REPORT OF THE ENQUIRY COMMITTEE

ON

GRID DISTURBANCE

IN NORTHERN REGION

ON 30th July 2012

AND

IN NORTHERN, EASTERN & NORTH-EASTERN REGION

ON 31st JULY 2012

16th AUGUST 2012
NEW DELHI

ACKNOWLEDGEMENT

The committee gratefully acknowledges the efforts put in by all assisting members to the enquiry committee namely :

a. Shri R. N. Nayak, CMD, POWERGRID
b. Shri S. K. Soonee, CEO, POSOCO
c. Shri Balvinder Singh, IPS Retired.

The Committee places on record the efforts of Shri K. K. Agrawal, Member (GO&D), CEA for overall coordination in the whole exercise of grid disturbance enquiry.

The committee also gratefully acknowledges and places on record its appreciation towards the following members of various sub-groups, for their efforts of in-depth analysis and compilation of grid disturbance analysis:

(i) Shri Manjit Singh, Member (Thermal), CEA
(ii) Shri P.K. Pahwa, Member Secretary, NRPC,
(iii) Dr. Anil Kulkarni, IIT-B, Mumbai,
(iv) Shri Ajit Singh, Ex-Addl. Secretary, Cabinet Secretariat
(v) Shri R.K. Verma, Chief Engineer I/c (DP&D), CEA
(vi) Shri Dinesh Chandra, Chief Engineer (I/C), GM Div., CEA
(vii) Shri Ajay Talegaonkar, SE (Operation), NRPC
(viii) Shri S. Satyanarayan, SE (Operation), WRPC,
(ix) Shri D. K. Srivastava, Director, GM Div., CEA

The committee expresses its appreciation of the cooperation extended by POWERGRID and POSOCO, for making the data available from various Sub-Stations/RLDCs.

Last but not the least Committee also acknowledges the efforts of all those persons who gave their valuable support directly or indirectly.

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Supplementary Volume:

A separate volume containing the relevant DR outputs during the grid disturbances on 30th and 31st July, 2012.

GLOSSARY:

ABT:	Availability Based Tariff
ATC:	Available Transfer Capacity
AUFLS:	Automatic Under Frequency Load Shedding
BLU:	Boiler Light Up
BTPS:	Badarpur Thermal Power Station
CB:	Circuit Breaker
CEA:	Central Electricity Authority
CERC:	Central Electricity Regulatory Commission
CESC:	Calcutta Electric Supply Company
CTU:	Central Transmission Utility
D/C:	Double Circuit
DMRC:	Delhi Metro Rail Corporation
DR:	Disturbance Recorder
df/dt:	Rate of change of frequency with time
EL:	Event Logger
ER:	Eastern Region
FGMO:	Free Governor Mode of Operation
FSC:	Fixed Series Compensation
GPS:	Gas Power Station
GT:	Gas Turbine
HVDC:	High Voltage Direct Current
MERC:	Maharashtra Electricity Regulatory Commission

NAPS: Narora Atomic Power Station

NER: North-Eastern Region

NR: Northern Region

PMU: Phasor Measurement Unit

PLCC: Power Line Carrier Communication

POSOCO: Power System Operation Corporation Ltd.

POWERGRID Powergrid Corporation of India Ltd

PPA: Power Purchase Agreement

PSS: Power System Stabilizer

RAPP: Rajasthan Atomic Power Plant

RPC: Regional Power Committee

RLDC: Regional Load Despatch Centre

SCADA: Supervisory Control and Data Acquisition System

SIL: Surge Impedance Loading

SR: Southern Region

STOA: Short Term Open Access

SVC: Static VAR Compensator

TTC: Total Transfer Capability

TCSC: Thyristor Controlled Series Compensation

UI: Unscheduled Interchange (under ABT)

VAR: Volt Ampere Reactive

WAFMS: Wide Area Frequency Measurement System

WR: Western Region

EXECUTIVE SUMMARY

There was a major grid disturbance in Northern Region at 02.33 hrs on 30-07-2012. Northern Regional Grid load was about 36,000 MW at the time of disturbance. Subsequently, there was another grid disturbance at 13.00 hrs on 31-07-2012 resulting in collapse of Northern, Eastern and North-Eastern regional grids. The total load of about 48,000 MW was affected in this black out. On both the days, few pockets survived from black out. Ministry of Power constituted an Enquiry Committee, to analyse the causes of these disturbances and to suggest measures to avoid recurrence of such disturbance in future.

The Committee analysed the output of Disturbance Recorders (DR), Event loggers (EL), PMUs, WAFMS, SCADA data and reports submitted by various SLDCs , RLDCs /NLDC, POWERGRID and generation utilities to arrive at the sequence of events leading to the blackouts on 30th July, 2012 and 31st July 2012. The Committee also interacted with POWERGRID and POSOCO on various aspects of these grid disturbances. Some teams also made field visits to sub-stations, generating stations, NRLDC, NLDC, UPSLDC and Haryana SLDC.

The Committee is of the opinion that no single factor was responsible for grid disturbances on 30th and 31st July 2012. After careful analysis of these grid disturbances, the Committee has identified several factors, which led to the collapse of the power systems on both the days, as given below:

Factors that led to the initiation of the Grid Disturbance on 30th July, 2012

a. Weak Inter-regional Corridors due to multiple outages: The system was weakened by multiple outages of transmission lines in the WR-NR interface. Effectively, 400 kV Bina-Gwalior-Agra (one circuit) was the only main AC circuit available between WR-NR interface prior to the grid disturbance.

b. High Loading on 400 kV Bina-Gwalior-Agra link: The overdrawal by some of the NR utilities, utilizing Unscheduled Interchange (UI), contributed to high loading on this tie line.

c. Inadequate response by SLDCs to the instructions of RLDCs to reduce overdrawal by the NR utilities and underdrawal/excess generation by the WR utilities.

d. Loss of 400 kV Bina-Gwalior link: Since the interregional interface was very weak, tripping of 400 kV Bina-Gwalior line on zone-3 protection of distance relay caused the NR system to separate from the WR. This happened due to load encroachment (high loading of line resulting in high line current and low bus voltage). However, there was no fault observed in the system.

Factors that led to the initiation of the Grid Disturbance on 31st July, 2012

(i) Weak Inter-regional Corridors due to multiple outages: The system was weakened by multiple outages of transmission lines in the NR-WR interface and the ER network near the ER-WR interface. On this day also, effectively 400 kV Bina-Gwalior-Agra (one circuit) was the only main circuit available between WR-NR.

(ii) High Loading on 400 kV Bina-Gwalior-Agra link: The overdrwal by NR utilities, utilizing Unscheduled Interchange (UI), contributed to high loading on this tie line. Although real power flow in this line was relatively lower than on 30th July, 2012, the reactive power flow in the line was higher, resulting in lower voltage at Bina end.

(iii) Inadequate Response by SLDCs to RLDCs' instructions on this day also to reduce overdrawl by the NR utilities and underdrawal by the WR utilities.

(iv) Loss of 400 kV Bina-Gwalior link: Similar to the initiation of the disturbance on 30th July, 2012, tripping of 400 kV Bina-Gwalior line on zone-3 protection of distance relay, due to load encroachment, caused the NR system to separate from the WR system. On this day also the DR records do not show occurrence of any fault in the system.

Brief Sequence of Events leading to the Grid Collapse on 30th and 31st July 2012

(i) On 30th July, 2012, after NR got separated from WR due to tripping of 400 kV Bina-Gwalior line, the NR loads were met through WR-ER-NR route, which caused power swing in the system. Since the center of swing was in the NR-ER interface, the corresponding tie lines tripped, isolating the NR system from the rest of the NEW grid system. The NR grid system collapsed due to under frequency and further power swing within the region.

(ii) On 31st July, 2012, after NR got separated from the WR due to tripping of 400 kV Bina-Gwalior line, the NR loads were met through WR-ER-NR route, which caused power swing in the system. On this day the center of swing was in the ER, near ER-WR interface, and, hence, after tripping of lines in the ER itself, a small part of ER (Ranchi and Rourkela), along with WR, got isolated from the rest of the NEW grid. This caused power swing in the NR-ER interface and resulted in further separation of the NR from the ER+NER system. Subsequently, all the three grids collapsed due to multiple tripping attributed to the internal power swings, under frequency and overvoltage at different places.

(iii) The WR system, however, survived due to tripping of few generators in this region on high frequency on both the days.

(iv) The Southern Region (SR), which was getting power from ER and WR, also survived on 31st July, 2012 with part loads remained fed from the WR and the operation of few defense mechanism, such as AUFLS and HVDC power ramping.

(v) On both the days, no evidence of any cyber attack has been found by the Committee.

Measures that could have saved the system from collapse:

In an emergency system operating condition, such as on 30th and 31st July 2012, even some of the corrective measures out of the list given below might have saved the system from the collapse.

(i) Better coordinated planning of outages of state and regional networks, specifically under depleted condition of the inter-regional power transfer corridors.

(ii) Mandatory activation of primary frequency response of Governors i.e. the generator's automatic response to adjust its output with variation in the frequency.

(iii) Under-frequency and df/dt based load shedding relief in the utilities' networks.

(iv) Dynamic security assessment and faster state estimation of the system at load despatch centers for better visualization and planning of the corrective actions.

(v) Adequate reactive power compensation, specifically Dynamic Compensation.

(vi) Better regulation to limit overdrawal/underdrawl under UI mechanism, specifically under insecure operation of the system.

(vii) Measures to avoid mal-operation of protective relays, such as the operation of distance protection under the load encroachment on both the days.

(viii) Deployment of adequate synchrophasor based Wide Area Monitoring System and System Protection Scheme.

Restoration of the system

The Committee observed that on both the days unduly long time was taken by some of the generating units in starting the units after start up power was made available**.**

Recommendations of the Committee

Detailed recommendations of the committee are given in the main report, which are summarized below.

i) An extensive review and audit of the Protection Systems should be carried out to avoid their undesirable operation.

ii) Frequency Control through Generation reserves/Ancillary services should be adopted, as presently employed UI mechanism is sometimes endangering the grid security. The present UI mechanism needs a review in view of its impact on recent disturbances.

iii) Primary response from generators and operation of defense mechanisms, like Under Frequency & df/dt based load shedding and Special Protection Schemes, should be ensured in accordance with provisions of the grid code so that grid can be saved in case of contingencies.

iv) A review of Total Transfer Capability (TTC) procedure should be carried out , so that it can also be revised under any significant change in system conditions, such as forced outage. This will also allow congestion charges to be applied to relieve the real time congestion.

v) Coordinated outage planning of transmission elements need to be carried out so that depletion of transmission system due to simultaneous outages of several transmission elements could be avoided.

vi) In order to avoid frequent outages/opening of lines under over voltages and also providing voltage support under steady state and dynamic conditions, installation of adequate static and dynamic reactive power compensators should be planned.

vii) Penal provisions of the Electricity Act, 2003 need to be reviewed to ensure better compliance of instructions of Load Desptach Centres and directions of Central Commission.

viii) Available assets, providing system security support such as HVDC, TCSC, SVC controls, should be optimally utilized, so that they provide necessary support in case of contingencies.

ix) Synchrophasor based WAMS should be widely employed across the network to improve the visibility, real time monitoring, protection and control of the system.

x) Load Desptach Centres should be equipped with Dynamic Security Assessment and faster State Estimation tools.

xi) There is need to plan islanding schemes to ensure supply to essential services and faster recovery in case of grid disruptions.

xii) There is need to grant more autonomy to all the Load Despatch Centres so that they can take and implement decisions relating to operation and security of the grid

xiii) To avoid congestion in intra-State transmission system, planning and investment at State level need to be improved.

xiv) Proper telemetry and communication should be ensured to Load Despatch Centres from various transmission elements and generating stations. No new transmission element/generation should be commissioned without the requisite telemetry facilities.

xv) Start up time of generating stations need to be shortened to facilitate faster recovery in case of grid disruptions.

xvi) There is a need to review transmission planning criteria in view of the growing complexity of the system.

xvii) System study groups must be strengthened in various power sector organizations.

xviii) It was also felt that a separate task force may be formed, involving experts from academics, power utilities and system operators, to carry out a detailed analysis of the present grid conditions and anticipated scenarios which might lead to any such disturbances in future. The committee may identify medium and long term corrective measures as well as technological solutions to improve the health of the grid.

CHAPTER-1

INTRODUCTION

1.1 There was a major grid disturbance at 02.33 hrs on 30-07-2012 in Northern region and again at 13.00 hrs on 31-07-2012 resulting in collapse of Northern, Eastern, North-Eastern regional grids barring a few pockets.

1.2 The first disturbance which led to the collapse of Northern Regional Electricity grid occurred at 02.33 hrs on 30th July, 2012, in which all states of Northern Region viz. Uttar Pradesh, Uttarakhand, Rajasthan, Punjab, Haryana, Himachal Pradesh, Jammu & Kashmir, Delhi and Union Territory of Chandigarh were affected. Northern Regional Grid's load was about 36,000 MW at the time of disturbance. Small islands which comprised of three units of BTPS with the load of approximately 250 MW in Delhi, NAPS on houseload, Area around Bhinmal (Rajasthan) with approximate load of 100 MW connected with Western Region survived the blackout. Restoration was completed by 16.00 hrs.

1.3 The second incident which was more severe than the previous one occurred at 13.00 hours on 31.7.2012, leading to loss of power supply in three regions of the country viz. Northern Region, Eastern Region and North Eastern Region affecting all states of Northern Region and also West Bengal, Bihar, Jharkhand, Odisha, Sikkim in Eastern region and Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland and Tripura in North-Eastern region. The total load of about 48,000 MW was affected in this black out. Islands comprising of NAPS, Anta GPS, Dadri GPS and Faridabad in Northern Region, Ib TPS / Sterite, Bokaro steel and CESC survived in Eastern Region. It has been reported that major part of the system could be restored in about 5 hrs, 8hrs and 2 hrs in Northern, Eastern and North-Eastern regions respectively.

1.4 To look into the detailed causes of these disturbances and to suggest remedial measures, Ministry of Power vide its OM No. 17/1/2012-OM Dt. 30-07-2012 constituted an Enquiry Committee headed by Chairperson, CEA and CEO, POSOCO and CMD POWERGRID as members. With the second major grid disturbance on 31-07-2012 involving three regions the Ministry of Power vide its OM No. 17/1/2012-OM Dt. 03-08-2012 modified the constitution of the above enquiry committee with following members:

(i)	Shri A.S. Bakshi, Chairperson, CEA	Chairman
(ii)	Shri A. Velayutham, Member (retd.), MERC	Member
(iii)	Dr. S. C. Srivastava, IIT Kanpur	Member
(iv)	Sh. K. K. Agrawal, Member (GO&D), CEA	Member Secretary

1.5 In addition, following members assisted the Committee:

(i) Shri R. N. Nayak, CMD, POWERGRID
(ii) Shri S. K. Soonee, CEO, POSOCO
(iii) Shri Balvinder Singh, IPS Retired.

1.6 The Terms of Reference of the Committee are as under:

a) To analyse the causes and circumstances leading to the grid disturbance affecting power supply in the affected region.
b) To suggest remedial measures to avoid recurrence of such disturbance in future.
c) To review the restoration of system following the disturbances and suggest measures for improvement in this regard, if any
d) Other relevant issues concerned with safe and secure operation of the Grid.

1.7 The Committee has been asked to submit its report by 16th August, 2012. A copy of MoP OM dated 3-8-2012 constituting the above Committee is given at **Annexure-1.1**.

1.8 First meeting of the initially constituted Enquiry Committee was held on 01-08-2012. Second meeting of the Enquiry Committee was held on 03-08-2012 which was attended by the members of the Committee and representatives of NLDC, all RPCs, RLDCs, POSOCO and POWERGRID.

1.9 The Committee constituted five sub-groups to facilitate detailed and quick analysis of various aspects of grid disturbances viz.

(i) 'Analysis of grid collapse on 30th& 31st July 2012 and simulation of the event' under Shri A. Velayutham, Ex. Member, MERC and Prof. S.C. Srivastava, IIT, Kanpur assisted by Dr. Anil Kulkarni, IIT, Bombay, Shri Ajay Talegaonkar, SE (Operation), NRPC & Shri S. Satyanarayan, SE (Operation), WRPC,

(ii) 'Islanding scheme for Railways & Delhi Metro' under Shri K.K. Agrawal, Member (GO&D), CEA,

(iii) 'Analysis of restoration process of thermal plants' under Shri Manjit Singh, Member (Thermal), CEA,

(iv) 'Islanding schemes in Northern Region' under Shri P.K. Pahwa, Member Secretary, NRPC,

(v) 'Cyber Security aspects' under Shri Ajit Singh, Ex-Addl. Secretary, Cabinet Secretariat and Shri R.K. Verma, Chief Engineer I/c (DP&D), CEA

1.10 In addition, a sub-group comprising Shri Dinesh Chandra, Chief Engineer I/c and Shri D.K. Srivastava, Director, Grid Management Division was formed to compile and prepare the report based on the progress made by the five sub-groups on day-to-day basis.

1.11 For secure grid operation after two grid collapses, following steps were taken immediately:

a) NLDC reduced the TTC of the Inter-Regional lines and other critical lines limiting to its SIL thereby necessary restrictions imposed on STOA.

b) CEA advised utilities that senior and experienced officials should be available in RLDCs, SLDCs, Generating Stations and Sub-Stations for at least one week.

c) CEA also advised to all generating stations to be responsive and develop a mechanism for bringing Units at the earliest in case of contingencies.

1.12 Enquiry Committee held its third meeting on 11-8-2012. On 12-8-2012, detailed discussions were held with POSOCO and POWERGRID at NLDC, New Delhi to have their view points on the causes of grid collapse. The Committee finalized its findings in its meetings on 14th and 15th August, 2012.

1.13 The Committee analysed the output of Disturbance Recorders (DR), Event loggers (EL), PMUs, WAFMS, SCADA data and reports submitted by various SLDCs , RLDCs /NLDC, POWERGRID and generation utilities to arrive at the sequence of events leading to the blackouts on 30th July, 2012 and 31st July 2012. The Committee also interacted with POWERGRID and POSOCO on various aspects of these grid disturbances. Some teams also made field visits to sub-stations, generating stations, NRLDC, NLDC, UPSLDC and Haryana SLDC.

Annexure 1.1

Most Immediate
By FAX / By Post

17/1/2012-OM
Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg,
New Delhi, dated 3rd August, 2012.

OFFICE MEMORANDUM

Subject: Constitution of a Committee to enquire into the Grid Disturbance that occurred in Northern, Eastern and North-Eastern Regions on 30th and 31st July, 2012

In modification of OM of even number dated 30th July, 2012, a Committee comprising following members is hereby constituted to enquire into the Grid Disturbances which occurred on 30th and 31st July, 2012 affecting the power supply in the Northern, Eastern and North-Eastern Regions :

(i)	Shri A.S. Bakshi, Chairman, CEA	Chairman
(ii)	Shri A. Velayutham, Member (Retd.), Maharashtra Electricity Regulatory Commission	Member
(iii)	Dr. S.C. Srivastava, IIT, Kanpur	Member

2. Shri K.K. Agarwal, Member (GO&D), CEA will be the Member Secretary of the Committee.

3. Following will be the Assisting Members :

(i) Shri R.N. Nayak, CMD, Power Grid Corporation of India Limited.
(ii) Shri S.K. Soonee, CEO, Power System Operation Corporation Limited.
(iii) Shri Balvinder Singh, IPS Retired

4. The Committee may co-opt other members as it may deem necessary.

5. The Terms of Reference of the Committee are as under :

(i) To analyse the causes and circumstances leading to the grid disturbance affecting power supply in the affected Region
(ii) To suggest remedial measures to avoid recurrence of such disturbance in future.
(iii) To review the restoration of system following the disturbances and suggest measures for improvement in this regard, if any.
(iv) Other relevant issues concerned with safe and secure operation of the Grid.

6. The Committee shall submit its Report by 16th August, 2012.

A.K. Saxena 03/8/12

(A.K. Saxena)
Director

CHAPTER-2

OVERVIEW OF REGIONAL GRIDS

2.1 Power system in the country is divided into five regional grids namely Northern, Western, Southern, Eastern and North Eastern grids. Except for Southern grid, remaining four regional grid operate in synchronism. Southern grid is connected to Eastern and Western grids through asynchronous links.

2.2 Northern Regional Grid

2.2.1 Northern Region is the largest in geographical area amongst the five regions in the country covering approximately 31% of the area and having largest number of constituents. It has largest sized hydro unit (250 MW at Tehri/ Nathpa Jhakri) in the country. Northern Grid has an installed generating capacity of about 56,058 MW as on 30.06.2012 comprising 34608 MW of thermal and 19830 MW of Hydro generation The Thermal-Hydro (including renewable) mix is of the order of 64:36. The installed capacity of nuclear stations is 1620 MW.

2.2.2 Major generating stations including Super Thermal Power Stations of NTPC at Rihand and Singrauli are located in the eastern part of the NR grid. Due to such concentration of generation in the eastern part of the grid and major load centers in the central and western part of the grid there is bulk power transmission from eastern to western part over long distances. To handle this bulk transmission of power, a point to point high voltage DC line viz. HVDC Rihand-Dadri bipole with capacity of 1500 MW exists and operates in parallel with 400 kV AC transmission network besides under lying 220 kV network.

2.2.3 During the month of July, 2012 the Peak demand of Northern Region was 41,659 MW against the Demand Met of 38,111 MW indicating a shortage of 3,548 MW (8.5%). The energy requirement of Northern Region was 29,580 MU against availability of 26,250 MU indicating shortage of 3,330 MU (11.3%.).

2.3 WESTERN REGIONAL GRID

The Western Grid has an installed capacity of 66757 MW (as on 30-06-2012) consisting of 49402 MW thermal, 7448 MW hydro, 1,840 MW nuclear and 7909.95 MW from renewable energy sources.

2.4 EASTERN REGIONAL GRID

The Eastern Grid has an installed capacity of 26838 MW (as on 30-06-2012) consisting of 22545 MW thermal, 3882 MW hydro and 411 MW from

renewable energy sources. The Eastern Regional grid operates in synchronism with Western, Northern and North-Eastern Regional grids.

2.5 NORTH-EASTERN REGIONAL GRID

2.5.1 The North-Eastern Grid has an installed capacity of 2454.94 MW as on 31-03-2012 consisting of 1026.94 MW thermal, 1200 MW hydro and 228.00 MW from renewable energy sources. The North-Eastern Grid operated in synchronism with Northern Grid, Eastern Grid and Western Grid. North Eastern Regional Grid is connected directly only to the Eastern Regional Grid and any export of power to the other Regions has to be wheeled through the Eastern Regional Grid.

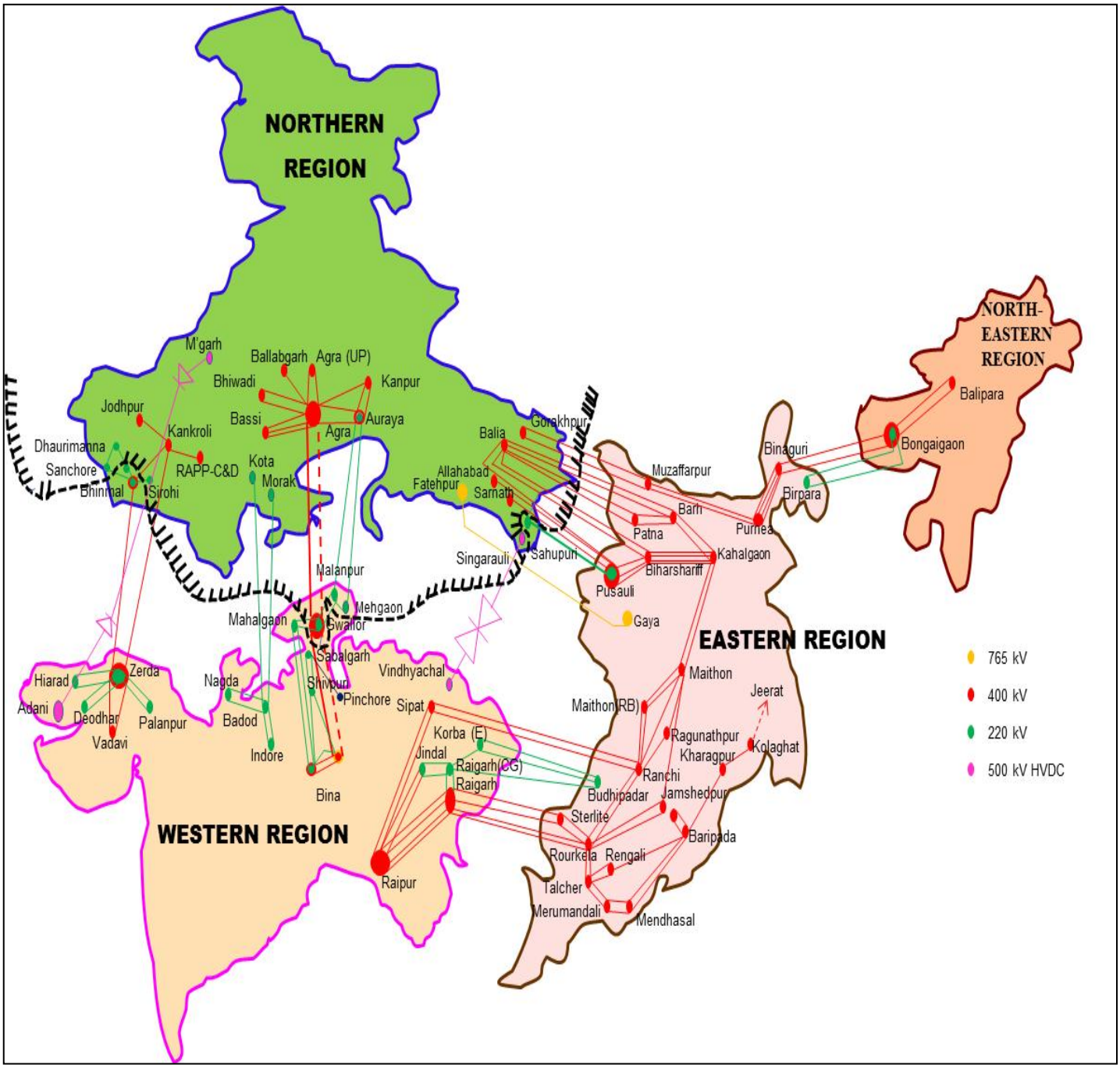
2.5.2 The power transfer from North-Eastern Region to Eastern Region is taking place over Bongaigaon – Malda 400 kV D/C lines and Birpara – Salakati 220 kV D/C lines.

2.6 Inter-regional interconnections

The interconnections between various regional grids is depicted in **Exhibit 2.1**

EXHIBIT – 2.1

2.1.1 Map indicating the IR links between NR, WR, ER and NER



Chapter-3

Analysis of Grid Disturbance on 30th July, 2012

3.1 Introduction

On 30th July, 2012 there was a grid disturbance in the NEW grid at 02:33:11 hrs that led to the separation of the NR grid from the rest of the NEW grid and eventually NR system collapsed. The pre-disturbance conditions, sequence of events and analysis of the disturbance are described below.

3.2 Pre-Disturbance Conditions

The details of the generation-demand and power export/import scenario in the four regions of the NEW grid on 30.07.2012 at 02:00 hrs are given below.

S.No.	Region	Generation	Demand	Import	Remarks
1	NR	32636 MW	38322MW	5686MW	
2	ER	12452 MW	12213MW	(-)239MW	Bhutan import 1127 MW
3	WR	33024 MW	28053MW	(-)6229MW	
4	NER	1367 MW	1314MW	(-) 53MW	
Total	NEW Grid	79479 MW	79902MW		

A number EHV lines were out prior to the disturbance and the same are listed in the enclosed Annexure- 3.1. The grid frequency, just prior to the disturbance, was 49.68 Hz.

3.3 Sequence of Events on 30th July, 2012

The committee studied the data provided by various SLDCs , RLDCs /NLDC , POWERGRID and generation utilities to analyse the sequence of events leading to the blackouts in Northern grid on 30th July, 2012. The committee experienced some difficulty in analysing the available information because of the time synchronisation problems at various stations. The committee, however, established the sequence of events based on correlation of the data from various sources like Disturbance Recorders (DRs), Event Loggers (ELs), few Phasor Measurement Units (PMUs) in the NR and WR at different stations and Wide Area Frequency Monitoring System (WAFMS) of IIT Bombay.

It may be noted that the NEW grid was operating in an insecure condition due to a large number of line outages particularly near the WR-NR interface. Though an exhaustive list of lines under outage is given at **Annexure-3.1**, it

may be noted that the following lines had tripped within an interval of a few hours prior to the grid disturbance.

1. 220 kV Badod(WR)-Modak(NR)
2. 220 kV Badod (WR)-Kota (NR)
3. 220 kV Gwalior-Mahalgaon ckt 2 (in WR but near WR-NR interface)
4. 220 kV Gwalior(PG)-Gwalior(MP)(in WR but near WR-NR interface causing only 220 kV Gwalior-Malanpur as only 220 kV NR-WR interconnection, and 220 kV Bina-Gwalior was no longer in parallel with 400 kV Gwalior-Bina)

Following are the sequence of the events, which took place on 30th July, 2012, leading to the Northern Grid blackout:

Sl.No.	Date & Time	Event
1.	30/07/2012 02:33:11.907 AM	400kV Bina – Gwalior-1 Line Tripped, Zone 3 tripping, Main-II
2.	30/07/2012 02:34	220 kV Gwalior-Malanpur 1. As per MP SLDC time is 02:34, but is **manual timing**. (This line has tripped probably just prior to sl no 1 above causing Malanpur and Mehgaon loads to be fed from NR system.)
3.	30/07/2012 02:33:13.438 AM	220 kV Bhinmal-Sanchor line, Zone-1 Tripped on Power Swing.++
With the above events, practically all the AC links from the WR to the NR were lost.		
4.	30/07/2012 02:33:13:927 AM	400 kV Jamshedpur – Rourkela line-2 tripped on Zone-3
5.	30/07/2012 02:33:13:996 AM	400 kV Jamshedpur – Rourkela line-1 tripped on Zone-3
6.	30/07/2012 02:33:15:400 AM	400 kV Gorakhpur-Muzaffarpur-2 tripped on Power Swing
7.	30/07/2012 02:33:15:425 AM	400 kV Gorakhpur-Muzaffarpur-1 tripped on Power Swing at Gorakhpur end. Line remained charged upto 3.03 am at Muzaffarpur end.
8.	30/07/2012 02:33:15:491 AM	400 kV Balia – Biharsharif-2 line tripped on power swing.
9.	30/07/2012 02:33:15:491 AM	400 kV Balia – Biharsharif-1 line tripped on Power swing.

10.	30/07/2012 02:33:15:542 AM	400 kV Patna – Balia (1 & 2) tripped on power swing++.
With the above events, all the AC links from the ER to the NR were lost. NR was islanded from the rest of the NEW grid and ultimately collapsed on under frequency . ER-WR-NER survived as one system.		

Some of the subsequent events of cascaded tripping are listed in **Annexure-3.2**, which has led the NR system to practically total blackout except a few pockets, such as Badarpur and NAPS (only household loads), which survived in islanded mode.

++ Power Swings: The rotors of synchronous machines inter-connected by AC lines tend to run at the same electrical speed in steady state due to the underlying physics of this system. When this system experiences small disturbances, restorative torques bring back the machines to synchronism (i.e., the same electrical speed). This response is characterized by an oscillatory behaviour since the underlying equations which determine the transient behaviour are like those of a spring-mass system. The oscillations are called "**swings**" and are seen in practically all parameters including line power flows. The oscillations die down if damping is adequate.
For large disturbances (e.g faults, loss of critical transmission links), the behaviour is non-linear and the electrical torques may be unable to bring all the generators to the same electrical speed. If this happens the angular difference between the generators goes on increasing (**Transient Instability or Angular Separation**). This causes large variations in voltage and power flow in lines.
Other equivalent terms are "Loss of Synchronism", "Out of Step", "Pole slipping", although the latter two terms are typically used if only one machine loses synchronism. In a multi-machine system groups of machines may separate.

3.4 Analysis of the Disturbance on 30th July 2012

I. It is observed that even though the frequency of the NEW grid (49.68 Hz) was near to its nominal value (50 Hz), a number of lines were not available due to either forced outages, planned outages or kept out to control high voltages. This resulted in a depleted transmission network, which, coupled with high demand in the Northern Region, resulted in an insecure state of the system operation.

II. From WR-NR interface, 400 kV Gwalior-Agra line was carrying about 1055 MW and 400 kV Zerda-Bhinmal was carrying about 369MW, while 400 kV Gwalior-Bina was carrying about 1450 MW. The loading on 400 kV Gwalior-Agra was high. The Surge Impedance Loading (SIL) of the 400 kV Gwalior-Agra and also Gwalior-Bina lines, which are 765 kV lines charged at 400 kV, is about 691 MW (uncompensated), but its thermal loading limit is much higher (for quad Bersimis conductor).

III. NR constituents were instructed by NRLDC to carry out load shedding to relieve the Gwalior-Agra line loading. However, the quantum of load shedding undertaken by the NR constituents seems to be insignificant. WRLDC also issued similar instructions to its constituents for reduction in generation.

IV. The 400 kV Agra-Gwalior line is fed from 400 kV Bina-Gwalior line in the WR.

V. At 02:33:11:907 hrs, the 400 kV Bina-Gwalior line in WR tripped on Zone 3 protection, which is due to load encroachment (DR records do not show any evidence of fault or swing). Prior to tripping the voltage was 374 kV at Bina end and the line was carrying about 1450 MW approximately as per DR report of POWERGRID for this line.

VI. With the tripping of the above line, the supply to NR from 400 kV Agra-Gwalior was lost. 400 kV Zerda-Bhinmal-Bhinmal (220 kV)-Sanchore (220 kV) and Dhaurimanna (220 kV) was the only AC tie link left between WR-NR. Subsequently 220 kV Bhinmal–Sanchore line tripped on power swing, and as per SLDC Rajasthan 220 kV Bhinmal-Dhaurimanna tripped on Zone 1distance protection. This resulted in loss of the WR-NR tie links. A small load at Bhinmal remained connected with WR system through the 400 kV Zerda-Bhinmal line.

VII. In some cases the impedance measured by a distance relay at one end of the line may reduce to a point where it is less than the tripping condition for that relay for back-up protection (Zone 3). This may happen even if there is no fault in the nearby transmission system, and may occur when the line carries a very heavy load. This phenomenon of the mal-operation of the distance relays is known as **'Load Encroachment'**. Generally, it is an unintended tripping for distance relays since no fault has actually occurred.

It may be noted that at the time of disturbance, the 400 kV Bina-Gwalior line experienced a lower voltage and higher load current (resulting in less impedance, seen by the relay, which, possibly, was below the zone-3 reach setting of the relay) caused the relay operation under load encroachment. It was informed by POSOCO that this line had not tripped earlier due to zone-3 operation under load encroachment, although few incidences of such operation of distance relays in Western Region are observed in prior disturbances.

VIII. The tripping of the 400 kV Bina-Gwalior line initiated a very large angular deviation between NR system on one side and ER+WR+NER system on the other side. The power from WR to NR was now routed via WR-ER-NR interface, which is a very long path.

IX. An illustrative simulation to understand angular separation of the WR and NR regions was carried out. The simulation confirms that the systems may separate under such conditions. The simulation details are given at **Annexure-3.3**

X. Due to large power flows in the WR-ER-NR route, 400 kV Jamshedpur-Rourkela double circuit (in ER) tripped on Zone 3 (**Exhibit 3.1** shows the angular separation).

XI. Though the NR system, at this stage, was still connected to the ER system (which was connected to the WR), the machines in the NR system had

started to slow down as compared to those in rest of the NEW grid. Therefore, angular separation between NR and the rest of the grid continued to increase. This situation would eventually lead to angular instability (loss of synchronism).

XII. It is well established that under such situations, the distance relays near the electrical center of this separation are prone to pick up. Accordingly 400 kV ties between ER and NR (BiharSharif-Balia, Muzzafarpur-Gorakhpur, Patna-Balia, and Sasaram-Balia) tripped.

XIII. Since 220 kV Pasauli-Sahupuri (ER-NR) line was operated in radial mode, Sahupuri loads remained fed from the ER system and survived.

XIV. The NR system was thereby isolated from the rest of the grid. In the NR system, there was loss of about 5800 MW import and resulted in decline of frequency. NR System has Automatic Under Frequency Load Shedding Scheme (AUFLS), which can shed about 4000 MW of loads, and df/dt relays scheme, which can shed about 6000MW of loads, to improve the frequency and save the system under such emergency situations. However, not adequate load relief from the AUFLS and df/dt relays was observed and the NR system collapsed except for a few pockets at Badarpur and NAPS.

XV. With the separation of NR from the rest of the grid, the ER+WR+NER grid had a surplus of about 5800 MW power exported to NR prior to the separation. This system had more generation and the frequency rose to 50.92 Hz and stabilized at 50.6 Hz. There was tripping of Korba (E) 2*250 MW, APL Mundra 2*660 MW, Dhuvaran 80 MW, Parli 210 MW and Nasik 210 MW units in WR and Mejia-B 400MW, DSTPS 250 MW and MPL 450MW in ER took place. APL Mundra units tripped on Special Protection Scheme. The reported loss of generation is of the order of 3340 MW.

XVI. The sudden rise in frequency, close to 51Hz in the WR, also indicates inadequate primary response from generating stations. The primary response if enabled in NR could also have helped in curtailing the initial frequency dip in the Northern region.

XVII. During restoration, at 03:39 hours, several units and transmission lines at NTPC Vindhyachal STPS tripped in Western Region which also affected the start-up process.

After the grid was restored on 30.07.2012, another grid disturbance took place on 31.07.2012 , the details of which are given in the next chapter.

Annexure 3.1

List of EHV Lines Out on 30.07.2012 Prior to Disturbance
(400 kV and above and Inter-Region 220 kV and above)
(as furnished by NLDC)

Sl No	Line	Voltage (kV)	Region	Out From Date	Remarks
	NR				
1	Fatehpur-Gaya	765	NR	27/07/12	Planned
2	Agra-Bassi-3	400	NR	28/07/12	Planned
3	Agra-Bassi-2	400	NR	28/07/12	Planned
4	Agra-Gwalior 2	400	WR-NR	28/07/12	Planned
5	Zerda-Kankroli	400	WR-NR	28/07/12	Planned
6	Agra-Fatehpur	765	NR	26/07/12	Constr Work
7	Bhiwadi-Neemrana	400	NR	23/07/12	HV Trip
8	Barh-Balia	400	ER-NR	29/07/12	HV Trip
9	Bhinmal-Kankroli	400	NR	29/07/12	Forced
10	Badod-Kota	220	WR-NR	29/07/12	Forced
11	Manesar-Neemrana	400	NR	15/07/12	Control HV
12	Bhilwara-Chhabra	400	NR	20/07/12	Control HV
13	Neemrana-Sikar	400	NR	20/07/12	Control HV
14	Barh-Balia 2	400	ER-NR	28/07/12	Control HV
15	Akal-Barmer 1	400	NR	28/07/12	Control HV
16	Chhabbra-Hindaun 2	400	NR	30/07/12	Control HV
17	Jodhpur II – RajWest 2	400	NR	30/07/12	Control HV
	WR				
1	Bina-Gwalior 2	400	WR	27/07/12	Planned
2	Nagda-Shujalpur 1	400	WR	07/07/12	Forced
3	Parli-Parli 2	400	WR	19/07/12	Forced
4	Satna-Bina 2	400	WR	26/07/12	Control HV
5	Damoh-Birsingpur 2	400	WR	13/07/12	Control HV
6	NAgda-RAjgarh 1	400	WR	20/07/12	Control HV
7	Seoni-Bina 1	765	WR	03/07/12	Control HV
8	Seoni-Wardha 2	765	WR	23/07/12	Control HV
9	Bina – Indore	400	WR	21/07/12	Possibly Bina-Nagda
10	Korba-Birsingpur	400	WR	05.07.12	Control HV
11	Birsingpur-Balco	400	WR	22/06/12	Control HV
12	Raigarh-Raipur 1	400	WR	20/07/12	Control HV
13	Raigarh-Raipur 2	400	WR	21/07/12	Control HV

14	Jabalpur-Itarsi 2	400	WR	20/07/12	Control HV
15	Itarsi-Khandwa 2	400	WR	20/07/12	Control HV
16	Nagda-Dehgam 1	400	WR	28/07/12	Control HV
17	Wardha-Akola-1	400	WR	20/07/12	Control HV
18	Parl(PG)-Sholapur 1	400	WR	23/07/12	Control HV
19	Bhadrawati-Parli 1	400	WR	21/07/12	Control HV
20	Aurangabad-Bhusawal	400	WR	27/06/12	Control HV
21	Aurangabad-Deepnagar	400	WR	03/07/12	Control HV
22	Karad-Kolhapur	400	WR	28/07/12	Control HV
23	Birsingpur-Katni	400	WR	14/06/12	Control HV
24	SSP-Rajgarh 2	400	WR	25/07/12	Control HV
25	ISP-Nagda	400	WR	24/07/12	Control HV
26	Itarsi-Bhopal	400	WR	29/07/12	Control HV
	ER				
1	Ranchi-MPL D/c	400	ER	27/07/12	Planned
2	Binaguri-Purnea 1	400	ER	18/07/12	Planned
3	Sagardighi-Durgapur	400	ER	25/07/12	Forced
4	Maithon-Durgapur 1	400	ER	28/07/12	Forced
5	Baripada-Mendhasal	400	ER	14/07/12	Forced

Annexure 3.2

Subsequent tripping of lines in ER and NR systems after separation on 30/07/2012

(only those given in the DRs are listed below)

11.	30/07/2012 02:33:16:251 AM	Line1(RAPP-B to C tie line) and Line2 (to Kota) tripped
12.	30/07/2012 02:33:16:261 AM	Line6 (RAPS-B to Udaipur)tripped
13.	30/07/2012 02:33:17:221 AM	Line4(RAPS-B to Chittor-1) tripped
14.	30/07/2012 02:33:17:231 AM	Line5 (RAPS-B to Chittor-2) tripped As a result ofthe events Sl. No.13-16, RAPS-B moved to house loading.
15.	30/07/2012 02:33:18:508 AM	Bihar shariff – Sasaram-4 tripped
16.	30/07/2012 02:33:20:667 AM	Kahalgaon – Bihar shariff (3 & 4) tripped
17.	30/07/2012 02:33:19:830 AM	Ballabgarh – Kanpur-II line tripped due to over voltage protection and received direct trip from Kanpur.
	30/07/2012 02:33:20:830 AM	Ballabgarh – Kanpur-III line tripped due to over voltage protection and received direct trip from Kanpur.
18.	30/07/2012 02:33:20:714 AM	Bihar shariff – Sasaram-3 tripped
19.	30/07/2012 02:33:22 AM	NAPS two units (150MW each) tripped by under frequency operation. 1. Frequency dipped to 47.7 Hz 2. The two units got isolated from grid and started operating in island mode supplying load to Simbholi and Khurja SSs.
20.	30/07/2012 02:33:24:965 AM	Tehri pooling – Meerut Line-1 tripped.
21.	30/07/2012 02:33:26:192 AM	Mandola – Bareilly Line-2 CB Operated PSB operated at 30/07/2012 02:33:15:142 AM and reset at 17.702 PSB operated at 30/07/2012 02:33:30:010 AM on Line-1.
22.	30/07/2012 02:33:28:172 AM	Mandola-Bawana-I tripped at Mandola end due to over voltage protection.
23.	30/07/2012 02:33:28:175 AM	Mandola-Bawana-II tripped
24.	30/07/2012 02:33:29.116 AM	Dadri – Maharanibagh Fault initiated, Appears Breaker was not opened.
With the available information, the Grid blackout started in some areas (as observed through the PMU frequency data) and the remaining events, listed below, are the cascading events resulting into the complete blackout.		

25.	30-07-2012 02:33:30.123 AM	Roorkee – Rishikesh and Roorkee-Muzaffarnagar lines tripped on SOTF
26.	30/07/2012 02:33:30.129 AM	Dadri – Rihand HVDC Pole-1 blocked Blocked from Rihand end
27.	30/07/2012 02:33:30.134 AM	Dadri – Rihand HVDC Pole-2 blocked Blocked from Rihand end
28.	30/07/2012 02:33:31.083 AM	Bassi – Agra-I CB652 Opened
29.	30/07/2012 02:43:33.589 AM	Bassi – Heerapura=II CB1252 Opened
30.	30/07/2012 02:33:36.617 AM	Tehri pooling – Koteshwar TOV1 Trip

Annexure-3.3

An Illustrative Example to demonstrate angular separation of NR-WR System

In order to illustrate that the angular separation can occur with the loss of a tie, a simplified two machine system was simulated, approximately representing NR and WR systems. We can look upon this system as a simplified representation of a two area system (NR and ER-WR-NER). We consider two tie lines, one short and one long.

In the simplified system, "NR" part draws 800MW on short tie and 400 MW on the longer tie. With the tripping of the shorter tie, Fig S-1 clearly shows that both systems go out of phase (in about 2.3 sec for this simplified Illustrative example). Fig S-2 shows severe power swings and oscillatory nature of voltage, MW and MVAR flows under this condition.

This simulation illustrates that angular separation between two systems followed by power swings is possible on loss of short tie. However as it is a simplified system, for specific answers to the collapse of the grids on 30th and 31st July 2012, a detailed load flow and transient stability simulation of the NR, ER, NER and WR grids is required.

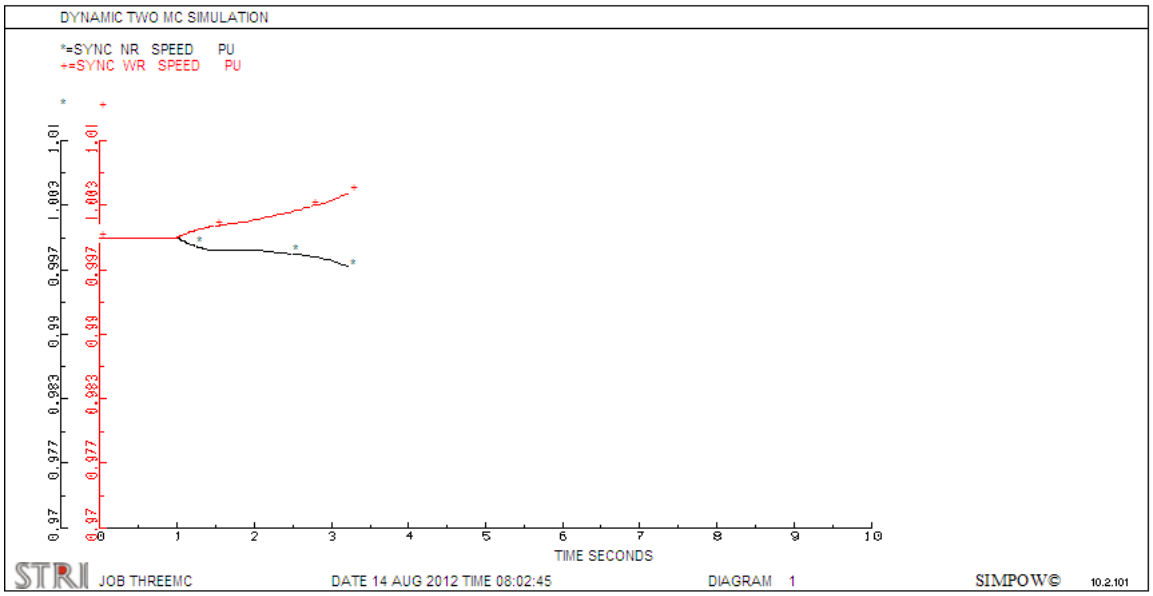


Fig S-1 : Loss of Short Tie Line
(Shows angles increasing continuously and later NR and WR are out of phase)

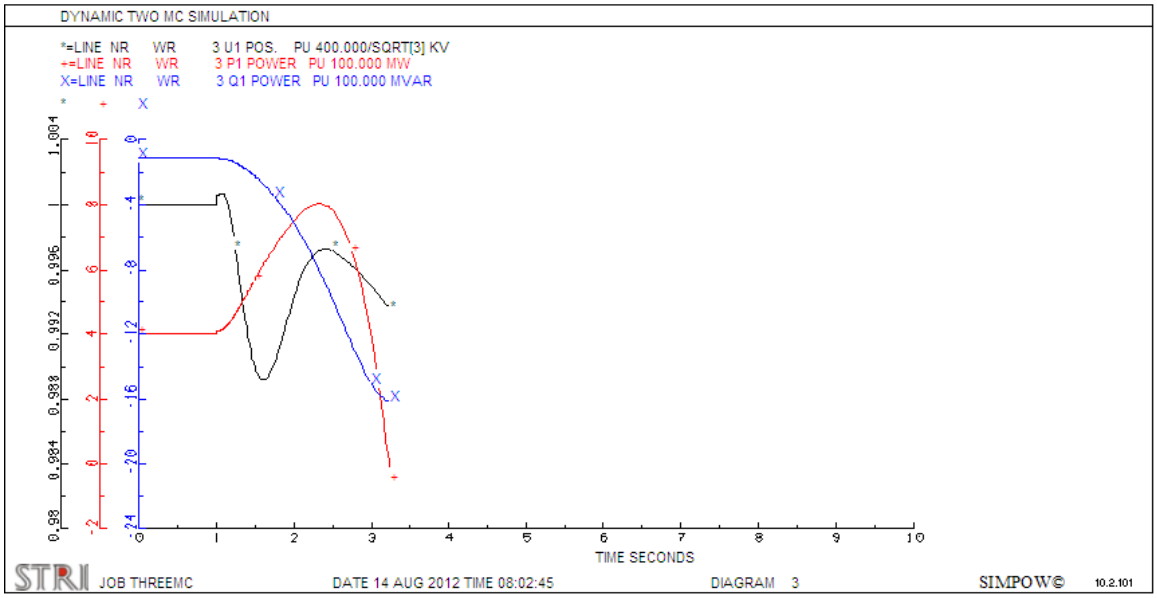


Fig S-2 : Loss of Short Tie Line
(Shows power swings between the two systems)

Exhibit 3.1

Recording Showing Angular Separation between NR and Rest of NEW Grid on 30/07/2012

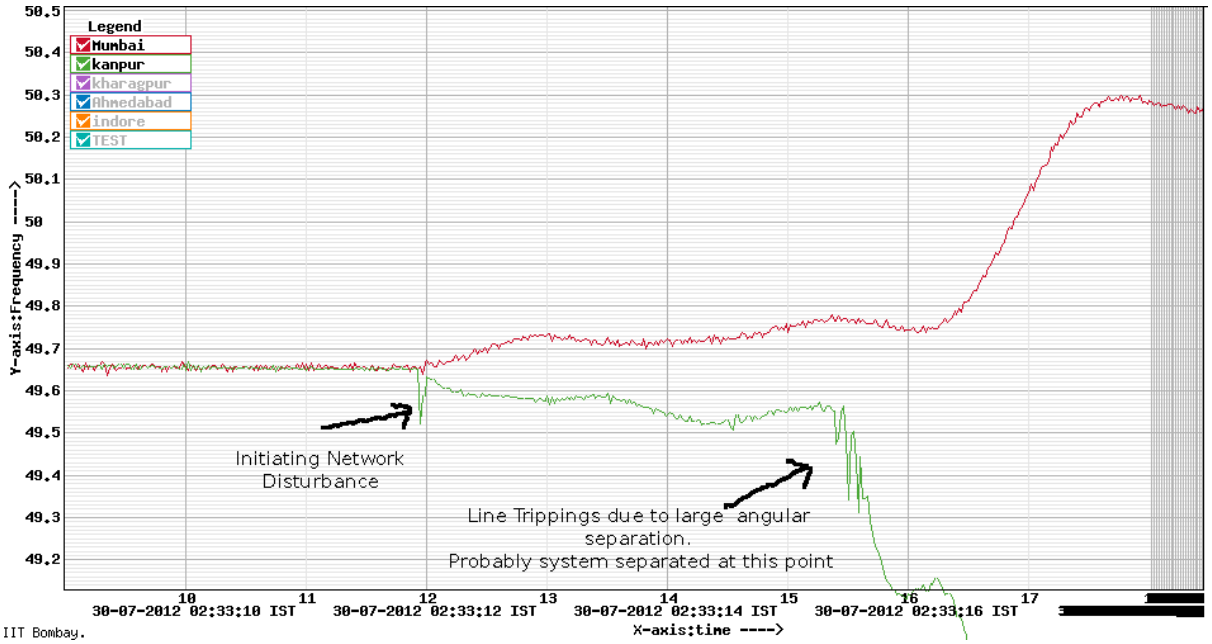


Fig 1: (source: Wide Area Frequency Measurement system developed by IIT-B, Mumbai.)

