	--	50
19	400kV	Koradi 2	--	125
20	400kV	Lonikand 1	--	50
21	400kV	Lonikand 2	--	125
22	400kV	Nagothane	--	80
23	400kV	Nandgaonpeth	--	80
24	400kV	Nanded	--	125
25	400kV	Padghe	--	80
26	400kV	Parli-M	--	50
27	400kV	Solapur-M	--	125
28	400kV	Tiroda	--	160
29	400kV	Vikhroli	--	125

# Maharashtra State Load Despatch Centre

30	400kV	Warora	125	
31	400kV	Kolhapur	--	125
32	400kV	Dhule	--	80
33	400kV	Kolhapur	--	80
34	220kV	Karanjade	--	80
35	110kV	Karanjade	--	20
36	220kV	Salsette	--	125
37	220kV	Gorai	--	120
<b>Total MVAR</b>			<b>125</b>	<b>4405</b>

Table 9: Bus reactor position in the State at 14:30 Hrs before the event

### Capacitor position at 14:30 hrs before the event

Utility	Total Capacitor bank (in MVAR)	Capacitor bank in service (in MVAR)	Capacitor bank out of service (in MVAR)
AEML	588.13	318.96	269.17
TPCL	503	289	214
Nashik Zone	1845.5	1316.1	529.4
Pune Zone	799.98	684.98	115
Karad Zone	353.18	238.18	115
Vashi Zone	25	25	0
<b>Total</b>	<b>4114.79</b>	<b>2872.22</b>	<b>1242.57</b>

Table 10: Capacitor position at 14:30 hrs before the event

### 2.5.1.4 List of elements not available

220kV Nashik (OCR) – Padghe & 220kV Nashik (GCR) – Airoli Knowledge Park were hand-tripped for load management in Nashik corridor.

Name of Line	Inter State / Intra State	Tripped Date	Tripped Time	Sync. Date	Sync. Time	Outage Type	Reason of Outage
400 KV element not available							
50 MVAR LINE REACTOR OF 400KV KUMBHARGAON(NANDED) CKT 1 AT 400KV PARLI	Intra State	05-03-2025	20:45			HT	Due to Voltage constraint LR kept out at Parly ss.
AURANGABAD(MS) - PUNE (GIS) CKT – 1	Intra State	03-03-2025	10:00	12-03-2025	15:15	HT	For load management
AURANGABAD(MS) - PUNE (GIS) CKT – 2	Intra State	10-03-2025	06:46	12-03-2025	15:15	HT	H/T AT WALUJ END ONLY.
220 KV element not available							
BUS COUPLER @ PHURSUNGI	Intra State	11-03-2025	07:36	14-03-2025	21:04	HT	Load management

## Maharashtra State Load Despatch Centre

220KV BUS SECTION BAY @ PEDAMBE	IntraState	03-04-2024	15:55			T	Tripped due to Y ph CT burst
WAGHIVALI (MSETCL) - ULWE GIS CKT - 2	IntraState	25-06-2024	08:05			T	Tripped on differential protection.
220KV KORADI II(400KV) - BUTIBORI 3 CKT II	IntraState	01-10-2024	13:11			HT	H/T From Koradi 2 end
KALWA - PANCHANAND	IntraState	17-10-2024	12:10			EO	For providing bunching at Loc. No. 691 by fixing T clamps & jumper connections to provide 2nd source to 220kV Taloja.
WAGHIVALI (MSETCL) - WAGHIVALI (TATA) CKT - 1	IntraState	30-12-2024	10:44			HT	Hand tripped only at Waghivali (TATA ) End only For load management on 220kV Ulwe - Waghivali ckt -1
WAGHIVALI (MSETCL) - WAGHIVALI (TATA) CKT - 2	IntraState	30-12-2024	10:44			HT	Hand tripped only at Waghivali (TATA ) End only For load management on 220kV Ulwe - Waghivali ckt -1
TROMBAY - DHARAVI 9	IntraState	19-01-2025	18:38			EO	Attending hotspot on BS-3
SAKI (AEML) - SAKI (TATA) CKT - 2	IntraState	21-01-2025	15:26			HT	Fire Caught near Marve Bridge
SAKI (AEML) - SAKI (TATA) CKT - 1	IntraState	21-01-2025	15:26			HT	fire caught near Marve bridge
EKLAHARE (OCR) - PADGHE	IntraState	11-02-2025	18:35		Continued	HT	H/T for load management.
EKLAHARE (OCR) - NAVASARI CKT - 2	IntraState	06-03-2025	19:27	12-03-2025	11:18	HT	H/T for load management.
MALEGAON-SATANA	IntraState	12-03-2025	01:18	12-03-2025	18:30	HT	Load management
ALEPHATA-PARGAON(KATHAPUR)	IntraState	12-03-2025	07:29	12-03-2025	22:34	HT	Load management
DAHANU - VIRAJ	IntraState	12-03-2025	09:55	12-03-2025	19:34	HT	MVAR Management
EKLAHARE (GCR) - AIROLI KNOW PARK	IntraState	12-03-2025	10:57	13-03-2025	01:03	HT	Load management

# Maharashtra State Load Despatch Centre

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220/22KV 50MVA PTR 3 @ BHOSARI 2	IntraState	24-07-2024	23:02			T	Tripped due to caught fire.
220/132 KV 150 MVA PTR NO 7 @ CHINCHWAD	IntraState	11-11-2024	03:05			T	Bucholz Protection
220/132 KV 80 MVA ICT 1 @ HINGANGHAT	IntraState	19-02-2025	12:45			HT	H/T Due to end of expected life of paper insulation of ICT
132 KV element not available							
MANSAR-PENCH	InterState	12-02-2025	19:12			HT	System Constraints H/T at Pench End.
CHAKAN- CHINCHWAD-BAJAJ AUTO CHAKAN TAP	IntraState	16-10-2024	07:02			HT	For Load Management
NANDURBAR - RAILWAY TSS	IntraState	11-03-2025	17:00	12-03-2025	19:50	T	Distance protection
HT : Hand Tripping, T : Tripping, PO : Planned Outage, EO : Emergency Outage							

Table 11: List of elements not available

Note: Elements in the affected area are highlighted.

## 2.6 Weather Conditions

Weather conditions in the affected area were normal.

### 3.2.1.3. Details of LTS and UVLS schemes in the affected region

In the Maharashtra network, as a part of system security, Load trimming scheme (LTS) on some 400kV and 220 kV elements & Under voltage load shedding (UVLS) schemes at some of 400kV substations are designed & implemented to shed the load in view of overloading of ICTs / Lines & to prevent voltage collapse respectively.

#### 3.1 LTS & UVLS schemes provided in Padghe S/s

- Load Trimming Scheme (LTS) on 400/220/100kV ICTs at Padghe:
  - Stage 1 – 302 MW, with 1 sec time delay
  - Stage 2 – 447 MW, with 3 sec time delay
- Under voltage load shedding setting on 400/220/100kV ICTs at Padghe:
  - Stage 1- 370kV, with 5 sec time delay
  - Stage 2- 370kV, with 10 sec time delay
- Load Trimming Scheme (LTS) on 400 Padghe – Babhaleshwar ckt 1& 2 at Padghe:
  - Stage 1- 1300 Amp, with 1.3 sec time delay

At 400kV Padghe substation, the load connected for relief from LTS operation of 400/220 ICTs, 400kV Babhaleshwar -1 & 2 lines & UVLS is same, i.e. Stage-1 -302 MW, & Stage-2- 447 MW respectively.

#### 3.2 UVLS scheme provided in 400kV Babhaleshwar S/s

- 220kV Babhaleshwar – A'nagar ckt – 1 – 371 kV with 5 sec time delay (Targeted load relief quantum – 218 MW)
- 220kV Babhaleshwar – A'nagar ckt – 2 – 371 kV with 5 sec time delay (Targeted load relief quantum – 218 MW)

#### 3.3 UVLS scheme provided in 400kV Lonikand S/s

- Stage 1- 370kV, with 3 sec time delay
- Stage 2- 370kV, with 5 sec time delay
- Targeted load relief quantum – 242 MW

#### 3.4 UVLS scheme provided in 400kV Jejuri S/s

- Stage 1- 370kV, with 5 sec time delay (Targeted load relief quantum – 125 MW)

#### 3.5 LTS scheme provided in 220kV Nashik (GCR) S/s

- On 220kV Nashik (GCR) – Babhaleshwar ckt 1 & 2:
  - LTS setting – PSM - 70 % (840 A) with 1.3 sec time delay
  - Targeted load relief quantum – 140 MW
- On 220/132kV ICT 1,2 & 6:
  - LTS setting – 110% (576 A) with 1.3 sec time delay
  - Targeted load relief quantum – 179.06 MW

## Maharashtra State Load Despatch Centre

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### 3.2.1.4. Sequence of Events (SoE)

As per flash report conveyed by WRLDC, on 12.03.2025 at 14:50, the 400 kV Degham-Jhanor D/C line tripped from the Jhanor end, while the 400 kV Jhanor - GPEC line also tripped due to an RYB fault. This further led to a generation loss at KAPS-3&4, KAPS-1&2, TAPS-3&4, and Ukai (T) in Gujarat State.

Hence, on 12.03.2025 at 14:50 hrs, Maharashtra grid experienced severe low voltages at multiple 400 kV locations.

Sr. No.	Name of substation	Before disturbance Voltage (kV) at 14:45 hrs *	After disturbance Voltage (kV) at 14:55 hrs *
1	400 kV Babhaleshwar	383.7	377.8
2	400 kV Padghe	386.7	<b>355.0</b>
3	400kV Kalwa	384.7	<b>353.4</b>
4	400kV Nagothane	388.7	<b>361.7</b>
5	400kV Kharghar	384.0	<b>361.0</b>
6	400kV Vikhroli	379.5	<b>349.8</b>
7	400kV Lonikand I	<b>374.9</b>	<b>361.7</b>
8	400 kV Lonikand II	<b>375.7</b>	<b>363.2</b>
9	400 kV Chakan	<b>375.8</b>	<b>360.9</b>
10	400 kV Jejuri	378.3	<b>368.0</b>
11	400 kV Talegaon (PG)	382.0	<b>364.0</b>
12	400 kV Kudus	387.0	<b>361.0</b>

Table 12: low voltages at multiple 400 kV locations

# Maharashtra State Load Despatch Centre

## 4.1 Sequence of Auto Defense Mechanism operation in Maharashtra

### 4.1.1 Sequence of Auto Defense Mechanism in Maharashtra

<i>Date</i>	<i>Time</i>	<i>Substation</i>	<i>Auto Defense mechanism operated</i>	<i>Remarks</i>	<i>Quantum Load Relief Obtained</i>
12-03-2025	14:50:59	220 kV Nashik GCR	Overcurrent LTS on 220 kV Nashik GCR - Babhleshwar-1& 2 lines Operated	Current above 840 A per circuit	179.06 MW
	14:51:07	400 kV Babhleshwar	Undervoltage LTS Stage-1 Operated	Voltage below 371 kV	436 MW
	14:51:18	400 kV PADGHE	Undervoltage LTS Stage-1 Operated	Voltage below 370 kV	547.89 MW
	14:51:23	400 kV PADGHE	Undervoltage LTS Stage-2 Operated	Voltage below 370 kV	
	14:51 *	400 kV PADGHE	Overcurrent LTS on 400kV Babhleshwar-1& 2 lines Operated	Current above 1300 A per circuit	
	14:51 *	400 kV Lonikand-1	Undervoltage LTS Stage-1&2 Operated	Voltage below 370 kV	242 MW
	14:51 *	400 kV Jejuri	Undervoltage LTS Stage-1 Operated	Voltage below 370 kV	74.64 MW
	14:51 *	220 kV Nashik GCR	Overcurrent LTS on 220/132kV ICT-1, 2 & 6 Operated	LTS Setting 110% (576A), 1.3Sec	34 MW
<b>TOTAL Auto Defense mechanism Load quantum Relief</b>					<b>1513.59 MW</b>

Table 13: Sequence of Auto Defense Mechanism in Maharashtra

\* Relay Time not synchronized with GPS; the sequence is as reported by SE PAC circles.

# Maharashtra State Load Despatch Centre

DR 220 kV Nashik GCR – Babhleshwar ckt 1&2 – Overcurrent LTS

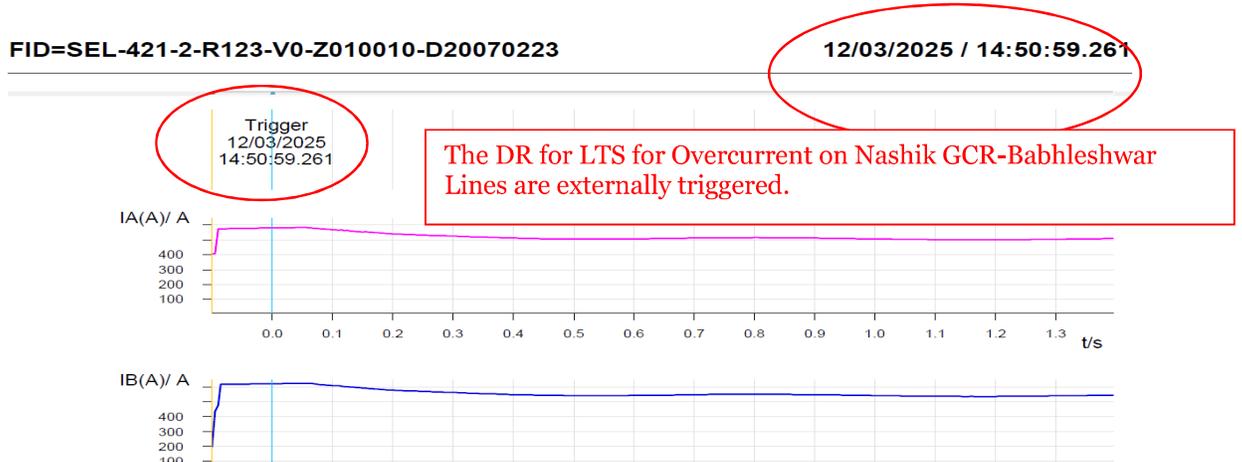


Figure 6: DR 220 kV Nashik GCR – Babhleshwar ckt 1&2 – Overcurrent LTS

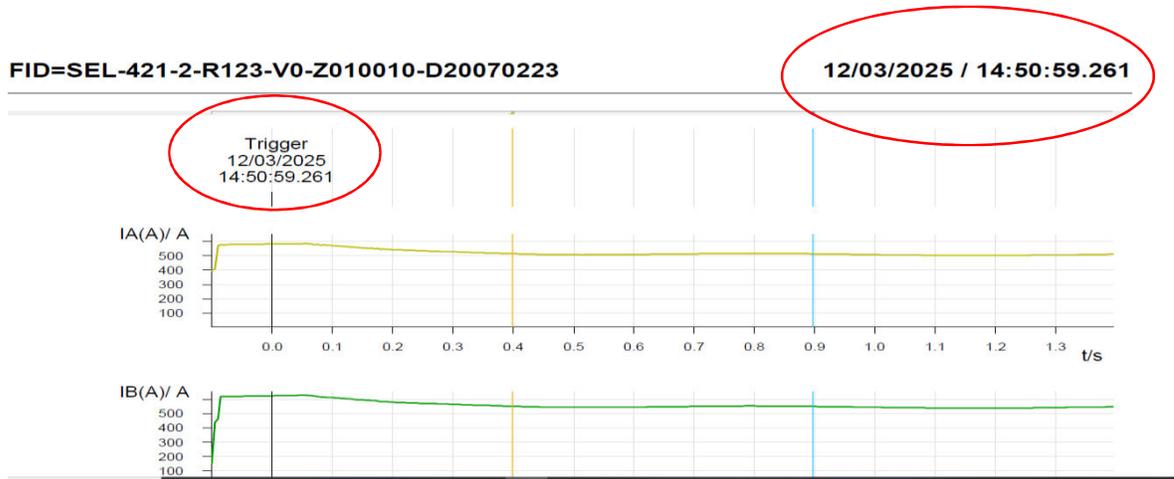


Figure 7: DR 220 kV Nashik GCR – Babhleshwar ckt 1&2 – Overcurrent LTS

# Maharashtra State Load Despatch Centre

DR 400 kV Babhleshwar – Under Voltage Stage-1 LTS

The DR depicts low voltages at Babhleshwar



Figure 8: DR 400 kV Babhleshwar – Under Voltage Stage-1 LTS

The second operation of UVLS DR depicts low voltages at Babhleshwar

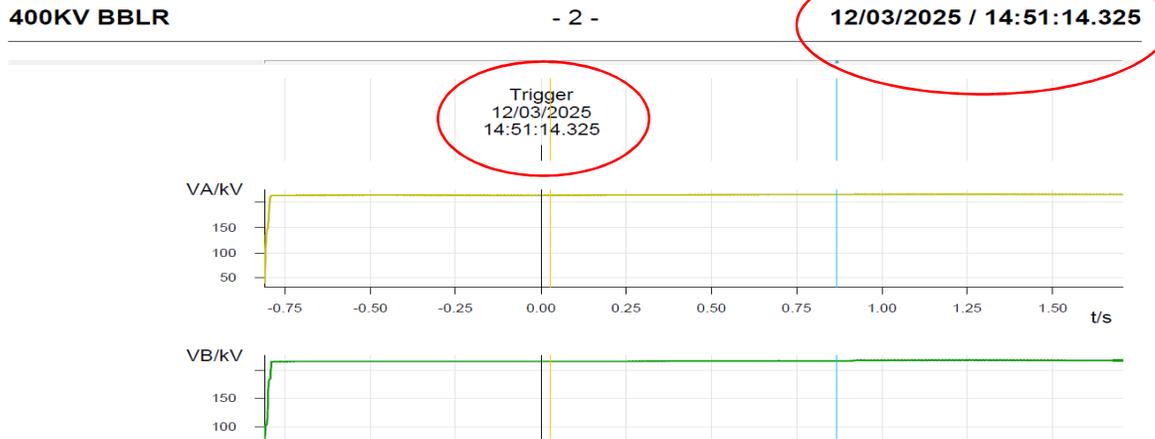


Figure 9: The second operation of UVLS DR depicts low voltages at Babhleshwar

# Maharashtra State Load Despatch Centre

DR 400 kV Padghe – Under Voltage Stage-1 LTS

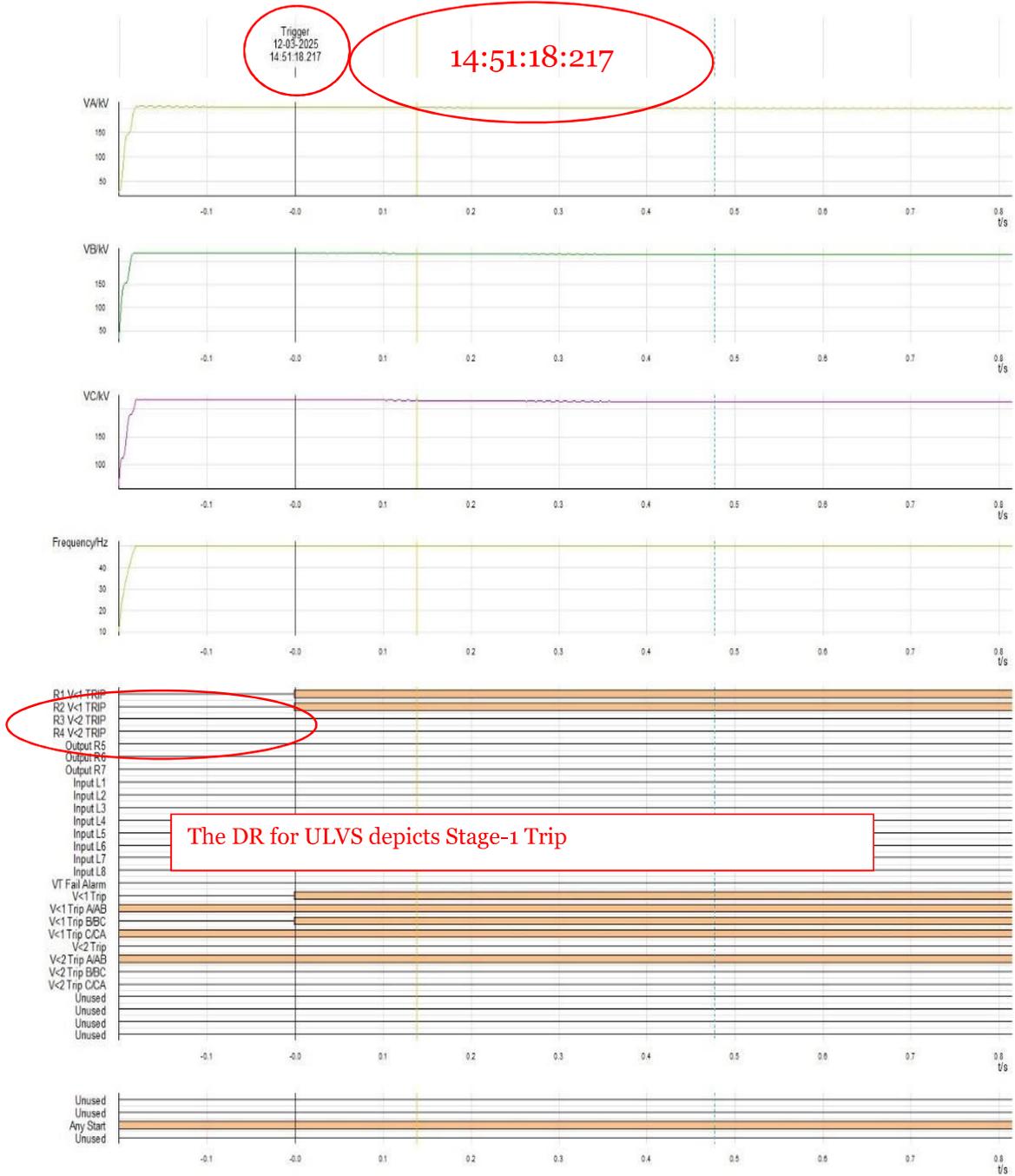


Figure 10: DR 400 kV Padghe – Under Voltage Stage-1 LTS

# Maharashtra State Load Despatch Centre

## DR 400 kV Padghe – Under Voltage Stage-2 LTS

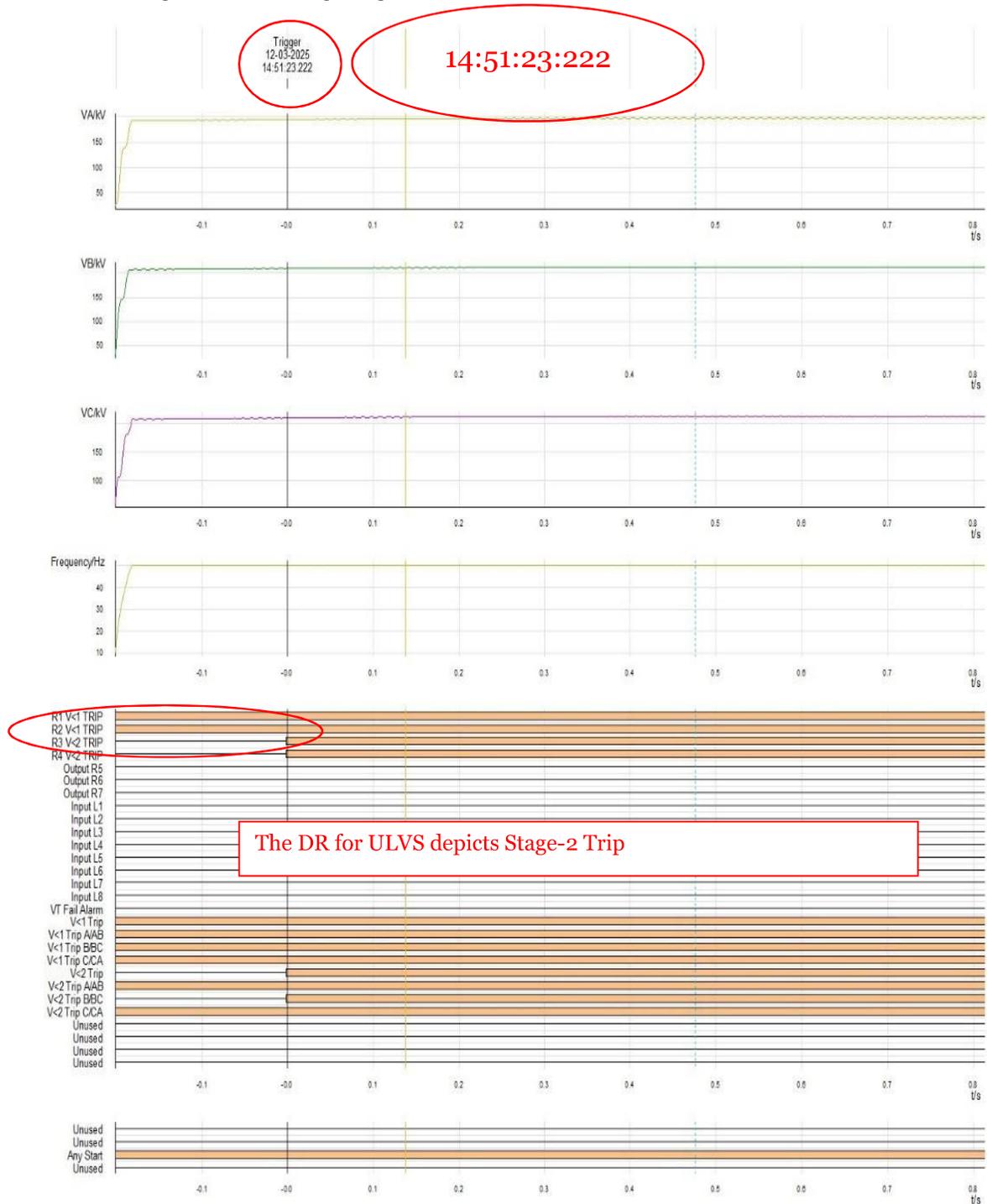


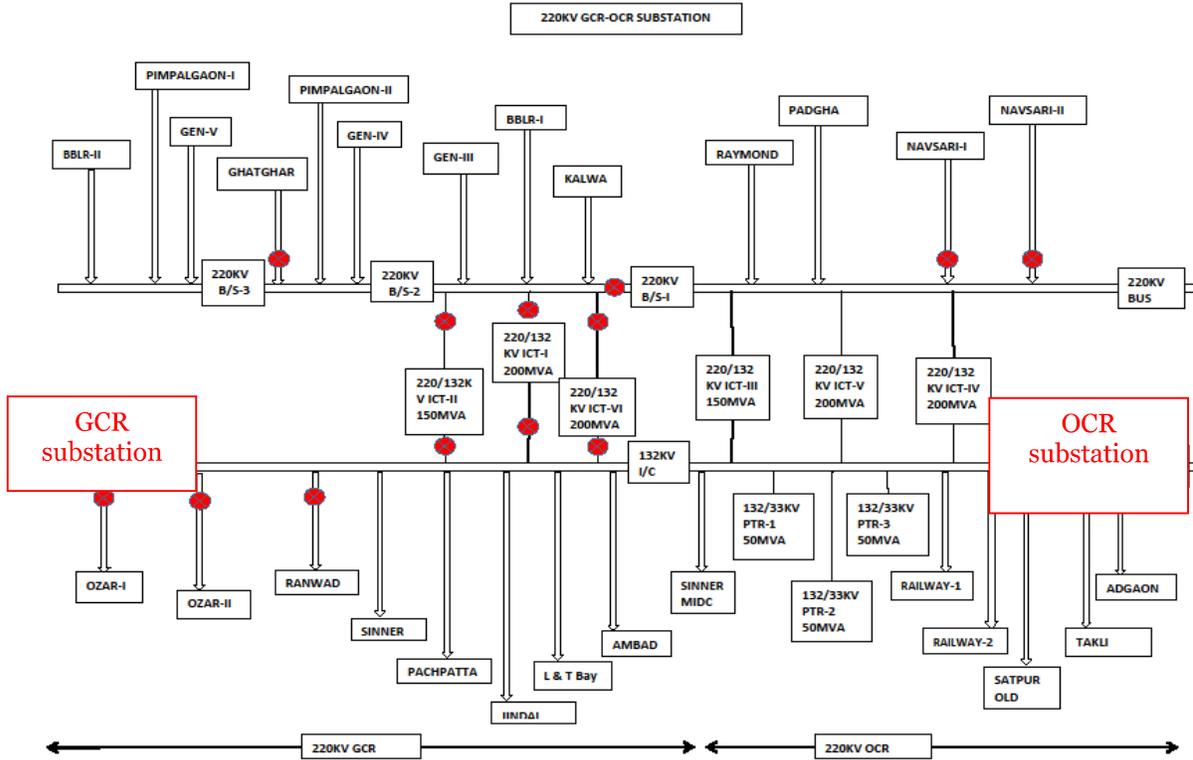
Figure 11: DR 400 kV Padghe – Under Voltage Stage-2 LTS

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## 4.1.2 Disturbance observed in Nashik Region

On 12.03.2025 at 14:51hrs, sudden drop in grid voltage observed under Nashik & Ahilya Nagar region (reported, 370 kV & 180 kV against 400 kV & 220 kV resp.).

### 4.1.2.1 Nashik GCR and OCR substation



At 14:50:59, LTS operated on 220 kV BBLR-1, 2 lines at GCR SS. On LTS 132 kV Ozar-1&2, Ranwad and 33kV load at 220 kV OCR, 132kV R'pimplas, Sinnar Old & Adgaon SS were cutoff.

PSB detection was recorded on Distance relay of Navsari 2 & Reliance LS (earlier Navsari-1) at 14:51:44Hrs at OCR SS.

#### Sequence of Events at 220 kV Nashik (OCR):

Name of SS	Name of Feeder / ICT TRIPPED	Date & TRIP Time	Relay Indications	
		Dt. 12.03.2025	W.I.	R.I.
220 kV Nashik GCR	220KV Bus Section - 1	14:51:13 Hrs	B/Up OC/EF Optd.	ER Argus, IDMTL Phase A (IDMT)=0.80, Phase B (IDMT)=0.88, Phase C (IDMT)=0.84 EF=0
	200MVA 220/132kV ICT-1	14:51:15 Hrs	HV B/Up OC/EF Optd.	HV ER Argus, LS, IDMTL Phase A (FWD) (LS)=0.59, 58.9V, Phase B (FWD) (LS)=0.60, 59.8V,

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	200MVA 220/132kV ICT-2	14:51:15 Hrs	B/Up OC/EF Optd.	Phase C (FWD) (LS)=0.59, 58.9V, IE (Rev)= 0A, VN=1.1V (CTR-
				HV ER Argus, LS, IDMTL
	Phase A (FWD) (LS)=0.42, 58.8V, Phase B (FWD) (LS)=0.42, 59.7V, Phase C (FWD) (LS)=0.42, 59.5V, IE (Rev)= 0A, VN=1.1V			
	200MVA 220/132kV ICT-6	14:51:15 Hrs	B/Up OC/EF Optd.	HV ER Argus, LS, IDMTL
				Phase A (FWD) (LS)=0.59, 58.8V, Phase B (FWD) (LS)=0.61, 59.8V, Phase C (FWD) (LS)=0.59, 59.6V, IE = 0.01A, VN=1.2V
	220kV Ghatghar	14:51:16 Hrs	B/Up OC/EF Optd.	ER Argus, IDMTL
				Phase A (FWD) (IDMT)=1.00xIN, 61.9V, Phase B (FWD) (IDMT)=1.08, 60V, Phase C (FWD) (IDMT)=1.05, 61.3V IE (Rev)= 0.07A
220 kV Raymond	220kV Washala	14:55 Hrs	B/Up OC/EF Optd.	Siemens, I11-0.97kA, IL2-1.05kA, IL3-1.02kA, Dir OC Trip, Ip Dir Trip
<i>On 15:07 hrs, at Nashik GCR, 220 Bus Sectionalizer-1 was taken in service.</i>				
220 kV Nashik OCR	220kV Navsari-2	15:07 Hrs	B/Up OC/EF Optd.	Sifang CSC211 (CTR-800/1A)
				3.552 INV OC FWD OP, Ia-1.242A, Ib-1.383A, Ic-1.305A
	220kV Reliance LS (Navsari-1)	15:07 Hrs	B/Up OC/EF Optd.	Sifang CSC211 (CTR-800/1A)
				3.451 INV OC FWD OP, Ia-0.985A, Ib-1.11A, Ic-1.039A

Table 14 Sequence of Events at 220 kV Nashik (OCR):

#### 4.1.2.2 400/220 kV Babhaleshwar substation

At 400 kV BBLR SS at 14:51:07 Hrs, 400kV UVLS optd. & 220 kV A'nagar 1&2 lines tripped on UVLS. From DR 4 instances of undervoltage were recorded 14:51:07, 14:51:014, 14:56:01 and 14:59:15Hrs. Both Ahilya-Nagar lines tripped in the first instance. (Undervoltage LTS Settings: - Voltage – 371 kV, Time - 5 Sec.)

However, as the A'nagar Sub-station was also fed from 400/220 kV Karjat, overloading of Karjat A'nagar line occurred resulting into tripping of that line. This further created overloading of connected 220 kV and 132 kV network resulting into trippings as below.

At 220 kV Belwandi SS at 14:51 Hrs, 220 kV Bus section, 200MVA ICT-2 & 50MVA TF-2 tripped on over current.

At 132 kV Patherdi SS at 14:51 Hrs, 132 kV Khandke line tripped on overcurrent.

Due to above tripping, supply failed at 220 kV Sonewadi, 132 kV Kedgaon, MIDC A'nagar, Khandke, Shrigonda and Rashin SS.



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## Observations: -

Due to source supply failure from Babhleshwar substation, Total load of 220 kV Ahilyanagar ss, has shifted to 220 kV Lines emanating from Karjat substation.

Further, 220 kV Karjat-A'nagar and 220 kV Bus-section at Belwandi s/stn tripped on overcurrent.

Hence, many downstream substations went into dark.

- A) UVLS & LTS at Babhleshwar needs to be reviewed in view of connection with Karjat substation. Instead of network opening, the LTS & UVLS schemes should disconnect required quantum of loads.
- B) 220 kV Karjat-A'nagar & 220 kV Karjat-Belwandi line overcurrent LTS is required.
- C) Back-up Overcurrent Protection settings in this area needs to be reviewed.

<b>Abstract of affected substations under EHV O&amp;M DIV Babhleshwar</b>						
<b>Sr No.</b>	<b>Voltage</b>	<b>Name of Substation</b>	<b>STATUS</b>	<b>From</b>	<b>To</b>	<b>Load affected (LBT) in MW</b>
1	220 kV	Belwandi	DARK	14:50	16:35	72.35
2	220 kV	Sonewadi	DARK	14:51	16:50	24.92
3	132 kV	Karjat	DARK	14:50	15:40	49.29
4	132 kV	Kedgaon	DARK	14:51	16:01	67.65
5	132 kV	Khandke	DARK	14:51	15:10	98.6
6	132 kV	MIDC A'Nagar	DARK	14:51	16:08	88.14
7	132 kV	Rashin	DARK	14:52	15:40	16.74
8	132 kV	Shrigonda	DARK	14:50	16:35	56.65
9	132 kV	Supa	DARK	14:51	16:01	72.63
10	132 kV	Wadzire	DARK	14:51	15:59	29.21
<b>Total Load Affected</b>						<b>576.18</b>

Table 16: Abstract of affected substations under EHV O&M DIV Babhleshwar

### 4.1.2.3 Observations of disturbance seen in Nashik region

Before the occurrence, 220kV Navsari-2 & Reliance LS (earlier Navsari-1) lines were importing (86MW each ckt) from Navsari at OCR SS.

After tripping of ICTs & Bus section at GCR SS, NTPS generation (GT3-124MW, GT4-115MW, GT5-114MW) were evacuated through 220kV BBLR 1&2 lines.

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**NTPS generation was evacuated through 220kV BBLR 1&2 lines  
(POWER FLOW TOWARDS BABHLESHWAR)**

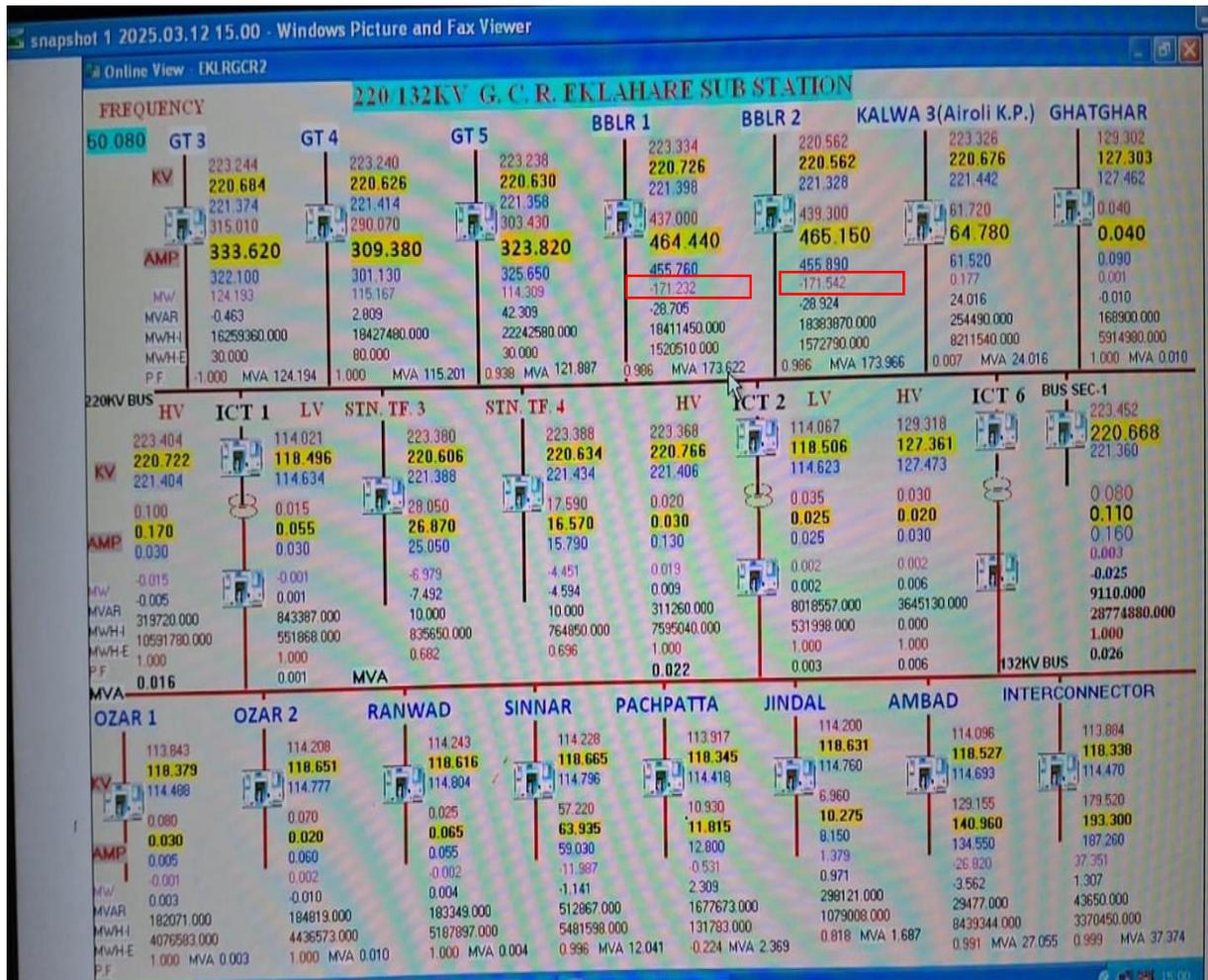


Figure 13: Snap shot of 220 kV OCR substation loadings

During restoration while charging 220kV Bus section-1 (15:07Hrs) at GCR SS, 220kV Navsari 2 & Reliance LS (earlier Navsari-1) ckt started drawing heavily from OCR (NTPS generation being in service) causing tripping of both ckt on overcurrent (1040A each ckt).

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## 4.2 SLDC Control Room Actions

### 4.2.1 Instruction by MSLDC to pick-up Hydro Generation of Maharashtra

Koyna Stage-IV Hydro generation (4 x 250 MW) was pickup up.

Around 14:30 hrs, low voltages (below 380 kV) were prevailing in Pune region. Till then, 2x250 MW units (Unit-2 and Unit-3) were under operation in generation mode, whereas 2x250 MW units (Unit-1 and Unit-4) were under operation in condenser mode.

Around 14:40 hrs, MSLDC instructed Koyna stage-IV Unit-4 (250 MW) to convert from condenser mode to generation mode, as per the requirement of Grid.

But, while converting from condenser mode to generation mode, Koyna stage-IV Unit-4 (250 MW) tripped at 14:45 hrs.

Around 14:47 hrs, MSLDC then instructed convert Koyna stage-IV Unit-1 (250 MW) from condenser mode to generation mode. Thus, around 14:50 hrs, Koyna stage-IV total generation pick-up from 500 MW to 750 MW.

<b>Time</b>	<b>Koyna Stage IV Generation as per SCADA (in MW)</b>
14:30	386.98
14:35	398.36
14:40	424.20
14:45	493.23
14:50	497.99
14:55	579.91
15:00	739.27
15:05	736.71
15:10	699.77
15:15	738.62
15:20	739.12
15:25	662.36
15:30	490.21

Table 17: Koyna Stage IV Generation as per SCADA (in MW)

At 15:25 hrs, Koyna stage-IV Unit-1 (250 MW) withdrawn due to downstream seal leakage observed. Generation decreased from 750 MW to 500 MW.

At 15:50 hrs, Koyna stage-IV Unit-4 (250 MW) was restored. Koyna stage-IV generation again increased from 500 MW to 750 MW.

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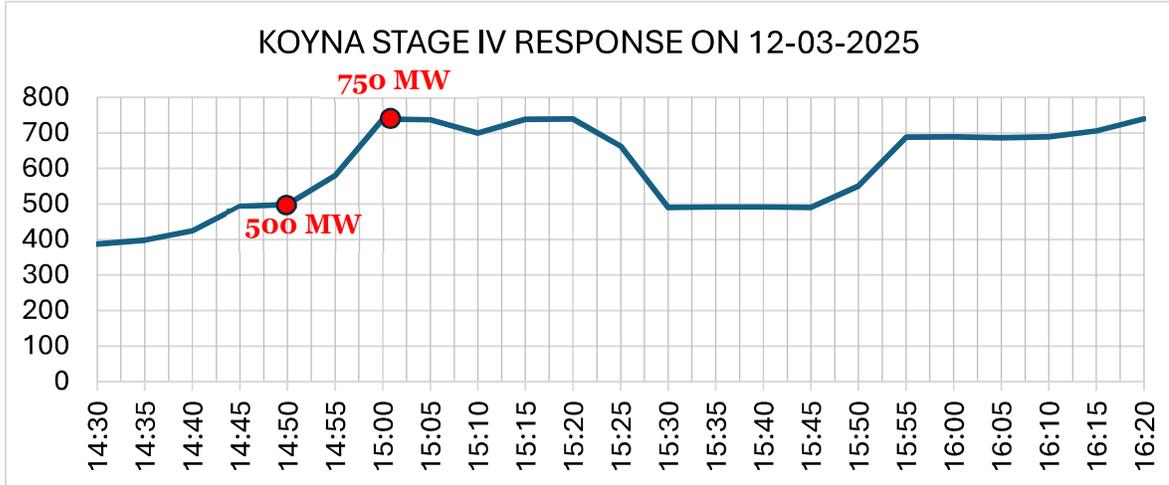


Figure 14: KOYNA STAGE IV RESPONSE ON 12-03-2025

MSLDC instructed TPCL to pick up Hydro generation (447 MW) to its maximum around 15:51 hrs

<i>Time</i>	<i>TPCL Hydro Generation as per PSCC SCADA (in MW)</i>
14:41:00	83
14:45:00	82
14:50:00	82
14:55:00	154
15:00:00	180
15:05:00	251
15:10:00	383
15:15:00	390

Table 18 TPCL Hydro Generation as per PSCC SCADA (in MW)

TPCL's Khopoli unit was not on bar as per requirement from TPC-D. It requires around 1 hour to pick up generation.

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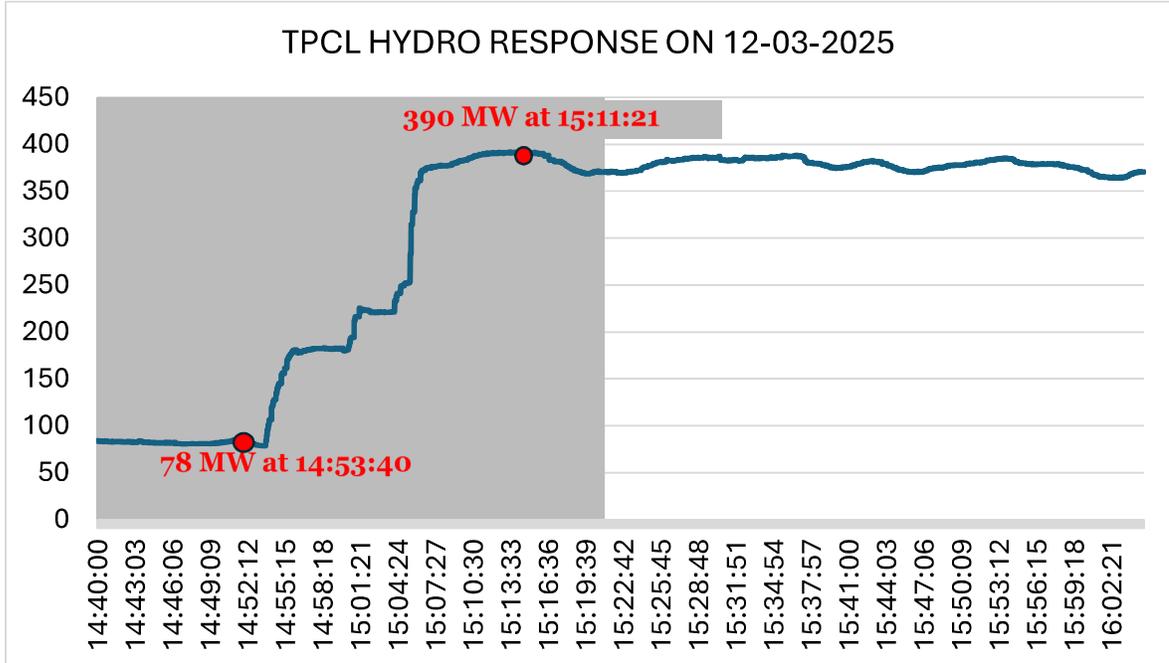


Figure 15: TPCL HYDRO RESPONSE ON 12-03-2025

Source : 1 sec SCADA Data from TPCL PSCC

Koyna Stage-I&II Hydro generation (600 MW) was instructed to immediately pickup to full capacity. But the response from Koyna Stage I&II was slow. Repeated instructed has resulted in generation rise from 40 MW (min) to 580 MW at 15:25 hrs.

Time	Koyna Stage I&II Generation as per SCADA (in MW)
14:30	37.6
14:35	37.4
14:40	37.4
14:45	37.4
14:50	37.4
14:55	37.4
15:00	37.4
15:05	37.4
15:10	38.9
15:15	39.7
15:20	185.8
15:25	569.1
15:30	569.4

Table 19: Koyna Stage I&II Generation as per SCADA (in MW)

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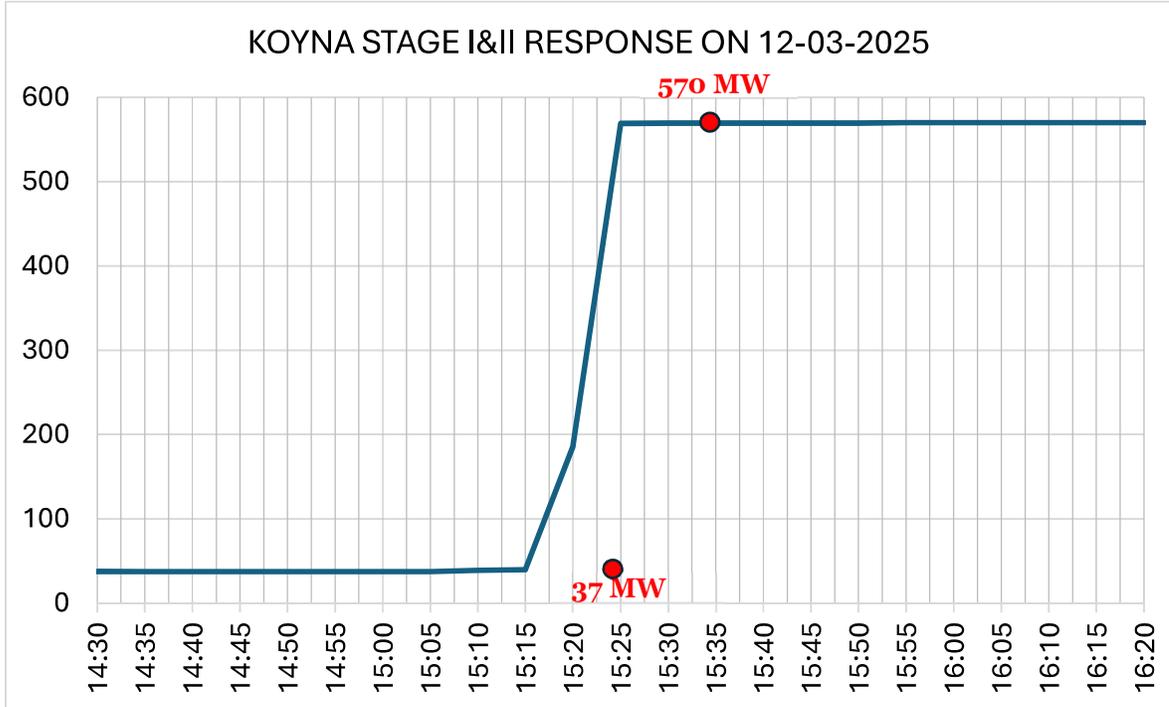


Figure 16: KOYNA STAGE I&II RESPONSE ON 12-03-2025

## 4.2.2 HVDC pickup instructions given by MSLDC

HVDC Bi-pole Power flowing from Chandrapur to Padghe was around 950 MW at 14:53:38 hrs, which was instructed for ramping to full capacity of 1500 MW, completed by 14:56:23 hrs.

PMU plot of HVDC total power seen at 400kV Padgha substation is shown below

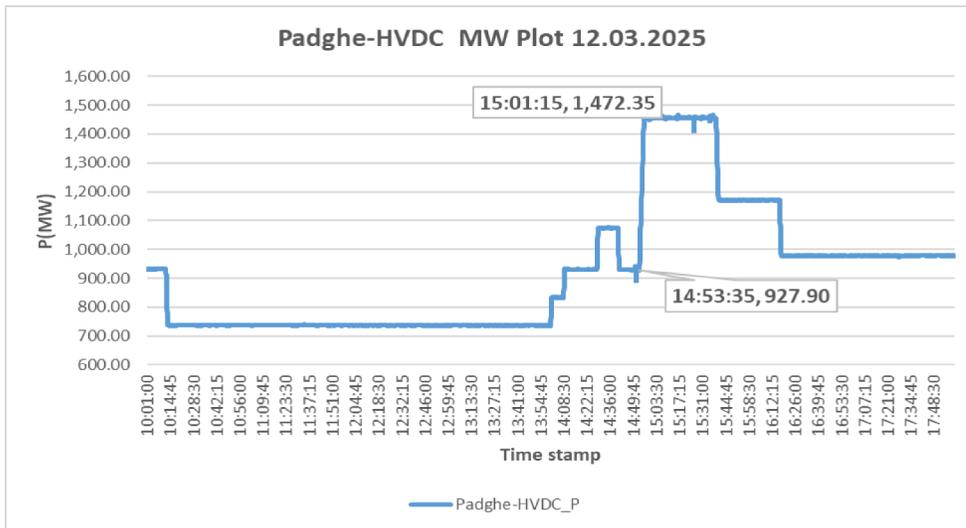


Figure 17: Padghe HVDC MW plot 12.03.2025

HVDC response recorded in event list Padghe terminal is shown below

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MSETCL ± 500KV HVDC TERMINAL STATION, PADGHA						 MAHATRANSCO Maharashtra State Electricity Transmission Co. Ltd.
Date : 12/03/2025 - 12/03/2025						
EVENTS HISTORY						
DATE	TIME	CH.	DESIGNATION	DESCRIPTION	STATUS	ALM. GROUP
12-03-2025	14:53:38.631	I-001-0211	S2.P1-AK-A41 (A42)	POWER RAMP	- INPROGRESS	NORMAL-EVENT
12-03-2025	14:53:40.344	I-001-0005	S2.P1-AK-A41 (A42)	CONTROL ORDER EXECUTED	- -	OPERATOR-LOG
12-03-2025	14:56:21.223	I-010-0081	S2.P1-WT-T1-L3	A&B BOTH POWER SUPPLY-XER COOLING	- NORMAL	CONV-XFMR
12-03-2025	14:56:23.414	I-001-0211	S2.P1-AK-A41 (A42)	POWER RAMP	- COMPLETED	NORMAL-EVENT

14:53:38.631 POWER RAMP INPROGRESS

12-03-2025 14:56:23.414 POWER RAMP COMPLETED

## 4.2.3 Manual Load Curtailment instructed by MSLDC

Sr. No.	Name of Substation	Load curtailment due to	District	Load affected (In MW)
1	400kV Padghe / 400kV Kalwa/ 220kV Boisar	DLS implementation	Thane/Raigad/Navi Mumbai	1061.34
2	400kV Nagothane	Emergency Handtripping of 220kV Nagothane – Wadkhal ckt 1 & 2 due to low voltage	Raigad	500
3	TPCL	DLS implementation	Kalyan	176
4	AEML	DLS implementation	Bhyander, Borivali, Mira road, Malad, Dahisar, Malvani, Charkop, Meghwadi & Juhu area	95
<b>Total Load shedding quantum</b>				<b>1832.34</b>

Table 20: Manual Load Curtailment instructed by MSLDC

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## 4.3 SCADA, PMU Plots & Snapshots

SCADA Snapshots at 14:55 Hrs i.e. after initiation of incidence:

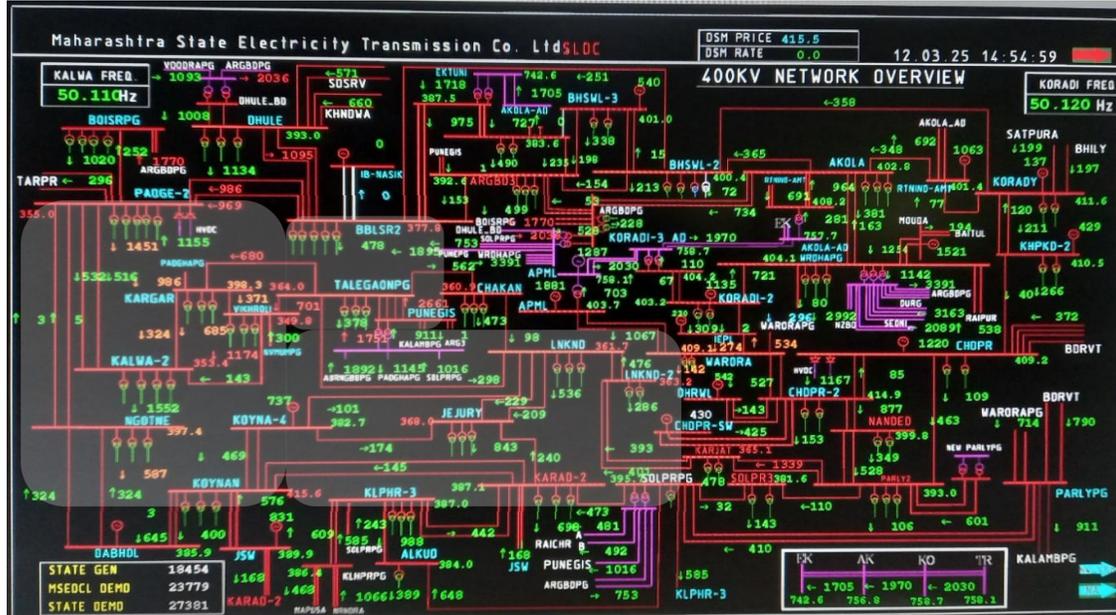


Figure 18: SCADA Snapshots at 14:55 Hrs i.e. after initiation of incidence:

400 kV Network Overview\_After Incidence (SCADA)

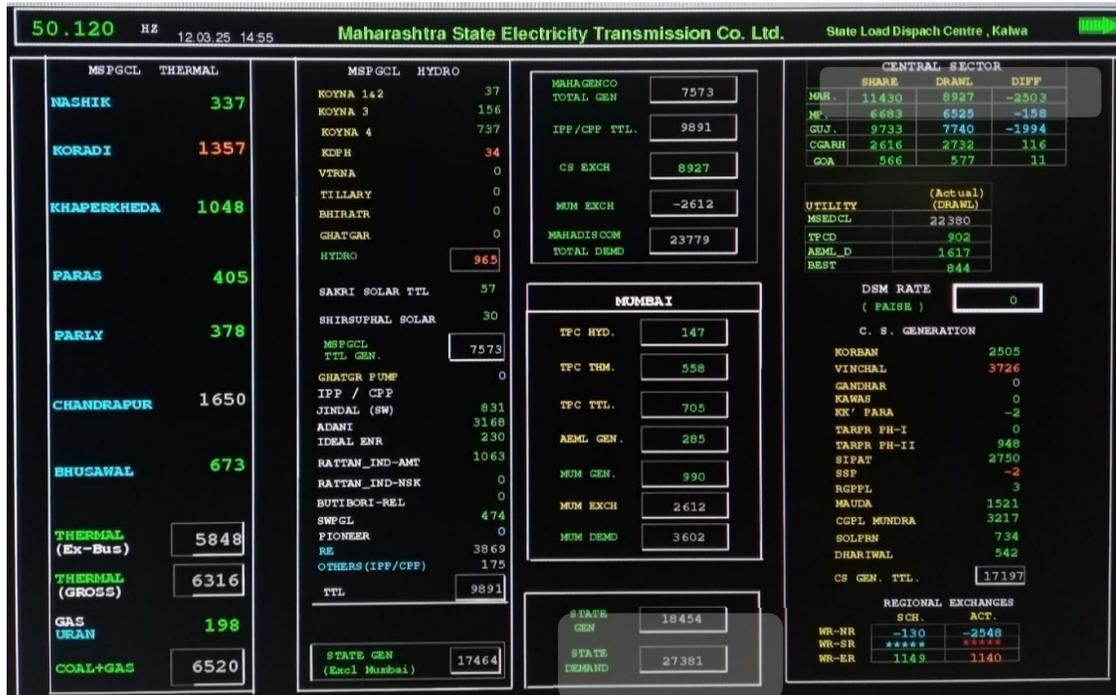


Figure 19: Resource Overview of the State\_After Incidence (SCADA)

SCADA Snapshots at 15:00 Hrs:

