ELECTRICAL POWER QUALITY & ENERGY AUDIT REPORT

M/S. Mallow International

SF No. 1039 / 1A & 1038/1
Near Arasu Colony, Vangal Main Road
Panchamadevi Post
Karur- 639004

Audited by

Department of Electrical & Electronics Engineering
(Accredited by National Board of Accreditation)

Saranathan College of Engineering

(NAAC Accreditation with A+ grade)
(Affiliated to Anna University – Chennai, Approved by AICTE - New Delhi)
Venkateshwara Nagar, Panjappur, Tiruchirappalli 620012
www.saranathan.ac.in

DECEMBER 2021

ENERGY AUDIT TEAM

STAFF MEMBERS

1. **Dr. R. NATARAJAN,** Head, Research and Development - Coordinator

2. **Dr. D. KALYANAKUMAR,** Professor, EEE Department & Certified Energy Auditor (Bureau of Energy Efficiency- A Statutory Body under Ministry of Power, Government of India)

3. **Mr. P. RAMESH BABU,** Assistant. Professor, EEE Department

4. **Mr. R. VENUGOPAL,** Assistant. Professor, EEE Department

STUDENTS - B.E. (EEE) III Year – 'B' Sec.

1. **P. SURENDRAN** (223096)

2. **A. MUTHU KARUPPAN** (223052)

3. **T.S. YUKESH KUMAR** (223097)

M/S. Mallow International,
SF No.1039 / 1A & 1038 /1,
Near Arasu Colony, Vangal Main Road,
Panchamadevi Post,
Karur – 639004.

Dear Sir,

The Energy Audit team from the **Department of Electrical and Electronics Engineering, Saranathan College of Engineering, Trichy-12,** has performed Electrical **Power Quality and Energy Audit on all the Electrical installations** at **Mallow International, unit-5, Karur** on 29th &30th November and 6th & 7th December 2021. Detailed measurements were carried out using **Power Quality Analyzer 434-II**, **Fluke**. The measurements were done at the prevailing load conditions. The observations and recommendations for corrective actions are brought out precisely in this report from the viewpoints of energy conservation, safety, reliability and sustainability. If your organization requires any support for implementing the corrective actions, based on this Energy Audit report, we could extend all the technical support.

Thanks, and regards,

Dr. D. Kalyanakumar
Certified Energy Auditor &
Energy Manager
Reg. No. EA-1589

Dr. C. Krishnakumar
Professor & Head

PREFACE

The Energy Conservation Act, 2001, defines Energy auditing as the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption. It facilitates a systematic approach to the energy management in a system, trying to balance the total energy input with its use. It identifies all the energy streams in a system and quantifies the use of energy according to its discrete functions. Energy has been identified as a crucial and balancing factor in the indices for sustainable development since the Earth Summit in 1992. Especially in the contemporary scenario, it is acknowledged that the heavy and unbalanced energy consumption adversely affects energy price and economic growth, and most countries now give priority to energy conservation methods.

The electric power that is generated in our country is in the form of a **50-Hertz (Hz)** alternating current (AC) sine wave. Today, there is widespread use of digital or microprocessor-controlled devices, as advanced technologies, in all areas of our businesses. Many of these new devices are more sensitive and may not operate properly when small variations or disruptions in the electrical supply occur. Some examples of problems that occur due to power quality issues are: Automatic Resets, Data Errors, Equipment Failure, Circuit Board Failure, Memory Loss, Power Supply Problems, UPS Alarms, Software Corruption, and Overheating of electrical distribution systems. With the advent of modern electronics, appliances became non-linear in the way they drew current through the mains electricity supply. The variable frequency drives and UPS systems are a major source of harmonics being injected into the electrical system and without proper protection, these harmonics can affect other parts of the industry and even the grid. Power quality can have a large detrimental effect on industrial processes and the commercial sector. Industrial processes differ in their requirements, from a power quality perspective, each having particular ‘weaknesses’ in terms of power quality attributes. The important power quality considerations to be accounted for the industrial end-user center around costs associated with machine down-time, clean-up costs, product quality and equipment failure.

ACKNOWLEDGEMENTS

At the outset we convey our thanks, on behalf of **Department of Electrical & Electronics Engineering, Saranathan College of Engineering,** to the Management of Mallow International for providing us an opportunity to conduct Power Quality / Energy Audit at Mallow International, Unit-V, Karur on 29 & 30-11-2021 and 06 & 07-12-2021.

We express our sincere Gratitude to

1. **Mr. R. Arul,** Managing Director for permitting us to perform the Energy Audit
2. **Mr. R. Ramprasad**, Chief Executive Officer (CEO)
3. **Mr. A. Suresh Samuel,** Vice-president (VP)
4. **Mr. S. Vijay Kumar,** Electrical Engineer

and the other shop floor, RO and ETP staff members for extending their full support, from time to time, by giving us the necessary inputs to carry out this very vital exercise of Energy Audit. We are also thankful to other staff members who were actively involved while collecting the data and conducting field measurements. Thanks to all the courtesies extended to us during our visit.

The Energy Audit team members express their thanks to the **Management, Dr. D. Valavan, Principal and Dr. C. Krishnakumar, Head, Department of Electrical & Electronics Engineering, Saranathan College of Engineering,** for letting the staff members of the auditing team to take up this task, amidst the tight academic schedule. Last but not the least, the team members convey their sincere gratitude to **Dr. R. Natarajan, Research Head, Saranathan College of Engineering,** a vital link in this task, for coordinating and extending his support throughout this auditing work for the successful and effective completion of the assignment on time.

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1 POWER SOURCE DETAILS

1.1 UTILITY POWER SOURCE DETAILS

LT SERVICE NO.1

LTCT SC.NO. 013-010-1635

Tariff: III-B

Dist.: PANJAMADEVI

Service Load:

Existing	:	48.49 Kw
Additional	:	61.91 Kw
TOTAL	**:**	**110.40 kW**

Date of Service Connection : 11-03-2019

Date of Test by MRT : 11-03-2019

CT Details:

Make	:	SAKTHI
Ratio	:	200 / 5A
VA / CL	:	5 / 0.5S

Sl. Nos:

134970 (R)

134971 (Y)

134972 (B)

MF: 40

LT SERVICE NO.2

LTCT SC.NO. 013-010-1010

Tariff: III-B

Dist.: PANJAMADEVI

Service Load:

	Existing	:	111.84 kw
	Additional	:	38.16 kw
	TOTAL	**:**	**150.00 kW**

Date of Service Connection : 03-05-2001

Date of Test by MRT : 02-01-2021

CT Details:

Make	:	SAKTHI
Ratio	:	300 / 5A
VA / CL	:	5 / 0.5S

Sl. Nos:

35246 (R)	A130703
35247 (Y)	A130704
35248 (B)	A130705

CT coil, Meter, Metering Box changed on 17-02-2018

CT coil changed on 02-01-2021 (from 200 / 5A to 300 / 5A)

MF: 60

LT SERVICE NO.3

SC.NO. 013-010-2987

Tariff	:	III-B
Dist.	:	PANJAMADEVI
Connected Load	:	49 kW
Date of Service Connection	:	11-08-2021

LT SERVICE NO.4

LTCT SC.NO. 013-010-2119

Tariff: III-B

Dist.: PANJAMADEVI

Service Load		:	(145 HP + 1000 W)
	Existing	:	109.17 kW
	Additional	:	40.00 kw
	TOTAL	**:**	**149.17 kW**

Date of Service Connection : 31-03-2013

Date of Test by MRT : 28-04-2021

CT Details:

Make	:	SAKTHI
Ratio	:	300 / 5A
VA / CL	:	5 / 0.5S

Cable changed on 18-01-2018

CT coils changed on 28-04-2021

Sl. Nos: 170626 (R)

170627 (Y)

170628 (B)

MF: 60

1.2 STANDBY POWER SOURCE DATA

1.2.1 82.5 kVA DG SET

Quantity: 1 No

ENGINE:

Frame Type: 4R 1040TA

Make: Kirloskar

RPM: 1500

S. No; 4H. 2501 / 0200043

77 kW / 105 HP

ISO 3046

ALTERNATOR:

Frame: KG 2251 D226L

kVA: 82.5 M/c. No: HL002A0805

Amps: 114.8 Rating S1 duty to IS 4722-1992

Volts: 415 INS. CL: F

RPM: 1500 PF: 0.8

Hz – 50 Rotation / DE - CW

Ambient – 40°C Bearings: DE -6312ZZ

NDE 6308ZZ

Excitation volts: 270 Excitation Amps: 4

Make: Kirloskar

1.2.2 160 kVA DG SET

Quantity: 1 No

ENGINE:

This engine conforms to the environment (protection) Rule 1988

Type Approval Certificate No: ARAI / MDEF /DGTA /CIL /-F28/2008-052

Model: 6BTAA5.9-G5

Rated HP / kW: 195 / 146m @ 1500 RPM

Sl. No: P84138680

Month and Year of Mfg.: 12-2013 S. No.: A035F498

Make: Cummins India Pvt. Ltd

Low Horse Power Business Unit

Pune: 411038.

ALTERNATOR:

Base kW: 128 50Hz Base kVA: 160 RPM: 1500 AVR: None PF: 0.8

Volts: 415 Amps: 222.6 Ambient: 40°C Temp Classification: 180 °C

Rating: Continuous Temp rise: 125 °C Excitation volts: 58 Excitation Amps: 2.3

Enclosure: IP23 Type: VCI 274F1 Sl. no: N13J432078 Frame / Core: VCI274F1

Phase: 3 Stator winding: 311 Stator connection: Series Star

Make: STAMFORD IEC: 34-1 ISO: 8528-3

1.2.3 320 kVA DG SET

Quantity: 1 No

Volts: 415 PF: 0.8 50 Hz 3-phase

Rated Current: 557A

*Full details are not available

2 CONNECTED LOADS

MV PANEL 1 (112 kW)	
RO	83.2
ATFD	26.1
EVAPORATOR	40
LAB	10
ETP	20.85
FULL LOAD	**180.15**

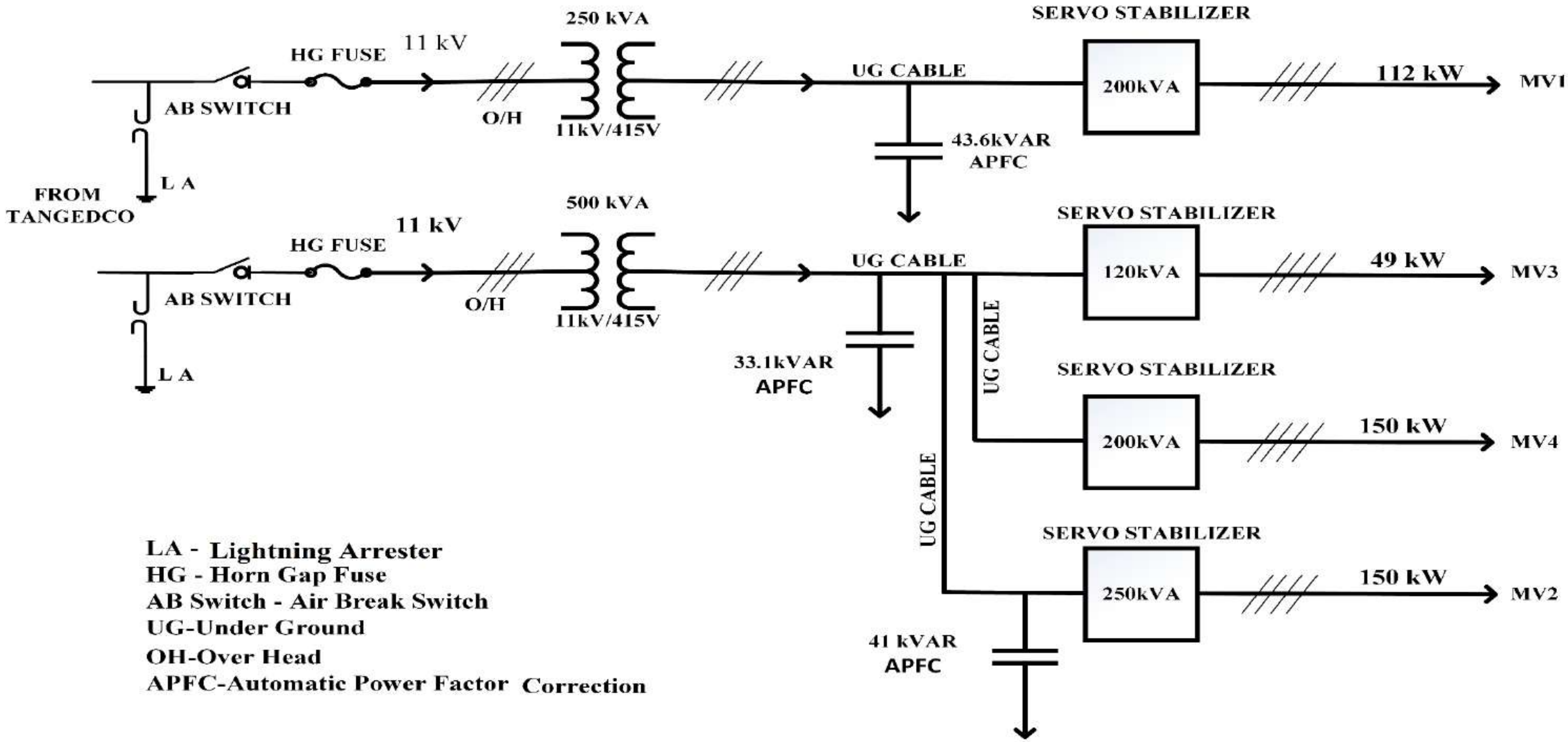
MV PANEL 2 (150 kW)	
Loop steamer	30.12
JIGGER	67.7
3TON BOILER	13.7
THERMOPACK	45.75
1TON BOILER	11.9
UF	16.7
HPP	15
AERATION	15.1
SINGING	26.52
WASHING RANGE	51.48
FULL LOAD	**293.97**

MV PANEL 3 (49 kW)	
BLOWER	40.7
COMPRESSOR	20
LIGHTING	20
FULL LOAD	**80.7**

MV PANEL 4 (150 kW)	
160KVA UPS	190.2
FULL LOAD	**190.2**

Total Load in kW	**745.02**

3 SINGLE LINE DIAGRAM (SLD)



4 TANGEDCO BILLING ANALYSIS

MV PANEL 1

Assessment Date	Assessment EntryDate	KWH Reading	KVAH Reading	EXPORT KWH Reading	EXPORT KVAH Reading	MAXIMUM DEMAND	POWER FACTOR	CONSUMED UNIT	CC Charges (Rs.)	Other Charges						Assessed Amount (Rs.)
										ETAX(Rs.)	WD(Rs)	EDC (Rs.)	DPF (Rs.)	FC (Rs.)	TOTAL (Rs.)	
30-11-2021	30-11-2021	19473.25	19654.18	0	0	109.28	0.99	32906.8	208958.18	10640.41	0	0	0	3920	14560.41	223518.6
30-10-2021	30-10-2021	18650.58	18825.86	0	0	101.84	0.99	31911.2	202636.12	10310.31	0	0	0	3920	14230.31	216866.4
30-9-2021	30-9-2021	17852.8	18024.06	0	0	103.92	0.99	31646.8	200957.18	10229.86	0	0	0	3920	14149.86	215107
31-8-2021	31-8-2021	17061.63	17228.35	0	0	106.14	0.99	32996.8	209529.68	10663.76	0	0	0	3920	14583.76	224113.4
30-7-2021	30-7-2021	16236.71	16397.87	0	0	103.52	0.99	28594.4	181574.44	9260.72	0	0	0	3920	13180.72	194755.2
30-6-2021	30-6-2021	15521.85	15679.16	0	0	100.48	0.99	56821.6	360817.16	18394.36	0	0	0	7840	26234.36	255061
31-5-2021	31-5-2021	Previous Assessment Amount Billed														131991
29-4-2021	29-4-2021	14101.31	14250.12	0	0	116.08	0.99	31372.8	199217.28	10165.61	0	101568.6	0	3920	115654.3	314871.5
31-3-2021	31-3-2021	13316.99	13460.39	0	0	105.06	0.99	36680.4	232920.54	11831.53	0	0	0	3920	15751.53	248672.1
27-2-2021	27-2-2021	12399.98	12537.67	0	0	115.12	0.99	29423.2	186837.32	9544.87	0	22890.88	0	3920	36355.75	223193.1
29-1-2021	29-1-2021	11664.4	11797.78	0	0	106.88	0.99	25488.4	161851.34	8279.82	0	0	0	3920	12199.82	174051.2
31-12-2020	31-12-2020	11027.19	11154.86	0	0	106.32	0.99	18507.6	117523.26	6063.41	0	0	0	3920	9983.41	127506.7
30-11-2020	30-11-2020	10564.5	10687.33	0	0	107.84	0.99	38549.6	244789.96	12428.5	0	0	0	3920	16348.5	261138.5
29-10-2020	29-10-2020	9600.76	9716.1	0	0	114.16	0.99	44232.8	280878.28	14245.16	0	18215.92	0	3920	36381.08	317259.4
29-9-2020	30-9-2020	8494.94	8601.11	0	0	111.28	0.99	41530.4	263718.04	13381.9	0	0	0	3920	17301.9	281019.9
31-8-2020	31-8-2020	7456.68	7554.48	0	0	112.48	0.99	39837.2	252966.22	12846.06	0	3853.29	0	3920	20619.35	273585.6
30-7-2020	30-7-2020	6460.75	6550.49	0	0	103.76	0.99	24656.8	156570.68	8010.53	0	0	0	3920	11930.53	168501.2
29-6-2020	30-6-2020	5844.33	5929.82	0	0	83.2	0.99	17313.2	109938.82	5643.3	0	0	0	3920	9563.3	119489
30-5-2020	1-5-2020	5411.5	5492.82	0	0	93.2	0.99	16032	101803.2	5255.3	0	0	0	3920	9175.3	110991
30-4-2020	30-4-2020	5010.7	5088.49	0	0	91.6	0.98	16519.2	104896.92	5566.85	0	0	0	7840	13406.85	11553
30-3-2020	30-3-2020	Previous Assessment Amount Billed														96694
28-2-2020	29-2-2020	4597.72	4666.47	0	0	81.28	0.99	15401.2	97797.62	5033.38	0	0	0	3920	8953.38	106751
29-1-2020	29-1-2020	4212.69	4277.46	0	0	87.04	0.98	13891.2	88209.12	4564.46	0	0	0	3920	8484.46	96694
26-12-2019	30-12-2019	3865.41	3928.31	0	0	86.08	0.98	15207.2	96565.72	4980.54	0	0	0	3920	8900.54	105466.3

MV PANEL 2

Assessment Date	Assessment Entry Date	KWH Reading	KVAH Reading	EXPORT KWH Reading	EXPORT KVAH Reading	MAXIMUM DEMAND	POWER FACTOR	CONSUMED UNIT	CC Charges (Rs.)	Other Charges						Assessed Amount (Rs.)
										ETAX (Rs.)	WD (Rs.)	EDC (Rs.)	DPF (Rs.)	FC (Rs.)	TOTAL (Rs.)	
30-11-2021	30-11-2021	30621.55	31065.4	0	0	115.88	0.99	42196.2	267945.87	15427.29	0	0	0	52500	67927.29	335873
30-10-2021	30-10-2021	29978.28	30411.16	0	0	131.48	0.99	45016.8	285856.68	16602.83	0	0	0	52500	69102.83	354960
30-9-2021	30-9-2021	29288	29710.3	0	0	152.24	0.99	61297.8	389241.03	22139.55	0	19878.35	0	52500	94517.9	483759
31-8-2021	31-8-2021	28326.37	28723.53	0	0	154.04	0.99	64203.6	407692.86	23097.14	0	34514.46	0	52500	110111.6	517804
30-7-2021	30-7-2021	27316.31	27690.38	0	0	144.2	0.99	59577.6	378317.76	21453.39	0	0	0	52500	73953.39	452271
30-6-2021	30-6-2021	26383.35	26738.4	0	0	139.04	0.99	106074	673569.9	38578.5	0	0	0	105000	143578.5	405343
31-5-2021	31-5-2021	Previous Assessment Amount Billed														411805
29-4-2021	29-4-2021	24675.45	24999.1	0	0	138.92	0.99	53524.2	339878.67	19426.43	0	0	0	52500	71926.43	411805
31-3-2021	31-3-2021	23843.38	24151.64	0	0	117.68	0.99	55332.6	351362.01	19633.1	0	0	0	52500	72133.1	423495
27-2-2021	27-2-2021	22981.17	23277.13	0	0	110.48	0.99	45274.8	287494.98	16317.25	0	0	0	52500	68817.25	356312
29-1-2021	29-1-2021	22286.59	22572.31	0	0	110.12	0.99	39328.2	249734.07	14305.77	0	0	0	49130.7	63436.44	313171
31-12-2020	31-12-2020	21658.6	21927.79	0	0	105.28	0.99	35514	225513.9	11461.2	0	0	0	3920	15381.2	240895
30-11-2020	30-11-2020	20770.75	21028.44	0	0	102	0.99	47018.4	298566.84	15106.84	0	0	0	3920	19026.84	317594
29-10-2020	29-10-2020	19595.29	19834.54	0	0	118.8	0.99	47590.8	302201.58	15318.33	0	32755.01	0	3920	51993.34	354195
29-9-2020	30-9-2020	18405	18622.38	0	0	104.48	0.99	43432.4	275795.74	13973.54	0	0	0	3920	17893.54	293689
31-8-2020	31-8-2020	17319.71	17518.32	0	0	113.28	0.99	47295.6	300327.06	15215.85	0	9735.91	0	3920	28871.76	329199
30-7-2020	30-7-2020	16137.32	16316.4	0	0	98.72	0.99	40086	254546.1	12900.56	0	0	0	3920	16820.56	271367
29-6-2020	30-6-2020	15135.17	15299.5	0	0	85.68	0.99	29640	188214	9561.2	0	0	0	3920	13481.2	201695
30-5-2020	1-5-2020	14394.17	14549.76	0	0	84.24	0.99	27125.6	172247.56	8761.1	0	0	0	3920	12681.1	184929
30-4-2020	30-4-2020	13716.03	13863.62	0	0	75.68	0.99	31244	198399.4	10185.97	0	0	0	7840	18025.97	21843
30-3-2020	30-3-2020	Previous Assessment Amount Billed														194582
28-2-2020	29-2-2020	12934.93	13075.19	0	0	77.92	0.99	28575.2	181452.52	9209.13	0	0	0	3920	13129.13	194582
29-1-2020	29-1-2020	12220.55	12352.48	0	0	77.92	0.99	25089.6	159318.96	8102.45	0	0	0	3920	12022.45	171341
26-12-2019	30-12-2019	11593.31	11717.91	0	0	76.96	0.99	22411.6	142313.66	7250.43	0	0	0	3920	11170.43	153484

MV PANEL 3

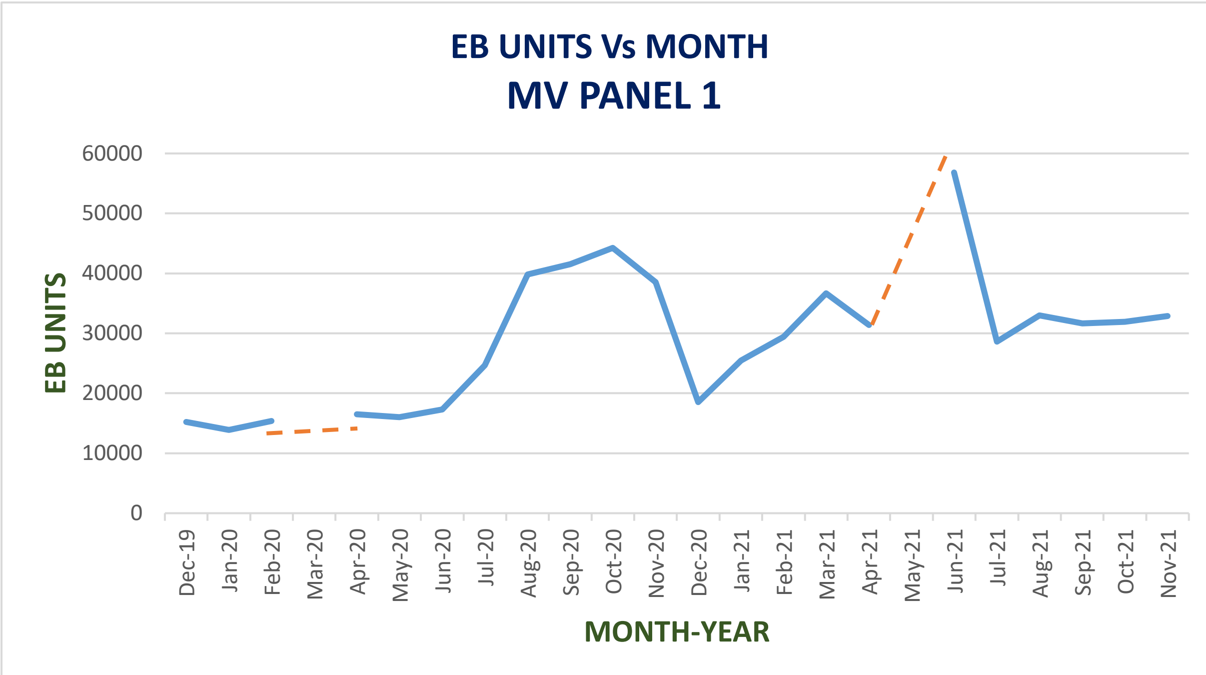
Assessment Date	Assessment Entry Date	KWH Reading	KVAH Reading	EXPORT KWH Reading	EXPORT KVAH Reading	MAXIMUM DEMAND	CONSUMED UNIT	POWER FACTOR	CC Charges (Rs.)	Other Charges						Assessed Amount (Rs.)
										ETAX (Rs.)	WD (Rs.)	EDC (Rs.)	DPF (Rs.)	FC (Rs.)	TOTAL (Rs.)	
30-11-2021	30-11-2021	44917.86	52075.6	0	0	129.98	30728.40	0.9	195125.3	12031.3	0	0	0	52500	64531.3	259657
30-10-2021	30-10-2021	44465.72	51575.4	0	0	125.72	31032.00	0.9	197053.2	12057.7	0	0	0	52500	64557.7	261611
30-9-2021	30-9-2021	44008.52	51067.9	0	0	123.92	28851.60	0.88	183207.7	11330.4	0	0	0	52500	63830.4	247038
31-8-2021	31-8-2021	43587.66	50592	0	0	126.08	31249.80	0.87	198436.2	12144.3	0	0	0	52500	64644.3	263081
30-7-2021	30-7-2021	43126.83	50065.1	0	0	129.5	30848.40	0.89	195887.3	12069.4	0	0	0	52500	64569.4	260457
30-6-2021	30-6-2021	42672.69	49553.3	0	0	132.68	56033.40	0.88	355812.1	22445.6	0	0	0	105000	127446	322507
31-5-2021	31-5-2021	Previous Assessment Amount Billed														160751
29-4-2021	30-4-2021	41798.8	48561	0	0	128.72	23018.40	0.88	146166.8	7619.49	0	0	0	6965	14584.5	160751
31-3-2021	31-3-2021	41239.18	47926.8	0	0	108.96	25681.20	0.88	163075.6	8344.53	0	0	0	3850	12194.5	175270
27-2-2021	27-2-2021	40597.15	47194.9	0	0	102.64	22102.00	0.87	140347.7	7197.64	0	0	0	3850	11047.6	151395
29-1-2021	29-1-2021	40044.6	46556.8	0	0	111.56	20133.20	0.88	127845.8	6588.29	0	2633.9	0	3850	13072.2	140918
31-12-2020	31-12-2020	39541.27	45984.7	0	0	111.32	17740.00	0.8	112649	6110.07	0	2330	5632.5	3850	17922.5	130572
30-11-2020	30-11-2020	39097.77	45430.5	0	0	96.84	26400.00	0.89	167640	8551.75	0	0	0	3850	12401.8	180042
29-10-2020	29-10-2020	38437.77	44690	0	0	100.28	26707.20	0.9	169590.7	8656.29	0	0	0	3850	12506.3	182097
29-9-2020	30-9-2020	37770.09	43948.5	0	0	107.12	25866.00	0.9	164249.1	8401.46	0	0	0	3850	12251.5	176501
31-8-2020	31-8-2020	37123.44	43232.7	0	0	108.64	28130.00	0.9	178625.5	9122.03	0	0	0	3850	12972	191598
30-7-2020	30-7-2020	36420.19	42447.2	0	0	105.84	26825.20	0.91	170340	8702.5	0	0	0	3850	12552.5	182893
29-6-2020	30-6-2020	35749.56	41713.2	0	0	118.16	22085.20	0.93	140241	7220.3	0	0	0	3850	114816	255057
30-5-2020	1-6-2020	35197.43	41118.8	0	0	115.16	21360.00	0.94	135636	6984.8	0	0	0	3850	30362.8	165999
30-4-2020	30-4-2020	34663.43	40549.6	0	0	100.44	15755.60	0.88	100048.1	5355.9	0	0	0	7700	13055.9	113104

