PATIKARI POWER PVT LTD

2 X 8 MW

Mandi District, Himachal Pradesh

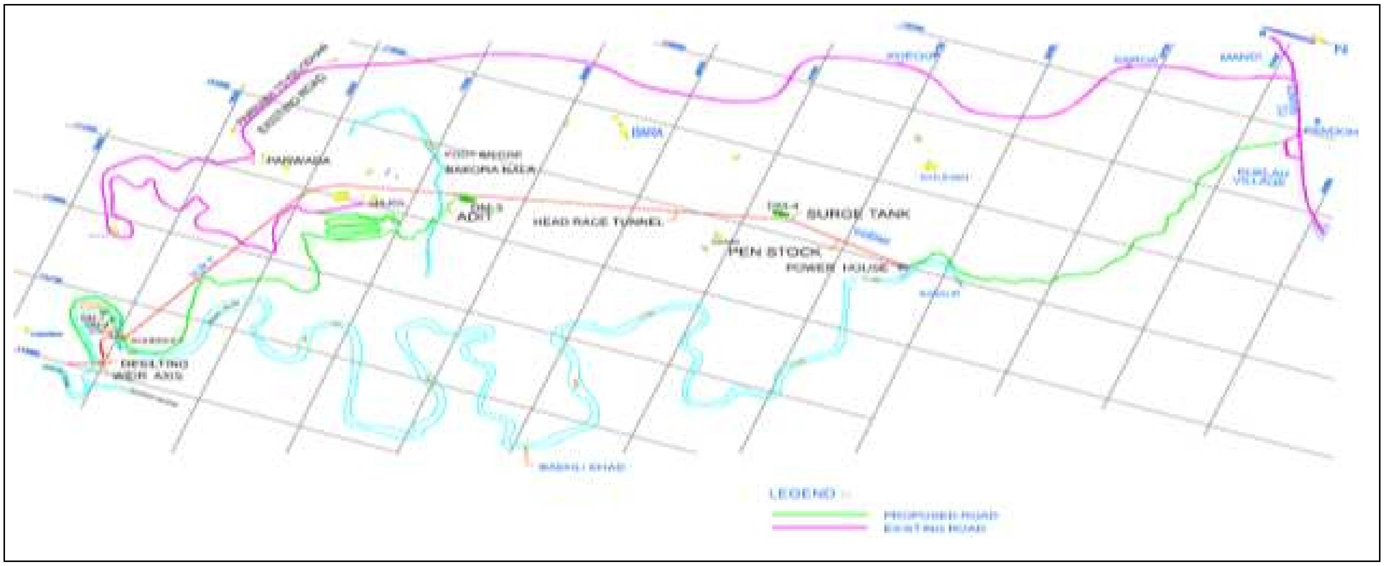



Annual O&M Report

FY 2011-12

Contents

1. Introduction



16 MW Patikari Project, implemented by Patikari Power Private Limited, is a run of the river hydro power project developed on Bakhli Khad, a tributary of Beas River and is located in Mandi district of Himachal Pradesh, India. Two (2) generating Units driven by horizontal shaft Pelton Turbines, each having a rated output of 8.0 MW, are installed in the Power Station. These generating Units are designed to run at fifteen (15) % continuous overload. The Design Energy of the Power Plant is 78.81 million KWh of electrical energy based on the 90% Dependable Discharge and rated output of 16 MW.

The project comprises of the following component structures:

i. A solid gravity un-gated weir of about 5m height, built in stone masonry and cement concrete

ii. One gated under sluice built in reinforced cement concrete

iii. A 2-bay power intake combined with surface de-silting tank built in stone masonry /reinforced cement concrete

iv. Cut and cover conduit outlet from the de-silting chamber connecting the head race tunnel

v. D-shaped concrete lined head race tunnel having 1.8m width and 2.1m height. Total length of tunnel from intake to surge shaft is about 3600m

vi. Two steel pipe aqueducts in the HRT, one across the Bakhli Khad and the other across the Bakora Nallah

vii. Restricted orifice type steel surge shaft of 3m diameter, at the outlet portal of HRT

viii. Penstock Butterfly Valve downstream of the surge shaft

ix. One surface steel penstock of 1.3m diameter and 680m length, bifurcated at the end into 0.9m diameter unit penstocks

x. Surface powerhouse on the left bank of the Bakhli Khad, equipped with 2 horizontal Pelton Wheel units each of 8 MW capacity

xi. Two numbers of 3-phase unit transformers and a surface switch yard located adjacent to the powerhouse

Patikari HE Project harnesses energy of the water in Bakhli Khad River diverted through a Diversion Weir and led to Desilting Tanks. After flushing the silt, if any, clean water is then fed to the Water Conductor System comprising of 3.6 km Head Race Tunnel including two (2) Aquaducts enroute, followed by Surface Steel Surge Shaft and 715 m long Penstock feeding water under pressure for driving two (2) hydro-generating Units in the Power House. After passing through the Turbines, water is led back to Bakhli Khad through Tail Race Channel.

Each of the two (2) Generating Units in Patikari Hydropower station comprises horizontal Pelton Turbine to which synchronous Generator is directly coupled, generating rated power of 8.0 MW at 11kV. Besides appropriate Unit and Station Auxiliaries, state of the art Control and Monitoring System (SCADA) has been installed in the Power Station to ensure optimum generation there from.

Power so generated is then being stepped up to 33kV through two (2) 11MVA Step-up Transformers and evacuated through one (1) double circuit 11km long 33kV Transmission Line terminating at the other end in 33kV Substation of HPSEB at Pandoh which is part of the HPSEB network. Patikari Power Private Limited have entered into a long term Power Purchase Agreement dated 5th July 2004 with HPSEB envisaging delivery of power from the Project at 33kV Substation of the Board at Pandoh in Mandi district of Himachal Pradesh. Tariff for the electricity to be supplied by the Project to the Board at this Delivery Point is Rs. 2.25 per kWH (fixed).

Design Energy of the project, based on the 90% Dependable year Discharge as adopted in the Detailed Project Report and without taking into account mandatory release of 15% discharge during lean discharge period, is 78.81 MU. However, discharge trend in Bakhli Khad as actually observed since commissioning of the project, does not match with above said Design discharges especially during eight lean discharge months even in years with normal monsoon rains. As a result, actual annual energy generation from the Project till date has been less than that of the Design Energy even during years with normal monsoon rains and in spite of both the units having been run continuously at around 15% overload capacity during monsoon months.

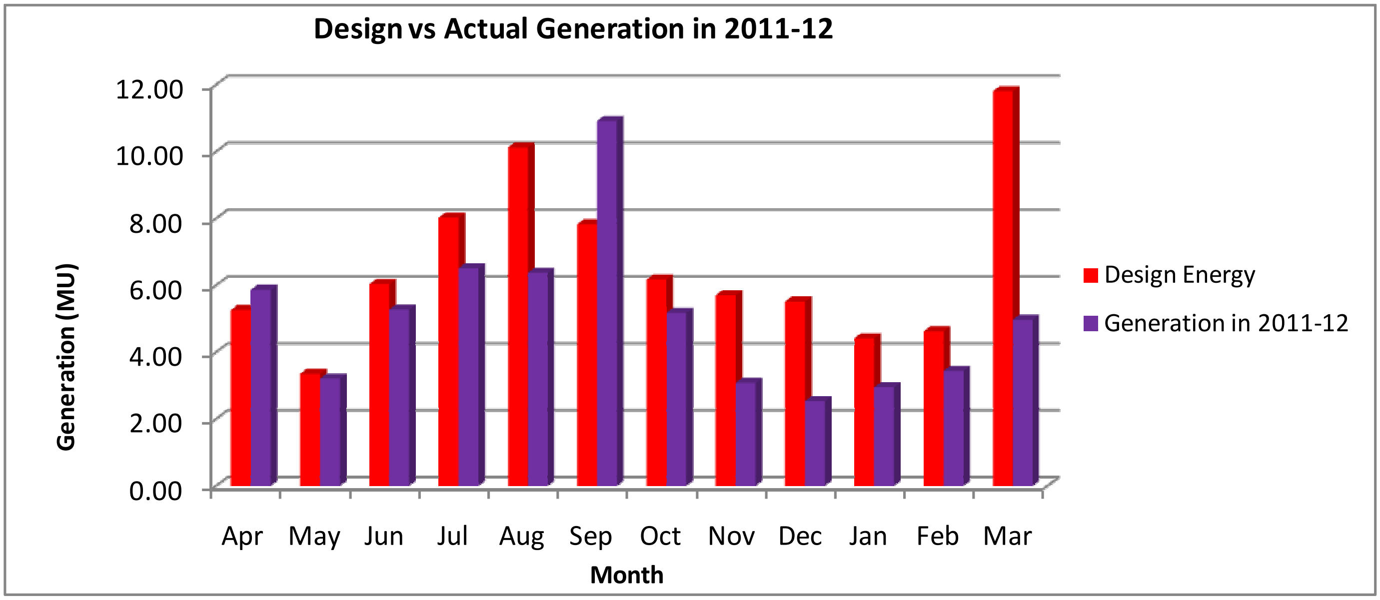
2. Plant Performance

2.1 Generation Data during the Year

Month wise Design Energy and corresponding actual generation from the Project during 2011-12 and reasons for variations between the two are tabulated hereunder.

Month	Design Energy (90% Dependable Year in MUs)	Actual Generation (MUs) during 2011-12	Actual Vs Design Energy (%)	Remarks
Apr	5.26	5.859	111.39	
May	3.35	3.203	95.61	Due to low discharge
Jun	6.03	5.269	87.38	Due to Rewinding & Restoration works of Unit-I
Jul	8.02	6.506	81.12	
Aug	10.12	6.369	62.93	
Sep	7.82	10.913	139.55	
Oct	6.17	5.172	83.82	Due to low discharge
Nov	5.70	3.075	53.95	
Dec	5.51	2.526	45.84	
Jan	4.41	2.942	66.71	
Feb	4.62	3.434	74.33	
Mar	11.80	4.963	42.06	
Total	**78.81**	**60.23**	**76.43**	

As evident from above, against Design Energy of 78.81 MU based on 90% Dependable Year Discharges, Project generated **60.23 MU** during the financial year 2011-12. The Generation during financial year 2011-12 was thus ***76.43%*** of the Design Energy.



2.2 Generation during four years of Operation since commissioning:

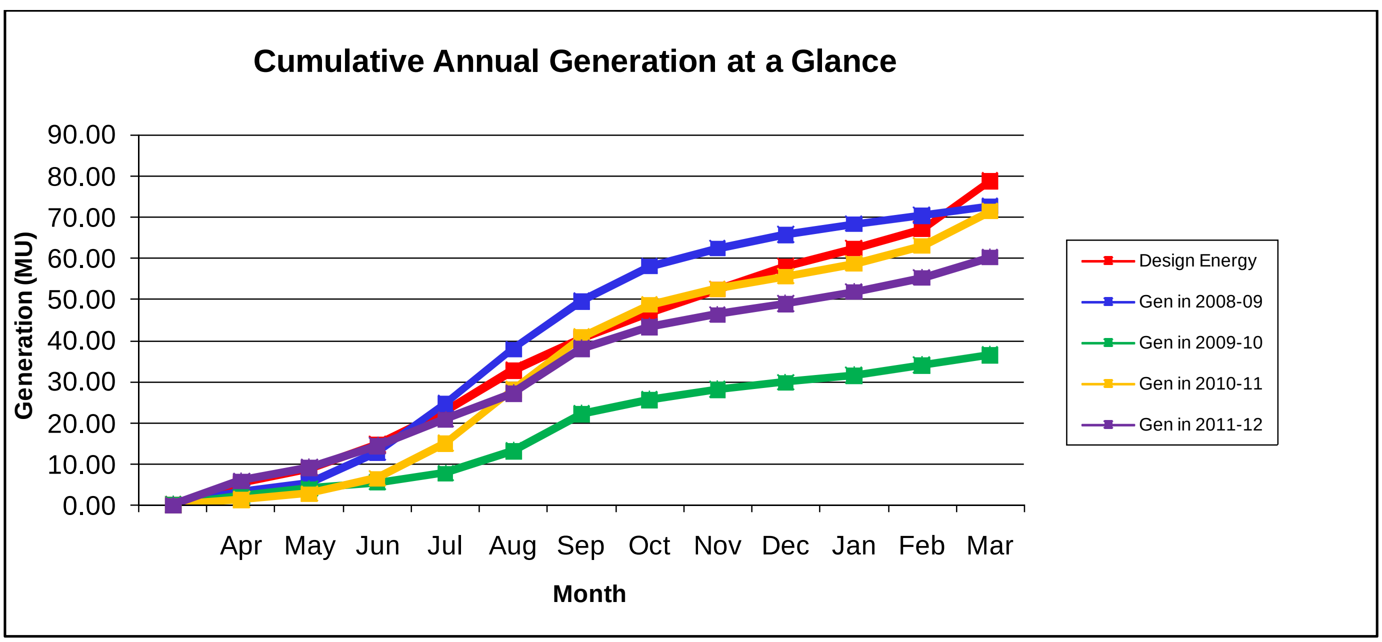
Month	Design Energy (90% Dependable Year in MUs)	Actual Generation (MUs) during 2008-09	Actual Generation (MUs) during 2009-10	Actual Generation (MUs) during 2010-11	Actual Generation (MUs) during 2011-12
Apr	5.26	3.08	2.28	1.29	5.859
May	3.35	2.36	1.68	1.51	3.203
Jun	6.03	7.20	1.50	3.72	5.269
Jul	8.02	12.02	2.22	8.42	6.506
Aug	10.12	13.21	5.49	13.05	6.369

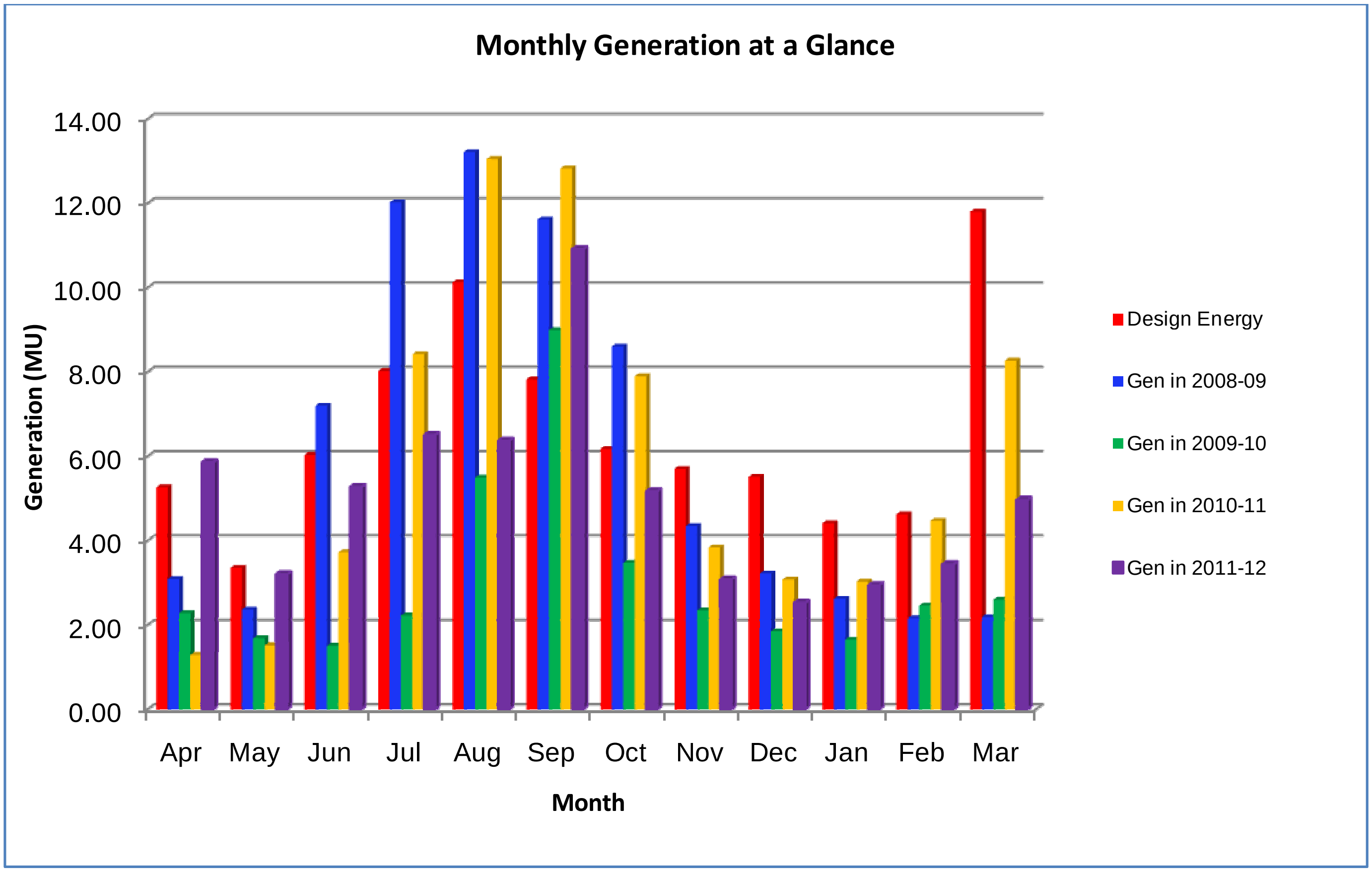
Sep	**7.82**	**11.61**	**8.99**	**12.82**	**10.913**
Oct	**6.17**	**8.60**	**3.47**	**7.90**	**5.172**
Nov	**5.70**	**4.34**	**2.34**	**3.83**	**3.075**
Dec	**5.51**	**3.22**	**1.84**	**3.07**	**2.526**
Jan	**4.41**	**2.62**	**1.65**	**3.03**	**2.942**
Feb	**4.62**	**2.16**	**2.46**	**4.47**	**3.434**
Mar	**11.80**	**2.18**	**2.59**	**8.26**	**4.963**
Total	**78.81**	**72.60**	**36.52**	**71.36**	**60.23**

Actual Generation during 2008-09, 2009-10 & 2010-11 was ***72.60 MU***, ***36.52 MU & 71.36 MU*** respectively. Hence the Generation during 2011-12 is ***82.96%, 164.95%*** and ***84.40%*** respectively of the Generation during 2008-09, 2009-10 & 2010-11.

Generation during Apr-11 & May-11 is the highest achieved during these months since commissioning of the project. However, the generation in May-11 was still less than the corresponding Design Energy.

Generation during the first quarter i.e. Apr-11 to Jun-11 was ***14.33 MU*** i.e. 97.88 % of the Design Energy of 14.64 MU which is the highest achieved so far for this quarter since commissioning of the project.





2.3 Discharge actually observed in the Bakhli Khad after commissioning.

Discharges actually observed in Bakhli Khad during lean discharge months after commissioning of the Project are much lower than the corresponding Design Discharges and many a times even less than the lowest monthly discharges recorded before commissioning as per DPR.

A comparison of discharges actually observed in Bakhli Khad after commissioning of the Project vis-a vis Design and earlier lowest recorded monthly discharges is given below.

Discharge Observed in Bakhli Khad (in cumecs)						
Month	90% Dependable Year Discharge	Lowest Monthly Discharge as per DPR prior to commissioning	Actual Discharge during 2008-09	Actual Discharge during 2009-10	Actual Discharge during 2010-11	Actual Discharge during 2011-12
Apr	2.45	1.79	1.80	1.12	0.69	2.87
May	1.52	1.29	1.03	0.76	0.76	1.60
Jun	2.81	1.23	4.84	0.74	2.40	3.52
July	6.15	3.47	5.98	1.02	5.34	6.73
Aug	4.56	4.56	8.01	3.03	12.55	10.05
Sep	3.65	3.65	5.90	6.32	9.44	6.65
Oct	2.79	2.70	3.72	1.54	3.67	2.43
Nov	2.66	1.77	2.08	1.15	1.87	1.55
Dec	2.49	1.43	1.48	0.88	1.49	1.25
Jan	1.99	1.16	1.25	0.82	1.48	1.53
Feb	2.26	0.89	1.15	1.28	2.44	1.78
Mar	6.46	1.20	1.07	1.18	3.87	2.44

2.3 Revenue Generation / Realization

Project delivered 5,18,34,816 Units of electricity to HPSEB during financial year 2011-12 after accounting for 12% Free Power to the Home State. Against the energy supplied and billed for the year 2011-12 amounting to INR 11,66,28,336, HPSEB released payments amounting to INR 12,29,86,512/- including the payment for March-11 amounting to INR 1,60,09,488/- released during April-11. Details about the monthly billings and receipts are tabulated hereunder:

Revenue Generation/Realization during Financial Year 2011-12				
S.No.	**Period**	**Total Saleable Energy (kWh)**	**Bill Raised**	**Amount Received**
1	----------	----------	----------	16009488*
2	01/04/11 to 01/05/11	5031840	11321640	11321640
3	01/05/11 to 01/06/11	2774112	6241752	6241752
4	01/06/11 to 01/07/11	4571424	10285704	10285704
5	01/07/11 to 01/08/11	5614752	12633192	12633192
6	01/08/11 to 01/09/11	5482752	12336192	12336192
7	01/09/11 to 01/10/11	9318144	20965824	20965824
8	01/10/11 to 01/11/11	4394016	9886536	9886536
9	01/11/11 to 01/12/11	2672736	6013656	6013656
10	01/12/11 to 01/01/12	2173248	4889808	4889808
11	01/01/12 to 01/02/12	2532288	5697648	5697648
12	01/02/12 to 01/03/12	2980032	6705072	6705072
13	01/03/12 to 01/04/12	4289472	9651312**	----------
	Total	**5,18,34,816**	**11,66,28,336**	**12,29,86,512**

- * Payment against Energy bill amounting to Rs. 1,60,09,488 raised for March-2011 was realized during April-2011.

- ** Energy bill amount of Rs. 96,51,312 for saleable energy of 42,89,472 units during March-2012 had been realized in April-2012.

- *** As per HPERC Order dated dated 16th Jul, 2010 & APTEL order dated 23rd Apr, 2012, we are entitled to additional payments from HPSEBL for increased tariff as under:

  - ✓ ***Rs 2.998 Crores*** from 16.07.2010 to 31.03.2012 ***(as per HPERC order)***
  - ✓ ***Rs 2.941 Crores*** from 18.01.2008 to 15.07.2010 ***(as per APTEL order)***

  However HPERC & APTEL Orders are subject to the order of High Court of Himachal Pradesh on writ petition filed by HPSEBL.

3. Preventive Maintenance

To minimize the plant outages and consequent avoidable generation loss of the project, periodic preventive maintenance schedules for all the equipments have been prepared & are being complied with. These periodic maintenance schedules are listed below.

- Daily maintenance schedule
- Weekly maintenance schedule
- Monthly maintenance schedule
- Quarterly maintenance schedule
- Half-Yearly maintenance schedule
- Yearly maintenance schedule

Apart from the above schedules, cleaning of both desanders prior to, during and after monsoons are being carried out

✓ **Cleaning of both Desanders at Weir Site –**

To avoid the choking of Desander channels during monsoon months, regular cleaning of the Trash Racks and De-sanders, as depicted in following photographs, is being carried out during monsoon months.

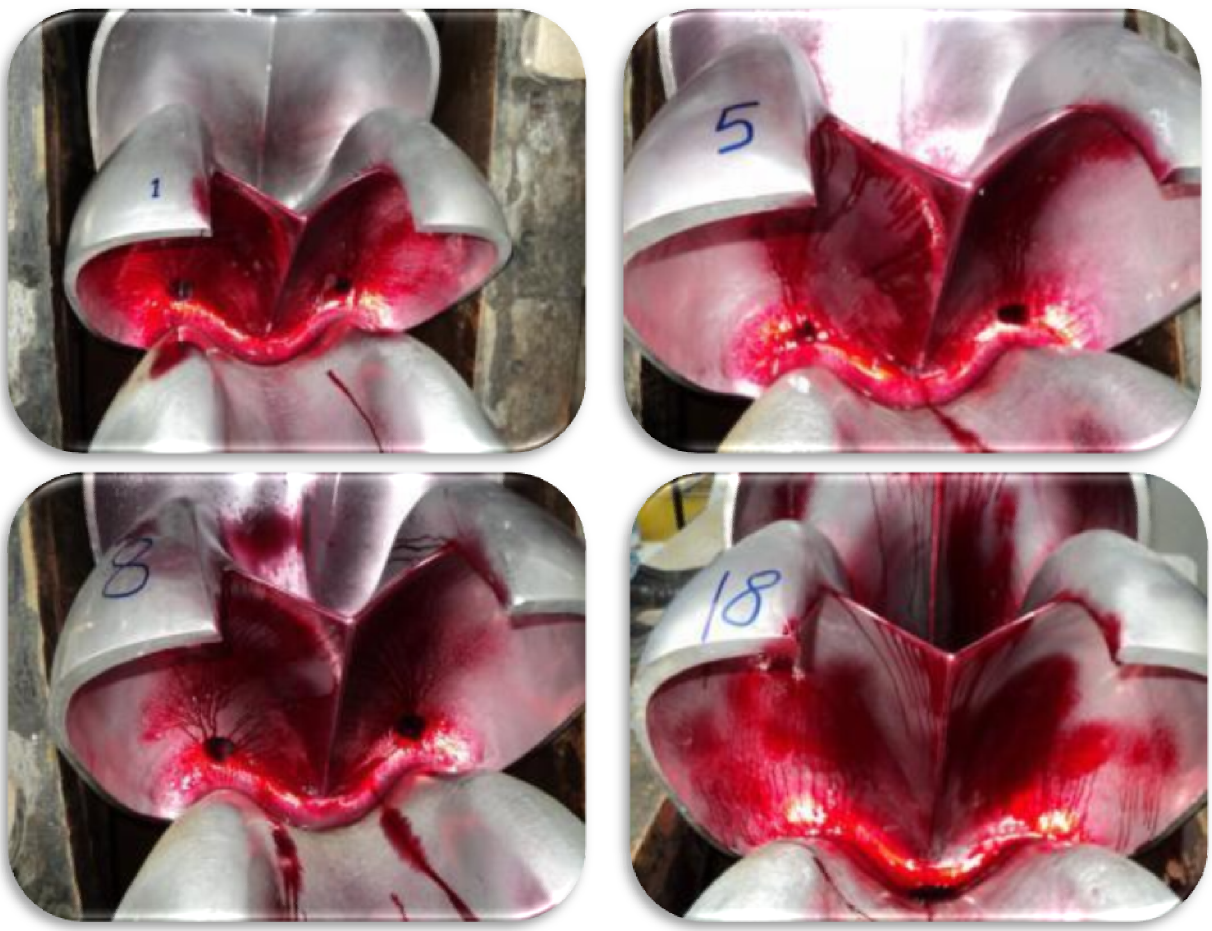
4 Post Monsoon Inspections

4.1 Underwater Parts

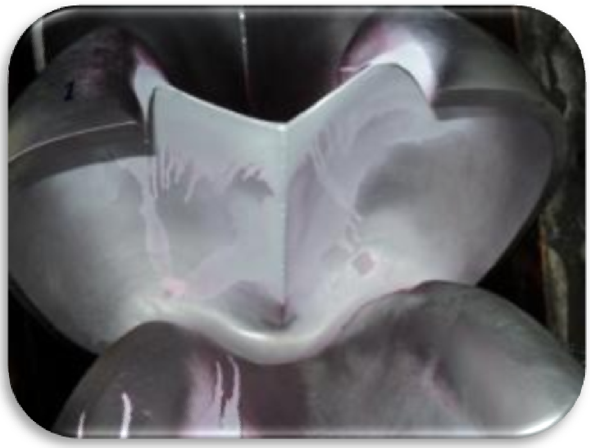
4.1.1 Runners:

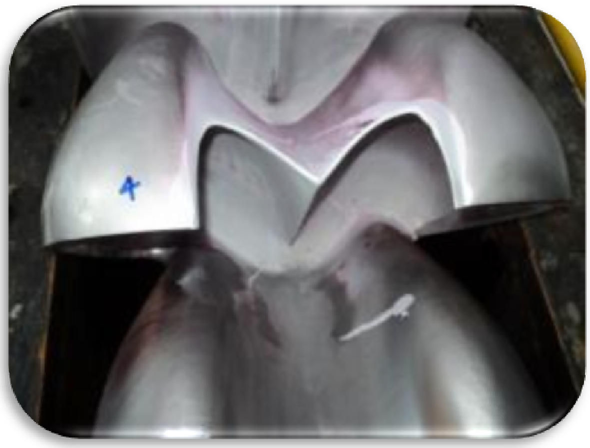
Runners of both the units have been inspected after the monsoon months. The unit wise photographs of Runner Buckets as taken during Dye Penetration Tests (DPT) are shown below.

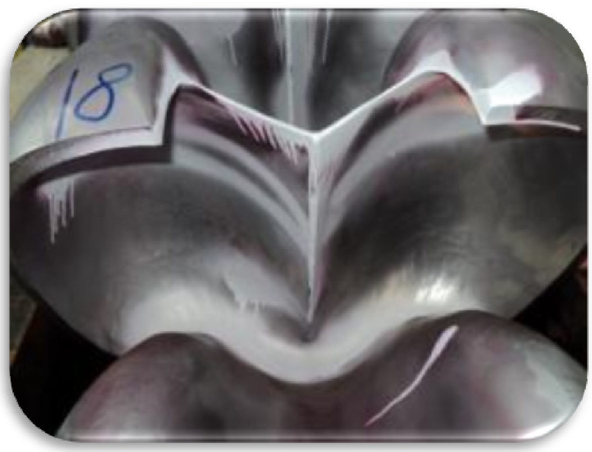
<u>Unit-I:</u>



Unit-II:







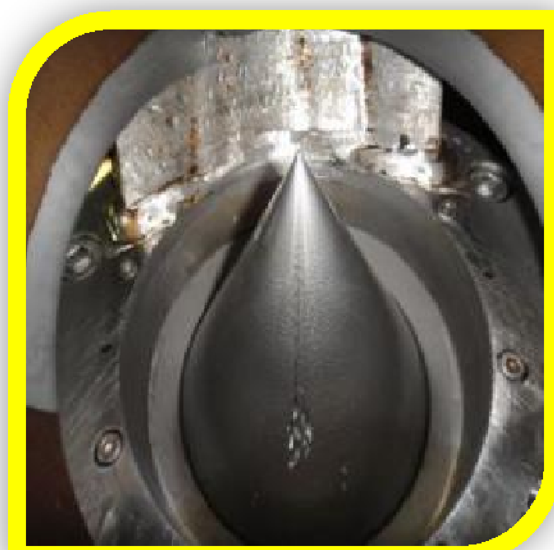
Observations during the Inspections:

No traces of appreciable erosion damages were found and as such no major overhauling works were required to be undertaken on the runners.

4.1.2 Nozzles:

Unit-I:

Unit-II:



Observations during the Inspections:

- ✓ Major dents & erosion were found on Unit-I Nozzle
- ✓ One dent in Unit-II nozzle due to striking of foreign material

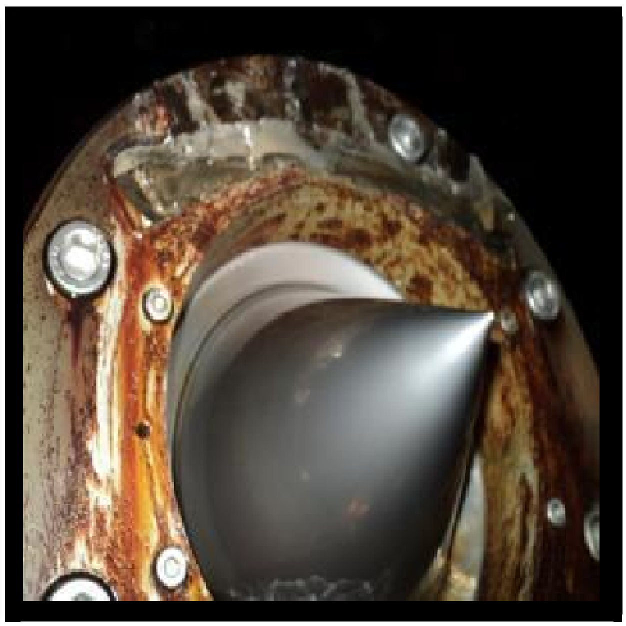
The nozzles of unit-I were replaced with the available spare ones. The damaged nozzles need touch-up works to be done. Nozzles of Unit-II, as such, didn't require any major maintenance/overhauling work.

4.1.3. Flanges with Buckler:

As the Flanges with Buckler of both units had been getting damaged, the same were inspected from time to time during the year. The unit wise photographs of such damaged Flanges are shown below.

<u>Unit-I:</u>

Unit-II:



Observations during the Inspections:

Flanges with Buckler of Unit-I had got damaged. The same had been replaced with the spare one. Unit-II had been operated with buckler. Flanges of Unit-II got rusted.

4.2 Weir Site & Approach Roads

Due to heavy rains and Floods from 13th to 16th August 2011, some damages have taken place to the approach roads to the Power House& Weir site. Wire crates for protection of De-sanders had also been damaged. Intensity of heavy flood waters in the river at power house site can be seen in the pictures given below.

The maximum river water level along the boundary of the Project structures observed during the heavy rains and floods from 13th to 16th August 2011 was recorded as 1032.50 m against the Machine Hall Floor elevation of 1032.35m.

The damages which occurred due to these heavy rains and floods are detailed herein:

- Approach road from Kuklah Village to Power House got damaged from various places
- Wire crates for road protection got damaged at some places
- Land Slides on Approach roads to Power House & Weir site
- Approach road to weir site got damaged at several places
- Wire crates beside Desanders on the downstream of the weir got damaged at various places

The photographs of the damaged areas are depicted below.






5 Annual Maintenance and Overhauling Works

Equipment wise maintenance schedules viz. Generator, Turbine & MIV, Power Transformers, Switchyard equipments, weir site structures etc. have already been issued to the Project. These maintenance schedules are strictly adhered by the project on regular basis. Maintenance of the following equipments/structures was carried out as per the maintenance schedule.

- Generator
- Generator Transformers & other Transformers
- Turbine & MIV
- Switchyard equipments
- EOT Crane
- Weir site structures

Following major Annual Maintenance and restoration works of the Power Plant were carried out during the year:

- ✓ Repairs of the wire crates downstream of Weir Site damaged during the last monsoon season
- ✓ Repair of Brake jet valves (motorized)
- ✓ Cleaning of Desanders at Dam site
- ✓ Painting of Penstock joints
- ✓ Replacement of damaged seals of Desilting gates
- ✓ Inspection of Nozzle (U-I), Flange with Buckler Inspection (U-I)
- ✓ Replacement of Needle-2, needle tip & mouth ring of Unit-I
- ✓ V-Notch Construction work at weir site for installation of online Discharge monitoring equipment
- ✓ Installation of online Discharge monitoring equipment at weir site

- ✓ Cleaning of Cooling Water pit, CW filter, MIV filter, Generator cooler filter
- ✓ Painting of structure at dam site & face-2,3 site, Butterfly valve (face 4)
- ✓ Repair of DG sets at Power House and Dam Site
- ✓ Covering of cable tray with G.I. sheets
- ✓ Inspection & replacement of upper & bottom Nozzle of Unit-I,
- ✓ Inspection & replacement of Flange with Buckler of Unit-I,
- ✓ Replacement of manual Break jet valve of Unit-I,
- ✓ Cleaning of MIV seal operating filter & cooling water filter of unit-I
- ✓ Repairing of motorized Break Jet Valve of Unit-II with welding & grinding using 309L Electrode
- ✓ Inspection of Nozzle & Flange with Buckler of Unit-II
- ✓ Servicing of Diesel Generator Set
- ✓ Replacement of Needle Position sensor of Nozzle-2 of Unit-I & Unit-II.
- ✓ Cleaning of Back flushing filter of Unit-I
- ✓ DPT Test & Inspection of Runner of Unit-I

Apart from the above, Service Order for hard coating of the Spare Runner has been issued to M/s Industrial Processors & Metalizers Pvt Ltd, Ghaziabad. The transportation of Runner, nozzle tips & mouth rings from site to vendor’s workshop can be taken up only after the repair of the approach road to Power house. Due to current funding constraints, this work has been planned to be taken up during next financial year (2012-13).

6 Civil Structures – Inspections & Restoration Works

6.1. Weir Site

As already stated in Para 4 above, some damages have taken place to the crate works & Weir site structures during heavy rains and floods from 13th to 16th August 2011.

The maximum river water level along the boundary of the Project structures corresponding to heavy rains and Floods from 13th to 16th August 2011 was recorded as 1032.50 m.

New India Insurance Company was informed about the damages due to heavy rains & flood and the surveyor appointed by the Insurance Company had visited the affected areas.

Team of Engineers from Civil Design wing at HO had also visited the affected areas. The damages resulting from the heavy rains & the corrective measures as proposed by Civil Design wing are summarized below.

- "About 19m long stretch of the crate wall on the downstream right side near to the surplus escape structure has been damaged. This repair work needs to be urgently completed otherwise subsequent floods can damage the de sander foundations."

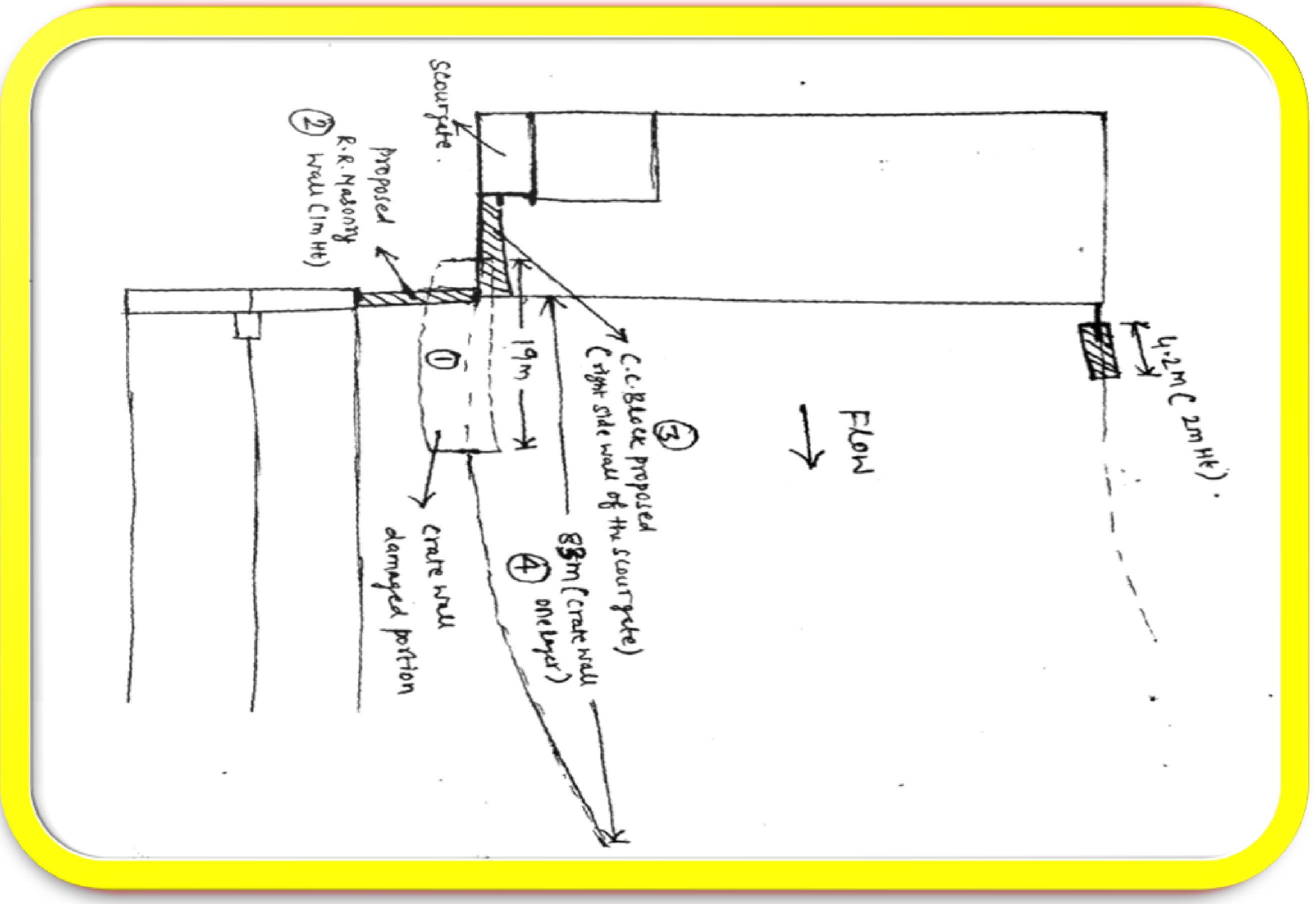
  "Following additional works are also needed in this portion

  - Extension of the left wing wall of the scour sluice up to the end of CC Block to guide the flow.
  - Construction of a cross wall of about 1 m on the right end of the surplus escape structure to prevent the flood waters spilling over to the terrace on the left side of the de sander."

- "Raising of the right side crate wall by 1 m to prevent the flood water spilling over to the terrace on the left side of the de-sander. During the last flood season, the flood water has over toppled this crate wall and flooded the terrace on left side of de- sander."

- "Repair of about 5 m portion of the crate wall on the left side."

The Civil Design wing thereafter provided a sketch showing details of the above mentioned repair works. The sketch is given below.



The detailed estimate of the abovementioned civil works has been prepared & accordingly as per the availability of funds, work orders were issued to local contractors namely Mr. Lal Singh & Mr. Krishan Kumar for the repair works of civil structures at weir site.

The repair works were completed in May-12 i.e. during the financial year 2012-13. The photographs of the repair works are depicted below.






6.2. Power House

Some damages have taken place to the approach roads to Power house during the heavy rains and floods from 13th to 16th August 2011.

Team of Engineers from Civil Design wing at HO visited the affected areas. The damages resulting from the heavy rains & the corrective measures as proposed by Civil Design wing are summarized below.

- "For the 5 Km long project road the following repair works are required to be done:
    - At five places, slope failures have occurred on the river side. The slopes need to be protected by building R.R. Masonry wall.
    - At two places slope failure of the hill of the right side bank have taken place. Materials lying on the road to be removed and the slope to be protected.
    - Blasting and removal of big sized boulders lying on the road at two places.
    - Repair of Cross Drainage works at two places.
    - Removing the cracked portion and laying new concrete on the transmission tower no.33."
- "Widening of the river using splitter upstream of the power house."
- "Packing boulders on left bank of Bakhli Khad river deploying excavator."
- "Water proofing of the roof of the control block."
- "Slope protection works behind the proposed location of staff building. Already a portion of the slope has fallen down."

The photographs of the damaged areas are reproduced below.

Due to the funds constraints, above mentioned works have been put on hold. However, the above said works shall be completed before the onset of next monsoons.

In view of the flood like situations during monsoons in preceding years of operation of the plant, the river widening works upstream of the power house is an important work to be completed on the priority as the power house is situated on the sharp turn at the left bank. Upstream view of the river where the river widening works are to be carried out are given below.

The above said works are planned to be completed before the onset of monsoons in the first quarter of the coming year i.e. 2012-13 as per the availability of the funds.

7 Unit-I : Breakdown & its Restoration

On the evening of 4th June 2011, Unit-I tripped due to operation of Stator differential protection. On checking the Stator, it was observed that insulation of two coils of R Phase winding had been damaged. This Generator has been supplied by M/s Exmont through M/s CKD Blansko of Czech Republic (subcontractor of EIPL) and the contractual warranty period of these machines had already expired after two (2) years of operation i.e. w.e.f. 20.01.2010.

On further examination after dismantling of Generator it was observed that number of Stator Core wedges were missing or broken. There was damage to winding coils inside core slots. Three end slots of the stator core adjacent to the damaged winding were badly blackened and pitted.

On preliminary inspection, it appeared that failure may be attributable to deterioration of inter-turn insulation over a period of time and ultimately leading to breakdown of main insulation of the Stator winding. Last blow would have come during heavy inrush of currents at the time of synchronization of Unit-1 on the day of failure which led to earth fault through the burnt insulation due to internal corona. Relays performed according to their setting by tripping on differential current on the damaged phase. Earthing PT did its job by limiting the ground current thus minimizing core damage. Third Harmonic ground protection did not operate as the fault was near phase end.

7.1 Rewinding & Restoration of Unit-I

M/s Fitwell Power Projects Pvt Ltd, Vadodara, who had erected these machines as subcontractor to M/s EIPL and have vast experience in site winding activities, were approached for mobilization of their Winding Team to the Power Plant for immediate dismantling of the winding, assessing the damage and undertaking the repair and restoration works of the damaged Generating Unit. Accordingly a Work Order was issued to M/s Fitwell for repair and restoration works of Generator-I.

M/s Fitwell immediately mobilized their experts (headed by Mr. Verghese, Ex BHEL winding expert) to site and after dismantling and assessing the damage, decision was taken to replace the damaged winding coils with the spare ones. It was observed that failure had been initiated with an inter turn insulation breakdown which would have lead to main insulation failure. Matter was also referred to OEM (M/s CKD and M/s Exmont) but there is no input from their end even after several reminders.

The initial photographs showing the damages are depicted below.

Photograph 1: Missing End Wedge

Photograph 2: Broken Wedge

Photograph 3: Core Damage (Upper side)

Photograph 4: Core Damage (Lower side)


Photograph 5: Pitted Stator Core Segment **Photograph 6: Missing End Wedge**


Photograph 7: Broken wedge pieces


Photograph 8: Damaged Coil

Photograph 9: Burnt Coil

M/s Fitwell team worked very hard round the clock to restore the damaged Generator within the minimum possible time. The damaged coils of the stator were replaced with the available spare ones.

The photographs showing initial repair works are given below.

Photograph 10: Initial Repair works by M/s Fitwell

However, the coils which had to be partially lifted (being two layered winding) to replace the damaged coils, failed during high voltage test as the insulation on these coils was found to be hardened.

The repeated attempts to replace the damaged winding coils (even after softening the insulation by localized internal heating using the DC current) failed in high voltage testing and spare winding coils thus got exhausted. These repeated failures of winding were mainly attributable to very hard, thick copper cross section used by Exmont (OEM) in place of soft, multi conductor winding.

To minimize the generation loss during monsoons, it was further decided to go ahead with local repairing of the last failed coils (Upper limb) in situ using some special type of insulating material and if successful, to use it till end of monsoon season. Though this was not a reliable method but if successful would have helped us to continue generation from this Unit during remaining period of the monsoons.

In the mean time, it was also decided to get the new winding coils manufactured indigenously for full generator using softer, multi-strand copper conductors and superior insulation. In view of this, various coil manufacturers were approached. Offers were received from M/s EMCO Electrodyne Pvt Ltd , GEN MOT coils and M/s Andritz Hydro Pvt Ltd.

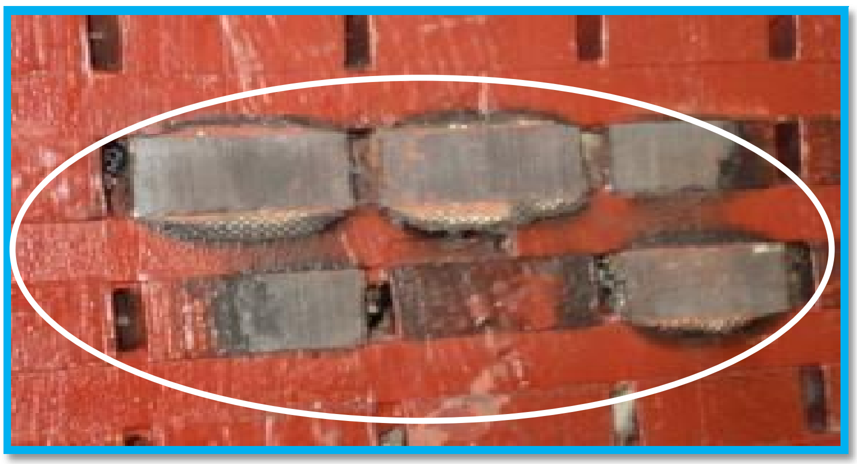
Due to competitive price and minimum time schedule offered by M/s EMCO Electrodyne Pvt Ltd. Mohali, and after assessing their technical competence and manufacturing facilities by visiting their works, order was placed on them for manufacture, supply & installation of complete set of stator winding.

Meanwhile, during the intervening period when manufacturing of new coils was in progress, local repair of damaged stator windings coils was continued at site. Though the locally repaired coil withstood the High voltage up to 10 KV for one minute but during high voltage tests of the winding two more coils failed, one of which was of lower limb and it was thus decided that now it was really not worth trying lifting of pitch of two layer winding to replace this coil due to past experience.

As manufacturing of new set of winding and assembly of generator being time consuming process, the matter was discussed with Alstom's Generator refurbishment expert, Mr Sushil Trivedi, who is an Ex-BHEL Haridwar engineer and a solution was thought of as an interim measure. It envisaged isolation of one coil each from both the parallel paths of each phase corresponding to the damaged coil and thus avoiding HV Test failure during lifting of coils and if successful operate the Unit without overloading at least during high flow season.

Adopting the above procedure, the Unit was temporarily restored and resynchronized on 15th July at 00:08 hrs and loaded up to 2 MW but at 02:35 hrs the Unit tripped and again the winding fault in the R-phase was reported. Thereafter, the rewinding of the Generator was only option left and accordingly actions had been initiated at site for completely removing the faulty windings etc.

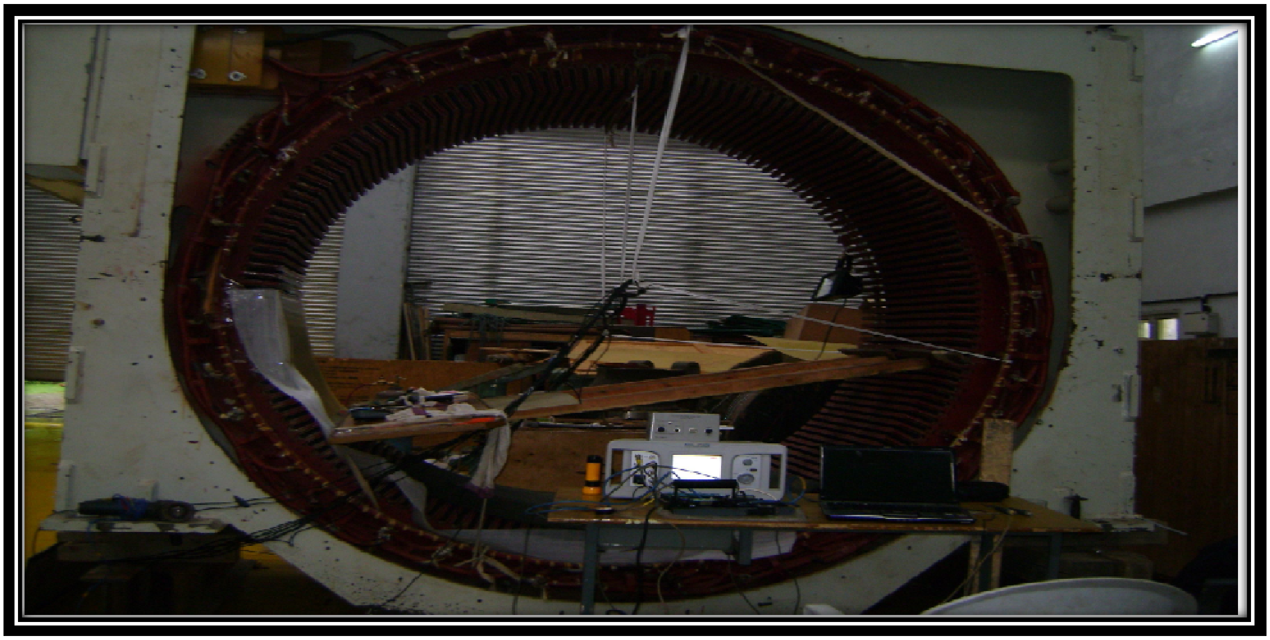
The photographs showing the damages noticed after dismantling the machine are given below.



Photograph 11: Damages after dismantling the machine

In the meantime, it was felt that to ascertain the healthiness of the core and to assess the extent of damage before / after the repair, ELCID (Electromagnetic Core Imperfection Detection) tests need to be conducted. In view of this, techno-commercial offers from the firms M/s MRTG Power Diagnostic Tests Pvt.Ltd, Hyderabad, M/s Powertest Asia Pvt. Ltd, Hyderabad and M/s Prognosys, Hyderabad were received. The service order was finally placed on M/s Prognosys EMS Pvt Ltd, Hyderabad for ELCID Test before and after the core repair.

ELCID Test through M/s Prognosys EMS Pvt Ltd was conducted before the core repair and damaged core packets were identified. The ELCID test report before core repair is enclosed as ***Appendix-1***. Some of the photographs showing damaged slots are shown below.



Photograph 12: ELCID Test Set up

Photograph 13: Core Faults seen in Slot no. 14

Photograph 14: Core Faults seen in Slot no. 14

The slots where the fault current was observed to be more than threshold value of 100 mAs are given in the table below.

ELCID FAULT CURRENT MORE THAN THRESHOLD VALUE OF 100 mAs:

	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 2	193	SLOT NO. 27	168
SLOT NO. 3	103	SLOT NO. 28	128
SLOT NO. 10	110	SLOT NO. 32	135
SLOT NO. 14	331	SLOT NO. 42	140
SLOT NO. 15	172	SLOT NO. 43	139
SLOT NO. 16	168	SLOT NO. 93	199
SLOT NO. 17	140	SLOT NO. 94	250
SLOT NO. 18	155	SLOT NO. 95	175
SLOT NO. 19	198	SLOT NO. 159	193
SLOT NO. 20	196	SLOT NO. 162	121
SLOT NO. 24	184		
SLOT NO. 25	220		
SLOT NO. 26	110		

In view of the repeated attempts to locally repair the damaged core spots not yielding the desired results, it was concluded that disassembling of core laminations and re-staggering after site rectifications of punchings is the only alternative left for safe and fastest restoration of the Generator under shutdown. Hence the service order had been placed on M/s GENMOT Coils, Bangalore for the stator core repair. The stator core repair works were carried out before taking up the rewinding of the Stator.

The scope of work related to core repair works are detailed below

- ✓ Taking slot dimensions and all stator core dimensions.
- ✓ Making of core building bars
- ✓ Removing the end bolts after removing the welding
- ✓ Removal of the segmental laminations one by one till 5 core packets
- ✓ Straightening of damaged laminations
- ✓ Removal of burs and varnishing
- ✓ Repairing of Air vent laminations
- ✓ Restacking of the laminations using building bars to attain correct alignment of the laminations
- ✓ Re-staggering of the damaged laminations during restacking
- ✓ Locking of the core with bolts tightening to attain original core dimensions
- ✓ Conducting Hot spot test. If OK the welding of core with end plate
- ✓ Locking of all bolts
- ✓ Conducting Repeat hot spot test and checking of the alignment of the laminations

- ✓ Removal of all burrs
- ✓ Cleaning of the core and checking of the slot width by using slot gauge in all the slots
- ✓ Checking of the alignment of the wedge groove

The stator core repair works was carried out by dismantling one end of the core and re-staggering the electro eroded laminations. The photographs showing the core repair works are given below.

Photograph 15: Core Repair Works

After the core repair works, ELCID test had been conducted again to ascertain the healthiness of the core. The ELCID test after repair indicated that major core laminations shorting which was in slot no. 14 was successfully removed. However, locations where ELCID currents were above threshold limit of 100 mAs, are required to be monitored for any abnormal temperature rise in these locations. For this, placing of RTD sensors in these locations was recommended which has been implemented. The ELCID Test report after core repair is enclosed as ***Appendix-2***.

1. ELCID test performed after partial restacking of core

Photograph 16: ELCID Test after partial restacking of core

As stated above, the order was issued to M/s EMCO for manufacture, supply & installation of complete set of stator winding.

Some important data of Generator coils are detailed below:

- No of slots - 162
- Core length - 820 mm
- Slot depth - 102 mm
- Coil Width x Height - 44.5x 19 mm
- Machine voltage - 11 kV
- Rated power - 8 MW+15% overload (9.2 MW)
- Present conductor size - 5.5x12.5 mm (2 conductors x 4 turns)
- Body insulation - 6 mm

Procedure for the manufacturing of new coils as adopted by M/s EMCO, is described below:

- The coils prepared from "Enameled Double Fiber Glass/ “Conductofol" covered, pure soft annealed, electrolytic copper conductors, shall be stack consolidated, and then accurately formed in a CNC coil-forming machine, and tested for dimensional accuracy by means of jigs and gauges
- Insulation taping to be done with CNC 6-axis taping machine, ensuring uniform lapping and tension, thereby increasing the effectiveness of the ground-wall thickness
- The slot section of the Resin Rich coil to be molded in a PLC electrically heated, hydraulic coil press under controlled temperature and pressure, for resin rich coils
- Corona treatment to be done with conducting and stress-grading paint / tape combinations
- The prepared coils then to be taped with sealing tapes and then to be pre-heated for proper bonding of the same to the overhang

Tests which were conducted on each manufactured coil are listed below:

- SURGE TEST for inter-turns insulation at 23 kV

- LEAKAGE CURRENT MEASUREMENT during 30 kV AC for 60 seconds
- TAN-DELTA (DISSIPATION FACTOR) TEST
- CORONA RESISTANCE TEST
- D.C. RESISTANCE TEST
- I.R.TEST before and after H.V. Test

After successful completion of the above tests on the newly manufactured coils, these coils were transported to Patikari site for rewinding works of Stator. Thereafter the rewinding team of M/s EMCO Electrodyne Pvt Ltd was deputed to site for rewinding works.

Laying of new winding coils in the Stator Core by the rewinding team of M/s EMCO was completed and brazing of end connections had been carried out where after taping, varnishing and drying out and HV testing of complete stator winding was taken up and completed.

Photograph 17: Stator Coil Rewinding works


Photograph 18: Stator Coil Rewinding works

After these operations, re-assembly of the Unit was carried out and re-commissioning of the Unit-I was successfully achieved on 3rd September 2011. The unit was made to run at 2 MW for first two hours and then 4 MW for next one hour followed by 6 MW & 7 MW. Finally the Unit was continuously operated at its rated capacity i.e. 8 MW. Stator winding temperatures were monitored and found to be within limits.

Thus, Generator of Unit-1 of 2x8 MW Patikari HEP remained out of service on account of stator winding failure from 4th Jun, 2011 till 3rd Sept, 2011.The downtime of the machine was thus approximately three (3) months.

7.2 Review of Protection Methodology

In order to avoid recurrence of similar winding failures / Unit breakdowns in future, efficacy of the existing Generator Protection philosophy / methodology was decided to be got reassessed and reviewed.

Various agencies undertaking such studies were approached for conducting the review and advising appropriate modifications, if need be. Offers were received from the following two Parties:

- M/s PEARL (Protection Engineering and Research Laboratories), Chennai

- M/s GE India Industrial Pvt Ltd, Bangalore

Work order for review of Protection system of Generators was issued to M/s PEARL. This review was limited to the protection schemes of Generators. The objective of this study was to determine the optimum settings for the generator protection relays deployed for protection of the generators.

M/s PEARL, after the comprehensive study, submitted its report along with the recommendations to overcome the present hiccups in the protection system. The Comprehensive Report of M/s PEARL is enclosed as ***Appendix-3***. Important recommendations on various protection issues as suggested by M/s PEARL in their Report are summarized hereunder:

- **Generator Grounding Methodology:**

  As per the existing scheme, neutral of both the generators are left un-grounded. It shall be changed to a resistance grounded system by grounding the generators via neutral grounding resistors (NGR) or grounding transformer.

- **Class B Tripping:**

  For effectiveness of Class B tripping, the isolation shall be done by tripping the 33kV circuit breaker. By doing so, for any un-cleared fault in the 33kV system, this class of tripping will isolate the power plant from the grid and allow the generator to continue to operate feeding its own auxiliary load. And as soon as the grid is restored, the power plant can be re-synchronized

- **Backup Protection at 11kV side of GTs:**

  It is suggested that the back-up over current protection shall also be enabled for the 11kV winding for the two generator transformers. This element can be programmed in the existing T60 relay itself.

- **Annunciation System for Protection Alarms:**

  It is suggested that all the protection alarms in the G30 relay shall be assigned to an output contact and wired to sound an audible alarm to alert the operator. Providing an audible alarm (with a different sound) for the trip command may also be preferred.

It was thus decided that neutral grounding resistors (NGR) shall be installed in both the generators of the plant. Accordingly, the Purchase Order for the proposed two (2) NGRs had been placed on M/s Lachhman Electronics, New Delhi

It was also decided to re-conduct the testing of protection relays after employing the new settings as suggested by M/s PEARL. As such, the Service Order for testing and resetting of Generator, Transformer & feeder relays has been placed on M/s INEL Power System Engineers, Bangalore. In line with above, review of the protection methodology employed for Generators of the Project & diagnostic Tests has been carried out and following preventive measures have been adopted for the trouble free operation of the plant:

- ***Installation of NGRs***

  In line with the recommendations of M/s PEARL, who reviewed the protection methodology employed for Generating Units of the Project, installation of NGRs at site was completed. Associated wiring & interlocking have also been implemented & already tested at site.

- ***Testing of Protection Relays***

  As a part of review of the protection methodology, new settings of Protection relays were proposed by M/s PEARL. M/s INEL Power, Bangalore was engaged for the resetting and testing of Protection Relays at site. After employing the new settings as suggested by M/s PEARL, testing was completed by using Omicron Kit & it was concluded that all the protections employed for Generators are now working properly.