Exhibit 3.1 (contd..)

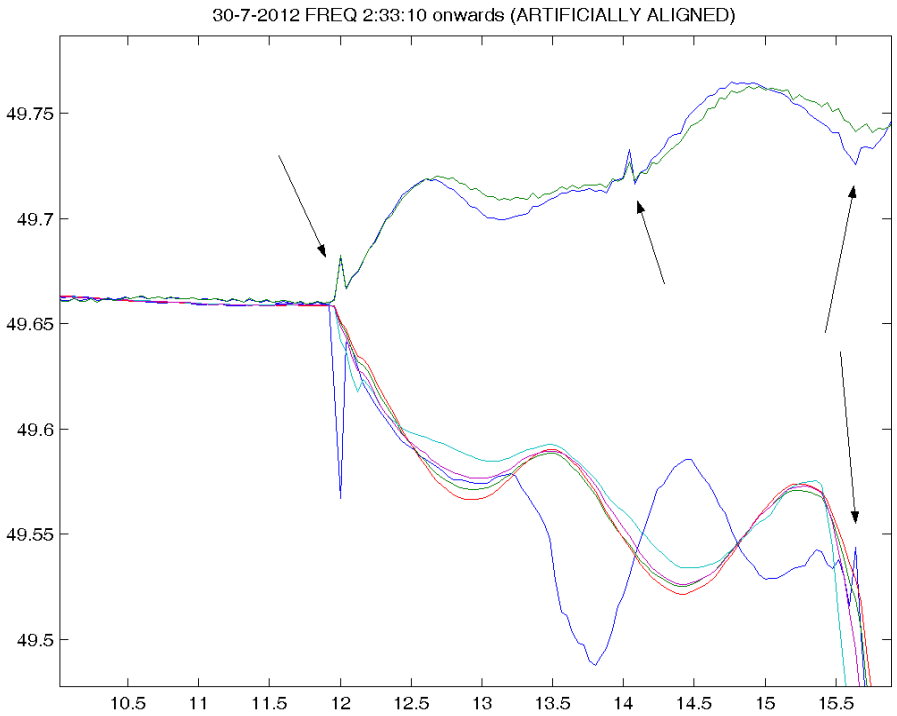


Fig 2: (source: PMU Data from WR and NR.) Note: There was time mismatch in WR PMUS and required to be logically aligned. Arrow indicates events.

Chapter-4

Analysis of Grid Disturbance on 31st July, 2012

4.1 Introduction

While the grid recovered from the black out of 30th July 2011, another major disturbance took place on 31st July 2012 in the NEW grid at 13:00:13 hrs that led to the separation of the NR, NER and ER from the WR and eventually led to the collapse of the NR, ER and NER grids. The pre-disturbance conditions, sequence of events and analysis of the disturbance are described below.

4.2 Pre-Disturbance Conditions on 31st July 2012

The details of the generation-demand as well as import/export of power in each of the four regions in the NEW grid on 31.07.2012 at 12:30 hrs are given below.

Sl. No	Region	Generation	Demand	Import	Remarks
1	NR	29884MW	33945MW	4061MW	
2	ER	13524MW	13179MW	(-) 345MW	Import from Bhutan 1114 MW.
3	WR	32612MW	28053MW	(-)4559MW	
4	NER	1014MW	1226MW	212MW	
Total	NEW Grid	76934MW	76403MW		

A number of EHV lines were out prior to the disturbance and the same are listed in **Annexure 4.1**. It may be noted that even after grid disturbance on the previous day, similar network operating conditions prevailed on this day as well. The frequency, just prior to the disturbance, was 49.84 Hz.

4.3 Sequence of Events on 31st July, 2012

It may be noted that the NEW grid was operating in an insecure condition even on 31st July 2012 due to a large number of line outages particularly near the WR-NR and ER-WR interfaces. Though an exhaustive list of lines under outage is given at **Annexure 4.1**, it may be mentioned that the following lines had tripped within an interval of a few hours prior to the grid disturbance.

1. 400 kV Zerda-Bhinmal
2. 400 kV Zerda- Kankroli
3. 220 kV Badod-Modak- tripped a few minutes before the event
4. 220 kV Badod-Kota- tripped a few mintutes before the event

In addition Surat Garh unit-1 also tripped around this time

The following are the sequence of events, which took place on 31st July 2012 leading to the blackouts in the Northern, North-Eastern and Eastern regions.

Sl.No.	Time	Event
1.	31/07/2012 13:00:13	400kVBina – Gwalior-1 line tripped at Bina end on Zone 3 Protection due to load encroachment, 400kV Bina-Gwalior-2 was already out of service.
2.	31/07/2012 13:00:13	220kV Bina – Gwalior-1 line tripped at Bina end due to R&B over current 220kV Bina – Gwalior-2 line tripped at Bina end due to R&B over current
3.	31/07/2012 13:00:13	220kV Shivpuri-Sabalgarh-1 tripped
4.	31/07/2012 13:00:13	132kV Pichhore-Shivpuri tripped
5.	31/07/2012 13:00:13	132kV Pichhore-Chanderi tripped ***Sequence of event nos 1-5 led to the isolation of the Gwalior region of MP from WR and formed part of the NR system.***
6. *	31/07/2012 13:00:15:548	220 kV bus coupler tripped at Tarkera tripped (details not available)
7. *	31/07/2012 13:00:13:600	400 kV Jamshedpur-Rourkela-1 tripped at Jamshedpur on Main-1 (RAZFEE) protection, appears to be due to load encroachment. The L-L voltage before trip was about 362 kV and line current as 1.98 kA (appx. loading 1241 MVA)
8. *	31/07/2012 13:00:17:948	400 kV Ranchi- Maithon-1 tripped due to Power Swing.
9.	31/07/2012 13:00:19.605	400 kV Rourkela -Sterlite-2 tripped due to Over voltage (timings need to be confirmed)
10.	31/07/2012 13:00:19.891	400 kV Rourkela-Talcher-2 tripped due to Power Swing
11.	31/07/2012 13:00:19.897	400 kV Rourkela – Talcher-1 tripped due to Power Swing
12.	31/07/2012 13:00:19.908	400 kV Rourkela – Raigarh-3 tripped due to Power Swing and Over voltage
13.	31/07/2012 13:00:19.925	400 kV Rourkela-Ranchi-1 tripped due to Power Swing, D/T received
14.*	31/07/2012 13:00:19:945	400 kV Ranchi-Sipat-2 tripped on Power Swing
15.*	31/07/2012 13:00:19:948	400 kV Raigarh-Rourkela-3 tripped on Power Swing

16.*	31/07/2012 13:00:19:974	400 kV Ranchi-Rourkela-1 tripped on Power Swing
17.*	31/07/2012 13:00:19:981	400 kV Talchar-Rourkela-2 tripped on Power Swing
18.*	31/07/2012 13:00:19:986	400 kV Talchar-Rourkela-1 tripped on Power Swing
19.*	31/07/2012 13:00:20:017	400 kV Ranchi-Raghunathpur tripped on Power Swing
With the above events, practically all the AC links from the WR to the rest of the grid were lost and WR got isolated along with Ranchi and Rourkela buses. *Events taken from the POSOCO & POWERGRID report submitted to CEA, which are based on the DR and EL reports.		
20.	31/07/2012 13:00:25.021	400 kV Rourkela-Raigarh-1 tripped on over voltage
21.	31/07/2012 13:00:26.091	400 kV Rourkela-Ranchi-2 tripped due to Power Swing
22.	31/07/2012 13:00:30.625	400 kV Ballabgarh-Kanpur ckt2, tripped due to reactance relay operation.
23.	31/07/2012 13:00:32.444	400 kV Ballabgarh-Kanpur ckt3, tripped due to reactance relay operation.
24.	31/07/2012 13:00:35.558	Suratgarh Unit-6 tripped due to Under frequency problem (timing to be confirmed)
25.	31/07/2012 13:01:14.788	Suratgarh Unit-2 tripped due to under frequency problem (timing to be confirmed)
26.	31/07/2012 13:01:23.793	Vindhyachal HVDC B/B block-1 AC bus north: abnormal frequency trip because of Vidhyachal-Singrauli line tripping, EL or DR not available for Vindhyachal-Singrauli line.
27.	31/07/2012 13:01:25.078	Suratgarh Unit-5 tripped due to Under frequency problem
28.	31/07/2012 13:01:26.003	Vindhyachal HVDC B/B block-2 AC bus north: abnormal frequency trip because of Vidhyachal-Singrauli line tripping
29.	31/07/2012 13:01:26.343	400 kV Kankroli-Jodhpur tripped ICT differential relay pickup due to dip in voltage, SOTF
30.	31/07/2012 13:01:26.633	Nathta-Jhakri Powe Plant U1 tripped due to under frequency.
31.	31/07/2012 13:01:26.779	Nathta-Jhakri Power Plant U3 tripped due to under frequency.
32.	31/07/2012 13:01:26.786	Nathta-Jhakri Power Plant U2 tripped due to under frequency
33.	31/07/2012 13:01:26.823	Nathta-Jhakri Power Plant U4 tripped due to under frequency

34.	31/07/2012 13:01:28.205	Muzaffarpur-Gorakhpur-2, 3ph protection operated and tripped the line
35.	31/07/2012 13:01:27.226	Bhiwadi-Bassi, 400kV line tripped , Z1, Three phase tripping, Bhiwadi end operated
36.	31/07/2012 13:01:27.228	Bhiwadi-Rewari, 220kV tripped, 3Ph distance protection, Z1 Operated
37.	31/07/2012 13:01:27.497	220kV Bassi-IG Nagar tripped, 3Ph fault
38.	31/07/2012 13:01:27.497	220kV Bassi-Bhagru tripped, Z1, three phase fault
39.	31/07/2012 13:01:27.940	220kV, Bassi-Dausa line tripped, Z1, three phase fault
40.	31/07/2012 13:01:28.031	Muzaffarpur-Gorakhpur-1 tripped, Z2 operated
41.	31/07/2012 13:01:28.224	400kV, Agra-Bhiwadi1 tripped, SOTF
42.	31/07/2012 13:01:28.226	400kV, Agra-Bhiwadi2 tripped, SOTF
43.	31/07/2012 13:01:28.363	Wagoora-Kishenpur (1&2) tripped, Power Swing
44.	31/07/2012 13:01:29.072	400kV, Meerat-Koteswar (1&2)tripped, Power swing detected
45.	31/07/2012 13:01:29.686	Mandola-Dadri (1&2) tripped
46.	31/07/2012 13:01:29.726	Kaithal-Patiala line-1 tripped
47.	31/07/2012 13:01:29.742	Dadri-Malerkotla line tripped, Power Swing
48.	31/07/2012 13:01:29.762	Agra-Auraiya-II tripped, Z3, Three Phase
49.	31/07/2012 13:01:29.777	Malerkotla-Patiala tripped, Power swing
50.	31/07/2012 13:01:29.780	Malerkotla-Ludhiana Tripped, Power swing
51.	31/07/2012 13:01:29.816	Moga-Jalandhar (1&2) triped, Power swing
52.	31/07/2012 13:01:29.832	Moga-Kishenpur-1 tripped, Power swing
53.	31/07/2012 13:01:29.920	Agra-Auraiya-I tripped, Z3, 3Ph
54.	31/07/2012 13:01:30.120	400kV, Ballabgarh-Maharanibagh Tripped, Z1, 3Ph tripping, SOTF
55.	31/07/2012 13:01:30.191	Kaithal-Kaithal-I tripped

56.	31/07/2012 13:01:30.276	Ballabhgarh-Gr Noida tripped, Z1, 3phase
57.	31/07/2012 13:01:30.320	Allahabad-Sasaram disturbance, PSB Operated. Another report is also available with different time stamping on the same event. Suspecting time synchronization problem.
58.	31/07/2012 13:01:30.368	Kanpur-Panki-1 tripped, Under voltage
59.	31/07/2012 13:01:30.630	Agra-Bassi-I, SOTF
60.	31/07/2012 13:01:30.689	Kaithal-Kaithal-II tripped
61.	31/07/2012 13:01:30.702	HVDC Balia-Bhiwadi tripped, AC under voltage protection
62.	31/07/2012 13:01:30.833	Balia-Biharshariff tripped, Power Swing
63.	31/07/2012 13:01:31.219	Meramundali-Jeypore tripped
64.**	31/07/2012 13:01:32.684	400kV, Patna-Balia-2 tripped, 3-ph fault
65.	31/07/2012 13:01:42.867	Dadri-Rihand HVDC pole-2 blocked
66.	31/07/2012 13:01:42.871	Dadri-Rihand HVDC pole-1 blocked
67.	31/07/2012 13:03:18.363	Kankroli-Debari, 220kV tripped, Under voltage protection

**After event 64, the NR got practically isolated from the ER+NER and frequency started dropping (observed in the NR system) after a gap of about 1 minutes from the previous major event.

The subsequent events of cascaded tripping led the NR, NER and ER system to practically total blackout.

4.4 ANALYSIS OF GRID DISTURBANCE ON 31st JULY, 2012:

I. It is interesting to note that on 31st July 2012 also, though the frequency of the NEW grid (49.84 Hz) was near to its nominal value (50 Hz), a large number of lines were not available due to either forced outages, planned outages or kept out to control high voltages which, coupled with high demand in the Northern Region, resulted in insecure state of the system operation.

II. NR constituents were instructed by NRLDC to carry out load shedding to reduce the over drawal. Similarly the WR constituents were also instructed by WRLDC to reduce generation to bring down the over injection of power.

However, the quantum of load shedding/generation reduction undertaken by the two constituents seems to be insignificant.

III. Just prior to the initiation of the major disturbance, NR-WR was connected through AC tie links between 400 kV Agra-Gwalior (one circuit), 220 kV Badod-Kota and 220 kV Badod-Modak lines.

IV. Badod-Modak line flow reached 288MW at about 12:58pm on 31st July, 2012 from

V. 103MW and got tripped due to overload. Similarly, 220 kV Badod-Kota line also reached a flow of 298MW from its earlier flow of 113MW and tripped due to overload. The rise in flow of these lines are possibly due to tripping of the Suratgarh generating unit-1 of 250 MW at about 12:50 hours in Rajasthan.

VI. At about 13:00:13 hrs, 400kV Bina-Gwalior-I line tripped on distance relay zone-3 protection, which is also due to load encroachment (as DR records do not show any evidence of fault or swing). As per DR report of PGCIL the loading on this line 1254 MVA and voltage was 362 kV at Bina end (Though the MW loading was less the previous tripping, due to lower voltage the MVAR flow was larger than previous incident).

VII. The load on the 220kV Bina-Gwalior-I&II suddenly increased to 447MW from 330MW and increased further. The power flow on 220kV Gwalior(PG)-Gwalior (MP) line-II was 188MW at 12:58:58pm and got reversed to -180MW. This resulted in the reverse flow of power from Gwalior (MP) to Gwalior (PG) and pumped in to 400kV system.

VIII. The power drawl of Auraiya from Mehalgaon resulted in the tripping of 220kV Bina-Gwalior- I&II, 220kV Shivpuri-Sabalgarh-I, 132kV Pichhore-Chanderi and 132kV Pichhore-Shivpuri. On 31.07.12 400kV Bina-Gwalior II and 400kV Gwalior-Agra II lines of POWERGRID were under shut down and 220kV Gwalior (PG)-Mahalgaon (GWL) -I, 220kV Gwalior-(PG) – Malanpur-II of MP were also under shut down since 29.07.2012. This situation led to the isolation of the Gwalior region of MP from WR and formed part of the NR system.

IX. The NR system was isolated from the WR system and the demand, which was earlier fed from the WR got routed through WR-ER-NR systems,

causing increase in the angular separation between the NR and WR systems, similar to the disturbance on 30th July 2012.

X. However, unlike the pattern on 30th July 2012, the electrical center of the angular separation appears to be slightly inside the ER system from the WR-ER interface. This resulted in tripping of lines connecting unlike Ranchi and Rourkela to the rest of the ER. These buses formed part of the WR, which got separated from the rest of ER+NR+NER at about 13:00:20 hrs.

XI. The frequency plots are available from PMUs and the WAFMS from the NR and WR only (see **Exhibit 4.1**). This shows that the frequency in the WR rose to 51.4 Hz and that in the rest of the NEW grid stabilized close to 48.12 Hz. The sudden rise in frequency, close to 51.4 Hz in the WR, again indicates absence of FGMO controls being activated in several generating stations. In fact, the FGMO operation in the rest of the NEW grid could have possibly recovered the frequency which stayed at 48.12 Hz for about a minute and probably avoided the further catastrophic failure.

XII. The WR system survived with the tripping of Sipat 660MW, DSPM 2*250 MW ESSAR 125 MW and KLTPS 69 MW generating units. APL 660 MW generating unit tripped on Special Protection Scheme, associated with tripping of Adani-Manindragarh HVDC and frequency stabilized at around 51 Hz.

XIII. Further the loss of import from about 3000 MW import from WR resulted in decline of frequency in the rest of the NEW grid, which has Automatic Under Frequency Load Shedding Scheme (AUFLS), that can shed about 5600 MW of loads, and df/dt relays scheme, which can shed about 6020MW of loads, to improve the frequency and save the system under such emergency situations. However, not adequate load relief from the AUFLS and df/dt relays was observed on 31st July 2012 also.

XIV. Subsequently, possibly due to some generator trip in the NR+NER+ER grid led large angular oscillations and drop in system frequency, which resulted in a large number of trippings in the NR, ER and NR-ER links. This cascaded tripping of lines was on overvoltage at few places, power swing or zone-3 protection and tripping of generators on under frequency. This initially separated NR from NER+ER. From PMU records NR systems has collapsed on under frequency. There is no PMU installed so far in ER+NER system. The system is also smaller in size with small Power Number and ER+NER systems collapsed except for few islands, like CESC, NALCO and BSP.

XV. It may be mentioned that with the collapse ER, the Southern Region lost about 2000 MW in feed from Talchar-Kolar HVDC and frequency declined from 50.06 Hz to 48.88 Hz as per SRLDC SCADA. The frequency controller at HVDC Bhadrawati increased the flow of WR to SR from 880 MW to 1100 MW. System Protection scheme at Kolar did not operate. It was informed by the SRPC that there was AUFLS relief of about 984MW in the SR.

XVI. It may be noted that both on 30th and 31st July 2012, lot of tripping of lines were observed due to over voltage and also substantial under voltage at the tail end of the heavily loaded lines were observed, which caused operation of distance protection. These extreme voltage situations could have been avoided with the proper reactive power absorption/support from reactors/capacitors, dynamic compensators as well as synchronous generators.

Annexure 4.1

List of EHV Lines Out on 31.07.2012 Prior to Disturbance
(400 kV and above and Inter-Region 220 kV and above)
(as furnished by NLDC)

Sl No	Line	Voltage (kV)	Region	Out From Date	Remarks
	NR				
1	Bassi-Jaipur 1	400	NR	28/07/12	Planned
2	Agra-Bassi-2	400	NR	28/07/12	Planned
3	Agra-Gwalior 2	400	WR-NR	28/07/12	Planned
4	Zerda-Kankroli	400	WR-NR	28/07/12	Planned
5	Agra-Fatehpur	765	NR	26/07/12	Constr Work
6	Bhiwadi-Neemrana	400	NR	23/07/12	HV Trip
7	Barh-Balia	400	ER-NR	29/07/12	HV Trip
8	Bhinmal-Kankroli	400	NR	29/07/12	Forced
9	Badod-Kota	220	WR-NR	29/07/12	Forced
10	Manesar-Neemrana	400	NR	15/07/12	Control HV
11	Gorakhpur(PG)-Lucknow 2	400	NR	30/07/12	Forced and kept open
12	Kota-Merta 1	400	NR	30/07/12	Forced
13	Heerapura-Hindaun 2	400	NR	30/07/12	Forced
14	Neemrana-Sikar	400	NR	20/07/12	Control HV
15	Barh-Balia 2	400	ER-NR	28/07/12	Control HV
16	Akal-Barmer 1	400	NR	28/07/12	Control HV
17	Chhabbra-Hindaun 2	400	NR	30/07/12	Control HV
18	Barmer-RajWest2	400	NR	30/07/12	Control HV
19	Jodhpur II – RajWest 2	400	NR	30/07/12	Control HV
	WR				
1	Bina-Gwalior 2	400	WR	27/07/12	Planned
2	Parli-Parli 2	400	WR	19/07/12	Forced
3	Damoh-Birsingpur 2	400	WR	13/07/12	Control HV
4	Nagda-Rajgarh 1	400	WR	20/07/12	Control HV
5	Seoni-Bina 1	765	WR	03/07/12	Control HV
6	Seoni-Wardha 2	765	WR	23/07/12	Control HV
7	Bina – Indore	400	WR	21/07/12	Possibly Bina-Nagda
8	Korba-Birsingpur	400	WR	05.07.12	Control HV
9	Birsingpur-Balco	400	WR	22/06/12	Control HV

10	Raigarh-Raipur 1	400	WR	20/07/12	Control HV
11	Itarsi-Khandwa 2	400	WR	20/07/12	Control HV
12	Bachau-Ranchodpur	400	WR	30/07/12	Forced
13	Wardha-Akola-1	400	WR	20/07/12	Control HV
14	Parl(PG)-Sholapur 1	400	WR	23/07/12	Control HV
15	Bhadrawati-Parli 1	400	WR	21/07/12	Control HV
16	Aurangabad-Bhusawal	400	WR	27/06/12	Control HV
17	Aurangabad-Deepnagar 2	400	WR	03/07/12	Control HV
18	Karad-Kolhapur 2	400	WR	28/07/12	Control HV
19	Kolhapur-Mapusa 2	400	WR	26/07/12	Control HV
20	SSP-Rajgarh 2	400	WR	25/07/12	Control HV
21	ISP-Nagda	400	WR	24/07/12	Control HV
22	Itarsi-Bhopal	400	WR	29/07/12	Control HV
23	Adani-Sami 1	400	WR	31/07/12	Control HV
24	Amreli-Jetpur	400	WR	31/07/12	Control HV
25	Asoj-Chorani 1	400	WR	31/07/12	Control HV
	ER				
1	Ranchi-MPL D/c	400	ER	27/07/12	Planned
2	Binaguri-Purnea 1	400	ER	18/07/12	Planned
3	Sagardighi-Durgapur	400	ER	25/07/12	Forced
4	Baripada-Mendhasal	400	ER	14/07/12	Forced

EXHIBIT 4.1

Recording Showing Angular Separation between NR and Rest of NEW Grid on 31/07/2012

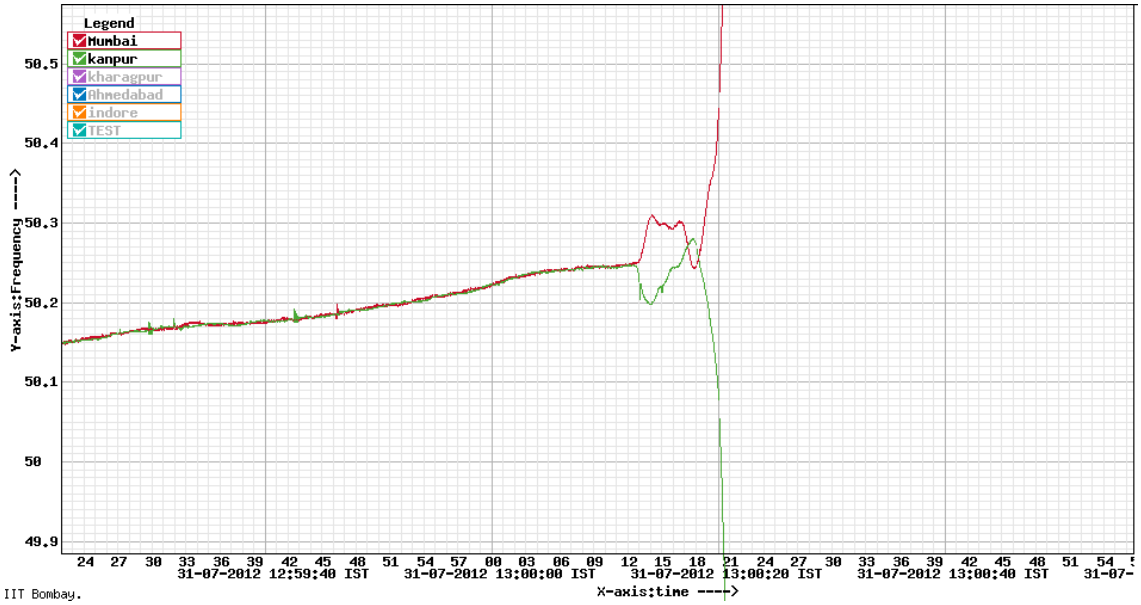


Fig 1: (source: Wide Area Frequency Measurement system developed by IIT-B, Mumbai.)

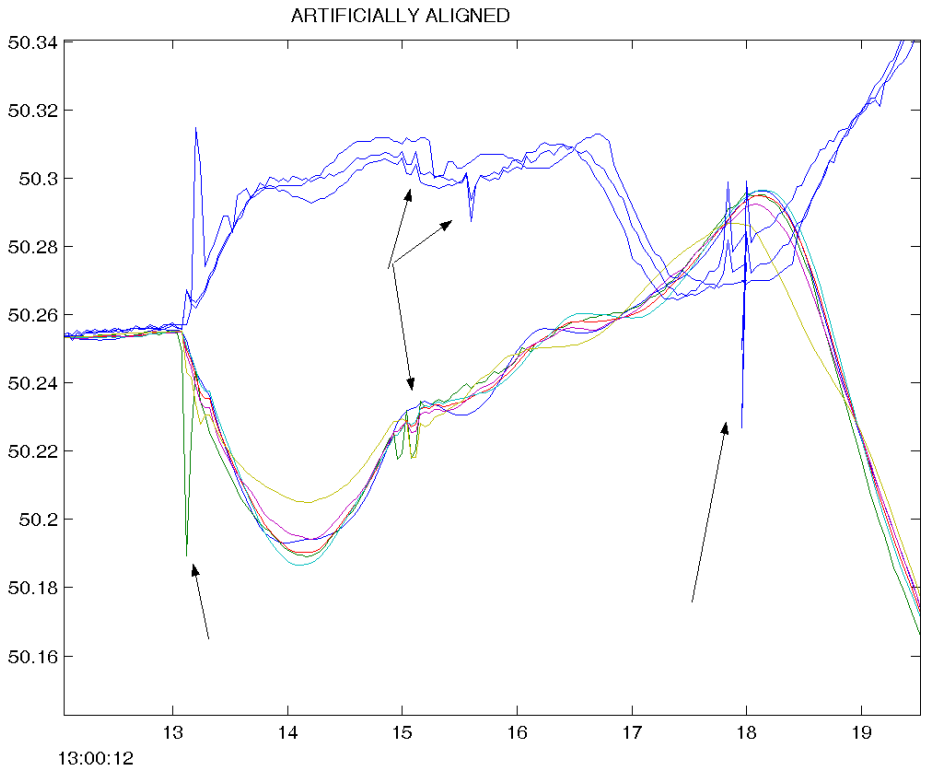


Fig 2: (source: PMU Data from WR and NR.) Note: There was time mismatch in WR PMUS and required to be logically aligned. Arrow indicates events.

Chapter- 5

FACTORS CONTRIBUTING TO GRID DISTURBANCES ON 30TH AND 31ST JULY 2012

5.1 As is the case with most system failures, no single factor was responsible for grid disturbances on 30th and 31st July 2012. After careful analysis of these grid disturbances, the Committee has identified several factors, which initiated collapse of power systems on these days. The Committee has also identified factors which could have saved the grids from total collapse. These factors are given below:

5.2 Factors that contributed to initiation of grid collapse

5.2.1 Depleted transmission network

It is observed that one circuit of 400 kV Bina-Gwalior-Agra section was taken under planned outage by POWERGRID from 11.47 AM of 28.07.2012 for up gradation to 765 kV level. A number of 400 kV lines were out prior to the incidence on both these days. The outage of 400 kV Bina-Gwalior–Agra for up-gradation work, non availability of 400 kV Zerda-Kankroli and 400 kV Bhinmal-Kankroli due to insulator problems in particular weakened the NR-WR Interface.

The availability of 400 kV Zerda-Bhinmal-Kankroli corridor requires to be improved by replacing porcelain insulators by polymer insulators at the earliest.

5.2.2 Overdrawals attributable to frequency control through commercial signals

5.2.2.1 One of the objectives of load despatch is to maintain power system parameters within permissible limits. The frequency, being one of the parameter has to be maintained at 50 Hz or close to 50 Hz. For historical reasons, the Indian grid Systems experienced poor frequency profile. In the 1990s, more loads were met with available generation at the cost of frequency. System was subjected to operate in the range of 48-51.5 Hz. Power quality and Grid security was compromised during this period. To enforce Grid discipline and to improve frequency profile, a new tariff mechanism was conceived in the early 1990s.The earlier PLF based tariff was replaced by Availability Based Tariff (ABT). Apart from fixed and variable charges, ABT had a third component, namely Unscheduled Interchange (UI) charge. UI charge is payable if an utility is deviating from schedule (Generation/drawal) depending on the frequency. ABT was first

implemented in the WR on 1st,July 2002. It was possible to implement it with the regulatory support. There was positive improvement in the frequency profile. Initially the frequency band stipulated was 49.0-50.5 Hz and subsequently the range was tightened by Central Commission. The present range is 49.5-50.2 Hz. Further tightening of the frequency band by Central Commission has been challenged in the court. In the interest of power quality and grid security, there is a definite need to operate the system at and very close to 50 Hz. It is further observed that Utilities resort to load shedding to earn revenue through UI to compensate their poor financial management. If the frequency profile is close to 50 HZ, UI rate is nominal and utilities tend to over draw/under draw thereby completely deviating from the schedule. If more number of utility players resort to such activity, it may even lead to load encroachment phenomena and grid disturbance, as has been observed in recent grid disturbances. One has to draw power only through long term , medium term or short term contracts. UI mechanism, which helped the system initially, need to be reviewed now.

5.2.2.2 Electricity Act 2003 mandates that the operating frequency range defined in Grid standard(section73(d)) and Grid Code(section 79(1)(h)) has to be adopted by LDCs. Utilities rushing to court to define frequency range may not be in the interest of secured grid operation and power quality.

5.2.2.3 Just to give an example, it may be pointed out that the "Union for the Co-ordination of Transmission of Electricity" (UCTE), an association of transmission system operators in the Europe, operates at 50 Hz± 0.02 Hz . Similarly, North American Electric Reliability Council (NERC) ensures each balancing area to plan operation at 60 Hz. Though unintentional deviation take place, they are addressed without compromising the stipulated frequency. Intentional deviation is not being done as schedules are treated as binding contracts.

5.2.2. In the developed Systems, it is possible to operate at the stipulated frequency as the participating systems takes care of their load–generation balance at the stipulated frequency. In Indian Grid, Utilities have to adopt such practice for healthy system operation.

5.2.3 Inability to control flow on 400 kV Bina-Gwalior-Agra line

5.2.3.1 It is clear from the messages issued by NRLDC to various SLDCs and recorded telephonic conversations that regional load dispatcher had made desperate efforts for reduction of overdrawals by various States, which in turn would have led to relieving of loading of 400 kV Bina-Gwalior-Agra line. In spite of records of load shedding in log book of SLDCs, it is evident that there was hardly any reduction in flow on this line. It is observed that NLDC is revising TTC in case of planned outage

of transmission elements and not in case of forced outage. During discussions, officials of NLDC had cited few reasons for not revising TTC on the day of disturbance. Firstly, in the opinion of NLDC, declaration of TTC is for the purpose of facilitating organized electricity trading contracts, which are cleared on day ahead basis and, therefore, revision of TTC in real time would not serve any purpose. Secondly, NLDC pointed out that calculation of TTC requires elaborate studies, which is a specialized task and cannot be performed by operators in real time. Thirdly, NLDC stated that regulatory provisions restrains them from applying congestion charges in case congestion is attributable to forced outage of transmission line in the corridor.

5.2.3.2 The very fact that provision to apply congestion charge forms part of the regulations on the issue of "*Measures to relieve congestion in real time*" indicates that security of the grid is main objective of such provision. However, the Committee tend to agree that calculation of TTC is a specialized task. However, ways and means can be found out to overcome this problem. The Committee has gone through relevant regulations of Central Commission. However, there is no provision which restrains NLDC from applying congestion charges. Further, para 5.4 of the "Detailed procedure for relieving congestion in real time operation" prepared by NLDC and approved by Central Commission does restrain NLDC from applying congestion charges in such situation but requires curtailment of transactions followed by revision of TTC. Thus, the procedure prepared under the provisions of a Regulation is not consistent with the Regulation. This aspect needs to be reviewed.

5.2.3.4 At present, there is no Automatic Generation Control (AGC)//tie line bias control in the network, which can automatically restrict the tie-line flows to the scheduled limit and also frequency at the nominal value.

5.2.4 Non-compliance of directions of LDCs and Regulatory Commissions

Non-compliance of instructions of RLDCs has been a problem since long. However, of late a disturbing trend of non compliance of directions of the Central Commission has been observed. The Committee is of the view that maximum penalty that can be imposed by Regulatory Commissions in accordance with the Electricity Act, 2003 is meager in comparison to damage that such non-compliance can cause to the grid. It is reported that in some cases, the penalty imposed by Central Commission has not been paid. States overdrawing from the grid often do not pay UI Charges which has contributed to infectiveness of ABT.

5.2.5 Protection System Issues

5.2.5.1 It is noted that on both days, the grid disturbance was initiated by tripping of 400 kV Bina-Gwalior line on zone-3 of Main-II protection, though there were several other concurrent conditions, which ultimately led to collapse of grid. There is no doubt that this tripping is attributable to load encroachment i.e. the current and voltage conditions were such that the protection system perceived it as fault (during fault, current becomes very high and voltage goes down to very low levels). Thereafter, there were several tripping on load encroachment and power swing. It is also noted that on both days, only Main-II protections operated and Main-I protection did not pick up.

5.2.5.2 It may also be noted that during the disturbances on 30th and 31st July, 2012, the 400 kV Bina-Gwalior line was not thermally overloaded i.e., the current rating (quad Bersimis conductor) of the line was not exceeded. However, the system was "insecure", i.e., the system was not stable for the loss of this line. System security requires that the system should be able to withstand credible contingencies.

5.3 Factors that could have saved the grid from collapse

5.3.1 Primary response from generators

5.3.1.1 The provision for putting all generating units on governor action has been part of Indian Electricity Grid Code (IEGC) for several years. However, this was not getting implemented as generators pointed out few difficulties including wide frequency fluctuations. However, in recent years, Central Commission has made concerted efforts to reduce the operating frequency band by periodically amending provisions in the IEGC and these regulatory provisions have been successful to large extent. Another difficulty cited in implementation of governor action was that the free governor action tries to lower the generation when frequency rises from a frequency lower than 50 Hz. This difficulty has also been addressed in the new IEGC issued in April 2010 by providing for restricting the governor action in such zone. In spite of the fact that impediments in implementation of governor action have been removed, there is still no evidence of governor action in Grid Disturbances on 30th and 31st July 2012. As mentioned elsewhere, had governor action been put into action during these disturbances, chances of survival of regional grid could have been more after isolation from NEW grid.

5.3.1.2 Another important aspect in relation to primary response is that it would be absolutely essential for survival of islands. In the wake of recent grid disturbances, the issue of formation of electrical islands as last resort to maintain essential services and quick restoration has come to fore. However, in case of imminent grid disturbance, if such electrical islands are

formed, their chances of survival would be abysmally low if generating units included in these islands are not on governor action.

5.3.2 Optimum utilization of available assets

5.3.2.1 A large number of high capacity 400 kV lines have been added to the intra-regional and inter-regional systems in the recent past. However, a significant number of lines are generally kept open to contain high voltages. This makes system weak and such system may not be able to cope contingency. The widespread prevalence of high voltages is pointer of insufficient reactive compensation.

5.3.2.2 Practically all generating units are equipped with Power System Stabilizers (PSS), which can save the grid from several potential destabilizing conditions. However, there is need to tune PSS periodically. Similarly, various devices/equipment available in power system such as HVDC, TCSC and SVC have stability features, which need to be enabled. There is no evidence that these devices had any stabilizing influence during grid disturbances on 30th and 31st July 2012. The system requires a large of dynamic compensators, which need to be established through detailed study.

5.3.2.3 Presently, nine number of Phasor Measurement Units (PMUs) have been put in place in Northern Region and 3 PMUs have been installed in Western Region. Even these limited number of PMUs have been helpful in the past in understanding behavior of the system. Also, these PMUs have been of immense help to this Committee in analysis of grid failures on 30th and 31st July 2012. POWERGRID has plans to install PMUs in a big way, as they are bedrock requirement for development of smart transmission grids. However, it is matter of concern that on the days of disturbances, data from PMUs at Agra in Northern Region and Vindhyachal in Western Region is not available. It appears that the PMUs in Western Region are not time synchronized.

5.3.3 Operation of defense mechanism

Defense mechanisms like load shedding based on under frequency relays (UFRs) and Rate of change of frequency (df/dt) relays have been adopted in all Regional Power Committees (RPCs) in accordance with provisions of IEGC. Similarly, increasing number of Special Protection Schemes are being employed to save system in case of contingencies. However, the experience of the recent grid disturbances reveal that practically there was no load relief from these schemes. The case in point is Northern Region, where UFR based load shedding of 4000 MW (in 3 stages) and df/dt based load shedding of about 6000 MW has been agreed. The Committee is of the opinion that after loss of about 5000-6000 MW to Northern Region, had these relays operated, the grid could have been saved. The Committee

has observed that so far violation of the various system security related provisions of IEGC issued by Central Commission and Grid Connectivity & Grid Standards issued by Authority has not been taken seriously and the attention has solely been on overdrawals from the grid.

5.3.4 Autonomy to Load Despatch Centres

5.3.4.1 The issue of lack of autonomy to Load Despatch Centres is on the horizon of policy makers for quite some time. In November 2007, Ministry of Power had constituted a Committee under Shri G.B. Pradhan, the then Additional Secretary in Ministry of Power. The mandate of this Committee was to examine issues relating to manpower, certification and incentives for the personnel employed on System Operation at various levels and also for ring-fencing the Load Despatch Centres to ensure their functional autonomy. This Committee had submitted its report in August 2008.

5.3.4.2 However, significant amount of efforts are required for implementation of recommendations of Pradhan Committee. One of the recommendations of the Pradhan Committee was to have qualified system operators. Towards this end, a certification programme has been started. But there is a need to provide incentives to those operators, who clear the certification examination as also recommended by the Pradhan Committee.

5.3.5 Intra-State transmission Planning and its implementation

In recent grid disturbances, it has been observed that overloading and consequent tripping of 220 kV system had pushed the system to the edge. It also appears that though inter-State system is being strengthened continuously, matching strengthening in intra-State transmission system has not been carried out. This not only limits ability of the States to draw power but also causes low voltage problems and unreliable supply to end consumers.

5.3.6 Dynamic security assessment and proper state estimation

At present the control centers do not have any tool to periodically assess the security condition of the system. They utilize only static state estimation results, which are being performed at 400 kV network at quite slow interval. The state estimator results are not quite reliable, due to non availability of data from a large number of RTUs. There is a need to arm the control centers with more advanced application functions and possibly perform the fast state estimation through synchrophasor measurements by deploying significant number of PMUs

The operators, at present, cannot readily determine whether the line loading will actually trip a relay. However, although they can, by doing an online contingency analysis, determine whether the system is secure or not. If the system is insecure (in an alert condition), the following preventive actions can be taken:

a) Use any controllable elements, like HVDC and TCSC, to re-route power flows. If continuous capability limits have been reached short time overload capabilities may be used to buy some time for other actions. The amount and effect of the rescheduling will have to be checked using online load flow/stability analysis.

b) Generation rescheduling may be attempted. An available hydro-generator may be called on to generate power.

c) Load tripping may be attempted to reduce line loading.

Chapter- 6

REVIEW OF ISLANDING SCHEMES

6.1 To avoid total blackout following a grid disturbance, a number of defense mechanisms and System Protection Schemes mainly comprising of generation backing down, contingency based load shedding, under frequency load shedding, df/dt load shedding etc already exist. The success of these schemes in avoiding grid disturbances to a large extent depends upon the severity, area of disturbance and system conditions prior to the disturbance. Also as a last resort some islanding schemes to save the generating stations are also in existence. During the disturbance which took place on 30th and 31st July 2012 some of the generators which survived in NR due to islanding or on house load were NAPP, BTPS , Dadri Gas, Faridabad Gas. The surviving generating units normally help in meeting essential loads and extending supply to other units within the same generating station and also to the nearby generators thereby helping in restoring the grid in reduced timeframe. The Committee reviewed the existing schemes and explored possibility of formulation of more islanding schemes in the NR.

6.2 A meeting in this regard was held on 7th August 2012 wherein members from various state utilities participated. After deliberations it was agreed that criteria for formation of islands should not be the geographical or electrical size but reliability of load-generation balance in the islands. There was agreement on the general philosophy on formation of islands, salient features of which are given below:

6.3 Guidelines for formation of islands

a) For the success of the islanding scheme, the load and generation of these islands should match and also it is necessary that generators within the island are operated with Governor action.

b) All control areas should endeavor to operationalize under frequency based load shedding scheme as first defense. Only if this defense mechanism fails and frequency continues its fall to dangerously low levels, formation of islands should be initiated as a last resort.

c) The probability of survival of islands will be realistic only when all the generating units are on free governor or on restricted governor mode in accordance with provisions of Indian Electricity Grid Code.

d) Islanding scheme could be a two-tier scheme. At frequency level of say 47.9 Hz, signal for formation of islands comprising of more than one generating stations along with pre-identified load could be initiated. However, if after the formation of island, frequency continues to fall further to say 47.7 Hz, these islands could be further broken into smaller islands comprising of single generating station with pre-identified loads.

e) For survival of the Islands, they should be created in such a manner that the possibility of generation exceeding load is more.

f) In case of hydro generators with limited pondage, islands should be created keeping peak generation in mind. This is because, in low hydro season, generation will practically be negligible during off-peak hours and hence creation of island may not serve any purpose.

g) Load-generation balance in pre-identified islands may change based on season, there would be need to review the scheme on seasonal basis. Such review should also capture network changes taking place in the interim period.

h) As far as possible, major essential loads such as hospitals etc should be incorporated in the islands. However, if this was not possible due to some reasons, efforts would be made to extend supply from these islands to essential loads on priority basis.

i) State load Dispatch Centers/ State Transmission Utilities along with the generating stations in their area should explore the possibility of formation of various islands.

6.4 Possibility of islanding of Delhi metro and Indian Railways

6.4.1 During the grid disturbances which occurred on 30th & 31st July 2012, Railways and Delhi Metro services were also affected. During the disturbance on 30th July 2012, Delhi Metro services were affected in the morning to the extent that services were delayed as the disturbance had occurred at 2:35 hours when metro services were off. This did not trouble the passengers. However, during second disturbance at 13:00 hours, the trains were in operation, and the passengers faced difficulties because of sudden stoppage of services. This problem could have been avoided if the metro network would have islanded with some generating station(s).

6.4.2 In view of the importance of Metro and other Rail network, the Committee held discussions with DMRC and Indian Railways on how islanding schemes could be developed for them.

6.5.3 Delhi Metro Rail Corporation (DMRC) have 200 trains running on 185 Kms metro rail network in Delhi fed from 13 nos. 220 kV substations, out of which one each was fed from UP and Haryana side and rest from DTL's 220 kV network in Delhi. DMRC was using its own 33 kV network for feeding stations and 25 kV network for meeting traction load. The distance between two metro power stations was in the range of 15 to 17 Kms as higher distance resulted in voltage drop and poor traction. The peak load of Delhi Metro was 120 MW with 50 MW station load and 70 MW traction load. Load per train was about 2 MW. DMRC had installed a DG set at each metro station to meet the load of lighting, ventilation and fire-fighting during main supply failures. They needed minimum 50 MW from at least 7 infeeds for traction purpose to keep their skeletal services running only for half an hour during contingencies like islanding of Delhi system from rest of the power grid for pulling the trains to the nearest station. Though they could feed their entire network from a single point, this would result into low voltage at distant locations. It was also noted that at any point of time, 10 trains are running inside the tunnels. If the power supply fails and the train stops inside the tunnel, then battery-backup is used to keep lights & fans running inside the compartments. In the event of power failure, it is not possible to open the doors of the compartments too. Batteries could provide backup supply for about half an hour only. Thereafter, fumes from the batteries start making the environment inside the tunnel suffocating. In view of this, it is essential to move the trains out of the tunnel and bring them to the nearest station within 15 minutes of supply-failure. In case, it is not possible, then passengers needed to be evacuated from the train under the guidance of trained metro staff.

6.5.4 Indian Railways were having a supply point every 30 – 50 Km distance to feed a section. In case of requirement of reduced load by the SLDCs / RLDC due to any contingency, they could manage to keep the trains running with availability of supply at each alternate section. They have allocation of 100 MW from NTPC's Dadri and Auraiya GPPs to meet the load of Delhi – Mughal Sarai section and their own dedicated transmission lines to draw power from the grid for the purpose. They also have supply from 2 locations in Delhi viz. Dhaula Kuan and Narela. Railways felt that this section could be considered for islanding during grid contingencies as this was one of the most important sections of Railways. They do not have allocation of power from any other central sector station to meet the load in any other section of their network in the country. For other sections, they have arrangement of supply from Distribution Companies of the concerned states and had a very good communication system between their control room and concerned SLDCs. During grid disturbances on 30th & 31st July 2012, Railways received full cooperation from SLDCs/RLDCs in restoration of supply to their network on priority, except in the Eastern Region, where supply was restored late reportedly due to non-availability of start-up power to the power stations in that region. Railways requested to get this examined and improve the arrangement of extending start-up supply in that

region. Railways would abide by the advice of the power station / SLDC / RLDC in the matter of connecting load on restoration of supply after grid disturbance. They also requested their services to be given priority at the time of restoration of grid.

6.5.5 It was noted that subsequent to grid failure at 1300 hours on 31st July 2012, two gas turbines (30 MW each) were started by Delhi and charged DMRC-I & II feeders after charging other important feeders. However, within a few minutes of charging of DMRC feeders, large fluctuations in the load were observed and the GTs tripped due to fall of frequency to the level of 47.4 Hz. It was felt that this might have been caused due to sudden connection of large quantum of traction load. If the load was connected by DMRC gradually in close coordination with GT control room, the machines could have continued to operate.

6.5.6 The Committee also examined the possibility of islanding of states including Delhi in the Northern Region under a grid contingency and recommends creation of four islands in Delhi. Delhi Metro's emergency load and a part of Indian Railways load could continue to remain connected with these islands at its minimum four different sub-stations in case of grid contingencies.

6.5.7 In case of failure of formation of islands in Delhi, Delhi Metro while availing supply from any source e.g. IP GTs, Dadri GPS, etc., should connect load in small steps in close coordination with Delhi SLDC and the generating station to avoid the possibility of tripping of the generating station. DMRC should also make necessary changes in the technical and communication arrangements in their system to ensure this. There should be reliable communication arrangement between DMRC and GT station at IP extension in Delhi. DMRC should re-distribute its load so as to make it balanced in all three phases for stable operation of connected power stations. Power could be supplied to Delhi Metro from Rithala GT station of TPDDL (one of the Distribution Companies in Delhi) as well if this station had black-start facility. There being some possibility of malfunctioning of islanding of Delhi in case of grid disturbances and delayed extension of supply thereafter, DMRC might consider installation of DG set(s) of appropriate capacity to move the trains stuck in the tunnels so as to ensure safety of passengers.