MV PANEL 4																
Assessment Date	Assessment Entry Date	KWH Reading	KVAH Reading	EXPORT KWH Reading	EXPORT KVAH Reading	MAXIMUM DEMAND	POWER FACTOR	CONSUMED UNIT	CC Charges (Rs.)	Other Charges						Assessed Amount (Rs.)
										ETAX (Rs.)	WD (Rs.)	EDC (Rs.)	DPF (Rs.)	FC (Rs.)	TOTAL (Rs.)	
30/10/2021	02-11-2021	25544	27490.2	0	0	44.14	0.93	25543.7	162202.5	9484.1	24330	0	0	3430	37244.51	199447
30/08/2021	02-09-2021		0	0	0	0.01		0	0	1.11	0	0	0	1086	1087.28	1087

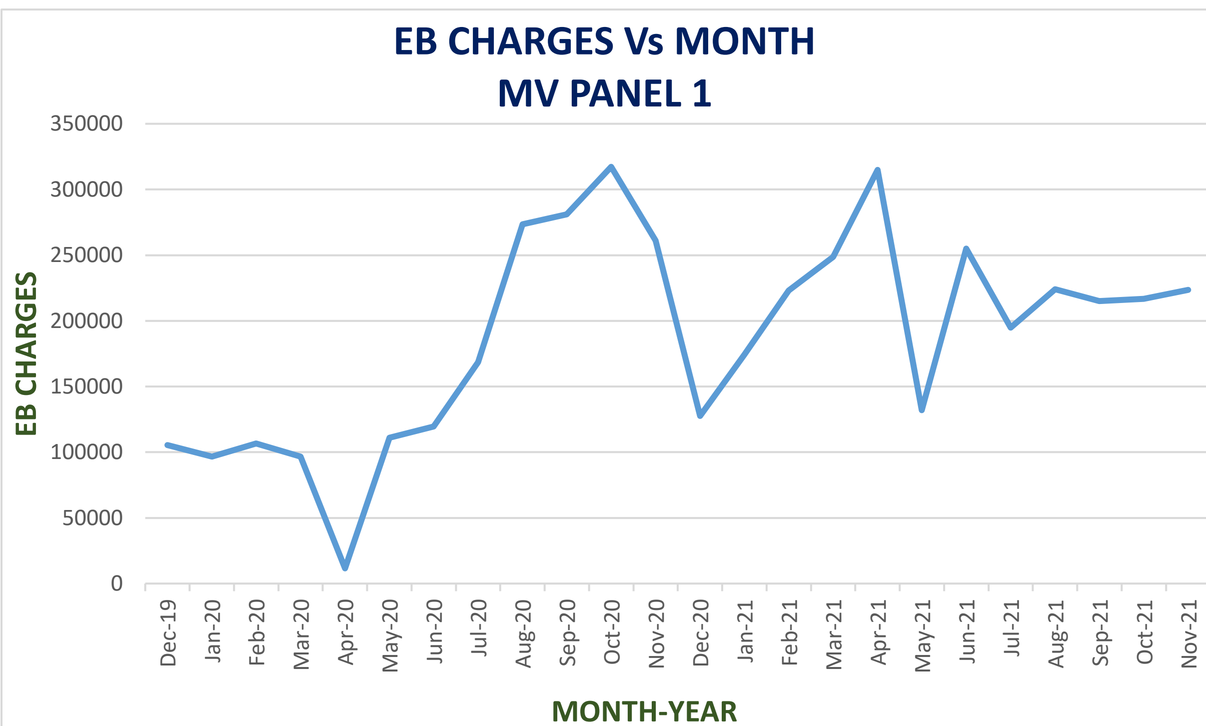
***Note: Service was obtained in the month of August 2021**

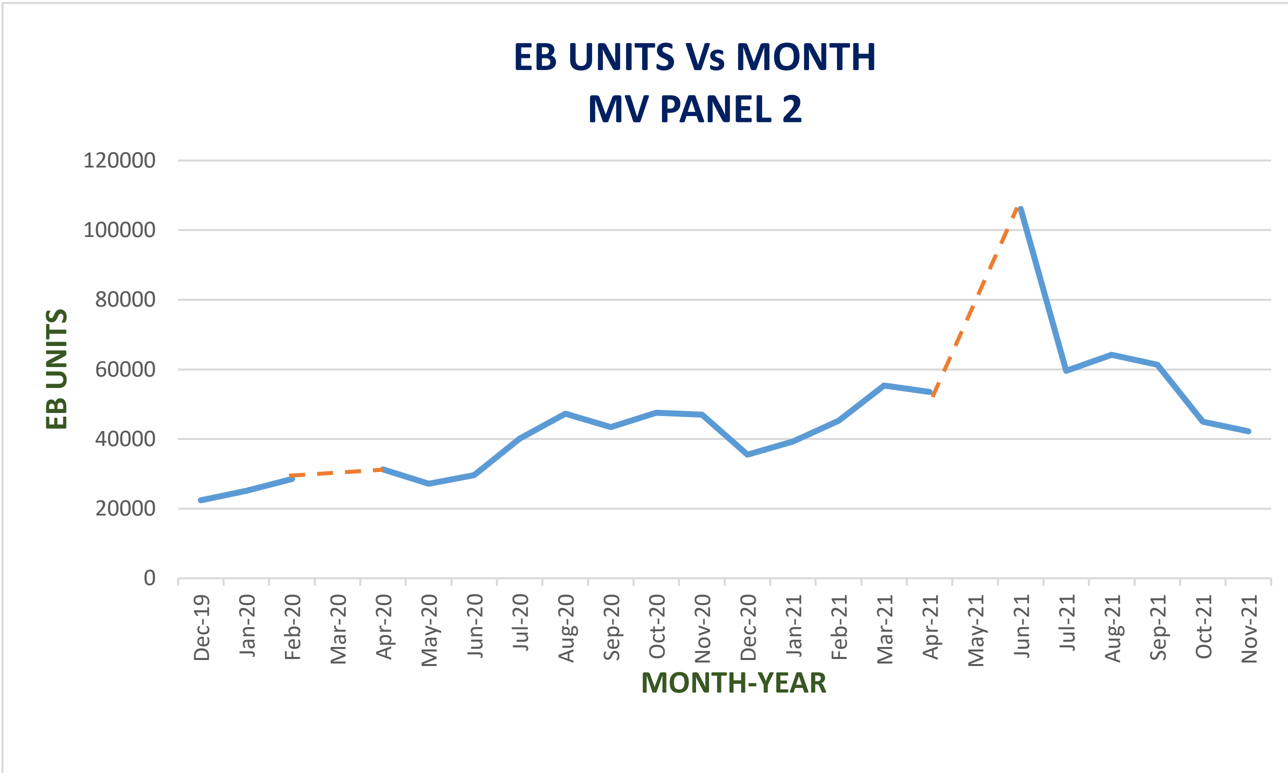
Month-wise total EB (TANGEDCO) charges for the Period December 2019 - November 2021

	ALL MV PANELS		
	Month	**Consumed unit**	**Assessed amount (₹)**
1	Nov-21	1,05,831.4	8,19,049
2	Oct-21	1,33,503.7	10,32,884
3	Sep-21	1,21,796.2	9,45,904
4	Aug-21	1,28,450.2	10,06,085
5	Jul-21	1,19,020.4	9,07,483
6	Jun-21	2,18,929	9,82,911
7	May-21	0	7,04,547
8	Apr-21	1,07,915.4	8,87,428
9	Mar-21	1,17694.2	8,47,437
10	Feb-21	96,800	7,30,900
11	Jan-21	84,949.8	6,28,140
12	Dec-20	71,761.6	4,98,974
13	Nov-20	11,1968	7,58,774
14	Oct-20	1,18,530.8	8,53,551
15	Sep-20	1,10,828.8	7,51,210
16	Aug-20	1,15,262.8	7,94,383
17	Jul-20	91,568	6,22,761
18	Jun-20	69,038.4	5,76,241
19	May-20	64,517.6	4,61,919
20	Apr-20	63,518.8	1,46,500
21	Mar-20	0	2,91,276
22	Feb-20	43,976.4	3,01,333
23	Jan-20	38,980.8	268035
24	Dec-19	37,618.8	258950

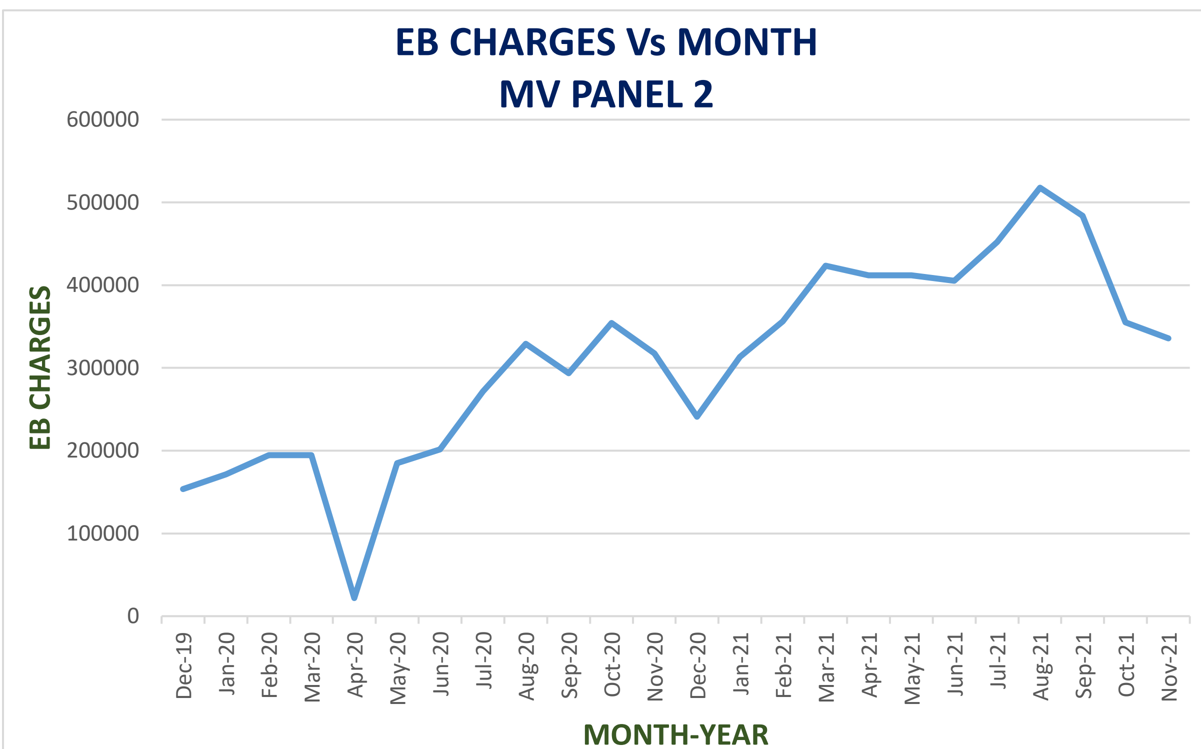


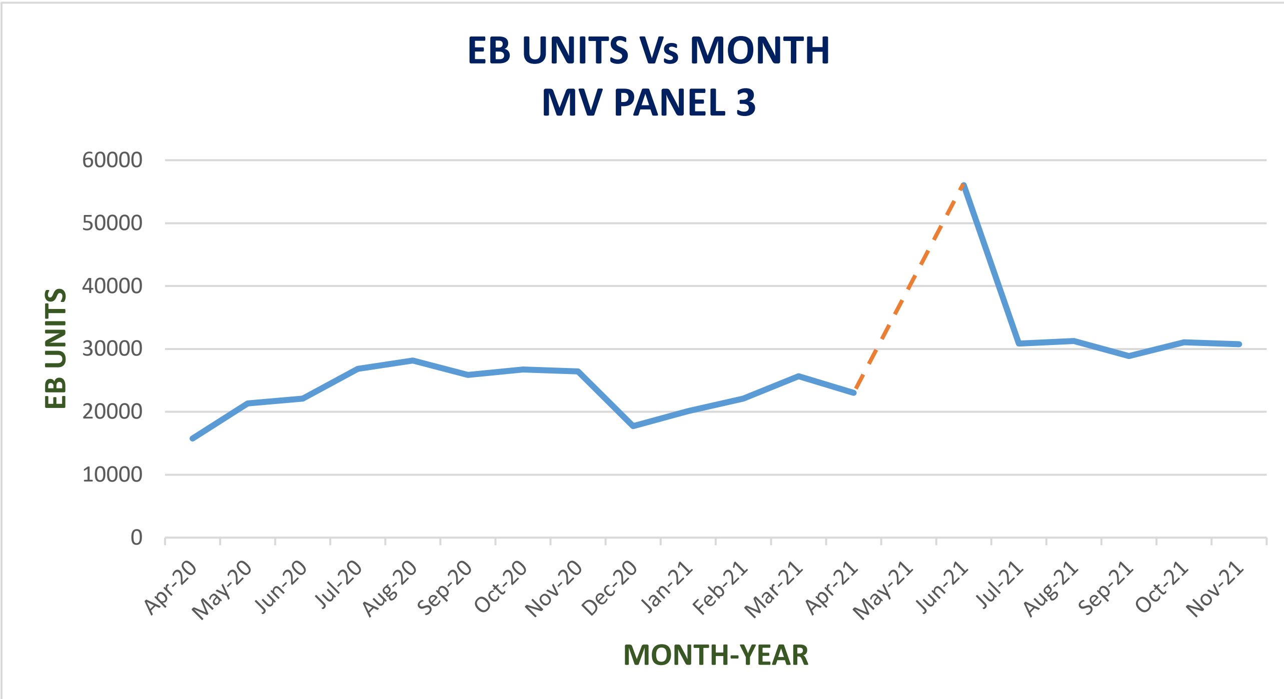
---- Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)



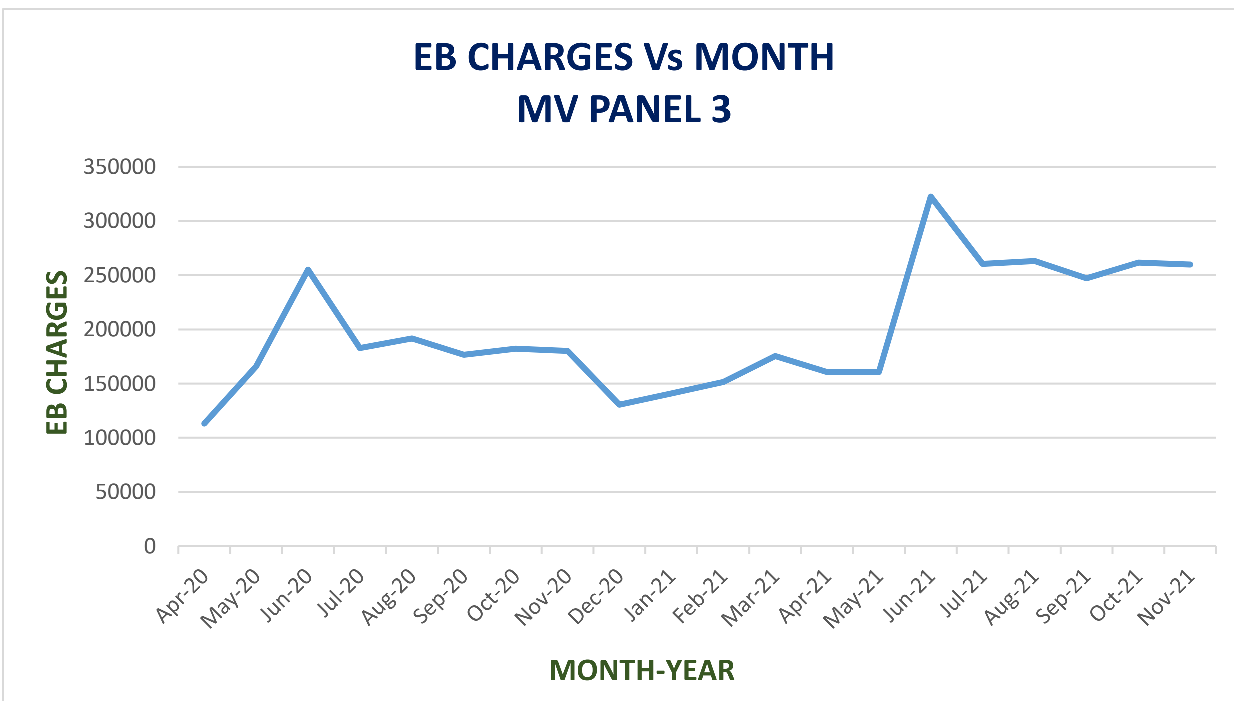


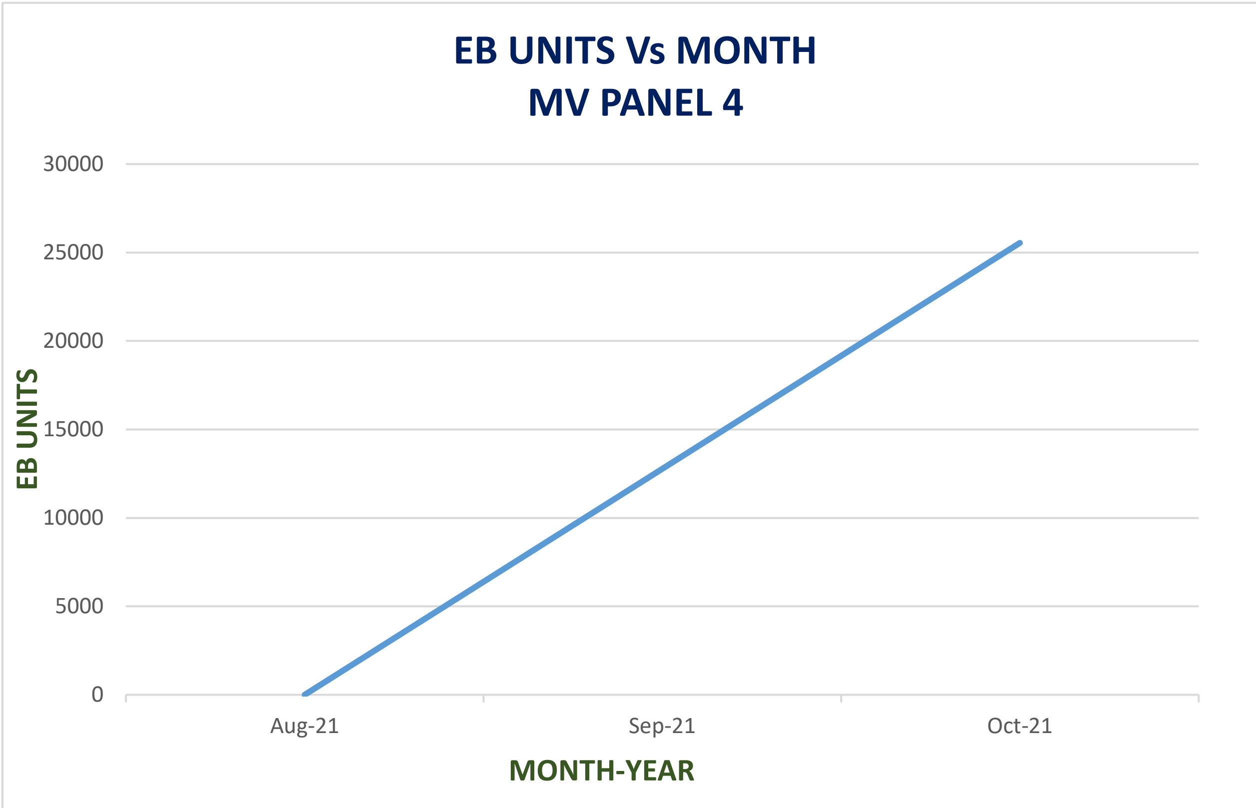
---- Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)

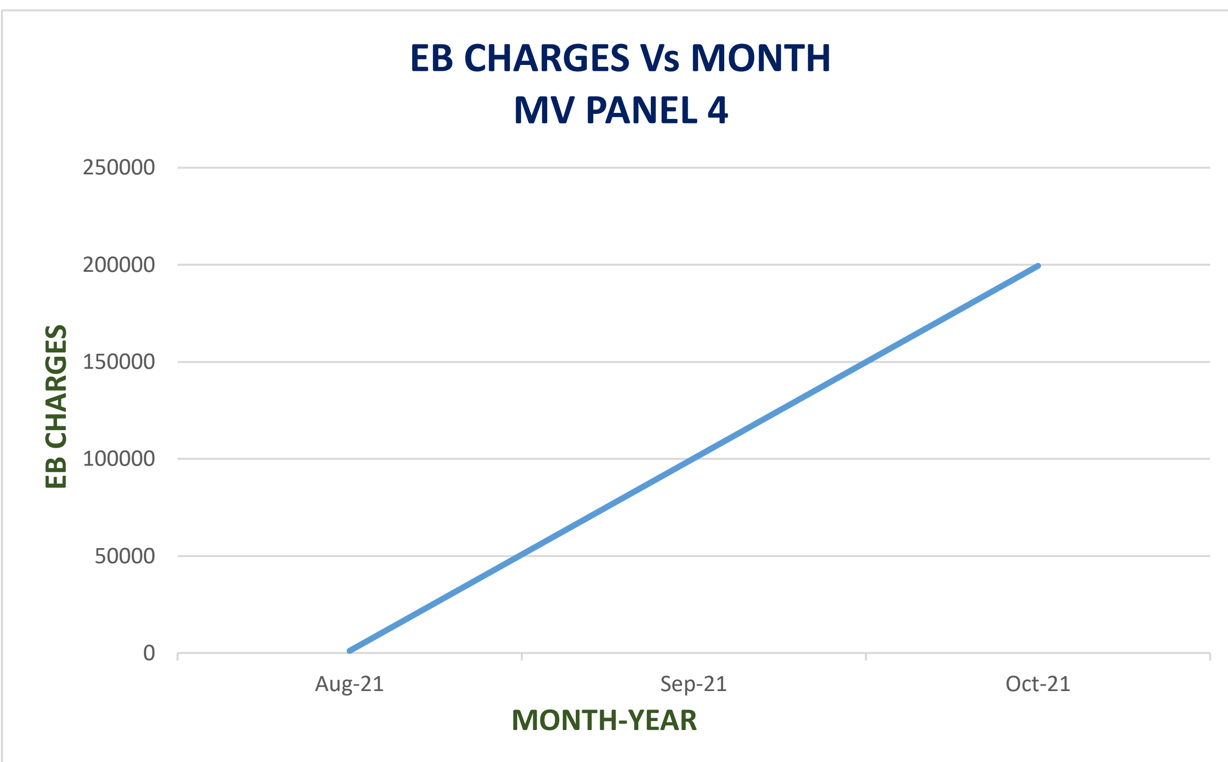


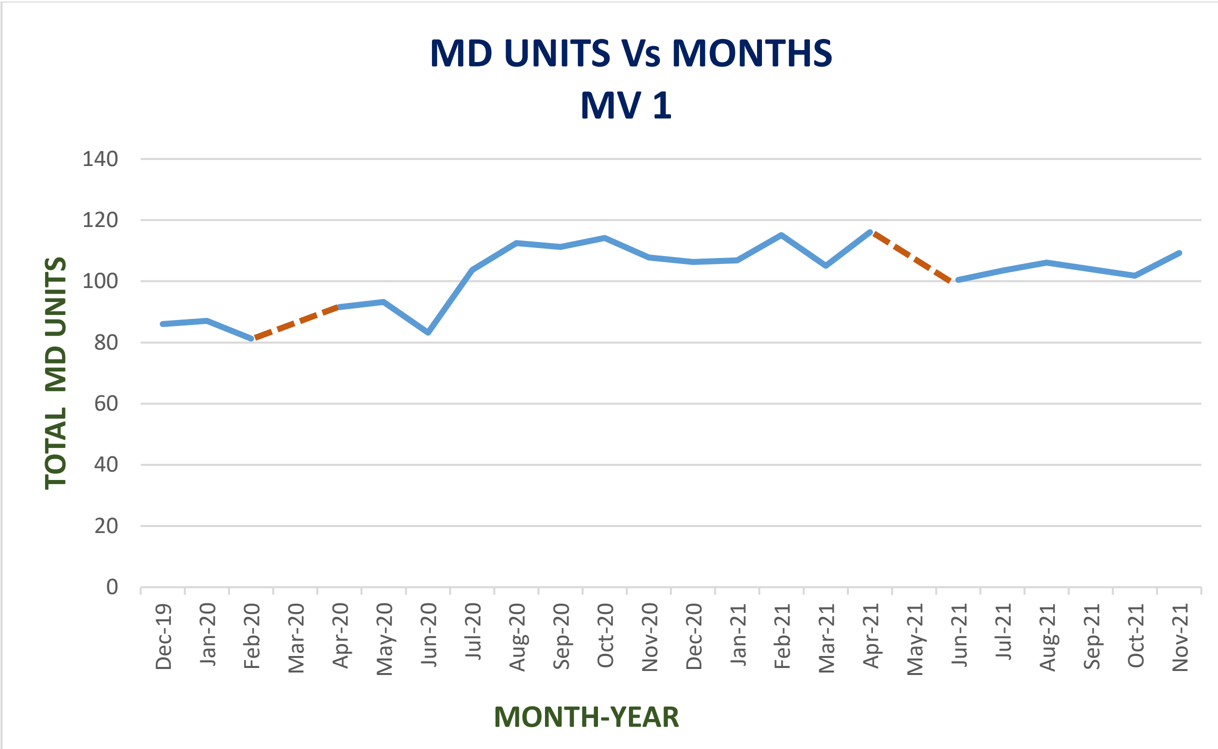


---- Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)