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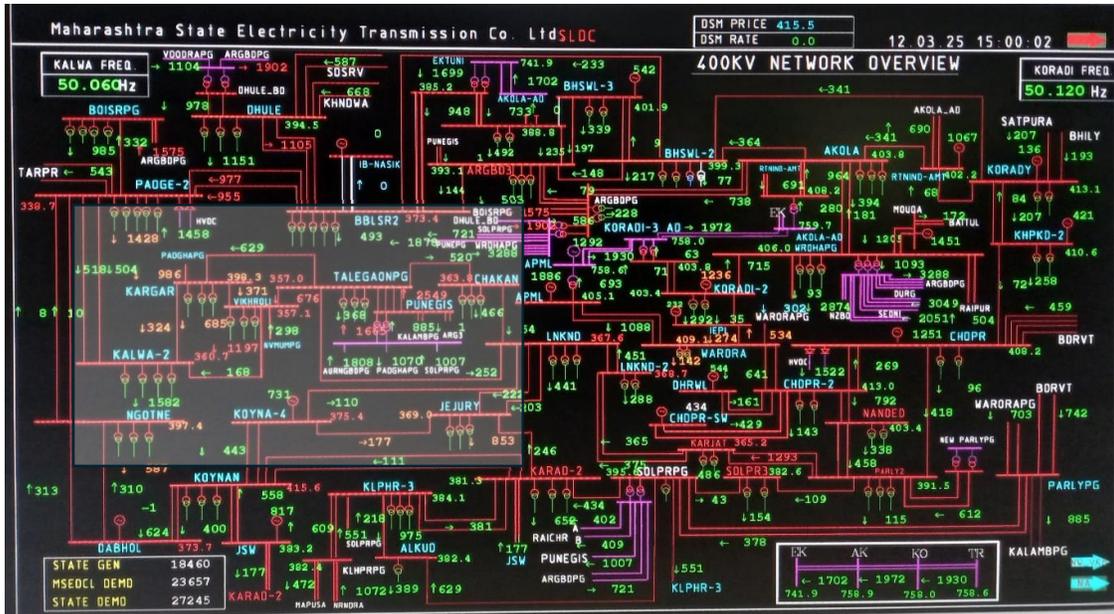


Figure 20: 400 kV Network Overview\_After Incidence (SCADA)



Figure 21: Resource Overview of the State\_After Incidence (SCADA)

# Maharashtra State Load Despatch Centre

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## 3.2.1.5. Root Cause Analysis

### 5.1 Primary Cause

As per the Preliminary Flash report of Trippings in South Gujarat prepared by WRLDC on 12.03.2025, the primary cause is as below:

- Following lines in Gujrat were already out:

Name of line	Reason of outage
400 kV Vapi- Sugen	Planned outage
400 kV Kosamba- Chara	Planned outage
400 kV Kosmba- Paccham	Forced outage
220 kV Kawas- Haldarwa 1	Emergency outage

Table 21: lines already out in Gujrat

- At 14:50 Hrs on 12-03-2025, 400 kV Degham - Jhanor D/C (Tripped from Jhanor end B-E fault & RYB fault respectively, lines remain in charged from Degham end) and 400 kV Jhanor - GPEC tripped (RYB fault as intimated by NTPC Jhanor).
- The trippings followed by generation loss at KAPS-3&4, KAPS-1&2, TAPS-3&4 and Ukai(T).
- There was total 2804 MW of generation loss in Gujrat/Maharashtra. The details are tabulated below:

Name of Generating Plant	Loss of Generation (MW)
KAPS 3&4 Unit 3 & 4	1264
Ukai(T) Unit-3, 4 & 6	610
SLPP	198
TAPS3&4 Unit 3 & 4	500
KAPS Stage 1&2 Unit-1	220

Table 22: Generation loss in Gujrat/Maharashtra

- Thereafter severe low voltages were observed in south Gujarat.
- Due to heavy rush of power flow from Maharashtra to south Gujarat, severe low voltages were also observed in western Maharashtra.
- Due to conductor snapping of 400 kV Aurangabad-Boisar-2 at 15:01 Hrs, severe low voltages observed in 400 kV and 220 kV of Boisar, Kala, Magarwada stations etc.
- The geographic area affected in Gujrat is shown below:

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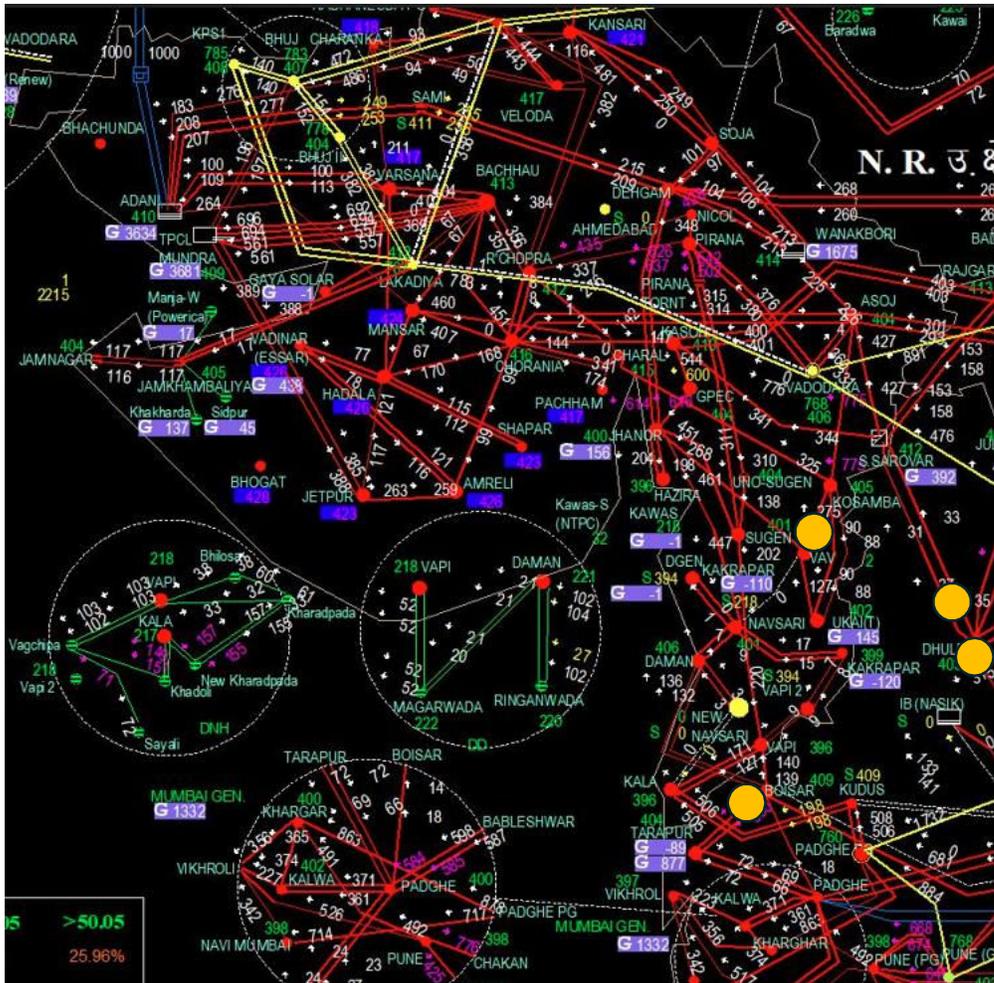
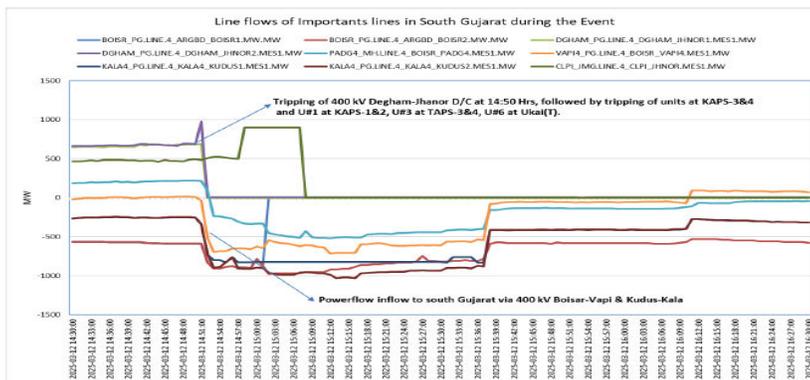


Figure 22: The geographic area affected in Gujrat



Indicates Affected Generation location on Gujrat Map (WRLDC)



(Source-WRLDC Report)

## 5.2 Contributing Factors

- Mumbai, MMR & Pune area in the State are highly urbanized areas having concentrated demand.
- The transmission network in this area is not adequate in comparison with the demand catered. Thus, some of the 400 kV & 220 kV lines are overloaded.
- Less synchronous Generating sources are available in these areas i.e. generation at Trombay, Uran & Dahanu.
- There is inadequate reactive compensation in these areas.
- Due to all above factors, the voltages in this area are on lower side during high demand period.
- Prior to the incidence, the voltages at 400 kV Padghe, 400 kV Kalwa, 400 kV Kharghar, 400 kV Lonikand 1, 400 kV Lonikand 2 were between 390 kV to 375 kV.
- As system voltages were already on lower side and heavy flow from 400 kV Padghe to Gujrat system through Tarapur & Boisar lines, voltages were drastically reduced.
- All above factors contributed in aggravating the poor system conditions.

## 5.3 Earlier observations of System Operators

- Under voltage issues were earlier also observed by system operator in Pune, Mumbai & MMR region & Various State grid alert reports also issued from time to time. Few of them are listed below:
  - Under voltage in Mumbai, Pune, Nashik region on 12.03.2025
  - Pune Region: Tripping of 400kV Talegaon (PG) – Lonikand 1 on 23.02.2025
  - Under voltages in Mumbai & Pune Region on 16.01.2025
  - Critical high loading of multiple transmission lines and ICTs resulting in N-1 non-compliance & low voltages at multiple 400kV nodes in Pune, Mumbai, MMR region on 17.04.2024
  - Pune Region Tripping of 400kV Talegaon (PG) – Lonikand & Chakan – Talegaon (PG) 12.03.2024
  - Under-voltages in Pune region on 20.02.2024
  - Load shedding incidences in Pune region due to severe low voltages in Grid during Apr – June 2023 issued on 20.09.2023

The prevailing and persistent under voltage scenario in this area pushes system into an alert operation state many time. SLDC had suggested for expediting the planned projects in this area; to relieve the 400 kV line overloading and under voltage issue. Particularly the schemes for evacuation of power from 400 kV Shikrapur needed an expedited completion. SLDC had also informed about the inadequate MVAR compensation available in this area causing the under voltage issue. The issue was also discussed at the state OCC. SLDC and STU have jointly conducted a study and identified locations where capacitive compensation is needed in this area. The shortfall indicated was to the tune of more than 2000 MVAR.

## 5.4 Analysis of the Incidence

### 5.4.1 Analysis at 400 kV Padghe S/s

#### 5.4.1.1 Frequency:

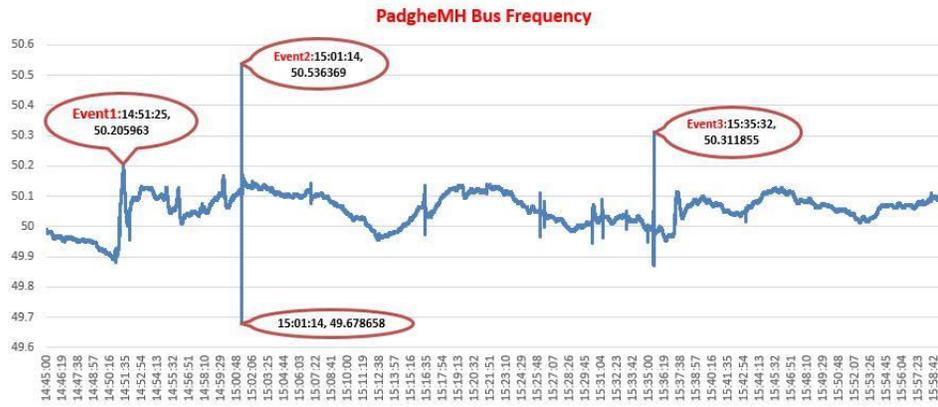


Figure 23: Frequency at 400 kV Padghe S/s. (PMU)

#### 5.4.1.2 Voltages:

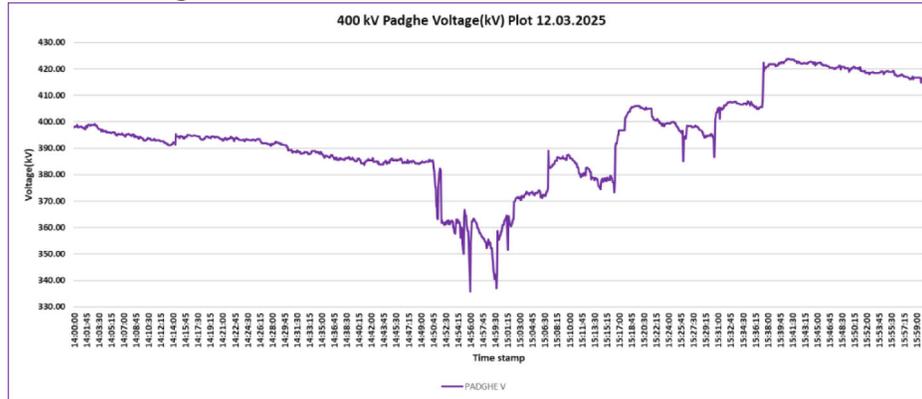


Figure 24: Voltage at 400 kV Padghe S/s. (SCADA)

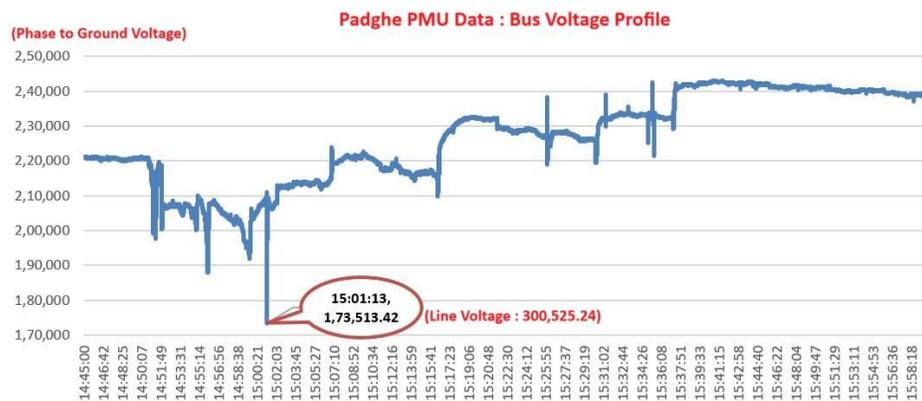


Figure 25: Voltage at 400 kV Padghe S/s. (PMU)

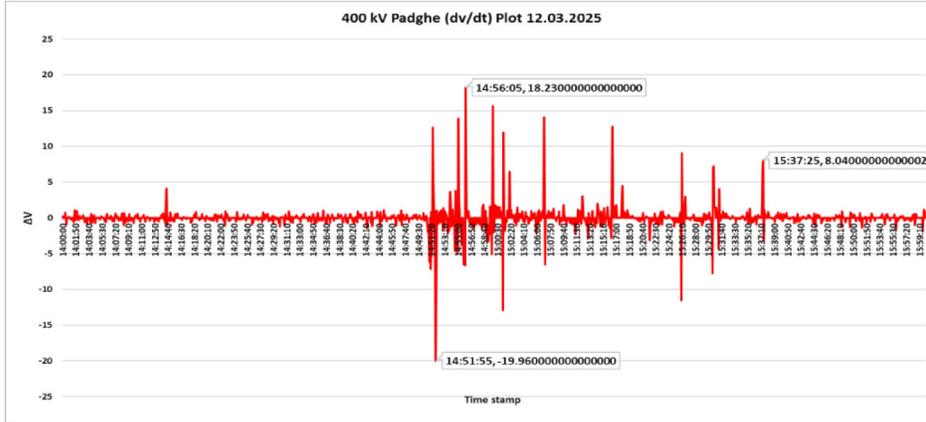


Figure 26: dv/dt plot at 400 kV Padghe S/s. (SCADA)

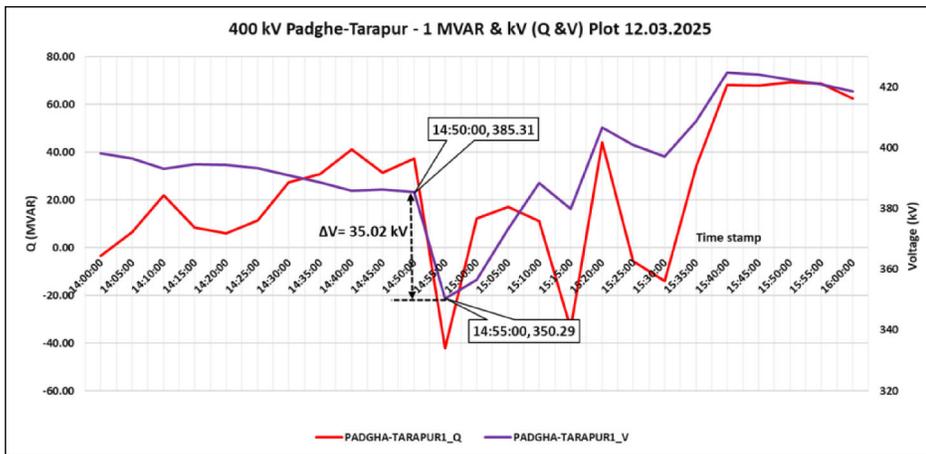


Figure 27: Reactive Power & Voltage plot of 400 kV Tarapur-Padghe-1 at Padghe end

From the above plots, it is observed that:

- Voltages at 400 kV Padghe S/s were already between the range of 400 to 390 kV.
- Voltage further reduced between 390-380 kV after 14:29 Hrs.
- During incidence, voltages further dipped to 338 kV at 14:56 Hrs from 385 kV at 14:49 Hrs.
- Thus, a drop of 35 kV was observed at 400 kV Padghe bus within a very short duration.

## 5.4.1.3 Sudden changes in Power flow on 400 kV lines connected to 400 kV Padghe

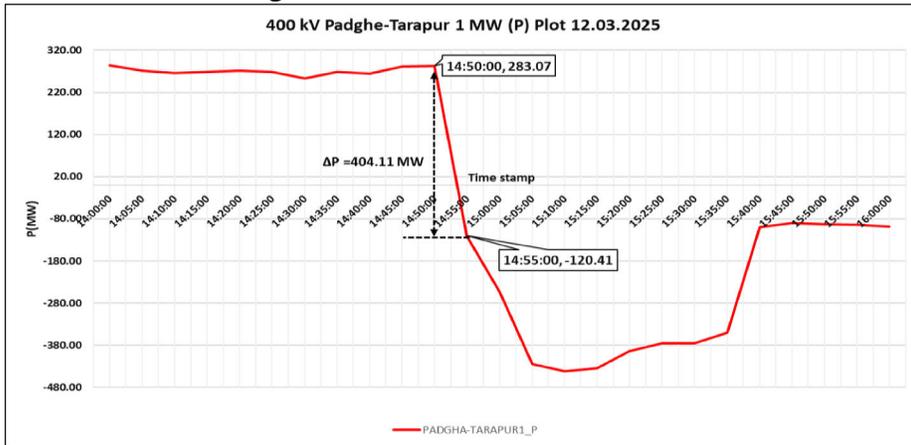


Figure 28: Active Power Flow on 400 kV Tarapur-Padghe-1 (SCADA)

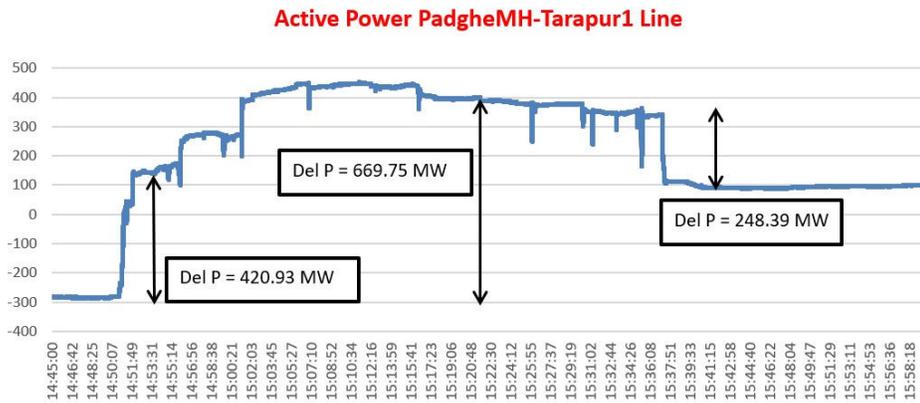


Figure 29: Active Power Flow on 400 kV Tarapur-Padghe-1 (PMU)

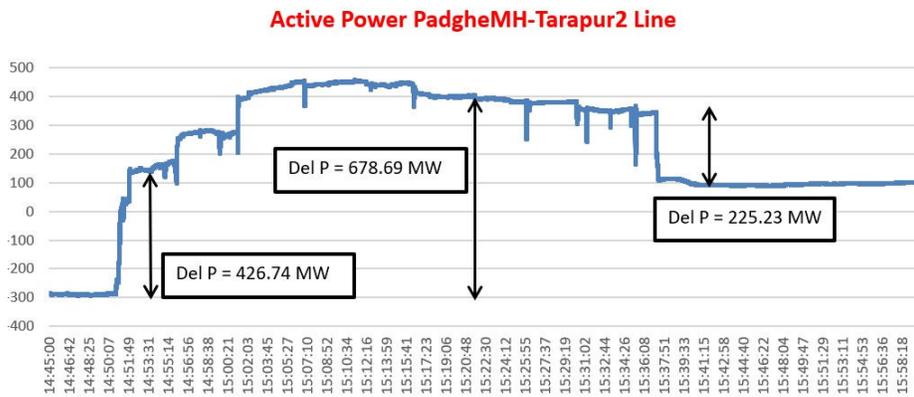


Figure 30: Active Power Flow on 400 kV Tarapur-Padghe-2 (PMU)

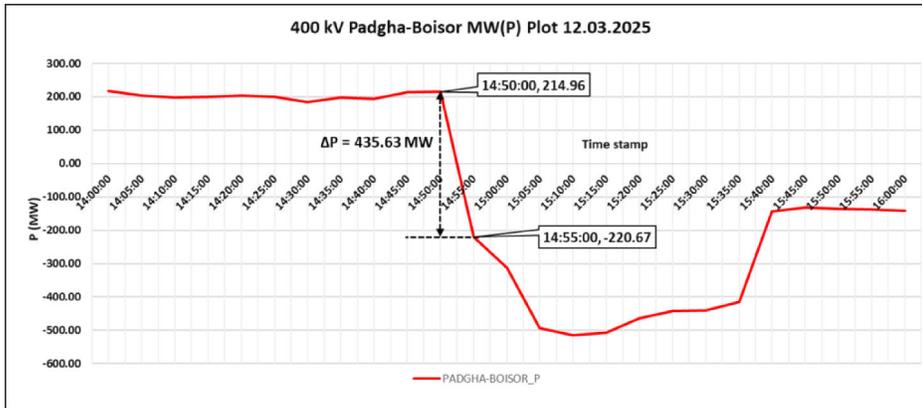


Figure 31: Active Power Flow on 400 kV Tarapur-Boisar (PG) (SCADA)

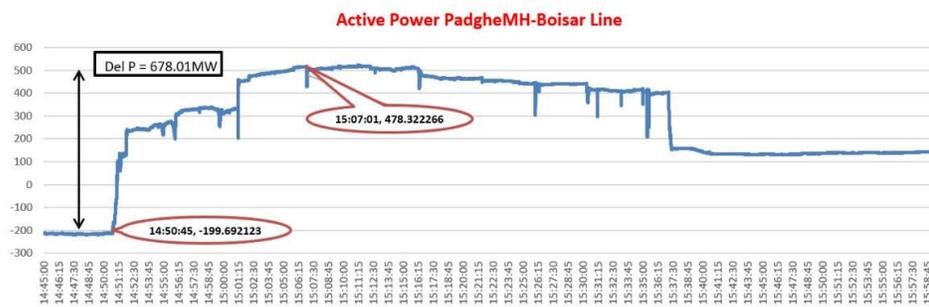


Figure 32: Active Power Flow on 400 kV Tarapur-Boisar (PG) (PMU)

From the plots, it is observed that:

- Prior to the occurrence, there was import of power from Tarapur to Padghe S/s.
- After incidence, i.e. after 14:49 Hrs, the power flow reversed and power started flowing from Padghe to Tarapur.
- Thus, a change in Power flow to the tune of 400 MW was observed.
- Also, a voltage drop of 35 kV was observed.
- A total power flow reversal of 724 MW was observed within a period of 15 minutes i.e. between 14: 49 Hrs to 15:10 Hrs on one circuit.
- There are two circuits of 400 kV Tarapur – Padghe line. Thus, total power flow reversal of 1450 MW was observed through both the circuits.
- Similarly, power reversal of 729 MW was observed on 400 kV Boisar (PG) – Padghe S/C line.
- Thus, total 2180 MW of power reversal was seen by the 400 kV Padghe bus.

### Impact of Power export on other lines at 400 kV Padghe:

- The power reversal from Padghe to Tarapur & Boisar (PG) resulted in to increased power from on 400 kV Babhaleshwar – Padghe D/C lines.
- Further, there was export from Padghe to Nagothane through 400 kV Padghe – Nagothane D/C lines before the incidence.
- However, after the incidence, power flow on these lines reversed and import was observed from Nagothane to Padghe bus.

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- Prior to the incidence, there was export of 1100 Mw of power from Padghe to Kalwa bus through 400 kV Padghe – Kalwa D/C lines.
- Export to Kalwa bus reduced to 788 MW with a reduction of 245 MW of power on these lines.
- Further, to limit the loading on 400 kV Babhaleshwar – Padghe D/C lines, MSLDC Grid Operator ramped up  $\pm$  500 kV Chandrapur-Padghe HVDC.
- The plots are shown below:

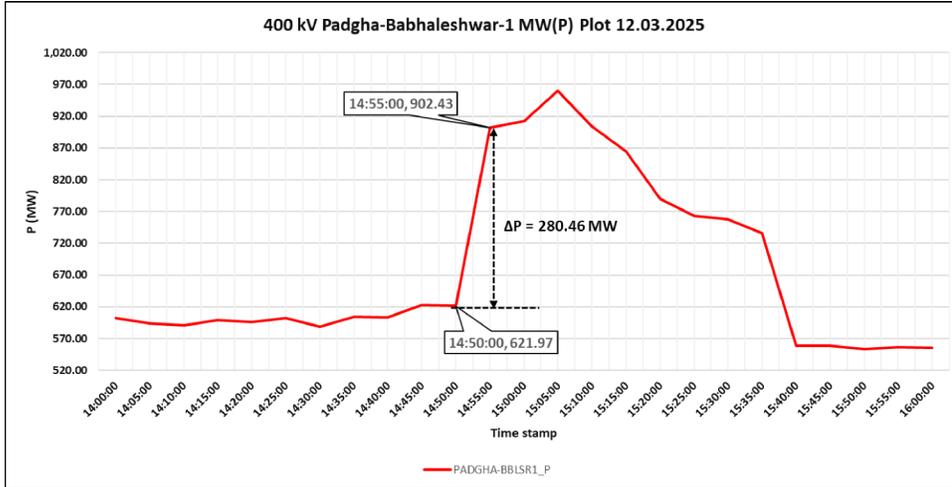


Figure 33: Active Power Flow on 400 kV Babhaleshwar-Padghe-1 (SCADA)

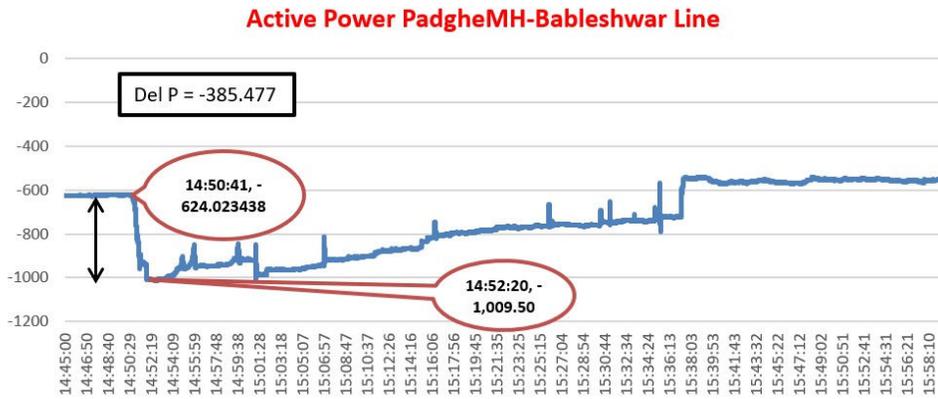


Figure 34 Active Power Flow on 400 kV Babhaleshwar-Padghe-1 (PMU)

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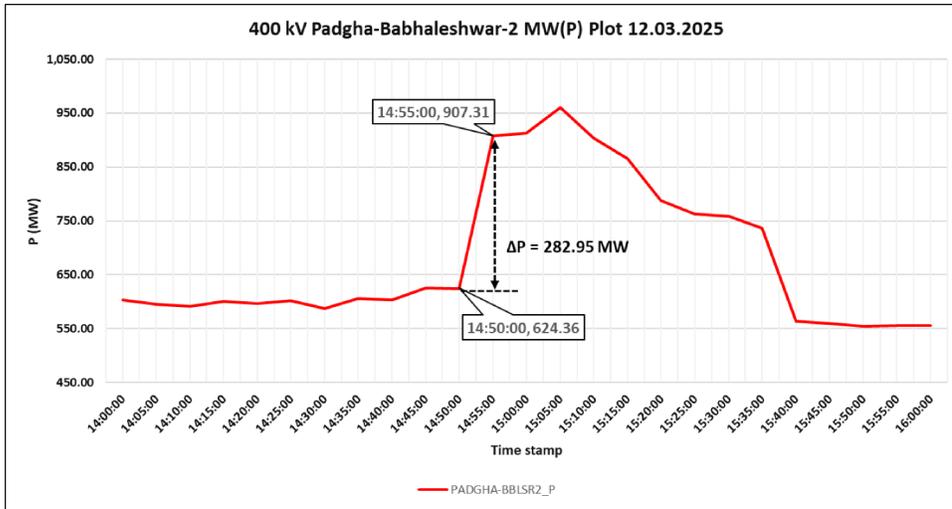


Figure 35 Active Power Flow on 400 kV Babhaleshwar-Padghe-2 (SCADA)

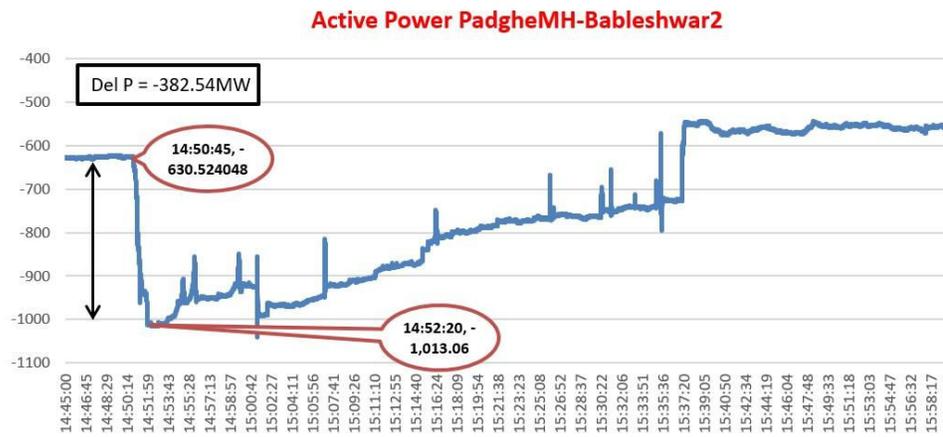


Figure 36 Active Power Flow on 400 kV Babhaleshwar-Padghe-2 (PMU)

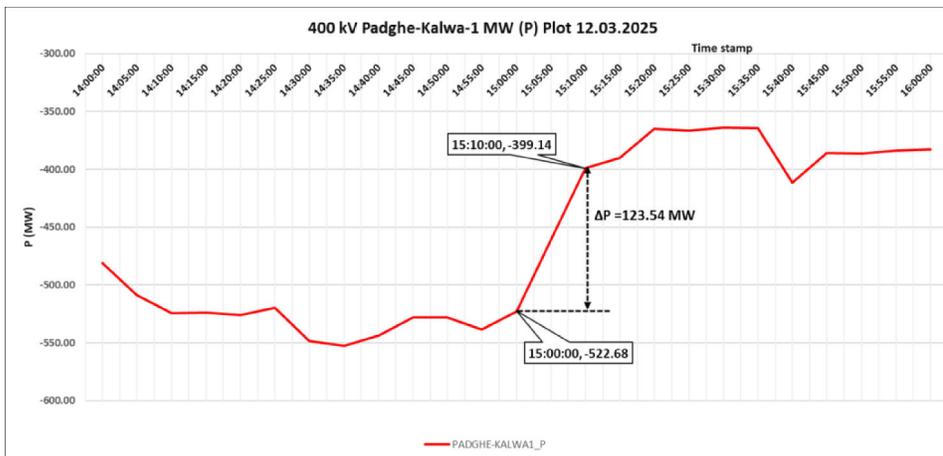


Figure 37 Active Power Flow on 400 kV Padghe-Kalwa-1 (SCADA)

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### Active Power PadgheMH-Kalwa1



Figure 38 Active Power Flow on 400 kV Padghe-Kalwa-1 (PMU)

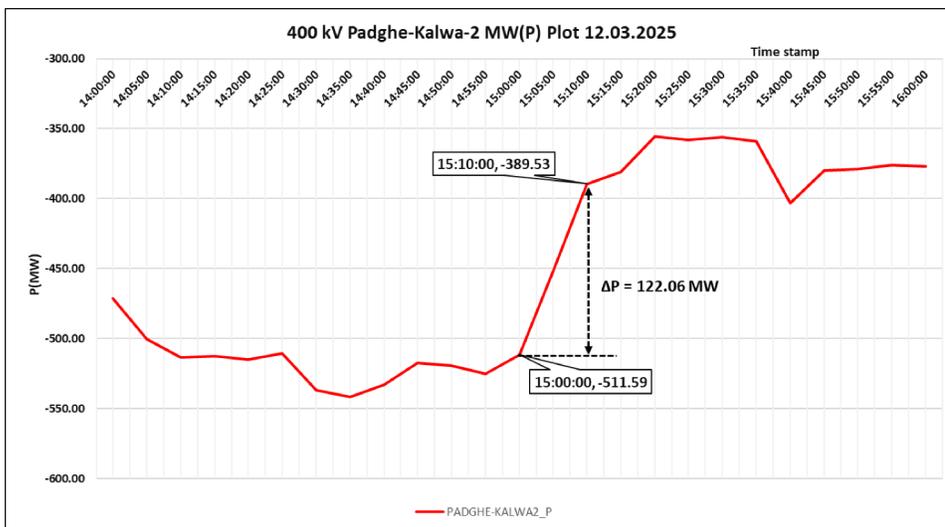


Figure 39 Active Power Flow on 400 kV Padghe-Kalwa-2 (SCADA)

### Active Power PadgheMH-Kalwa2



Figure 40 Active Power Flow on 400 kV Padghe-Kalwa-2 (PMU)

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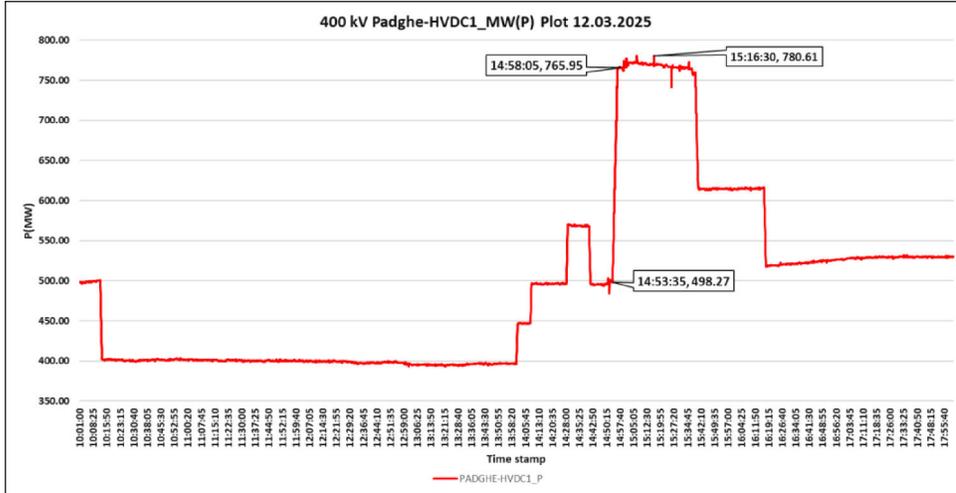


Figure 41 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-1 (SCADA)

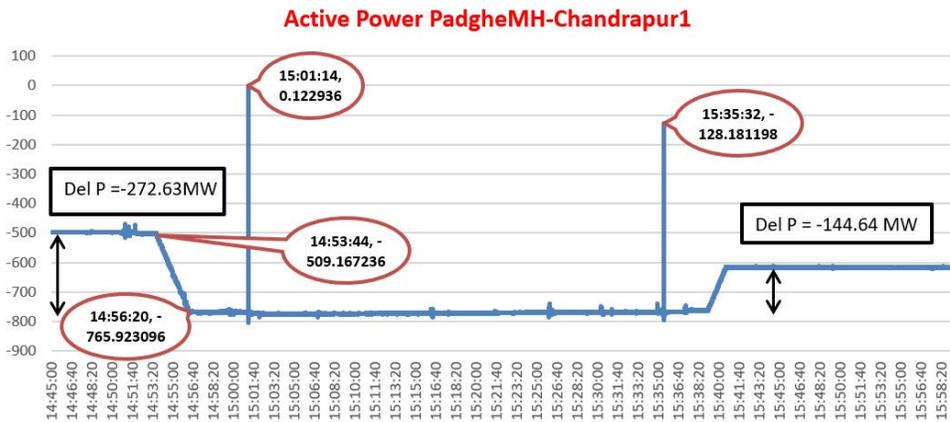


Figure 42 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-1 (PMU)

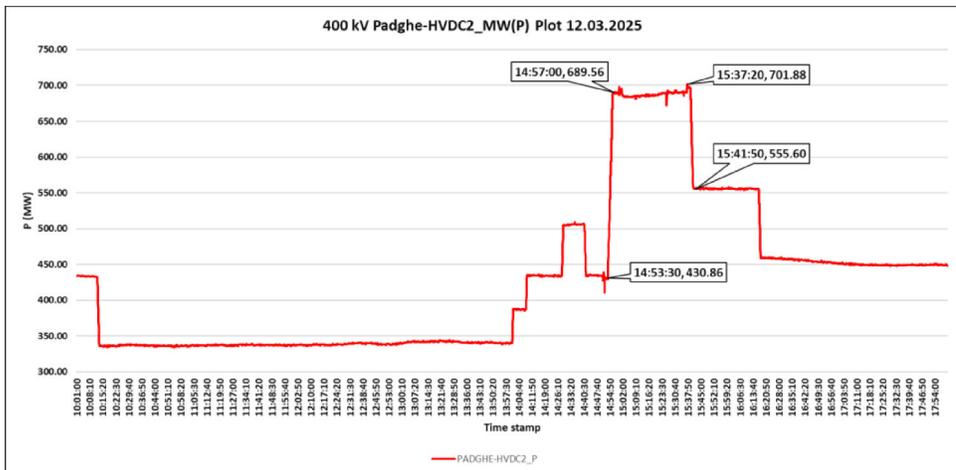


Figure 43 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-2 (SCADA)

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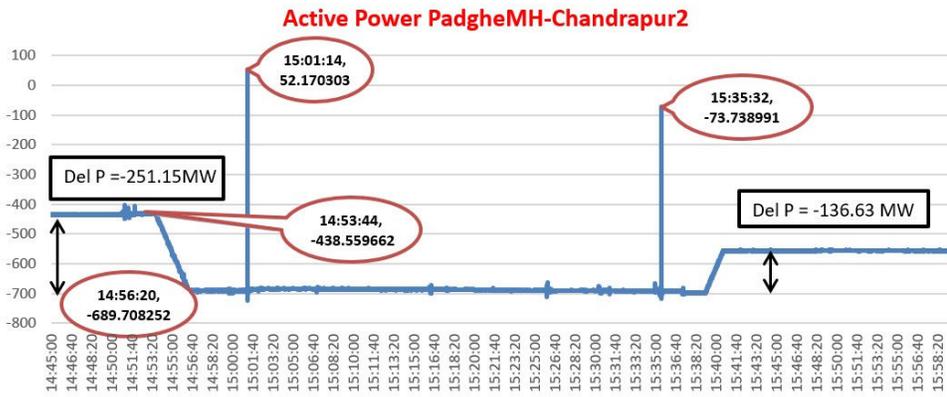


Figure 44 Active power flow on + 500 kV Chandrapur-Padghe HVDC Pole-2 (PMU)

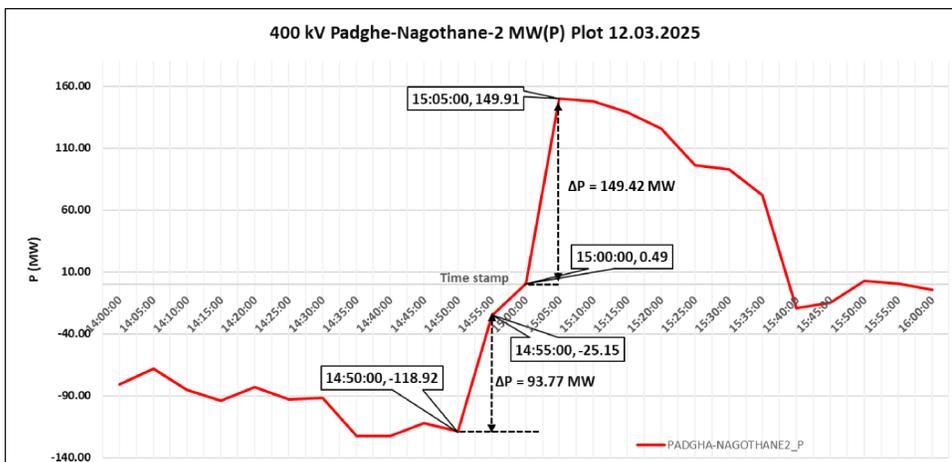


Figure 45 Active Power flow on 400 kV Nagothane – Padghe-2 (SCADA)

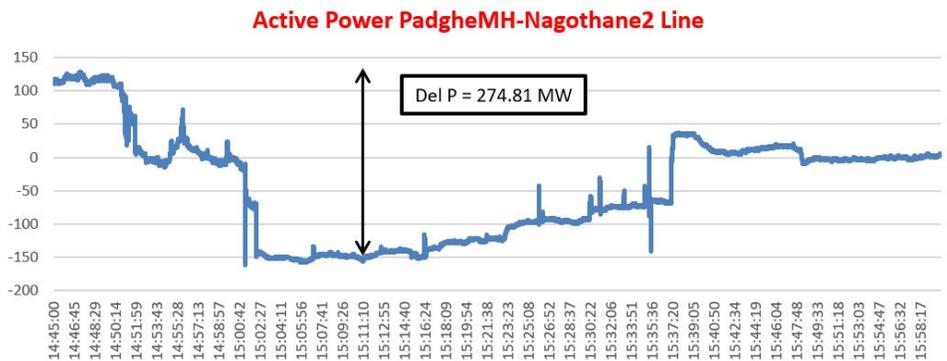


Figure 46 Active Power flow on 400 kV Nagothane – Padghe-2 (PMU)

From the above plots, it is observed that:

- The loading on 400 kV Babhaleshwar – Padghe D/C increased from 1246 MW to more than 2000 MW suddenly i.e. increase of around >754 MW was observed.
- The export on 400 kV Nagothane – Padghe – 2 line reduced from 119 MW to 25 MW from Padghe to Nagothane initially. After 14:55 Hrs, the power reversal was observed on this line and power was imported from Nagothane Bus. Thus, a total 243 MW was observed on

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this circuit. As there are two circuits, a total change in power flow to the tune of 500 MW was observed on 400 kV Nagothane – Padghe D/C lines.

- As the loading on 400 kV Babhaleshwar – Padghe D/C was increased drastically, MSLDC Grid Operator ramped up HVDC which was operating at 928 MW. HVDC was picked-up to its full capacity of 1500 MW by the Operator.

## 5.4.2 Behavior of Generators

### 5.4.2.1 Trombay Generating Units

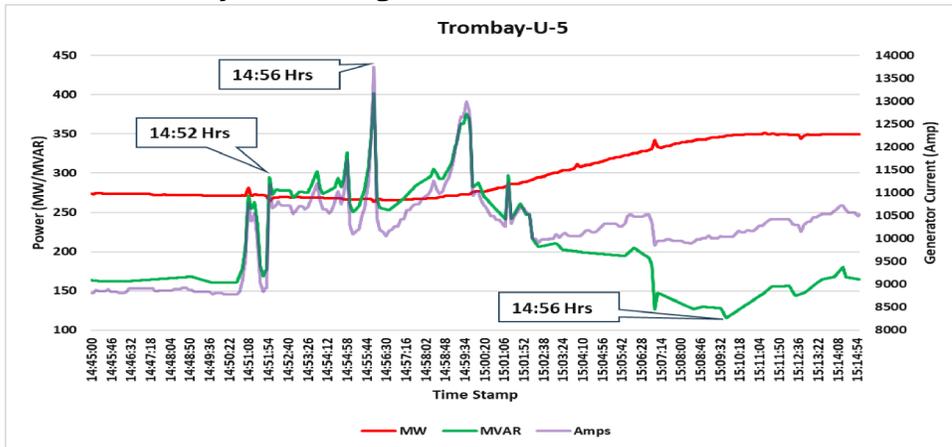


Figure 47 Trombay Unit-5 (500 MW): P, Q & Gen Current (Source: TPCL)

From the above, plot, it is observed that the Trombay Unit-5 supported the Grid by injecting Reactive Power. In Unit-5 Max Generator current recorded was 13755 amps for a very short duration reflected as a spike seen in the plot. The rated full load current is 10640 amps. In such case, there was possibility of loss of this unit if such overloading had continued.

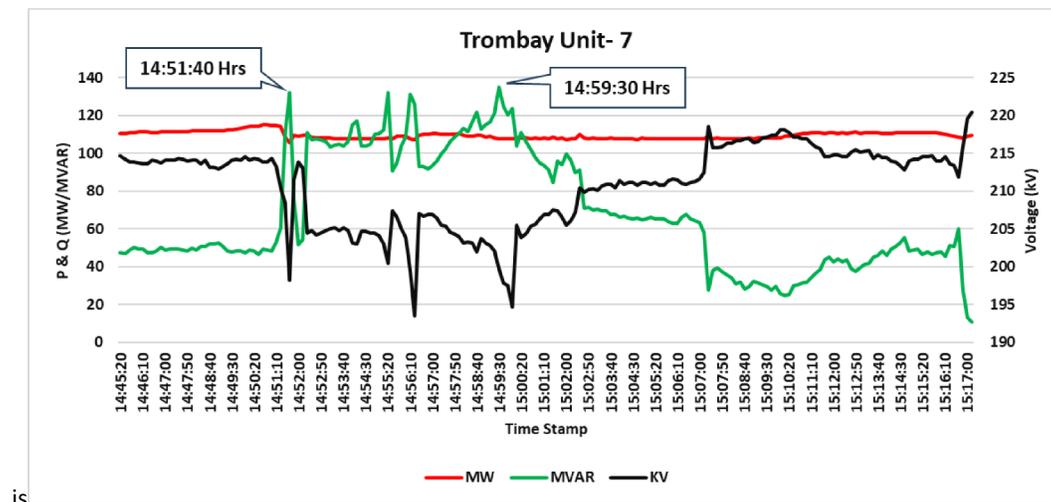


Figure 48 Trombay Unit-7 (180 MW): P, Q & Bus Voltage (Source: TPCL)

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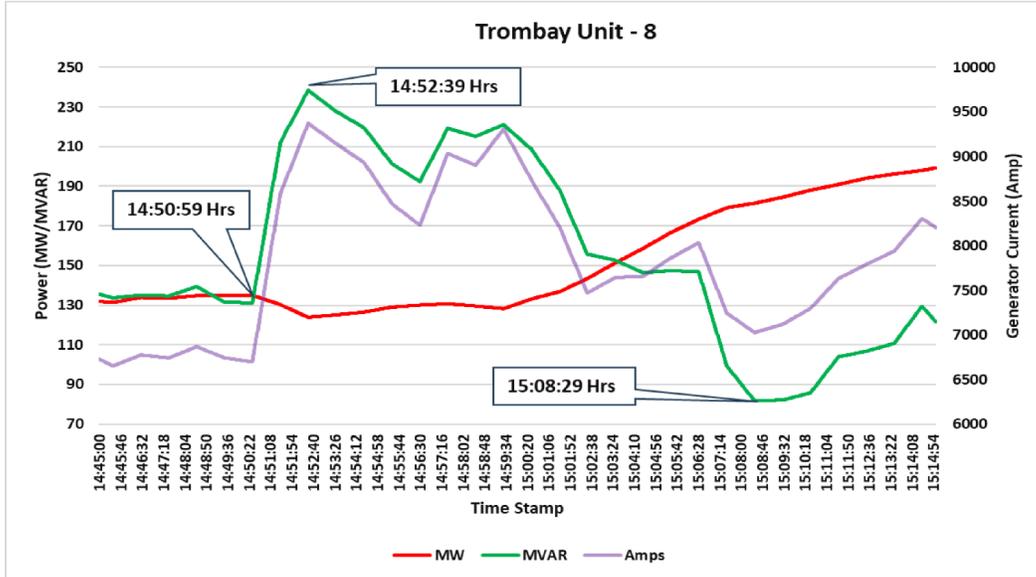


Figure 49 Trombay Unit-8 (250 MW): P, Q & Gen Current (Source: TPCL)

From the above plots, it was observed that the Trombay Units provided Active & Reactive Power Support to the Grid.

It was observed that due to very low Grid side voltages, there was a possibility of tripping of auxiliary systems.

### 5.4.2.2 Dahanu Generating Units:

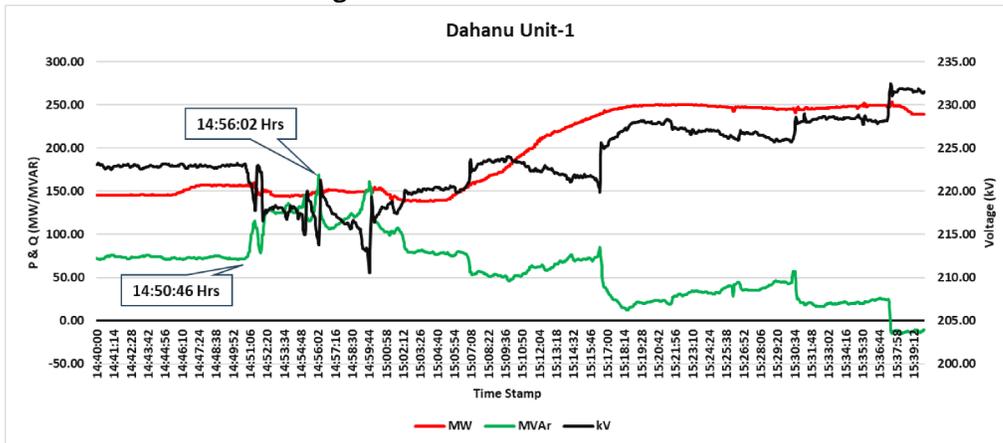


Figure 50 Dahanu Unit-1 (250 MW): P, Q & Bus Voltage (Source: AEML)

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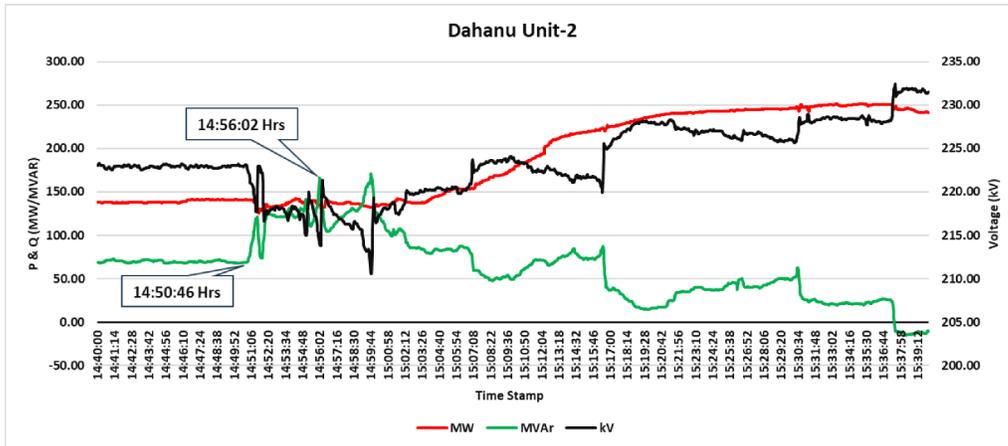


Figure 51 Dahanu Unit-2 (250 MW): P, Q & Bus Voltage (Source: AEML)

From the above plots, it is observed that AEML Dahanu units provided Active & Reactive Power support to the Grid.

### 5.4.3. APML Units, Tiroda:

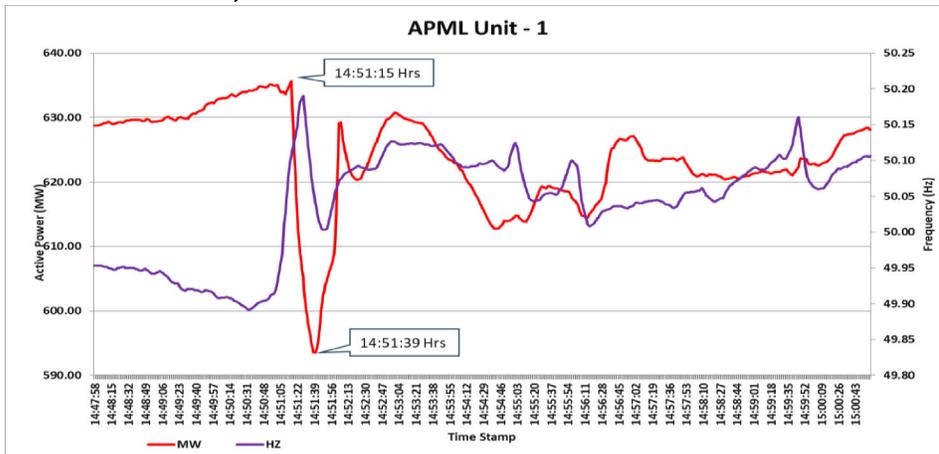


Figure 52 APML Unit-1 (660 MW): Active Power & Frequency (Source: APML)

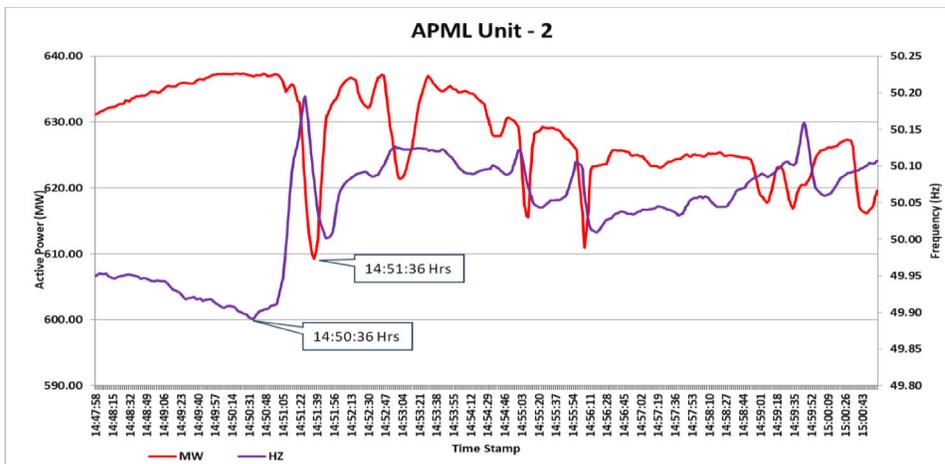


Figure 53 APML Unit-2 (660 MW): Active Power & Frequency (Source: APML)

# Maharashtra State Load Despatch Centre

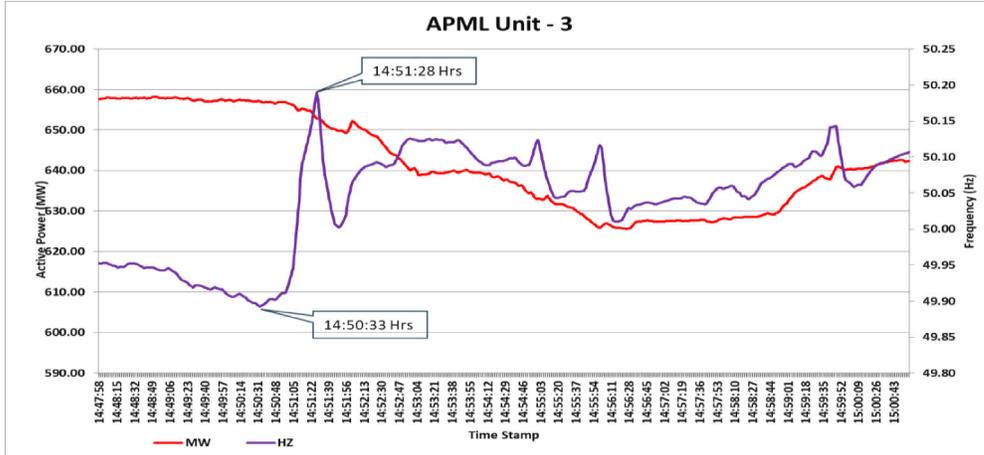


Figure 54 APML Unit-3 (660 MW): Active Power & Frequency (Source: APML)

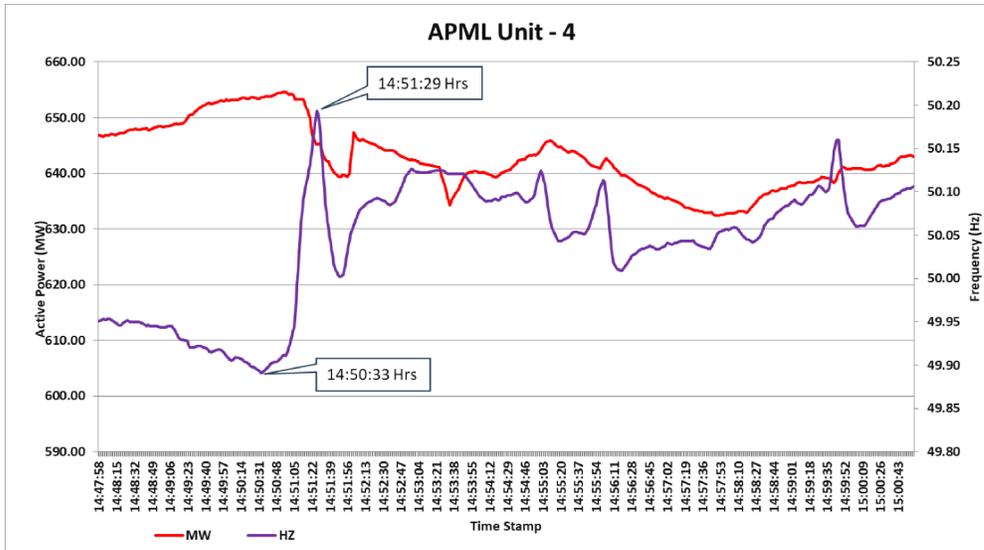


Figure 55 APML Unit-4 (660 MW): Active Power & Frequency (Source: APML)

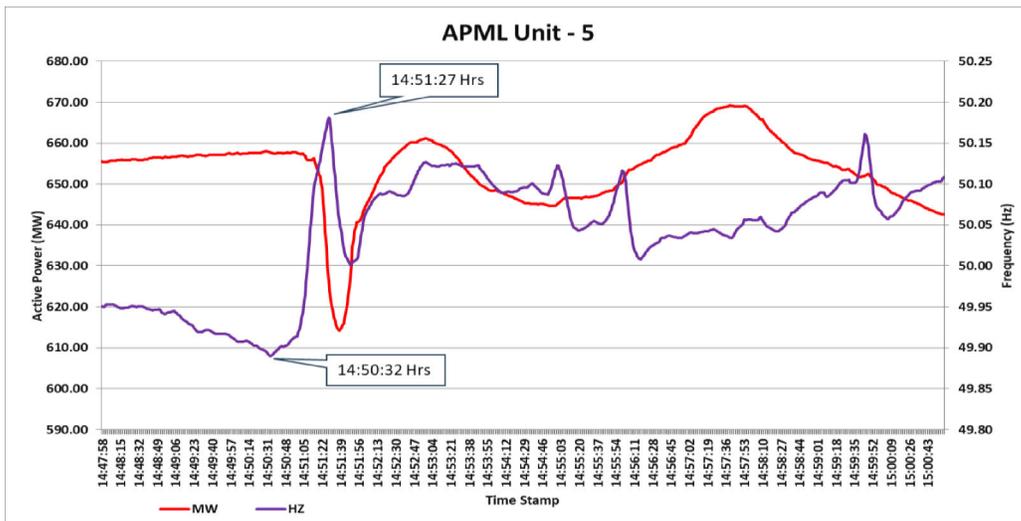


Figure 56 APML Unit-5 (660 MW): Active Power & Frequency (Source: APML)

# Maharashtra State Load Despatch Centre

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From the plots of APML Units, it is observed that the active power injection is varying according to the Grid Frequency. Further, the incidence was away from the Generating units, however, these units have responded to the changes in the System conditions.