6.4.8 As regards Indian Railways, islanding scheme could be prepared for Auraiya GPS along with Railways' and other loads. This could feed about half of Delhi-Mughal Sarai section. Remaining half could be fed from Dadri GPS, which is envisaged to be islanded with a part of Delhi's load. In case of failure of formation of Auraiya island, Railways while availing supply from Auraiya GPS after its black-start, should connect load in small steps in close coordination with the power station to avoid the possibility of its collapse again. Keeping in view the fluctuating nature of traction load, no unit should be started with such load. However, the supply should be extended to

Railways / DMRC by the power station / SLDC on priority after starting the unit(s) with other types of balanced and more or less constant loads.

6.5 As per the resolution adopted in meeting taken by Hon'ble Minister of Power with Chief Ministers and Power Ministers of Northern State on 6th August 2012 the schemes prepared by States would be deliberated by them with CEA, POWERGRID and NRPC. Indian Railway and DMRC may further firm up the islanding schemes in consultation with CEA, POWERGRID and RPCs. Other islanding schemes should also be prepared on similar lines.

Chapter- 7

REVIEW OF RESTORATION OF THERMAL POWER STATIONS

7.1 Background

The black start procedure has already been prepared by RLDCs and is available with all utilities. However, during the recent grid disturbances it has been observed that substantially longer time has been taken by certain generating stations to come on bars. In view of this, discussions were held with the utilities to review the time taken in restoration of generation after the recent grid disturbances. NRLDC, NLDC and UPSLDC also participated. Major observations and recommendations are given below:

7.2 Observations

i. Some of the utilities expressed that to initiate start up process, certain delays were encountered on account of commercial issues in obtaining the start- up power supply from other outside agencies.

ii. Most of hydro stations were ready to provide the start-up power immediately after the grid disturbance. However due to complete collapse of the entire grid, the required quantum of load commensurate with the generation build-up rate were not available despite close coordination and intimation given to the concerned load dispatch centres and personal contact with the counterpart distribution utilities. A pre-defined arrangement for availability of loads under such emergency conditions would have hastened the process of restoring the power supply. This may require to be looked into by the concerned agencies.

iii. NRLDC suggested that the load dispatch centres should be authorized to advise action to the concerned utilities for extending power supply immediately to the black-starting units through exchange of special emergency code between the concerned load dispatch centres. This process would facilitate quicker restoration by cutting down time required in taking administrative clearance which is otherwise obtained under normal grid operation conditions.

iv. Existing Black start procedures should be frequently reviewed in line with the fast changing grid scenario and addition of generation capacity. The facilities available with existing and upcoming IPPs should also form part of these procedures for the purpose of extending start up supply to black starting units in the vicinity.

v. All utilities felt the need to strengthen and have a dedicated communication network between SLDCs and all power plants in the respective control areas, which does not adequately exist at present and the agencies depend mainly on mobile phone facility, which is not completely reliable for such purposes. Availability of reliable and efficient communication facilities at all active installations connected to the grid is essential to ensure faster restoration.

vi. Various load dispatch centres, substations and generating stations, which are to implement the restoration operations in the real-time, upon receiving instructions from the apex load dispatch centres are not adequately managed in terms of experienced manpower and also particularly during odd hours. Utilities therefore expressed that the qualified operating personnel having undergone orientation courses under certification programme should be posted there.

vii. While examining the restoration data received from various utilities, it was observed that certain delays had occurred in lighting up the units, after start up supply was made available. The observed time duration ranged from 2 to 23 hours for Singrauli STPS and 2 hrs to 7 hrs for units at Unchhar, Rihand, Dadri(coal), Tanda and 1 to 16 hours for various units at Anpara, Obra, Paricha and Panki stations. At GGSSTP the time ranged from 2 to 9 hours. The utilities intimated that in case of some units LP diaphragms had burst during the occurrence, for which additional time was taken to rectify/replace the diaphragms.

viii. It was observed that after lighting up of the units, some of the units had taken longer time than others to synchronize with the grid. The observed time duration ranged from 2 hours to 4 hours in case of various generating units at Singrauli, Unchahar, Badarpur & Rihand TPSs and 2 hours to 9 hours for units at Anpara, Obra, Paricha and Panki stations. In case of gas based stations the time duration ranged between 1 to 6 hrs at Auraiya, Dadri and Faridabad for GTs and 3 to 7 hours for STGs.

On 30.7.2012, in DTL system GTs 1,2,5 were restored during 0250 to 0430 hours (generation of order of 80 MW) and later GT3 was synchronised at 0640 hours (30 MW) with STGs 1,2,3 resuming generation between 0810 to 0840 hours (order 60 MW). On 31.7.2012, in DTL system GTs 1,2,3,5,6 were restored during 1310-1445 hours (

order 141 MW) and STGs 1,2,3 resuming generation between 1615 to 1646 hours (order 51 MW)

Badarpur TPS had earlier survived and had operated in Island mode with units nos. 1,3 and 5 till 0658 hours on 30.7.2012 when the island collapsed and power was later extended to the station at 0710 hours from 220 kV DTL system at Sarita Vihar and unit no.3 was first synchronized at 1025 hours.

Faridabad GPS which had tripped at 0233 hours on 30.7.2012 was synchronized with grid at 0552 hours. It however tripped at 0658 hours with the collapse of Badarpur island. Faridabad GPS was later synchronized at 0844 hours with grid.

ix. While extending the power to Singrauli TPS, through HVDC Vindhyachal by pass route there had been tripping at Vidhyachal resulting delay in making start up power available to the station. The possibility of extending power to Singrauli from Pipri Hydro on 30th July in closer coordination between NRLDC, SLDC, UPJVUNL, UPRVUNL and NTPC would have resulted time-saving in affecting quicker start-up power to NTPC generating units. UPRVUNL suggested that Pipri-Hydel should be synchronized with Western grid through Vindhyachal-Shaktinagar-Anpara 400 kV line and 132 kV Anpara-Pipri line. This would ensure stability of voltage of Pipri machines and more machines of Pipri-Hydel could be started up.

x. In case of major hydro station, BBMB intimated that on 30th July 2012 the system was fully connected to grid by 0902 hours and on 31st July 2012 at 1553 hours. GGSSTP Ropar received start up power from Bhakra source at 0841 hours on 30th July 2012 and unit #2 boiler lighted up first at 1020 hours. The unit was synchronized at 1218 hours via Bhakra (220KV)-Ganguwal (220/132KV)-132KV Ropar-GGSSTP route and on 31st July 2012 unit # 2 boiler lighted up at 1640 hrs and synchronised at 1740 hours via Nalagarh(PG)-220KV Mohali-GGSSTP route.

xi. In ER, Kahalgaon and Farakka STPS received start up power from WR through Sipat-Ranchi and could not receive power earlier from hydro due to tripping of Teesta HPS on 3rd harmonic, over-voltages and under frequency and mismatch in generation with remote loads over long EHV lines. Despite multi-attempts of black starts at Tala, Chukha and Teesta,

the startup power could not be extended to Farakka / Kahalgaon from the hydro sources.

xii. It was also brought out that start-up power could be extended to number of stations simultaneously so that stations could use them for preparatory activities like CW pumps, compressors etc. and actual start-up could be attempted after specific clearance from the source providing start-up power. This could considerably expedite the start-up as preparatory activities not needing much power could be taken up by number of stations simultaneously thus considerably reducing the start-up times.

7.3 Analysis of Restoration Process of Thermal Power Stations

Detailed analysis of start-up process for the grid disturbance of 30th July 2012 has been made so as to examine the restoration process and areas of possible improvements. The salient observations are given in subsequent paras:-

7.3.1 Availability of start-up power

Salient abstracts of the receipt of start-up power in the region are as under:-

Table 7.1: Availability of start-up power in Northern Region 30th July 2012

Time Elapsed Before Start-up power Became Available after Disturbance (Hrs)	Stations (Nos)	Cumulative number of Stations
< 1	2	2
1 to 1.5	4	6
1.5 to 2.0	5	11
2.0 to 2.5	2	13
2.5 to 3.0	0	13
3.0 to 3.5	3	16
3.5 to 4.0	2	18
4.0 to 4.5	4	22
4.5 to 5.0	3	25
5.0 to 6.0	1	26

It may therefore be seen that more than 50 % of the affected stations in the region received start-up power after 3hrs. Only 2 stations in the region could receive start-up power within 1 hour. Also 8 stations received start up power after 4 hours. Maximum time taken for any station to receive start-up power was 6 hours for Ropar TPS.

The reasons for delay in receiving start-up power by most of the thermal power stations may require to be looked into from grid system point of view. A normative or bench mark time frame for extending start-up power to each of the TPS may be evolved by the RPCs in consultation with the constituents and RLDC so as to ensure that significant delays are not encountered in extending start-up power. A fact that emerged during discussions was that since the present grid failure occurred after almost a decade, the preparedness and response was perhaps not upto the level expected. More frequent need of having periodic mock exercises to ensure preparedness of all stakeholders involved as actual grid disturbances needs emphasis.

7.3.2 Restoration of Thermal Power Stations

Coal fired thermal power stations involve considerable amount of preparatory actions before actual start-up like operationalizing major auxiliary systems like circulating water (CW) system, compressed air system. Also start-up power is required to be provided to each unit and station auxiliary which involves charging up of number of transformers within the station sequentially and in turn is time consuming. In the above context, suggestions made at Para B above that start-up power should be extended as soon as possible so that stations could initiate preparatory activities and actual start-up process could be attempted immediately upon receiving start-up power.

It was also brought out by the stations that sudden tripping of the unit at high load lead to bursting of LP Turbine diaphragms in many of the units requiring replacement before start-up could be taken up and involved about 4 hrs for replacement of diaphragms for each unit.

7.3.3 Start-Up And Restoration Times

With a view to analyze the restoration process of thermal stations, data regarding time of availability of start-up power, time of taking up Boiler light up (BLU), time till synchronization and time of achieving full load were sought from the stations. The status of receipt of data from the stations is furnished below in Table-7.2.

Table 7.2: Receipt of restoration data from stations

Station	Utility	Status of Receipt of Data	Remarks
BADARPUR TPS	NTPC Ltd.	√	
RAJGHAT TPS	IPGPCL	√	
I.P.CCPP	IPGPCL	√	Station Islanded
PRAGATI CCPP	IPGPCL	√	
PRAGATI CCGT-III	IPGPCL	**x**	
RITHALA CCPP	NDPL	√	Station not running
PANIPAT TPS	HPGCL	**X**	
YAMUNA NAGAR TPS	HPGCL	**X**	
RAJIV GANDHI TPS	HPGCL	**X**	
INDIRA GANDHI STPP	APCPL	**X**	
MAHATMA GANDHI TPS	JhPL(HR)	**X**	
FARIDABAD CCPP	NTPC Ltd.	√	
GND TPS(BHATINDA)	PSPCL	**X**	
GH TPS (LEH.MOH.)	PSPCL	**X**	
ROPAR TPS	PSPCL	√	
KOTA TPS	RRVUNL	√	
SURATGARH TPS	RRVUNL	√	
CHHABRA TPP	RRVUNL	√	
RAMGARH CCPP	RRVUNL	√	
DHOLPUR CCPP	RRVUNL	√	
ANTA CCPP	NTPC Ltd.	√	
OBRA TPS	UPRVUNL	√	
PANKI TPS	UPRVUNL	√	
HARDUAGANJ TPS	UPRVUNL	√	
PARICHHA TPS	UPRVUNL	√	
ANPARA TPS	UPRVUNL	√	
SINGRAULI STPS	NTPC Ltd.	√	
RIHAND STPS	NTPC Ltd.	√	
UNCHAHAR TPS	NTPC Ltd.	√	
DADRI (NCTPP)	NTPC Ltd.	√	
TANDA TPS	NTPC Ltd.	√	
AURAIYA CCPP	NTPC Ltd.	√	
DADRI CCPP	NTPC Ltd.	√	

As may be seen, while data has been received from most of the stations, the data from several other stations was not received and thus their

restoration pattern could not be analyzed. The analysis for stations for which data for boiler light up was received have been made in respect of time of synchronization after BLU.

7.3.4 Initiation of Boiler Light Up

As brought out above, initiation of start-up of a coal fired station takes considerable time after receipt of start-up power due to preparatory activities involved. As the time for BLU have not been received from number of stations, the actual time taken for preparatory activities as also maintenance like replacement of diaphragms etc. could not be ascertained.

Details of BLU undertaken are furnished in Table-7.3. From the data on BLU available it is seen that there are considerable variations between the time taken for BLU of the first unit after receipt of start-up power.

Table 7.3: Time elapsed (Hrs) before BLU was undertaken after receipt of Start up power

Station	1st	2nd	3rd	4th	5th	6th	7th
Anapara	03:12	04:52	05:01	06:08	16:20		
Obra	01:00	01:58	05:55	07:23	15:25		
Paricha	03:45	07:30					
Panki	01:00	06:38					
Kota	N.A	N.A	N.A	SD	N.A	N.A	N.A
Suratgarh	N.A	N.A	SD	N.A	N.A	N.A	N.A
Chabra	SD	N.A					
Giral	N.A	SD					
RajWest	NA	SD	NA	NA			
Barsingsar	NA	SD					
Ropar	01:39	01:54	03:09	04:59	09:29	25.00	
Rajghat	SD	01:12					
Singrauli	01:36	04:06	07:53	09:56	10:56	15:34	22:51
Rihand	N.A	N.A	N.A	N.A			
Unchahar	02:35	04:52	05:08	06:00	06:29		
Tanda	N.A	N.A	N.A	N.A			
Dadri Coal	N.A	N.A	N.A	N.A	N.A	N.A	
Badarpur	N.A	N.A	N.A	N.A			

Note: Timelines indicate total elapsed time before successive units were taken for start up and DO NOT refer to unit numbers

From the table it may be seen that few Stations like Obra and Panki undertook first BLU after 1 hour of receipt of start-up power. Ropar and Singrauli attempted first BLU after 01:40 hrs after receiving start-up power. Several Stations could undertake first BLU only after 2.5 to 3 hrs of receiving start-up power.

Also large variations are seen in undertaking further unit start-ups after taking BLU of first unit. The data of time elapsed before undertaking subsequent BLUs have also been analysed and presented in the Table-7.4. From the table it may be seen that while for some of the units the BLU was taken up within very short interval of 10-20 minutes of BLU of previous unit, in most of the cases the BLU for subsequent unit was taken up 2 to 3 hours after the BLU of preceding unit and in many cases exceptionally large time of 8 to 10 hours have been taken. The utilities were asked for the reasons for delay in start up of the units; however no reasons for delay have been furnished. Further discussions need to be undertaken in this regard.

Table 7.4: Time interval between successive BLUs

Station	1st	2nd	3rd	4th	5th	6th	7th
Anapara	03:12	01:40	00:09	01:07	10:12		
Obra	01:00	00:58	03:57	01:28	08:02		
Paricha	03:45	03:45					
Panki	01:00	05:38					
Kota	N.A	N.A	N.A	SD	N.A	N.A	N.A
Suratgarh	N.A	N.A	SD	N.A	N.A	N.A	N.A
Chabra	SD	N.A					
Giral	N.A	SD					
RajWest	NA	SD	NA	NA			
Barsingsar	NA	SD					
Ropar	01:39	00:15	01:15	01:50	04:30	14.31	
Rajghat	SD	01:12					
Singrauli	01:36	02:30	03:47	02:03	01:00	04:38	07:17
Rihand	N.A	N.A	N.A	N.A			
Unchahar	02:35	02:17	00:16	00:52	00:29		
Tanda	N.A	N.A	N.A	N.A			
Dadri Coal	N.A	N.A	N.A	N.A	N.A	N.A	
Badarpur	N.A	N.A	N.A	N.A			

Note-Time for 1st unit indicates time taken after start-up power. Timelines for other units indicate time taken after BLU of previous unit.

7.3.5 Unit Synchronization after Boiler Light Up

The details of time taken for synchronization after BLU are furnished in Table- 7.5. Even from the limited number of Stations where data of both BLU time and synchronization time is available, it is seen that the time taken for synchronization after BLU varies considerably.

Table 7.5: Time taken for synchronization after BLU

Station	1st	2nd	3rd	4th	5th	6th	7th
Anapara	02:41	04:36	06:29	08:07	09:10		
Obra	01:43	03:55	04:07	04:52	05:30		
Paricha	04:04	05:23					
Panki	03:14	05:28					
Kota	N.A	N.A	N.A	SD	N.A	N.A	N.A
Suratgarh	N.A	N.A	SD	N.A	N.A	N.A	N.A
Chabra	SD	N.A					
Giral	N.A	SD					
RajWest	NA	SD	NA	NA			
Barsingsar	NA	SD					
Ropar	01:25	01:55	01:58	02:55	04:15	05:50	
Rajghat	SD	01:00					
Singrauli	01:21	01:42	02:08	02:10	02:28	03:21	03:51
Rihand	N.A	N.A	N.A	N.A			
Unchahar	01:46	01:57	02:04	03:03	03:51		
Tanda	N.A	N.A	N.A	N.A			
Dadri Coal	N.A	N.A	N.A	N.A	N.A	N.A	
Badarpur	N.A	N.A	N.A	N.A			

As may be seen that the time for synchronization after BLU varies from a low of 1.2 hrs to as high as 3 to 4 hrs and even exceptionally high at 8 to 10 hrs for some of the units. Many of the NTPC units took 3 to 4 hrs for synchronization after BLU.

It may be mentioned that time taken from BLU to synchronization is expected to be fairly comparable for the units of similar design with similar start up regimes and thus such large differences in timelines are not understood. Details of problems/constraints encountered during start-up process and delays occurred may require to be looked into further in respect of constraints bottlenecks faced in this context.

7.3.6 Time from start-up power to Unit Synchronization

Since timeline for undertaking BLU were not made available by most Stations, an analysis of total time taken upto synchronization from receipt of start-up power has been made to understand the trend that emerged. These timelines however would be indicative of combined impact of constraints/delays occurred in preparatory activities (before BLU) and during the start-up process. The details of time taken for synchronization after start-up power are furnished in Table-7.6

Table 7.6: Total Time S.U Power to Synchronization

Station	1st	2nd	3rd	4th	5th	6th	7th
Anapara	05:53	10:44	11:30	12:59	25.30		
Obra	03:41	06:30	09:50	11:30	20:17		
Paricha	07:49	12:53					
Panki	04:14	12:06					
Kota	**02:55**	03:43	03:48	05:34	07:08	11:28	SD
Suratgarh	06:26	09:44	11:05	12:39	39	SD	
Chabra	SD	05:24					
Giral	22:20	SD					
RajWest	11:43	13:08	23:07	SD			
Barsingsar	48.32	SD					
Ropar	**03:19**	03:37	08:59	09:14	11:24	27.55	
Rajghat	SD	02:12					
Singrauli	03:44	07:27	09:14	12:06	12:38	19:25	25.19
Rihand	04:40	06:38	11:54	SD			
Unchahar	04:32	06:56	07:46	08:11	10:20		
Tanda	**02:10**	02:45	04:09				
Dadri Coal	04:02	06:00	07:24	08:13	08:30		
Badarpur	03:15	03:47	04:19	08:00	10.50		

Note: Timelines indicate order of synchronization of units and not unit numbers

The variability seen here is similar to the variability seen in timelines from start-up power to BLU and BLU to synchronization – rather the variability seen here is much more prominent. Amongst the 210 MW units, Kota was the first station to achieve synchronization within 2.55 hrs from start-up power followed by Ropar achieving synchronization of one unit in 3.19 hrs. Singrauli achieved synchronization of first unit in 3.44 hrs. Rest of the Stations achieved first synchronization beyond 4 hrs and some Stations like Paricha and Anapara could achieve their first synchronization in 6 to 8 hrs. Badarpur could achieve synchronization of its 210 MW unit in 8 hrs.

Amongst the smaller size units, Tanda and Rajghat TPS achieved their first synchronization in 2.10 hrs after start-up power whereas other Stations like Badarpur and Panki took 3 to 4 hrs to achieve first synchronization. Obra achieved synchronization of 50 MW unit in 6.30 hrs though it was the second synchronization for the Station. The lignite fired Circulating Fluidized Bed Combustion (CFBC) units had taken exceedingly long time to achieve their first synchronization.

Further, analysis of time taken for subsequent synchronizations have also been analysed and presented in the Table-7.7. Here again similar large variability is seen. Ropar and Kota TPS achieved most rapid successive synchronizations with second and fourth synchronization at Ropar in 18 and 15 minutes and second and third synchronization at Kota in 48 minutes and 05 minutes, however the subsequent synchronizations took longer. Amongst the smaller size units, Tanda TPS achieved rapid second synchronization in 35 minutes.

Table 7.7: Time taken for successive Synchronizations

Station	1st	2nd	3rd	4th	5th	6th	7th
Anapara	05:53	04:51	00:46	01:29	12:31		
Obra	03:41	02:49	03:20	01:40	08:47		
Paricha	07:49	05:04					
Panki	04:14	07:52					
Kota	02:55	00:48	00:05	01:46	01:34	04:20	SD
Suratgarh	06.26	3.18	01.21	01.34	04.20	SD	
Chabra	SD	05:24					
Giral	22:20	SD					
RajWest	11:43	01:25	09:59	SD			
Barsingsar	48.32	SD					
Ropar	03:19	00:18	05:22	00:15	02:10	16.31	
Rajghat	SD	02:12					
Singrauli	03:44	03:43	01:47	02:52	00:32	06:47	05:54
Rihand	04:40	01:58	05:16	SD			
Unchahar	04:32	02:24	00:50	00:25	02:09		
Tanda	02:10	00:35	01:24				
Dadri Coal	04:02	01:58	01:24	00:49	00:17		
Badarpur	03:15	00:32	00:32	03:41	02.50		

Note-Time for 1st unit indicates time taken after start-up power. Timelines for other units indicate time taken after synchronization of previous unit

The large variations in synchronization times and successive synchronization times with many of the stations achieving timelines far

better to others is indicative of the potential improvements possible in most of the stations with better/faster preparation.

7.3.7 Gas Based Stations

Gas fired stations are looked upon as rapid source of power after such grid disturbances as preparatory activities required are far less and start ups of Gas turbines (GTs) are fast. Details of time taken for synchronization of GT Stations a re given in Table-7.8.

Table 7.8: Gas fired stations - Time taken from start-up power to Synchronization

Station	Unit#1	Unit#2	Unit#3	Unit#4	Unit#5	Unit#6
Dholpur	03:29	SD	SD			
Ramgarh	09:08	08:28	SD			
Pragati CCPP	01:41	01:34	03:47			
IP CCGT	Islanded	Islanded	Islanded	Islanded	Islanded	Islanded
Anta	02:37	00:46	01:36	05:00		
Auraiya	02:14	00:53	03:32			
Dadri Gas	03:03	03:41	06:15	03:51	SD	08:00
Faridabad	02:52	04:10	06:38			

Note: Cells coloured yellow indicate Steam Turbine unit

It may thus be seen that even the Gas turbine units have taken unduly long time for start-up. While the first Gas turbine units could come up at Anta and Auraiya in about 50 minutes, the Gas turbine units at most other stations and even the subsequent Gas turbine units at these stations took far longer time of 2 to 4 hours. Such large start-up times for Gas turbine units need to be looked into with a view to make Gas turbine units a dependable source of rapid restoration power.

7.4 Conclusions and Suggestions

Based on the discussions brought out in the foregoing paragraphs, the suggestions for faster restoration of thermal power stations are as under:-

1. A well coordinated and documented process for supply of start-up power may be put in place under the overall coordination of NLDC clearly bringing out the following:

    a. Existing Black start procedures should be frequently reviewed in line with the fast changing grid scenario and addition of generation capacity. The facilities available with existing and upcoming IPPs

should also form part of these procedures for the purpose of extending start up supply to black starting units in the vicinity.

b. Explicit instructions to all stake holders to supply start-up power without any commercial considerations that could be settled later.

c. Micro level load management for lines and loads may be envisaged for extending start-up power through pre-defined arrangement for availability of loads under emergency conditions so as to avoid frequent tripping while extending start-up supply.

d. Authorizing Load dispatch centres to advise action to the concerned utilities for extending power supply immediately to the black-starting units through exchange of special emergency code between the concerned load dispatch centres.

e. A normative or bench mark time frame for extending start-up power to each of the TPS. This may be evolved by the RPC in consultation with the constituents and RLDC so as to ensure that significant delays are not faced in extending start-up power.

2. There is a need to strengthen communication and have a dedicated communication network between SLDCs and all power plants in the respective control areas. The mobile phone facility presently used, is not considered reliable for such communication. Reliable and efficient communication facilities at all active installations connected to the grid is essential to ensure faster restoration.

3. Key installations/sub-stations should be managed by experienced manpower particularly during odd hours – like Qualified operating personnel having undergone orientation courses under certification programme.

4. A system to extend start-up power to number of stations simultaneously for preparatory activities could be considered. The actual start-up could be attempted after specific clearance from the source providing start-up power. This could expedite start-ups as preparatory activities not needing much power could be taken up by number of stations simultaneously.

5. Large variations are observed in time taken for initiation of unit start up (Boiler light up) by the stations after availability of start-up power and also for start ups/light up of subsequent units. Also, while subsequent start-ups were very fast (10-20 minutes) in some of the units, in other cases they took considerably longer – several hours.

   Reasons for the delays in attempting first start-up and subsequent start-ups may be examined by the utilities in consultation with CEA. A standard procedure for preparatory activities and sequence of start up may be put in place by the stations to restore units as early as possible.

6. Large variations have also been observed in time taken by the stations for synchronization after Boiler light up which are normally not expected. Detailed analysis of times taken especially from BLU to synchronization may be made by the utilities in consultation with CEA so as to identify constraints/bottlenecks faced during unit start-up for remedial action.

7. The large variations in synchronization times and successive synchronization times achieved with many of the stations achieving timelines far better to others is indicative of the potential improvements possible in most of the stations with better/faster preparation. Further, in most cases the start-up times appear to be considerably higher than the manufacturers/OEM recommendations. Optimal start-up/ restoration procedures by the stations in consultation with OEMs.

8. Long start-up times taken by most Gas turbine units need to be investigated to develop Gas turbine units as reliable source of fast restoration power.

Chapter- 8

CYBER SECURITY ASPECTS

8.1 With regard to cyber security, the Committee examined the apprehension that grid disturbances on 30th and 31st July 2012 could have been initiated by cyber attack. In addition the Committee also examined following aspects-

a) Status of IT intervention in the operation of Power Sector
b) Measures taken by various stakeholders to counter any possible cyber attack in their system
c) Communication facilities available between various stake holders

8.2 Field Visit

8.2.1 To assess the situation, visit to NRLDC, 400 kV sub-station of POWERGRID at Agra and Rihand Super Thermal Power Station was undertaken to examine the present automation & communication arrangements at the Power Sub stations & Thermal Power Plants.

8.2.2 During the visit to the 400 kV Grid Sub-station at Agra, it was observed that the switching for operation is independent of computer networking. The commands are issued locally to carry out switching operations at the sub stations and there is no automated system of event recording on a continuous basis. Similarly, in the case of generating plants, as observed during the visit, each unit has its own control and is no way connected with the outside network and the performance logging of the station data is recorded & archived for each generating unit separately.

8.2.3 During the visit to NRLDC and 400 KV sub station, it has been observed that there are no dedicated telecom facilities available between various control centres, and generating stations. If NRDLC observes any abnormality in the operation in the grid, they inform the same to the concerned SLDC/ Station either through public telephone or on leased line network. Since public telephone network may not be reliable in many cases specially in remote/ rural areas and more so in case of grid disturbance and total power failure like the present one, there is an urgent need to provide dedicated network for this purpose. It has also been observed that there may be errors/ loss of data received from remote (RTUs) at the data center and there may be failure of data coming from a station in case of power breakdown because of UPS not working properly or batteries being weak.

8.3 Discussion & findings

8.3.1 The matter was discussed with the representatives of POWERGRID, NTPC, NHPC and POSCO. The issue of cyber security was examined in detail to ensure that adequate mechanism is available with all the stakeholders to prevent any attack on the systems.

8.3.2 It was pointed out during the discussion that the Cyber attacks can be perpetrated from any side either by outsiders or by insiders and may have far–reaching and detrimental effects on power systems controls, that could lead to the destabilization of the supply capabilities of energy sector and may have a cascading effect on the national security /economy. Cyber security vulnerabilities in generation sector are localized and its impact can shut down one unit or plant. The affect of vulnerabilities in centralized systems e.g. SCADA etc used in transmission sector is wide and may have potential impact on the synchronous operation of entire Power System leading to Grid collapse. As far as distribution sector is concerned, where bulk of automation are visible, the impact of cyber attack on centralized SCADA /DMS can lead to disruption of services to critical customers like hospitals, metro etc. which is critical for the units involved but at the same time not global and widespread.

8.3.3 It was informed to all the stakeholders that CERT-In (Indian Computer Emergency Response Teams), Department of Information Technology, Ministry of Communication and Information Technology, Government of India has prepared a Crisis Management Plan (CMP) for countering cyber attacks and cyber terrorism for preventing the large scale disruption in the functioning of critical information systems of Government, Public and Private sector resources and services. Ministry of Power has also constituted CERT-Thermal, CERT-Hydro and CERT-Transmission with nodal agencies as NTPC, NHPC and POWERGRID respectively, to take necessary action to prevent cyber attacks on the Utilities under their jurisdiction.

8.3.4 The Committee in course of meeting with stakeholders, reviewed existence of appropriate security policies and procedures as envisaged in the Crisis Management Plan prepared and circulated by CERT- India. In course of discussion, it emerged that no abnormal cyber event was observed by the stakeholders prior to and during grid disturbances on both occasions. The matter was also discussed with the officers of CERT-In to asses the present arrangement and preparedness of the stack holders to avoid any cyber attack on their system.

8.3.5 After going through the records, discussion & field visits, it is observed that the operation of grid is primarily manual and operations are done locally except in case of few 400 kV S/Ss which are controlled from remote locations through dedicated networks. At present there is no wide area network at grid control level and there is no communication with power utilities using public domain. **The Committee is of the opinion that that Grid Disturbance could NOT have been caused by a cyber attack**.

8.4 Suggestions

8.4.1 During the discussions and according to the feed back provided by the stakeholders it emerged that Power Sector stack holders have taken adequate steps to prevent the cyber attack on their system and also have dedicated organisational polices in this regard.

8.4.2 The existing communication network should be maintained properly. RTUs and communication equipments should have uninterrupted power supply with proper battery back up so that in case of total power failure, supervisory commands & control channels do not fail.

8.4.3 Regular cyber vulnerability test/mock drills/cyber audit/and other measures as per the crisis management plan of CERT- In should be carried out regularly by all the stakeholders.

8.4.4 A cyber audit specifically to detect malware targeting Industrial Control Systems (ICS) should be conducted at critical plants and sub-stations after any abnormal event.

8.4.5 A dedicated team of IT Personnel for cyber security in all the Power Stations and Sub-stations should be developed and proper training for the team members should also be conducted regularly by the respective organizations to upgrade their skills.

8.4.6 Mitigation strategies for countering physical attacks have to be drawn by all the power utilities.

8.4.7 Regulatory framework should be created for cyber security in the power sector.

8.4.8 An Office/ Body of Cyber Security Auditors should be created within Power Sector.

8.4.9 Vendors for cyber security systems should be developed as per International / National standards.

8.4.10 For smooth operation of grid systems, it is absolutely important that all the power generating and distributing stations are connected on a very reliable telecom network.

i) A proper network may be built up preferably using MPLS (Multi Protocol Label Switching) which is simple, cost effective and reliable. In remote place where connectivity is a problem, the stations can use dedicated fibre cable from the nearest node

ii) Since POWERGRID has its own fibre optic cables, practically covering all major nodes and power stations, a proper communication/IT network may be built using dedicated fibres to avoid any cyber attack on the power system.

Chapter- 9

RECOMMENDATIONS

9.1 Review of Protection Systems

9.1.1 There is a need to review protection schemes. This Committee concurs with recommendation of previous enquiry committees that a thorough third party protection audit need to be carried out in time bound manner. This exercise should be repeated periodically and monitored by RPCs.

Action: RPCs, CTU, STUs
Time Frame: 1 year

9.1.2 Till protection audit is taken up, there is need to take immediate review of zone-3 philosophy in particular. Techniques are available to modify characteristics of the relay so that it can distinguish between load encroachment and faults. These techniques and other alternatives should be explored immediately.

Action: RPCs, CTU, STUs
Time Frame: Immediate

9.1.3 The application of synchrophasor measurements from PMUs should be explored for protection systems. There is also an urgent need to deploy Special Protection System (SPS) in critical transmission elements. Also there is need to make already approved SPS operational.

Action: RPCs, CTU
Time Frame: 1 year

9.1.4 A complete independent audit of time synchronization of DRs, ELs and PMUs should be carried out.

Action: Generators, CTU, STUs
Time Frame: 1 month

9.2 Frequency Control through Generation reserves/Ancillary services

9.2.1 Frequency band needs to be further tightened and brought close to 50 Hz. POSOCO may file an urgency application in Supreme Court for early resolution of the issue in view of the recent grid disturbances.

Action: POSOCO
Time Frame: 1 month

9.2.2 A review of UI mechanism should be carried out in view of its impact on recent grid disturbances. Frequency control through UI may be phased out in a time bound manner and Generation reserves/Ancillary services may be used for frequency control. Appropriate regulatory mechanism needs to be put in place for this purpose. POSOCO should take up the matter with CERC.

Action: POSOCO
Time Frame: 3 months

9.3 Ensuring proper functioning of defense mechanism

All STUs should immediately enable under frequency and df/dt based load shedding schemes. Central Commission should explore ways and means for implementation of various regulations issued under the Electricity Act, 2003. Any violation of these regulations can prove to be costly as has been the case this time. RPCs need to take up the matter for compliance. In case non-compliance persists, POSOCO should approach Central Commission.

Action: STUs, RPCs, POSOCO
Time Frame: Immediate

9.4 Ensuring primary frequency response from generators

All out efforts should be made to implement provisions of IEGC with regard to governor action. Central Commission needs to look into ways and means to hasten implementation of provisions of IEGC including that on governor action. POSOCO need to take up the matter with Central Commission.

Action: POSOCO
Time Frame: 3 months

9.5 Revising Total Transfer Capability (TTC) based on change in system conditions

9.5.1 POSOCO should take up with Central Commission the issue of inconsistency between Congestion regulation and the detailed procedure framed there under so that congestion due to forced outages and Unscheduled Interchange (UI) can be handled effectively.

Action: POSOCO
Time Frame: 1 month

9.5.2 NLDC and each RLDC should have one real-time security desk in all the shifts to be manned by engineer capable of carrying out TTC calculations. To facilitate this, manpower at NLDC and RLDCs need to be enhanced with regulatory support to take care of financial aspects. Till this arrangement can be firmed up, various scenarios of outages could be built, which then can be used by despatcher in real time. Faster algorithm for calculation of TTC may be adopted by the load despatchers to update it in real time under outage conditions.

Action: POSOCO
Time Frame: 6 months

9.6 Coordinated outage planning of transmission elements

Outage planning of inter-State and inter-regional transmission elements should be carried out in a coordinated manner at RPC fora (say Operation Co-ordination sub-committee of RPCs) in accordance with regulation 5 of Central Electricity Authority (Grid Standards) Regulation, 2010 and Section 5.7.1 of Indian Electricity Grid Code. In case need for emergency maintenance arises in between two meeting of Operation Co-ordination sub-committee, NLDC and RLDCs should allow such maintenance after carefully looking at prevailing system conditions under intimation to RPC Secretariat.

Action: RPCs
Time Frame: Immediate

9.7 Reactive power planning

In order to avoid frequent outages/opening of lines under over voltages and also providing voltage support under steady state and dynamic conditions, installation of adequate static and dynamic reactive power compensators should be planned.

Action: CEA, CTU, STUs
Time Frame: 6 months

9.8 Review of penal provisions of the Electricity Act, 2003

The powers of Load Despatch Centres and Regulatory Commissions related to non-compliance of statutory/regulatory provisions including that for non-compliance of directions and non-payment of UI charges, need review. Appropriate amendments need to be carried out in the Electricity Act, 2003 after such review.

Action: Ministry of Power, Govt. of India
Time Frame: 6 months

9.9 Optimum utilization of available assets

9.9.1 The regulatory provisions regarding absorption of reactive power by generating units needs to be implemented.

Action: POSOCO
Time Frame: Immediate

9.9.2 An audit of devices such as HVDC, TCSC, SVC and PSS should be done immediately to ensure that their stability features are enabled. Further, exercise of PSS tuning should be planned and implemented. Settings of these dynamic stabilizing devices should be reviewed at appropriate intervals.

Action: CTU, STUs, Generators
Time Frame: 6 months

9.9.3 Functioning of existing PMUs and availability of their output to RLDCs and accuracy of time synchronization should be monitored on daily basis and, if required, corrective actions should be taken on priority basis.

Action: CTU, POSOCO
Time Frame: Immediate

9.10 Deployments of WAMS

9.10.1 The synchrophasor based WAMS employing PMUs offer a wide applications for real time monitoring and control of the system, specially under the dynamic conditions. Adequate number of PMUs should be installed to improve the visibility and real time monitoring of the system. Further the applications related to the synchrophasor based wide area monitoring, protection and control should be embedded in the system.

Action: CTU
Time Frame: 1 year

9.10.2 Possibility of voltage collapse prediction, sensing global power system conditions derived from local measurements may be explored.

Action: RPCs
Time Frame: 1 year

9.11 Need of Dynamic Security Assessment and review of State Estimation

In order to assess the system security in real time and assess the vulnerability condition of the system, dynamic security assessment need to be periodically carried out at the control centers. A proper review and upgradation of the state estimation procedure is required to improve the visibility and situational awareness of the system.

Action: POSOCO
Time Frame: 6 months

9.12 Implementation of islanding schemes

Efforts should be made to design islanding scheme based on frequency sensing relays so that in case of imminent grid failure, electrical islands can be formed. These electrical islands can not only help in maintaining supply to essential services but would also help in faster restoration of grid.

Action: CEA, RPCs, POWERGRID, STUs, SLDCs and Generators
Time Frame: 6 months

9.13 Autonomy to Load Despatch Centres

9.13.1 As National Grid is on the horizon, homogenization of system operation philosophy is need of the hour. The present organizational set up of Load Despatch Centres need to be reviewed. System operation needs to be entrusted to Independent System Operator (ISO). In addition, SLDCs should be reinforced and ring fenced for ensuring functional autonomy.

Action: Govt. of India, State Govts.
Time Frame: 1 year

9.13.2 Training and certification of system operators need to be given focused attention. Sufficient financial incentives need to be given to certified system operators so that system operation gets recognized as specialized activity.

Action: Govt. of India, State Govts.
Time Frame: 3 months

9.14 Development of Intra-State transmission system

Intra-State transmission system needs to be planned and strengthened in a better way to avoid problems of frequent congestion.

Action: STUs
Time Frame: 2 years

9.15 Network visualization

9.15.1 Appropriate amendments should be carried out in Grid Connectivity Standards to restrain connectivity of a generating station or a transmission element without required communication and telemetry facilities.

Action: CEA,
Time Frame: 6 months

9.15.2 The Communication network should be strengthened by putting fibre optic communication system. Further, the Communication network should be maintained properly to ensure reliability of data at Load Despatch Cenres.

Action: CTU and STUs
Time Frame: One years

9.15.3 RTUs and communication equipments should have uninterrupted power supply with proper battery backup so that in case of total power failure, supervisory control and data acquisition channels do not fail.

Action: CTU and STUs
Time Frame: 3 months

9.15.4 In case of existing generating stations or transmission elements without telemetry facility, the same should be put in place at the earliest. If prolonged operation without telemetry continues, POSOCO should approach Central Commission.

Action: RPCs, POSOCO
Time Frame: 6 months

9.16 Reduction in Start-up time for Generators:

Large variations are observed in time taken for initiation of unit start up (Boiler light up) by the stations after availability of start-up power and also for start ups/light up of subsequent units. While subsequent start-ups were very fast (10-20 minutes) in some of the units, in other cases they took considerably longer time – several hours. Reasons for the delays in attempting first start-up and subsequent start-ups may be examined by the utilities in consultation with CEA. A standard procedure for preparatory activities and sequence of start up may be put in place by the stations to restore units as early as possible particularly in contingencies.

Action: CEA, Generating Utilities and RLDCs
Time Frame:one year

9.17 Review of Transmission Planning Criteria

At inter-State level, the entire landscape has changed over past few years. With de-licensing of generation and provision of open access in Electricity Act, 2003 and development of organized electricity markets, lot of generation is coming in the form of merchant generation. Four out of the five regions have been integrated and formation of National Grid is on the horizon. Under such scenario, there is need review the Transmission Planning criteria.

Action: CEA
Time Frame: 3 months

9.18 Strengthening of system study groups in various power sector organizations:

There is need to reinforce system study groups in power sector organisations to analyse the system behaviour under different network status/ tripping of lines/outage of generators. Where these do not exist, these should be created.

Action: CEA, CTU and STU
Time Span: one year

9.19 Formation of a task force to study the grid security issues:

It was felt that a separate task force may be formed, involving experts from academics, power utilities and system operators, to carry out a detailed analysis of the present grid conditions and anticipated scenarios which might lead to any such disturbances in future. The committee may identify medium and long term corrective measures as well as technological solutions to improve the health of the grid.

Action: MOP, CEA
Time Frame: 1 month

9.20 Improved telecom infrastructure for cyber security

For smooth operation of grid systems, it is absolutely important that all the power generating and distributing stations are connected on a very reliable telecom network.

(i) A proper network may be built up preferably using MPLS(Multi Protocol Label Switching) which is simple, cost effective and reliable. In remote place where connectivity is a problem, the stations can use dedicated fibre cable from the nearest node

(ii) Since POWERGRID has its own fibre optic cables, practically covering all major nodes and power stations, a proper communication/IT network may be built using dedicated fibres to avoid any cyber attack on the power system.

Action: CTU, STUs
Time Frame: 1 year

Srivastava 16.8.2012
(S.C. Srivastava)
Member

A. Velayutham 16/08/2012
(A. Velayutham)
Member

(K.K. Agrawal)
Member Secretary

16/8/12
(A.S. Bakshi)
Chairman

SUPPLEMENTARY MATERIAL

FOR

THE REPORT OF

THE ENQUIRY COMMITTEE FOR THE GRID DISTURBANCES

ON 30TH AND 31ST JULY, 2012

16th August, 2012

CONTENTS:

EXHIBIT - 1

POWER MAP

Indicating Inter-Regional Lines

Between

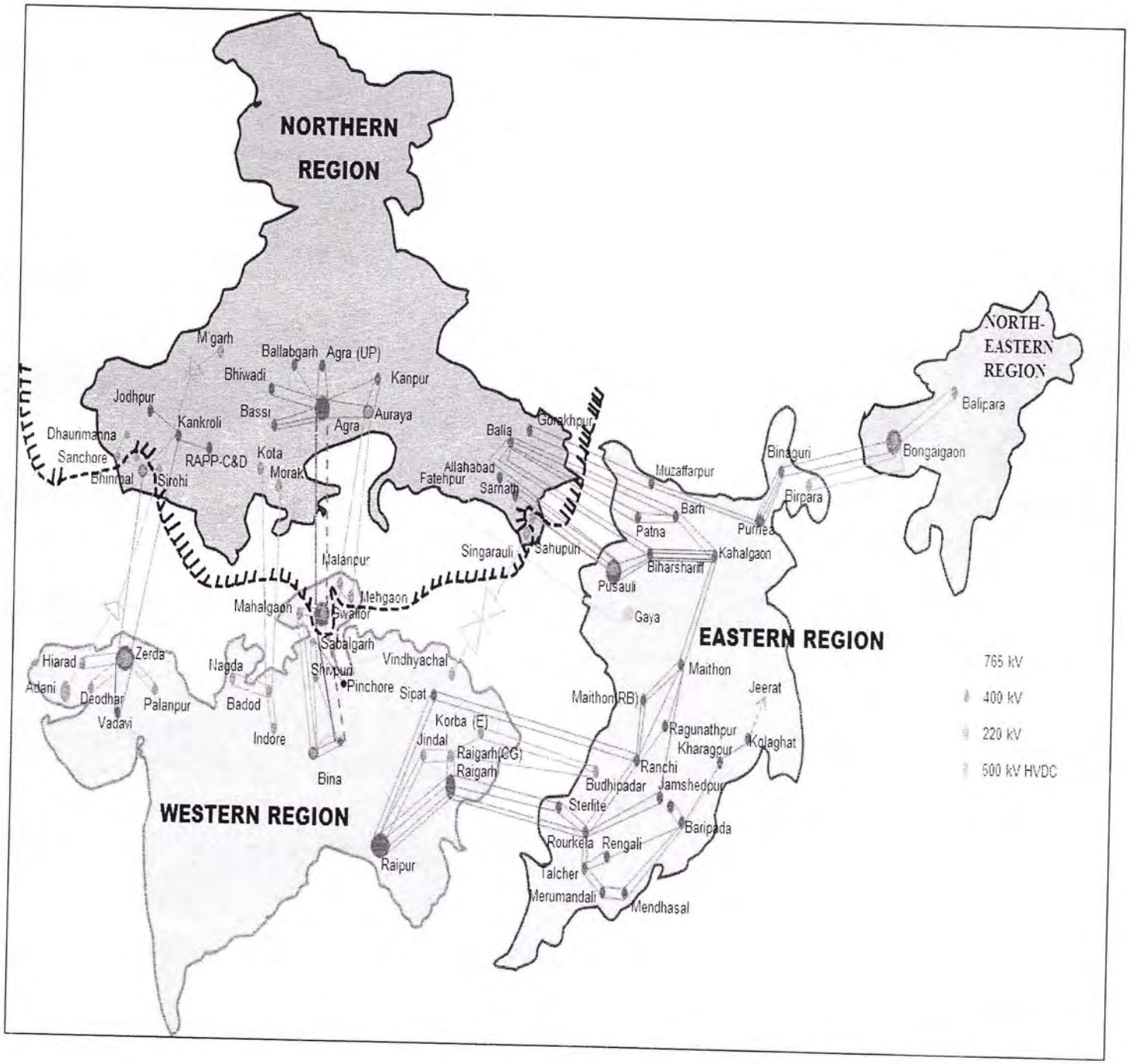
Northern, Western, Eastern

&

North-Eastern Regions

EXHIBIT – 1

2.1.1 Map indicating the IR links between NR, WR, ER and NER



Report on grid disturbance in Northern region on 30th July 2012

1. **Incident:** Grid Disturbance in Northern Region

2. **Date and Time of Event:** 02.35 hrs of 30th July 2012

3. **Antecedent Conditions** (@ 02.32 hrs, 30th July 2012)

a. Frequency: Pre-Incident – 49.68 Hz ; Post-Incident - 50.46 Hz, rose to 50.92 Hz
b. MP Schedule 1633 MW
c. MP Drawal 1190 MW
d. MP Demand 3413 MW
e. MP Thermal Generation 1597 MW
f. Hydel Gen incl. ISP and OSP 723 MW

Prefault Conditions:-

On 30.07.12, Badod- Kota line was idle charged from badod end since 29.07.2012 due to breaker problem at Kota-end. At 21:00 Hrs on 29.07.2012 the load on 220 KV Badod-Modak line was 144 MW which started increasing despite repeated persuasion by MP-SLDC to control within safe limits and at 00.00 hrs of 30.07.2012, the line load on Badod-Modak reached 276 MW and increased to about 300 MW at 00.10 hrs resulting in tripping of 220 KV Badod-Modak line on Over Load condition. The flow on this line at different timings is given hereunder :

Date	Time	Flow
29.07.2012	21:00	144
	21:30	166
	22:00	135
	22:15	190
	22:30	279
	23:00	272
	23:30	252
30.07.2012	00.00	273
	00.05	292
	00.06 to 00.09	301
	00.10	0 Line tripped on O/L

At around 00.05hrs, 160 MVA X'mer at 220 KV Sabalgarh tripped on over current. This has resulted the over loading on x'mers at 220 KV Mehalgaon S/s (Gwalior) and at around 00.20 hrs 132 KV Motizheel (Gwalior)- Banmore Ckt I & II hand tripped to avoid overloading of X'mers at 220 KV Mehalgaon S/s (Gwalior). 160MVA X'mer at 220 KV Sabalgarh charged at 01.35 Hrs.

220 KV Gwalior(PGCIL) – Mahalgaon (Gwalior) ckt –I and 220 KV Gwalior (PGCIL) – Malanpur-II were under S/D since 29.07.2012. At 01.35 hrs 220 KV Gwalior(PGCIL) – Mahalgaon Circuit –II tripped on over load. The power flow on this circuit before tripping was about 270 MW. With this tripping 220 KV Mahalgaon S/s completely got isolated from 400 KV Gwalior (PG) S/s. The load of about 280 MW of 220 KV Malanpur, 220 KV Mehgaon s/s along with 100 MW export to Auraiya of NR was on 400 KV Gwalior (PG).

Occurrence / Tripping at around 02.34 Hr-

220 KV Gwalior (PG) – Malanpur- I tripped on over load. Prior to tripping load on this ckt was about 280 MW. It is expected that Auraiya has drawn more power from Malanpur and Mehgaon which caused tripping of 220 KV Gwalior (PG) – Malanpur- I line. Prior to tripping, 400 KV Bina- Gwalior-II and 400 KV Gwalior – Agra-II was under shut down. No tripping was observed on 220 KV Malanpur-Auraiya, Malanpur-Mehgaon & 220 KV Mehgaon-Auraiya, however as remote end supply failed, the supply to 220 KV Mehgaon was also failed. The supply interruption occurred to all 132 KV substations connected with 220 KV Malanpur s/s and 220 KV Mehgaon s/s.

Restoration Process

1. At 01.35 hrs 160 MVA X'mer at 220 KV Sabalgarh Charged.
2. At 02.45 hrs 132 KV Motizheel –Banmore Ckt I & II charged & Supply extended to 220 KV Malanpur and 220KV Mehagaon s/s .
3. At 03.26 hrs 220 KV Badod-Modak Ckt charged
4. At 03.42 hrs 400 KV ISP-Satpura charged.
5. At 04.04 hrs 220 KV Malanpur-Auraiya charged.
6. At 04.09 hrs 220 KV Mehgaon-Auraiya charged.
7. At 05.12 hrs 400 KV Bina- Gwalior –I charged
8. At 05.35 hrs 220 KV Gwalior(PG)- Malanpur –I charged.
9. At 05.38 hrs 220 KV Gwalior(PG)-Mehalgaon Ckt charged.
9. At 06.45 hrs 400 KV Gwalior – Agra-I charged.