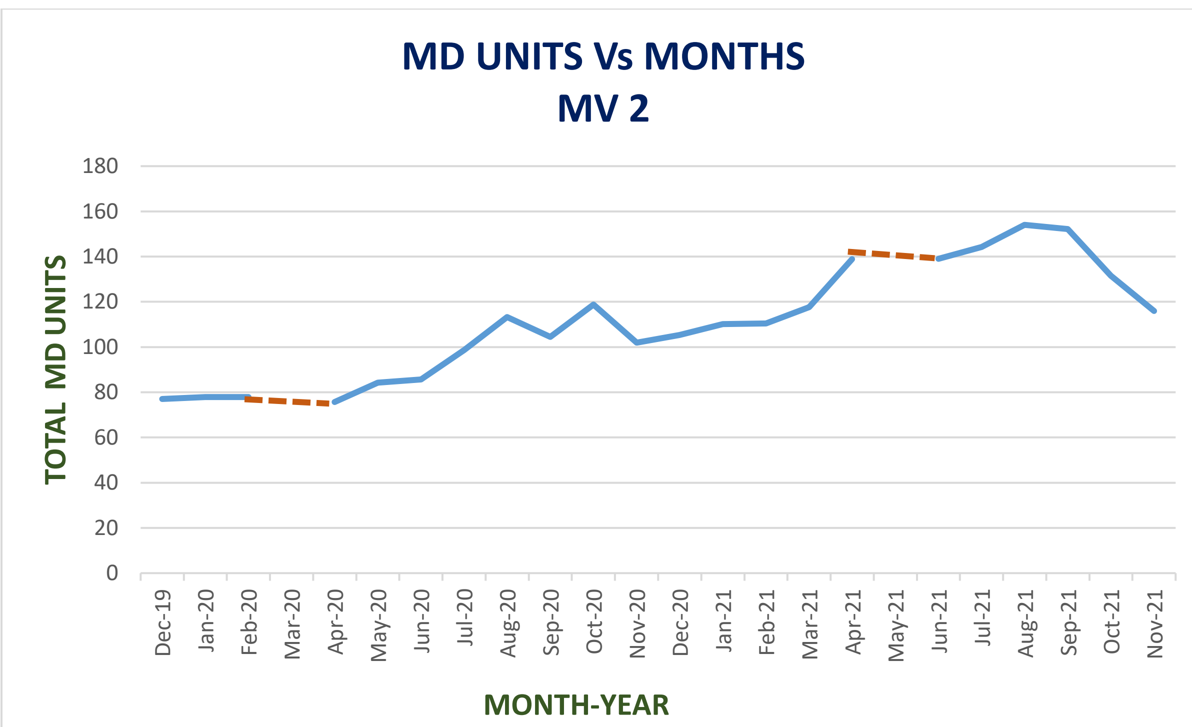



EB UNITS Vs MONTH
MV PANEL 4
30000
25000
20000
15000
10000
5000
0
EB UNITS
Aug-21
Sep-21
Oct-21
MONTH-YEAR

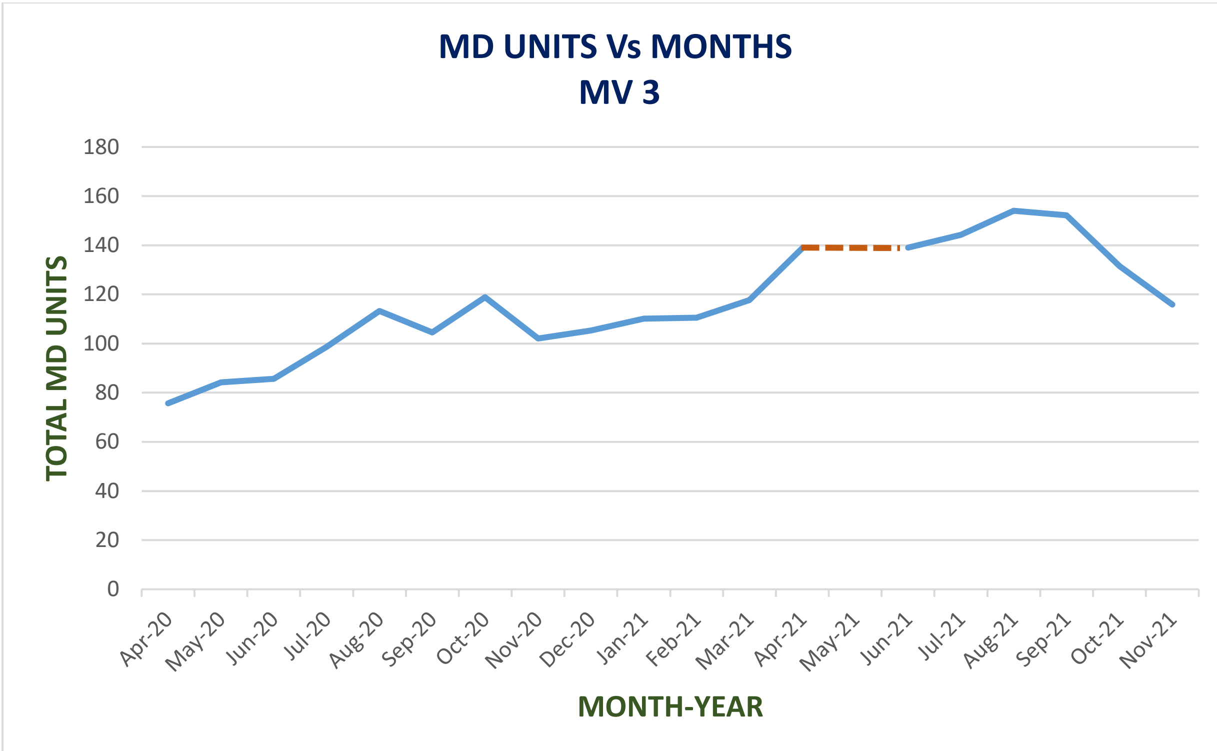

EB CHARGES Vs MONTH
MV PANEL 4
250000
200000
150000
100000
50000
0
EB CHARGES
Aug-21
Sep-21
Oct-21
MONTH-YEAR



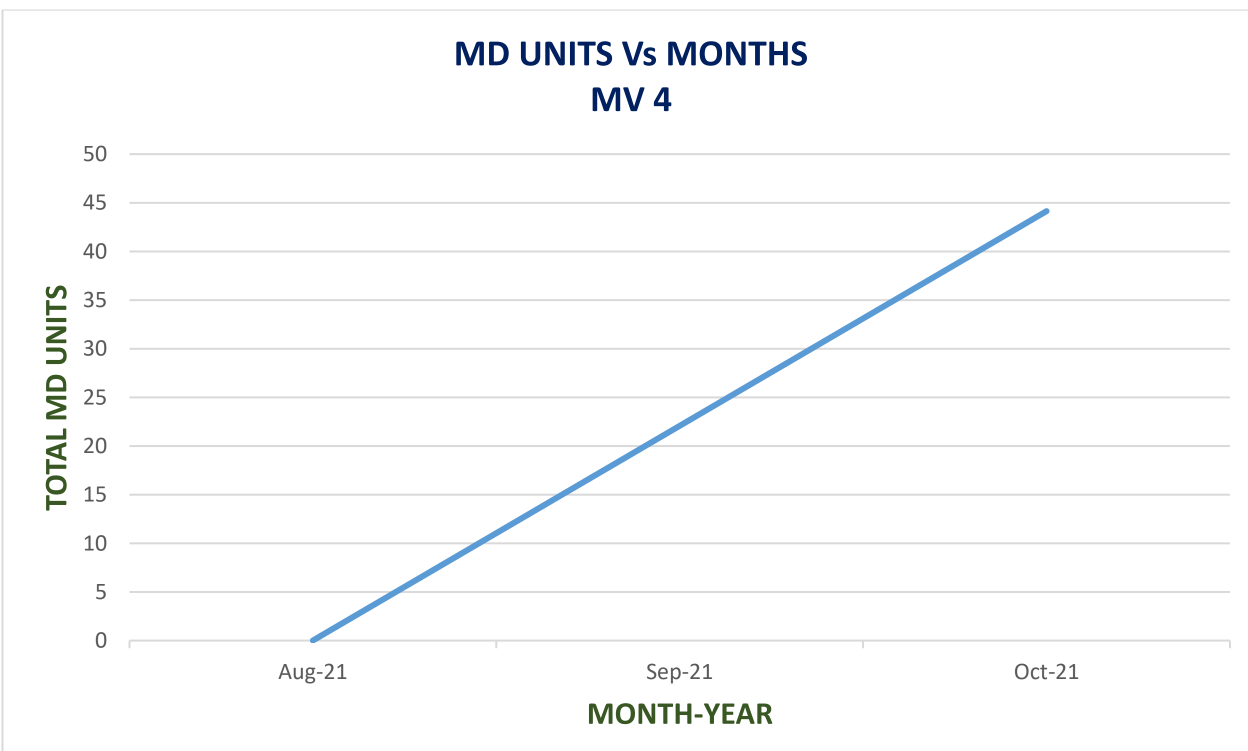
---- Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)

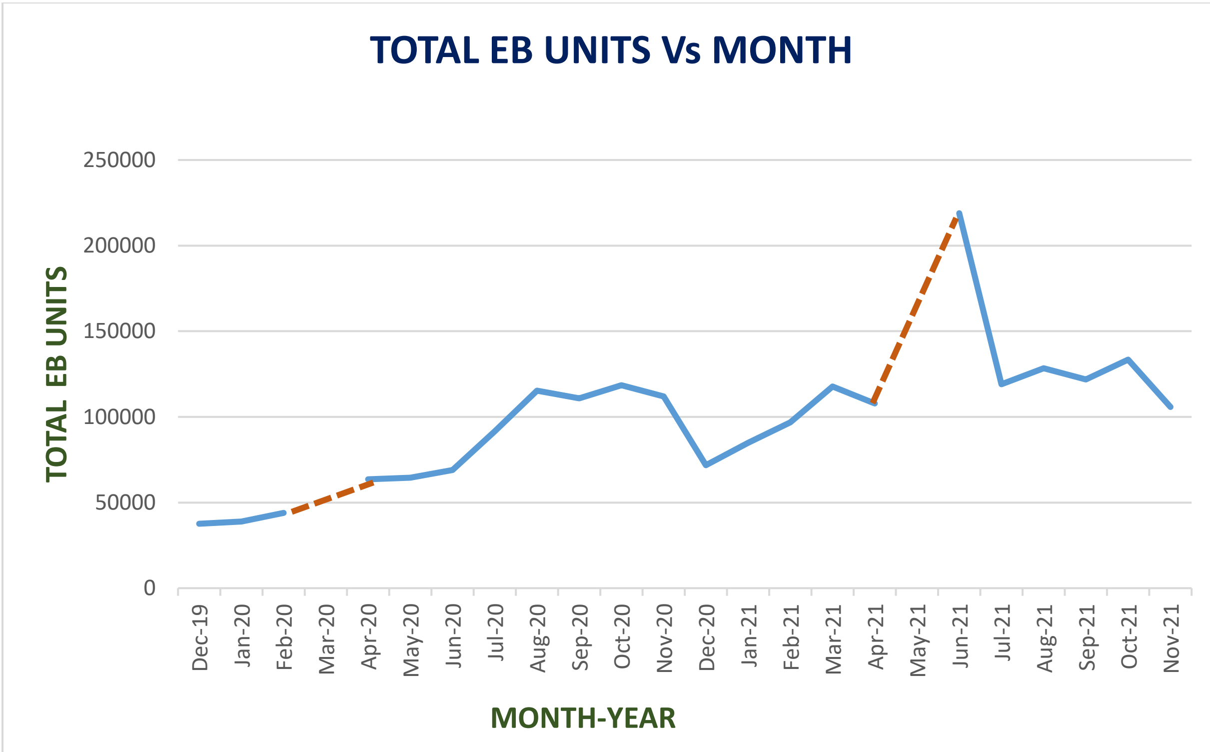


---- Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)

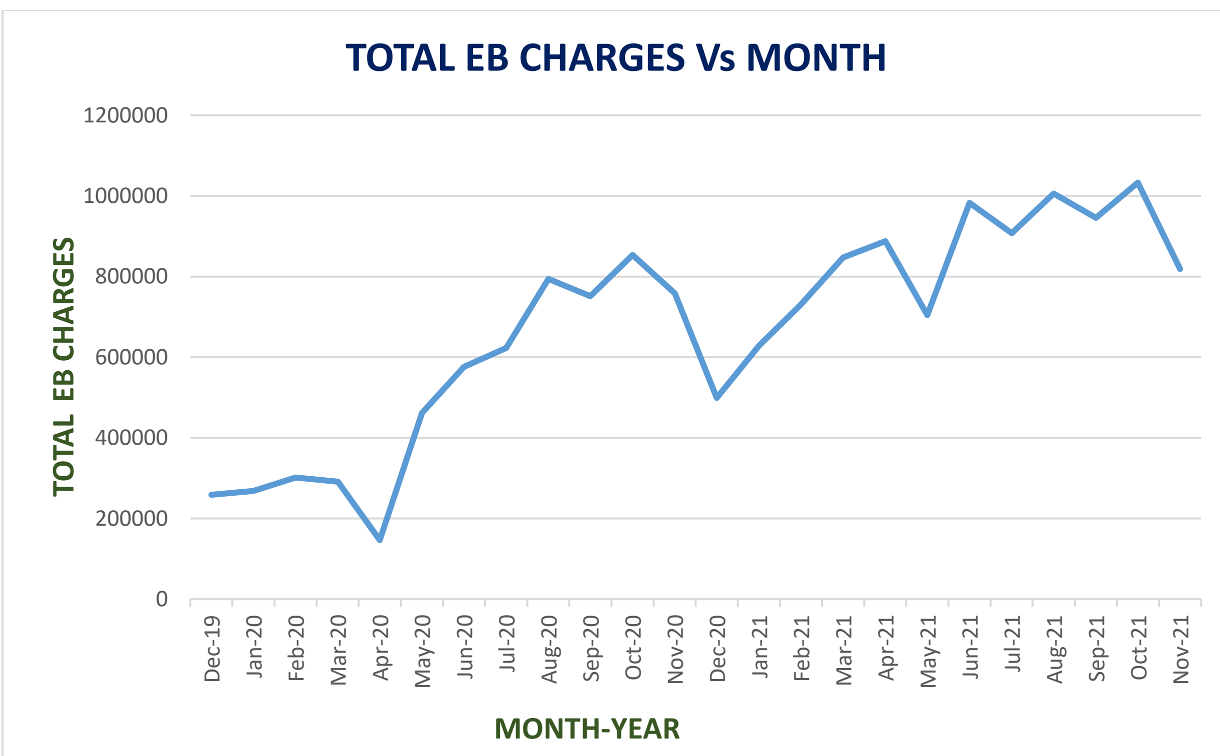


Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)





Indicates previous reading assessment taken for tariff estimation (due to COVID-19 Pandemic)



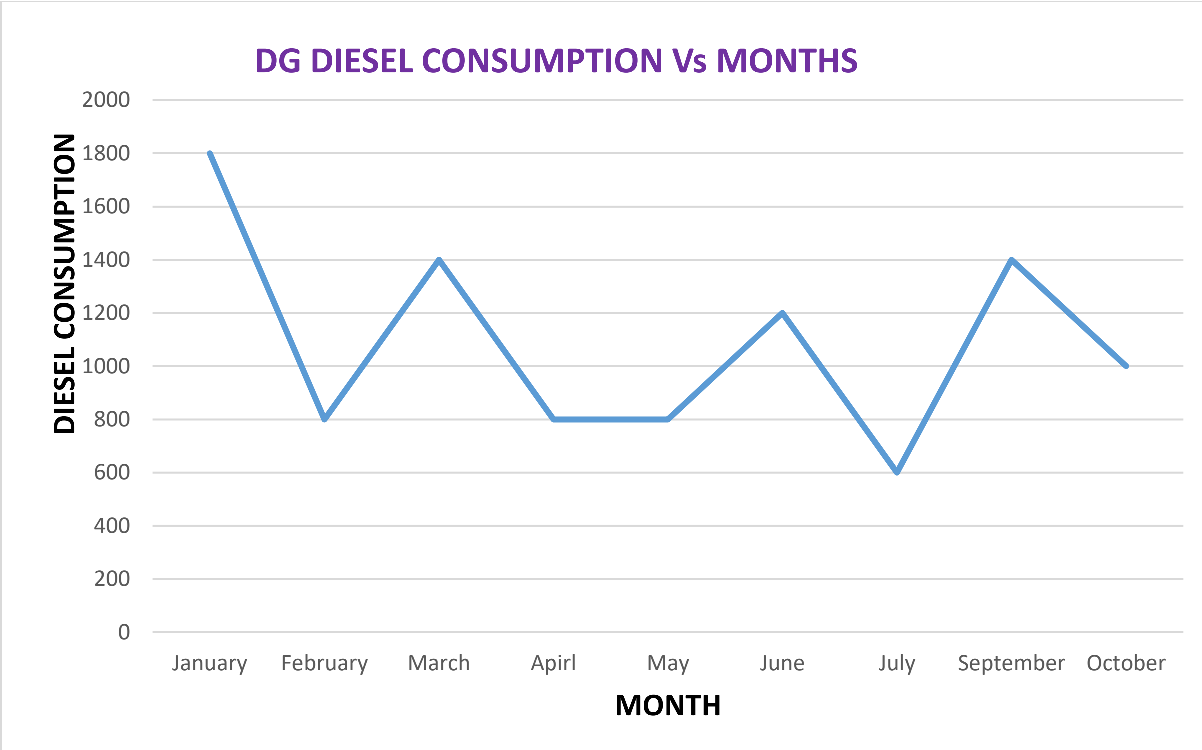
4.1.1 Observations and Recommendations

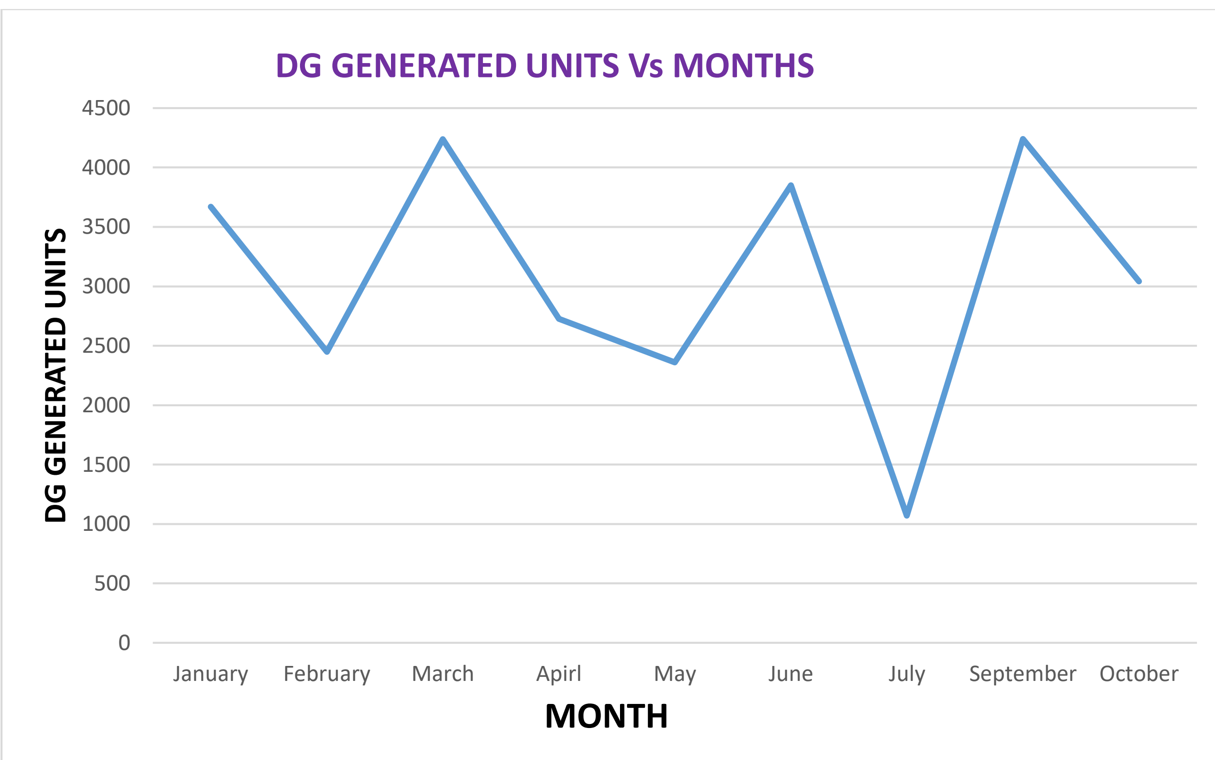
- It was observed that the Maximum Demand (MD) real time values have exceeded the permitted MD limits several times in MV 1 to MV 3 panels

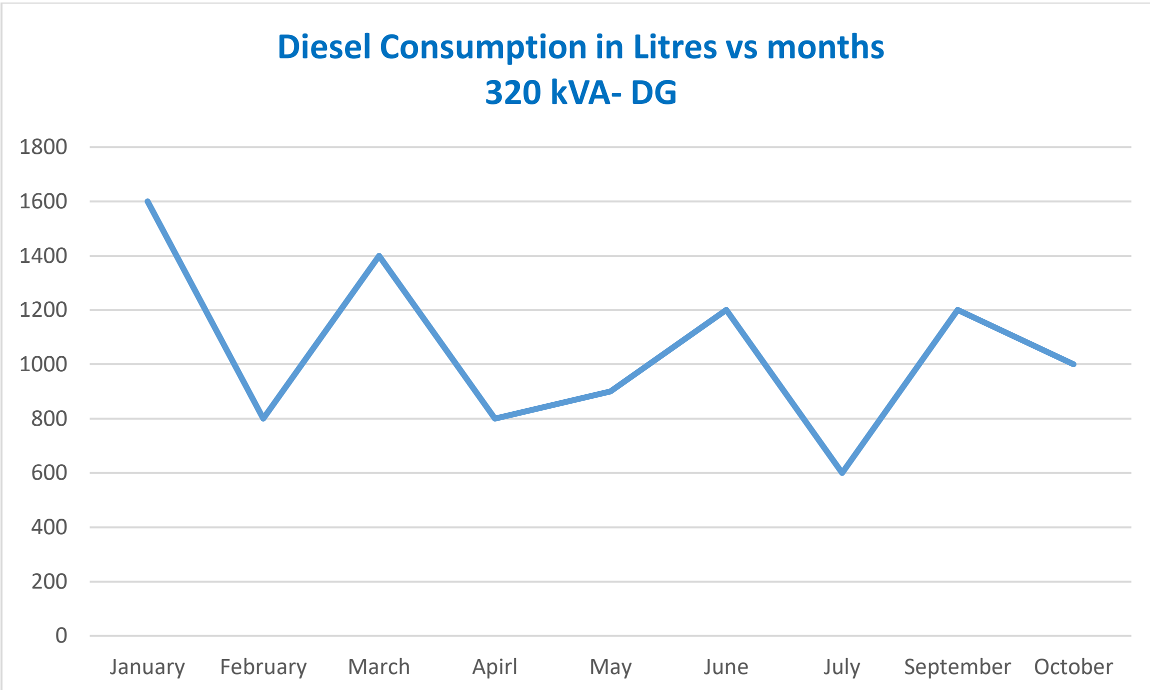
- It is understood that MD alarm alerts are provided through MD controller. The healthiness of MD controller/ alarm circuits needs to be checked for proper functioning in order to avoid such recurrences in the future.