## 5.5 Impact on Grid Stability

### 5.5.1 Possibility of load encroachment of Distance protection in Zone-3

From the SoE recorded in SCADA System, it has been observed that for 400 kV Babhaleshwar – Padghe-2 line, Zone-3 signal had picked up indicating possibility of load encroachment, however it was cleared after one second. Also, PSD was initiated. In such case, there was possibility of tripping of this line which would have worsened the grid conditions.

Date	Time	Message Group	WinCC Message Text	Value
12-03-2025	14:55:34	PADGHE\400kV\BABHALESHWAR-2\MAIN-1	PSD START	RAISED
12-03-2025	14:55:34	PADGHE\400kV\BABHALESHWAR-2\MAIN-1	PSD START	CLEARED
12-03-2025	15:01:11	PADGHE\400kV\TARAPUR-2\MAIN-2	ZONE-3 START	RAISED
12-03-2025	15:01:12	PADGHE\400kV\TARAPUR-2\MAIN-2	ZONE-3 START	CLEARED
12-03-2025	15:40:37	PADGHE\400kV\BABHALESHWAR-2\MAIN-1	PSD START	RAISED
12-03-2025	15:40:37	PADGHE\400kV\BABHALESHWAR-2\MAIN-1	PSD START	CLEARED

Table 23 Possibility of load encroachment of Distance protection in Zone-3

### 5.5.2 Analysis of Angular Difference from PMU data

Voltage angle monitoring using **Phasor Measurement Unit (PMU) data** is a critical tool for system operators to assess **grid stability, detect stress conditions, and prevent large-scale disturbances**. The angular separation between buses provides a real-time indication of power system stress—**large angular differences can signal instability, while sudden deviations may indicate system stress or potential islanding events**. By continuously tracking **voltage angle trends**, operators can identify early warning signs of oscillations, power flow reversals, and potential separation risks between different regions of the grid. **PMU-based angle monitoring** also aids in **post-event analysis**, helping to understand dynamic responses to disturbances, validate system models, and improve operational decisions. With high-speed data acquisition (milliseconds resolution), PMUs enable **rapid corrective actions**, such as adjusting power flows via **HVDC modulation, FACTS devices, or generation re-dispatch**, ensuring grid security under stressed conditions. In the event of **voltage collapse in Maharashtra on 12.03.2025, angular difference monitoring** helped reveal inter-area stability issues, assisting operators in deploying timely mitigation strategies.

Voltage Angles between 400 kV Kalwa-Lonikand-1, 400 kV Kalwa-Kolhapur & 400 kV Chandrapur-Kalwa buses is shown below:

# Maharashtra State Load Despatch Centre

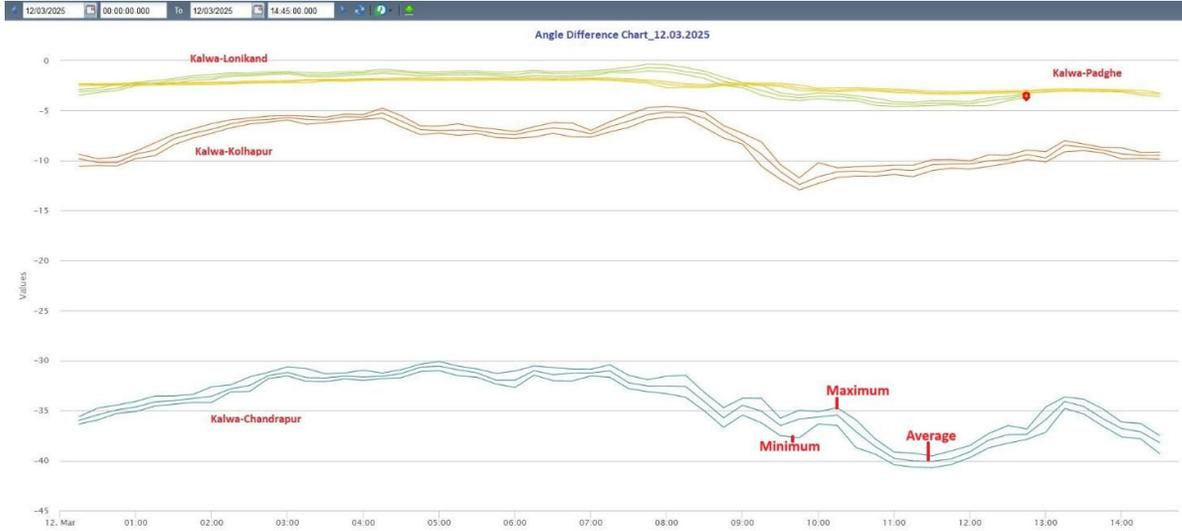


Figure 57 Angular Difference before incidence (PMU)

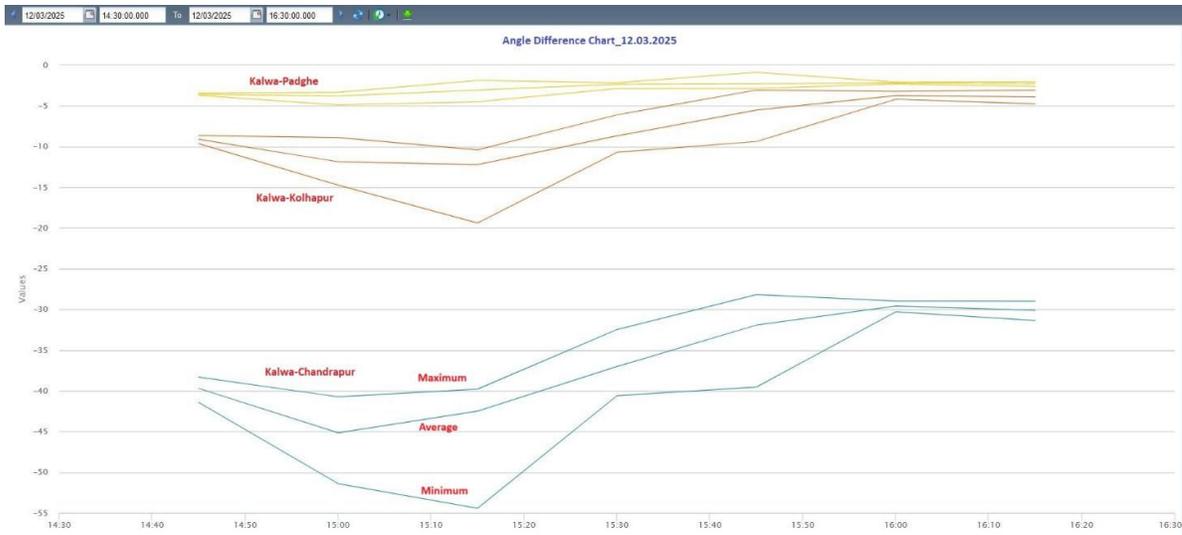


Figure 58 Angular Difference After incidence (PMU)

## 5.5.2.1 Snapshots of PMU Screen indicating Angular difference & df/dt: At 14:45:08 Hrs: (Before incidence)

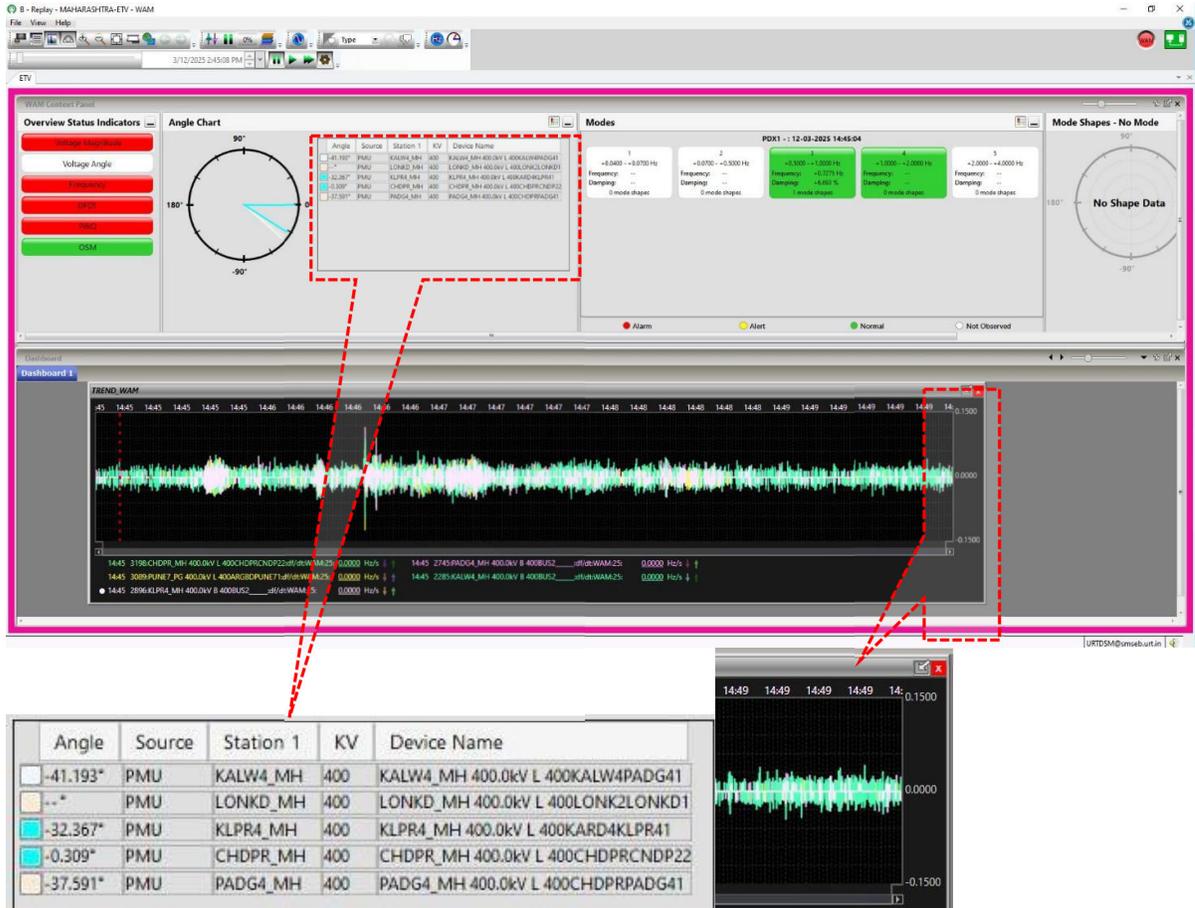
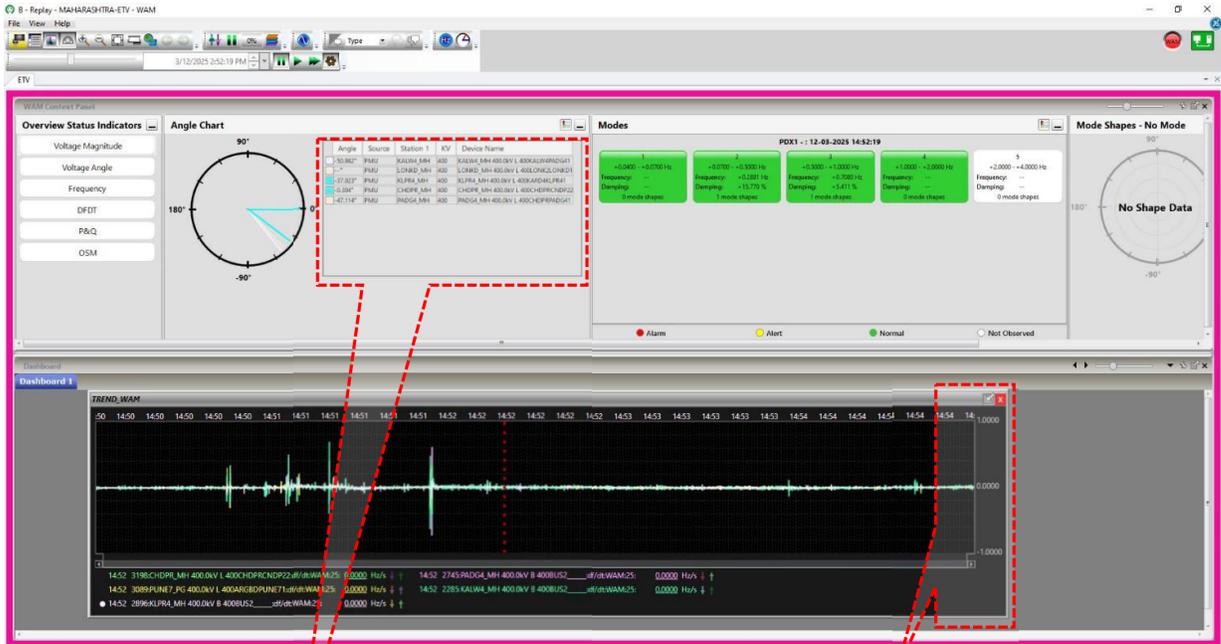


Figure 59 Snapshots of PMU Screen indicating Angular difference & df/dt: At 14:45:08 Hrs: (Before incidence)

# Maharashtra State Load Despatch Centre

At 14:52:19 Hrs: (After incidence)



Angle	Source	Station 1	KV	Device Name
-50.982°	PMU	KALW4_MH	400	KALW4_MH 400.0kV L 400KALW4PADG41
--*	PMU	LONKD_MH	400	LONKD_MH 400.0kV L 400LONK2LONKD1
-37.023°	PMU	KLPR4_MH	400	KLPR4_MH 400.0kV L 400KARD4KLPR41
-0.304°	PMU	CHDPR_MH	400	CHDPR_MH 400.0kV L 400CHDPRCNDP22
-47.114°	PMU	PADG4_MH	400	PADG4_MH 400.0kV L 400CHDPRPADG41



Figure 60 Snapshots of PMU Screen indicating Angular difference & df/dt: At 14:52:19 Hrs: (after incidence)

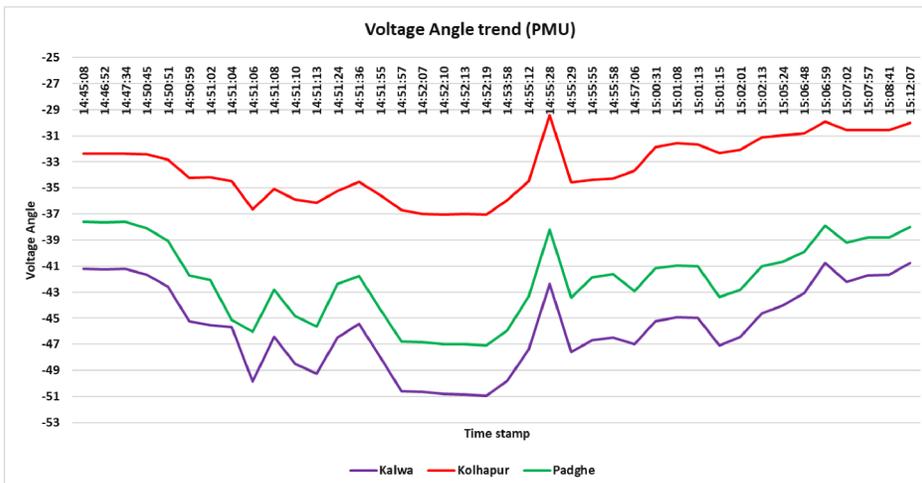


Figure 61 Voltage Angle Plot (PMU)

## 5.5.2.2 Observations on Voltage Angle Behavior

- **Before the Incident (14:45:08 hrs):**
  - The **voltage angle at Kalwa bus** was within the normal operating range of **-30° to -40°**. The angular difference between Padgha and Kalwa bus is usually @ 3-4°
  - Angular differences across major corridors were within acceptable stability margins.
- **After the Incident (14:52:19 hrs):**
  - The voltage angle at Kalwa bus spiked to **-51°**, indicating increased stress on the system.
  - A significant increase in angular difference of **9.78°** was observed post-disturbance, highlighting a possible separation risk between Eastern and Western Maharashtra.
  - The rapid increase in angular separation suggests low generation availability in Western **Maharashtra**, leading to higher power imports from Eastern Maharashtra.

## 5.5.2.3 Interpretation of Angular Plots

- A **sharp rise in angular difference** indicates increased system stress and reduced synchronism across regions.
- **Large angular separation (>50°)** between buses can lead to system instability or islanding.
- The observed **change of ~9.78°** suggests the grid was approaching critical stability limits, requiring immediate corrective actions.

## 5.5.3 Frequency deviation

The maximum & minimum frequency recorded during the event was 50.53 Hz & 49.67 Hz respectively. Padghe Bus frequency deviation is shown in the following graph:

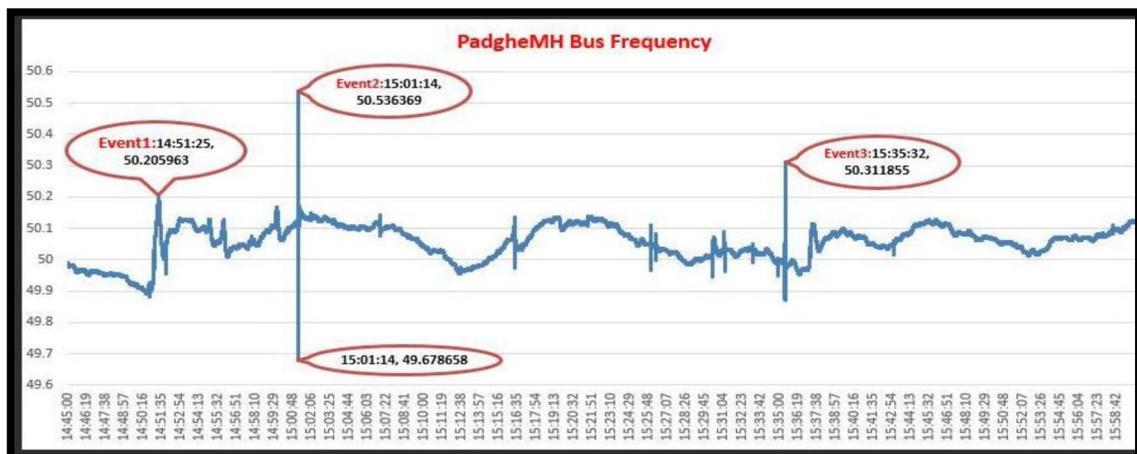


Figure 62 frequency deviation during event 1

During the Event 1:

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At 14:50:45:576 hrs, frequency was 49.88 Hz, suddenly, at 14:51:25:576 hrs it reaches to 50.2 Hz.

At 14:51:54 Hrs frequency dropped to 49.955 Hz.

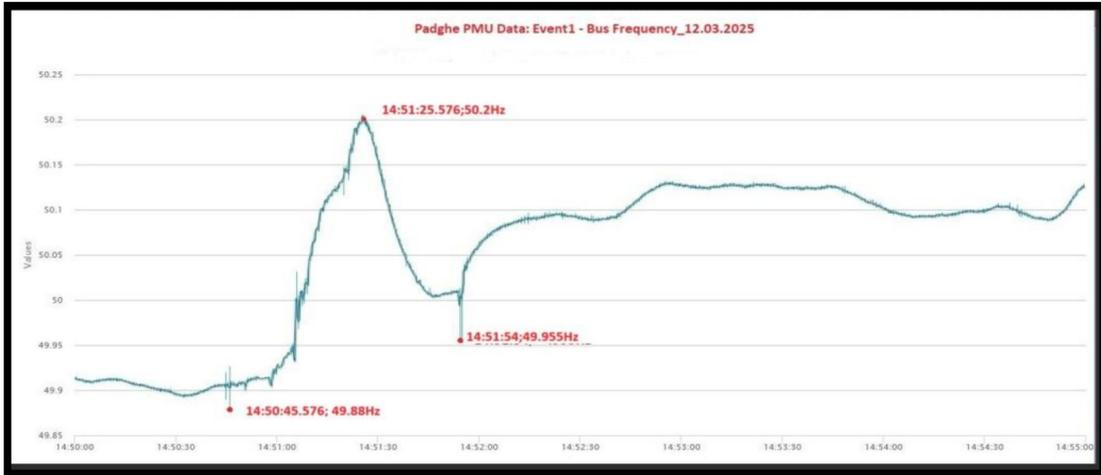


Figure 63 frequency deviation during event 2

During the Event 2:

At 15:01:13.480 hrs, frequency was 50.11 Hz, suddenly, at 15:01:13.520 hrs (within 40 ms) frequency dropped to 49.67 Hz.

At 15:01:13.600 hrs frequency reached to 50.53 Hz, whereas at 15:01:13.840 hrs (after 240ms) frequency dropped to 50.12 Hz.

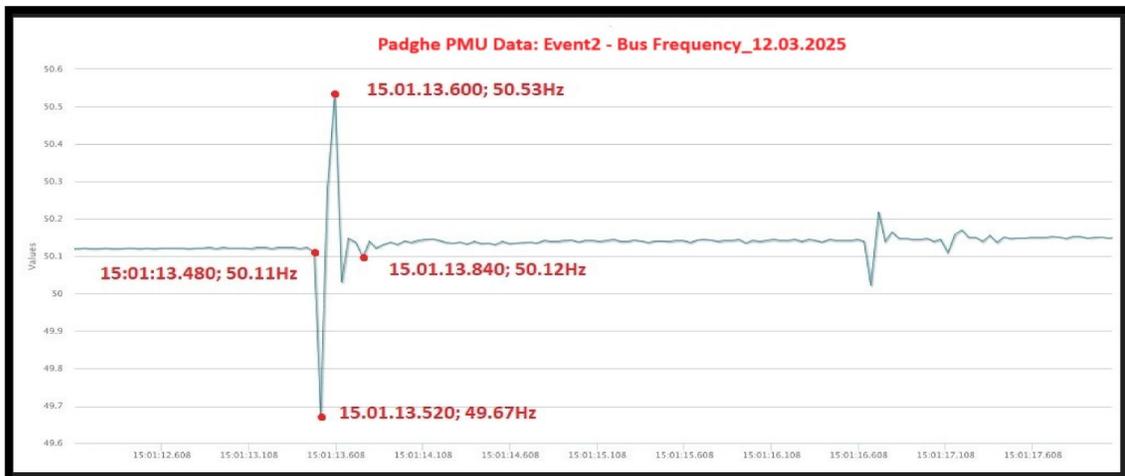


Figure 64 frequency deviation during event 3

During the Event 3:

At 15:35:31.640 hrs, frequency was 49.87 Hz and within 40 msec, i.e. at 15:35:31.680 hrs, frequency reached to 50.311 Hz.

Again at 15:35:31.760 hrs (after 80ms), frequency dropped to 49.97 Hz.

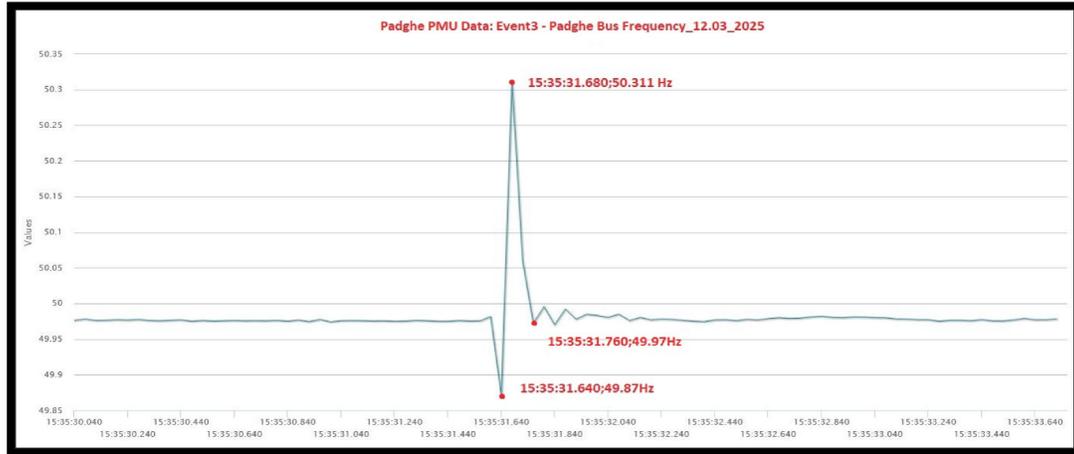


Figure 65 frequency deviation at 15:35:31:760

During the grid disturbance, significant **frequency deviations** were recorded across the Maharashtra grid, particularly at the **Padghe Bus**. The **maximum frequency reached 50.53 Hz**, while the **minimum dropped to 49.67 Hz**, indicating severe system stress.

### 5.5.3.1 Key Frequency Deviations Observed:

#### 1. Event 1 (14:50:45:576 - 14:51:54 hrs):

- Frequency initially recorded at **49.88 Hz**.
- Within **40 seconds**, it surged to **50.2 Hz**.
- Shortly after, it dropped again to **49.955 Hz**, reflecting system instability.

#### 2. Event 2 (15:01:13:480 hrs):

- At **15:01:13.480 hrs**, frequency was **50.11 Hz**.
- Within **40 milliseconds**, it dropped to **49.67 Hz**.
- At **15:01:13.600 hrs**, it peaked to **50.53 Hz**, before falling again to **50.12 Hz** in **240 ms**.

#### 3. Event 3 (15:35:31:640 hrs):

- At **15:35:31.640 hrs**, frequency was **49.87 Hz**.
- In just **40 milliseconds**, it surged to **50.311 Hz**.
- At **15:35:31.760 hrs (after 80 ms)**, it dropped again to **49.97 Hz**.

### 5.5.3.2. Analysis & Impact:

- These rapid **frequency swings** indicate **generator tripping, sudden load variations, and reactive power deficiencies**.
- The **high rate of change of frequency (df/dt)** suggests a **dynamic instability** in response to grid fluctuations.
- The df/dt did not trigger even after such variations as the frequency did not reach the pick value of 49.2 Hz.

### 5.5.4. Voltage Collapse

There was severe impact on 400 kV Voltages at multiple locations in the State especially in MMR & Pune area. Due to these low voltages load shedding under UVLS scheme took place. Further, to avoid further voltage collapse, manual load shedding was carried out in Mumbai, MMR & Pune area. The Voltage plots at various Sub-stations is shown below:

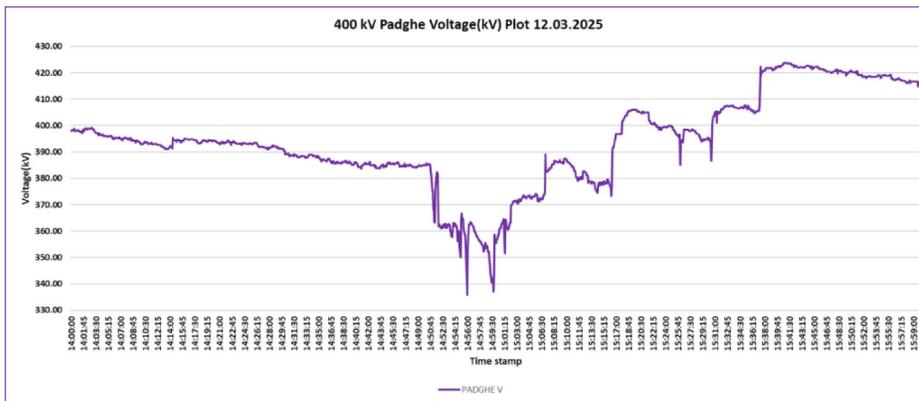


Figure 66 Voltage at 400 kV Padghe S/s. (SCADA)

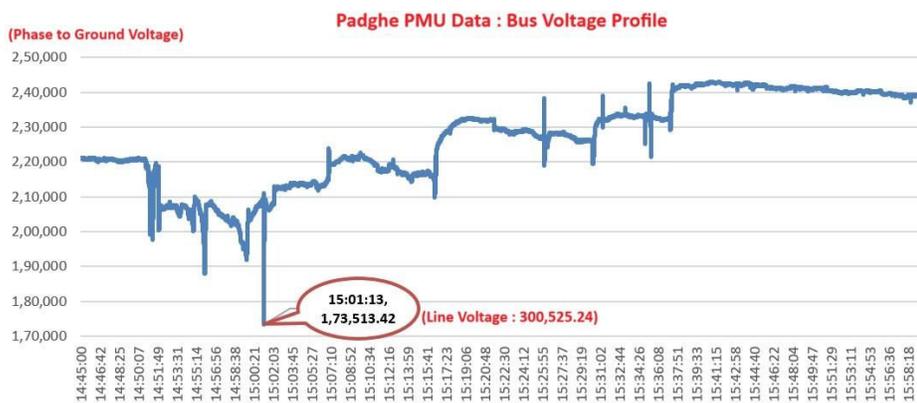


Figure 67 Voltage at 400 kV Padghe S/s. (PMU)

# Maharashtra State Load Despatch Centre

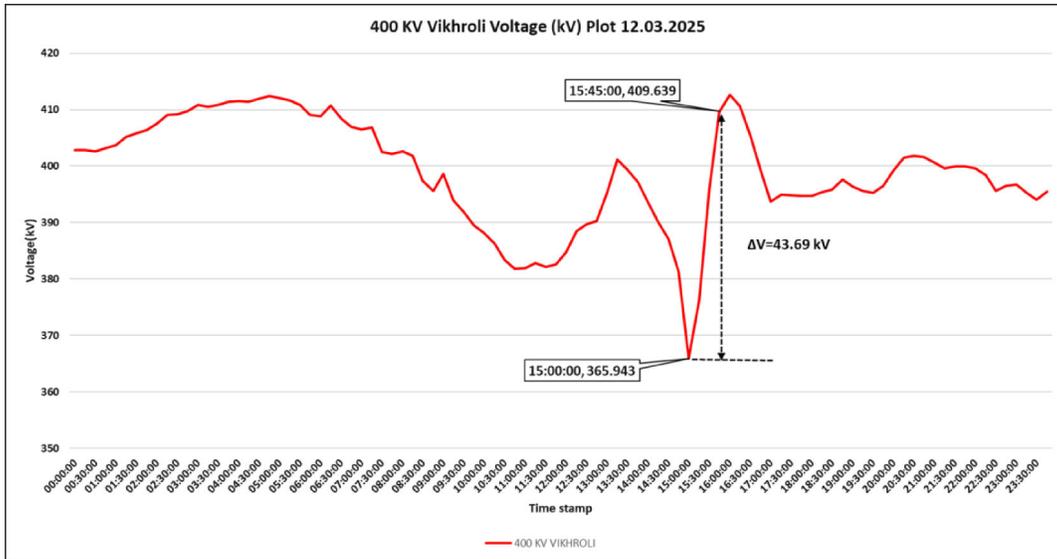


Figure 68 Voltage at 400 kV Vikhroli S/s. (SCADA)

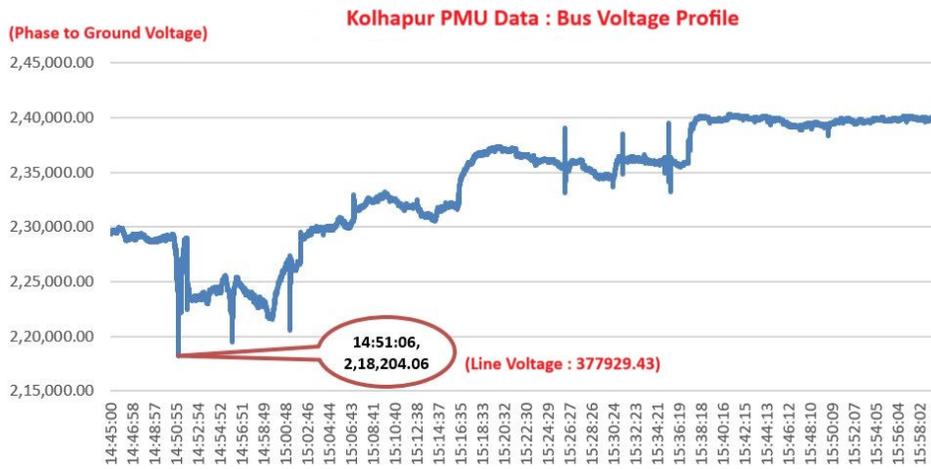


Figure 69 Voltage at 400 kV Kolhapur S/s. (PMU)

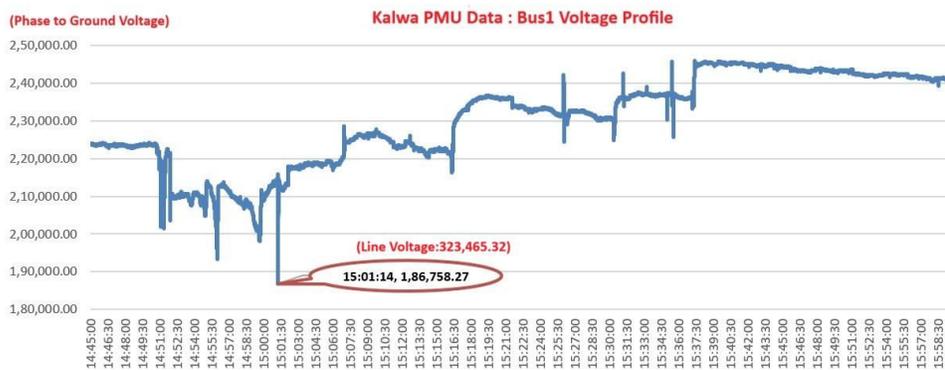


Figure 70 Voltage at 400 kV Kalwa S/s. (PMU)

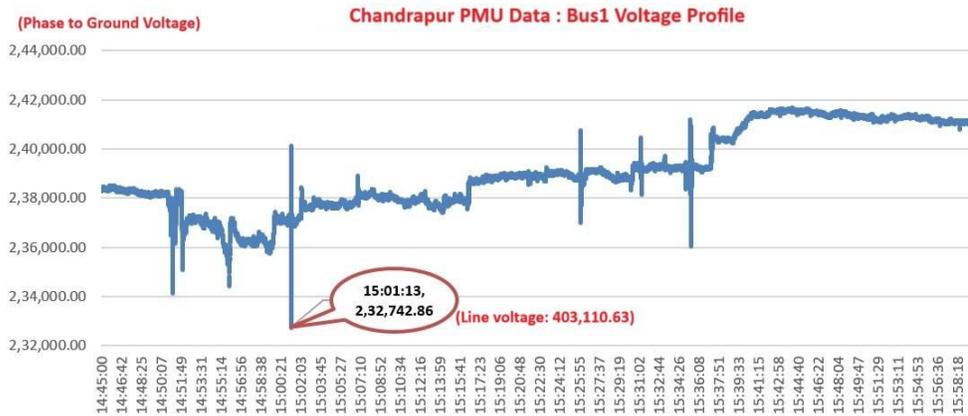


Figure 71 Voltage at 400 kV Chandrapur S/s. (PMU)

### 5.5.5 Difference in Phase Voltages at Padghe

The Phase to Ground Voltage plot at 400 kV Padghe bus is shown below:

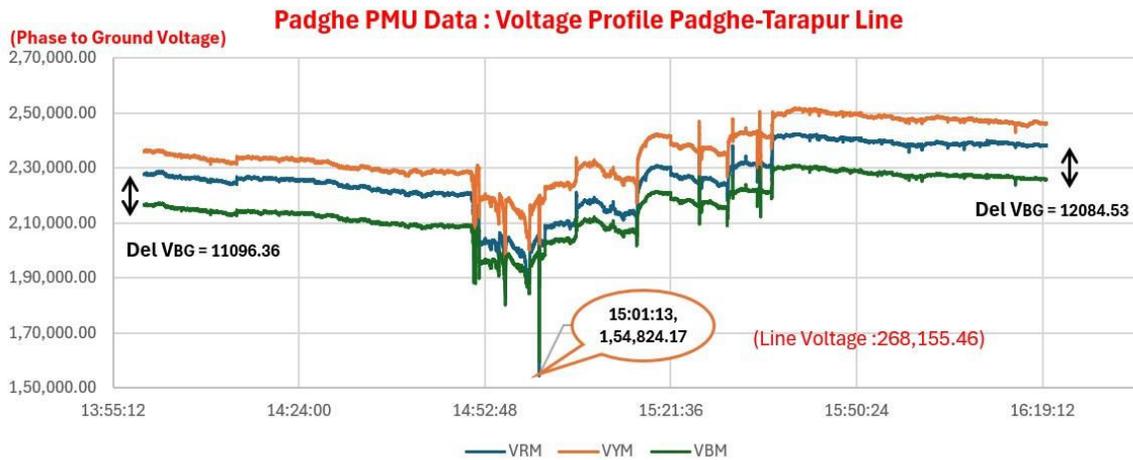


Figure 72 Phase to Ground Voltage plot at 400 kV Padghe (PMU)

This data is recorded by PMU installed on 400 kV Tarapur – Padghe line at Padghe end. It is observed that there is significant difference of around 11 kV in the voltage of all the phases. Hence, checking of the instrument transformers (CVTs) and CVT circuits for identification cause of such errors is essential.

### 5.5.6 Analyzing P-V and Q-V Curves & Understanding Voltage Stability Margin (VSM)

Analyzing **P-V (Active Power vs. Voltage)** and **Q-V (Reactive Power vs. Voltage)** curves is essential in power system studies to assess **voltage stability and the system's ability to handle increasing loads**. The **P-V curve** helps determine the maximum active power that can be transferred before voltage collapse, while the **Q-V curve** evaluates the reactive power support needed to maintain stable voltages. These curves help system operators **identify weak points, set preventive control measures, and optimize reactive power compensation strategies**.

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The **Voltage Stability Margin (VSM)** is a critical metric derived from these curves that quantifies how close the system is to instability. In the **P-V curve**, VSM is the difference between the current operating power and the maximum power the system can sustain before voltage collapse. In the **Q-V curve**, VSM represents the available reactive power margin before voltage instability occurs. A **low or negative VSM** indicates a system at risk of voltage collapse, requiring **reactive power support, load shedding, or transmission reinforcement** to ensure stability.

Considering this, P-V and Q-V curves for a particular time frame of the incidence are plotted. The plots are shown below:

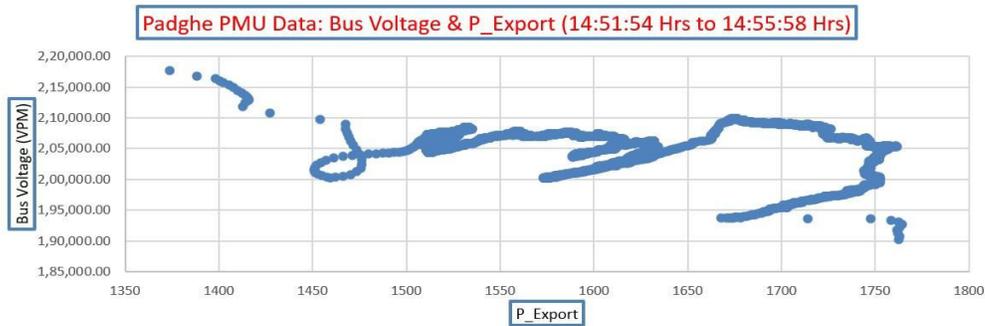


Figure 73 Export Active Power v/s Voltage plot at Padghe on all 400 kV lines (PMU)

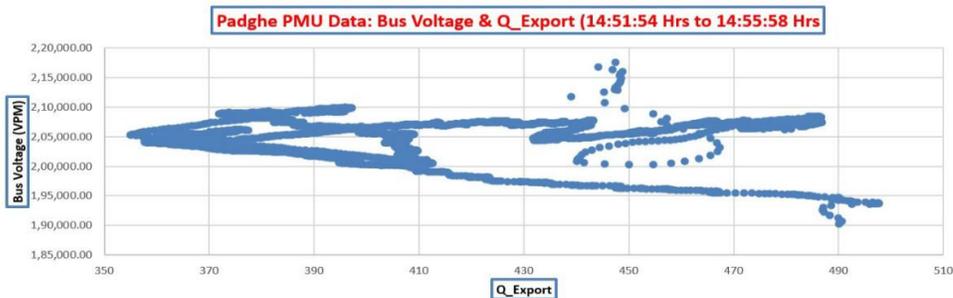


Figure 74 Export Reactive Power v/s Voltage plot at Padghe on all 400 kV lines (PMU)

The observations from these plots are tabulated below.

P-Import	Voltage	Delta P	Delta V
2815.095	217618.11		
2857.614	200296.06	42.519	-17322.05
2994.42	200186.02	136.806	-110.04
3070.10	193740.78	75.68	-6445.24
		<b>255.005</b>	<b>-23877.33</b>

The VSM of 255 MW indicates the short margin for transfer of power was available with maintaining stability.

# Maharashtra State Load Despatch Centre

Q-Import	Voltage	Delta Q	Delta V
559.267	217618.11		
571.859	200296.06	12.592	-17322.05
524.842	200186.02	-47.017	-110.04
617.88	193740.78	93.038	-6445.24
		<b>58.613</b>	<b>-23877.33</b>

### 3.2.1.6. Impact Assessment

#### 6.1 Affected Load & Generation

- During the event, to improve the system voltages, all thermal generation picked up to its full capacity.
- Koyna & Tata hydro picked up to its full capacity
- Instructions given to all generators for MVAR generation for voltage improvement.

#### 6.2 Affected Areas

For bringing Maharashtra Power system to normal state of operation curtailment also carried out along with the LTS / UVLS operation. Details of load loss due to LTS / UVLS operation and manual DLS is listed as below:

Sr.No.	Name of Substation	Load curtailment due to	District	Load affected (In MW)
1.	400kV Padghe	LTS & UVLS operation	Thane	547.89
2.	400kV Padghe / 400kV Kalwa/ 220kV Boisar	DLS implementation	Thane/Raigad/Navi Mumbai	1061.34
3.	400kV Nagothane	Emergency Handtripping of 220kV Nagothane – Wadkhal ckt 1 & 2 due to low voltage	Raigad	500
4.	400kV Babhaleshwar	UVLS Operation	Partly Ahmednagar District	436
5.	220kV Nashik GCR	LTS Operation	Nashik	213.06
6.	Other 220kV / 132 kV substation under Babhaleshwar	Load before tripping	Nashik	576.18
7.	400kV Jejuri	UVLS operation	Pune	74.64
8.	400kV Lonikand	UVLS operation	Pune	242
9.	TPCL	DLS implementation	Kalyan	176
10.	AEML	DLS implementation	Bhyander, Borivali, Mira road, Malad, Dahisar, Malvani, Charkop, Meghwadi & Juhu area	95
<b>Total Load shedding quantum</b>				<b>3922.11</b>

Table 24 Affected Areas

# Maharashtra State Load Despatch Centre

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### 6.3 Energy Not Served (ENS)

Total 7.56 MUs were not served during the disturbance period from 14:55 Hrs to 17:45 Hrs.

#### 3.2.1.7. Restoration Process

##### 7.1 Time taken for Restoration

Load shedding was implemented at 14:55 hrs during under voltage condition and restoration process completed by 17:58 hrs.

Restoration details of load loss and curtailment carried for bringing Maharashtra power system to normal state of operation.

The details of load restoration at Kalwa circle depicted as follows:

Sr. No.	Name of Substation	Load relief (MW)	Restoration Time (Hrs)
1	220kV Boisar	14.65	16:43
2	220kV Nalasopara	24	16:48
3	220kV Vasai	18	16:13
4	220kV Viraj	14.90	16:42
5	100kV Vasai	45.40	15:32
6	220kV Bhaveghar	8.02	16:45
7	132kV Palghar	39.97	16:25
8	132kV Dahanu	50.75	16:40
9	132kV MIDC	33.70	16:18
10	220kV Wada	112.98	17:27
11	220kV Bapgaon	23	16:00
12	100kV Mumbra	24	16:10
13	220kV Kamba	50.2	16:40
14	220kV Mahape	15.8	16:06
15	220kV Temghar	77.3	16:38
16	100kV Bhiwandi	112	16:35
17	220kV Mulund	67.3	16:44
18	220kV Bhandup division	388.7	16:26
19	220kV Colorchem	46.67	16:25
20	220kV AKP	30	16:28
<b>Total</b>		<b>1197</b>	

Table 25 load restoration at Kalwa circle

The details of load restoration at Panvel circle depicted as follows:

Sr.No.	Name of Substation	Load relief (MW)	Restoration Time (Hrs)
1	400kV Kharghar	62	16:14
2	400kV Nagothane	510	16:04
3	EHV O&M DN., Panvel	9.36	15:08
4	EHV O&M DN., Dombivali	38	17:10
<b>Total</b>		<b>619.36</b>	

Table 26 load restoration at Panvel circle

## Maharashtra State Load Despatch Centre

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The details of load restoration at Padghe circle depicted as follows:

Sr. No.	Name of Substation	Load relief (In MW)	Restoration Time (Hrs)
1	100kV Ambernath	62.87	16:45
2	100kV Shahapur	38	16:50
3	100kV Bhiwandi	112	16:33
4	100kV Padghe	48	16:40
5	100kV Mohane	32	16:22
<b>Total</b>		<b>292.87</b>	

*Table 27 load restoration at Padghe circle*

The details of load restoration at Pune Zone depicted as follows:

Sr. No.	Name of Substation	Load relief (In MW)	Restoration Time (Hrs)
1	400kV Lonikand	242	16:47
2	400kV Jejuri	74.64	17:58
<b>Total</b>		<b>316.64</b>	

*Table 28 load restoration at Pune Zone*

The details of load restoration at Nashik Zone depicted as follows:

Sr. No.	Name of Substation	Load relief (In MW)	Restoration Time (Hrs)
1	400kV Babhaleshwar	436	16:15
2	EHV O&M Div Babhaleashwar	576.18	16:50
3	220kV Nashik GCR	213.06	15:48
<b>Total</b>		<b>1225.24</b>	

*Table 29 load restoration at Nashik Zone*

The details of load restoration at TPCL area depicted as follows:

Sr. No.	Name of Substation	Load relief (In MW)	Restoration Time (Hrs)
1	Ambernath	55	16:20
2	Kolshet	26	16:21
3	Kalyan	64	16:24
4	Salsette	31	16:02
<b>Total</b>		<b>176</b>	

*Table 30 load restoration at TPCL area*

The details of load restoration at AEML area depicted as follows:

# Maharashtra State Load Despatch Centre

Sr. No.	Name of Distribution Substation (DSS)	Load relief (In MW)	Restoration Time (Hrs)
1	Bhayander	6	15:56
2	Vinamra	7	15:58
3	CPWD	10	15:55
4	Dahisar	7	15:59
5	Mira road	6	16:01
6	Ganesh Nagar	7	15:56
7	Meghwadi	12	15:56
8	Malad	9	15:57
9	Juhu	13	16:06
10	Devidas Lane	12	15:36
11	Gokuldharm	6	15:09
<b>Total</b>		<b>95</b>	

Table 31 load restoration at AEML area

## 7.2 Actions taken by MSLDC

- The HVDC system ramped up to its full capacity of 1500 MW.
- Koyna and Tata hydro generation ramped up to their full capacity.
- All thermal generation units ramped up
- Load shedding was implemented at various locations, with total AG curtailment instructions issued through LM, Cell Management, and MSEDCL.
- Instructions were given to all generators to generate MVAR for voltage improvement.
- Centralized MOD was operated in DSM software as per system requirements.

## 7.3 Challenges faced during Restoration

The initiation of the fault was in Gujrat, which is beyond the control area of Maharashtra State, so immediate recognition of the issue was difficult to the Maharashtra System operation team. Still, taking cue from the line overloading, immediate actions were initiated by the operations team present at the control room. The LTS and UVLS operations are currently not available in the SLDC SCADA system. Also, some communication gap was observed in reporting of these instances to the SLDC control room.

The Koyna hydro response was delayed for some machines than normal during the event. The frequency fluctuations and severe under voltages created a difficult condition for the responding generators which were on FGMO, particularly in Mumbai area. Severe under voltage could have caused loss of auxiliaries.

After the last grid disturbance, a load curtailment protocol for Mumbai is decided and available with the SLDC control room. However, the spread of the occurrence being large, quick decision making about locations of load curtailment was challenging.

# Maharashtra State Load Despatch Centre

## 3.2.1.8. Recommendations & Mitigating measures

### 8.1 Short Term

#### 8.1.1 System Strengthening:

- 1) Following Transmission Schemes proposed in MMR & Pune Area should be completed on top priority:

Sr. No.	Name of Scheme	Proposed Year
1	220 kV DC line from 765 kV Shikrapur PG to 220 kV Khed City - 18 kms	(2024-25)
2	220 kV DC line from 765 kV Shikrapur PG to 220 kV Ranjangaon S/s using existing corridor - 10 kms	(2024-25)
3	Reorientation of 220 kV Babhleshwar - Ranjangaon ckt & Lonikand - Ranjangaon Ckt at Khed City - 5 kms	(2024-25)
4	HTLS conductor of 400 kV Lonikand - Chakan (NEW)	(2025-26)
5	220kV TalegaonPG-Chakan DC with HTLS conductor - 6km	(2025-26)
6	HTLS conductor of 400 kV Talegaon (PG) - Chakan (NEW)	(2025-26)
7		
8	400kV LILO - Lonikand-I Jejuri at 765kV Shikrapur PG -30km approx.	(2026-27)
9	220kV Pune-III (ISTS-New) (PG) – Nandedcity 220kV D/C line.- 60km (Western Region Network expansion scheme)	(2026-27)
10	LILO of both ckt of 220 kV Jejuri (M) – Phursungi (M) D/C line- 5km along with HTLS conductor at 765/400/220 kV Pune-III (ISTS-New) (PG) S/s with HTLS conductor (twin zebra equivalent) (Western Region Network expansion scheme)	(2026-27)
11	HTLS conductor of 400 kV Lonikand - Talegaon (PG) (NEW)	(2026-27)

Table 32 Transmission Schemes proposed in MMR & Pune Area

- 2) To address low voltage issues in MMR, Pune & Nashik area:

- Commissioning of 1425 MVAR, 170 MVAR & 160 MVAR compensation planned at Pune, Vashi and Nasik respectively.

#### 8.1.2 Protection

- 1) Review of provisioning of UVLS schemes at identified 400 kV Sub-stations where UVLS is presently not provided is essential.
- 2) Review of 400 kV Babhaleshwar UVLS scheme so as to have necessary load curtailment instead of network opening.
- 3) Provisioning of LTS scheme on 220/132 kV ICTs at Nashik.
- 4) Verification of protection settings of Bus coupler at 220 kV Nashik OCR.
- 5) Review of LTS Scheme of all 400 kV ICTs ensuring availability of such scheme on each individual ICT.

### 8.1.3 Automation & Communication

- 1) MSLDC has participated in the ULDC scheme of Grid-India for SCADA system in Western Region. WRLDC need to expediate the activities under ULDC project so that actual work can be initiated & SCADA system can be commissioned at MSLDC on priority.
- 2) All LTS schemes installed at important Transmission elements viz. ICTs & 400 kV lines, should be integrated in MSLDC & ALDC SCADA System.
- 3) Separate Screen with alert facility for all LTS Schemes to be maintained in MSLDC & ALDC Control Room.
- 4) List of Sub-stations in MMR & Mumbai area for installation of PMUs has been issued by STU to TPCL & AEML. Hence, TPCL & AEML along with MSETCL need to expedite the work of installation of PMUs and its integration with MSLDC URTDSM System.

### 8.1.4 Procedural Review

- 1) List of critical and non-critical loads/feeders for all the Sub-stations in the State should be prepared. Load Trimming Protocol for entire State like the protocol prepared for MMR & Mumbai region should be prepared for faster response & avoiding mis-communication during implementation. The list should be updated on six-monthly basis.
- 2) The PCC should review all the LTS, SPS, UVLS settings routinely. Healthiness of all the LTS, SPS, UVLS schemes should be ensured by all the transmission licensees and report should be sent to MSLDC.
- 3) Trials of LTS, SPS, UVLS schemes should be taken by all the transmission licensees and report should be sent to MSLDC.

## 8.2 Long Term

### 8.2.1 Grid Strengthening:

- 1) Integrated Resource Planning for Mumbai, MMR & Pune cluster:
  - Around 15000 MW load is concentrated in Mumbai, MMR & Pune area.
  - This area has limited embedded generation, inadequate transmission network and Reactive Power compensation.
  - Hence, it is suggested that an integrated resource planning study for this area with increasing demand needs to be carried out by STU.
  - While carrying out such integrated resource planning study, ensuring availability of enough synchronous generating sources for maintaining grid inertia, reactive support and fulfilling necessary active power support in case of islanding operation, these aspects shall be taken care of.

## 2) **Planning of Adequate Reactive power compensation and timely implementation:**

- Reactive Power Requirement Studies need to be carried out on yearly basis by STU.
- Dynamic compensation through STATCOM, SVC, etc in MMR & Pune region with high density of loads and changing nature of loads in future (with increasing no. of Data Centres, Metro in this area) need to be considered.
- With installation of around 25 GW Solar Generation under various schemes in the State, daily variations in the Thermal generation to the tune of around 4000 MW is expected. There might be need of two shift operation of thermal units. Thus, the reactive support from Thermal Generation will not be adequate. Hence, reactive power support from VRE sources needs to be ensured.
- STU & transmission licensees should ensure timely commissioning of the reactive compensation.

## 3) **Upgradation of existing HVDC Capacity:**

During the incidence,  $\pm 500$  kV, 1500 MW Chandrapur – Padghe HVDC played important role in providing additional power at 400 kV Padghe bus when high export started from Padghe to Tarapur & Boisar (PG) and limiting the loading on 400 kV Babhaleshwar – Padghe D/C lines.

Considering severely low voltages at multiple locations in MMR & Pune area, VSC based HVDC can provide reactive power support.

Hence, the option of upgrading the existing Chandrapur – Padghe HVDC to 3000 MW VSC based HVDC needs to be explored on top priority. It is learnt that the existing line capacity is adequate for 3000 MW capacity. Hence, upgradation of terminal stations only will be required. This aspect should be verified by STU on priority.

## 8.2.2 **Protection, Communication & Automation**

### 1) **Enhancing full visibility of Maharashtra Power system at MSLDC:**

At present complete visibility of all the 765 kV & 400 kV Sub-stations is available at MSLDC & ALDC.

The visibility of transmission elements at 220 kV level & below 50 %.

Hence, execution of planned schemes for ensuring full visibility of Maharashtra Power System to MSLDC needs to be expediated.

### 2) **Expansion of Optical Fibre Communication backbone:**

The utility of PMU data was seen during handling of this incidence as well as for post-incidence analysis as detailed in this report. Hence, an expansion of Optical Fibre communication backbone ensuring availability of necessary communication infrastructure for placing of PMUs at all critical locations in the Maharashtra Transmission System is required.

### 3) Use of State Estimator & ADMS for reliable Grid Operations:

- MSLDC has already participated in the ULDC Scheme of Grid India. In the proposed SCADA System, features of State Estimator, ADMS, etc are covered.
- Hence, Grid India should expedite the issuance of Lol for the shortlisted vendor so that SCADA System can be commissioned on priority.

### 4) Installation of PMUs under Wide-Area Measurement System (WAMS) for situational awareness:

- For situational awareness, MSLDC is using PMU data installed at 5 Nos. of 400 kV Sub-stations.
- In first phase, MSLDC has already requested STU for installation of PMUs at critical locations in MMR region and all 400 KV s/stns of MSETCL. STU has further directed TPCL, AEML & MSETCL to install the PMUs at the earliest. This work needs to be completed on priority.
- In the second phase, STU should direct all transmission utilities to install PMUs at strategic locations & RE Plants. MSLDC should simultaneously arrange to install PDCs for integration of PMUs having latest configurations and softwares required for data analytics and decision support.

### 5) Requirement of Integrated Data handling Platform:

- While carrying out post-incidence analysis, SLDC faced some challenges for handling large data sets generated at different monitoring systems. The real time analysis or any post incidence analysis in the modern power system will require handling of very large data sets. The complexity increases with multiple types of data emerging out of different systems like SCADA, PMU, Metering, Protection systems, Scheduling systems, etc.
- In this respect, MSLDC has already explored option for the use of Integrated Data handling platform having capability of integration with various softwares over different communication protocols. A Proof of Value (PoV) is successfully completed in the month of Feb-2025. Hence, there is a need to use such data handling platform at MSLDC as large sized data is daily generated. This will enhance the performance of MSLDC & the State Grid.
- SLDC needs to expedite the creation of integrated data handling platform.

### 8.2.3 Needed Regulatory Framework in the State for handling Grid disturbances

- SLDC has identified following areas in which the supportive regulatory framework would be needed for handling of Grid disturbances.
  - Establishing mechanism for availability of Spinning Reserve in the Intra-State System.
  - Need of SCED & SCUC in the State.