Areas Affected by disturbance:

220 KV Malanpur, 220 KV Mehgaon, 132 KV S/s Morar, 132 KV Ambah,132 KV S/s Porsa, 132 KV S/s Bhind ,132 KV S/s Ron,132 KV S/s Lahar, 132 KV S/s Seondha - **20 Minutes**
132 KV S/s Banmore, 132 KV S/s Morena – **10 Minutes**

Total Load Loss : About 200 MW in MP area.

EXHIBIT - 2

DETAILS OF

EVENT LOGGER

AND DISTURBANCE RECORDER

AT DIFFERENT LOCATIONS

ON

30TH JULY, 2012

Actions Taken : The hydel units at Bargi (1 m/c), Indirasagar (2 machines), Omkareshwar (2 m/c) were taken out before tripping from 00.00 to 1.15 Hrs and load shedding was completely lifted from 00.00 Hrs. After the occurrence at 02:34 Hrs, hydel generation was again reduced (One machine of ISP & OSP stopped at 02.45 hrs) to curtail frequency.

At 03.39 hrs VSTPS unit No. 3, 4, 5, 7, 8 & 10 also tripped. 132 KV Vindhyachal- Waidhan-Morwa ckt tripped from Morwa end. The ckt was normalized at 03.50 Hrs.

***

Exhibit-2.1: DR of 400kV Bina-Gwalior-1 at Bina end

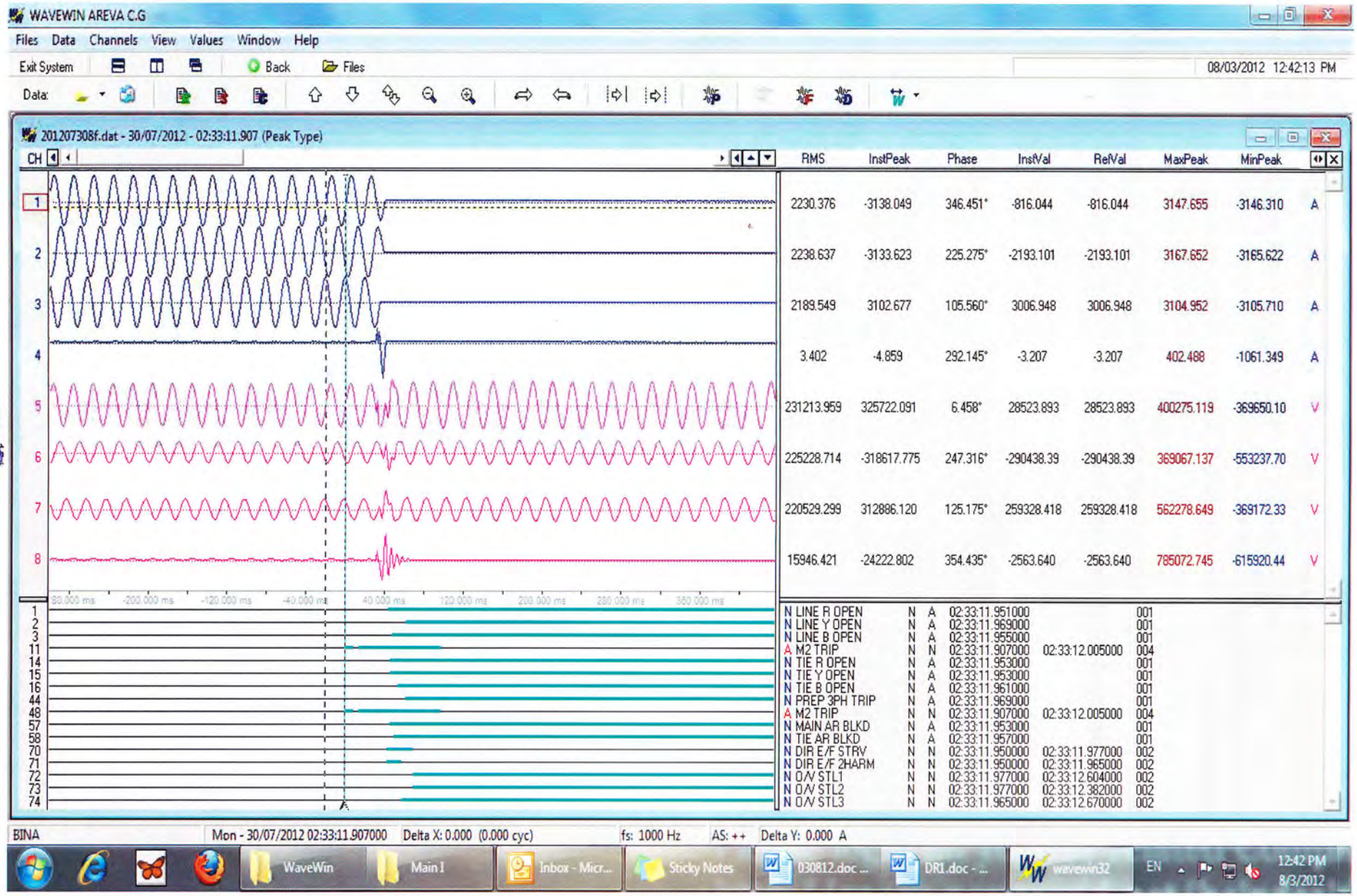


Exhibit- 2.2 DR at Gwalior

ABB - Disturbance Report

General data

Name	Value
Station name	400KV Agra line
Object name	Gwalior-Agra1 line
Unit name	REL 670
Line length	Not applicable
System Frequency	50.0 Hz
Recording number	801
Trigger signal name	TEF1-STRV
Trig date and time	7/30/2012 2:33:11.947 AM
Pre-trig recording time	300 ms
Post trig recording time	1999 ms
Total recording time	2324 ms
Max. recording time	3000 ms
Recording in Test mode	No
Type of time synchronization	SNTP
IED type	REL670 1B
IED version	1.000
Sampling frequency	1.0 kHz
Disturbance recorder	Installed
Event recorder	Installed
Fault locator	Not Installed
Active setting group during recording	1

ABB - Disturbance Report

Fault location

Name	Value
Fault loop type	Not applicable
Fault location	Not applicable
Status of fault calculation	Not applicable
Fault Direction	Not applicable

ABB - Disturbance Report

Analog channels

Number	Channel name	Prefault RMS	Prefault angle	Fault RMS	Fault angle
1	LINE_A_IL1	1.8 kA	-105.7°	0.2 kA	94.9°
2	LINE_A_IL2	1.7 kA	133.7°	0.2 kA	-21.3°
3	LINE_A_IL3	1.7 kA	14.9°	0.2 kA	-141.8°
4	LINE_A_IN	0.0 kA	152.7°	0.0 kA	9.3°
7	LINE_UL1	209.6 kV	-119.4°	246.8 kV	-148.4°
8	LINE_UL2	208.7 kV	120.0°	246.0 kV	91.3°
9	LINE_UL3	208.6 kV	0.0°	246.0 kV	-28.2°
10	LINE_UN	2.3 kV	-49.2°	1.4 kV	29.4°

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
1	M-CB RPH OPEN	1	1	0	0
2	M-CB YPH OPEN	1	1	0	0
3	M-CB BPH OPEN	1	1	0	0
4	MAIN-1 CR REC	1	1	0	0
5	MAIN-1 TRIP	1	1	0	0
6	M/TIE AR OPTD	1	1	0	0
7	M-I O/V TRIP	1	1	0	0
8	STUB/TEF OPTD	1	1	0	0
9	DT CH1/2 RECD	1	1	0	0
10	MAIN-II CR	1	1	0	0
11	MAIN-II TRIP	1	1	0	0
12	ZM03-START	1	1	0	0
13	BFR OPTD	1	1	0	0
14	T-CB RPH OPEN	1	1	0	0
15	T-CB YPH OPEN	1	1	0	0
16	T-CB BPH OPEN	1	1	0	0
17	SOTF-TRIP	1	1	0	0
18	ZCOM-TRIP	1	1	0	0
19	OV STG-1 TRIP	1	1	0	0
20	OV STG-2 TRIP	1	1	0	0
21	ZCAL_IREVBL	1	1	0	0
22	PHS-STFWL1	1	1	0	0
23	PHS-STFWL2	1	1	0	0
24	PHS-STFWL3	1	1	0	0
25	PHS-STFWPE	1	1	0	0
26	PSD1-START	1	1	0	0
27	IEF-TRIP	1	1	0	0
28	IOC1-TRIP	1	1	0	0
30	C-FAIL	1	1	0	0
31	M2DEF-TRIP	1	1	0	0
32	L1 FUSE FAIL	1	1	0	0
33	A/R UNSUCC	1	1	0	0
34	DT_REC_CH1	1	1	0	0
35	DT_REC_CH2	1	1	0	0
36	DRB03-INPUT36	1	1	0	0
37	BFP BUTR	1	1	0	0
38	BFP TRRET	1	1	0	0
39	Z1_TRIP	1	1	0	0
40	M2 PSB	1	1	0	0
41	Z1_START	1	1	0	0
42	Z2-TRIP	1	1	0	0
43	3PH_GR_A_TRIP	1	1	0	0
44	3PH_GR_B_TRIP	1	1	0	0
47	TEF-Trip	1	1	0	0
48	TEST MODE ON	1	1	0	0
49	GR B DC FAIL	1	1	0	0
50	CB READY	1	1	1	0
52	C CH1 FAIL	1	1	0	0
54	INC S2 DC FAI	1	1	0	0
55	M2 CS	1	1	0	0

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
56	Z2-START	1	1	0	0
57	Z3-TRIP	1	1	0	0
58	Z4-TRIP	1	1	0	0
59	Z4-START	1	1	0	0
60	Z5-TRIP	1	1	0	0
61	Z5-START	1	1	0	0
62	TIE AR UNCS	1	1	0	0
63	PRE 3PH TRIP	1	1	0	0
66	BFR_OPTD	1	1	0	0
67	TOC1-TRIP	1	1	0	0
68	BRC	1	1	0	0
69	TEF1-START	1	1	0	0
70	TEF1-STFW	1	1	0	0
71	TEF1-STRV	1	1	1	1
72	TEF1-2NDHARMD	1	1	1	0
73	EFC1-TRIP	1	1	0	0
75	EFCA-TRWEI	1	1	0	0
76	EFC_IREVBL	1	1	0	0
77	TUV1-TRIP	1	1	0	0
78	TUV1-START	1	1	0	0
79	ZCAL-TRWEI	1	1	0	0
80	TOV1-START	1	1	0	0
81	GMAIN2 DEF TR	1	1	0	0
82	GMAIN2 TRIP	1	1	0	0
83	GMAIN2 PSB	1	1	0	0
84	GMAIN2 CS	1	1	0	0
85	GMAIN2 CR	1	1	0	0
86	GMAIN2 CF	1	1	0	0
87	GMAIN2 TOV	1	1	0	0
88	TIE_BFR_OPTD	1	1	0	0
95	SetGR1 ACTIVE	1	1	1	0
96	SetGR2 ACTIVE	1	1	0	0

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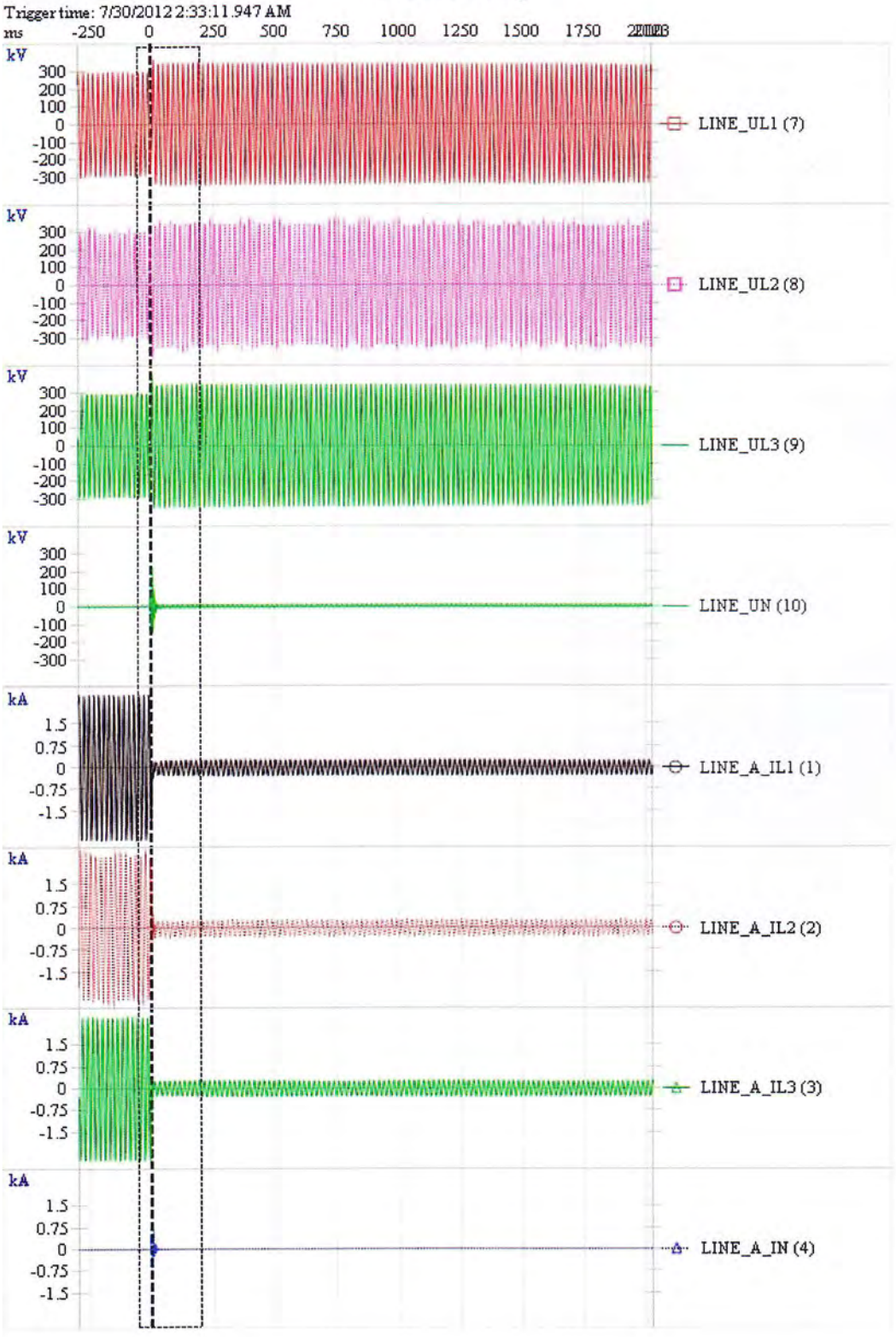
ABB - Disturbance Report

Total recording



Recording file: 20120730e8
Date: 7/30/2012 2:33:11 AM
Station/Bay: 400KV Agra line/1
Template: C:\PCMDataBases\DR\templates\default.xml

ABB - Disturbance Report

Total recording

Trigger time: 7/30/2012 2:33:11.947 AM

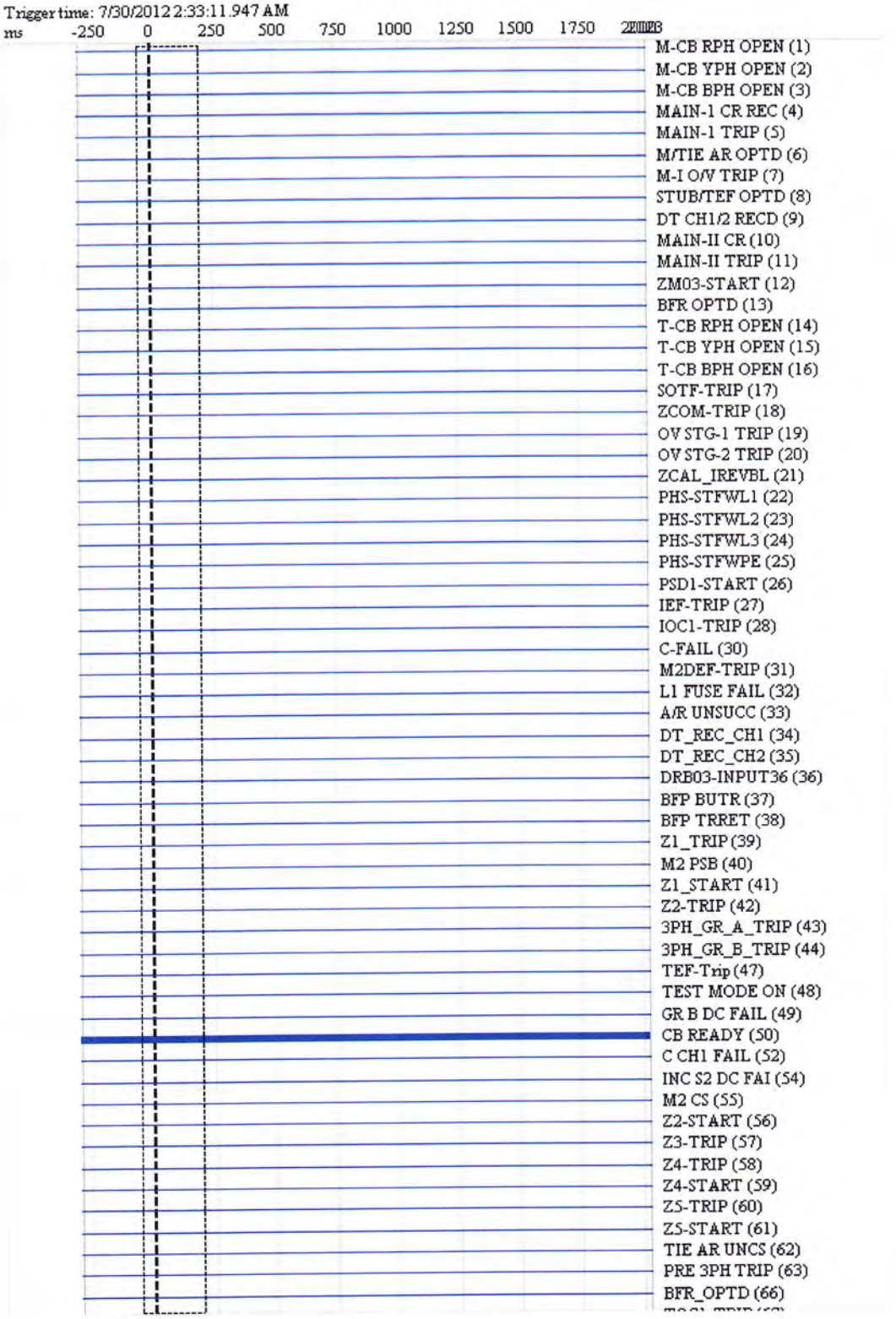


ABB - Disturbance Report

Disturbance 1

Trigger time: 7/30/2012 2:33:11.947 AM

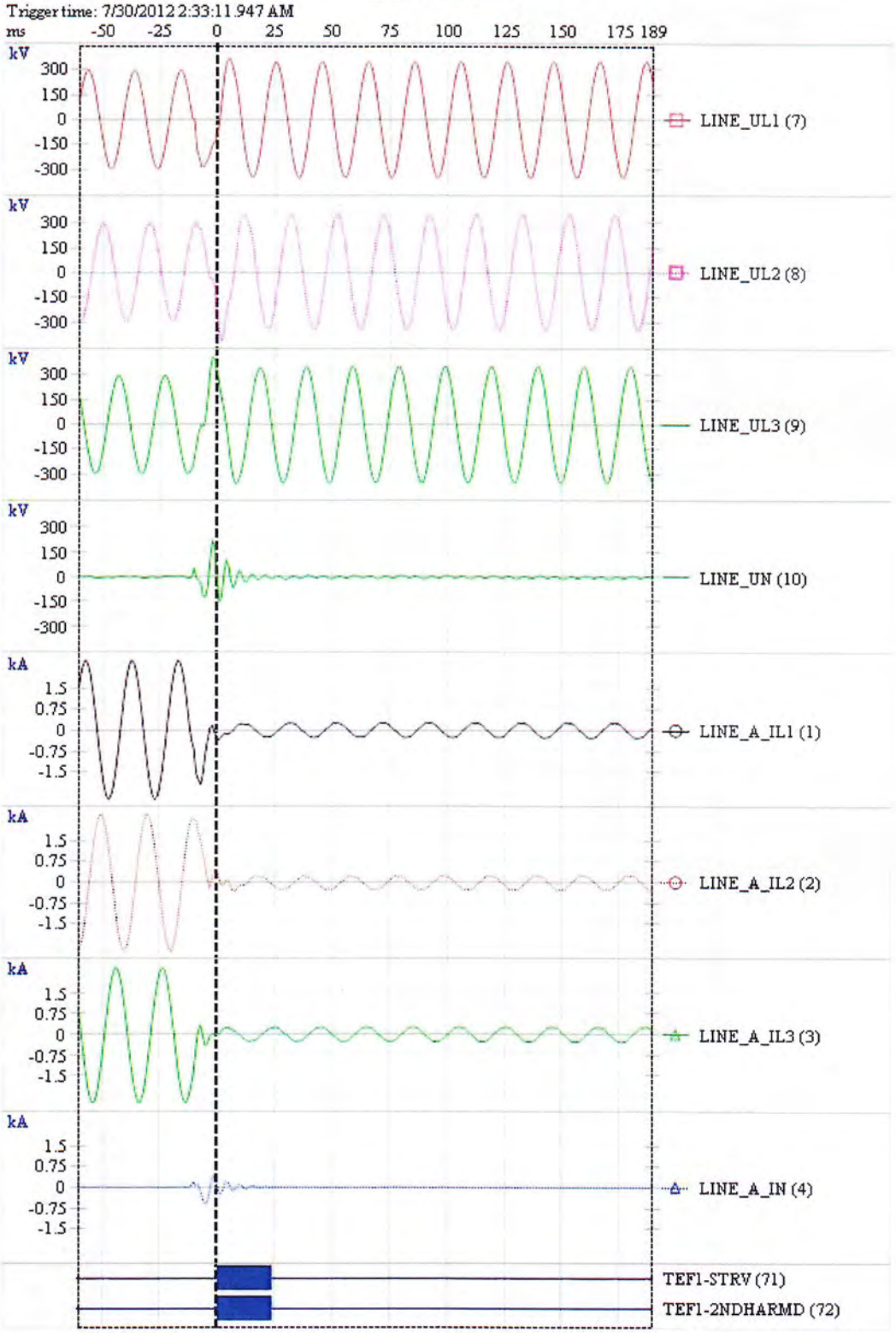
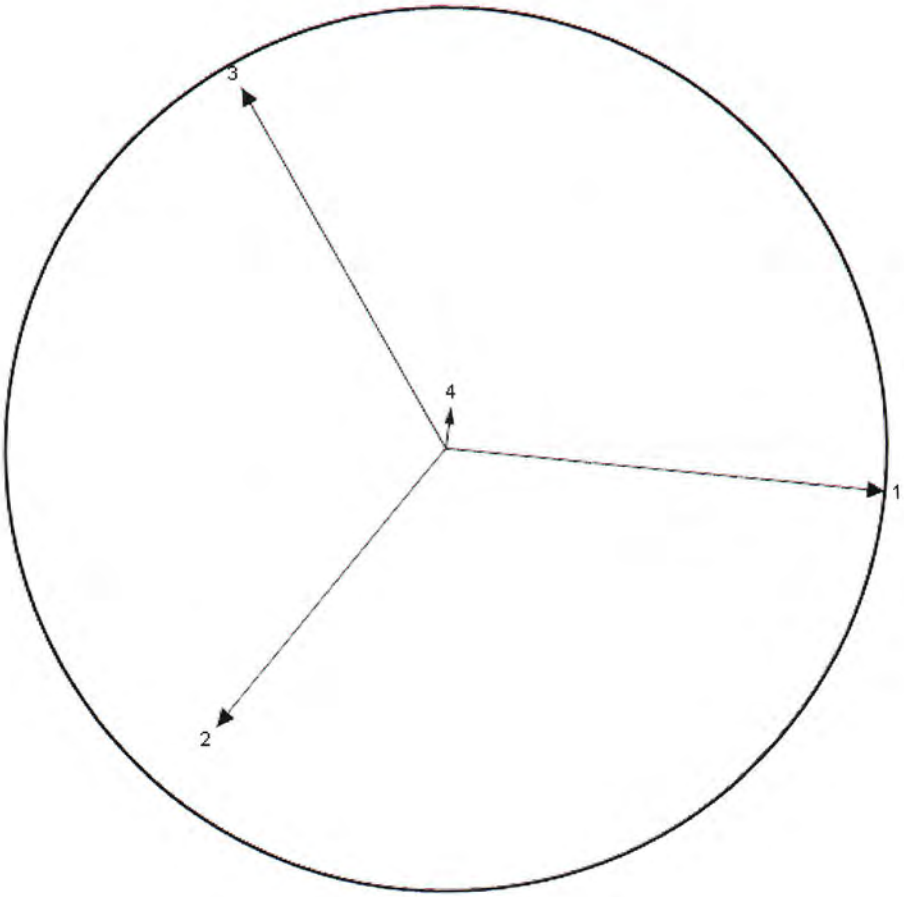


ABB - Disturbance Report

Disturbance 1 (Voltages)

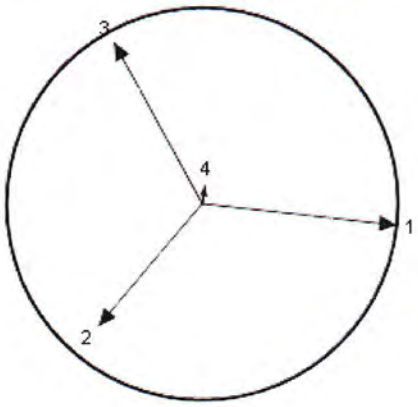


Calculation interval: -10 to 8 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	227.3	353.7°
2	LINE_UL2	185.6	229.6°
3	LINE_UL3	213.8	118.7°
4	LINE_UN	21.4	81.9°

ABB - Disturbance Report

Disturbance 1 (Voltages)



Calculation interval: -10 to 8 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	227.3	353.7°
2	LINE_UL2	185.6	229.6°
3	LINE_UL3	213.8	118.7°
4	LINE_UN	21.4	81.9°

Disturbance 1 (Currents)

Calculation interval: -10 to 8 ms

Number	ID	RMS (kA)	Angle
1	LINE_A_IL1	0.4	13.1°
2	LINE_A_IL2	0.4	192.5°
3	LINE_A_IL3	0.1	11.2°
4	LINE_A_IN	0.1	13.2°

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ABB - Disturbance Report

Event list

Number	Name	Status	Time
71	TEF1-STRV	On	7/30/2012 2:33:11.947 AM
72	TEF1-2NDHARMD	On	7/30/2012 2:33:11.947 AM
71	TEF1-STRV	Off	7/30/2012 2:33:11.971 AM
72	TEF1-2NDHARMD	Off	7/30/2012 2:33:11.971 AM

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Exhibit-2,3 DR at Bhinmal

ABB - Disturbance Report

General data

Name	Value
Station name	bhinmal
Object name	220kv sanchore
Unit name	REL670
Line length	Not applicable
System Frequency	50.0 Hz
Recording number	37
Trigger signal name	PSB-OPTD
Trig date and time	7/30/2012 2:33:13.167 AM
Pre-trig recording time	100 ms
Post trig recording time	1999 ms
Total recording time	2925 ms
Max. recording time	6000 ms
Recording in Test mode	No
Type of time synchronization	SNTP
IED type	L67I11 01
IED version	1.101
Sampling frequency	1.0 kHz
Disturbance recorder	Installed
Event recorder	Installed
Fault locator	Not Installed
Active setting group during recording	1

ABB - Disturbance Report

Fault location

Name	Value
Fault loop type	Not applicable
Fault location	Not applicable
Status of fault calculation	Not applicable
Fault Direction	Not applicable

ABB - Disturbance Report

Analog channels

Number	Channel name	Prefault RMS	Prefault angle	Fault RMS	Fault angle
1	LINE_A_IL1	0.8 kA	-128.6°	0.8 kA	-128.6°
2	LINE_A_IL2	0.8 kA	109.5°	0.8 kA	109.5°
3	LINE_A_IL3	0.8 kA	-8.7°	0.8 kA	-8.7°
4	LINE_A_IN	0.0 kA	-84.5°	0.0 kA	-84.5°
5	LINE_UL1	102.1 kV	-119.5°	102.1 kV	-119.5°
6	LINE_UL2	102.6 kV	120.1°	102.6 kV	120.1°
7	LINE_UL3	102.1 kV	0.0°	102.1 kV	0.0°

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
1	TRIP	1	1	0	0
2	TRIP-R	1	1	0	0
3	TRIP-Y	1	1	0	0
4	TRIP-B	1	1	0	0
6	BROKEN-COND	0	1	0	0
7	ZM01-TRIP	1	1	0	0
8	ZM01-START	1	1	0	0
9	ZM02-TRIP	1	1	0	0
10	ZM02-START	1	1	0	0
11	ZM03-TRIP	1	1	0	0
12	ZM03-START	1	1	0	0
13	ZM04-TRIP	0	1	0	0
14	ZM04-START	0	1	0	0
15	ZM05-TRIP	1	1	0	0
16	ZM05-START	1	1	0	0
17	SOTF-TRIP	1	1	0	0
18	ZCOM-TRIP	1	1	0	0
22	PHS-STFWL1	1	1	0	0
23	PHS-STFWL2	1	1	0	0
24	PHS-STFWL3	1	1	0	0
25	PHS-STFWPE	1	1	0	0
26	PSB-OPTD	1	1	1	1
30	AR_UNSUC	0	1	0	0
32	FUSE FAIL	1	1	0	0
41	DC1_FAIL	0	1	0	0
45	MAIN_CB_OPN-R	0	1	1	0
46	MAIN_CB_OPN-Y	0	1	1	0
47	MAIN_CB_OPN-B	0	1	1	0
49	SOTF_INI	0	1	0	0
50	M2_CARR_OT	0	1	0	0
51	CARRIER_REC	1	1	0	0
53	CARR_CH_FAIL	0	1	0	0
63	DT_TRIP_REC	0	1	0	0
64	TUV1-TRIP	0	1	0	0
65	M2_CAR_OT	0	1	0	0
66	CARR_REC_CH1	1	1	0	0
81	TR_R_MAIN_CB	0	1	0	0
82	TR_Y_MAIN_CB	0	1	0	0
83	TR_B_MAIN_CB	0	1	0	0
84	CARR_SEND	1	1	0	0
85	TR_R_TBC_CB	0	1	0	0
86	TR_Y_TBC_CB	0	1	0	0
87	TR_B_TBC_CB	0	1	0	0
88	AR_CLOSE_MAIN	1	1	0	0
89	AR_CLOSE_TBC	0	1	0	0
90	TRIP_3P_MAIN	0	1	0	0
91	TRIP_3P_TBC	0	1	0	0
92	OV TRI[P	1	1	0	0
93	OV STG-1 TRIP	1	1	0	0
94	OV STG-2 TRIP	1	1	0	0

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
95	OV START	1	1	0	0

ABB - Disturbance Report

Disturbance 1

Trigger time: 7/30/2012 2:33:13.167 AM

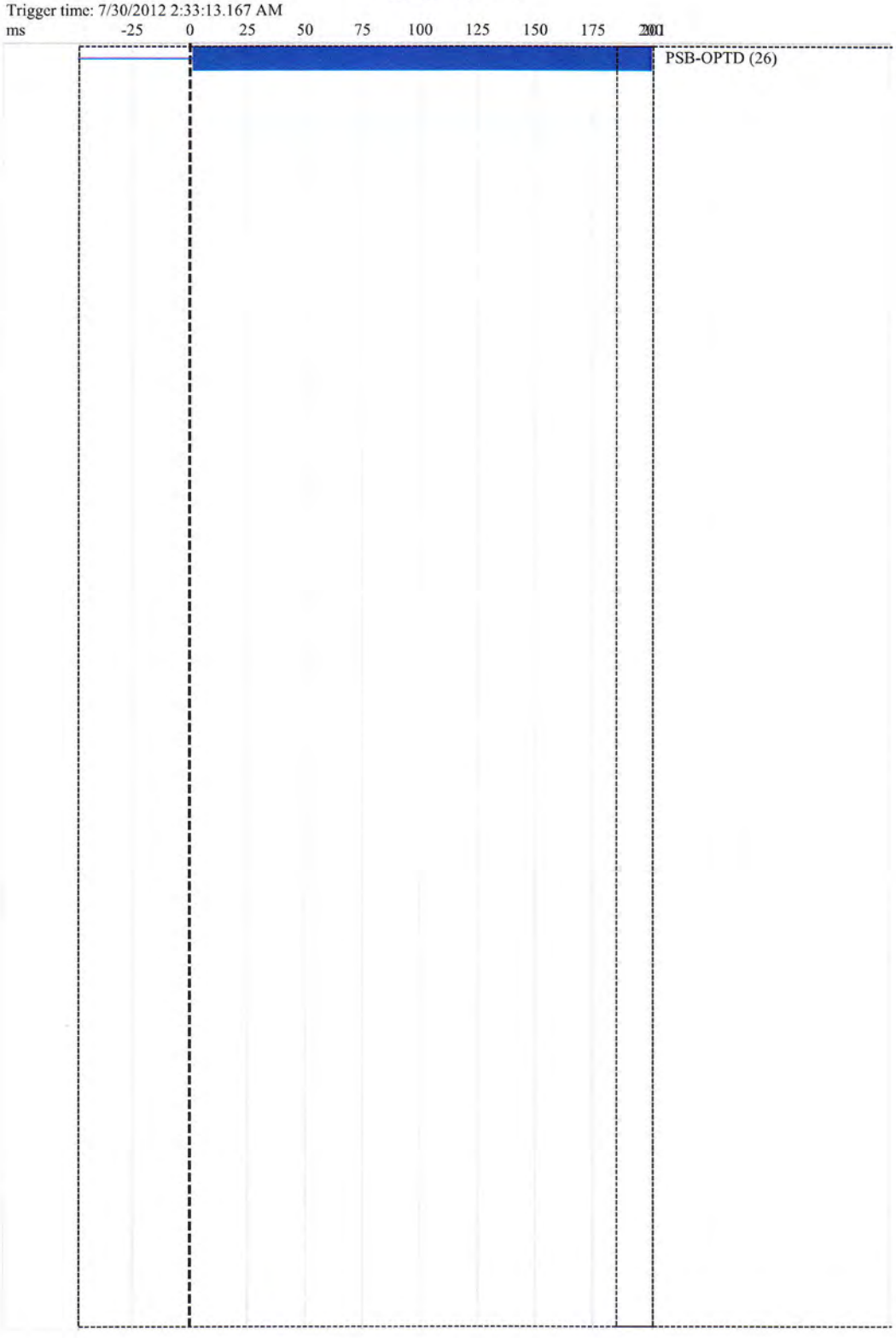

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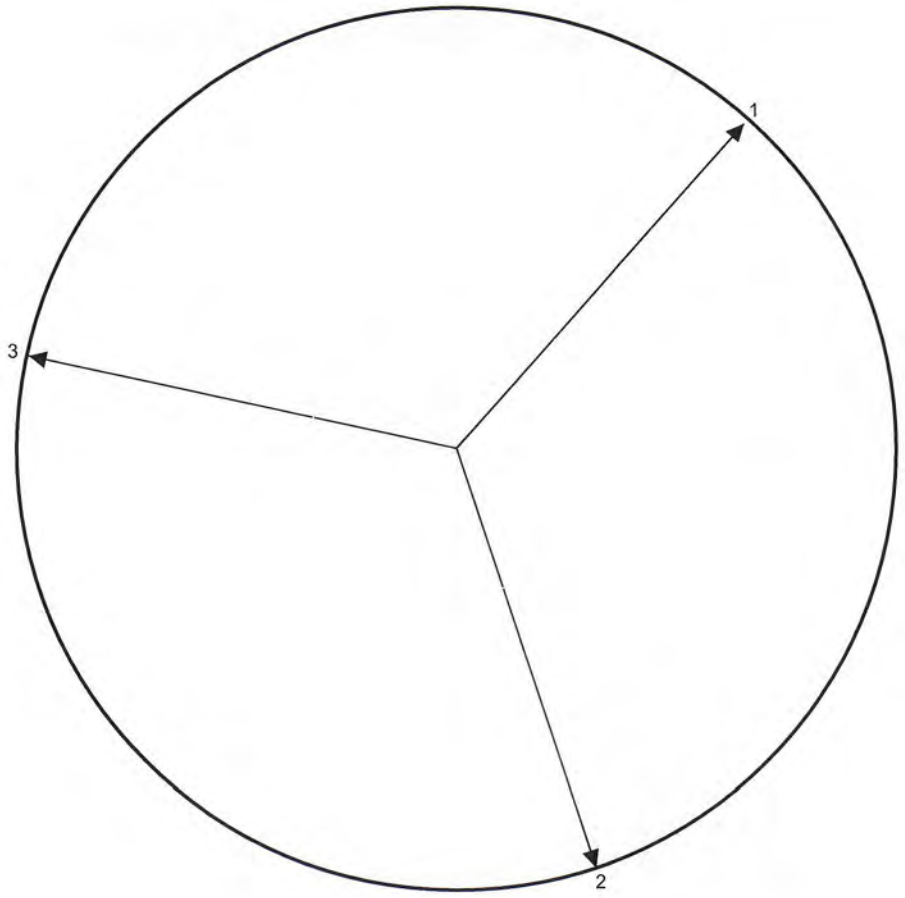
ABB - Disturbance Report

Disturbance 1 (Voltages)

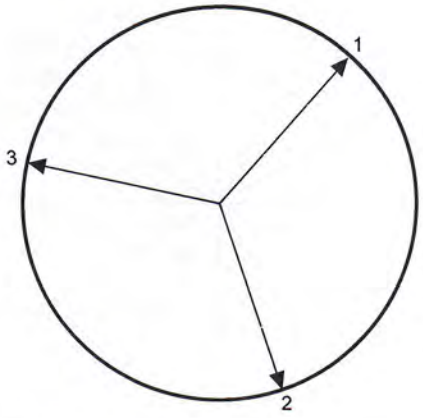


Calculation interval: 2 to 20 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	100.5	48.6°
2	LINE_UL2	102.0	288.5°
3	LINE_UL3	101.6	167.8°

ABB - Disturbance Report

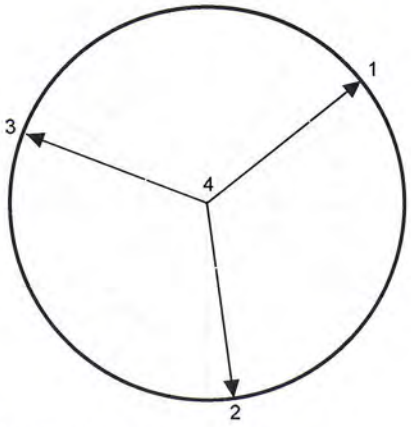
Disturbance 1 (Voltages)



Calculation interval: 2 to 20 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	100.5	48.6°
2	LINE_UL2	102.0	288.5°
3	LINE_UL3	101.6	167.8°

Disturbance 1 (Currents)



Calculation interval: 2 to 20 ms

Number	ID	RMS (kA)	Angle
1	LINE_A_IL1	0.8	38.9°
2	LINE_A_IL2	0.8	277.8°
3	LINE_A_IL3	0.8	159.1°
4	LINE_A_IN	0.0	85.0°

ABB - Disturbance Report

Event list

Number	Name	Status	Time
26	PSB-OPTD	On	7/30/2012 2:33:13.167 AM
22	PHS-STFWL1	On	7/30/2012 2:33:13.401 AM
24	PHS-STFWL3	On	7/30/2012 2:33:13.401 AM
23	PHS-STFWL2	On	7/30/2012 2:33:13.416 AM
45	MAIN_CB_OPN-R	On	7/30/2012 2:33:13.474 AM
46	MAIN_CB_OPN-Y	On	7/30/2012 2:33:13.474 AM
47	MAIN_CB_OPN-B	On	7/30/2012 2:33:13.476 AM
22	PHS-STFWL1	Off	7/30/2012 2:33:13.476 AM
24	PHS-STFWL3	Off	7/30/2012 2:33:13.476 AM
23	PHS-STFWL2	Off	7/30/2012 2:33:13.476 AM
26	PSB-OPTD	Off	7/30/2012 2:33:13.992 AM

Exhibit 2.4 Rajasthan SLDC Event Report

EVENT REPORT
(From Rajasthan)

1. Time of Event: **02.34 Hrs.** Date of Event: **30.07.12**
2. Location: **Northern Region (Rajasthan)**
3. Plant and/or equipment directly involved: SSTPS, KSTPS, Giral TPS,Ramgarh GTPS ,DCCPP,CTPP, Rajwest Power Pvt.Ltd.,Barsinsar, RAPP# 2, Wind Power Plants(WPP)
4. Description and cause of event: **Northern Grid Failure.**
5. Antecedent condition (at 2.30 hrs.)

A).Generation

Unit	MW	Remarks
KSTPS # 1	96	
KSTPS # 2	98	
KSTPS # 3	199	
KSTPS # 4	0	Already under S/D to attend feed water leakage.
KSTPS # 5	197	
KSTPS # 6	195	
KSTPS # 7	192	
SSTPS # 1	238	
SSTPS # 2	244	
SSTPS # 3	0	Already under S/D for over-hauling work.
SSTPS # 4	248	
SSTPS # 5	243	
SSTPS # 6	248	
DCCPP GT #1	143	
DCCPP GT #2	0	Already under S/D due to less gas.
Chhabra # 1	247	
Chhabra # 2	214	
Ramgarh GT # 1	28	
Ramgarh GT # 2	31	
Ramgarh STG	10	
RAPP A	192	
Giral # 1	48	
Giral # 2	0	Already under S/D due to leakage in seal pot 2.
Rajwest # 1	36	
Rajwest # 3	135	
Rajwest # 4	135	
Rajwest # 2	0	Already under S/D due to annual maintenance.

Barsinghsar # 1	114	
Barsinghsar # 2	0	Already under S/D due to boiler tube leakage.

5 (B) Load loss

i) Rajasthan demand - 6302 MW.

a) Own generation - 4531 MW.

b) NR schedule - 1718 MW.

c) Overdrawl - 31 MW

ii) Frequency - 49.84 Hz. (Block ending at 2.30 AM)

iii) Voltage of important GSS- Enclosed at Annexure -1.

iv) Flow in the tie line prior to the grid disturbance – Enclosed at Annexure -2.

v) Weather condition prior to the event (Rajasthan) – Normal.

6. Generation interrupted.

Unit	MW	Time of tripping	Time of synch.	Duration	Loss of generation (in MWh)
KSTPS # 1	96	02.34	07.22	3.48	364.8
KSTPS # 2	98	02.34	10.47	8.13	805.23
KSTPS # 3	199	02.34	07.27	3.53	772.78
KSTPS # 4	0	-	-	-	S/D
KSTPS # 5	197	02.34	09.13	6.39	1310.05
KSTPS # 6	195	02.34	06.34	4.00	780.00
KSTPS # 7	192	02.34	15.07	12.33	2409.6
SSTPS # 1	238	02.34	12.16	09.42	2308.6
SSTPS # 2	244	02.34	15.34	13.00	3172
SSTPS # 3	0	-	-	-	S/D
SSTPS # 4	248	02.34	20.54 31/7/12	18.20	10490.4
SSTPS # 5	243	02.34	18.29	15.55	3867.7
SSTPS # 6	248	02.34	16.55	14.21	3558.8
DCCPP GT #1	143	02.34	09.35	7.01	1001
DCCPP GT #2	0	-	-	-	S/D
Chhabra # 1	247	02.34			Due to problem gone in S/D
Chhabra # 2	214	02.34	09.26	6.52	1469.46
Ramgarh GT # 1	28	02.34	12.35	10.01	280
Ramgarh GT # 2	31	02.34	11.55	9.21	289.85
Ramgarh STG	10	02.34			S/D
RAPP A	192	02.34	13.58 1/8/12	59.24	11404.8
Giral # 1	48	02.34	02.00	23.26	1126

			31/7/12		
Giral # 2	0	-	-	-	S/D
Rajwest # 1	36	02.34	2.27 31.7.12	23.53	259.79
Rajwest # 3	135	02.34	15.03	12.29	1687.5
Rajwest # 4	135	02.34	16.28	13.54	1876.5
Rajwest # 2	0	-	-	-	S/D
Barsinghsar # 1	114	02.34	5.30 1/8/12	50.56	5806.4
Barsinghsar # 2	0	-	-	-	S/D

7. Relevant system data(copies to be attached)

S.No.	Description	The individual data / report received from Suratgarh –STPS, Kota STPS, Barsinghsar TPS, Giral TPS, Ramgarh Gas Station as received are enclosed at Annexure -3.
1	Disturbance Recorder	
2	Event logger	
3	Data acquisition system	
4	Any other	

8.&9. Sequence of tripping with time & relay flags.

S.N.	Name of Feeder/Transformer	Time of tripping	Time of closing	Relay indications
1	220 kV Kota-Badod	15.12/ 29.07.12	16.45	**Kota End:** M-I,C phase,21CG,dist.8.3 kM,M-II,C phase,Z1,dist.6.78 kM **Badod end:**Dist.prot.,carrier send,Gen.trip,RYB phase,Z1,286 RYB,386 RYB
2	220 kV Modak-Badod	00.10	03.35	**Kota End:** No tripping **Badod end:**O/L,TOC 1,86,286 RYB,STFW trip O/C
3	220 kV Bhinmal(PG)-Sanchore	02.33	03.25	Bhinmal End: O/V Sanchore End: No Tripping
4	220 kV Bhinmal-Dhorimanna	02.34	03.05	Bhinmal End: Dist.Prot.,Z1,A B C phase,dist.25 kM Dhorimanna End: No Tripping
5	KSTPS # 1	02.34	07.22	81B, 86G, 86GB, 86GT
6	KSTPS # 2	02.34	10.47	81B, 86G, 86GB, 86GT.
7	KSTPS # 3	02.34	07.27	81B, 86G, 86GB, 86GT
8	KSTPS # 5	02.34	09.13	81B, 86GX, 86GY, 86GBX, 86GBY.
9	KSTPS # 6	02.34	06.34	81B, 86GX, 86GY, 86GBX, 86GBY.

10	KSTPS # 7	02.34	15.07	81B, 86GX, 86GY, 86GBX, 86GBY.
11	SSTPS # 1	02.34	12.16	Under frequency
12	SSTPS # 2	02.34	15.34	Under frequency
13	SSTPS # 4	02.34	20.54 31/7/12	Over voltage/ Under freq.
14	SSTPS # 5	02.34	18.29	Over voltage/ Under freq.
15	SSTPS # 6	02.34	16.55	Over voltage/ Under freq.
16	DCCPP GT #1	02.34	09.35	Yet to receive.
17	Chhabra # 1	02.34		
18	Chhabra # 2	02.34	09.26	Yet to receive.
19	Ramgarh GT # 1	02.34	12.35	Under frequency.
20	Ramgarh GT # 2	02.34	11.55	Under frequency.
21	Ramgarh STG	02.34		Under frequency.
22	RAPP A	02.34	13.58 1/8/12	
23	Giral # 1	02.34	02.00	Under frequency.
24	Rajwest # 1	02.34	02.27/ 31.07.12	Yet to receive.
25	Rajwest # 3	02.34	15.03	Yet to receive.
26	Rajwest # 4	02.34	16.28	Yet to receive.
27	Barsinghsar # 1	02.34	5.30 1/8/12	Under frequency.

10. Details of under frequency and df/dt realy operation :- Enclosed at Annexure-4. (page…..).

11. Sequence of restoration with time

S.N.	Name of Feeder/Transformer	Time of tripping	Time of closing	Relay indications
1	220 kV Bhinmal-Dhorimanna	02.34	03.05	Bhinmal End: Dist.Prot.,Z1,A B C phase,dist.25 kM Dhorimanna End: No Tripping
2	220 kV Dhorimanna-Rajwest Power	Manually tripped.	03.20	-
3	220 kV Rajwest-Barmer-II	Manually tripped.	03.20	-
4	220 kV Bhinmal(PG)-Sanchore	02.33	03.25	Bhinmal End: O/V Sanchore End: No Tripping
5	132 kV Jaisalmer-Amarsagar	Manually tripped.	03.27	-
6	132 kV Jaisalmer-Ramgarh GTPS	Manually tripped.	03.27	-
7	220 kV Amarsagar-Mada	Manually tripped.	03.27	-

8	220 kV AmarsagarAkal	Manually tripped.	03.27	-
9	220 kV Barmer-Mada	Manually tripped.	03.27	-
10	220 kV Modak-Badod	00.10	03.35	**Modak End:** No tripping **Badod end:**O/L,TOC 1,86,286 RYB,STFW trip O/C
11	132 kV Modak-Railway	Manually tripped.	03.35	-
12	220 kV Barmer-Giral TPS-I	Manually tripped.	03.40	-
13	220 kV Modak-KTPS	Manually tripped.	03.40	-
14	220 kV Amarsagar-Phalodi	Manually tripped.	03.48	-
15	132 kV RPS-Kota	Manually tripped.	03.49	-
16	132 kV Kota-Railway	Manually tripped.	03.50	-
17	220 kV Kota-KTPS	Manually tripped.	03.52	-
18	220 kV Kota-Anta	Manually tripped.	03.55	-
19	220 kV Modak-Jhalawar	Manually tripped.	04.02	-
20	220 kV Jhalawar-CTPP	Manually tripped.	04.02	-
21	220 kV KTPS-Heerapura	Manually tripped.	04.11	-
22	220 kV Barmer-Giral TPS-I	Manually tripped.	04.22	-
23	132 kV Heerapura-Chambal	Manually tripped.	04.22	-
24	220 kV Barmer-Giral TPS-III	Manually tripped.	04.23	-
25	132 kV Kota-RAPP A	Manually tripped.	04.23	-
26	220 kV Rajwest-Barmer-I	Manually tripped.	04.29	-
27	132 kV Amarsagar-Tejwa-I	Manually tripped.	04.35	-
28	220 kV KTPS-Kota(PG)	Manually tripped.	04.38	-
29	220 kV Kota(PG)-RAPP C	Manually tripped.	04.38	-
30	220 kV Giral TPS-Akal	Manually tripped.	04.53	-
31	220 kV Phalodi-Barsinsar	Manually tripped.	04.58	-

32	132 kV Kota-RAPP B	Manually tripped.	04.59	-
33	220 kV Phalodi-Tinwari	Manually tripped.	05.08	-
34	220 kV Heerapura-Khetri	Manually tripped.	05.13	-
35	220 kV Anta-Dausa	Manually tripped.	05.22	-
36	220 kV Dausa-Hindaun	Manually tripped.	05.40	-
37	220 kV Khetri-Jhunjhunu	Manually tripped.	05.42	-
38	220 kV Jhunjhunu-Ratangarh	Manually tripped.	05.42	-
39	220 kV Ratangarh-SSTPS	Manually tripped.	05.43	-
40	220 kV Hindaun-Dholpur	Manually tripped.	05.55	-
41	220 kV Ratangarh-Ratngarh(400kV GSS)	Manually tripped.	06.01	-
42	220 kV Ratngarh(400kV GSS)-Bikaner	Manually tripped.	06.01	-
43	220 kV Dholpur-DCPP	Manually tripped.	06.05	-
44	220 kV Bikaner-Barsinsar	Manually tripped.	06.36	-
45	220 kV Barmer-Balotra	Manually tripped.	07.24	-
46	220 kV KTPS-Beawar	Manually tripped.	07.41	-
47	220 kV Beawar-RAS	Manually tripped.	07.41	-
48	132 kV Amarsagar-Tejwa-II	Manually tripped.	11.05	-
49	220 kV Kota-Badod	15.12/ 29.07.12	16.45	**Kota End:** M-I,C phase,21CG,dist.8.3 kM,M-II,C phase,Z1,dist.6.78 kM **Badod end:**Dist.prot.,carrier send,Gen.trip,RYB phase,Z1,286 RYB,386 RYB

12. Any other relevant information and observation.

A) Supply Restoration time at various Power Plants

S.No.	Name of Generating Stations	Time
1	Rajwest Power	03.20 Hrs.
2	Giral TPS	03.40 Hrs.
3	Ramgarh GTPS	03.27 Hrs.
4	Wind Power	03.27 Hrs.
5	SSTPS	05.50 Hrs.
6	KSTPS	03.39 Hrs.
7	DCCPP	06.06 Hrs.
8	CTPP	04.02 Hrs.
9	RAPP A	04.23 Hrs.
10	RAPP B	04.59 Hrs.
11	Barsingsar	04.58 Hrs.
12	Anta	03.55 Hrs.