7.3 Diagnostic Tests on Windings

In order to determine the healthiness or otherwise of the stator windings / cores, it was decided to conduct the diagnostic tests viz. Partial Discharge Test & Tan Delta Test of the windings on both Generators and ELCID test on the core of Unit-2 Stator.

Work order for aforesaid diagnostic tests was issued to M/s Prognosys EMS Pvt Ltd. Bangalore.

These diagnostic tests were completed whereafter a comprehensive report was submitted by M/s Prognosys. The report is enclosed as ***Appendix-4***. Unit wise conclusions & recommended actions as proposed by M/s Prognosys EMS Pvt Ltd. in their Report are reproduced herein.

- ***"Unit-I Stator Winding***

  From the assessment conducted, it is concluded that the stator winding test parameters are within limits for the winding of Unit-I. This indicates stator winding insulation is in acceptable condition. The obtained values need to be considered as finger prints in trend analysis under condition monitoring program."

- ***"Unit-II Stator Winding***

  From the assessment conducted based on tan delta and partial discharge test analysis, it is concluded that the stator winding is not in healthy condition. Assessment indicates that, stator winding has deteriorated to larger extent. The deterioration process is of serious concern. As the Generator is in operation, with time, this deterioration process will affect the main ground wall insulation leading to winding failure. Hence for a permanent solution, it is recommended to completely rewind the stator with new coils at next available opportunity."

- ***"Unit-II Stator Core***

  From the detailed assessment conducted, it is established that fault current is more than 100 mA in few locations. It is recommended to attend this problem. This may be done by removing *lamination shorting portions and restoring of insulation between the lamination in these areas. This core repair can be taken up during rewinding process of Unit-II."*

In view of the above, it was recommended thereafter that the complete set of stator winding coil of unit-II may be procured at the earliest opportunity.

- *"As an interim solution and till such time rewinding of Unit II Stator is taken up, the partial discharge deposits on insulation surface have been cleaned and the corona control varnish has been applied in overhang portion and this Unit has been kept in operation."*

8 New Installations in the Power House Premises

8.1 Installation of Neutral Grounding Resistors (NGR) in Power House

As per the suggestions of M/s PEARL who reviewed the protection methodology of the plant, it was decided that neutral grounding resistors (NGR) may be installed in both the generators of the plant. Accordingly the Purchase Order was issued to M/s Lachhman Electronics, New Delhi for the procurement of two (2) numbers of NGRs.

The installations of the NGRS at site have now been completed & the necessary checks of interlocking & other protections had been conducted successfully. The photographs of the installed NGRs are produced herein.

8.2 Installation of On-Line Discharge Monitoring equipment at weir site

As per notification issued by HPPCB, a discharge equivalent to 15% of the minimum inflow observed during lean season in the river has to be released.

Every year, Project is required to get formal Consent to Operate the plant from the H.P. State Pollution Control Board. The HPPCB has made it obligatory to first install the on-line discharge monitoring equipment at the weir site for the compliance of the release of the mandatory release before the permission to operate is renewed.

In this connection, Microprocessor based Open Channel flow measuring system manufactured by M/s Interface Devices & Services had been installed in the V-Notch for the online measurement of the environmental flow. On-Line Discharge monitoring equipment had also been installed at Weir Site.

The Online system has started measuring the discharge and the records are being stored in the data logger of the device. The photographs of the installation are depicted below.

V-notch with online monitoring instrument

Control panel for device at Control Room

View of downstream discharge

Display of the flow measuring device

9 Loss of Generation - Causes and Corrective steps

9.1. Loss of Generation due to various reasons viz. plant outages, forced Grid outages & repair works during the year under report was to the tune of **11.73 MU** out of which, Generation loss of **10.76 MU** was attributable to the repair & restoration works of Unit-I.

Month wise Generation loss details due to repair & restoration works of Unit-I Generator are summarized below.

Generation Loss due to Repair & Restoration works of Unit-I	
Month	**Generation loss due to Repair works of unit-I (MU)**
Jun-11	**0.54**
Jul-11	**3.88**
Aug-11	**5.74**
Sep-11	**0.59**
Total	**10.76**

There are following two main factors responsible for the loss of generation from the Project in general:

- External Evacuation Constraints
- Plant Outages

9.2. External Evacuation Constraints

External constraints mainly comprise of the Grid outages in the HPSEB networks & back down instructions. Generation loss due to grid/HPSEB transmission lines tripping incidents during financial year 2011-12 was to the tune of 0.33 MU.

This issue of grid/HPSEB transmission lines tripping incidents had been persistently followed up with the Board to eliminate such outages to the maximum extent possible and remove all evacuation constraints being faced by the project. As a result, this year the grid/HPSEB transmission lines tripping incidents have somewhat been reduced now. The generation loss due to these factors was only 41.2 % of preceding year generation loss.

9.3. Plant Outages

Short and prolonged plant outages are the other major factor contributing to substantial generation loss from the project. However, by strictly implementing the preventive maintenance schedules, these outages can be reduced to a large extent thus minimizing the breakdown time of the machines. As minimization of plant outages is in our control, it was thought appropriate to glean the generation data to find out the causes for such outages and take corrective steps to avoid these failures to the maximum extent in future.

Loss of Generation due to plant outage & grid outage in the financial year under report & during preceding four years is summarized below.

Generation Loss of Patikari HEP											
	Year	FY 2007-08		FY 2008-09		FY 2009-10		FY 2010-11		FY 2011-12	
Outage/ Tripping Type	Description	Outage Duration (Min)	Energy Loss (MU)	Outage Duration (Min)	Energy Loss (MU)	Outage Duration (Min)	Energy Loss (MU)	Outage Duration (Min)	Energy Loss (MU)	Outage Duration (Min)	Energy Loss (MU)
Plant Outage	Malfunctioning of Vibration sensor related	184	0.01747	298	0.04361	0	0.00000	254	0.04020	0	0.00000
	Trash Rack choking related	0	0.00000	4283	0.57517	0	0.00000	323	0.03722	2895	0.35767
	Cooling water filter & MIV filter related	0	0.00000	32	0.00511	101	0.00909	1976	0.27827	86	0.01331
	Flange with Buckler related	0	0.00000	0	0.00000	231	0.03080	921	0.14584	0	0.00000
	Transmission Line Related	0	0.00000	579	0.08252	88	0.00293	290	0.03190	14	0.00216
	Governor software modification	0	0.00000	0	0.00000	0	0.00000	539	0.06030	0	0.00000
	Shutdown/Trippings due to testing viz. SCADA, PD & Tan Delta etc	0	0.00000	0	0.00000	0	0.00000	0	0.00000	399	0.03453
	Rewinding & Restoration Works of Unit-I	0	0.00000	0	0.00000	0	0.00000	0	0.00000	129600	10.76000
	Other miscellaneous trippings	2434	0.15629	6387	0.88956	0	0.00000	820	0.11698	1625	0.23522
Grid Outage	Grid Outage (>20 min)	587	0.05260	1199	0.20433	349	0.01955	524	0.04990	345	0.05242
	Grid Outage (<20 min)	95	0.02672	946	0.44762	89	0.04021	775	0.58561	656	0.27848
	Backdown Instructions	0	0.00000	10234	0.74394	99	0.00528	2245	0.16782	0	0.00000
	Total	**3300**	**0.25308**	**23958**	**2.99186**	**957**	**0.10786**	**8667**	**1.51404**	**135620**	**11.73379**

In this context it would be appropriate to look into the break-up of generation loss due to different categories of Plant outages. As a result of proper preventive maintenance schedule, the Generation loss due to choking of Cooling Water & MIV filters & Patikari feeder's faults were reduced to a large extent this year as compared to previous year. At every available opportunity, Cooling Water filters & cooling water pit and MIV filters were cleaned. There were no incidents of tripping due to flange with buckler as we have procured / repaired in advance spare flange with bucklers & kept as handy in the power house.

Main factors contributing the plant outages & their mitigating measures are detailed below;

9.3.1. Cooling water filter related:

Earlier only one (1) set of cooling water filters was installed in the cooling water system. Cooling water filters used to get choked due to the silt coming from the river water leading to the forced shutdown of the plant and consequent loss of generation.

To cater for such exigency, one (1) additional (spare) set of cooling water filters had been procured last year and installed to act as the standby filter thereby reducing the downtime of the plant. As a result of which the generation loss due to such incident was reduced this year.

9.3.2. Flange with Buckler related:

Flanges with Buckler have been getting damaged off and on during operation of the Turbines. Different modified versions of Flanges with Buckler have been tried but problem is still not completely solved. Two (2) no. of damaged Flanges with Buckler have been got repaired with some modifications. Their performance will be monitored during coming monsoon rains. In the meantime, change in design of the Flange with Buckler in consultation with the OEM and other manufacturers are also being explored.

9.3.3. Malfunctioning of sensors:

High vibrations indication and tripping of Units was due to malfunctioning of the sensors. Vibration monitoring sensors have been procured and faulty ones have been replaced. As a result of which there were no incidents of such trippings in the year under report.

9.3.4. Trash Rack choking related:

Trash Rack choking has contributed to the generation loss during monsoon season. Floating Drums arrangement for diversion of drift wood towards open Weir has been provided at the intake to avoid the clogging of the trash racks to the maximum extent possible. Continuous clearing of Trash Racks manually during monsoon months is also being carried out. These measures have yielded the desired positive results.

For ensuring uninterrupted clearing out of the trash / debris upstream of Trash Racks during monsoon months, a CGI sheets covering arrangement has also been provided over the trash rack bridge to enable workmen to continue working during rains as well.

9.3.5. Other miscellaneous trippings:

The operating philosophy of the Turbine Unit and the software of the associated Digital Governor of the project had originally been programmed and engineered considering that in case of any fault, the turbine unit would come to a standstill condition and main inlet valve (spherical valve) would also be closed till the fault is removed. Subsequently it has been observed during the operation of the plant that even for transitory external non urgent electrical faults, the turbine is tripped with closure of Main Inlet Valve which led to delayed restarting / synchronization of Units and consequent avoidable loss of generation.

To reduce the restoration time in the event of tripping, required modifications in the software of the Governor were devised and got incorporated. This modification in the Governor software has reduced the start up duration of the machines following the grid failures, consequently minimizing the generation loss.

Inspections and preventive maintenance of Patikari to Pandoh sub-station feeders has reduced trippings on these feeders and consequent generation loss.

A comparison of Actual generation loss due to various plant outages in Million Units during financial year 2011-12 & preceding year is tabulated as under:

Type of Plant Outage	FY 2010-11	FY 2011-12
Choking of Cooling Water and MIV Filters	0.278	0.013
Break down of Flanges with Buckler	0.146	0.000
Malfunctioning of various sensors	0.040	0.000
Choking of Trash Racks	0.037	0.358
Patikari Feeder's faults	0.032	0.002
Other miscellaneous causes	0.116	0.235

10 *Inventory Management*

Adequate optimum stocks of spares are being maintained in the Plant stores to cater for any preventive as well as other maintenance requirements of the Power Station. The consumption of Electrical, Mechanical & General store material is being regularly reported and monitored on monthly basis.

Following important items of equipment and spares had been procured during the FY 2011-12.

- Four (4) nos of Connectors for nozzle position sensor
- One (1) set of manual valve for Brake jet valve
- One (1) set of motorized valve for Brake jet valve
- Five (5) Nos of Inductive proximity switch
- One (1) no of Nozzle position sensor
- Spares for GCS & Turbine
- Spares for Illumination system
- Three (3) nos of Flanges with Buckler
- Spare parts of Diesel Generator set
- Spare UPS (Uninterrupted power supply)

11 Critical Issues – Resolved / Under Follow up

11.1 Permanent Residential set up for O&M staff

Earlier O&M Staff had been accommodated in the Porta cabin installed near the power house. However, as the land on which the Porta cabin transit camp had been constructed happened to be in the state forest area, concerned HP forest division ordered vacation of the forest land. As the Porta Cabin has been dismantled as per these orders, the O&M staff residing there have been relocated and provided rented accommodation in Pandoh, wherefrom they are required to commute daily to and from Power House in three shifts.

Proper accommodation for the O&M staff near Power Station is absolutely essential for safe and smooth operation of the Plant especially during monsoon months.

Alternative locations for construction of residential buildings for O&M staff were thereafter explored. In this context, a survey of the land adjacent to Power Plant Gate and some land behind it along the hill slope already acquired by the Project which is not a Forest land, was got conducted. Accordingly the construction drawings & estimates have been issued by Civil Design wing.

Construction of the field accommodation set up as per approved drawings has been put on hold due to funds constraints. Procurement of material and construction of the accommodation set up as per approved drawings shall be taken up in the financial year 2012-13 as per the availability of funds.

Materials of dismantled porta cabins are still lying in the power house premises, which are proposed to be disposed off during coming financial year.

11.2 Signing of Supplementary PPA

As per the HPERC's Order dated 16th Jul, 2010, increase of 29 paise in the tariff under change of Law has been allowed. The increase of 29 paise in the tariff has not been implemented so far, since the Supplementary PPA has not been signed till date by the Board.

We are entitled to additional revenue amounting to Rs. 2.998 Crores (@27 paise / unit) upto the year under report ending Mar-12 on this account for which bill can be raised only after signing of the SPPA.

Case was being pursued regularly with the Board. However HPSEBL had now filed an appeal in HP High Court against above said HPERC Order. The court has granted the stay of said Order and as such this case is still pending decision.

11.3. Appeal filed in APTEL

Petition was filed with HPERC on August 22, 2008 for upward revision of the existing tariff of Rs. 2.25 for Patikari HEP. In connection with the above, HPERC's decision dated 16th Jul, 2010 had earlier been received.

Since HPERC had not agreed to our request for determination of the Tariff but have allowed a relief under change of law only, a Petition had earlier been filed with Appellate Tribunal for Electricity (APTEL) against the HPERC order dated 16th Jul, 2010 appealing for:

- Allowing increase of 29 paise in tariff from the date of commissioning instead of date of the issue of the order i.e. 16th Jul, 2010
- Redetermination of tariff based on the incurred cost and as per CERC norms.

Order on our Petition filed with Appellate Tribunal for Electricity (APTEL) against the HPERC order dated 16th Jul, 2010 and for determination of tariff for 16 MW Patikari Hydro Electric Project has now been passed.

Summary of the Order is as under:

- ✓ Revision of tariff on account of change in State Government Policy would be effective from date of implementation of State Government Policy by PPL and not prospectively as decided by HPERC.
- ✓ PPPL has not been successful in establishing undue influence or misuse of dominant position by HPSEB in making PPPL enter into the PPA for sale of power from Patikari Hydro Electric Project.
- ✓ HPERC can review already concluded PPA according to its own regulations.

PPPL had sought review of tariff on following two grounds:

a) Lower Return On Equity (ROE) expected under fixed tariff of Rs. 2.25/kWh; and

b) Lower water discharges in river compared to the hydrology data provided by HPSEB.

Whereas **a)** above has not been acceded to by APTEL, PPPL has been allowed to approach HPERC for relief on account of b**)** above.

The implementation of APTEL's order will be effective from and subject to the order of High Court of Himachal Pradesh on writ petition filed by HPSEBL.

11.4 CDM Benefit to the Project

The CDM revenue to the tune of Rs. 3.48 Crores against the generation during 2010 has been received in May 2011. The CDM revenue pertaining of variable market price to the tune of Rs. 3.5 lakhs & 2.2 lakhs against the generation during 2009 & 2010 respectively has been received in September 2011.

The Fourth Verification process towards issuance of CERs for the generation year 2011 has successfully completed by LRQA, the DOE, and the project has already been submitted to UNFCCC with an request for issuance of CERs.

Expected CERs of 47,209 are likely to be issued on 13th June as per UNFCCC, if the reviewer does not raise any queries on the documentation.

As such the saleable CERs to EDF would be 46,265 which in turn would fetch revenue amounting to Rs. 3.75 Crores approximately. This is expected to be received by the month of June 2012.

11.5 Claims of HPSEB & PPPL

HPSEB's had earlier preferred a claim of Rs.308.45 lakhs against the expenditure incurred by them on Survey & Investigations in the Project including compound interest @10% per annum up to 31.08.2008. It was noted that an amount of Rs. 48.94 lakhs was indicated to be spent in year 2004-05 i.e. after the Effective Date. When this anomaly was pointed out, HPSEB revised its claim to Rs.2.84 Crores (0.90 Crs principal + 1.94 Crs interest till 31.07.2010).

Our claim pertaining to costs incurred on renovation of installations at Pandoh Substation and strengthening of 33 kV feeders of the HPSEBL from Pandoh to Bijni to the tune of Rs.1,17,60,414.87, carried out by our Company on behalf of HPSEBL prior to commissioning of the Project, was also pending with the Board.

HPSEB had also unilaterally deducted an amount of Rs. 133 lakhs from Energy Bills for September 2010 & October 2010 without any prior intimation to PPPL against Survey & Investigation expenditure claimed to have been incurred by the Board.

A composite settlement was agreed upon between PPPL & HPSEBL on the issue after the various meetings with the Director (Projects) HPSEBL.

Mutual claims between the Company and HPSEB Ltd. regarding Survey & Investigation expenses and interest as well as strengthening of transmission lines beyond Delivery Point have now been amicably settled. A cheque from HPSEBL amounting to Rs. 1,41,171/- by way of final settlement between the parties has now been received by the Company from the Board.

11.6 Insurance Claims

An insurance claim on New India Insurance Company pertaining to the damages in Project area due to heavy rains & floods from 13th to 16th August, 2011 has already been lodged. The surveyor appointed by the Insurance Company had already visited the affected areas. The documents as sought by the surveyor had been submitted except for the supporting work orders, bills & payment proofs for restoration work which shall be submitted after completion of restoration works.

Another claim on Insurance Company pertaining to the damages in Project area due to floods during 2nd week of August, 2007 is still under follow up. The estimated cost of restoration works for Insurance claims was around Rs. 5.80 Crores for damages in 2007. The surveyor assessed damages at Rs. 3.66 Crores against said claim. The Insurance Co., however, offered to pay Rs. 0.48 Crores only. Hence, the matter had already been referred to Arbitral Tribunal and is still under adjudication / settlement.

11.7 Payment to Penstock Land owners

Private land had been used for the construction of Penstocks of the project. However the registry of the land in favour of the company was not done at that time.

Land owners whose land was acquired for the construction of Penstocks had been identified. Negotiations with the land owners for settlement & registration are under process. As of now there is no breakthrough in this matter.

11.8 Taking Over of Project Roads by HP PWD

Mr. Jai Ram Thakur, Cabinet Minister of HP Government and local MLA, along with the SE PWD, Mandi and XEN PWD had visited the Power House site on 23rd July 2010 to assess the possibility of routing a road on the river side upstream of the Patikari Power House.

After site inspection the SE HPPWD was of the opinion that routing of the road by extending the crates into the river and by pushing the fence inside towards the power house shall be feasible.

It was thereafter suggested that HPPWD prepare their proposal for routing the road and share it with us for review by the design wing.

Following roads have been constructed by the project during its execution

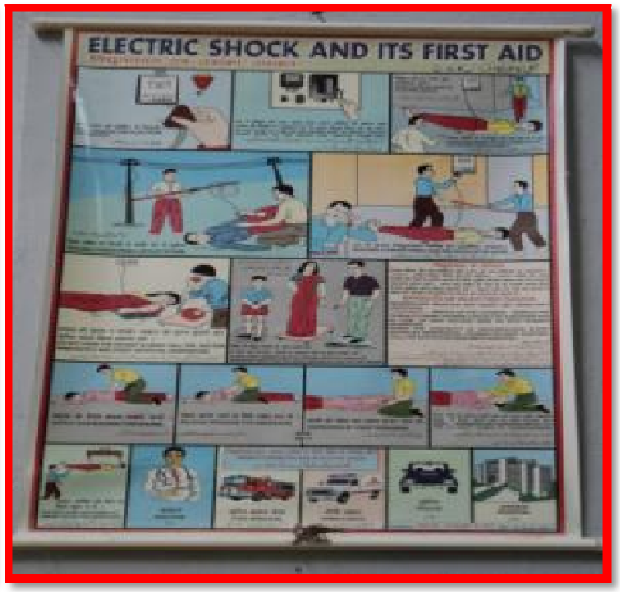
- Kuklah village to Power House (Length – 5.25 km)
- Road to Weir site (Length – 3.85 km)
- Main Road to Adit-II (Length – 3.75 km)

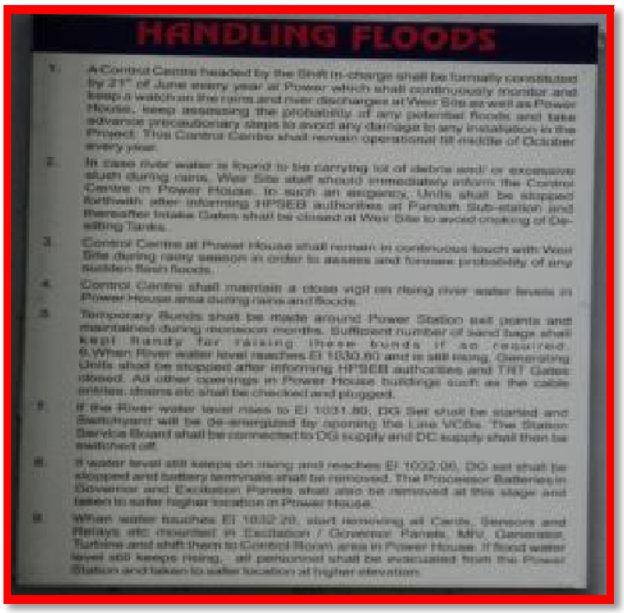
Our company had incurred an expenditure of Rs. 10.34 Crores on the construction of above roads and acquisition of land for the same.

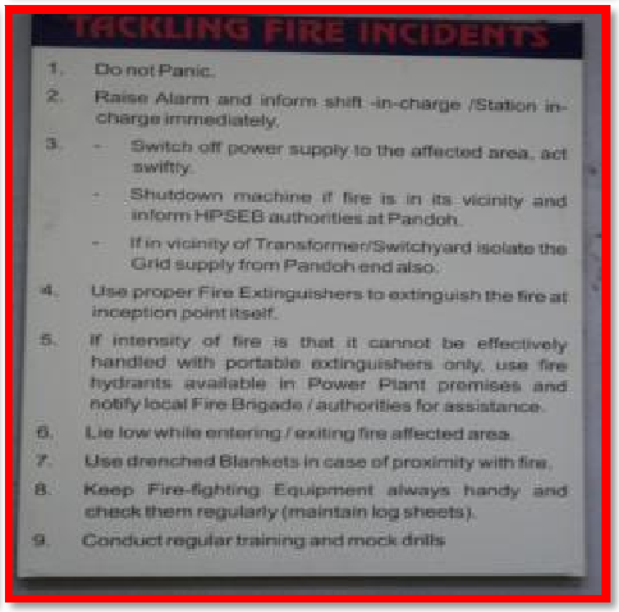
However, handing over of the Project roads to HP PWD is still pending.

12 Safety Measures

Safety Manual had been issued to the Plant & the Safety measures as per the manual had been strictly complied. Safety charts had been displayed in the power house area. Mock drills related to Fire Protection / Flood Protection / any other natural calamity Protection had been arranged annually in & around power house area to ensure preparedness for such exigencies.







13 Employees Welfare Measures

The manpower deployed in the project is listed below.

S. No	Status	Name of Employee	Designation	Department	Native Place
1	Staff	Shyam Lal	Assistant Manager	Electrical	Himachal
2	Staff	Saurajit Samantaray	Senior Engineer	Electrical	Odisha
3	Staff	Gurdev Singh Thakur	Junior Engineer	Electrical	Himachal
4	Staff	Kuldeep Kumar	Supervisor	Civil	Himachal
5	Staff	Abdul Khan	Shift Operator	Mechanical	Himachal
6	Staff	Ravi Kumar	Junior Engineer	Mechanical	Himachal
7	Staff	Deepak Sharma	Junior Engineer	Electrical	Himachal
8	Staff	Ashish Kumar	DET	Electrical	Himachal
9	Workman	Pushpraj	Assistant	Administration	Himachal
10	Workman	Khem Singh	Magazine Supervisor	Civil	Himachal
11	Workman	Kasmer Singh	Survey Assistant	Survey	Himachal
12	Workman	Jeevanand	Survey Assistant	Survey	Himachal
13	Workman	Sanjay Kumar	Guage reader	Survey	Himachal
14	Workman	Ravinder Kumar	Electrician	Electrical	Himachal
15	Workman	Ram Pal	Mechanic	Mechanical	Himachal
16	Workman	Krishan Chand	Electrician	Electrical	Himachal
17	Workman	Biharilal	Watchman	Administration	Himachal
18	Workman	Labh Singh	Supervisor	Store	Himachal
19	Workman	Kishan Chand	Helper		Himachal
20	Workman	Manohar Lal	Helper		Himachal
21	Workman	Nanak Chand	Meson	Civil	Himachal
22	Workman	Het Ram	Operator		Himachal
23	Workman	Chint Ram	Helper		Himachal
24	Workman	Viraj Kumar	Helper		Himachal

Various issues related to Employees Welfare which are under consideration of the Company Management are as under:

- ✓ **Regularization of the services of some land losers**
- ✓ **Construction of permanent hostel as well as residential family accommodation near Power Station for O&M Staff** – It has already envisaged & planned. As of now, the lodging arrangement for O&M staff has been provided in Pandoh and transport facility has also been provided at company cost.
- ✓ **Review of Annual wages** – Review of the annual wages of the O&M staff is carried out based on the performance of the employee & accordingly they are compensated.
- ✓ **Training of O&M Staff** – Various trainings related to operation & maintenance of small hydro plants & interpersonal relationships are being imparted to the employees. Employees underwent the following training session in the year under report.
  - Creating Team Synergy
  - Diagnostic approach for maintenance of Electrical rotating equipments in Power Station & Industries

14 Action Plan for next Financial Year

Various issues / works related to plant which are planned to be taken up subject to the availability of funds are as under:

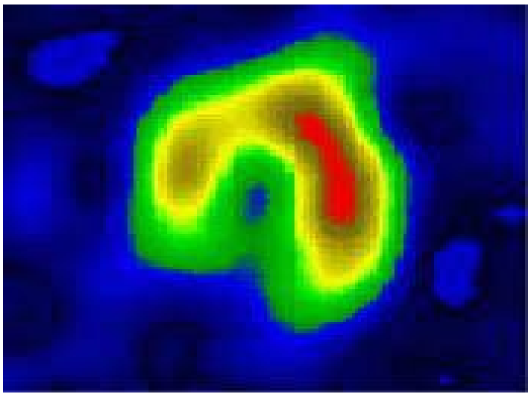
- Repair & Restoration of damaged civil structures at weir site due to heavy rains and Floods from 13th to 16th August 2011.
- Repair & Restoration of damaged portion of approach roads to power house & weir site.
- Rewinding of Unit-II Generator.
- Conduction of ELCID Test (before rewinding), Partial Discharge & Tan Delta Test (after rewinding) of Unit-II Generator.
- Hard coating of one (1) no. of Runner, one (1) set of Nozzle tip & mouth ring.
- Construction of permanent hostel as well as residential family accommodation near Power Station for O&M Staff.
- Procurement of essential spares viz. manual & motorized valve for break jet, flange with bucklers, sensors, CPU of Generator relay G30 & Transformer relay T60 etc.
- Creation of website of Patikari Power plant.
- Widening of the river using splitter upstream of the power house.
- Packing boulders on left bank of Bakhli Khad river deploying excavator.
- Water proofing of the roof of the control block.

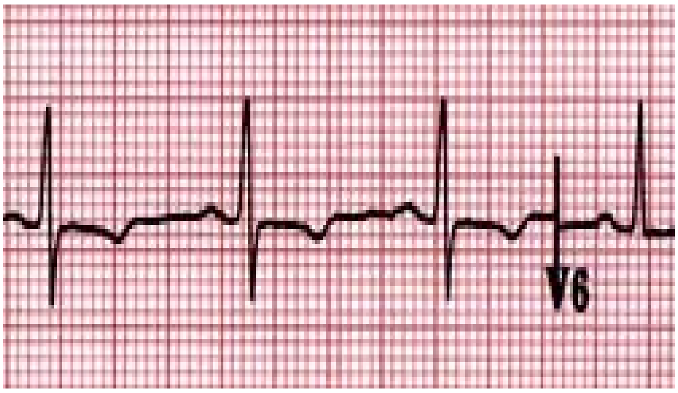
CLIENT: PATIKARI POWER
UNIT ›› **02,** MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**

ELCID Test Report

GENERATOR STATOR

PATIKARI HYDRO GENERATING STATION - PANDOH





Contract Ref.: S. O. 10200005
July 2011

Prognosys
VISION TO SCIENTIFIC PREDICTION

ELCID TEST ON GENERATOR STATOR

CLIENT	**PATIKARI POWER PRIVATE LIMITED**
MACHINE DETAILS	UNIT ›› **02**, MAKE ›› **EX-MONT**, RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR VOLTS ›› **11 KV**,STATOR AMPS ›› **509 A,** P.F ›› **0.85.**

Prepared and Authorized by:

Mahender Reddy
Director – Technical
Prognosys EMS (P) Limited
www.prognosys.co.in

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1.0 ELCID TEST

The generator stator core is built from thousands of thin steel sheets (laminations). These laminations are coated with a thin layer of varnish for prevention of circulating induced currents also known as eddy currents, which are induced because of rotating magnetic flux produced by the rotor. Hence, it can be envisaged that any defects in the inter-laminar insulation causes fault currents to flow locally in core. These circulating currents can thus cause localized overheating and hot spots in the damaged areas and this may further damage the core. In extreme cases, sufficient heat is generated to cause melting of small parts of core and premature failure of the winding insulation. Thus these hot spots should be detected and corresponding repair works must be carried out before the condition worsens. Unlike the core ring flux test that had several disadvantages like running of high current/voltage, mechanical stresses etc, the digital ELCID test uses only a fraction (4%) of rated flux level to generate fault currents within the core body. These currents are then sensed by a pick up coil. The digital ELCID test helps in assessing the condition of Generator/motor core and gives vital information in the development of trend analysis, for use in diagnostic and predictive maintenance.

It offers the following facilities:

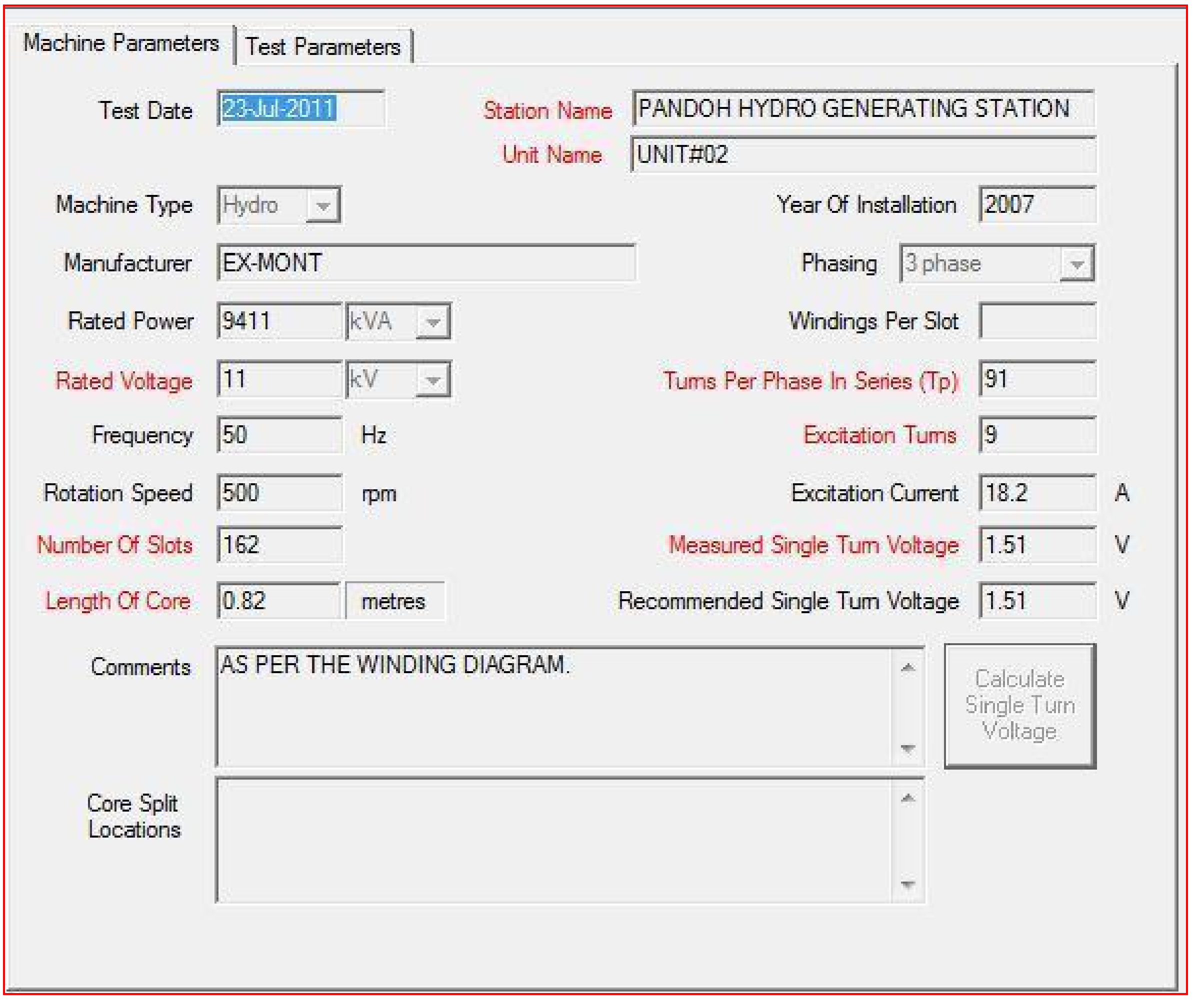
- Identification of faults below the winding.
- Distinguishes between surface faults and deep faults.
- Fault location is pin-pointed accurately.

Principle:

The circumferential magnetic field of the core is due to the excitation, plus that due to any fault currents present. The effect of the magnetic fields is to produce magnetic potential gradient on the core surface. This magnetic potential gradient is detected by specially wound coil known as Chattock coil, which provides an output proportional to the difference in the magnetic potential between its two ends.

The ELCID equipment tests a core for faults by exciting the core using a toroidal winding to produce a ring flux of only 4% of its normal level of excitation. A sensing head (Chattock coil) is then passed overthe surface of the core to detect magnetically the presence of fault currents themselves rather than the heating effect they produce. The output of the Chattock coils is a dc voltage proportional to the fault current component in phase quadrature with the core excitation current. The signal is an analogous signal, which is converted into a digital signal and displayed or stored in PC.

Test details:



Machine Parameters | Test Parameters

Test Date	23-Jul-2011	Station Name	PANDOH HYDRO GENERATING STATION
		Unit Name	UNIT#02
Machine Type	Hydro	Year Of Installation	2007
Manufacturer	EX-MONT	Phasing	3 phase
Rated Power	9411 kVA	Windings Per Slot	
Rated Voltage	11 kV	Turns Per Phase In Series (Tp)	91
Frequency	50 Hz	Excitation Turns	9
Rotation Speed	500 rpm	Excitation Current	18.2 A
Number Of Slots	162	Measured Single Turn Voltage	1.51 V
Length Of Core	0.82 metres	Recommended Single Turn Voltage	1.51 V

Comments: AS PER THE WINDING DIAGRAM.

Calculate Single Turn Voltage

Core Split Locations:

ELCID FAULT CURRENT PEAK VALUES FOR SLOTS:

	FAULT CURRENT(mA)		FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 1	90	SLOT NO. 31	88	SLOT NO. 61	56
SLOT NO. 2	193	SLOT NO. 32	135	SLOT NO. 62	26
SLOT NO. 3	103	SLOT NO. 33	90	SLOT NO. 63	45
SLOT NO. 4	46	SLOT NO. 34	88	SLOT NO. 64	74
SLOT NO. 5	43	SLOT NO. 35	65	SLOT NO. 65	49
SLOT NO. 6	75	SLOT NO. 36	37	SLOT NO. 66	28
SLOT NO. 7	50	SLOT NO. 37	29	SLOT NO. 67	34
SLOT NO. 8	92	SLOT NO. 38	58	SLOT NO. 68	48
SLOT NO. 9	70	SLOT NO. 39	44	SLOT NO. 69	37
SLOT NO. 10	110	SLOT NO. 40	35	SLOT NO. 70	37
SLOT NO. 11	95	SLOT NO. 41	20	SLOT NO. 71	42
SLOT NO. 12	56	SLOT NO. 42	140	SLOT NO. 72	41
SLOT NO. 13	84	SLOT NO. 43	139	SLOT NO. 73	29
SLOT NO. 14	331	SLOT NO. 44	36	SLOT NO. 74	27
SLOT NO. 15	172	SLOT NO. 45	35	SLOT NO. 75	27
SLOT NO. 16	168	SLOT NO. 46	52	SLOT NO. 76	30
SLOT NO. 17	140	SLOT NO. 47	61	SLOT NO. 77	50
SLOT NO. 18	155	SLOT NO. 48	56	SLOT NO. 78	37
SLOT NO. 19	198	SLOT NO. 49	58	SLOT NO. 79	48
SLOT NO. 20	196	SLOT NO. 50	46	SLOT NO. 80	27
SLOT NO. 21	81	SLOT NO. 51	19	SLOT NO. 81	50
SLOT NO. 22	64	SLOT NO. 52	35	SLOT NO. 81	37
SLOT NO. 23	57	SLOT NO. 53	45	SLOT NO. 83	29
SLOT NO. 24	184	SLOT NO. 54	73	SLOT NO. 84	68
SLOT NO. 25	220	SLOT NO. 55	30	SLOT NO. 85	35
SLOT NO. 26	110	SLOT NO. 56	44	SLOT NO. 86	31
SLOT NO. 27	168	SLOT NO. 57	56	SLOT NO. 87	73
SLOT NO. 28	128	SLOT NO. 58	39	SLOT NO. 88	39
SLOT NO. 29	82	SLOT NO. 59	41	SLOT NO. 89	42
SLOT NO. 30	86	SLOT NO. 60	69	SLOT NO. 90	43

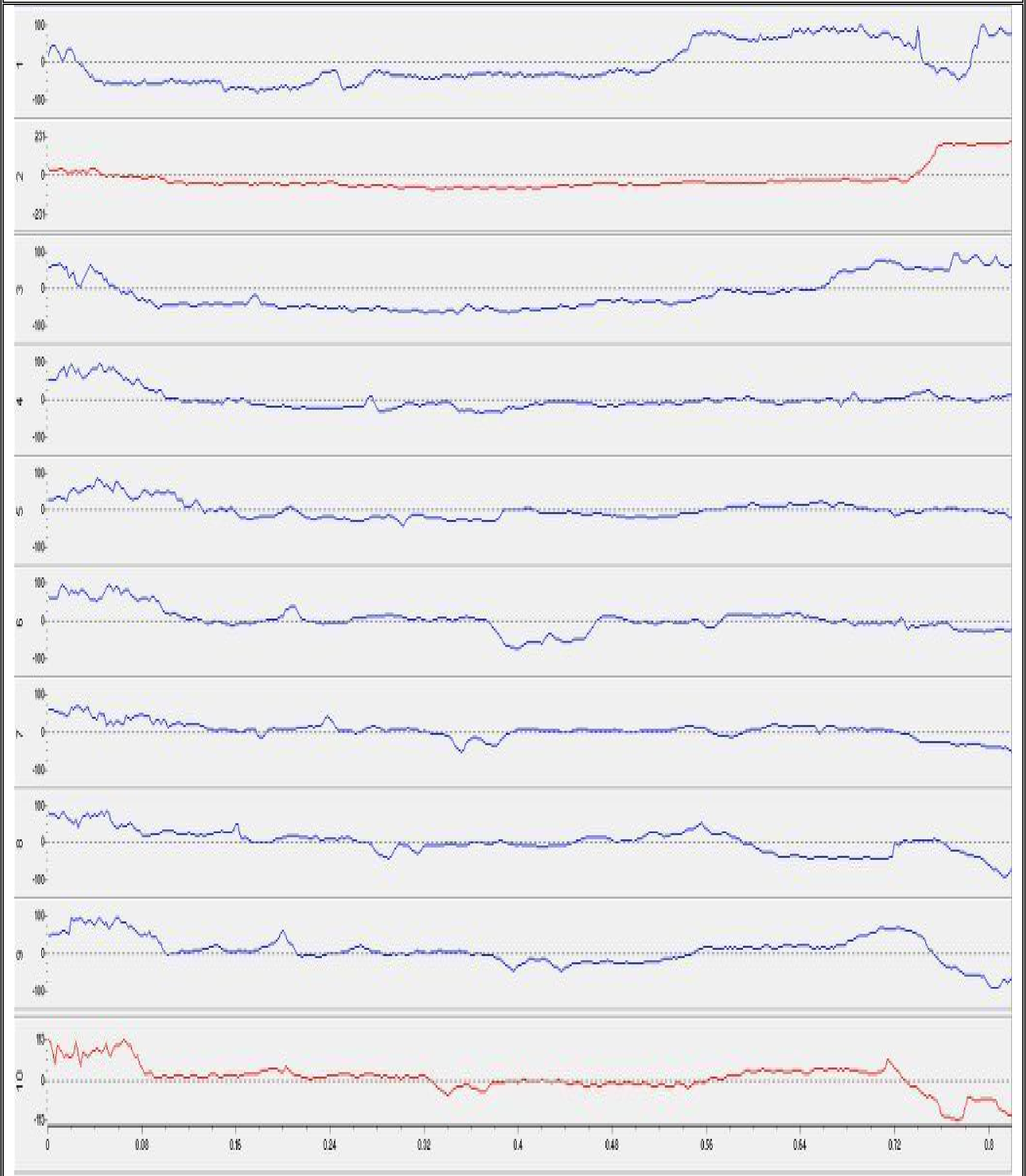
	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 91	32	SLOT NO. 122	16
SLOT NO. 92	88	SLOT NO. 123	10
SLOT NO. 93	199	SLOT NO. 124	15
SLOT NO. 94	250	SLOT NO. 125	24
SLOT NO. 95	175	SLOT NO. 126	41
SLOT NO. 96	47	SLOT NO. 127	23
SLOT NO. 97	46	SLOT NO. 128	30
SLOT NO. 98	38	SLOT NO. 129	32
SLOT NO. 99	33	SLOT NO. 130	23
SLOT NO. 100	26	SLOT NO. 131	88
SLOT NO. 101	45	SLOT NO. 132	15
SLOT NO. 102	43	SLOT NO. 133	16
SLOT NO. 103	42	SLOT NO. 134	59
SLOT NO. 104	44	SLOT NO. 135	31
SLOT NO. 105	29	SLOT NO. 136	21
SLOT NO. 106	22	SLOT NO. 137	41
SLOT NO. 107	41	SLOT NO. 138	53
SLOT NO. 108	49	SLOT NO. 139	71
SLOT NO. 109	25	SLOT NO. 140	72
SLOT NO. 110	23	SLOT NO. 141	50
SLOT NO. 111	18	SLOT NO. 142	32
SLOT NO. 112	20	SLOT NO. 143	63
SLOT NO. 113	25	SLOT NO. 144	67
SLOT NO. 114	20	SLOT NO. 145	37
SLOT NO. 115	42	SLOT NO. 146	77
SLOT NO. 116	20	SLOT NO. 147	46
SLOT NO. 117	17	SLOT NO. 148	62
SLOT NO. 118	28	SLOT NO. 150	71
SLOT NO. 119	66	SLOT NO. 151	75
SLOT NO. 120	41	SLOT NO. 152	48
SLOT NO. 121	25	SLOT NO. 153	94

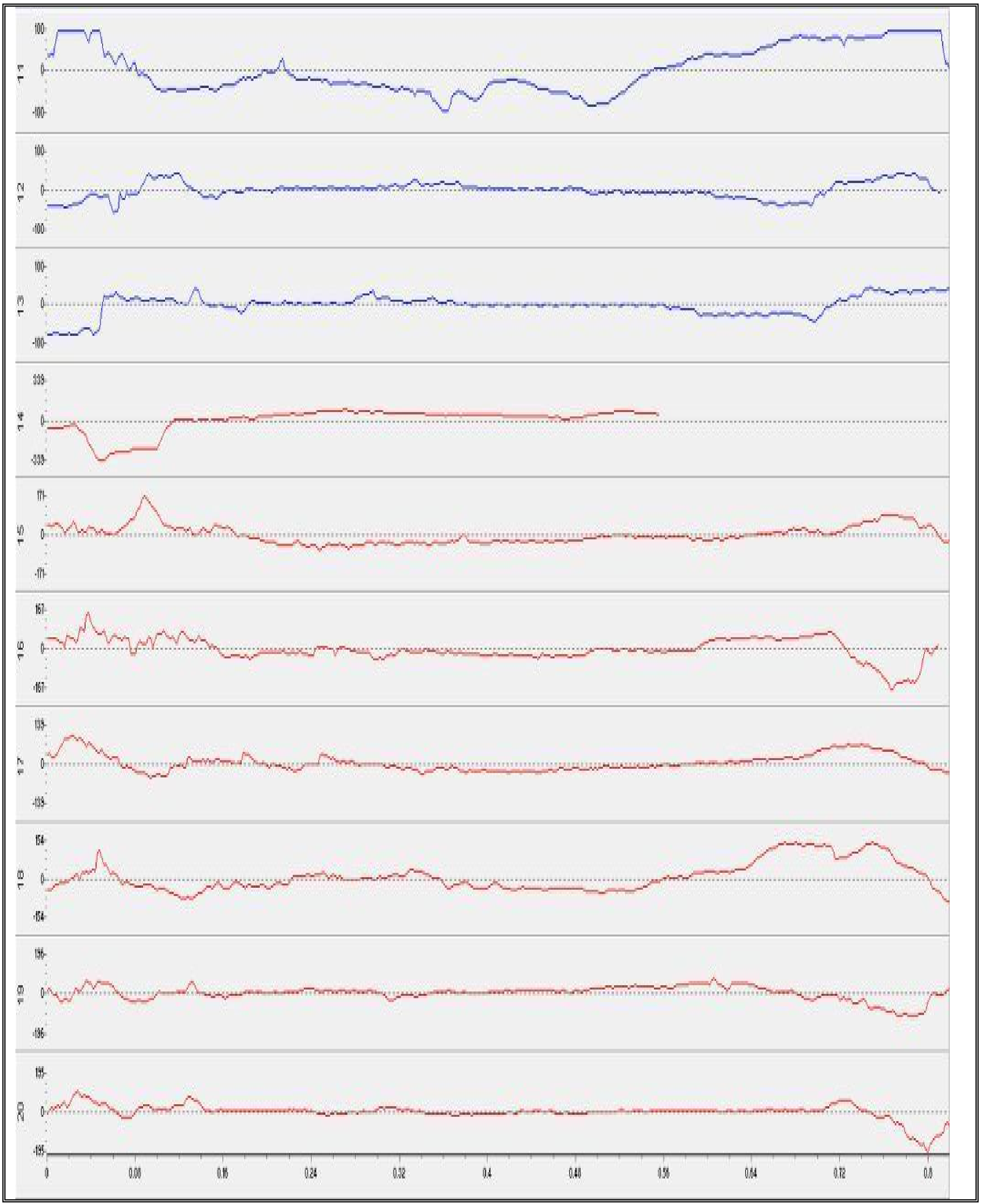
	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 154	48	SLOT NO. 159	193
SLOT NO. 155	91	SLOT NO. 160	72
SLOT NO. 156	64	SLOT NO. 161	66
SLOT NO. 157	64	SLOT NO. 162	121
SLOT NO. 158	66		

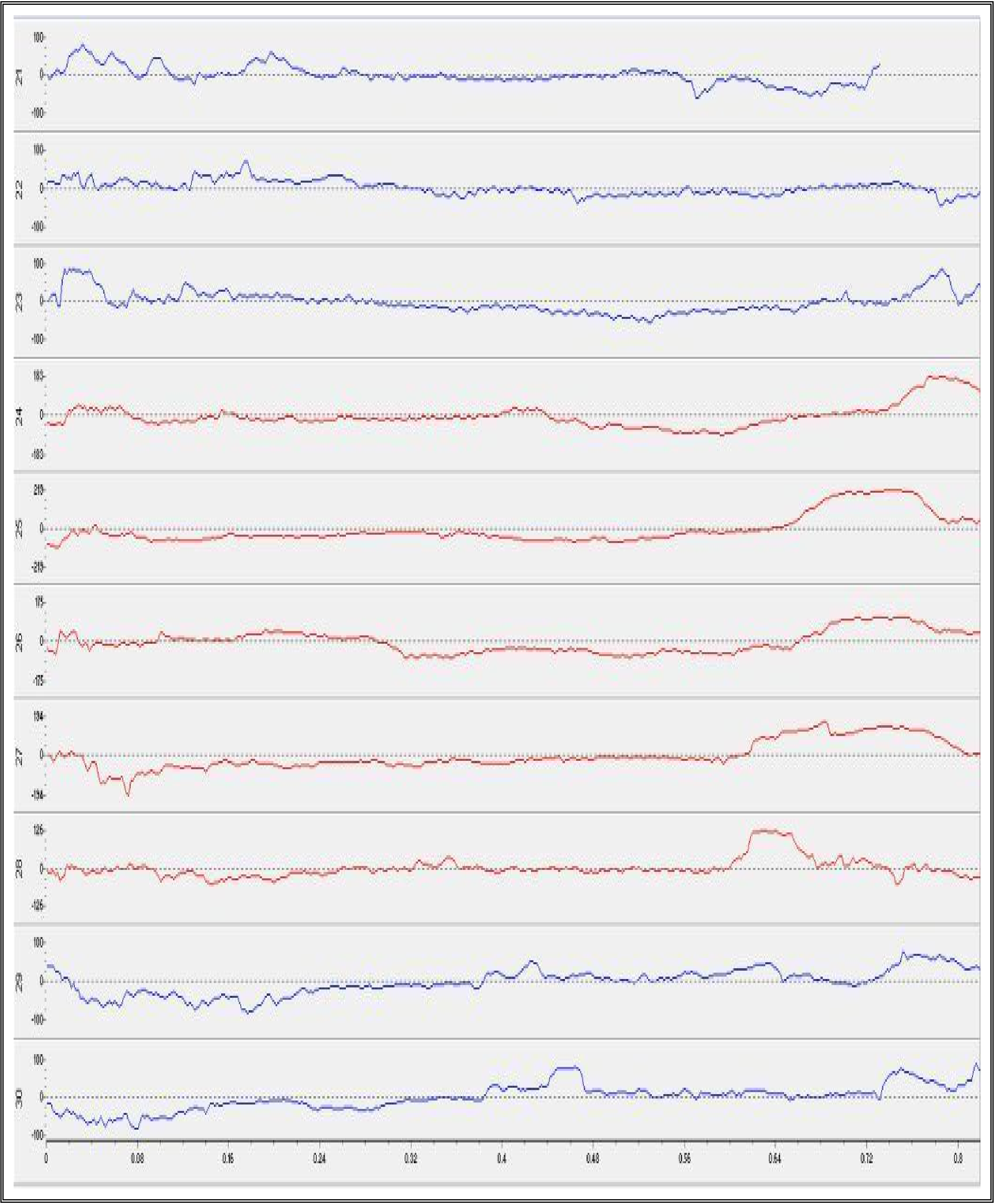
ELCID FAULT CURRENT MORE THAN THRESHOLD VALUE OF 100 mAs:

	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 2	193	SLOT NO. 27	168
SLOT NO. 3	103	SLOT NO. 28	128
SLOT NO. 10	110	SLOT NO. 32	135
SLOT NO. 14	331	SLOT NO. 42	140
SLOT NO. 15	172	SLOT NO. 43	139
SLOT NO. 16	168	SLOT NO. 93	199
SLOT NO. 17	140	SLOT NO. 94	250
SLOT NO. 18	155	SLOT NO. 95	175
SLOT NO. 19	198	SLOT NO. 159	193
SLOT NO. 20	196	SLOT NO. 162	121
SLOT NO. 24	184		
SLOT NO. 25	220		
SLOT NO. 26	110		

ELCID FAULT CURRENT GRAPHS OF SLOTS



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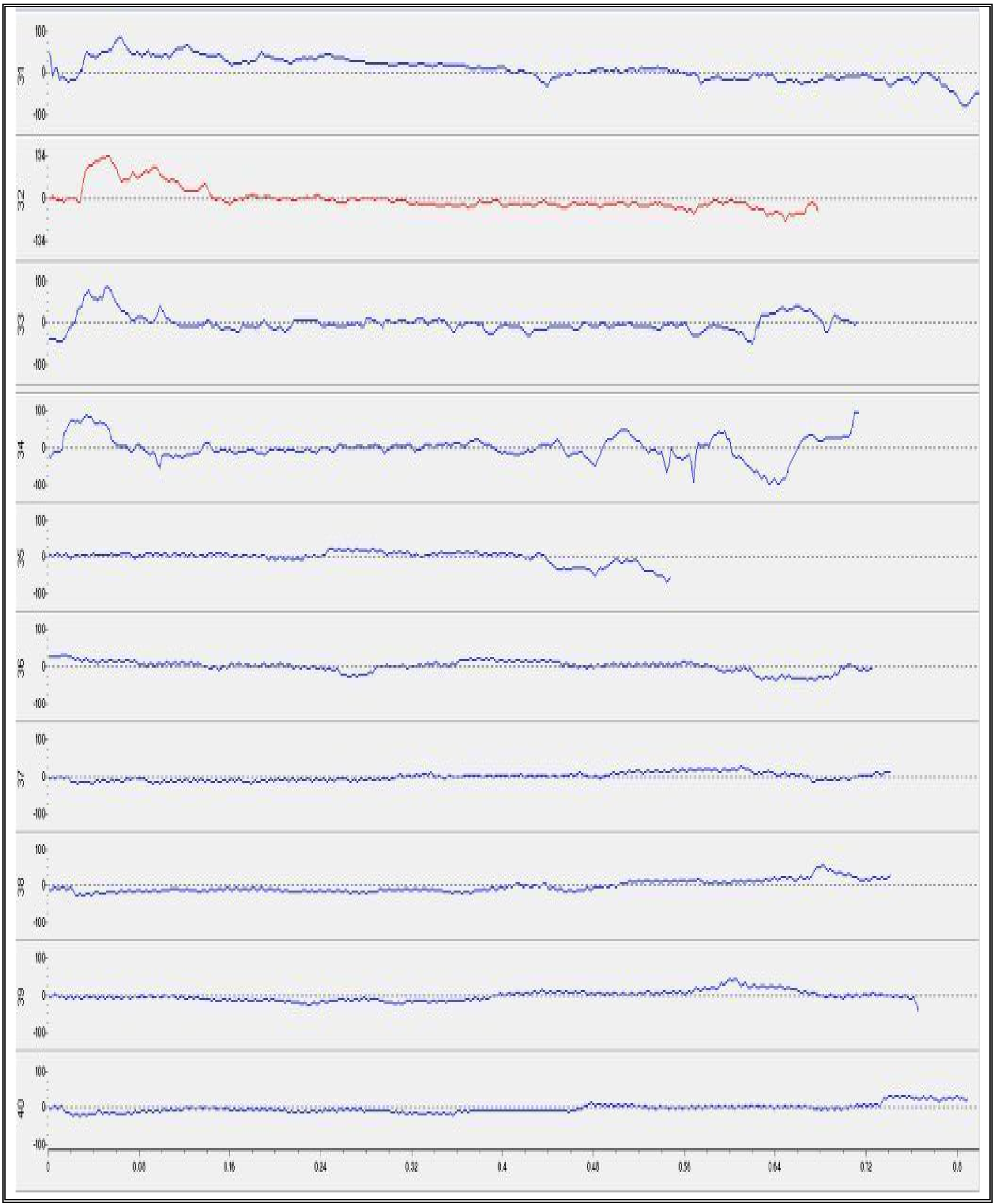
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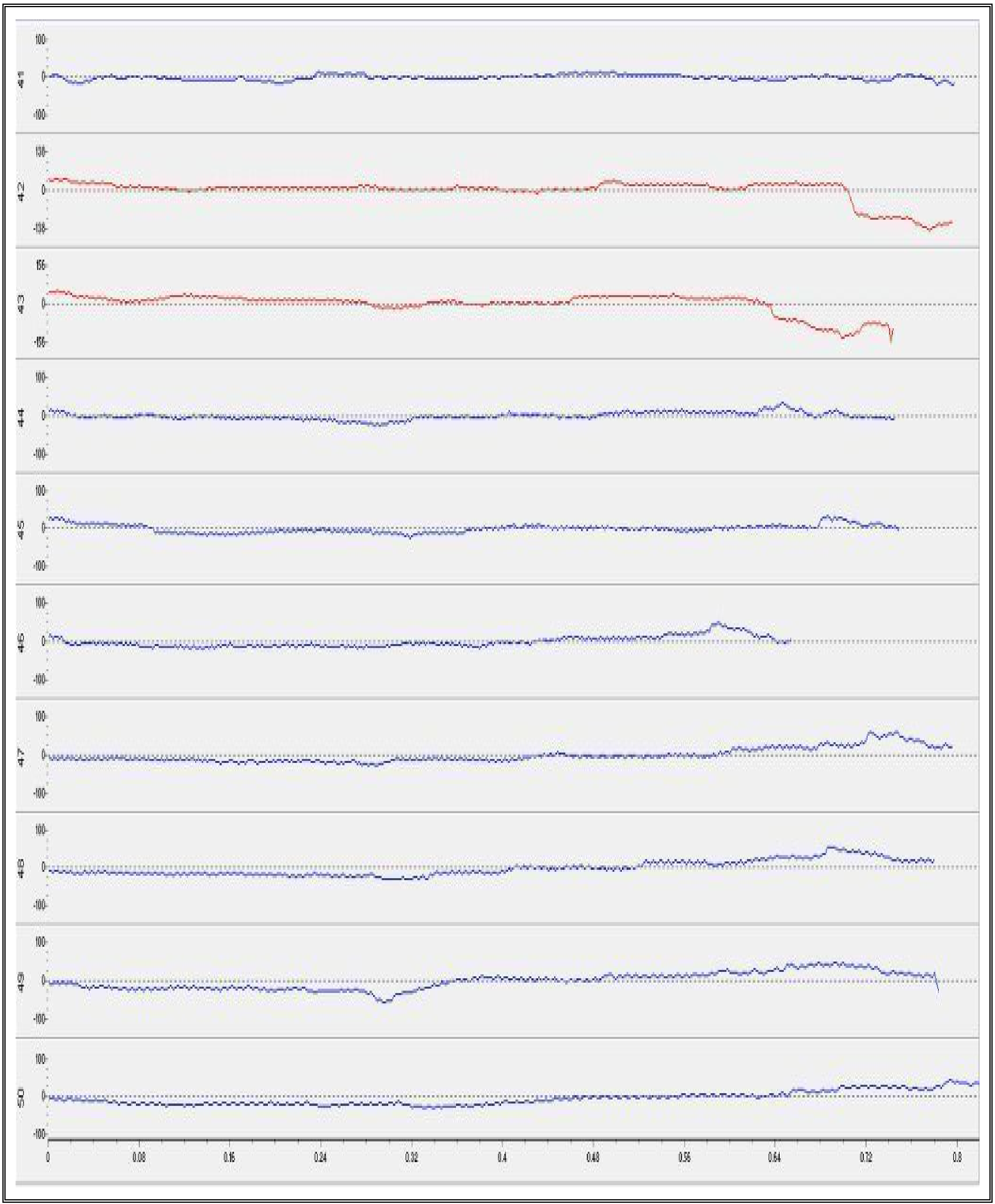
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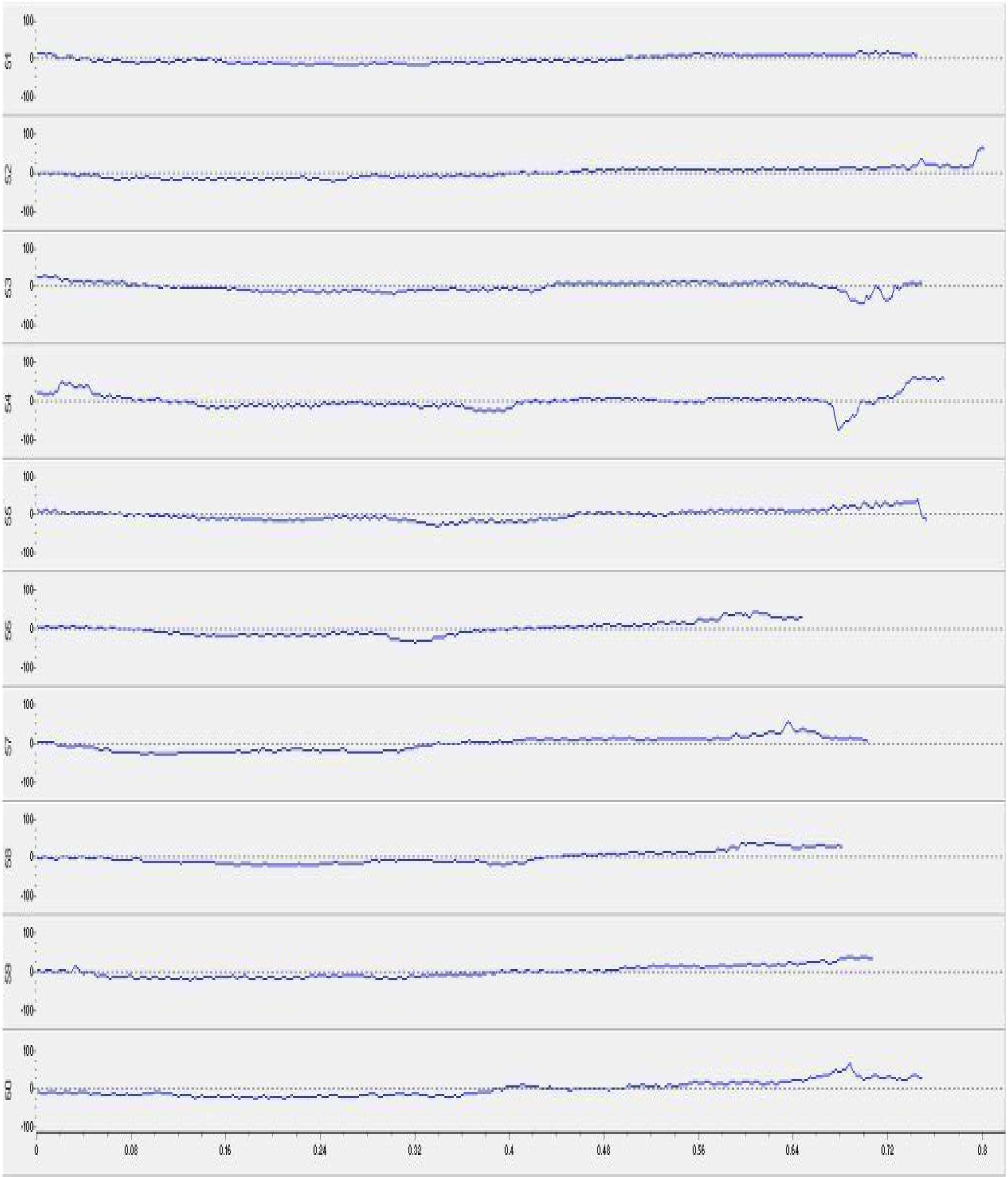
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CLIENT: PATIKARI POWER