# Maharashtra State Load Despatch Centre

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The High-Level Committee constituted by Hon'ble MERC for enquiry of the partial Grid disturbance in MMR & Mumbai area occurred on 12.10.2020 has recommended to carry out study for implementation of SCED & SCUC for scheduling embedded generation.

Accordingly, MSLDC in collaboration with IIT, Bombay has undertaken studies using GAMS software to optimize internal resources & to consider security constraints prior to despatch of power in the State. MSLDC is the first SLDC carrying out such studies apart from NLDC.

The preliminary study report has been submitted to Hon'ble MERC on 11.11.2024. further, a petition has been filed with Hon'ble MERC on 20.03.2025 for seeking approval for carrying out pilot operation of the same in the state. The petition has been admitted vide Case No. 51 of 2025.

### 8.3 Training & Awareness, Need for SLDC & Transmission Utilities:

- The Govt. of Maharashtra Committee constituted for enquiry of the partial Grid disturbance in MMR & Mumbai area occurred on 12.10.2020 has issued following recommendations:
  - *A task force should be set up to study emerging technologies and trends, and their impact on planning of the Mumbai network. The technologies/systems may include*
    - *Electrical Vehicles/ Battery charging infrastructure and management*
    - *Grid Scale battery storage*
    - *Roof-top solar PV systems*
    - *Fault Current Limiters.*
  - *The staff of all utilities should keep abreast of the evolving trends, practices and technologies. This requires the following. (GoM Committee)*
    - *Participation in national and international seminars, workshops and tutorials.*
    - *Presenting case studies and experiences.*
    - *Access to journals and periodicals of CIGRE, IEEE, standards etc.*
    - *Peer-to-peer interactions. Sharing of experiences, best practices with other utilities.*
    - *Visit to installations of new technologies in India and abroad.*
    - *Undergoing training in continuing education programs.*

Hence, it is needed to review the existing training & awareness processes in line with above recommendations.

- MSLDC should consider creation of dedicated training cell.

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**3.2.2. State Grid Alert Report: Pune Region**

## State Grid Alert Report: Pune Region

Date: 13.05.2025

### Tripping of 400kV Talegaon PG (Pune AIS) — Lonikand-1 on 06.05.2025 at 16:31 hrs

#### Tripping Event:

On 06.05.2025 at 16:31 hrs, 400kV Talegaon PG (Pune AIS) — Lonikand-1 tripped at Lonikand -1 end only on Distance Protection and A/R operated at Talegaon PG end. After thorough line patrolling, fire was observed under the line, between Loc no 78 & 79 in sugarcane field.

#### Antecedent condition:

- 1) 400kV Talegaon PG (Pune AIS) is an important grid s/s. On dt 06.05.2025 at 12:51 Hrs 400kV bus coupler at Chakan substation was hand tripped to reduce 400kV Talegaon PG (Pune AIS) – Chakan line loading. This activity was carried out to save Koyana hydro utilization.
- 2) Due to this loading on Talegaon (PG)-Chakan and Talegaon-Lonikand line was as below

Line	Time	Loading in MW & in	Remarks
Talegaon (PG)-Chakan	16:30 hrs	533 MW (846A)	Before tripping event
Talegaon (PG)-Lonikand	16:30 hrs	802 MW (1295A)	Before tripping event

Table 33 loading on Talegaon (PG)-Chakan and Talegaon-Lonikand line

- 3) At 16:31 Hrs 400kV Talegaon PG (Pune AIS) — Lonikand-1 line tripped from lonikand end only and A/R operated successfully at Talegaon PG resulting the **State grid into an alert mode**. Any further tripping in such situation would have pushed the Grid into emergency state, with likelihood of spreading of occurrence.
- 4) Due to this ICTs at 400kV Chakan & 400 KV Chakan- Talegaon line overloaded resulting in operation of Load Trimming Scheme (LTS) Stage -I and Stage II and thus approx. 603 MW of load was automatically curtailed in Pune region.

# Maharashtra State Load Despatch Centre

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Substation wise load curtailment is as below:

Name of substation	Load in MW
220kV Bhosari -1	115
220kV Theur	16.8
220kV Chinchwad	96.08
132kV Rahatani	38.07
132kV Ganeshkhind	17.04
400kV Chakan	103
132kV sanaswadi	36.49
132kV Kuruli	21.81
220kV Chakan	78.52
220kV Bridghestone	37.25
220kV Kathapur	11.43

Table 34 Substation wise load curtailment

## **Action taken by MSLDC**

- 1) In order to avoid any further grid disturbance & to restore the tripped line, MSLDC has taken following actions:
- 2) Koyna stage-I, II & IV hydro generation (approx. 700-800 MW) was picked up.
- 3) Talegaon (PG)- Lonikand line charged from Lonikand end at 16:44 Hrs.
- 4) Load restored at 16:52 Hrs.
- 5) Koyana generation is withdrawn gradually.

## **Load curtailment: -**

- 1) The Load Trimming Scheme (LTS) on 400 KV Chakan- Talegaon line, Stage -I and Stage II operated and thus approx. 603 MW of load was automatically curtailed in Pune region.
- 2) Further, to control the loading on 400KV Talegaon (PG)- Lonikand line DLS was already started for about 25MW at 1320 A.

## **Important Measures required: -**

- 1) To expediate the 220 kV evacuation scheme from Pune GIS (Shikrapur) towards Lonikand and Ranjangaon substation.
- 2) To expediate the completion of 220 kV Talegaon PG — Chakan MIDC D/C lines.
- 3) To expedite the implementation of MVAR compensation schemes in the transmission network of Pune, MMR and Nashik region.

## Maharashtra State Load Despatch Centre

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- 4) To monitor and maintain important 400kV and 220 kV transmission grid lines connected to Pune, MMR and Nasik in view of upcoming summer season.

  
(Shashank Jewalikar)  
Executive Director, MSLDC

**Submitted w.r.s. to:**

1. Hon'ble Additional Chief Secretary (Energy), Govt. Of Maharashtra.
2. Hon'ble Chairman and Managing Director, MSETCL, Mumbai.
3. The Member Secretary, WRPC, Mumbai.
4. The Director (Operations), MSETCL, Mumbai.
5. The Director (Operations), MSEDCL, Mumbai,
6. The Director (Operations), MSPGCL, Mumbai.
7. The Executive Director, WRLDC, Mumbai.

**Copy to:**

1. The Chief Engineer, STU, C.O. MSETCL / PP, C.O. MSEDCL

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**3.2.3. System disturbance due to Multiple line tripping at 400 kV Warora substation on 10.06.2025**

# Maharashtra State Load Despatch Centre

No. 01272

Date: 18.06.2025

## System disturbance due to multiple line trippings at 400kV Warora substation on 10.06.2025.

1. **Brief description of the event:** On dated 10.06.2025 Multiple line trippings took place at 400 kV Warora substation, Nagpur Zone from 00:02 Hrs to 00:25Hrs,
2. **Utilities involved:**
  - i. MSETCL, Maharashtra.
  - ii. APMML
  - iii. IEPL.
3. **Disturbance category:** GD 1
4. **Date of Protection Last Audit Carried out:** 27.01.2023 (internal)
5. **Antecedent conditions:** -
  - i. Weather condition: Heavy wind, lightening and stormy weather condition at Warora region.
  - ii. Transmission elements loading prior to event:

Sr. No.	Transmission Line / ICT /Gen. Unit	Loading in (MW)
1	400 kV Adani ckt 1	504 MW (Imp)
2	400 kV Adani ckt 2	499 MW (Imp)
3	400 kV IEPL	177 MW (IMP)
4	400 kV PGCIL ckt	809 MW (Exp)
5	400 kV Chandrapur II ckt 1	44 MW (Exp)
6	400 kV Chandrapur II ckt 2	43 MW (Exp)
7	400/220 kV ICT 1	142 MW (EXP)
8	400/220 kV ICT 2	142 MW (EXP)
9	220 kV Bhugaon ckt 1	160 MW (EXP)
10	220 kV Bhugaon ckt 2	166 MW (EXP)
11	220 kV Warora old ckt 1	19 MW (EXP)
12	220 kV Warora old ckt 2	17 MW (EXP)
13	APML Generation Unit 1	630 MW
14	APML Generation Unit 2	650 MW
15	APML Generation Unit 3	650 MW

Table 35 Transmission elements loading prior to event

### iii. State Generation and Demand

	State Generation (MW)	State Demand (MW)
At 00:00 hrs	18178 MW	23766 MW

Source- SCADA data at MSLDC.

6. **Brief Details of System Disturbance:**
  - i. Before the disturbance, at 00:02 hrs 400kV Warora – Chandrapur 2 ckt II tripped from both ends in Z1, Bph to E. At 00:10 hrs 400kV Warora – IEPL ckt tripped from both ends due to dislocation of Rph LA at Warora end causing Rph-Yph

## Maharashtra State Load Despatch Centre

fault. The line tripped in Z1 from Warora end & tripped in Z2 at IEPL end. At 00:13 hrs 220kV Warora old ckt II got tripped from both ends in Z1, Bph-E.

- ii. At 00:25 Hrs, 400kV Warora – Adani ckt II, B ph line CVT jumper got dislocated causing Yph – B ph fault on 400kV Warora – Adani ckt II. For this fault the line tripped at Adani end in Z2, as B Ph line CVT jumper got opened main I and main II protections at Warora end got blocked due absence of line CVT voltage. Causing tripping of other lines at 400 kV Warora bus in reverse zone (Z4) and in Z2 from remote end.
- iii. APM Gen, Unit 1 also got tripped due to increased loading on 765/400 kV ICT at APM end on ICT SPS protection.

### 7. Sequence of Events on 10.06.2025:

Sr, No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	400kV Warora – Chandrapur 2 ckt II	00:02 hrs	05:34 hrs	Local: Z1, Bph to E Remote: Z1, Bph to E
2	400kV Warora – IEPL ckt	00:10 hrs	19:44 hrs	Local: Z1, R-Yph Remote: Z2, R-Yph
3	220kV Warora-warora old ckt II	00:15 hrs	03:05 hrs	Local: Z1, Bph to E Remote: Z1, Bph to E
4	400kV Warora – Adani ckt II	00:25 hrs	15:52 hrs	Local: CVT fail, M1,M2 block. Remote: Z2, Y-Bph
5	400 kV Warora- Adani ckt 1	00:25 hrs	18:43 hrs	Local: Zone 4, Phase YB, Remote: Zone2, Phase YB
6	400 kV Warora-Warora PG	00:25 hrs	06:53 hrs	Local: Zone 4, Phase YB Remote: Zone 2, Phase YB
7	400 kV Warora- Chandrapur ckt 1	00:25 hrs	02:03 hrs	Local: Zone 4, Phase YB, remote: Nil
8	220 kV Bhugaon Ckt I	00:25 hrs	03:16 hrs	HT at local end Remote: Zone 3 Phase YB,
9	220 kV Bhugaon Ckt II	00:25 hrs	03:18 hrs	HT at local end Remote: Zone 3 Phase YB
10	220kV Warora old ckt I	00:25 hrs	03:08 hrs	HT at local end, Remote: B/up, Zone 3 Start
11	Adani Gen, unit-1	00:25 hrs	08:08 hrs	SPS stage 2 for ICT at APM end.
12	400/220 kV ICT 1,2, Spare ICT & Bus Reactor	01:18	ICT1: 02:08 hrs ICT2: 03:43 hrs	HT at local end

Table 36 Sequence of Events on 10.06.2025:

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## 8. PMU data

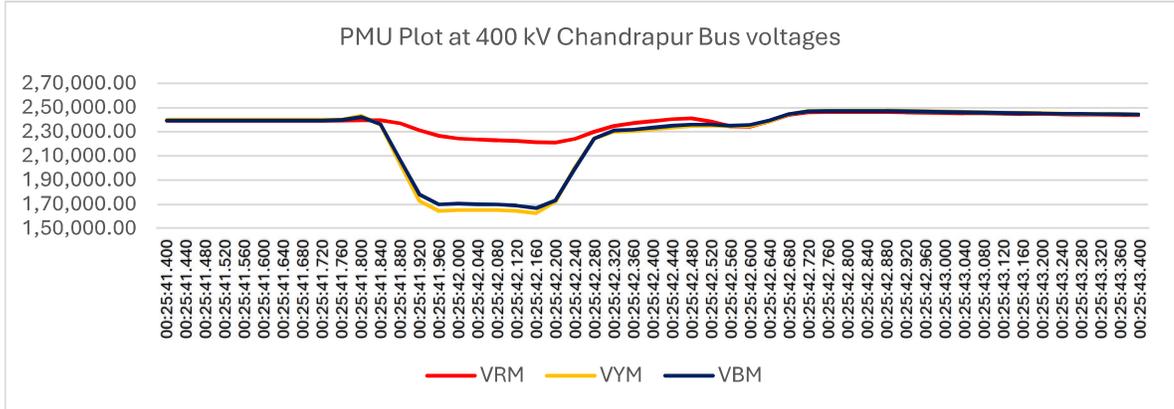


Figure 75 PMU Plot at 400 kV Chandrapur Bus voltages

Source- PMU located at 400kV Chandrapur substation.

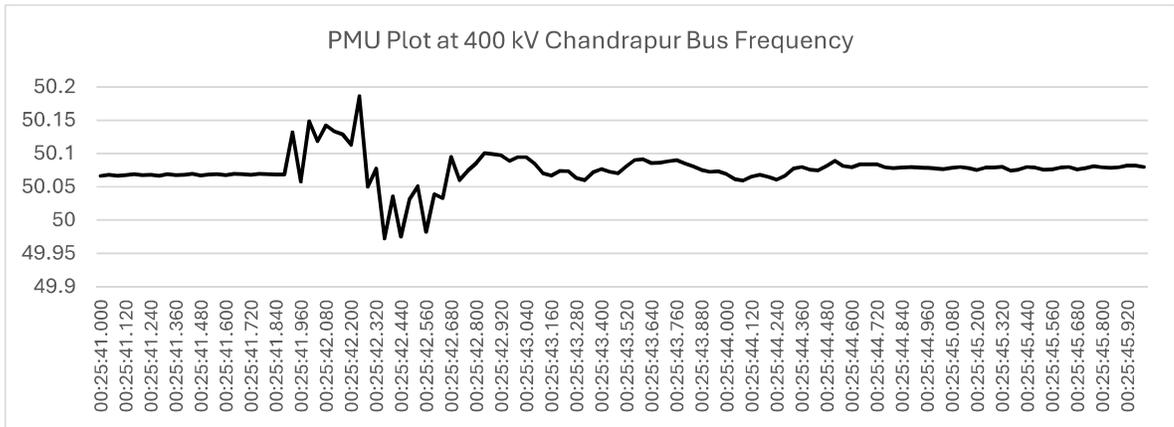


Figure 76 PMU Plot at 400 kV Chandrapur Bus Frequency

Source- PMU located at 400kV Chandrapur substation

### Observations from PMU plots:

Sr.No	Parameter	Values
1	Voltage drop	239.6 kV to 165. 2kV Voltage drop of 74kV
2	Frequency disturbance	50.18 Hz (max) to 49.97 Hz (min)
3	Duration	920ms

### 9. MSLDC Observations:

- i. For 400kV Warora- Adani line 2: As the Main 1 and Main 2 protections were blocked due to VT supply failure.
- ii. 400kV Warora-IEPL line tripped in Z2 at IEPL end. The Carrier aided Scheme for this line did not operate.
- iii. 400kV Warora PG, 400kV IEPL, 400kV APLM & 400kV Chandrapur 2 line got tripped in zone 2 from remote ends.

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- iv. The ICTs 1 and 2 were feeding the fault, Its ICT IV O/C, EF protections did not operate during the disturbance as ROT comes out to be more than the Zone 3 time delays of 220 kV Lines at remote ends.
- v. APML Gen, Unit 1 also got tripped on ICT SPS protection due to Transmission constraint as 765/400 kV ICT was only generation evacuation path.

## **10. Remedial Measures Suggested:**

- i. Relays unblocking logic & settings in Case VT fuse fail needs to be verified.
- ii. Non operation of carrier aided trip at IEPL to be reviewed.
- iii. The zone 2-time delays at 400 kV Warora end and remote ends needs to be reviewed in accordance with the protection guidelines.
- iv. The Time coordination of ICT 1 & 2's HV, IV OC/EF relays need to be reviewed in accordance with the bus fault levels and protection guidelines.
- v. Reverse zone time delays of all 400 kV feeders at 400 kV Warora end needs to be complying to protection manual. deviations if any needs to be justified.
- vi. During Such events when Transmission constraints arise for generation evacuation at 400 kV APML end, Hence an Additional 765/400 kV ICT needs to be provided.
- vii. Protection Audit of 400 kV Warora substation to be carried out at earliest.

Submitted for information please



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

## **Submitted w.r.s. to:**

- 1. The Director (Operations), MSETCL, Mumbai.
- 2. The Executive Director, WRLDC, Mumbai.
- 3. The Executive Director, MSLDC, Airoli.
- 4. The Chairperson, State PCC and The Chief Engineer (ACI&P)  
---- It is requested to include this disturbance in the upcoming state PCC meeting.
- 5. The Chief Engineer, STU, C.O. MSETCL.
- 6. The Superintending Engineer, Protection, WRPC, Mumbai.

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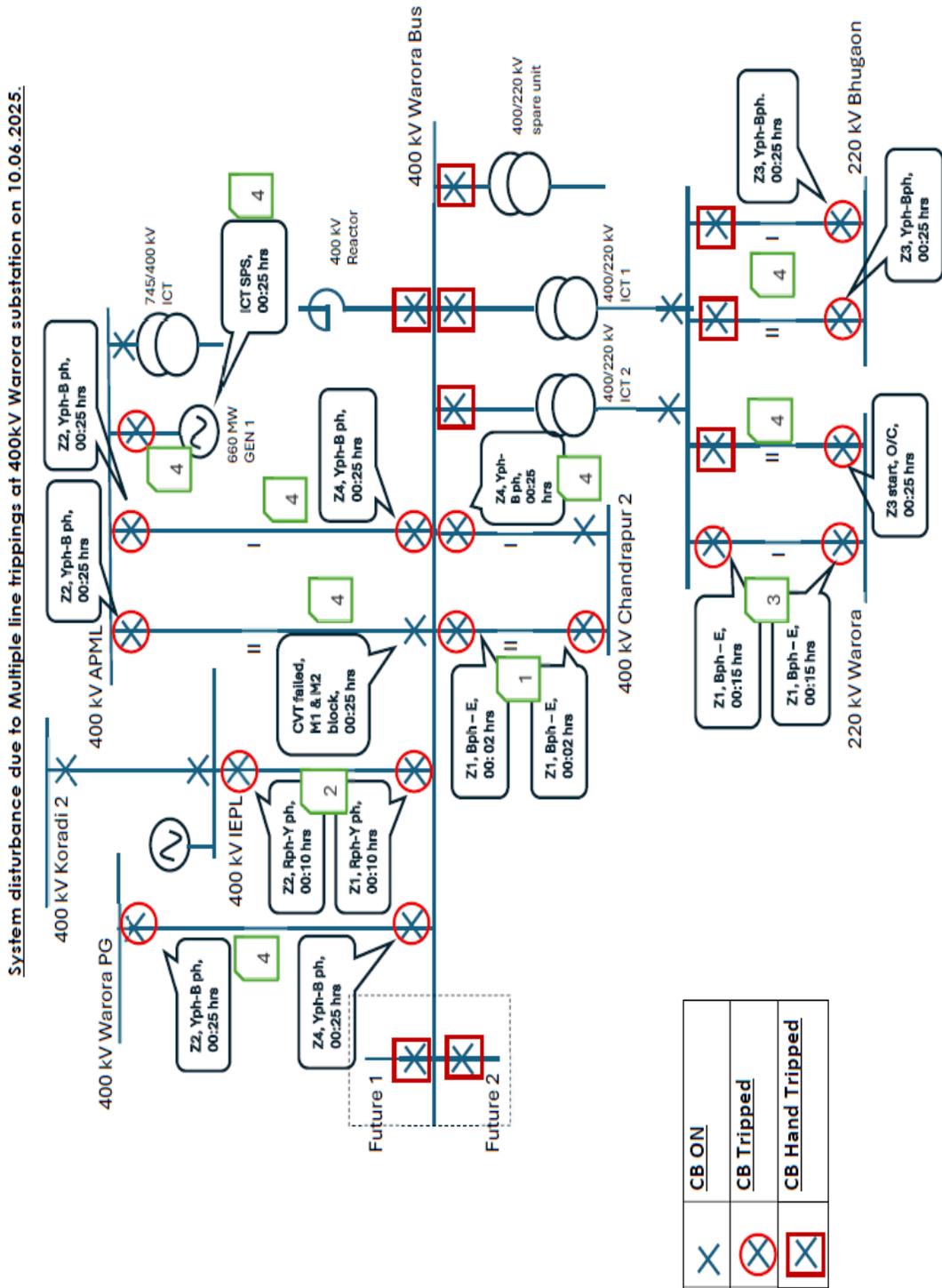


Figure 77 System disturbance due to multiple line trippings at 400kV Warora substation on 10.06.2025

**3.2.4. Occurrence at 400 kV Karad substation due to non-operation of 220 kV RADSS make bus bar scheme on 29.06.2025.**

# Maharashtra State Load Despatch Centre

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**No. 01475**

**Date: 11.07.2025**

**Occurrence report at 400kV Karad ss due to non-operation of 220kV RADSS make Busbar on 29.06.2025 at 05:25 Hrs.**

1. **Brief description of the event:** On 29.06.2025 at 05:25 Hrs. at 400 kV Karad s/s, during bus fault at 220 kV Oglewadi Line Bay, the 220kV Busbar protection failed to operate causing tripping of elements connected to 220kV Bus-1 and 03 nos of 315 MVA, 400/220kV ICTs along with 220kV Bus coupler.
2. **Utilities involved:** MSETCL, Maharashtra.
3. **Disturbance category:** GD 1
4. **Date of Protection Last Audit Carried out:** 26,27,28 May 2025 (internal)
5. **Antecedent conditions:** -
  - i. Weather condition: Cloudy.
  - ii. Transmission elements loading prior to event:

Sr No	Name of elements on 400 kV main bus 1	Loading in (MW)	Sr No	Name of element on 400 kV main bus 2	Loading in (MW)
1	400 kV Talandge 2	186 (Imp)	5	400 kV Talandge 1	187 (Imp)
2	400 kV N-Koyna 2	162 (Exp)	6	400 kV Jejuri	309 (Exp)
3	400 kV Jaigadh 1	64 (Imp)	7	400 kV Solapur PG	198 (Imp)
4	315 MVA,400/220 kV ICT 1	23 (Exp)	8	400 kV N-Koyna 1	163 (Exp)
			9	400 kV Jaigadh 2	65 (Imp)
			10	315 MVA,400/220 kV ICT 2	23 (Exp)
			11	315 MVA,400/220 kV ICT 3	23 (Exp)

*Table 37 Transmission elements loading prior to event main bus 1*

Sr No	Name of elements on 220 kV main bus 1	Loading in (MW)	Sr No	Name of element on 220 kV main bus 2	Loading in (MW)
1	220 kV Sadawaghpur 2	27 (Imp)	8	220 kV Kiniwathar	31 (Exp)
2	220 kV Khanapur	24 (Exp)	9	220 kV Dasgaon	17 (Exp)
3	220 kV Kadegaon	43 (Exp)	10	220 kV Nerle	46 (Exp)
4	220 kV Oglewadi 1	05 (Imp)	11	220 kV Hiwarwadi	09 (Exp)
5	220 kV Mudshingi 4	14 (Exp)	12	220 kV Malharpeth	29 (imp)
6	220 kV Nigde	36 (Imp)	13	220 kV Mudshingi 2	14 (Exp)
7	315 MVA,400/220 kV ICT 1	23 (Imp)	14	220 kV Oglewadi 2	05 (Imp)
			15	220 kV Sadawaghapur 1	27 (Imp)
			16	315 MVA,400/220 kV ICT 2	23 (Imp)
			17	315 MVA,400/220 kV ICT 3	23 (Imp)

*Table 38 Transmission elements loading prior to event main bus 2*

*Source- ABT data at 400 kV Karad SS at 05:00 Hrs*

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### iii. State Generation and Demand

	State Generation (MW)	State Demand (MW)
At 05:15 hrs	15190 MW	21427 MW

*Source- SCADA data at MSLDC.*

**6. Generation / Load affected:** Nil

**7. Brief Details of System Disturbance:**

On dated 29.06.2025 at 05:25 Hrs, at 400 kV Karad s/s the 220 kV Oglewadi Line's R-ph stub bus string insulator flash-over took place. Due to flash-over the R-ph conductor (CB to CT) dis-engaged from its hardware & came in vicinity with the sub bus gantry structure. For this bus fault, 220kV Busbar protection failed to operate causing all lines connected to 220kV main bus-1 tripping on Distance protection, zone-2 from remote ends. The 220kV Kadegaon line, 220 kV Bus-coupler and 315 MVA, 400/220 kV ICT-1 also tripped on back up protection.

Furthermore, 315 MVA, 400/220 kV ICT-2 and 315 MVA, 400/220 kV ICT-3 connected to 220 kV main bus-2 tripped on HS OC protection. The cause for non-operation of 220 kV RADSS busbar was investigated by MSETCL. It was found that aux CTs used in busbar cores of ICT-1,2 & 3 were not in accordance with the high impedance busbar scheme. The same were replaced and busbar scheme was tested on 03.07.2015 and busbar scheme operation found in order.

**8. Sequence of Events on 29.06.2025:**

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	315 MVA, 400/220 kV, ICT-2 (on 220 kV main bus 2)	20.05.25 05:25 Hrs	20.05.25 06:53 Hrs	B/up prot. R ph HS,86A, B.
2	315 MVA, 400/220 kV, ICT-3 (on 220 kV main bus 2)	20.05.25 05:25 Hrs	20.05.25 06:56 Hrs	B/up prot. OC DMT
3	220 kV Bus Coupler	20.05.25 05:25 Hrs	20.05.25 07:02 Hrs	B/up prot. R ph HS,86A, B.
4	315 MVA, 400/220 kV, ICT-1 (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 07:06 Hrs	B/up prot. OC IDMT, 86 optd
5	220 kV Mudshingi-4 (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 07:12 Hrs	Local: Nil Remote: Rph, Z2, 2.4 kA, 79.9 km.
6	220 kV Vita-1 (Khanapur) (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 07:17 Hrs	Local: Nil Remote: Rph, Z2, 788.4 A, 79.58 km.
7	220 kV Nigde (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 07:24 Hrs	Local: Nil Remote: Rph, Z2, 45.9 km.
8	220 kV Sadawaghapur-2 (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 08:14 Hrs	Local: Nil Remote: Rph, Z2,

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9	220 kV Oglewadi (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 14:26 Hrs	Local: Nil Remote: Rph, Z2, 1.014 A, 8.98 km.
10	220 kV Kedgaon (on 220 kV main bus 1)	20.05.25 05:25 Hrs	20.05.25 07:10 Hrs	Local: Nil Remote: B/up prot

Table 39 Sequence of Events on 29.06.2025

## 9. PMU data

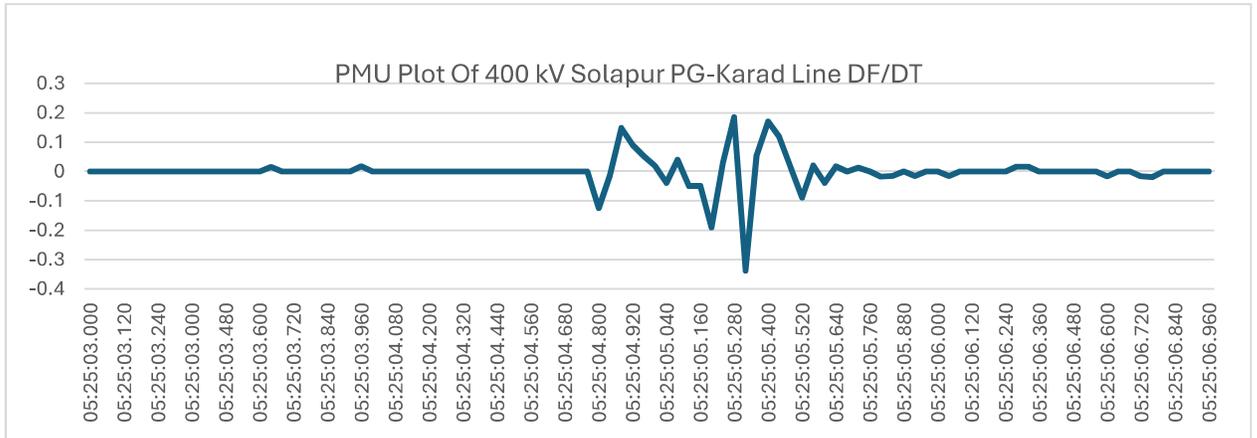
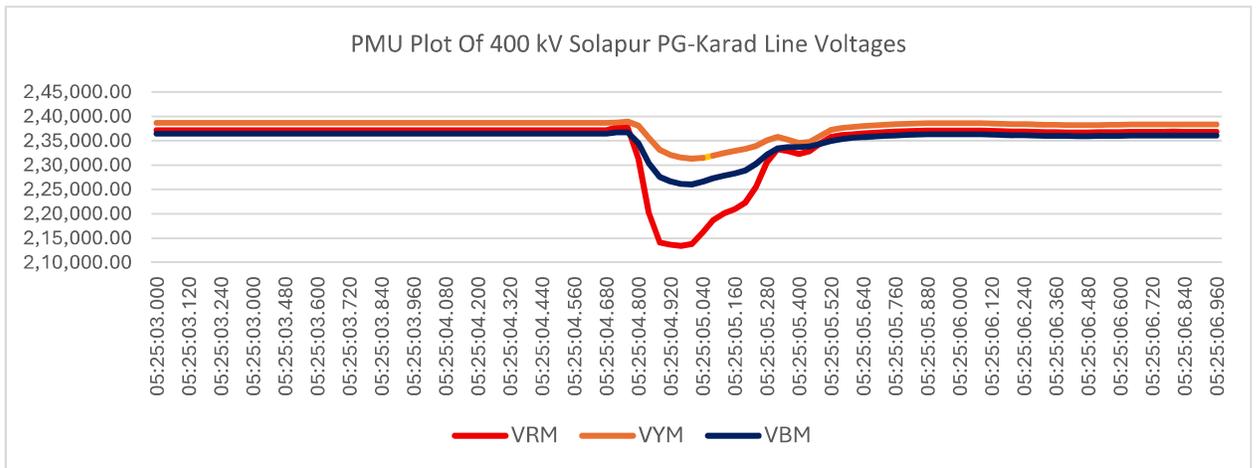


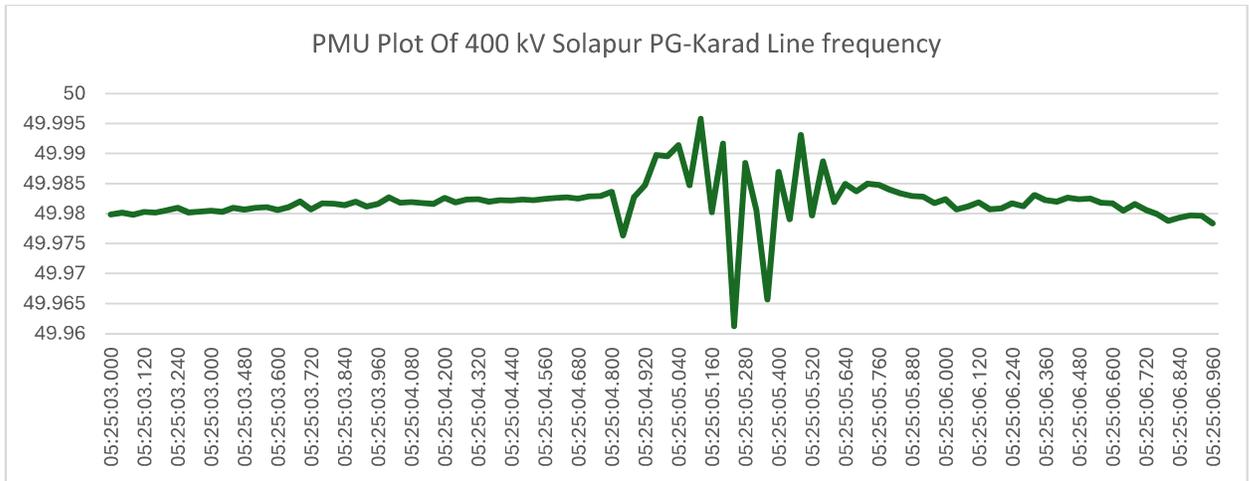
Figure 78 PMU Plot Of 400 kV Solapur PG-Karad Line DF/DT

Source- PMU located at 400 kV Solapur PG ss on 400kV Solapur PG-Karad Line



Source- PMU located at 400 kV Solapur PG ss on 400kV Solapur PG-Karad Line.

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Source- PMU located at 400 kV Solapur PG ss on 400kV Solapur PG-Karad Line.

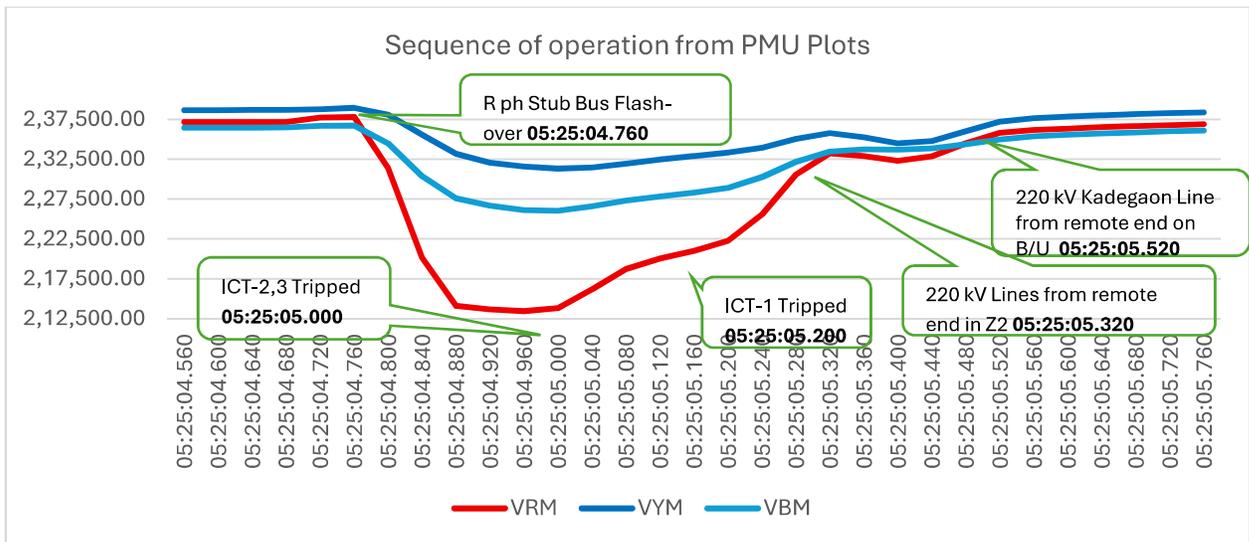


Figure 79 Sequence of operation from PMU Plots

### Observations from PMU plots:

Sr.No	Parameter	Values
1	Voltage drop	236.4 kV to 213.4kV, Voltage drop of 23kV
2	Frequency disturbance	49.99 Hz (max) to 49.96 Hz (min)
3	Duration of voltage drop	720ms

Table 40 Observations from PMU plots:

# Maharashtra State Load Despatch Centre

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## **10. MSLDC Observations:**

- i. 220 kV Busbar Protection failed to operate for bus fault in 220 kV Ogalewadi-1 bay.
- ii. During the occurrence, ICT-2 and ICT-3, HV side High-Set OC protection operated (ICT-2,3-165ms) before 220 kV bus coupler (DMT delay-0.2sec), which is undesirable. Before operation of HV High-Set OC protection of ICT-2 and ICT-3, protections of Bus coupler should have isolated the fault.
- iii. During the occurrence, all 220 kV lines connected to 220 kV main bus-1 should have tripped on distance protection in reverse zone and the 220 kV lines connected bus-2 should have picked up on distance protection in reverse zone.
- iv. 220 kV Kadegaon line did not trip in zone-2 from remote end. The 220 kV Kadegaon line tripped on back up protection from 220 kV Kadegaon End.
- v. After this Occurrence, all ICTs LV CT ratios changed to 800/1 from 1600/1. Aux CTs of all ICTs of 220 kV Side busbar protection were replaced. The Base CT ratio for 220 kV busbar is kept 1200/1.

## **11. Remedial Measures Suggested by MSLDC:**

- i. The Time co-ordination between ICT-1, ICT-2 and ICT-3 HV high-set and bus-coupler protections need to be verified for such cases and modifications in protection settings needs to be carried out accordingly.
- ii. The Time coordination settings of ICT-1 ,2 and 3's HV, IV OC/EF relays for High set & Normal inverse functions need to be reviewed in accordance with the bus fault levels and protection guidelines.
- iii. At 400 kV Karad ss, settings for reverse zone function of all distance relays needs to be verified in context of non-operation/ non-pickup. The reverse zone function to be tested for same fault.
- iv. For 220kV Karad- Kadegaon line non operation of distance relay at 220 kV Kadegaon end need to be analyzed.
- v. Old RADSS busbar needs to be replaced with new numerical busbar.
- vi. During Busbar testing the Aux CTs knee point testing & primary resistance measurement needs to be carried out.

Submitted for information and needful action please.



(Girish Pantoji)  
Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

# Maharashtra State Load Despatch Centre

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**Submitted w.r.s. to:**

1. The Director (Operations), MSETCL, Mumbai.
2. The Executive Director, MSLDC, Airoli.
3. The Chairperson, State PCC and The Chief Engineer (ACI&P) ---- It is requested to include this disturbance in the upcoming state PCC meeting.

**Copy to:**

1. The Superintending Engineer, PAC Circle, Karad, MSETCL.

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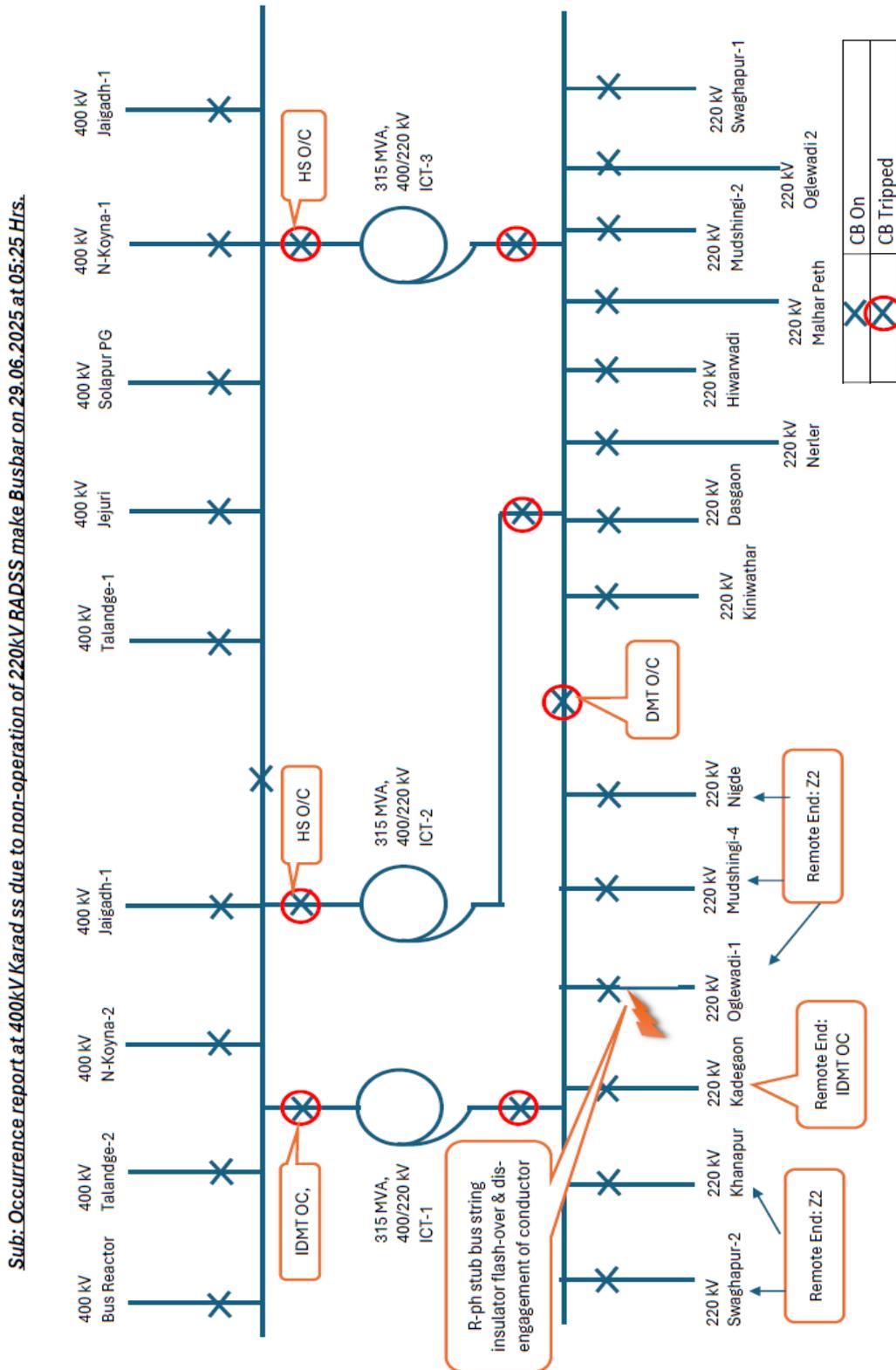


Figure 80 Occurrence at 400 kV Karad substation due to non-operation of 220 kV RADSS make bus bar scheme on 29.06.2025.

### **3.2.5. Disturbance in MMR area (Dombivali, Ambarnath, Badlapur region) in view of tripping of 220 kV Padghe Pal Line on 04.07.2025.**

# Maharashtra State Load Despatch Centre

## MAHARASHTRA STATE LOAD DESPATCH CENTER

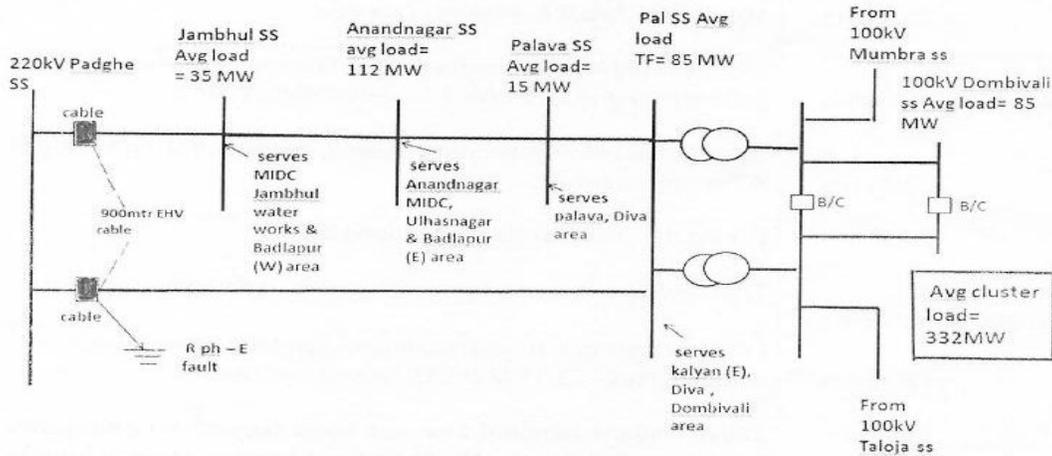
No 01583.

Date: 23.07.2025

**Disturbance in MMR area ( especially in Dombivali, Ambernath, Badlapur region) in view of tripping of 220kV Padghe-PAL line on 04.07.2025.**

**Background:**

220kV Padghe-PAL line and 220kV Padghe- Jambhul line are major source lines for 220kV PAL, 220kV Jambhul, 220kV Anandnagar, 220kV Palava & downstream 100kV Dombivali substation. These substations are feeding supply to important load centers, catering urban residential, water supply as well as industrial load in Dombivali, parts of Kalyan, Ulhasnagar, Ambernath MIDC, Badlapur, Diva area.



Above source lines are having underground cable portion about 900mtrs in length and 11km away from 400/220kV Padghe substation, rest part of lines is overhead. LTS setting on 220kV Jambhul-Anandnagar line is 728 A for 1.3 sec.

**Incidence & LTS operations in MMR:-**

- On 4.07.2025 at 13:12 Hrs 220kV Padghe-PAL line tripped Rph –E fault. Sequences of events are as below:-

Date	Time	Description of event
04.07.2025	13:12 Hrs	220kV Padghe-PAL line tripped Rph –E fault.
	16:07 Hrs	After line patrolling trial taken & line tripped again
	20:53 Hrs	LTS operated due to overloading of Jambhul- Anandnagr line. Load affected= 61.6MW. LTS restored at 21:03 Hrs.
05.07.2025	03:42 Hrs	Again trial taken & the line tripped again. After this tripping cable fault was confirmed.

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## Disturbance in MMR region

	14:30 Hrs	For load management 100kV PAL- Talaja line taken in service & about 25 MW load of 100kV dombivali s/s diverted on 100kV Talaja s/s. ICT-1 LV & 100kV Bus coupler hand tripped at PAL s/s.
07.07.2025	10:48 Hrs	100kV PAL- Talaja line hand tripped due to overloading of 220kV Talaja to 100kV Talaja lines.
	20:02 Hrs	100kV PAL- Talaja line taken in service.
09.07.2025	11:10 Hrs	LTS operated due to overloading of Jambhul – Anandnagar line. Load affected= 61.79 MW. LTS restored at 11:16 Hrs.
	20:21 Hrs	Spare cable with termination utilized, Padghe- PAL line charged & kept for soak test.
	22:57 Hrs	During the soak test the line tripped again.
10.07.2025	08:36 Hrs	Trail taken on said line, but the line tripped immediately.
	18:45 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 62.17 MW. LTS restored at 18:47 Hrs.
	18:54 Hrs	<b>220kV Padghe-Jambhul line was hand tripped on emergency basis from Padghe s/s. The Rph circuit breaker top pad jumper found broken &amp; heavy sparking observed. Since 220kV Padghe-Jambhul was the only source line 220kV PAL, 220kV Jambhul, 220kV Anandnagar, 220kV Palava, part of 100kV Dombivali s/s went into dark , affecting total load of 265 MW</b>
	19:43 Hrs	220kV Padghe- Jambhul line charged through TBC at Padghe & thus affected load was restored.
12.07.2025	10:14 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 59.37 MW. LTS restored at 10:17 Hrs.
14.07.2025	12:43 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 58.5 MW. LTS restored at 12:57 Hrs
16.07.2025	15:29 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 53.89 MW. LTS restored at 15:32 Hrs
17.07.2025	09:37 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 55.82 MW. LTS restored at 09:41 Hrs
	09:58 Hrs	LTS operated due to overloading of Jambhul- Anandnagar line. Load affected= 47.5 MW. LTS restored at 10:04 Hrs
	11:16 Hrs	LTS operated due to overloading of Jambhul-Anandnagar line. Load affected= 60.12 MW. LTS restored at 11:22 Hrs

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## Disturbance in MMR region

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### Restoration ( Temporary ) :-

- On 19.07.2025, 220kV Padghe-PAL line was taken in service at 16:12 Hrs through 6 nos of ERS towers.
- As on date, the EHV cable fault on 220kV Padghe- PAL line is under removal process.

### MSLDC Observations/Measures:-

#### Observations:-

- It is observed that due to EHV cable failures, load loss of longer duration is taking place at many locations. Considering the duration for attending the cable faults the present practice of cable laying needs to be reviewed. It is seen that the EHV overhead corridor is lost at such places with usage of cables. This practice of using U/G EHV cable causing corridor loss to be reviewed.

#### Short term measures :-

- The cable of 220kV Padghe-PAL line needs urgent restoration, as festival of Ganapati is approaching.
- The cable portion of 900mts on source lines i.e. 220kV Padghe- PAL & 220kV Jambhul needs regular monitoring & maintenance, as these source lines caters around 250-300 MW of load in MMR
- HTLS conversion of 220kV Padghe-PAL & 220kV Padghe- Jambhul lines is to be expedited.



(Milind Deole)  
Chief engineer ( I/C),  
MSLDC, Airoli.

### Submitted w.r.s. to:-

1. The Director (Operations), MSETCL, Mumbai.
2. The Director ( Projects), MSETCL, Mumbai.
3. The Executive Director, MSLDC, Airoli.

### Copy f.w.cs.to:-

1. The Chief Engineer, STU, C.O. MSETCL.
2. The Chief Engineer, Trans O&M , C.O. MSETCL.

## **3.2.6. Long Duration Load Loss in Pune Region.**

# Maharashtra State Load Despatch Centre

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**Long Duration load loss in Pune Region**

**Date: 07.07.2025**

**Trippings on 220 kV Pegasis- Infosys line and 220 kV Pirangut – Hingewadi-2 line on 02.07.2025 and 06.07.2025 respectively due to EHV Cable Faults.**

**Antecedent Condition: -**

On 02.07.2025 at 20:21Hrs, 220 kV Pegasis- Infosys line tripped from both ends on Rph-E due to cable fault. After this tripping, 220 kV Pirangut ss, 220 kV Hingewadi-2 ss and 220 kV Pegasus ss were fed by 220 KV Kandalgaon ss. And 220 kV Infosys ss, 220 kV Hingewadi-1 ss were fed from 220 Chinchwad-2 ss.

To have redundancy of supply for 220 kV Infosys ss, Bunching was attempted from 220 kV Pirangut- Hingewadi-2 line to 220 kV Infosys – Hingewadi-1 on 06.07.2025.

**Tripping Event:**

During Charging of the bunching arrangement at 14:09 Hrs on 06.07.2025, 220 kV Pirangut- Hingewadi-2 line got tripped at 220 kV Hingewadi-1, 220 kV Pirangut end alongwith 220 kV bus coupler at 220 kV Chinchwad-2 ss.

Due to these trippings, 220 kV Flag ship ss and 220 kV Hingewadi-1 ss supply failed. The Supply to 220 kV Flagship ss was restored from 220 kV Parvati ss at 14:26 Hrs. The 220kV Hingewadi-1 ss supply was restored from 220 kV Chinchwad-2 ss at 14:38 Hrs by charging of 220 kV bus coupler.

At 17:09 Hrs, the bunching arrangement was removed and 220 kV Hingewadi-1- Infosys line was taken in service.

The 220 kV Pirangut- Hingewadi-2 was charged again after removal of bunching arrangement and while charging it tripped again. The Cable section of 220 kV Pirangut- Hingewadi-2 line was then isolated and Line was charged.

The load Loss during above said tripping are as bellows:

Sr. No.	Substation	Date & Time	Duration	Load loss
1	220 kV Hingewadi-1	02.07.2025 20:21 Hrs to 20:43 Hrs	00:22 min	63.2 MW
2	220 kV Infosys	02.07.2025 20:21 Hrs to 21:12 Hrs	00:51 min	3.4 MW

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3	220 kV Hingewadi-2	06.07.2025 14:10 Hrs to 07.07.2025 14:30 Hrs	24:20 Hrs	50 MW Only 07 MW restored. 43 MW yet to restored.
4	220 kV Infosys	06.07.2025 14:10 Hrs 17:09 Hrs	02:59 Hrs	2.13 MW
5	220 kV Hingewadi-1	06.07.2025 14:10 Hrs to 14:40 Hrs	30 min	36 MW
6	220 kV Pegasus	06.07.2025 14:10 Hrs to 07.07.2025 07:15 Hrs	17:05 Hrs	3.16 MW
7	220 kV Nextra data	06.07.2025 14:10 Hrs	Restored by own DG set.	15.59 MW
8	220 kV Flagship	06.07.2025 14:10 Hrs to 14:26 Hrs	16 min	24 MW

*Table 41 load Loss during the event*

At Present,

1. 220 kV Pegasus – Infosys line and 220 kV Pirangut – Hingewadi-2 line (cable Portion) are not in service due to cable faults.
2. Due to above said trippings Supply to 220 KV Hingewadi-2 ss, 220 kV Pegasus ss and 220 kV Nextra Data ss got affected and the substations are in dark.
3. 220 kV Pirangut ss is on single source of supply from 220 kV Kandalgaon ss.

### **Action taken by MSLDC:**

To avoid any further grid disturbance & to restore the tripped line, MSLDC has taken following actions:

1. Instructions to restore the original orientation were given.
2. Issued codes/Instructions for trial at each time/event.

### **Remedial Measure Suggested:**

1. Redundant 220 kV corridor between Chinchwad, Hingewadi-1, Hingewadi-2, Hingewadi-3 should be planned.
2. Redundant 220 kV evacuation corridor between 400 kV Hingewadi-3 and 220kV Hingewadi-2 should also be planned in view of upcoming projects at 400kV Hingewadi-3/ Jejuri corridor.
3. Review of 220 kV Network planning in view of planned 400 kV and 765 kV network around Pune.

# Maharashtra State Load Despatch Centre

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4. Efforts should be taken to minimize the EHV Cable network while replacing it from existing overhead network to reduce such events and dependency on cable networks, in view of difficulties in restoration.

  
(Shashank Jewalikar)  
Executive Director, MSLDC

**Submitted w.r.s. to:**

1. Hon'ble Additional Chief Secretary (Energy), Govt. Of Maharashtra.
2. Hon'ble Chairman and Managing Director, MSETCL, Mumbai.
3. The Member Secretary, WRPC, Mumbai.
4. The Director (Operations), MSETCL, Mumbai
5. The Director (Operations), MSEDCL, Mumbai,
6. The Director (Operations), MSPGCL, Mumbai.
7. The Executive Director, WRLDC, Mumbai.

**Copy to:**

1. The Chief Engineer, STU, C.O. MSETCL / PP, C.O. MSEDCL

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## Maharashtra State Load Despatch Centre

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### **3.2.7. State Grid Alert Report: Mumbai and MMR region dated 30.07.2025.**

# Maharashtra State Load Despatch Centre

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## State Grid Alert Report: Mumbai and MMR Region. Date: 30.07.2025

**Tripping of 400 kV Padgha (PG) - Navi Mumbai (PG) Line and 400 kV Padgha (PG) – Kharghar line on 30.07.2025 at 03:45 hrs and 12:20 hrs respectively.**

### Antecedent Grid condition:

- 1) The AEML Dahanu Generation unit -1, 250MW is under planned outage.
- 2) 400 kV Padghe (PG)–Navi Mumbai (PG) line and 400 kV Padgha (PG) – Kharghar lines are critical source lines for Mumbai and MMR region.
- 3) The loadings of Major 400 kV Source lines to Mumbai before incident were as below:

Sr. No.	Line	Loading at 03:00 hrs	Remarks
1	400 kV Kalwa -Padghe ckt 1	273 MW	Import to Kalwa
2	400 kV Kalwa -Padghe ckt 2	275 MW	Import to Kalwa
3	400 kV Padgha (PG) – Kharghar	491 MW	Import to Kharghar
4	400 kV Navi Mumbai (PG) - Vikroli	185 MW	Import to Vikroli
5	400 kV Talegaon (PG) – Kharghar	452 MW	Import to Kharghar
6	400 kV Talegaon (PG) – Navi Mumbai (PG)	452 MW	Import to Navi Mumbai
7	400 kV Kalwa – Vikroli	140 MW	Import to Kalwa
8	400 kV Kharghar-Kalwa	202 MW	Import to Kalwa
9	500 kV HVDC Bi-Pole	639 MW	Import to Padgha

Table 42 loadings of Major 400 kV Source lines to Mumbai before incident

- 4) Mumbai Generation: 734 MW
- 5) State Generation: 13777 MW

Mumbai Demand: 2090 MW  
State Demand: 18415 MW

# Maharashtra State Load Despatch Centre

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## Grid Alert:

- 1) At 03:45 hrs; 400kV Padghe (PG)–Navi Mumbai (PG) line tripped on B ph- E fault from both ends. A trial was carried out at 07:45 hrs, but the line again tripped on SOTF, indicating persistent fault. The line is under breakdown condition.
- 2) At 12:20 hrs, 400 kV Padgha (PG) – Kharghar line tripped on Rph- E fault and at the same time, LBB protection operated at 400 kV Padgha (PG) ss. **These tripping pushed the State Grid Alert state: Mumbai and MMR Region.**
- 3) Due to Tripping of the above two lines, the loading on 400 kV source lines to Mumbai changed as below:

Sr. No.	Line	Loading in MW at 15:00 hrs	Remarks
1	400 kV Kalwa -Padghe ckt 1	657 MW	Import to Kalwa
2	400 kV Kalwa -Padghe ckt 2	672 MW	Import to Kalwa
3	400 kV Padgha (PG)- Kharghar	<b>0 MW</b>	<b>Line tripped</b>
4	400 kV Navi Mumbai (PG) - Vikroli	78 MW	Import to Vikroli
5	400 kV Talegaon (PG) – Kharghar	598 MW	Import to Kharghar
6	400 kV Talegaon (PG) – Navi Mumbai (PG)	561 MW	Import to Navi Mumbai
7	400 kV Kalwa – Vikroli	218 MW	Import to Vikroli (Flow reversed)
8	400 kV Kharghar-Kalwa	57 MW	Import to Kharghar (Flow reversed)
9.	500 kV HVDC Bi-Pole	1271 MW	Towards Padgha

Table 43 Changed loading on 400 kV source lines to Mumbai

- 4) Mumbai Generation: - 1364 MW      Mumbai Demand: 3105 MW
- 5) State Generation:            15369 MW      State Demand: 21844 MW
- 6) At 14:53 hrs, a trial was taken on 400 kV Padgha(PG) – Kharghar line, it immediately got tripped on Rph -E, SOTF.
- 7) The Padgha(PG) – Navi Mumbai (PG) line was charged at 16:45 hrs. The line tripped at 16:48 hrs on Yph- E fault.

# Maharashtra State Load Despatch Centre

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## **Actions taken by MSLDC**

To avoid any further grid disturbance, MSLDC has taken following actions:

- 1) Tata Thermal unit-8 picked up to its full capacity i.e. 250 MW. at 10:15hrs
- 2) AEML Dahanu Generation unit -2 picked up to its full capacity at 10:15 hrs.
- 3) Tata Thermal Unit 5-picked up to its full capacity i.e. 500 MW at 12:30hrs.
- 4) Tata Hydro picked up to its full capacity i.e. 447 MW at 12:46 hrs.
- 5) Nashik Thermal Generation Unit 3, 4 and 5 picked up to its full capacity i.e. 422MW at 13:45 hrs.
- 6) Ghatghar Hydro Generation was picked up (125 MW) at 13:25 to 16:30 hrs.
- 7) Till time, MSLDC is continuously following up with PGCIL (WRTMC-1), Sterlite control room & WRLDC for early restoration of lines.
- 8) There is NO Load curtailment in Mumbai & MMR region.
- 9) All the stakeholders are informed to be on alert and ensure the availability of lines and equipment feeding the Mumbai and MMR area.