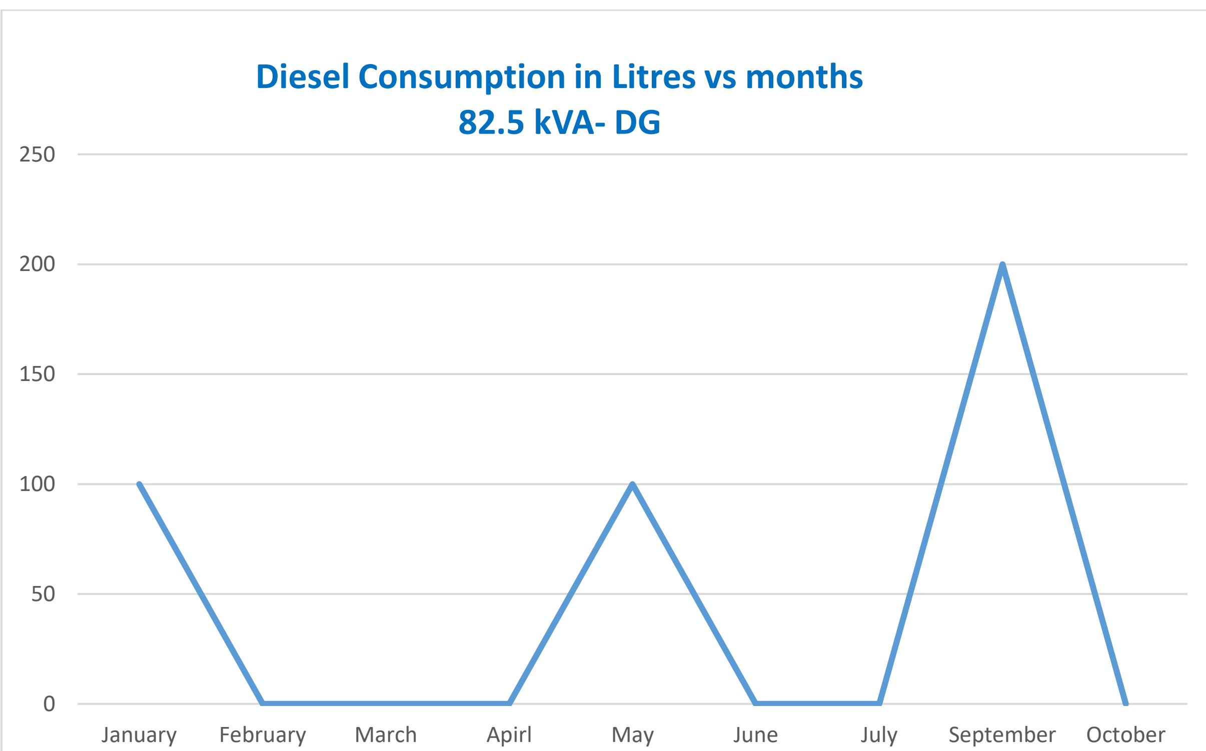
5 POWER GENERATION AND DIESEL CONSUMPTION DETAILS FOR 2021

	DG		**Diesel consumption in litres**		
Month	**kWH**	**Diesel**	**320 kVA**	**160 kVA**	**82.5 kVA**
January	3670	1800	1600	100	100
February	2450	800	800	0	0
March	4239	1400	1400	0	0
April	2726	800	800	0	0
May	2361	1000	900	0	100
June	3850	1200	1200	0	0
July	1070	600	600	0	0
September	4240	1400	1200	0	200
October	3043	1000	1000	0	0

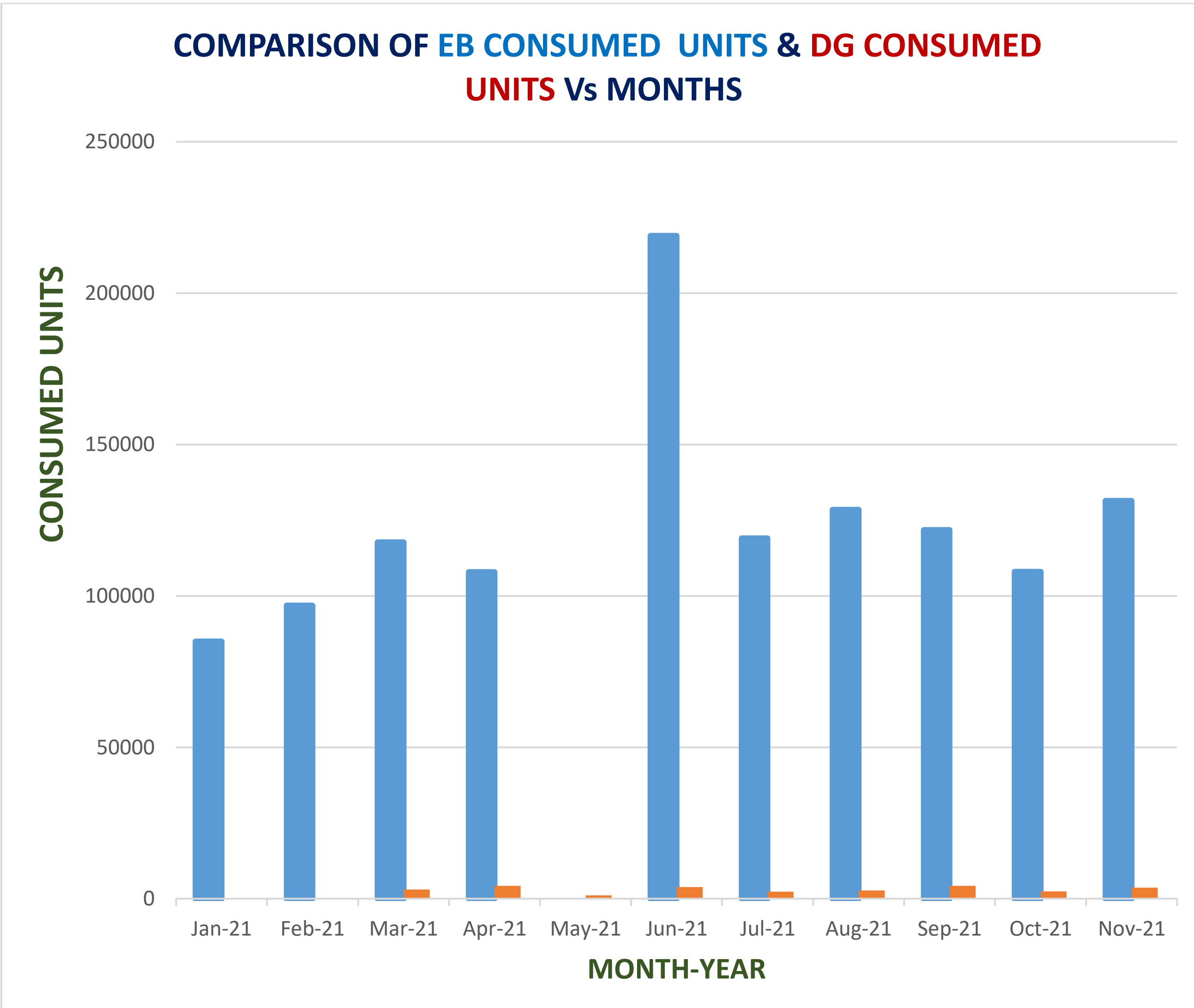

DG DIESEL CONSUMPTION Vs MONTHS
DIESEL CONSUMPTION
2000
1800
1600
1400
1200
1000
800
600
400
200
0
January
February
March
Apirl
May
June
July
September
October
MONTH


DG GENERATED UNITS Vs MONTHS
DG GENERATED UNITS
4500
4000
3500
3000
2500
2000
1500
1000
500
0
January
February
March
Apirl
May
June
July
September
October
MONTH


Diesel Consumption in Litres vs months
320 kVA- DG
1800
1600
1400
1200
1000
800
600
400
200
0
January
February
March
Apirl
May
June
July
September
October


Diesel Consumption in Litres vs months
82.5 kVA- DG
250
200
150
100
50
0
January
February
March
Apirl
May
June
July
September
October

6 UTILITY *VS.* STANDBY POWER UTILIZATION: COMPARISON



6.1.1 Recommendations

- The feasibility of mixing additives with diesel and engine lube oil may be examined, in consultation with DG engine manufacturer, for better performance of the engine.

7 ELECTRICAL MEASUREMENTS

7.1 MV PANELS

MV PANEL 1

MV PANEL 1					
S. No.	**PARAMETERS**	**R**	**Y**	**B**	**TOTAL VALUE**
1	Phase Neutral Voltage (V)	244	238.2	241.1	241.10
2	Line to Line Voltage (V)	419.6	414.9	418.3	417.60
3	Line Current (A)	99.4	93.8	100	97.73
4	Crest Factor Current	1.59	1.68	1.6	1.62
5	Crest Factor Voltage	1.45	1.45	1.44	1.45
6	Active Power (kw)	20.23	18.94	19.72	58.89
7	Reactive Power (kVAr)	23.88	22.46	22.91	69.25
8	Apparent Power (kVA)	12.45	11.71	11.36	35.52
9	Power Factor	0.85	0.85	0.87	0.86
10	True Power Factor	0.85	0.84	0.86	0.85
11	Unbalance (%)	0.65			0.65
12	Neutral Current (A)	6.9			6.9
13	Neutral Ground Voltage (V)	3.2			3.2

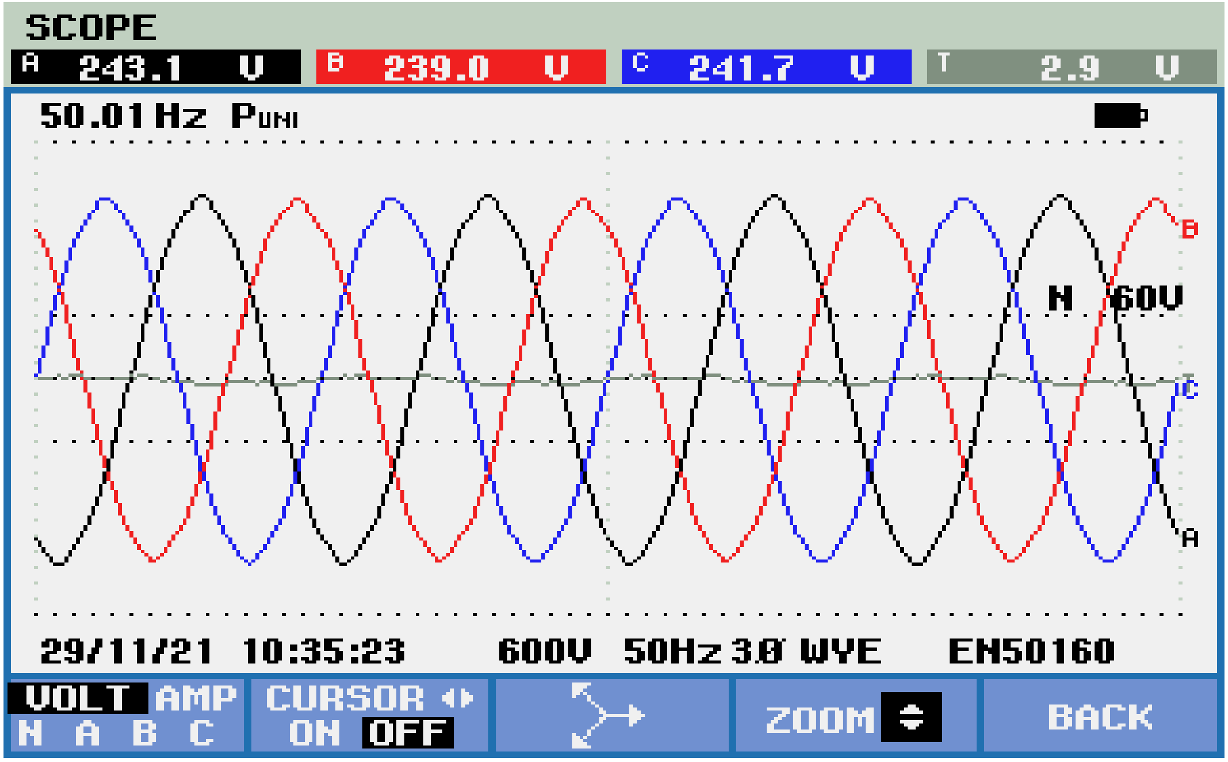
MV 1 Voltage Harmonics (%)						
Date	Time	Order	**Harmonic AN Avg.**	**Harmonic BN Avg.**	**Harmonic CN Avg.**	**Harmonic NG Avg.**
29-11-2021	10.52 am (Data logger)	0	0.04	0.02	0.06	14.84
		1	100	100	100	100
		2	0.04	0.03	0.03	0.67
		3	0.18	0.1	0.03	35.22
		4	0.02	0.03	0.03	0.43
		5	0.47	0.49	0.28	10
		6	0.03	0.04	0.04	3.15
		7	1.29	1.15	1.18	7.87
		8	0.03	0.04	0.04	0.56
		9	0.03	0.04	0.07	8.22
		10	0.04	0.04	0.04	1.04
		11	0.78	0.98	0.8	3.84

MV 1 THD V (%)					
Date	**Time**	**THD AN Avg.**	**THD BN Avg.**	**THD CN Avg.**	**THD NG Avg.**
29-11-2021	10.52 am (Data logger)	1.67	1.73	1.55	40.92

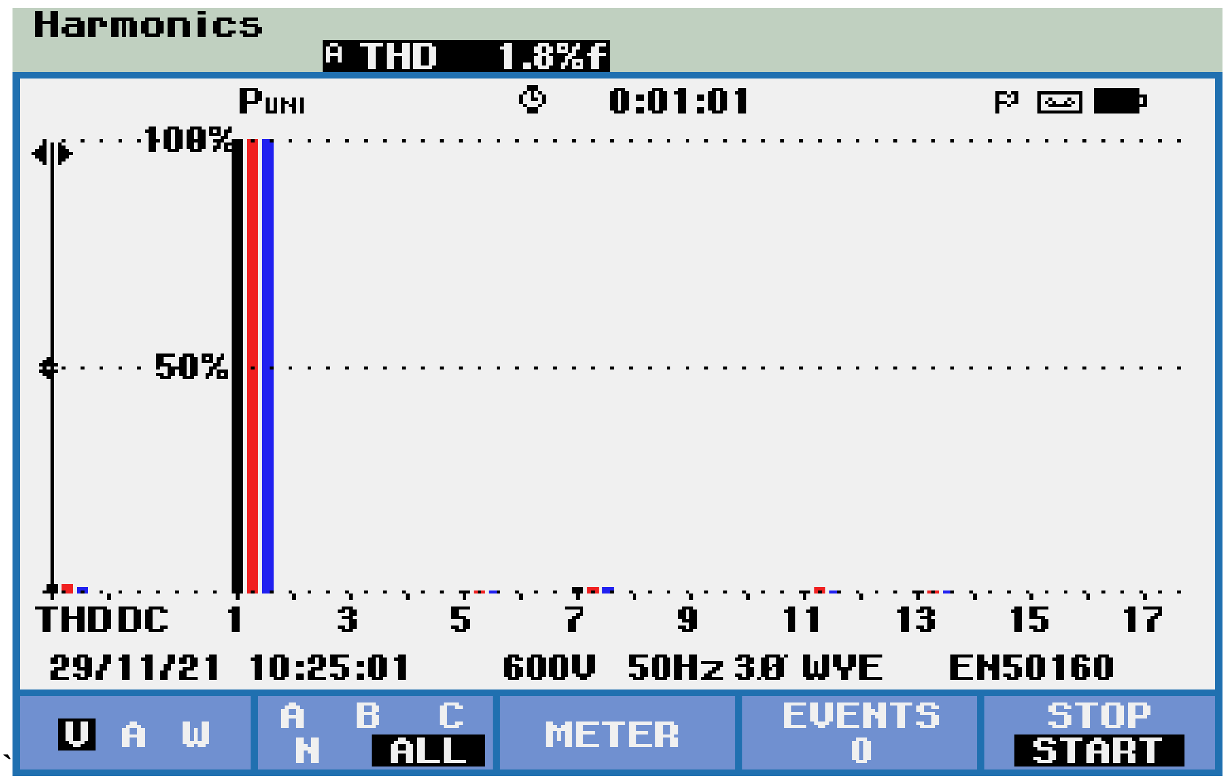
MV 1 Current Harmonics (%)						
Date	**Time**	**Order**	**Harmonics A Avg.**	**Harmonics B Avg.**	**Harmonics C Avg.**	**Harmonics N Avg.**
29-11-2021	10.52 am (Data logger)	0	0	0	0	0
		1	100	100	100	100
		2	0.35	0.35	0.36	3.98
		3	1.32	0.82	0.58	8.48
		4	0.12	0.16	0.15	1.99
		5	12.6	14.52	13.34	10.27
		6	0.14	0.16	0.16	1.57
		7	6.97	7.68	6.99	8.73
		8	0.09	0.1	0.1	1.23
		9	0.23	0.3	0.14	16.58
		10	0.04	0.05	0.05	1.19
		11	0.52	0.82	1.02	4.11

MV 1 THD A (%)					
Date	**Time**	**THD A Avg.**	**THD B Avg.**	**THD C Avg.**	**THD N Avg.**
29-11-2021	10.52 am (Data logger)	14.67	16.71	15.36	30.9

Voltage Harmonics Wave Form 3φ



Voltage Harmonics Spectrum



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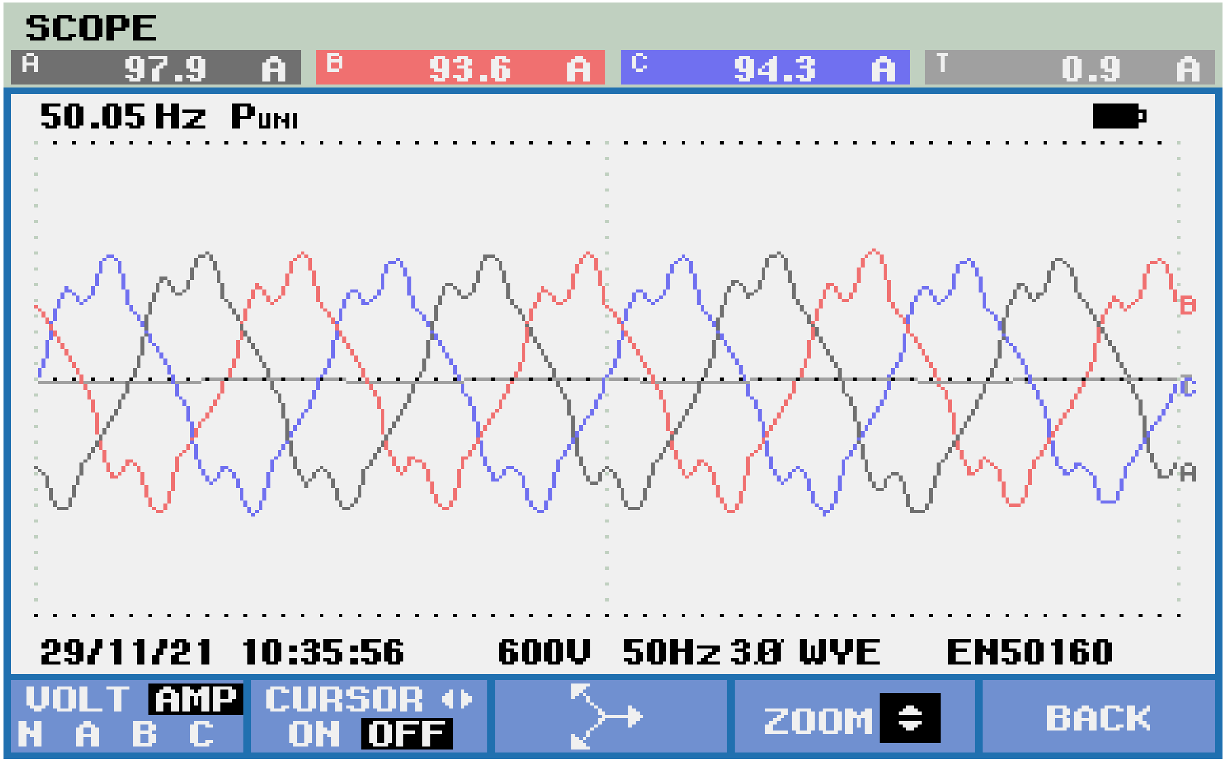
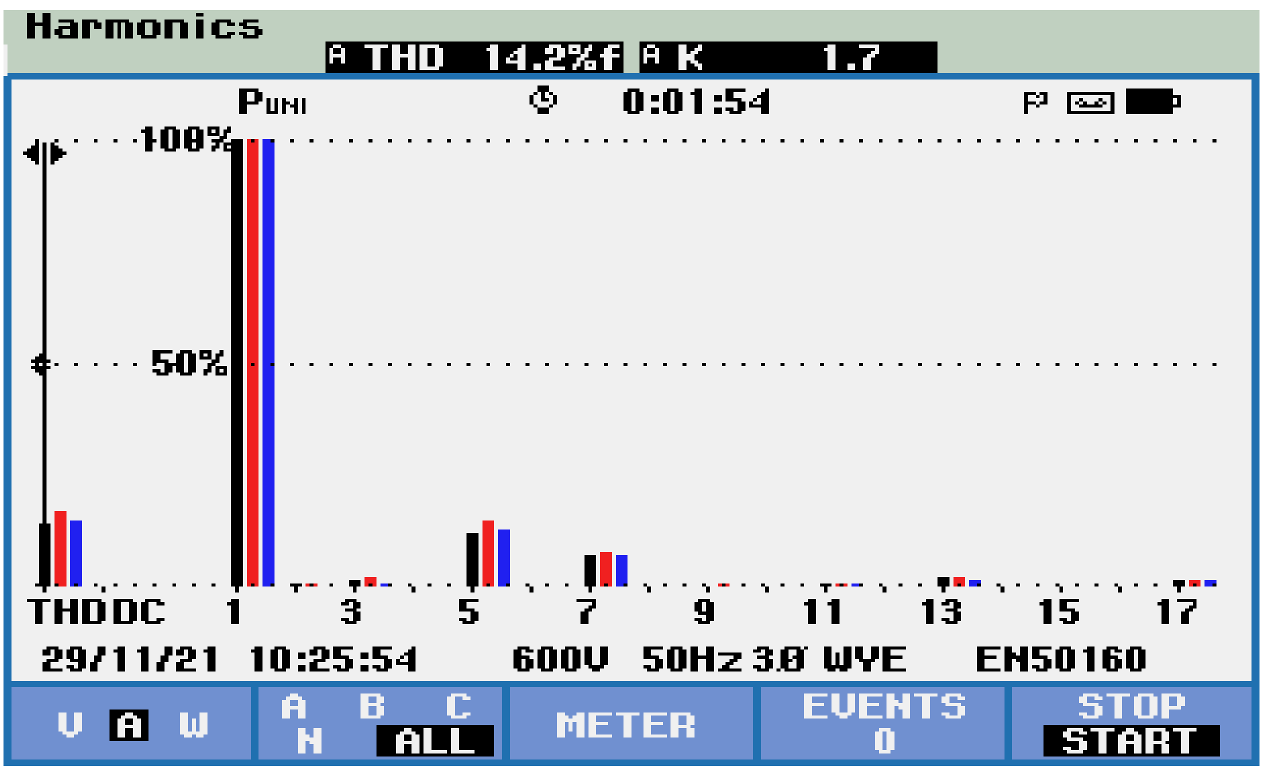
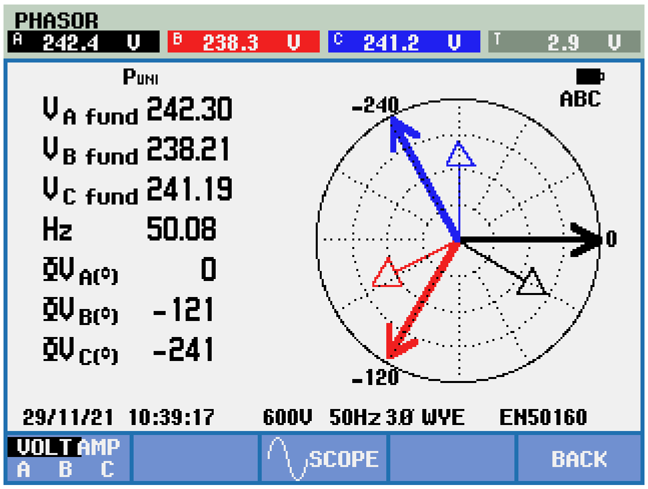
Current Harmonics Wave Form 3 φ



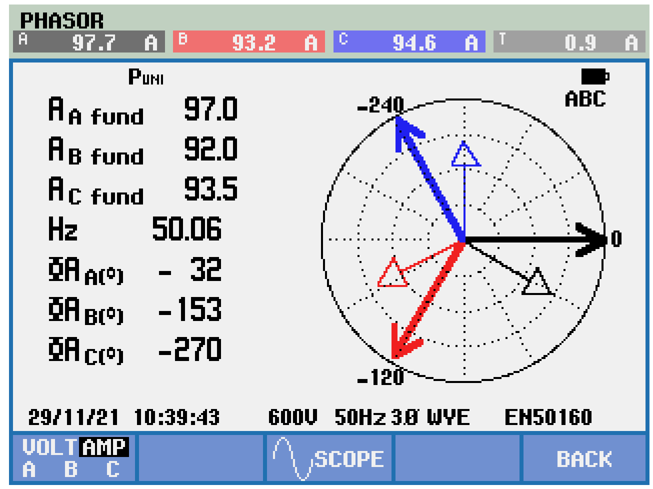
Current Harmonics Spectrum



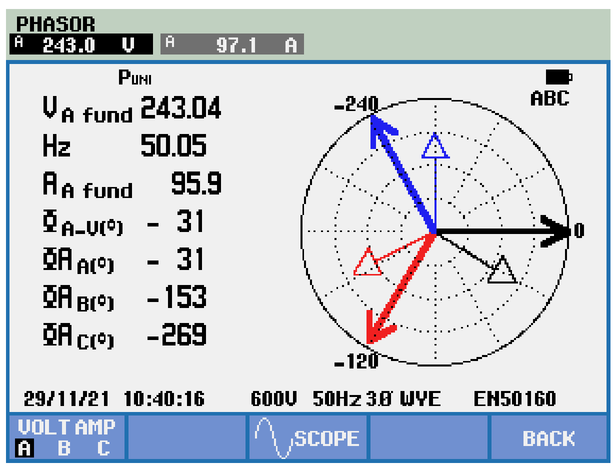
Voltage Phasor for all phases



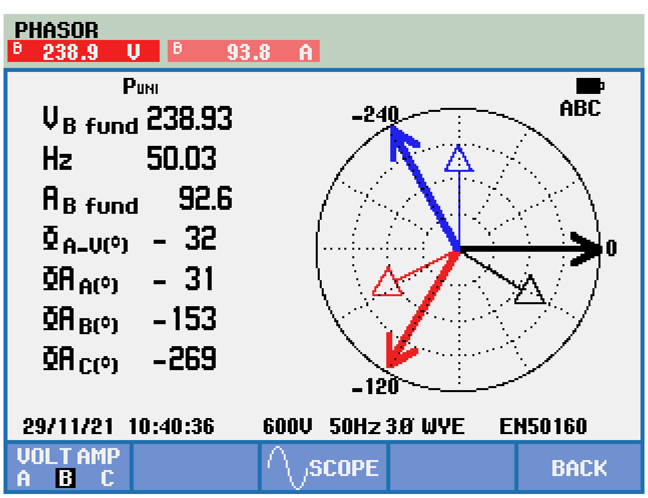
Current Phasor for all phases



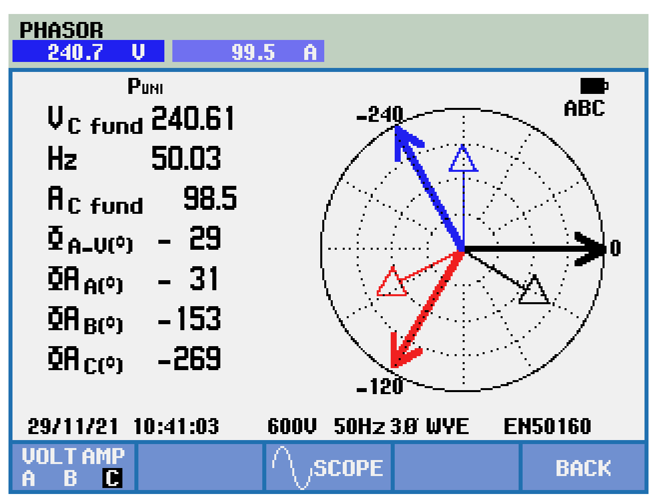
R - Voltage and Current Phasor



Y -Voltage and Current Phasor



B - Voltage and Current Phasor



MV PANEL 2

MV PANEL 2					
S.NO	**PARAMETERS**	**R**	**Y**	**B**	**TOTAL VALUE**
1	Phase Neutral Voltage (V)	236.6	239.5	238.7	238.3
2	Line to Line Voltage (V)	413.9	412.9	411	412.6
3	Line Current (A)	112.9	108.8	100.3	107.3
4	Crest Factor Current	1.65	1.72	1.84	1.7
5	Crest Factor Voltage	1.41	1.42	1.42	1.4
6	Active Power (kw)	24.45	25.79	22.39	72.6
7	Reactive Power (kVAr)	8.88	11.64	10.93	31.5
8	Apparent Power (kVA)	26.51	28.92	25.56	81.0
9	Power Factor	0.95	0.91	0.91	0.9
10	True Power Factor	0.92	0.89	0.88	0.9
11	Unbalance (%)	0.38			0.38
12	Neutral Current (A)	14.7			14.7
13	Neutral Ground Voltage (V)	4.6			4.6