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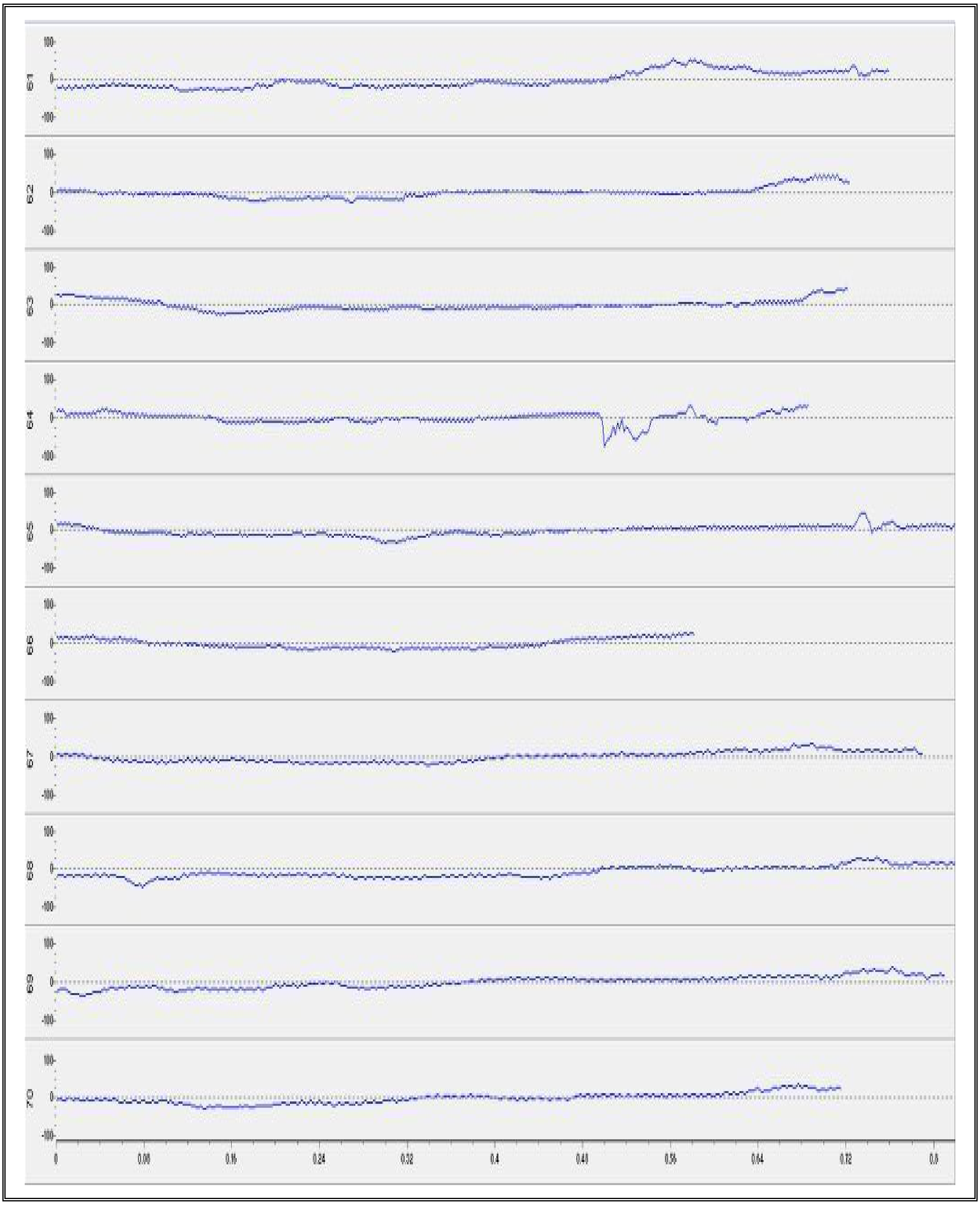

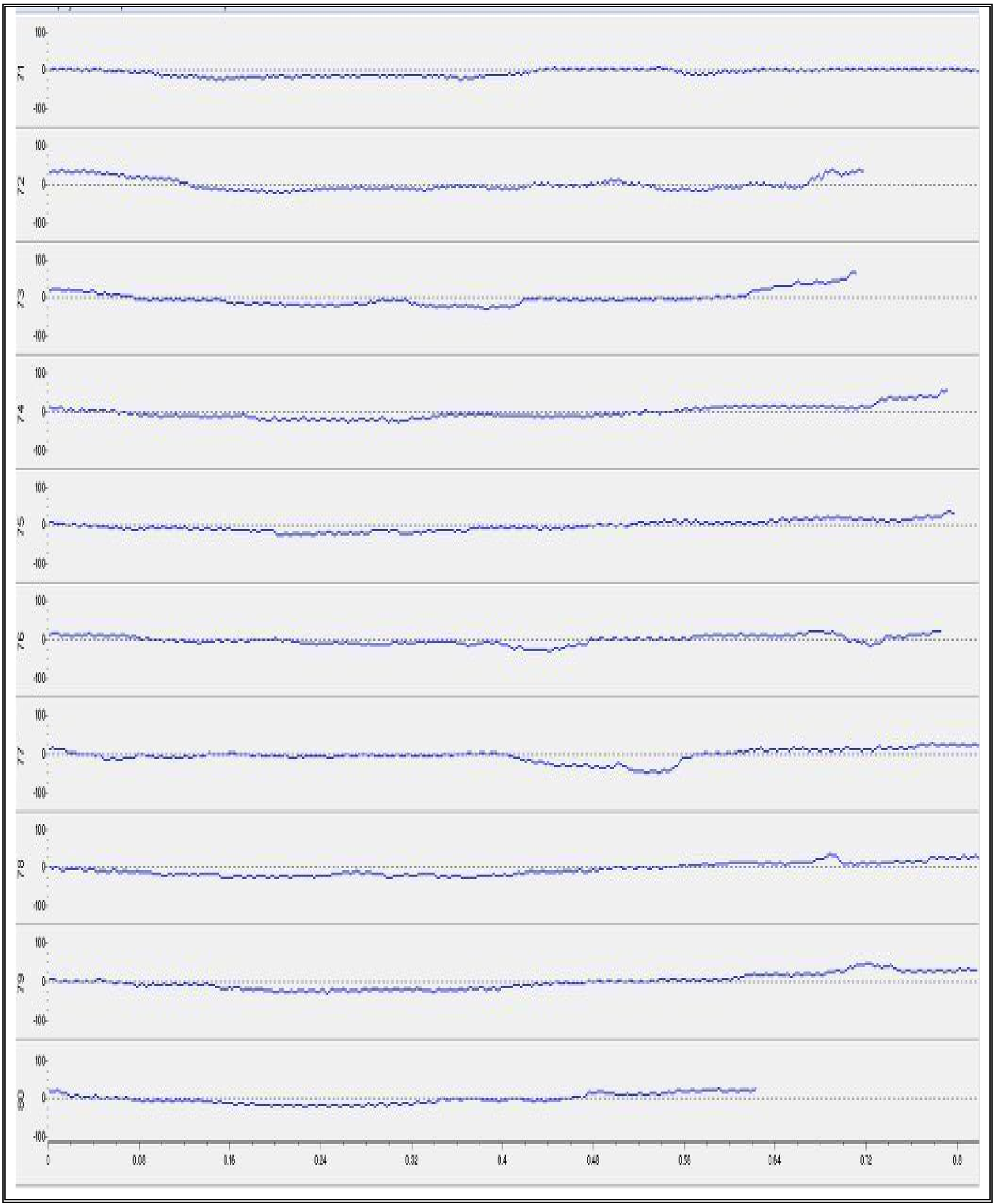
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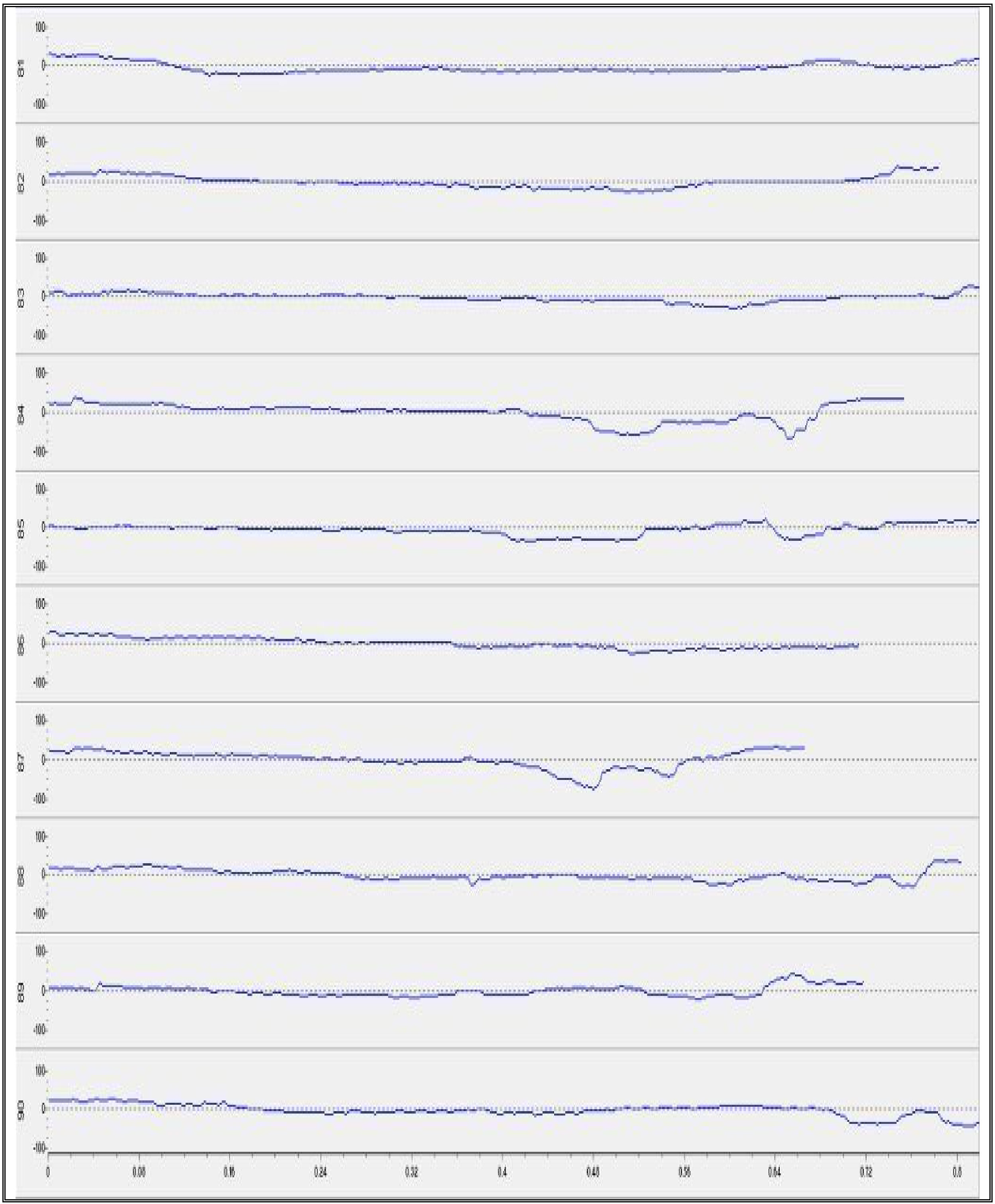
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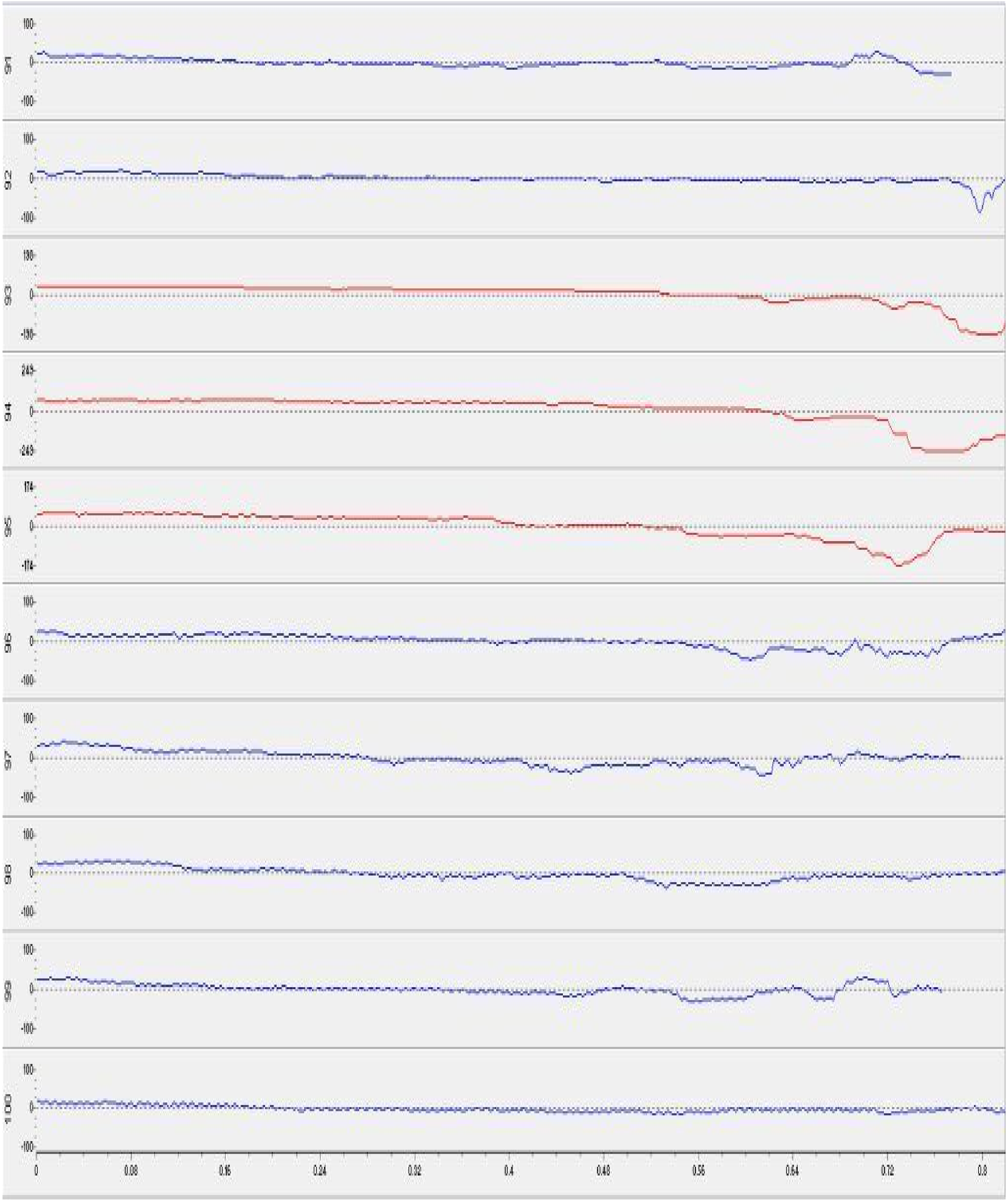

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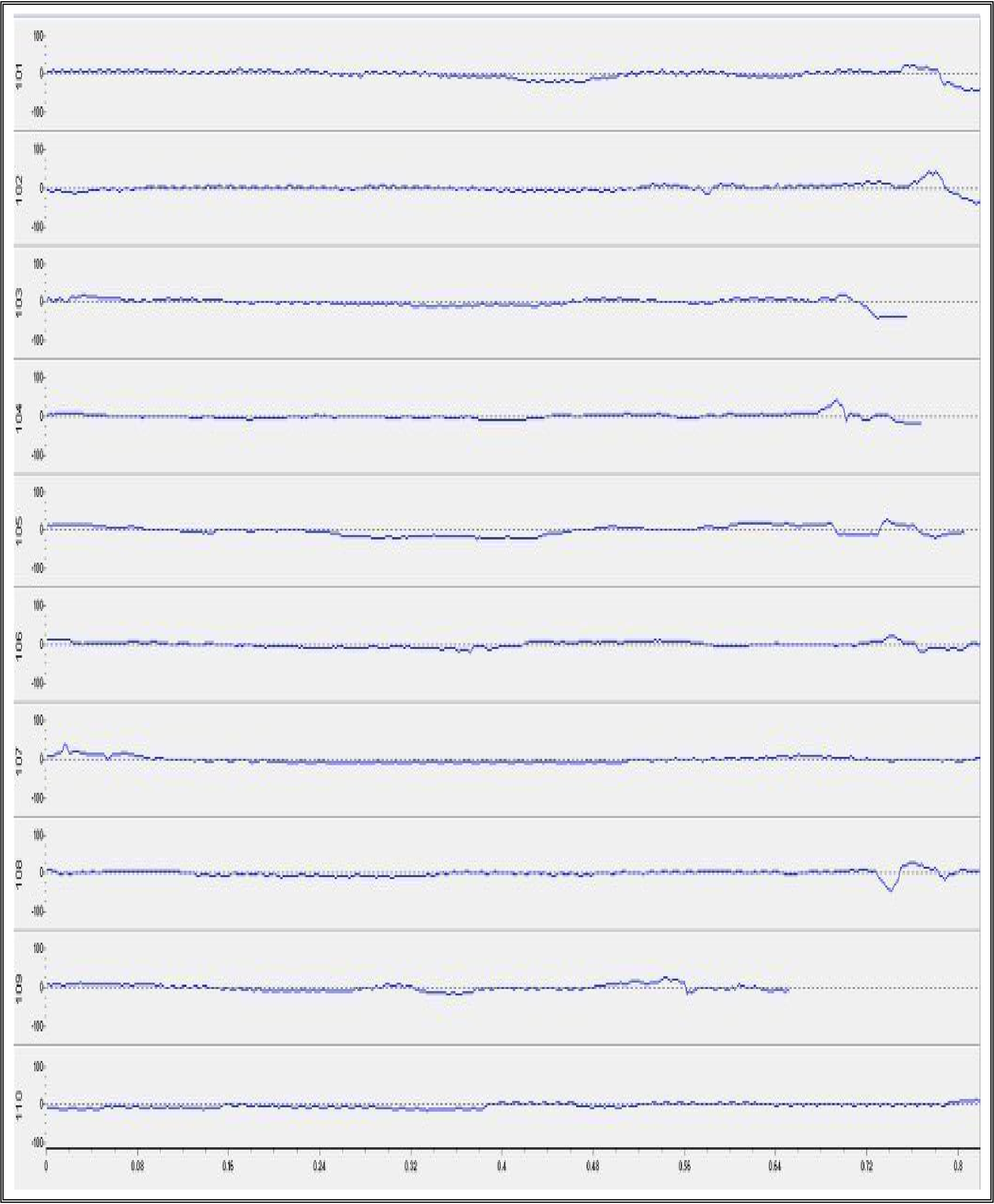
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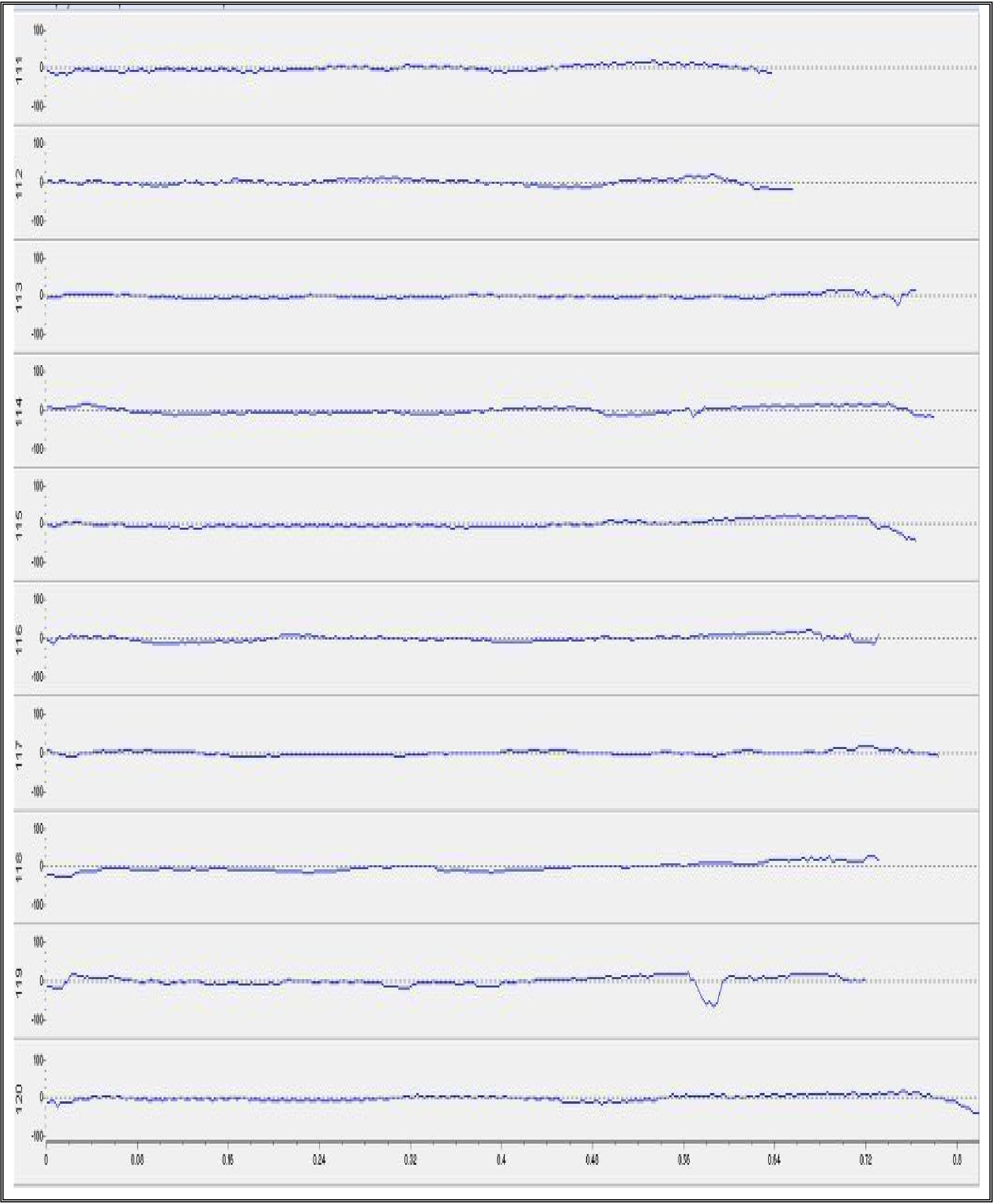
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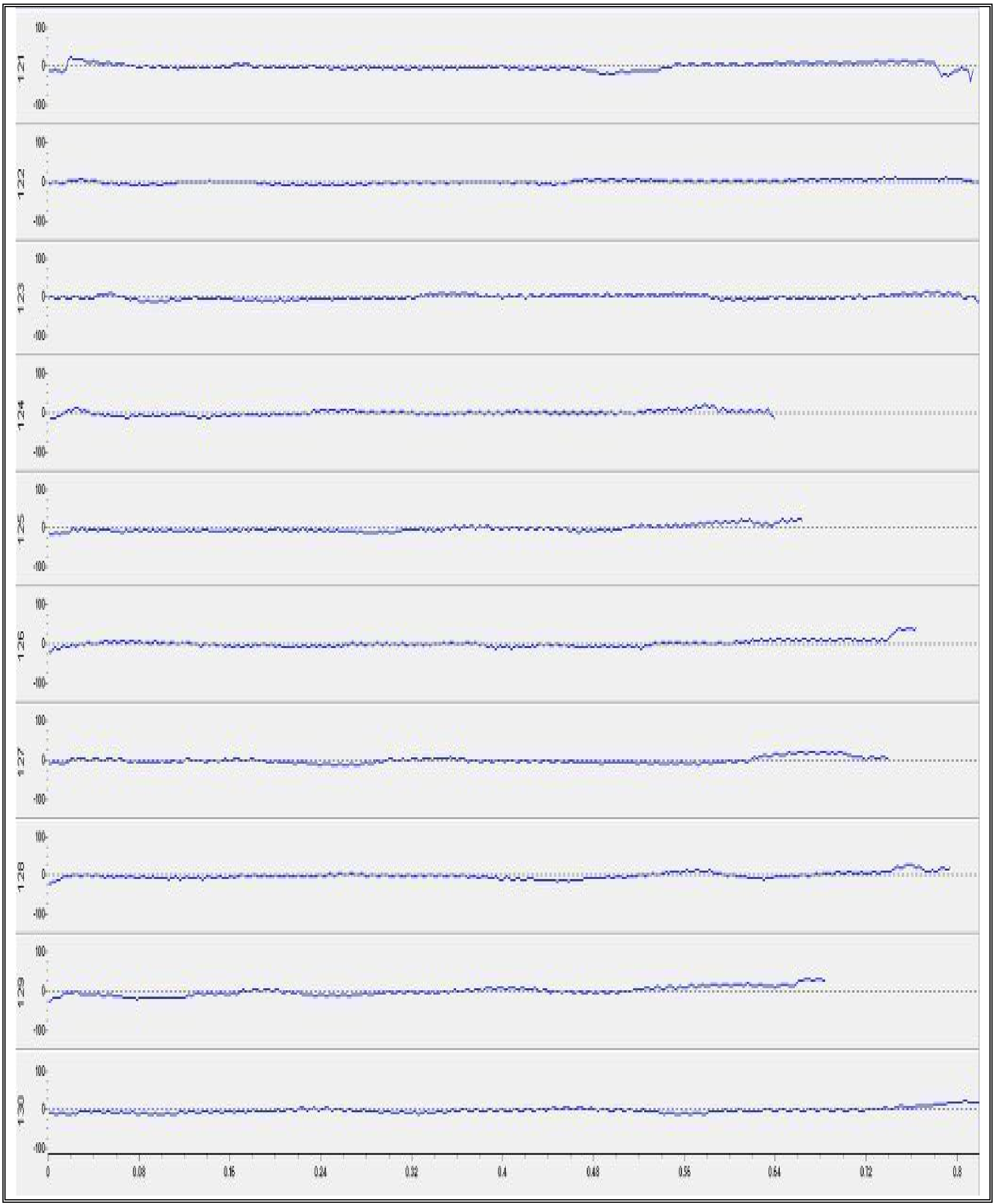
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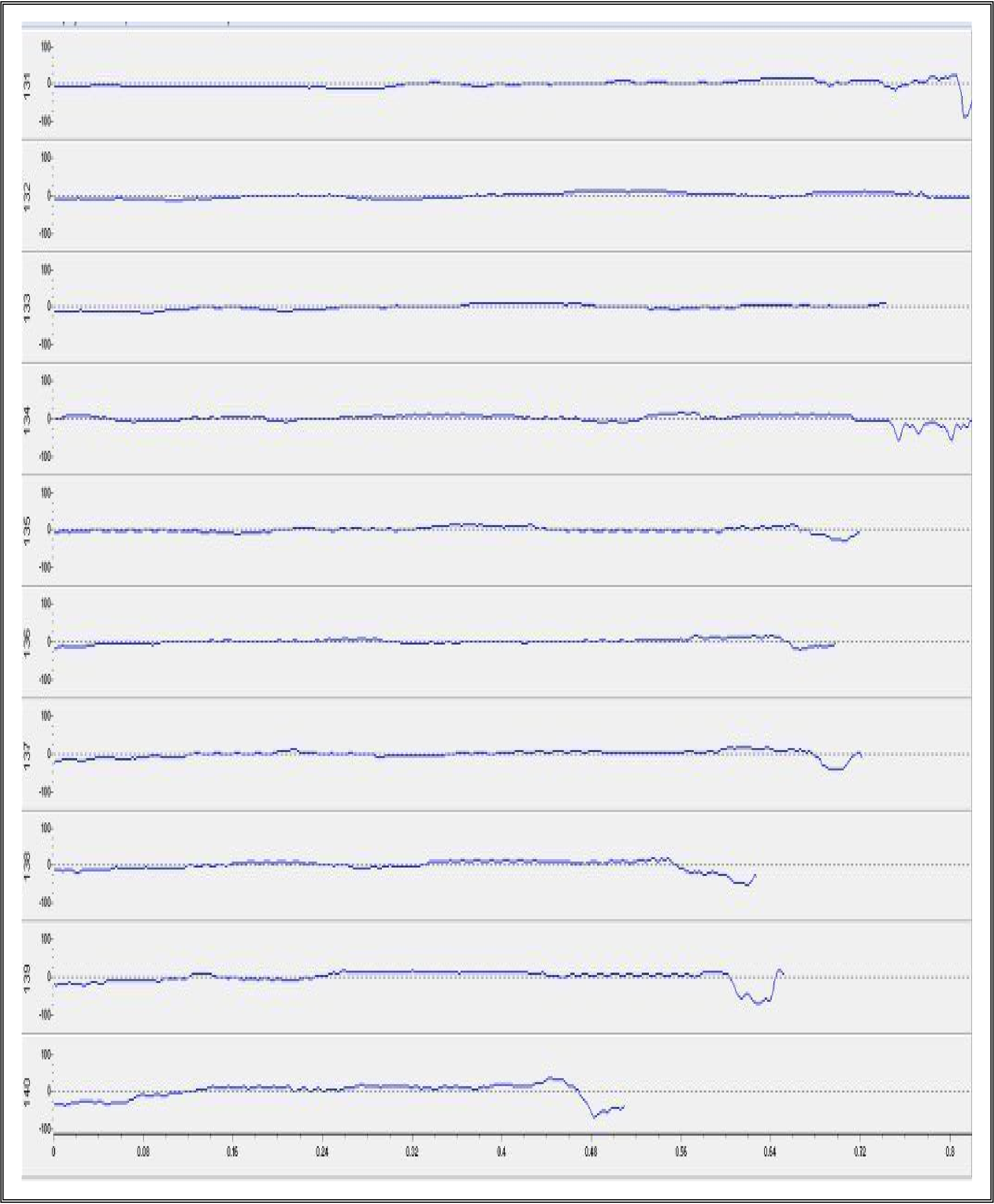
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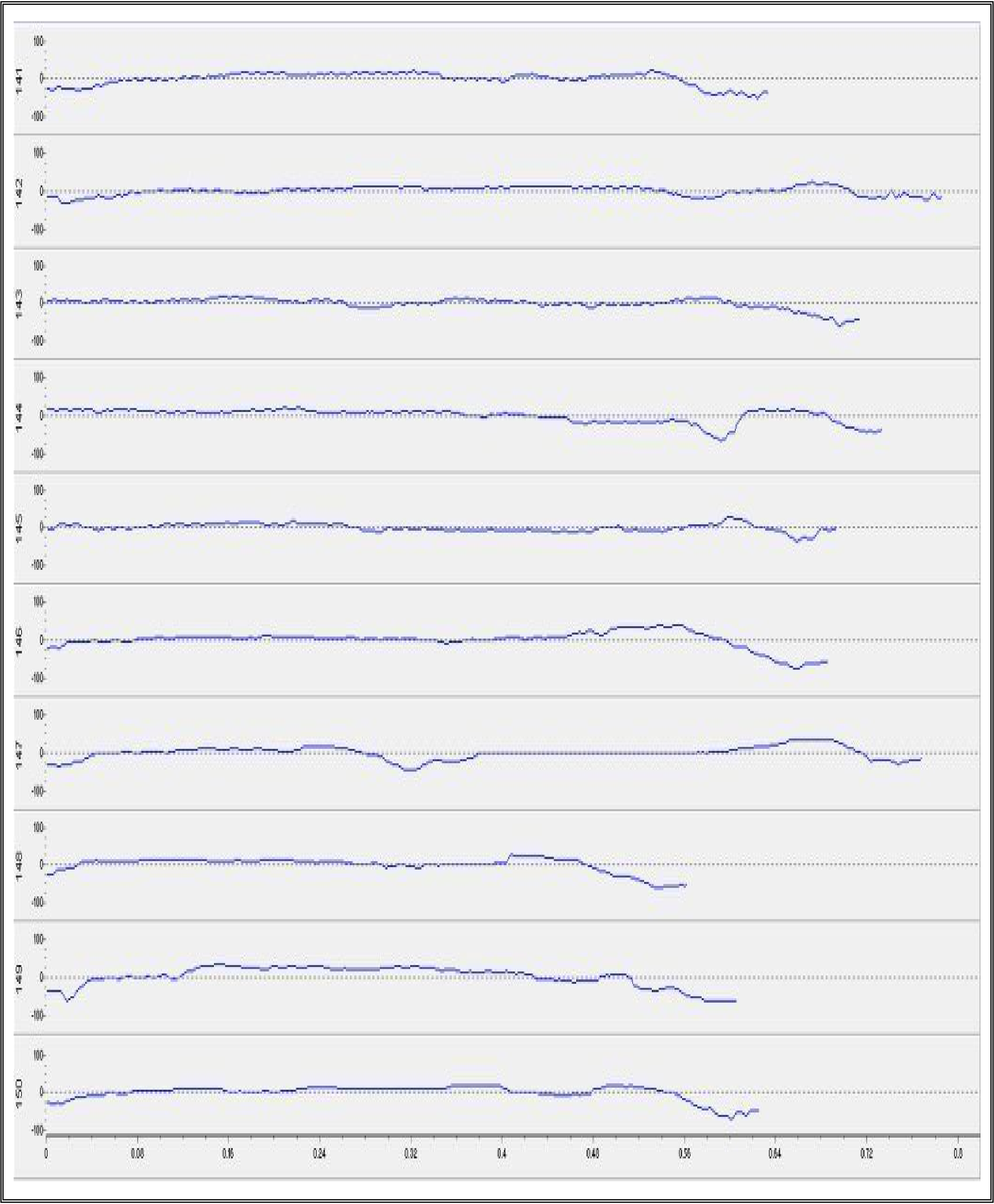
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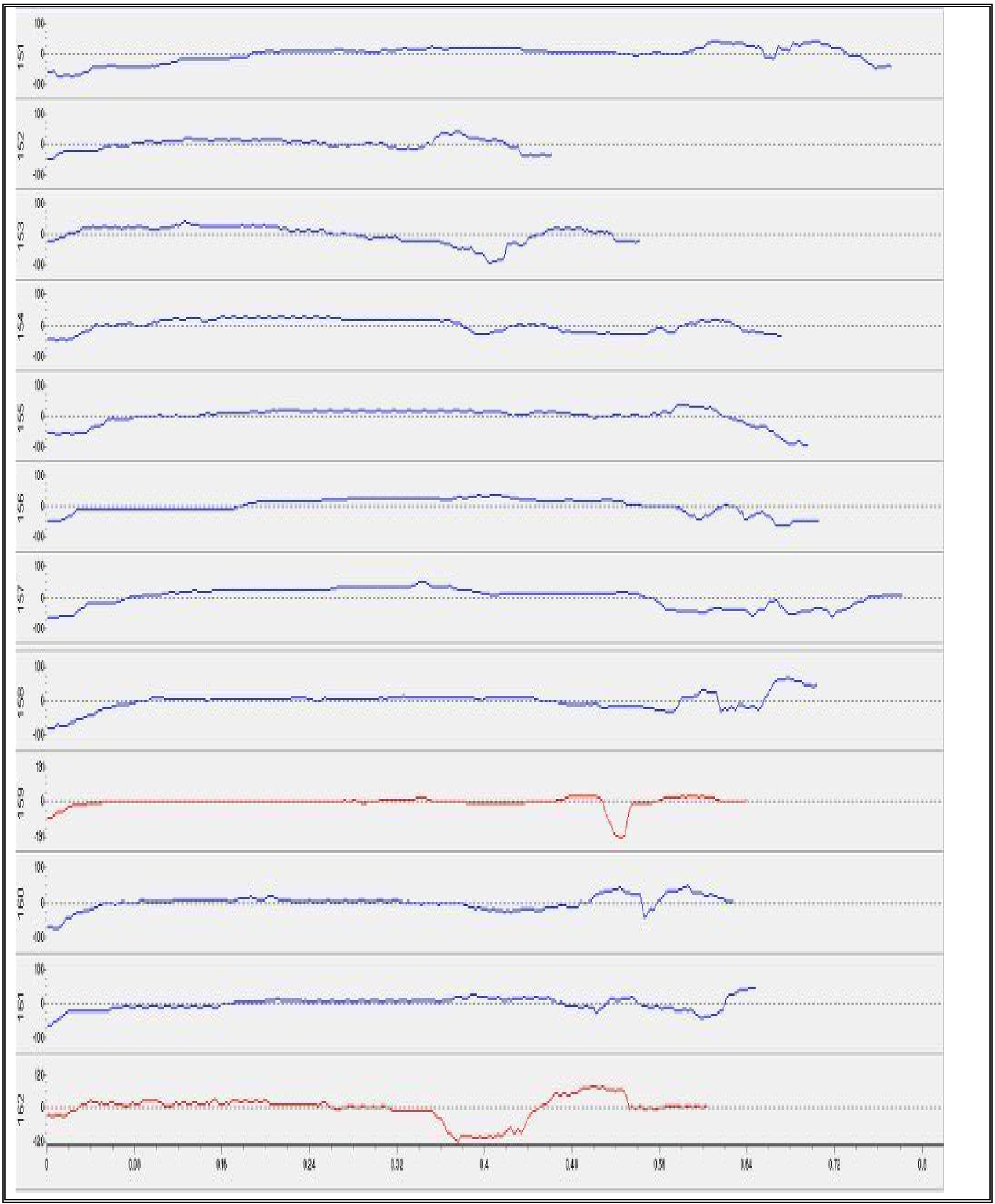


2.0 ANALYSIS AND RECOMMENDATIONS:

2.1 ASSESSMENT:

ELCID test was performed to assess the condition of core inter-laminar insulation and following conclusions drawn:

1.0 The major core fault is observed in slot no 14 on both side wall regions, the fault is observed in packet 2, 3 and 4. The maximum fault current in slot 14 is found to be 331 mAs, which is much above threshold value.

2.0 Repair attempt was performed in slot 14 in packet 4 by filling mica flakes and the ELCID fault current values have come down from previous observed values.

3.0 The fault current was also observed to be more than threshold value in other locations as given in the table above. Graphs indicate all of this faults locations are in teeth portion.

2.2 CONCLUSION AND RECOMMENDED ACTION:

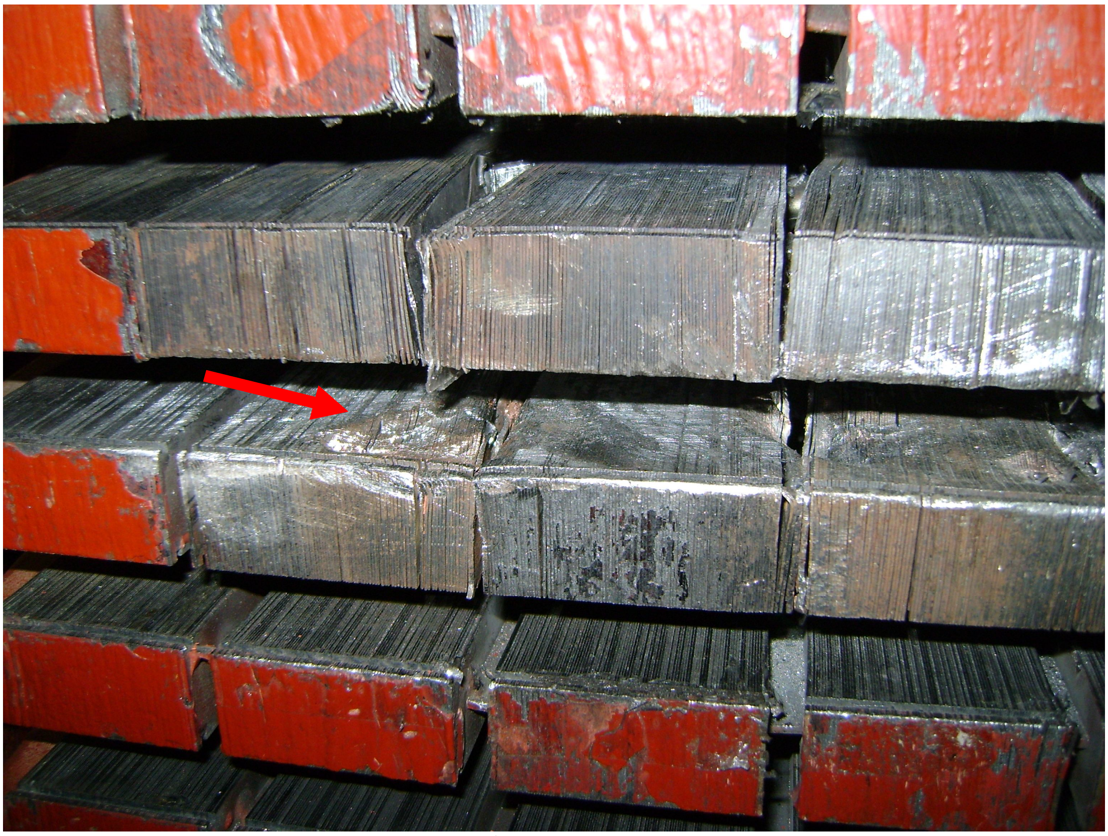
The detailed assessment on ELCID test indicate that the intensity of core lamination shorting is more in slot 14, to remove the lamination shorting various repair techniques needs to be attempted like grinding of molten metal on the surface, applying electro-chemical etching at the fault area, filling the mica flake insulation between the laminations by loosening the core as possible.

Also the above repair techniques need to be applied on other than slot 14 locations, where the ELCID fault current values are above threshold limit.

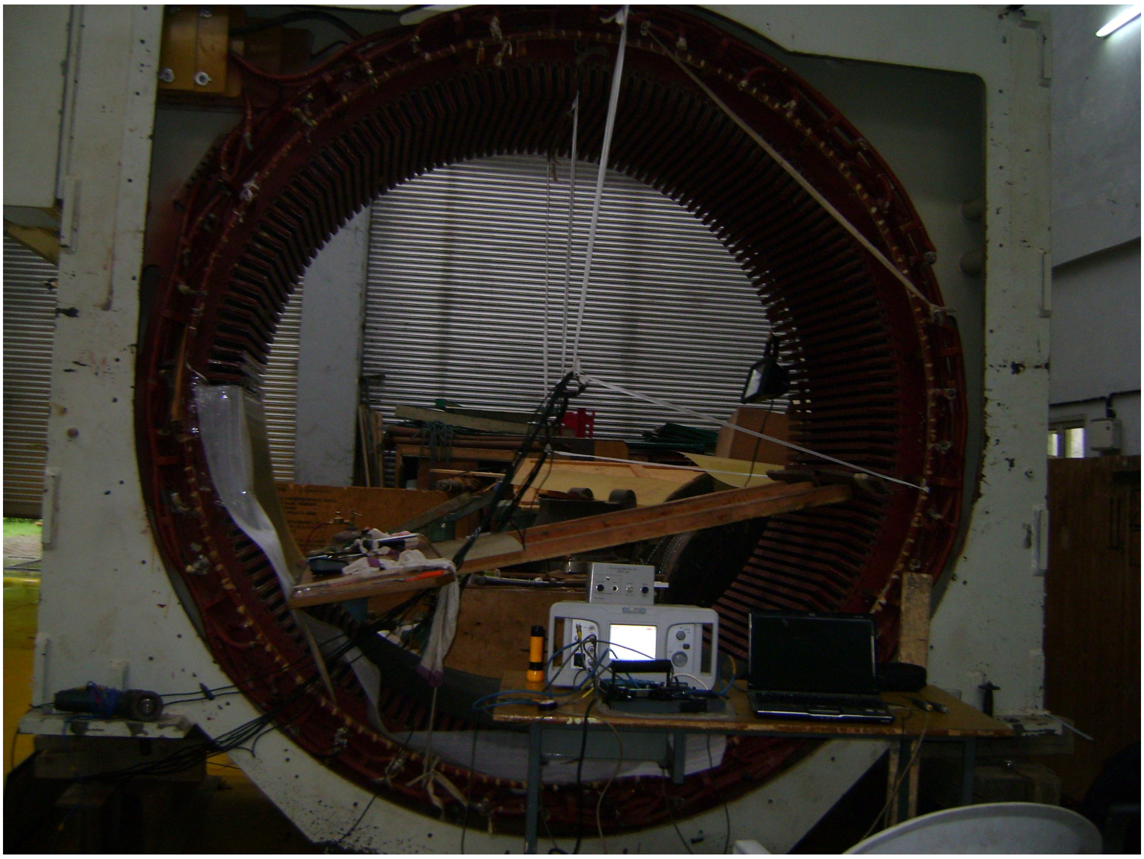
ELCID test needs to be repeated after entire core repair, to assess the core condition after repair.

ANNEXURE 1 : PHOTOGRAPHS

1. Core fault seen in slot no. 14



2. Core fault seen in slot 14.



3. ELCID test setup

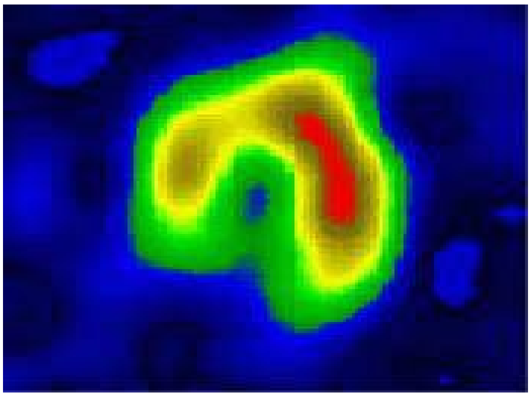
APPENDIX - 2

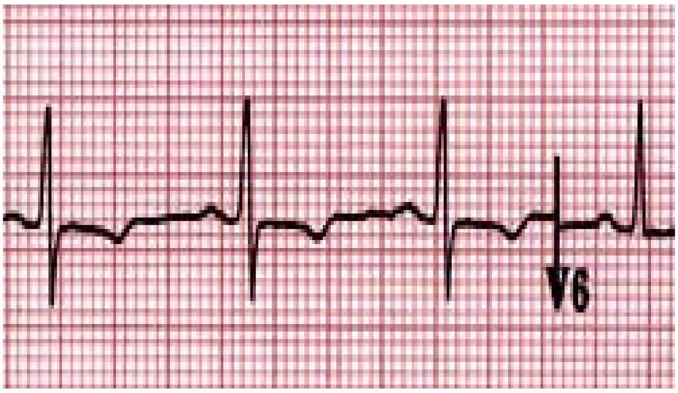
CLIENT: PATIKARI POWER
UNIT ›› **02**, MAKE ›› **EX-MONT**, RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV**, AMPS ›› **509 A,** P.F ›› **0.85.**

ELCID Test Report After Partial Repair

GENERATOR STATOR

PATIKARI HYDRO GENERATING STATION - PANDOH





Contract Ref.: S. O. 1020000008
August 2011

Prognosys
VISION TO SCIENTIFIC PREDICTION

ELCID TEST ON GENERATOR STATOR

CLIENT	**PATIKARI POWER PRIVATE LIMITED**
MACHINE DETAILS	UNIT ›› **02,** MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR VOLTS ›› **11 KV,** STATOR AMPS ›› **509 A,** P.F ›› **0.85.**

Prepared and Authorized by:

Mahender Reddy
Director – Technical
Prognosys EMS (P) Limited
www.prognosys.co.in

INDEX

1.0 DIGITAL ELCID TEST

The generator stator core is built from thousands of thin steel sheets (laminations). These laminations are coated with a thin layer of varnish for prevention of circulating induced currents also known as eddy currents, which are induced because of rotating magnetic flux produced by the rotor. Hence, it can be envisaged that any defects in the inter-laminar insulation causes fault currents to flow locally in core. These circulating currents can thus cause localized overheating and hot spots in the damaged areas and this may further damage the core. In extreme cases, sufficient heat is generated to cause melting of small parts of core and premature failure of the winding insulation. Thus these hot spots should be detected and corresponding repair works must be carried out before the condition worsens. Unlike the core ring flux test that had several disadvantages like running of high current/voltage, mechanical stresses etc, the digital ELCID test uses only a fraction (4%) of rated flux level to generate fault currents within the core body. These currents are then sensed by a pick up coil. The digital ELCID test helps in assessing the condition of Generator/motor core and gives vital information in the development of trend analysis, for use in diagnostic and predictive maintenance.

It offers the following facilities:

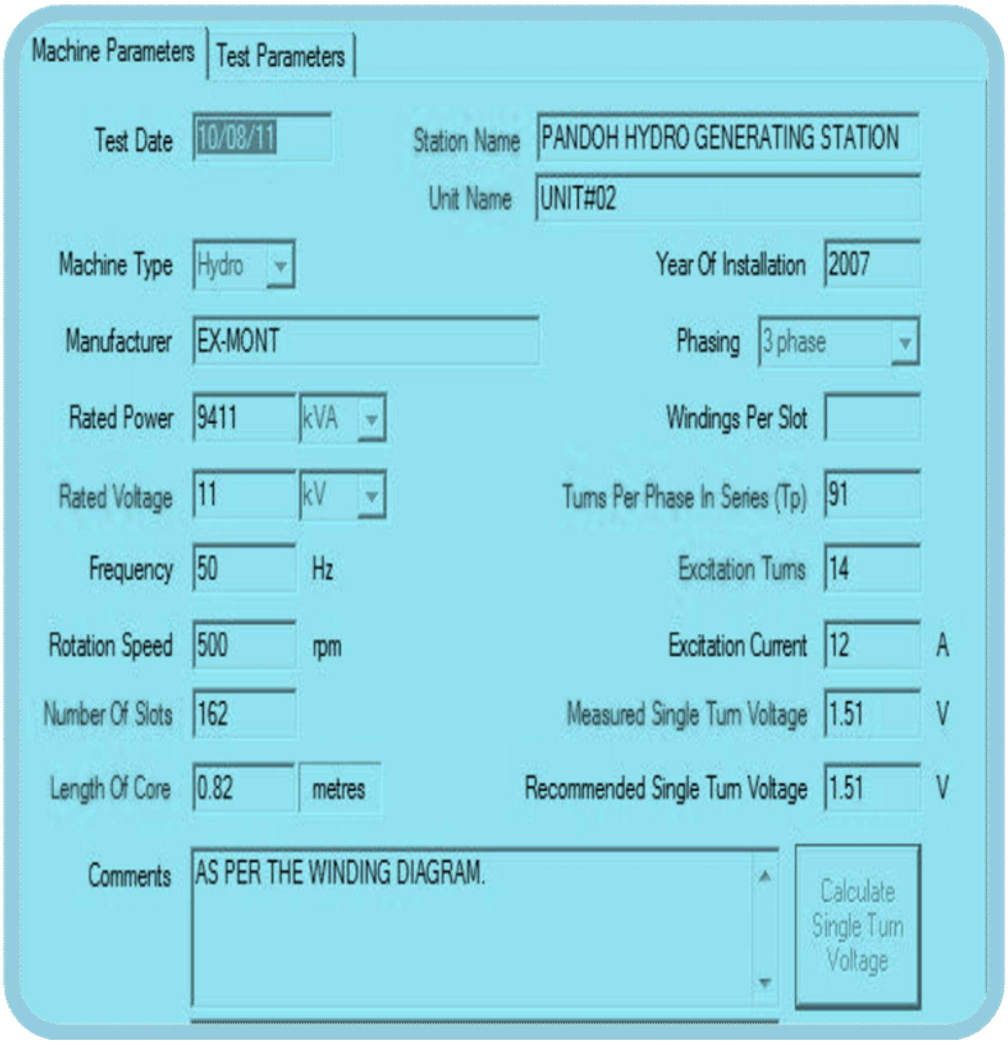
- Identification of faults below the winding.
- Distinguishes between surface faults and deep faults.
- Fault location is pin-pointed accurately.

Principle:

The circumferential magnetic field of the core is due to the excitation, plus that due to any fault currents present. The effect of the magnetic fields is to produce magnetic potential gradient on the core surface. This magnetic potential gradient is detected by specially wound coil known as Chattock coil, which provides an output proportional to the difference in the magnetic potential between its two ends.

The ELCID equipment tests a core for faults by exciting the core using a toroidal winding to produce a ring flux of only 4% of its normal level of excitation. A sensing head (Chattock coil) is then passed overthe surface of the core to detect magnetically the presence of fault currents themselves rather than the heating effect they produce. The output of the Chattock coils is a dc voltage proportional to the fault current component in phase quadrature with the core excitation current. The signal is an analogous signal, which is converted into a digital signal and displayed or stored in PC.

Test details:



Machine Parameters | Test Parameters

Test Date	10/08/11	Station Name	PANDOH HYDRO GENERATING STATION
		Unit Name	UNIT#02
Machine Type	Hydro	Year Of Installation	2007
Manufacturer	EX-MONT	Phasing	3 phase
Rated Power	9411 kVA	Windings Per Slot	
Rated Voltage	11 kV	Turns Per Phase In Series (Tp)	91
Frequency	50 Hz	Excitation Turns	14
Rotation Speed	500 rpm	Excitation Current	12 A
Number Of Slots	162	Measured Single Turn Voltage	1.51 V
Length Of Core	0.82 metres	Recommended Single Turn Voltage	1.51 V

Comments: AS PER THE WINDING DIAGRAM.