**Shashank Jewalikar**  
**Executive Director, MSLDC**

## **Submitted w.r.s. to:**

1. Hon'ble Additional Chief Secretary (Energy), Govt. Of Maharashtra.
2. Hon'ble Chairman and Managing Director, MSETCL, Mumbai.
3. The Member Secretary, WRPC, Mumbai.
4. The Director (Operations), MSETCL, Mumbai.
5. The Director (Operations), MSEDCL, Mumbai, 6. The Director (Operations), MSPGCL, Mumbai.
7. The Executive Director, WRLDC, Mumbai.

## **Copy to:**

1. The Chief Engineer, STU, O&M C.O. MSETCL
2. The Chief Engineer PP, C.O. MSEDCL.

# Maharashtra State Load Despatch Centre

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## **3.2.8. State Grid Alert Report: Mumbai and MMR region dated 30-31.07.2025.**

# Maharashtra State Load Despatch Centre

## State Grid Alert Report: Mumbai and MMR Region.

Date: 02.08.2025

In continuation with State Grid Alert Report: Mumbai and MMR Region on 30 & 31.07.2025

### The state grid alert state continues.

Presently, following 400 kV source lines to Mumbai are under forced outage / Breakdown.

Sr. no.	400 kV source lines to Mumbai, MMR	B/D from
1	400 kV Padgha (PG) – Kharghar	12:20 hrs, on 30.07.2025
2	400 kV Padgha (PG) – Navi Mumbai (PG)	03:45 hrs, on 30.07.2025
3	400 kV Navi Mumbai (PG) – Vikhroli	03:24 hrs, on 31.07.2025

Table 44 400 kV source lines to Mumbai are under forced outage / Breakdown.

The 250 MW Dahanu generation Unit 1 is under planned outage.

### Sequence of events subsequent to earlier grid alert report on 31.07.2025-

Sr. No	Date	Time	Event
1	01.08.2025	01:20 hrs	A test charge trial (up to location no. 56) from Kharghar end was taken on 400 kV Padgha (PG) – Kharghar line. The trial was successful
2		08:45 hrs	400kV Padgha(PG)- Kharghar line hand tripped from Kharghar end.
3		21:53 hrs	Trial was attempted on 400 kV Padgha (PG) – Kharghar line (up to location no. 56) from Padgha (PG) end. The trial failed and the line tripped
4	02.08.2025	00:47 hrs	HVDC Pole-2 tripped on DC differential current trip indication at Padgha end.
5		05:58 hrs	HVDC Pole-2 taken in service.
6		12:12 hrs	Outage availed on 220kV Adani – Ghodbunder line for formation of 220kV Borivali-Kudus ckt-II.

# Maharashtra State Load Despatch Centre

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7	16:53 hrs	400kV Pune GIS – Talegaon (PG) & 400kV Talegaon (PG)-Vikhroli lines tripped simultaneously.
8	17:20 hrs	400kV Talegaon (PG)- Vihkroli line taken in service.
		400 kV Pune GIS- Talegaon PG line is under breakdown

Table 45 Sequence of events subsequent to earlier grid alert report on 31.07.2025

### **Actions taken by MSLDC**

To avoid any further grid disturbance, MSLDC has taken following actions:

- 1) Tata Thermal unit-8 picked up to its full capacity i.e. 250 MW. at 10:15 hrs on 30.07.2025.
- 2) AEML Dahanu Generation unit -2 picked up to its full capacity at 10:15 hrs, on 30.07.2025.
- 3) Tata Thermal Unit 5-picked up to its full capacity i.e. 500 MW at 12:30hrs, on 30.07.2025.
- 4) Tata Hydro picked up to its full capacity i.e. 447 MW at 12:46 hrs, on 30.07.2025.
- 5) Nashik Thermal Generation Unit 3, 4 and 5 picked up to its full capacity i.e. 422MW at 13:45 hrs, on 30.07.2025.
- 6) Ghatghar Hydro Generation was picked up (125 MW) at 13:25 to 16:30hrs, on 30.07.2025.
- 7) Till time, MSLDC is continuously following up with PGCIL (WRTMC-1), Sterlite control room & WRLDC for early restoration of lines.
- 8) There is NO Load curtailment in Mumbai & MMR region.
- 9) The LTS settings of 400kV Kalwa- Padgha ckt 1&2 are revised to 2310 A on 31.07.2025.
- 10) All the stakeholders are informed to be on alert and respond to MSLDC instructions promptly in real time.

### **Actions proposed by MSLDC**

A Meetings were conducted on 31st July 2025, 1st August 2025, and 2nd August 2025 with key stakeholders including WRLDC, AEML, TPC, and Sterlite to discuss the recent contingencies affecting the Mumbai region.

During these deliberations, it was observed that the tripping in the MUMML transmission network are primarily attributed to multiple failures of polymer insulators. The issue has been identified as a significant contributor to the recurring disturbances, necessitating urgent remedial actions and a thorough root cause analysis for such failures. Considering the criticality of these lines and the nature of these failures, a complete replacement plan for all the insulators from this lot is essential to ensure system reliability.

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The Actions proposed by MSLDC are as below:

1. Restoration of all MUMML, one after another at an earliest in view of grid security  
..... Responsibility MUMML.
2. Revision in MMR LTS by establishing a new sensing point for 400kV VihkroliTalegaon (PG) line at 400kV Vihkroli s/s instead of existing 400kV KalwaVihkroli line.  
..... Responsibility MSETCL, KVTL.
3. All the planned activities for taking load on 400 kV Kudus to be completed on top priority.  
..... Responsibility MSETCL. AEML
5. The incidences of polymer disc insulator failures of multiple lines in Mumbai area is to be investigated thoroughly. MUMML needs to ensure that all the insulators from the faulty lot are replaced for safer grid operations of Mumbai area in upcoming seasons.  
..... Responsibility MUMML.
6. MSPGCL and TATA Power to ensure full availability of GAS generations as per requirements...  
..... Responsibility MSPGCL and TATA Power.
7. Requested to review the ongoing planned outage of ADTPS Unit-1 (from 13.07.2025 to 21.08.2025) for possible early restoration.
8. To tackle any further grid deterioration, all Generators in Mumbai area and Uran, Ghatghar generations are to be taken as per requirements. The Generation control rooms should be alert and ensure availability.
9. All the LTS and Islanding schemes shall be monitored and kept fully functional and available. No unplanned communication / protection element outage affecting these schemes shall be taken up.
10. All stakeholders are informed to be on alert mode and ensure the availability of lines and equipment feeding Mumbai & MMR area and respond to MSLDC's Control room instructions in Real Time.

## Submitted w.r.s. to:

1. Hon'ble Additional Chief Secretary  
(Energy), Govt. Of Maharashtra.
2. Hon'ble Chairman and Managing Director,  
MSETCL, Mumbai.
3. The Member Secretary, WRPC, Mumbai.
4. The Director (Operations), MSETCL, Mumbai.
5. The Director (Operations), MSEDCL, Mumbai, 6. The Director  
(Operations), MSPGCL, Mumbai.
7. The Executive Director, WRLDC, Mumbai.

  
(Shashank Jewalikar)  
Executive Director,  
MSLDC

## Copy to:

1. The Chief Engineer, STU, C.O. MSETCL
2. The Chief Engineer, PP, C.O. MSEDCL.
3. All the concerned stakeholders

## **3.2.9. Occurrence of 220 kV busbar bar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.**

# Maharashtra State Load Despatch Centre

No. 01686

Date: 05.08.2025

## Occurrence report of 220 kV Busbar protection operation at 220kV Bhosari-1 ss during first-time charging of 220 kV GIS Micro- Soft Bay (210) on 18.06.2025.

### Background:

220 kV Bhosari-1 ss is a major load centre in Pune area. It is connected to 400 kV Chakan ss & 400 kV Lonikand ss via 220 kV Lines. 220 kV Bhosari-1 ss, caters urban residential, industrial loads of @ 130 MW in Pune region.

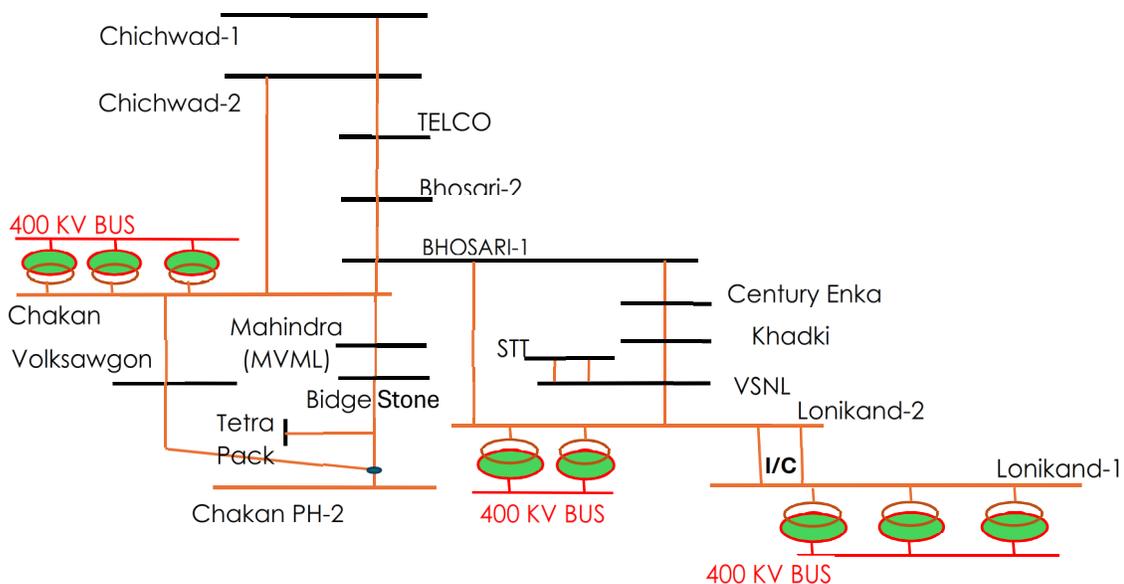


Figure 81 220 kV Network around 220 kV Bhosari-1 ss.

**Brief description of the event:** At 220 kV Bhosari -1 ss, during first time charging of 220 kV GIS Microsoft Bay (210) on 18.06.2025 20:04 Hrs., 220 kV Elements connected to 220 kV Main Bus-1 tripped due to operation of 220 kV Busbar Protection.

1. **Utilities involved:** MSETCL, Maharashtra.
2. **Disturbance category:** GD 1
3. **Antecedent conditions:**
  - i. Weather condition: clear.

# Maharashtra State Load Despatch Centre

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## ii. Transmission elements loading prior to event:

Sr No	Name of element on 220 kV main bus-section-1	Loading in (MW)	Sr No	Name of elements on 220kV main bus section-2	Loading in (MW)
1	220 kV Century Enka	54 MW (Imp)	1	220 kV Bhosari -2	158 MW (Exp)
2	220/22 kV, 80 MVA TF-1	55 MW (Exp)	2	220 kV Chakan	98 MW (Imp)
3	220 kV GIS Microsoft Line-1 Bay (211)	FTC	3	220 kV Lonikand-2 (via TBC)	132 MW (Imp)
4	220 kV GIS Microsoft Line-2 Bay (210)	FTC	4	220/22 kV, 80 MVA TF-3	47 MW (Exp)
			5	220/22 kV, 75 MVA, TF-2	24 MW (Exp)

Table 46 Transmission elements loading prior to event

## iii. State Generation and Demand

	State Generation (MW)	State Demand (MW)
At 20:00 hrs	17870 MW	24551 MW

*Source- SCADA data at MSLDC.*

## 4. Brief Details of System Disturbance:

1. On dated 18.06.2025, at 220 kV Bhosari-1 ss, first time charging of GIS 220 kV GIS busbars, 220 kV GIS Microsoft Line bays (210) & (211), 220 kV Bus Coupler along with 220 kV, 2000 Sq.mm UG cable was scheduled.
2. For FTC purpose, as a precautionary measure following works were carried out at 220 kV Bhosari-1 ss:
  - a. 220 kV Lonikand-2 line was shifted to 220 kV Bus section-1 via TBC.
  - b. 220 kV AIS bus-section (hybrid) kept open.
  - c. For 220 kV Century Enka Line the Non-directional H.S. function of B/U protection was enabled and kept as 3000A/with 150 msec delay.
3. In existing bus-bar due to non-availability of bay configuration space, 220 kV GIS Line Bay (211) was configured in parallel with 220/22 kV, 80 MVA TF-1. The tripping of bus bar trip relay was also extended to 220 kV GIS Microsoft Line Bay (211).

# Maharashtra State Load Despatch Centre

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## **5. Sequence of Events on 18.06.2025:**

Sr.No.	Time	Event
1	19:18 Hrs	220 kV GIS bus-1 was charged.
2	19:49 Hrs	220 kV GIS Microsoft Line Bay (211) along with 220 kV, 2000 Sq.mm UG cable up to 220 kV Microsoft ss line side isolator was charged.
3	20:02 Hrs	220 kV GIS Microsoft Line Bay (210) with its line side isolator open was charged.
4	20:04 Hrs	due to flash over inside interrupter chamber of 220 kV GIS Microsoft Line Bay (210), 220 kV busbar protection operated (BB2) causing tripping of elements on 220 kV bus section-1.

Table 47 Sequence of Events on 18.06.2025

After Busbar operation, the 220 kV GIS Microsoft Line Bay (210) was hand tripped, all GIS isolators were opened & the GIS was disconnected from AIS and normalcy was restored through 220 kV AIS B/S.

## **6. Tripping and Restoration details:**

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	220 kV B/S (AIS, Hybrid)	HT for FTC	20:13	HT for FTC
2	220/22 kV, 80 MVA. TF-1	20:04	20:16	BB2, Bph, Idiff :4.38 Amps
3	220 kV Century Enka Line	20:04	20:19	
4	220 kV GIS Microsoft Line-1 Bay (211)	20:04	Kept OFF	
5	220 kV GIS Microsoft Line-1 Bay (210)	HT	Kept Off	HT

Table 48 Tripping and Restoration details

**7. Generation / Load affected:** Loading on 80 MVA, 220/22 kV TF-1 : 55 MW.

## **8. MSLDC Observations:**

- i. After completion of FTC procedure of SLDC, the consent for FTC proposal for charging of 220 kV GIS busbar, 220 kV GIS Microsoft Line bays (210) & (211), 220 kV Bus Coupler along with 220 kV UG cable (2000 Sqmm) at 220 kV Bhosari-1 ss was issued and accordingly the charging code for above said elements was issued by SLDC vide code 951,952.
- ii. The protection healthiness undertaking through email for 220 kV GIS Microsoft line bay (211) was received from EE PAC-II, Pune.
- iii. At 20:04 Hrs. after charging of 220 kV GIS Microsoft Line bays (210), due to flash over inside interrupter chamber of 210 bay, the 220 kV Bus bar protection

# Maharashtra State Load Despatch Centre

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operated. 220 kV Century Enka, 220/22 kV, 80 MVA. TF-1 were tripped and as tripping command from 220 kV busbar protection was extended to 220 kV GIS Microsoft line-1 bay (211) it got tripped.

- iv. 220 kV GIS Microsoft line-2 bay (210) was not integrated in existing 220 kV busbar protection scheme. It was hand tripped after bus bar protection operation.
- v. At 220 kV Bhosari-1 ss, existing bus bar scheme is of NR make RCS91S scheme has only 10 nos. of bay configuration capacity. The scheme does not support additional bay configuration. Therefore, 220 kV GIS line bay (211) was configured in parallel with 220/22 kV, 80 MVA TF-1 and tripping command from 220 kV busbar protection was extended to 220 kV GIS Microsoft line-1 bay (211).
- vi. It is seen that ,220 kV GIS Microsoft line-2 bay (210) and 220 kV GIS B/S bay are not integrated in existing bus bar scheme and the busbar trip command was not extended for these bays.

## **9. Remarks / Remedial Measures Suggested by MSLDC:**

- i. The Protection information was not provided to SLDC in FTC proposal under format-3 (Protection Healthiness).
- ii. The existing bus bar scheme of 10 nos, bays is to be up graded to new busbar scheme at the earliest.
- iii. The occurrence needs to be discussed in SPC meeting, for eliminating such incidences in future.



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

## **Submitted w.r.s. to:**

1. The Director (Operations), MSETCL, Mumbai.
2. The Executive Director, MSLDC, Airoli.
3. The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli.
4. The Chief Engineer, EHV PC O&M Zone Pune.

## **Copy. to:**

1. The Superintending Engineer, PAC Circle Pune.

**Occurrence report of 220 kV Busbar protection operation at 220kV Bhosari-1 ss during first-time charging of 220 kV GIS Micro- Soft Bay (210) on 18.06.2025.**

**SLD for 220 kV Busbar prot.operation at 220kV Bhosari-1 ss during first-time charging of 220 kV GIS MicroSoft Bay (210) on 18.06.2025.**

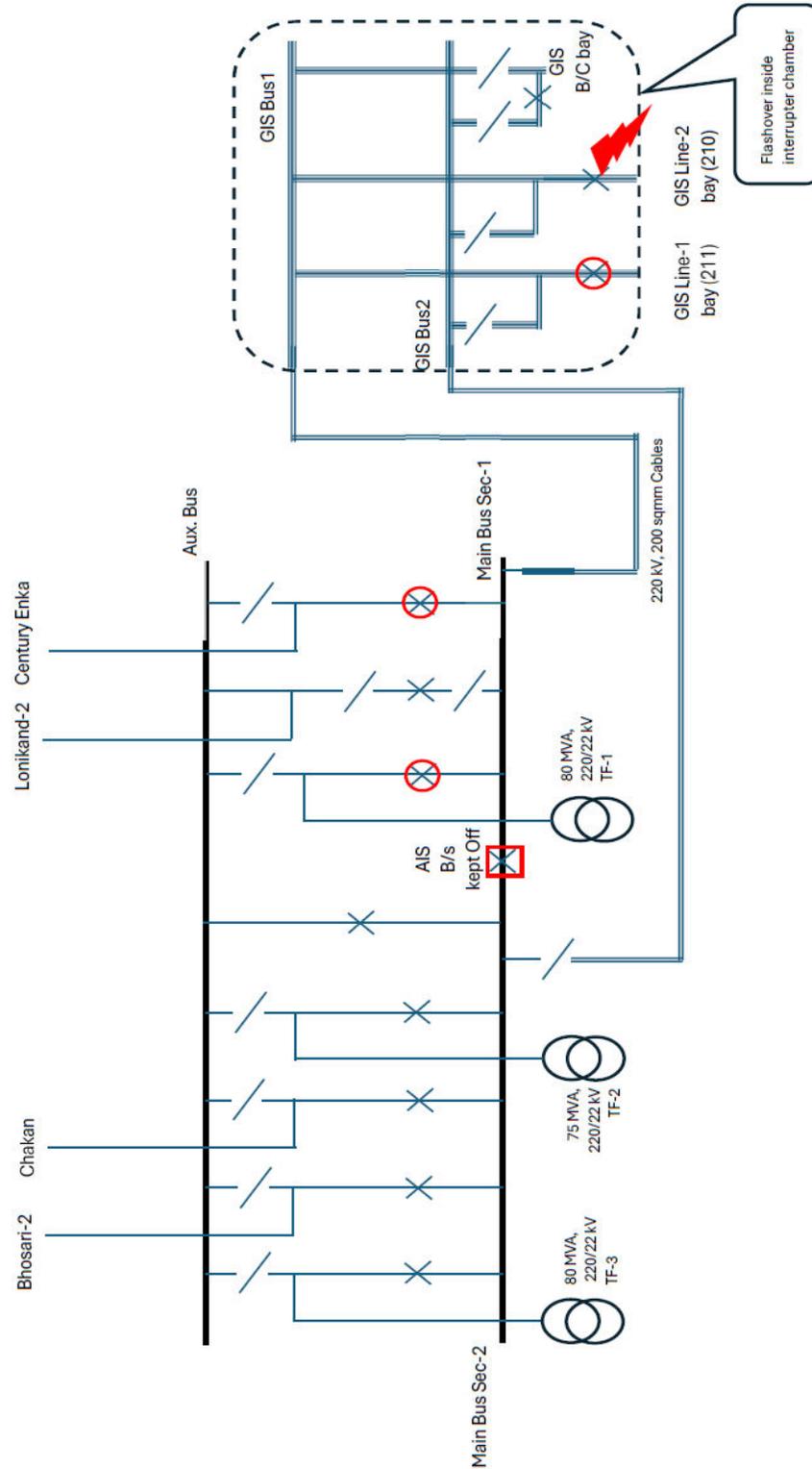


Figure 82 Occurrence of 220 kV busbar bar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.

**3.2.10. Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025.**

No. 01775

Date: 14.08.2025

## Occurrence report of multiple lines tripping at 400kV Nagothane ss on 16.07.2025.

### Brief description of the event:

On 16.07.2025 at 15:52 Hrs, during a bay shifting operation at 400 kV Nagothane Substation, 220 kV feeder bays were transferred from Main bus-I to Main bus-II via the TBC. During this process, upon switching OFF the Bus Coupler CB, the following 220 kV lines tripped simultaneously on distance protection:

- i. 220 kV Wadkhal-1
- ii. 220 kV POSCO
- iii. 220 kV Wadkhal-2
- iv. 220 kV ACCIL

1. Utilities involved: MSETCL, Maharashtra.
2. Disturbance category: GD 1
3. Date of Protection Last Audit Carried out: June 2022 (TPPA)
4. Grid Location of 220 kV Nagothane Bus:

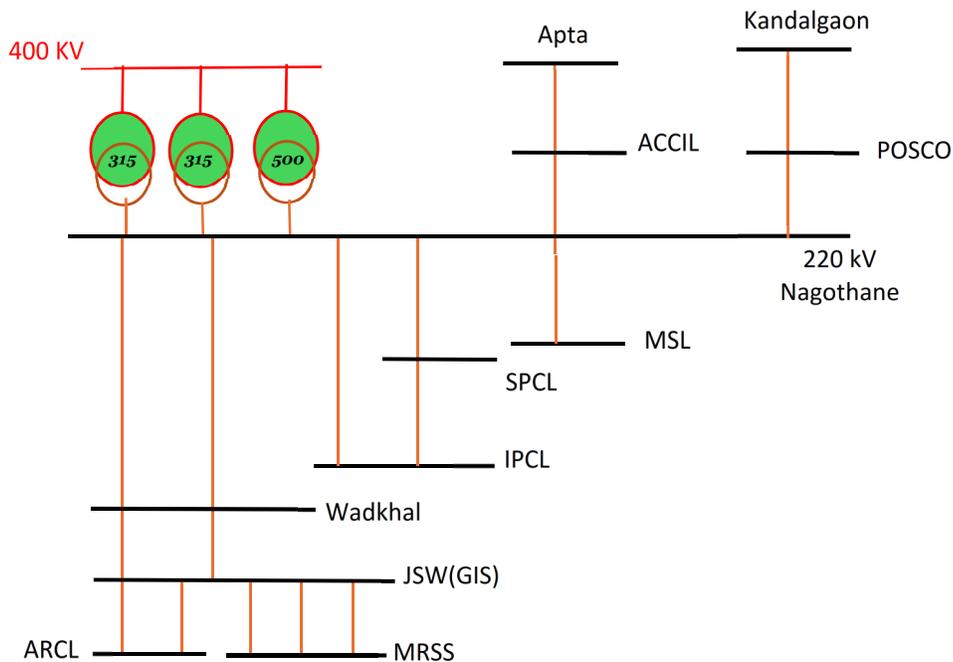


Figure 83 Grid Location of 220 kV Nagothane Bus

# Maharashtra State Load Despatch Centre

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## 5. Antecedent conditions: -

- i. Weather condition: Normal.
- ii. Transmission elements loading prior to event:
- iii. 400 kV Nagothane ss has Main-1 Main-2 + Auxiliary busbar configuration for 220 kV Level.

Sr No	Name of elements on 220 kV Main bus-I	Loading in (MW)	Sr No	Name of element on 220 kV Main bus-II	Loading in (MW)
1	400/220/33 kV 315 MVA, ICT 1	170 MW	1	400/220/33 kV, 500 MVA, ICT-3	254 MW
2	400/220/33 kV 315 MVA, ICT2	177 MW	2	220 kV Wadkhal-2	241 MW
3	220 kV Wadkhal-1	241 MW	3	220 kV ACCIL	24 MW
4	220 kV MSL	08 MW	4	220/22 kV, 25 MVA, PTR-2	02 MW
5	220 kV POSCO	40 MW	5	220 kV SPCL	17 MW
6	220/22 kV, 25 MVA, PTR-1	14 MW	..	..	..
7	220 kV IPCL	09 MW	..	..	..

Table 49 Transmission elements loading prior to event

## 6. State Generation and Demand

..	State Generation (MW)	State Demand (MW)
At 15:30. hrs	14171 MW	23483 MW

SCADA Data at MSLDC

7. Generation / Load affected: Load of 546 MW for @ 10 min.

## 8. Brief Details of System Disturbance:

- i. At 400 kV Nagothane Substation, an outage was availed on 220 kV Main bus-I to carry out connection of jumpers for the newly constructed 220 kV Bus Coupler Bay. During this outage, all associated 220 kV bays were successfully shifted from 220 kV Main bus-I to 220 kV Main bus-II to make 220 kV Main bus-1 isolated, for bus jumpering works.
- ii. After successful shifting of all 220 kV bays from 220 kV Main bus-I to 220 kV Main bus-II through the 220kV TBC, the 220kV Bus-Coupler CB was manually tripped to isolate 220kV Main bus-I.
- iii. However, upon operation (manual tripping) of the 220 kV Bus Coupler CB, multiple 220kV lines tripped simultaneously. (220KV Nagothane-Wadkhal-I, 220KV Nagothane-Wadkhal -II, 220KV Nagothane -POSCO & 220KV Nagothane -ACCIL)
- iv. The 220 kV Bus Coupler CB was closed again immediately, and the tripped feeders were restored.

# Maharashtra State Load Despatch Centre

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## 9. Sequence of Events on 16.07.2025:

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	220KV NAGOTHANE-WADKHAL-I	15:52 HRS	16:06 HRS	Dist Prot. Op., Carrier fail, Prot VT supply fail, A/R L/O.
2	220KV NAGOTHANE-WADKHAL-II	15:52 HRS	15:59 HRS	Dist Prot. Op., Prot VT supply fail, A/R L/O.
3	220KV NAGOTHANE-POSCO	15:52 HRS	16:00 HRS	Dist Prot. Op., Dist scheme VT supply fail, Definite trip L/O.
4	220KV NAGOTHANE-ACCIL	15:52 HRS	16:01 HRS	Dist Prot. Op., PDR, VT selection failed, A/R operated/ Definite trip A/R lockout, Back up O/C and E/F operated.

Table 50 Sequence of Events on 16.07.2025

### MSLDC Observations:

- i. As per the occurrence report received from the SE, PACC, Vashi, after successful shifting all 220 kV bays from 220 kV Main bus-I to 220 kV Main bus-II, and before manual tripping of the 220kV Bus-Coupler CB, PT supply to all feeder's protection relays was checked and found normal i.e. it is understood that 220 kV bus-II PT supply is selected for all these bays.
- ii. At the time of tripping, the load current was approximately 30–40% of the respective CT ratios on the 220 kV ACCIL & 220 kV POSCO lines, and the PT supply for the R & B phases was absent, causing tripping.
- iii. The PT selection scheme and the associated PT selection relays for 220kV Main Bus-1 and Bus-2 are old. Due to improper electrical operation of the PT selection relays, some, certain selection relays have to operated manually.
- iv. Following the incident, the operating coils of the PT selection relays (75B1 & 75B2) - which are used for selecting the protection cores of 220kV Bus-2 in the 220kV Wadkhal-2 and 220kV ACCIL bays—were found burnt
- v. In addition to the PT selection issues, there is also an existing problem of PT secondary mixing between 220kV PT-1 and PT-2 at 400 kV Nagothane ss. This PT mixing can lead to incorrect voltage inputs to protection relays. Also, the R and B ph PT fuses of the 220kV Main Bus-2 PT were found burnt in the PT secondary box. The PT secondary mixing issue still exists.
- vi. For the 220 kV Nagothane–ACCIL line, the Auto Reclose operated indication was observed, suggesting the operation of the Auto Reclose cycle. In addition, Backup O/C and E/F operated indications also appeared in the relay indications.

# Maharashtra State Load Despatch Centre

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vii. All the Disturbance Records (DRs) submitted for the incident were found to be not GPS time-synchronized.

## **10. Remedial Measures Suggested by MSLDC:**

- i. Considering that the existing PT selection scheme is of an old age & design, and the PT selection relays are having repeated operational issues. It is recommended to replace the existing PT selection scheme relays with new, reliable relays, and to install isolator selector switches for all bays. This upgrade is essential to ensure the proper functioning of the PT selection scheme and to enhance the overall reliability of the protection system at the substation. Also, Immediate attention is required to resolve the PT secondary mixing issue.
- ii. The PT selection scheme the trip-blocking logic and related settings of distance relays needs to be thoroughly reviewed. Any necessary modifications should be implemented to prevent such unwanted tripping in the future.
- iii. The Auto Reclose operation & Backup O/C and E/F operation indications of the 220 kV Nagothane–ACCIL line needs to be investigated, and any necessary modifications should be implemented.
- iv. All Disturbance Records (DRs) are required to be properly GPS time-synchronized to ensure accurate event analysis and correlation as per MEGC 2020, Clause No. 25.1.
- v. A third-party protection audit needs to be carried out for 400/220 kV Nagothane ss, at the earliest.

Submitted for information and needful action please.



(Girish Pantoji)

Chief Engineer (I/C), MSLDC

Encl- SLD of disturbance.

### **Submitted w.r.s. to:**

- The Director (Operations), MSETCL, Mumbai.
- The Executive Director, MSLDC, Airoli.
- The Chairperson, State PCC and The Chief Engineer (ACI&P) ---- It is requested to include this disturbance in the upcoming state PCC meeting.
- The Chief Engineer, EHV PC O&M Zone, MSETCL, Vashi.

### **Copy to:**

1. The Superintending Engineer, PAC Circle, MSETCL, Vashi

Sub: Occurrence report of multiple lines tripping at 400kV Nagothane ss on 16.07.2025

**SLD of Occurrence report of multiple lines tripping at 400kV Nagothane ss on 16.07.2025**

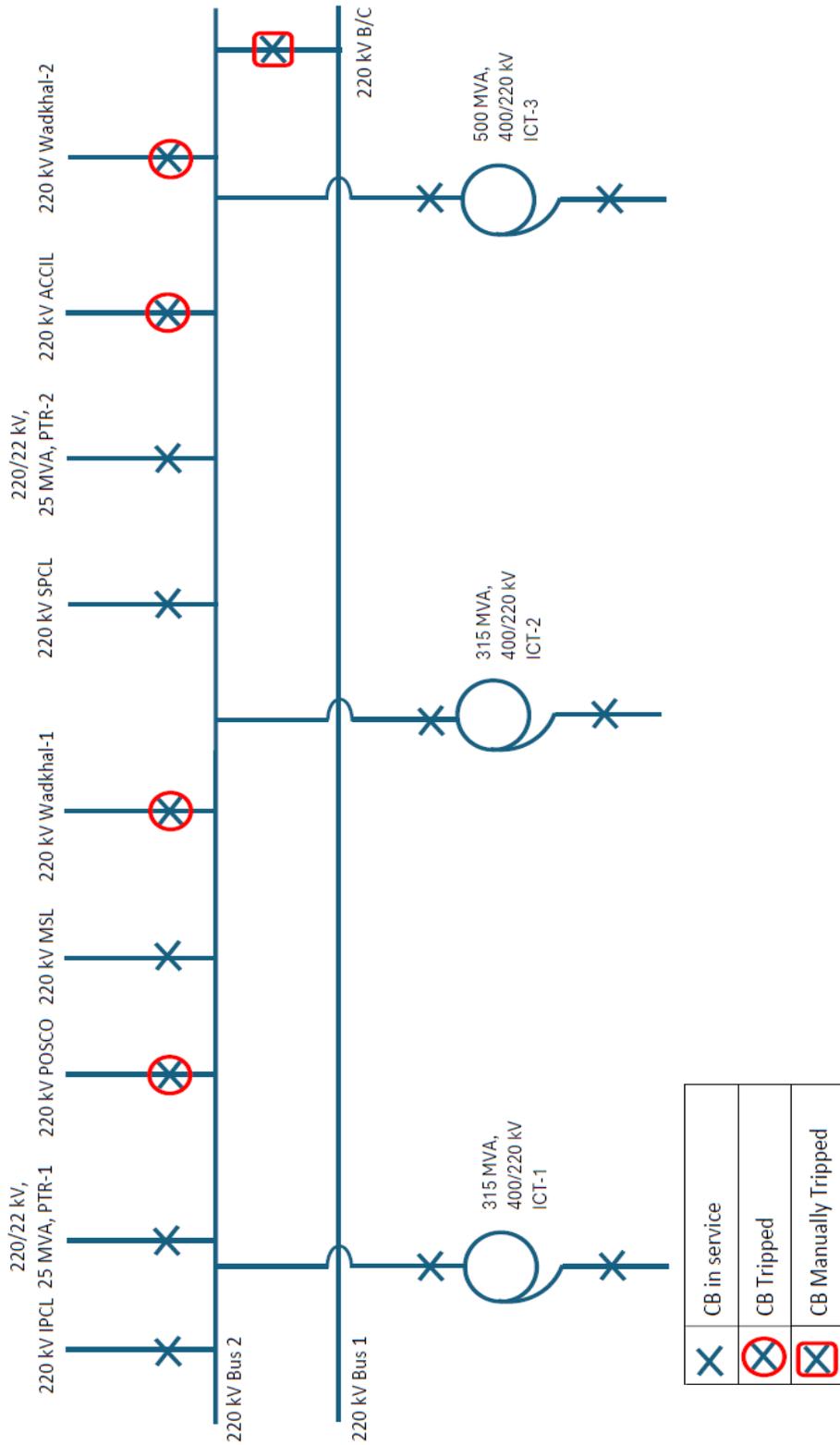


Figure 84 Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025.

**3.2.11. Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.**



# Maharashtra State Load Despatch Centre

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## **Brief description of the event:**

On 15.08.25 at 19:00 hrs., a Y–B phase fault occurred on the 220 kV VIPL–Butibori-1 Ckt-4. Consequently, backup overcurrent (O/C) protection operated at both ends. However, at the 220 kV VIPL ss end, the Y-phase CB pole failed to operate (stuck condition), which resulted in the operation of LBB protection for Bus-1 at 220 kV VIPL ss.

Due to operation of LBB protection 220 kV VIPL ss for Bus-1, all elements connected to Bus-1 were tripped, namely:

- i. 220kV VIPL–Butibori 3 Ckt-1
- ii. Station Transformer (220/6.9kV, 25 MVA)
- iii. Generator Transformer GT-1 (20/220kV, 370MVA)
- iv. 220kV Bus Coupler

Above elements tripped on operation of the respective 96 trip relays. Further, following elements also got tripped:

- i. 220 kV Butibori-1– VIPL Ckt-3
- ii. 220 kV Khaperkheda – Butibori-1 line
- iii. 220kV Purti - Butibori-3 line

1. **Utilities involved:** VIPL (Adani) and MSETCL.
2. **Disturbance category:** GD 1
3. **Last Protection Audit carried out:** 20 03.2025- 220 kV ButiBori-3 ss  
25 03.2025- 220 kV ButiBori-1 ss  
Nil – 220 kV VIPL ss.
4. **Antecedent conditions: -**
  - iv. Weather condition: Heavy raining and lightning.
  - v. Transmission elements loading prior to event: At VIPL end,

Sr No	Name of element on 220 kV main bus-1	Loading in (MW)	Sr No	Name of elements on 220kV main bus-2	Loading in (MW)
1	220 kV GT-1 (20/220kV, 370MVA)	239 MW (imp) (Ex.bus Gen. 204MW@19:00hr at ALDC SCADA)	1	220 kV GT-2	No load
2	ST-1 (220/6.9kV, 25 MVA)	5.7 MW (exp)	2	220 kV VIPL-Butibori-1 ckt-3	131.59 (Exp)
3	220 kV VIPL-Butibori-1 ckt-4	131.59 (exp)	3	220 kV VIPL-Butibori-3 ckt-2	38.74 (imp)
4	220 kV VIPL-Butibori-3 ckt-1	30.45 (imp)			
5	220kV Bus coupler	NA			

Table 51 Transmission elements loading prior to event

# Maharashtra State Load Despatch Centre

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1	220 kV Butibori-1 – Khaparkheda	04.09 MW
2	220 kV Butibori-3 – Purti -	39.04 MW

## vi. State Generation and Demand

	State Generation (MW)	State Demand (MW)
At 18:30 hrs	12470 MW	18819 MW

*Source- SCADA data at MSLDC.*

## 5. **Brief Details of System Disturbance:**

- i. A line differential protection scheme has been implemented between:  
220 kV VIPL–Butibori-1 Ckts 3 & 4  
220 kV VIPL–Butibori-3 Ckts 1 & 2
- ii. Due to a communication failure, the line differential relay for 220 kV VIPL–Butibori-1 Ckt-4 was already out of service before the incident. Further, Communication Fail LED alarm was persistent for 220 kV VIPL–Butibori-1 Ckt 3 and 220 kV VIPL–Butibori-3 Ckts 1 also along with 220 kV VIPL–Butibori-1 Ckts 4 from both ends (as per SE, PAC, Nagpur Letter No. 623 Dtd: 22.08.2025.)
- iii. On 15.08.2025 at 19:00 hrs, a Y–B phase fault occurred on the 220 kV VIPL–Butibori-1 Ckt-4. As the line differential protection was out of service, the fault was detected by the overcurrent (OC) protection at both ends, which issued a trip command. The circuit breaker (CB) at 220kV Butibori-1 ss operated correctly and successfully cleared the fault.
- iv. However, at the VIPL end, the Y-phase pole of the 220 kV VIPL–Butibori-1 Ckt-4 CB got stuck, resulting in Local Breaker Backup (LBB) operation, incorporated in the Busbar protection relay (Siemens, type 7SS522). Consequently, all elements connected to Main Bus-1, along with the bus coupler. (tripped within 431 msec).
- v. Meanwhile, the following lines also tripped:
  - i. 220 kV Butibori-1 – VIPL Ckt-3 (tripped in 240 msec on backup o/c protection from the 220kV Butibori-1 SS end.)
  - ii. 220 kV Khaparkheda – Butibori-1 line tripped on Distance protection in Zone-2 from the 220kV Khaparkheda SS end.
  - iii. 220 kV Purti - Butibori-3 line (tripped on backup o/c protection in 326 msec from the 220kV Purti SS end.)
- vi. As per ALDC report, the 220 kV VIPL substation end, the elements connected to Main Bus-2 were hand-tripped due to heavy rain and lightning conditions, as the location and nature of the fault could not be immediately ascertained. After HT of 220kV VIPL-Butibori-3 ckt-2 at VIPL end, the 220 kV VIPL ss went into dark and GT-2 got discharged.

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## 6. Tripping and Restoration details:

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	300 MW GT-1	15.08.2025 at 19:00 hrs	15.08.2025 at 21:40 hrs	At VIPL SS: Following Elements Tripped on LBB protection due to Yph pole stuck up of 220kV VIPL-Butibori-1 ckt-4.
2	ST-1	15.08.2025 at 19:00 hrs	15.08.2025 at 21:30 hrs	
3	220kV Bus coupler at VIPL	15.08.2025 at 19:00 hrs	15.08.2025 at 21:35 hrs	
4	220kV VIPL-Butibori-3 ckt-1	15.08.2025 at 19:00 hrs	15.08.2025 at 21:23 hrs	
5	220kV Butibori-3 – Purti line (Purti End)	15.08.2025 at 19:00 hrs	15.08.2025 at 19:57 hrs	Purti SS End: O/C tripped due to IR=590A, IY=2.3kA, IB=2.3kA
6	220kV Khaparkheda – Butibori-1 line (Khaparkheda end)	15.08.2025 at 19:00 hrs	15.08.2025 at 21:30 hrs	Khaparkheda SS End: Distance relay optd Zone 2, Yph, Bph, 61.7 km, IL2=0.39 KA, IL3= 1.88 KA.
7	220 kV Butibori-1 – VIPL Ckt-3 (Butibori-1 end)	15.08.2025 at 19:00 hrs	16.08.2025 at 00:46 hrs	Butibori 1 SS End: Dir OC, Yph, Bph, 86, IL2= 10.08 KA, IL3= 8.59 KA. VIPL End: Hand Tripped
8	300 MW GT-2 (no-generation)	15.08.2025 at 19:25 hrs	16.08.2025 at 01:36 hrs	Hand tripped.
9	220kV VIPL-Butibori-3 ckt-2 (VIPL end)	15.08.2025 at 19:25 hrs	16.08.2025 at 02:17 hrs	Hand tripped.
10	220kV VIPL-Butibori-1 ckt-4	15.08.2025 at 19:00 hrs	17.08.2025 at 19:19 hrs	Butibori 1 SS End: OC/EF relay optd (Siemens) : B-ph tripped, trip relay-86, IL3=10.22kA, VIPL SS End: Dir Overcurrent (R-2.02 kA, Y-31.92 kA, B-16.00 kA) Yph jumper broken at loc no. 5, its Yph pole of CB got stuck at 220 kV VIPL end.

Table 52 Tripping and Restoration details

7. **Generation / Load affected:** Generation loss: 239MW- GT-1 at 220 kV VIPL ss. GT-2 was on No-Generation. (As per SE, PAC, Nagpur L.No. 623 Dtd: 22.08.2025.)

## 8. **MSLDC Observations:**

- i. It is observed that for the 220 kV VIPL–Butibori-1 Ckts 3 & 4, line differential relays (Siemens Type 7SD610) have been provided as the main protection due to the short line length (1.86 km). These relays are not equipped with a line distance protection feature.
- ii. The 220 kV Butibori-1 – VIPL Ckt-3 (connected to 220 kV Main Bus-2) tripped from the Butibori-1 end during the fault on the 220 kV VIPL – Butibori-1 Ckt-4 (connected to 220 kV Main Bus-1).

# Maharashtra State Load Despatch Centre

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- iii. The 220 kV Khaparkheda–Butibori-1 line tripped on distance protection in Z-2 from the Khaparkheda end. The Z-2 reach setting appears to have overreached, due to the very short next adjacent lines.
- iv. For the 220 kV Purti–Butibori-3-line, fault on the 220 kV VIPL–Butibori-1 Ckt-4 was detected in Zone-3. As per the DR, the distance relay at Purti end was picked up, and the line tripped on overcurrent (OC) protection in 326 ms, prior to the LBB operation at 220 kV VIPL ss. Such tripping of the line from Purti end on OC protection is not desirable.
- v. It is observed that during the occurrence, following CBs were found stuck at 220 kV VIPL ss due to rusting of latch rollers and failure of trip coils noted during inspection. As pr RCA report from M/s VIPL the works are carried out are also listed below:
  - i. 220 kV VIPL – Butibori-1 Ckt-4 (Y ph)- (Protection trip):
  - ii. 220kV VIPL-Butibori-3 ckt-2 (B ph) – (manual electrical trip):
  - iii. 300 MW GT-2 (B ph) – (manual electrical trip)
- vi. From the report received ALDC comments on the occurrence, following points are observed:
  - i. The actual system scenario at 220 kV VIPL substation was not correctly reported to ALDC by the 220 kV VIPL substation personnel during the occurrence. The VIPL Shift In-charge initially reported a station blackout to ALDC; however, Main Bus–2 was charged through the 220 kV VIPL–Butibori–3 Ckt–2, with GT–2 in a back-charged condition.
  - ii. During the event, none of the involved substations could identify or confirm the fault location when reporting to ALDC. Additionally, SCADA data visibility for VIPL SS was lost at ALDC.
  - iii. When ALDC instructed hand-tripping of the 220 kV VIPL–Butibori–3 Ckt–2 at the VIPL end, no objection was raised by VIPL regarding the fact that this would de-energize Main Bus–2, will affect GT–2’s auxiliary supply, and could not extend auxiliary supply to GT–1.
  - iv. After HT of 220kV VIPL-Butibori-3 ckt-2 at VIPL end, the 220 kV VIPL ss went into dark and GT-2 got discharged.

## **9. Remarks / Remedial Measures Suggested by MSLDC:**

- i. The line differential protection for VIPL–Butibori-1 Ckts 3 & 4 needs to be reliable and always available. **M/s VIPL is requested to attend the issues related to Fibre optic links on top priority.** On failure of Fibre optic links immediate reporting to ALDC & PAC Circle needs to be done and restoration process should be initiated. Redundant communication channel like PLCC links needs to be made available for these lines.

## Maharashtra State Load Despatch Centre

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- ii. The Line protection relays should be such that both differential and distance protection features are available in it. In case the line differential protection is out of service, then distance protection feature along with carrier aided scheme will be enabled to ensure dependable primary protection.
- iii. The tripping of 220 kV Butibori-1 – VIPL Ckt-3 (connected to 220 kV Main Bus-2) from the Butibori-1 end during the fault on the 220 kV VIPL – Butibori-1 Ckt-4 (connected to 220 kV Main Bus-1) is undesirable. A review of the overcurrent protection coordination is required to ensure selective and reliable fault clearance.
- iv. The OC/EF relay settings at 220 kV Purti substation end for the 220 kV Butibori-3 line need to be revised as per protection guidelines. A review of the distance and overcurrent protection coordination is required to ensure selective and reliable fault clearance. The Bus Coupler OC/EF relay settings at 220 kV VIPL, 220 kV Butibori-1, and 220 kV Butibori-3 substations need to be reviewed in line with protection guidelines and prevailing fault levels.
- v. On analyzing the submitted DRs regarding incident, it is observed that, Separate digital channels for Busbar trip, LBB trip, and LBB initiation, Communication link failure need to be assigned in the DR of the protection relay. The Protection relays need to be GPS time synchronized. The PCC and ACIP guideline Regarding DR triggering are to be followed. The DR assignments are to be verified in annual protection audit.
- vi. As the 220 kV VIPL ss was not in service long time in past & in view of stuck CBs, it is suggested to carry out CB overhauling and regular maintenance activities of all CBs as per OEM recommendations. The CB diagnostic test reports after overhauling are to be verified by ACIP and PAC circle.
- vii. A Third-party protection audit and Protection co-ordination as per PCM, PCC WRPC guidelines of all substations involved in the occurrence needs to be carried out within 06 months, so as to avoid any repeat of such occurrence in future.
- viii. Voice communication system between all 03 Ss involved in the occurrence i.e. (220kV Butibori-1, 220kV Butibori-3, and 220kV VIPL) with MSLDC and ALDC (VOIP, hotline PLCC, dialup PLCC) are required to be established.
- ix. The SPS scheme provided for overloading of ICTs at 220 kV Butibori-1, 220 kV Abhijit Line, and 220 kV Wardha Line is presently operating in manual mode. The scheme is designed to back down 60 MW of generation at VIPL in two stages manually. However, for timely and reliable operation, this SPS scheme needs to be automated.

# Maharashtra State Load Despatch Centre

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- x. The 220 kV Koradi-II (400 kV) – Butibori-3 Circuit-I & II and 220 kV Butibori-1 – Butibori-3 lines have been kept hand-tripped to control the overloading of 220/132 kV, 2 × 100 MVA ICT-I & II at 220 kV Butibori-1 Substation. In this regard, the capacity enhancement or addition of ICTs needs to be expediated to ensure reliable system operations. (Included in STU plan 2025-26).
- xi. Backup UPS supply to all SCADA equipment (HMI, Network switches, routers etc) at all 03 Substations involved i.e. (220kV Butibori-1, 220kV Butibori-3, and 220kV VIPL) is required for continuous SCADA visibility as the same was affected during the incident.



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli.  
..... To discuss this occurrence in up-coming PCC meeting.
- 4) The Chief Engineer, EHV PC O&M Zone Nagpur.
- 5) The Chief Engineer, ALDC Ambazari, Nagpur.
- 6) M/s VIPL Adani Infrastructure Management Services Ltd. Butibori Industrial Area,  
Nagpur, Maharashtra

**Copy. to:**

- |  |   |   |
|--|---|---|
| <ol style="list-style-type: none"><li>1) The Superintending Engineer, PAC Circle Nagpur.</li><li>2) The Superintending Engineer, ALDC Ambazari<br/>Nagpur.</li></ol> | } | .....To immediately address the SCADA visibility issues in respect of M/s VIPL & Butibori 1 & 3 ss. |
|--|---|---|

**Occurrence report of 220 kV LBB protection operation at 220kV VIPL s/s along with multiple lines tripping on 15.08.2025.**

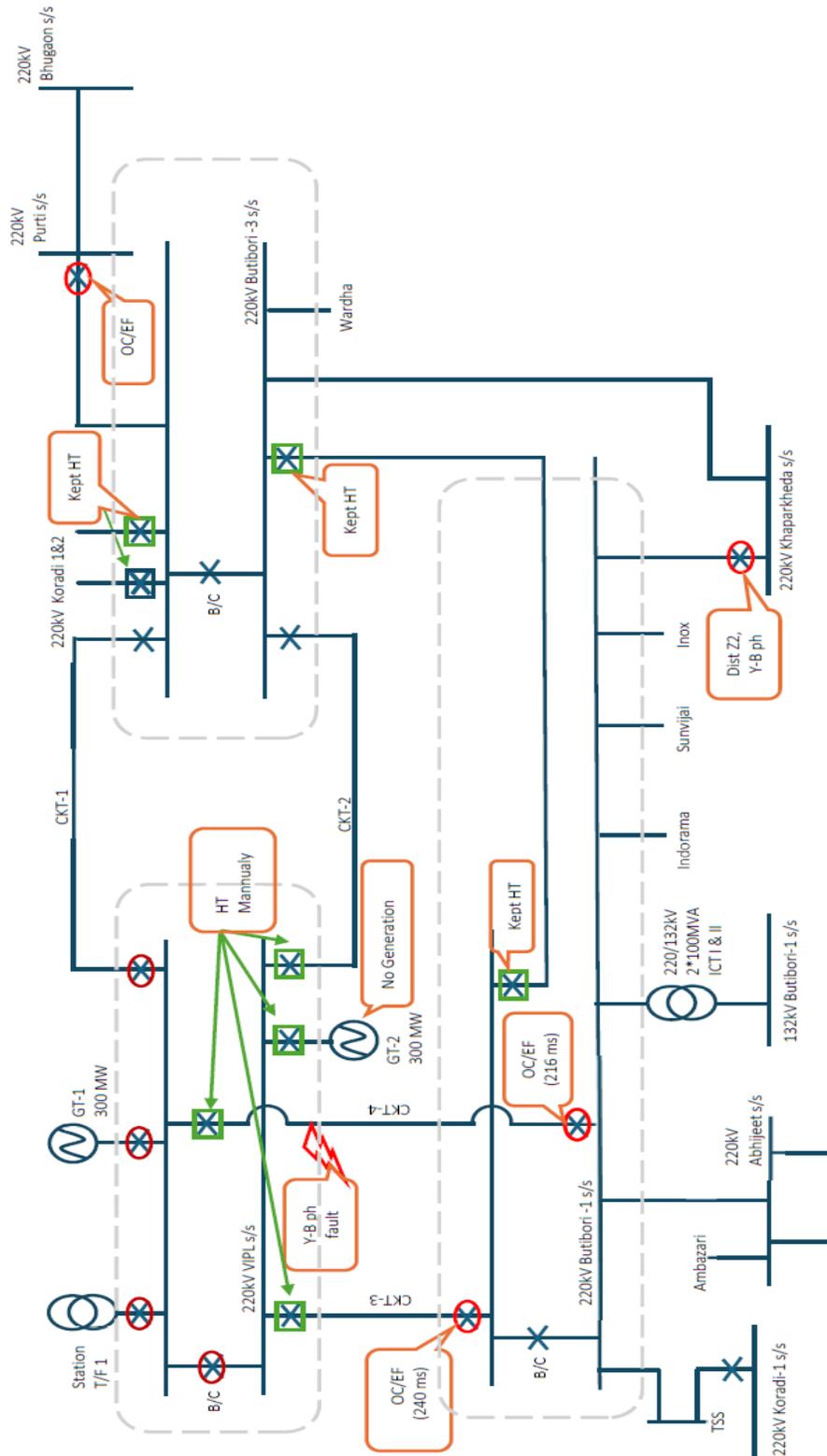


Figure 85 Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.

**3.2.12. Occurrence of LBB protection operations at 100kV Padgha substation on 29.07.2025 and 13.08.2025.**

# Maharashtra State Load Despatch Centre

No. 2002

Date: 19.09.2025

## Occurrence report of 100 kV LBB protection operations at 100kV Padgha ss on 29.07.2025 and 13.08.2025.

### Background:

The 400/220/100 kV Padgha substation, is very important grid substation for Mumbai & MMR region. 100kV Padgha substation feeds the important residential, commercial & industrial load of Kalyan, Ulhasnagar, Ambernath, Badlapur, Bhiwandi, Shahapur, Murbad area.

Padgha's 100 kV system also feeds vital water supply installations at 100kV Pise, 100kV Old and 100kV New Panjrapur s/s. These substations supply power to water pumping and purification stations responsible for Mumbai and Thane's water supply.

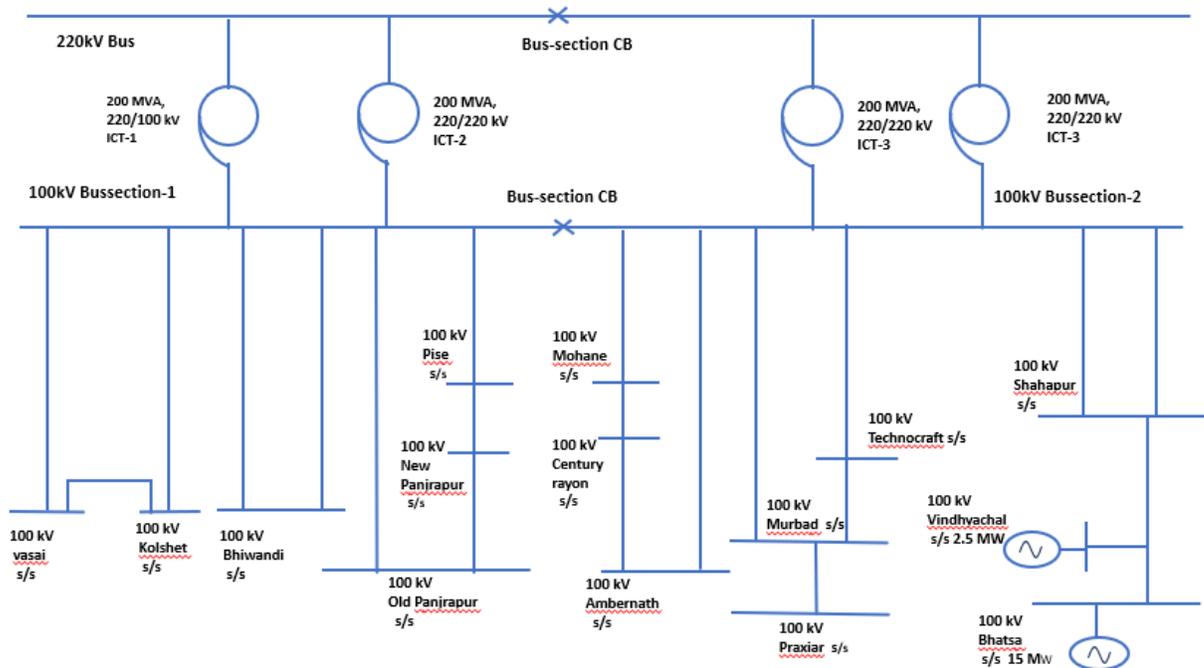


Fig:1 - Network around 100kV Padgha ss.

# Maharashtra State Load Despatch Centre

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## **Brief description of the event:**

Following LBB protection occurrences occurred at 100kV Padgha s/s within shorter span

- 1) On 29.07.2025 at 03:45 hrs 100kV Bus section 1 tripped on LBB protection with Bph to E fault in Zone 1 on 100kV Padgha- Bhiwandi line -1. The line auto reclosed at both ends but tripped at both ends as fault current persisted in B ph. Even though the CB opened at Bhiwandi s/s end, the current persisted through 'B' phase pole of AREVA make CB at 100kV Padgha end resulting LBB operation of 100kV Bus section 1.
- 2) On 13.08.2025 at 03:09 hrs 100kV Bus section 1 tripped on LBB protection with Bph to E fault in Zone 1 on 100kV Padgha- Bhiwandi line -2. The line auto reclosed at both ends but tripped after reclaim time at both ends as fault reappeared in B ph . Even though the CB opened at both ends, the current persisted through 'B' phase pole of AREVA make CB at 100kV Padgha end resulting LBB operation of 100kV Bus section 1.

In both cases following elements connected to Bus section 1 tripped on LBB protection operation

- i) 200 MVA, 220/100 kV ICT-1
- ii) 200 MVA, 220/100 kV ICT-2
- iii) 100 kV Padgha- Bhiwandi line -1 (tripped on 29.07.2025 only)
- iv) 100 kV Padgha- Bhiwandi line -2
- v) 100kV Padgha – Vasai line
- vi) 100kV Padgha-Kolshet line
- vii) 100kV Padgha- Pise line
- viii) 100kV Padgha-Panjrapur line.
- ix) 50 MVA 100/22 kV, BHEL TF

**Above elements tripped on operation of the respective 96 trip relays.**

1. **Utilities involved:** MSETCL.
2. **Disturbance category:** GD 1
3. **Last Protection Audit carried out:** 11.10.2024 (TPA)
4. **Antecedent conditions: -**
  - i. Weather condition: Heavy & incessant rain, extreme humid.

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## ii. Transmission elements loading prior to event:

Sr No	Name of element on	Loading in (MW) On 29.07.2025 at 03:00 hrs	Loading in (MW) On 13.08.2025 at 03:00 hrs
1	200 MVA, 220/100 kV ICT-1	86 (import to bus)	88.59
2	200 MVA, 220/100 kV ICT-2	86 (import to bus)	88.49
3	200 MVA, 220/100kV ICT-3	76.88 (import to bus)	71.90
4	200 MVA, 220/100kV ICT-4	87.66 (import to bus)	87.66
5	100kV Padgha- Bhiwandi-1	50 (exp)	52.94 (exp) (Through TBC)
6	100 kV Padgha-Bhiwandi -2	50 (exp)	50
7	100kV Padgha- Vasai	17 (exp)	9.80 (exp)
8	100kV Padgha- kolshet	0.50 (exp)	2.68 (exp)
9	100kV Padgha- Pise	18 (exp)	17.89 (exp)
10	100kV Padgha- Panjrapur	11 (exp)	11.30 (exp)
11	100kV Padgha- Shahapur-1	5.83 (Exp)	15.41 (Exp)
12	100kV Padgha- Shahapur-2	5.94 (Exp)	15.59 (Exp)
13	100kV Padgha- Murbad	18.94 (Exp)	13.75 (Exp)
14	100kV Padgha- Technocraft	18.94 (Exp)	13.75 (Exp)
15	100kV Padgha- Ambernath	56.52 (Exp)	55.86 (Exp)
16	100kV Padgha- Mohane	63.26 (Exp)	62.89 (Exp)
17	50 MVA 100/22 kV, BHEL	22 (exp)	16.11 (exp)

## iii. State Generation and Demand

	State Generation (MW)	State Demand (MW)
On 29.07.2025 at 03:00 hrs	13897 MW	18321 MW
On 13.08.2025 at 03:00 hrs	13537 MW	21701 MW

*Source- SCADA data at MSLDC.*

## 5. Brief Details of System Disturbances:

### A) For LBB operation on 29.07.2025 at 03.45 hrs

- i. There was heavy rain & incessant rain at time of tripping of **100kV Padgha-Bhiwandi line no 1.**
- ii. At 03.45 hrs the line tripped at both ends in Zone -1 on Bph -E fault. The line auto reclosed successfully at both ends, however, tripped subsequently at both ends as fault persist.
- iii. As per fault record of line at Padgha end, even though the CB of said line found physically opened, eventually failed to interrupt the fault which persisted until LBB operation time of 200msec leading to LBB tripping of 100kV Bus-1.
- iv. The line conductor of 100 kV Padgha bhiwand line 1 was found decapped at crossing point of Samruddhi highway.