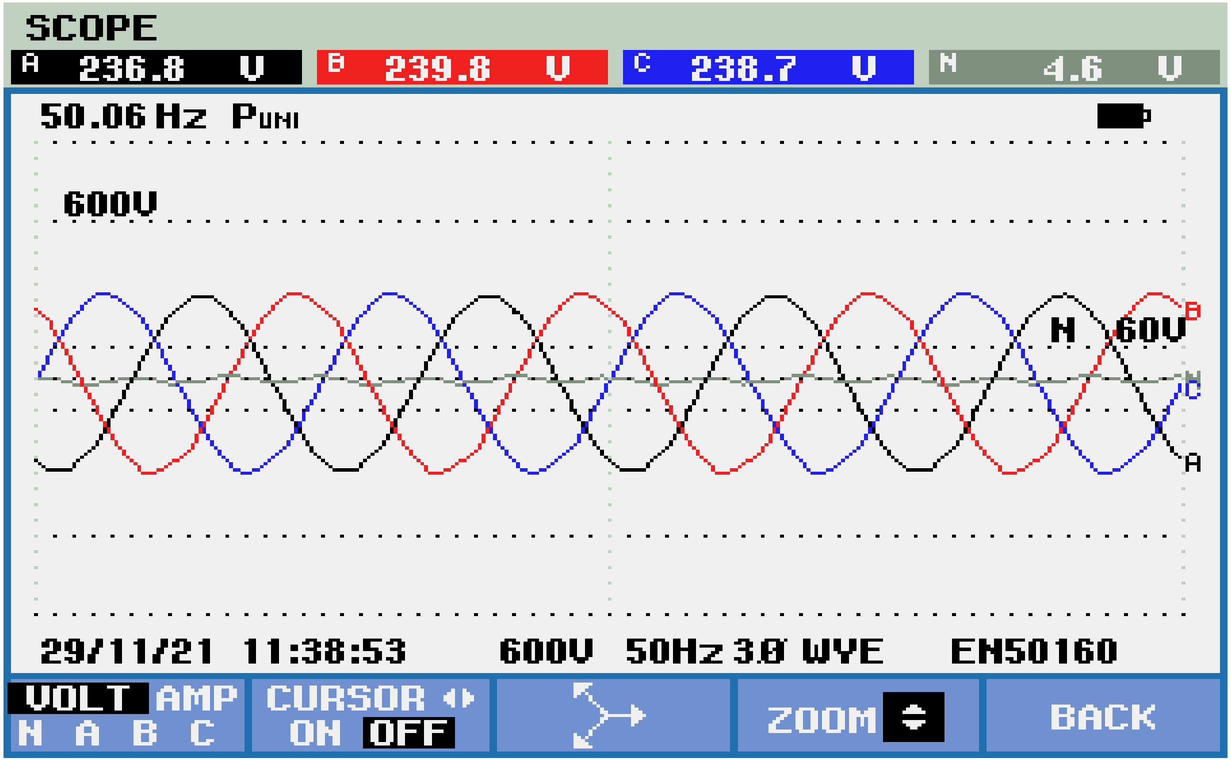
MV 2 Voltage Harmonics (%)						
Date	**Time**	**Order**	**Harmonic AN Avg.**	**Harmonic BN Avg..**	**Harmonic CN Avg.**	**Harmonic NG Avg.**
29-11-2021	11.48 am (Data logger)	0	0	0	0	0
		1	100	100	100	100
		2	0.41	0.39	0.47	3.7
		3	5.04	1.54	2.46	83.22
		4	0.15	0.09	0.1	2.8
		5	9.92	12.61	12.93	53.71
		6	0.1	0.08	0.08	1.75
		7	6.3	7.9	7.25	25.21
		8	0.07	0.06	0.08	1.02
		9	0.61	0.42	0.88	7.84
		10	0.05	0.04	0.05	0.83
		11	2.38	2.68	3.06	7.81

MV 2 THD V (%)					
Date	**Time**	**THD AN Avg.**	**THD BN Avg.**	**THD CN Avg.**	**THD NG Avg.**
29-11-2021	11.48 am (Data logger)	1.15	1.48	1.22	138.84

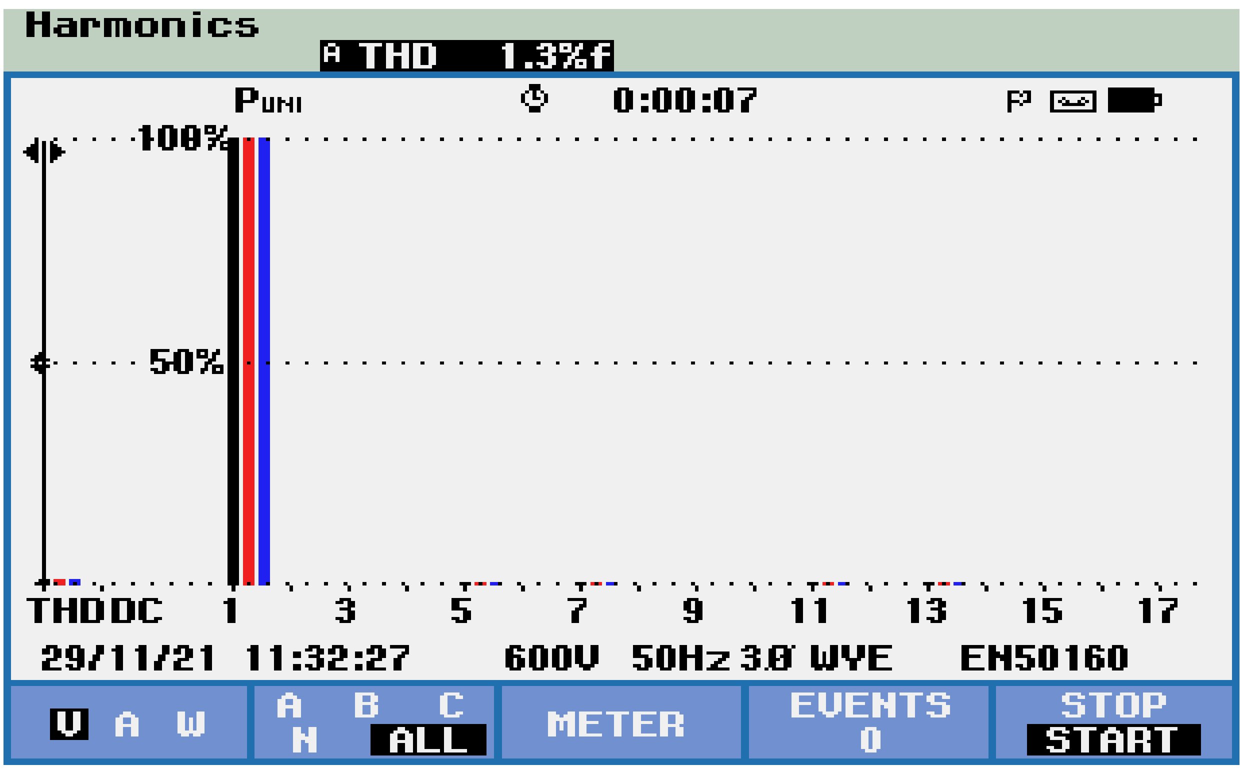
MV 2 Current Harmonics (%)						
Date	**Time**	**Order**	**Harmonics A Avg.**	**Harmonics B Avg.**	**Harmonics C Avg.**	**Harmonics N Avg.**
29-11-2021	11.48 am (Data logger)	0	0	0	0	0
		1	100	100	100	100
		2	0.41	0.39	0.47	3.7
		3	5.04	1.54	2.46	83.22
		4	0.15	0.09	0.1	2.8
		5	9.92	12.61	12.93	53.71
		6	0.1	0.08	0.08	1.75
		7	6.3	7.9	7.25	25.21
		8	0.07	0.06	0.08	1.02
		9	0.61	0.42	0.88	7.84
		10	0.05	0.04	0.05	0.83
		11	2.38	2.68	3.06	7.81

MV 2 THD A (%)					
Date	**Time**	**THD A Avg.**	**THD B Avg.**	**THD C Avg.**	**THD N Avg.**
29-11-2021	11.48 am (Data logger)	13.23	15.44	15.6	103.45

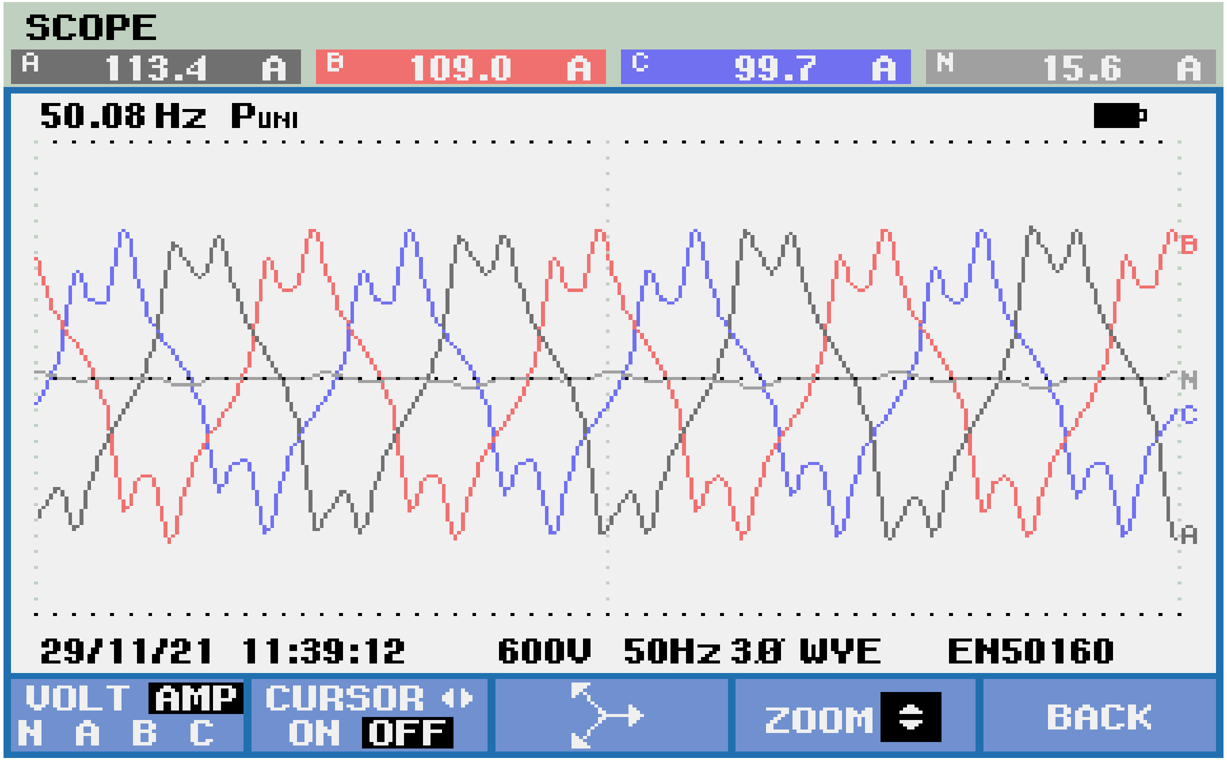
Voltage Harmonics Wave Form 3φ



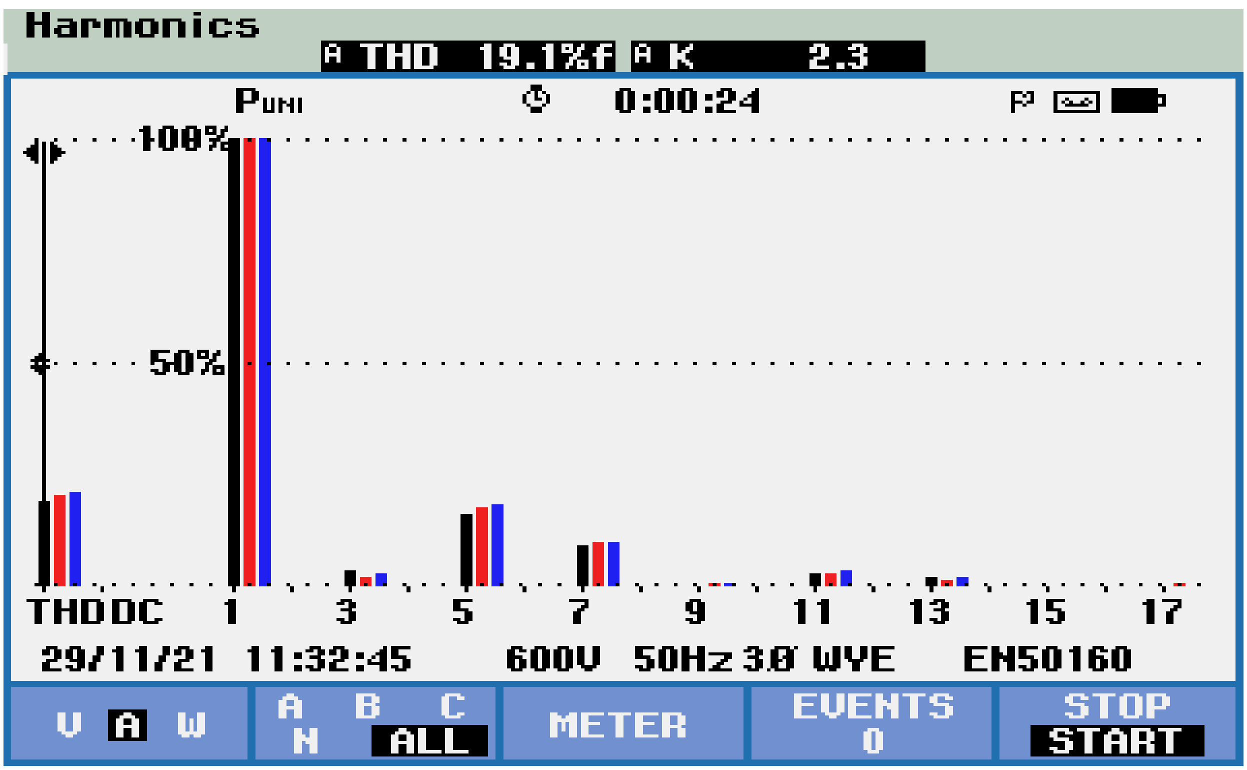
Voltage Harmonics Spectrum



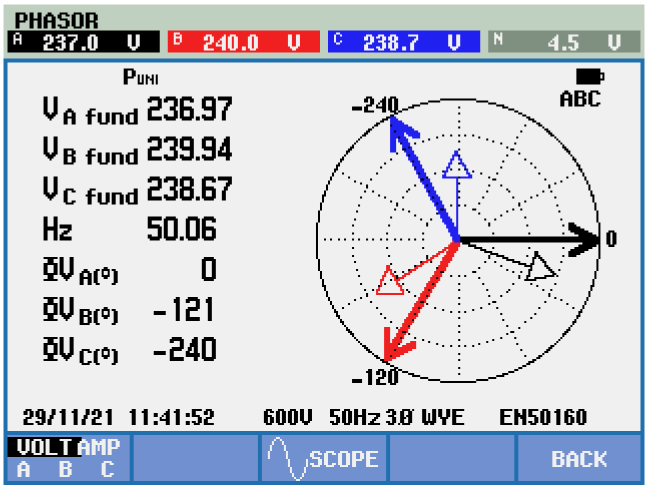
Current Harmonics Wave Form 3φ



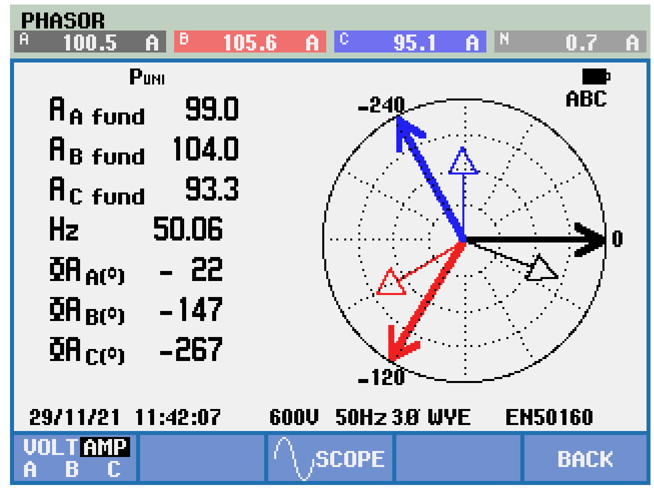
Current Harmonics Spectrum



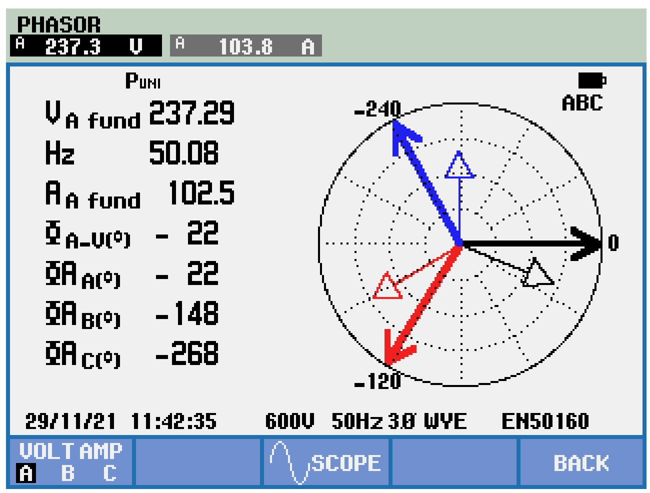
Voltage Phasor for all phases



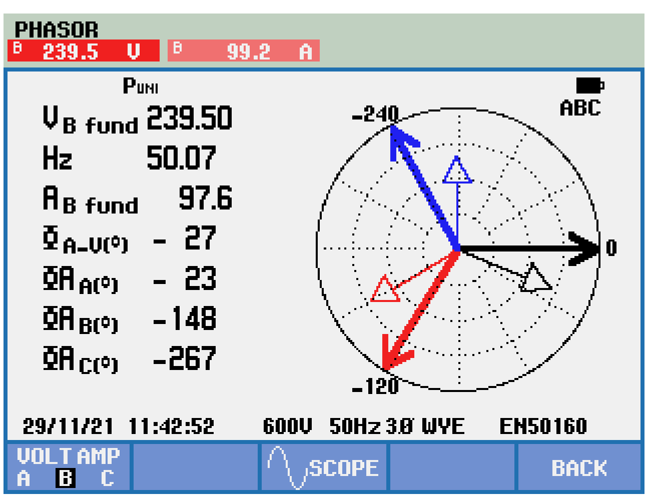
Current Phasor for all phases



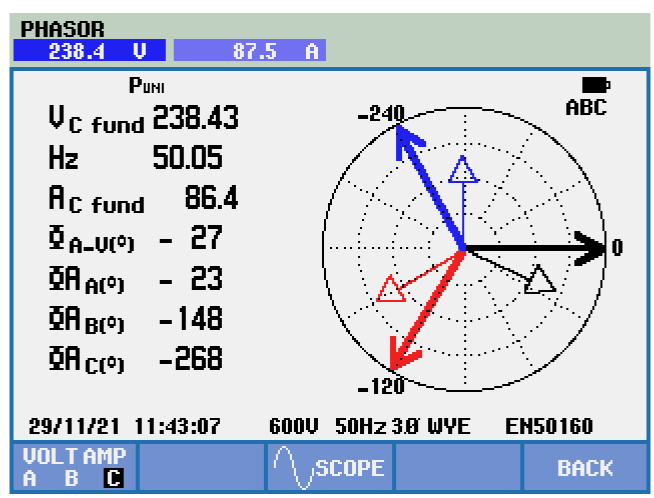
R - Voltage and Current Phasor



Y - Voltage and Current Phasor



B - Voltage and Current Phasor



MV PANEL 3

MV PANEL 3					
S. No.	**PARAMETERS**	**R**	**Y**	**B**	**TOTAL VALUE**
1	Phase Neutral Voltage (V)	236.8	241	239.5	239.10
2	Line to Line Voltage (V)	415.3	415	412.1	414.13
3	Line Current (A)	33.6	29.7	38.3	33.87
4	Crest Factor Current	1.76	1.77	1.73	1.75
5	Crest Factor Voltage	1.42	1.42	1.42	1.42
6	Active Power (kw)	6.78	6.13	8.26	21.17
7	Reactive Power (kVAr)	7.93	7.16	9.07	24.16
8	Apparent Power (kVA)	3.7	3.8	3.17	10.67
9	Power Factor	0.88	0.89	0.93	0.90
10	True Power Factor	0.85	0.86	0.91	0.87
11	Unbalance (%)	0.49			0.49
12	Neutral Current (A)	5			5.00
13	Neutral Ground Voltage (V)	5.3			5.30

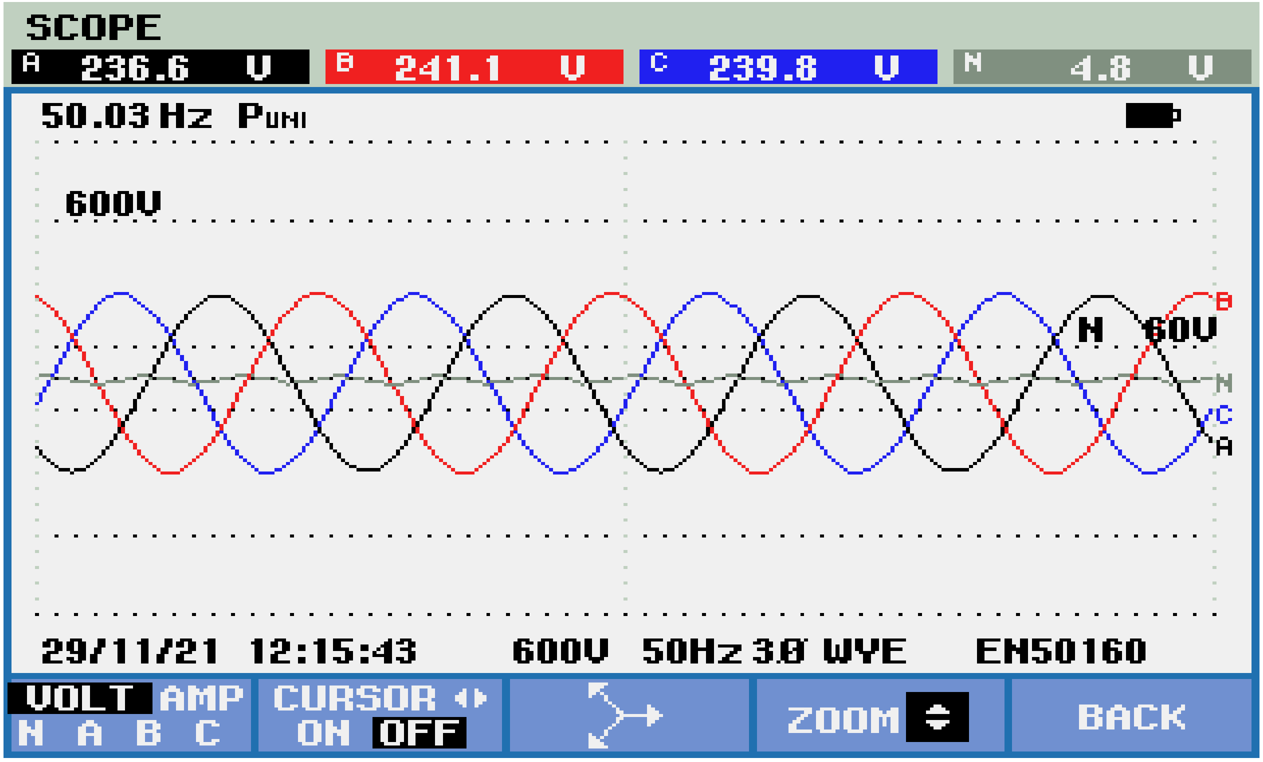
MV 3 Voltage Harmonics (%)						
Date	**Time**	**Order**	**Harmonic AN Avg.**	**Harmonic BN Avg.**	**Harmonic CN Avg.**	**Harmonic NG Avg.**
29-11-2021	12.22 pm (Data logger)	0	0.05	0.03	0.08	6.98
		1	100	100	100	100
		2	0.04	0.03	0.05	3.85
		3	0.23	0.18	0.15	327.67
		4	0.01	0.01	0.02	2.12
		5	0.27	0.49	0.46	21.65
		6	0.02	0.03	0.02	8.27
		7	0.88	0.77	0.9	27.46
		8	0.01	0.02	0.03	6.45
		9	0.04	0.23	0.18	83.33
		10	0.01	0.01	0.01	7.83
		11	0.08	0.06	0.17	17.33