Calculate Single Turn Voltage

ELCID FAULT CURRENT PEAK VALUES FOR SLOTS:

	FAULT CURRENT(mA)		FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 1	141	SLOT NO. 31	47	SLOT NO. 61	39
SLOT NO. 2	225	SLOT NO. 32	48	SLOT NO. 62	53
SLOT NO. 3	125	SLOT NO. 33	77	SLOT NO. 63	36
SLOT NO. 4	35	SLOT NO. 34	70	SLOT NO. 64	32
SLOT NO. 5	40	SLOT NO. 35	78	SLOT NO. 65	23
SLOT NO. 6	55	SLOT NO. 36	51	SLOT NO. 66	23
SLOT NO. 7	45	SLOT NO. 37	31	SLOT NO. 67	52
SLOT NO. 8	46	SLOT NO. 38	42	SLOT NO. 68	40
SLOT NO. 9	52	SLOT NO. 39	45	SLOT NO. 69	44
SLOT NO. 10	62	SLOT NO. 40	36	SLOT NO. 70	35
SLOT NO. 11	43	SLOT NO. 41	20	SLOT NO. 71	40
SLOT NO. 12	35	SLOT NO. 42	128	SLOT NO. 72	45
SLOT NO. 13	38	SLOT NO. 43	160	SLOT NO. 73	53
SLOT NO. 14	30	SLOT NO. 44	40	SLOT NO. 74	42
SLOT NO. 15	65	SLOT NO. 45	58	SLOT NO. 75	28
SLOT NO. 16	71	SLOT NO. 46	69	SLOT NO. 76	27
SLOT NO. 17	67	SLOT NO. 47	65	SLOT NO. 77	25
SLOT NO. 18	124	SLOT NO. 48	36	SLOT NO. 78	31
SLOT NO. 19	135	SLOT NO. 49	45	SLOT NO. 79	45
SLOT NO. 20	86	SLOT NO. 50	52	SLOT NO. 80	30
SLOT NO. 21	39	SLOT NO. 51	50	SLOT NO. 81	55
SLOT NO. 22	33	SLOT NO. 52	36	SLOT NO. 81	36
SLOT NO. 23	21	SLOT NO. 53	38	SLOT NO. 83	32
SLOT NO. 24	180	SLOT NO. 54	50	SLOT NO. 84	70
SLOT NO. 25	319	SLOT NO. 55	40	SLOT NO. 85	44
SLOT NO. 26	129	SLOT NO. 56	53	SLOT NO. 86	26
SLOT NO. 27	211	SLOT NO. 57	34	SLOT NO. 87	65
SLOT NO. 28	69	SLOT NO. 58	43	SLOT NO. 88	42
SLOT NO. 29	52	SLOT NO. 59	38	SLOT NO. 89	40
SLOT NO. 30	58	SLOT NO. 60	23	SLOT NO. 90	50

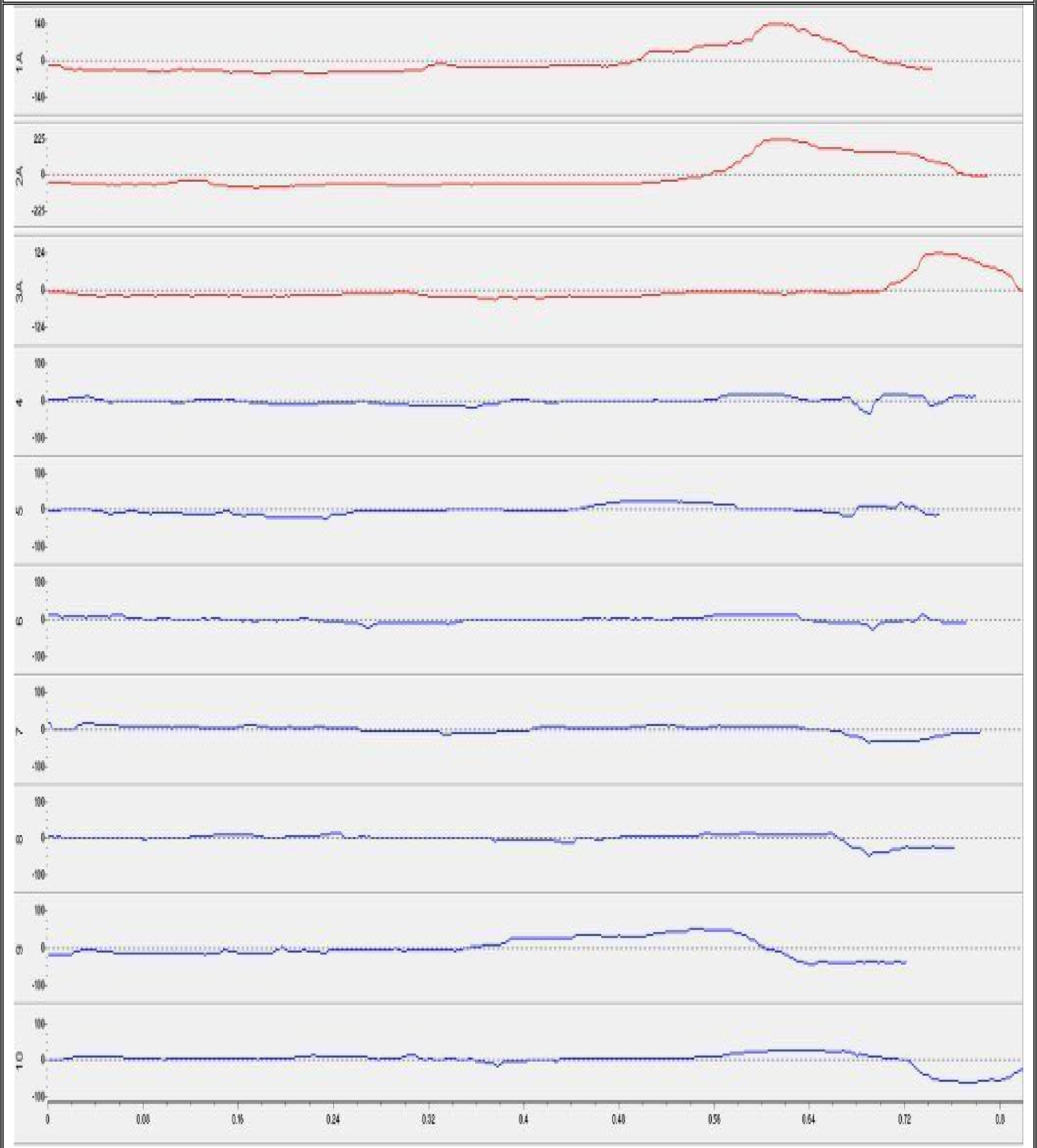
	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 91	32	SLOT NO. 122	25
SLOT NO. 92	44	SLOT NO. 123	20
SLOT NO. 93	180	SLOT NO. 124	22
SLOT NO. 94	211	SLOT NO. 125	20
SLOT NO. 95	173	SLOT NO. 126	35
SLOT NO. 96	71	SLOT NO. 127	25
SLOT NO. 97	82	SLOT NO. 128	34
SLOT NO. 98	49	SLOT NO. 129	30
SLOT NO. 99	30	SLOT NO. 130	25
SLOT NO. 100	35	SLOT NO. 131	54
SLOT NO. 101	41	SLOT NO. 132	25
SLOT NO. 102	49	SLOT NO. 133	36
SLOT NO. 103	35	SLOT NO. 134	50
SLOT NO. 104	37	SLOT NO. 135	35
SLOT NO. 105	30	SLOT NO. 136	24
SLOT NO. 106	38	SLOT NO. 137	35
SLOT NO. 107	45	SLOT NO. 138	45
SLOT NO. 108	46	SLOT NO. 139	54
SLOT NO. 109	27	SLOT NO. 140	47
SLOT NO. 110	85	SLOT NO. 141	54
SLOT NO. 111	24	SLOT NO. 142	32
SLOT NO. 112	22	SLOT NO. 143	45
SLOT NO. 113	28	SLOT NO. 144	43
SLOT NO. 114	25	SLOT NO. 145	30
SLOT NO. 115	40	SLOT NO. 146	65
SLOT NO. 116	34	SLOT NO. 147	46
SLOT NO. 117	25	SLOT NO. 148	60
SLOT NO. 118	35	SLOT NO. 150	51
SLOT NO. 119	60	SLOT NO. 151	76
SLOT NO. 120	35	SLOT NO. 152	76
SLOT NO. 121	33	SLOT NO. 153	128

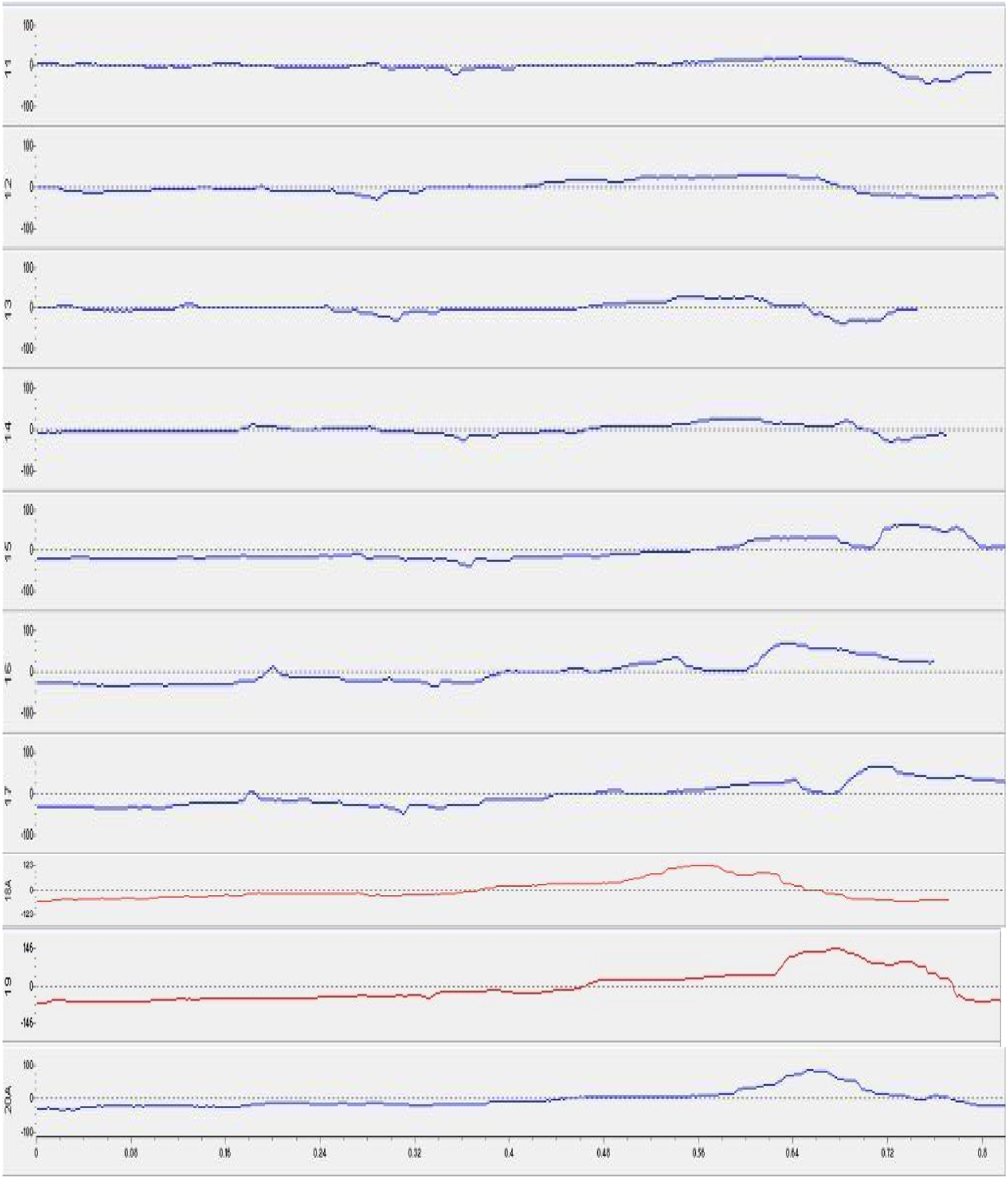
	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 154	50	SLOT NO. 159	80
SLOT NO. 155	49	SLOT NO. 160	102
SLOT NO. 156	31	SLOT NO. 161	107
SLOT NO. 157	60	SLOT NO. 162	166
SLOT NO. 158	69		

ELCID FAULT CURRENT PEAK VALUES FOR SLOTS WHOSE VALUES ARE GREATER THAN 100 mA:

	FAULT CURRENT(mA)		FAULT CURRENT(mA)
SLOT NO. 1	141	SLOT NO. 42	128
SLOT NO. 2	225	SLOT NO. 43	160
SLOT NO. 3	125	SLOT NO. 93	180
SLOT NO. 18	124	SLOT NO. 94	211
SLOT NO. 19	135	SLOT NO. 95	173
SLOT NO. 24	180	SLOT NO. 153	128
SLOT NO. 25	319	SLOT NO. 160	102
SLOT NO. 26	129	SLOT NO. 161	107
SLOT NO. 27	211	SLOT NO. 162	166

ELCID FAULT CURRENT GRAPHS OF SLOTS

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15
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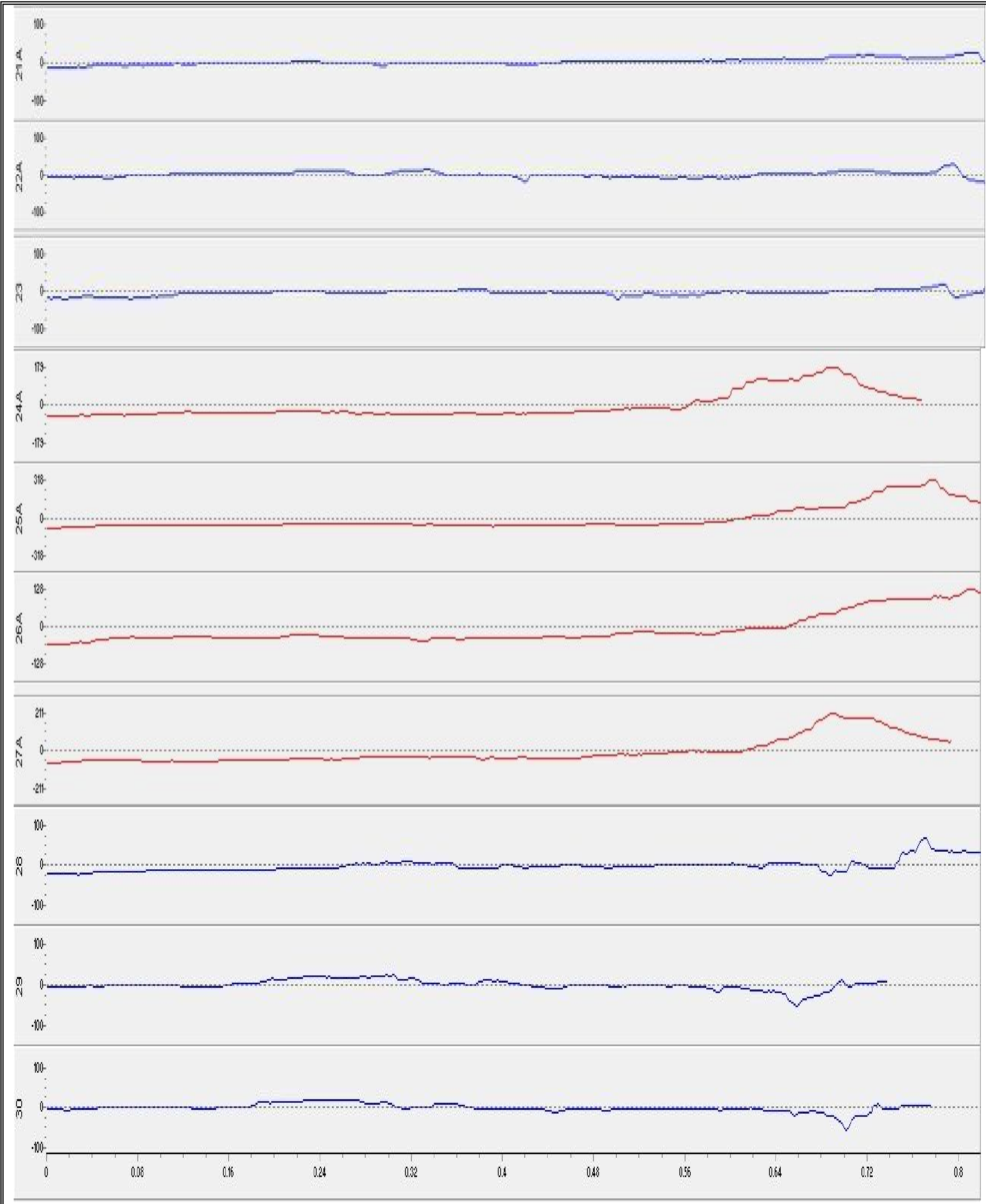
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-318
26 A
128
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27 A
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-100
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-100
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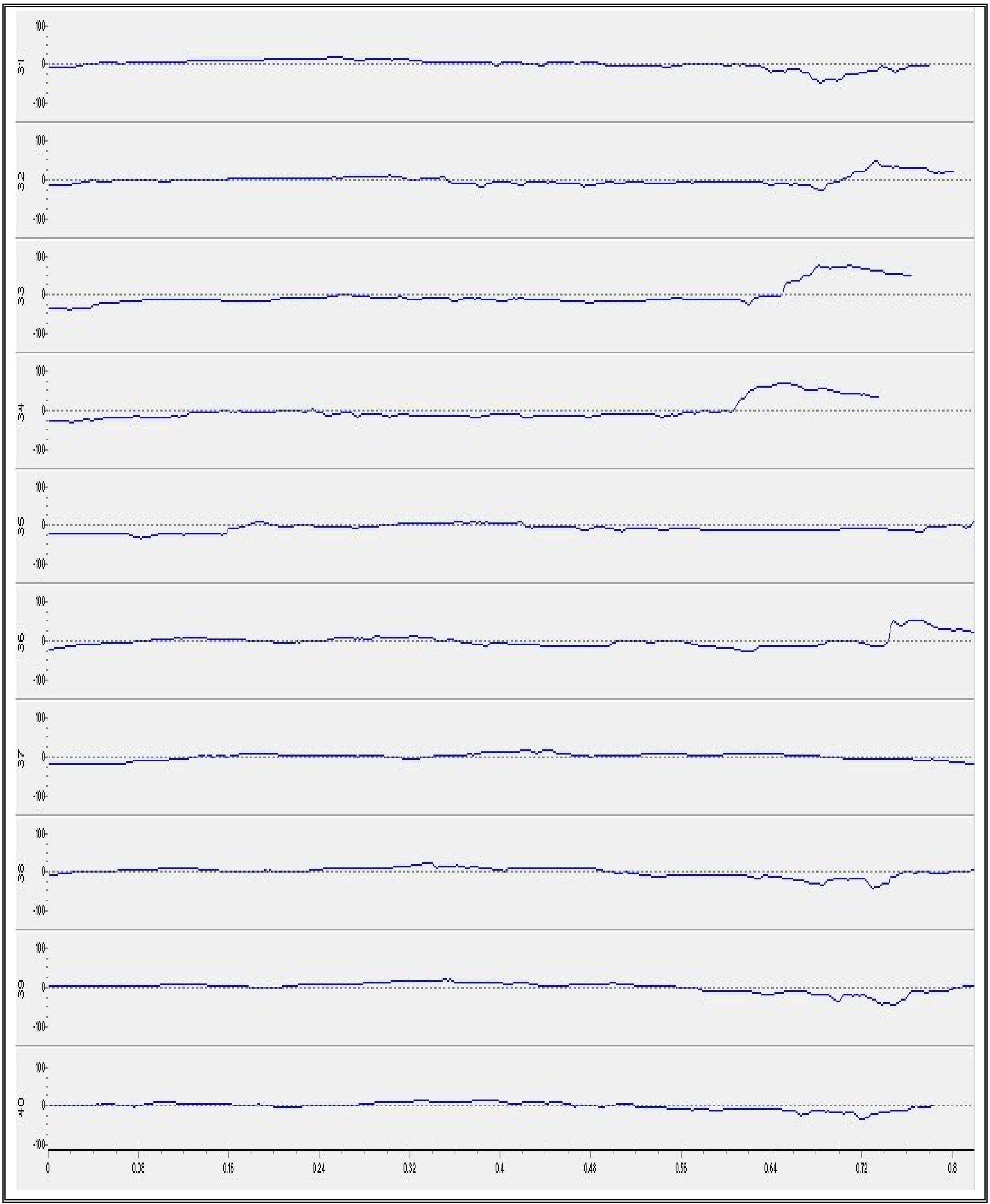

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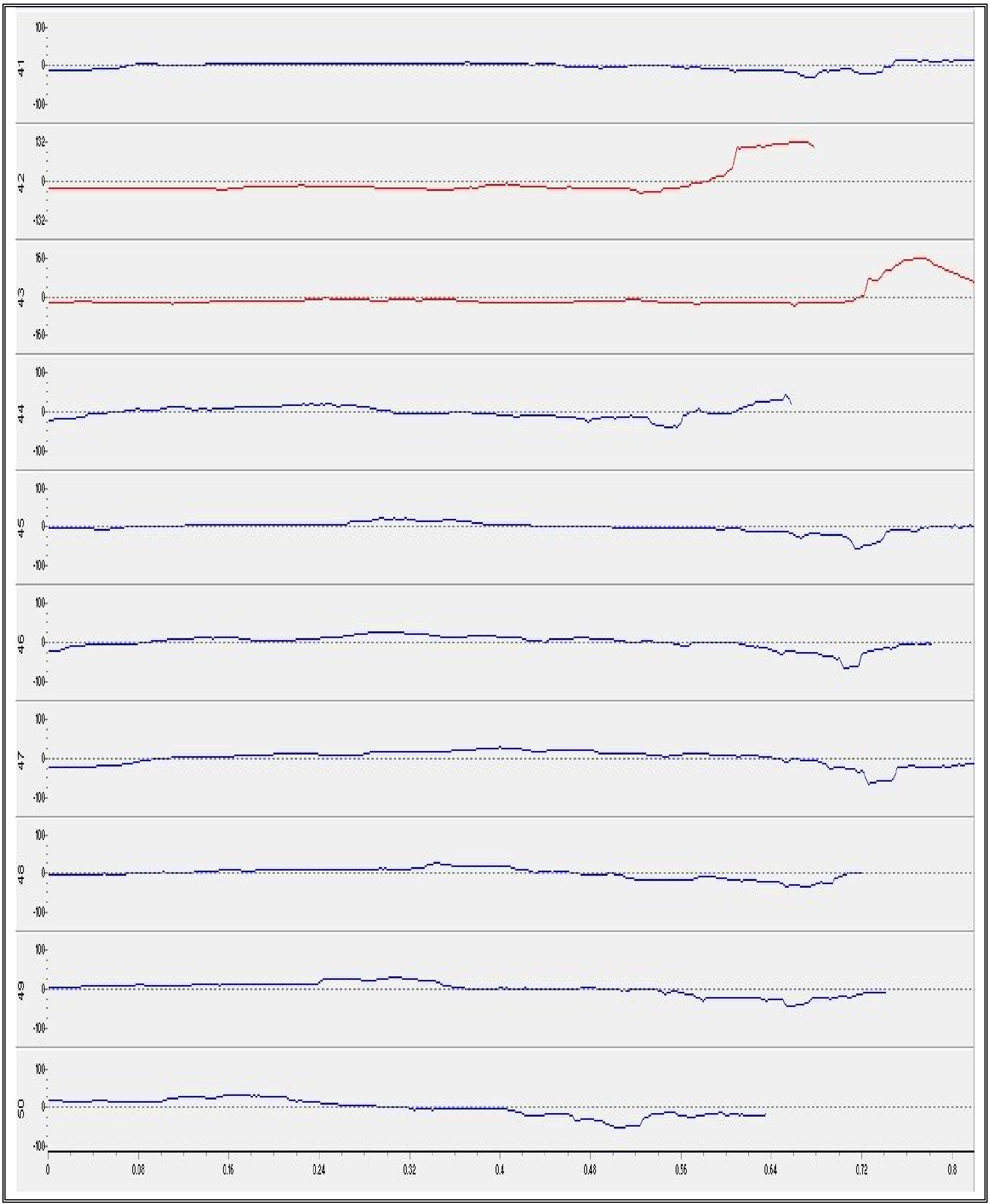
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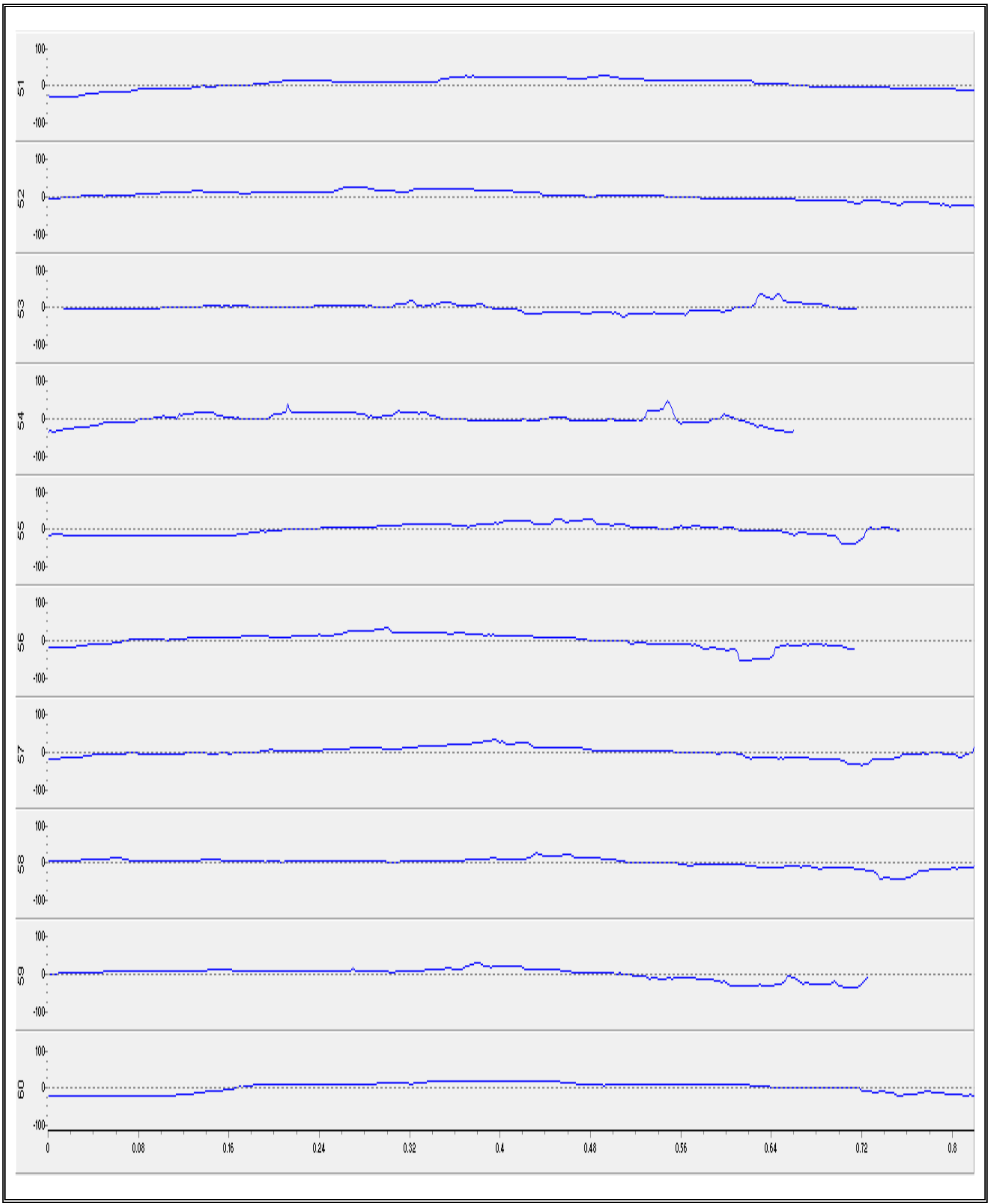
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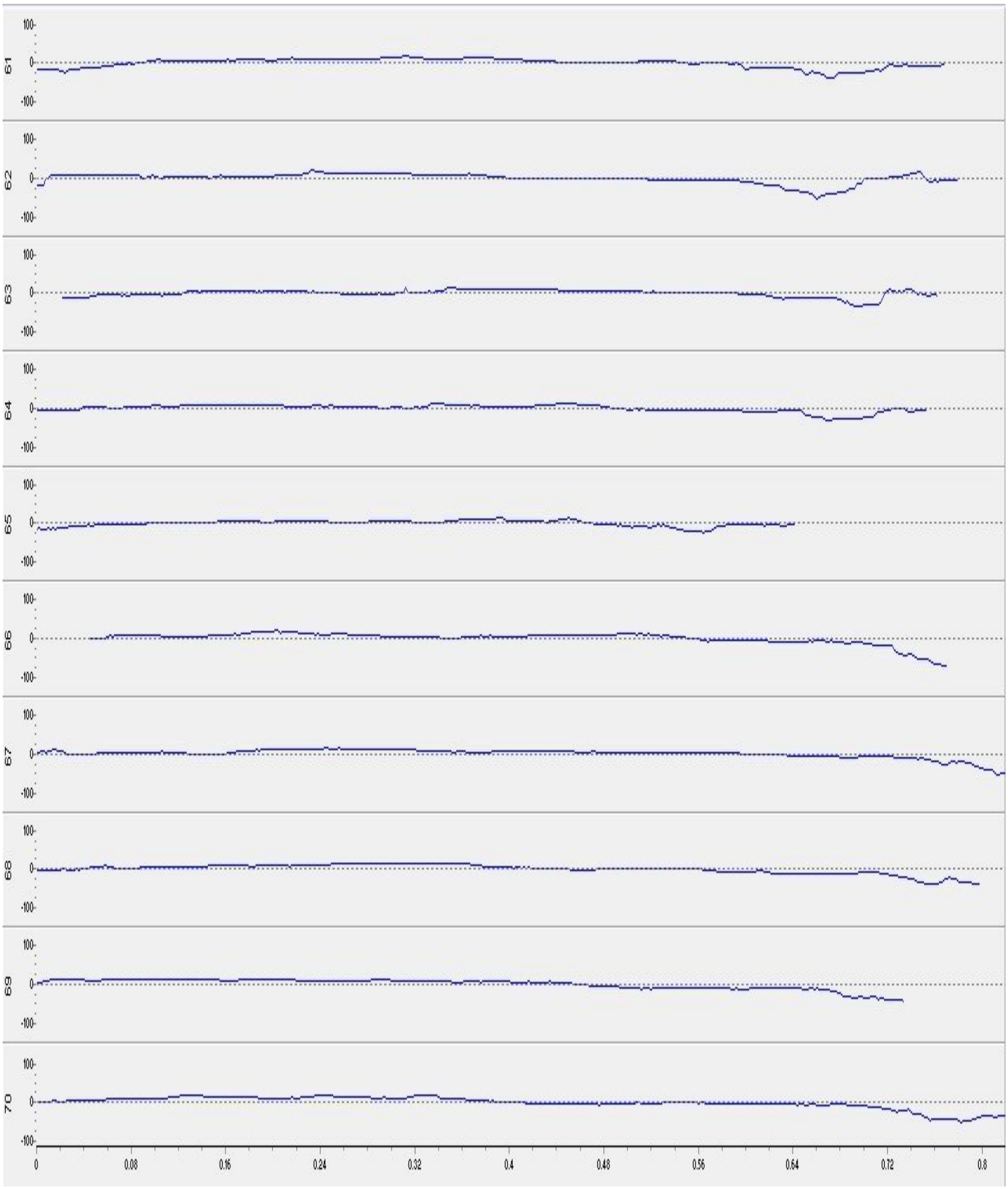
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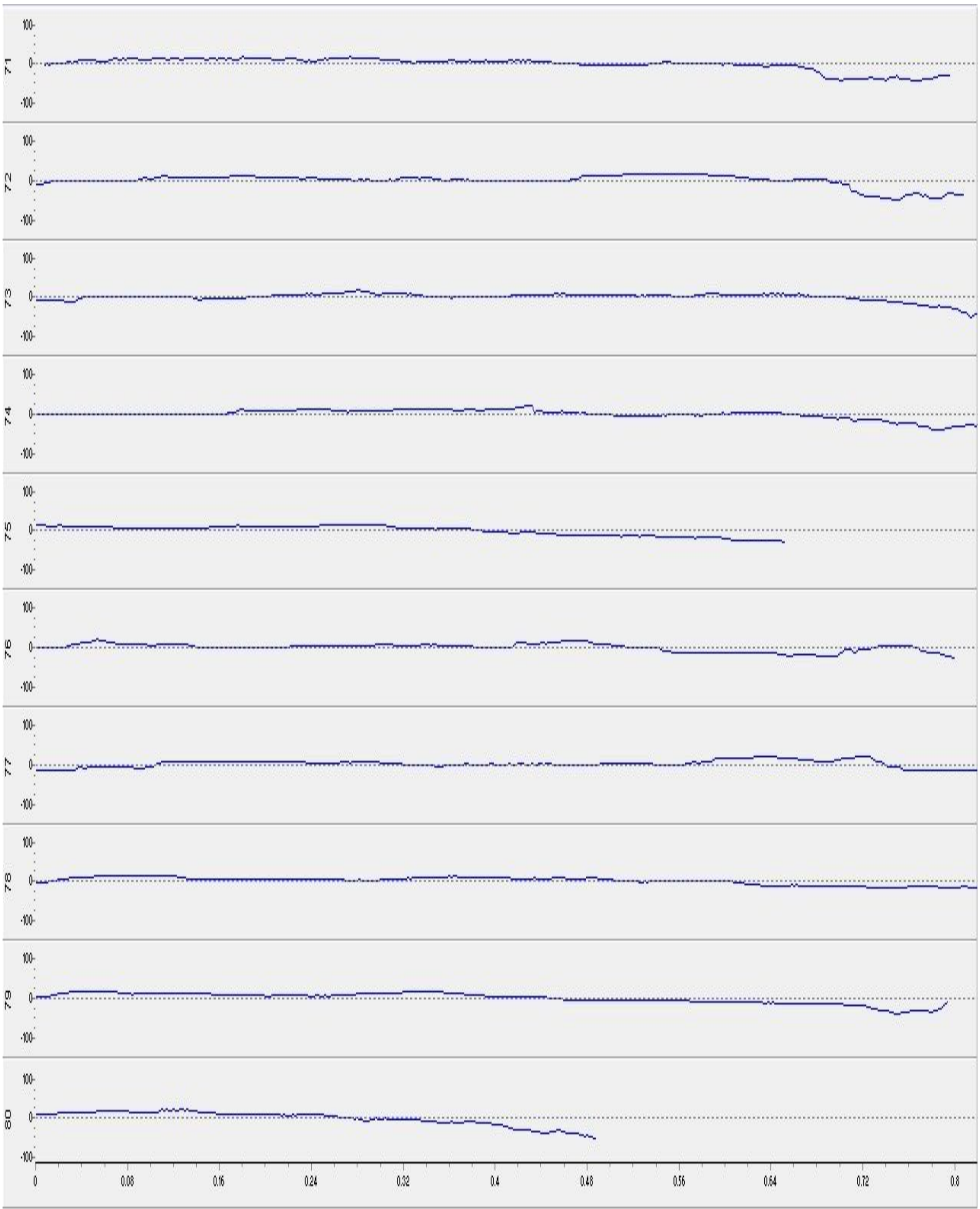
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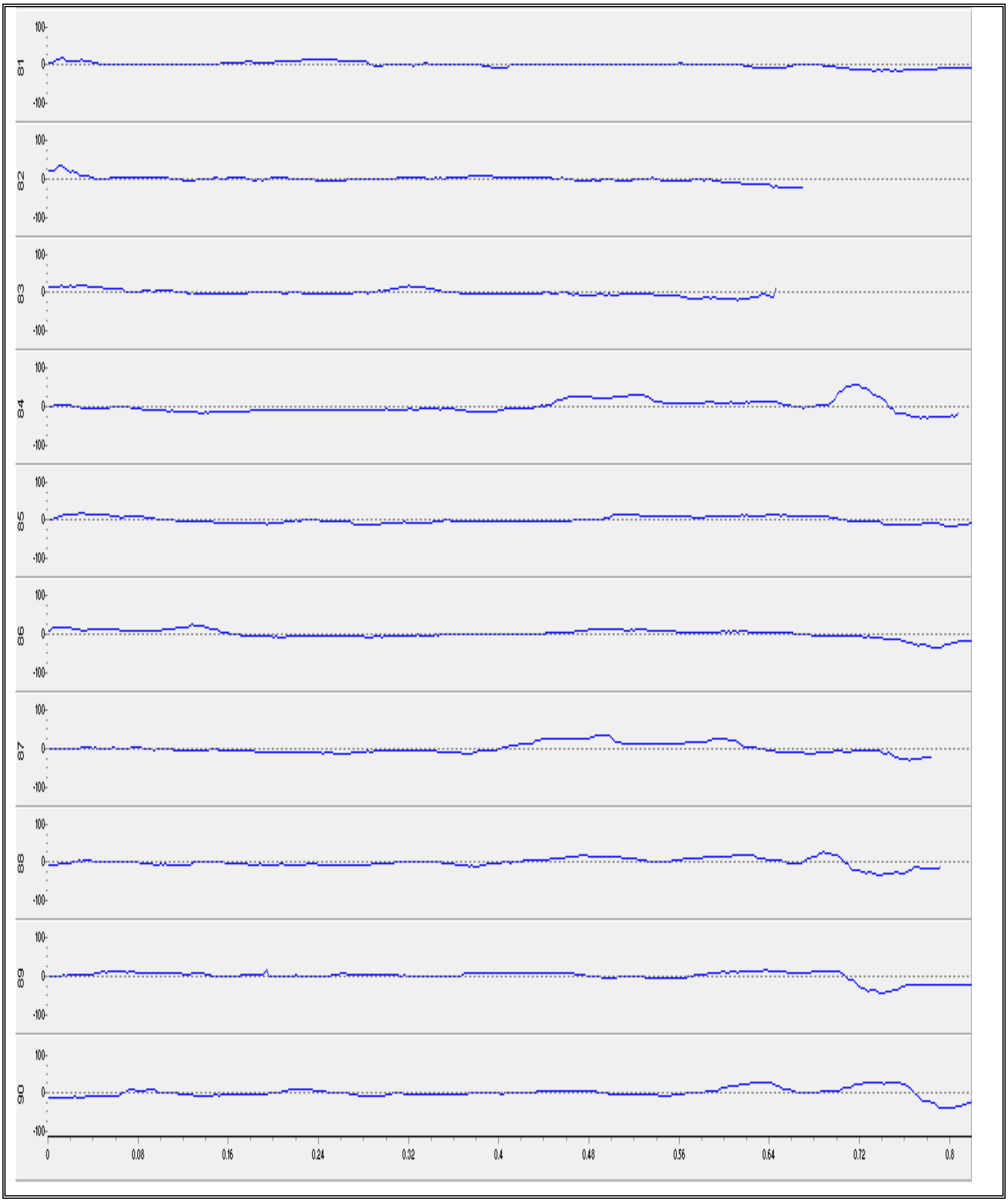
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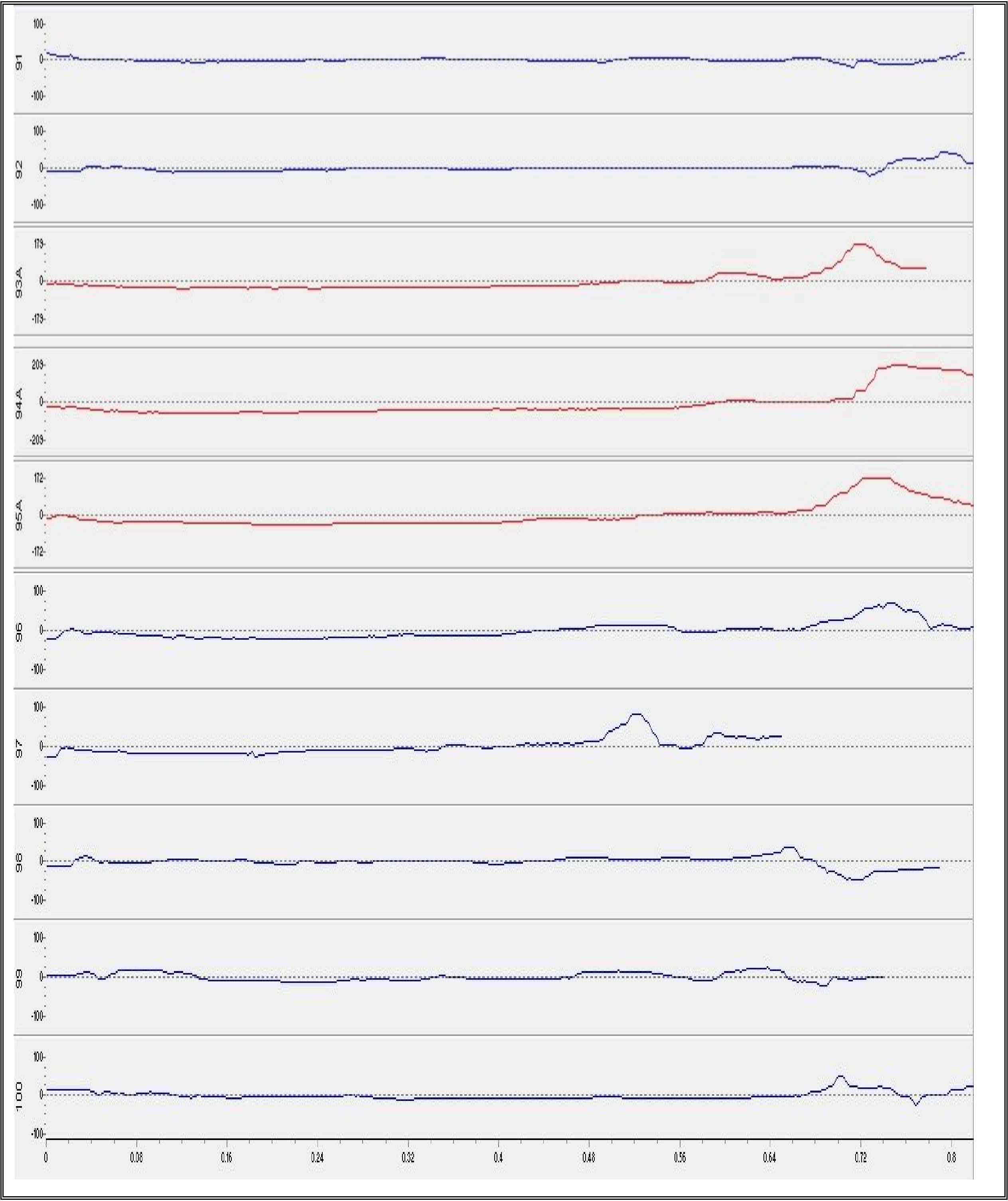

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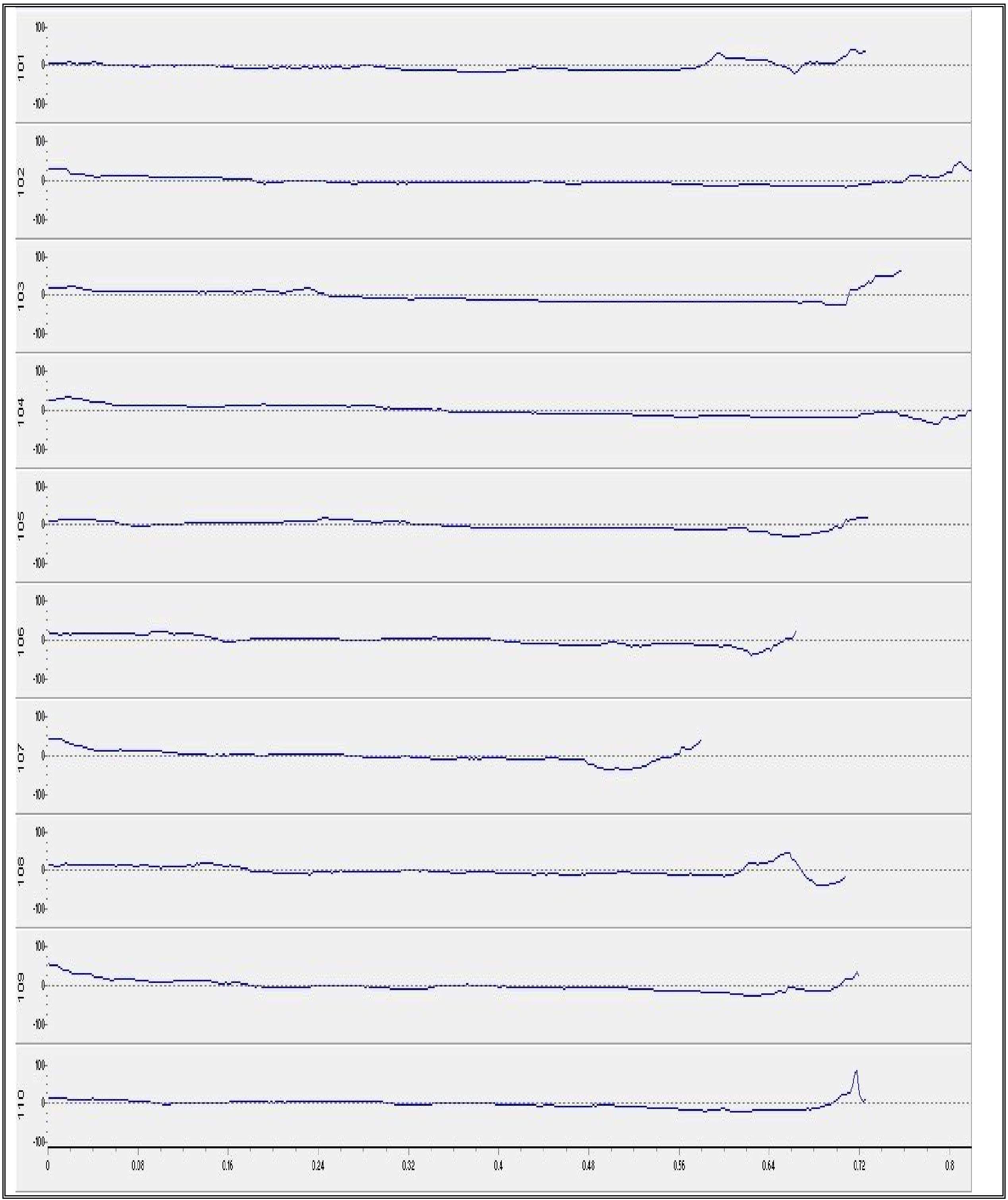
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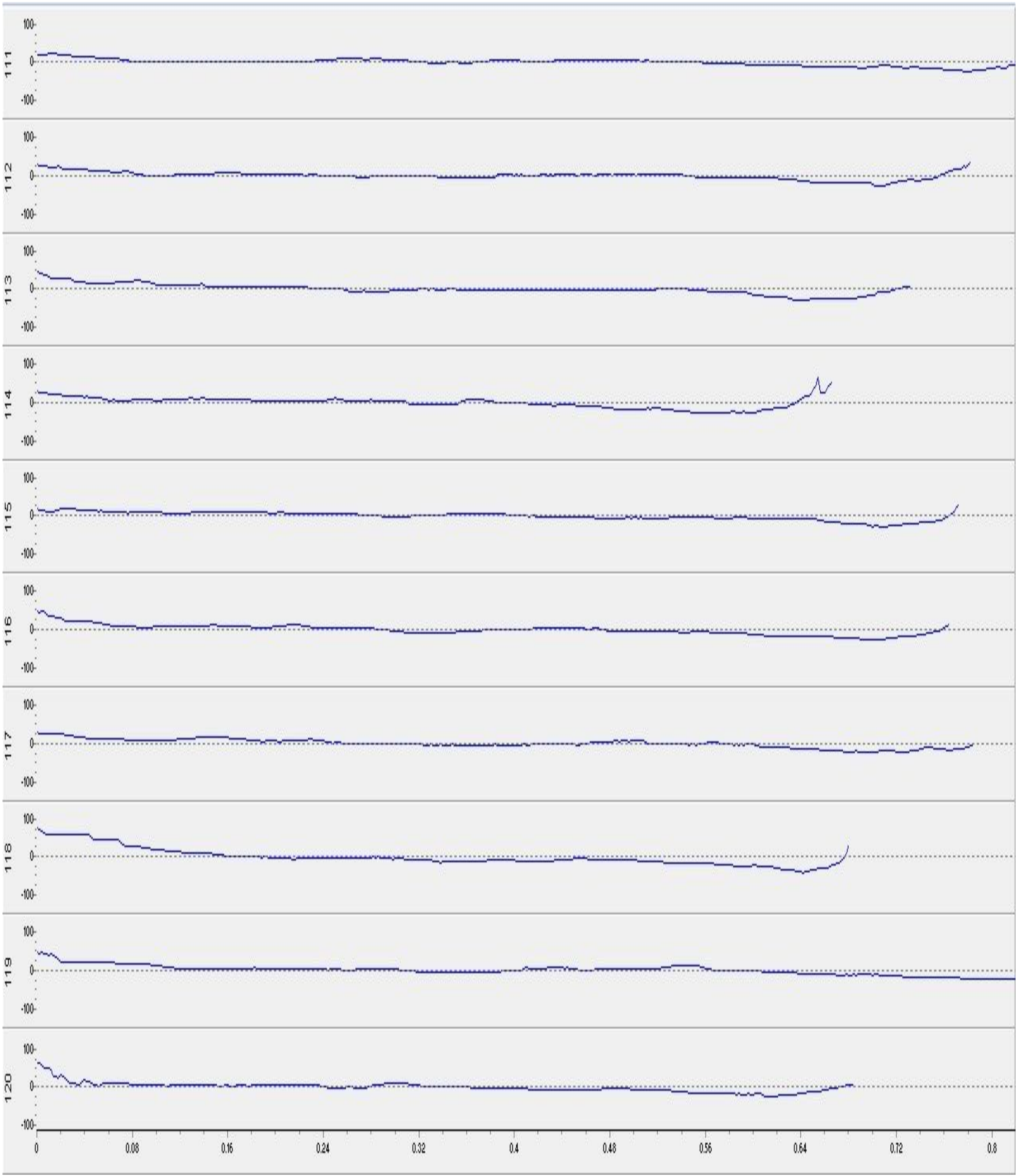
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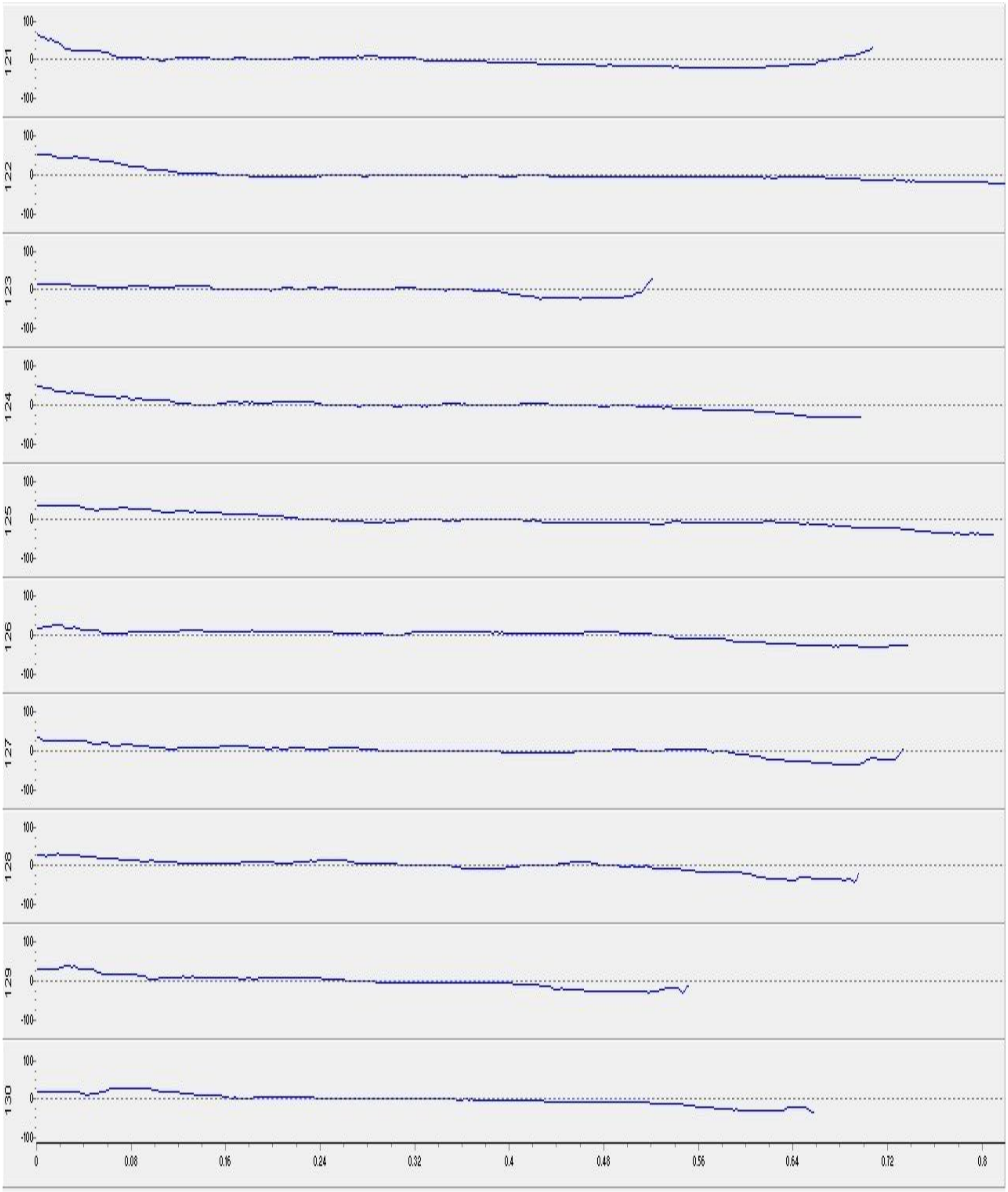

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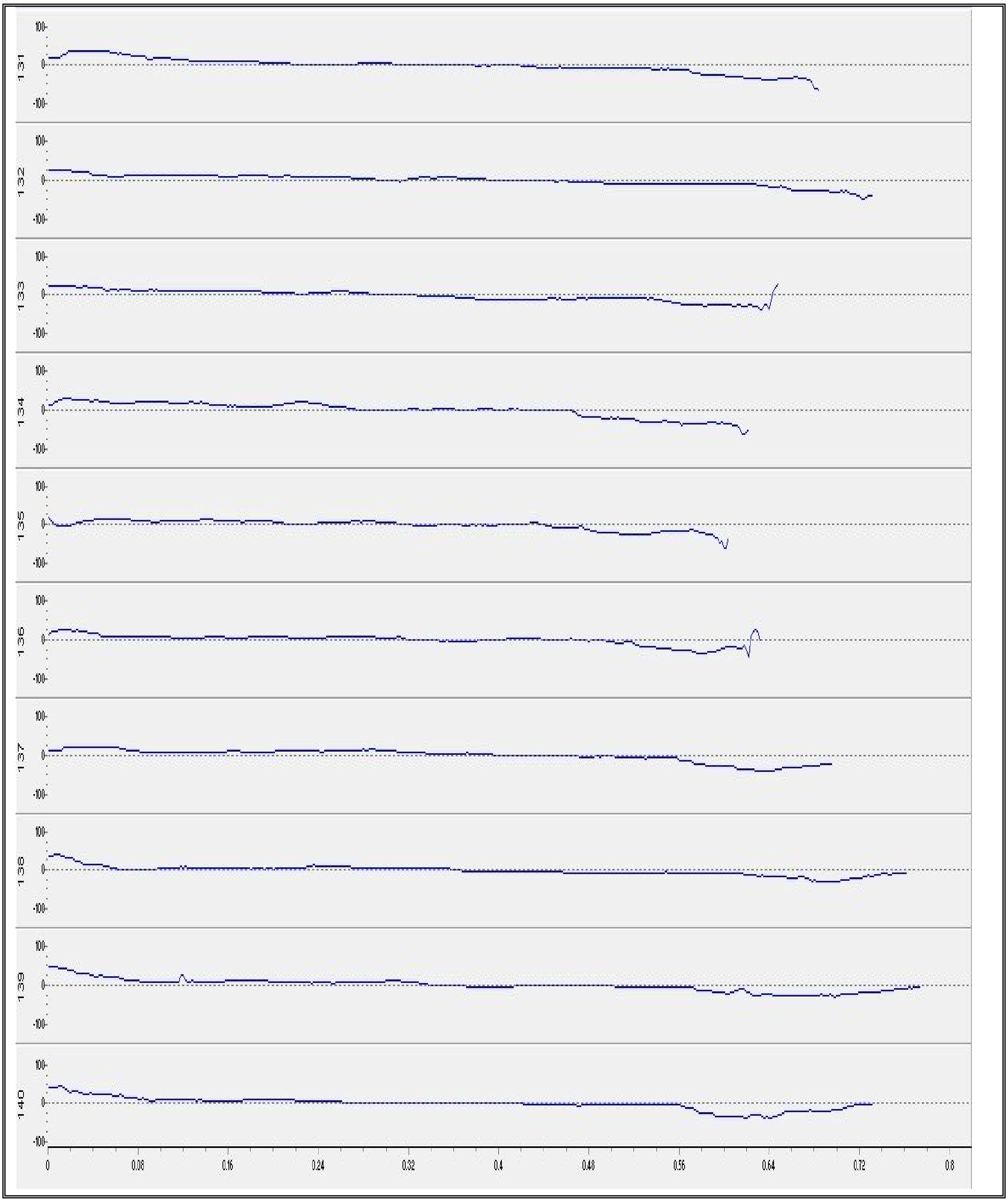
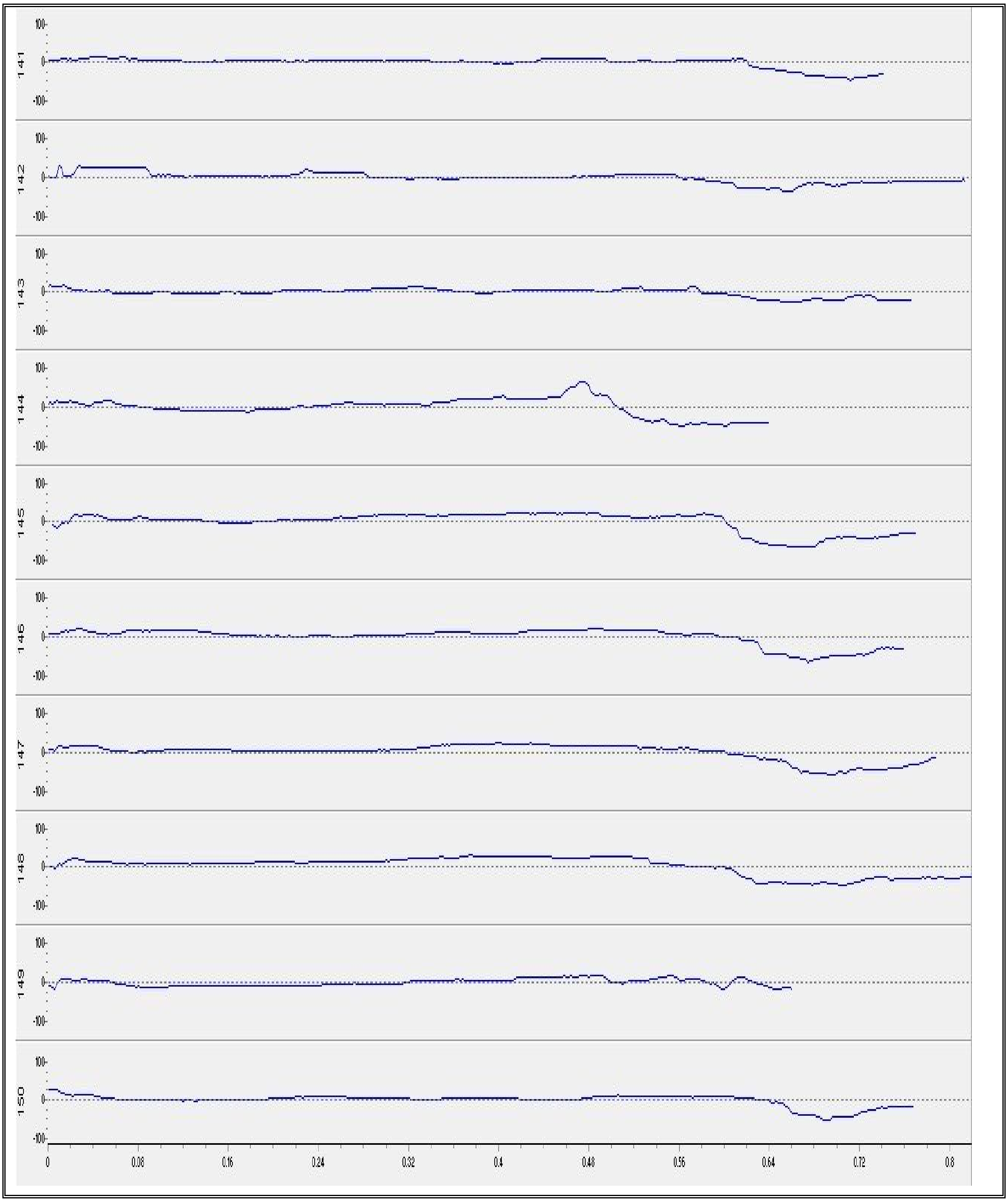
0.4
0.48
0.56
0.64
0.72
0.8

CLIENT: PATIKARI POWER

UNIT ›› **02,** MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**

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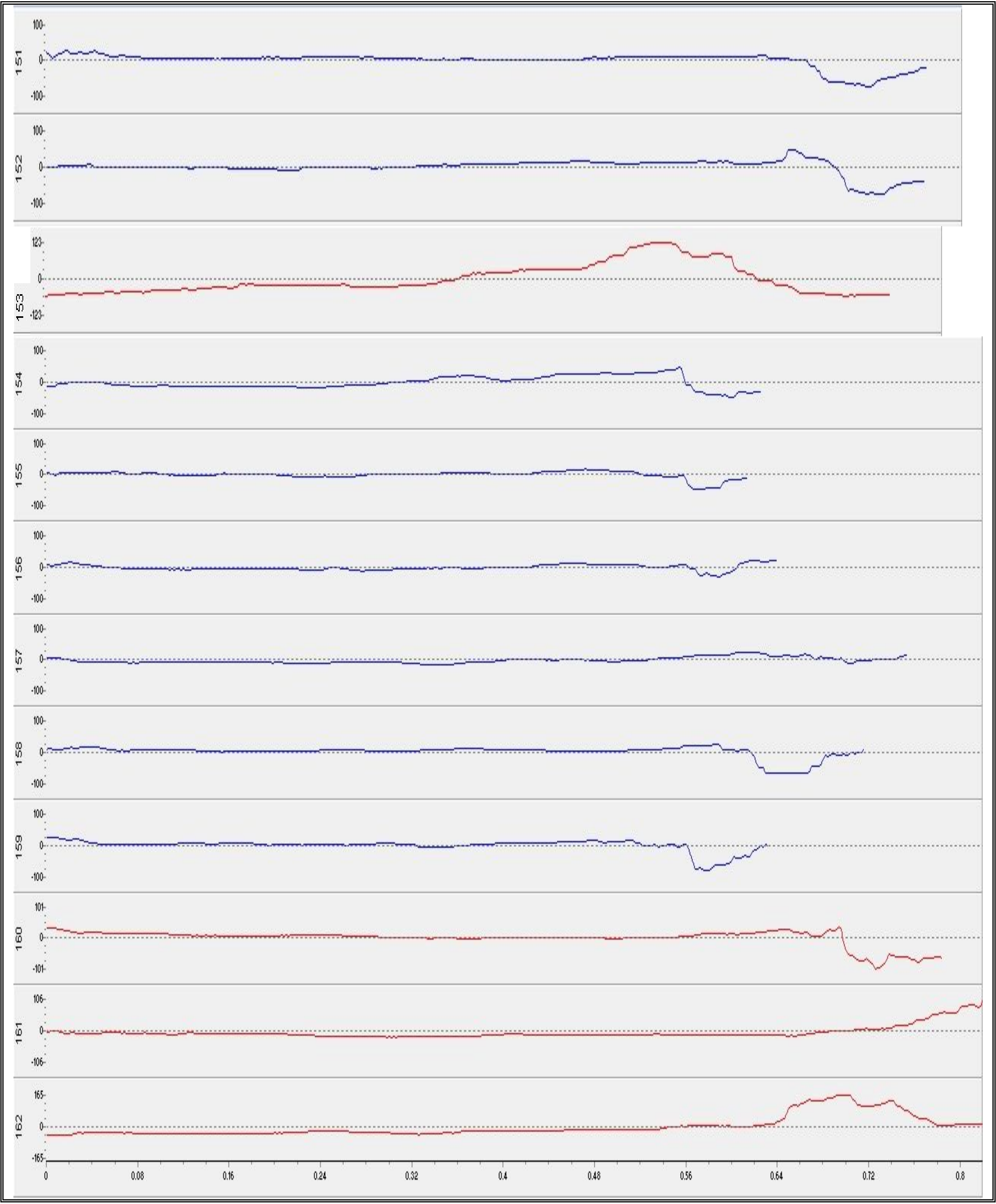
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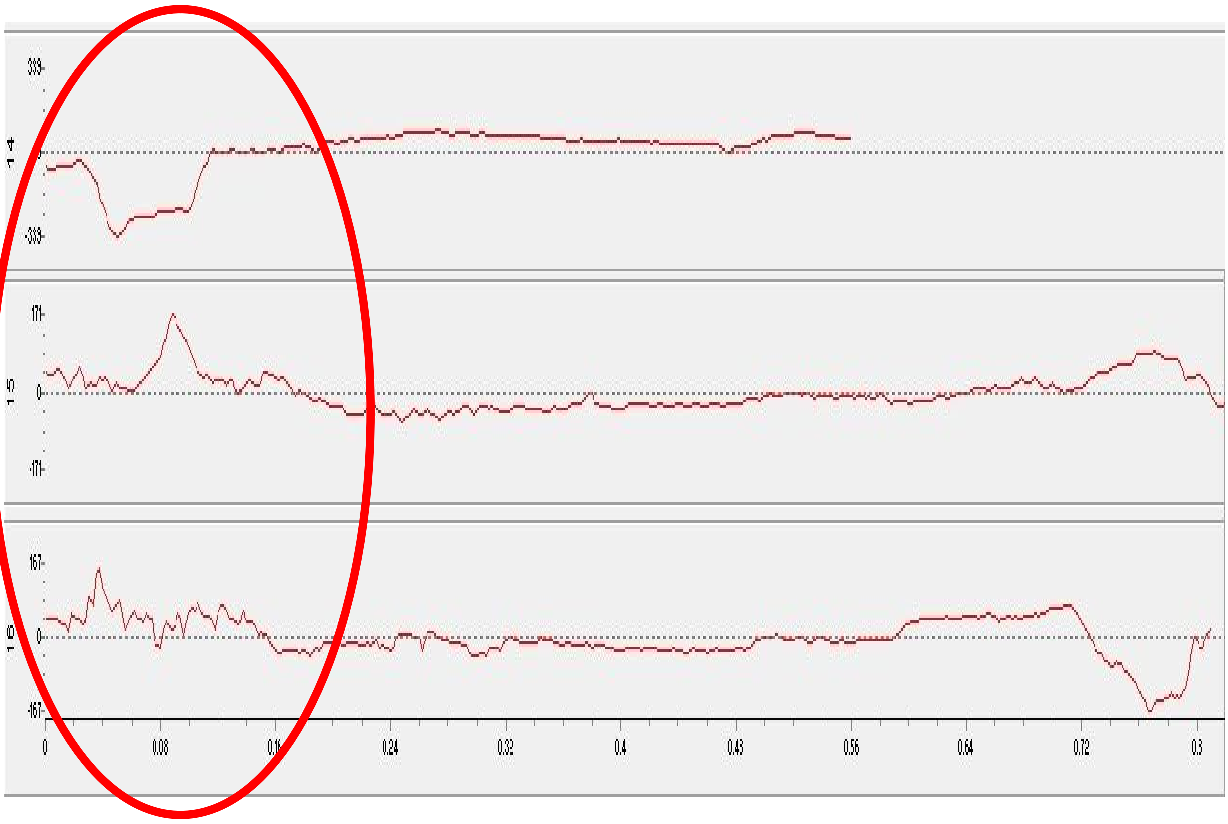
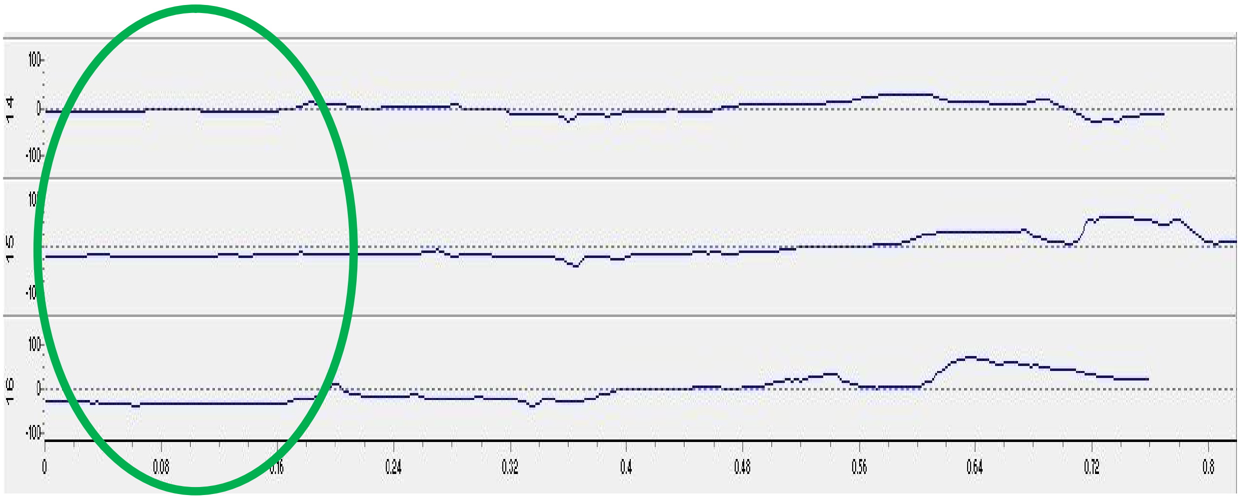
ELCID GRAPHS BEFORE PARTIAL RESTAKING OF THE CORE



ELCID GRAPHS AFTER PARTIAL RESTAKING AND REPAIR OF THE CORE



2.0 ANALYSIS AND RECOMMENDATIONS:

2.1 ASSESSMENT:

ELCID test was performed to assess the condition of core inter-laminar insulation and following conclusions drawn:

1.0 The major core fault which was observed in slot no 14 on both side wall regions in packet 2, 3 and 4. Before restacking the maximum fault current in this slot 14 is found to be 331 mAs, which is much above threshold value.