# Maharashtra State Load Despatch Centre

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## B) For LBB operation on 13.08.2025 at 03.09 hrs

1. There was heavy rain & incessant rain at time of tripping oh **100kV Padgha-Bhiwandi line no 2.**
2. At 03.09.09 hrs the line tripped at both ends in Zone -1 on Bph -E fault. The CBs of lines open at both ends & auto reclosed.
3. **After elapse of reclaim time of 25 sec** the line tripped again at both ends on Bph-E fault at 03.09.53 hrs .
4. As per fault record of line at Padgha end, even though the CB of said line found physically opened, eventually failed to interrupt the fault which persisted until LBB operation time of 200msec leading to LBB tripping of 100kV Bus-1.

### 6. Tripping and Restoration details:

Sr. No.	Transmission / Generation Element	Tripping Date & Time	Restoration date & Time	Cause/ Relay indication	Tripping Date & Time	Restoration date & Time	Cause/ Relay indication
1	200 MVA, 220/100 kV ICT-1	29.07.2025, 03:45 hrs	29.07.2025, 03:57 hrs	Tripped due to LBB operation of 100 kV Padgha-Bhiwandi line no-1	13.08.2025, 03:09 hrs	13.08.2025, 03:46 hrs	Tripped due to LBB operation of 100 kV Padgha-Bhiwandi line no-2
2	200 MVA, 220/100 kV ICT-2	29.07.2025, 03:45 hrs	29.07.2025, 04:02 hrs		13.08.2025, 03:09 hrs	13.08.2025, 03:46 hrs	
3	100kV Padgha-Pise	29.07.2025, 03:45 hrs	29.07.2025, 04:07 hrs		13.08.2025, 03:09 hrs	13.08.2025, 03:46 hrs	
4	100kV Padgha-Panjrapur	29.07.2025, 03:45 hrs	29.07.2025, 04:08 hrs		13.08.2025, 03:09 hrs	13.08.2025, 03:47 hrs	
5	100kV Padgha-kolshet	29.07.2025, 03:45 hrs	29.07.2025, 04:09 hrs		13.08.2025, 03:09 hrs	13.08.2025, 03:50 hrs	
6	100kV Padgha-Vasai	29.07.2025, 03:45 hrs	29.07.2025, 03:10 hrs		13.08.2025, 03:09 hrs	13.08.2025, 03:54 hrs	
7	50 MVA 100/22 kV, BHEL	29.07.2025, 03:45 hrs	29.07.2025, 04:02 hrs		13.08.2025, 03:09 hrs	13.08.2025, 04:29 hrs	
8	100kV Padgha-Bhiwandi line -2	29.07.2025, 03:45 hrs	29.07.2025, 04:09 hrs		13.08.2025, 03:09 hrs	14.08.2025, 01:48 hrs	
9	100kV Padgha-Bhiwandi line -1	29.07.2025, 03:45 hrs	29.07.2025, 17:16 hrs	Dist prot, Bph-E , Zone 1	NA	NA	NA

Table 53 Tripping and Restoration details

# Maharashtra State Load Despatch Centre

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- 7. Generation / Load affected:** 1) Load affected on 29.07.2025- 168 .5 MW for 00:25 hrs  
2) Load affected on 13.08.2025- 57.78 MW for 00.25 hrs

**8. MSLDC Observations:**

- i. Bays connected to 100kV Main-Bus section -1 and 100kV Main -Bussection-2 are as below.

Sr.No		Name of Element	Remark
1	100kV Bus section 1	100kV Padgha- Bhiwandi line -1	Both source lines of 100kV Bhiwandi s/s are on Bus section 1
2		100kV Padgha- Bhiwandi line -2	
3		100kV Padgha- Vasai	
4		100kV Padgha- kolshet	
5		100kV Padgha- Pise	Both source lines of 100kV Pise, 100kV Old Panjrapur, 100kV New Panjrapur ring main are on Bus section 1
6		100kV Padgha- Panjrapur	
7	100kV Bus section 2	100kV Padgha- shahapur-1	Both source lines of 100kV Shahapur s/s are on Bus section 2
8		100kV Padgha- shahapur-2	
9		100kV Padgha- Murbad	Both source lines of 100kV Murbad s/s, EHV consumer such as Technocraft, Praxiar are on Bus section 2
10		100kV Padgha- Technocraft	
11		100kV Padgha- Ambernath	Both source lines of 100kV Ambernath, 100kV Mohane, 100kV Centuy Rayon ring main are on Bus section 2
12		100kV Padgha- Mohane	

*Table 54 Bays connected to 100kV Main-Bus section -1 and 100kV Main -Bussection-2*

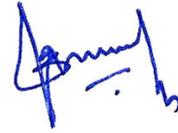
**9. Remarks / Remedial Measures Suggested by MSLDC:**

- i. Since both the source lines for above mentioned substations/ring mains are on same bus, in the event of LBB/Busbar operation complete blackout of respective substation/ring main will occur. Hence the source lines need to be distributed across Bus-1 & Bus-2 at the earliest to avoid complete blackout of respective substation.

# Maharashtra State Load Despatch Centre

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- ii. The SF6 gas analysis of all EHV circuit breakers needs to be carried out.
- iii. Diagnostic testing for all CBs needs to be carried out and reports shall be verified by respective PAC circle.



(Girish Pantoji)  
Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli.
- 4) The Chief Engineer, EHV PC O&M Zone Vashi.

**Copy. to:**

- 1) The Superintending Engineer, PAC Circle Vashi.
- 2) The Superintending Engineer, HVDC T&T circle Padgha.

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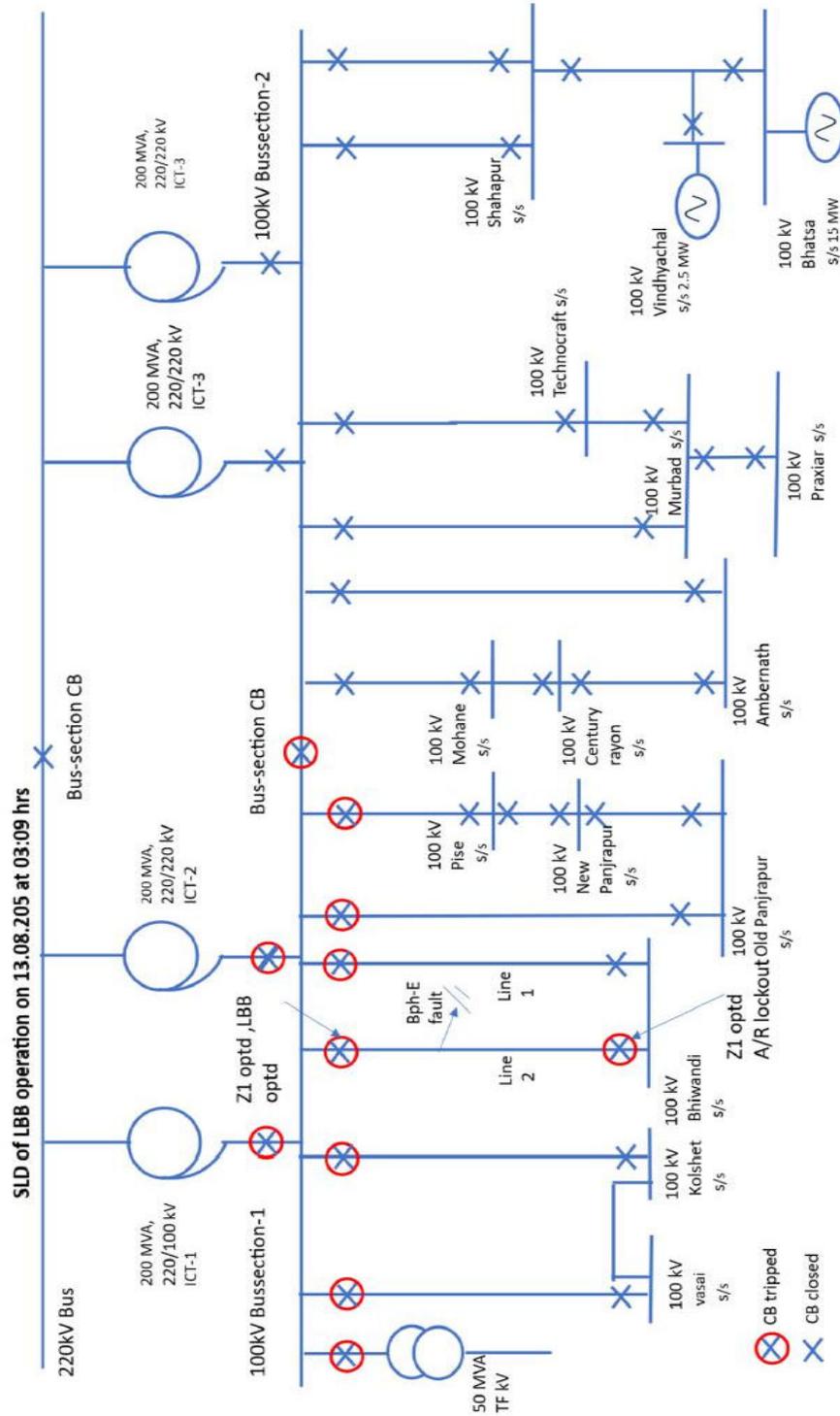


Figure 86 Occurrence of LBB protection operations at 100kV Padgha substation on 29.07.2025 and 13.08.2025.

**3.2.13. Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.**

# Maharashtra State Load Despatch Centre

No.: 02131

Date: 07.10.2025

## Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur on 06.09.2025.

### Background:

The 400 kV Chandrapur GCR (Generation Control Room) ss plays a crucial role in managing and evacuating power from the Chandrapur Super Thermal Power Station to the state's grid. This substation is a critical node in Maharashtra's power grid. It is associated with key transmission lines and other substations, such as the 400 kV Chandrapur–Padghe HVDC transmission system, which is built to supply power to the Mumbai region.

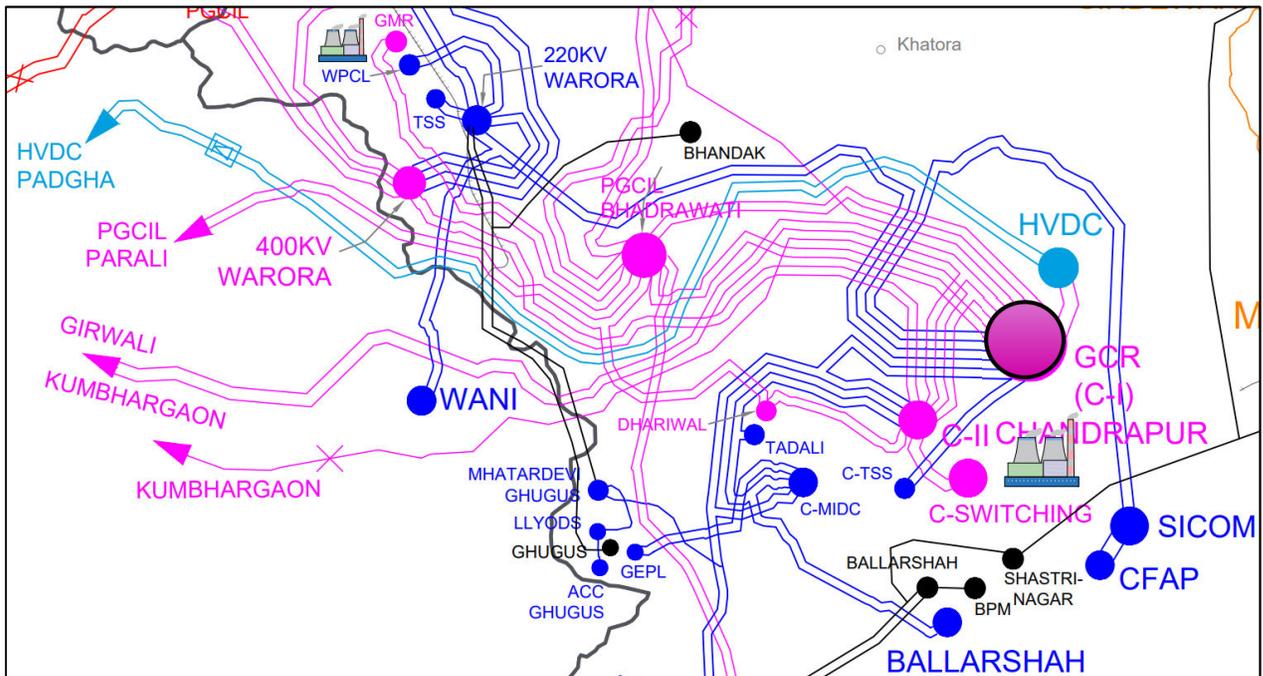


Figure 87 400 kV Network around 400 kV Chandrapur ss

### Brief description of the event:

On 06.09.2025 at 05:14 hrs, due to failure of the Y-phase Current Transformer (CT) of the 400kV HVDC Circuit-2 Bay (connected to 400 kV Bus-2), the Busbar Differential Protection for 400kV Main Bus-2 at 400kV GCR Chandrapur Substation operated, resulting in the tripping of all feeders connected to 400 kV Bus-2.

Additionally, GTR-5 and GTR-7, connected to Bus-1, also tripped due to auxiliary supply issues linked to Station Transformers.

# Maharashtra State Load Despatch Centre

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1. **Utilities involved:** MSETCL, MSPGCL
2. **Disturbance category:** GD 1
3. **Last Protection Audit carried out:** March 2024 (TPA)
4. **Antecedent conditions: -**
  - iv. 400kV GTR-3 – Already OFF
  - v. 400kV Station Transformer T/F-3 – Already OFF
  - vi. 400kV GTR-4 – Already OFF

vii. Transmission elements loading prior to event: At 400 kV Chandrapur ss (2M+1A Bus)

Sr No	Name of element on 400 kV Main Bus-1	Loading in (MW)	Sr No	Name of elements on 400 kV Main Bus-2	Loading in (MW)
1	400kV GTR-5	276	1	400kV CHD-2 Ckt 2	170
2	400kV GTR-7	213	2	400kV STN TF-5	21
3	400kV ICT-2	49	3	400kV HVDC Ckt 2	501
4	400kV GTR-3	Already OFF	4	400/220kV ICT 1	42
5	400kV PGCIL Ckt-3	137	5	400kV Parli Ckt 3	379
6	400kV PGCIL Ckt-4	138	6	400kV PGCIL Ckt-1	175
7	400kV CHD-2 Ckt-1	177	7	400kV PGCIL Ckt-2	174
8	400kV Khaparkheda	225	8	400kV GTR-4	Already OFF
9	400kV STN TF-4	11	9	400kV GTR-6	273
10	400kV HVDC Ckt-1	513	10	400kV Spare ICT	No load
11	400kV STN TF-3	Already OFF			

Figure 88 Transmission elements loading prior to event: At 400 kV Chandrapur ss

Ref: MSETCL/SE/PACC/NGP/TECH/J-1/0664 Date: 09/09/2025

#### viii. **State Generation and Demand**

	State Generation (MW)	State Demand (MW)
At 05:00 hrs	13282 MW	19386 MW

*Source- SCADA data at MSLDC.*

#### 5. **Brief Details of System Disturbance:**

On 06.09.2025 at 05:14 hrs, at 400 kV GCR Chandrapur, 400 kV Bus-2 tripped on operation of Busbar Differential Protection (ZIV make) due to failure of the Y-phase CT of 400 kV HVDC Ckt-2 bay.

All feeders on 400 kV Bus-2 along with the 400 kV bus coupler tripped, and GTR-5 & GTR-7 on Bus-1 also tripped. This resulted in a generation loss of 762 MW with no load loss. Bus-2 was restored at 06:30 hrs, most feeders by 07:42 hrs, GTR-5 at 10:51 hrs, GTR-6 at 17:32 hrs, while GTR-7 remained OFF. The faulty CT (BHEL,

# Maharashtra State Load Despatch Centre

commissioned 1998) was replaced with a new CGL CT and control cables, after which HVDC Ckt-2 was restored on 07.09.2025 at 05:39 hrs.

## 6. Tripping and Restoration details:

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	400kV Bus Coupler	06/09/2025 05:14Hrs.	06/09/2025 06:30 hrs.	Bus-2 tripped on operation of Busbar Differential Protection (ZIV make) due to failure of the Y-phase CT of 400 kV HVDC Ckt-2 bay.  Indication: 1) Bus-II Operated 2) Y-Ph Diff. Operated 3) Check zone Operated
2	400kV Station T/F 5		06/09/2025 06:38 hrs.	
3	400kV PGCIL Ckt 1		06/09/2025 06:54 hrs.	
4	400kV PGCIL Ckt 2		06/09/2025 07:00 hrs.	
5	400kV PARLI-3		06/09/2025 07:15 hrs.	
6	400kV CHD2 CKT2		06/09/2025 07:28 hrs.	
7	400kV ICT-1	06/09/2025 05:14Hrs.	06/09/2025 07:37 hrs.	
8	400kV SPARE ICT		06/09/2025 07:42 hrs.	
9	400kV GTR 6		06/09/2025 17:32Hrs.	
10	400kV GTR 7		Kept OFF as per info. from MahaGenco	
11	400kV GTR 5		06/09/2025 10:51 hrs	
12	400kV HVDC CKT2		07/09/2025 05:39Hrs.	
13	400kV GTR 4	OFF	OFF	
14	400kV Station T/F 3	OFF	OFF	

Table 55 Tripping and Restoration details

# Maharashtra State Load Despatch Centre

**7. Generation / Load affected:**

Load Power loss and /or generation (in MW): Generation Loss = 762MW.

Sr. No.	400kV Bay	LBT (MW)
1	400kV GTR-5	276 MW
2	400kV GTR-7	213 MW
3	400kV GTR-6	273 MW
	<b>Total (Generation Loss)</b>	<b>762 MW</b>

Table 56 Load Power loss and /or generation (in MW)

**PMU Plots :**

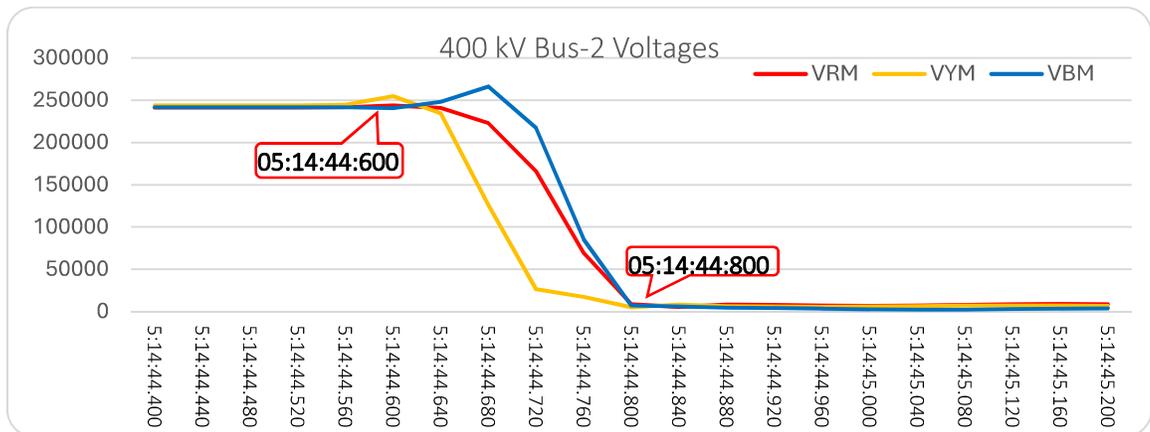


Figure 89 400 kV Bus 2 Voltages PMU Plots of PMUs at 400 kV Chandrapur ss

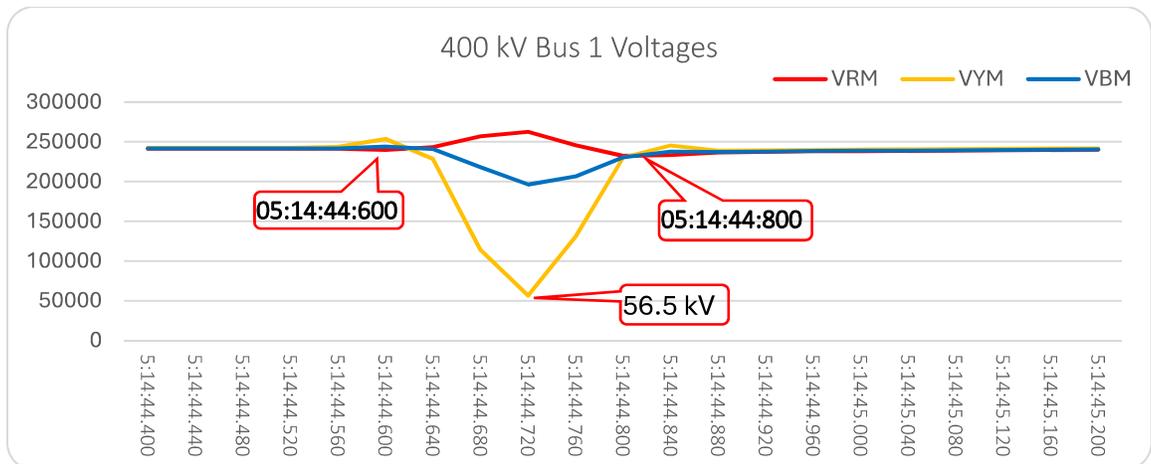


Figure 90 400 kV Bus 1 Voltages PMU Plots of PMUs at 400 kV Chandrapur ss

# Maharashtra State Load Despatch Centre

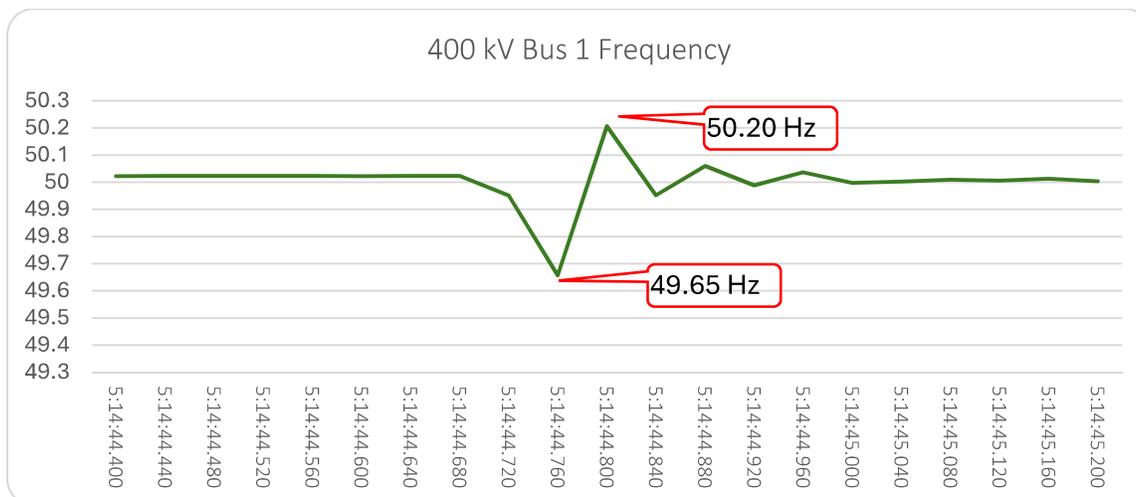


Figure 91 400 kV Bus 1 Frequency

*PMU Plots of PMU at 400 kV Chandrapur ss*

Sr.No	Parameter	Values
1	Voltage drop of Yph at healthy bus ( $V_{PH-N}$ )	241.7 kV to 56.5 kV Voltage drop of 185 kV
2	Frequency disturbance	50.20 Hz (max) to 49.65 Hz (min)
3	Duration	200 msec

## 8. MSLDC Observations:

- i. The incident occurred due to failure of Y-phase CT (Make: BHEL, Sr. No. 6160899) of 400kV HVDC Ckt-2 bay, resulting in 400 kV Bus-2 fault. Busbar Differential Protection (ZIV) operated correctly and isolated 400 kV Bus-2.
- ii. The Bus bar relay operations are in order; all 400 kV Bus-2 connected elements and the 400 kV bus coupler tripped via respective 96 relays. Bus bar Relay Check zone also operated correctly.
- iii. GTR-7, which was fed through auxiliary supply from STN TF-5 and connected to 400 kV Bus-1, tripped because STN TF-5 (connected to 400 kV Bus-2) tripped on Bus protection. GTR-5, also connected to 400 kV Bus-1, tripped even though its station transformer STN TF-4 was on Bus-1. MAHAGENCO later confirmed that the tripping of GTR-5 was due to an auxiliary board (station distribution) issue of STN TF-4 at the PCR end.

# Maharashtra State Load Despatch Centre

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- iv. Failed Y-phase CT (Make: BHEL, Sr. No. 6160899) of 400kV HVDC Ckt-2 bay was commissioned in 1998 and had last Tan Delta & Capacitance test in Dec 2023, which was within limits (Capacitance = 867.30 pF; Tan  $\delta$  = 0.241%).
- v. After completion of the replacement of the 400 kV Y-phase CT and allied control cable works, the 400 kV Chandrapur–HVDC Ckt-2 was charged on 07.09.2025 at 05:39 hrs.

## **9. Remarks / Remedial Measures Suggested by MSLDC:**

- i. It is observed that the failed CT was commissioned in 1998 and has completed 27 years of service. Ageing CTs, CVTs, PTs, and breakers may suffer from insulation degradation, leading to catastrophic failures without prior warning. Even if periodic diagnostic tests (Tan Delta, Capacitance, IR, etc.) appear normal, hidden deterioration can cause insulation breakdowns. Ageing oil-filled equipment poses higher risks of fire, oil leakage, or explosion in case of failure. Such aged EHV equipment are to be identified and replaced on top priority. It is learnt that LE scheme proposal of aged EHV equipment is in process which has to be expedited.
- ii. Regular thermography of EHV switchyard equipment such as CTs, CVTs, LAs, bushings, transformers, and bus conductors is essential for detecting hotspots caused by loose joints, contact resistance, or insulation deterioration. It is useful for ageing equipment where hidden defects may not appear in routine tests. Thermography enables early failure prediction.
- iii. Regular checks for oil leakages and oil levels in oil-filled EHV equipment are essential, and any leakages must be attended promptly to ensure reliability and prevent equipment failure.
- iv. In current busbar configuration, Bus 1 is connected with 11 bays and Bus 2 with 10 bays, any bus fault protection operation such as a Local Breaker Backup (LBB) or a busbar protection trip can result in the simultaneous outage of a large number of critical bays. This poses a significant risk to system reliability and operational continuity. To mitigate the impact of such contingencies and enhance overall system resilience, it is suggested to explore the feasibility of subdividing the existing busbars into multiple sections. By introducing bus-sectionalizers and bus-couplers, faults or planned outages can be confined to

# Maharashtra State Load Despatch Centre

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smaller segments, thereby limiting the number of affected bays, reducing the disturbance area, and improving fault isolation and system flexibility.

- v. The tripping of GTR-5 (296 MW) and GTR -7 (213 MW) which were connected to Bus-1 needs detailed investigation and steps needs to be taken to avoid such tripping in future. **The auxiliary supply changeover scheme is to be reviewed. The non availability of 400 kV STN TF -3 from 01.03.2025 is to be revived at the earliest**, for reliability of auxiliary supply to generating units.



(Girish Pantoji)  
Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Director (Operations), MSPGCL, Mumbai.
- 3) The Executive Director, MSLDC, Airoli.
- 4) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli...it is requested to discuss this disturbance in upcoming PCC meeting.
- 5) The Chief Engineer, CSTPS, MSPGCL, Chandrapur.
- 6) The Chief Engineer, EHV PC O&M Zone Nagpur.
- 7) The Chief Engineer, ALDC Ambazari, Nagpur.

**Copy. to:**

- 1) The Superintending Engineer, PAC Circle Nagpur.
- 2) The Superintending Engineer, ALDC Ambazari Nagpur.

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# Maharashtra State Load Despatch Centre

**Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur on 06.09.2025.**

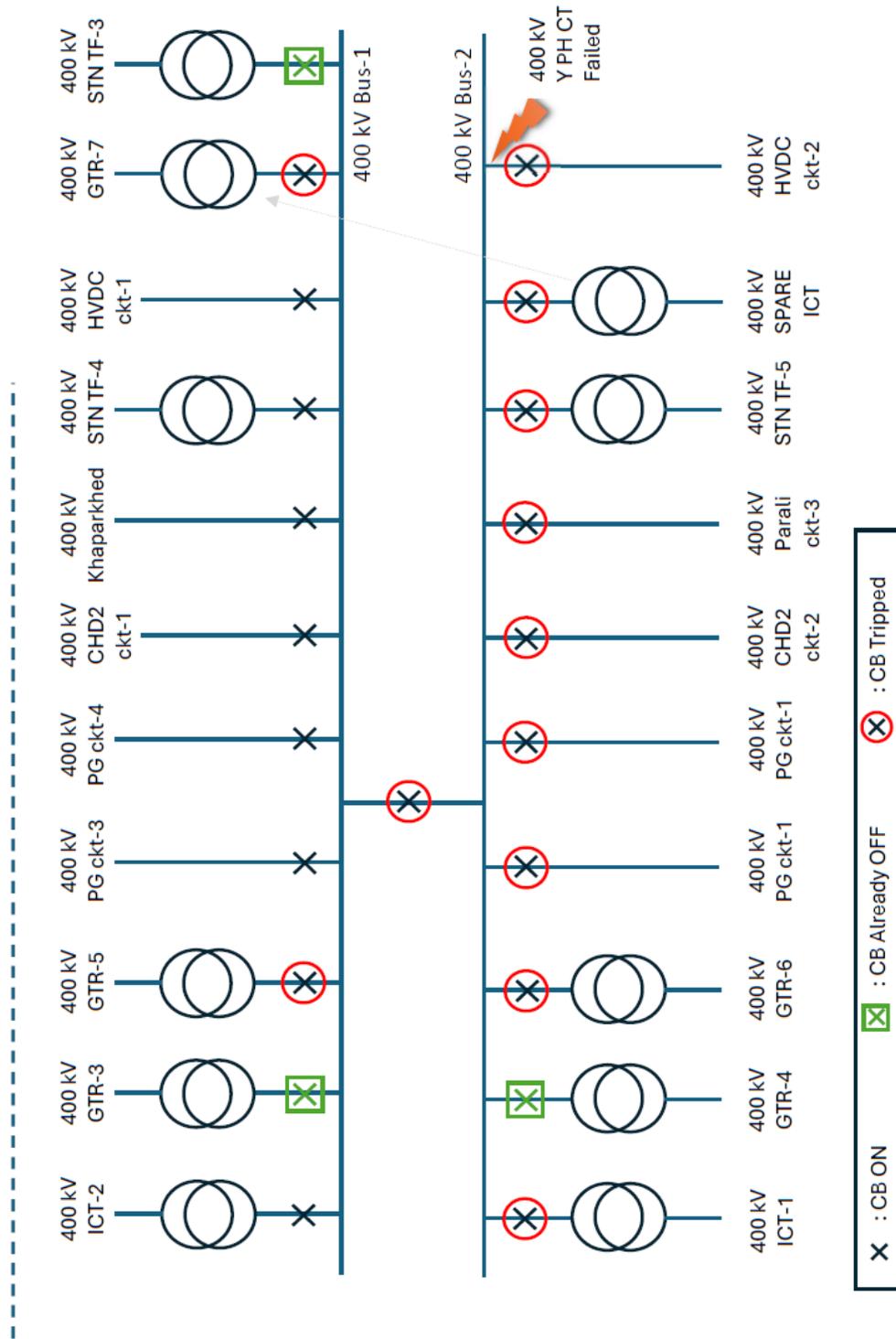


Figure 92 Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.

## **3.2.14. Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025**

# Maharashtra State Load Despatch Centre

No: 2233

Date: 17/10/2025

## Occurrence report of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane ss on 10.09.2025.

### Background:

The 400 kV Nagothane ss, situated in the Raigad region of Maharashtra, is a key node in the state's transmission network. It is connected to the 400 kV Padghe ss through two transmission lines and to the 400 kV Dabhol ss via another two lines, forming a vital corridor for the transmission of generation from Dabhol towards Mumbai through Padghe. The substation has installed transformation capacity of 03 nos interconnecting transformers (ICTs)— 02\* 315 MVA and 1\*500 MVA —providing a total transformation capacity of 1130 MVA. In addition to transmission role,

400 kV Nagothane ss feeds substantial regional load demand by supplying power to major industrial and commercial loads in Raigad district through 220 kV feeders - Wadkhal 1 & 2, IPCL, SPCL, MSL, POSCO, and ACCIL.

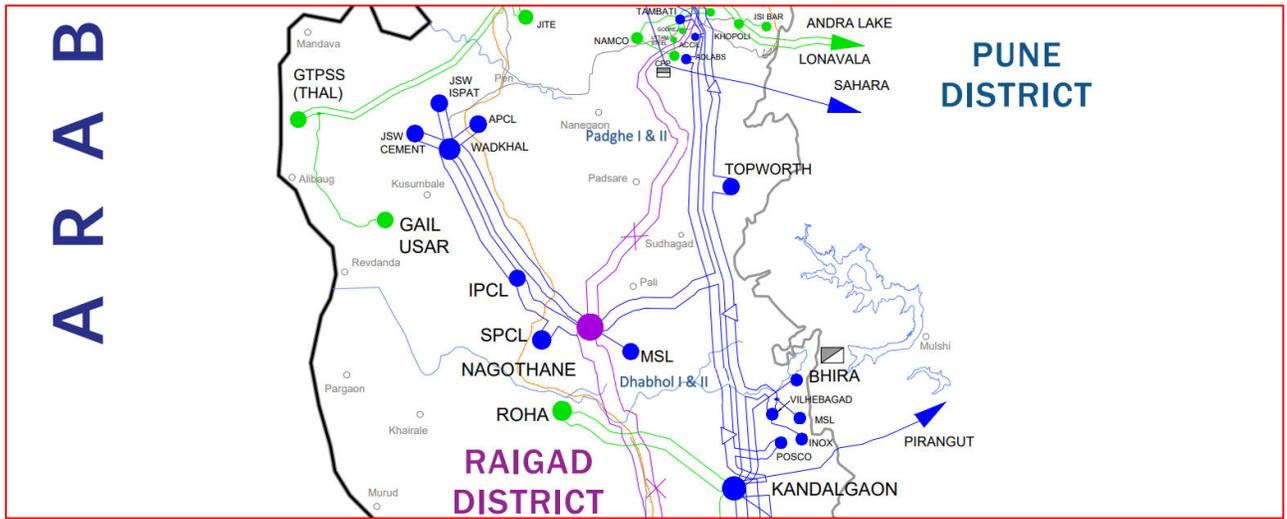


Figure 93 EHV Network around 400 kV Nagothane ss

### Brief description of the event:

During charging of the 400 kV extended bus, a failure and decapping of the extended B-ph bus insulator string occurred. The insulator string failure resulted in the operation of the 400 kV Bus-1(A) busbar protection scheme, leading to tripping of all 400 kV elements connected to 400 kV Bus-1 and the 400 kV Bus Coupler on 10.09.2025 at 22:31 hrs.

#### 1. Utilities involved:

MSETCL

# Maharashtra State Load Despatch Centre

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2. **Disturbance category:** GD 1
3. **Last Protection Audit carried out:** June 2022 (TPPA)

4. **Antecedent conditions: -**

- i. Weather - Clear
- ii. 400kV Padghe-1 line – Already OFF (to maintain safe work clearance)
- iii. Transmission elements loading prior to event: At 400 kV Nagothane ss (2M+1A Bus)

Sr No	Name of element on 400 kV Main Bus-1	Loading in (MW)	Sr No	Name of elements on 400 kV Main Bus-2	Loading in (MW)
1	315 MVA, 400/220 kV ICT-1	-181 (Exp)		400 kV Dabhol-2	379 MW(Imp)
2	315 MVA, 400/220 kV ICT-2	-187 (EXP)		500 MVA, 400/220 kV ICT=3	270 MW (Imp)
3	400 kV Dabhol-1	379 (Imp)		167 MVA spare ICT	0 MW
4	400 kV Padghe-2	105 (Imp)		105 MVA, Spare Ict	0 MW

Table 57 Transmission elements loading prior to event: At 400 kV Nagothane

5. **State Generation and Demand**

	State Generation (MW)	State Demand (MW)
At 22:30 hrs	16851 MW	23728 MW

*Source- SCADA data at MSLDC.*

6. **Brief Details of System Disturbance:**

At 400 kV Nagothane Substation, construction work of a new 501 MVA, 400/220 kV ICT and new 400 kV Bus Coupler is in progress.

On 09.09.2025, an outage was availed for carrying out 400 kV bus extension jumper connection work from the existing 400 kV Main Bus-1 to the newly extended bus (for the new 400 kV Bus Coupler). During this activity, 400 kV Padghe Ckt-1 was taken out of service for maintaining safe clearance to work.

After successful completion of the jumper work, 400 kV Bus-1 bays that were connected to 400 kV Bus-2 were shifted back to 400 kV Bus-1, and normalcy was restored on 10.09.2025 at 22:31 hrs.

Subsequently, after charging of the 400 kV extended bus, a failure and decapping of the extended B-phase bus insulator string occurred.

This failure bus insulator string led to the operation of the 400 kV Bus-1(A) busbar protection scheme, resulting in the tripping of all 400 kV elements connected to 400 kV Bus-1 and the 400 kV Bus Coupler on 10.09.2025 at 22:31 hrs.

As the failure /decapping of the B-phase string insulator on the extended bus occurred, the fault (of magnitude-15 kA) was sensed in Zone-1(A) by the NR make busbar

# Maharashtra State Load Despatch Centre

protection scheme. During this operation, there was no load loss, as all loads were being fed through 400 kV Main Bus-2.

For completion of the work and replacement of the faulty extended bus string insulator, the 400 kV Main Bus-1 was kept de-energized. All the tripped elements were subsequently restored on Main Bus-2 in consultation with SLDC, and system normalcy was restored.

**7. Tripping and Restoration details:**

Sr. No.	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	315 MVA, 400/220 kV ICT-1	10/09/2025 23:36 Hrs.	11/09/2025 00:35 HRS	The failure insulator string resulted in the operation of the 400 kV Bus-1(A) busbar protection scheme.
2	315 MVA, 400/220 kV ICT-2		11/09/2025 00:35 HRS	
3	400 kV Dabhol-1		11/09/2025 00:35 HRS	
4	400 kV Padghe-2		11/09/2025 00:35 HRS	

Table 58 Tripping and Restoration details

**8. Generation / Load affected:**

Load Power loss and /or generation (in MW): Nil.

**9. PMU Plots :**

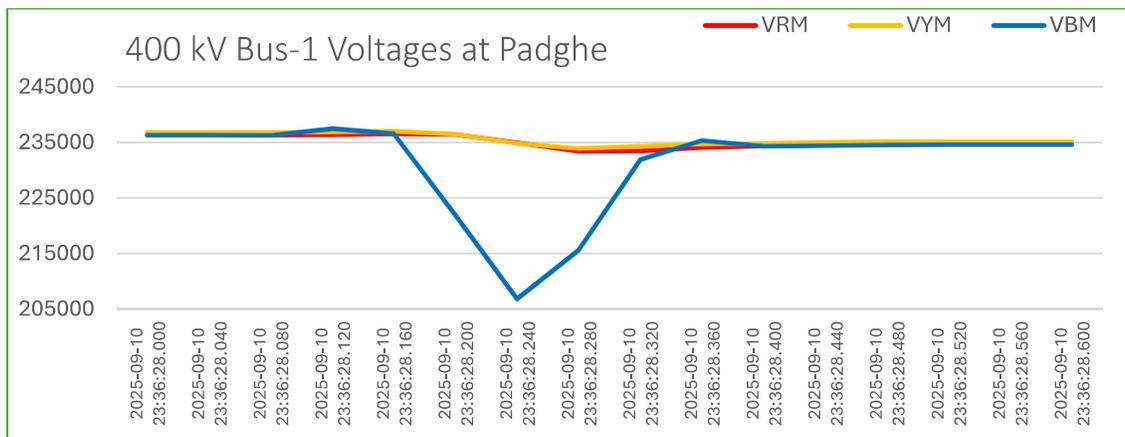


Figure 94 PMU Plots of PMUs at 400 kV Padghe ss Bus-1

# Maharashtra State Load Despatch Centre

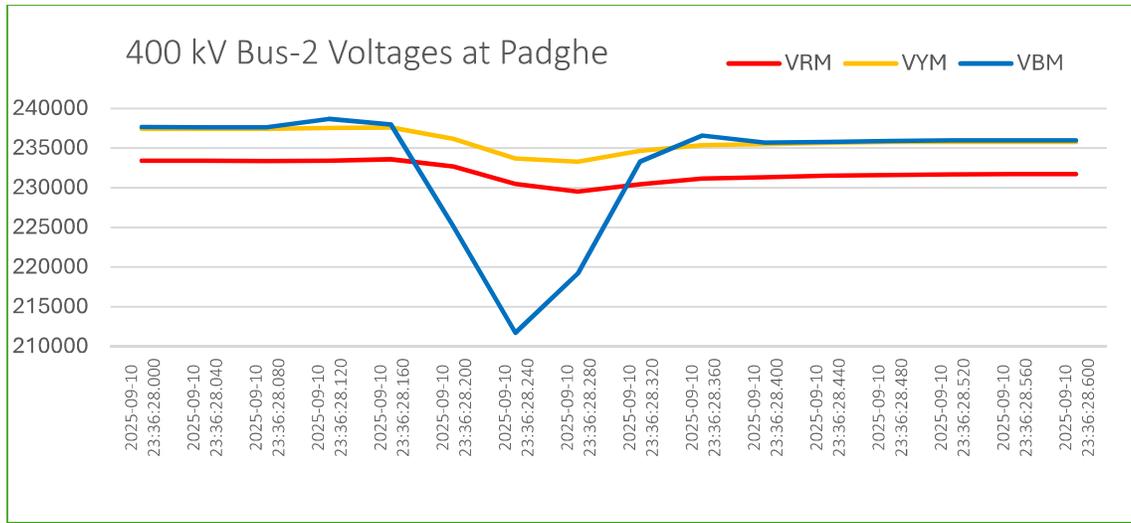


Figure 95 PMU Plots of PMUs at 400 kV Padhe ss Bus-2

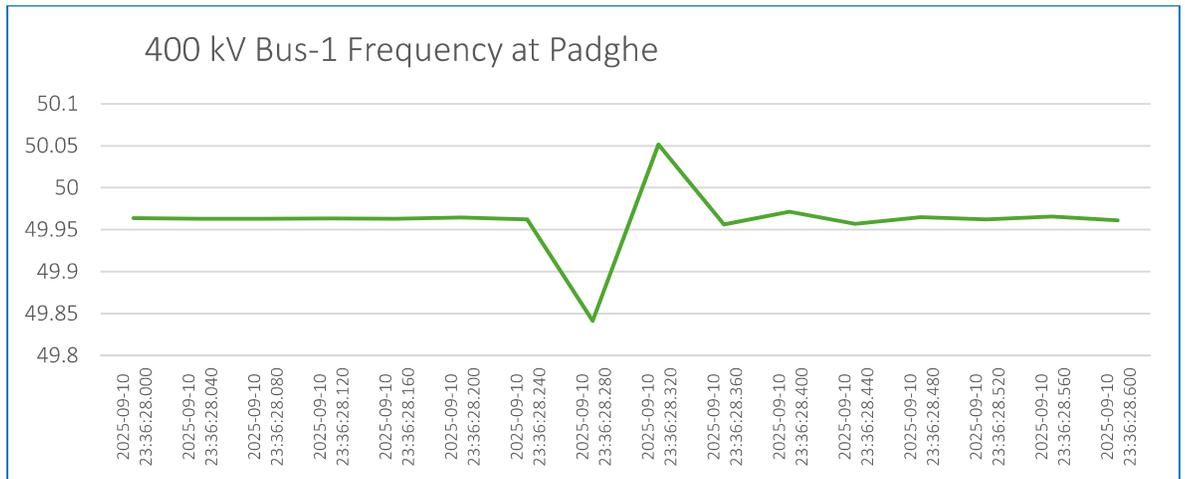


Figure 96 PMU Plots of PMUs at 400 kV Padhe ss Bus-1

Sr.No	Parameter	Values
1	Voltage drop of Yph at 400 kV bus-1 at Padghe ( $V_{PH-N}$ )	236.27 kV to 206.81 kV Voltage drop of 29.45 kV
2	Frequency disturbance	50.05 Hz (max) to 49.84 Hz (min)
3	Duration	360 msec

# Maharashtra State Load Despatch Centre

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## **10. MSLDC Observations:**

- i. The incident occurred due to failure and decapping of new B-phase string insulator on the newly extended 400 kV bus at Nagothane. It indicates a possible mechanical weakness, material defect, or improper installation/quality issue in the newly supplied insulator strings used for the extension work.
- ii. Disc insulators used for the extended bus are of IEC (Insulators & Electricals Company, Bhopal) make, 120 kN rating.
- iii. The NR make busbar protection system operated correctly for the fault within Zone-1(A). The tripping of Bus-1 bays and bus coupler to isolate the fault is in order.

## **11. Remarks / Remedial Measures Suggested by MSLDC:**

- i. It is observed that the failed insulator string is a part of extended 400 kV Bus and put in service first time. Random testing, healthiness Check of such insulators needs to be confirmed prior to charging. Thorough inspection and testing of all insulator strings and associated bus hardware before energizing any new or extended bus section.
- ii. Individual disc and whole String IR values are to be taken before first time use. It can be used as further reference for diagnostic checks of disc insulators.
- iii. The Quality Control Department i.e. Design Section, C.O. Mumbai, need to analyze the quality of the disc insulators of M/s IEC make and investigate any similar failures under MSETCL and to take suitable measures so as to prevent such occurrences in the future.
- iv. PID testing, Thermo-vision tests of these insulator strings needs to be carried out for existing and newly extended bus to avoid such occurrences in future.
- v. Due to the failure of the extended bus disc insulators, the ongoing O&M activity for charging the extended bus for the new 400 kV bus coupler has been suspended. The subsequent course of action in this regard needs to be communicated to MSLDC.
- vi. Vide its letter regarding occurrence report no. 1775 dtd.14.08.2025, MSLDC has suggested for Protection audit and GPS time synchronization of Disturbance Recorders at substation. The compliance regarding the same needs to be submitted, at the earliest.



(Girish Pantoji)  
Chief Engineer(I/C), MSLDC

# Maharashtra State Load Despatch Centre

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Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli...*it is requested to discuss this disturbance in upcoming PCC meeting.*
- 4) The Chief Engineer, EHV PC O&M Zone Vashi... *it is requested to take necessary holistic measures at 400 kV Nagothane ss, so as to minimize occurrences.*

**Copy. to:**

- 1) The Superintending Engineer, PAC Circle Vashi.
- 2) The Superintending Engineer, EHV O&M circle, Panvel.

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SLD Occurrence of 400KV BUS-1 at 400kV Nagothane S/s on 10.09.2025 (Bus configuration: - 2 Main + 1 Auxiliary bus)

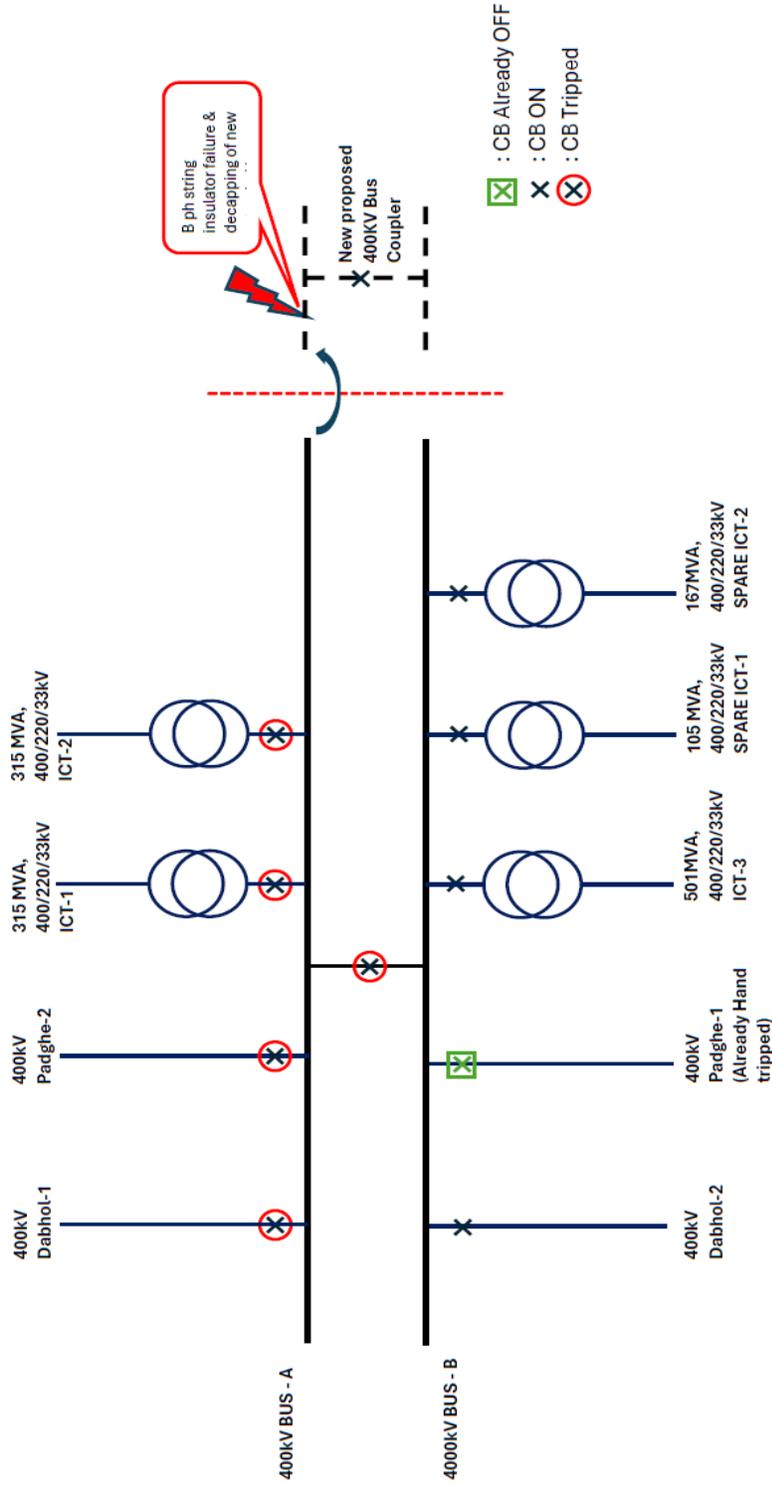


Figure 97 Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025

**3.2.15. Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400kV Deep-nagar substation on 19.09.2025.**

# Maharashtra State Load Despatch Centre

No: 2421

Date: 10.11.2025

## Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deepnagar substation on 19.09.2025.

### Background:

The 400 kV Deepnagar substation is a vital node for managing and evacuating power from the Bhusawal Super Thermal Power Station to the state's grid. The generation connected to the 400 kV Deepnagar substation includes the 500 MW GT-4 unit, the 500 MW GT-5 unit, and the 660 MW GT-6 unit. It is associated with key 400 kV transmission lines such as the 400 kV Khadka ckt- I & II, Walunj, and Thaptitanda lines. The 400 kV Deepnagar substation has an installed transformation capacity of 1002 MVA at 400/220 kV, which caters to the industrial, agricultural, and domestic loads of the Dhule, Jalgaon, and Nandurbar districts.

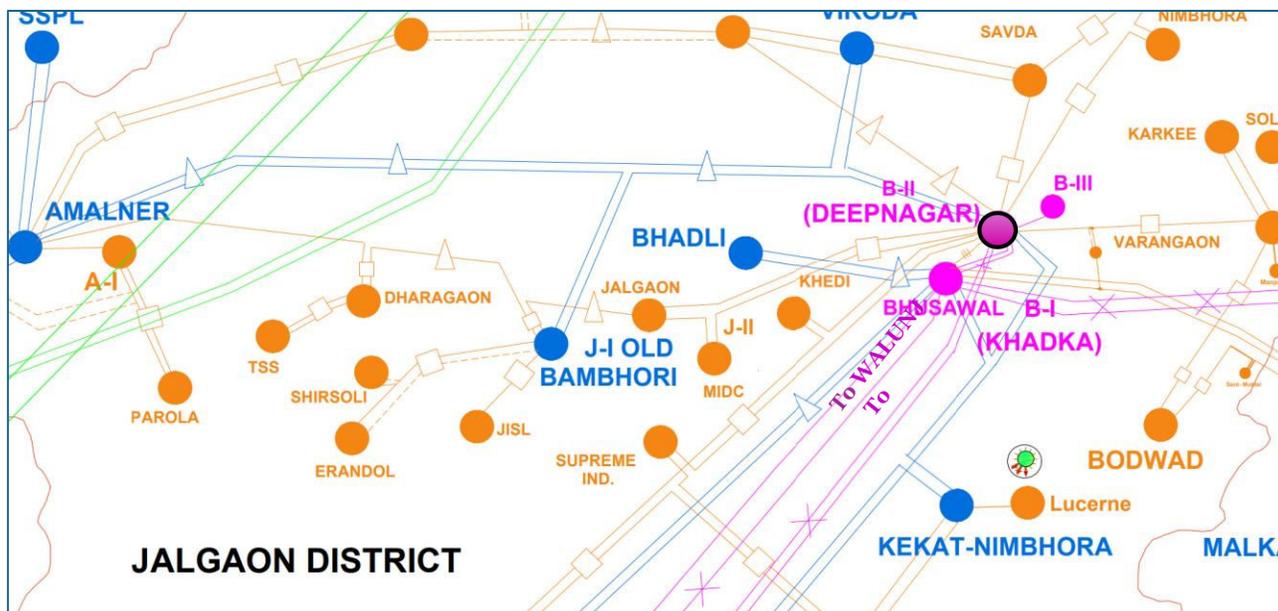


Figure 98 400 kV and 220 kV Network around 400 kV Deepnagar substation.

### Brief description of the event:

On 19.09.2025 at 04:25 Hrs, 400 kV Deepnagar–Khadka Ckt-1 tripped with distance & teed protection due to bursting of R-ph line current transformer (CT). 400 kV Deepnagar–Khadka Ckt-2 also tripped on teed differential protection. Simultaneously, 400 kV Busbar Protection operated, resulting in the tripping of all circuit breakers connected to Main Bus-2.

# Maharashtra State Load Despatch Centre

- 1. Utilities involved:** MSETCL, MSPGCL
- 2. Disturbance category:** GD 1
- 3. Last Protection Audit carried out:** 04.03.2024 to 07.03.2024 (TPA)
- 4. Antecedent conditions: -**
  - ix. 660 MW GT-6 unit Under shutdown (MSPGCL)
  - x. Transmission elements loading prior to event: At 400 kV Deepnagar ss (One and half CB)

Sr No	Name of element on 400 kV Main Bus-1	Loading in (MW)	Sr No	Name of elements on 400 kV Main Bus-2	Loading in (MW)
1	500 MW GT-4 Unit	267	1	400/220kV,501 MVA ICT-I	-110
2	500 MW GT-5Unit	271	2	400/220kV,501 MVA ICT-II	-109
3	400/11kV 80MVA Stn 4A	-4.57	3	400/220kV,167 MVA Sp ICT	--
4	400/11kV 80MVA Stn 4B	-3.47	4	400kV Khadka Ckt-I	04
5	660 MW GT-6 Unit	OFF	5	400kV Khadka Ckt-II	05
6	400/11kV,110MVA STN 6A	-8.54	6	400kV Aurangabad Ckt	-150
7	400/11kV 110MVA STN 6B	-5.52	7	400kV Thaptitanda Ckt	-72

Ref: MSETCL/SE/PACC/Nsk/TECH/J-1/439 Date: 29/09/2025

## 5. State Generation and Demand

Date and Time	State Generation (MW)	State Demand (MW)
19.09.2025; at 04:00 hrs	11839 MW	19336 MW

Source- SCADA data at MSLDC.

## 6. Brief Details of System Disturbance:

On 19.09.2025 at 04:26:34 hrs, the R-ph line CT of the 400 kV Deepnagar–Khadka Ckt-1 at 400 kV Deepnagar Substation got burst. As the fault occurred within the teed protection zone, the 400 kV Deepnagar–Khadka Ckt-1 tripped on Zone-1 distance protection and the teed protection scheme. A permissive carrier trip command was sent to the remote end (i.e. 400 kV Khadka Substation).

Although the 400 kV Deepnagar–Khadka Circuit-1 tripped at both ends and the initial fault was cleared, fumes from the burst R-ph line CT were not extinguished. The location of failed R-ph line CT of 400 kV Deepnagar–Khadka Ckt-1, is in close physical proximity to the B-ph busbar conductor and insulator strings of the 400 kV Main Bus-2 (see the sketch attached). During the CT bursting, carbonized oil and soot were expelled and subsequently deposited on the B-ph insulator strings, bus post insulators, conductors, and adjacent metallic structures of 400 kV Main Bus-2. This contamination led to the formation of transient low-impedance conductive paths between the B-ph of 400 kV Main Bus-2 and earth, resulting in a secondary fault on the 400 kV Main Bus-2.

The 400 kV Busbar Differential Protection (87BB) operated due to B-ph differential element, resulting in the isolation of 400 kV Main Bus-2 through the tripping of all circuit breakers (CBs) connected to it.

# Maharashtra State Load Despatch Centre

400 kV Deepnagar–Khadka Ckt-2 is located adjacent to 400 kV Deepnagar Khadka ckt-1 bay. The faulted (burst) R ph CT shares the same gantry and structural framework with 400 kV Deepnagar Khadka ckt-2, B ph CT. The Carbon deposition on gantry hardware and string insulators of 400 kV Deepnagar Khadka ckt-2, created path for leakage currents and partial conduction. Causing operation of Khadka Ckt-2 on differential teed protection & DT was sent to the remote end (i.e. 400 kV Khadka Substation).

The ICT-1 & ICT-2 (LV side) tripped as per the protection scheme — Main HV 96 protection-initiated trip command (386) to ICT LV.