S.No.	Name of Generating Stations	Time
1	Rajwest Power	03.20 Hrs.
2	Giral TPS	03.40 Hrs.
3	Ramgarh GTPS	03.27 Hrs.
4	Wind Power	03.27 Hrs.
5	SSTPS	05.50 Hrs.
6	KSTPS	03.39 Hrs.
7	DCCPP	06.06 Hrs.
8	CTPP	04.02 Hrs.
9	RAPP A	04.23 Hrs.
10	RAPP B	04.59 Hrs.
11	Barsingsar	04.58 Hrs.
12	Anta	03.55 Hrs.

Exhibit- DR at Rourkela

File: Monday 30 July 2012 02.33.13.001.DAT - 30/07/2012 - 02:33:13.867 - Secondary - (Peak Type) Page: 1

```
* File Information::
* ----------------
           Station: JAMSHEDPUR-II
            Device: 8
         File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\JAMSHEDPUR#2\1\DR\Monday
         File Size: 244801 Bytes
     Prefault Time: 30/07/2012 02:33:13.671000
        Fault Time: 30/07/2012 02:33:13.867000
         Save Time: 07/30/2012 16:10:04
      Process Time: 07/30/2012 16:10:27
 Start Date && Time: 30/07/2012 02:33:13.671000
   End Date && Time: 30/07/2012 02:33:15.181657
     File Duration: 1  Sec(s) - 510 Mils(s) - 657 Mics(s)
 Sampling Frequency: 1191.895113, 839.000  Microsecond Rate
    Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* ------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff   pUnits    Description
 330631.000  -308282.500   281436.781  180744.688   31.7000   22348.500  100692.094     V       1-VA
 400624.600  -422244.000   284285.594  172663.969   31.7000   21619.400  111621.625     V       2-VB
 298772.500  -298550.600   219381.406   39016.047   31.7000     221.900  180365.359     V       3-VC
 423099.900  -425984.600   295720.188    5134.650   31.7000    2884.700  290585.538     V       4-VN
   1615.770    -1613.008     1440.830       2.110    2.7620       2.762    1438.720     A       5-IA
   1731.774    -1729.012     1574.340       4.219    2.7620       2.762    1570.121     A       6-IB
   1903.018    -1897.494     1354.016      91.485    2.7620       5.524    1262.531     A       7-IC
   2035.594    -2019.022     1444.297      96.926    2.7620      16.572    1347.371     A       8-IN

* Events/Sensors Activity Summary:
* --------------------------------
>Fst  Lst  Fst-Change       Lst-Change       Changes    Description
  N    N   02:33:14.364322  02:33:14.426369  002          2-MAIN2 CR REC
  N    N   02:33:13.917666  xx:xx:xx.xxxxxx  001          4-MAIN CB RPH OPEN
  N    N   02:33:13.867326  02:33:13.948155  002          5-R5 MAIN RPH TRIP
  N    N   02:33:13.917666  xx:xx:xx.xxxxxx  001          6-MAIN CB BPH OPEN
  N    N   02:33:13.882428  02:33:13.960264  002          8-MAIN 2 TRIP
  N    N   02:33:13.921022  xx:xx:xx.xxxxxx  001         14-TIE CB RPH OPEN
  N    N   02:33:13.917666  xx:xx:xx.xxxxxx  001         15-TIE CB YPH OPEN
  N    N   02:33:13.867326  02:33:13.904242  002         18-Z1
  N    N   02:33:14.172574  02:33:14.374414  002         21-Z4
  N    N   02:33:13.927734  xx:xx:xx.xxxxxx  001         31-MAIN CB YPH OPEN
```

30/07/12 PKBela 30.07.12

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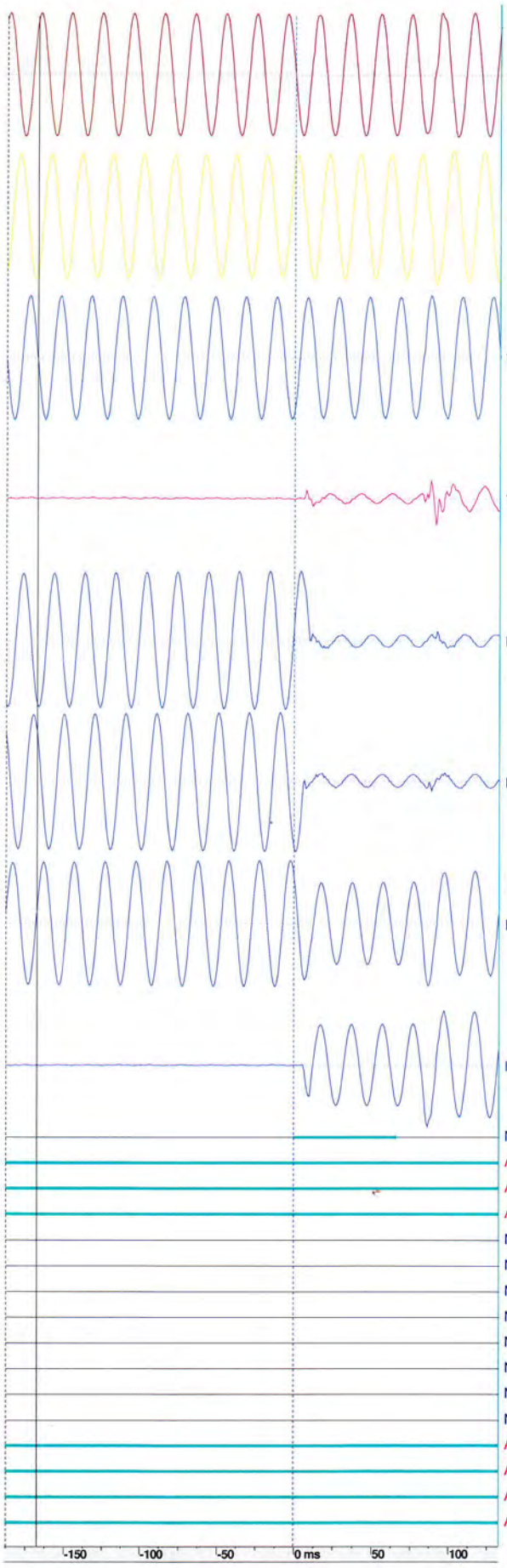
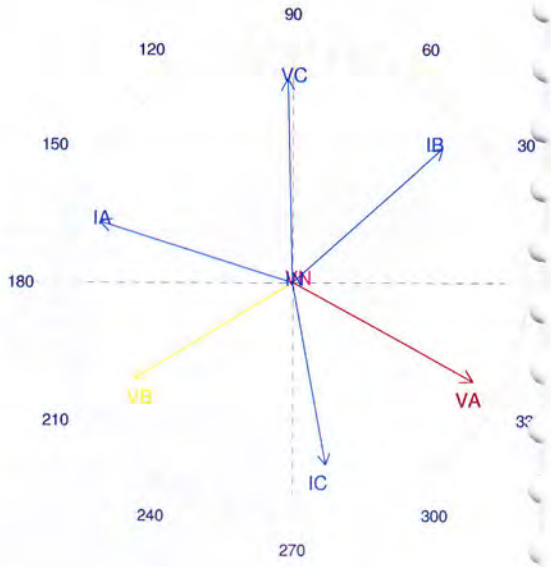
Exhibit- 2·6 DR at Jamshedpur

CH	Title	RMS	InstPeak
1	VA	219182.837	-309613.900
2	VB	218530.787	-309835.800
3	VC	220280.355	311864.600
4	VN	2062.176	4025.900
5	IA	1238.908	1753.870
6	IB	1276.942	1806.348
7	IC	1246.218	-1764.918
8	IN	7.416	2.762





1	N	M2 CARR RECEVIE	N	N	02:33:08.712936	02:33:08.780056	002
2	A	M-CB RPH CLOSE	A	A			000
3	A	M-CB YPH CLOSE	A	A			000
4	A	M-CB B PH CLOSE	A	N	02:33:09.197097		001
5	N	M1 CARR RECEIVE	N	N			000
6	N	MAIN 1 OPTD	N	N			000
7	N	MAIN/TIE AR OPYD	N	N			000
8	N	O/V ST1&2 OPTD	N	N			000
9	N	M2 OR TEE1&2 OPT	N	N	02:33:09.175257	02:33:09.255804	002
10	N	DIRECT TRIP	N	N			000
11	N	B/B PROTN OPTD	N	N			000
12	N	M-CB LBB OPTD	N	N			000
13	A	TIE-CB RPH CLOSE	A	A			000
14	A	TIE-CB YPH CLOSE	A	A			000
15	A	TIE-CB BPH CLOSE	A	N	02:33:09.202137		001
16	A	CSS IN SERV	A	A			000

ROURKELA-2 DT: 30/07/2012 02:33:08.545136 Dt: 167800 microsec - 8.39 Cyc 1191.8951 AS: ON

```
* File Information::
* ------------------
           Station: ROURKELA-2
            Device: 4
         File Name: C:\DOCUMENTS AND SETTINGS\CONTROLROOM\MY DOCUMENTS\S1 STUDIO\JAMSHEDPUR\ROURKELA-2\1\DR\Monday 30 July 2
         File Size: 244801 Bytes
     Prefault Time: 30/07/2012 02:33:08.525000
        Fault Time: 30/07/2012 02:33:08.713000
         Save Time: 07/29/2012 20:13:42
      Process Time: 08/01/2012 01:20:06
 Start Date && Time: 30/07/2012 02:33:08.525000
   End Date && Time: 30/07/2012 02:33:10.034937
     File Duration: 1  Sec(s) - 509 Mils(s) - 937 Mics(s)
 Sampling Frequency: 1191.895113, 839.000  Microsecond Rate
    Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff   pUnits    Description
 314971.200  -310628.300   295881.781  193702.750    31.7000    4342.900  102179.031     V        1-VA
 328697.300  -347875.800   263363.594  158249.688    31.7000   19178.500  105113.906     V        2-VB
 319028.800  -312688.800   237634.625   10746.300    31.7000    6340.000  226888.325     V        3-VC
 312530.300  -323181.500   219835.094    1583.996    31.7000   10651.200  218251.098     V        4-VN
   1809.110    -1811.872     1707.275     108.877     2.7620       2.762    1598.398     A        5-IA
   1864.350    -1867.112     1345.094      94.814     2.7620       2.762    1250.280     A        6-IB
   1985.878    -1994.164     1410.770       1.516     2.7620       8.286    1409.254     A        7-IC
   2115.692    -2118.454     1498.163       4.367     2.7620       2.762    1493.796     A        8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change       Lst-Change       Changes    Description
  N    N    02:33:08.712936  02:33:08.780056  002          1-M2 CARR RECEVIE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000          2-M-CB RPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000          3-M-CB YPH CLOSE
  A    A    02:33:09.197097  xx:xx:xx.xxxxxx  001          4-M-CB B PH CLOSE
  N    N    02:33:09.175257  02:33:09.255804  002          9-M2 OR TEE1&2 OPT
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         13-TIE-CB RPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         14-TIE-CB YPH CLOSE
  A    A    02:33:09.202137  xx:xx:xx.xxxxxx  001         15-TIE-CB BPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         16-CSS IN SERV
  N    N    02:33:09.165177  02:33:09.195417  002         18-Z1
  N    N    02:33:09.003897  02:33:09.163497  002         21-Z4
  N    N    02:33:08.970297  02:33:09.195417  002         28-Any Start
  N    N    02:33:09.165177  02:33:09.245760  002         30-Any Trip
```

Exhibit-27 . Rourkela-Jamshedpur-I DR phasors

Monday 30 July 2012 02.33.13.000.DAT - 30/07/2012 - 02:33:13.945 - Secondary - (Peak Type) Page: 2

Title	RMS	InstPeak	Phase	InstVal
VA	217687.485	307046.200	112.485°	-120111.300
VB	213056.624	300230.700	353.074°	300230.700
VC	220100.732	-311187.200	232.776°	-188519.900
VN	5511.684	-9414.900	177.915°	-8368.800
IA	1288.983	1809.110	112.776°	-709.834
IB	1337.956	1883.684	352.996°	1883.684
IC	1311.446	-1856.084	230.437°	-1190.422
IN	14.713	-5.524	114.911°	-16.572

N	MAIN CB-RPH OPEN	N	A	02:33:13.993988		001
N	MAIN CB-YPH OPEN	N	A	02:33:13.993988		001
N	MAIN CB-BPH OPEN	N	A	02:33:13.995668		001
A	BUSBAR PROT OPTD	A	A			000
N	TIE CB-RPH OPEN	N	A	02:33:13.977208		001
N	TIE CB-YPH OPEN	N	A	02:33:13.977208		001
N	TIE CB-BPH OPEN	N	A	02:33:13.975530		001
N	Z1	N	N	02:33:13.945328	02:33:13.990632	002

30/07/12

RKBehera
30.07.12

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File: Monday 30 July 2012 02.33.13.000.DAT - 30/07/2012 - 02:33:13.945 - Secondary - (Peak Type) **Page: 1**

```
* File Information::
* ----------------
          Station: ROURKELA S.S
           Device: 7
        File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\JAMSHERDPUR#1\1\DR\Monday
        File Size: 244801 Bytes
     Prefault Time: 30/07/2012 02:33:13.749000
       Fault Time: 30/07/2012 02:33:13.945000
        Save Time: 07/30/2012 11:27:06
     Process Time: 07/30/2012 16:15:42
Start Date && Time: 30/07/2012 02:33:13.749000
  End Date && Time: 30/07/2012 02:33:15.259177
    File Duration: 1  Sec(s) - 510 Mils(s) - 177 Mics(s)
Sampling Frequency: 1191.895113, 839.000  Microsecond Rate
    Line Frequency: 50.000000
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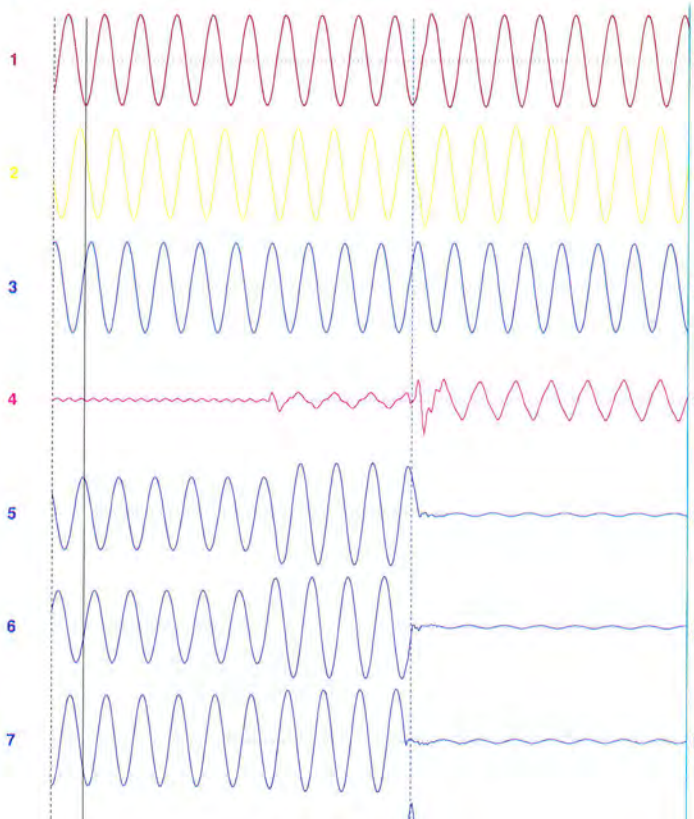
```
* Maximum/Minimum Analog Summary:
* ------------------------------
>  Max-Inst      Min-Inst       Max-RMS      Min-RMS     One-Bit    Inst-Diff     RMS-Diff   pUnits    Description
 339855.700   -308060.600    255304.813   120301.500    31.7000    31795.100   135003.313     V       1-VA
 353518.400   -395077.100    300737.906   184863.688    31.7000    41558.700   115874.219     V       2-VB
 359129.300   -311167.200    233469.188   114772.117    31.7000    47962.100   118697.070     V       3-VC
 317412.100   -272810.200    169091.391     4287.228    31.7000    44601.900   164804.163     V       4-VN
   2579.708     -2582.470      1831.752       53.167     2.7620        2.762     1778.585     A       5-IA
   2695.712     -2673.616      1928.823       53.441     2.7620       22.096     1875.382     A       6-IB
   2107.406     -2118.454      1499.416       53.161     2.7620       11.048     1446.255     A       7-IC
    640.784     -1615.770       710.228        2.033     2.7620      974.986      708.195     A       8-IN
```

```
* Events/Sensors Activity Summary:
* --------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N    02:33:13.993988  xx:xx:xx.xxxxxx   001          1-MAIN CB-RPH OPEN
  N    N    02:33:13.993988  xx:xx:xx.xxxxxx   001          2-MAIN CB-YPH OPEN
  N    N    02:33:13.995666  xx:xx:xx.xxxxxx   001          3-MAIN CB-BPH OPEN
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000         12-BUSBAR PROT OPTD
  N    N    02:33:13.977208  xx:xx:xx.xxxxxx   001         14-TIE CB-RPH OPEN
  N    N    02:33:13.977208  xx:xx:xx.xxxxxx   001         15-TIE CB-YPH OPEN
  N    N    02:33:13.975530  xx:xx:xx.xxxxxx   001         16-TIE CB-BPH OPEN
  N    N    02:33:13.945326  02:33:13.990632   002         18-Z1
```

Monday 30 July 2012 02.33.10.000.DAT - 30/07/2012 - 02:33:10.339 - Secondary - (Peak Type)

Exhibit 2.8 OR at Jamshedpur



CH	Title	RMS	InstPeak	Phase	InstVal	RefVal	MaxPeak
1	VA	207737.544	-303686.000	210.415°	-303686.000	-290562.200	315668.600
2	VB	222536.940	302418.000	89.499°	159926.500	115197.800	326763.600
3	VC	213153.423	-303147.100	326.477°	142903.600	168739.100	306570.700
4	VN	3889.177	5072.000	326.391°	-855.900	-6625.300	82293.200
5	IA	1258.726	1811.872	43.045°	1787.014	2002.450	2563.136
6	IB	1389.940	-1883.684	280.796°	-626.974	-472.302	2673.616
7	IC	1280.199	1845.016	156.182°	-1135.182	35.906	2101.882
8	IN	14.424	24.858	51.430°	24.858	1566.054	1759.394

1	N	MAIN-2 CARR RECV	N	N	02:33:10.338682	02:33:10.402671	002
2	A	M - CB RPH CLOSE	A	A			000
3	A	M - CB YPH CLOSE	A	A			000
4	A	M - CB BPH CLOSE	A	A			000
5	N	MAIN-1 CARR RECV	N	N			000
6	N	MAIN-1 OPTD	N	N			000
7	N	MAIN/TIE A/R OPT	N	N			000
8	N	0/V STAGE1/2OPTD	N	N			000
9	N	MAIN 2 /B U OPTD	N	N			000
10	N	DIRECT TRIP RECV	N	N			000
11	N	B/B PROT OPTD	N	N			000
12	N	LBB MAIN/TIE OPT	N	N			000
13	A	TIE CB RPH CLOSE	A	A			000
14	A	TIE CB YPH CLOSE	A	A			000
15	A	TIE CB BPH CLOSE	A	A			000
16	N	PREPARE 3PH TRIP	N	N			000
17	N	IN>1 Trip	N	N			000
18	N	Any Int. Trip B	N	N			000
19	N	Any Trip A	N	N			000
20	N	Any Trip B	N	N			000
21	N	Any Trip C	N	N			000
22	N	VTS Fast	N	N			000
23	N	Z1 Not Filtered	N	N			000
24	N	F<4 Trip	N	N			000
25	N	F>1 Start	N	N			000
26	N	V<3 Start C	N	N			000
27	N	PAP Start C	N	N			000
28	N	I2>4 Start	N	N			000
29	N	Z1	N	N			000
30	N	VN>1 Start	N	N			000

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ROURKELA-1 DT: 30/07/2012 02:33:10.156619 Dt: 182063 microsec - 9.10 Cyc 1191.8951 AS: ON

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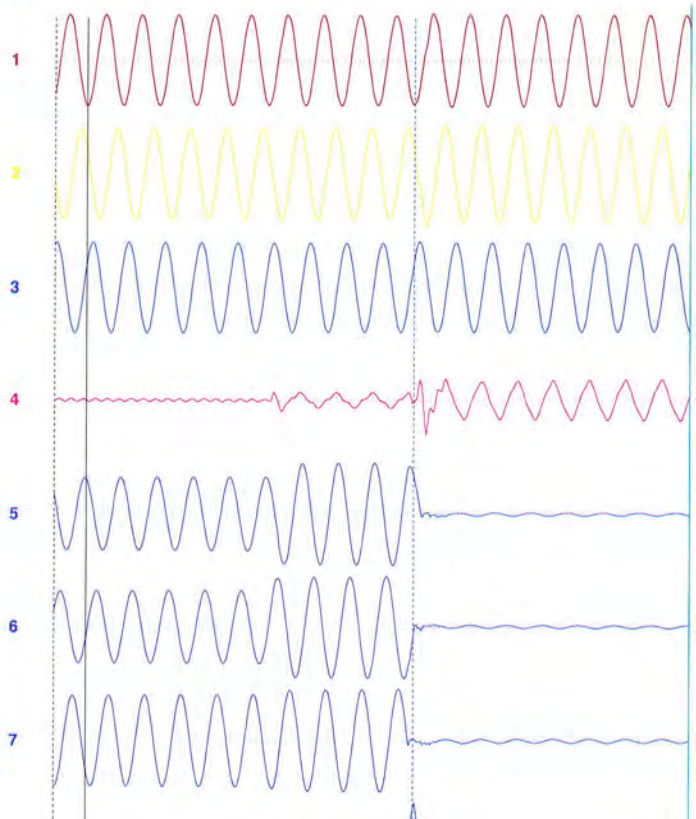
Monday 30 July 2012 02.33.10.000.DAT - 30/07/2012 - 02:33:10.339 - Secondary - (Peak Type) Exhibit 2.8 DR at Jamshedpur



CH	Title	RMS	InstPeak	Phase	InstVal	RefVal	MaxPeak
1	VA	207737.544	-303686.000	210.415°	-303686.000	-290562.200	315668.600
2	VB	222536.940	302418.000	89.499°	159926.500	115197.800	326763.600
3	VC	213153.423	-303147.100	326.477°	142903.600	168739.100	306570.700
4	VN	3889.177	5072.000	326.391°	-855.900	-6625.300	82293.200
5	IA	1258.726	1811.872	43.045°	1787.014	2002.450	2563.136
6	IB	1389.940	-1883.684	280.796°	-626.974	-472.302	2673.616
7	IC	1280.199	1845.016	156.182°	-1135.182	35.906	2101.882
8	IN	14.424	24.858	51.430°	24.858	1566.054	1759.394

1	N	MAIN-2 CARR RECV	N	N	02:33:10.338682	02:33:10.402671	002
2	A	M - CB RPH CLOSE	A	A			000
3	A	M - CB YPH CLOSE	A	A			000
4	A	M - CB BPH CLOSE	A	A			000
5	N	MAIN-1 CARR RECV	N	N			000
6	N	MAIN-1 OPTD	N	N			000
7	N	MAIN/TIE A/R OPT	N	N			000
8	N	0/V STAGE1/2OPTD	N	N			000
9	N	MAIN 2 /B U OPTD	N	N			000
10	N	DIRECT TRIP RECV	N	N			000
11	N	B/B PROT OPTD	N	N			000
12	N	LBB MAIN/TIE OPT	N	N			000
13	A	TIE CB RPH CLOSE	A	A			000
14	A	TIE CB YPH CLOSE	A	A			000
15	A	TIE CB BPH CLOSE	A	A			000
16	N	PREPARE 3PH TRIP	N	N			000
17	N	IN>1 Trip	N	N			000
18	N	Any Int. Trip B	N	N			000
19	N	Any Trip A	N	N			000
20	N	Any Trip B	N	N			000
21	N	Any Trip C	N	N			000
22	N	VTS Fast	N	N			000
23	N	Z1 Not Filtered	N	N			000
24	N	F<4 Trip	N	N			000
25	N	F>1 Start	N	N			000
26	N	V<3 Start C	N	N			000
27	N	PAP Start C	N	N			000
28	N	I2>4 Start	N	N			000
29	N	Z1	N	N			000
30	N	VN>1 Start	N	N			000

~~192~~

ROURKELA-1 DT: 30/07/2012 02:33:10.156619 Dt: 182063 microsec - 9.10 Cyc 1191.8951 AS: ON

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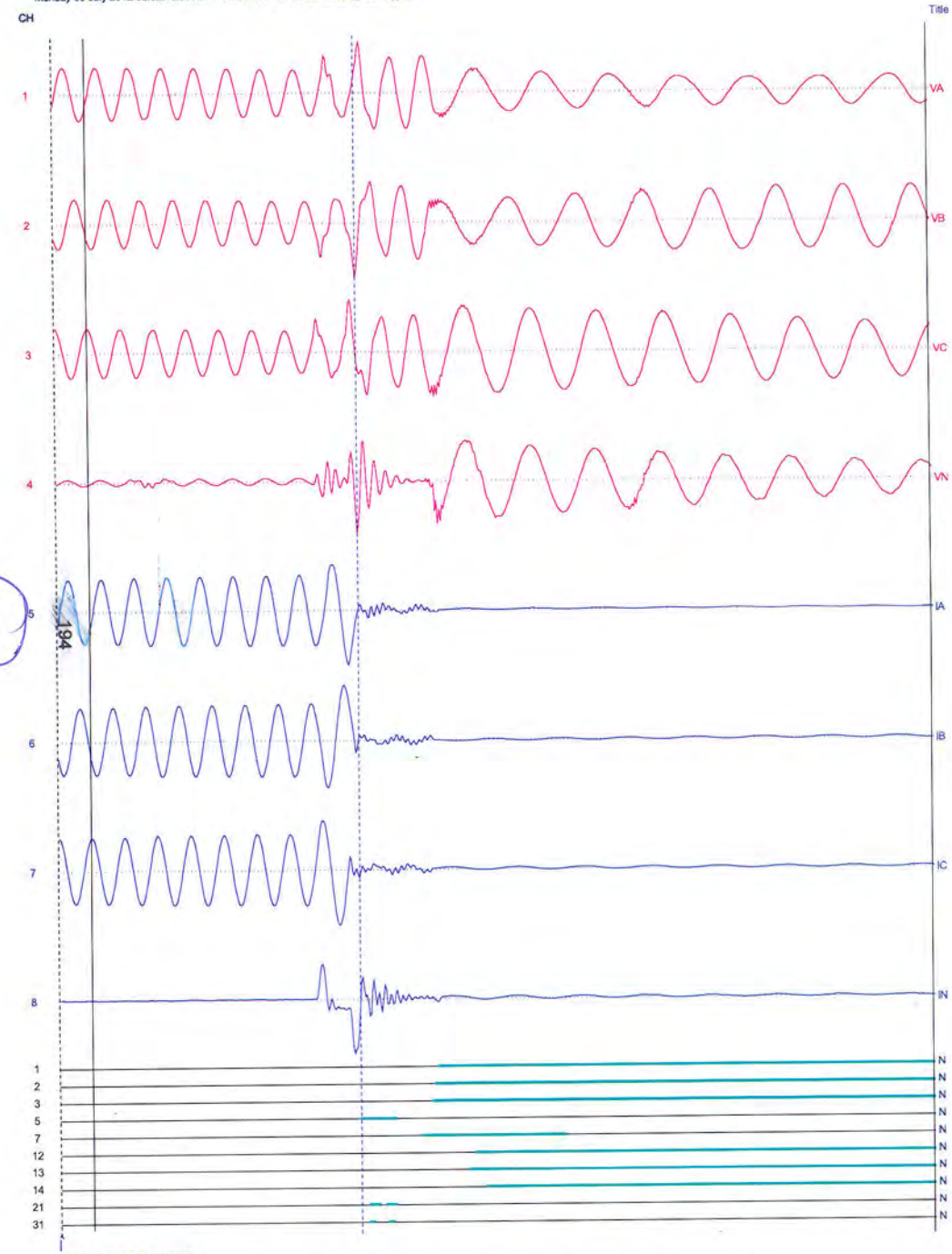
```
* File Information::
* ------------------
           Station: ROURKELA-1
            Device: 2
         File Name: C:\DOCUMENTS AND SETTINGS\CONTROLROOM\MY DOCUMENTS\S1 STUDIO\JAMSHEDPUR\ROURKELA-I\1\DR\Monday 30 July 2
         File Size: 244801 Bytes
     Prefault Time: 30/07/2012 02:33:10.139000
        Fault Time: 30/07/2012 02:33:10.339000
         Save Time: 08/01/2012 07:27:06
      Process Time: 08/01/2012 07:28:17
 Start Date && Time: 30/07/2012 02:33:10.139000
   End Date && Time: 30/07/2012 02:33:11.648889
     File Duration: 1  Sec(s) - 509 Mils(s) - 889 Mics(s)
 Sampling Frequency: 1191.895113, 839.000  Microsecond Rate
    Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst      Min-Inst       Max-RMS      Min-RMS     One-Bit    Inst-Diff     RMS-Diff   pUnits     Description
 315668.600   -313449.600    225387.000   133738.391    31.7000     2219.000    91648.609     V         1-VA
 326763.600   -345054.500    241538.547    68884.102    31.7000    18290.900   172654.445     V         2-VB
 306570.700   -303147.100    296976.813   187579.234    31.7000     3423.600   109397.578     V         3-VC
  82293.200   -115071.000     54698.418     2848.947    31.7000    32777.800    51849.471     V         4-VN
   2563.136     -2560.374      1821.575       48.873     2.7620        2.762     1772.702     A         5-IA
   2673.616     -2695.712      1914.945       48.983     2.7620       22.096     1865.962     A         6-IB
   2101.882     -2096.358      1839.492       47.459     2.7620        5.524     1792.033     A         7-IC
   1759.394      -643.546       739.677        4.434     2.7620     1115.848      735.243     A         8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N    02:33:10.338682  02:33:10.402671   002          1-MAIN-2 CARR RECV
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000          2-M - CB RPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000          3-M - CB YPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000          4-M - CB BPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000         13-TIE CB RPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000         14-TIE CB YPH CLOSE
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000         15-TIE CB BPH CLOSE
```

Monday 30 July 2012 02.32.16.000.DAT - 30/07/2012 - 02:32:16.521 (Peak Type)



CH	Title	RMS	InstPeak	Phase	InstVal	RefVal	MaxPeak	MinPeak	Units	PixsDisp	DFTPeak	Crest
1	VA	122946.934	-173367.300	333.130°	-73987.800	83783.100	332247.700	-236894.10	V	53	173857.121	1.414
2	VB	115573.536	-160085.000	215.713°	-97033.700	-357576.00	263110.000	-357576.00	V	53	163434.783	1.414
3	VC	114864.401	160243.500	92.296°	160243.500	-57630.600	335798.100	-289452.70	V	53	162434.393	1.414
4	VN	13952.544	-20129.500	323.675°	-10809.700	-331423.50	259718.100	-331423.50	V	53	19711.302	1.413
5	IA	2418.764	-3431.025	328.363°	-1779.050	71.825	4834.375	-5696.275	A	3286	3420.604	1.414
6	IB	2474.202	-3524.950	208.226°	-1679.600	276.250	5751.525	-4928.300	A	3286	3499.000	1.414
7	IC	2448.548	3475.225	87.237°	3475.225	-806.650	5143.775	-5762.575	A	3286	3462.732	1.414
8	IN	9.832	16.575	112.310°	16.575	-458.575	1779.050	-2779.075	A	6784	8.858	0.901

1	N	L1_MAIN_CB_OPN_R	N	A	02:32:16.568160		001
2	N	L2_MAIN CB OPN_Y	N	A	02:32:16.566480		001
3	N	L3_MAIN CB OPN B	N	A	02:32:16.564800		001
5	N	L5_M1_CRR_RECV	N	N	02:32:16.521120	02:32:16.542960	002
7	N	L6_DT_1-2 RECV	N	N	02:32:16.558080	02:32:16.645440	002
12	N	L11_TIE_R PH_OPN	N	A	02:32:16.590000		001
13	N	L12_TIE_Y PH_OPN	N	A	02:32:16.586640		001
14	N	L13_TIE_B PH_OPN	N	A	02:32:16.596720		001
21	N	Any Start	N	N	02:32:16.526160	02:32:16.542960	004
31	N	3ph Fault	N	N	02:32:16.526160	02:32:16.541280	004

30/07/2012 02:32:16.338000

MUZAF PUR D 30/07/ 02:32 158160 t 162 micro 8.1 1 0000 ON

Exhibit-29 EL at Gorakhpur

ABB

Monday, 30 July 2012

02:33:15.4	AA02-D5-25	+	MUZAFFARPUR 1 Main-1 three phase Protection optd.
02:33:15.4	AA02-D5-26	+	MUZAFFARPUR 1 Main-1 Distance protection optd.
02:33:15.4	AA02-D5-24	+	MUZAFFARPUR 1 Main-1 Carrier send
02:33:15.4	AA02-D6-01	+	MUZAFFARPUR 1 Main-1 Z2/Z3/Multi Ph Optd
02:33:15.4	AA02-D3-27	+	MUZAFFARPUR 2 Main-1 Distance protection optd
02:33:15.4	AA02-D3-25	+	MUZAFFARPUR 2 Main-1 Carrier send
02:33:15.4	AA02-D3-26	+	MUZAFFARPUR 2 Main-1 3-phase Protection optd
02:33:15.4	AA02-D7-03	-	MUZAFFARPUR 1 Main CB R Ph. Bkr. Close
02:33:15.4	AA02-D7-04	-	MUZAFFARPUR 1 Main CB Y Ph. Bkr. Close
02:33:15.4	AA02-D7-20	-	MUZAFFARPUR 1 Tie CB R Ph. Bkr. Close
02:33:15.4	AA02-D7-22	-	MUZAFFARPUR 1 Tie CB B Ph. Bkr. Close
02:33:15.4	AA02-D7-05	-	MUZAFFARPUR 1 Main CB B Ph. Bkr. Close
02:33:15.4	AA02-D7-21	-	MUZAFFARPUR 1 Tie CB Y Ph. Bkr. Close
02:33:15.4	AA02-D4-02	+	MUZAFFARPUR 2 Main-1 Z2/Z3/Multi Ph Optd
02:33:15.4	AA02-D5-22	-	MUZAFFARPUR 2 Tie CB Y Ph. Bkr. Close
02:33:15.4	AA02-D5-23	-	MUZAFFARPUR 2 Tie CB B Ph. Bkr. Close
02:33:15.4	AA02-D5-21	-	MUZAFFARPUR 2 Tie CB R Ph. Bkr. Close
02:33:15.4	AA02-D5-04	-	MUZAFFARPUR 2 Main CB R Ph. Bkr. Close
02:33:15.4	AA02-D5-05	-	MUZAFFARPUR 2 Main CB Y Ph. Bkr. Close
02:33:15.4	AA02-D5-06	-	MUZAFFARPUR 2 Main CB B Ph. Bkr. Close
02:33:15.4	AA02-D1-14	+	GORAKHPUR 2/ICT-3 Tie CB AC Fail
02:33:15.4	AA02-D4-31	+	MUZAFFARPUR 2 Direct Trip Send-1
02:33:15.4	AA02-D4-32	+	MUZAFFARPUR 2 Direct Trip Send-2
02:33:15.4	AA02-D4-31	-	MUZAFFARPUR 2 Direct Trip Send-1
02:33:15.4	AA02-D4-31	+	MUZAFFARPUR 2 Direct Trip Send-1
02:33:15.4	AA02-D6-22	+	MUZAFFARPUR 1 Autoreclose Lockout
02:33:15.4	AA02-D6-24	+	MUZAFFARPUR 1 Autoreclosed unsuccessful from Bkr.
02:33:15.4	AA01-D8-06	+	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	-	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	+	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	-	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	+	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	-	ICT-2 Normal supply failure
02:33:15.4	AA01-D8-06	+	ICT-2 Normal supply failure
02:33:15.4	AA02-D4-23	+	MUZAFFARPUR 2 Autoreclose Lockout
02:33:15.4	AA02-D4-25	+	MUZAFFARPUR 2 Autoreclosed unsuccessful from Bkr.
02:33:15.5	AA02-D5-25	-	MUZAFFARPUR 1 Main-1 three phase Protection optd.
02:33:15.5	AA02-D5-26	-	MUZAFFARPUR 1 Main-1 Distance protection optd.
02:33:15.5	AA02-D6-01	-	MUZAFFARPUR 1 Main-1 Z2/Z3/Multi Ph Optd
02:33:15.5	AA02-D5-24	-	MUZAFFARPUR 1 Main-1 Carrier send
02:33:15.5	AA02-D3-26	-	MUZAFFARPUR 2 Main-1 3-phase Protection optd
02:33:15.5	AA02-D3-27	-	MUZAFFARPUR 2 Main-1 Distance protection optd
02:33:15.5	AA02-D4-02	-	MUZAFFARPUR 2 Main-1 Z2/Z3/Multi Ph Optd
02:33:15.5	AA02-D4-31	-	MUZAFFARPUR 2 Direct Trip Send-1
02:33:15.5	AA02-D4-32	-	MUZAFFARPUR 2 Direct Trip Send-2
02:33:15.5	AA02-D3-25	-	MUZAFFARPUR 2 Main-1 Carrier send
02:33:15.5	AA02-D1-14	-	GORAKHPUR 2/ICT-3 Tie CB AC Fail
02:33:15.9	AA02-D6-24	-	MUZAFFARPUR 1 Autoreclosed unsuccessful from Bkr.
02:33:15.9	AA02-D6-22	-	MUZAFFARPUR 1 Autoreclose Lockout
02:33:15.9	AA02-D4-25	-	MUZAFFARPUR 2 Autoreclosed unsuccessful from Bkr.
02:33:15.9	AA02-D4-23	-	MUZAFFARPUR 2 Autoreclose Lockout
02:33:16.7	AA02-D4-26	+	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:16.7	AA02-D4-26	-	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:16.8	AA02-D4-26	+	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:20.7	AA02-D4-26	-	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:20.7	AA02-D4-26	+	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:20.8	AA02-D4-26	-	MUZAFFARPUR 2 Main CB Trouble Alarm
02:33:27.0	AA01-D3-14	+	LUCKNOW 2/ICT-1 Tie CB AC Fail
02:33:27.4	AA02-D1-14	+	GORAKHPUR 2/ICT-3 Tie CB AC Fail
02:33:27.9	AA01-D3-14	-	LUCKNOW 2/ICT-1 Tie CB AC Fail
02:33:28.2	AA01-D3-14	+	LUCKNOW 2/ICT-1 Tie CB AC Fail

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Monday 30 July 2012 02.33.15.000.DAT - 30/07/2012 - 02:33:15.397 (Peak Type)

Exhibit-2 DR at Muzaffarpur

CH	Title	RMS	InstPeak	Phase	InstVal	RefVal	MaxPeak	MinPeak	Units	PixsDisp	DFTPeak	Crest
1	VA	125307.594	-176093.500	296.000°	-157295.40	80581.400	378276.100	-380209.80	V	64	177201.291	1.414
2	VB	118837.454	167090.700	178.293°	3233.400	-177298.10	384457.600	-384774.60	V	64	168051.227	1.414
3	VC	116416.246	162082.100	56.128°	136690.400	58835.200	386169.400	-373489.40	V	64	164631.308	1.414
4	VN	12477.445	-18132.400	274.761°	-17371.600	-37913.200	271605.600	-311547.60	V	64	17626.254	1.413
5	IA	2413.280	-3397.875	291.478°	-3165.825	718.250	3740.425	-3718.325	A	6592	3412.853	1.414
6	IB	2443.858	3447.600	170.938°	530.400	469.625	3806.725	-3795.675	A	6464	3456.083	1.414
7	IC	2423.419	3431.025	50.715°	2674.100	-392.275	3734.900	-3768.050	A	6528	3427.163	1.414
8	IN	17.508	38.675	76.026°	38.675	795.600	1165.775	-2668.575	A	9216	23.597	1.348

5	N	L5_M1_CRR_RECV	N	N	02.33.15.397480	02.33.15.498280	002	
18	A	L17_REACTR-PROTN	A	A			000	

MUZAFARPUR DT: 30/07/2012 02:33:15.231160 Dt: 165480 microsec = 8.27 Cyc 1190.0000 AS: ON

Exhibit-211: DR at Biharshariff

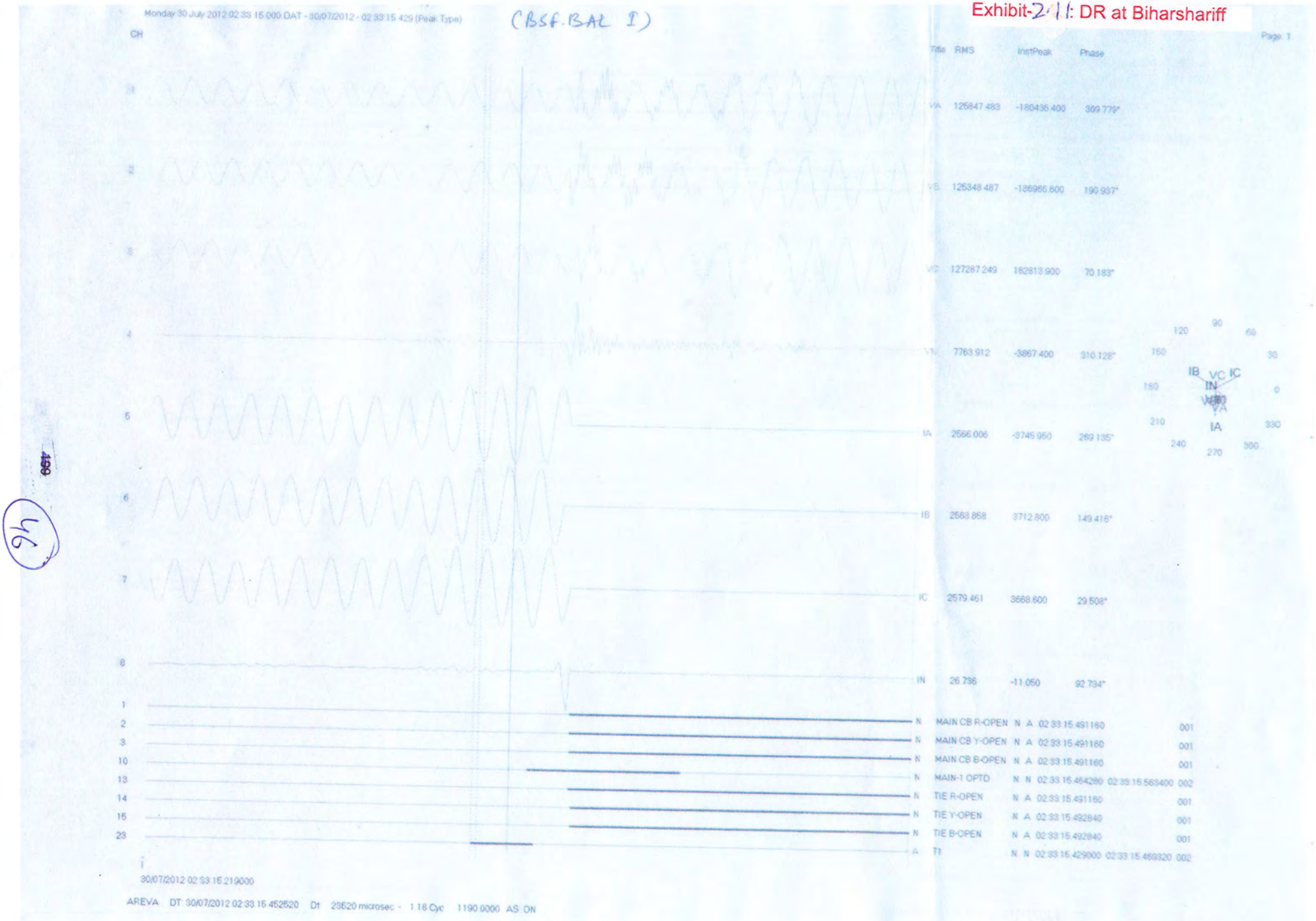

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Exhibit-21: DR at Biharshariff

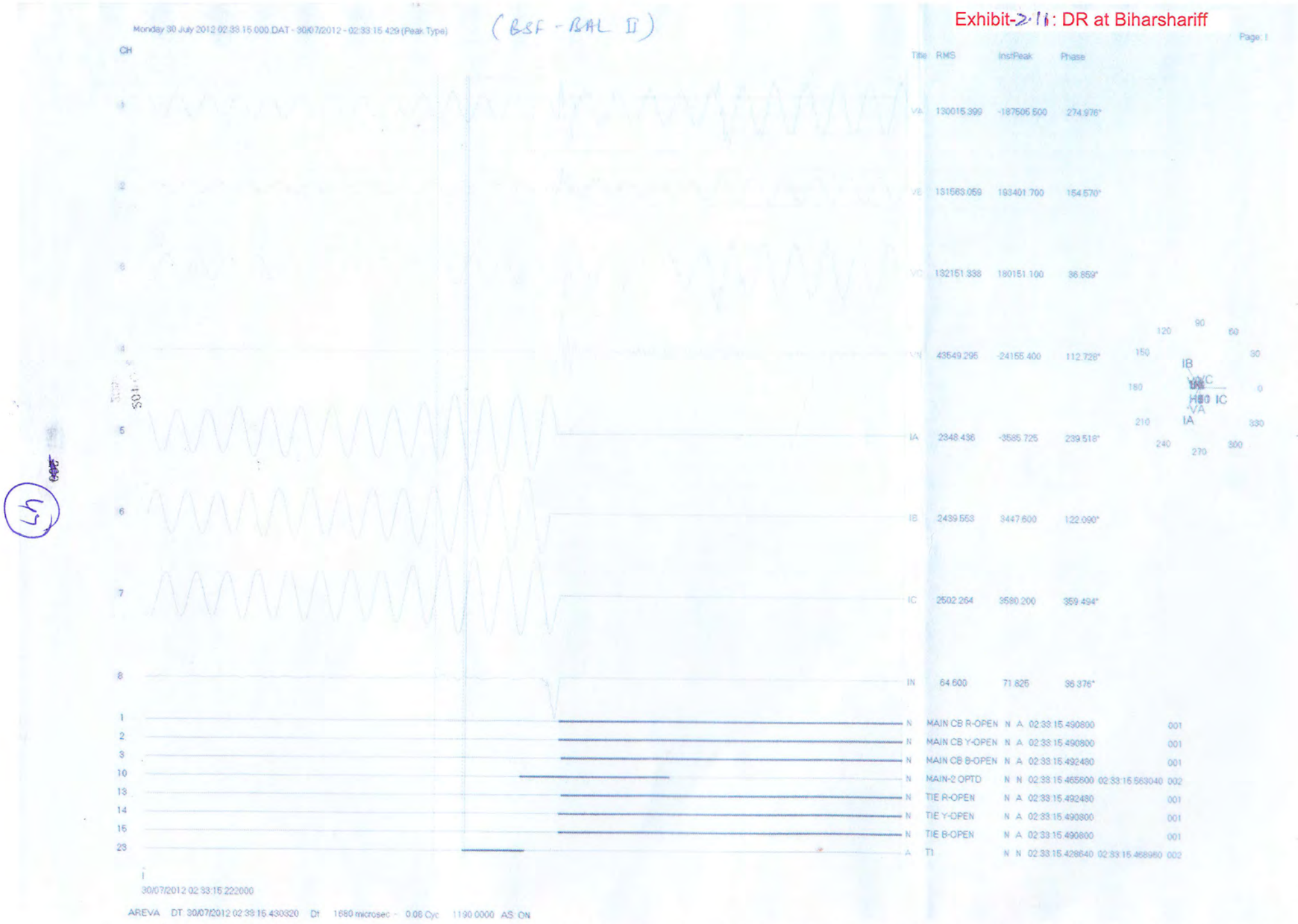

Exhibit-2.12EL at Biharshariff

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Historical Events for 7/30/12 02:00:00 to 7/30/12 03:00:00
# 1
Points included: All

                    ****************** Events on 7/30/12 ***************
***
01:N 02:01:21.687 #  599 400KV CB 1952 COMPRESSOR START
01:30 Jul 12 02:05:06
01: A02:08:15.035 #  132 400 KV KHG-III CARR PROTN CH-I FAIL/OUT OF SE
RVICE
01:N 02:18:34.133 #  132 400 KV KHG-III CARR PROTN CH-I FAIL/OUT OF SE
RVICE
01: A02:33:14.808 #  242 BSF-BALIA # 2 MAIN-II PSB ALARM
01: A02:33:14.810 #   93 BSF-BALIA # 1 MAIN-II PSB ALARM
01: A02:33:14.914 #  147 400 KV KHG-BSF III CAR-I/II RECD FOR MAIN-II
01: A02:33:15.025 #  362 400KV ICT-2 TROUBLE ALARM
01:N 02:33:15.034 #  147 400 KV KHG-BSF III CAR-I/II RECD FOR MAIN-II
01: A02:33:15.268 #  335 400KV CB 1352 TROUBLE ALARM
01: A02:33:15.271 #  312 400KV CB 952 TROUBLE ALARM
01: A02:33:15.293 #  442 400KV CB 1452 TROUBLE ALARM
01: A02:33:15.294 #  398 400KV CB 1952 TROUBLE ALARM
01: A02:33:15.294 #  346 400KV CB 852 TROUBLE ALARM
01: A02:33:15.296 #  449 400KV CB 1552 TROUBLE ALARM
01:N 02:33:15.307 #  312 400KV CB 952 TROUBLE ALARM
01: A02:33:15.313 #  433 400KV CB 2052 TROUBLE ALARM
01: A02:33:15.345 #  261 400KV CB 1852 TROUBLE ALARM
01: A02:33:15.353 #  312 400KV CB 952 TROUBLE ALARM
01: A02:33:15.369 #  353 400KV CB 2352 TROUBLE ALARM
01: A02:33:15.414 #  294 400KV CB 1752 TROUBLE ALARM
01: A02:33:15.430 #  391 400KV CB 2152 TROUBLE ALARM
01: A02:33:15.468 #  105 BSF-BALIA # 1 MAIN-II Y-PH START
01: A02:33:15.470 #  246 BSF-BALIA # 2 MAIN-II R-PH TRIP
01: A02:33:15.472 #  111 BSF-BALIA # 1 MAIN-II B-PH START
01: A02:33:15.473 #  247 BSF-BALIA # 2 MAIN-II Y-PH TRIP
01: A02:33:15.473 #  248 BSF-BALIA # 2 MAIN-II B-PH TRIP.
01: A02:33:15.473 #   95 BSF-BALIA # 1 MAIN-II R-PH START
01: A02:33:15.475 #  228 BSF-BALIA # 2 MAIN-II CARRIER SEND
01: A02:33:15.475 #   92 BSF-BALIA # 2 MAIN-II OPTD.
01: A02:33:15.476 #  159 BSF-BALIA # 1 MAIN CB B-PH OPEN
01: A02:33:15.476 #   78 BSF-BALIA # 1 MAIN-II CARRIER SEND
01: A02:33:15.476 #    1 BSF-BALIA # 1 TIE CB (552) R-PH OPEN
01: A02:33:15.476 #    2 BSF-BALIA # 1 TIE CB (552) Y-PH OPEN
01: A02:33:15.477 #  127 BSF-BALIA # 1 MAIN CB R-PH OPEN
01: A02:33:15.477 #  128 BSF-BALIA # 1 MAIN CB Y-PH OPEN
01: A02:33:15.477 #    6 BSF-BALIA # 1 TIE CB (552) B-PH OPEN
01: A02:33:15.478 #  241 BSF-BALIA # 2 MAIN-II RELAY OPTD.
01: A02:33:15.481 #  483 BSF-BALIA # 2 MAIN CB A/R L/O
01: A02:33:15.484 #  484 BSF-BALIA # 2 MAIN CB R-PH OPEN
01: A02:33:15.485 #  485 BSF-BALIA # 2 MAIN CB Y-PH OPEN
01: A02:33:15.485 #  486 BSF-BALIA # 2 MAIN CB B-PH OPEN
01:N 02:33:15.494 #  335 400KV CB 1352 TROUBLE ALARM
01: A02:33:15.499 #  126 BSF-BALIA # 1 MAIN CB A/R L/O
01:N 02:33:15.504 #  346 400KV CB 852 TROUBLE ALARM
01:N 02:33:15.510 #  353 400KV CB 2352 TROUBLE ALARM
01:N 02:33:15.513 #  312 400KV CB 952 TROUBLE ALARM
01:N 02:33:15.514 #  433 400KV CB 2052 TROUBLE ALARM
01:N 02:33:15.514 #  442 400KV CB 1452 TROUBLE ALARM
01: A02:33:15.515 #  348 400KV CB 852 A/R L/O
01:N 02:33:15.517 #  449 400KV CB 1552 TROUBLE ALARM
01:N 02:33:15.520 #  261 400KV CB 1852 TROUBLE ALARM
01:N 02:33:15.520 #  294 400KV CB 1752 TROUBLE ALARM
01:N 02:33:15.521 #  391 400KV CB 2152 TROUBLE ALARM
01:N 02:33:15.522 #  398 400KV CB 1952 TROUBLE ALARM


Historical Events for 7/30/12 02:00:00 to 7/30/12 03:00:00           Pa
# 2
Points included: All
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(48)

********** Events on 7/30/12 **********

***

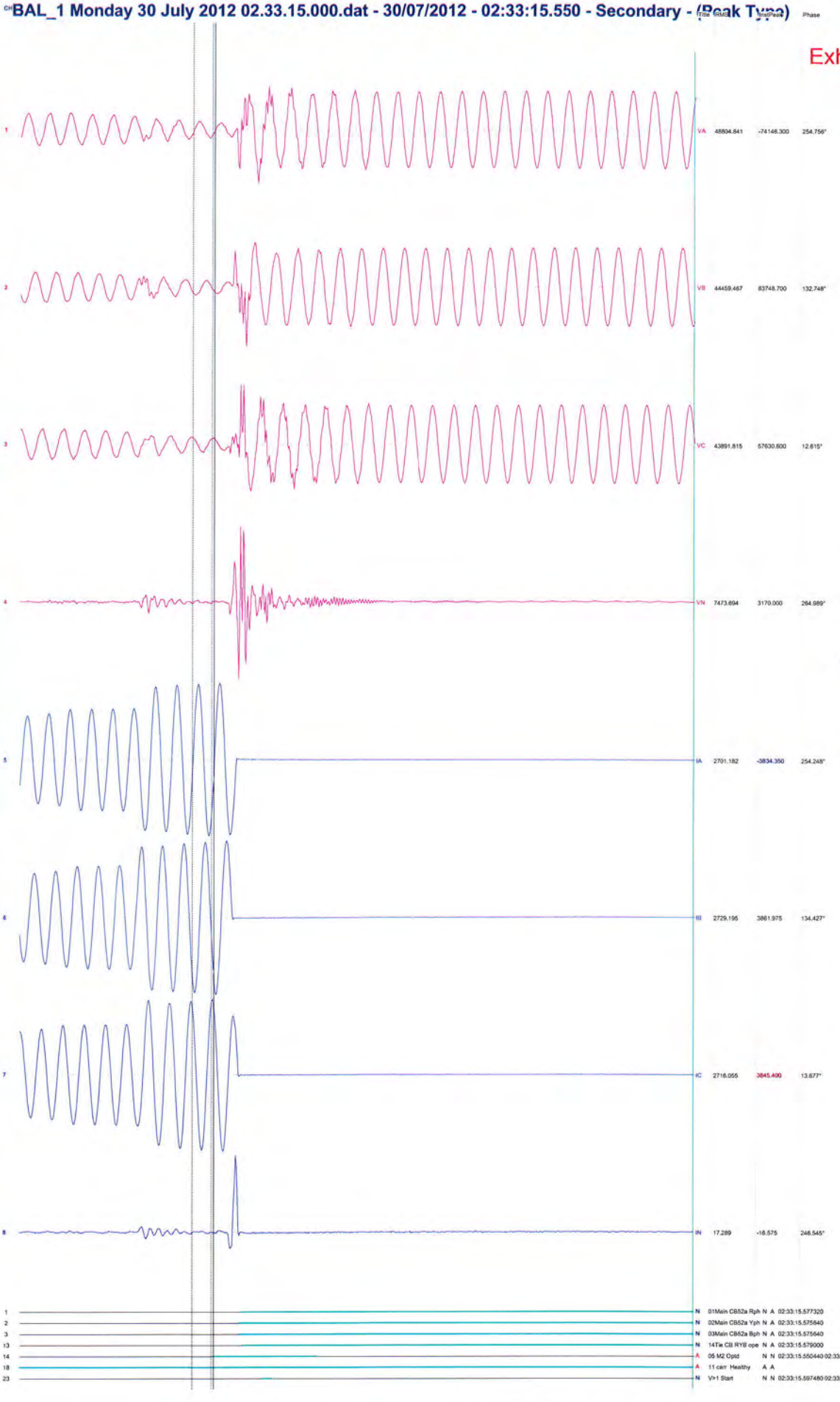
01:N 02:33:15.557 # 92 BSF-BALIA # 2 MAIN-II OPTD.
01:N 02:33:15.558 # 241 BSF-BALIA # 2 MAIN-II RELAY OPTD.
01:N 02:33:15.558 # 95 BSF-BALIA # 1 MAIN-II R-PH START
01:N 02:33:15.559 # 362 400KV TCT-2 TROUBLE ALARM
01:N 02:33:15.559 # 247 BSF-BALIA # 2 MAIN-II Y-PH TRIP
01:N 02:33:15.559 # 248 BSF-BALIA # 2 MAIN-II B-PH TRIP.
01:N 02:33:15.559 # 105 BSF-BALIA # 1 MAIN-II Y-PH START
01:N 02:33:15.559 # 111 BSF-BALIA # 1 MAIN-II B-PH START
01:N 02:33:15.561 # 246 BSF-BALIA # 2 MAIN-II R-PH TRIP
01:N 02:33:15.578 # 78 BSF-BALIA # 1 MAIN-II CARRIER SEND
01:N 02:33:15.579 # 228 BSF-BALIA # 2 MAIN-II CARRIER SEND
01:N 02:33:15.583 # 242 BSF-BALIA # 2 MAIN-II PSB ALARM
01: A02:33:16.040 # 43 ICT-3 HYDRANT ALARM-2
01:N 02:33:20.587 # 93 BSF-BALIA # 1 MAIN-II PSB ALARM
01: A02:33:20.645 # 164 400 KV KHG-BSF CKT.-III DT-I/II RECEIVED
01: A02:33:20.652 # 226 400 KV BSF-KHG CKT.-IV DT-I/II RECEIVED
01: A02:33:20.658 # 232 400 KV KHG-IV-TIE-KHG-III GR.B 3-PHASE TRIP
01: A02:33:20.666 # 234 400 KV KHG-BSF-IV GR.B 3-PHASE TRIP
01: A02:33:20.666 # 231 400 KV KHG-IV-TIE-KHG-III GR.A 3-PHASE TRIP
01: A02:33:20.667 # 233 400 KV KHG-BSF-IV GR.A 3-PHASE TRIP
01: A02:33:20.673 # 172 400 KV KHG-BSF-III GR.B 3-PHASE PROTECTION TR

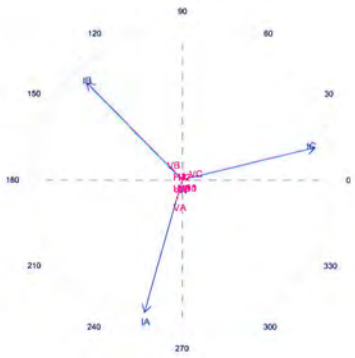
IP

01: A02:33:20.680 # 73 BSF-KHG # 3 & 4 TIE CB (2952) R-PH OPEN
01: A02:33:20.680 # 74 BSF-KHG # 3 & 4 TIE CB (2952) Y-PH OPEN
01: A02:33:20.680 # 75 BSF-KHG # 3 & 4 TIE CB (2952) B-PH OPEN
01: A02:33:20.687 # 117 400 KV CB 2852 Y-PH OPEN
01: A02:33:20.687 # 118 400 KV CB 2852 B-PH OPEN
01: A02:33:20.688 # 116 400 KV CB 2852 R-PH OPEN
01: A02:33:20.695 # 66 BSF-KHG # 3 MAIN CB (3052) R-PH OPEN
01: A02:33:20.695 # 67 BSF-KHG # 3 MAIN CB (3052) Y-PH OPEN
01: A02:33:20.695 # 68 BSF-KHG # 3 MAIN CB (3052) B-PH OPEN
01: A02:33:20.775 # 167 400 KV CB 3052 COMPRESSOR START
01:N 02:33:20.778 # 168 400 KV CB 3052 COMPRESSOR STOP
01:N 02:33:20.875 # 226 400 KV BSF-KHG CKT.-IV DT-I/II RECEIVED
01:N 02:33:20.880 # 164 400 KV KHG-BSF CKT.-III DT-I/II RECEIVED
01:N 02:40:29.158 # 167 400 KV CB 3052 COMPRESSOR START
01: A02:40:29.160 # 168 400 KV CB 3052 COMPRESSOR STOP

Exhibit- 213 DR at Patna

CHBAL_1 Monday 30 July 2012 02.33.15.000.dat - 30/07/2012 - 02:33:15.550 - Secondary - (Peak Type)





PATNA S/Stn DT: 30/07/2012 02:33:15.551280 Dt: 1680 microsec - 0.08 Cyc 1190.4762 AS: ON

50