Partial Repair was performed at this fault location by partially restacking the core and the ELCID test was repeated, ELCID test indicated the fault current values are well within limits indicating the removal of lamination shorting which was existing before the repair. The fault current values and graphs are as given in the report above.

2.0 The fault current which was observed to be more than threshold value in other locations as given in the table above could not be reduced further by the repair techniques adopted. The fault current values and graphs are as given in the report above.

2.2 CONCLUSION AND RECOMMENDED ACTION:

The detailed assessment on ELCID test after repair indicate that the major core lamination shorting which was in slot 14 was successfully removed and thereby restored the core healthiness, However in few locations where the ELCID currents are above threshold limits, needs to be monitored for any abnormal temperature rise in this locations, this can be done by placing the RTD sensors at this locations and monitor the temperature, this is already recommended in our preliminary site report.

Also recommended to repeat the ELCID test, during next major overhaul to assess the core condition.

ANNEXURE 1 : PHOTOGRAPHS

1. ELCID test performed after partial restacking of core

APPENDIX - 3

Annexure - I

G30 Relay Setting Table

Project: Generator Protection Setting for 2 x 9.2 MW Patikari

Customer: Patikari Power Private Limited

Revision Control

Revision	Date	Changes
A	11th Sept. 2011	First submission

Protection Engineering And Research Laboratories
No. 20, Gnd Floor, Sait Colony Ist street, Egmore, Chennai, 600 008, Tamil Nadu, India.
Telephone: ++91 (0) 44 2819 4224. www.pearlabs.com

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
USER PROGRAMMABLE LEDS				
	LED 1: OPERAND	XFMR PCNT DIFF OP	XFMR PCNT DIFF OP	
	LED 1: TYPE	Latched	Latched	
	LED 2: OPERAND	3RD HARM NTRL UV OP	3RD HARM NTRL UV OP	
	LED 2: TYPE	Latched	Latched	
	LED 3: OPERAND	DIR POWER 1 OP	DIR POWER 1 OP	
	LED 3: TYPE	Latched	Latched	
	LED 4: OPERAND	NEUTRAL TOC1 OP	GEN UNBAL STG1 OP	
	LED 4: TYPE	Latched	Latched	
	LED 5: OPERAND	LOSS EXCIT OP	LOSS EXCIT OP	
	LED 5: TYPE	Latched	Latched	
	LED 6: OPERAND	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	LED 6: TYPE	Latched	Latched	
	LED 7: OPERAND	PHASE TOC1 OP	PHASE TOC1 OP	
	LED 7: TYPE	Latched	Latched	
	LED 8: OPERAND	PHASE UV1 OP	PHASE UV1 OP	
	LED 8: TYPE	Latched	Latched	
	LED 9: OPERAND	PHASE OV1 OP	PHASE OV1 OP	
	LED 9: TYPE	Latched	Latched	
	LED 10: OPERAND	UNDERFREQ 1 OP	UNDERFREQ 1 OP	
	LED 10: TYPE	Latched	Latched	
	LED 11: OPERAND	SRC1 VT FUSE FAIL OP	SRC1 VT FUSE FAIL OP	
	LED 11: TYPE	Latched	Latched	
	LED 12: OPERAND	OFF	OFF	
	LED 13: OPERAND	OFF	OFF	
	LED 14: OPERAND	OFF	OFF	
	LED 15: OPERAND	OFF	OFF	
	LED 16: OPERAND	OFF	OFF	
	LED 17: OPERAND	OFF	OFF	
	LED 18: OPERAND	OFF	OFF	
	LED 19: OPERAND	OFF	OFF	
	LED 20: OPERAND	OFF	OFF	
	LED 21: OPERAND	OFF	OFF	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	LED 22: OPERAND	OFF	OFF	
	LED 23: OPERAND	OFF	OFF	
	LED 24: OPERAND	OFF	OFF	
	LED 25: OPERAND	GE2CB CLOSE On(H1A)	G1 CB CLOSE On(H1a)	
	LED 25: TYPE	Self-Reset	Self-Reset	
	LED 26: OPERAND	GE21CB OPEN On(H1C)	G1 CB OPEN On(H1c)	
	LED 26: TYPE	Self-Reset	Self-Reset	
	LED 27: OPERAND	CLASS A TRP On(H2A)	CLASS A TRP On(H2a)	
	LED 27: TYPE	Self-Reset	Self-Reset	
	LED 28: OPERAND	CLASS B TRP On(H2C)	CLASS B TRP On(H2c)	
	LED 28: TYPE	Self-Reset	Self-Reset	
	LED 29: OPERAND	CLASS C TRP On(H3A)	CLASS C TRP On(H3a)	
	LED 29: TYPE	Self-Reset	Self-Reset	
	LED 30: OPERAND	CL.A TRP FAU On(H3C)	CL.A TRP FAU On(H3c)	
	LED 30: TYPE	Self-Reset	Self-Reset	
	LED 31: OPERAND	CL.B TRP FAU On(H4A)	CL.B TRP FAU On(H4a)	
	LED 31: TYPE	Self-Reset	Self-Reset	
	LED 32: OPERAND	CL.C TRP FAU On(H4C)	CL.C TRP FAU On(H4c)	
	LED 32: TYPE	Self-Reset	Self-Reset	
	LED 33: OPERAND	ROTOR EF1 OP On(H5A)	ROTOR EF1 OP On(H5a)	
	LED 33: TYPE	Self-Reset	Self-Reset	
	LED 34: OPERAND	ROTOR EF2 OP On(H5C)	ROTOR EF2 OP On(H5c)	
	LED 34: TYPE	Self-Reset	Self-Reset	
	LED 35: OPERAND	FDR1 PRTN FA On(H6C)	FDR1 PRTN FA On(H6c)	
	LED 35: TYPE	Self-Reset	Self-Reset	
	LED 36: OPERAND	FDR2 PRTN FA On(H7A)	FDR2 PRTN FA On(H7a)	
	LED 36: TYPE	Self-Reset	Self-Reset	
	LED 37: OPERAND	OFF	OFF	
	LED 38: OPERAND	OFF	OFF	
	LED 39: OPERAND	OFF	OFF	
	LED 40: OPERAND	OFF	OFF	
	LED 41: OPERAND	OFF	OFF	
	LED 42: OPERAND	OFF	OFF	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	LED 43: OPERAND	OFF	OFF	
	LED 44: OPERAND	OFF	OFF	
	LED 45: OPERAND	OFF	OFF	
	LED 46: OPERAND	OFF	OFF	
	LED 47: OPERAND	OFF	OFF	
	LED 48: OPERAND	OFF	OFF	
CONTROL PUSHBUTTONS				
	CPB 1: Function	Enabled	Enabled	
	CPB 1: Events	Disabled	Disabled	
	CPB 2: Function	Disabled	Disabled	
	CPB 2: Events	Disabled	Disabled	
	CPB 3: Function	Disabled	Disabled	
	CPB 3: Events	Disabled	Disabled	
SYSTEM SETUP: AC INPUTS: CURRENT				
	CT F1: Phase CT Primary	600 A	600 A	
	CT F1: Phase CT Secondary	5 A	5 A	
	CT F1: Ground CT Primary	1 A	1 A	
	CT F1: Ground CT Secondary	1 A	1 A	
	CT F5: Phase CT Primary	600 A	600 A	
	CT F5: Phase CT Secondary	5 A	5 A	
	CT F5: Ground CT Primary	1 A	1 A	
	CT F5: Ground CT Secondary	1 A	1 A	
	CT M1: Phase CT Primary	1 A	1 A	
	CT M1: Phase CT Secondary	1 A	1 A	
	CT M1: Ground CT Primary	1 A	1 A	
	CT M1: Ground CT Secondary	1 A	1 A	
VOLTAGE				
	VT M5: Phase VT Connection	Wye	Wye	
	VT M5: Phase VT Secondary	63.5 V	63.5 V	
	VT M5: Phase VT Ratio	100.00 :1	100.00 :1	
	VT M5: Auxiliary VT Connection	Vag	Vn	
	VT M5: Auxiliary VT Secondary	63.5 V	63.5 V	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	VT M5: Auxiliary VT Ratio	100.00 :1	100.00 :1	
POWER SYSTEM				
	Nominal Frequency	50 Hz	50 Hz	
	Phase Rotation	ABC	ABC	
	Reverse Phase Rotation	OFF	OFF	
	Frequency And Phase Reference	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	Frequency Tracking Function	Enabled	Enabled	
SIGNAL SOURCES				
	SOURCE 1: Name	SRC 1	SRC 1	
	SOURCE 1: Phase CT	F1	F1	
	SOURCE 1: Ground CT	None	None	
	SOURCE 1: Phase VT	M5	M5	
	SOURCE 1: Auxiliary VT	M5	M5	
	SOURCE 2: Name	SRC 2	SRC 2	
	SOURCE 2: Phase CT	F5	F5	
	SOURCE 2: Ground CT	None	None	
	SOURCE 2: Phase VT	None	None	
	SOURCE 2: Auxiliary VT	None	None	
	SOURCE 3: Name	SRC 3	SRC 3	
	SOURCE 3: Phase CT	None	None	
	SOURCE 3: Ground CT	None	None	
	SOURCE 3: Phase VT	None	None	
	SOURCE 3: Auxiliary VT	None	None	
	SOURCE 4: Name	SRC 4	SRC 4	
	SOURCE 4: Phase CT	None	None	
	SOURCE 4: Ground CT	None	None	
	SOURCE 4: Phase VT	None	None	
	SOURCE 4: Auxiliary VT	None	None	
TRANSFORMER: GENERAL				
	Reference Winding Selection	Automatic Selection	Automatic Selection	
	Phase Compensation	Internal (software)	Internal (software)	
WINDINGS				

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	WINDING 1: Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	WINDING 1: Rated MVA	10.820 MVA	10.820 MVA	
	WINDING 1: Nominal Phs-phs Voltage	11.000 kV	11.000 kV	
	WINDING 1: Connection	Wye	Wye	
	WINDING 1: Grounding	Not within zone	Not within zone	
	WINDING 1: Angle Wrt Winding 1	0.0 deg	0.0 deg	
	WINDING 2: Source	SRC 2 (SRC 2)	SRC 2 (SRC 2)	
	WINDING 2: Rated MVA	10.820 MVA	10.820 MVA	
	WINDING 2: Nominal Phs-phs Voltage	11.000 kV	11.000 kV	
	WINDING 2: Connection	Wye	Wye	
	WINDING 2: Grounding	Not within zone	Not within zone	
	WINDING 2: Angle Wrt Winding 1	0.0 deg	0.0 deg	
FLEXLOGIC: FLEXLOGIC EQUATION EDITOR				
	FlexLogic Entry 1	XFMR PCNT DIFF OP	XFMR PCNT DIFF OP	
	FlexLogic Entry 2	PHASE OV1 OP	PHASE OV1 OP	
	FlexLogic Entry 3	LOSS EXCIT OP	LOSS EXCIT OP	
	FlexLogic Entry 4	CLASS C TRP On(H3A)	CLASS C TRP On(H3a)	
	FlexLogic Entry 5	3RD HARM NTRL UV OP	3RD HARM NTRL UV OP	
	FlexLogic Entry 6	OR(5)	OR(5)	
	FlexLogic Entry 7	= 86A (VO1)	= 86A (VO1)	For CLASS A Tripping
	FlexLogic Entry 8	NEUTRAL TOC1 OP	GEN UNBAL STG1 OP	Neutral over current protection is disabled. Instead the generator unbalance protection that is enabled now is added in the CLASS B tripping logic
	FlexLogic Entry 9	DIR POWER 1 OP	DIR POWER 1 OP	
	FlexLogic Entry 10	PHASE UV1 OP	PHASE UV1 OP	
	FlexLogic Entry 11	UNDERFREQ 1 OP	UNDERFREQ 1 OP	
	FlexLogic Entry 12	PHASE TOC1 OP	PHASE TOC1 OP	
	FlexLogic Entry 13	OR(5)	OR(5)	
	FlexLogic Entry 14	= 86B (VO2)	= 86B (VO2)	For CLASS B Tripping

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	FlexLogic Entry 15	SPARE On(H7C)	SPARE On(H7c)	Configured for GENERATOR Mechanical tripping input for wiring in future
	FlexLogic Entry 16	SPARE On(H8A)	SPARE On(H8a)	Configured for TURBINE Mechanical tripping input for wiring in future
	FlexLogic Entry 17	OR(2)	OR(2)	
	FlexLogic Entry 18	= 86C (VO3)	= 86C (VO3)	For CLASS C Tripping
	FlexLogic Entry 19	86A On (VO1)	86A On (VO1)	
	FlexLogic Entry 20	86B On (VO2)	86B On (VO2)	
	FlexLogic Entry 21	86C On (VO3)	86C On (VO3)	
	FlexLogic Entry 22	OR(3)	OR(3)	
	FlexLogic Entry 23	= TRIP (VO4)	= TRIP (VO4)	Assigning Virtual Output for ANY Trip
	FlexLogic Entry 24	CLASS A TRP On(H2A)	CLASS A TRP On(H2a)	CBF Protection Initiation from CLASS A tripping
	FlexLogic Entry 25	CLASS B TRP On(H2C)	CLASS B TRP On(H2c)	CBF Protection Initiation from CLASS B tripping
	FlexLogic Entry 26	CLASS C TRP On(H3A)	CLASS C TRP On(H3a)	CBF Protection Initiation from CLASS C tripping
	FlexLogic Entry 27	OR(3)	OR(3)	
	FlexLogic Entry 28	BFP (FE 1) OP	BFP (FE 1) OP	CBF protectoin current comparator signal
	FlexLogic Entry 29	AND(2)	AND(2)	
	FlexLogic Entry 30	TIMER 1	TIMER 1	CBF protectoin timer signal
	FlexLogic Entry 31	= BFP (VO5)	= BFP (VO5)	
	FlexLogic Entry 32	XFMR PCNT DIFF OP	XFMR PCNT DIFF OP	
	FlexLogic Entry 33	= Virt Op 16 (VO16)	= Virt Op 16 (VO16)	
	FlexLogic Entry 34	3RD HARM NTRL UV OP	3RD HARM NTRL UV OP	
	FlexLogic Entry 35	= Virt Op 17 (VO17)	= Virt Op 17 (VO17)	
	FlexLogic Entry 36	DIR POWER 1 OP	DIR POWER 1 OP	
	FlexLogic Entry 37	= Virt Op 18 (VO18)	= Virt Op 18 (VO18)	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	FlexLogic Entry 38	NEUTRAL TOC1 OP	GEN UNBAL STG1 OP	Neutral over current protection is disabled. Instead the generator unbalance protection that is enabled now is assigned to Virtual Output 19
	FlexLogic Entry 39	= Virt Op 19 (VO19)	= Virt Op 19 (VO19)	
	FlexLogic Entry 40	LOSS EXCIT OP	LOSS EXCIT OP	
	FlexLogic Entry 41	= Virt Op 20 (VO20)	= Virt Op 20 (VO20)	
	FlexLogic Entry 42	BFP On (VO5)	BFP On (VO5)	Breaker Failure Protection Operation is already assigned to Virtual Output 5, hence this is redundant
	FlexLogic Entry 43	= Virt Op 21 (VO21)	= Virt Op 21 (VO21)	
	FlexLogic Entry 44	PHASE TOC1 OP	PHASE TOC1 OP	
	FlexLogic Entry 45	= Virt Op 22 (VO22)	= Virt Op 22 (VO22)	
	FlexLogic Entry 46	PHASE UV1 OP	PHASE UV1 OP	
	FlexLogic Entry 47	= Virt Op 23 (VO23)	= Virt Op 23 (VO23)	
	FlexLogic Entry 48	PHASE OV1 OP	PHASE OV1 OP	
	FlexLogic Entry 49	= Virt Op 24 (VO24)	= Virt Op 24 (VO24)	
	FlexLogic Entry 50	UNDERFREQ 1 OP	UNDERFREQ 1 OP	
	FlexLogic Entry 51	= Virt Op 25 (VO25)	= Virt Op 25 (VO25)	
	FlexLogic Entry 52	SRC1 VT FUSE FAIL OP	SRC1 VT FUSE FAIL OP	
	FlexLogic Entry 53	= Virt Op 26 (VO26)	= Virt Op 26 (VO26)	
	FlexLogic Entry 54	86A On (VO1)	86A On (VO1)	
	FlexLogic Entry 55	86B On (VO2)	86B On (VO2)	
	FlexLogic Entry 56	OR(2)	OR(2)	
	FlexLogic Entry 57	= OSC TRIGGER (VO6)	= OSC TRIGGER (VO6)	
	FlexLogic Entry 58	PHASE UV2 OP	PHASE UV2 OP	
	FlexLogic Entry 59	UNDERFREQ 2 OP	UNDERFREQ 2 OP	
	FlexLogic Entry 60	OR(2)	NEUTRAL OV1 OP	Neutral over voltage stage 1 added to ALARM signal
	FlexLogic Entry 61	= ALARAM (VO15)	AUX OV 1 OP	Aux. over voltage stage 1 added to ALARM signal

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	FlexLogic Entry 62	END	GEN UNBAL STG2 OP	Generator unbalance stage 2 added to ALARM signal
	FlexLogic Entry 63	END	OR(5)	
	FlexLogic Entry 64	END	= ALARM (VO15)	
	FlexLogic Entry 65	END	SRC1 VT FUSE FAIL OP	
	FlexLogic Entry 66	END	G1 CB CLOSE Off(H1a)	
	FlexLogic Entry 67	END	OR(2)	
	FlexLogic Entry 68	END	= UV Blocking (VO27)	Virtual Output for blocking under voltage protectoin when PT fuse fails or GCB is open
	FlexLogic Entry 69	END	END	
FLEXLOGIC TIMERS				
	Timer 1: Type	millisecond	millisecond	
	Timer 1: Pickup Delay	1000	200	
	Timer 1: Dropout Delay	0	0	
FLEXELEMENTS				
	FLEXELEMENTS 1: Function	Enabled	Enabled	
	FLEXELEMENTS 1: Name	BFP	BFP	
	FLEXELEMENTS 1: InputPlus	SRC1 I_1 Mag	SRC1 I_1 Mag	
	FLEXELEMENTS 1: InputMinus	OFF	OFF	
	FLEXELEMENTS 1: InputMode	SIGNED	ABSOLUTE	
	FLEXELEMENTS 1: Compare Mode	LEVEL	LEVEL	
	FLEXELEMENTS 1: Direction Type	OVER	OVER	
	FLEXELEMENTS 1: Pickup	0.960 pu	0.050 pu	
	FLEXELEMENTS 1: Hysteresis	0.03	0.03	
	FLEXELEMENTS 1: DeltaTUnits	Milliseconds	Milliseconds	
	FLEXELEMENTS 1: DeltaT	20	20	
	FLEXELEMENTS 1: Pickup Delay	0.000 s	0.000 s	
	FLEXELEMENTS 1: Reset Delay	0.000 s	0.000 s	
	FLEXELEMENTS 1: Block	OFF	OFF	
	FLEXELEMENTS 1: Target	Disabled	Disabled	
	FLEXELEMENTS 1: Events	Disabled	Disabled	
	FLEXELEMENTS 2: Function	Disabled	Disabled	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	FLEXELEMENTS 3: Function	Disabled	Disabled	
	FLEXELEMENTS 4: Function	Disabled	Disabled	
	FLEXELEMENTS 5: Function	Disabled	Disabled	
	FLEXELEMENTS 6: Function	Disabled	Disabled	
	FLEXELEMENTS 7: Function	Disabled	Disabled	
	FLEXELEMENTS 8: Function	Disabled	Disabled	
	FLEXELEMENTS 9: Function	Disabled	Disabled	
	FLEXELEMENTS 10: Function	Disabled	Disabled	
	FLEXELEMENTS 11: Function	Disabled	Disabled	
	FLEXELEMENTS 12: Function	Disabled	Disabled	
	FLEXELEMENTS 13: Function	Disabled	Disabled	
	FLEXELEMENTS 14: Function	Disabled	Disabled	
	FLEXELEMENTS 15: Function	Disabled	Disabled	
	FLEXELEMENTS 16: Function	Disabled	Disabled	
GROUPED ELEMENTS: GROUP 1: TRANSFORMER: PERCENT DIFFERENTIAL [GROUP 1]				
	Function	Enabled	Enabled	CLASS A TRIPPING
	Pickup	0.150 pu	0.150 pu	Since 5P class CTs are used lower settings may have problems. It is understood that during commissioning time, this setting had to be increased as the relay tripped with lower setting
	Slope 1	15%	0.15	
	Break 1	2.000 pu	2.000 pu	
	Break 2	6.000 pu	6.000 pu	
	Slope 2	60%	0.6	
	Inrush Inhibit Function	Disabled	Disabled	
	Inrush Inhibit Mode	2-out-of-3	2-out-of-3	
	Inrush Inhibit Level	20.0 % fo	20.0 % fo	
	Overexcitation Inhibit Function	Disabled	Disabled	
	Overexcitation Inhibit Level	10.0 % fo	10.0 % fo	
	Block	OFF	OFF	
	Target	Latched	Latched	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Events	Enabled	Enabled	
PHASE CURRENT: PHASE TOC [GROUP 1]				
	PHASE TOC1: Function	Enabled	Enabled	CLASS B TRIPPING
	PHASE TOC1: Signal Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	PHASE TOC1: Input	Phasor	Phasor	
	PHASE TOC1: Pickup	0.940 pu	1.100 pu	Providing 15% margin over the maximum load current
	PHASE TOC1: Curve	IAC Inverse	IAC Inverse	
	PHASE TOC1: TD Multiplier	0.4	0.4	
	PHASE TOC1: Reset	Instantaneous	Instantaneous	
	PHASE TOC1: Voltage Restraint	Enabled	Enabled	
	PHASE TOC1: Block A	SRC1 VT FUSE FAIL OP	SRC1 VT FUSE FAIL OP	
	PHASE TOC1: Block B	OFF	OFF	
	PHASE TOC1: Block C	OFF	OFF	
	PHASE TOC1: Target	Latched	Latched	
	PHASE TOC1: Events	Enabled	Enabled	
PHASE IOC [GROUP 1]				
	PHASE IOC1: Function	Disabled	Disabled	
	PHASE IOC2: Function	Disabled	Disabled	
PHASE DIRECTIONAL [GROUP 1]				
	PHASE DIR1: Function	Disabled	Disabled	
NEUTRAL CURRENT: NEUTRAL TOC [GROUP 1]				
	NEUTRAL TOC1: Function	Enabled	Disabled	Since the generator is not grounded, current based earth fault protection will be not be effective. Hence this protection is proposed to be disabled
	NEUTRAL TOC1: Source	SRC 1 (SRC 1)		
	NEUTRAL TOC1: Input	Phasor		
	NEUTRAL TOC1: Pickup	0.100 pu		
	NEUTRAL TOC1: Curve	Definite Time		
	NEUTRAL TOC1: TD Multiplier	5		

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	NEUTRAL TOC1: Reset	Instantaneous		
	NEUTRAL TOC1: Block	OFF		
	NEUTRAL TOC1: Target	Latched		
	NEUTRAL TOC1: Events	Enabled		
NEUTRAL IOC [GROUP 1]				
	NEUTRAL IOC1: Function	Disabled	Disabled	
NEUTRAL DIRECTIONAL OC [GROUP 1]				
	NEUTRAL DIR OC1: Function	Disabled	Disabled	
GROUND CURRENT: GROUND TOC [GROUP 1]				
	GROUND TOC1: Function	Disabled	Disabled	
GROUND IOC [GROUP 1]				
	GROUND IOC1: Function	Disabled	Disabled	
RESTRICTED GROUND FAULT [GROUP 1]				
	RGF1: Function	Disabled	Disabled	
GENERATOR UNBALANCE [GROUP 1]				
	Function	Disabled	Enabled	This protection is essential to ensure the safety of the generator. When the loading on the machine is unbalance, rotor heating will increase and can exceed its limits leading to damage to the rotor.
	Source		SRC 1 (SRC 1)	
	Inom		0.947 pu	
	Stage 1 Pickup		0.08	CLASS B TRIPPING
	Stage 1 K-Value		14	
	Stage 1 Tmin		0.250 s	
	Stage 1 Tmax		600.0 s	
	Stage 1 K-Reset		240.0 s	
	Stage 2 Pickup		0.056	FOR ALARM
	Stage 2 Pickup Delay		10.0 s	
	Block		OFF	
	Target		Latched	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Events		Disabled	
SPLIT PHASE [GROUP 1]				
	Function	Disabled	Disabled	
NEGATIVE SEQUENCE CURRENT: NEGATIVE SEQUENCE DIRECTIONAL OC [GROUP 1]				
	NEGATIVE SEQ DIR OC1: Function	Disabled	Disabled	
VOLTAGE ELEMENTS: PHASE UV [GROUP 1]				
	PHASE UV1: Function	Enabled	Enabled	CLASS B TRIPPING
	PHASE UV1: Signal Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	PHASE UV1: Mode	Phase to Ground	Phase to Phase	
	PHASE UV1: Pickup	0.750 pu	0.750 pu	
	PHASE UV1: Curve	Definite Time	Definite Time	
	PHASE UV1: Delay	5.00 s	5.00 s	
	PHASE UV1: Minimum Voltage	0.000 pu	0.000 pu	
	PHASE UV1: Block	GE2CB CLOSE Off(H1a)	UV Blocking On (VO27)	To block undervoltage on VT fuse failure or Gen CB open. The virtual output 27 (VO27) is configured with ORed output of VT fuse failure and GCB open status
	PHASE UV1: Target	Latched	Latched	
	PHASE UV1: Events	Enabled	Enabled	
	PHASE UV2: Function	Enabled	Enabled	
	PHASE UV2: Signal Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	FOR ALARM
	PHASE UV2: Mode	Phase to Ground	Phase to Phase	
	PHASE UV2: Pickup	0.900 pu	0.900 pu	
	PHASE UV2: Curve	Definite Time	Definite Time	
	PHASE UV2: Delay	3.00 s	3.00 s	
	PHASE UV2: Minimum Voltage	0.000 pu	0.000 pu	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	PHASE UV2: Block	GE2CB CLOSE Off(H1a)	UV Blocking On (VO27)	To block undervoltage on VT fuse failure or Gen CB open. The virtual output 27 (VO27) is configured with ORed output of VT fuse failure and GCB open status
	PHASE UV2: Target	Latched	Latched	
	PHASE UV2: Events	Disabled	Disabled	
	PHASE UV3: Function	Disabled	Disabled	
PHASE OV [GROUP 1]				
	PHASE OV1: Function	Enabled	Enabled	CLASS A TRIPPING
	PHASE OV1: Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	PHASE OV1: Pickup	1.150 pu	1.150 pu	
	PHASE OV1: Delay	2.00 s	2.00 s	
	PHASE OV1: Reset Delay	0.00 s	0.00 s	
	PHASE OV1: Block	OFF	OFF	
	PHASE OV1: Target	Latched	Latched	
	PHASE OV1: Events	Enabled	Enabled	
NEUTRAL OV [GROUP 1]				
	NEUTRAL OV 1: Function	Disabled	Enabled	FOR ALARM To detect earth fault
	NEUTRAL OV 1: Source		SRC 1 (SRC 1)	
	NEUTRAL OV 1: Pickup		0.150 pu	
	NEUTRAL OV 1: Curve		Definite Time	
	NEUTRAL OV 1: Pickup Delay		3.00 s	
	NEUTRAL OV 1: Reset Delay		0.00 s	
	NEUTRAL OV 1: Block		OFF	
	NEUTRAL OV 1: Target		Latched	
	NEUTRAL OV 1: Events		Disabled	
	NEUTRAL OV 2: Function		Disabled	
	NEUTRAL OV 3: Function		Disabled	
NEGATIVE SEQUENCE OV [GROUP 1]				

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	NEG SEQ OV1: Function	Disabled	Disabled	
AUXILIARY UV [GROUP 1]				
	AUXILIARY UV 1: Function	Disabled	Disabled	
AUXILIARY OV [GROUP 1]				
	AUXILIARY OV 1: Function	Disabled	Enabled	FOR ALARM To detect earth fault
	AUXILIARY OV 1: Source		SRC 1 (SRC 1)	
	AUXILIARY OV 1: Pickup		0.050 pu	
	AUXILIARY OV 1: Pickup Delay		3.00 s	
	AUXILIARY OV 1: Reset Delay		0.00 s	
	AUXILIARY OV 1: Block		OFF	
	AUXILIARY OV 1: Target		Latched	
	AUXILIARY OV 1: Events		Disabled	
VOLTS PER HERTZ [GROUP 1]				
	VOLTS PER HERTZ 1: Function	Disabled	Disabled	
LOSS OF EXCITATION [GROUP 1]				
	Function	Enabled	Enabled	
	Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	Center 1	8.11 ohm	8.11 ohm	
	Radius 1	6.71 ohm	6.71 ohm	
	UV Supervision Enable 1	Enabled	Enabled	
	Pickup Delay 1	0.300 s	0.300 s	
	Center 2	8.11 ohm	8.11 ohm	
	Radius 2	6.71 ohm	6.71 ohm	
	UV Supervision Enable 2	Enabled	Disabled	Second stage set without under voltage supervision
	Pickup Delay 2	0.500 s	2.000 s	Longer dealy of 2s suggested for loss of exciation without undervoltage. Provides sufficient margin for power swings
	UV Supervision	0.700 pu	0.700 pu	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Block	OFF	SRC1 VT FUSE FAIL OP	Since voltage input is used for loss of excitation protection, VT fuse failure should block this element
	Target	Latched	Latched	
	Events	Enabled	Enabled	
ACCIDENTAL ENERGIZATION [GROUP 1]				
	Function	Disabled	Disabled	
STATOR GROUND: STATOR GROUND SOURCE [GROUP 1]				
	Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
3RD HARMONIC NTRL UV [GROUP 1]				
	Function	Enabled	Enabled	
	Pickup	0.1000 pu	0.1000 pu	
	Delay	2.00 s	2.00 s	
	Max Power	1.150 pu	1.150 pu	
	Min Power	0.000 pu	0.000 pu	
	Volt Supervision	0.500 pu	0.500 pu	
	Block	OFF	OFF	
	Target	Latched	Latched	
	Events	Enabled	Enabled	
POWER: SENSITIVE DIRECTIONAL POWER: SENSITIVE DIRECTIONAL POWER [GROUP 1]				
	SENS DIR POWER1: Function	Enabled	Enabled	
	SENS DIR POWER1: Signal Source	SRC 2 (SRC 2)	SRC 2 (SRC 2)	
	SENS DIR POWER1: Sensitive Directional Power RCA	180 deg	180 deg	
	SENS DIR POWER1: Sensitive Directional Power Calibration	0.00 deg	0.00 deg	
	SENS DIR POWER1: Stage 1 SMIN	0.050 pu	0.050 pu	
	SENS DIR POWER1: Stage 1 Delay	5.00 s	5.00 s	
	SENS DIR POWER1: Stage 2 SMIN	0.050 pu	0.050 pu	
	SENS DIR POWER1: Stage 2 Delay	7.00 s	5.00 s	
	SENS DIR POWER1: Block	OFF	G1 CB OPEN On(H1c)	
	SENS DIR POWER1: Target	Latched	Latched	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	SENS DIR POWER1: Events	Enabled	Enabled	
	SENS DIR POWER2: Function	Enabled	Disabled	This stage is neither configured for alarm nor tripping. Hence this stage is disabled.
	SENS DIR POWER2: Signal Source	SRC 2 (SRC 2)		
	SENS DIR POWER2: Sensitive Directional Power RCA	180 deg		
	SENS DIR POWER2: Sensitive Directional Power Calibration	0.00 deg		
	SENS DIR POWER2: Stage 1 SMIN	0.030 pu		
	SENS DIR POWER2: Stage 1 Delay	5.00 s		
	SENS DIR POWER2: Stage 2 SMIN	0.030 pu		
	SENS DIR POWER2: Stage 2 Delay	7.00 s		
	SENS DIR POWER2: Block	OFF		
	SENS DIR POWER2: Target	Latched		
	SENS DIR POWER2: Events	Disabled		
UNDERFREQUENCY				
	UNDERFREQUENCY 1: Function	Enabled	Enabled	
	UNDERFREQUENCY 1: Block	G1 CB CLOSE Off(H1a)	G1 CB CLOSE Off(H1a)	
	UNDERFREQUENCY 1: Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	UNDERFREQUENCY 1: Min Volt/Amp	0.10 pu	0.10 pu	
	UNDERFREQUENCY 1: Pickup	47.50 Hz	47.50 Hz	
	UNDERFREQUENCY 1: Pickup Delay	2.000 s	2.000 s	
	UNDERFREQUENCY 1: Reset Delay	0.000 s	0.000 s	
	UNDERFREQUENCY 1: Target	Latched	Latched	
	UNDERFREQUENCY 1: Events	Enabled	Enabled	
	UNDERFREQUENCY 2: Function	Enabled	Enabled	
	UNDERFREQUENCY 2: Block	G1 CB CLOSE Off(H1a)	G1 CB CLOSE Off(H1a)	
	UNDERFREQUENCY 2: Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	UNDERFREQUENCY 2: Min Volt/Amp	0.10 pu	0.10 pu	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	UNDERFREQUENCY 2: Pickup	48.50 Hz	48.50 Hz	
	UNDERFREQUENCY 2: Pickup Delay	2.000 s	0.500 s	
	UNDERFREQUENCY 2: Reset Delay	0.000 s	0.000 s	
	UNDERFREQUENCY 2: Target	Latched	Latched	
	UNDERFREQUENCY 2: Events	Disabled	Disabled	
	UNDERFREQUENCY 3: Function	Disabled	Disabled	
	UNDERFREQUENCY 4: Function	Disabled	Disabled	
	UNDERFREQUENCY 5: Function	Disabled	Disabled	
	UNDERFREQUENCY 6: Function	Disabled	Disabled	
OVERFREQUENCY				
	OVERFREQUENCY 1: Function	Disabled	Disabled	
	OVERFREQUENCY 2: Function	Disabled	Disabled	
	OVERFREQUENCY 3: Function	Disabled	Disabled	
	OVERFREQUENCY 4: Function	Disabled	Disabled	
SYNCHROCHECK				
	SYNCHROCHECK1: Function	Disabled	Disabled	
	SYNCHROCHECK2: Function	Disabled	Disabled	
DIGITAL ELEMENTS				
	Digital Element 1 Function	Enabled	Enabled	
	Digital Element 1 Name	BFP TRIP	BFP TRIP	
	Digital Element 1 Input	BFP On (VO5)	BFP On (VO5)	
	Digital Element 1 Pickup Delay	0.000 s	0.000 s	
	Digital Element 1 Reset Delay	0.000 s	0.000 s	
	Digital Element 1 Pickup Led	Enabled	Enabled	
	Digital Element 1 Block	OFF	OFF	
	Digital Element 1 Target	Latched	Latched	
	Digital Element 1 Events	Enabled	Enabled	
	Digital Element 2 Function	Enabled	Enabled	
	Digital Element 2 Name	REVERSE POWER	GEN UNBALANCE	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Digital Element 2 Input	DIR POWER 1 OP	GEN UNBAL STG2 OP	Reverse Power Stage 1 is already configured for tripping. Hence this need not be again configured as a digtal element for alarm
	Digital Element 2 Pickup Delay	0.000 s	0.000 s	
	Digital Element 2 Reset Delay	0.000 s	0.000 s	
	Digital Element 2 Pickup Led	Enabled	Enabled	
	Digital Element 2 Block	OFF	OFF	
	Digital Element 2 Target	Latched	Latched	
	Digital Element 2 Events	Enabled	Enabled	
	Digital Element 3 Function	Enabled	Enabled	
	Digital Element 3 Name	U/V ALARAM	U/V ALARAM	
	Digital Element 3 Input	PHASE UV2 OP	PHASE UV2 OP	
	Digital Element 3 Pickup Delay	0.000 s	0.000 s	
	Digital Element 3 Reset Delay	0.000 s	0.000 s	
	Digital Element 3 Pickup Led	Enabled	Enabled	
	Digital Element 3 Block	OFF	OFF	
	Digital Element 3 Target	Latched	Latched	
	Digital Element 3 Events	Enabled	Enabled	
	Digital Element 4 Function	Enabled	Enabled	
	Digital Element 4 Name	U/F ALARAM	U/F ALARAM	
	Digital Element 4 Input	UNDERFREQ 2 OP	UNDERFREQ 2 OP	
	Digital Element 4 Pickup Delay	0.000 s	0.000 s	
	Digital Element 4 Reset Delay	0.000 s	0.000 s	
	Digital Element 4 Pickup Led	Enabled	Enabled	
	Digital Element 4 Block	OFF	OFF	
	Digital Element 4 Target	Latched	Latched	
	Digital Element 4 Events	Enabled	Enabled	
	Digital Element 5 Function	Disabled	Enabled	
	Digital Element 5 Name		95% SEF - RES. V	
	Digital Element 5 Input		NEUTRAL OV1 OP	
	Digital Element 5 Pickup Delay		0.000 s	
	Digital Element 5 Reset Delay		0.000 s	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Digital Element 5 Pickup Led		Enabled	
	Digital Element 5 Block		OFF	
	Digital Element 5 Target		Latched	
	Digital Element 5 Events		Enabled	
	Digital Element 6 Function	Disabled	Enabled	
	Digital Element 6 Name		95% SEF - VN	
	Digital Element 6 Input		AUX OV 1 OP	
	Digital Element 6 Pickup Delay		0.000 s	
	Digital Element 6 Reset Delay		0.000 s	
	Digital Element 6 Pickup Led		Enabled	
	Digital Element 6 Block		OFF	
	Digital Element 6 Target		Latched	
	Digital Element 6 Events		Enabled	
	Digital Element 7 Function	Disabled	Disabled	
	Digital Element 8 Function	Disabled	Disabled	
	Digital Element 9 Function	Disabled	Disabled	
	Digital Element 10 Function	Disabled	Disabled	
	Digital Element 11 Function	Disabled	Disabled	
	Digital Element 12 Function	Disabled	Disabled	
	Digital Element 13 Function	Disabled	Disabled	
	Digital Element 14 Function	Disabled	Disabled	
	Digital Element 15 Function	Disabled	Disabled	
	Digital Element 16 Function	Disabled	Disabled	
	Digital Element 17 Function	Disabled	Disabled	
	Digital Element 18 Function	Disabled	Disabled	
	Digital Element 19 Function	Disabled	Disabled	
	Digital Element 20 Function	Disabled	Disabled	
	Digital Element 21 Function	Disabled	Disabled	
	Digital Element 22 Function	Disabled	Disabled	
	Digital Element 23 Function	Disabled	Disabled	
	Digital Element 24 Function	Disabled	Disabled	
	Digital Element 25 Function	Disabled	Disabled	
	Digital Element 26 Function	Disabled	Disabled	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Digital Element 27 Function	Disabled	Disabled	
	Digital Element 28 Function	Disabled	Disabled	
	Digital Element 29 Function	Disabled	Disabled	
	Digital Element 30 Function	Disabled	Disabled	
	Digital Element 31 Function	Disabled	Disabled	
	Digital Element 32 Function	Disabled	Disabled	
	Digital Element 33 Function	Disabled	Disabled	
	Digital Element 34 Function	Disabled	Disabled	
	Digital Element 35 Function	Disabled	Disabled	
	Digital Element 36 Function	Disabled	Disabled	
	Digital Element 37 Function	Disabled	Disabled	
	Digital Element 38 Function	Disabled	Disabled	
	Digital Element 39 Function	Disabled	Disabled	
	Digital Element 40 Function	Disabled	Disabled	
	Digital Element 41 Function	Disabled	Disabled	
	Digital Element 42 Function	Disabled	Disabled	
	Digital Element 43 Function	Disabled	Disabled	
	Digital Element 44 Function	Disabled	Disabled	
	Digital Element 45 Function	Disabled	Disabled	
	Digital Element 46 Function	Disabled	Disabled	
	Digital Element 47 Function	Disabled	Disabled	
	Digital Element 48 Function	Disabled	Disabled	
MONITORING ELEMENTS: VT FUSE FAILURE				
	VT FUSE FAILURE 1: Function	Enabled	Enabled	
	VT FUSE FAILURE 2: Function	Disabled	Disabled	
	VT FUSE FAILURE 3: Function	Disabled	Disabled	
	VT FUSE FAILURE 4: Function	Disabled	Disabled	
FREQUENCY RATE OF CHANGE				
	FREQ RATE 1: Function	Disabled	Disabled	
	FREQ RATE 2: Function	Disabled	Disabled	
	FREQ RATE 3: Function	Disabled	Disabled	
	FREQ RATE 4: Function	Disabled	Disabled	
FREQUENCY OOB ACCUMULATION				

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Freq OOB Accumulator Source	SRC 1 (SRC 1)	SRC 1 (SRC 1)	
	Freq OOB Accumulator Min V A	0.10 pu	0.10 pu	
	Freq OOB Accumulator Block	OFF	OFF	
	Freq OOB Accumulator Target	Self-reset	Self-reset	
	Freq OOB Accumulator Events	Disabled	Disabled	
	Freq OOB Accumulator 1 Function	Disabled	Disabled	
	Freq OOB Accumulator 2 Function	Disabled	Disabled	
	Freq OOB Accumulator 3 Function	Disabled	Disabled	
	Freq OOB Accumulator 4 Function	Disabled	Disabled	
	Freq OOB Accumulator 5 Function	Disabled	Disabled	
	Freq OOB Accumulator 6 Function	Disabled	Disabled	
	Freq OOB Accumulator 7 Function	Disabled	Disabled	
INPUTS/OUTPUTS: CONTACT INPUTS				
	[H1A] Contact Input 1 ID	GE2CB CLOSE	G1 CB CLOSE	The label for the breaker staus changed. G1 refers to the GCB of Generator 1. For Generator 2 relay, this tag has to be G2 CB CLOSE
	[H1A] Contact Input 1 Debounce Time	2.0 ms	2.0 ms	
	[H1A] Contact Input 1 Events	Enabled	Enabled	
	[H1C] Contact Input 2 ID	GE21CB OPEN	G1 CB OPEN	The label for the breaker staus changed. G1 refers to the GCB of Generator 1. For Generator 2 relay, this tag has to be G2 CB OPEN
	[H1C] Contact Input 2 Debounce Time	2.0 ms	2.0 ms	
	[H1C] Contact Input 2 Events	Enabled	Enabled	
	[H2A] Contact Input 3 ID	CLASS A TRP	CLASS A TRP	
	[H2A] Contact Input 3 Debounce Time	2.0 ms	2.0 ms	
	[H2A] Contact Input 3 Events	Enabled	Enabled	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	[H2C] Contact Input 4 ID	CLASS B TRP	CLASS B TRP	
	[H2C] Contact Input 4 Debounce Time	2.0 ms	2.0 ms	
	[H2C] Contact Input 4 Events	Enabled	Enabled	
	[H3A] Contact Input 5 ID	CLASS C TRP	CLASS C TRP	
	[H3A] Contact Input 5 Debounce Time	2.0 ms	2.0 ms	
	[H3A] Contact Input 5 Events	Enabled	Enabled	
	[H3C] Contact Input 6 ID	CL.A TRP FAU	CL.A TRP FAU	
	[H3C] Contact Input 6 Debounce Time	2.0 ms	2.0 ms	
	[H3C] Contact Input 6 Events	Enabled	Enabled	
	[H4A] Contact Input 7 ID	CL.B TRP FAU	CL.B TRP FAU	
	[H4A] Contact Input 7 Debounce Time	2.0 ms	2.0 ms	
	[H4A] Contact Input 7 Events	Enabled	Enabled	
	[H4C] Contact Input 8 ID	CL.C TRP FAU	CL.C TRP FAU	
	[H4C] Contact Input 8 Debounce Time	2.0 ms	2.0 ms	
	[H4C] Contact Input 8 Events	Enabled	Enabled	
	[H5A] Contact Input 9 ID	ROTOR EF1 OP	ROTOR EF1 OP	
	[H5A] Contact Input 9 Debounce Time	2.0 ms	2.0 ms	
	[H5A] Contact Input 9 Events	Enabled	Enabled	
	[H5C] Contact Input 10 ID	ROTOR EF2 OP	ROTOR EF2 OP	
	[H5C] Contact Input 10 Debounce Time	2.0 ms	2.0 ms	
	[H5C] Contact Input 10 Events	Enabled	Enabled	
	[H6A] Contact Input 11 ID	ROTOR EF FAU	ROTOR EF FAU	
	[H6A] Contact Input 11 Debounce Time	2.0 ms	2.0 ms	
	[H6A] Contact Input 11 Events	Enabled	Enabled	
	[H6C] Contact Input 12 ID	FDR1 PRTN FA	FDR1 PRTN FA	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	[H6C] Contact Input 12 Debounce Time	2.0 ms	2.0 ms	
	[H6C] Contact Input 12 Events	Enabled	Enabled	
	[H7A] Contact Input 13 ID	FDR2 PRTN FA	FDR2 PRTN FA	
	[H7A] Contact Input 13 Debounce Time	2.0 ms	2.0 ms	
	[H7A] Contact Input 13 Events	Enabled	Enabled	
	[H7C] Contact Input 14 ID	SPARE	SPARE	Configured in the Flex Logic Equation for GENERATOR Mechanical trip input
	[H7C] Contact Input 14 Debounce Time	2.0 ms	2.0 ms	
	[H7C] Contact Input 14 Events	Disabled	Disabled	
	[H8A] Contact Input 15 ID	SPARE	SPARE	Configured in the Flex Logic Equation for TRUBINE Mechanical trip input
	[H8A] Contact Input 15 Debounce Time	2.0 ms	2.0 ms	
	[H8A] Contact Input 15 Events	Disabled	Disabled	
	[H8C] Contact Input 16 ID	SPARE	SPARE	
CONTACT INPUT THRESHOLDS				
	G1 CB CLOSE : G1 CB OPEN : CLASS A TRP : CLASS B TRP(H1A : H1C : H2A : H2C)	84 Vdc	84 Vdc	
	CLASS C TRP : CL.A TRP FAU : CL.B TRP FAU : CL.C TRP FAU(H3A : H3C : H4A : H4C)	84 Vdc	84 Vdc	
	ROTOR EF1 OP : ROTOR EF2 OP : ROTOR EF FAU : FDR1 PRTN FA(H5A : H5C : H6A : H6C)	84 Vdc	84 Vdc	
	FDR2 PRTN FA : SPARE : SPARE : SPARE(H7A : H7C : H8A : H8C)	84 Vdc	84 Vdc	
CONTACT OUTPUTS				

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	[P1] Contact Output 1 ID	CLASS A TRIP	CLASS A TRIP	
	[P1] Contact Output 1 Operate	86A On (VO1)	86A On (VO1)	
	[P1] Contact Output 1 Seal-In	OFF	OFF	
	[P1] Contact Output 1 Events	Enabled	Enabled	
	[P2] Contact Output 2 ID	CLASS B TRIP	CLASS B TRIP	
	[P2] Contact Output 2 Operate	86B On (VO2)	86B On (VO2)	
	[P2] Contact Output 2 Seal-In	OFF	OFF	
	[P2] Contact Output 2 Events	Enabled	Enabled	
	[P3] Contact Output 3 ID	CLASS C TRIP	CLASS C TRIP	
	[P3] Contact Output 3 Operate	86C On (VO3)	86C On (VO3)	
	[P3] Contact Output 3 Seal-In	OFF	OFF	
	[P3] Contact Output 3 Events	Enabled	Enabled	
	[P4] Contact Output 4 ID	BFP TRIP	BFP TRIP	
	[P4] Contact Output 4 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[P4] Contact Output 4 Seal-In	OFF	OFF	
	[P4] Contact Output 4 Events	Enabled	Enabled	
	[P5] Contact Output 5 ID	SPARE	SPARE	
	[P6] Contact Output 6 ID	SPARE	SPARE	
	[P7] Contact Output 7 ID	SPARE	SPARE	
	[P8] Contact Output 8 ID	SPARE	SPARE	
	[U1] Contact Output 9 ID	BFP TRIP	BFP TRIP	
	[U1] Contact Output 9 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[U1] Contact Output 9 Seal-In	OFF	OFF	
	[U1] Contact Output 9 Events	Enabled	Enabled	
	[U2] Contact Output 10 ID	BFP TRIP	BFP TRIP	
	[U2] Contact Output 10 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[U2] Contact Output 10 Seal-In	OFF	OFF	
	[U2] Contact Output 10 Events	Enabled	Enabled	
	[U3] Contact Output 11 ID	BFP TRIP	BFP TRIP	
	[U3] Contact Output 11 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[U3] Contact Output 11 Seal-In	OFF	OFF	
	[U3] Contact Output 11 Events	Enabled	Enabled	
	[U4] Contact Output 12 ID	BFP TRIP	BFP TRIP	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	[U4] Contact Output 12 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[U4] Contact Output 12 Seal-In	OFF	OFF	
	[U4] Contact Output 12 Events	Enabled	Enabled	
	[U5] Contact Output 13 ID	BFP TRIP	BFP TRIP	
	[U5] Contact Output 13 Operate	BFP TRIP(DE1) OP	BFP TRIP(DE1) OP	
	[U5] Contact Output 13 Seal-In	OFF	OFF	
	[U5] Contact Output 13 Events	Enabled	Enabled	
	[U6] Contact Output 14 ID	SPARE	SPARE	
	[U7] Contact Output 15 ID	SPARE	SPARE	
	[U8] Contact Output 16 ID	TRP RLY REST	TRP RLY REST	
	[U8] Contact Output 16 Operate	CONTROL PUSHBUTTON 1 ON	CONTROL PUSHBUTTON 1 ON	
	[U8] Contact Output 16 Seal-In	OFF	OFF	
	[U8] Contact Output 16 Events	Enabled	Enabled	
VIRTUAL OUTPUTS				
	Virtual Output 1 ID	86A	86A	
	Virtual Output 1 Events	Enabled	Enabled	
	Virtual Output 2 ID	86B	86B	
	Virtual Output 2 Events	Enabled	Enabled	
	Virtual Output 3 ID	86C	86C	
	Virtual Output 3 Events	Enabled	Enabled	
	Virtual Output 4 ID	TRIP	TRIP	
	Virtual Output 4 Events	Enabled	Enabled	
	Virtual Output 5 ID	BFP	BFP	
	Virtual Output 5 Events	Enabled	Enabled	
	Virtual Output 6 ID	OSC TRIGGER	OSC TRIGGER	
	Virtual Output 6 Events	Enabled	Enabled	
	Virtual Output 7 Events	Disabled	Disabled	
	Virtual Output 8 Events	Disabled	Disabled	
	Virtual Output 9 Events	Disabled	Disabled	
	Virtual Output 10 Events	Disabled	Disabled	
	Virtual Output 11 Events	Disabled	Disabled	
	Virtual Output 12 Events	Disabled	Disabled	
	Virtual Output 13 Events	Disabled	Disabled	

	PARAMETERS	EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Virtual Output 14 Events	Disabled	Disabled	
	Virtual Output 15 ID	ALARAM	ALARM	
	Virtual Output 15 Events	Enabled	Enabled	
	Virtual Output 16 ID	Virt Op 16	DIFF. OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 16 Events	Disabled	Enabled	
	Virtual Output 17 ID	Virt Op 17	3RD HRM UV OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 17 Events	Disabled	Enabled	
	Virtual Output 18 ID	Virt Op 18	DIR PWR 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 18 Events	Disabled	Enabled	
	Virtual Output 19 ID	Virt Op 19	UNBALANCE 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 19 Events	Disabled	Enabled	
	Virtual Output 20 ID	Virt Op 20	LOSS OF EXEC OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 20 Events	Disabled	Enabled	
	Virtual Output 21 ID	Virt Op 21	BFP OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 21 Events	Disabled	Enabled	
	Virtual Output 22 ID	Virt Op 22	PH OC 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 22 Events	Disabled	Enabled	
	Virtual Output 23 ID	Virt Op 23	PH UV 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 23 Events	Disabled	Enabled	
	Virtual Output 24 ID	Virt Op 24	PH OV 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 24 Events	Disabled	Enabled	
	Virtual Output 25 ID	Virt Op 25	UF 1 OP	Labelled as per the Flex Logic Equation assignment
	Virtual Output 25 Events	Disabled	Enabled	

PARAMETERS		EXISTING SETTINGS	PROPOSED SETTINGS	REMARKS
	Virtual Output 26 ID	Virt Op 26	VT FF OP	
	Virtual Output 26 Events	Disabled	Enabled	Labelled as per the Flex Logic Equation assignment
	Virtual Output 27 ID	Virt Op 27	Virt Op 27	
	Virtual Output 27 Events	Disabled	Disabled	

Relay Setting Calculation Study Report

Protection Engineering And Research Laboratories

Relay Setting Calculation

Study Report

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Author	Dr. G. Pradeep Kumar, PEARL
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Revisions

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Abbreviations & Definitions

AVR	Automatic Voltage Regulator
CB	Circuit Breaker
CT	Current Transformer
EF	Earth Fault
GT	Generator Transformer
GCB	Generator Circuit Breaker
NGR	Neutral Grounding Resistor
OC	Over Current
OV	Over Voltage
PT	Potential Transformer (Voltage Transformer)
UV	Under Voltage
VT	Voltage Transformer

1. Introduction

This is the report for the protection study conducted to calculate the generator protection relay settings for the 2 x 9.2 MW hyrdo-electric power plant of M/s Patikari Power Private Limited in Himachal Pradesh, India.

This report is organized in three chapters:

- **Chapter 1** is the introduction chapter where the objective of this study and the system that was studied are described.
- **Chapter 2** describes the protection philosophy adopted for calculating settings for protections under the scope of this study.
- **Chapter 3** highlights the issues noticed while reviewing the protection relay settings and that require to be noted.

There is one Annexure to this report:

- **Annexure-I** contains the existing and proposed settings for the generator protection relay in the G30 relay's menu format.

1.1. Objective

The objective of this study is to determine the optimum settings for the generator protection relays applied for protecting the two 9.2 MW generators. The settings shall be recommended to ensure maximum sensitivity for in-zone faults, at the same time ensuring stability/coordination for faults outside the protected zone.

1.2. Scope of Study

The scope of this protection study is listed below.

- Study and Review of existing settings for the generator protection relay
- Verify the existing protection scheme for the generator protection and suggest any changes if required.

1.3. System & Data

The system in the scope of this study includes two generators [D1]. M/s Patikari Power provided the details of these generators [E1].

The relevant generator data used in this study is listed in Table 1.1

Table 1.1: Data for generator 1 & 2

Parameter	Value	Unit
Apparent Power	10.82	MVA
Active Power	9.2	MW
Power Factor	0.85	
Voltage	11	kV
Speed	500	Rpm
Synchronous Reactance, Xd	100	%
Transient Reactance, Xd'	21	%
Sub-transient Reactance, Xd"	15	%
Negative Sequence Reactance, X_2	17	%
Zero Sequence Reactance, X_0	5	%
Negative sequence continuous withstand (I_2s)	8 *	%
Negative seq. short time withstand (I_2^2t)	20 *	

** Typical values were assumed [M2], as they were not given.*

The details of the protection relay used for generator protection are provided in Table 1.2.

Table 1.2: Generator protection relay details

Description	Data
Relay Type	G30
Relay Make	GE Multilin
Relay Model No.	G30-N03-HCH-F8H-H6D-M8F-P67-U67-WXX
Protections Included	All protections for the generator except for rotor earth fault is included in the above G30. Rotor earth fault protection alone is provided in an external relay type MRR1

Details of current and voltage transformers used for protection is provided in Table 1.3

Table 1.3: CT & PT details

Description	Data
Phase side CT (Three Phases)	
Ratio	600/5
Class	5P10
Burden	30VA
Neutral side CT (Three Phases)	
Ratio	600/5
Class	5P10
Burden	30VA
Phase side PT (Three Phase)	
Ratio	11kV/√3 : 110V/√3
Class	3P
Burden	30VA
Neutral side CT (Single Phase)	
Ratio	11kV/√3 : 110V/√3
Class	0.5
Burden	30VA

2. Setting Calculation Philosophy

The settings for the protection relays must ensure the fastest possible fault clearance without compromising on selectivity. Based on this philosophy, the approach followed for calculating the settings for the relays is described in this section.

2.1. Input & Output Configuration

A comprehensive generator management relay type G30 provides the generator protection. This single relay has all the protections except for rotor earth fault. Relay type MRR1 is provided for two-stage rotor earth fault protection. The setting philosophy adopted for calculating the settings for the generator protection is given in the following sub-sections.

2.1.1. Tripping Classes

As per the generator protection schematic diagram (No. 81649.1-02 REV-01), there are three master trip relays. They are designated as 86A (CLASS A), 86B(CLASS B) and 86C(CLASS C).

The 86A master trip relay is assigned for total shutdown of the machine and is wired to trip the generator circuit breaker (GCB), field circuit breaker and turbine. In the G30 relay configuration, all protections that operate for generator internal faults are to be assigned to trip this master trip relay. Figure 2.1 shows the graphic representation of the "Flex Logic Equation" for the CLASS A tripping. The "Virtual Output 1"(VO1) is assigned to operate the output contact 1 of G30, which is wired to initiate tripping of the 86A master trip relay.