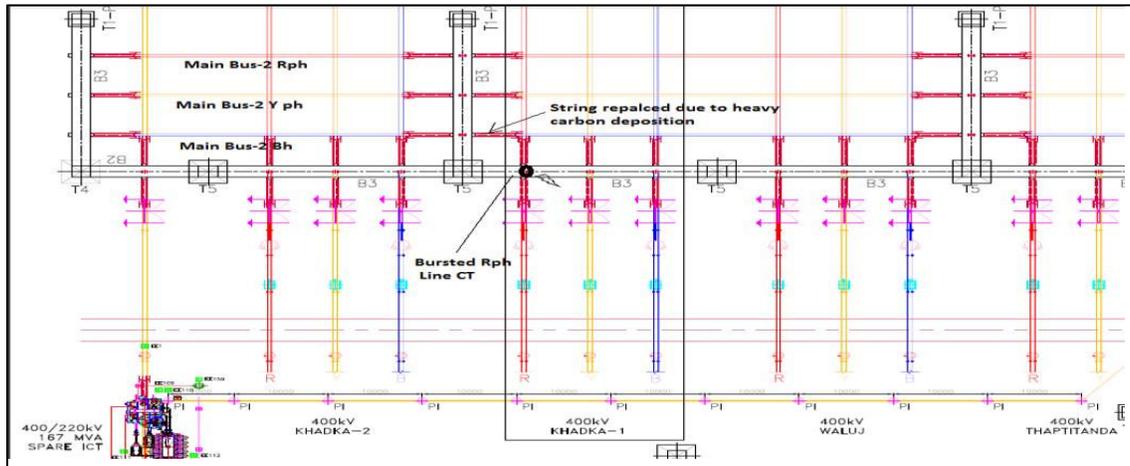


Figure 99 Physical location of Burst R ph CT of 400 kV Deepnagar Khadka -1 bay at 400 kV Deepnagar ss

## 7. Tripping and Restoration details:

Sr. No	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications
1	400kV Khadka Deepnagar Ckt-1	19.09.2025, 04:27Hrs	24.09.2025, 11.09Hrs	<b>Khadka Ckt-1:</b> Zone-1 trip, Diff Bph.186,286
2	400kV Khadka Deepnagar Ckt-2	19.09.2025, 04:27Hrs	19.09.2025, 15.56Hrs	<b>Khadka Ckt-2:</b> Diff Bph. 186, 286.
3	400 kV Main Bus-2	19.09.2025, 04:27Hrs	20.09.2025, 07.15Hrs	<b>Bus Bar:</b> Bus-2 Differential Operated Sp ICT-96; Khadka-1: <b>Main-96;</b>
4	400/220kV 167MVA Spare ICT	19.09.2025, 04:27Hrs	20.09.2025, 07.15Hrs	Khadka-2: <b>Main -96;</b> Thaptitanda: <b>Main-96;</b> Waluj ckt: <b>Main -96</b> 400/220kV 501MVA ICT I: <b>HV-96 &amp; MV 386</b> 400/220kV 501MVA ICT II: <b>HV -96 &amp; MV 386</b> GT-5 <b>Tie -96</b> STN 6A <b>Tie-96</b> STN 6B <b>Tie- 96</b> GT6 <b>Tie -96</b>

Table 59 Tripping and Restoration details

# Maharashtra State Load Despatch Centre

**8. Generation / Load affected:**

Load Power loss and /or generation (in MW): Generation Loss = Nil.

**9. PMU Plots :**

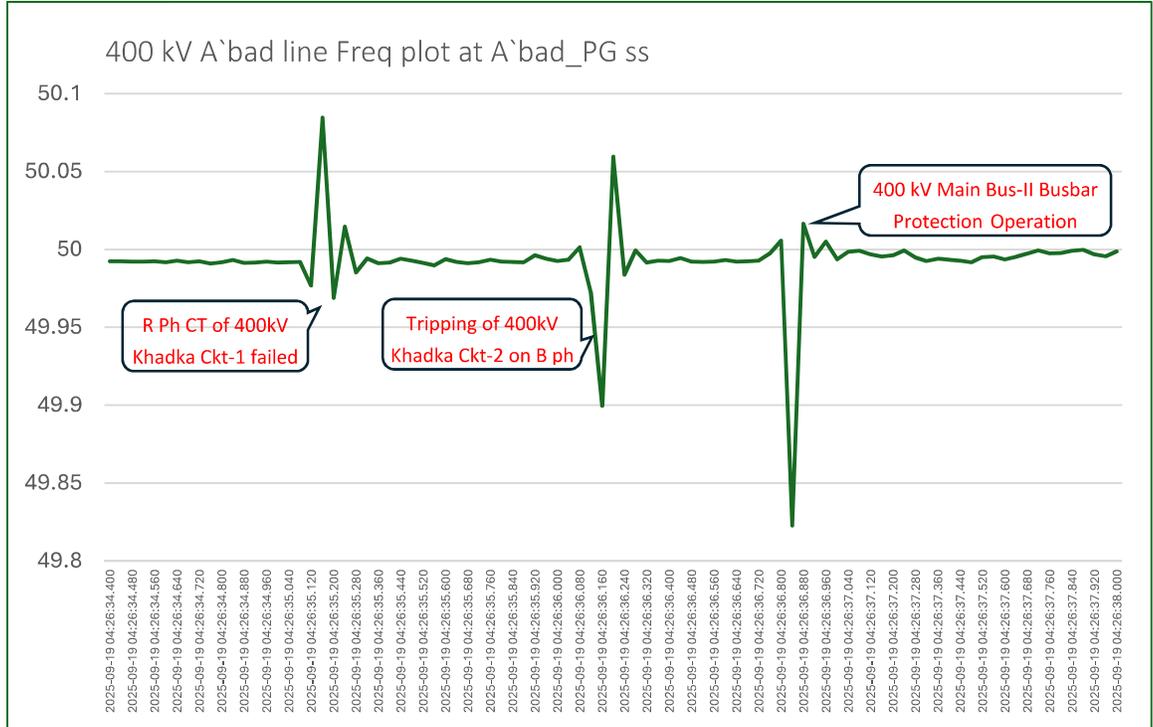


Figure 100 PMU Plots of PMUs at 400 kVA` bad\_PG ss

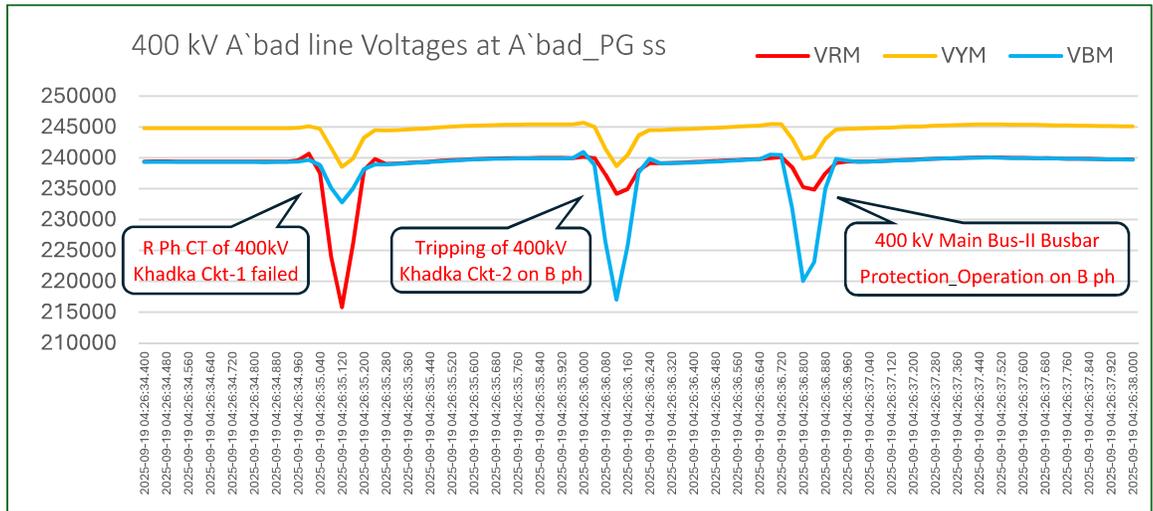


Figure 101 PMU Plots of PMUs at 400 kVA` bad\_PG ss

## 10. Disturbance Recorder data :

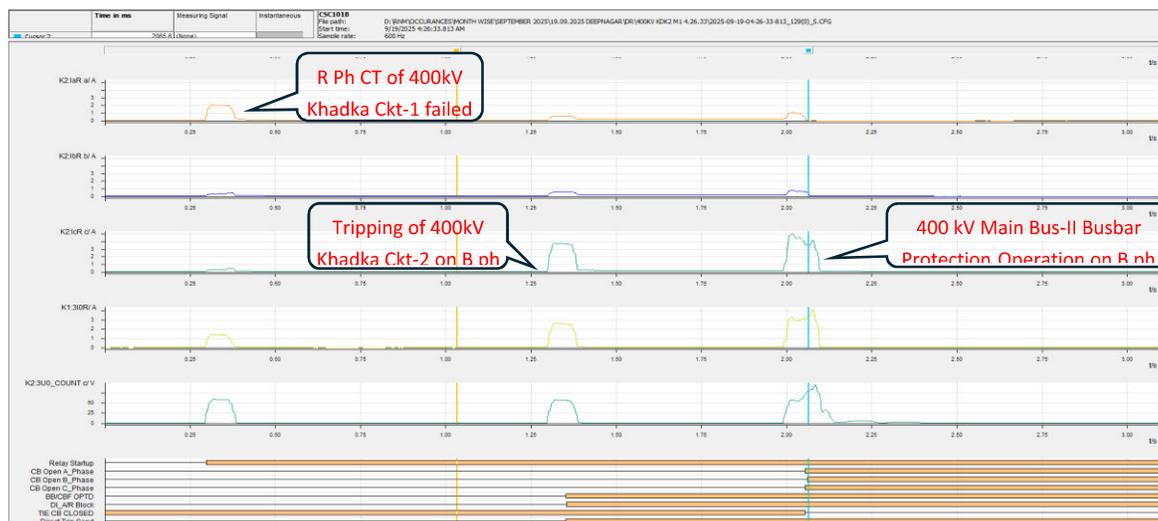


Figure 102 Disturbance Recorder plots of 400 kV deepnagar- Khadka2 M1 relay

Sr.No	Parameter	Values
1	Voltage drop of R ph ( $V_{PH-N}$ ) Voltage drop of Y ph ( $V_{PH-N}$ ) Voltage drop of B ph ( $V_{PH-N}$ )	239.3 kV to 215.7 kV (drop: 23.6 kV) 244.8 kV to 238.5 kV (drop: 6.3 kV) 239.9 kV to 217.0 kV (drop: 22.9 kV)
2	Frequency disturbance	50.08 Hz (max) – 49.82 Hz (min)
3	Duration of disturbance	4:26:36:960 - 4:26:34:920 = 2.040 sec

## 11. MSLDC Observations:

- i. The incident occurred due to failure of R-ph CT (Make: Areva, Sr. No. 200810134) of 400kV Deepnagar Khadka Ckt-1 bay, causing a 400 kV Bus-2 fault. Busbar Differential Protection operated correctly and isolated 400 kV Bus-2.
- ii. The Bus bar relay operations are in order; all 400 kV Bus-2 connected elements and the 400 kV Tie CBs tripped via respective 96 relays.
- iii. The ICT-1 & ICT-2 - IV sides tripped as per the protection scheme — 400 kV Bus-2 Busbar protection trip relay (196) -initiated trip command to ICTs HV Trip Coils 1 & 2 and ICT IV Master trip relays. The ICT remained in charged condition through 400 kV Main Bus 1 via its Tie Bay.
- iv. Failed R-ph CT (Make: Areva, Sr. No. 200810134) of 400kV Deepnagar Khadka Ckt-1 bay was commissioned in 2012 (mfg. Yr: 2008) and had last Tan Delta & Capacitance test in March 25, which was within limits (Capacitance = 1094 pF; Tan  $\delta$  = 0.28%).

# Maharashtra State Load Despatch Centre

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- v. After bursting the R Ph CT of 400kV Khadka -Deepnagar Ckt-1 caught fire and due to splashing of burning oil on CT cables, the cables also got burnt.
- vi. During the CT bursting, carbonized oil and soot were expelled and it subsequently deposited on the nearby insulator strings, conductors, and adjacent metallic structures of 400 kV Main Bus-2. After cleaning the 400 kV Bus-II normalcy was restored.
- vii. After completion of the replacement of the 400 kV R-phase CT and allied control cable works, the 400 kV Deepnagar Khadka Ckt-1 was charged on 24.09.2025, 11.09Hrs.
- viii. 400 kV Khadka -A'Bad (Waluj) line has been hand-tripped from 13.09.2025,01:45 to 19.09.2025,06:41 to avoid system over-voltages.

## **12. Remarks / Remedial Measures Suggested by MSLDC:**

1. During Busbar protection operation, The ICT-1 & ICT-2 - IV sides tripped as per the protection scheme —400 kV Bus-2 Busbar protection trip relay (196) - initiated trip command to ICTs HV Trip Coils 1 & 2 and ICT IV Master trip relays. The ICT remained in charged condition through 400 kV Main Bus 1 via its Tie Bay. Notably, both ICTs could have remained in service, being well isolated from the faulty Main Bus-2, if the bus bar trip relay (196) had not initiated a trip command to the IV side trip relay (386). Therefore, a suitable trip logic modification is recommended while tripping IV sides of ICTs to prevent unnecessary tripping under Such conditions.
2. Through Chemical cleaning of the affected area of Bus bar and bays nearby needs to carry out to have desired insulation levels, Also, to ensure healthiness of Bus insulators it is recommended to carry out PID testing of all the 400 kV Bus II insulators and of overall insulators installed at substation.
3. The Reason for failure of CT needs to be analyzed in depth. Regular thermography of EHV switchyard equipment such as CTs, CVTs, LAs, bushings, transformers, and bus conductors is essential for detecting hotspots caused by loose joints, contact resistance and insulation deterioration. It is useful for equipment where hidden defects may not appear in routine tests. Thermography enables early failure prediction in substation equipment.
4. Regular checks for oil leakages and oil levels in oil-filled EHV equipment are essential, any leakages must be attended promptly to ensure reliability and prevent equipment failure. Particularly in monsoon/ rainy season, oil leakages

## Maharashtra State Load Despatch Centre

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are difficult to detect. Hence Regular thermography of substation equipment is very much beneficial to predict abnormalities if any.

5. The GPS time synchronization of protective relays and disturbance recorders needs to be ensured as per as per MEGC 2020, Clause No. 25.1.



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli...it is requested to discuss this disturbance in upcoming PCC meeting.
- 4) The Chief Engineer, EHV PC O&M Zone Nashik.
- 5) The Chief Engineer, ALDC Ambazari, Nagpur.

**Copy to:**

- 1) The Superintending Engineer, PAC Circle Nashik.

**Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deepnagar substations on 19.09.2025.**

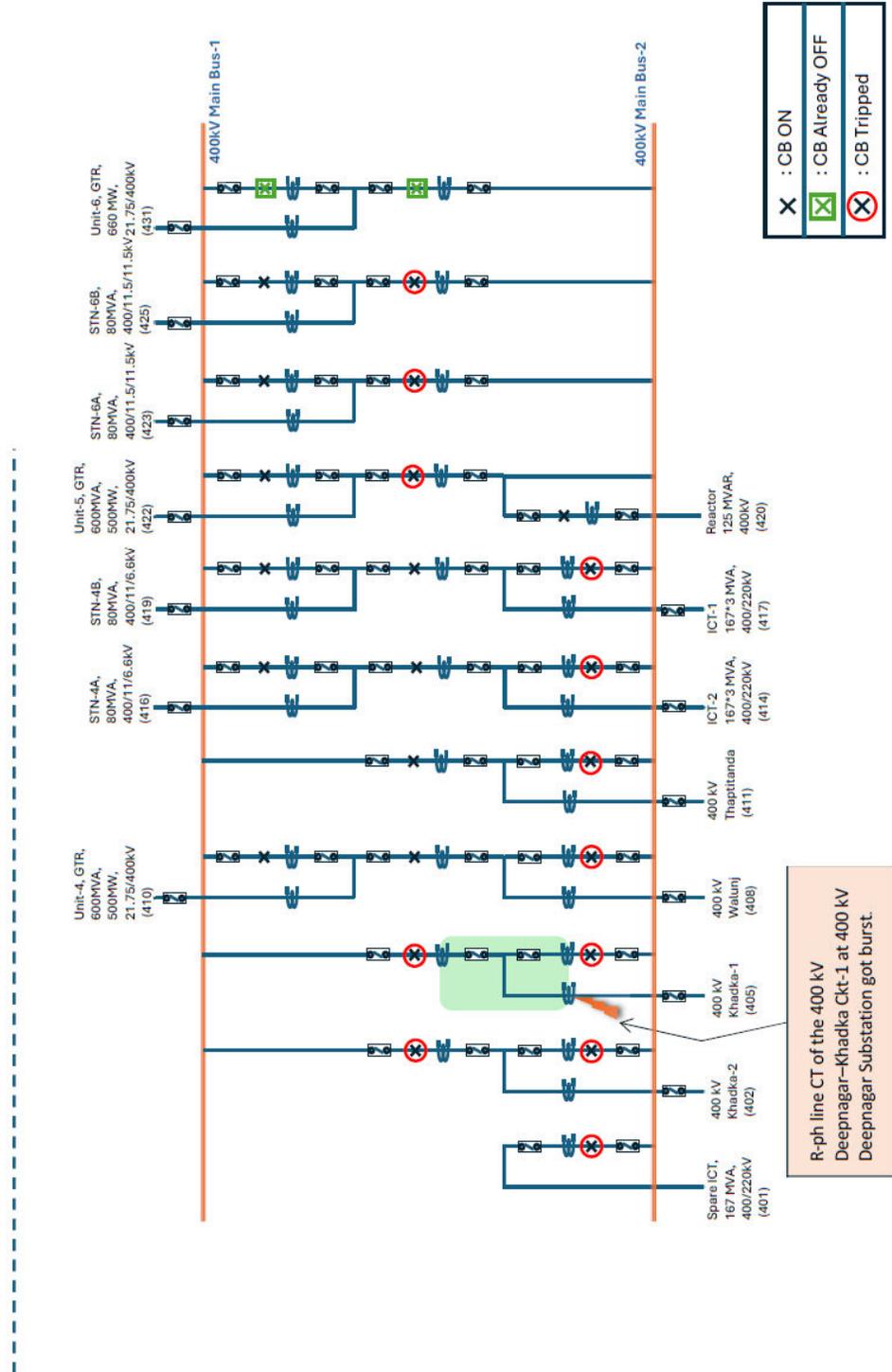


Figure 103 Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deep-nagar substation on 19.09.2025

**3.2.16. Occurrence of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.**

# Maharashtra State Load Despatch Centre

No:2691

Date: 10 DEC 2025

## Occurrence report of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 S/S and multi-line tripping.

### Background:

The 400 kV Chandrapur -2 ss plays an important role in managing and evacuating power from the Chandrapur Super Thermal Power Station and M/s Dhariwal Generation to the state's grid. This substation is a critical node in Maharashtra's power grid. It is associated with key transmission lines and other substations, such as the 400 kV Chandrapur ckt I & II, Nanded ckt I & II, Chandrapur (Sw) ckt I & II, Dhariwal ckt I & II, Warora (PG) ckt I & II. The Substation is main outlet to 400 kV Dhariwal Gen Units (600 MW) and MSPGCL's 400 kV Chandrapur unit 8 & 9 (1000 MW)

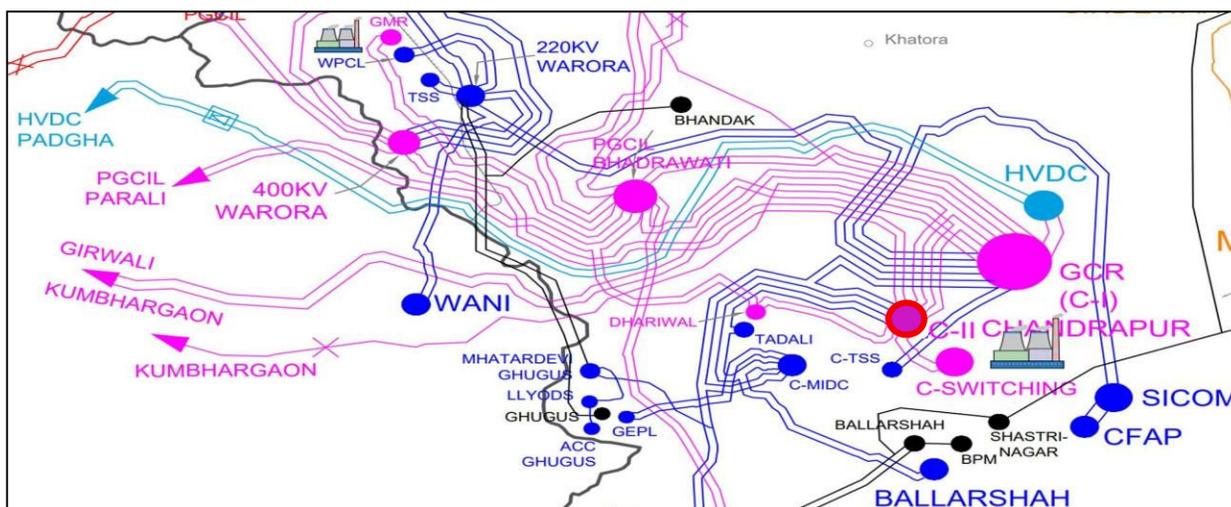


Figure 104 400 kV Network around 400 kV Chandrapur-2 ss.

### **1. Brief description of the event:**

On 21.10.2025 at 20:02 hrs, at 400 kV Chandrapur-2 ss, the 400 kV Chandrapur (SW) Ckt-2's (connected to Main Bus-1) Y-phase IPS tube between the bus isolator and circuit breaker got detached from the Main Bus-1 isolator and came into the vicinity of the circuit breaker structure.

This abnormal condition led to the tripping of 08 nos of lines from the remote end on Y-phase Zone-1/Zone-2 protection, along with the operation of the 400 kV busbar protection system (Make: ABB, Type: REB500) for Main Bus-1 at 20:02 hrs at the 400 kV Chandrapur-2 substation.

# Maharashtra State Load Despatch Centre

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Further, after about 5 seconds at 20:02:31 hrs, 400kV Nanded-1, 400kV Warora Ckt-1, 400 kV Chandrapur (SW) Ckt-1 and 400kV Dhariwal Ckt-1 were tripped on Over Voltage Protection (Only Main-2 P444 relay O/V protection operated) from local end.

2. **Utilities involved:** MSETCL, MSPGCL, Dhariwal, PGCIL
3. **Disturbance category:** GD-1
4. **Last Protection Audit carried out:** TPA, February 2025
5. **Antecedent Conditions:** Partial cloudy, Normal

At 400 kV Chandrapur STPGS: Unit 5 & 7 Under RSD.

Bus configuration & load prior to occurrence: - 1 & ½ CB Configuration.

Sr.No.	400 kV Main Bus-1		400 kV main Bus II	
	Name of Bay	Loads MW	Name of Bay	Loads MW
1	400kV Chandrapur (Sw) ckt-1	251(Imp)	400kV GCR ckt-1	87(Exp)
2	400kV Chandrapur (Sw) ckt-2	254(Imp)	400kV GCR ckt-2	77(Exp)
3	400kV DIL ckt-1	83(Imp)	400kV NANDED ckt-1	377(Exp)
4	400kV DIL ckt-2	83(Imp)	400kV NANDED ckt-2	379(Exp)
5	400kV WARORA ckt-1	177(Imp)	400kV ICT-1	106(Exp)
6	400kV WARORA ckt-2	176(Imp)	400kV ICT-2	Under Outage

Figure 105 Bus configuration & load prior to occurrence

## 6. **State Generation and Demand**

Date and time	State Generation (MW)	State Demand (MW)
21.10.2025; at 20:00 hrs	12944 MW	19269 MW

Source- SCADA data at MSLDC.

## 7. **Brief Details of System Disturbance:**

According to detailed analysis report submitted by SE PAC Circle Nagpur. MSETCL, On 21.10.2025 at 20:02:25.670 hrs, due to the detachment of the Y-phase IPS tube between the Bus-1 Isolator and the Circuit Breaker of the 400 kV Chandrapur (Sw) Ckt-2, which came into vicinity of the CB structure. Out of 10 lines connected to Chandrapur-2 ss: 07 lines tripped on Y-phase Zone-2 from their respective remote ends. 01 line tripped on Y-phase Zone-1 from the remote end.

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The IPS tube was electrically disconnected from 400 kV Bus1, but remained connected to the Circuit Breaker, which corresponds to the P1 side of the Bus CT 400 kV Switching Ckt-2 (Bay 404).

At 400kV Chandrapur-2 ss,

- i. 400kV Chandrapur-2- Chandrapur (Sw) Ckt-2 tripped on Yph, Zone-1 from 400kV Chandrapur (Sw) end only (LL: 2.3 km, IFL: 6kA).
- ii. 400kV Chandrapur-2- Chandrapur (Sw) Ckt-1 tripped on Yph, Zone-2 from 400kV Chandrapur (Sw) end only (LL: 2.3 km, IFL: 7kA).
- iii. 400kV Chandrapur-2-Nanded Ckt-1 tripped on Yph Zone-2 from 400kV Nanded end after 500ms (LL: 277 km, IFL: 1.2kA).
- iv. 400kV Chandrapur-2-Nanded Ckt-2 tripped on Yph Zone-2 from 400kV Nanded end after 500ms (LL: 301.3 km, IFL: 1.1kA).
- v. 400kV Chandrapur-2-DIL Ckt-1 tripped on Yph Zone-2 from 400kV DIL end after 500ms (LL: 9.5 km, IFL: 3.5kA).
- vi. 400kV Chandrapur-2-DIL Ckt-2 tripped on Yph Zone-2 from 400kV DIL end after 500ms (LL: 9.5 km, IFL: 3.5kA).
- vii. 400kV Chandrapur-1-Warora Ckt-1 tripped on Yph Zone-2 from 400kV Warora end after 500 ms (LL: 45.75 km, IFL: 2.4kA).
- viii. 400kV Chandrapur-2-Warora Ckt-1 tripped on Yph Zone-2 from 400kV Warora end after 500 ms (LL: 45.75 km, IFL: 2.4kA).

Distance protections Zone 3 were only picked up for 400 kV Chandrapur-2–GCR Ckts-1 & 2 at the remote end and these ckts remained in service. Simultaneous tripping was also recorded at 400 kV GCR, Khaperkheda, Parli, and Dhariwal substations.

After around 620 ms, at 20:02:26.238 hrs, the 400 kV Busbar Protection (ABB REB500) operated for 400 kV Bus-1, resulting in tripping of all Main CBs connected to 400 kV Bus-1 at 400 kV Chandrapur-2 ss.

Since the remaining lines were still charged through Bus-2 via Tie bays on no loads, a due to overvoltage condition (after about 5 seconds), at 20:02:31 hrs, the following circuits tripped on Main-2 (P444) Overvoltage Stage-1 protection at the local Chandrapur-2 end:

- i. 400 kV Nanded Ckt-1.
- ii. 400 kV Warora Ckt-1.
- iii. 400 kV Switching Ckt-1.
- iv. 400 kV DIL Ckt-1.

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## **Tripping at Other Remote SS Locations (Fault instant at 20:02:25.670 hrs)**

### **a) At 400 kV Chandrapur GCR ss**

- i. 400kV GCR-Khaperkheda Ckt tripped on Y-ph Zone-2 at 400kV Khaperkheda end (500msec) with fault current magnitude of about 2.8kA and DT received (on operation of 86A/86B of Kh'kheda) at GCR end.
- ii. 400kV GCR-Parli-3 Ckt tripped on Y-ph Zone-2 at 400kV Parli end (500ms) with fault current magnitude of about 1kA. After 5 Sec, Parli -3 Ckt tripped on O/V protection Stage-1 at 400kV Parali end and DT received at GCR end.
- iii. 400kV GT-4 is tripped due to tripping of both FD fan and subsequent MFT and turbine trip.
- iv. 400kV GCR-CHD-2 Ckt-1 and Ckt-2 were not tripped. Only Zone-3 Started at 400kV GCR end.
- v. 400kV GCR-PGCIL Ckt-2 tripped on O/V protection stage-1 at 400kV GCR end (after 5 Sec).

### **b) At 400 kV Chandrapur (Sw) Station**

- i. 400kV Chandrapur (Sw) - Chandrapur -2 Ckt-2 Tripped on Y-ph Zone-1.
- ii. 400kV Chandrapur (Sw) - Chandrapur -2 Ckt-1 Tripped on Y-ph Zone-2 after 350ms.
- iii. GT-8 and GT-9 are tripped due to isolation from GRID.

### **c) At 400 kV Warora**

- i. 400kV Warora-CHD-2 Ckt-1 tripped on Y-ph Zone-2 after 500ms
- ii. 400kV Warora-CHD-2 Ckt-2 tripped on Y-ph Zone-2 after 500ms.

### **d) At 400 kV Dhariwal (Private Generation Utility)**

- i. 400kV Chandrapur-2 Ckt-1 tripped on Y-ph, Zone-2 after 500ms
- ii. 400kV Chandrapur-2 Ckt-2 tripped on Y-ph, Zone-2 after 500ms
- iii. 400kV Dhariwal- Parali PG Ckt-4 tripped on Y-ph, Zone-4 after 500ms
- iv. Unit-1 generator tripped on voltage-controlled o/c protection after 500msec.
- v. Unit-2 generator tripped on voltage-controlled o/c protection after 500msec
- vi. STN TF-1 tripped on HV back up derived earth fault stage-2 protection.

### **e) Following 400 kV lines in the region also got tripped on Zone 2**

- i. 400 kV Parli (PG) -Dhariwal line.
- ii. 400 kV Raipur- Bhadrawatii (PG) ckt 1 & 3
- iii. 400 kV Bhilai- Bhadrawatii (PG) line.

# Maharashtra State Load Despatch Centre

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## 8. SOE (derived from DRs received from substation involved):

Sr.No	Event	Time
1	Fault Occurrence	t = 0
2	400 kV Chandrapur 2 - Chandrapur (Sw) Ckt II tripped on Z-1 from remote end	t = 0
3	<ul style="list-style-type: none"> <li>i. 400 kV Chandrapur 2-Chandrapur (Sw) Ckt I tripped on Z-2 from remote end</li> <li>ii. GT-8 and GT-9 are tripped due to isolation from GRID.</li> </ul>	t1 = t+350ms
4	STN TF-1 tripped on HV back up derived earth fault	t2 = t+400 ms
5	400kV Dhariwal- Parali PG CB tripped in Z-4 at 400kV Dhariwal end	t3 = t+480 ms
6	<ul style="list-style-type: none"> <li>iii. 400kV Chandrapur-2-Nanded Ckt-1 tripped on Zone-2 from 400kV Nanded end.</li> <li>iv. 400kV Chandrapur-2-Nanded Ckt-2 tripped on Zone-2 from 400kV Nanded end.</li> <li>v. 400kV Chandrapur-2-DIL Ckt-1 tripped on Zone-2 from 400kV DIL end.</li> <li>vi. 400kV Chandrapur-2-DIL Ckt-2 tripped on Zone-2 from 400kV DIL end.</li> <li>vii. 400kV Chandrapur-1-Warora Ckt-1 tripped on Zone-2 from 400kV Warora end.</li> <li>viii. 400kV Chandrapur-1-Warora Ckt-2 tripped on Zone-2 from 400kV Warora end</li> <li>ix. 400kV GT-4 is tripped due to tripping of both FD fan and subsequent MFT and turbine trip.</li> <li>x. At 400 kV Dhariwal Unit-1 generator tripped on voltage-controlled o/c protection after 500msec.</li> <li>xi. At 400 kV Dhariwal Unit-2 generator tripped on voltage-controlled o/c protection after 500msec</li> <li>xii. 400kV GCR-Khaperkheda Ckt tripped on Zone-2 at 400kV Khaperkheda end</li> <li>xiii. 400kV GCR-Parli-3 Ckt tripped on Zone-2 at 400kV Parli end.</li> <li>xiv. 400 kV Dhariwal- Parli PG ckt tripped on Zone-2 at 400kV Parli PG end.</li> </ul>	t4 = t+500 ms

## Maharashtra State Load Despatch Centre

	<p>xv. 400 kV Raipur- Bhadrawatii (PG) ckt 1 &amp; 3 tripped on Zone-2 at 400kV Raipur end.</p> <p>xvi. 400 kV Bhilai- Bhadrawatii (PG) line tripped on Zone-2 at 400kV Bhilai end.</p>	
7	<p>400 kV Busbar Protection (ABB REB500) operated for 400 kV Bus-1, resulting in tripping of all Main CBs connected to 400 kV Bus-1 at 400 kV Chandrapur-2 ss.</p> <p>i. 400 kV Chandrapur 2 - Chandrapur (Sw) Ckt 1</p> <p>ii. 400 kV Chandrapur 2 - Chandrapur (Sw) Ckt 2</p> <p>iii. 400 kV Chandrapur 2 - Dhariwal Ckt 1</p> <p>iv. 400 kV Chandrapur 2 - Dhariwal Ckt 2</p> <p>v. 400 kV Chandrapur 2 - Warora Ckt 1</p> <p>vi. 400 kV Chandrapur 2 - Warora Ckt 2</p> <p>vii. 400 kV Spare bay</p> <p>viii. 400 kV ICT 1 tie bay</p>	t4 = t+620 ms
8	<p>Due to over voltages following Line tripping took place:</p> <p>i. 400 kV Chandrapur 2 - Chandrapur (Sw) Ckt I tie CB and DT sent to remote end.</p> <p>ii. 400 kV Chandrapur 2 - Dhariwal Ckt I tie CB and DT sent to remote end.</p> <p>iii. 400 kV Chandrapur 2 - Warora Ckt I tie CB and DT sent to remote end.</p> <p>iv. 400 kV Chandrapur 2 - Nanded Ckt I tie CB and DT sent to remote end.</p> <p>v. 400kV Parli-Chandrapur GCR Ckt OV relay operated at Parali end and DT sent to remote end.</p> <p>vi. 400kV Bhadrawati PG -Chandrapur GCR Ckt 3 OV relay operated at Bhadrawati PG end and DT sent to remote end.</p> <p>vii. 400 kV Raipur- Bhadrawatii (PG) ckt 3 OV relay operated at Raipur end and DT sent to remote end.</p> <p>viii. 400kV Chandrapur GCR -Khaperkheda Ckt OV relay operated at Khaperkheda end and DT sent to remote end.</p>	t4 = t+5sec

Table 60 SOE (derived from DRs received from substation involved)

# Maharashtra State Load Despatch Centre

## 9. Tripping and Restoration details:

Sr. No	Transmission / Generation Element	Trip Time	Relay Indications	Restoration Time
1	400 kV Chandrapur 2 -Warora ckt I	20:03 Hrs; 21.10.2025	Main Bay- 96 Remote- Yph, Z2	21:23 Hrs; 21.10.2025 and BUS-1 charged
2	400 kV Chandrapur 2 -Warora ckt II	20:03 Hrs; 21.10.2025	Main Bay- 96 Tie Bay- OV 86A, 86B Remote- Yph, Z2	21:32 Hrs; 21.10.2025
3	400 kV Chandrapur 2- Chandrapur (Sw) Ckt I	20:03 Hrs; 21.10.2025	Main Bay- 96 Remote- Yph, Z2	22:02 Hrs; 21.10.2025
4	400 kV Chandrapur 2- Chandrapur (Sw) Ckt II	20:03 Hrs; 21.10.2025	Main Bay- 96 Tie Bay- OV 86A, 86B Remote- Yph, Z1	02:32 Hrs; 22.10.2025
5	400 kV Chandrapur 2- Dhariwal ckt I	20:03 Hrs; 21.10.2025	Main Bay- 96 Tie Bay- OV 86A, 86B Remote- Yph, Z2	20:38 Hrs; 21.10.2025
6	400 kV Chandrapur 2- Dhariwal ckt II	20:03 Hrs; 21.10.2025	Main Bay- 96 Remote- Yph, Z2	22:20 Hrs; 21.10.2025
7	400 kV Chandrapur 2-Nanded ckt I	20:03 Hrs; 21.10.2025	Tie Bay- OV 86A, 86B	23:34 Hrs; 21.10.2025
8	400 kV Chandrapur 2-Nanded ckt II	20:03 Hrs; 21.10.2025	Remote- Yph, Z2	23:16 Hrs; 21.10.2025
9	400 kV Chandrapur GCR - Khaparkheda ckt	20:03 Hrs; 21.10.2025	DT recd, Remote- Yph, Z2	22:00 Hrs; 21.10.2025
10	400 kV Chandrapur GCR -Parly ckt	20:03 Hrs; 21.10.2025	Remote- Yph, Z2	22:04 Hrs; 21.10.2025
11	400 kV Chandrapur GCR- Bhadrawati ckt 2	20:03 Hrs; 21.10.2025	OV 86A, 86B	23:26 Hrs; 21.10.2025
12	400 kV Chandrapur 2 Spare Bay (413)	20:03 Hrs; 21.10.2025	Main- 96	23:51 Hrs; 21.10.2025
13	400 kV Chandrapur 2 ICT1 (432) TIE BAY	20:03 Hrs; 21.10.2025	Tie-96	00:01 Hrs; 22.10.2025
14	400 kV Chandrapur 2 ICT1 (432) TIE BAY	20:03 Hrs; 21.10.2025	Tie-96	Out of Service
15	MSPGCL Chandrapur (Sw) Unit 9 (500 MW)	20:03 Hrs; 21.10.2025	isolation from GRID	16:11 Hrs; 22.10.2025
16	MSPGCL Chandrapur (Sw) Unit 8 (500 MW)	20:03 Hrs; 21.10.2025	isolation from GRID	16:52 Hrs; 22.10.2025
17	Chandrapur CSTPS unit 4	20:03 Hrs; 21.10.2025	MFT and Turbine trip.	01:03 Hrs; 22.10.2025

Table 61 Tripping and Restoration details:

# Maharashtra State Load Despatch Centre

## 10. Generation / Load affected:

i. Generation Affected at Chandrapur (Sw) & GCR

Unit-8: 270 MW

Unit 9: 260 MW

Unit 4: 101 MW

**Total Generation Affected of MSPGCL: 631 MW**

ii. Generation Affected at Dhariwal

Unit 1- 200 MW

Unit 2 - 280 MW

**Total Generation Affected of Dhariwal: 480 MW.**

**Total Generation Affected: 1280 MW**

## 11. PMU Plots:

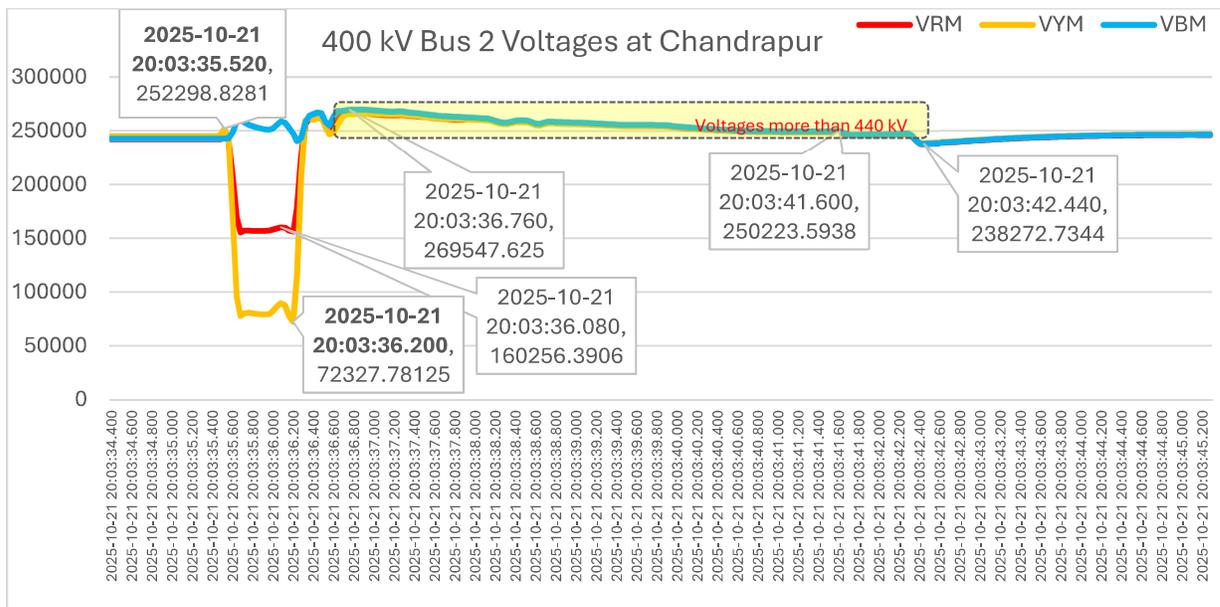


Figure 106 400 kV Bus 2 Voltages at Chandrapur

## 12. PMU Plots observation:

1. Before the occurrence System Voltage observed was 420 kV.
2. During the occurrence Voltage drops observed: 436.98 kV to 125.27 kV on Y Ph.
3. The IPS tube detachment instance occurred (Fault Instance) at 20:03:35:520 hrs.

# Maharashtra State Load Despatch Centre

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4. The 400 kV lines connected to 400 kV Main Bus 1 tripped in Zone 2 from remote ends at 20:03:36:080 hrs.
5. At 20:03:36:200 hrs, 400 kV Main Bus1 Busbar Protection operated.
6. After operation of 400 kV Main Bus 1 Busbar Protection, system voltage are seen more than 440 kV (110%).
7. Between 20:03:41.600 to 20:03:42.400 hrs due to over voltages further Tie Bays and line tripping took place.

### **13. MSLDC Obsevation:**

1. At 400 kV Chandrapur-2 ss, for 400 kV Chandrapur (Sw) ckt-2, (from DR of Differential relay (RED670) & BCU (REC 670)) it is observed that,
  - i. The fault appeared at 20:02:25.640 hrs, the remote end of CB 400 kV Chandrapur (Sw) ckt-2 operated for the fault in Zone 1 (Instantaneously).
  - ii. In relay (RED 670), the fault current of magnitude 03 Amps (secondary) is seen for 20-30 msec However, the voltage dip of magnitude from 66.7volts to 0.7volts (secondary) is observed to be continued after till 650 msec. it indicates fault infeed was cut off from remote end but the fault was persisting and fed through 400 kV Main Bus 2 via tie bay.
  - iii. The Zone 4 of RED670 relay also got picked up for a short duration of 50msec as the fault was towards bus. Carrier was seen received from end.
  - iv. The persisting nature of fault can also be seen in DR (triggered by 96 relay) of BCU (REC 670) where fault infeed currents of magnitude 22 Amps (secondary) is seen till 20:02:26.260 hrs (i.e. 640 msec).
2. At 20:02:26:260 hrs, after delay of @ 620 msec from appearance of the fault 400 kV Busbar protection (REB 500) of 400 kV Bus 1 got operated and all the CBs connected to 400 kV Bus -1 tripped. It is suspected that the busbar's delayed response was due to shifts in fault-current phase angles, which depend on the fault's position and nature.
3. At 400kV Chandrapur-2 s/s, after about 5sec, i.e. at 20:02:31.651 hrs, following lines which were charged through Tie Bay from 400 kV Bus 2 tripped on overvoltage YB ph (263 kV- Ph-N)
  - i. 400kV Nanded ckt-1
  - ii. 400kV Warora ckt-1
  - iii. 400kV Switching Ckt-1
  - iv. 400kV Dhariwal ckt-1Overvoltage (O/V) protection Stage-1 operated on the Main-2 relay (P444), causing these lines to trip on O/V protection. DT command was sent to remote end.
4. Overvoltage (O/V) protection operation has also occurred for the following 400 kV Lines in the region

# Maharashtra State Load Despatch Centre

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- i. 400 kV Chandrapur GCR- Bhadrawatii (PG) ckt 3 (O/V at Bhadrawatii (PG) end DT sent to Chandrapur GCR end.)
  - ii. 400 kV Chandrapur GCR- Khaparkheda line. (O/V at Khaparkheda end DT sent to Chandrapur GCR end.)
  - iii. 400 kV Raipur- Bhadrawatii (PG) ckt 3 (O/V at Raipur end DT sent to Bhadrawati (PG) end.)
  - iv. 400 kV Bhilai- Bhadrawatii (PG) line. (O/V at Bhilai end DT sent to Bhadrawati (PG) end.)
5. At 400 kV Chandrapur (Sw) ss, GT-8 and GT-9 were tripped due to isolation from GRID. And At 400 kV Chandrapur GCR ss, Generation Unit -4 tripped due to FD fan trip caused by system jerk resulting in MFT and Turbine trip.
  6. At 400 kV Dhariwal SS, Generation Unit-1 tripped on voltage-controlled o/c protection (500msec). Generation Unit-2 tripped on voltage-controlled o/c protection (500msec). The STN TF-1 tripped on HV back up derived earth fault stage-2 protection (400 ms).
  7. At 21.23 hrs on 21.10.2025, Chandrapur 2 -Warora ckt 2 was charged to energise 400 kV Bus 1. The remaining bays were charged as per the Tripping and restoration details and normalcy was restored.
  8. During the occurrence the Line reactors of 400 kV Chandrapur-2 – Nanded ckt 1 and 2 were not in service.

#### **14. MSLDC Suggestions:**

1. The delayed operation of 400 kV Main Bus bar protection scheme (ABB REB500) needs to be thoroughly investigated. The Scheme was last tested in March 2024. Also, In view of non-generation of DR in CU of BB relay due to lower firmware version. The firmware version needs to be updated.
2. The 400 kV Chandrapur (Sw)- Chandrapur 2 ckt-2 tripped in zone 1 for remote end bus fault. Zone 1 reach needs to be reviewed.
3. Considering very short line lengths, the line differential protections of 400kV Chandrapur2- Switching Ckt 1 & 2 and 400 kV Chandrapur2- Chandrapur GCR ckt 1 & 2 are to be kept always in service and healthy, and in case of any communication failure related to line differential protection relay, it shall be attended promptly.
4. The 400kV Dhariwal- Parali PG CB tripped in Y Ph, Zone 4 for the fault. Zone 4 reach needs to be reviewed.
5. Distance protections Zone 3 was only picked up for 400 kV Chandrapur-2–GCR Ckts- 1 & 2 at the remote end and these ckts remained in service. The Zone 2 reaches need to be reviewed
6. All Disturbance Recorders (DRs) at all substations involved in occurrence are required to be GPS time-synchronized and configured according to ACIP guidelines to ensure accurate event analysis and correlation as per MEGC 2020, Clause No. 25.1.
7. Regular thermography of EHV switchyard equipment such as CTs, CVTs, LAs, bushings, transformers, CBs, Isolators and bus conductors, IPS tubes is essential for

# Maharashtra State Load Despatch Centre

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detecting hotspots caused by loose joints, contact resistance, or insulation deterioration. Thermography enables early failure prediction.

8. In view of higher system voltage and long line length the Line reactors of 400 kV Chandrapur-2 – Nanded ckt 1 and 2 and 400 kV Chandrapur GCR- Parli are to be taken in service



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli...it is requested to discuss this disturbance in upcoming PCC meeting.
- 4) The Chief Engineer, EHV PC O&M Zone Nagpur / Ch. Sambahji Nagar.
- 5) The Chief Engineer, ALDC Ambazari, Nagpur.

**Copy. to:**

- 1) The Superintending Engineer, PAC Circle Nagpur / Ch. Sambahji Nagar.
- 2) The Superintending Engineer, ALDC Ambazari Nagpur.

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Occurrence SLD of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 S/S and multi-line tripping.

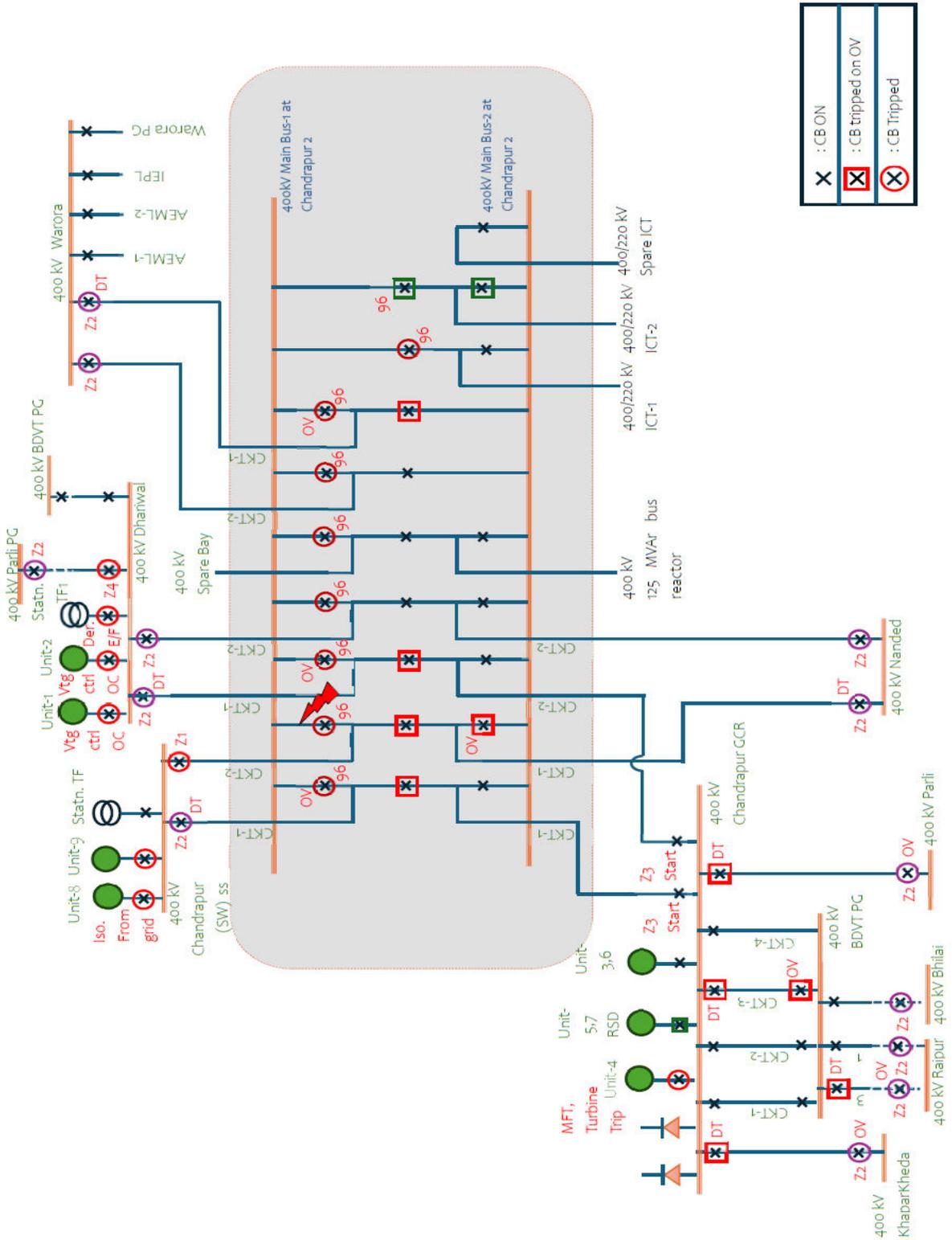


Figure 107 Occurrence of 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.

**3.2.17. Report of multiple occurrences on 220 kV Busbar at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.**

# Maharashtra State Load Despatch Centre

No: 02857

Date: 30 Dec 2025

## Report of multiple occurrences on 220 kV Busbar at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.

### Background:

The 220 kV Uran Substation, located in Raigad district, Maharashtra, receives generation from the Uran GTPS of MSPGCL, which comprises 4 × 108 MW gas turbine units (GT-5, GT-6, GT-7, GT-8) and 2 × 120 MW Waste Heat Recovery (WHR) units (A0 and B0). Total = 672 MW.

The 220 kV Uran substation is interconnected with the 400 kV Kharghar substation through double-circuit transmission lines, which are LIL0ed at the 220 kV Ulwe and Waghvali substations. Additionally, Uran is linked to the 220 kV Apta substation through four circuits, and it also has connections to the 220 kV JNPT and 220 kV ONGC substations. The 220 kV Uran ss is a major infeed point for Mumbai and MMR. It is also an important part of Uran Islanding scheme.

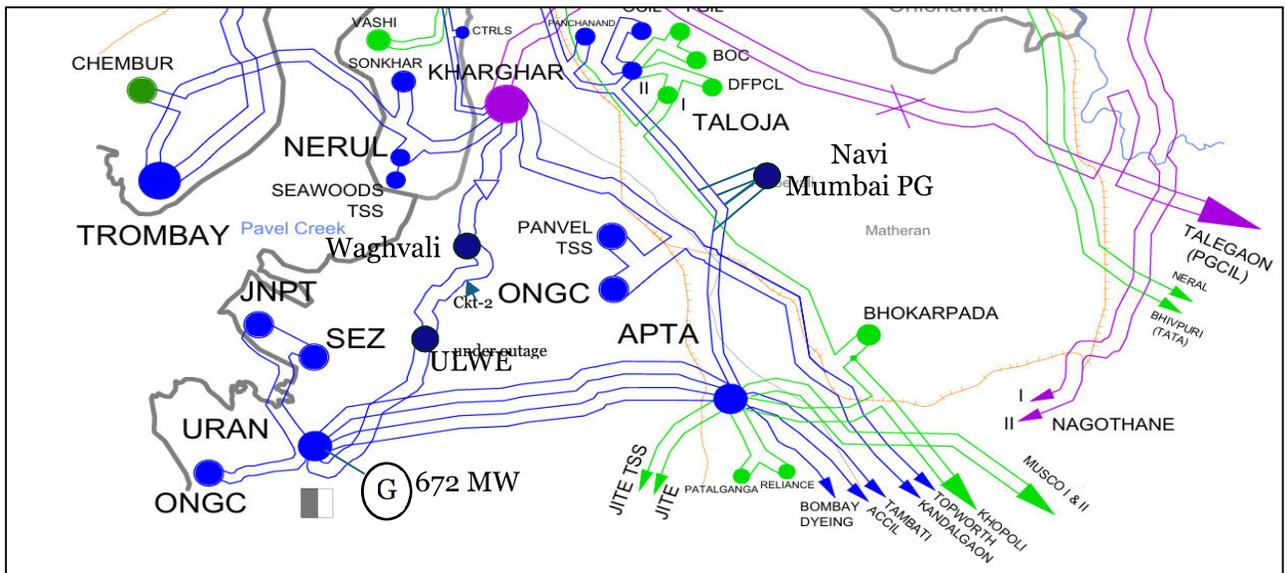


Figure 108 220 kV Network around 220 kV Uran substation

# Maharashtra State Load Despatch Centre

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## 1. Brief description of the event:

**Event 1:** On 09.09.2025 at 03:24 hrs, the R-phase pole of the GT Unit-8 circuit breaker got burst, which initiated the operation of the busbar protection scheme for 220 kV Bus-2. Consequently, all 220 kV feeders connected to Bus-2, and 220 kV Bus Coupler got tripped. As a result, all elements associated with 220 kV Bus-2 were disconnected from the system.

**Event 2:** On 08.10.2025 at 17.55 hrs, LBB command was initiated from GTPS end of Generation B0 unit bay due to which busbar protection relay of 220kV Bus-2 operated on LBB trip.

**Event 3:** On 14.11.2025 at 02:22 hrs, the R-phase CT of the 220 kV Bus-Coupler burst and caught fire. Consequently, the busbar protection operated as designed, resulting in the tripping of both 220 kV Bus-1 and Bus-2. This led to the tripping of all 220 kV elements connected to Bus-1 and Bus-2, along with the Bus-Coupler.

- |           |  |                |
|-----------|--|----------------|
| <b>2.</b> | <b><u>Utilities involved:</u></b>                | MSETCL, MSPGCL |
| <b>3.</b> | <b><u>Disturbance category:</u></b>              | GD 1           |
| <b>4.</b> | <b><u>Last Protection Audit carried out:</u></b> | 19.07.2024     |
| <b>5.</b> | <b><u>Antecedent conditions: -</u></b>           |                |

Transmission elements loading prior to events 220 kV Main Bus-1

Sr No	Name of element on 220 kV Main Bus-1	Loading in (MW) On 09.09.2025	Loading in (MW) On 08.10.2025	Loading in (MW) On 14.11.2025
1	220KV Ulwe-2	43	14	98
2	220 kV Apta-2	-8	-10	-45
3	220 kV Apta-4	-8	-9	-45
4	220 kV ONGC	-8	-7	-8
5	220 kV,50 MVA T.F.-1	-13	-11	12.70
6	220 kV AO Unit	-0.885	-1.03	-32.68
7	220 kV G.T. Unit-6	Out of service	Out of service	-91.78
8	220 kV G.T. Unit-7	Out of service	Out of service	-101.54
9	220 kV Gen.Stn TF-1	Out of service	Out of service	Out of service

*Table 62 Transmission elements loading prior to events*

Sr No	Name of elements on 220 kV Main Bus-2	Loading in (MW) On 09.09.2025	Loading in (MW) On 08.10.2025	Loading in (MW) On 14.11.2025
1	220KV Ulwe-1	42	19	99
2	220 kV Apta-1	-8	-8	-45
3	220 kV Apta-3	-8	-11	-45
4	220 kV JNPT SEZ	-11	-9	-9
5	220 kV , 50 MVA T.F.-2	-14	-17	-13.45

# Maharashtra State Load Despatch Centre

6	220 kV Gen.Stn TF-2	Out of service	Out of service	Out of service
7	220 kV G.T. Unit-8	Synchronizing Mode	80	-95.16
8	220 kV BO Unit	-2	39	-103.33
	220 kV G.T. Unit-5	Out of service	Out of service	Out of service

Table 63 Transmission elements loading prior to events

Source- EE PAC Panel Occurrence reports.

## 6. State Generation and Demand

Date and Time	State Generation (MW)	State Demand (MW)
08.10.2025 at 17.30 hrs	15023	21009
14.11.2025 at 02:00 hrs	12948	18823

Source- SCADA data at MSLDC.

## 7. Brief Details of System Disturbances:

### Event 1:

In reference to EE PAC Dn Panel occurrence report no: 258 dated 24.09.2025, On 09.09.2025 at 03:24 hrs, at 220 kV Uran Sub-Station, the 220 kV GT-8 bay, which had been charged at 03:16 hrs on Bus-2, was in synchronization mode when the R-phase pole of the GT-8 circuit breaker burst. This resulted in the operation of the 220 kV Busbar Protection, leading to isolation of Bus-2.

During the post-incident inspection, leakage of SF<sub>6</sub> gas was observed in the SF<sub>6</sub> gas piping of the R-phase and B-phase breaker poles of the GT-8 circuit breaker.

### Event 2:

In reference to SE PAC Circle Vashi occurrence report no: 442 dated 13.11.2025, On 08.10.2025 at 17:55 hrs, at 220 kV Uran Sub-station, the LBB initiation command was received from the 220 kV WHRP B0 generating unit GTPS Uran. This unit is connected to 220 kV Bus-2, and the LBB Operation resulted in the tripping of all 220 kV bays connected to Main Bus-2.