```
* File Information::
* ------------------
            Station: PATNA S/Stn
             Device: 1
          File Name: C:\DOCUMENTS AND SETTINGS\ADMINISTRATOR\MY DOCUMENTS\S1 STUDIO\ERTS-1 (PATNA SS)\PATNA SS\400 KV\P442-BALIA
          File Size: 241537 Bytes
      Prefault Time: 30/07/2012 02:33:15.369000
         Fault Time: 30/07/2012 02:33:15.550000
          Save Time: 07/30/2012 03:20:52
       Process Time: 07/30/2012 12:52:02
 Start Date && Time: 30/07/2012 02:33:15.369000
   End Date && Time: 30/07/2012 02:33:16.874016
      File Duration: 1  Sec(s) - 505 Mils(s) - 16 Mics(s)
 Sampling Frequency: 1190.476190, 840.000  Microsecond Rate
     Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst      Min-Inst       Max-RMS      Min-RMS     One-Bit    Inst-Diff     RMS-Diff   pUnits     Description
 384742.900   -473661.400    251419.578   41038.680    31.7000    88918.500   210380.898     V         1-VA
 398627.500   -523842.500    269118.219   36358.766    31.7000   125215.000   232759.453     V         2-VB
 532750.200   -412670.600    283442.719   38182.680    31.7000   120079.600   245260.039     V         3-VC
 663195.700   -683388.600    326984.656      95.100    31.7000    20192.900   326889.556     V         4-VN
   3861.975     -3834.350      2727.123       2.256     5.5250       27.625     2724.868     A         5-IA
   3917.225     -3911.700      2764.808       3.190     5.5250        5.525     2761.618     A         6-IB
   3845.400     -3884.075      2734.631       2.984     5.5250       38.675     2731.648     A         7-IC
   1961.375      -414.375       676.837       5.525     5.5250     1547.000      671.312     A         8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N    02:33:15.577320  xx:xx:xx.xxxxxx   001          1-01Main CB52a Rph
  N    N    02:33:15.575640  xx:xx:xx.xxxxxx   001          2-02Main CB52a Yph
  N    N    02:33:15.575640  xx:xx:xx.xxxxxx   001          3-03Main CB52a Bph
  N    N    02:33:15.579000  xx:xx:xx.xxxxxx   001         13-14Tie CB RYB ope
  N    N    02:33:15.550440  02:33:15.649560   002         14-05 M2 Optd
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx   000         18-11 carr  Healthy
  N    N    02:33:15.597480  02:33:15.607560   002         23-V>1 Start
```

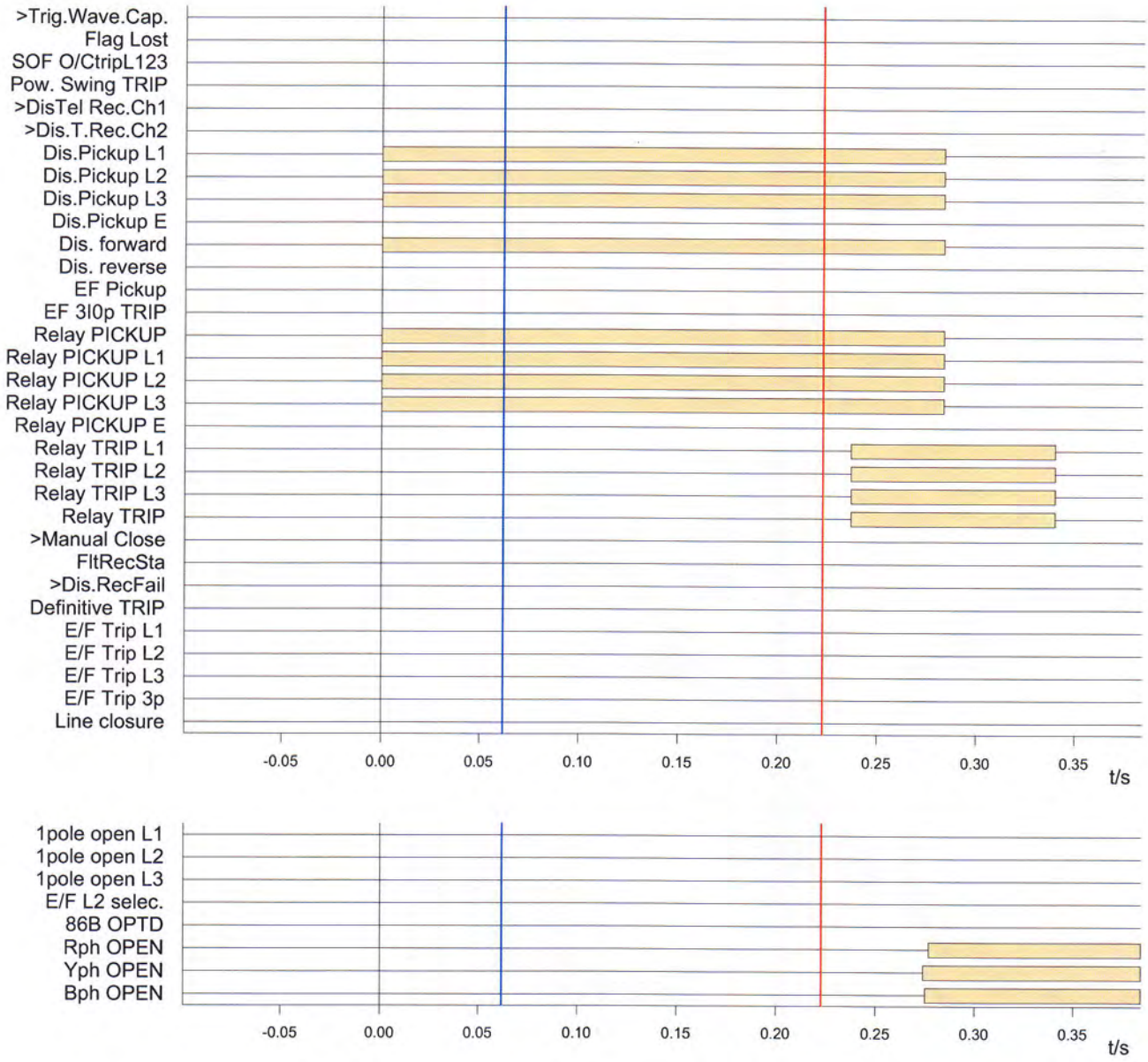

>Trig.Wave.Cap.
Flag Lost
SOF O/CtripL123
Pow. Swing TRIP
>DisTel Rec.Ch1
>Dis.T.Rec.Ch2
Dis.Pickup L1
Dis.Pickup L2
Dis.Pickup L3
Dis.Pickup E
Dis. forward
Dis. reverse
EF Pickup
EF 3I0p TRIP
Relay PICKUP
Relay PICKUP L1
Relay PICKUP L2
Relay PICKUP L3
Relay PICKUP E
Relay TRIP L1
Relay TRIP L2
Relay TRIP L3
Relay TRIP
>Manual Close
FltRecSta
>Dis.RecFail
Definitive TRIP
E/F Trip L1
E/F Trip L2
E/F Trip L3
E/F Trip 3p
Line closure
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
t/s
1pole open L1
1pole open L2
1pole open L3
E/F L2 selec.
86B OPTD
Rph OPEN
Yph OPEN
Bph OPEN
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
t/s

Exhibit-214 EL at Patna

Events Report

Print Date Time: 30-July-2012 9:29

S	Date	Origin	Name	State
	7/30/2012 02:33:15:538 AM	ERTS-I PATNA S/S/400kV/BALIA1-7SA52/PROTECTION	21M2-ZONE1	OPERATED
	7/30/2012 02:33:15:538 AM	ERTS-I PATNA S/S/400kV/BALIA1-7SA52/PROTECTION	PTRC_TRIP	OPERATED
	7/30/2012 02:33:15:538 AM	ERTS-I PATNA S/S/400kV/BALIA1-7SA52/PROTECTION	21M2-R-PH	OPERATED
	7/30/2012 02:33:15:538 AM	ERTS-I PATNA S/S/400kV/BALIA1-7SA52/PROTECTION	21M2-Y-PH	OPERATED
	7/30/2012 02:33:15:538 AM	ERTS-I PATNA S/S/400kV/BALIA1-7SA52/PROTECTION	21M2-B-PH	OPERATED
	7/30/2012 02:33:15:541 AM	ERTS-I PATNA S/S/400kV/BALIA2-7SA52/PROTECTION	21M2-ZONE1	OPERATED
	7/30/2012 02:33:15:542 AM	ERTS-I PATNA S/S/400kV/BALIA2-7SA52/PROTECTION	PTRC_TRIP	OPERATED
	7/30/2012 02:33:15:542 AM	ERTS-I PATNA S/S/400kV/BALIA2-7SA52/PROTECTION	21M2-R-PH	OPERATED
	7/30/2012 02:33:15:542 AM	ERTS-I PATNA S/S/400kV/BALIA2-7SA52/PROTECTION	21M2-Y-PH	OPERATED
	7/30/2012 02:33:15:542 AM	ERTS-I PATNA S/S/400kV/BALIA2-7SA52/PROTECTION	21M2-B-PH	OPERATED
	7/30/2012 02:33:15:550 AM	ERTS-I PATNA S/S/400kV/BAL1-P442-21M1/SYSTEM	MAIN2 DIST_PROT	OPERATED
	7/30/2012 02:33:15:551 AM	ERTS-I PATNA S/S/400kV/BRH1-P442-21R/SYSTEM	CVT FUSE FAIL	HEALTHY
	7/30/2012 02:33:15:556 AM	ERTS-I PATNA S/S/400kV/BAL2-P442-21M1/SYSTEM	MAIN2 DIST_PROT	OPERATED
	7/30/2012 02:33:15:566 AM	ERTS-I PATNA S/S/400kV/BALIA1-TIE-BRH2/CB 4-1452	PHASE R POSITION	OPEN
	7/30/2012 02:33:15:566 AM	ERTS-I PATNA S/S/400kV/BALIA1-TIE-BRH2/CB 4-1452	PHASE Y POSITION	OPEN
	7/30/2012 02:33:15:566 AM	ERTS-I PATNA S/S/400kV/BALIA1-TIE-BRH2/CB 4-1452	PHASE B POSITION	OPEN
	7/30/2012 02:33:15:566 AM	ERTS-I PATNA S/S/400kV/BALIA1-TIE-BRH2/CB 4-1452	POSITION	OPEN
	7/30/2012 02:33:15:567 AM	ERTS-I PATNA S/S/400kV/BALIA-1/CB 4-1352	PHASE Y POSITION	OPEN
	7/30/2012 02:33:15:567 AM	ERTS-I PATNA S/S/400kV/BALIA-2/CB 4-1652	PHASE R POSITION	OPEN
	7/30/2012 02:33:15:567 AM	ERTS-I PATNA S/S/400kV/BALIA-2/CB 4-1652	PHASE B POSITION	OPEN
	7/30/2012 02:33:15:568 AM	ERTS-I PATNA S/S/400kV/BALIA-2/CB 4-1652	POSITION	OPEN

53

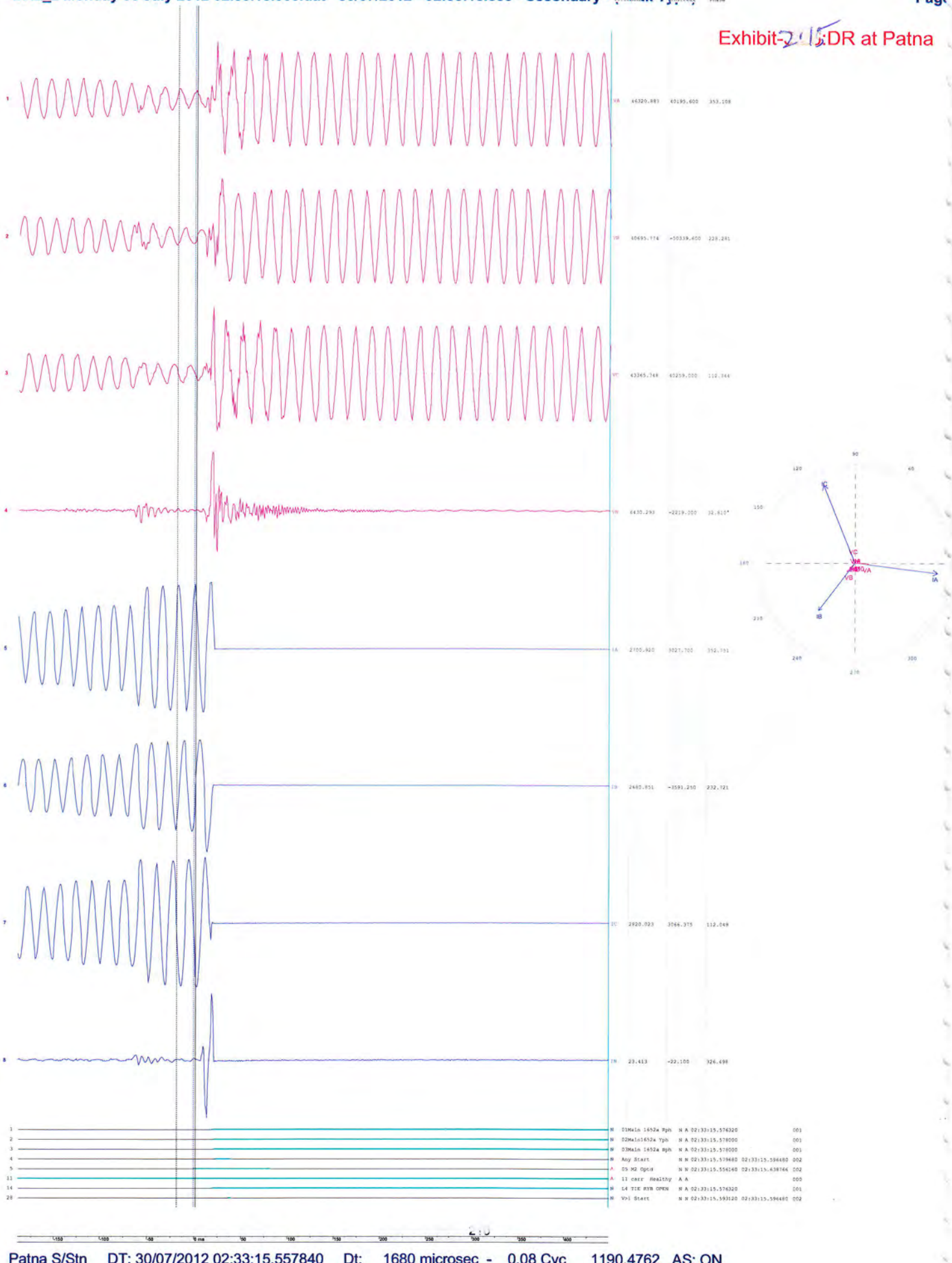
Events Report

Print Date/Time: 30-July-2012 9:29

S	Date	Origin	Name	State
	7/30/2012 02:33:15:568 AM	ERTS-I PATNA S/S 400kV BALIA-1 CB 4-1352	PHASE R POSITION	OPEN
	7/30/2012 02:33:15:568 AM	ERTS-I PATNA S/S 400kV BALIA-1 CB 4-1352	PHASE B POSITION	OPEN
	7/30/2012 02:33:15:568 AM	ERTS-I PATNA S/S 400kV BALIA-2 CB 4-1652	PHASE Y POSITION	OPEN
	7/30/2012 02:33:15:568 AM	ERTS-I PATNA S/S 400kV BALIA-2 CB 4-1652	POSITION	OPEN
	7/30/2012 02:33:15:569 AM	ERTS-I PATNA S/S 400kV BALIA2-TIE-BRH1 CB 4-1752	PHASE Y POSITION	OPEN
	7/30/2012 02:33:15:570 AM	ERTS-I PATNA S/S 400kV BALIA2-TIE-BRH1 CB 4-1752	PHASE R POSITION	OPEN
	7/30/2012 02:33:15:576 AM	ERTS-I PATNA S/S 400kV BALIA2-TIE-BRH1 CB 4-1752	PHASE B POSITION	OPEN
	7/30/2012 02:33:15:576 AM	ERTS-I PATNA S/S 400kV BALIA2-TIE-BRH1 CB 4-1752	POSITION	OPEN
	7/30/2012 02:33:15:577 AM	ERTS-I PATNA S/S 400kV BALIA2-TIE-BRH1 PROTECTION	186 LO RELAY OPR	OPERATED
	7/30/2012 02:33:15:578 AM	ERTS-I PATNA S/S 400kV BALIA-2 PROTECTION	A/R LO RELAY	OPERATED
	7/30/2012 02:33:15:579 AM	ERTS-I PATNA S/S 400kV BAL2-P442-21M1 SYSTEM	TIE CB R Y B OPEN	OPERATED
	7/30/2012 02:33:15:581 AM	ERTS-I PATNA S/S 400kV BALIA1-TIE-BRH2 PROTECTION	186 LO RELAY OPR	OPERATED
	7/30/2012 02:33:15:583 AM	ERTS-I PATNA S/S 400kV BALIA-1 PROTECTION	A/R LO RELAY	OPERATED
	7/30/2012 02:33:15:640 AM	ERTS-I PATNA S/S 400kV BALIA1-7SA52 PROTECTION	21M2-/ZONE1	NORMAL
	7/30/2012 02:33:15:640 AM	ERTS-I PATNA S/S 400kV BALIA1-7SA52 PROTECTION	PTRC TRIP	NORMAL
	7/30/2012 02:33:15:640 AM	ERTS-I PATNA S/S 400kV BALIA1-7SA52 PROTECTION	21M2-R-PH	NORMAL
	7/30/2012 02:33:15:640 AM	ERTS-I PATNA S/S 400kV BALIA1-7SA52 PROTECTION	21M2-Y-PH	NORMAL
	7/30/2012 02:33:15:640 AM	ERTS-I PATNA S/S 400kV BALIA1-7SA52 PROTECTION	21M2-B-PH	NORMAL
	7/30/2012 02:33:15:641 AM	ERTS-I PATNA S/S 400kV BALIA2-7SA52 PROTECTION	21M2-/ZONE1	NORMAL
	7/30/2012 02:33:15:641 AM	ERTS-I PATNA S/S 400kV BALIA2-7SA52 PROTECTION	PTRC TRIP	NORMAL
	7/30/2012 02:33:15:641 AM	ERTS-I PATNA S/S 400kV BALIA2-7SA52 PROTECTION	21M2-R-PH	NORMAL

Exhibit-215 DR at Patna

BAL_2 Monday 30 July 2012 02.33.15.000.dat - 30/07/2012 - 02:33:15.556 - Secondary - (Peak Type)

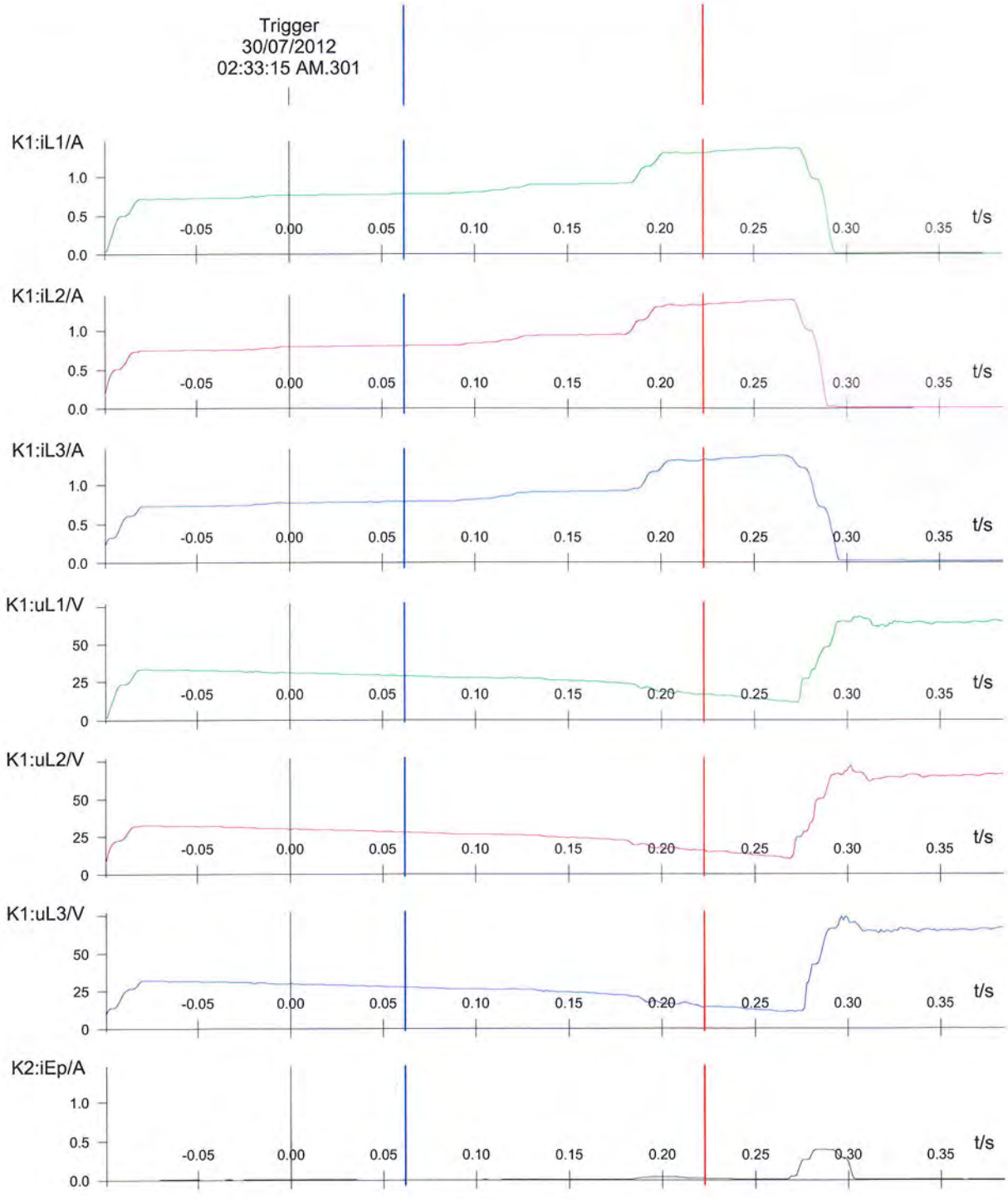


Patna S/Stn DT: 30/07/2012 02:33:15.557840 Dt: 1680 microsec - 0.08 Cyc 1190.4762 AS: ON

Exhibit-215 DR at Patna

Name: PGCIL PATNA / 400KV FEEDERS BALIA - I BALIA1 FINAL
Filename: C:\SIEMENS\DIGSI4\D4PROJ\PGCIL_~1\P7DI\GV\SD\0000001E\SAMPLES\FAULT\FR000046
Fault start: 30/07/2012 02:33:15 AM.202
Scanning frequency: 1000 Hz

Cursor 1: 62 ms
Cursor 2: 223 ms
Representation: secondary


Trigger
30/07/2012
02:33:15 AM.301
K1:iL1/A
K1:iL2/A
K1:iL3/A
K1:uL1/V
K1:uL2/V
K1:uL3/V
K2:iEp/A
t/s
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35

File: BAL_2 Monday 30 July 2012 02.33.15.000.dat - 30/07/2012 - 02:33:15.556 - Secondary - (Peak Type)

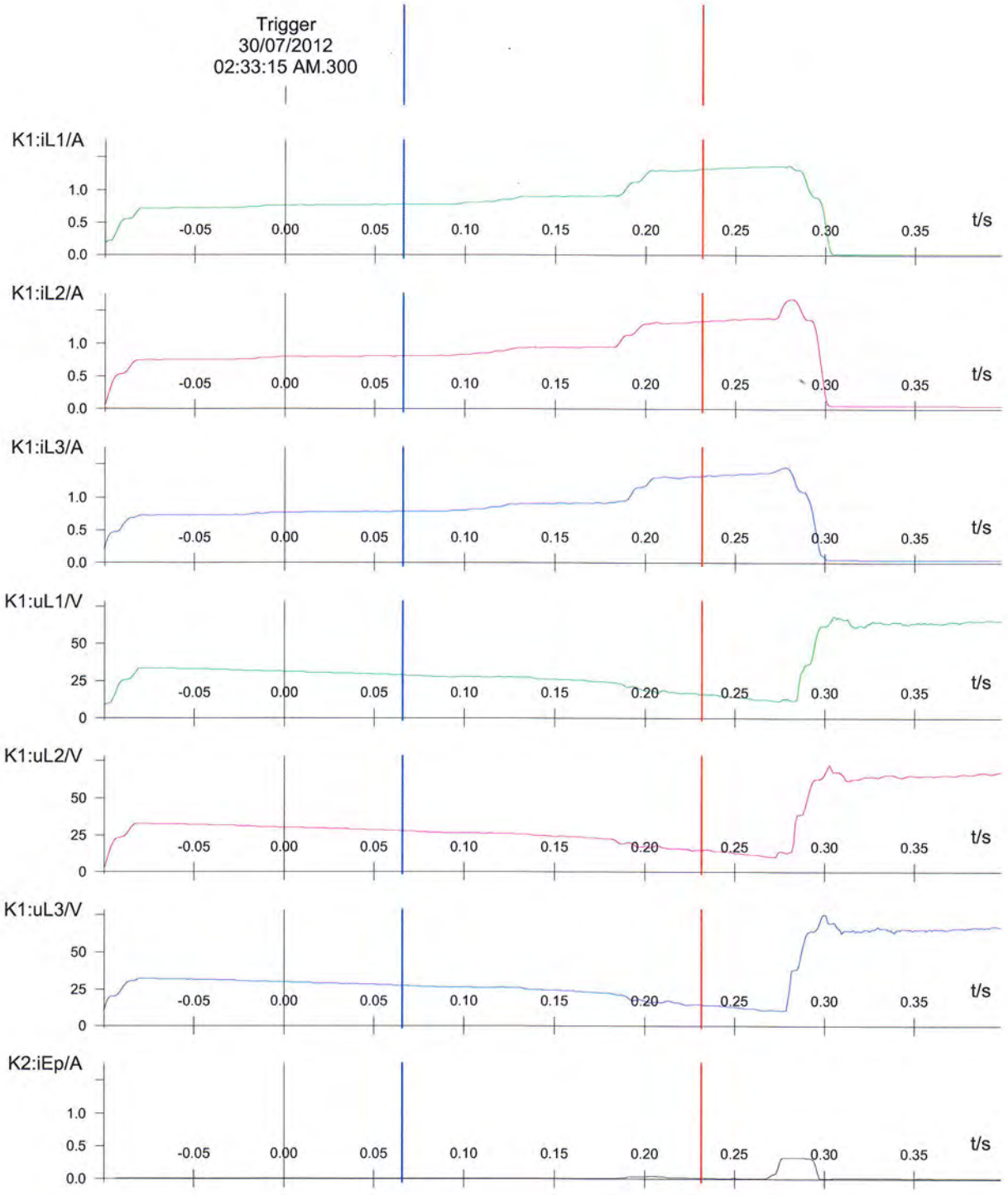
```
* File Information::
* ------------------
           Station: Patna S/Stn
            Device: 1
         File Name: C:\DOCUMENTS AND SETTINGS\ADMINISTRATOR\MY DOCUMENTS\S1 STUDIO\ERTS-1 (PATNA SS)\PATNA SS\400 KV\P442-BALIA2-
         File Size: 241537 Bytes
     Prefault Time: 30/07/2012 02:33:15.368000
        Fault Time: 30/07/2012 02:33:15.556000
         Save Time: 07/30/2012 03:22:38
      Process Time: 07/30/2012 12:54:08
 Start Date && Time: 30/07/2012 02:33:15.368000
   End Date && Time: 30/07/2012 02:33:16.874816
     File Duration: 1  Sec(s) - 506 Mils(s) - 816 Mics(s)
 Sampling Frequency: 1190.476190, 840.000  Microsecond Rate
    Line Frequency: 50.000000