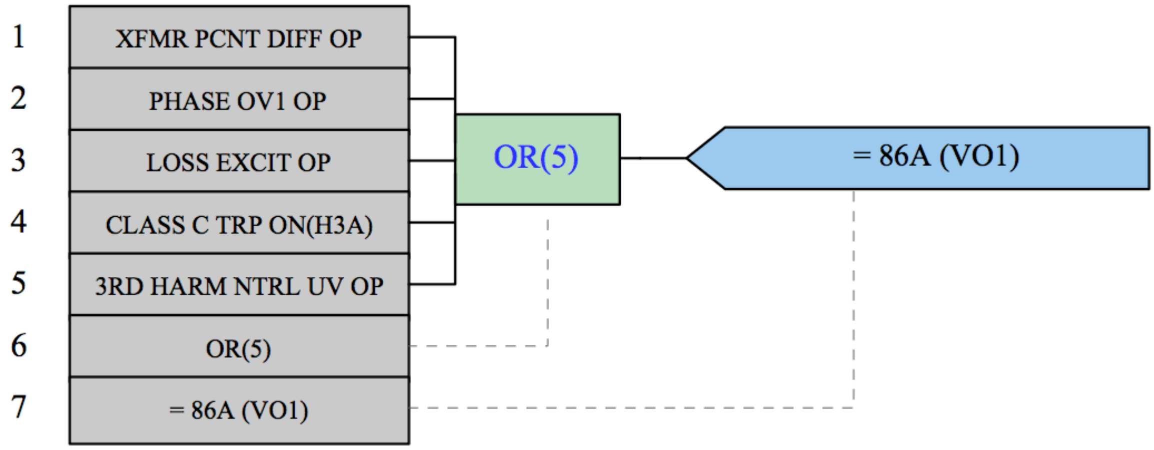


Figure 2.1: Graphic representation of Flex Logic Equation for CLASS A tripping

The 86B master trip relay is wired to trip only the GCB. This effectively isolates the generator from the rest of the system. In G30 relay configuration, all protections that operate for external un-cleared faults in the system are to be assigned for this master trip relay. As compared to the existing setting, the generator unbalance protection (tripping stage 1) has been added to this logic. At the same time, the neutral over current protection (which is a current based earth fault protection) has been removed as this protection will not work for this system, as the ground fault currents will be negligible. Figure 2.2 shows the graphic representation of the "Flex Logic Equation" for the CLASS B tripping. The "Virtual Output 2"(VO2) is assigned to operate the output contact 2 of G30, which is wired to initiate tripping of the 86B master trip relay.

Note:

This CLASS B tripping is usually employed to isolate the generator from the system without shutting down the generator, for any un-cleared faults in the system. The advantage of this class of tripping is that the generator can be re-synchronized with the system quickly, once it is confirmed that the system is normal. However in the system at Patikari, the generators are directly connected to the 11kV bus and power for the auxiliaries for the generator is tapped from the 11kV bus. As per the currently engineered scheme [D2], the class 86B trip relay trips the generator breaker that connects the generator to the 11kV bus. By doing so there is no guarantee that the generator will survive the disturbance as the auxiliary power is still being fed from the affected 11kV system. The generator auxiliary system, which is connected to the affected 11kV system, can be interrupted, leading to the total shutdown of the generator. Also once the *generator breaker is tripped, the load on the generator will become zero and most generators will not be able to sustain 100% load throw-off and continue to run with no-load.*

If this class of tripping has to be effective then the isolation will have to be done by tripping the 33kV circuit breaker. By doing so for any un-cleared fault in the 33kV system, this class of tripping will isolate the power plant from the grid and allow the generator to continue to operate feeding its own auxiliary load. And as soon as the grid is healthy the power plant can be re-synchronized.

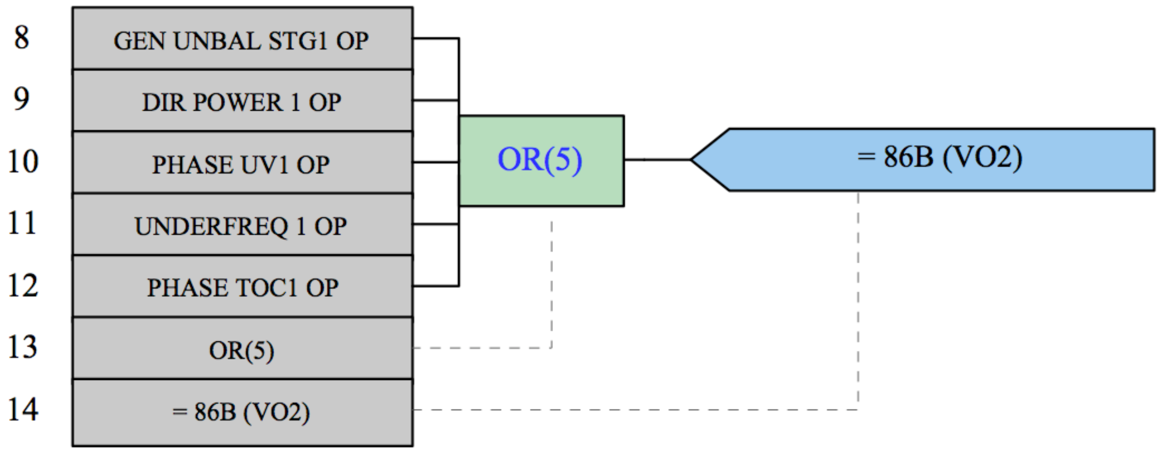


Figure 2.2: Graphic representation of Flex Logic Equation for CLASS B tripping

The 86C master trip relay is also assigned for total shutdown of the machine and is wired to trip the generator circuit breaker (GCB), field circuit breaker and turbine. This class of tripping is provided for all non-electrical faults. The non-electrical tripping signal from mechanical protection systems for the generator and turbine are wired to the 86C master trip relay directly. However one output contact of the G30 relay is also wired to trip the 86C relay. Hence a logic has been configured in the "Flex Logic Equation" of G30 to initiate the tripping of the 86C relay when any of the two spare digital inputs (H7C or H8A) is energized. By wiring generator and turbine mechanical tripping contacts to these two digital inputs, non-electrical tripping can also be logged in the G30 relay. This will be useful for analysis of tripping incidents. Figure 2.3 shows the graphic representation of the "Flex Logic Equation" for the CLASS C tripping. As of now the two digital inputs are designated as spare and disabled in the setting. When these digital inputs are wired, these digital inputs need to be enabled and labelled. The "Virtual Output 3"(VO3) is assigned to operate the output contact 3 of G30, which is wired to initiate tripping of the 86C master trip relay.

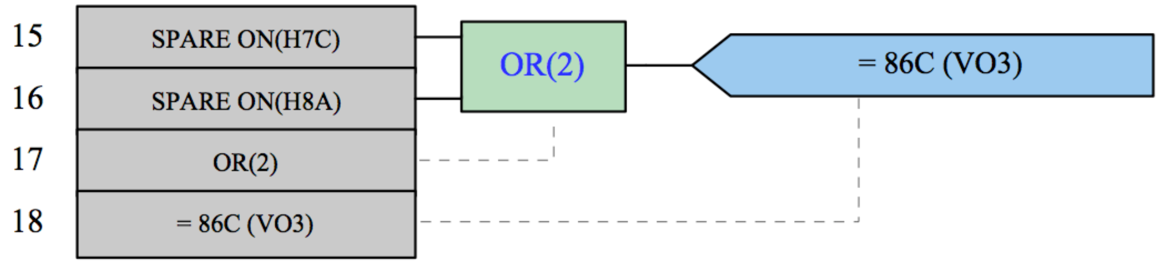


Figure 2.3: Graphic representation of Flex Logic Equation for CLASS C tripping

All the above settings are included in the Annexure I.

2.1.2. Circuit Breaker Failure Protection & Tripping Logic

The circuit breaker failure(CBF) protection for the GCB is provided in the G30 relay. This protection is provided using the "Flex Element", "FlexLogic Timers" and Flex Logic Equation". The CBF protection logic is initiated by the operation of any of the three master trip relays (86A, 86B & 86C). A contact from each of these relays is wired to the digital inputs H2A, H2C and H3A respectively.

A current comparator detects the successful opening of the circuit breaker following a trip command. This comparator is programmed in "FlexElement 1". The pick-up setting of this comparator was originally set to 0.96pu (generator full load current). However for effective CBF operation for generator circuits, the pick-up sensitivity should be around 5%. Hence the setting of the comparator is proposed to be reduced to 0.05 pu. The input mode is also changed from "SIGNED" to "ABSOLUTE" to ensure that the element operates for current flowing in both directions.

The time delay for the CBF element is usually set to 200ms (to account for the breaker opening time, current comparator reset and safety margin). This delay is provided in the "Flex Logic Timer1". The existing value of this timer is 1000ms and it is proposed to reduce it to 200ms. Figure 2.4 shows the graphic representation of the "Flex Logic Equation" for the CBF protection. The "Virtual Output 5"(VO5) is assigned to the "Digital Element 1" in G30 relay and labelled as "BFP TRIP". This "Digital Element 1" is assigned to operate the output contacts 4, 9, 10, 11, 12 and 13 of G30, which are wired to initiate tripping of the turbine, other generator's circuit breaker, 11kV circuit breaker of GT-1, 11kV circuit breaker of GT-2, 11kV circuit breaker of SST-1 and 11kV circuit breaker of SST-2 respectively.

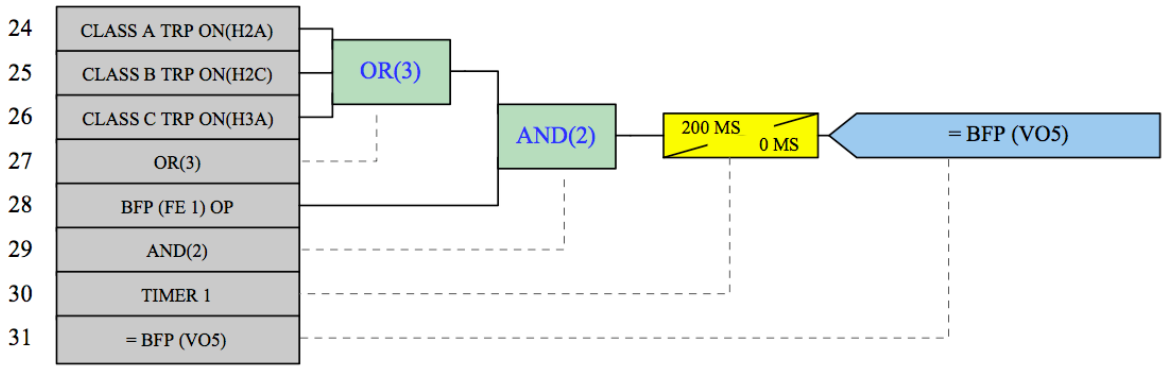


Figure 2.4: Graphic representation of Flex Logic Equation for CBF protection

All the above settings are included in the Annexure I.

2.1.3. Input AC Analogue Channel Configuration

The channel configuration for the analogue inputs (currents and voltages) is done as per the protection schematic diagram [D2]. The three phase CTs from the phase side of the generator is wired to input "F1" and designated as "Source 1" (SRC 1). The three phase CTs from the neutral side of the generator is wired to input "F5" and designated as "Source 2" (SRC 2). The three phase voltage from the phase side PT is wired to the input "M5" and designated as "Source 1" (SRC 1). The single phase neutral to ground voltage, measured by the single phase PT connected between the generator neutral and ground is wired to the auxiliary input "M5" and is also designated as "Source 1" (SRC 1). These settings are included in the Annexure I.

2.1.4. Digital Input Configuration

The model of the G30 relay used has 16 digital inputs. As per the schematic diagram [D2], 13 of these digital inputs (input 1 to 13) are wired. These inputs are programmed as per the wiring. These inputs are also assigned correctly in the Flex Logic Equation as per the application. Digital inputs 14 and 15 are assigned in the Flex Logic Equation for external mechanical trip inputs from generator and turbine respectively. However as per the schematic diagram [D2], these inputs are not wired. These mechanical trip signals are directly wired to operate the master trip relay 86C. Hence it is not mandatory to wire these digital inputs. However by wiring these mechanical trip inputs to the G30 relay, their operation will also be logged in the relay's record during a trip event, hence it is advisable to wire these inputs if possible. These settings are included in the Annexure I.

2.1.5. Digital Output Configuration

The model of G30 relay used has 16 output contacts. Outputs 1, 2 and 3 are wired for operating master trip relays 86A, 86B & 86C respectively. Output contacts 4, 10, 11, 12 and 13 are wired for tripping the other breakers of the 11kV system in case of the generator CB failure. Contact 16 is wired for resetting the master trip relay. All these outputs are configured in the Flex Logic Equation as per the schematic diagram. These settings are included in the Annexure I.

2.2. Protection Settings

There are six settings groups in G30 relay. For this application, the setting "Group 1" alone is utilised. All the settings of the protection elements are to be programmed in this group 1. All the other five setting groups are to be disabled.

2.2.1. Generator Differential Protection (87G)

The generator differential protection is provided by the "TRANSFORMER PERCENTAGE DIFFERENTIAL" element in the G30 relay. This element is a biased differential element. The biased differential element's pick-up and slope are set to the minimum value that would ensure stability during normal operation. This is influenced by the amount of spill current expected during normal loads and external faults. The accuracy class of CTs and similarity of the two CT characteristics used for the differential protection plays a major role in the amount of spill current. Since the differential protection is connected to a 5P class CT, a pickup setting of 0.15 pu adopted. The first slope is set to 15% and the second slope is set to 60%. This protection is assigned for CLASS A tripping.

These are the existing settings and are retained as such. These settings are included in the Annexure I.

2.2.2. Voltage Dependent Over Current (51V)

The voltage dependent over current protection is provided to protect the generator from un-cleared downstream faults, when sustained fault current feed from the generator can reduce to the load current magnitude (as Xd = 100%). The G30 relay provides a voltage restraint over current element in its "PHASE CURRENT" element. The first stage of this element "PHASE TOC 1" in G30 is used for this protection. The pick-up setting of this element is set to 1.1pu to avoid operation during normal loads (with sufficient margin). The existing setting was 0.94pu, which can cause this element to pick-up for full load itself.

The operating characteristic of this element is selected as "IAC Inverse" as the downstream circuits' over current (OC) elements are set with this operating characteristic (the 33kV side OC elements of GT-1 & GT-2). The existing time dial multiplier (TDM) setting of 0.4 is retained. Considering the fact that the downstream OC element's TDM setting is 0.3 (with a pick-up of 0.94 p), the existing TDM setting of 0.4 should be ok. It also has to be noted that for any downstream faults, the fault current seen by the downstream relay will be twice that seen by the relay at the generator (as there are two generators in service always). This protection is assigned for CLASS B tripping. These settings are included in the Annexure I.

2.2.3. Negative Phase Sequence Current Protection (46)

This protection is required to protect the generator rotor from damage when the generator is operated delivering un-balance currents beyond its withstand limits. Usually the generator manufacturer provides the continuous (I_{2S}) and short time ($K=I_2^2t$) negative sequence current withstand limits of the generator. However these values were not available. Hence typical values for generators of this type were assumed as recommended in reference [M2].

This protection is provided by the "GENERATOR UNBALANCE" element in G30. This element has two stages. The first stage "GEN UNBAL STG1" is an inverse-time stage and is configured for CLASS B tripping. The pick-up setting of this stage is set 8% of the generator rated current (which is the assumed continuous negative sequence withstand current of the generator). The time constant "K" is set to 14 (considering a operating time margin of 30%). The minimum/maximum operating times and reset time constants are set with typical values.

The second stage "GEN UNBAL STG2" is configured as an alarm stage and is set to 5.6% (70% of the continuous negative sequence withstand of the generator). This element is provided with a definite time delay of 10s to avoid un-necessary alarms during transients. This element is configured to "Digital Element 2" and labeled for alarm indication on the relay.

It has to be noted that this protection is disabled at present and it is suggested that this protection be enabled and set as explained above. These settings are included in the Annexure I.

2.2.4. Under Voltage Protection (27)

Under voltage condition is not harmful to the generator. Hence this protection is not critical. However in the existing settings two-stage under voltage protections are used. The first stage (PHASE UNDERVOLTAGE1) is set to 0.75pu with a definite time delay of 5s. This stage is configured for CLASS B tripping. The second stage (PHASE UNDERVOLTAGE2) is set to 0.9pu with a definite time delay of 3s. This second stage is assigned for alarm. These existing settings are retained in the new proposed settings.

The voltage measurement mode for the under voltage elements is set as "Phase to Ground" in the existing settings. Given the fact that the generators are un-grounded, this measurement mode will not give the correct generator voltage. Hence in the proposed setting the measurement mode is set as "Phase to Phase".

In the existing settings the under voltage elements are blocked with the generator CB is open. However the under voltage protection has to be blocked even when the VT fuse fails. Hence in the proposed setting, a virtual output (VO27) is created from the ORed output of the generator CB open and VT fuse failure operated statuses (configured in the Flex Logic Equation). This VO27 signal is used to block the under voltage element.

These settings are included in the Annexure I.

2.2.5. Phase Over Voltage Protection (59)

The phase over voltage protection is provided to protect the generator insulation from failure due to over voltage. This element in G30 (PHASE OVERVOLTAGE1) is set to 1.15pu with a definite time delay of 2s. The time delay is to provide sufficient time for the AVR to respond and do the necessary correction. The over voltage element is configured for CLASS A tripping. These existing settings are retained in the proposed setting.

These settings are included in the Annexure I.

2.2.6. Residual Over Voltage Protection (59N)

This protection in G30 relay (NEUTRAL OV1) operates on the residual voltage calculated by the G30 relay. This residual voltage is calculated from the three-phase voltage measured by the relay. This protection is used to detect earth faults in high impedance grounded or un-grounded power system. Since these generators are un-grounded, this protection element is proposed to be enabled and set to detect earth faults up to 95% of the stator winding. However since both the generators are connected to the 11kV bus directly, this voltage based earth fault protection provided for any of the generators will operate for earth faults in both the generators. In fact this residual over voltage based earth fault protection will operate for earth faults in any part of the 11kV system. Hence this protection cannot be used for tripping. This protection is provided with a definite time delay of 3s and assigned for alarm only. This element is configured to "Digital Element 5" and labelled for alarm indication on the relay.

It has to be noted that this protection is disabled at present and it is suggested that this protection be enabled and set as explained above. These settings are included in the Annexure I.

2.2.7. Neutral Over Voltage Protection (59G)

This protection in G30 relay (AUXILIARY OV1) operates on the measured neutral to ground voltage. This voltage is wired to the auxiliary voltage input of the G30 relay from the single phase VT connected between the generator neutral and ground. This protection is also used to detect earth faults in high impedance grounded or un-grounded power system. This protection will act similar to the residual over voltage protection explained in Section 2.2.6. This protection is also set to detect earth faults up to 95% of the stator winding. This protection will also operate for earth faults in any part of the 11kV system. Hence this protection also cannot be used for tripping. This protection is provided with a definite time delay of 3s and assigned for alarm only. This element is configured to "Digital Element 6" and labelled for alarm indication on the relay.

It has to be noted that this protection is also disabled at present and it is suggested that this protection be enabled and set as explained above. These settings are included in the Annexure I.

If the above two protections (residual over voltage & neutral over voltage protection) are not enabled, then there is no effective earth fault protection for the generator. The 3rd harmonic based stator earth fault protection provided (detailed in Section 2.2.10) will be effective only for faults closer to the generator neutral. With the proposed setting earth faults up to 95% of the generator winding will be detected and alarm will be generated. However immediate manual action will still be necessary to isolate the faulted section. With the present grounding method, this is the best solution. As explained in Section 3.1, if the grounding system is changed, then automatic detection and isolation of earth faults will be possible using current based earth fault protection.

2.2.8. Loss of Excitation Protection (40)

Loss of excitation protection is provided to detect failure of excitation input to the generator. When the excitation to the generator fails the machine starts operating as an induction generator. This can cause the generator rotor to heat up fast. If not detected and tripped, the generator rotor can get damaged. Also when the generator operates as an induction generator, it draws high amount of reactive power from the system. This can cause the system voltage to collapse thereby harming the system (or other parallel generators).

Loss of excitation is detected by an impedance element with an offset circular characteristic along the negative reactance axis. In G30 relay two stage LOSS OF EXCITATION protection is provided. The first stage characteristics is set with an offset of 0.5Xd' and diameter of Xd. This element is interlocked with an under voltage element set at 0.7pu. A small time delay of 0.3s is provided for this element to avoid operation during transients. The second stage characteristic is set with the same offset and diameter settings, but without under voltage interlock. A longer time delay of 2s is provided for this element. These elements are set to be blocked on the operation of VT fuse fail protection.

The loss of excitation protection is configured for CLASS A tripping. These settings are included in the Annexure I.

2.2.9. Reverse Active Power Protection (32)

Reverse active power protection is provided for the generator to detect loss of prime mover. On the failure of prime mover, the generator starts operating as a synchronous motor, drawing active power from the system. The amount of active power drawn from the system would depend on the motoring power of the generator. The DIRECTIONAL POWER 1 element in G30 is set for this protection. The existing setting is provided with a reverse power pick-up of 0.05pu with a definite time delay of 5s. This pick-up setting corresponds to 6.25% of the generator rating. Given the fact that the protection is fed from a 5P class CT, more sensitive settings are not advisable. Hence the existing settings are retained in the proposed setting also. This element is configured for CLASS B tripping. It has to be noted, that since the prime mover is already failed, anyway this will lead to total generator shut down. In the existing setting, a second stage element with 0.03pu pick-up and 5s delay is also enabled. However this second stage is not used for tripping or alarm. Hence in the proposed setting this second stage is disabled.

These settings are included in the Annexure I.

2.2.10. Stator Earth Fault Protection (100%)

Stator earth fault protection based on third harmonic under voltage principle is provided to detect earth faults closer to the generator neutral point. In G30 relay, this protection is provided by the "3RD HARM NTRL UV" element. This protection extracts the third harmonic voltage from the generator neutral to ground voltage. The setting of this element is done after measuring the third harmonic voltage during all normal conditions. It is presumed that the existing settings are made after proper measurements. Hence it is proposed that the existing settings be retained. This element is set to CLASS A tripping. These settings are included in the Annexure I.

As explained in Section 2.2.6, since the generators are directly connected to the 11kV bus, this element may operate for faults in the 11kV bus or parallel generator. Hence once the generator grounding system is re-designed (as suggested in Section 3.1) this protection can be disabled.

2.2.11. Under Frequency Protection (81U)

Two stages of under frequency elements are provided in the existing settings of G30 relay. The first stage (UNDERFREQ 1) is set to 47.5 Hz with a time delay of 2s. This element is configured for CLASS B tripping. These existing settings are retained in the proposed settings. The second stage (UNDERFREQ 2) is used as an alarm stage. It is set to 48.5 Hz. These existing settings are retained in the proposed setting also. The existing time delay for the alarm stage is 2s, which is proposed to be reduced to 0.5s. This will provide some opportunity to the operator to take some corrective action. These settings are included in the Annexure I.

3. Discussion on Protection Study

Issues noticed while reviewing the protection relay settings that require to be noted are highlighted in this section.

3.1. Generator Grounding Methodology

At present both the generators are connected to the 11kV bus directly. The neutral of both the generators are left un-grounded. The single phase PT connected between generator neutral and ground is used to only measure the generator neutral to ground voltage and provide this input to the protection relay. This PT will offer very high impedance for ground fault currents. Hence effectively the entire 11kV system at the power plant is working as an ungrounded system. In such a system the only way to detect ground faults is by measuring residual voltage. This protection was kept disabled in the G30 relay. In the proposed settings this protection is suggested to be enabled. However since both the generators are connected directly to the 11kV bus (without any transformer), residual voltage based earth fault protection will not be able to locate the fault. This protection for a generator will operate for earth faults anywhere in the 11kV system. Hence with the present system configuration, it is not recommended to configure this earth fault protection for tripping. This element is configured for alarm only. With this configuration, whenever there is an earth fault in a generator, both the generator's G30 relay will give an alarm (by the operation of the neutral over voltage protection). After this, manual intervention will be required to isolate this fault. First the GCB of one generator will have to be opened to see if the other machines neutral over voltage protection resets, if it does then it has to be concluded that the machine that was isolated has a fault. If the parallel machines protection does not reset, then the fault can be in that generator or in any other part of the 11kV system. The procedure needs to be continued to isolate each circuit sequentially to locate the fault. This may take a long time. During this period the system will have to operate with one earth fault, which may not be a good practice. Also during this period the voltages in the un-faulted phases will increase and if any part of the 11kV system is not designed for this higher voltage rating, insulation failure can occur.

3.1.1. Solution

The best solution would be to change the 11kV system to a resistance grounded system. For generators of this rating, it is a normal practice to limit the ground fault currents to 100A. This can be done by grounding the generator via neutral grounding resistors (NGR). Since there are two generators, each will have to be provided with its own NGR. Also since both the generators are directly connected to the bus, isolators will have to be provided on the grounding path with operational interlocks to ensure that only one of the generators is grounded at any time. Also when one generator (which is previously grounded through the NGR) is shut down, the other generator will have to be grounded.

Another and much reliable method would be to provide a grounding transformer on the 11kV bus (a zig-zag or a delta-star transformer) with a NGR limiting the current to 100A. In this case both the generators neutral will be left as it is now. There is also no need for any operational interlock as the grounding transformer will be always in service.

Once the 11kV system is changed as a resistance grounded system with 100A current limit, current based earth fault protection can be enabled for all the circuits and co-ordinated. These protections can then be wired for tripping and will automatically isolate the faulted section during earth faults.

3.2. CLASS B Tripping

CLASS B tripping is usually employed to isolate the generator from the system without shutting down the generator, for any un-cleared faults in the system. The advantage of this class of tripping is that the generator can be re-synchronized with the system quickly, once it is confirmed that the system is normal. However in the system at Patikari, the generators are directly connected to the 11kV bus and power for the auxiliaries for the generator is tapped from the 11kV bus. As per the currently engineered scheme [D2], the class 86B trip relay trips the generator breaker that connects the generator to the 11kV bus. By doing so there is no guarantee that the generator will survive the disturbance as the auxiliary power is still being fed from the affected 11kV system. The generator auxiliary system, which is connected to the affected 11kV system, can be interrupted, leading to the total shutdown of the generator. Also once the generator breaker is tripped, the load on the generator will become zero and most generators will not be able to sustain 100% load throw-off and continue to run with no-load.

If this class of tripping has to be effective then the isolation will have to be done by tripping the 33kV circuit breaker. By doing so, for any un-cleared fault in the 33kV system, this class of tripping will isolate the power plant from the grid and allow the generator to continue to operate feeding its own auxiliary load. And as soon as the grid is healthy the power plant can be re-synchronized.

3.3. Backup Protection at 11kV side of GTs

Though the scope of this study was limited to reviewing the protection for the two generators, for setting the back-up protection for the generator, the setting of the downstream protection was taken. For this the settings of the downstream GTs (11kV/33kV) protection were taken (provided in T60 relay). While doing this it was observed that for these transformers, the back-up over current protection is provided only on the 33kV side. On the 11kV side no back-up over current protection is enabled. This can lead to unwanted tripping of both the generators for a fault in the 11kV side of the transformer, which is not cleared by its differential protection. It is suggested that the back-up over current protection be enabled for the 11kV winding also for these two transformers. This element can be programmed in the existing T60 relay itself.

3.4. Annunciation System for Protection Alarms

While going through the schematic diagram for the generators, it was observed that there is no alarm facia or annunciation scheme in the generator protection panel. As of now any protection alarm generated by the G30 relay is only displayed on the relays own LCD panel. This is not a good engineering practice. It is very much possible that the operator fails to notice these LCD messages, as they may not be sitting in front of the relay. The operator may only notice this alarm when he or she happens to go to the front panel of the relay.

It is suggested that all the protection alarms in the G30 relay be assigned to an output contact and wired to sound an audible alarm to alert the operator. Providing an audible alarm (with a different sound) for the trip command is also preferred.

Appendixes

A. Document & Drawings

In this section, the documents and drawings provided by M/s Patikari Power, from which the data for this study are taken are listed.

A.1. Drawings

D1 Drawing number EEPL-PTK-07, Rev 4, titled "SINGLE LINE DIAGRAM".

D2 Drawing number 81649.1-02 REV:01, Rev 4, titled "SCHEMATIC DIAGRAM FOR GENERATOR PROTECTION PANEL".

A.2. Equipment Data

E1 Generator & protection relay data were provided in a Microsoft word file named, "Basic Parameters.docx"

A.3. Existing Setting

S1 Existing settings in the generator protection relay for G1 & G2 were provided in a Microsoft excel file named "Generator.xls"

A.4. Relay Manuals

The following relay Manual was downloaded from the manufacturer's website for the purpose of this study:

M1 G30 Generator Management Relay, UR Series Instruction Manual, G30 Revision: 4.9x, Manual P/N: 1601-0166-M2 (GEK-113207A)

M2 "Network Protection And Automation Guide", First Edition: July 2002, published by ALSTOM – ISBN : 2-9518589-0-6

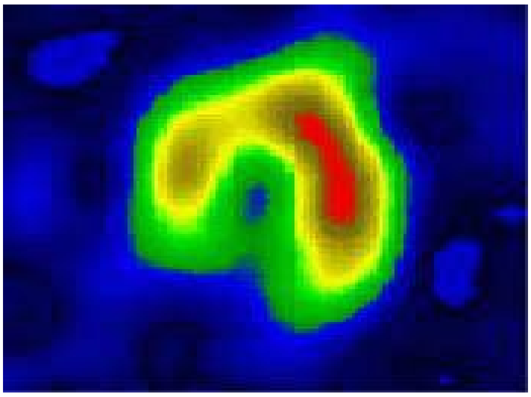
CLIENT: PATIKARI POWER

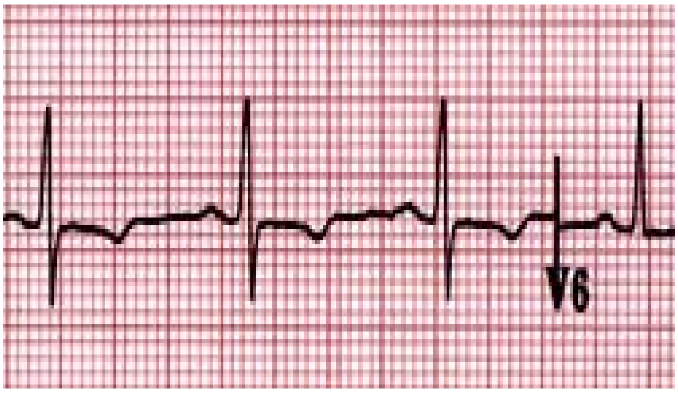
Machine S. No. ›› 402764-1, MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**

Tan delta and Partial Discharge Test Report

GENERATOR STATOR

PATIKARI HYDRO GENERATING STATION - PANDOH





Contract Ref.: S. O. 1020000014
October 2011

Prognosys
VISION TO SCIENTIFIC PREDICTION

GENERATOR DETAILS

MACHINE	GENERATOR
MAKE	EX MONT
TYPE	SGH-1470-12K110
SERIAL NO	402764-1
POWER RATING	9411 KVA
STATOR VOLTS	11000V
STATOR CURRENT	509 A
ROTOR SPEED	500 RPM
CLASS OF INSULATION	‘ F ’
SYSTEM FREQUENCY	50 Hz
POWER FACTOR	0.85
NO OF PHASES	3
YEAR OF MANUFACTURE	2007 *

*** Stator undergone total rewound in 2011**

Index

1.0 TESTS ON STATOR

1.1 IR & PI Measurement:

IR and PI Test on complete winding @ 2.5 KV				
	R-E	**Y-E**	**B-E**	**RYB-E**
1. IR (15 SES)	2.22 GΩ	2.11 GΩ	2.22 GΩ	0.85 GΩ
2. IR (1 MIN)	5.23 GΩ	5.15 GΩ	5.21 GΩ	2.13 GΩ
3. IR (10 MIN)	23.80 GΩ	23.0 GΩ	23.7 GΩ	9.56 GΩ
PI	**4.56**	**4.46**	**4.55**	**4.48**

Test Conditions: Ambt. Temperature: 15 ° C,

1.2 TAN δ & CAPACITANCE MEASUREMENTS

TAN DELTA & CAPACITANCE MEASUREMENTS				
Phase	**Mode**	**KV**	**%PF**	**Cap** (μF)
R Phase Ground Insulation	GND- YB	1.270	0.940	0.16670
R Phase Ground Insulation	GND- YB	2.540	1.006	0.16691
R Phase Ground Insulation	GND- YB	3.810	1.093	0.16712
R Phase Ground Insulation	GND- YB	5.080	1.217	0.16739
R Phase Ground Insulation	GND- YB	6.350	1.372	0.16761
Y Phase Ground Insulation	GND- YB	1.270	0.955	0.16822
Y Phase Ground Insulation	GND- YB	2.540	1.015	0.16850
Y Phase Ground Insulation	GND- YB	3.810	1.096	0.16868
Y Phase Ground Insulation	GND- YB	5.080	1.215	0.16896
Y Phase Ground Insulation	GND- YB	6.350	1.356	0.16918
B Phase Ground Insulation	GND- YB	1.270	0.940	0.16704
B Phase Ground Insulation	GND- YB	2.540	1.008	0.16735
B Phase Ground Insulation	GND- YB	3.810	1.094	0.16752
B Phase Ground Insulation	GND- YB	5.080	1.211	0.16774
B Phase Ground Insulation	GND- YB	6.350	1.356	0.16799
RYB – E Insulation	GND- YB	1.270	0.897	0.48733
RYB – E Insulation	GND- YB	2.540	0.966	0.48776
RYB – E Insulation	GND- YB	3.810	1.052	0.48828
RYB – E Insulation	GND- YB	5.080	1.191	0.48924
RYB – E Insulation	GND- YB	6.350	1.369	0.49049

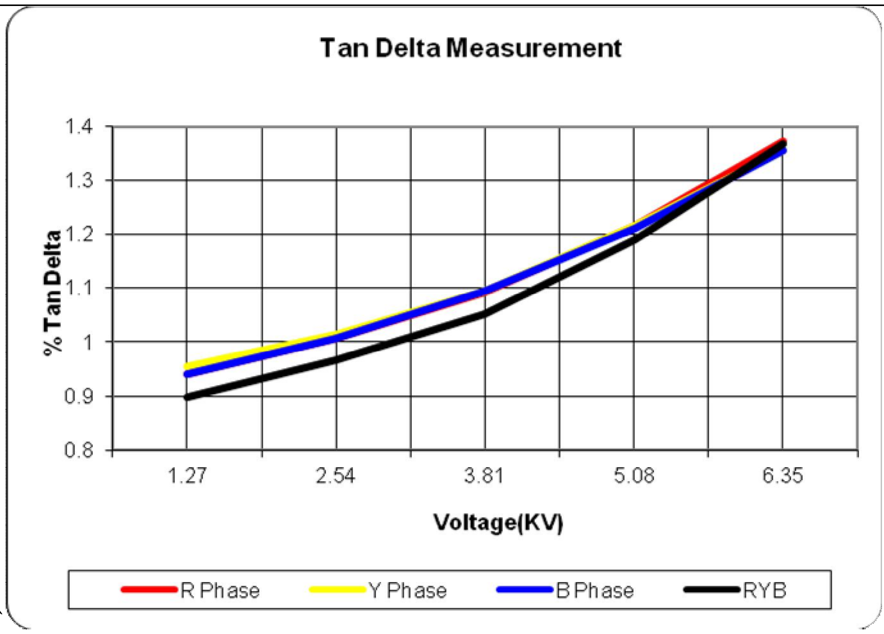
Ambient temp : 15 deg C

PARAMETERS FROM ANALYSIS

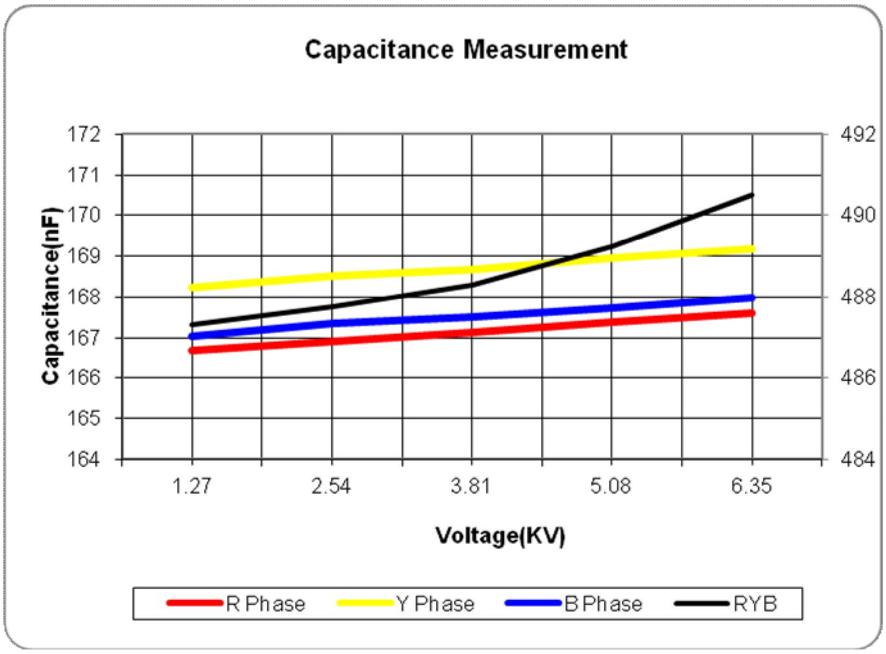
	R	**Y**	**B**	**Acceptable Criteria**
<1> Discharge Inception Voltage (kV)	3	3	3	--
<2> Discharging Void Volume Content (%)	0.546	0.571	0.569	**< 1.0**
<3> Tan Delta Tip Up (%)	0.432	0.401	0.416	**< 1.0**

ASSESSMENT:

1. The base tan delta values (tan delta at low voltage) obtained are on low side indicating insulation is free from moisture and surface contamination.
2. The tan delta tip up value on all phases is within limits indicating that the partial discharge activity in the winding insulation is on lower side. The Tan Delta ‘tip-up’ indicated that the void content of the stator winding insulation was within normal parameters for the new insulation, and that the continuity and condition of the semi-conductive slot coating and stress control coating were acceptable.
3. Overall the low rise of tan delta with voltage and lower tan delta tip-up indicates the good condition of dielectric winding insulation.
4. The comparative analysis of tan delta and capacitance values among the phases indicate no abnormalities.
5. The obtained values needs to be considered as finger prints in trend analysis under condition monitoring program.



Tan Delta Measurement
1.4
1.3
1.2
1.1
1
0.9
0.8
% Tan Delta
1.27
2.54
3.81
5.08
6.35
Voltage(KV)
R Phase
Y Phase
B Phase
RYB



Capacitance Measurement
172
171
170
169
168
167
166
165
164
Capacitance(nF)
492
490
488
486
484
1.27
2.54
3.81
5.08
6.35
Voltage(KV)
R Phase
Y Phase
B Phase
RYB

1.3 PARTIAL DISCHARGE ANALYSIS:

<1> CYCLE OF MAJOR P.D. ACTIVITY	**Dominant in negative cycle**
<2> PREDOMINANT P.D. PULSES	**Slot discharges type PD**

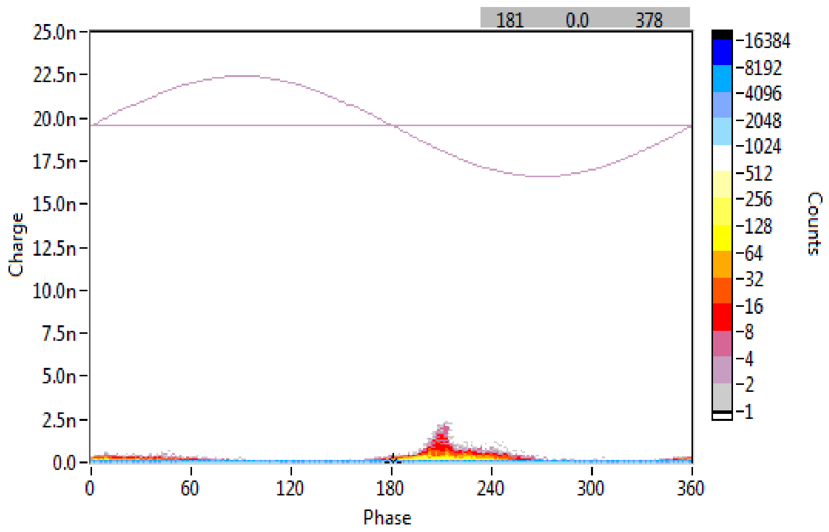
ASSESSMENT:

1. Partial Discharge pattern for all phases individually suggest that the partial discharges are mainly slot discharges type and also indicate the presence of internal discharges.
2. Partial discharge magnitude charge value as measured is found to be in acceptable range. The partial discharge inception voltage is also found to be on acceptable level indicating healthiness of insulation condition.
3. Assessment indicates the partial discharges levels on this winding are within limits and the readings need to be compared during next testing for trend analysis. Also the comparative analysis of partial discharge values and patterns among the phases indicate no abnormalities.
4. Partial Discharges patterns obtained indicate no abnormality and needs to be considered as finger prints for trend analysis under condition monitoring.

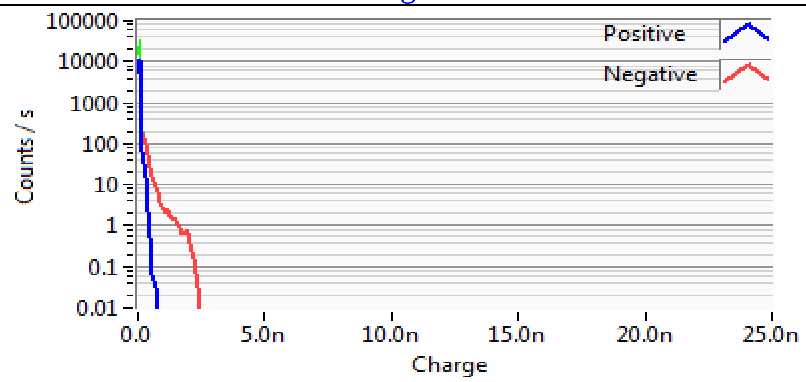
CLIENT: PATIKARI POWER
Machine S. No. ›› 402764-1, MAKE ›› **EX-MONT**, RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV**, AMPS ›› **509 A,** P.F ›› **0.85.**

Partial Discharge pattern of R Phase @ 3 kV

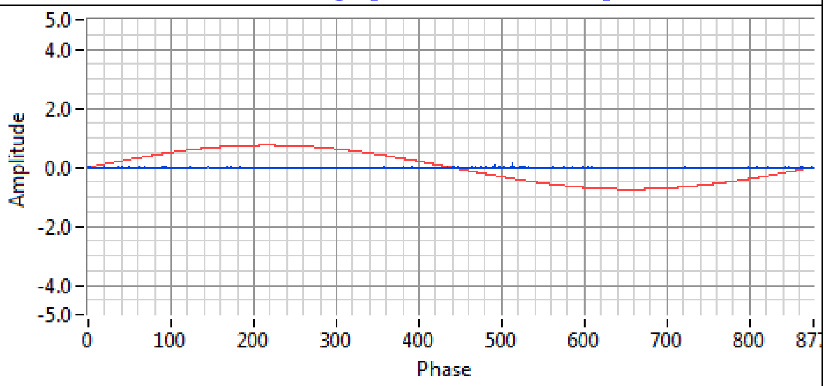
Partial Discharge Pattern



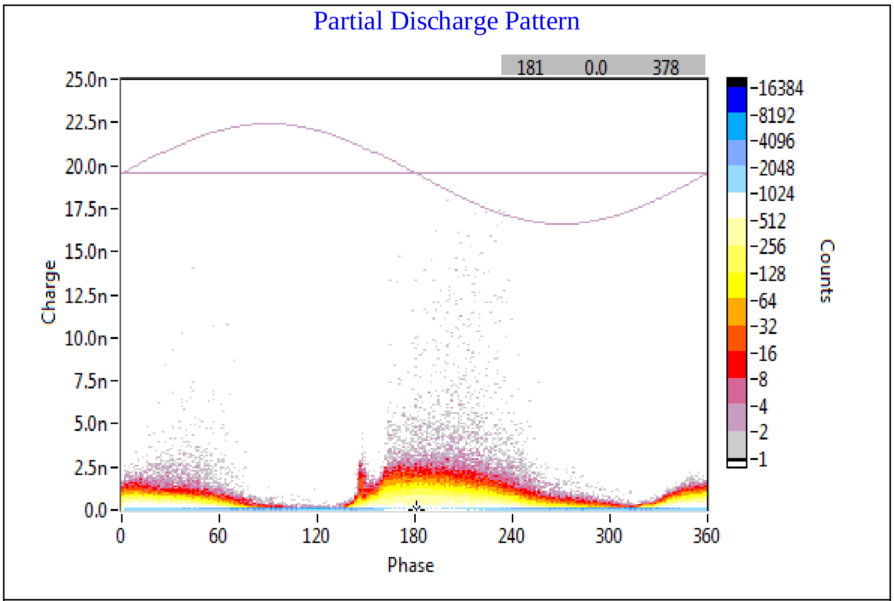
Partial Discharge Characteristics

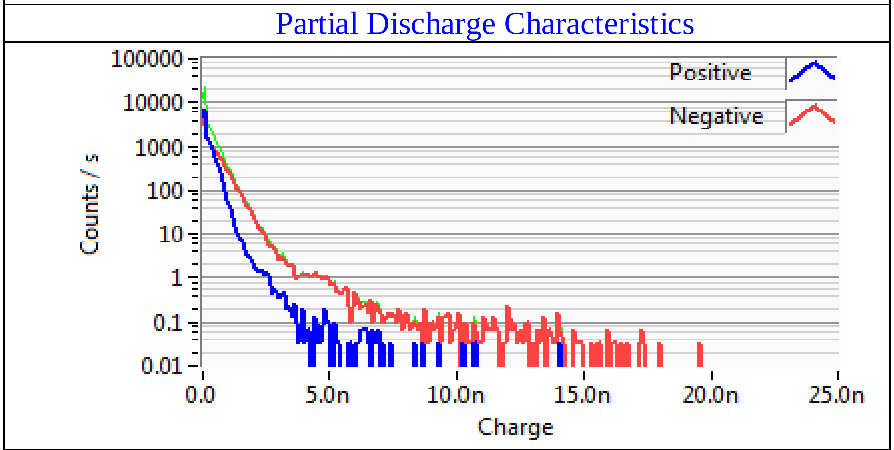


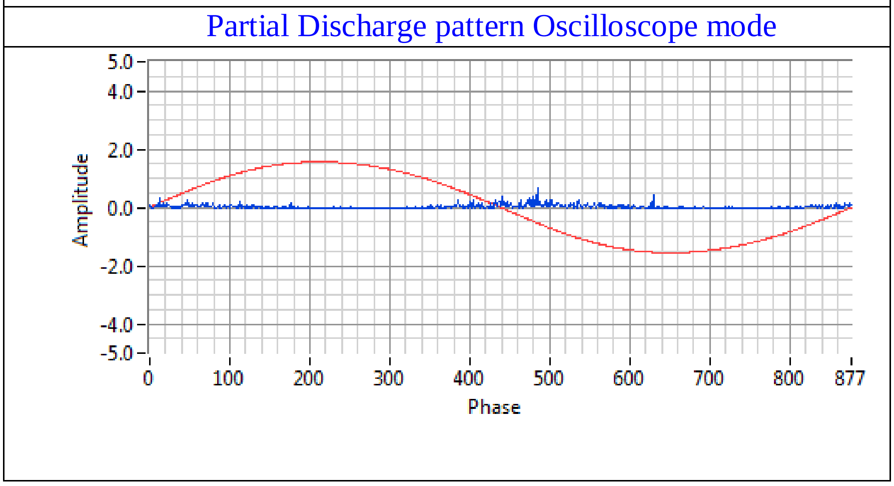
Partial Discharge pattern Oscilloscope mode



Partial Discharge pattern of R Phase @ 6.35 kV

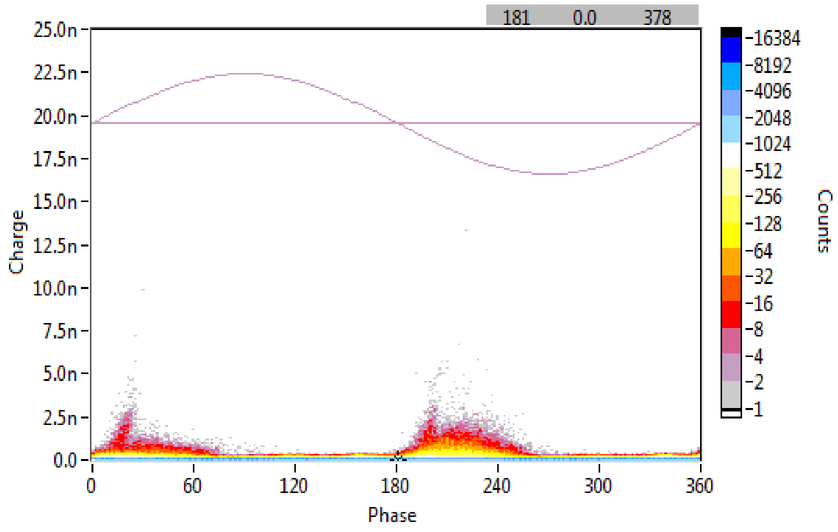




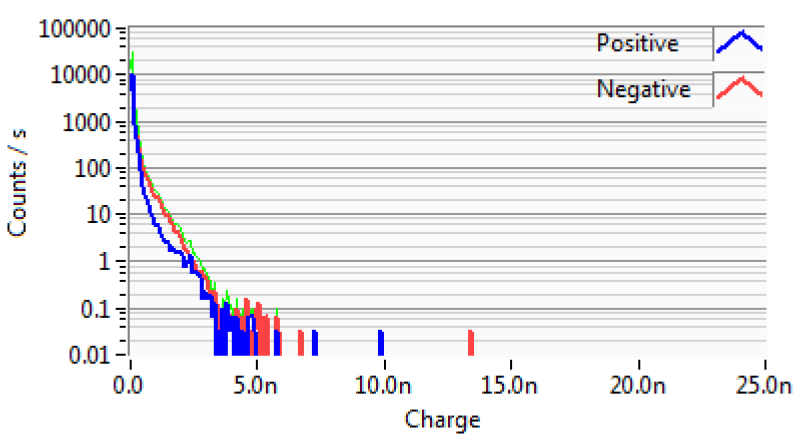


Partial Discharge pattern of Y Phase @ 3 kV

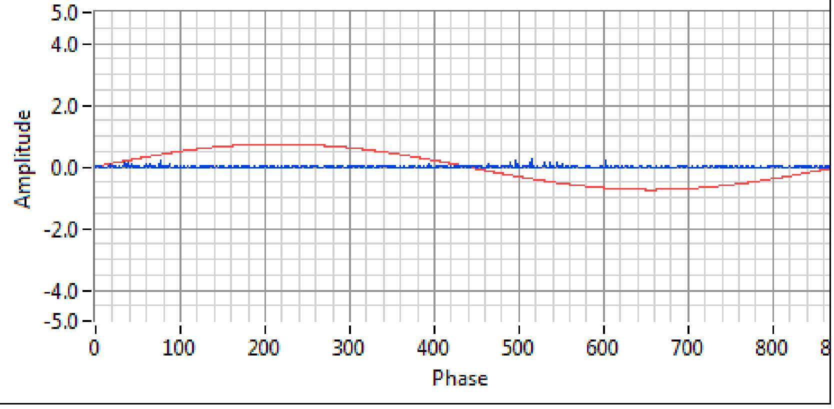
Partial Discharge Pattern



Partial Discharge Characteristics

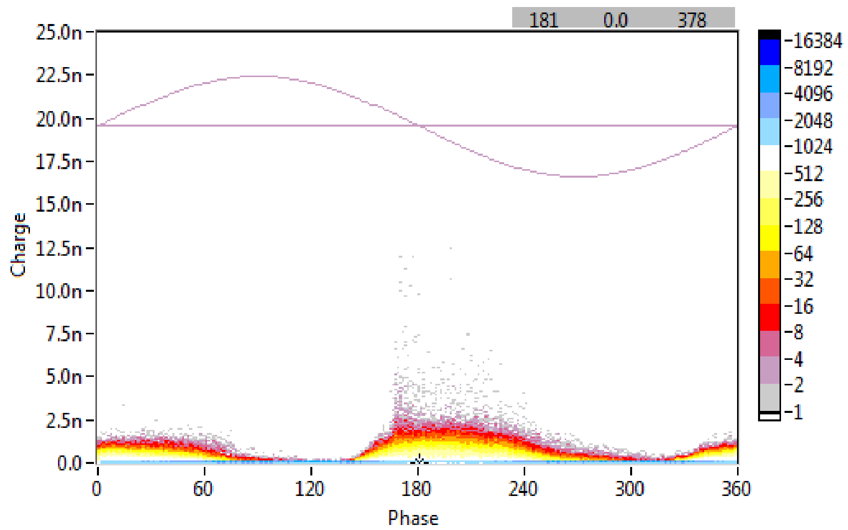


Partial Discharge pattern Oscilloscope mode

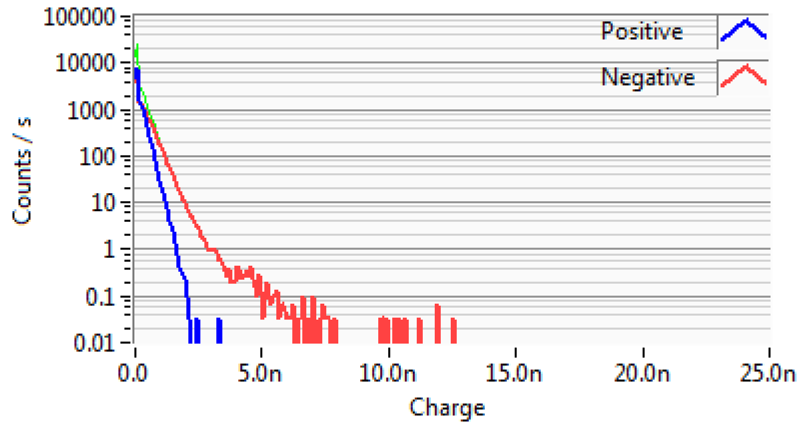


Partial Discharge pattern of Y Phase @ 6.35 kV

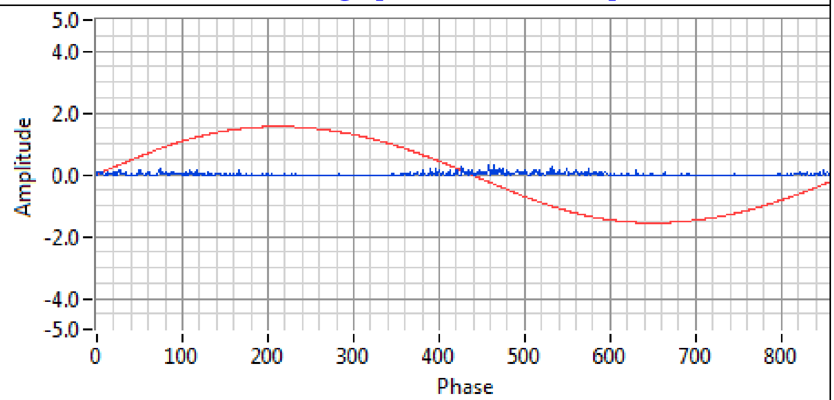
Partial Discharge Pattern



Partial Discharge Characteristics

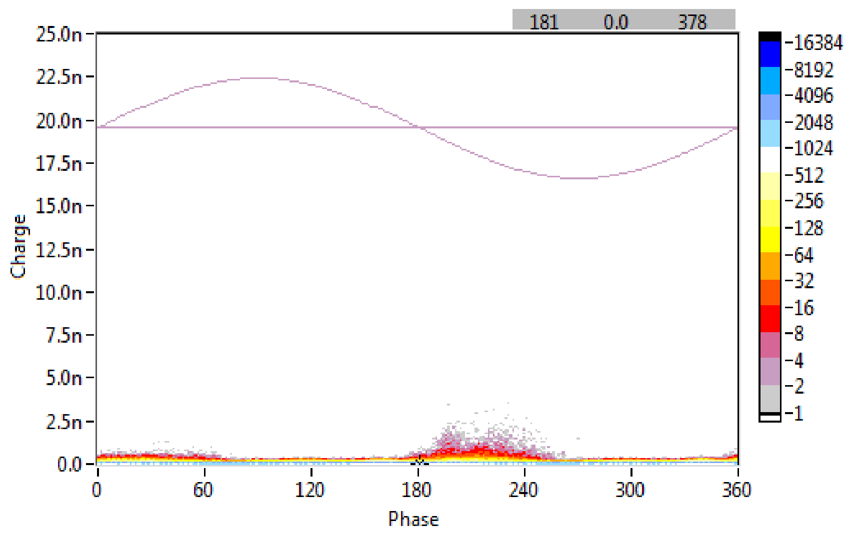


Partial Discharge pattern Oscilloscope mode

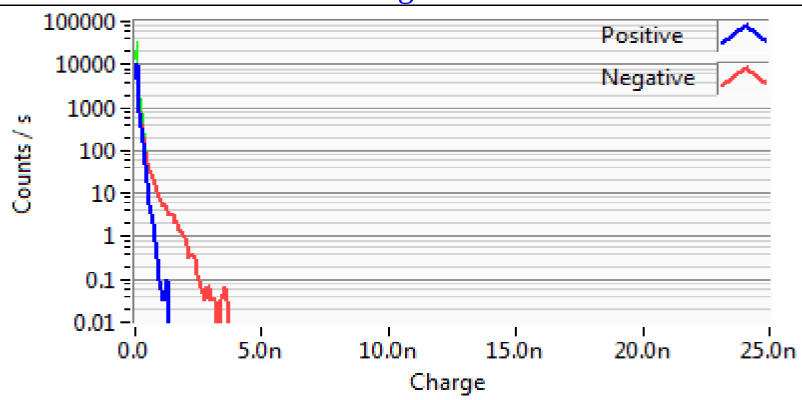


Partial Discharge pattern of B Phase @ 3 kV

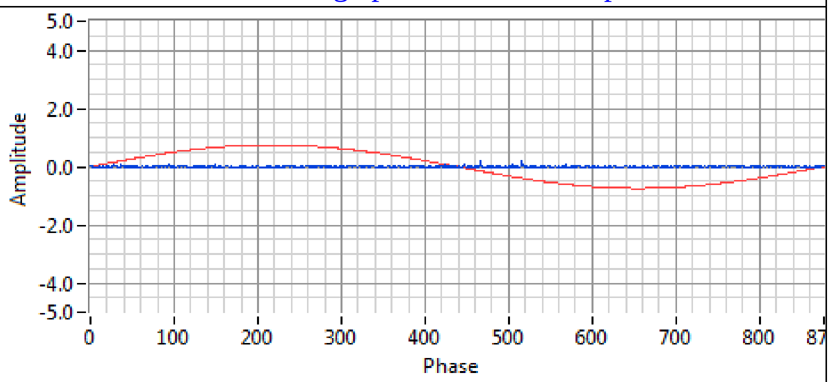
Partial Discharge Pattern



Partial Discharge Characteristics

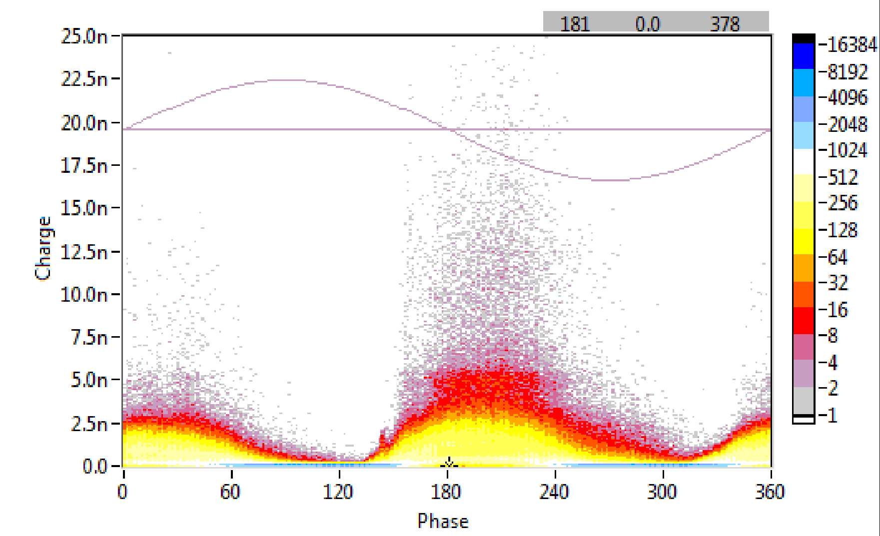


Partial Discharge pattern Oscilloscope mode

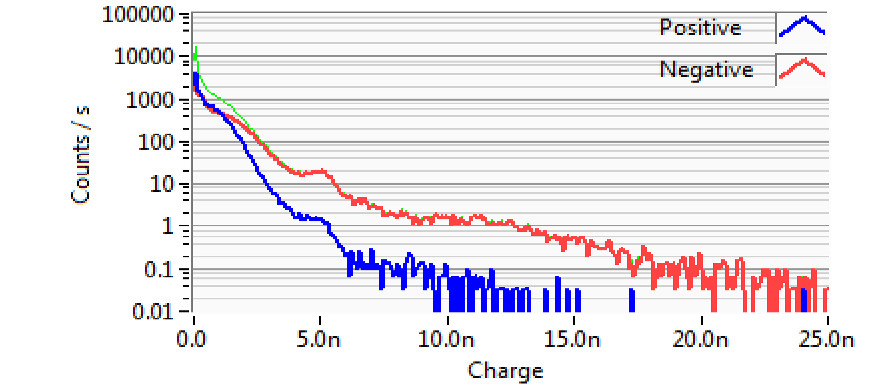


Partial Discharge pattern of B Phase @ 6.35 kV

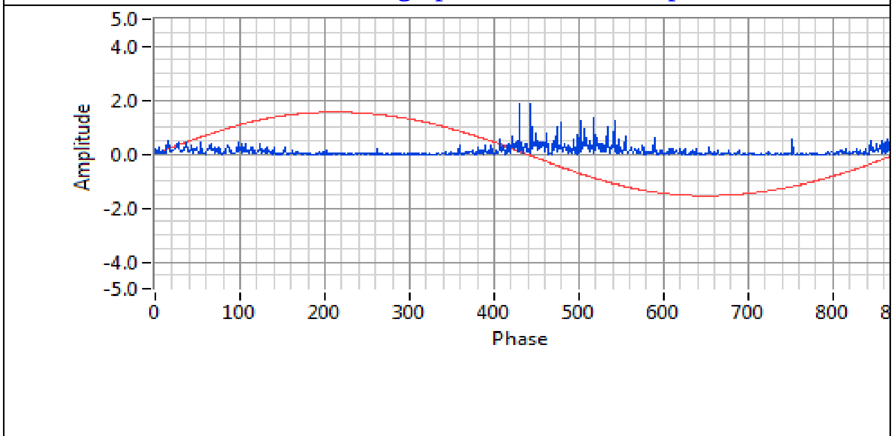
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



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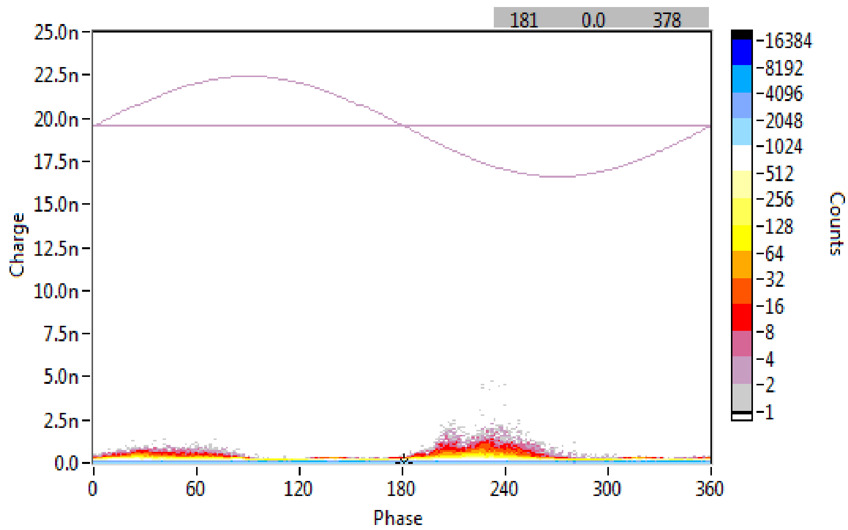
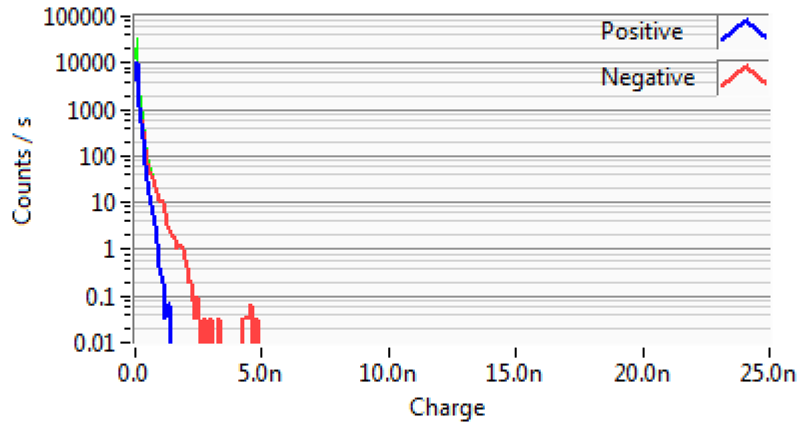
Partial Discharge pattern of RYB Phase @ 3 kV

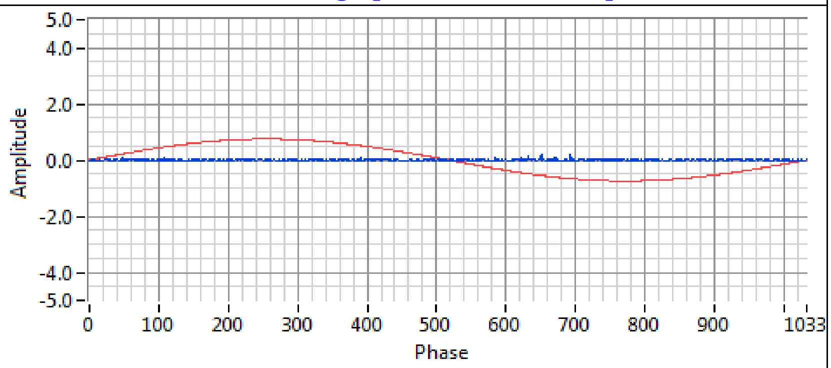
Partial Discharge Pattern



Partial Discharge Characteristics

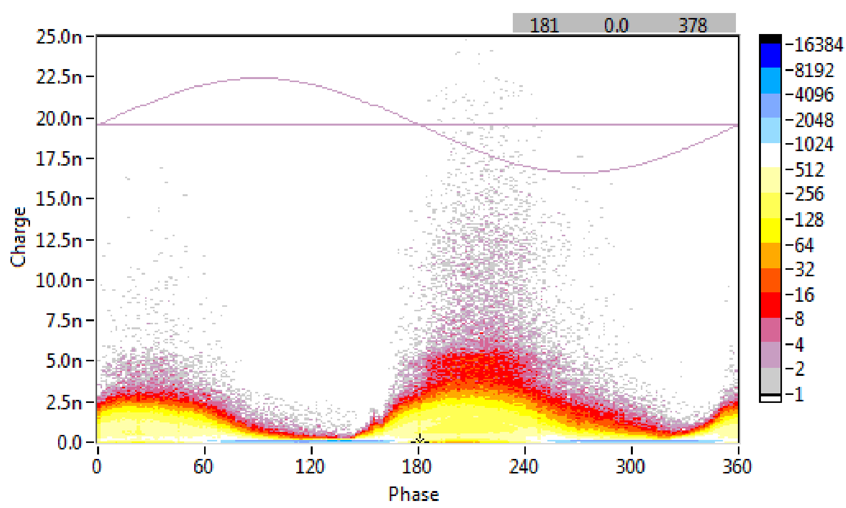


Partial Discharge pattern Oscilloscope mode

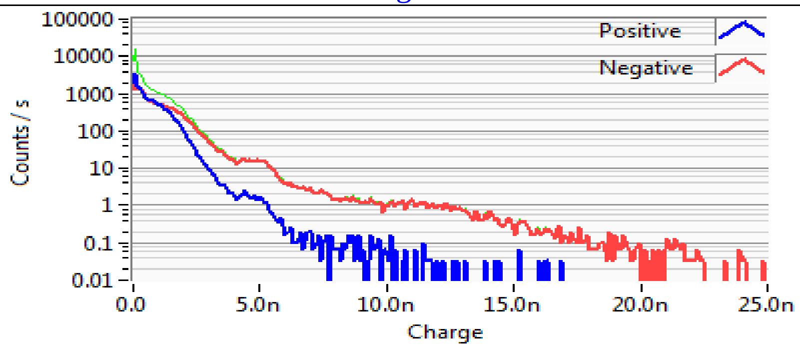


Partial Discharge pattern of RYB Phase @ 6.35 kV

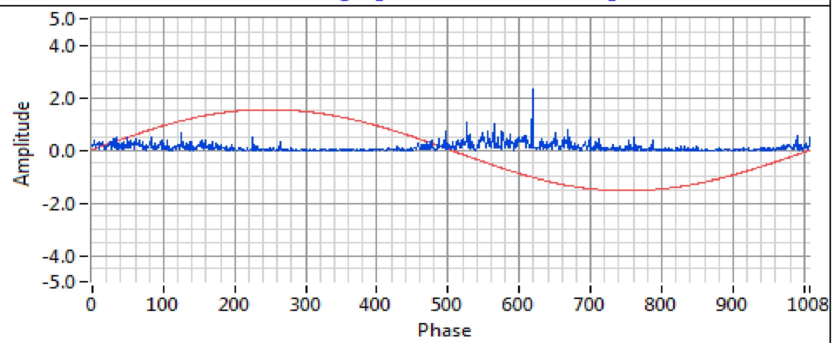
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



2.0 ANALYSIS

2.1 ASSESSMENT ON STATOR

Insulation Resistance (IR) and Polarisation Index (PI) values obtained are well within Acceptable range.