The LBB relays for all GTPS bays are commissioned in the GTPS control room, and their initiation outputs are wired through the OGM box to the MSETCL busbar protection scheme via an auxiliary relay for selective bus tripping.

From the DR of the busbar protection, it is observed that, the triggering LBB initiation signal from GTPS reached the binary input of the busbar relay, which in turn issued a selective trip command to all 96 relays connected to 220 kV Bus-2. Consequently, all bays on Bus-2 were isolated.

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### Event 3:

In reference to EE PAC Dn Panvel occurrence report no: 311 dated 26.11.2025, On 14.11.2025 at 02:22 hrs, the R-phase CT of the Bus-Coupler Bay burst and caught heavy fire and smoke. The fault was detected in both Zone-A and Zone-B of the busbar protection. The busbar protection operated correctly for both zones and initiated tripping 220 kV Bus 1 & Bus 2.

The 220 kV Apta-1 line tripped on Bph, Zone 1 at 220 kV Uran ss during the occurrence.

### 8. Tripping and Restoration details:

Sr. No.	Name of the Feeder / Equipment	Occurrence/ Restoration Date & time 09.09.2025	Occurrence/ Restoration Date & time 08.10.2025	Cause/Relay Indications
1	220 KV BUS COUPLER	09.09.2025; 03:24 hrs - 04:30 hrs	08.10.2025; 17:55 hrs - 19:10 hrs	09.09.2025 at 03:24 hrs On R-ph pole of the GT-8 circuit breaker burst.
2	220kv Uran - APTA -1	09.09.2025; 03:24 hrs- 04:32 hrs	08.10.2025; 17:55 hrs - 19:10 hrs	<b>Bus 2 Trip</b> Trip Signal Check Zone Trip, R/I-BB Relay REB670 (ABB)
3	220kv Uran - APTA -3	09.09.2025; 03:24 hrs - 04:33 hrs	17:55 hrs 17:55 hrs - 19:15 hrs	87BBR -Start, Trip 87BBY -Start 87BBB -Start,
4	220kv Uran - Ulwe -1	09.09.2025; 03:24 hrs - 04:36 hrs	08.10.2025; 17:55 hrs -19:17 hrs	ZB Idiff.= 28.88 kA
5	220kv Uran -SEZ	09.09.2025; 03:24 hrs - 04:35 hrs	08.10.2025; 17:55 hrs- 19:21 hrs	08.10.2025 at 03:24 hrs Bus 2 Trip, Bus 2 LBB Trip Trip Signal Check Zone B Trip, <b>BO LBBX</b>
6	50 MVA T/F NO -2	09.09.2025; 03:24 hrs - 04:37 hrs	08.10.2025; 17:55 hrs – 19:27 hrs	<b>Relay optd.</b> WI- BB Relay REB670 (ABB), Bay04(BO Bay) Prot TR ZB BFP Trip, ZB Common Trip
7	GT WHRP BO	09.09.2025; 03:24 hrs - 05:31 hrs	08.10.2025; 17:55 hrs - 10.10.2025 05:58 hrs	87BBR -Trip, 87BBY -Trip 87BBB -trio. ZB Idiff.= 00kA
8	GT UNIT 8	09.09.2025; 03:24 hrs - 11.09.2025; 21:05 hrs	08.10.2025; 17:55 hrs - 10.10.2025 00:25 hrs	

Table 64 Tripping and Restoration details

# Maharashtra State Load Despatch Centre

## 9. Tripping and Restoration details on 14.11.2025:

Sr. No	Transmission / Generation Element	Trip Time	Restoration Time	Cause/Relay Indications	
1	220 kV bus coupler	14.11.2025 02:22 Hrs	15.11.2025 03:01 Hrs	R-phase CT of the 220 kV Bus-Coupler Bay burst <b>Bus-1 Trip, Bus 2 Trip,</b> Trip Signal Check Zone Trip, R/I-BB Relay REB670 (ABB) 87BBR -Start, Trip 87BBY -Start 87BBB -Start ZA Idiff.= 19.6kA, ZB Idiff.= 19.5kA	
2	220kv Uran - APTA -3	14.11.2025 02:22 Hrs	14.11.2025 03:43 Hrs		
3	220kv Uran - Ulwe -1	14.11.2025 02:22 Hrs	14.11.2025 03:44 Hrs		
4	220kv Uran -SEZ	14.11.2025 02:22 Hrs	14.11.2025 03:43 Hrs		
5	50 MVA T/F NO -2	14.11.2025 02:22 Hrs	14.11.2025 03:45 Hrs		
6	GT WHRP BO	14.11.2025 02:22 Hrs	14.11.2025 11:07 Hrs		
7	GT UNIT 8	14.11.2025 02:22 Hrs	14.11.2025 08:08 Hrs		
8	220KV Ulwe-2	14.11.2025 02:22 Hrs	14.11.2025 03:38 Hrs		
9	220 kV Apta-2	14.11.2025 02:22 Hrs	14.11.2025 03:30 Hrs		
10	220 kV Apta-4	14.11.2025 02:22 Hrs	14.11.2025 03:23 Hrs		
11	220 kV ONGC	14.11.2025 02:22 Hrs	14.11.2025 03:38 Hrs		
12	220 kV,50 MVA T.F.-1	14.11.2025 02:22 Hrs	14.11.2025 03:28 Hrs		
13	220 kV AO Unit	14.11.2025 02:22 Hrs	14.11.2025 20:47Hrs		
15	220 kV G.T. Unit-6	14.11.2025 02:22 Hrs	14.11.2025 15:47 Hrs		
16	220 kV G.T. Unit-7	14.11.2025 02:22 Hrs	15.11.2025 08:27 Hrs		
17	220kv Uran - APTA -1	14.11.2025 02:22 Hrs	14.11.2025 06:34 Hrs		Dist Prot Relay: Alstom P442 Start Phase: C-N, Zone-1 trip, Fault Values: IA: 3.202 kA, IB:533.9 A, IC:310.0 A. VAN:129.4 kV, VBN: 224.9 kV, VCN:4.627kV Distance:9.3km

Table 65 Tripping and Restoration details on 14.11.2025

# Maharashtra State Load Despatch Centre

## 10. Generation / Load affected:

- |  |   |
|--|---|
| i. Load Power loss and /or generation (in MW) on 09.09.2025:   | Load Loss = 14 MW                             |
| ii. Load Power loss and /or generation (in MW) on 08.10.2025:  | Generation Loss = 119 MW<br>Load Loss = 17 MW |
| iii. Load Power loss and /or generation (in MW) on 14.11.2025: | Generation Loss = 426 MW<br>Load Loss = 26 MW |

## 11. Disturbance Recorder data :

- i. Bus bar relay DR on 09.09.2025; 03:24 hrs

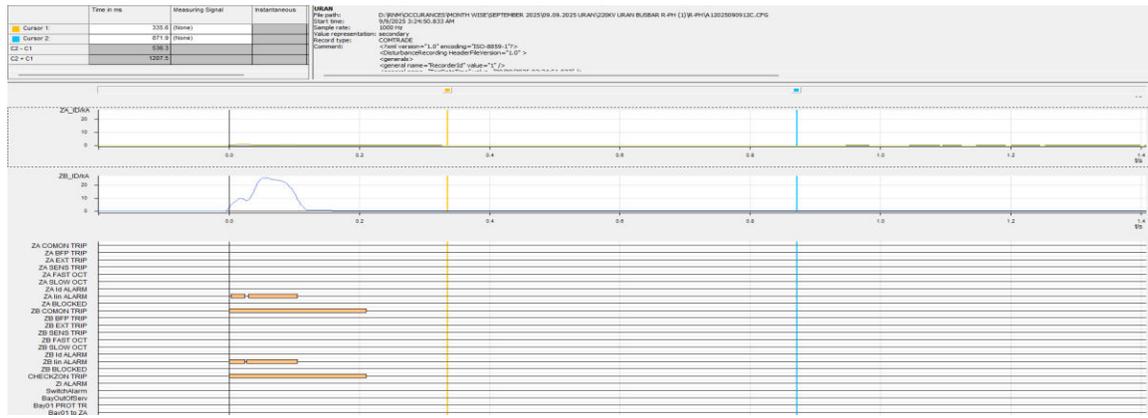


Figure 109 Bus bar relay DR on 09.09.2025; 03:24 hrs

- ii. Bus bar relay event log on 08.10.2025; 17:55 hrs

Type	Date & Time	Signal name	Status	Additional info
P	10/8/2025 7:26:23.457 PM	Bay04 to ZB	Off	25-10-08 19.26;23.457,Bay04 to ZB,0
P	10/8/2025 5:40:14.694 PM	Bay04 PROT TR	Off	25-10-08 17.40;14.694,Bay04 PROT TR,0
P	10/8/2025 5:40:14.694 PM	ZB BFP TRIP	Off	25-10-08 17.40;14.694,ZB BFP TRIP,0
P	10/8/2025 5:40:14.694 PM	ZB COMON TRIP	Off	25-10-08 17.40;14.694,ZB COMON TRIP,0
P	10/8/2025 5:24:06.247 PM	Bay04 PROT TR	On	25-10-08 17.24;06.247,Bay04 PROT TR,1
P	10/8/2025 5:24:06.247 PM	ZB BFP TRIP	On	25-10-08 17.24;06.247,ZB BFP TRIP,1
P	10/8/2025 5:24:06.247 PM	ZB COMON TRIP	On	25-10-08 17.24;06.247,ZB COMON TRIP,1

Table 66 Bus bar relay event log on 08.10.2025; 17:55 hrs

iii. Busbar relay DR On 14.11.2025 at 02:22 hrs,

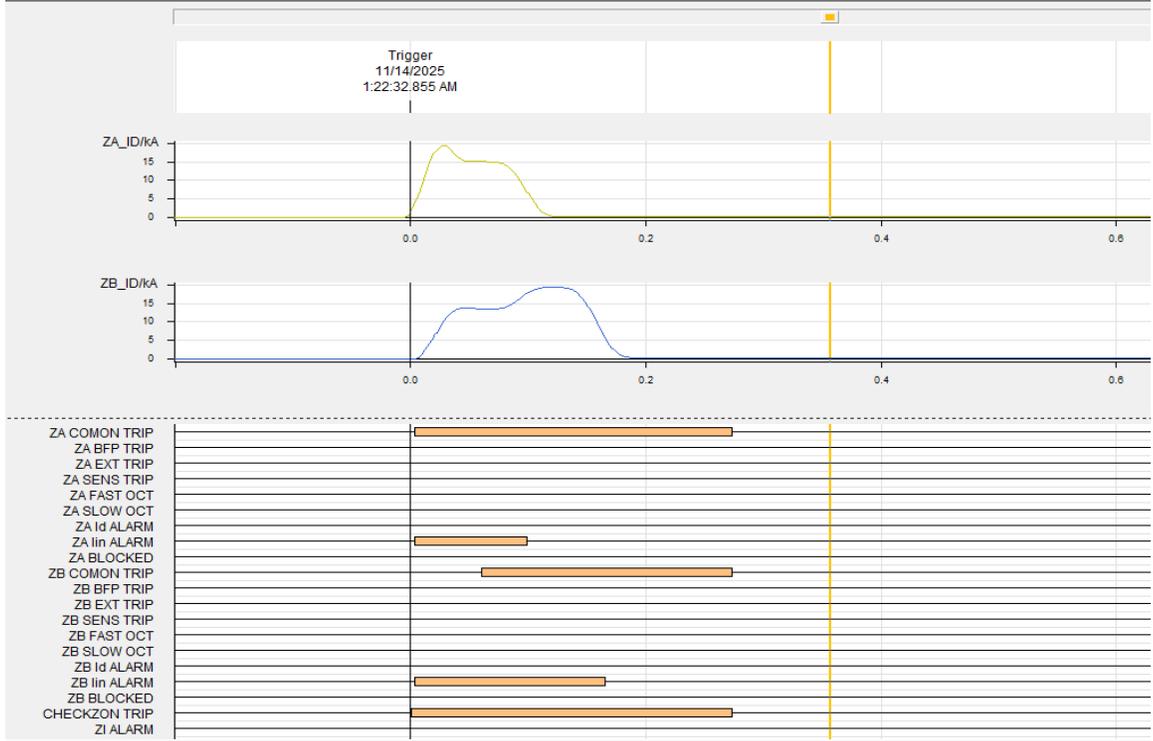


Figure 110 Busbar relay DR On 14.11.2025 at 02:22 hrs,

- ix. From DR it is observed that, Bus-Bar Relay sensed the fault initially in Zone A as Zone A given instantaneous tripping to all the bay connected to Bus A with Bus-coupler Bay, Hence the Fault was cleared from BUS-1 side,
- x. Thereafter BB relay sensed the fault in Zone B and after 60msec extended trip command to all the bays connected to main Bus-2 and the fault was totally cleared from Bus-2 side.

**12. MSLDC Observations:**

1. On 09.09.2025 at 03:24 hrs, the occurrence took place due to bursting of R-phase pole of the GT-8 circuit breaker which had been charged at 03:16 hrs on Bus-2, was in synchronization mode.
2. During the post-incident inspection on 09.09.2025, as per EE PAC Dn Panel occurrence report leakage of SF<sub>6</sub> gas was observed in the SF<sub>6</sub> gas piping of the R-phase and B-phase breaker poles of the GT-8 circuit breaker.
3. 220KV GT-8 CB's R ph and B ph breaker poles and operating mechanisms were replaced with spare CB of 220kV ST TF-1.

# Maharashtra State Load Despatch Centre

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4. On 08.10.2025 @ 17:55 hrs, Bus bar protection for 220 kV Bus-2 operated, due to LBB command was initiated from WHRP GT B0 GTPS unit resulting in tripping of all 220 kV Feeders on 220 kV Bus-2 and 220 kV Bus Coupler.
5. At the time of occurrence on 08.10.2025, GTPS bays GT-6, GT-7 & Gen. Stn TF-1 of 220 kV bus-1 & GT-5, Gen. Stn TF-2 of 220 kV bus-2 were out of service due to unavailability of gas from ONGC Uran.
6. As per the occurrence report from EE PAC Panvel, at GTPS end, a single Siemens make numerical relay is used for multipurpose protection functions including LBB protection and the LBB relays for all GTPS bays are commissioned in GTPS control room & initiation commands from LBB relays are wired up through OGM box to MSETCL bus bar scheme through aux. relay for selective bus trip.
7. On 14.11.2025 at 02:22 hrs incident occurred due to failure of R-ph CT (Make: ITC make) of 220 kV Bus coupler bay, causing a 220 kV Bus-1 & Bus-2 fault. Busbar Differential Protection operated correctly and both the 220 kV Buses gets isolated.
8. From DR it is observed that, Bus-Bar Relay sensed the fault initially in Zone A as Zone A given instantaneous tripping to all the bay connected to Bus A with Bus-coupler Bay, Hence the Fault was cleared from BUS-1 side, Thereafter BB relay sensed the fault in Zone B and after 60msec extended trip command to all the bays connected to main Bus-2 and the fault was totally cleared from Bus-2 side.
9. During the occurrence, the 220 kV Apta-1 line tripped on Zone-1, B-phase of the distance relay from the Uran end only. DR analysis indicates that the B-phase PT voltage dipped to nearly 4 kV, which was significantly lower compared to other lines connected to Bus-2. The actual fault, however, was on the R-phase and was in the reverse direction with respect to the Apta-1 relay.
10. The failed R Ph CT as well as Y Ph (ITC make) CTs are replaced by spare ABB Make CTs.

### **13. Remarks / Remedial Measures Suggested by MSLDC:**

1. On 14.11.2025, the unwanted Zone-1 operation of the 220 kV Apta-1 distance relay on the reverse direction R-ph fault needs to be analyzed thoroughly.
2. The Reason for failure of R Ph CB pole of GT-8 circuit breaker & B ph CT of Bus coupler bay on 14.11.2025 needs to be analyzed in depth. Regular thermography of EHV switchyard equipment such as CTs, CBs, PTs, CVTs, LAs, bushings, transformers, and bus conductors is essential for detecting hotspots caused by loose joints, contact resistance and insulation deterioration. It is

## Maharashtra State Load Despatch Centre

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- useful for equipment where hidden defects may not appear in routine tests. Thermography enables early failure prediction in substation yard equipment.
3. At GTPS Uran end, single Siemens make numerical relays are used for multipurpose protection functions including LBB protection. It is suggested that stand alone relay should be used for LBB protection & LBB setting need to be revised as per Ramkrishna committee guideline at Generation end for all bay.
  4. Regular checks for oil leakages and oil levels in oil-filled EHV equipment are essential, any leakages must be attended promptly to ensure reliability and prevent equipment failure. Considering the criticality of the substation and the associated generation, thermo-vision scanning of conductor joints and equipment should be carried out more frequently (preferably on a weekly basis) to ensure early detection of hotspots and prevent potential failures.
  5. The Diagnostic testing (C & Tan d measurements of CTs and CRM, DCRM, CB timing, Dew Point Measurements, SF6 purity tests of CBs) and maintenance activities of EHV yard equipment are to be carried out regularly and efforts are to be taken to eliminate the occurrence. Considering the criticality of the substation and the associated generation, the frequency of Diagnostic testing activities needs to increased.
  6. The 220 kV Uran ss being critical substation of MMR, LES scheme for aged equipment, if any, needs to carried out.
  7. The GPS time synchronization of protective relays and disturbance recorders needs to be ensured as per as per MEGC 2020, Clause No. 25.1.



(Girish Pantoji)

Chief Engineer(I/C), MSLDC

Encl- SLD of disturbance.

# Maharashtra State Load Despatch Centre

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**Submitted w.r.s. to:**

- 1) The Director (Operations), MSETCL, Mumbai.
- 2) The Executive Director, MSLDC, Airoli.
- 3) The Chairperson, State PCC and The Chief Engineer (ACI&P), MSETCL, Airoli...it is requested to discuss this disturbance in upcoming PCC meeting.
- 4) The Chief Engineer, EHV PC O&M Zone Vashi.
- 5) The Chief Engineer, GTPS Uran, MSPGCL.

**Copy to:**

- 2) The Superintending Engineer, PAC Circle Vashi.
- 3) The Superintending Engineer, Testing Circle, Koradi. MSPGCL.
- 4) Executive Engineer, Testing, Uran GTPS. MSPGCL.

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**SLD of occurrences on 220 kV Main Bus-I & II Busbars at 220KV Uran substation on 14.11.2025.**

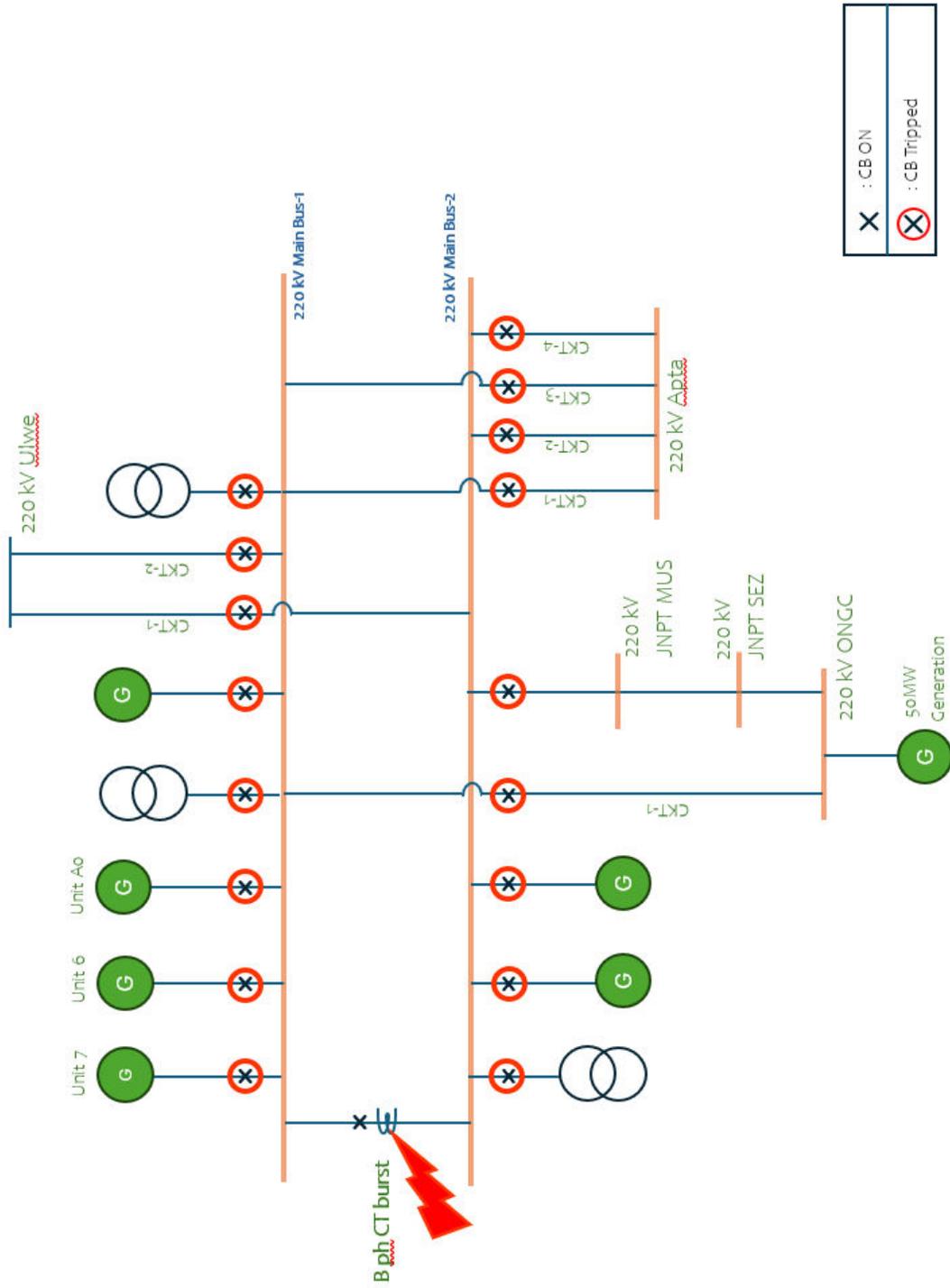


Figure 111 SLD of occurrences on 220 kV Main Bus-I & II Busbars at 220KV Uran substation on 14.11.2025.

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## **Chapter 4: Observations and Remarks / Remedial measures suggested by MSLDC.**

### 4.1. MSLDC Observations during the Major grid occurrences

#### 4.1.1. Voltage Collapse event on 12.03.2025 in Maharashtra

- During the Voltage collapse event on 12.03.2025 The event was initiated in the Gujarat power system, (outside the operational control area of Maharashtra State.) Due to which, immediate recognition of the root cause of event at the Maharashtra SLDC was challenging. However, the operations team at the SLDC control room promptly observed abnormal loadings on critical Maharashtra transmission lines and initiated timely corrective actions looking at system behavior.
- At present, the operation status of Load Trimming Schemes (LTS) and Under Voltage Load Shedding (UVLS) is not directly visible in the SLDC SCADA system. In addition, gaps were observed in real-time communication regarding the operation of these schemes from field substations to the SLDC control room, affecting situational awareness during the event.
- During the event, the response of Koyna hydro generating units were slower than normal for some machines (generating units), which slightly reduced the immediate availability of fast reactive and active power support.
- The system experienced significant frequency fluctuations and severe under-voltage conditions, creating a challenging operating environment for generators operating under Free Governor Mode of Operation (FGMO), particularly in the Mumbai area. Prolonged low-voltage conditions posed a risk of auxiliary supply failure at some generating stations.
- Following the previous grid disturbance, a defined load curtailment protocol for Mumbai is available with the SLDC control room. However, due to the wide geographical spread and rapid evolution of the disturbance, taking quick decisions regarding the most effective locations for load curtailment was operationally challenging.

#### 4.1.2. System disturbance at 400 kV Warora substation on 10.06.2025

- The Main-1 and Main-2 protections of the 400 kV Warora–Adani Line-2 were unavailable during the event due to failure of VT supply, which affected normal protection operation. The 400 kV Warora–IEPL line tripped in Zone-2 from the IEPL end. The carrier-aided tripping scheme associated with this line did not operate, resulting in delayed fault clearance.

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- ICT-1 and ICT-2 were feeding the fault during the disturbance. However, their over-current and earth-fault protections did not operate, as the calculated relay operating time was longer than the Zone-3-time delay of the associated 220 kV lines at remote ends.
- APML Generator Unit-1 tripped on ICT Special Protection Scheme (SPS) due to transmission constraints, as the 765/400 kV ICT was the only available evacuation path for generation at that time.

## 4.1.3. System disturbance at 400 kV Karad substation due to non-operation of 220 kV bus bar scheme on 29.06.2025

- During the disturbance, the 220 kV busbar protection did not operate for a bus fault at the 220 kV Ogalewadi-1 bay, which is not the intended behavior for such faults.
- During the event, the high-set overcurrent protection on the HV side of ICT-2 and ICT-3 operated very quickly (approximately 165 ms), before the 220 kV bus coupler protection, which has a definite time delay of 0.2 seconds. Ideally, the bus coupler protection should have isolated the fault first, preventing the operation of transformer protections.
- For a bus fault on 220 kV main bus-1, all 220 kV lines connected to bus-1 should have tripped in the reverse zone of their distance protections, while the 220 kV lines connected to bus-2 should have only picked up the reverse zone without tripping. This expected protection response was not fully observed during the occurrence.
- The 220 kV Kadegaon line did not trip in Zone-2 from the remote end as expected. Instead, the line was cleared later by backup protection from the 220 kV Kadegaon end.

## 4.1.4. Occurrence of 220 kV busbar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.

- After FTC of the 220 kV GIS Microsoft line bay (210), a flashover occurred inside the interrupter chamber of bay 210. As a result, the 220 kV busbar protection got operated,
- The 220 kV GIS Microsoft line-2 bay (210) was not integrated into the existing 220 kV busbar protection scheme. Therefore, after the busbar protection operation, this bay had to be tripped manually.
- At 220 kV Bhosari-1 Substation, the existing NR make RCS91S busbar protection scheme supports only up to 10 bays and does not allow further bay addition. Due to this limitation, the 220 kV GIS Microsoft line-1 bay (211) was configured in parallel with the 220/22 kV, 80 MVA Transformer-1, and hence received the busbar protection tripping command.
- It was observed that the 220 kV GIS Microsoft line-2 bay (210) and the 220 kV GIS bus section bay were not integrated into the existing busbar protection scheme. Consequently, the busbar protection trip command was not extended to these bays.

## 4.1.5. Occurrence of multiple line tripping at 400 kV Nagothane substation on 16.06.2025.

- During the event, despite moderate line loading, R and B phase PT supply was lost, leading to feeder trippings.
- The PT selection scheme is old and unreliable; some PT selection relays required manual operation.
- Post-event inspection showed burnt operating coils of PT selection relays (75B1 and 75B2).
- PT secondary mixing between PT-1 and PT-2 exists at 400 kV Nagothane, and R & B phase PT fuses of 220 kV Bus-II were found burnt.
- Auto-reclose operation indication along with backup O/C and E/F indications was observed on the 220 kV Nagothane–ACCIL line.
- Disturbance records submitted were not GPS time-synchronized, affecting accurate event analysis.

## 4.1.6. Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.

- The 220 kV VIPL–Butibori-1 Circuits 3 & 4 are protected only by line differential relays due to very short line length and do not have distance protection.
- During a fault on 220 kV VIPL–Butibori-1 Ckt-4 (Bus-1), the parallel Ckt-3 (Bus-2) tripped from the Butibori-1 end, indicating unintended operation.
- The 220 kV Khaparkheda–Butibori-1 line tripped in Zone-2 from Khaparkheda end, with Z-2 reach likely overreaching due to short adjacent lines.
- The 220 kV Purti–Butibori-3 line detected the fault in Zone-3, but tripped on overcurrent protection before LBB operation at VIPL, which is not desirable.
- During the event, multiple circuit breakers at 220 kV VIPL substation were found stuck due to rusting and trip coil failures, leading to manual tripping of lines and GT-2.
- Incorrect and incomplete system status was reported by VIPL substation to ALDC; a station blackout was reported even though Main Bus-2 was charged and GT-2 was back-fed.
- Fault location could not be identified by substations, and SCADA visibility of VIPL substation was lost at ALDC.
- Hand tripping of 220 kV VIPL–Butibori-3 Ckt-2, resulted in complete blackout of VIPL substation and loss of GT-2 auxiliary supply

4.1.7. Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.

- The incident was caused by failure of the Y-phase CT of the 400 kV HVDC Ckt-2 bay, which resulted in a fault on 400 kV Bus-2. The busbar differential protection operated correctly and isolated Bus-2.
- All protections related to 400 kV Bus-2 functioned as intended, and all connected elements including the bus coupler tripped properly. The busbar check zone also operated correctly.
- GTR-7 tripped due to loss of auxiliary supply after tripping of its feeding station transformer (STN TF-5) connected to Bus-2. GTR-5 also tripped, later confirmed to be due to an internal auxiliary supply issue of STN TF-4.
- The failed Y-phase CT was commissioned in 1998 and had last undergone testing in December 2023, with test results within permissible limits.

4.1.8. Occurrence at 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025

- The incident occurred due to failure and decapping of a new B-phase insulator string on the newly extended 400 kV bus at Nagothane, indicating possible issues related to mechanical strength, material quality, or installation.

4.1.9. Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deep-nagar substation on 19.09.2025.

- The incident occurred due to failure of the R-phase CT of the 400 kV Deepnagar–Khadka Ckt-1 bay, resulting in a fault on 400 kV Bus-2. The busbar differential protection operated correctly and isolated Bus-2.
- The CT failure led to fire and burning of control cables, and carbonized oil and soot were deposited on nearby insulators, conductors, and bus structures.
- All protections related to 400 kV Bus-2 functioned as designed, and all connected bays and tie circuit breakers tripped properly. ICT-1 and ICT-2 tripped as per the protection scheme on Bus-2 busbar protection but remained charged through 400 kV Main Bus-1 via the tie bay.
- The failed CT was commissioned in 2012 and had undergone Tan Delta and capacitance testing in March 2025, with results within permissible limits.

- 4.1.10. Occurrence at 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.
- The fault occurred on 400 kV Chandrapur (SW) Ckt-2 and was cleared instantly from the remote end in Zone-1. However, the fault continued to be fed through 400 kV Bus-2 via the tie bay, indicating a persisting bus-related fault.
  - Relay records (DR) show continued voltage dip and fault current for about 620–650 ms, confirming sustained fault infeed even after remote-end tripping.
  - After about 620 ms, 400 kV Bus-1 busbar protection operated and tripped all connected bays to isolate the fault.
  - Around 5 seconds later, multiple 400 kV lines charged through Bus-2 tripped on overvoltage protection due to high system voltage.
  - Overvoltage protection also operated on several nearby 400 kV lines in the Chandrapur–Bhadrawati–Khaparkheda–Raipur–Bhilai corridor.
  - Due to grid disturbance, GT-8 and GT-9 at Chandrapur (SW) tripped on grid isolation, and Chandrapur GCR Unit-4 tripped due to turbine protection following system disturbance.
  - At Dhariwal substation, both generating units and the station transformer tripped on voltage-controlled overcurrent and earth-fault protections.
  - During the event, line reactors of 400 kV Chandrapur-2–Nanded Circuits 1 and 2 were not in service, contributing to overvoltage conditions.
- 4.1.11. Multiple occurrences on 220 kV Busbars at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.
- On 09.09.2025, disturbance occurred due to bursting of the R-phase pole of the GT-8 circuit breaker, which had been charged on 220 kV Bus-2 and was in synchronizing mode.
  - Post-incident inspection revealed SF<sub>6</sub> gas leakage in the R- and B-phase gas piping of the GT-8 circuit breaker.
  - The R- and B-phase breaker poles and operating mechanisms of the 220 kV GT-8 CB were replaced using a spare breaker from 220 kV Station Transformer-1.
  - On 08.10.2025, 220 kV Bus-2 busbar protection operated due to an LBB initiation from WHRP GT B0 GTPS unit, resulting in tripping of all feeders connected to 220 kV Bus-2 and the bus coupler.
  - At that time, several GTPS bays on both 220 kV Bus-1 and Bus-2 were already out of service due to non-availability of gas supply from ONGC Uran.
  - At GTPS, a single Siemens numerical relay is used for multiple protection functions, including LBB, with LBB initiation wired through auxiliary relays to the MSETCL busbar protection scheme.

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- On 14.11.2025 at 02:22 hrs, a fault occurred due to failure of the R-phase CT of the 220 kV bus-coupler bay, leading to faults on both 220 kV Bus-1 and Bus-2; busbar differential protection operated correctly and isolated both buses.
- Relay records show the fault was first cleared from Bus-1 (Zone-A operation) and then fully cleared from Bus-2 after about 60 ms (Zone-B operation).
- During this event, the 220 kV Apta-1 line tripped in Zone-1 from the Uran end due to a sharp dip in B-phase PT voltage, even though the actual fault was on R-phase and in the reverse direction.

## 4.2. MSLDC Remarks / Remedial measures during the Major grid occurrences

### 4.2.1. Voltage Collapse event on 12.03.2025 in Maharashtra

#### 4.2.1.1. *Short-Term Measures*

## 1. **System Strengthening**

To improve system reliability in the Mumbai, MMR and Pune areas, the following transmission schemes shall be completed on priority as per their targeted timelines:

- Construction of 220 kV D/C lines from 765 kV Shikrapur PG to Khed City and Ranjangaon substations.
- Re-orientation of 220 kV Babhaleshwar–Ranjangaon and Lonikand–Ranjangaon circuits at Khed City.
- Implementation of HTLS conductors on identified 400 kV and 220 kV corridors including Lonikand–Chakan, Talegaon–Chakan and Talegaon–Lonikand lines.
- Execution of 400 kV LILO schemes and new 220 kV corridors under Western Region Network Expansion schemes.

These schemes are essential to reduce congestion, improve load transfer capability, and enhance voltage stability in high-load pockets.

To address persistent low-voltage conditions in MMR, Pune and Nashik areas, commissioning of planned reactive power compensation of about 1425 MVAR at Pune, 170 MVAR at Vashi, and 160 MVAR at Nashik shall be ensured on priority.

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## **2. Protection**

- i. Review and provision of Under Voltage Load Shedding (UVLS) schemes at all identified 400 kV substations where such schemes are presently not available.
- ii. Review of existing UVLS scheme at 400 kV Babhaleshwar to ensure effective load relief instead of network element tripping.
- iii. Provision of Load Trimming Scheme (LTS) on 220/132 kV ICTs at Nashik.
- iv. Verification and correction of protection settings of the 220 kV Bus Coupler at Nashik OCR.
- v. Review of LTS implementation on all 400 kV ICTs to ensure availability on each individual transformer.

## **3 Automation and Communication**

- i. MSLDC has joined the ULDC scheme of Grid-India for implementation of the new SCADA system. WRLDC is requested to expedite execution so that commissioning at MSLDC can be completed at the earliest.
- ii. All LTS schemes provided on major transmission elements such as ICTs and 400 kV lines shall be integrated with MSLDC and ALDC SCADA systems.
- iii. A dedicated alarm and display screen for LTS operations shall be provided at MSLDC and ALDC control rooms for better situational awareness.
- iv. STU has already communicated the list of substations in MMR and Mumbai for PMU installation to TPCL and AEML. All concerned utilities shall expedite PMU installation and ensure their integration with the MSLDC URTDSM system.

## **4 Procedural Review**

- i. A state-wide list of critical and non-critical loads/feeders shall be prepared for all substations. A uniform Load Trimming Protocol, similar to the one implemented for MMR and Mumbai, shall be prepared for the entire State to enable faster and error-free implementation during emergencies. This list shall be reviewed and updated at least once every six months.
- ii. All LTS, SPS and UVLS schemes shall be periodically reviewed by the Protection Committee (PCC). Healthiness and correctness of these schemes shall be ensured by respective transmission licensees, and compliance reports shall be submitted to MSLDC.
- iii. Periodic testing and trial operation of LTS, SPS and UVLS schemes shall be carried out by transmission licensees, and test reports shall be submitted to MSLDC.

## 4.2.1.2. Long-Term Measures

### 1 **Grid Strengthening**

#### i. **Integrated Resource Planning for Mumbai–MMR–Pune Cluster**

- Nearly 15,000 MW of load is concentrated in Mumbai, MMR and Pune region.
- The area has limited embedded generation, constrained transmission capacity and inadequate reactive power support.
- An integrated resource planning study for this region shall be undertaken by STU, considering future demand growth.
- The study shall ensure availability of adequate synchronous generation to provide inertia, reactive power support, and active power during islanding or contingency conditions.

#### ii. **Reactive Power Planning and Compensation**

- Reactive power requirement studies shall be carried out annually by STU.
- Dynamic reactive compensation such as STATCOMs and SVCs shall be planned for high-load and rapidly changing load areas, especially considering increasing penetration of data centres and metro loads.
- With large-scale solar capacity addition (~25 GW) in the State, thermal generation will increasingly operate in cycling mode, reducing available reactive support. Hence, adequate reactive capability from renewable and grid-side compensation systems must be ensured.
- Timely commissioning of planned reactive compensation schemes shall be strictly monitored.

#### iii. **Upgradation of HVDC Capacity**

- During the disturbance, the  $\pm 500$  kV, 1500 MW Chandrapur–Padghe HVDC link played a crucial role in supporting voltage and power transfer.
- Considering widespread low-voltage conditions, VSC-based HVDC with reactive power control capability would significantly enhance grid support.
- Upgradation of the existing Chandrapur–Padghe HVDC to **3000 MW VSC-based configuration** should be examined on priority.
- As the transmission line corridor is reportedly adequate, only terminal station upgrades may be required, which should be verified by STU.

## **2 Protection, Communication and Automation**

### **i. Enhancing system visibility at MSLDC**

- Full visibility of 765 kV and 400 kV substations is available at MSLDC; however, visibility below 220 kV is presently limited.
- Planned schemes for extending visibility of 220 kV and lower voltage levels shall be expedited to achieve comprehensive system monitoring.

### **ii. Expansion of Optical Fibre Communication Network**

- PMU-based analysis during the disturbance proved valuable.
- Expansion of optical fibre infrastructure is essential to support PMU deployment at all critical substations and generating stations.

### **iii. State Estimator and ADMS Implementation**

- Under the ULDC scheme, advanced applications such as State Estimator and ADMS are planned.
- Grid-India is requested to expedite issuance of Lol and execution so that commissioning at MSLDC can be achieved at the earliest.

### **iv. Wide Area Measurement System (WAMS) Expansion**

- At present, PMUs are available at limited 400 kV substations.
- In Phase-I, PMUs shall be installed at all identified critical substations in MMR and across all 400 kV substations.
- In Phase-II, PMUs should be extended to strategic locations including RE pooling stations.
- MSLDC shall install Phasor Data Concentrators (PDCs) with advanced analytics and decision-support capabilities.

### **v. Integrated Data Handling Platform**

- During post-disturbance analysis, challenges were observed in handling large volumes of heterogeneous data from SCADA, PMUs, meters, protection systems and scheduling tools.
- An integrated data handling platform capable of multi-source data integration and analytics is therefore essential.
- MSLDC has completed a Proof of Value (PoV) in February 2025 for such a platform.
- Implementation of this platform shall be expedited to improve operational analysis, decision-making and overall grid reliability.

#### 4.2.1.3. *Regulatory Framework Support*

To strengthen grid disturbance management, the following regulatory measures are required:

- Establishment of a mechanism for ensuring availability of spinning reserves within the intra-State system.
- Introduction of Security Constrained Economic Dispatch (SCED) and Security Constrained Unit Commitment (SCUC) at the State level.

In line with the recommendations of the High-Level Committee constituted by Hon'ble MERC after the 12.10.2020 disturbance, MSLDC has undertaken detailed studies on SCED/SCUC implementation in collaboration with IIT Bombay using GAMS-based optimization tools.

Implementation of these mechanisms will significantly enhance secure, economic and reliable operation of the Maharashtra power system.

#### 4.2.2. System disturbance at 400 kV Warora substation on 10.06.2025

- To avoid recurrence of such events, verification of relay unblocking logic under VT fuse failure, review of carrier-aided tripping at IEPL, and rationalization of Zone-2 and reverse zone time delays at 400 kV Warora are essential in line with protection guidelines.
- Time coordination of HV/IV protections of ICT-1 & 2 shall be reviewed considering prevailing fault levels. A comprehensive protection audit of 400 kV Warora substation should be carried out at the earliest to ensure overall system reliability and compliance.
- Strengthening of evacuation capability at 400 kV APML end through provision of an additional 765/400 kV ICT is recommended to address transmission constraints.
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#### 4.2.3. System disturbance at 400 kV Karad substation due to non-operation of 220 kV bus bar scheme on 29.06.2025

- To prevent recurrence of such incidents, time coordination between ICT-1, ICT-2 and ICT-3 HV high-set protections and bus-coupler protections shall be verified and revised wherever required. The HV and IV OC/EF relay settings of ICT-1, 2 and 3, for both high-set and normal inverse characteristics, shall be reviewed in line with prevailing bus fault levels and protection coordination guidelines.
- The non-operation of the distance relay at 220 kV Kadegaon end for the Karad–Kadegaon line shall be analyzed in detail. The existing old RADSS busbar protection shall be replaced with a modern numerical busbar protection scheme.

# Maharashtra State Load Despatch Centre

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- During busbar testing, auxiliary CT knee-point testing and primary resistance measurement shall also be carried out to ensure reliable protection performance.

#### 4.2.4. Disturbance in MMR area (Dombivali, Ambarnath, Badlapur region) in view of tripping of 220 kV Padghe Pal Line on 04.07.2025. & Long duration load loss in Pune region.

Frequent failures of EHV cables at multiple locations have resulted in long-duration load losses, mainly due to the extended time required for fault localization, excavation, joint repair, and restoration. Considering the prolonged restoration time associated with cable faults, the existing practice of extensive EHV cable laying needs to be reviewed.

It is also observed that, with the adoption of underground cables, the available overhead transmission corridor is permanently lost, thereby reducing operational flexibility and availability of alternate power flow paths. In this context, the faulty portion of the 220 kV Padghe–Pal line requires urgent attention and early restoration.

Further, the existing EHV cable corridors in Mumbai, MMR, and PMR regions require regular condition monitoring, diagnostic measurements, and preventive maintenance, including periodic testing to detect insulation degradation and incipient faults.

In view of increasing load, network complexity, and upcoming transmission projects, the following system-level measures are recommended in Pune region:

1. A redundant 220 kV corridor between Chinchwad, Hinjewadi-1, Hinjewadi-2, and Hinjewadi-3 should be planned to improve reliability and meet contingency requirements for this high-load corridor.
2. A redundant 220 kV evacuation corridor between 400 kV Hinjewadi-3 and 220 kV Hinjewadi-2 should also be planned, considering upcoming projects associated with the 400 kV Hinjewadi-3 / Jejuri corridor.
3. A comprehensive review of the 220 kV network planning around Pune should be undertaken in view of the proposed and upcoming 400 kV and 765 kV transmission network, to ensure adequate redundancy, coordination, and long-term system reliability.
4. Efforts should be made to minimize the use of EHV underground cables, particularly where overhead corridors already exist or are technically feasible. Replacement of overhead lines with cables should be avoided to the extent possible, as cable-based networks involve longer restoration times and higher dependency risks during failures.

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5. HTLS conversion of existing heavily loaded overhead corridors in Mumbai, MMR and PMR regions should be taken up on priority, as it enhances power transfer capability without requiring additional right-of-way and reduces dependence on underground cable systems.

4.2.5. Occurrence report of 220 kV busbar protection operation at 220 kV Bhosari 1 substation during FTC of 220 kV GIS Microsoft Bay 210 on 18.06.2025.

- Protection-related information was not submitted to SLDC along with the FTC proposal under Format-3 (Protection Healthiness), which is a mandatory requirement. The same needs to be ensured for all future FTC submissions.

4.2.6. Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping on 15.08.2025.

- The existing PT selection scheme, being of old design and vintage, has exhibited repeated operational issues. It is recommended to replace the existing PT selection relays with new and reliable numerical relays and to provide isolator selector switches for all bays. Immediate corrective action is also required to resolve the PT secondary mixing issue, to ensure proper functioning of the PT selection scheme and overall protection reliability at the substation.
- All Disturbance Records (DRs) shall be properly GPS time-synchronized to enable accurate sequence-of-events analysis and correlation, in compliance with MEGC 2020, Clause 25.1.
- A third-party protection audit of 400/220 kV Nagothane Substation should be carried out at the earliest, to comprehensively assess protection schemes, logic, settings, and implementation gaps.

4.2.7. Occurrence of 220 kV LBB protection operation at 220 kV VIPL substation along with multiple lines tripping.

- The line differential protection for VIPL–Butibori-1 Circuits-3 & 4 shall be reliable and continuously available. M/s VIPL shall attend fibre-optic communication issues on top priority. Redundant communication channels (PLCC / alternate paths) shall be provided to ensure dependable protection.
- Since 220 kV VIPL Substation remained out of service for a prolonged period and instances of stuck CBs were observed, CB overhauling and regular maintenance shall be carried out for all circuit breakers as per OEM recommendations. Post-overhauling CB diagnostic test reports shall be verified by ACIP and PAC Circle.

# Maharashtra State Load Despatch Centre

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- A third-party protection audit, including protection coordination review as per PCM and PCC-WRPC guidelines, shall be carried out for all substations involved in the occurrence within six (06) months, to prevent recurrence of similar incidents.
- Reliable voice communication systems (VoIP / Hotline PLCC / Dial-up PLCC) shall be established between 220 kV Butibori-1, 220 kV Butibori-3, and 220 kV VIPL Substations, and with MSLDC and ALDC, for effective real-time coordination during contingencies.
- The existing SPS scheme for ICT overloading at 220 kV Butibori-1, associated with 220 kV Abhijit Line and 220 kV Wardha Line, is presently operating in manual mode. The scheme, designed to back down 60 MW generation at VIPL in two stages, shall be automated to ensure timely and reliable operation.
- 220 kV Koradi-II (400 kV) – Butibori-3 Circuits-I & II and 220 kV Butibori-1 – Butibori-3 lines are presently hand-tripped to control overloading of 2 × 100 MVA, 220/132 kV ICT-I & II at Butibori-1. Capacity enhancement / addition of ICTs shall be expedited to ensure reliable system operation (already included in STU Plan 2025-26).
- Backup UPS supply shall be provided to all SCADA equipment (HMI, network switches, routers, etc.) at 220 kV Butibori-1, 220 kV Butibori-3, and 220 kV VIPL Substations, as SCADA visibility was affected during the incident.

#### 4.2.8. Occurrence of 400 kV Main Bus-II Busbar Protection Operation at 400KV GCR Chandrapur substation on 06.09.2025.

- It is observed that the failed CT was commissioned in 1998 and has completed 27 years of service. Ageing EHV equipment such as CTs, CVTs, PTs, and circuit breakers are susceptible to insulation degradation, which can result in sudden catastrophic failures without prior warning. Even when periodic diagnostic tests (Tan Delta, Capacitance, IR, etc.) indicate normal results, hidden deterioration mechanisms may still lead to insulation breakdown. Such aged EHV assets shall be identified and prioritized for replacement. It is noted that the Life Extension (LE) scheme proposal for ageing EHV equipment is under process, which needs to be expedited on top priority.
- Regular thermographic scanning of EHV switchyard equipment including CTs, CVTs, LAs, bushings, transformers, and bus conductors is essential to detect hotspots arising from loose joints, increased contact resistance, or insulation deterioration. Thermography is particularly effective for ageing equipment, where latent defects may not manifest during routine electrical tests. This practice enables early detection and failure prediction, thereby improving system reliability.
- In the existing busbar configuration, Bus-1 is connected with 11 bays and Bus-2 with 10 bays. Any operation of busbar protection or Local Breaker Backup (LBB) may therefore lead to the simultaneous outage of a large number of critical bays, posing a significant risk to system reliability and operational continuity. To mitigate the impact of such contingencies, it is

# Maharashtra State Load Despatch Centre

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recommended to examine the feasibility of subdividing the existing busbars into multiple sections by providing bus sectionalisers and bus couplers. This will help in restricting faults to smaller segments, reducing the disturbance area, improving fault isolation, and enhancing overall system flexibility and resilience.

- The tripping of GTR-5 (296 MW) and GTR-7 (213 MW), which were connected to Bus-1, requires detailed investigation. Corrective measures shall be implemented to prevent recurrence of such tripping events.
- The auxiliary supply changeover scheme shall be reviewed for adequacy and reliability. Further, the 400 kV STN Transformer-3, which has been unavailable since 01.03.2025, shall be restored at the earliest, as its non-availability adversely impacts the reliability of auxiliary power supply to generating units.

#### 4.2.9. Occurrence of 400 kV Main Bus-1 Busbar Protection Operation at 400KV Nagothane substation on 10.09.2025

- It is observed that the failed insulator string was part of the extended 400 kV bus and was energized for the first time. Random sampling, healthiness checks, and acceptance testing of such insulators shall be mandatorily confirmed prior to charging. A thorough inspection and testing of all insulator strings and associated bus hardware shall be carried out before energizing any new or extended bus section.
- The Quality Control / Design Section, C.O. Mumbai, shall analyze the quality performance of disc insulators prior to supply. Any similar failures within the network shall be investigated, and corrective and preventive measures shall be finalized to avoid recurrence of such failures in future.

#### 4.2.10. Occurrence report of 400 kV Main Bus-II Busbar Protection Operation at 400KV Deep-nagar substation on 19.09.2025.

- Review and suitably modify the trip logic for IV-side tripping of ICTs, so as to avoid unnecessary transformer tripping during busbar faults when adequate isolation from the faulty bus exists.

4.2.11. Occurrence at 400 kV Bus-1 bus bar protection operation at 400kV Chandrapur-2 substation and multi-line tripping.

- The delayed operation of the 400 kV Main Busbar protection scheme (ABB REB500) needs detailed investigation. The scheme was last tested in March 2024. Further, it is observed that Disturbance Records (DRs) were not generated in the Central Unit (CU) of the busbar relay due to a lower firmware version. The firmware shall be upgraded at the earliest to ensure proper DR generation and reliable post-fault analysis.
- All Disturbance Recorders (DRs) at substations involved in the occurrence shall be GPS time-synchronized and configured in line with ACIP guidelines, in compliance with MEGC 2020, Clause No. 25.1, to ensure accurate sequence-of-events analysis and correlation.
- Regular thermographic scanning of EHV switchyard equipment such as CTs, CVTs, LAs, bushings, transformers, circuit breakers, isolators, bus conductors, and IPS tubes is essential to detect hotspots due to loose joints, increased contact resistance, or insulation deterioration. Thermography enables early failure prediction and improves asset reliability.
- In view of higher system voltage and long line lengths, the line reactors of 400 kV Chandrapur-2 – Nanded Ckt-1 & 2, and 400 kV Chandrapur GCR – Parli shall be taken into service, as per system requirements, to control over-voltage and improve voltage profile.

4.2.12. Multiple occurrences on 220 kV Busbars at 220 kV Uran substation on 09.09.2025, 08.10.2025 & 14.11.2025.

- At GTPS Uran, single Siemens numerical relays are presently used for multiple protection functions, including LBB protection. It is recommended to provide stand-alone dedicated LBB relays for all bays at the generation end. LBB settings shall be reviewed and revised as per Ramkrishna Committee guidelines to ensure dependable and selective operation.

Maharashtra State Load Despatch Centre

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## **Chapter 5. Common Challenges Encountered During Grid Disturbance Analysis**

Grid disturbance analysis is a critical function for identifying root causes, understanding system behaviour, and preventing recurrence of adverse events. During the analysis of grid disturbances and major operational occurrences in the Maharashtra Power System, SLDC has consistently encountered the following categories of challenges.

### **5.1 Data Availability, Quality, and Timeliness**

Effective disturbance analysis depends on the availability of complete, accurate, and timely data. However, SLDC frequently faces:

- **Non-availability of a single-point data collection mechanism**, with disturbance-related data scattered across multiple systems and agencies, leading to delays, manual effort, and incomplete insights.
- **Delay, non-submission, or submission of incomplete disturbance data** by stakeholders, including missing disturbance recorder files, event logs, relay indications, and restoration details.
- **Inaccurate or partially incorrect initial information** received during stressed system conditions, which affects early assessment and subsequent event reconstruction.

These issues significantly hinder timely analysis and affect the quality of reporting and learning outcomes.

### **5.2 System Observability, SCADA Visibility, and Communication Constraints**

Effective grid disturbance management and post-event analysis require comprehensive system observability, reliable SCADA visibility, and robust communication infrastructure. However, SLDC consistently encounters the following challenges across the Maharashtra Power System:

- Inadequate SCADA visibility from several substations, **where real-time information such as breaker and isolator status, voltage levels, power flows, and protection indications is either totally not available, partially available, unreliable, or intermittently lost.**
- Incomplete SCADA integration and communication limitations, **including legacy RTUs, communication link failures resulting in loss or degradation of real-time system visibility during critical events.**

- Limited availability and coverage of Phasor Measurement Units (PMUs), **which restricts high-resolution monitoring of dynamic system behaviour such as voltage instability, oscillations, angle separation, and fast-evolving disturbances.**
- Partial or complete loss of SCADA visibility during major disturbances, **affecting situational awareness at SLDC and ALDC levels, particularly with respect to voltage profile evolution, LTS and special protection scheme operations.**
- Communication delays **between substations, generating stations, transmission utilities, ALDCs, and SLDC, leading to delayed confirmation of system conditions and restoration status.**
- Manual field operations and site constraints, **such as locally operated breakers, stuck equipment, and delayed feedback from field staff, which may not be captured in SCADA logs and complicate event reconstruction.**

These limitations significantly reduce real-time situational awareness, delay operational decision-making and restoration actions, and constrain the accuracy and depth of post-disturbance analysis.

## 5.3 Time Synchronisation and Event Reconstruction Challenges

Accurate reconstruction of grid disturbances requires precise time alignment across multiple data sources. SLDC encounters:

- Lack of GPS time synchronisation among disturbance recorders, protection relays, and event loggers at several substations.
- Inconsistent or missing time stamps, making it difficult to establish the correct sequence of events across different locations.
- Challenges in correlating SCADA data with protection system records, particularly during cascading or multi-location disturbances.

These issues complicate root cause identification and assessment of protection system performance.

## 5.4. Complexity of Protection System Operations

Modern power systems involve multiple layers of protection that may operate simultaneously during disturbances. Key challenges include:

- **Concurrent operation of multiple protection schemes**, such as distance protection, differential protection, busbar protection, LBB, SPS, OV protection, UVLS, and LTS.

- **Difficulty in identifying the primary initiating event** when several protection schemes operate within a short time interval. The availability of local and central SCADA logs is crucial for this purpose.

This complexity necessitates detailed, time-intensive analysis to correctly interpret protection actions and system response. The increasing complexity of protection systems, fusion of communication, protection and automation domains need special attention. The capacity building of human resources in these areas is essential with a special focus at utility level.

## 5.5. Legacy Systems and Heterogeneous Technology Environment

The coexistence of older and newer technologies introduces additional challenges:

- **Operation of legacy electromechanical relays alongside modern numerical relays**, resulting in inconsistent data formats and uneven availability of disturbance records.
- **Limited or absent disturbance recording capability** in older protection schemes.
- **Increased dependence on manual inputs** where automated data capture is not available.

Such heterogeneity affects the depth and consistency of disturbance analysis.

## 5.6. Human Factors and Operational Preparedness

The effectiveness of disturbance reporting and analysis is also influenced by human and procedural aspects:

- **Operating and field staff require continuous and structured training** for timely reporting, correct assessment of primary system conditions, and accurate interpretation of protection and SCADA indications.
- Inadequate understanding of evolving system conditions or protection behaviour at the field level can lead to misinterpretation of events, delayed escalation, and inconsistencies between field reports and system data.

Strengthening operator training and standardising reporting practices are therefore essential for improving disturbance analysis quality.

## 5.7. Geographical Spread and Multi-Stakeholder Coordination

Grid disturbances in Maharashtra often span large geographical areas and involve multiple entities, leading to:

## Maharashtra State Load Despatch Centre

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- **Wide geographical spread of disturbances**, covering several regions, substations, and voltage levels.
- **Dependence on multiple stakeholders**, including generation, transmission, and distribution utilities, for timely and accurate data.
- **Coordination challenges** arising from differing operational priorities and response timelines.

These factors increase the time and effort required for comprehensive analysis.

### 5.8. Regulatory and Procedural Constraints

SLDC is required to comply with statutory reporting timelines, which presents challenges such as:

- **Mandatory timelines for submission of flash reports and detailed disturbance reports.**
- **Need for revisions or supplementary analysis as additional data becomes available after initial submissions.**
- **Balancing speed with analytical depth, while maintaining accuracy and regulatory compliance.**

*These challenges highlight the need for strengthening system observability, improving SCADA and PMU coverage, enhancing data quality and time synchronisation, and building institutional and human capacity.*

## **Chapter 6: Conclusion**

The Grid Disturbance Analysis Compendium – 2025 presents a consolidated record of major grid disturbances and system events that occurred in the Maharashtra Power System during the year 2025. The document has been prepared by Maharashtra State Load Dispatch Centre (MSLDC) in accordance with the provisions of the Indian Electricity Grid Code (IEGC), 2023 and the Maharashtra Electricity Grid Code (MEGC), 2020, with the objective of ensuring systematic reporting, analysis, and learning from grid disturbances.

The disturbances analyzed during the year include voltage collapse events, multiple transmission line trippings, busbar protection operations, LBB operations, and other protection-related incidents at 400 kV and 220 kV levels. These events highlight the increasing operational challenges associated with high load concentration, stressed transmission corridors, ageing equipment, and growing dependency on protection and automation systems for grid security.

The analysis indicates that while protection systems, LTS/UVLS schemes, and operator actions have largely helped in containing disturbances and preventing widespread blackouts, several events were influenced by equipment failures, non-availability of network elements, protection mal-operations, and limitations in real-time data availability. Such issues underline the need for continuous improvement in asset health monitoring, protection coordination, and system visibility.

The role of MSLDC in real-time grid monitoring, coordination with transmission licensees, generating stations, distribution licensees, and WRLDC, and in ensuring timely restoration has been critical in managing these disturbances. The post-disturbance analyses carried out using SCADA data, disturbance recorder outputs, event logs, and field inputs have helped in identifying root causes and system-level weaknesses.

The observations and remedial measures brought out in this compendium emphasize the need for strengthening transmission infrastructure, improving reactive power management, ensuring availability of reliable disturbance data, and enhancing automation and communication systems. Timely submission of disturbance-related information by all stakeholders, as mandated under the Grid Code, remains essential for effective analysis and corrective action.

Going forward, coordinated efforts by SLDC, transmission utilities, generating companies, and distribution licensees are required to enhance grid reliability and operational preparedness. Focus on preventive maintenance, replacement of ageing equipment, strengthening of protection systems, deployment of modern monitoring tools such as PMUs, and regular training of operating personnel will contribute significantly to improving system resilience.

This compendium serves as a reference document for system operators, planners, and stakeholders to understand the nature of grid disturbances encountered during 2025 and the lessons derived from them.

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It reinforces MSLDC's commitment towards transparent reporting, regulatory compliance, and continuous improvement in ensuring safe, secure, and reliable operation of the Maharashtra Power System.

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