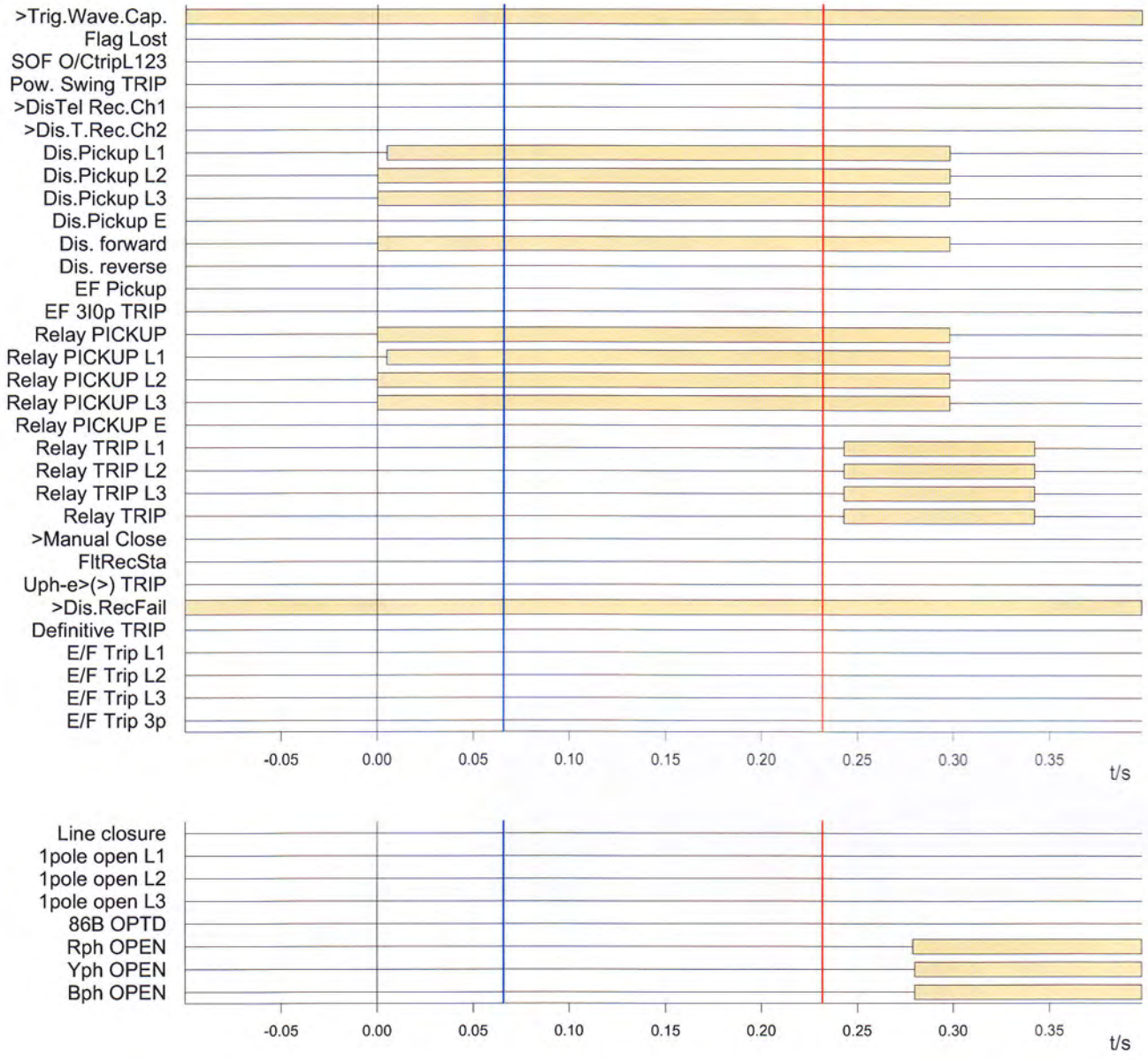
* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff   pUnits    Description
 420120.100  -408486.200   278139.219   37515.895   31.7000   11633.900  240623.324    V        1-VA
 421134.500  -350570.300   282146.906    6783.800   31.7000   70564.200  275363.106    V        2-VB
 486246.300  -422148.900   291659.875   36759.336   31.7000   64097.400  254900.539    V        3-VC
 427347.700  -301435.300   200737.156    1109.500   31.7000  125912.400  199627.656    V        4-VN
   3994.575    -3850.925     2976.753       2.984    5.5250     143.650    2973.769    A        5-IA
   3900.650    -5646.550     3582.172       5.525    5.5250    1745.900    3576.647    A        6-IB
   3972.475    -3867.500     3060.448       2.304    5.5250     104.975    3058.144    A        7-IC
   1773.525    -1547.000      785.118       4.650    5.5250     226.525     780.468    A        8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change       Lst-Change       Changes    Description
  N    N    02:33:15.576320  xx:xx:xx.xxxxxx  001          1-01Main 1652a Rph
  N    N    02:33:15.578000  xx:xx:xx.xxxxxx  001          2-02Main1652a Yph
  N    N    02:33:15.578000  xx:xx:xx.xxxxxx  001          3-03Main 1652a Bph
  N    N    02:33:15.579680  02:33:15.596480  002          4-Any Start
  N    N    02:33:15.556160  02:33:15.638766  002          5-05 M2 Optd
  A    A    xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         11-11 carr  Healthy
  N    N    02:33:15.576320  xx:xx:xx.xxxxxx  001         14-L4 TIE RYB OPEN
  N    N    02:33:15.593120  02:33:15.596480  002         28-V>1 Start
```

Name: PGCIL PATNA / 400KV FEEDERS BALIA - II BALIA - 2 FINAL
Filename: C:\SIEMENS\DIGSI4\D4PROJ\PGCIL_~1\P7DI\GV\SD\00000021\SAMPLES\FAULT\FR000017
Fault start: 30/07/2012 02:33:15 AM.200
Scanning frequency: 1000 Hz

Cursor 1: 66 ms
Cursor 2: 232 ms
Representation: secondary


Trigger
30/07/2012
02:33:15 AM.300
K1:iL1/A
K1:iL2/A
K1:iL3/A
K1:uL1/V
K1:uL2/V
K1:uL3/V
K2:iEp/A
t/s
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35


>Trig.Wave.Cap.
Flag Lost
SOF O/CtripL123
Pow. Swing TRIP
>DisTel Rec.Ch1
>Dis.T.Rec.Ch2
Dis.Pickup L1
Dis.Pickup L2
Dis.Pickup L3
Dis.Pickup E
Dis. forward
Dis. reverse
EF Pickup
EF 3I0p TRIP
Relay PICKUP
Relay PICKUP L1
Relay PICKUP L2
Relay PICKUP L3
Relay PICKUP E
Relay TRIP L1
Relay TRIP L2
Relay TRIP L3
Relay TRIP
>Manual Close
FltRecSta
Uph-e>(>) TRIP
>Dis.RecFail
Definitive TRIP
E/F Trip L1
E/F Trip L2
E/F Trip L3
E/F Trip 3p
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
t/s

Line closure
1pole open L1
1pole open L2
1pole open L3
86B OPTD
Rph OPEN
Yph OPEN
Bph OPEN
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
t/s

Exhibit-246: DR at Sasaram

ABB - Disturbance Report

General data

Name	Value
Station name	SASARAM
Object name	SASARAM-BALLIA
Unit name	MAIN-2
Line length	Not applicable
System Frequency	50.0 Hz
Recording number	522
Trigger signal name	PSB-OPTD
Trig date and time	7/30/2012 3:31:24.367 AM
Pre-trig recording time	200 ms
Post trig recording time	224 ms
Total recording time	1699 ms
Max. recording time	1500 ms
Recording in Test mode	No
Type of time synchronization	NONE
IED type	L67I11 01
IED version	1.101
Sampling frequency	1.0 kHz
Disturbance recorder	Installed
Event recorder	Installed
Fault locator	Not Installed
Active setting group during recording	1

ABB - Disturbance Report

Fault location

Name	Value
Fault loop type	Not applicable
Fault location	Not applicable
Status of fault calculation	Not applicable
Fault Direction	Not applicable

ABB - Disturbance Report

Analog channels

Number	Channel name	Prefault RMS	Prefault angle	Fault RMS	Fault angle
1	LINE_A_IL1	0.7 kA	-101.9°	0.7 kA	-101.7°
2	LINE_A_IL2	0.7 kA	134.6°	0.7 kA	134.4°
3	LINE_A_IL3	0.7 kA	17.3°	0.7 kA	17.2°
4	LINE_A_IN	0.0 kA	128.6°	0.0 kA	120.6°
5	LINE_UL1	176.3 kV	-120.1°	173.6 kV	-120.4°
6	LINE_UL2	176.2 kV	120.5°	174.2 kV	120.4°
7	LINE_UL3	172.8 kV	0.0°	170.8 kV	-0.3°

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
1	ZM01-TRIP	1	1	0	0
2	ZM01-START	1	1	0	0
3	ZM02-TRIP	1	1	0	0
4	ZM02-START	1	1	0	0
5	ZM03-TRIP	1	1	0	0
6	ZM03-START	1	1	0	0
7	ZM04-TRIP	1	1	0	0
8	ZM04-START	1	1	0	0
9	ZM05-TRIP	1	1	0	0
10	ZM05-START	1	1	0	0
11	ZCOM-TRIP	1	1	0	0
12	CARRIER_REC	1	1	0	0
13	PHS-STFWL1	1	1	0	0
14	PHS-STFWL2	1	1	0	0
15	PHS-STFWL3	1	1	0	0
16	PHS-STFWPE	1	1	0	0
17	SOTF-TRIP	1	1	0	0
18	PSB-OPTD	1	1	1	1
19	TOC1-TRIP	1	1	0	0
20	TOC1-START	1	1	0	0
21	TEF1-TRIP	1	1	0	0
22	TEF1-START	1	1	0	0
23	TUV1-TRIP	1	1	0	0
24	TUV1-START	1	1	0	0
25	TOV1-TRIP	1	1	0	0
26	TOV1-START	1	1	0	0
28	STUB_TRIP	0	1	0	0
29	TOC1-TRIP	0	1	0	0
30	TOC1-START	0	1	0	0
31	FUSE FAIL	0	1	0	0
32	CTSU_FAIL	0	1	0	0
33	TR_R_MAIN_CB	0	1	0	0
34	TR_Y_MAIN_CB	0	1	0	0
35	TR_B_MAIN_CB	0	1	0	0
36	TR_R_TIE_CB	0	1	0	0
37	TR_Y_TIE_CB	0	1	0	0
38	TR_B_TIE_CB	0	1	0	0
39	TRIP-R	0	1	0	0
40	TRIP-Y	0	1	0	0
41	TRIP-B	0	1	0	0
42	AR_UNSUC	0	1	0	0
44	PREP_3PH_TRIP	0	1	1	0
45	AR_CLOSE_MAIN	0	1	0	0
46	AR_CLOSE_TBC	0	1	0	0
47	3 PH TRIP	0	1	0	0
48	TIE 3 PH TRIP	0	1	0	0
49	SOTF_INI	0	1	0	0
50	STUB_TRIP	0	1	0	0
51	CARRIER_RECEI	0	1	0	0
53	CARR CH FAIL	0	1	1	0

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
57	TEF_TRIP	1	1	0	0
88	STUB_RELEASE	0	1	1	0
92	BROKEN-COND	0	1	0	0
93	MAIN CB R-OPE	0	1	1	0
94	MAIN CB Y-OPE	0	1	1	0
95	MAIN CB B-OPE	0	1	1	0
96	CR CH-2 FAIL	0	1	1	0

ABB - Disturbance Report

Total recording

Trigger time: 7/30/2012 3:31:24.367 AM

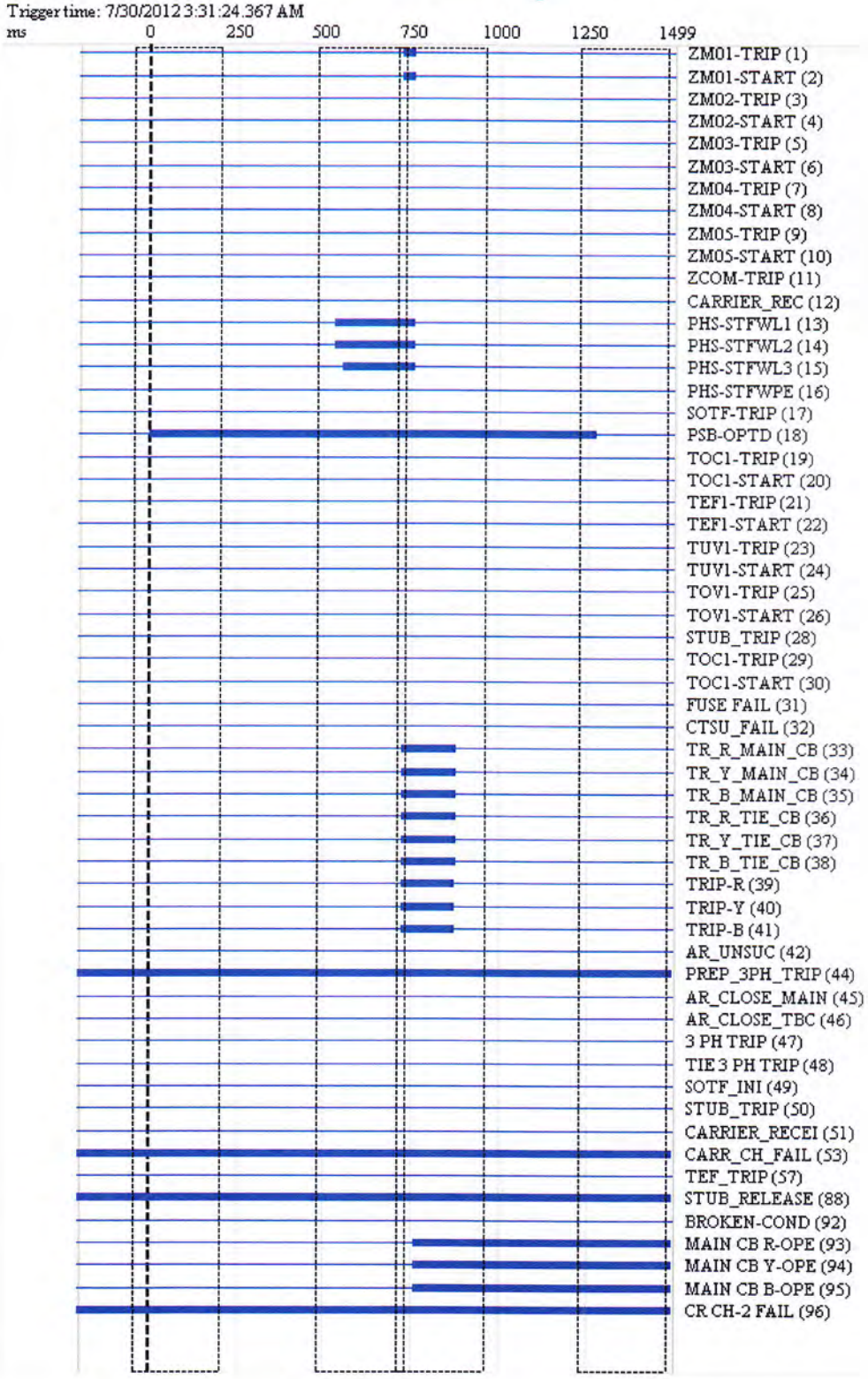


ABB - Disturbance Report

Disturbance 1

Trigger time: 7/30/2012 3:31:24.367 AM

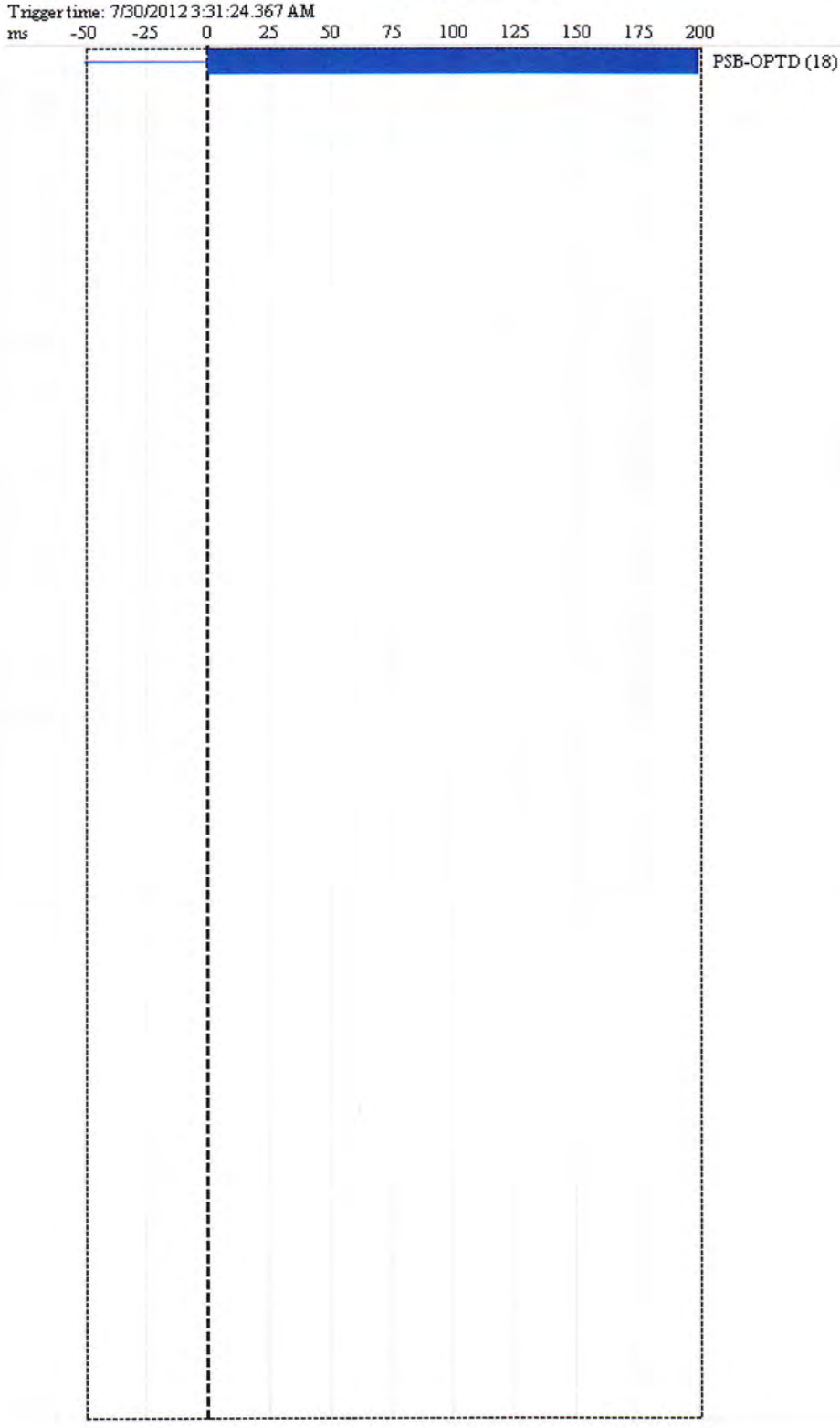


ABB - Disturbance Report

Event list

Number	Name	Status	Time
18	PSB-OPTD	On	7/30/2012 3:31:24.367 AM
13	PHS-STFWL1	On	7/30/2012 3:31:24.895 AM
14	PHS-STFWL2	On	7/30/2012 3:31:24.895 AM
15	PHS-STFWL3	On	7/30/2012 3:31:24.916 AM
1	ZM01-TRIP	On	7/30/2012 3:31:25.087 AM
2	ZM01-START	On	7/30/2012 3:31:25.087 AM
39	TRIP-R	On	7/30/2012 3:31:25.087 AM
40	TRIP-Y	On	7/30/2012 3:31:25.087 AM
41	TRIP-B	On	7/30/2012 3:31:25.087 AM
33	TR_R_MAIN_CB	On	7/30/2012 3:31:25.090 AM
34	TR_Y_MAIN_CB	On	7/30/2012 3:31:25.090 AM
35	TR_B_MAIN_CB	On	7/30/2012 3:31:25.090 AM
36	TR_R_TIE_CB	On	7/30/2012 3:31:25.090 AM
37	TR_Y_TIE_CB	On	7/30/2012 3:31:25.090 AM
38	TR_B_TIE_CB	On	7/30/2012 3:31:25.090 AM
95	MAIN CB B-OPE	On	7/30/2012 3:31:25.122 AM
94	MAIN CB Y-OPE	On	7/30/2012 3:31:25.123 AM
93	MAIN CB R-OPE	On	7/30/2012 3:31:25.123 AM
1	ZM01-TRIP	Off	7/30/2012 3:31:25.123 AM
2	ZM01-START	Off	7/30/2012 3:31:25.123 AM
13	PHS-STFWL1	Off	7/30/2012 3:31:25.123 AM
15	PHS-STFWL3	Off	7/30/2012 3:31:25.123 AM
14	PHS-STFWL2	Off	7/30/2012 3:31:25.123 AM
39	TRIP-R	Off	7/30/2012 3:31:25.240 AM
40	TRIP-Y	Off	7/30/2012 3:31:25.240 AM
41	TRIP-B	Off	7/30/2012 3:31:25.240 AM
33	TR_R_MAIN_CB	Off	7/30/2012 3:31:25.243 AM
34	TR_Y_MAIN_CB	Off	7/30/2012 3:31:25.243 AM
35	TR_B_MAIN_CB	Off	7/30/2012 3:31:25.243 AM
36	TR_R_TIE_CB	Off	7/30/2012 3:31:25.243 AM
37	TR_Y_TIE_CB	Off	7/30/2012 3:31:25.243 AM
38	TR_B_TIE_CB	Off	7/30/2012 3:31:25.243 AM
18	PSB-OPTD	Off	7/30/2012 3:31:25.642 AM

EXHIBIT - 3

DETAILS OF

EVENT LOGGER

AND DISTURBANCE RECORDER

AT DIFFERENT LOCATIONS

ON

31ST JULY, 2012

EXHIBIT-3 : DR at Bina

ABB - Disturbance Report

General data

Name	Value
Station name	BINA
Object name	GWALIOR LINE-1
Unit name	REL 670
Line length	Not applicable
System Frequency	50.0 Hz
Recording number	289
Trigger signal name	LINE_A_IL3
Trig date and time	7/31/2012 13:00:11.475
Pre-trig recording time	300 ms
Post trig recording time	2500 ms
Total recording time	2980 ms
Max. recording time	3000 ms
Recording in Test mode	No
Type of time synchronization	SNTP
IED type	REL670 1B
IED version	1.000
Sampling frequency	1.0 kHz
Disturbance recorder	Installed
Event recorder	Installed
Fault locator	Not Installed
Active setting group during recording	1

ABB - Disturbance Report

Fault location

Name	Value
Fault loop type	Not applicable
Fault location	Not applicable
Status of fault calculation	Not applicable
Fault Direction	Not applicable

ABB - Disturbance Report

Analog channels

Number	Channel name	Prefault RMS	Prefault angle	Fault RMS	Fault angle
1	LINE_A_IL1	2.0 kA	-142.2°	2.0 kA	-142.2°
2	LINE_A_IL2	2.0 kA	97.6°	2.0 kA	97.6°
3	LINE_A_IL3	2.0 kA	-22.3°	2.0 kA	-22.3°
4	LINE_A_IN	0.0 kA	114.0°	0.0 kA	114.0°
7	LINE_UL1	218.0 kV	-119.0°	218.0 kV	-119.0°
8	LINE_UL2	213.2 kV	122.3°	213.2 kV	122.3°
9	LINE_UL3	209.1 kV	0.0°	209.1 kV	0.0°
10	LINE_UN	14.9 kV	-134.8°	14.9 kV	-134.8°

ABB - Disturbance Report

Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
1	LINE R OPEN	1	1	1	0
2	LINE Y OPEN	1	1	1	0
3	LINE B OPEN	1	1	1	0
4	M1 CR	1	1	0	0
5	M1 TRIP	1	1	0	0
6	A/R OPTD	1	1	0	0
7	OV STAGE1/2	1	1	0	0
8	STUB TRIP	1	1	0	0
9	DT REC CH1/2	1	1	0	0
10	M2 CR	1	1	0	0
11	M2 TRIP	1	1	0	0
12	CARR AID TRIP	1	1	0	0
13	LBB OPTD	1	1	0	0
14	TIE R OPEN	1	1	1	0
15	TIE Y OPEN	1	1	1	0
16	TIE B OPEN	1	1	1	0
17	ZONE1 START	1	1	0	0
18	ZONE2 START	1	1	0	0
19	ZONE3 START	1	1	0	0
20	ZONE4 START	1	1	0	0
21	ZONE5 START	0	1	0	0
22	SOTF TRIP	1	1	0	0
23	FUSE-FAIL	1	1	0	0
24	BROKEN COND	1	1	0	0
26	TRIP RPH	1	1	0	0
27	TRIP YPH	1	1	0	0
28	TRIP BPH	1	1	0	0
29	ZONE1 TRIP	1	1	0	0
30	ZONE2 TRIP	1	1	0	0
31	ZONE3 TRIP	1	1	0	0
32	ZONE4 TRIP	1	1	0	0
33	ZONE5 TRIP	1	1	0	0
34	START RPH	1	1	0	0
35	START YPH	1	1	0	0
36	START BPH	1	1	0	0
37	START N	1	1	0	0
38	POWER SWING	1	1	0	0
39	DT REC CH1	1	1	0	0
40	DT REC CH2	1	1	0	0
41	3PH_GR_A_TRIP	1	1	0	0
42	3PH_GR_B_TRIP	1	1	0	0
43	M1_A/R OPTD	1	1	0	0
44	A/R UNSUCCESS	1	1	0	0
45	PREP 3PH TRIP	1	1	1	0
46	TIE_AR_OPTD	1	1	0	0
47	TIE_AR_UNSUCC	1	1	0	0
48	BB_OPTD	1	1	0	0
49	M2 TRIP	1	1	0	0
50	M2 DEF TRIP	1	1	0	0
52	M2 PSB	1	1	0	0

98 73

ABB - Disturbance Report

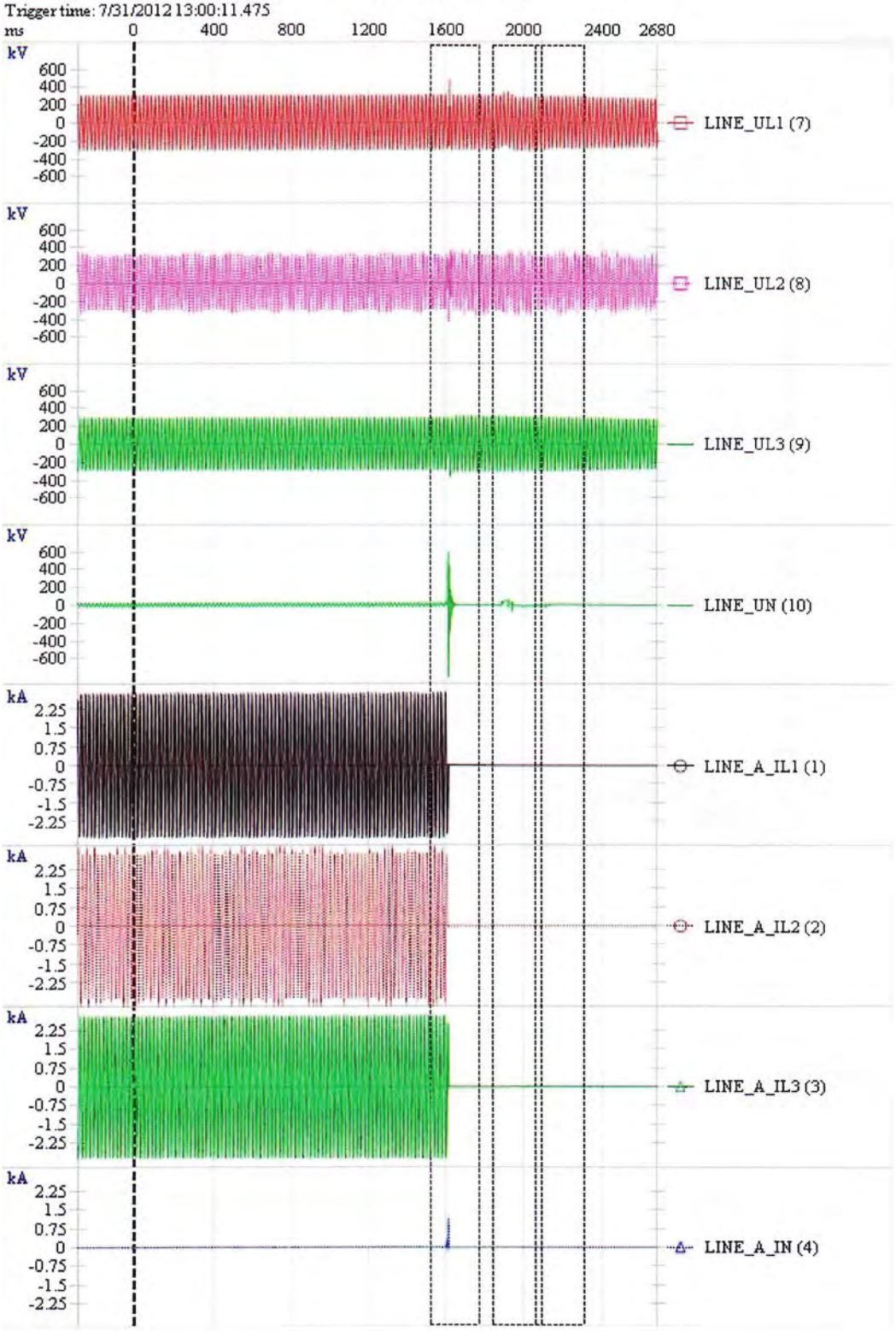
Digital channels

Number	Channel name	Trigger enabled	Trig level	Channel value at trig time	Trigger status at trig time
53	M2 CS	1	1	0	0
54	M2 CR	1	1	0	0
55	M2 CF OUT SER	1	1	0	0
56	OV_SG1_OPTD	1	1	0	0
57	OV_SG2_OPTD	1	1	0	0
58	C-CH1-FAIL	1	1	0	0
59	MAIN AR BLKD	1	1	1	0
60	TIE AR BLKD	1	1	1	0
61	DT SEND CH1	1	1	0	0
63	CARR SEND	1	1	0	0
65	ZCAL-IREV	0	1	0	0
66	ZCAL-TRWEI	0	1	0	0
67	ZCAL-TRWEIL1	0	1	0	0
68	ZCAL-TRWEIL2	0	1	0	0
69	ZCAL-TRWEIL3	0	1	0	0
70	ZCAL-ECHO	0	1	0	0
71	DIR E/F TRIP	1	1	0	0
72	DIR E/F START	0	1	0	0
73	DIR E/F STFW	0	1	0	0
74	DIR E/F STRV	0	1	0	0
75	DIR E/F 2HARM	0	1	0	0
76	O/V STL1	1	1	0	0
77	O/V STL2	0	1	0	0
78	O/V STL3	0	1	0	0
81	MAIN_TRIP_R	0	1	0	0
82	MAIN_TRIP_Y	0	1	0	0
83	MAIN_TRIP_B	0	1	0	0
84	TIE_TRIP_R	0	1	0	0
85	TIE_TRIP_Y	0	1	0	0
86	TIE_TRIP_B	0	1	0	0

ABB - Disturbance Report

Total recording

Trigger time: 7/31/2012 13:00:11.475



75

ABB - Disturbance Report

Total recording

Trigger time: 7/31/2012 13:00:11.475

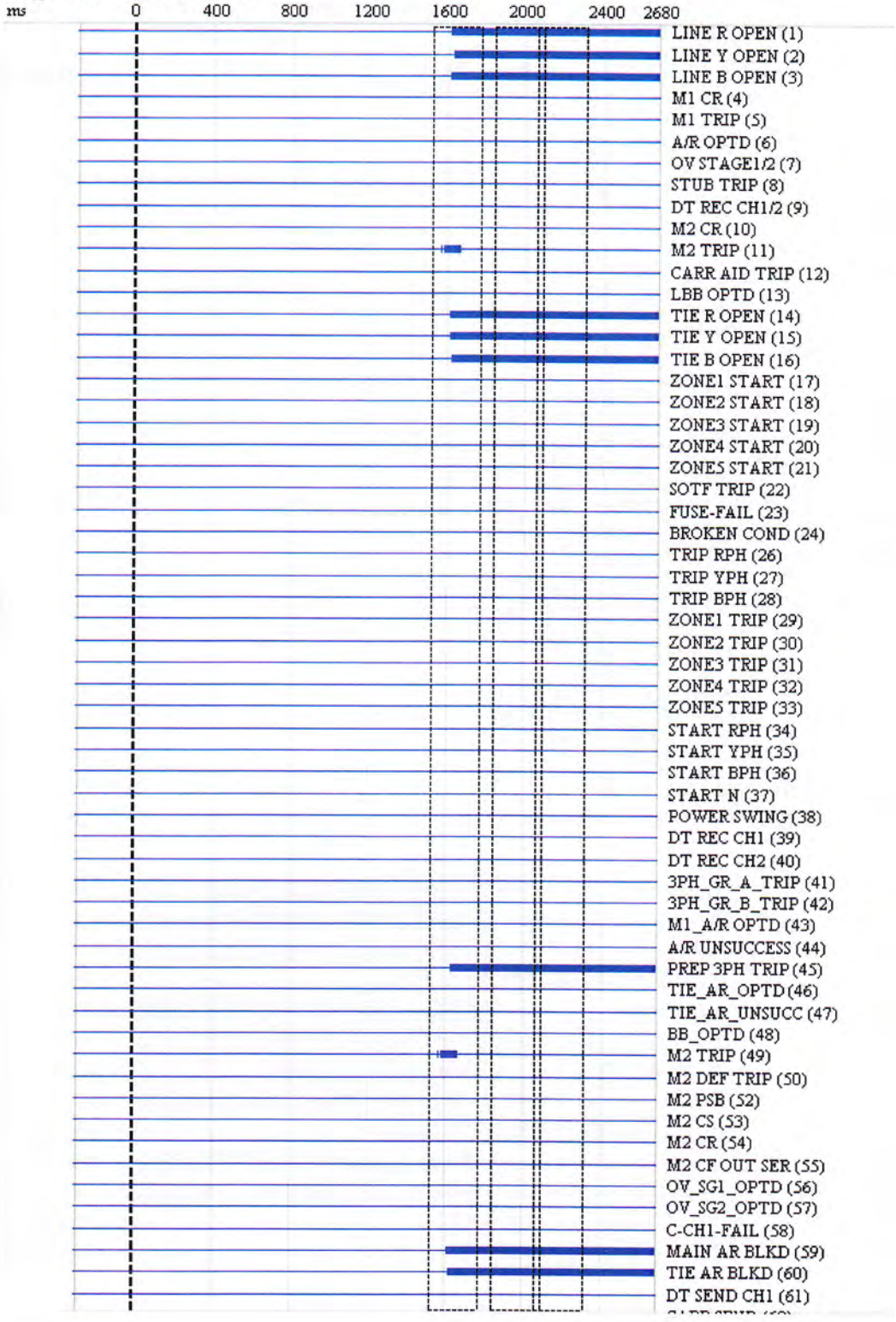


ABB - Disturbance Report

Disturbance 1

Trigger time: 7/31/2012 13:00:11.475

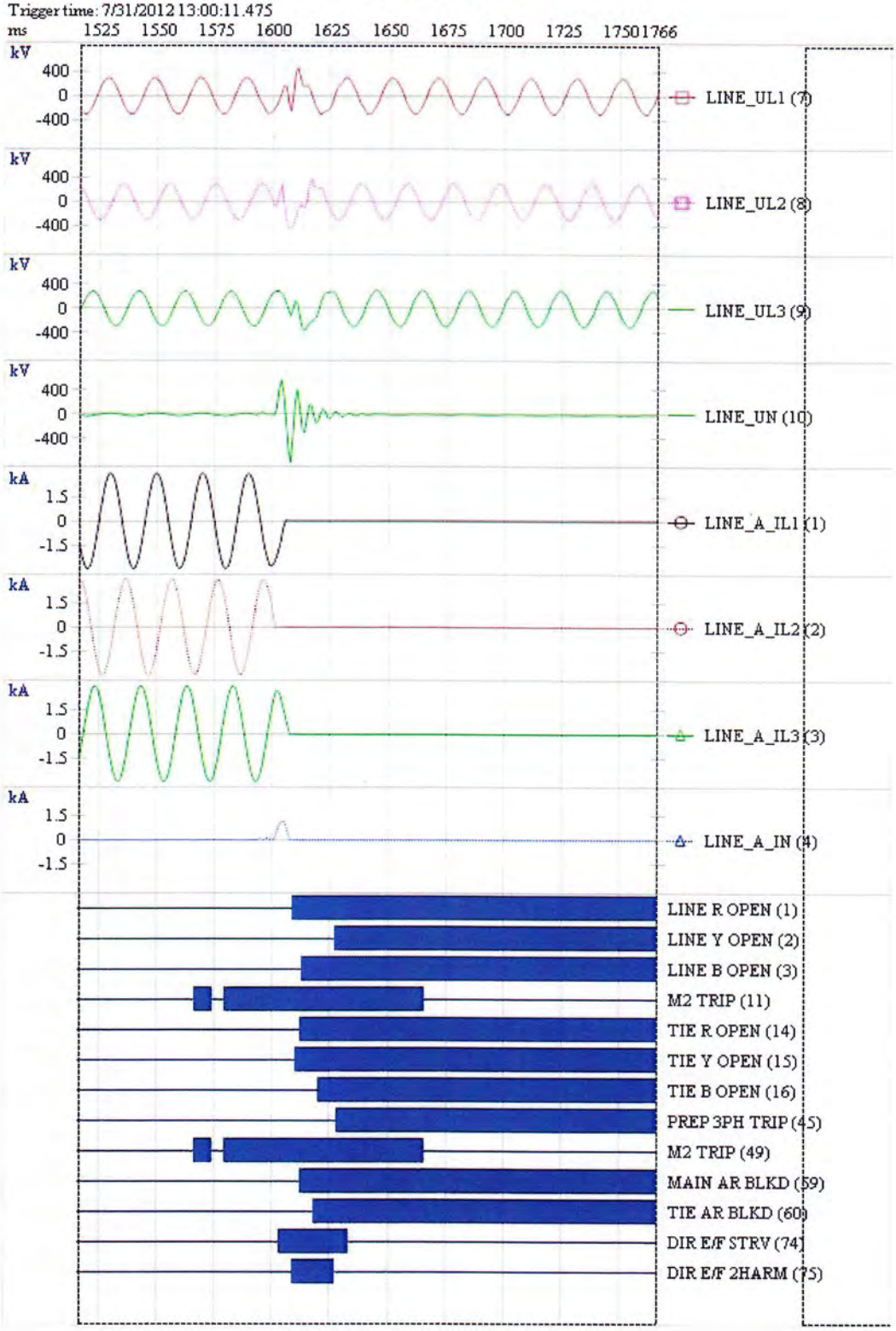
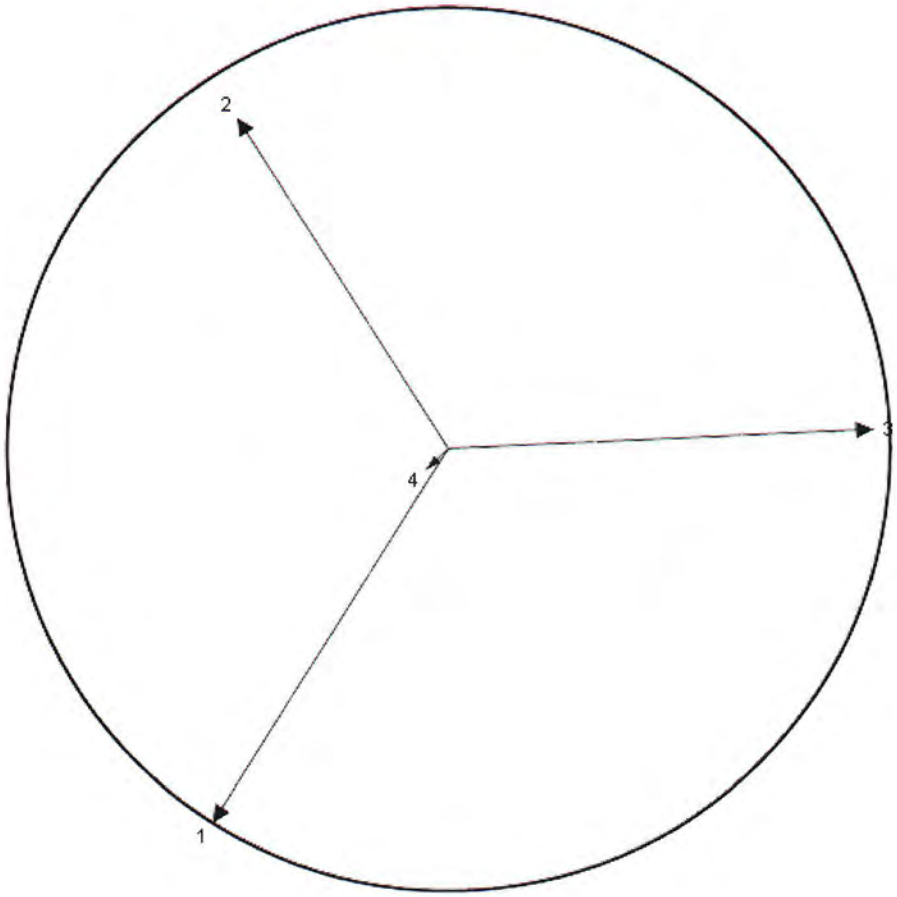


ABB - Disturbance Report

Disturbance 1 (Voltages)

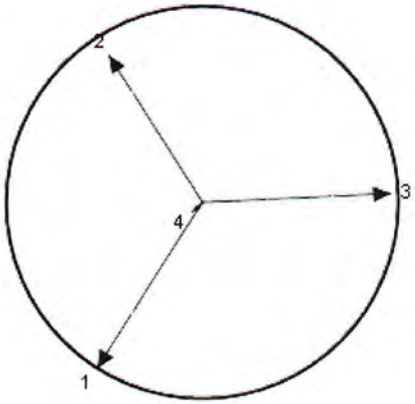


Calculation interval: 1567 to 1585 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	214.8	237.6°
2	LINE_UL2	191.4	122.5°
3	LINE_UL3	206.9	2.6°
4	LINE_UN	15.1	223.3°

ABB - Disturbance Report

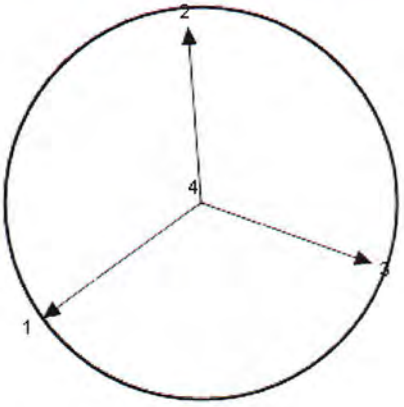
Disturbance 1 (Voltages)



Calculation interval: 1567 to 1585 ms

Number	ID	RMS (kV)	Angle
1	LINE_UL1	214.8	237.6°
2	LINE_UL2	191.4	122.5°
3	LINE_UL3	206.9	2.6°
4	LINE_UN	15.1	223.3°

Disturbance 1 (Currents)



Calculation interval: 1567 to 1585 ms

Number	ID	RMS (kA)	Angle
1	LINE_A_IL1	2.1	216.1°
2	LINE_A_IL2	1.9	94.4°
3	LINE_A_IL3	1.9	340.6°
4	LINE_A_IN	0.0	109.0°

ABB - Disturbance Report

Event list

Number	Name	Status	Time
11	M2 TRIP	On	7/31/2012 13:00:13.041
49	M2 TRIP	On	7/31/2012 13:00:13.041
11	M2 TRIP	Off	7/31/2012 13:00:13.049
49	M2 TRIP	Off	7/31/2012 13:00:13.049
11	M2 TRIP	On	7/31/2012 13:00:13.054
49	M2 TRIP	On	7/31/2012 13:00:13.054
74	DIR E/F STRV	On	7/31/2012 13:00:13.077
75	DIR E/F 2HARM	On	7/31/2012 13:00:13.083
1	LINE R OPEN	On	7/31/2012 13:00:13.084
15	TIE Y OPEN	On	7/31/2012 13:00:13.085
14	TIE R OPEN	On	7/31/2012 13:00:13.087
59	MAIN AR BLKD	On	7/31/2012 13:00:13.087
3	LINE B OPEN	On	7/31/2012 13:00:13.088
60	TIE AR BLKD	On	7/31/2012 13:00:13.093
16	TIE B OPEN	On	7/31/2012 13:00:13.095
75	DIR E/F 2HARM	Off	7/31/2012 13:00:13.101
2	LINE Y OPEN	On	7/31/2012 13:00:13.102
45	PREP 3PH TRIP	On	7/31/2012 13:00:13.103
74	DIR E/F STRV	Off	7/31/2012 13:00:13.107
11	M2 TRIP	Off	7/31/2012 13:00:13.141
49	M2 TRIP	Off	7/31/2012 13:00:13.141

Statistical Reporting

EXHIBIT: B.2 Gwalior Substation Statistical Reporting

Report Variable: VB

400 kV BB1 Volts BR

Change

Select variable for reporting.

From: July 2012 — Today: 7/31/2012 — 16:08:58

To: July 2012 — Today: 7/31/2012 — 16:08:58

Print Report | View Graphic | Save

	Time Stamp	Value
741	2012-07-31 13:03:45	0
742	2012-07-31 13:03:30	0
743	2012-07-31 13:03:15	0
744	2012-07-31 13:03:00	0
745	2012-07-31 13:02:45	0
746	2012-07-31 13:02:30	0
747	2012-07-31 13:02:15	0
748	2012-07-31 13:02:00	0
749	2012-07-31 13:01:45	0
750	2012-07-31 13:01:30	241.104
751	2012-07-31 13:01:15	398.667
752	2012-07-31 13:01:00	399.624
753	2012-07-31 13:00:45	399.185
754	2012-07-31 13:00:30	403.037
755	2012-07-31 13:00:15	353.919
756	2012-07-31 13:00:00	325.185
757	2012-07-31 12:59:45	327.001
758	2012-07-31 12:59:30	327.217
759	2012-07-31 12:59:15	327.614
760	2012-07-31 12:59:00	326.626
761	2012-07-31 12:58:45	327.902
762	2012-07-31 12:58:30	327.833
763	2012-07-31 12:58:15	326.253
764	2012-07-31 12:58:00	329.651
765	2012-07-31 12:57:45	333.512

First Entry: 394.432 at 2012-07-30 16:09:00

Last Entry: 402.141 at 2012-07-31 16:08:45

Maximum Value: 414.105 at 2012-07-31 07:03:45

Minimum Value: 0.0 at 2012-07-31 13:01:45

Absolute Max Value: 0.0 at 2012-07-31 13:01:45

Absolute Min Value: 414.105 at 2012-07-31 07:03:45

Range: 414.105

Average: 390.182

Statistical Reporting

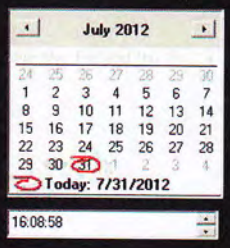
EXHIBIT: 3.2 Gwalior Substation
Statistical Reporting

Report Variable: VR

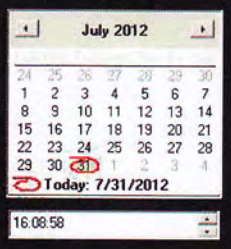
400 kV BB1 Volts RY

Change

From:



To:



Print Report | View Graphic | Save

	Time Stamp	Value
741	2012-07-31 13:03:45	0
742	2012-07-31 13:03:30	0
743	2012-07-31 13:03:15	0
744	2012-07-31 13:03:00	0
745	2012-07-31 13:02:45	0
746	2012-07-31 13:02:30	0
747	2012-07-31 13:02:15	0
748	2012-07-31 13:02:00	0
749	2012-07-31 13:01:45	4.08887
750	2012-07-31 13:01:30	120.396
751	2012-07-31 13:01:15	403.143
752	2012-07-31 13:01:00	403.52
753	2012-07-31 13:00:45	403.057
754	2012-07-31 13:00:30	405.842
755	2012-07-31 13:00:15	305.591
756	2012-07-31 13:00:00	331.445
757	2012-07-31 12:59:45	332.368
758	2012-07-31 12:59:30	332.148
759	2012-07-31 12:59:15	333.043
760	2012-07-31 12:59:00	333.514
761	2012-07-31 12:58:45	335.605
762	2012-07-31 12:58:30	333.952
763	2012-07-31 12:58:15	332.199
764	2012-07-31 12:58:00	336.946
765	2012-07-31 12:57:45	339.79

First Entry: 399.371 at 2012-07-30 16:09:00

Last Entry: 409.293 at 2012-07-31 16:08:45

Maximum Value: 425.331 at 2012-07-31 14:17:00

Minimum Value: 0.0 at 2012-07-31 13:02:00

Absolute Max Value: 0.0 at 2012-07-31 13:02:00

Absolute Min Value: 425.331 at 2012-07-31 14:17:00

Range: 425.331

Average: 395.387

Statistical Reporting

EXHIBIT: 8.2 Gwalior Substation Statistical Reporting

Report Variable: VY

400 kV BB1 Volts YB

Change

From:

To:

Print Report | View Graphic | Save

	Time Stamp	Value
741	2012-07-31 13:03:45	0
742	2012-07-31 13:03:30	0
743	2012-07-31 13:03:15	0
744	2012-07-31 13:03:00	0
745	2012-07-31 13:02:45	0
746	2012-07-31 13:02:30	0
747	2012-07-31 13:02:15	0
748	2012-07-31 13:02:00	0
749	2012-07-31 13:01:45	0
750	2012-07-31 13:01:30	263.008
751	2012-07-31 13:01:15	401.547
752	2012-07-31 13:01:00	402.904
753	2012-07-31 13:00:45	402.378
754	2012-07-31 13:00:30	405.859
755	2012-07-31 13:00:15	327.658
756	2012-07-31 13:00:00	329.055
757	2012-07-31 12:59:45	330.326
758	2012-07-31 12:59:30	331.389
759	2012-07-31 12:59:15	330.645
760	2012-07-31 12:59:00	329.668
761	2012-07-31 12:58:45	332.017
762	2012-07-31 12:58:30	330.597
763	2012-07-31 12:58:15	329.543
764	2012-07-31 12:58:00	334.616
765	2012-07-31 12:57:45	337.869

First Entry: 399.131 at 2012-07-30 16:09:00

Last Entry: 405.693 at 2012-07-31 16:08:45

Maximum Value: 417.722 at 2012-07-31 07:05:00

Minimum Value: 0.0 at 2012-07-31 13:01:45

Absolute Max Value: 0.0 at 2012-07-31 13:01:45

Absolute Min Value: 417.722 at 2012-07-31 07:05:00

Range: 417.722

Average: 394.18

POWER GRID CORPORATION OF INDIA LIMITED

Form No: 403303
Region: Eastern -I

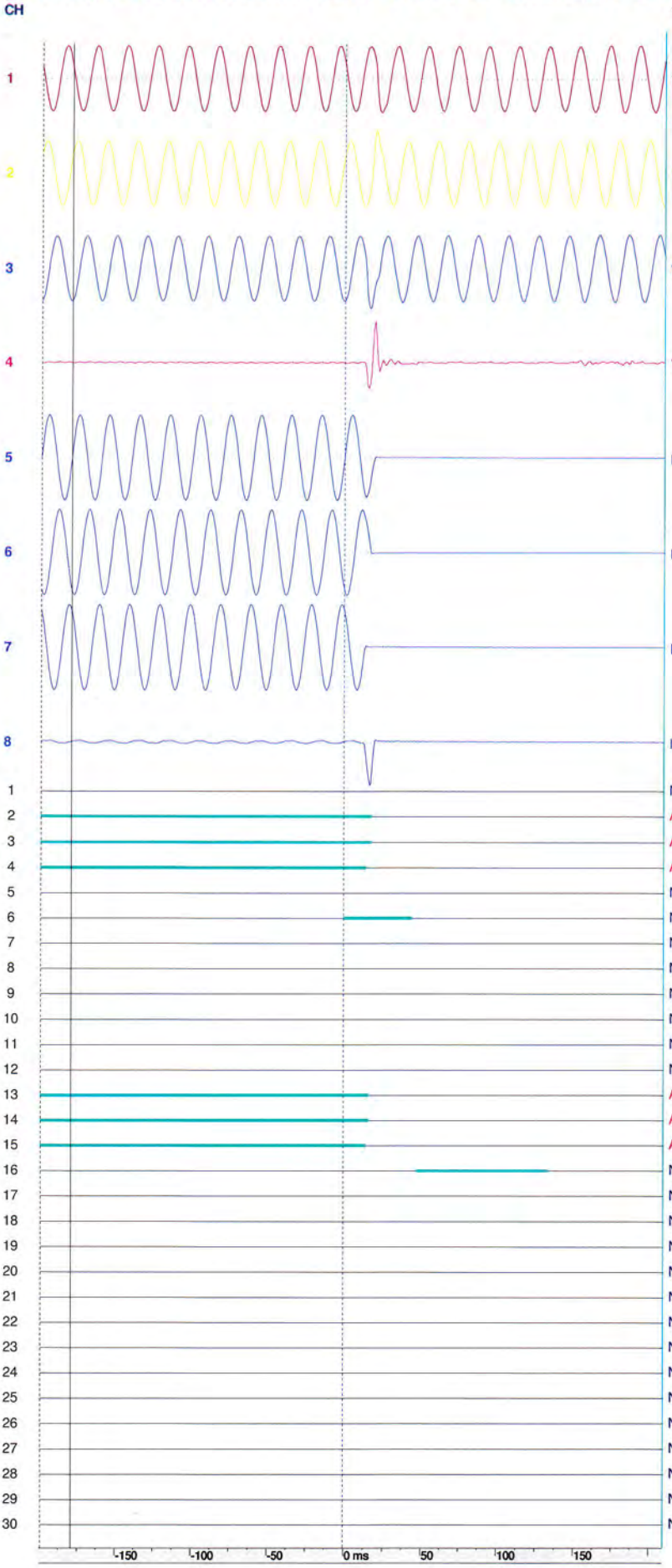
Substation: Jamshedpur

Relay flag details after Line/ ICT / Reactor tripping

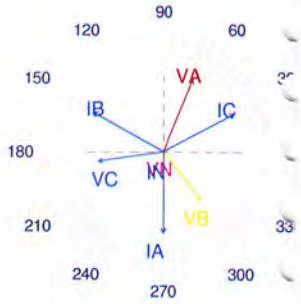
no	Date & Time of Tripping	Name of Line/ ICT/ Bus Reactor	Relay flag details				Relay flag details of other end.				LA Counter Reading	
			Control Panel	Main I	Main II	Other Relay	Control Panel	Main I	Main II	Other Relay	Before Tripping	After Tripping
01.	31.07. 2012 13:00 Hrs.	400 KV J-R # I LINE	1. Main-I/II protection start/Trip 2.Direct Trip Channel I/II received. 2. CB Auto Trip.	---		1.Flag relay-Direct Trip Channel-I/II received.	1. Over Voltage Stage I/II Trip 2. CB Auto Trip.	O/V stage-I, R-Phase Operated		--	R-100 Y-06 B-12	R-100 Y-06 B-12

02.08.12

Tuesday 31 July 2012 13.00.13.000.DAT - 31/07/2012 - 13:00:13.207 - Secondary - (Peak Type) Exhibit 33 DR at Jamshedpur



CH	Title	RMS	InstPeak	Phase
1	VA	211042.345	295856.100	67.875°
2	VB	208913.147	-292654.400	307.758°
3	VC	209968.238	-293415.200	188.141°
4	VN	3437.374	4406.300	126.774°
5	IA	1929.369	-2731.618	270.032°
6	IB	1989.173	2817.240	150.688°
7	IC	1972.668	2795.144	28.156°
8	IN	26.044	-38.668	283.792°



1	N	MAIN-2 CARR RECV	N	N			000
2	A	M - CB RPH CLOSE	A	N	13:00:13.225198		001
3	A	M - CB YPH CLOSE	A	N	13:00:13.225198		001
4	A	M - CB BPH CLOSE	A	N	13:00:13.221882		001
5	N	MAIN-1 CARR RECV	N	N			000
6	N	MAIN-1 OPTD	N	N	13:00:13.206960	13:00:13.251726	002
7	N	MAIN/TIE A/R OPT	N	N			000
8	N	0/V STAGE1/2OPTD	N	N			000
9	N	MAIN 2 /B U OPTD	N	N			000
10	N	DIRECT TRIP RECV	N	N			000
11	N	B/B PROT OPTD	N	N			000
12	N	LBB MAIN/TIE OPT	N	N			000
13	A	TIE CB RPH CLOSE	A	N	13:00:13.223540		001
14	A	TIE CB YPH CLOSE	A	N	13:00:13.223540		001
15	A	TIE CB BPH CLOSE	A	N	13:00:13.221882		001
16	N	PREPARE 3PH TRIP	N	N	13:00:13.255042	13:00:13.341215	002
17	N	IN>1 Trip	N	N			000
18	N	Any Int. Trip B	N	N			000
19	N	Any Trip A	N	N			000
20	N	Any Trip B	N	N			000
21	N	Any Trip C	N	N			000
22	N	VTS Fast	N	N			000
23	N	Z1 Not Filtered	N	N			000
24	N	F<4 Trip	N	N			000
25	N	F>1 Start	N	N			000
26	N	V<3 Start C	N	N			000
27	N	PAP Start C	N	N			000
28	N	I2>4 Start	N	N			000
29	N	Z1	N	N			000
30	N	VN>1 Start	N	N			000

-150 -100 -50 0 ms 50 100 150

ROURKELA-1 DT: 31/07/2012 13:00:13.027896 Dt: 179064 microsec - 8.95 Cyc 1206.2726 AS: ON

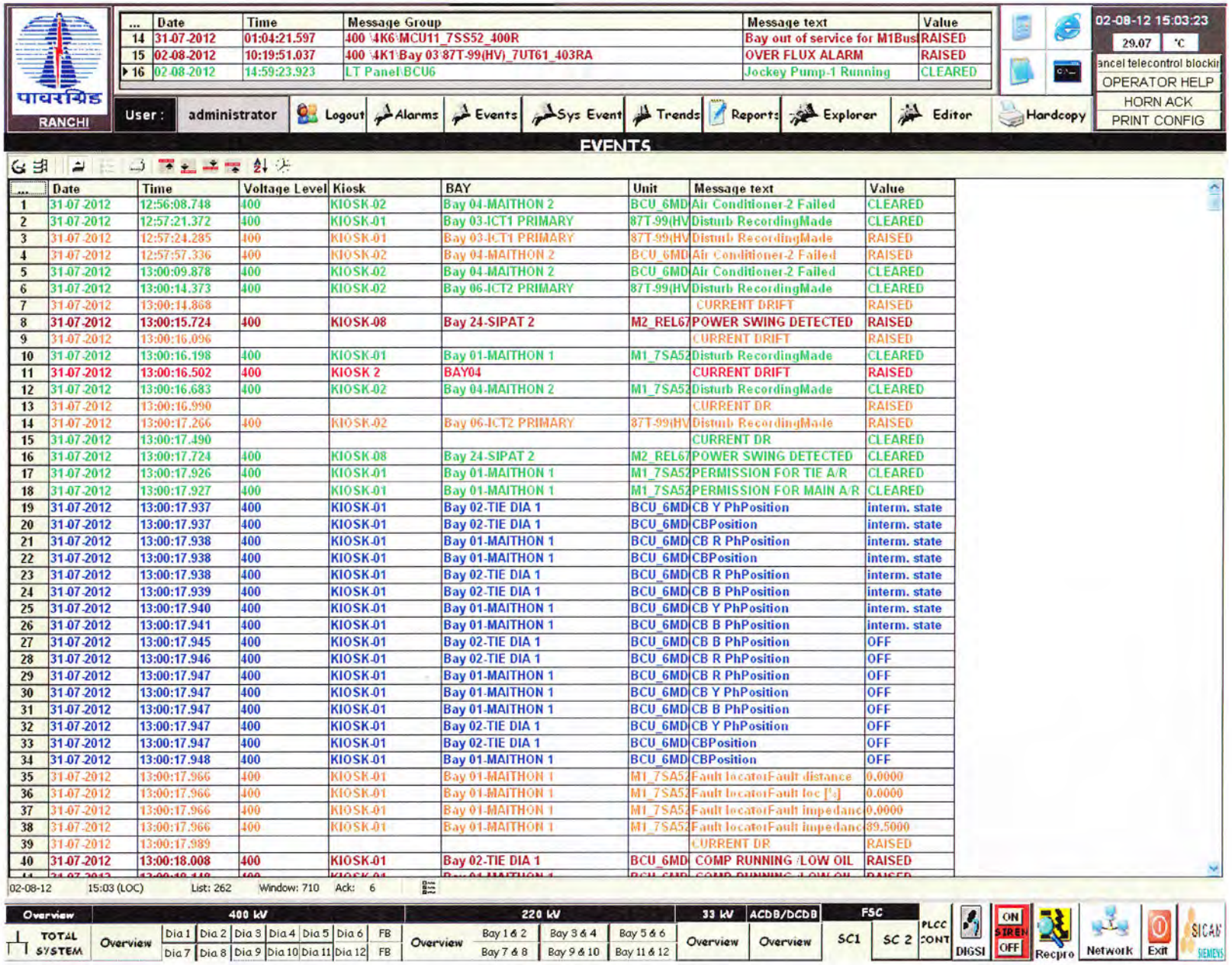
85