The low base tan delta values and low tip up values in tan delta test indicate insulation is in good condition. Low tan delta values indicate low dielectric losses within the insulation, the tan delta tip up value on all phases is within limits, indicating that the partial discharge activity in the winding insulation is on lower side. Values derived from the Tan Delta 'tip-up' indicated that the void content of the stator winding insulation was within normal parameters for the new insulation, and that the continuity and condition of the semi-conductive slot coating and stress control coating were acceptable. The comparative analysis of tan delta and capacitance values among the phases indicate no abnormalities. The obtained values needs to be considered as finger prints in trend analysis under condition monitoring program.

Partial Discharge pattern for all phases individually suggest that the partial discharges are mainly slot discharges type and also indicate internal discharges. Partial discharge magnitude charge value as measured is found to be in acceptable range. Assessment indicates the partial discharges levels on this winding are within limits and the readings need to be compared during next testing for trend analysis. Partial Discharges patterns obtained indicate no abnormality and needs to be considered as finger prints for trend analysis under condition monitoring.

3.0 CONCLUSION AND RECOMMENDED ACTION

Based on the diagnostic tests results assessment, the following conclusions and recommendations had been drawn.

STATOR WINDING

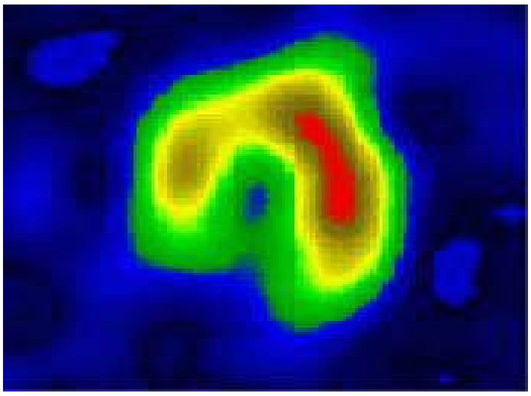
From the assessment conducted, it is concluded that the stator winding test parameters are within limits for the winding. This indicates stator winding insulation is in acceptable condition. The obtained values needs to be considered as finger prints in trend analysis under condition monitoring program.

CLIENT: PATIKARI POWER	
Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**	

Tan delta, Partial Discharge and ELCID Test Report

GENERATOR STATOR

PATIKARI HYDRO GENERATING STATION - PANDOH



Contract Ref.: S. O. 1020000013 & 14

October 2011

Prognosys
VISION TO SCIENTIFIC PREDICTION

GENERATOR DETAILS

MACHINE	GENERATOR
MAKE	EX MONT
TYPE	SGH-1470-12K110
SERIAL NO	402764-2
POWER RATING	9411 KVA
STATOR VOLTS	11000V
STATOR CURRENT	509 A
ROTOR SPEED	500 RPM
CLASS OF INSULATION	‘F ’
SYSTEM FREQUENCY	50 Hz
POWER FACTOR	0.85
NO OF PHASES	3
YEAROF MANUFACTURE	2007

Index

1.0 TESTS ON STATOR

1.1 IR & PI MEASUREMENT

IR and PI Test on complete winding @ 2.5 KV

	R-E	**Y-E**	**B-E**	**RYB-E**
1. IR (15 SES)	4.05 GΩ	3.26 GΩ	2.81 GΩ	1.70 GΩ
2. IR (1 MIN)	10.7 GΩ	9.26 GΩ	5.93 GΩ	3.93 GΩ
3. IR (10 MIN)	40.7 GΩ	34.7 GΩ	14.1 GΩ	12.7 GΩ
PI	**3.72**	**3.69**	**2.37**	**3.23**

Test Conditions: Ambt. Temperature: 15 ° C,

1.2 TAN δ & CAPACITANCE MEASUREMENTS

TAN DELTA & CAPACITANCE MEASUREMENTS				
Phase	**Mode**	**KV**	**%PF**	**Cap (uF)**
R Phase Ground Insulation	GND- YB	1.270	0.521	0.12795
R Phase Ground Insulation	GND- YB	2.540	0.640	0.12810
R Phase Ground Insulation	GND- YB	3.810	0.746	0.12829
R Phase Ground Insulation	GND- YB	5.080	0.975	0.12861
R Phase Ground Insulation	GND- YB	6.350	1.396	0.12928
Y Phase Ground Insulation	GND- YB	1.270	0.558	0.12868
Y Phase Ground Insulation	GND- YB	2.540	0.648	0.12879
Y Phase Ground Insulation	GND- YB	3.810	0.761	0.12903
Y Phase Ground Insulation	GND- YB	5.080	1.004	0.12939
Y Phase Ground Insulation	GND- YB	6.350	1.429	0.13009
B Phase Ground Insulation	GND- YB	1.270	0.563	0.12874
B Phase Ground Insulation	GND- YB	2.540	0.652	0.12886
B Phase Ground Insulation	GND- YB	3.810	0.766	0.12909
B Phase Ground Insulation	GND- YB	5.080	0.991	0.12944
B Phase Ground Insulation	GND- YB	6.350	1.398	0.13010
RYB – E Insulation	GND- YB	1.270	0.584	0.37128
RYB – E Insulation	GND- YB	2.540	0.680	0.37162
RYB – E Insulation	GND- YB	3.810	0.810	0.37203
RYB – E Insulation	GND- YB	5.080	1.067	0.37317
RYB – E Insulation	GND- YB	6.350	1.433	0.37502

Test Conditions: Ambt. Temperature: 15 ° C

PARAMETERS FROM ANALYSIS

	R	**Y**	**B**	**Acceptable Criteria**
<1> Discharge Inception Voltage (kV)	3.5	3.5	3.5	**--**
<2> Discharging Void Volume Content (%)	1.039	1.096	1.056	**< 1.0**
<3> Tan Delta Tip Up (%)	0.875	0.871	0.835	**< 1.0**

ASSESSMENT:

1. The base tan delta values (tan delta at 2 kV) obtained are on low side indicating insulation is free from moisture and surface contamination.
2. The tan delta values for all phases with rise of voltage are seen to increase with voltage steeply. This indicates high dielectric power loss indicating voids in the insulation and activity of partial discharges in the winding insulation to large extent.
3. The **tan delta tip up** value on all phases is near to the limits indicating that the partial discharge activity is on higher side. Values derived from the Tan Delta 'tip-up' indicated that the void content of the stator winding insulation was above normal for the age and type of insulation.
4. Overall the high rise of tan delta with voltage indicates the deteriorated condition of dielectric winding insulation.
5. The **void content** in the winding insulation derived is above limits, clearly indicating the high partial discharge activity present in the insulation. Also the capacitance and tan delta graphs with voltage rise indicate high discharges in the voids present in the insulation.

CLIENT: PATIKARI POWER

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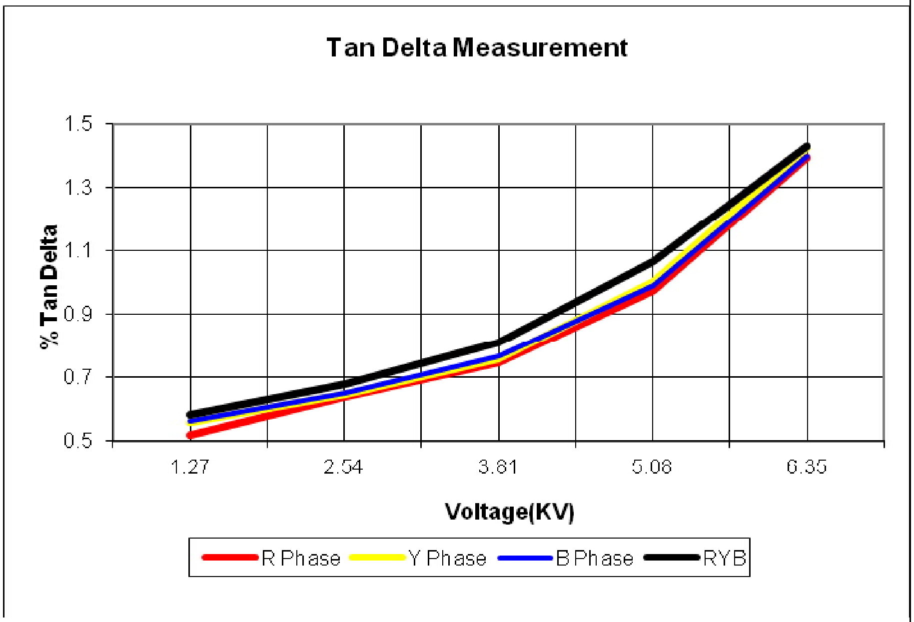

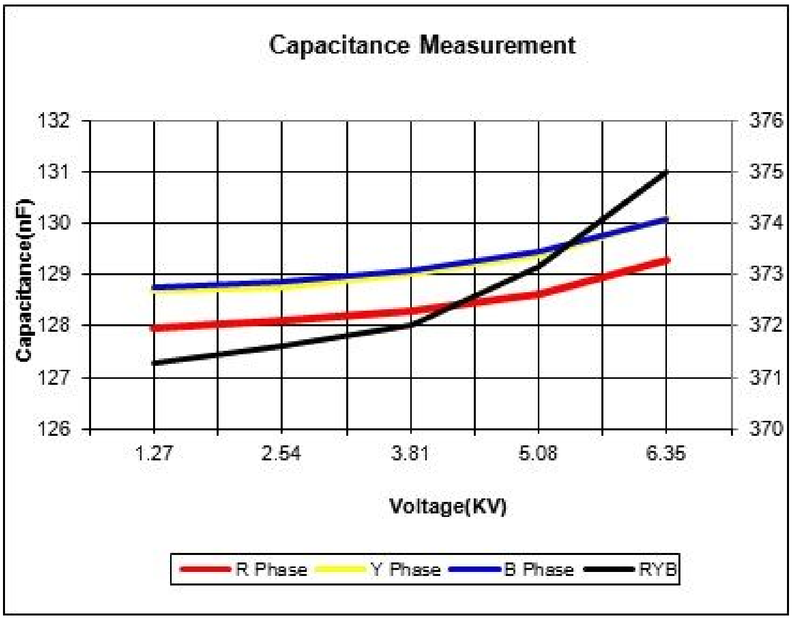

1.3 PARTIAL DISCHARGE ANALYSIS

<1> CYCLE OF MAJOR P.D. ACTIVITY	**Almost equal in both cycles**
<2> PREDOMINANT P.D. PULSES	**Slot, end winding and internal type PD**

ASSESSMENT:

1. Partial Discharge pattern for all phases suggest that the partial discharges are occurring at slot region and end winding region, the discharge pattern also indicates the internal discharges occurring within the insulation.

2. Partial discharge magnitude charge value as measured is found to be on much higher side, indicating that the discharge levels in the winding are occurring to greater extent. The partial discharge inception voltage is also found to be on lower side indicating deterioration of insulation condition.

3. Assessment indicates the partial discharges levels on this winding are much above limits for this type and age of insulation.

CLIENT: PATIKARI POWER

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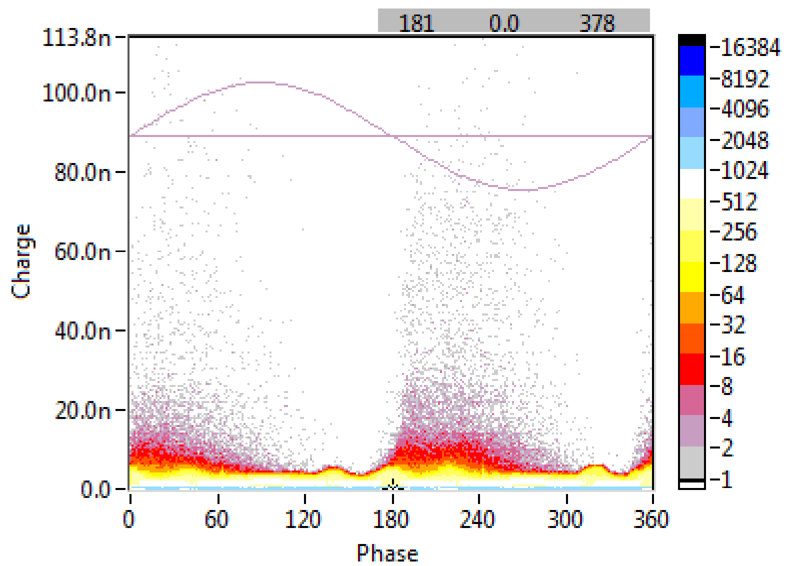
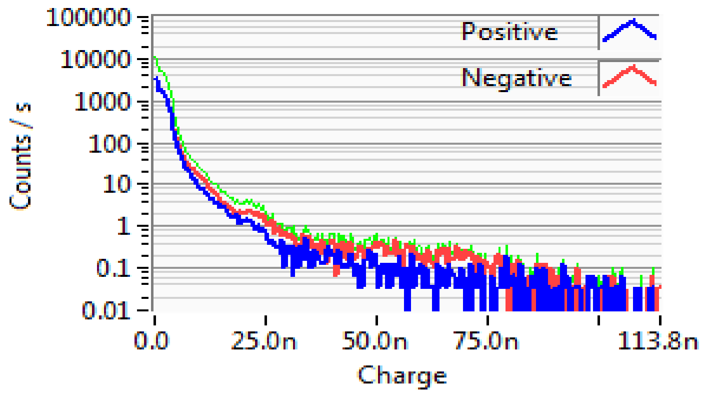
Partial Discharge pattern of R Phase @ 3 kV

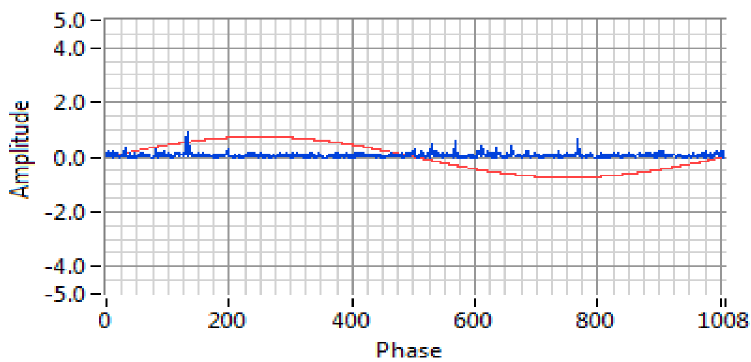
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



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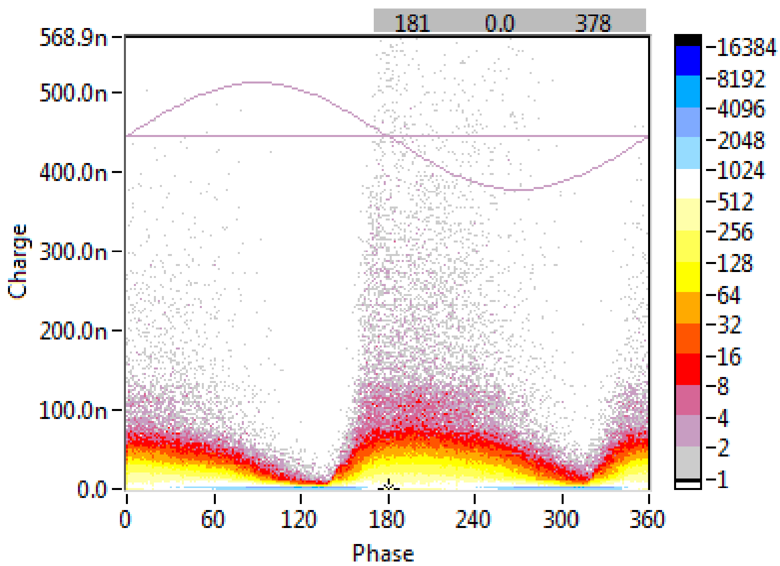
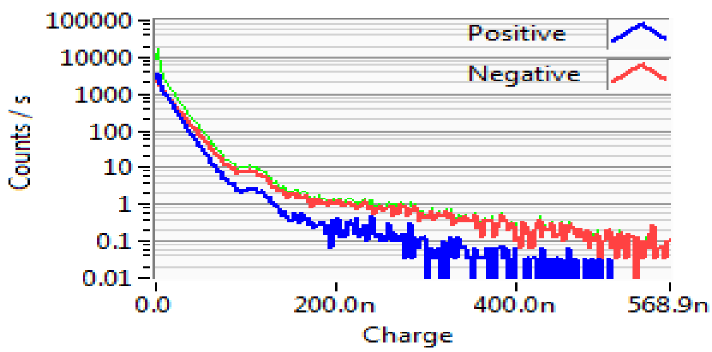
Partial Discharge pattern of R Phase @ 6.35 kV

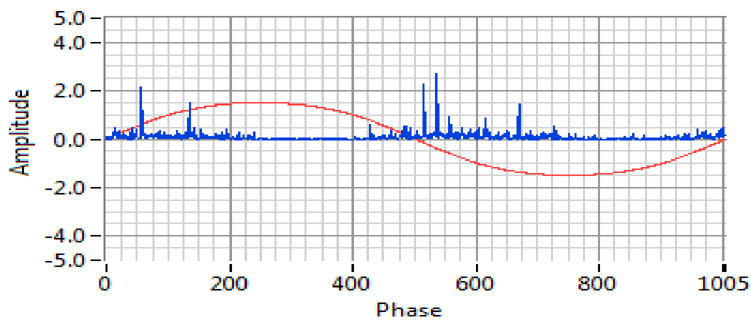
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



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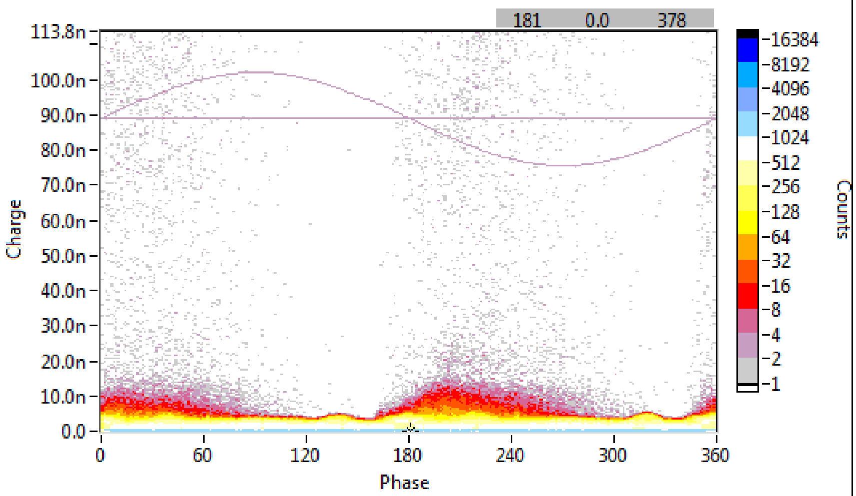
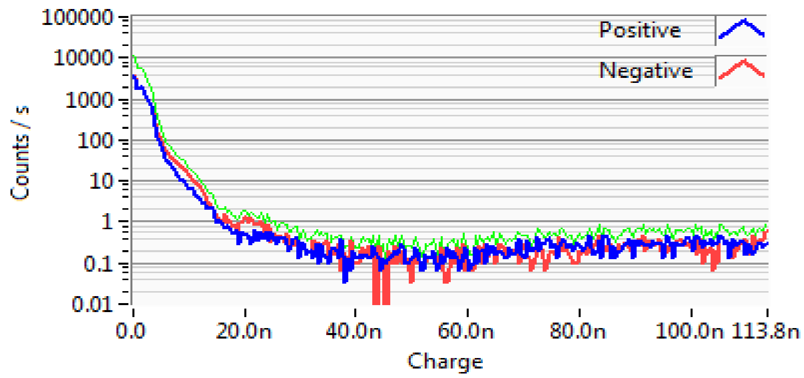
Partial Discharge pattern of Y Phase @ 3 kV

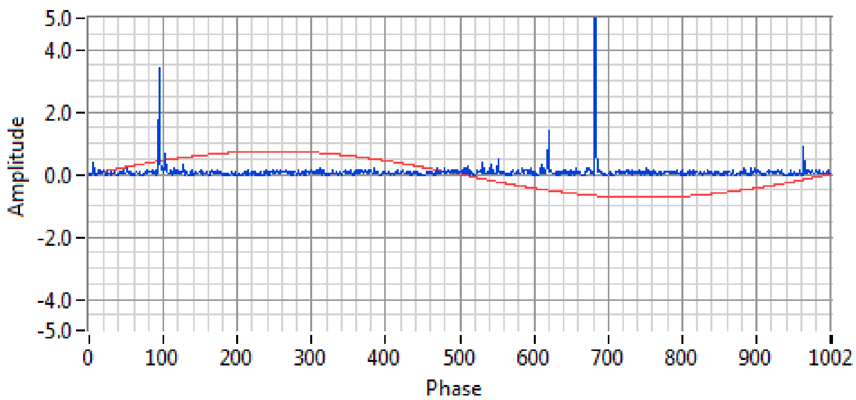
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



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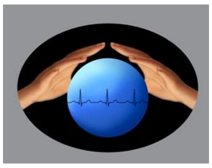
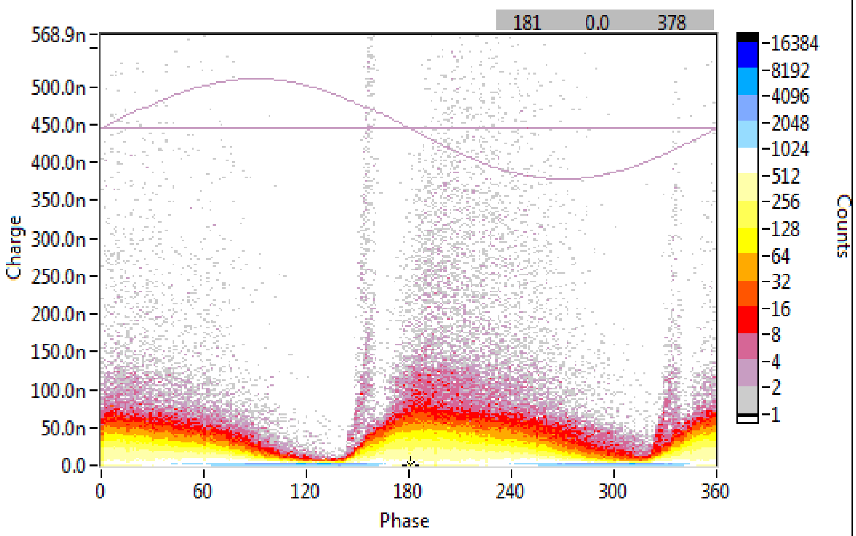
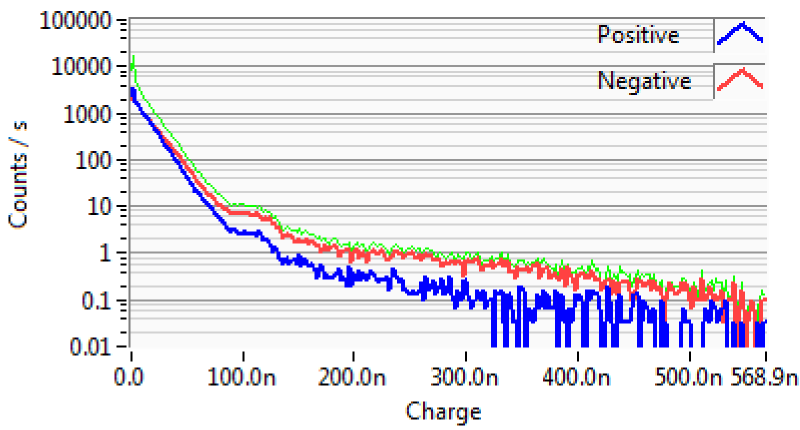
Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**	

Partial Discharge pattern of Y Phase @ 6.35 kV

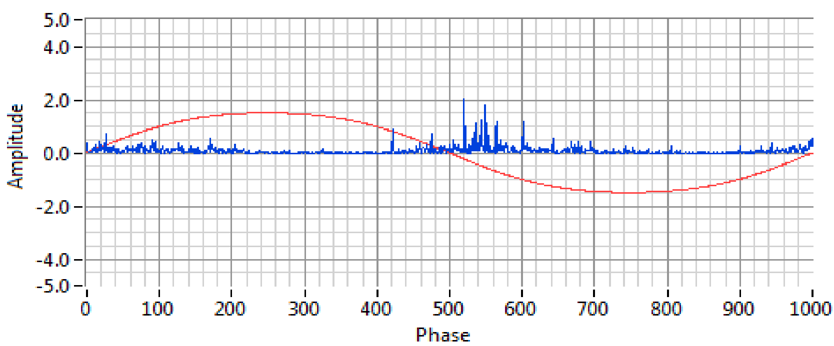
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



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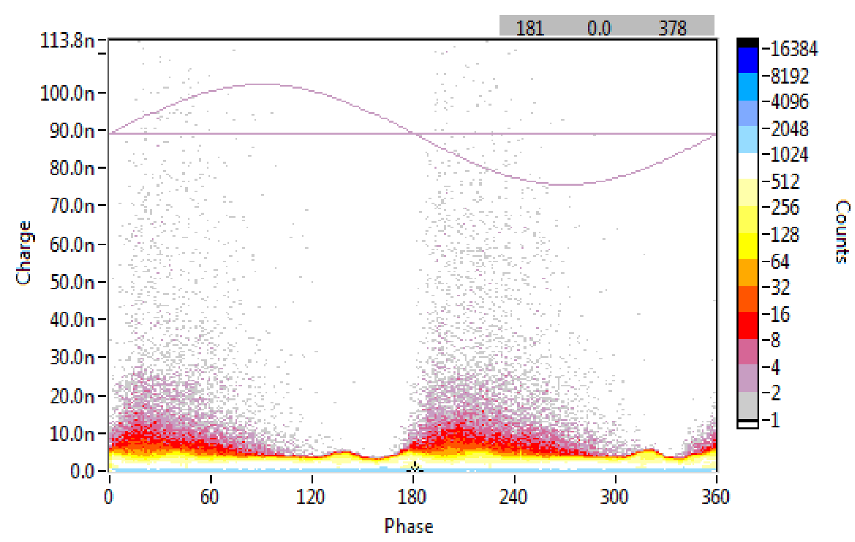
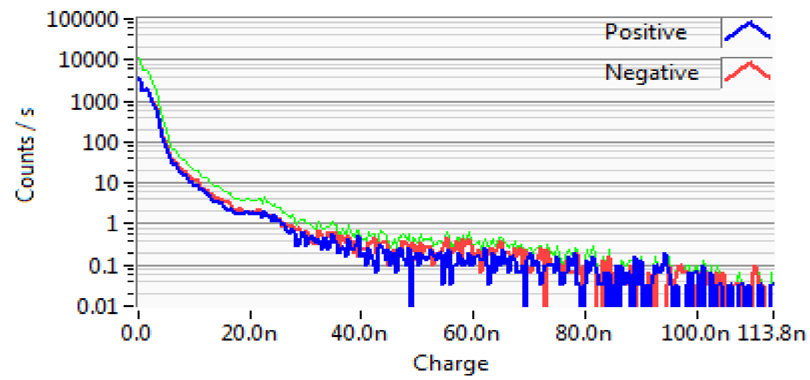
Partial Discharge pattern of B Phase @ 3 kV

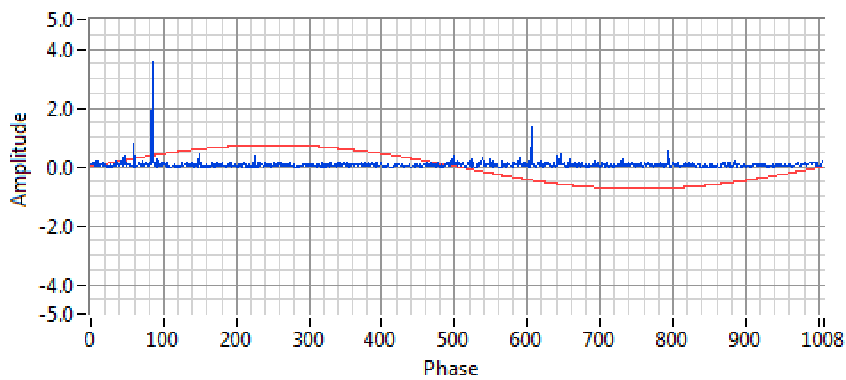
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode

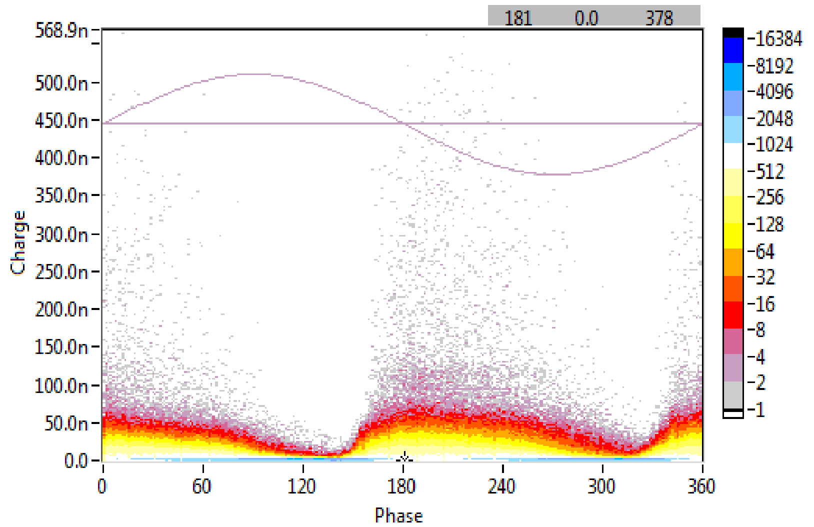


CLIENT: PATIKARI POWER

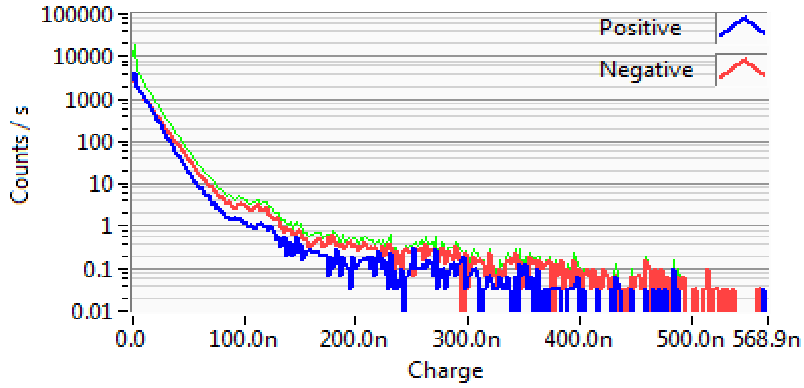
Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**

Partial Discharge pattern of B Phase @ 6.35 kV

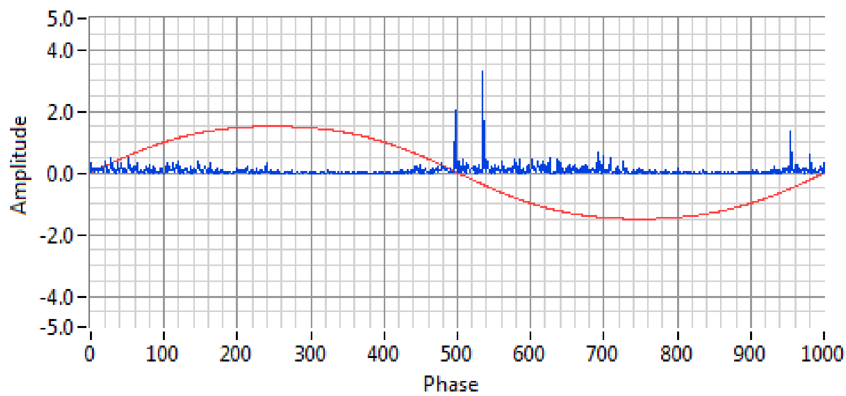
Partial Discharge Pattern



Partial Discharge Characteristics



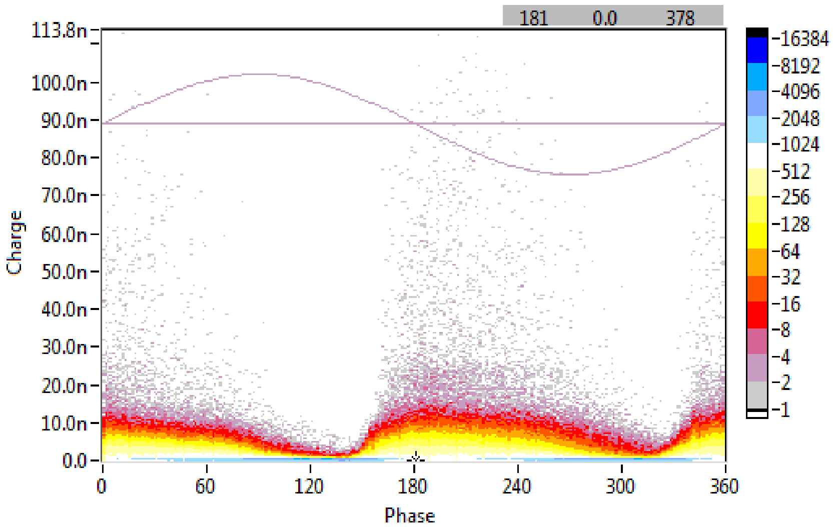
Partial Discharge pattern Oscilloscope mode



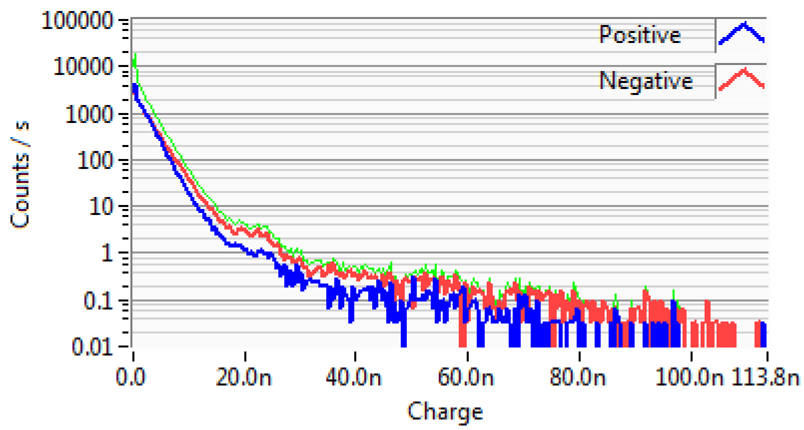
CLIENT: PATIKARI POWER	
Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT,** RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV,** AMPS ›› **509 A,** P.F ›› **0.85.**	

Partial Discharge pattern of RYB Phase @ 3 kV

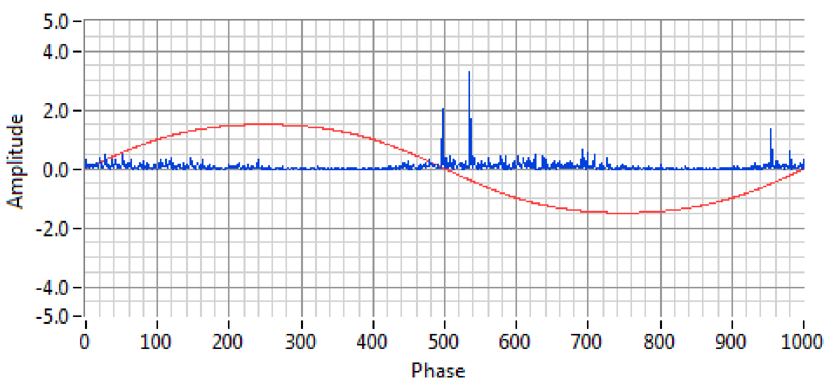
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode

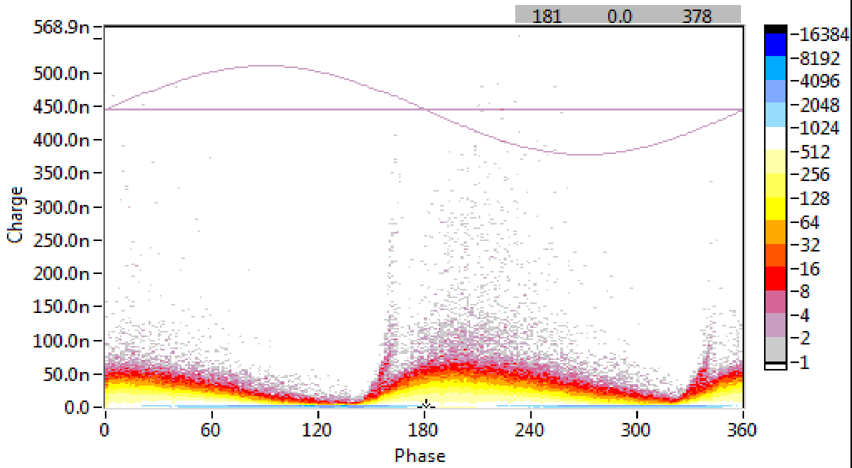


CLIENT: PATIKARI POWER

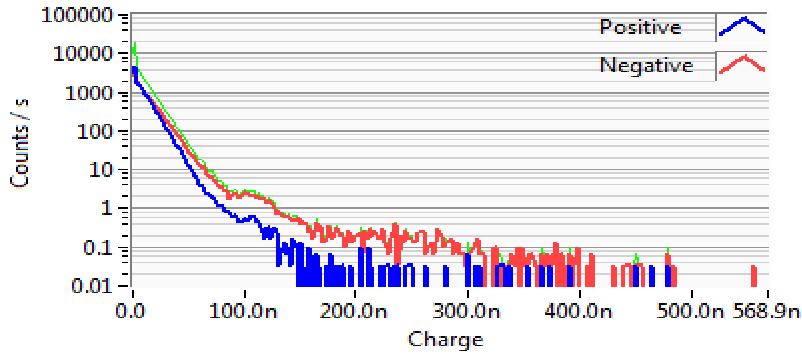
Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT**, RATING ›› **9.4 MVA,** SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV**, AMPS ›› **509 A,** P.F ›› **0.85.**

Partial Discharge pattern of RYB Phase @ 6.35 kV

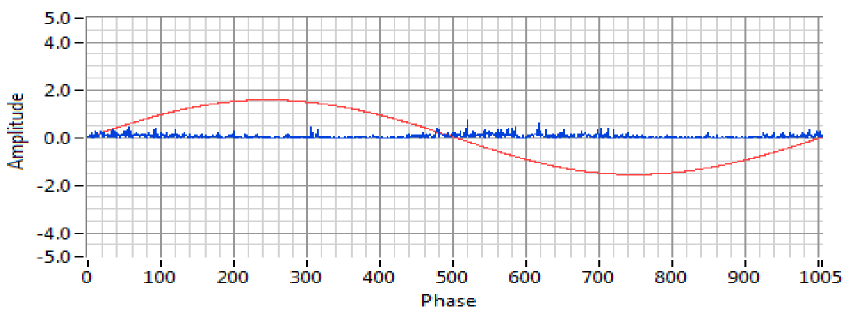
Partial Discharge Pattern



Partial Discharge Characteristics



Partial Discharge pattern Oscilloscope mode



1.4 DIGITAL ELCID TEST

The generator stator core is built from thousands of thin steel sheets (laminations). These laminations are coated with a thin layer of varnish for prevention of circulating induced currents also known as eddy currents, which are induced because of rotating magnetic flux produced by the rotor. Hence, it can be envisaged that any defects in the inter-laminar insulation causes fault currents to flow locally in core. These circulating currents can thus cause localized overheating and hot spots in the damaged areas and this may further damage the core. In extreme cases, sufficient heat is generated to cause melting of small parts of core and premature failure of the winding insulation. Thus these hot spots should be detected and corresponding repair works must be carried out before the condition worsens. Unlike the core ring flux test that had several disadvantages like running of high current/voltage, mechanical stresses etc, the digital ELCID test uses only a fraction (4%) of rated flux level to generate fault currents within the core body. These currents are then sensed by a pick up coil. The digital ELCID test helps in assessing the condition of Generator/motor core and gives vital information in the development of trend analysis, for use in diagnostic and predictive maintenance.

It offers the following facilities:

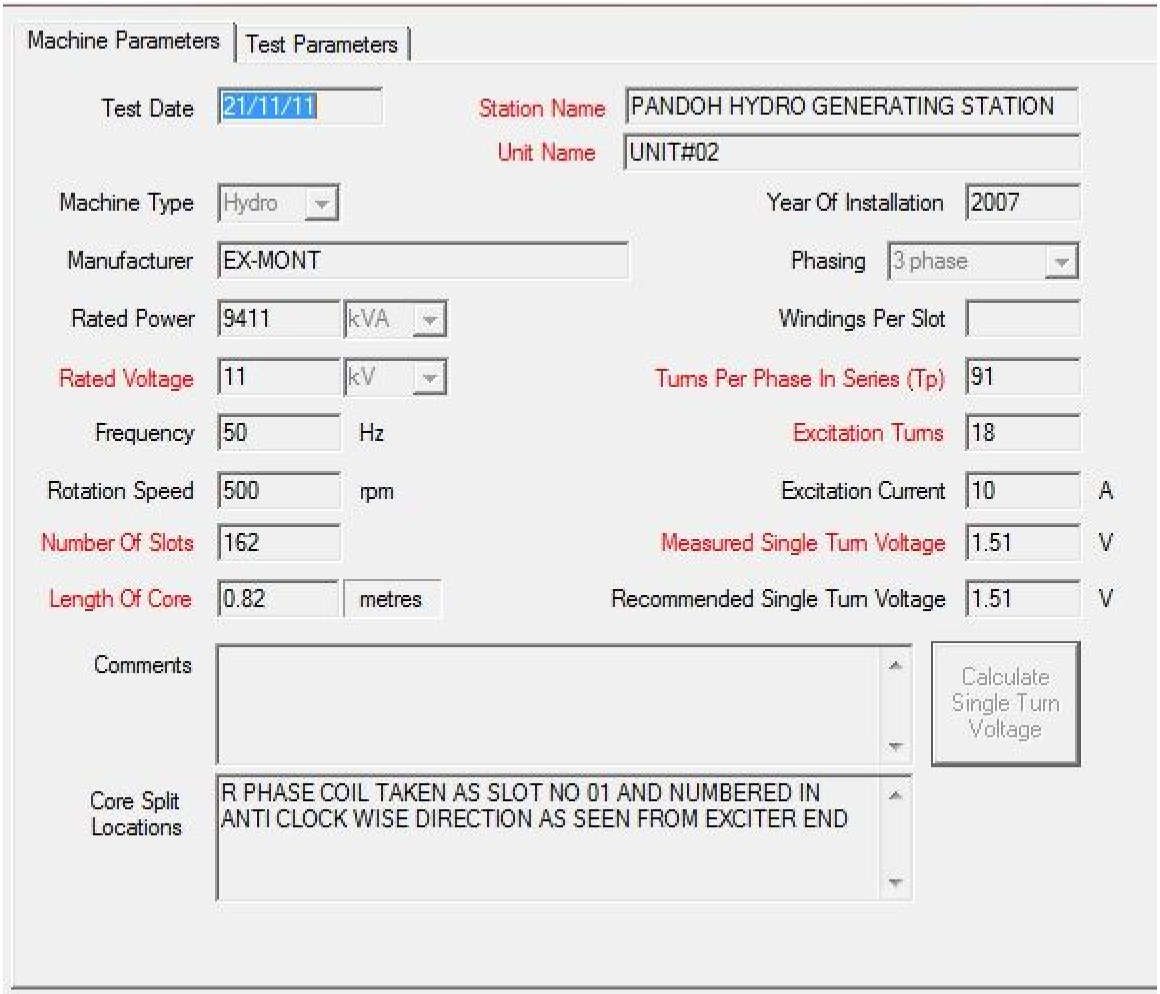
- Identification of faults below the winding.
- Distinguishes between surface faults and deep faults.
- Fault location is pin-pointed accurately.

Principle:

The circumferential magnetic field of the core is due to the excitation, plus that due to any fault currents present. The effect of the magnetic fields is to produce magnetic potential gradient on the core surface. This magnetic potential gradient is detected by specially wound coil known as Chattock coil, which provides an output proportional to the difference in the magnetic potential between its two ends.

The ELCID equipment tests a core for faults by exciting the core using a toroidal winding to produce a ring flux of only 4% of its normal level of excitation. A sensing head (Chattock coil) is then passed over the surface of the core to detect magnetically the presence of fault currents themselves rather than the heating effect they produce. The output of the Chattock coils is a dc voltage proportional to the fault current component in phase quadrature with the core excitation current. The signal is an analogous signal, which is converted into a digital signal and displayed or stored in PC.

TEST DETAILS:


Machine Parameters | Test Parameters

Test Date	21/11/11	Station Name	PANDOH HYDRO GENERATING STATION
		Unit Name	UNIT#02
Machine Type	Hydro	Year Of Installation	2007
Manufacturer	EX-MONT	Phasing	3 phase
Rated Power	9411 kVA	Windings Per Slot	
Rated Voltage	11 kV	Turns Per Phase In Series (Tp)	91
Frequency	50 Hz	Excitation Turns	18
Rotation Speed	500 rpm	Excitation Current	10 A
Number Of Slots	162	Measured Single Turn Voltage	1.51 V
Length Of Core	0.82 metres	Recommended Single Turn Voltage	1.51 V

Comments:

Calculate Single Turn Voltage

Core Split Locations: R PHASE COIL TAKEN AS SLOT NO 01 AND NUMBERED IN ANTI CLOCK WISE DIRECTION AS SEEN FROM EXCITER END

ASSESSMENT:

All the 162 slots were scanned for checking of core inter-laminar insulation shorting. Graphs and tables of maximum fault current in each slot is as follows. The graphs indicate values less than **200 mA** in all slots. The fault current values at few locations in various slots as mentioned in table below is observed to be more than 100 mA.

.