MV 3 THD V (%)					
Date	Time	**THD AN Avg.**	**THD BN Avg.**	**THD CN Avg.**	**THD NG Avg.**
29-11-2021	12.22 pm (Data logger)	1.1	1.08	1.17	327.67

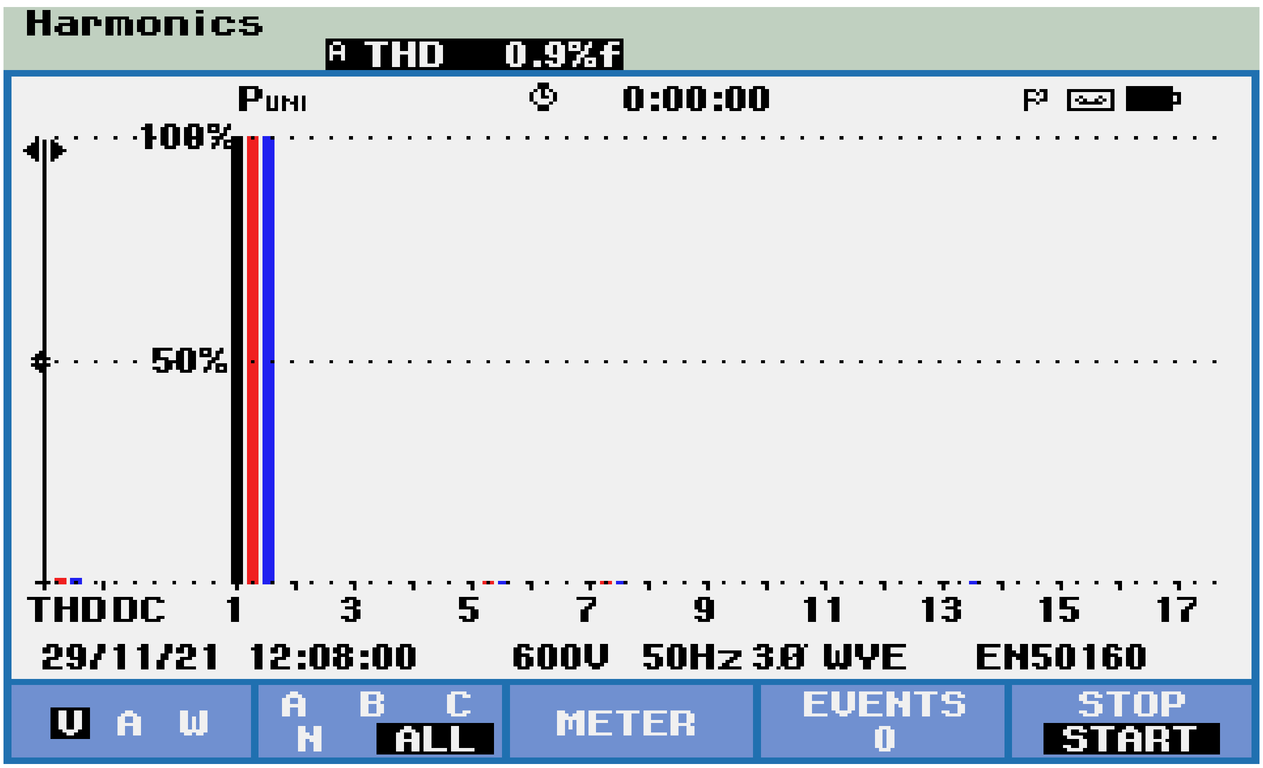
MV 3 Current Harmonics (%)						
Date	**Time**	**Order**	**Harmonics A Avg.**	**Harmonics B Avg.**	**Harmonics C Avg.**	**Harmonics N Avg.**
29-11-2021	12.22 pm (Data logger)	0	0	0	0	0
		1	100	100	100	100
		2	0.59	0.25	1.59	13.02
		3	1.06	5.06	2.25	23.46
		4	0.16	0.2	0.18	1.05
		5	20.83	25.58	20.38	8.5
		6	0.11	0.17	0.21	1.53
		7	13.96	16.46	12.23	5.42
		8	0.06	0.06	0.12	0.85
		9	0.45	0.5	0.42	6.22
		10	0.08	0.06	0.08	0.55
		11	2.33	2.52	2.18	2.22

MV 3 THD A (%)					
Date	**Time**	**THD A Avg.**	**THD B Avg.**	**THD C Avg.**	**THD N Avg.**
29-11-2021	12.22 pm (Data logger)	25.46	31.27	24.29	30.07

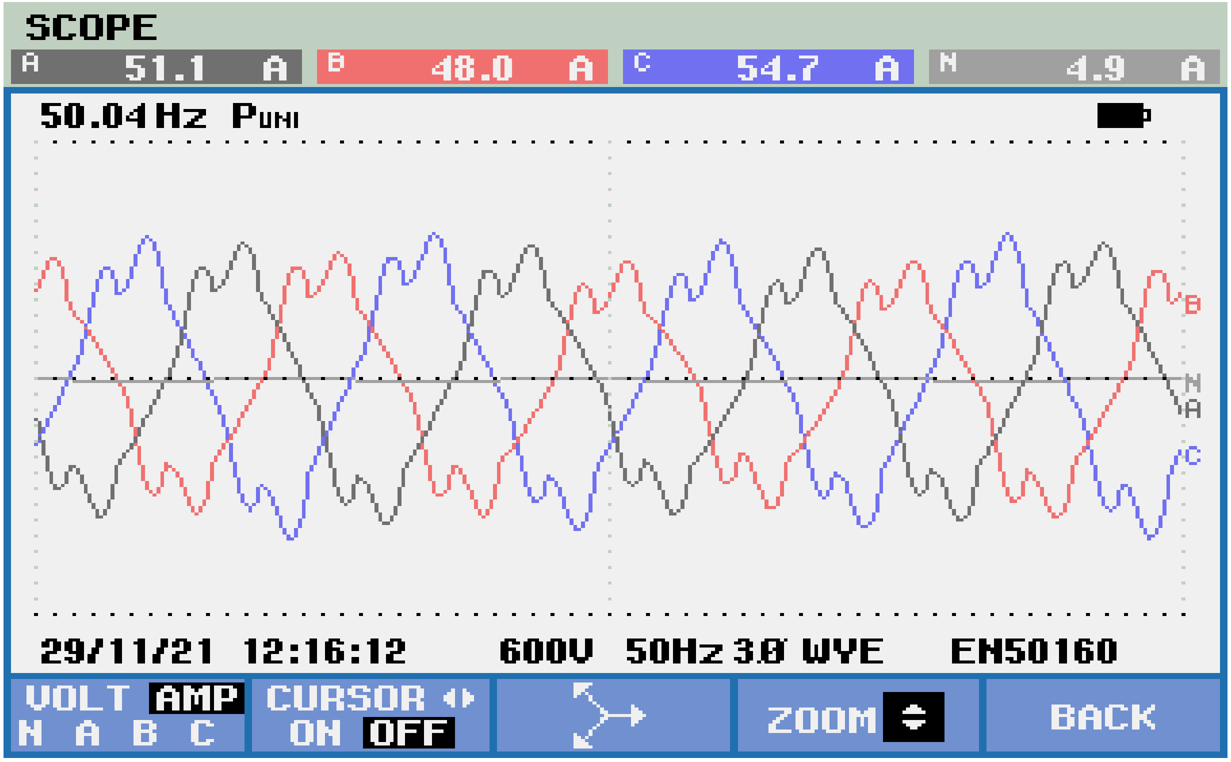
Voltage Harmonics Wave Form 3φ



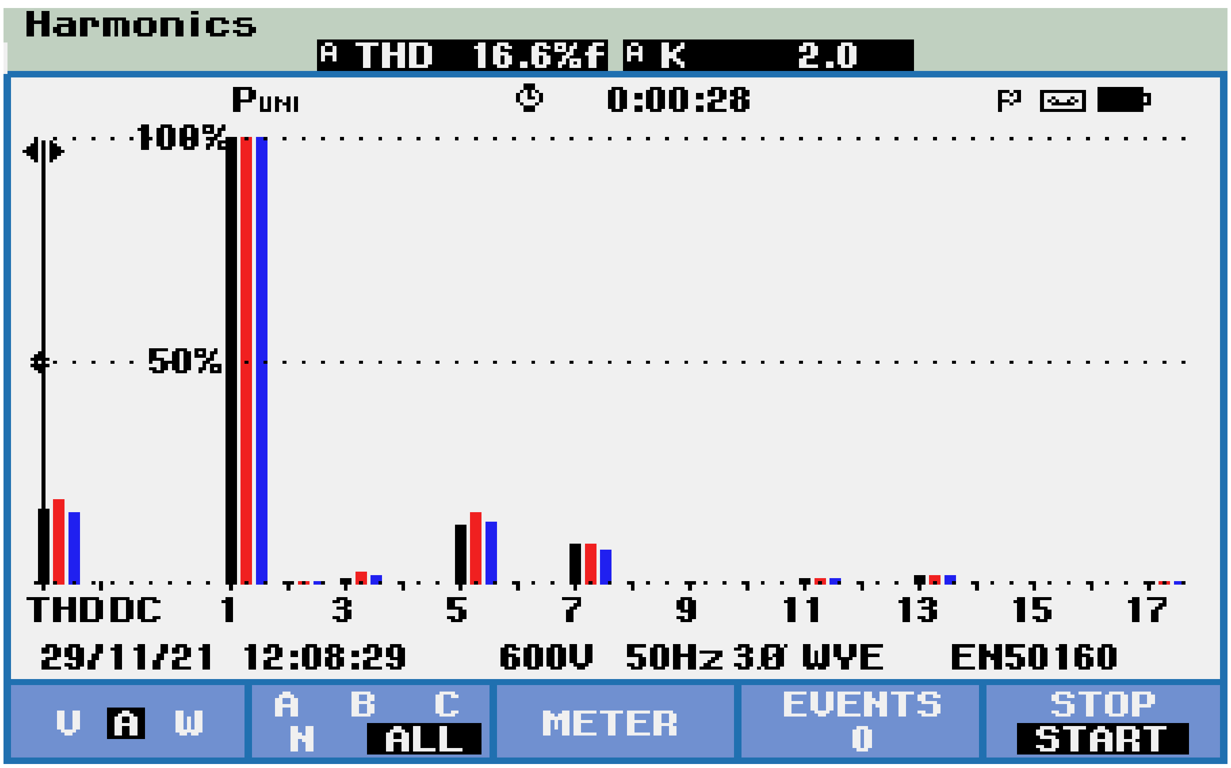
Voltage Harmonics Spectrum



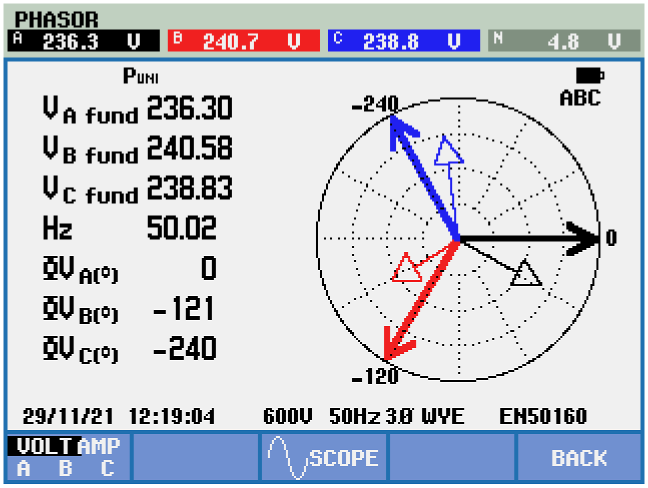
Current Harmonics Wave Form 3φ



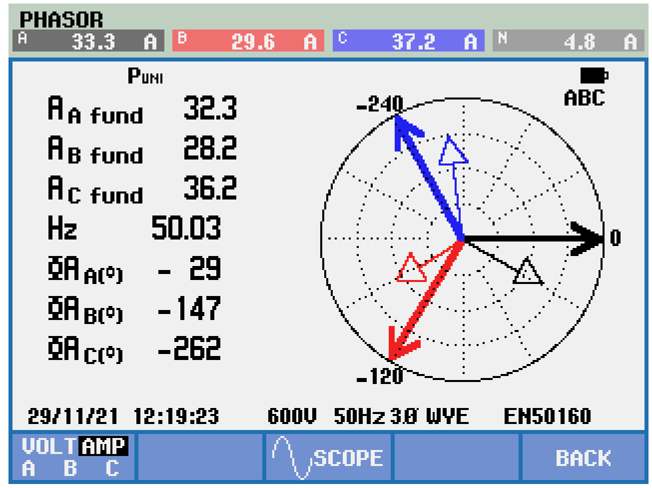
Current Harmonics Spectrum



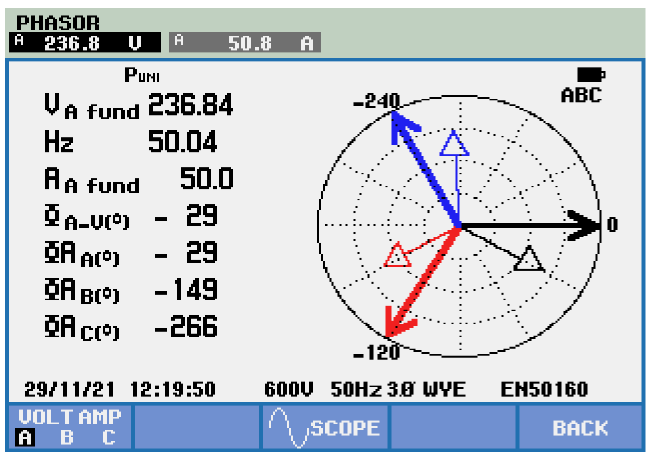
Voltage Phasor for all phases



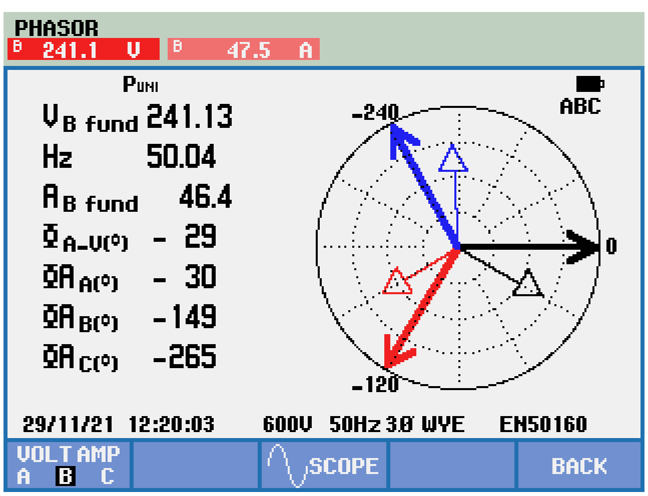
Current Phasor for all phases



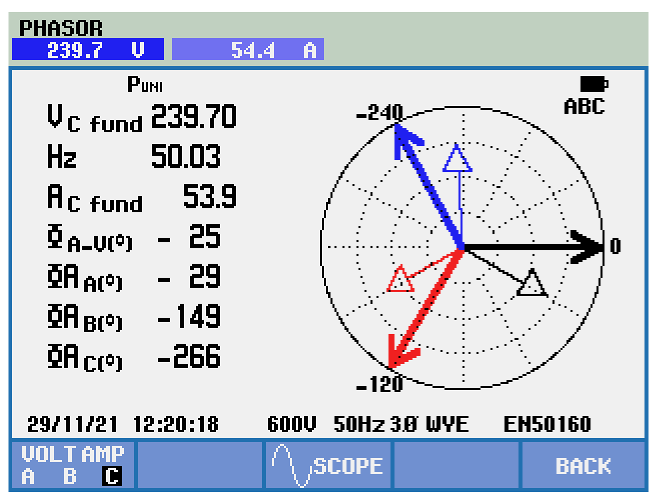
R - Voltage and Current Phasor



Y - Voltage and Current Phasor



B - Voltage and Current Phasor



MV PANEL 4

MV PANEL 4					
S.NO	**PARAMETERS**	**R**	**Y**	**B**	**TOTAL VALUE**
1	Phase Neutral Voltage (V)	233.2	231.4	233.5	232.7
2	Line to Line Voltage (V)	404.4	401.5	403.1	403.0
3	Line Current (A)	142.6	141	139.3	141.0
4	Crest Factor Current	1.55	1.57	1.54	1.55
5	Crest Factor Voltage	1.43	1.42	1.42	1.42
6	Active Power (kw)	33.27	32.59	32.71	98.57
7	Reactive Power (kVAr)	3.85	4.08	4.04	11.97
8	Apparent Power (k)	33.62	32.97	33.08	99.67
9	Power Factor	0.99	0.99	0.99	0.99
10	True Power Factor	0.99	0.99	0.99	0.99
11	Unbalance (%)	0.37			0.37
12	Neutral Current (A)	1.4			1.4
13	Neutral Ground Voltage (V)	6.6			6.6

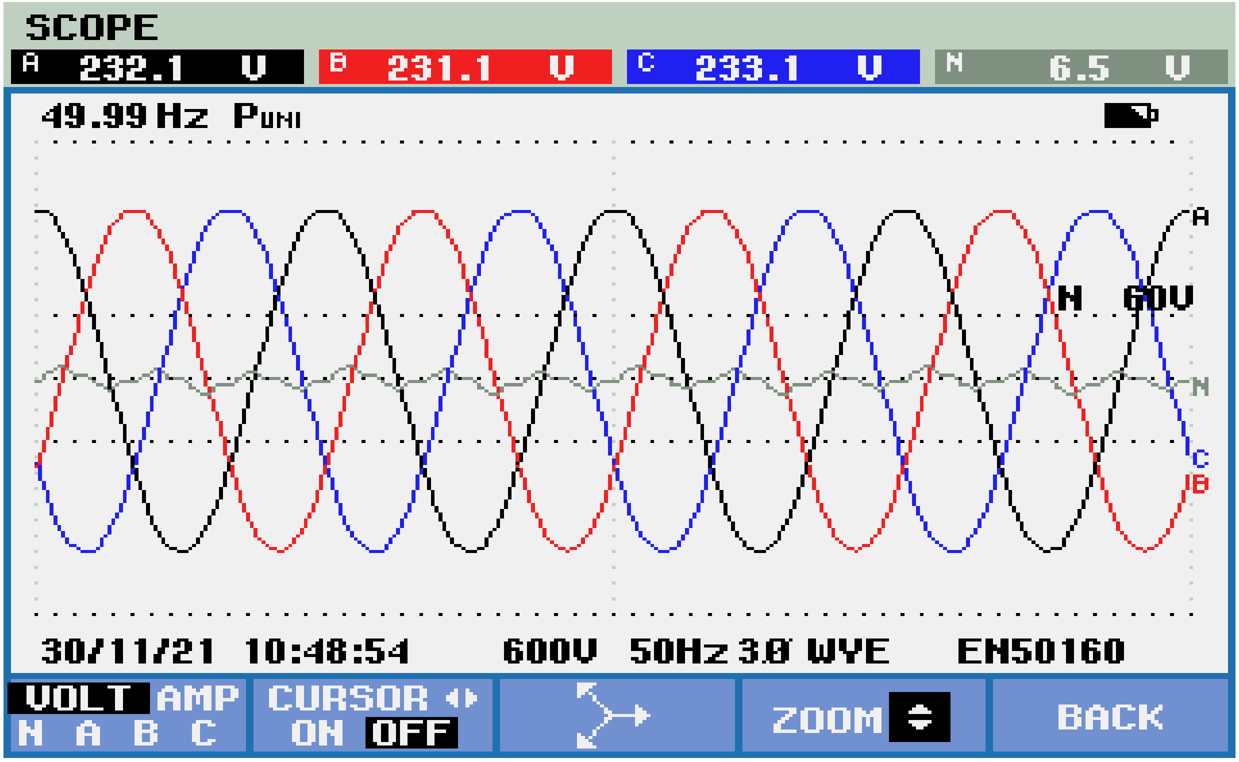
MV 4 Voltage Harmonics (%)						
Date	**Time**	**Order**	**Harmonic AN Avg.**	**Harmonic BN Avg.**	**Harmonic CN Avg.**	**Harmonic NG Avg.**
30-11-2021	1.00pm (Data logger)	0	0.03	0.01	0.03	12.2
		1	100	100	100	100
		2	0.04	0.02	0.03	1.76
		3	0.18	0.09	0.14	326.92
		4	0.03	0.02	0.04	0.81
		5	1.08	1.22	1.38	13.81
		6	0.03	0.03	0.03	2.38
		7	0.23	0.09	0.16	6.95
		8	0.03	0.04	0.04	1.04
		9	0.08	0.16	0.13	99.42
		10	0.04	0.03	0.04	1.2
		11	0.52	0.54	0.73	1.68

MV 4 THD V(%)					
Date	**Time**	**THD AN Avg.**	**THD BN Avg.**	**THD CN Avg.**	**THD NG Avg.**
30-11-2021	1.00pm (Data logger)	1.48	1.64	1.85	327.67

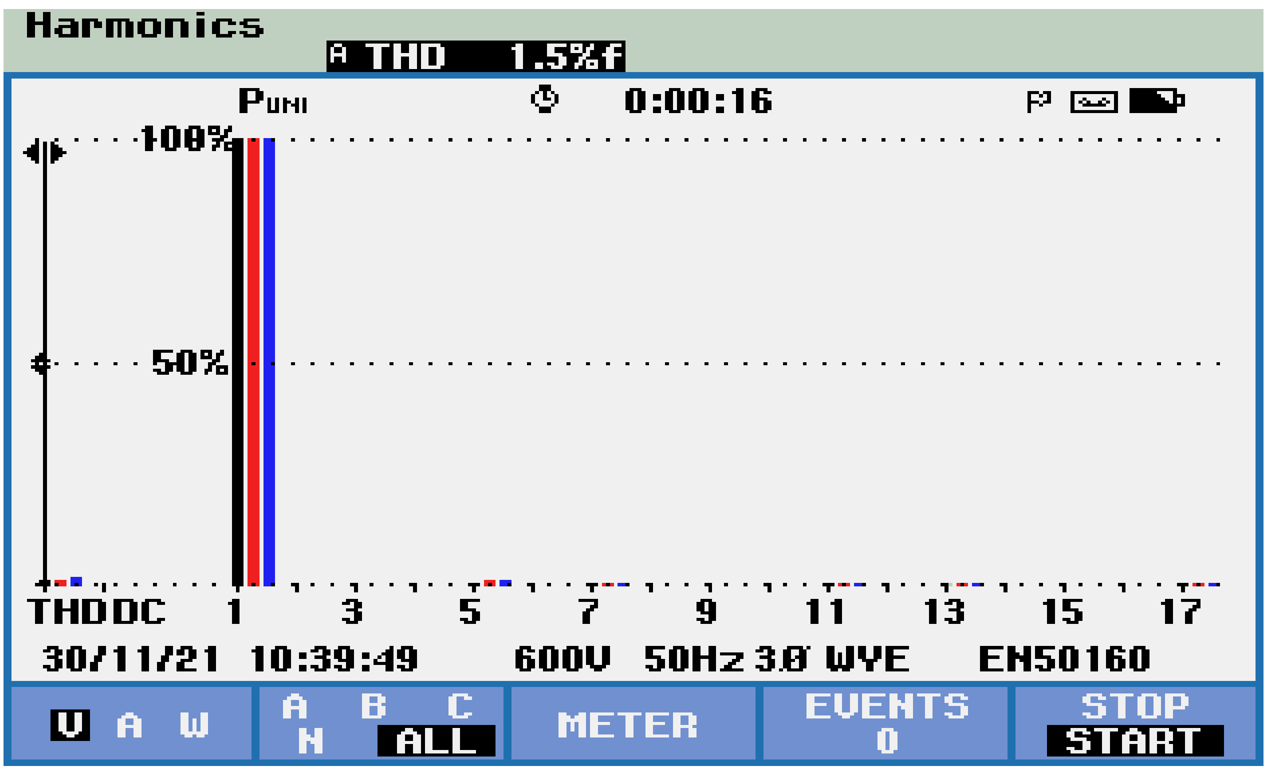
MV 4 Current Harmonics (%)						
Date	**Time**	**Order**	**Harmonics A Avg.**	**Harmonics B Avg.**	**Harmonics C Avg.**	**Harmonics N Avg.**
30-11-2021	1.00pm (Data logger)	0	0	0	0	0
		1	100	100	100	100
		2	0.3	0.29	0.3	3.8
		3	0.44	0.55	0.55	194.53
		4	0.18	0.16	0.18	1.9
		5	4.63	4.18	4.39	3.08
		6	0.16	0.14	0.16	1.95
		7	1.28	1.31	1.36	3.04
		8	0.15	0.13	0.16	1.06
		9	0.19	0.28	0.32	70.92
		10	0.16	0.14	0.16	1.01
		11	1.79	1.46	1.72	2.7

MV 4 THD A(%)					
Date	**Time**	**THD A Avg.**	**THD B Avg.**	**THD C Avg.**	**THD N Avg.**
30-11-2021	1.00pm (Data logger)	5.82	5.53	5.7	210.31