```
* File Information::
* ------------------
            Station: ROURKELA-1
             Device: 2
          File Name: C:\DOCUMENTS AND SETTINGS\CONTROLROOM\MY DOCUMENTS\S1 STUDIO\JAMSHEDPUR\ROURKELA-I\1\DR\Tuesday 31 July
          File Size: 248065 Bytes
      Prefault Time: 31/07/2012 13:00:13.008000
         Fault Time: 31/07/2012 13:00:13.207000
          Save Time: 07/31/2012 01:12:22
       Process Time: 08/02/2012 04:00:00
 Start Date && Time: 31/07/2012 13:00:13.008000
   End Date && Time: 31/07/2012 13:00:14.518955
     File Duration: 1  Sec(s) - 510 Mils(s) - 955 Mics(s)
 Sampling Frequency: 1206.272618, 829.000  Microsecond Rate
     Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff   pUnits    Description
 304795.500  -310311.300   232270.656   70905.328   31.7000    5515.800  161365.328     V        1-VA
 393206.800  -302101.000   260845.375  164540.266   31.7000   91105.800   96305.109     V        2-VB
 309613.900  -364803.600   293225.000  170431.766   31.7000   55189.700  122793.234     V        3-VC
 377166.600  -234104.500   141155.844    2599.400   31.7000  143062.100  138556.444     V        4-VN
   2728.856    -2734.380     2071.187       1.705    2.7620       5.524    2069.483     A        5-IA
   2817.240    -2820.002     2678.637       0.916    2.7620       2.762    2677.720     A        6-IB
   2797.906    -2792.382     2458.180       0.949    2.7620       5.524    2457.231     A        7-IC
     55.240    -1173.850      447.910       1.871    2.7620    1118.610     446.040     A        8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change       Lst-Change       Changes    Description
  A    A    13:00:13.225198  xx:xx:xx.xxxxxx  001          2-M - CB RPH CLOSE
  A    A    13:00:13.225198  xx:xx:xx.xxxxxx  001          3-M - CB YPH CLOSE
  A    A    13:00:13.221882  xx:xx:xx.xxxxxx  001          4-M - CB BPH CLOSE
  N    N    13:00:13.206960  13:00:13.251726  002          6-MAIN-1 OPTD
  A    A    13:00:13.223540  xx:xx:xx.xxxxxx  001         13-TIE CB RPH CLOSE
  A    A    13:00:13.223540  xx:xx:xx.xxxxxx  001         14-TIE CB YPH CLOSE
  A    A    13:00:13.221882  xx:xx:xx.xxxxxx  001         15-TIE CB BPH CLOSE
  N    N    13:00:13.255042  13:00:13.341215  002         16-PREPARE 3PH TRIP
```

EXHIBIT-8.4: Ranchi EL



...	Date	Time	Message Group	Message text	Value
14	31-07-2012	01:04:21.597	400 \4K6\MCU11_7SS52_400R	Bay out of service for M1Bus	RAISED
15	02-08-2012	10:19:51.037	400 \4K1\Bay 03\87T-99(HV)_7UT61_403RA	OVER FLUX ALARM	RAISED
▸16	02-08-2012	14:59:23.923	LT Panel\BCU6	Jockey Pump-1 Running	CLEARED

EVENTS

...	Date	Time	Voltage Level	Kiosk	BAY	Unit	Message text	Value
1	31-07-2012	12:56:08.748	400	KIOSK-02	Bay 04-MAITHON 2	BCU_6MD	Air Conditioner-2 Failed	CLEARED
2	31-07-2012	12:57:21.372	400	KIOSK-01	Bay 03-ICT1 PRIMARY	87T-99(HV	Disturb RecordingMade	CLEARED
3	31-07-2012	12:57:24.285	400	KIOSK-01	Bay 03-ICT1 PRIMARY	87T-99(HV	Disturb RecordingMade	RAISED
4	31-07-2012	12:57:57.336	400	KIOSK-02	Bay 04-MAITHON 2	BCU_6MD	Air Conditioner-2 Failed	RAISED
5	31-07-2012	13:00:09.878	400	KIOSK-02	Bay 04-MAITHON 2	BCU_6MD	Air Conditioner-2 Failed	CLEARED
6	31-07-2012	13:00:14.373	400	KIOSK-02	Bay 06-ICT2 PRIMARY	87T-99(HV	Disturb RecordingMade	CLEARED
7	31-07-2012	13:00:14.868					CURRENT DRIFT	RAISED
8	31-07-2012	13:00:15.724	400	KIOSK-08	Bay 24-SIPAT 2	M2_REL67	POWER SWING DETECTED	RAISED
9	31-07-2012	13:00:16.096					CURRENT DRIFT	RAISED
10	31-07-2012	13:00:16.198	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	Disturb RecordingMade	CLEARED
11	31-07-2012	13:00:16.502	400	KIOSK 2	BAY04		CURRENT DRIFT	RAISED
12	31-07-2012	13:00:16.683	400	KIOSK-02	Bay 04-MAITHON 2	M1_7SA52	Disturb RecordingMade	CLEARED
13	31-07-2012	13:00:16.990					CURRENT DR	RAISED
14	31-07-2012	13:00:17.266	400	KIOSK-02	Bay 06-ICT2 PRIMARY	87T-99(HV	Disturb RecordingMade	RAISED
15	31-07-2012	13:00:17.490					CURRENT DR	CLEARED
16	31-07-2012	13:00:17.724	400	KIOSK-08	Bay 24-SIPAT 2	M2_REL67	POWER SWING DETECTED	CLEARED
17	31-07-2012	13:00:17.926	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	PERMISSION FOR TIE A/R	CLEARED
18	31-07-2012	13:00:17.927	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	PERMISSION FOR MAIN A/R	CLEARED
19	31-07-2012	13:00:17.937	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB Y PhPosition	interm. state
20	31-07-2012	13:00:17.937	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CBPosition	interm. state
21	31-07-2012	13:00:17.938	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB R PhPosition	interm. state
22	31-07-2012	13:00:17.938	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CBPosition	interm. state
23	31-07-2012	13:00:17.938	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB R PhPosition	interm. state
24	31-07-2012	13:00:17.939	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB B PhPosition	interm. state
25	31-07-2012	13:00:17.940	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB Y PhPosition	interm. state
26	31-07-2012	13:00:17.941	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB B PhPosition	interm. state
27	31-07-2012	13:00:17.945	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB B PhPosition	OFF
28	31-07-2012	13:00:17.946	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB R PhPosition	OFF
29	31-07-2012	13:00:17.947	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB R PhPosition	OFF
30	31-07-2012	13:00:17.947	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB Y PhPosition	OFF
31	31-07-2012	13:00:17.947	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CB B PhPosition	OFF
32	31-07-2012	13:00:17.947	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CB Y PhPosition	OFF
33	31-07-2012	13:00:17.947	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	CBPosition	OFF
34	31-07-2012	13:00:17.948	400	KIOSK-01	Bay 01-MAITHON 1	BCU_6MD	CBPosition	OFF
35	31-07-2012	13:00:17.966	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	Fault locatorFault distance	0.0000
36	31-07-2012	13:00:17.966	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	Fault locatorFault loc [%]	0.0000
37	31-07-2012	13:00:17.966	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	Fault locatorFault impedanc	0.0000
38	31-07-2012	13:00:17.966	400	KIOSK-01	Bay 01-MAITHON 1	M1_7SA52	Fault locatorFault impedanc	89.5000
39	31-07-2012	13:00:17.989					CURRENT DR	RAISED
40	31-07-2012	13:00:18.008	400	KIOSK-01	Bay 02-TIE DIA 1	BCU_6MD	COMP RUNNING /LOW OIL	RAISED

02-08-12 15:03 (LOC) List: 262 Window: 710 Ack: 6

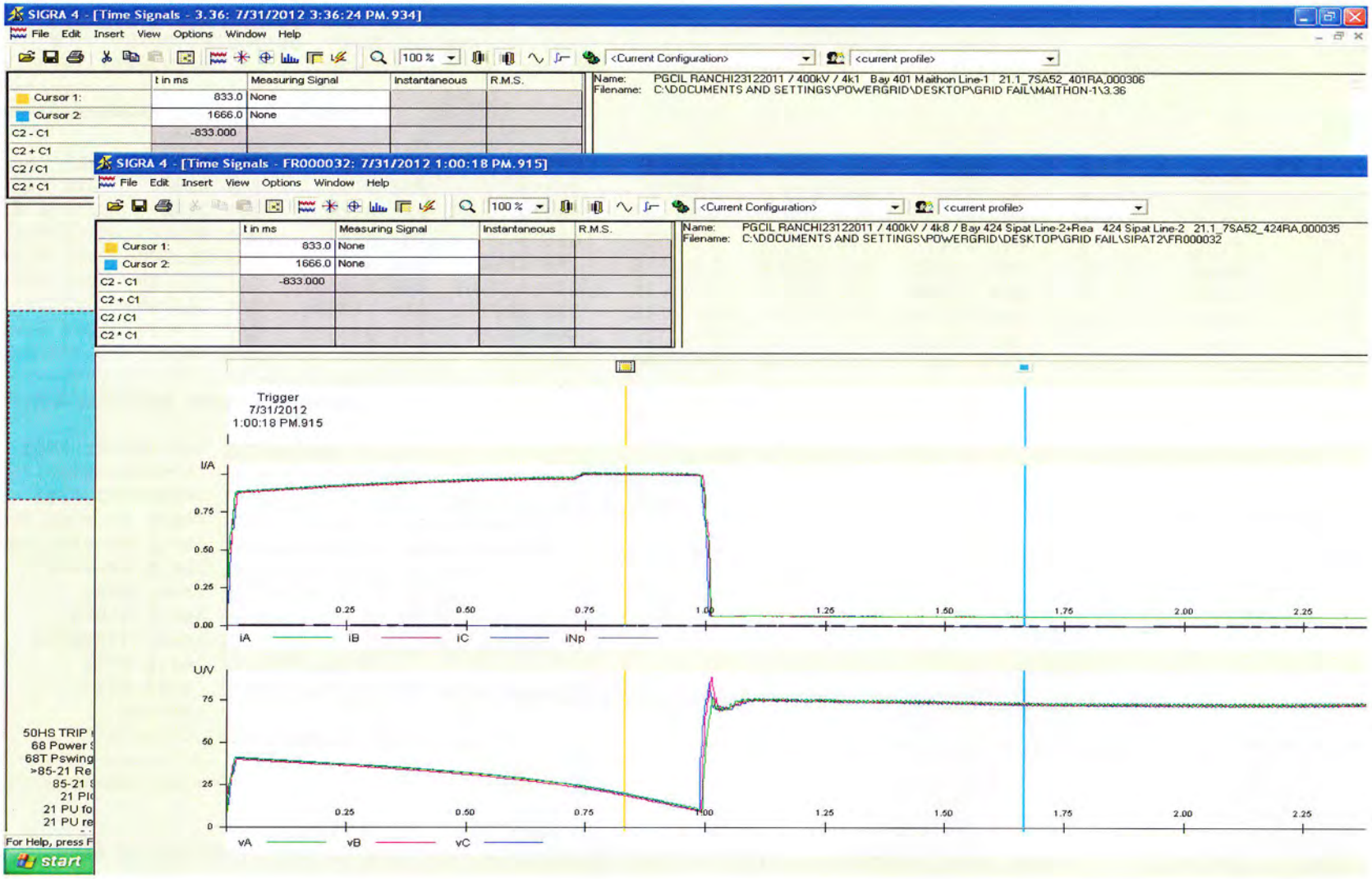
File: Tuesday 31 July 2012 13.00.19.000.DAT - 31/07/2012 - 13:00:19.605 - Secondary - (Peak Type)

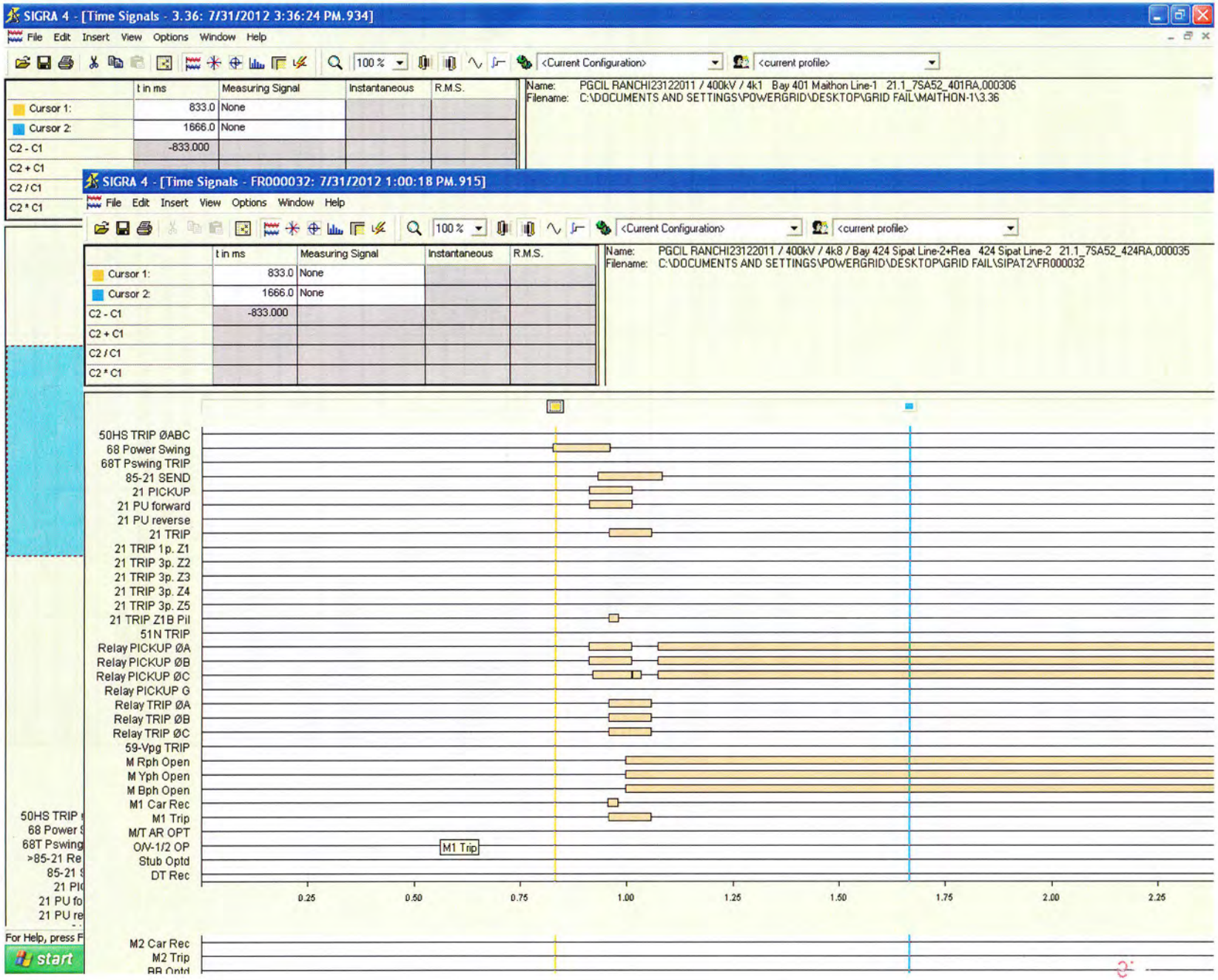

```
* File Information:
* ------------------
            Station: SEL JHARS # 2
             Device: 6
          File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\SEL JHAR #2\1\DR\Tuesday 31
          File Size: 248065 Bytes
     Prefault Time: 31/07/2012 13:00:19.406000
        Fault Time: 31/07/2012 13:00:19.605000
         Save Time: 07/31/2012 18:48:22
      Process Time: 08/01/2012 12:14:15
 Start Date && Time: 31/07/2012 13:00:19.406000
   End Date && Time: 31/07/2012 13:00:20.908411
      File Duration: 1  Sec(s) - 502 Mils(s) - 411 Mics(s)
 Sampling Frequency: 1206.272618, 829.000  Microsecond Rate
     Line Frequency: 50.000000
```

```
* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS      Min-RMS     One-Bit    Inst-Diff     RMS-Diff   pUnits    Description
 431975.900  -424431.300   305986.406   38323.465    31.7000     7544.600   267662.941     V       1-VA
 459491.500  -494995.500   309647.438  114861.586    31.7000    35504.000   194785.852     V       2-VB
 432292.900  -431690.600   307999.844  121878.422    31.7000      602.300   186121.422     V       3-VC
 354374.300  -256706.600   117278.852    3561.844    31.7000    97667.700   113717.008     V       4-VN
   2759.238    -2745.428     1971.681       1.869     2.7620       13.810     1969.812     A       5-IA
   2913.910    -2930.482     2336.924       1.132     2.7620       16.572     2335.792     A       6-IB
   2875.242    -2858.670     2634.948       1.798     2.7620       16.572     2633.150     A       7-IC
     74.574    -1557.768      600.977       2.447     2.7620     1483.194      598.529     A       8-IN
```

```
* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N   13:00:19.604960  13:00:19.649726   002        14-A/R LOCK Z2_Z3
  N    N   13:00:19.604960  13:00:19.649726   002        23-GPR-A TRIP
  N    N   13:00:19.604960  13:00:19.649726   002        24-GPR-B TRIP
```

EXHIBIT-8.5: DR at Ranchi



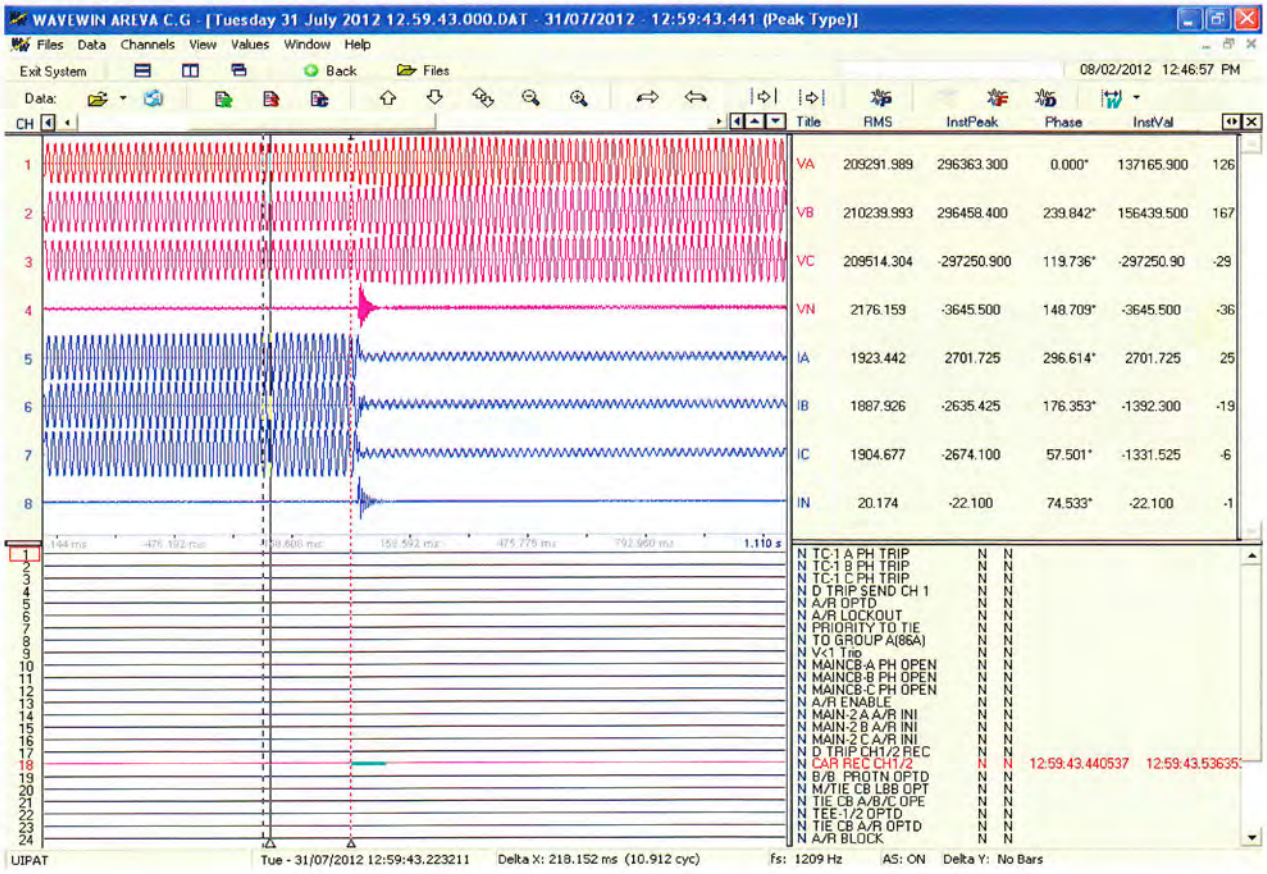

SIGRA 4 - [Time Signals - 3.36: 7/31/2012 3:36:24 PM.934]
File Edit Insert View Options Window Help
100 %
<Current Configuration>
<current profile>
t in ms | Measuring Signal | Instantaneous | R.M.S.
Cursor 1: 833.0 None
Cursor 2: 1666.0 None
C2 - C1 -833.000
C2 + C1
C2 / C1
C2 * C1
Name: PGCIL RANCHI23122011 / 400kV / 4k1 Bay 401 Maithon Line-1 21.1_7SA52_401RA,000306
Filename: C:\DOCUMENTS AND SETTINGS\POWERGRID\DESKTOP\GRID FAIL\MAITHON-1\3.36
SIGRA 4 - [Time Signals - FR000032: 7/31/2012 1:00:18 PM.915]
File Edit Insert View Options Window Help
100 %
<Current Configuration>
<current profile>
t in ms | Measuring Signal | Instantaneous | R.M.S.
Cursor 1: 833.0 None
Cursor 2: 1666.0 None
C2 - C1 -833.000
C2 + C1
C2 / C1
C2 * C1
Name: PGCIL RANCHI23122011 / 400kV / 4k8 / Bay 424 Sipat Line-2+Rea 424 Sipat Line-2 21.1_7SA52_424RA,000035
Filename: C:\DOCUMENTS AND SETTINGS\POWERGRID\DESKTOP\GRID FAIL\SIPAT2\FR000032
50HS TRIP ØABC
68 Power Swing
68T Pswing TRIP
85-21 SEND
21 PICKUP
21 PU forward
21 PU reverse
21 TRIP
21 TRIP 1p. Z1
21 TRIP 3p. Z2
21 TRIP 3p. Z3
21 TRIP 3p. Z4
21 TRIP 3p. Z5
21 TRIP Z1B Pil
51N TRIP
Relay PICKUP ØA
Relay PICKUP ØB
Relay PICKUP ØC
Relay PICKUP G
Relay TRIP ØA
Relay TRIP ØB
Relay TRIP ØC
59-Vpg TRIP
M Rph Open
M Yph Open
M Bph Open
M1 Car Rec
M1 Trip
M/T AR OPT
O/V-1/2 OP
Stub Optd
DT Rec
M1 Trip
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
M2 Car Rec
M2 Trip
For Help, press F
start

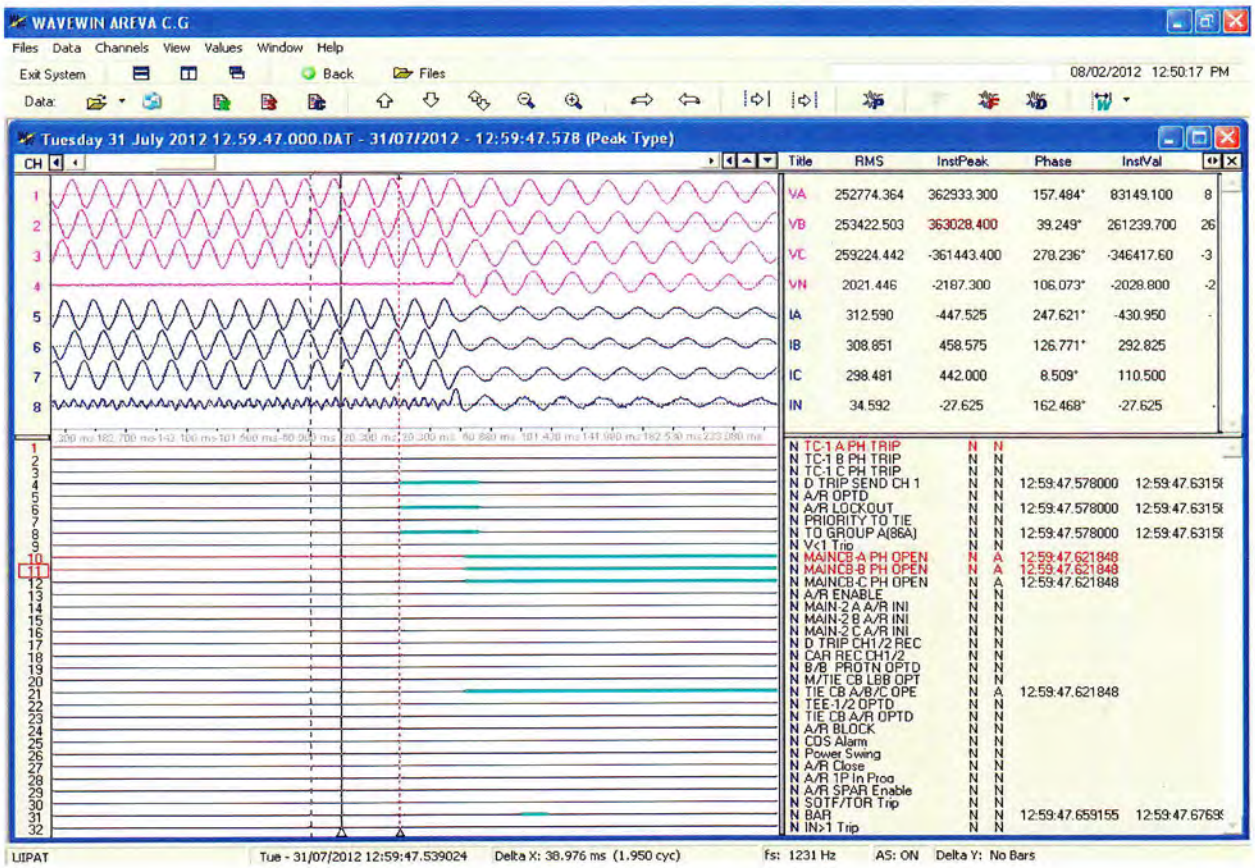
NTPC **SIPAT**

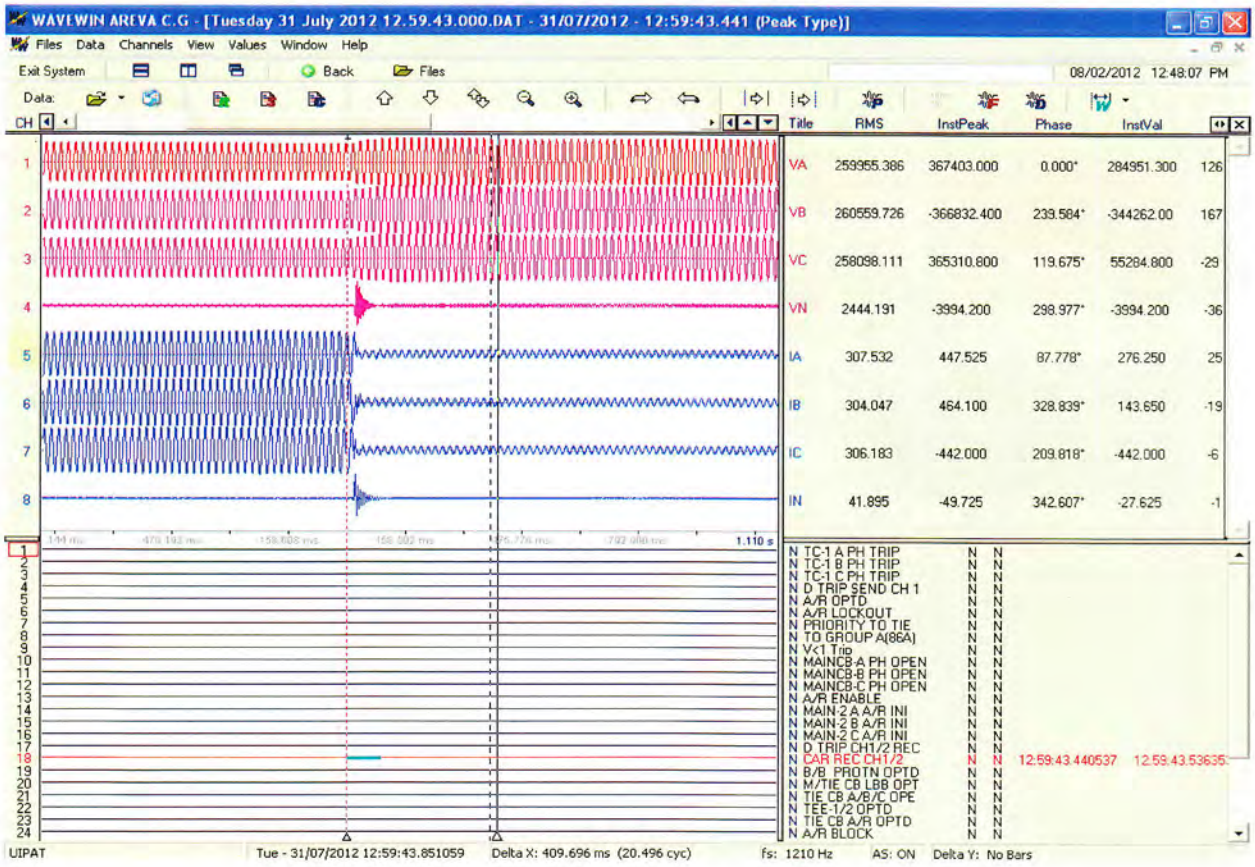
Feeder Description		Sipat - Ranchi-2			
Date and time		31.07.2012		12.59.43 hrs	
Date and time of Charging		31.07.2012		14.16 hrs	
Indications					
Relays at Sipat End			Relays at Other End		
	Main1	**Main2**		**Main1**	**Main2**
	PSB	PSB			
	Over Voltage St-1				
	86A Operated				
LEDs at Sipat End			LEDs at Other End		
	PSB	PSB			
Distance from Sipat KM			Distance from Other end		
		NA			NA
Fault Voltage at Sipat end			Fault current at other end		
		450KV			
Sequence of events			Sequence of events		
	Remote CB trip				
	Carrier Received				
	Over Voltage Stage-1 trip				
	Direct Trip Sent				
PLCC DATA					
	SIPAT			**OTHER END**	
	CH1	**CH2**		**CH1**	**CH2**
Code-1 TX	0	0	Code-1 TX		
Code-1 RX	1	0	Code-1 RX		
Code-2 TX	0	1	Code-2 TX		
Code-2 RX	0	1	Code-2 RX		
Code-3 TX	3	4	Code-3 TX		
Code-3 RX	1	3	Code-3 RX		
Wheter AR took place					
SIPAT	Main	Tie	OTHER END	Main	Tie
	NA	NA		NA	NA
Brief description of the event					

It is observed from DR that at 12.59.43hrs, PSB is detected at Sipat end and load flow has become Zero and permissive carrier is received from Ranchi end. It seems that distance Z1 tripped at other end and all three poles tripped. After tripping of the CB at remote end, line voltage has increased to about 450KV and Sipat end breaker tripped on Over Voltage Stage-1 protection at 12.59.47.

Load flow before tripping					
	LANCO	Raipur-1	Raipur-2	Raipur-3	Ranchi-1
MW	-406	-100	-102	406	0
MVAR	70	-62	-63	-70	0
	Ranchi-2	Seoni-1	Seoni-2		
MW	380	827	811		
MVAR	-260	-236	-323		


WAVEWIN AREVA C.G - [Tuesday 31 July 2012 12.59.43.000.DAT - 31/07/2012 - 12:59:43.441 (Peak Type)]
Files Data Channels View Values Window Help
Exit System
Back
Files
08/02/2012 12:46:57 PM
Data:
CH
Title RMS InstPeak Phase InstVal
VA 209291.989 296363.300 0.000° 137165.900 126
VB 210239.993 296458.400 239.842° 156439.500 167
VC 209514.304 -297250.900 119.736° -297250.90 -29
VN 2176.159 -3645.500 148.709° -3645.500 -36
IA 1923.442 2701.725 296.614° 2701.725 25
IB 1887.926 -2635.425 176.353° -1392.300 -19
IC 1904.677 -2674.100 57.501° -1331.525 -6
IN 20.174 -22.100 74.533° -22.100 -1
N TC-1 A PH TRIP N N
N TC-1 B PH TRIP N N
N TC-1 C PH TRIP N N
N D TRIP SEND CH 1 N N
N A/R OPTD N N
N A/R LOCKOUT N N
N PRIORITY TO TIE N N
N TO GROUP A(86A) N N
N V<1 Trip N N
N MAINCB-A PH OPEN N N
N MAINCB-B PH OPEN N N
N MAINCB-C PH OPEN N N
N A/R ENABLE N N
N MAIN-2 A A/R INI N N
N MAIN-2 B A/R INI N N
N MAIN-2 C A/R INI N N
N D TRIP CH1/2 REC N N
N CAR REC CH1/2 N N 12:59:43.440537
N B/B PROTN OPTD N N
N M/TIE CB LBB OPT N N
N TIE CB A/B/C OPE N N
N TEE-1/2 OPTD N N
N TIE CB A/R OPTD N N
N A/R BLOCK N N
UIPAT
Tue - 31/07/2012 12:59:43.223211
Delta X: 218.152 ms (10.912 cyc)
fs: 1209 Hz
AS: ON
Delta Y: No Bars


WAVEWIN AREVA C.G
Files Data Channels View Values Window Help
Exit System
Back
Files
08/02/2012 12:50:17 PM
Data:
Tuesday 31 July 2012 12.59.47.000.DAT - 31/07/2012 - 12:59:47.578 (Peak Type)
CH
Title RMS InstPeak Phase InstVal
VA 252774.364 362933.300 157.484° 83149.100 8
VB 253422.503 363028.400 39.249° 261239.700 26
VC 259224.442 -361443.400 278.236° -346417.60 -3
VN 2021.446 -2187.300 106.073° -2028.800 -2
IA 312.590 -447.525 247.621° -430.950
IB 308.851 458.575 126.771° 292.825
IC 298.481 442.000 8.509° 110.500
IN 34.592 -27.625 162.468° -27.625
N TC-1 A PH TRIP N N
N TC-1 B PH TRIP N N
N TC-1 C PH TRIP N N
N D TRIP SEND CH 1 N N 12:59:47.578000 12:59:47.6315
N A/R OPTD N N
N A/R LOCKOUT N N 12:59:47.578000 12:59:47.6315
N PRIORITY TO TIE N N
N TO GROUP A(86A) N N 12:59:47.578000 12:59:47.6315
N V<1 Trip N N
N MAINCB-A PH OPEN N A 12:59:47.621848
N MAINCB-B PH OPEN N A 12:59:47.621848
N MAINCB-C PH OPEN N A 12:59:47.621848
N A/R ENABLE N N
N MAIN-2 A A/R INI N N
N MAIN-2 B A/R INI N N
N MAIN-2 C A/R INI N N
N D TRIP CH1/2 REC N N
N CAR REC CH1/2 N N
N B/B PROTN OPTD N N
N M/TIE CB LBB OPT N N
N TIE CB A/B/C OPE N A 12:59:47.621848
N TEE-1/2 OPTD N N
N TIE CB A/R OPTD N N
N A/R BLOCK N N
N COS Alarm N N
N Power Swing N N
N A/R Close N N
N A/R 1P In Prog N N
N A/R SPAR Enable N N
N SOTF/TOR Trip N N
N BAR N N 12:59:47.659155 12:59:47.6769
N IN>1 Trip N N
UIPAT
Tue - 31/07/2012 12:59:47.539024
Delta X: 38.976 ms (1.950 cyc)
fs: 1231 Hz
AS: ON
Delta Y: No Bars


WAVEWIN AREVA C.G - [Tuesday 31 July 2012 12.59.43.000.DAT - 31/07/2012 - 12:59:43.441 (Peak Type)]
Files Data Channels View Values Window Help
Exit System
Back
Files
08/02/2012 12:48:07 PM
Data:
CH
Title RMS InstPeak Phase InstVal
VA 259955.386 367403.000 0.000° 284951.300 126
VB 260559.726 -366832.400 239.584° -344262.00 167
VC 258098.111 365310.800 119.675° 55284.800 -29
VN 2444.191 -3994.200 298.977° -3994.200 -36
IA 307.532 447.525 87.778° 276.250 25
IB 304.047 464.100 328.839° 143.650 -19
IC 306.183 -442.000 209.818° -442.000 -6
IN 41.895 -49.725 342.607° -27.625 -1
1.110 s
N TC-1 A PH TRIP N N
N TC-1 B PH TRIP N N
N TC-1 C PH TRIP N N
N D TRIP SEND CH 1 N N
N A/R OPTD N N
N A/R LOCKOUT N N
N PRIORITY TO TIE N N
N TO GROUP A(86A) N N
N V<1 Trip N N
N MAINCB-A PH OPEN N N
N MAINCB-B PH OPEN N N
N MAINCB-C PH OPEN N N
N A/R ENABLE N N
N MAIN-2 A A/R INI N N
N MAIN-2 B A/R INI N N
N MAIN-2 C A/R INI N N
N D TRIP CH1/2 REC N N
N CAR REC CH1/2 N N 12:59:43.440537 12:59:43.53635
N B/B PROTN OPTD N N
N M/TIE CB LBB OPT N N
N TIE CB A/B/C OPE N N
N TEE-1/2 OPTD N N
N TIE CB A/R OPTD N N
N A/R BLOCK N N
UIPAT
Tue - 31/07/2012 12:59:43.851059
Delta X: 409.696 ms (20.496 cyc)
fs: 1210 Hz
AS: ON
Delta Y: No Bars

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```
* File Information::
* ------------------
            Station: RAIGARH LINE#2
             Device: 5
          File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\RAIGARH#3\1\DR\Tuesd
          File Size: 248065 Bytes
      Prefault Time: 31/07/2012 13:00:19.392000
         Fault Time: 31/07/2012 13:00:19.908000
          Save Time: 07/31/2012 18:27:28
       Process Time: 08/01/2012 10:49:22
 Start Date && Time: 31/07/2012 13:00:19.392000
   End Date && Time: 31/07/2012 13:00:20.903267
      File Duration: 1  Sec(s) - 511 Mils(s) - 267 Mics(s)
 Sampling Frequency: 1206.272618, 829.000  Microsecond Rate
    Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff  pUnits    Description
 471410.700  -473598.000   309631.750  25178.682   31.7000    2187.300  284453.068       V      1-VA
 502793.700  -478416.400   319327.844  23095.588   31.7000   24377.300  296232.256       V      2-VB
 464119.700  -482125.300   313990.250  23803.064   31.7000   18005.600  290187.186       V      3-VC
 429218.000  -507707.200   214756.109    221.900   31.7000   78489.200  214534.209       V      4-VN
   3016.104    -3005.056     2134.521      0.255    2.7620      11.048    2134.266       A      5-IA
   2969.150    -2982.960     2117.624      1.040    2.7620      13.810    2116.584       A      6-IB
   2922.196    -2924.958     2220.648      1.247    2.7620       2.762    2219.401       A      7-IC
   1267.758      -66.288      495.232      2.257    2.7620    1201.470     492.975       A      8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change       Lst-Change       Changes    Description
  N    N   13:00:19.907638  xx:xx:xx.xxxxxx  001          7-ANN-PSB
  N    N   13:00:19.907638  xx:xx:xx.xxxxxx  001          8-TO E/L PSB
  N    N   13:00:19.909296  13:00:19.917586  002         14-A/R LOCK Z2_Z3
  N    N   13:00:19.909296  13:00:19.917586  002         23-GPR-A TRIP
  N    N   13:00:19.909296  13:00:19.917586  002         24-GPR-B TRIP
```

EXHIBIT-6.17: DR at Rourkela

File: Tuesday 31 July 2012 13.00.19.000.DAT - 31/07/2012 - 13:00:19.925 - Secondary - (Peak Type) Page: 1

```
* File Information::
* ------------------
            Station: RANCHI LINE#1
             Device: 4
          File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\RANCHI#1\1\DR\Tuesday 31 Ju
          File Size: 248065 Bytes
      Prefault Time: 31/07/2012 13:00:19.716000
         Fault Time: 31/07/2012 13:00:19.925000
          Save Time: 07/31/2012 18:37:52
       Process Time: 08/01/2012 10:52:56
 Start Date && Time: 31/07/2012 13:00:19.716000
   End Date && Time: 31/07/2012 13:00:21.233579
      File Duration: 1  Sec(s) - 517 Mils(s) - 579 Mics(s)
 Sampling Frequency: 1206.272618, 829.000  Microsecond Rate
     Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff   pUnits    Description
 444212.100  -409500.600   266004.906  23889.273   31.7000   34711.500  242115.633     V       1-VA
 427125.800  -834312.300   335170.594  21427.199   31.7000  407186.500  313743.395     V       2-VB
 723964.600  -496517.100   333779.781  22368.039   31.7000  227447.500  311411.742     V       3-VC
 851779.000 -1038713.900   477982.906   4078.843   31.7000  186934.900  473904.063     V       4-VN
   4419.200    -2560.374     2406.911      1.870    2.7620    1858.826    2405.041     A       5-IA
   2604.566    -2651.520     1802.196      1.261    2.7620      46.954    1800.935     A       6-IB
   2546.564    -2599.042     1808.580      1.870    2.7620      52.478    1806.710     A       7-IC
   2831.050     -215.436     1274.322      0.000    2.7620    2615.614    1274.322     A       8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N   13:00:19.924908  13:00:20.163208  009          2-Any Start
  N    N   13:00:19.926566  13:00:19.972990  002          3-Z1
  N    N   13:00:19.926566  13:00:19.982938  002         16-CARRIER SEND
  N    N   13:00:19.974648  xx:xx:xx.xxxxxx  001         17-MCB R-PH OPEN
  N    N   13:00:19.971332  xx:xx:xx.xxxxxx  001         18-MCB Y-PH OPEN
  N    N   13:00:19.971332  xx:xx:xx.xxxxxx  001         19-MCB B-PH OPEN
  A    A   xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         28-CR CH-1 HEALTHY
  N    N   13:00:19.956410  xx:xx:xx.xxxxxx  001         30-TIE CB R-PH OPEN
  N    N   13:00:19.958068  xx:xx:xx.xxxxxx  001         31-TIE CB Y-PH OPEN
  N    N   13:00:19.959726  xx:xx:xx.xxxxxx  001         32-TIE CB B-PH OPEN
```

EXHIBIT-37: DR at Rourkela

File: Tuesday 31 July 2012 13.00.19.000.DAT - 31/07/2012 - 13:00:19.891 - Secondary - (Peak Type)


```
* File Information::
* ------------------
          Station: PG-ROURKELA
           Device: 2
        File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\TALCHER#2\1\DR\Tuesday 31 J
        File Size: 248065 Bytes
    Prefault Time: 31/07/2012 13:00:19.679000
       Fault Time: 31/07/2012 13:00:19.891000
        Save Time: 07/31/2012 18:54:12
     Process Time: 08/01/2012 10:45:07
Start Date && Time: 31/07/2012 13:00:19.679000
  End Date && Time: 31/07/2012 13:00:21.179972
     File Duration: 1  Sec(s) - 500 Mils(s) - 972 Mics(s)
Sampling Frequency: 1207.729469, 828.000  Microsecond Rate
    Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff  pUnits  Description
 467162.900  -456099.600   350927.250  22200.830   31.7000   11063.300  328726.420       V  1-VA
 495090.600  -442500.300   332871.906  16169.873   31.7000   52590.300  316702.033       V  2-VB
 458762.400  -486753.500   333896.656  22743.936   31.7000   27991.100  311152.721       V  3-VC
 463834.400  -576020.700   330068.875   1426.500   31.7000  112186.300  328642.375       V  4-VN
   4394.342    -4419.200     3125.932     33.747    2.7620      24.858    3092.185       A  5-IA
   4259.004    -4234.146     3516.021     39.356    2.7620      24.858    3476.666       A  6-IB
   4449.582    -4413.676     3177.404     42.316    2.7620      35.906    3135.088       A  7-IC
   1129.658    -2960.864     1114.948      2.762    2.7620    1831.206    1112.186       A  8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N   13:00:19.890968  13:00:19.957208   002          5-MAIN2 CR REC
  N    N   13:00:19.897592  13:00:19.924088   002         20-Power Swing
```

EXHIBIT-B19: DR at Rourkela


```
* File Information::
* ------------------
          Station: PG-ROURKELA
           Device: 1
        File Name: D:\DOCUMENTS AND SETTINGS\SERVER\MY DOCUMENTS\S1 STUDIO\PGCIL ROURKELA\TALCHER#1\1\DR\Tuesday 31 J
        File Size: 248065 Bytes
    Prefault Time: 31/07/2012 13:00:19.695000
       Fault Time: 31/07/2012 13:00:19.897000
        Save Time: 07/31/2012 18:50:18
     Process Time: 08/01/2012 10:47:06
Start Date && Time: 31/07/2012 13:00:19.695000
  End Date && Time: 31/07/2012 13:00:21.206267
    File Duration: 1  Sec(s) - 511 Mils(s) - 267 Mics(s)
Sampling Frequency: 1206.272618, 829.000  Microsecond Rate
   Line Frequency: 50.000000

* Maximum/Minimum Analog Summary:
* -------------------------------
>  Max-Inst     Min-Inst      Max-RMS     Min-RMS    One-Bit   Inst-Diff    RMS-Diff  pUnits   Description
 465609.600  -443483.000   303961.781  21040.037   31.7000   22126.600  282921.744    V       1-VA
 465831.500  -423195.000   307008.063  16468.717   31.7000   42636.500  290539.346    V       2-VB
 530721.400  -289325.900   225282.484  22277.053   31.7000  241395.500  203005.432    V       3-VC
 929729.300  -746313.100   495358.563   2179.614   31.7000  183416.200  493178.948    V       4-VN
   6316.694    -5819.534     4210.086      1.817    2.7620     497.160    4208.269    A       5-IA
   5783.628    -7918.654     4211.632      4.444    2.7620    2135.026    4207.189    A       6-IB
   6708.898    -5891.346     4181.712      1.755    2.7620     817.552    4179.957    A       7-IC
   2576.946    -4723.020     2984.505      3.144    2.7620    2146.074    2981.361    A       8-IN

* Events/Sensors Activity Summary:
* ---------------------------------
>Fst  Lst  Fst-Change        Lst-Change        Changes    Description
  N    N   13:00:19.948674  13:00:20.036548  002          1-Any Trip
  N    N   13:00:19.907224  13:00:19.993440  002          2-DIST Start A
  N    N   13:00:19.897276  13:00:19.993440  002          3-DIST Start B
  N    N   13:00:19.897276  13:00:19.993440  002          4-DIST Start C
  N    N   13:00:19.985150  xx:xx:xx.xxxxxx  001          7-MAIN CB RPH OPEN
  N    N   13:00:19.985150  xx:xx:xx.xxxxxx  001          8-MAIN CB YPH OPEN
  N    N   13:00:19.986808  xx:xx:xx.xxxxxx  001          9-MAIN CB BPH OPEN
  A    A   xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         17-TIE CB RPH OPEN
  A    A   xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         18-TIE CB YPH OPEN
  A    A   xx:xx:xx.xxxxxx  xx:xx:xx.xxxxxx  000         19-TIE CB BPH OPEN
  N    N   13:00:19.993440  13:00:21.006478  008         20-Power Swing
```