CLIENT: PATIKARI POWER

Machine S. No. ›› 402764-2, MAKE ›› **EX-MONT**, RATING ›› **9.4 MVA**, SPEED ›› **500** RPM , STATOR - VOLTS ›› **11 KV**, AMPS ›› **509 A**, P.F ›› **0.85.**

ELCID FAULT CURRENT PEAK VALUES FOR SLOTS:

	FAULT CURRENT (mA)		FAULT CURRENT (mA)		FAULT CURRENT (mA)
SLOT NO. 1	59	SLOT NO. 31	64	SLOT NO. 61	91
SLOT NO. 2	77	SLOT NO. 32	51	SLOT NO. 62	86
SLOT NO. 3	62	SLOT NO. 33	70	SLOT NO. 63	71
SLOT NO. 4	131	SLOT NO. 34	77	SLOT NO. 64	97
SLOT NO. 5	60	SLOT NO. 35	67	SLOT NO. 65	71
SLOT NO. 6	60	SLOT NO. 36	47	SLOT NO. 66	85
SLOT NO. 7	55	SLOT NO. 37	60	SLOT NO. 67	53
SLOT NO. 8	66	SLOT NO. 38	45	SLOT NO. 68	58
SLOT NO. 9	73	SLOT NO. 39	49	SLOT NO. 69	61
SLOT NO. 10	65	SLOT NO. 40	51	SLOT NO. 70	56
SLOT NO. 11	69	SLOT NO. 41	42	SLOT NO. 71	88
SLOT NO. 12	58	SLOT NO. 42	29	SLOT NO. 72	85
SLOT NO. 13	107	SLOT NO. 43	57	SLOT NO. 73	71
SLOT NO. 14	79	SLOT NO. 44	114	SLOT NO. 74	126
SLOT NO. 15	76	SLOT NO. 45	67	SLOT NO. 75	89
SLOT NO. 16	47	SLOT NO. 46	47	SLOT NO. 76	71
SLOT NO. 17	68	SLOT NO. 47	49	SLOT NO. 77	72
SLOT NO. 18	59	SLOT NO. 48	37	SLOT NO. 78	162
SLOT NO. 19	63	SLOT NO. 49	37	SLOT NO. 79	139
SLOT NO. 20	54	SLOT NO. 50	73	SLOT NO. 80	144
SLOT NO. 21	52	SLOT NO. 51	44	SLOT NO. 81	163
SLOT NO. 22	71	SLOT NO. 52	76	SLOT NO. 82	104
SLOT NO. 23	52	SLOT NO. 53	67	SLOT NO. 83	120
SLOT NO. 24	51	SLOT NO. 54	50	SLOT NO. 84	134
SLOT NO. 25	72	SLOT NO. 55	54	SLOT NO. 85	185
SLOT NO. 26	56	SLOT NO. 56	84	SLOT NO. 86	116
SLOT NO. 27	65	SLOT NO. 57	64	SLOT NO. 87	142
SLOT NO. 28	49	SLOT NO. 58	30	SLOT NO. 88	97
SLOT NO. 29	41	SLOT NO. 59	81	SLOT NO. 89	61
SLOT NO. 30	89	SLOT NO. 60	93	SLOT NO. 90	96

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	FAULT CURRENT (mA)		FAULT CURRENT (mA)
SLOT NO. 91	123	SLOT NO. 122	52
SLOT NO. 92	122	SLOT NO. 123	49
SLOT NO. 93	82	SLOT NO. 124	58
SLOT NO. 94	91	SLOT NO. 125	88
SLOT NO. 95	82	SLOT NO. 126	63
SLOT NO. 96	64	SLOT NO. 127	69
SLOT NO. 97	58	SLOT NO. 128	47
SLOT NO. 98	122	SLOT NO. 129	43
SLOT NO. 99	49	SLOT NO. 130	58
SLOT NO. 100	111	SLOT NO. 131	45
SLOT NO. 101	164	SLOT NO. 132	42
SLOT NO. 102	63	SLOT NO. 133	67
SLOT NO. 103	76	SLOT NO. 134	73
SLOT NO. 104	79	SLOT NO. 135	97
SLOT NO. 105	87	SLOT NO. 136	90
SLOT NO. 106	87	SLOT NO. 137	42
SLOT NO. 107	73	SLOT NO. 138	86
SLOT NO. 108	76	SLOT NO. 139	77
SLOT NO. 109	61	SLOT NO. 140	88
SLOT NO. 110	48	SLOT NO. 141	56
SLOT NO. 111	56	SLOT NO. 142	78
SLOT NO. 112	53	SLOT NO. 143	129
SLOT NO. 113	53	SLOT NO. 144	157
SLOT NO. 114	64	SLOT NO. 145	88
SLOT NO. 115	56	SLOT NO. 146	89
SLOT NO. 116	55	SLOT NO. 147	61
SLOT NO. 117	43	SLOT NO. 148	114
SLOT NO. 118	47	SLOT NO. 149	139
SLOT NO. 119	54	SLOT NO. 150	178
SLOT NO. 120	46	SLOT NO. 151	142
SLOT NO. 121	53	SLOT NO. 152	70

	FAULT CURRENT (mA)		FAULT CURRENT (mA)
SLOT NO. 153	76	SLOT NO. 158	77
SLOT NO. 154	52	SLOT NO. 159	74
SLOT NO. 155	58	SLOT NO. 160	91
SLOT NO. 156	62	SLOT NO. 161	64
SLOT NO. 157	83	SLOT NO. 162	66

ELCID FAULT CURRENT PEAK VALUES FOR SLOTS WHOSE VALUES ARE GREATER THAN 100 mA:

	FAULT CURRENT (mA)		FAULT CURRENT (mA)
SLOT NO. 4	131	SLOT NO. 87	142
SLOT NO. 13	107	SLOT NO. 91	123
SLOT NO. 44	114	SLOT NO. 92	122
SLOT NO. 74	126	SLOT NO. 98	122
SLOT NO. 78	162	SLOT NO. 100	111
SLOT NO. 79	139	SLOT NO. 101	164
SLOT NO. 80	144	SLOT NO. 143	129
SLOT NO. 81	163	SLOT NO. 144	157
SLOT NO. 82	104	SLOT NO. 148	114
SLOT NO. 83	120	SLOT NO. 149	139
SLOT NO. 84	134	SLOT NO. 150	178
SLOT NO. 85	185	SLOT NO. 151	142
	SLOT NO. 86	116	

CLIENT: PATIKARI POWER
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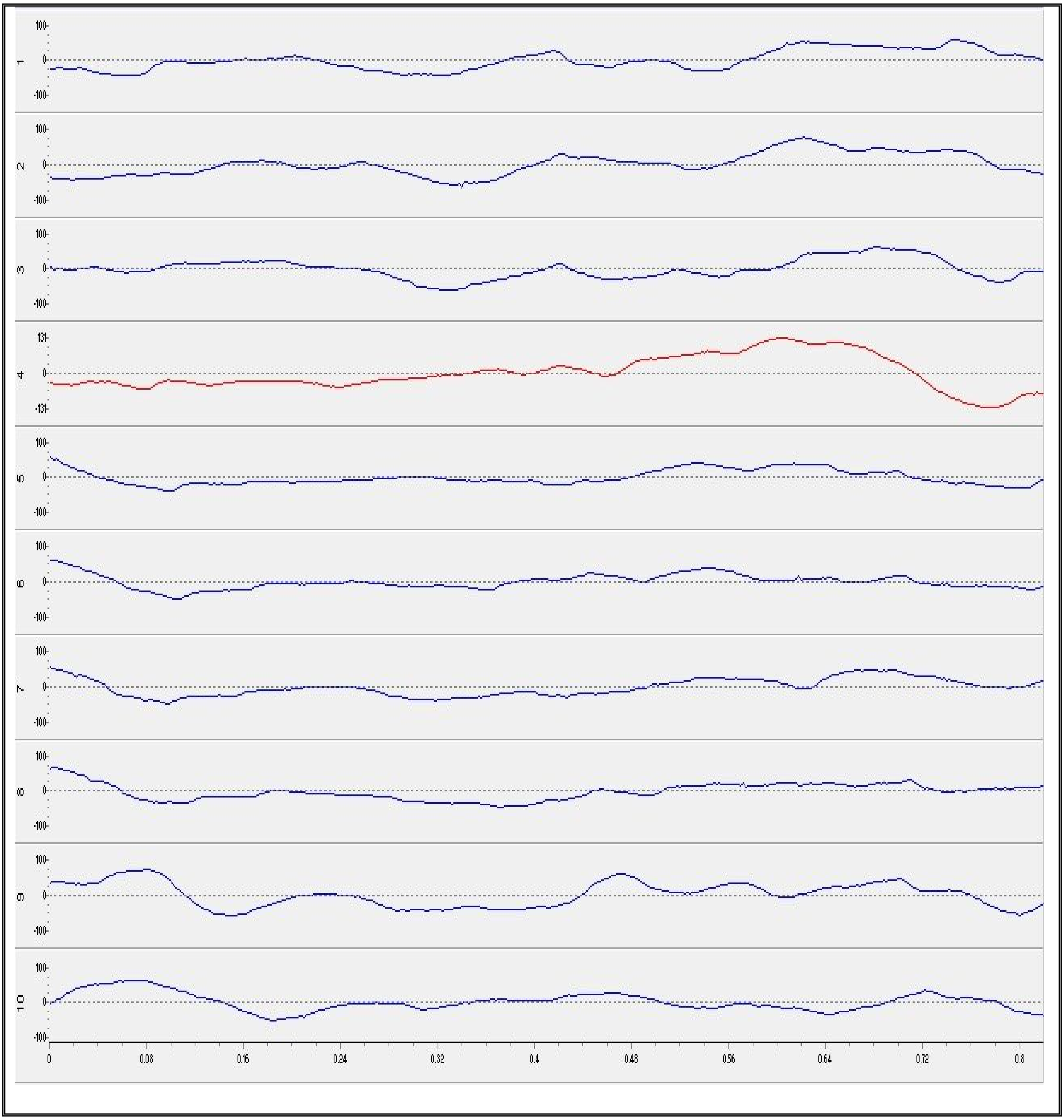
ELCID GRAPHS :



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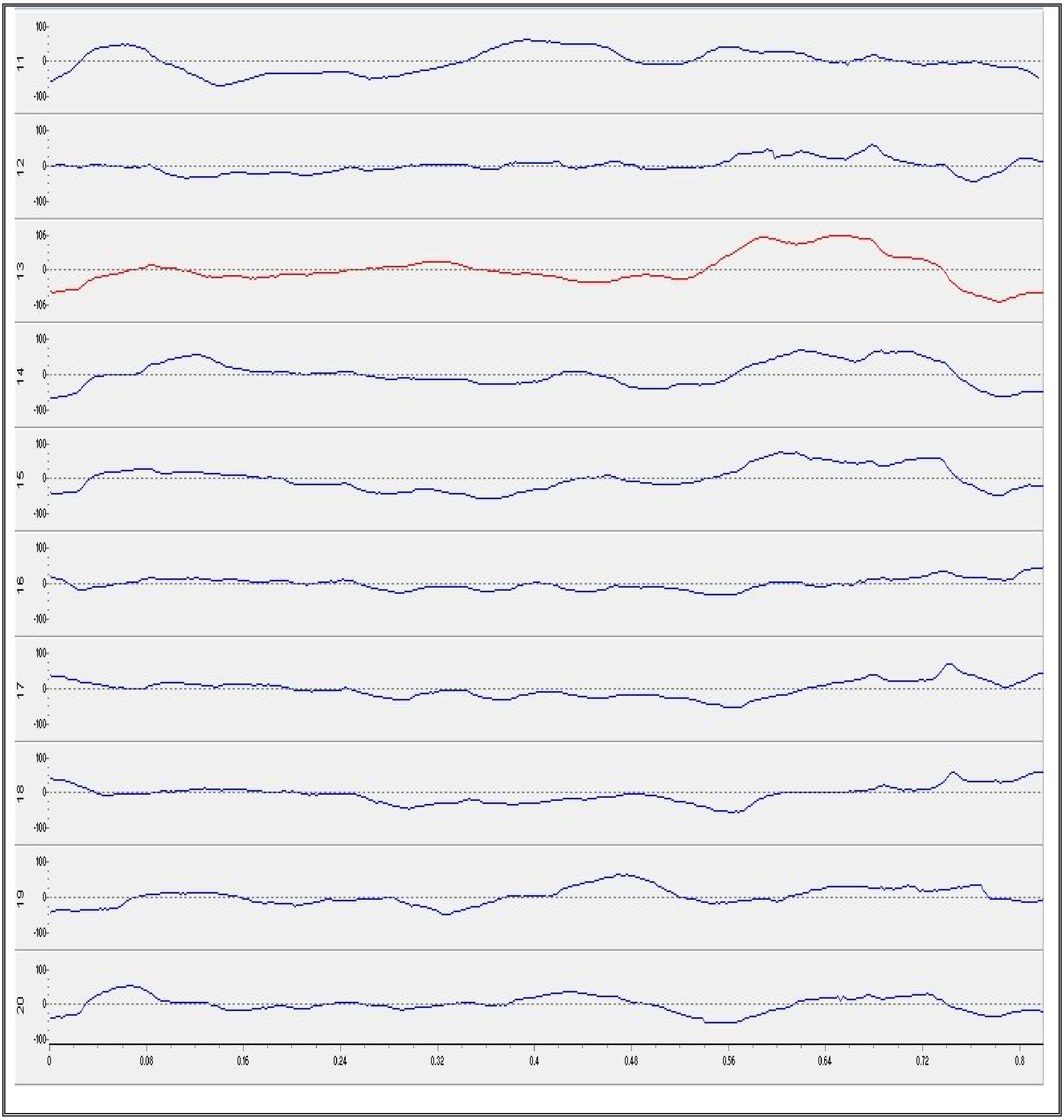

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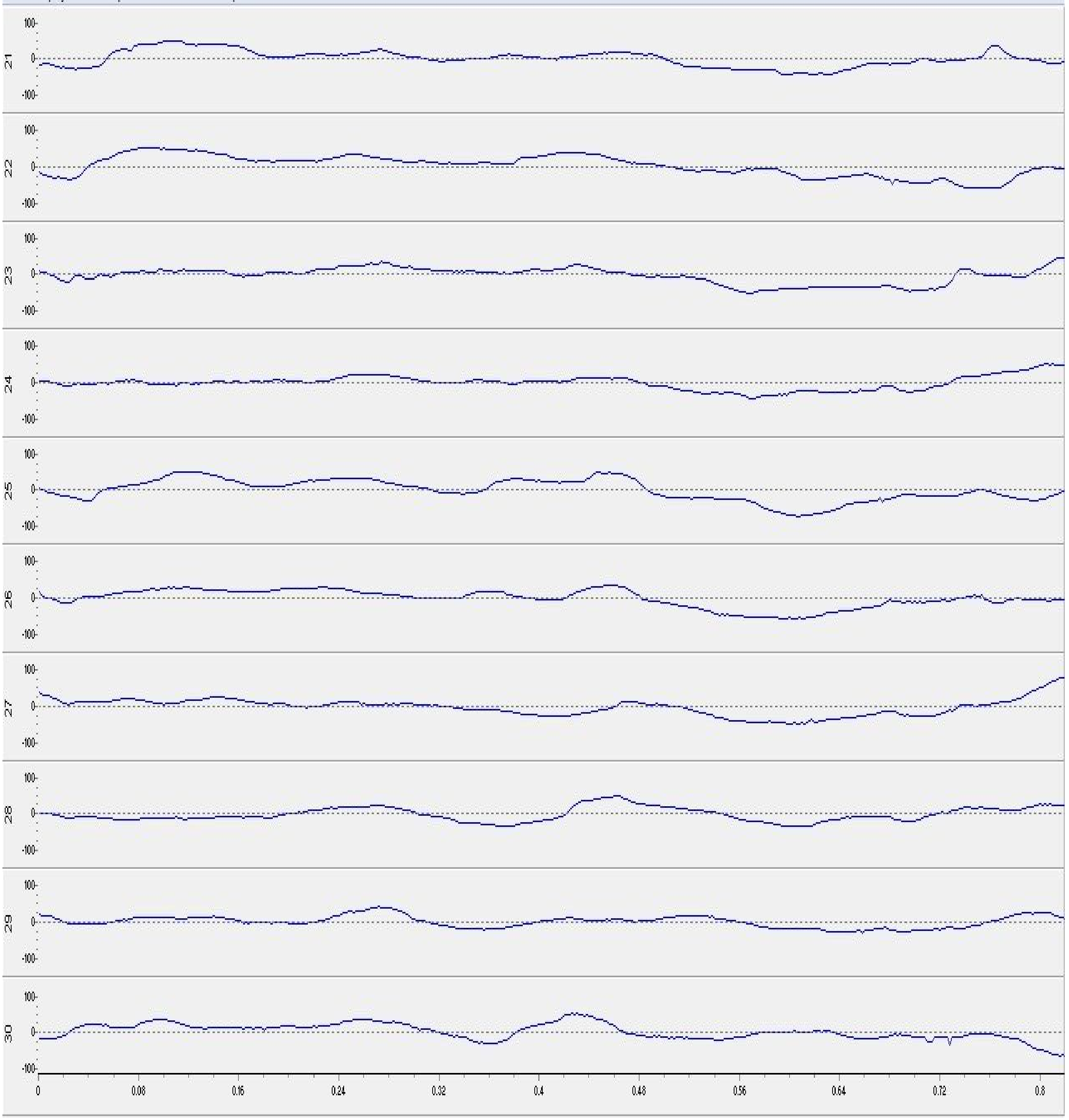
P.F ›› **0.85.**



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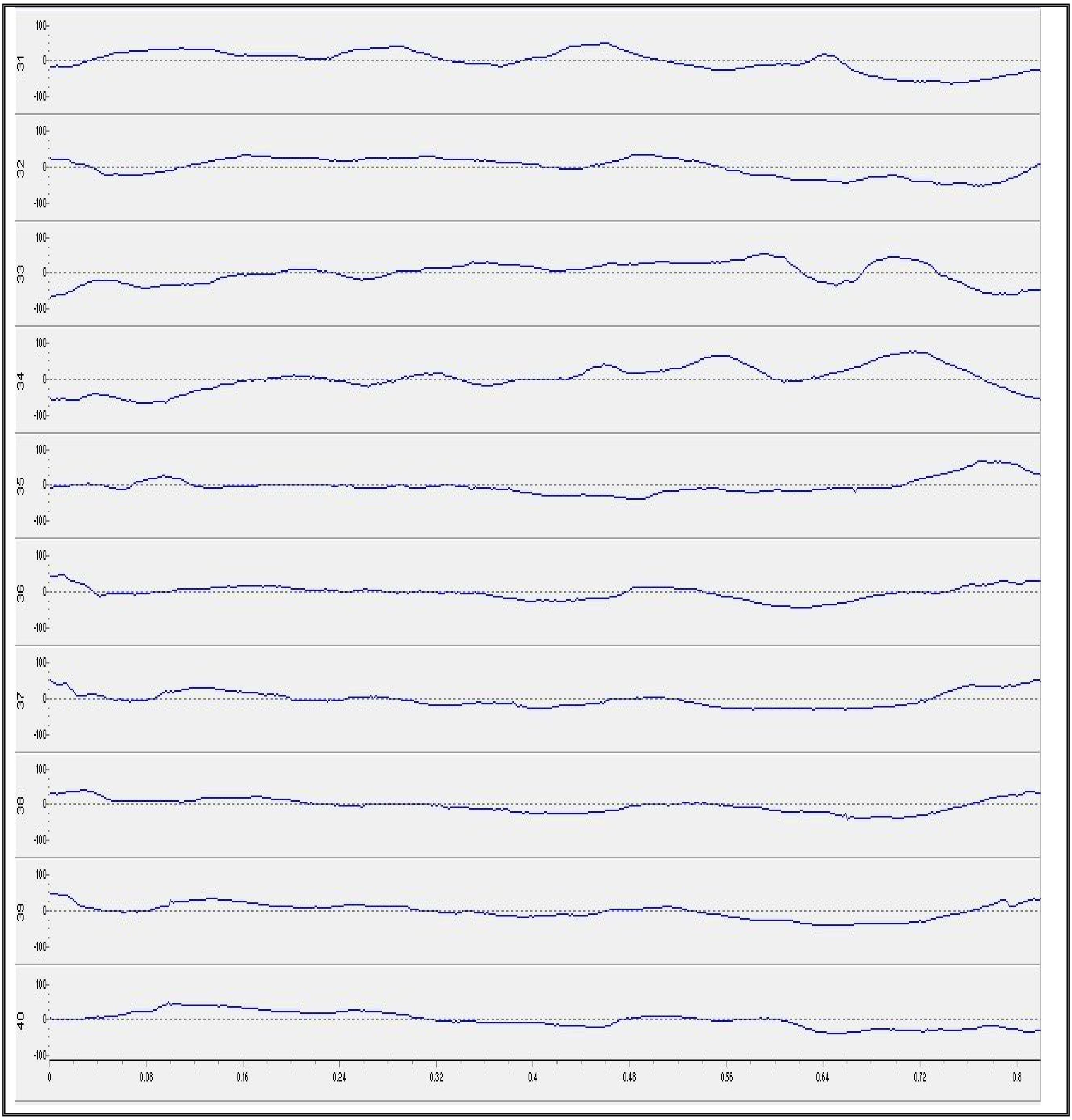

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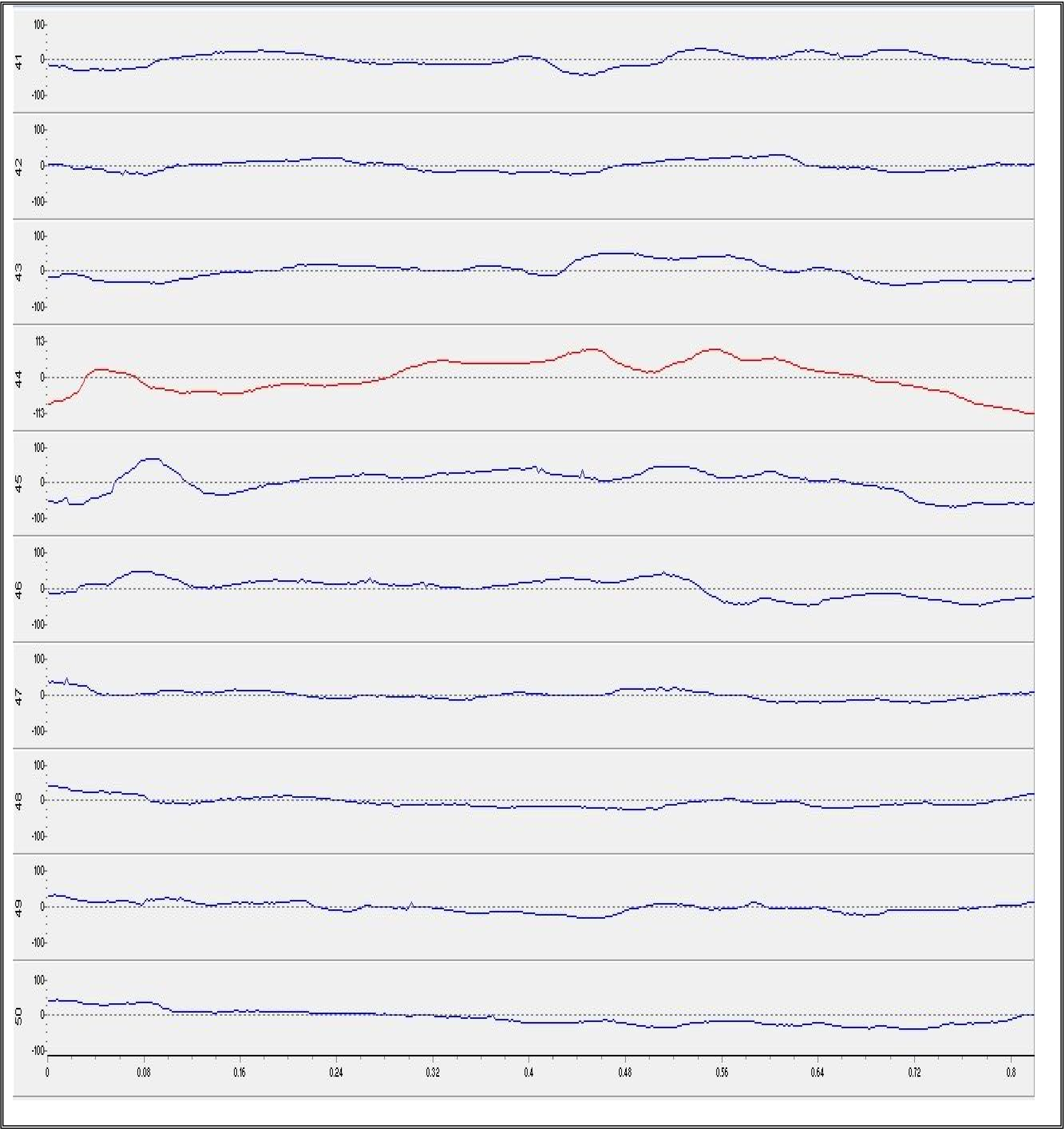

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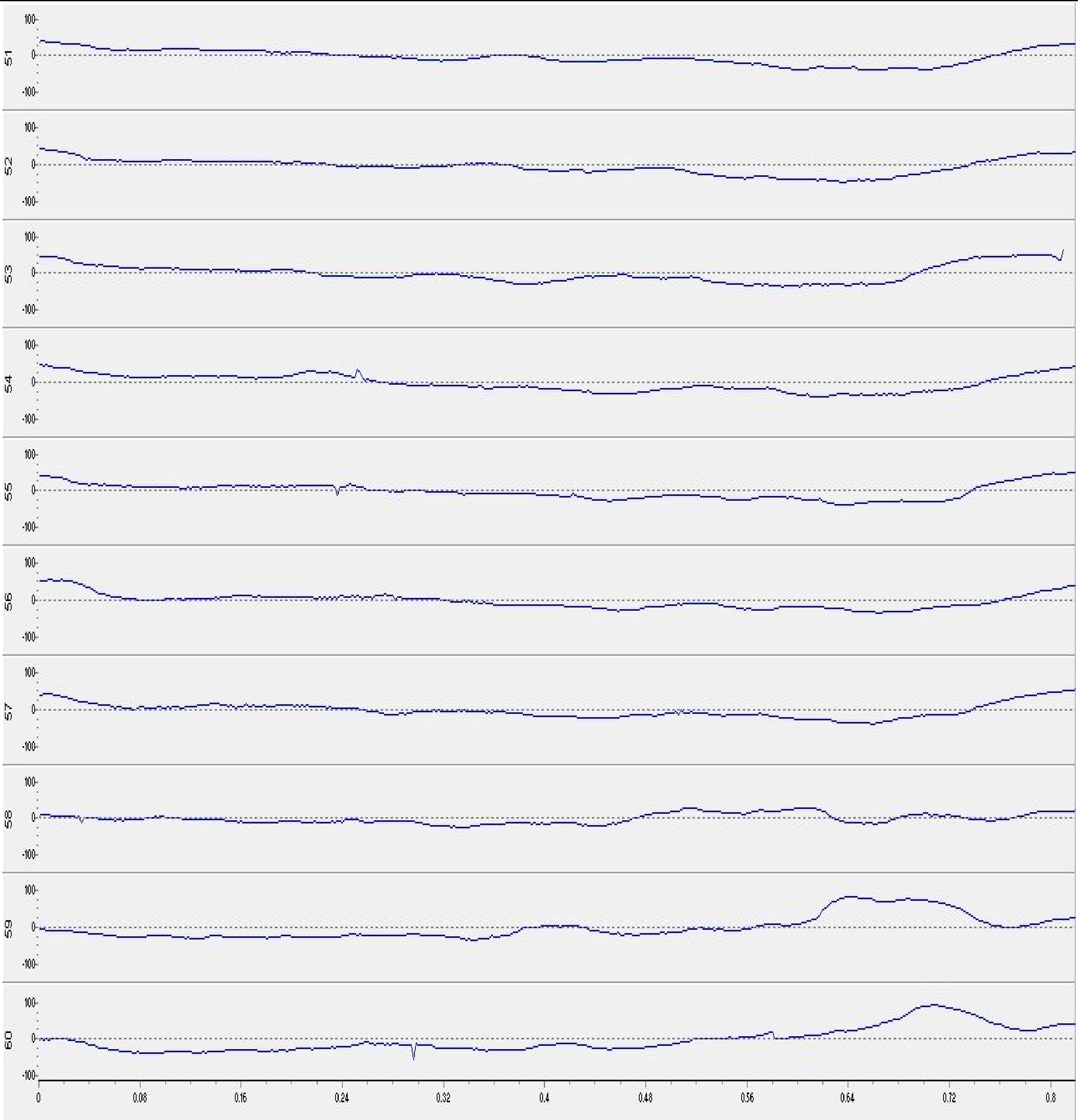

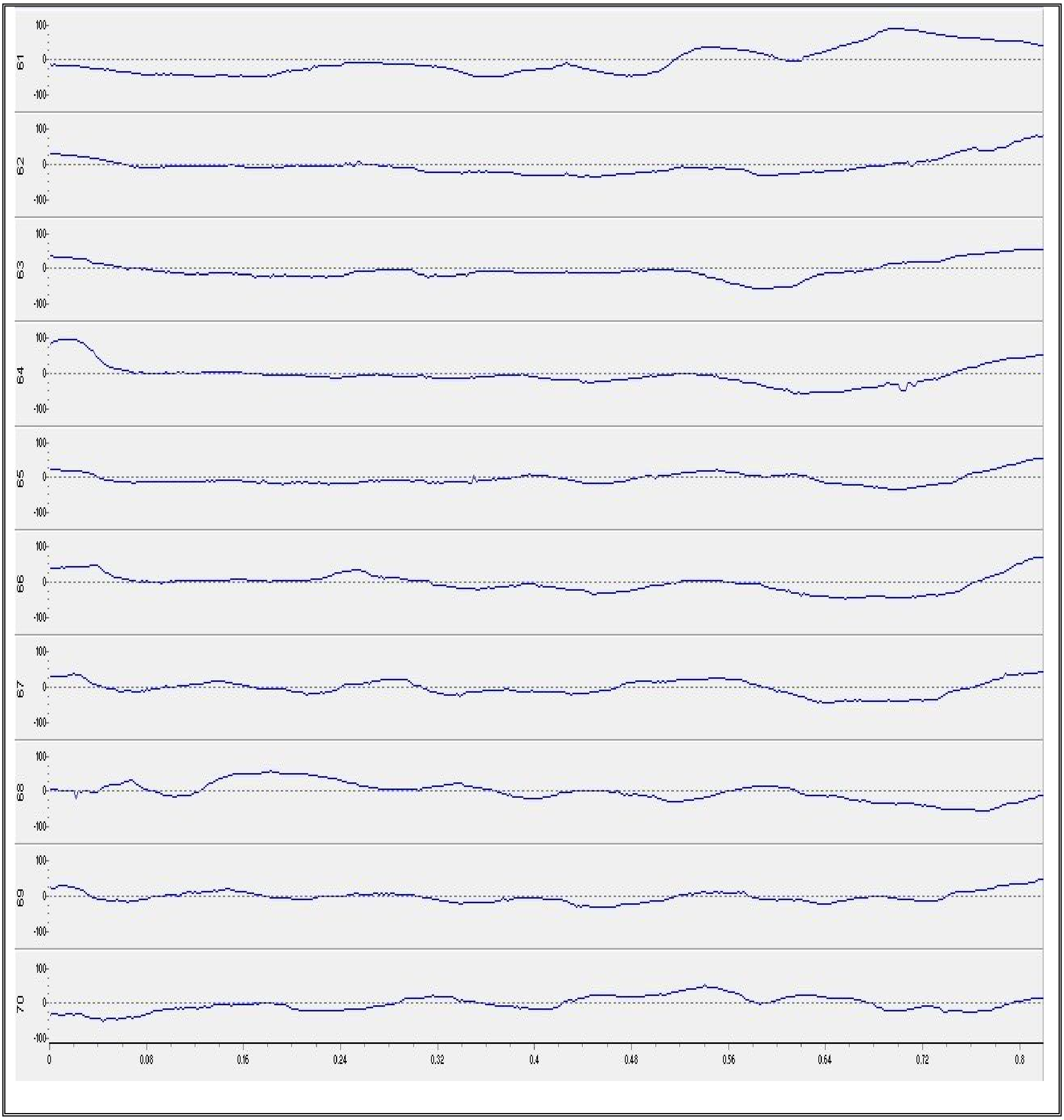

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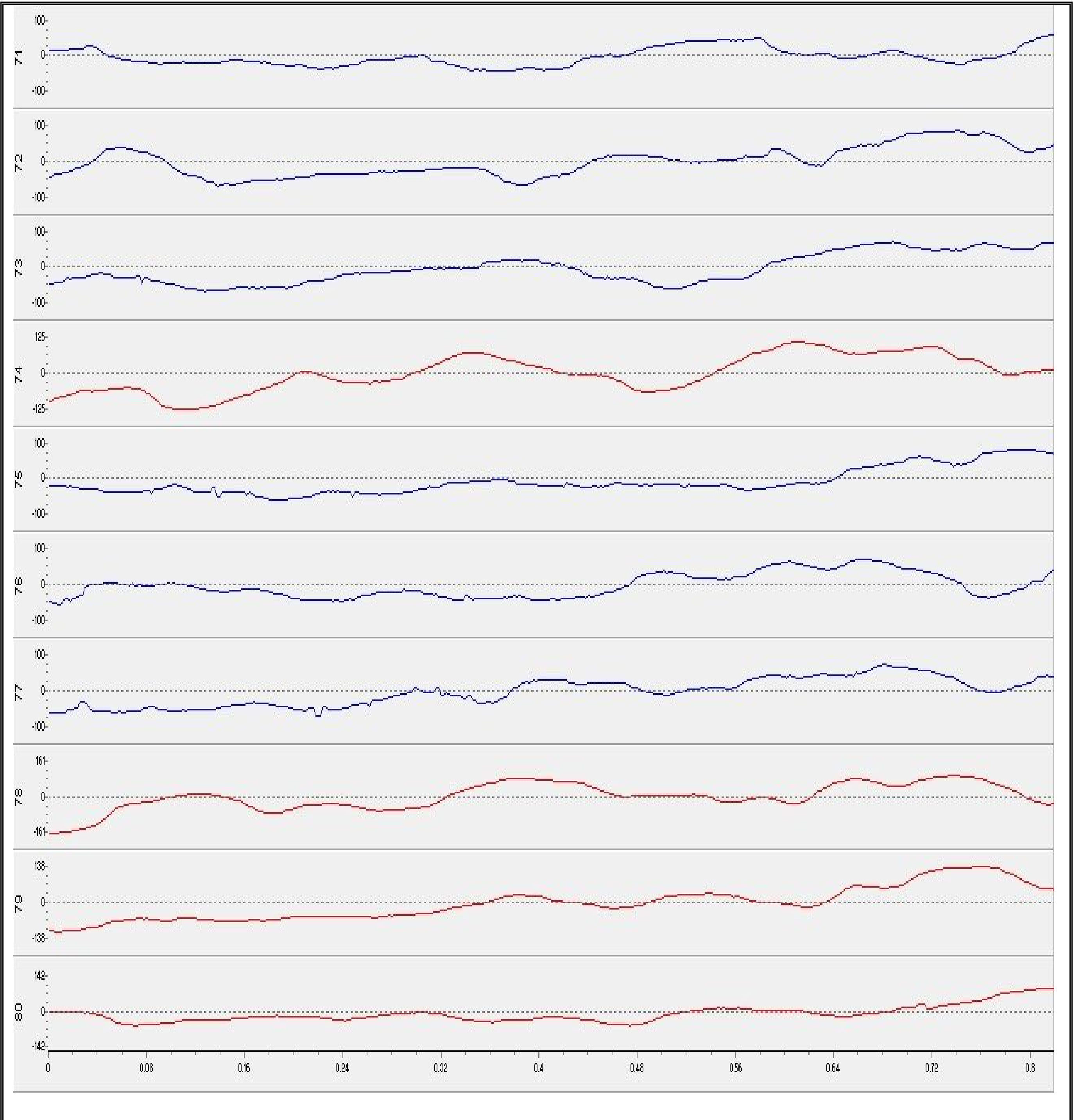

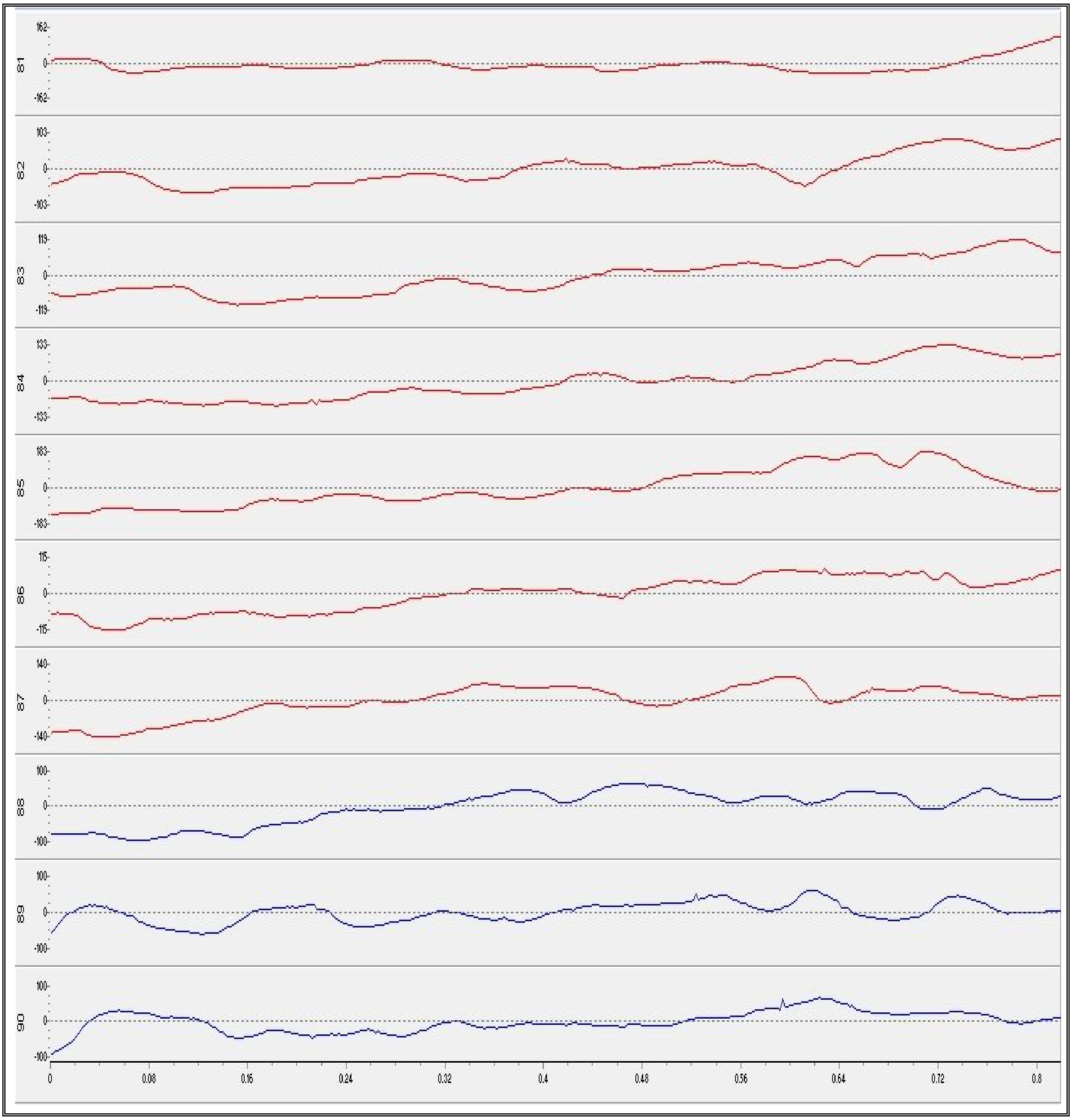
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-100
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0.08
0.16
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0.48
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0.72
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CLIENT: PATIKARI POWER

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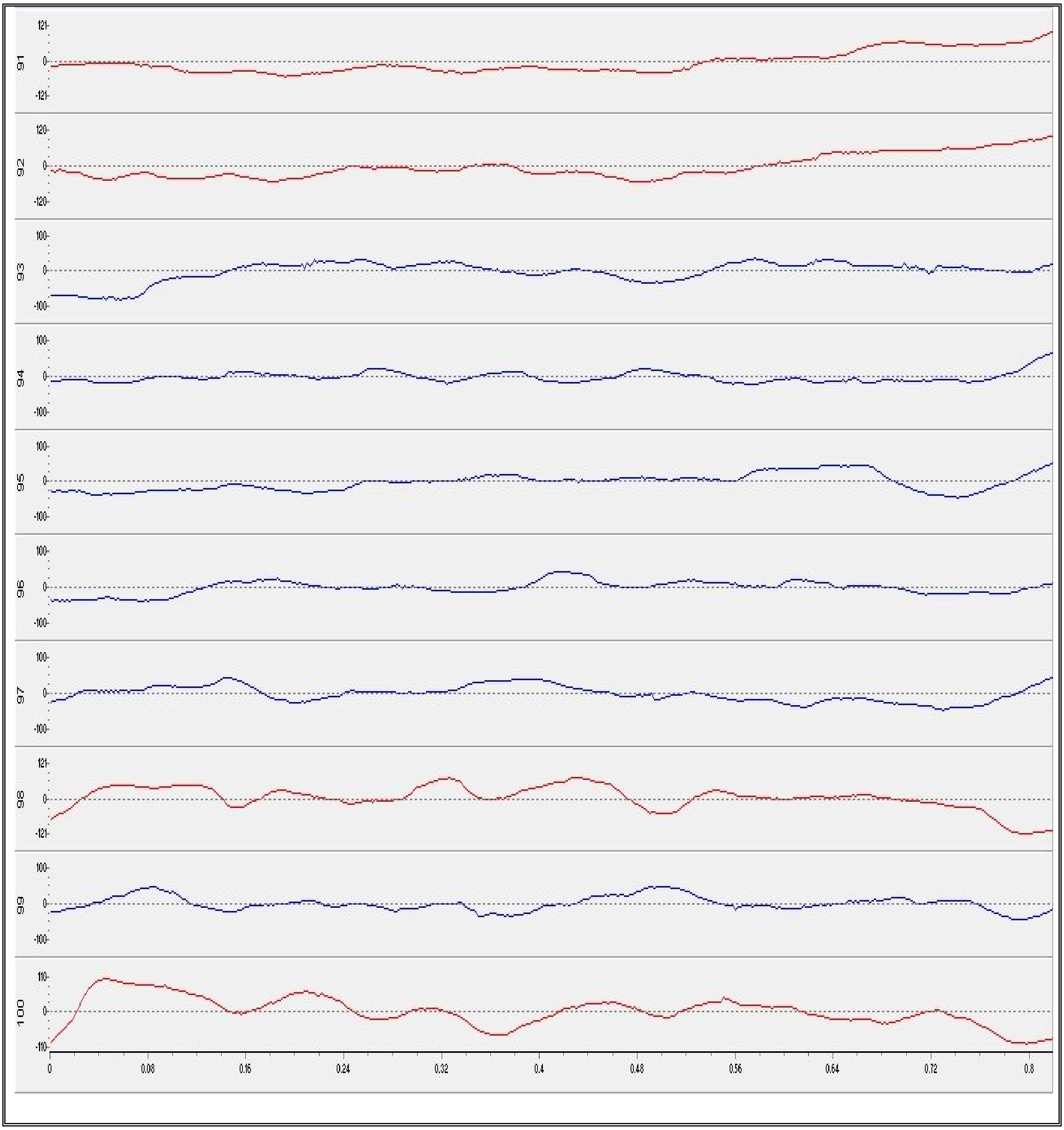

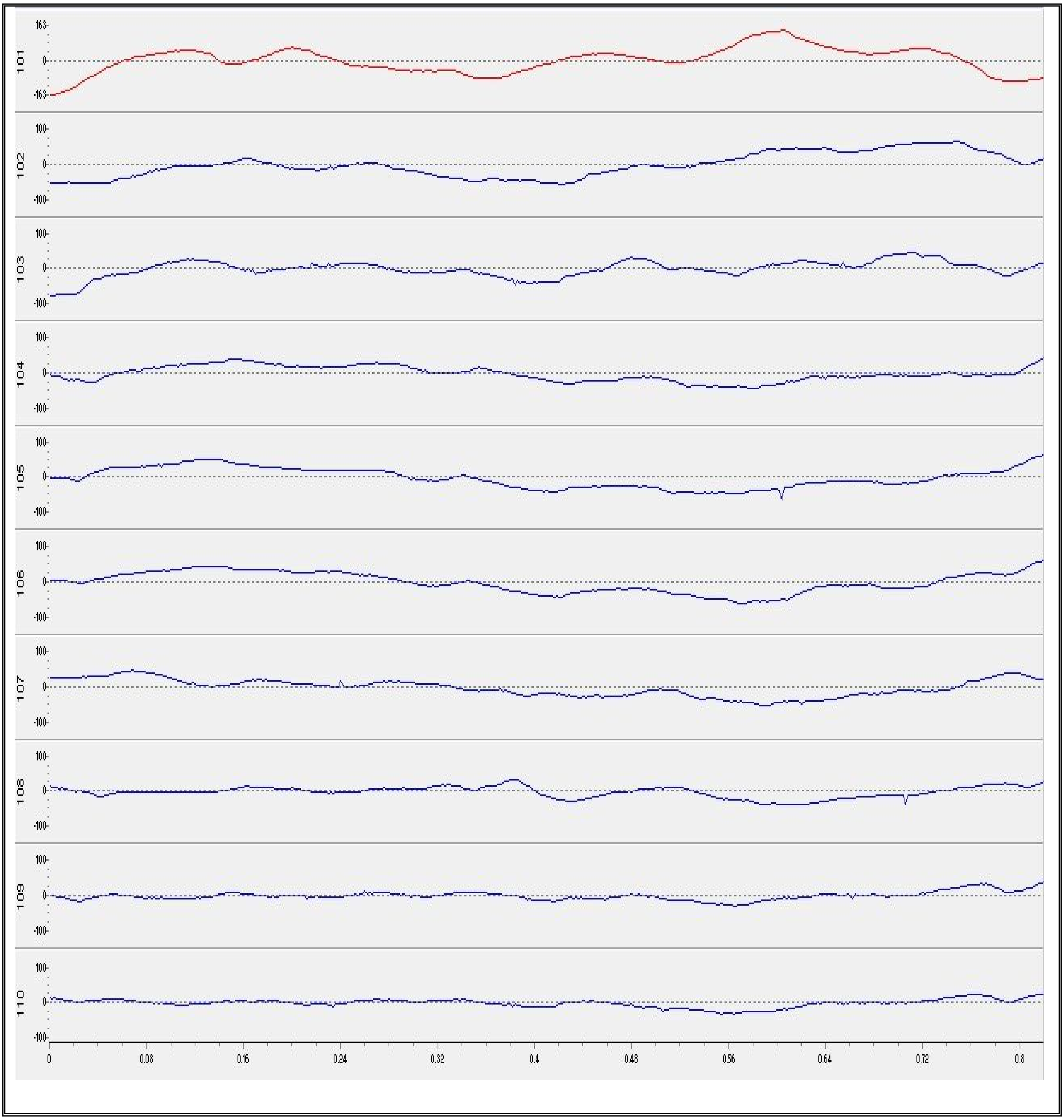
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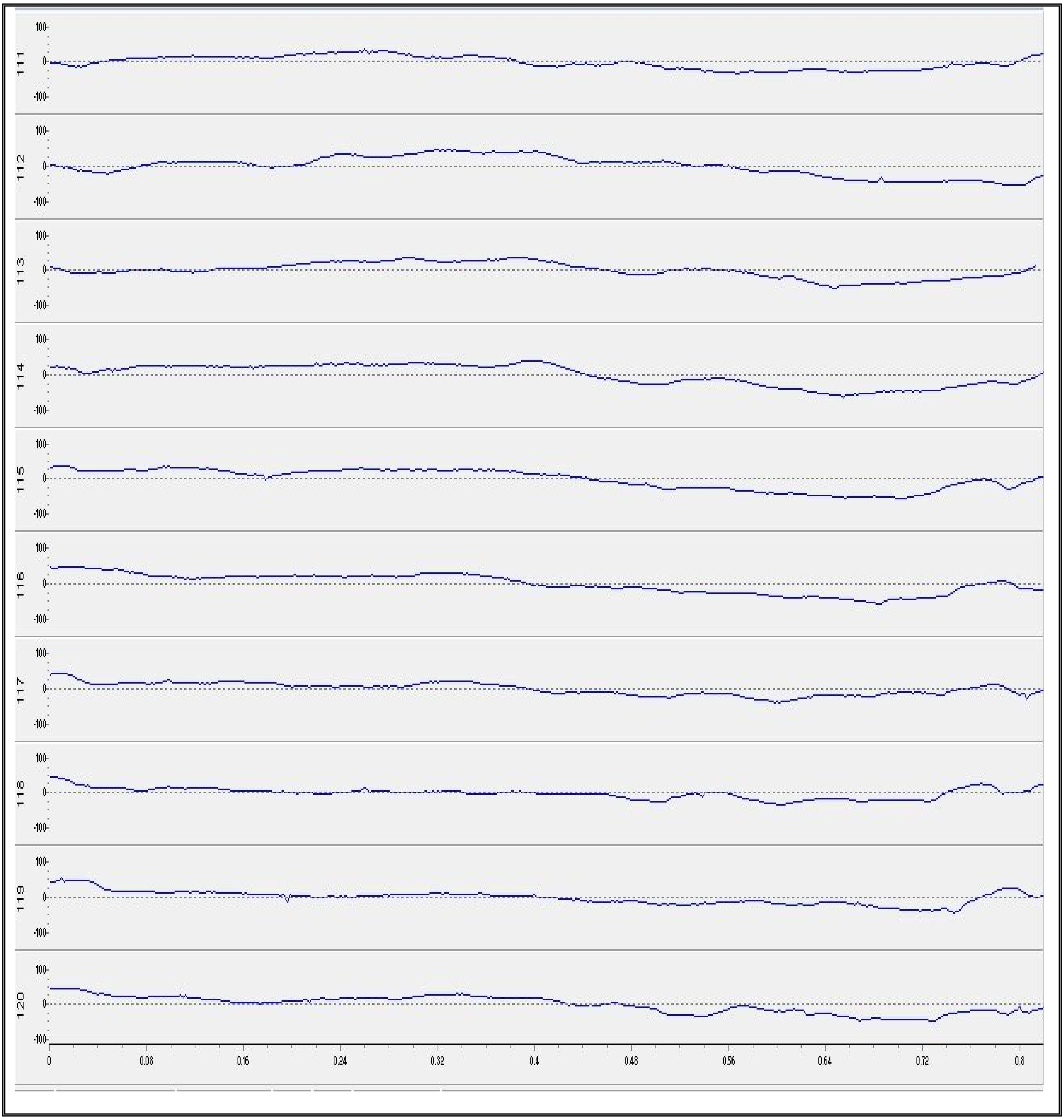

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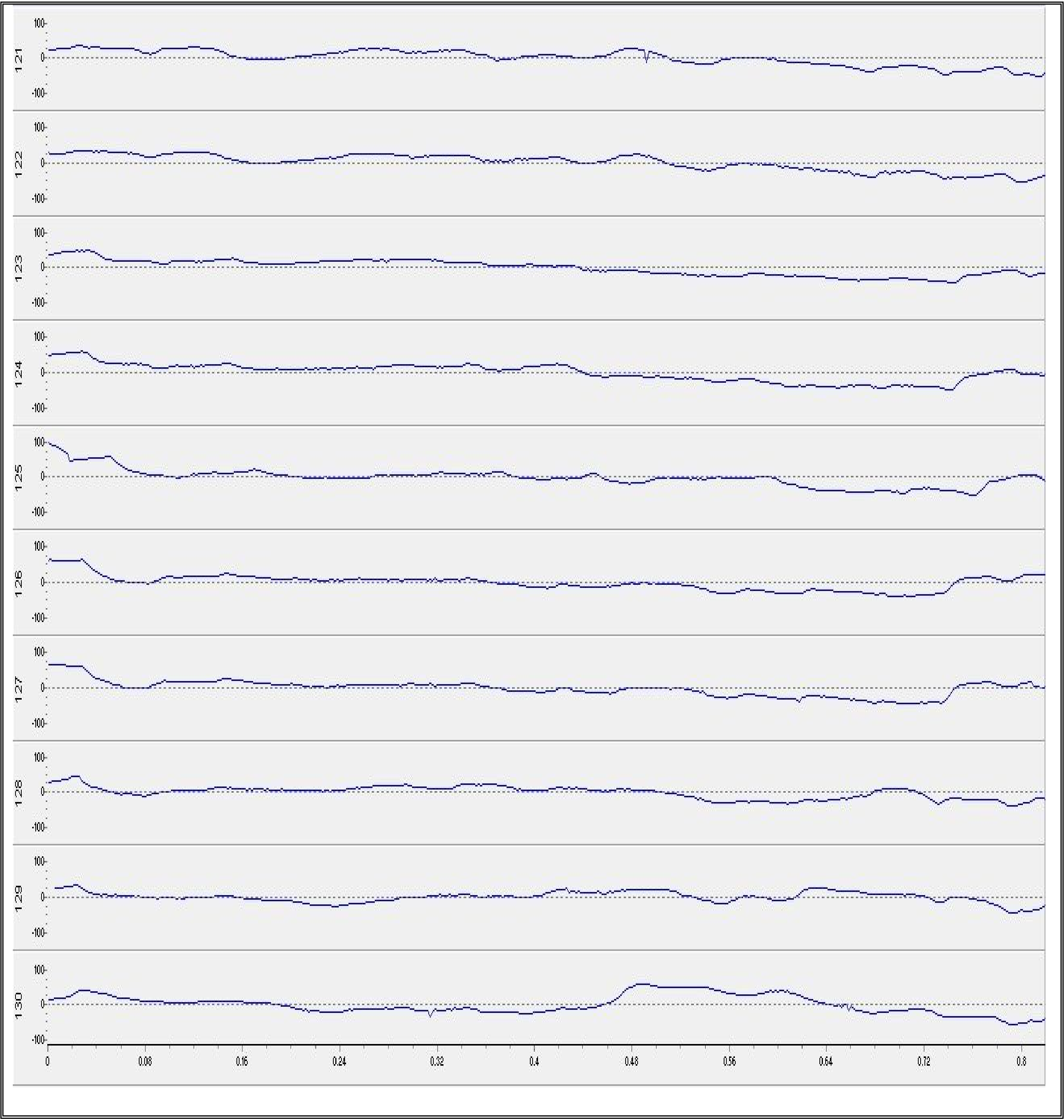

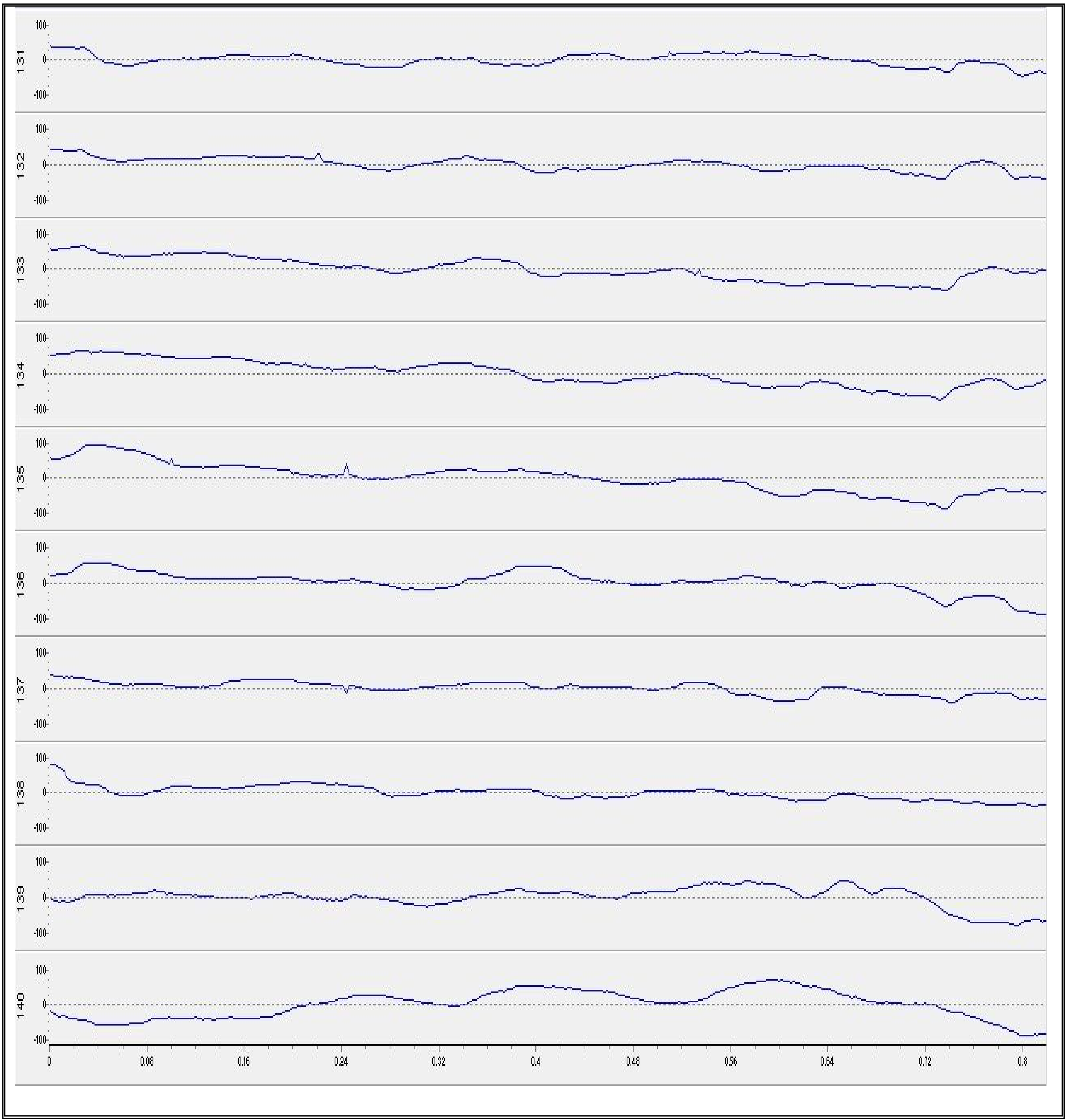
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CLIENT: PATIKARI POWER

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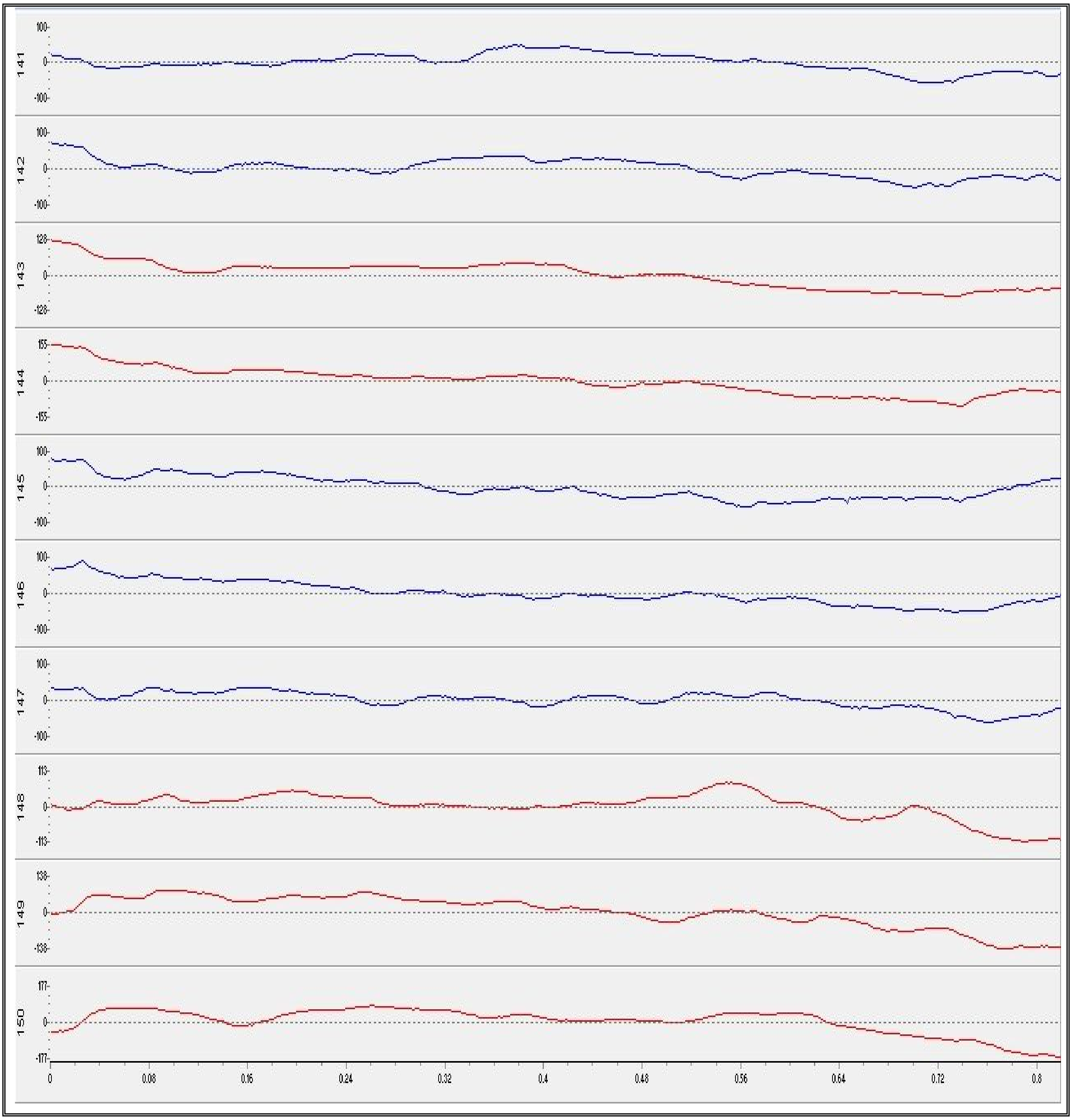

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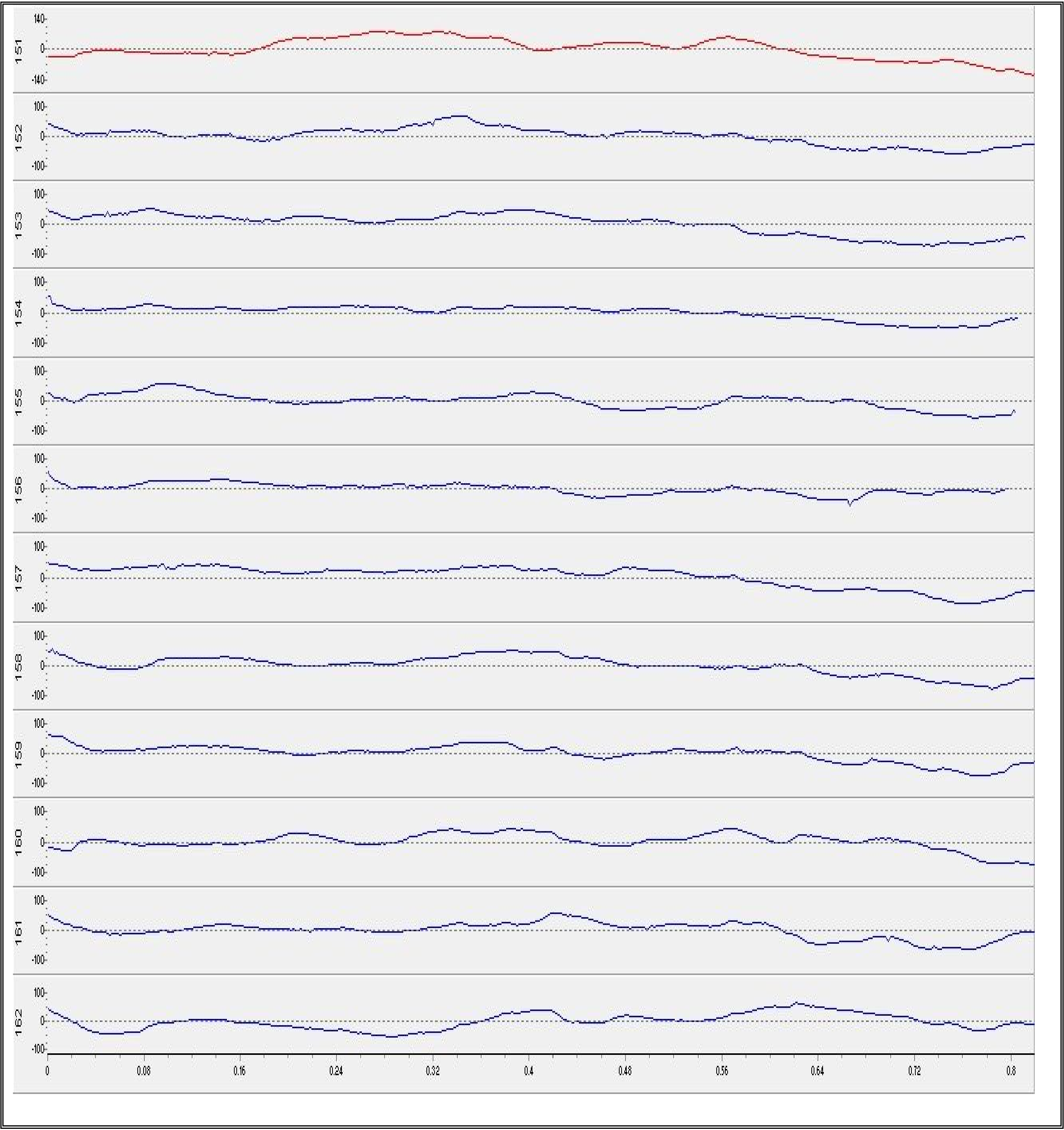

2.0 ANALYSIS

2.1 ASSESSMENT ON GENERATOR

2.1.1 STATOR WINDING

Insulation Resistance (IR) and Polarisation Index (PI) values obtained are within Acceptable range. The values indicate that the winding is free from contamination and other major abnormalities. The comparative analysis of IR and PI test results among the phases indicate B phase IR values are on lower side as compared to other two phases.

The base tan delta values obtained are within limits indicating no surface contamination on the winding insulation. The tan delta values for all phases with rise of voltage are seen to increase with voltage steeply. This indicates high dielectric power loss indicating voids in the insulation and activity of partial discharges in the winding insulation to large extent. The tan delta tip up value on all phases is near to limits indicating that the partial discharge activity is on higher side. The void content in the winding insulation derived is above limits, clearly indicating the high partial discharge activity present in the insulation. Also the capacitance and tan delta graphs with voltage rise indicate high discharges in the voids present in the insulation.

Partial Discharge pattern for all phases suggest that the partial discharges are occurring at slot region and end winding region, the discharge pattern also indicates the internal discharges occurring within the insulation. Partial discharge magnitude charge value as measured is found to be on much higher side, indicating that the discharge levels in the winding are occurring to greater extent. The partial discharge inception voltage is also found to be on lower side indicating deterioration of insulation condition. Assessment indicates the partial discharges levels on this winding are much above limits for this type and age of insulation.

2.1.2 STATOR CORE

The ELCID test results indicate fault current values less than **200 mA** in all slots. The fault current values at few locations in various slots is observed to be more than 100 mA, these points need to be monitored during next testing and necessary action to be taken as required.

3.0 CONCLUSION AND RECOMMENDED ACTION

Based on the condition assessment study, the following conclusions and recommendations had been drawn for Predictive maintenance and Life extension program.

STATOR WINDING

From the assessment conducted based on tan delta and partial discharge test analysis, which is as mentioned in section 2.0, it is concluded that the stator winding is not in healthy condition. Assessment indicates that, stator winding has deteriorated to larger extent. The deterioration process is of serious concern as the Generator is put into operation, with time this deterioration processes will effect the main ground wall insulation leading to winding failure. Hence for a permanent solution, we recommend to completely rewind the stator with new coils at next available opportunity.

STATOR CORE

From the detailed assessment conducted, which is as mentioned in section 2.0, Stator core assessment indicated excess fault current more than 100 mAs in few locations, it is recommended to attend this points to remove lamination shorting portions and restoring of insulation between the lamination in this areas. This core repair can be taken up during rewind process.