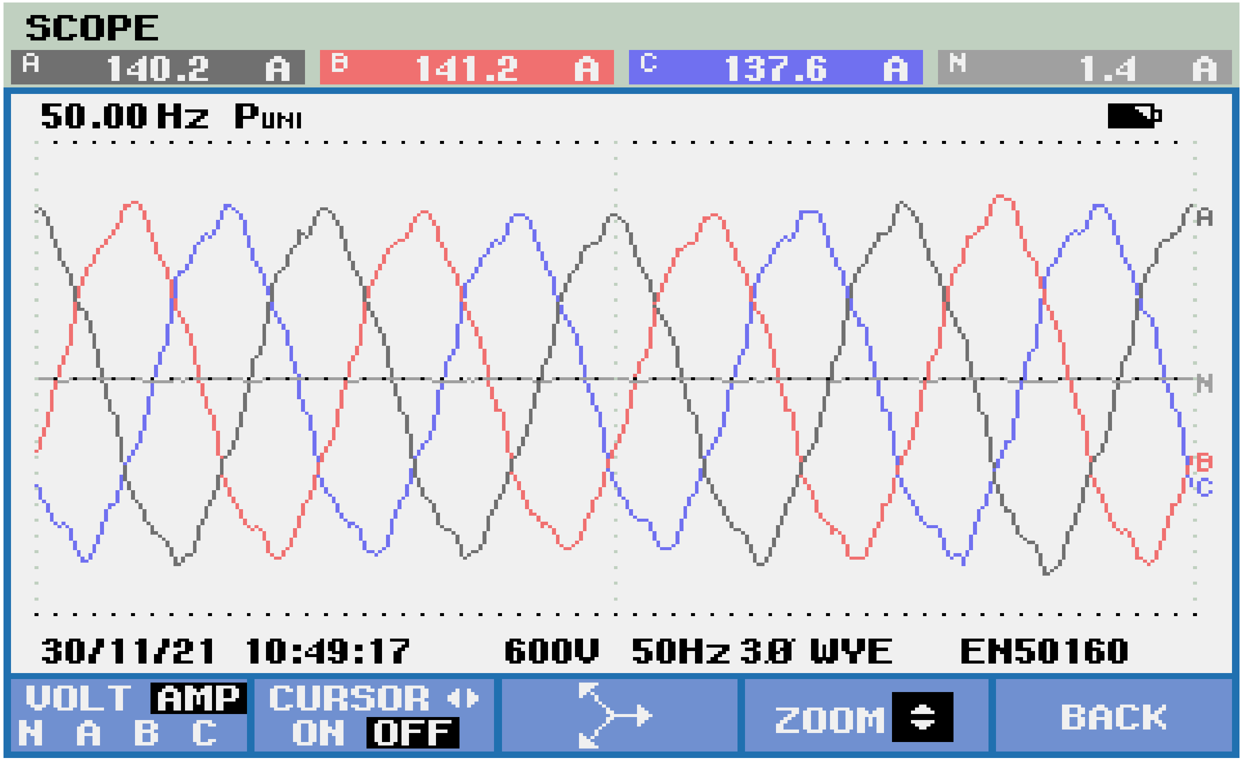
Voltage Harmonics Wave Form 3φ



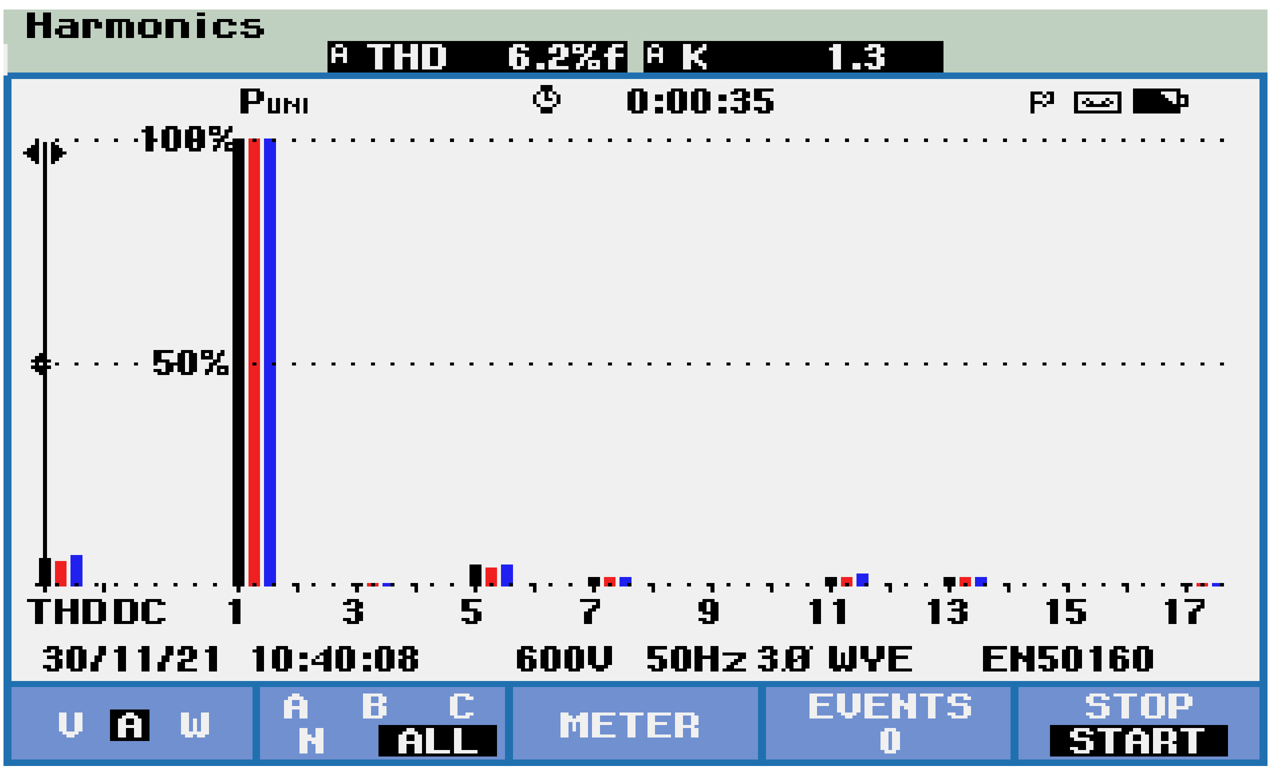
Voltage Harmonics Spectrum



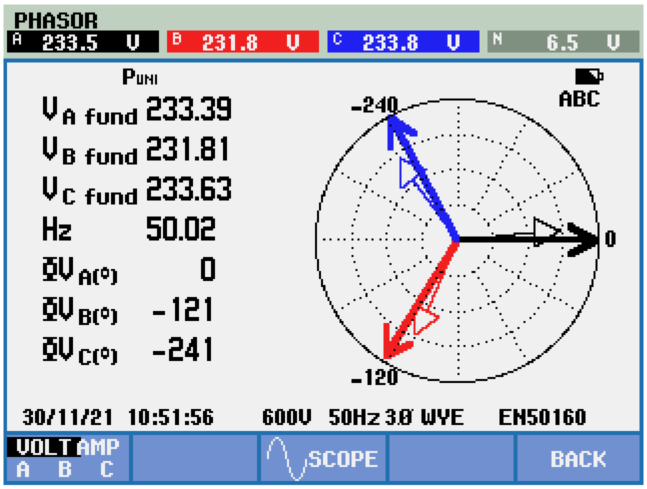
Current Harmonics Wave Form 3φ



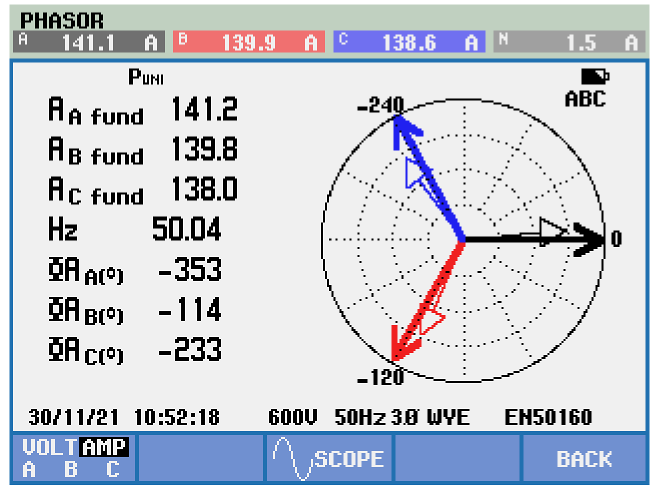
Current Harmonics Spectrum



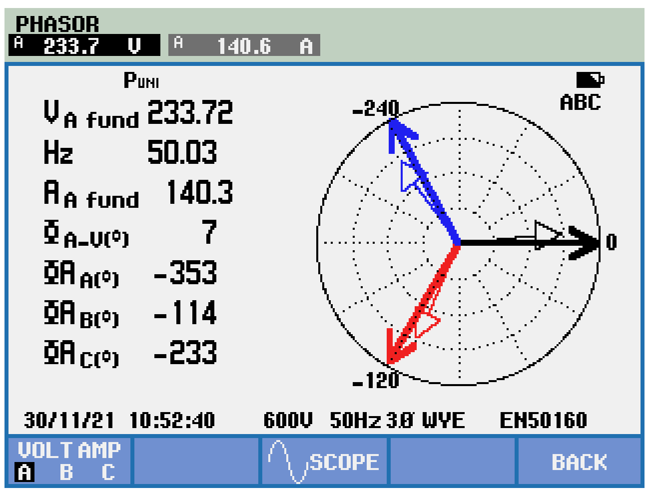
Voltage Phasor for all phases



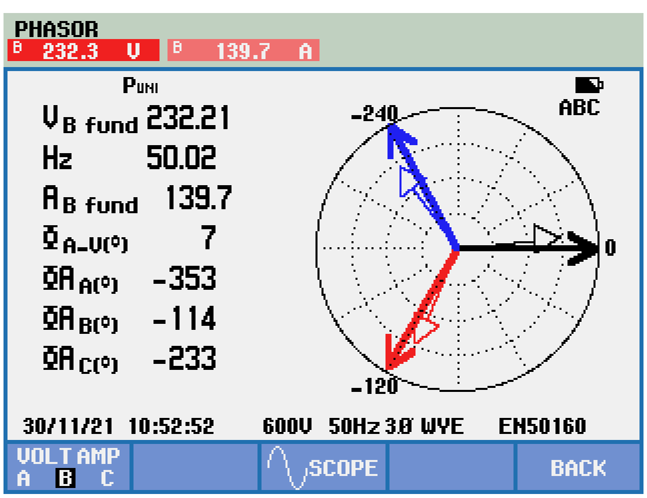
Current Phasor for all phases



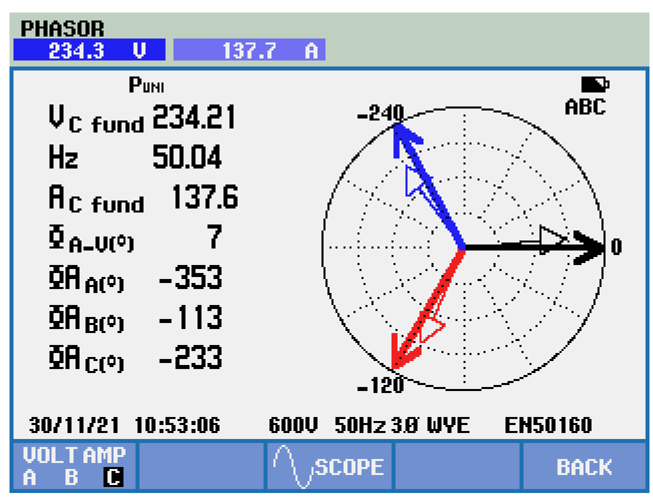
R - Voltage and Current Phasor



Y - Voltage and Current Phasor



B - Voltage and Current Phasor



7.1.1 *Observations and Recommendations*

- ✓ The measurements carried out on all the medium voltage panels in the power room indicate high values of current distortions (THD- Total harmonic distortion). Limits for these distortions stipulated by the relevant standards are attached in this report. Obviously, it is seen that the measured values exceed well beyond the acceptable limit namely 8%.
- ✓ Presently TANGEDCO impose penalty charges in the EB bill for all the HT consumers in who exceed the distortion limits and for the LT consumers there is no issue. Such high distortions will produce overheating, energy loss and nuisance tripping.
- ✓ The distortions could be mitigated through installation of appropriate harmonic filters. Solution to correct this issue is not required for Mallow International since the industry is coming under LT service.
- ✓ However, it is recommended to prevent further aggravation of these distortions while adding future loads (VFDs, UPS or any power electronic devices). While procuring the new equipment, it must be demanded from the manufacturer of the product to submit a test report to show that current THD and voltage THD values are within the acceptable limits as per the attached national / international standards.
- ✓ In all the Medium voltage panels (MV-1 to 4), Generator change over panel, Standby Generators local panels, etc. the cable gland plates are not provided and the bottom is kept open. If any rat enters inside the energized panel boards, from the bottom the cable trench, it could be a major havoc resulting in short circuit and flash over leading to a major interruption and break down. This needs corrective action and could be carried out during shut down
- ✓ In the entire panel boards underground cables are not taken through cable glands. This needs corrective action and could be done only during shut down.
- ✓ It requires labour force to re fix the cables through cable glands in all the panel boards.
- ✓ Grounding of all the panel boards in power room, generator locations, servo stabilizers, etc. were not done properly and not meeting the safety requirements as per the national standards. Extracts of grounding requirements are categorically brought out in this report to execute the corrections. This should be done under shut down.

- ✓ Under the scope for re audit (based on the previous audit report), the voltages measured in the panel boards (LT distribution) are maintained in the 400 volts region only. So there is no question of energy wastage due to over voltage and under voltage. The savings obtained on account of maintaining correct voltage cannot be quantified.
- ✓ In MV-1, MV-2 & MV-3 service connections, excess demand charges were paid for exceeding the permitted maximum demand. We understand that alerting alarms were provided through maximum demand controller in the MV panels to control the demand. Despite this protection and alerting, the demand had exceeded means that the protection arrangement healthiness needs to be reviewed.
- ✓ Should Mallow International require our assistance to implement the corrective measures for providing proper earthing for panel boards, motors, cable gland termination, fixing gland plates on all the panel boards, re installation of all grounding system, etc., we could support to complete the work deploying an A-grade electrical contractor under total shut down. Before that the contactor has to make a visit to your premises to assess the quantum of work, materials requirements, time duration requirements and submit a quotation. Because this task is a labour intensive job.
- ✓ All the grounding arrangements need to be identified and properly done.
- ✓ The lighting board power supply should be segregated from PDB-3 and should not be mixed up with power loads.
- ✓ 10kVA UPS input power is taken from lighting board. This must be taken from power distribution board only.
- ✓ We understand that cables feeding power supply to all the panels are of inadequate length to take it through the cable gland plates. In the future, whenever the cables are laid, a two-metre diameter ring formation of the cable has to be provided at each end of termination to make use of the same in case of any termination failures at any of the ends (source side or load side).
- ✓ UG cable sizes have to be indicated at the rear side of all the main panel boards, servo stabilizers, generator panel boards, etc.

7.1.2 References

Acceptable limits for harmonic distortion

TABLE 1 (IEEE 519-2014, PG. 7) VOLTAGE DISTORTION LIMITS

Bus voltage *V* at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \le 1.0$ kV	5.0	8.0
1 kV < $V \le 69$ kV	3.0	5.0
69 kV < $V \le 161$ kV	1.5	2.5
161 kV < V	1.0	1.5[a]

TABLE 2 (IEEE 519-2014, PG. 7)
CURRENT DISTORTION LIMITS FOR SYSTEMS RATED 120 V THROUGH 69 KV

I_{SC}/I_L	Individual harmonic limits (Odd harmonics)[a,b]					TDD Required
	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	
<20[c]	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Ministry of Power

(Central Electricity Authority)

Notification No: 12/X/STD(CONN)/GM/CEA (21-Feb-07)

The Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007

No.12/X/STD(CONN)/GM/CEA.--Whereas the draft of the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2006 were published as required by Subjection (2) of Section 177 of the Electricity Act, 2003 (36 of 2003) read with rule 3 of the Electricity (Procedure for previous Publication) Rules, 2005;

Now, therefore, in exercise of powers conferred by Section 7 and clause (b) of Section 73 read with Sub-section (2) of Section 177 of Electricity Act, 2003, the Central Electricity Authority hereby makes the following Regulations for regulating the technical standards for connectivity to the grid, namely:--

1. Short title and commencement

(1) These Regulations may be called the Central Electricity Authority (technical Standards for Connectivity of the Grid) Regulation, 2007.

(2) These Regulations shall come into force on the date of their publication in the Official Gazette.

(b) for direct current (DC) Supply (Applicable to new sub-stations): Sub-stations of transmission system for 132 kV and above and sub-stations of all generating stations: There shall be two sets of batteries, each equipped with its own charger.

For sub-stations below 132 kV: there shall be one set of battery and charger.

(7) Earth Fault Factor for an effectively earthed system shall be not more than 1.4.

Part IV

Grid Connectivity Standards applicable to the Distribution Systems and Bulk Consumers

The following additional requirements shall be complied with, besides the connectivity conditions in these regulations and general Standards for Connectivity to the Grid given in Part-I and those applicable to transmission lines and sub-stations in Part -III.

1. Under Frequency/df/dt Relays

Under frequency and df/dt (rate of change of frequency with time) relays shall be employed for automatic load control in a contingency to ensure grid security under conditions of falling grid frequency in accordance with the decision taken in the Regional Power Committee.

2. Reactive Power

The distribution licensees shall provide adequate reactive compensation to compensate the inductive reactive power requirement in their system so that they do not depend upon the grid for reactive power support. The power factor of the distribution system and bulk consumer shall not be less than 0.95.

3. Voltage and Current Harmonics

(1) The total harmonic distortion for voltage at the connection point shall not exceed 5% with no individual harmonic higher than 3%.

(2) The total harmonic distortion for current drawn from the transmission system at the connection point shall not exceed 8%.

(3) The limits prescribed in (1) and (2) shall be implemented in a phased manner so as to achieve complete compliance not later than five years from the date of publication of these regulations in the official Gazette.

4. Voltage Unbalance

The Voltage Unbalance at 33 kV and above shall not exceed 3.0%.

7.2 AUTOMATIC POWER FACTOR CORRECTION (APFC) PANELS

7.2.1 43.6 kVAr Panel

Current Measurements

S. No.	kVAr rating	Measured current			Rated current (A)	Status	Condition
		R	Y	B			
1	1	1.2	1.2	1.3	1.3	ON	Good
2	2.1	0	0	0	2.8	OFF	----
3	3	0	0	0	3.9	OFF	----
4	5	6.3	6.1	6.4	6.6	ON	Good
5	5	6.3	6.2	6	6.6	ON	Good
6	7.5	10.1	9.6	10	9.8	ON	Good
7	10	12.7	12.4	12.8	13.1	ON	Good
8	10	12.5	12.4	12.7	13.1	ON	Good
Total	**43.6**	**49.1**	**47.9**	**49.2**	**57.2**		

Voltage Measurements

RY	YB	BR	Average
421 V	**416.8 V**	**418.8 V**	**418.8 V**

7.2.2 Observations and Recommendations

- Energized Capacitors were healthy.
- Electromagnetic contactors have to be properly identified with regard to intelligent meter LEDs indications from C1 to C8.
- Panel has to be provided with two separate distinct body earthing.

7.2.3 41 kVAr Panel

Current Measurements

S. No.	kVAr rating	Measured current			Rated current (A)	Status	Condition
		R	Y	B			
1	1	0	0	0	1.3	OFF	----
2	2	1.3	1.3	2.5	2.46	ON	Defective
3	3	0	0	0	3.9	OFF	----
4	5	0	0	0	6.6	OFF	-----
5	5	0	3.5	3.5	6.6	ON	Defective
6	7.5	9.4	9.4	9.9	9.8	ON	Good
7	7.5	9.7	9.5	9.8	9.8	ON	Good
8	10	0	0	0	13.1	ON	Defective
Total	41	20.4	23.7	25.7	53.56		

Voltage Measurements

RY	YB	BR	Average
420 V	416 V	418 V	418 V

7.2.4 Observations and Recommendations

- Some Capacitors were found defective and need replacement.
- Electromagnetic contactors have to be properly identified with regard to intelligent meter LEDs indications from C1 to C8.
- Panel has to be provided with two separate distinct body earthing.

7.2.5 33.1 kVAr Panel

Current Measurements

S. No.	kVAr rating	Measured current			Rated current (A)	Status	Condition
		R	Y	B			
1	1	0	0	0	1.3	OFF	----
2	2.1	2.4	2.7	2.6	2.8	ON	Good
3	5	0	0	0	6.6	OFF	-----
4	7.5	6.3	6.2	6.4	6.6	ON	Good
5	7.5	0	0	0	9.8	ON	Defective
6	10	0	0	0	13.1	OFF	----
Total	33.1	8.7	8.9	9	40.2		

Voltage Measurements

RY	YB	BR	Average
419 V	424 V	421 V	421.3 V

7.2.6 Observations and Recommendations

- One Capacitor was found defective and needs replacement.
- Electromagnetic contactors have to be properly identified with regard to intelligent meter LEDs indications from C1 to C8.
- Panel has to be provided with two separate distinct body earthing.

7.3 UPS UNITS

7.3.1 160 kVA UPS

S. No.	160kVA UPS			
1	Input Power	101 kVA		
2	Input frequency	49.9 Hz		
3	Input current	R	Y	B
		143 A	141 A	142 A
4	Input voltage	RN	YN	BN
		235 V	234 V	235 V
5	Output Power	96 kW, 98 kVA		
6	Output frequency	49.9 Hz		
7	Output current	140 A	138 A	149 A
8	Percentage loading	60%	58%	63%
9	Inverter voltage	227 V	226 V	226 V
10	Inverter frequency	49.9 HZ		
11	DC voltage	687 V		
12	Total Battery (150 AH) voltage (52 Nos. × 12 V)	624 V		
13	Mains Input voltage at incoming switch	405.2 V	403 V	403.7 V
14	Mains input current	141.1 A	140.8 A	139.6 A

7.3.2 Observations and Recommendations

- Operation is found normal.
- Battery conditions are good
- Readings are normal but for the harmonic distortions.
- Cable terminations through cable gland and proper earthing of adequate sizing have to be carried out.

7.3.3 60 kVA UPS

S. No.	60 kVA UPS			
1	Output power (kVA)	**L1**	**L2**	**L3**
		12.2	11.3	13.1
2	Output power (kW)	9.3	8.2	10.5
3	Percentage loading	60%	55%	65%
4	System temperature	26 ºC		
5	Mains voltage	**L1-L2**	**L2-L3**	**L3-L1**
		413 V	409 V	412 V
6	Bypass voltage	414 V	410 V	413 V
7	Output voltage	399 V	399 V	400 V
8	Mains frequency	50 Hz		
9	Output frequency	50 Hz		
10	Bypass frequency	50 Hz		
11	Output current	52.5 A	49.4 A	57.2 A
		L1-N	L2-N	L3-N
12	Output voltage	230 V	231 V	231 V
13	Mains voltage	240 V	238 V	237 V
14	Bypass voltage	239 V	237 V	237 V
15	Output peak current	88.5 A	82.4 A	95.3 A
16	Battery voltage 40 nos x 12 V= 480 V 75 AH	**B+**	**B-**	
		272 V	272 V	
17	Mains incoming current	41.4 A	42.3 A	43.3 A
18	Mains incoming voltage	413.4 V	411.4 V	409 V
19	Mains phase voltage	236.6 V	239.3 V	239.6 V

7.3.4 Observations and Recommendations

- Operation is found normal.
- Battery conditions are good.
- Readings are normal but for the harmonic distortions.
- Cable terminations through cable gland and proper earthing of adequate sizing have to be carried out.

7.4 MOTORS

S. No.	Description	Rating	Measurements			% Loading
			R	Y	B	
1	RO stage 1 High Pressure pump	30 HP/22 kW	19.4 A	21.2 A	19.3 A	44%
2	RO stage-2 High Pressure pump	20 HP/15 kW	19.9	20	21	68%
3	RO stage 3 High Pressure pump	20 HP/15 kW	17.2	16.6	17.5	57%
4.	RO stage 4 High Pressure pump	20 HP / 15 kW	19.6	18.1	19.7	64%
5.	**RO stage 1 Feed pump**	**10 HP/7.5 kW**	**17.4**	**14.7**	**14.6**	**100%**
6	**RO stage 2 Feed pump**	**5.5 kW**	**7.6**	**6.4**	**6.2**	**56%**
7	**RO stage 3 Feed pump**	**2.2 kW**	**4.8**	**4.6**	**4.1**	**100%**
8	RO stage 4 Feed pump	3.7 kW	4.4	3.8	3.6	52%
9	3Ton Boiler ID fan	9.3 kW	13.8	13	14.6	73%
10	Feed Water Pump 1	Not available	5.4	5.6	5.4	
11	Feed Water Pump 2	2.2 kW	OFF			
12	1 Ton Boiler ID fan	12.5 HP/ 9.3 kW	9.9	9.8	10	53%
13	Thermopac Boiler FD fan	5 HP/3.7 kW	4.6	4.2	4	57%
14	Circulating oil pump no1	20 HP/15 kW	18.3	21.2	20.3	66%
15	ID fan Motor	15 HP/11 kW	13.7	14	13.9	62%
	Loop ager					
16	Blower 1 &2	3.7 kW × 2	7.1	7.1	7.1	11.6%
17	Blower 3 &4	3.7 kW ×2	7.2	7.2	7.2	10%
18	Feeding	0.8 kW	1.9	1.9	1.9	33.9%
19	Chain	0.8 kW	0.8	0.8	0.8	18.3%
20	Exhaust 1	2.2 kW	2.8	2.8	2.8	14.5%
21	Exhaust 2	2.2 kW	3	3	3	16%
22	Plaiter 1 &2	1.5 kW × 2	3.9	3.9	3.9	17.8%
23	Spray pump Right bottom	3.7 kW	3.6	3.6	3.6	35%
24	Loop cutter	0.8 kW	1.1	1.1	1.1	23.5%
	Stenter					
25	Left chain	9.7 kW	14.04	14.04	14.04	35%
26	Right chain	9.7 kW	14.05	14.05	14.05	34.1%
27	Infeed pump	3.9 kW	4.2	4.2	4.2	32%
28	LH pinning	--	OFF			

S. No.	Description	Rating	Measurements			% Loading
			R	Y	B	
29	RH pinning	--	OFF			
30	Infeed bottom	3.9 kW	2.2	2.2	2.2	7.8%
31	Delivery Roll	3.9 kW	1.9	1.9	1.9	2.8%
32	Batcher	3 kW	3.3	3.3	3.3	43.4%
33	Plaiter arm	--	OFF			
34	Inlet scary	3.9 kW	4.7	4.7	4.7	33%
35	Outlet scary	3.9 kW	1.9	1.9	1.9	1.2%
	Stenter Machine blower section					
36	C1 blower	7.5 kW × 14 Nos.	5.8	5.8	5.8	12.8%
37	C2 & C3 lower	7.5 kW	12.5	12.5	12.5	16.8%
38	C2 & C3 upper	7.5 kW	12.7	12.7	12.7	17%
39	C4 & C5 lower	7.5 kW	11.2	11.2	11.2	16.5%
40	C4 & C5 upper	7.5 kW	12.1	12.1	12.1	16.2%
41	C1 upper	7.5 kW	6	6	6	14.1%
42	Exhaust 1	3.7 kW	3.3	3.3	3.3	10.2%
43	Exhaust 2	5.5 kW	5.7	5.7	5.7	30.8%
44	Outlet top	3.9 kW	5.04	5.04	5.04	2.2%
45	C6 & C7 lower	7.5 kW	12.09	12.09	12.09	3.6%
46	C6 & C7 upper	7.5 kW	12.35	12.35	12.35	8.9%
	Hy Jigger 2					
47	Hydraulic motor	11 kW	11.5	11.5	11.5	40%
48	Circulation motor	2.2 kW	3.4	3.4	3.3	75%
	Hy Jigger 1		OFF			
	HY Jigger 5					
49	Hydraulic motor	11 kW	14.27	14.27	14.27	58%
50	Circulation motor	2.2 kW	3.9	3.8	3.3	75%
	HY Jigger 6					
51	Hydraulic motor	11 kW	11.35	11.35	11.35	33%
52	Circulation motor	2.2 kW	3.9	4.1	3.6	86%
	Washing Range					
53	Entry	3.7 kW	OFF			
54	Squeezer 1	3.7 kW	3.9	3.9	3.9	22.5%
55	Squeezer 2	3.7 kW	4.9	4.9	4.9	26.6%
56	Squeezer 3	3.7 kW	4.9	4.9	4.9	33%
57	Squeezer 4	3.7 kW	4.8	4.8	4.8	31.7%
58	Heavy nip	7.5 kW	5.8	5.8	5.8	25.2%
59	Drying	0.75 kW × 9 Nos.	7.9	7.9	7.9	62%
60	Batching	3.7 kW	3.3	3.2	3.2	21.6%
61	Circulation pump 1st bath	3.7 kW	2.4	2.4	2.4	27.4%
62	Circulating pump 3rd bath	3.7 kW	0.98	0.98	0.98	14.8%

S. No.	Description	Rating	Measurements			% Loading
			R	Y	B	
63	Circulating pump 2nd bath	2.2 kW	1.6	1.9	1.8	40%
64	Circulating pump 4th bath	2.2 kW	2	1.4	1.6	37%
65	**ETP UF**	**3.7 kW**	**9.5**	**9.3**	**8.9**	**100%**
	Evaporator					
66	**Balance feed pump**	**1.5 kW**	**2**	**1.7**	**1.4**	**57%**
67	1st transfer pump	1.1 kW	1.4	1.4	1.4	62%
68	**Cooling tower fan**	**7.5 kW**	**13.1**	**11.8**	**11.5**	**81%**
69	2nd circulation pump	3.7 kW	4.3	4.2	4	56%
70	Circulation pump	3.7 kW	4.3	3.8	3.7	66%
71	2nd transfer pump	0.7 5kW	1.3	1.2	1.4	87%
72	3rd circulation pump	5.5 kW	6	6	6.8	57%
73	Reject water pump	0.75 kW	1.2	1.2	1.1	78%
74	**Vacuum pump**	**7.5 kW**	**10.6**	**9**	**10.1**	**66%**
75	**Cooling tower pump**	**7.5 kW**	**10.3**	**8.6**	**8.8**	**62%**
76	**Condensate pump**	**1.5 kW**	**1.8**	**1.7**	**1.4**	**54%**
77	Main feed pump	1.5 kW	2.7	2.6	2.7	89%
78	Compressor 1	11 kW	18.2	18.6	18.2	83%
79	Compressor2	7.5 kW	12	11	11.7	77%
80	**Blower (ETP)**	**25 HP/18.5 kW**	**19**	**19.3**	**13.4**	**46%**

7.4.1 Observations and Recommendations

- **RO stage 1 Feed pump** - Current drawn by the motor in all the three phases are not equal. This will overheat the motor windings due to negative sequence currents produced by unbalance currents. The motor seems to be overloaded. Also, this will result in energy loss continuously.
- **Blower (ETP) -** There seems to be large unbalance in the current drawn. Continuously running under this condition will result in over heating of motor windings and continuous energy loss.

- **Condensate pump (Evaporator section):** Unbalance currents were recorded. Cause of Energy loss.

- **Cooling Tower pump (Evaporator section) -** Motor draws unbalance currents. Result in energy loss

- **Balance Feed pump (Evaporator section) -** Motor draws unbalance currents. Result in energy loss.

- **ETP (UF) Motor-** Appears to be overloaded

- **Cooling Tower Fan (Evaporator section) -** Motor draws unbalance currents leading to overheating and energy loss.

- **Vacuum Pump (Evaporator section)-** Motor draws unbalance currents leading to energy loss.

- **RO Stage 3 Feed pump –** Seems to be overloaded.

- The motors indicated above have to be monitored for a few days for overloading and unbalance consistency and better to go for replacement with IE3/IE4 motors, if the above motors were already rewound.

- It is recommended to provide over voltage and under voltage alarm in the MV panels to ensure that all the motors operate at the optimum voltage values to avoid energy loss.

- Majority of the motors' enclosures are not grounded properly. This needs to be corrected on priority basis from safety point of view. Also, the earthing leads connecting the motor enclosures, on few motors, are of inadequate size.

- Under the scope for re audit (based on the previous audit report), the voltages measured in the panel boards (LT distribution) are maintained in the 400 volts region only. So there is no question of energy wastage due to over voltage and under voltage. The energy savings obtained on account of maintaining correct voltage levels cannot be quantified.

- Under scope for the re audit (based on previous audit report) we are unable to measure the savings due to the V belts replacements

- Under the scope for re audit (based on previous audit report- under efficiency motors replacement), the motors that are fitted with the VFDs automatically adjust the speed based on the load and the efficiency improves accordingly.

7.5 UTILITY TARIFF METER

1) MV -1 Panel

	U1	U2	U3
Voltage Harmonics (THD)	2.7%	3.2%	2.8%
Current Harmonics (THD)	34.4%	40.1%	38.9%

2) MV-2 Panel

Voltage Harmonics (THD)	1.2 %	2 %	2.1%
Current Harmonics (THD)	52.5%	62.1%	60 %

7.5.1 Observations and Recommendations

- The readings taken on all the LT CT service Energy meters, on a different day, also revealed high level of current harmonic distortions. Hence, it looks the distortions are consistent
- VFDs, servo stabilizers and UPS units are the major culprits for the high level of harmonic distortions. There is no need to take corrective action for containing the current harmonics within the limits because TANGEDCO impose penalty charges for harmonic distortions (exceeding the limits) only for the HT consumer. The penalty charges are not applicable for the LT consumers at present. However, as a precautionary measure, Mallow International must take care while installing new nonlinear loads (VFDs, UPS & other power electronic devices). In all your purchase orders, while procuring such devices in future, you must indicate the limits of current harmonic distortion as 8% and voltage harmonic distortions as 3%; this must be part of your purchase order terms and conditions. Insist for practical testing and demonstration in the field to check this conformity.

8 USEFUL TIPS AND GUIDELINES FOR MOTORS

8.1 MOTORS (Energy conservation measures)

- Properly size to load for optimum efficiency
  (High efficiency motors offer 4 to 5% higher efficiency than standard motors
- Use energy efficiency motors where economical
- Check mechanical alignment with the driven equipment
- Provide proper ventilation
  (for every 10 deg C increase in motor temperature over recommended peak, the motor life is estimated to be halved)
- Check under voltage and over voltage conditions
- Balance the three-phase power supply
  (an imbalanced voltage can reduce 3 to 5% in the motor input power)
- Demand efficiency restoration after motor rewinding
  (if rewinding is not done properly, the efficiency can be reduced 5 to 8%)

8.2 ENERGY EFFICIENT MOTORS

Electric motors convert electrical power into mechanical power within a motor driven system. In industrial applications, electric motor driven systems are used for various applications such as pumping, compressed air, fans, conveyors etc. The system approach for optimizing energy efficiency of motor-driven system is recommended, which include the following:

- ✓ Use of energy efficient motors;
- ✓ Selecting the driven equipment—like pumps, fans, compressors, transmissions, variable speed drives—right type and size, and high efficiency;
- ✓ Efficient operation of the complete system.

From the motor perspective, when buying a new motor, operating cost and not just the purchase cost should be the main consideration. In a single year the cost of energy can be up to 10 times the purchase cost. Over the life of the motor it is by far the most significant cost. Old motors, typically more than 15 years and operating for over 5000 hours in a year can be considered for replacement with energy-efficient motors to reduce energy costs.

8.2.1 IE Classification

International Efficiency (IE) is a new trend around the world in describing the energy efficiency of motors. The IE classes IE1 to IE4 are well developed, while the IE5 is under

Class Type	Class Number
Standard efficiency	IE1
High efficiency	IE2
Premium efficiency	IE3
Super premium efficiency	IE4

Energy Savings with Energy Efficient Motor

The annual energy saving by upgrading to more efficient motor is calculated as per the following formula:

$$\textbf{\textit{Annual Energy Saving (kWh per year)}} =$$

$$\textbf{\textit{Annual Energy Consumption of Motor (kWh per year) x Percentage of Energy Saving (\%)}}$$

The energy saving (%) can be calculated using the following formula:

$$\textbf{\textit{Percentage of Energy Saving}}\ (\%) = \left(1 - \frac{\textbf{\textit{Efficiency of Old Motor}}\ (\%)}{\textbf{\textit{Efficiency of New Motor}}\ (\%)}\right) \textbf{\textit{x}}\ \mathbf{100\%}$$

If the annual energy consumption of motor is not available, it can be estimated with the following formula:

$$\textbf{\textit{Annual Energy Consumption of Motor (kWh per Year)}} = \frac{\textit{Rated power of motor}}{\textit{Rated efficiency}}\ \textit{x rated hours per day x operating days per year}$$

Replacing IE1 motor with IE3

Annual Energy Consumption (kWh per Year) = 37 kW/0.912 x 10 hours per day x 360 days/ year = 1,46,052 kWh

It is proposed to replace IE1 is replaced with IE3 motor as per following specifications:

Rated Power	37 kW
No. of Poles	4
Efficiency	93.9 (IE3)
Designed Lifespan	400,000 hours

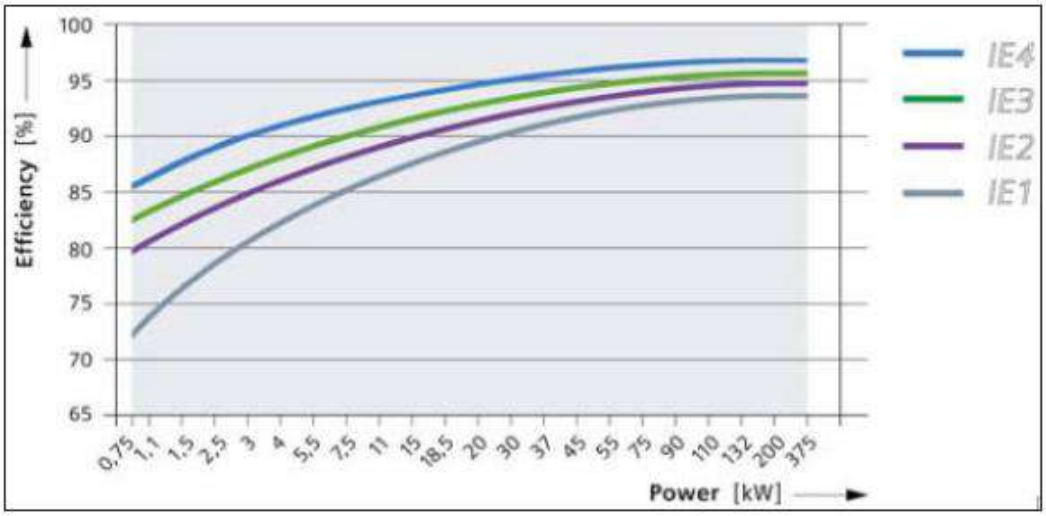
The percentage of energy-saving and the anticipated annual energy saving is calculated below:

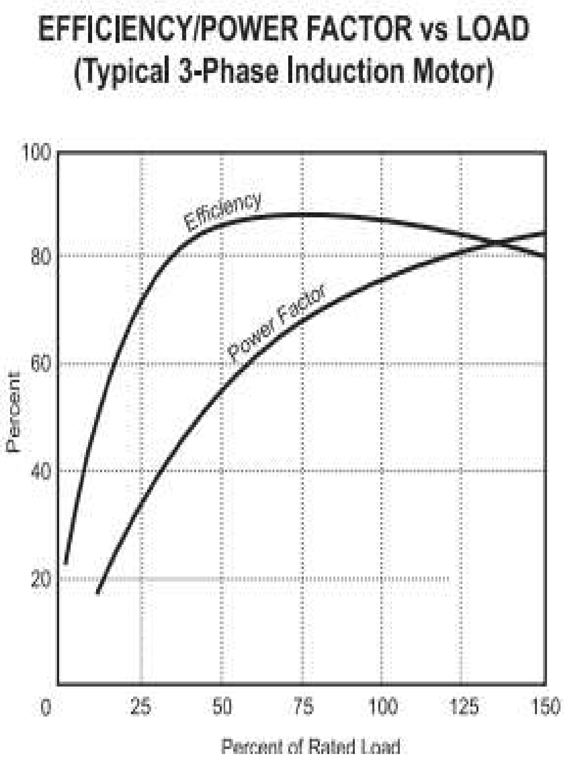
$$\textit{Percentage of Energy Saving}\ (\%) = \left(1 - \frac{91.2}{93.9}\right) x\ 100\% = 2.88\%$$

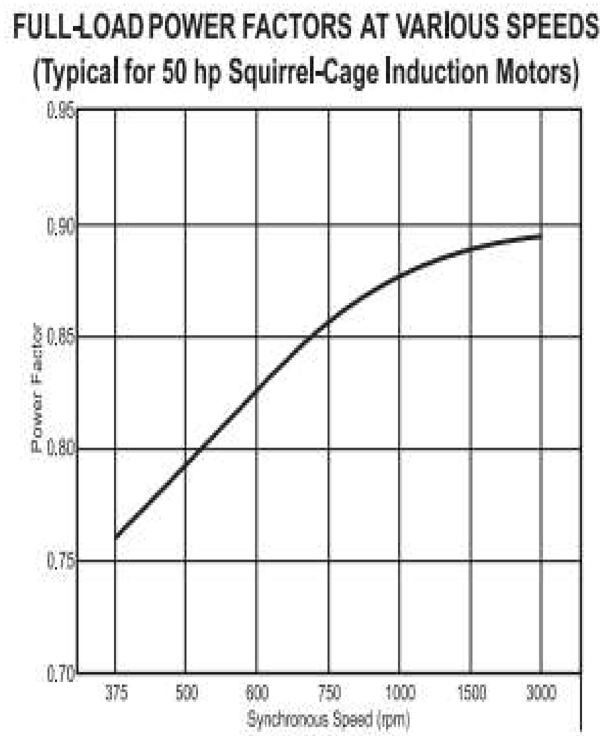
$$\textit{Annual Energy Saving (kWh per Year)} = 1,46,052\ \textit{kWh per year x}\ 2.88/100$$
$$= 4206\ kWh/Year$$

Efficiency classes IE1 to IE4

Source: IEC 60034-30-1







Stray Load Losses:

These losses are difficult to measure with any accuracy. IEEE Standard 112 gives a complicated method, which is rarely used on shop floor. IS and IEC standards take a fixed value as 0.5 % of input. The actual value of stray losses is likely to be more. IEEE – 112 specifies values from 0.9 % to 1.8 % (see Table 2.1.)

Table 2.1 Motor Rating Vs. Stray Losses - IEEE

Motor Rating	Stray Losses
1 – 125 HP	1.8 %
125 – 500 HP	1.5 %
501 – 2499 HP	1.2 %
2500 and above	0.9 %

Pointers for Users:

It must be clear that accurate determination of efficiency is very difficult. The same motor tested by different methods and by same methods by different manufacturers can give a difference of 2 %. In view of this, for selecting high efficiency motors, the following can be done:

a. When purchasing large number of small motors or a large motor, ask for a detailed test certificate. If possible, try to remain present during the tests; this will add cost.

b. See that efficiency values are specified without any tolerance

c. Check the actual input current and kW, if replacement is done

d. For new motors, keep a record of no load input power and current

e. Use values of efficiency for comparison and for confirming; rely on measured inputs for all calculations.

Voltage Unbalance

Voltage unbalance, the condition where the voltages in the three phases are not equal, can be still more detrimental to motor performance and motor life. Unbalance typically occurs as a result of supplying single-phase loads disproportionately from one of the phases. It can also result from the use of different sizes of cables in the distribution system. An example of the effect of voltage unbalance on motor performance is shown in Table 2.4.

Table 2.4 Example of the Effect of Voltage Unbalance on Motor Performance

Parameter	Percent unbalance in voltage		
	0.30	**2.30**	**5.40**
Unbalance in current (%)	0.4	17.7	40.0
Increased temperature rise (^{0}C)	0.18	10.6	58

The NEMA (National Electrical Manufacturers Association of USA) standard definition of voltage unbalance is given by the following equation:

$$Voltage\ unbalance = \frac{Maximum\ deviation\ from\ mean\ of\ V_{ab}, V_{bc}, V_{ca}}{Mean\ of\ (V_{ab}, V_{bc}, V_{ca})}$$

As an example, consider a three-phase supply system (in volts):

The line-line voltages are:

$V_{ab} = 410$ $V_{bc} = 417$ $V_{ca} = 408$

% Voltage Unbalance = (417 – 411.7/ 411.667) x 100 = 1.29 %

Common Causes of Voltage Unbalance

It is recommended that the voltage unbalance at the motor terminals not exceed 1% , anything above this will lead to derating of the motor. The common causes of voltage unbalance are

Some of the more common causes of unbalanced voltages are:

- Unbalanced incoming utility supply
- Unequal transformer tap settings
- Large single phase distribution transformer on the system
- Open phase on the primary of a 3 phase transformer on the distribution system
- Faults or grounds in the power transformer
- Open delta connected transformer banks
- A blown fuse on a 3 phase bank of power factor improvement capacitors
- Unequal impedance in conductors of power supply wiring
- Unbalanced distribution of single phase loads such as lighting
- Heavy reactive single phase loads such as welders

Voltage unbalance is probably the leading power factor problem that results in motor over heating and premature motor failure.

Voltage unbalance causes extremely high current imbalance. The magnitude of current imbalance may be 6 to 10 times as large as the voltage imbalance. A motor will run hotter when operating on a power supply with voltage unbalance. The additional temperature rise is estimated with the following equation

$$\text{Additional temperature rise} = 2 \times (\%\ \text{Voltage unbalance})^2$$

For example, if the voltage unbalance is 2% for a motor operating at 100 °C, the additional temperature rise will be 8 °C. The winding insulation life is reduced by one half for each 10 °C increase in operating temperature.

Motor Loading

Measuring Load

% Loading of the motor can be estimated by the following relation:

$$\%\ Loading = \frac{Input\ power\ drawn\ by\ the\ motor\ (kW)\ at\ existing\ load}{Name\ plate\ full\ load\ kW\ rating\ /\ name\ plate\ full\ load\ motor\ efficiency} x100$$

(or)

$$\%\ Loading = \frac{Input\ power\ drawn\ by\ the\ motor\ (kW)\ at\ existing\ load}{\sqrt{3}\ x\ kV\ x\ I\ x\ Cos\phi}\ x\ 100$$

- Never assume power factor
- Loading should not be estimated as the ratio of currents.

$$Motor\ Loading\ \% = \frac{Actual\ operating\ load\ of\ the\ motor}{Rated\ capacity\ of\ the\ motor}\ x\ 100$$

Sizing to Variable Load

Industrial motors frequently operate under varying load conditions due to process requirements. A common practice in cases where such variable-loads are found is to select a motor based on the highest anticipated load. In many instances, an alternative approach is typically less costly, more efficient, and provides equally satisfactory operation. With this approach, the optimum rating for the motor is selected on the basis of the load duration curve for the particular application. Thus, rather than selecting a motor of high rating that would operate at full capacity for only a short period, a motor would be selected with a rating slightly lower than the peak anticipated load and would operate at overload for a short period of time. Since operating within the thermal capacity of the motor insulation is of greatest concern in a motor operating at higher than its rated load, the motor rating is selected as that which would result in the same temperature rise under continuous full-load operation as the weighted average temperature rise over the actual operating cycle. Under extreme load changes, e.g. frequent starts / stops, or high inertial loads, this method of calculating the motor rating is unsuitable since it would underestimate the heating that would occur.

Where loads vary substantially with time, in addition to proper motor sizing, the control strategy employed can have a significant impact on motor electricity use. Traditionally, mechanical means (e.g. throttle valves in piping systems) have been used when lower output is required. More efficient speed control mechanisms include multi-speed motors, eddy-current couplings, fluid couplings, and solid-state electronic variable speed drives.

Maintenance

Inadequate maintenance of motors can significantly increase losses and lead to unreliable operation. For example, improper lubrication can cause increased friction in both the motor and associated drive transmission equipment. Resistance losses in the motor, which rise with temperature, would increase. Providing adequate ventilation and keeping motor cooling ducts clean can help dissipate heat to reduce excessive losses. The life of the insulation in the motor would also be longer : for every 10^{0}C increase in motor operating temperature over the recommended peak, the time before rewinding would be needed is estimated to be halved.

A checklist of good maintenance practices to help insure proper motor operation would include:

- Inspecting motors regularly for wear in bearings and housings (to reduce frictional losses) and for dirt/dust in motor ventilating ducts (to ensure proper heat dissipation).

- Checking load conditions to ensure that the motor is not over or under loaded. A change in motor load from the last test indicates a change in the driven load, the cause of which should be understood.

- Lubricating appropriately. Manufacturers generally give recommendations for how and when to lubricate their motors. Inadequate lubrication can cause problems, as noted above. Over-lubrication can also create problems, e.g. excess oil or grease from the motor bearings can enter the motor and saturate the motor insulation, causing premature failure or creating a fire risk.

- Checking periodically for proper alignment of the motor and the driven equipment. Improper alignment can cause shafts and bearings to wear quickly, resulting in damage to both the motor and the driven equipment.
- Ensuring that supply wiring and terminal box are properly sized and installed. Inspect regularly the connections at the motor and starter to be sure that they are clean and tight.

Age

Most motor cores in India are manufactured from silicon steel or de-carbonized cold-rolled steel, the electrical properties of which do not change measurably with age. However, poor maintenance (inadequate lubrication of bearings, insufficient cleaning of air cooling passages, etc.) can cause a deterioration in motor efficiency over time. Ambient conditions can also have a detrimental effect on motor performance. For example, excessively high temperatures, high dust loading, corrosive atmosphere, and humidity can impair insulation properties; mechanical stresses due to load cycling can lead to misalignment. However, with adequate care, motor performance can be maintained.

Rewinding Effects on Energy Efficiency

It is common practice in industry to rewind burnt-out motors. The population of rewound motors in some industries exceeds 50 % of the total population. Careful rewinding can sometimes maintain motor efficiency at previous levels, but in most cases, losses in efficiency result. Rewinding can affect a number of factors that contribute to deteriorated motor efficiency: winding and slot design, winding material, insulation performance, and operating temperature. For example, a common problem occurs when heat is applied to strip old windings: the insulation between laminations can be damaged, thereby increasing eddy current losses. A change in the air gap may affect power factor and output torque.

However, if proper measures are taken, motor efficiency can be maintained, and in some cases increased, after rewinding. Efficiency can be improved by changing the winding design, though the power factor could be affected in the process. Using wires of greater cross section, slot size permitting, would reduce stator losses thereby increasing efficiency. However, it is generally recommended that the original design of the motor be preserved during the rewind, unless there are specific, load-related reasons for redesign.

The impact of rewinding on motor efficiency and power factor can be easily assessed if the no-load losses of a motor are known before and after rewinding. Maintaining documentation of no-load losses and no-load speed from the time of purchase of each motor can facilitate assessing this impact. For example, comparison of no load current and stator resistance per phase of a rewound motor with the original no-load current and stator resistance at the same voltage can be one of the indicators to assess the efficacy of rewinding.

Performance Evaluation of Rewound Motors

Ideally, a comparison should be made of the efficiency before and after a rewinding. A relatively simple procedure for evaluating rewind quality is to keep a log of no-load input current for each motor in the population. This figure increases with poor quality rewinds. A review of the rewind shop's procedure should also provide some indication of the quality of work. When rewinding a motor, if smaller diameter wire is used, the resistance and the I^2R losses will increase.

Monitoring Format for Rewound Motors

Section	Equipment Code	Motor Code	Motor Type		No Load Current				Starter Resistance/phase		No load loss	
			Sq.Cage	Slip Ring	New Motor		After Rewinding		New	Rewound	New	Rewound
					A	V	A	V			Watts	Watts

Power Supply Quality

Motor performance is affected considerably by the quality of input power that is the actual volts and frequency available at motor terminals vis-à-vis rated values as well as voltage and frequency variations and voltage unbalance across the three phases. Motors in India must comply with standards set by the Bureau of Indian Standards (BIS) for tolerance to variations in input power quality. The BIS standards specify that a motor should be capable of delivering its rated output with a voltage variation of +/- 6 % and frequency variation of +/- 3 %. Fluctuations much larger than these are quite common in utility-supplied electricity in India. Voltage fluctuations can have detrimental impacts on motor performance.

Reducing Under-loading

Probably the most common practice contributing to sub-optimal motor efficiency is that of under-loading. Under-loading results in lower efficiency and power factor, and higher-than-necessary first cost for the motor and related control equipment. Under-loading is common for several reasons. Original equipment manufacturers tend to use a large safety factor in motors they select. Under-loading of the motor may also occur from under-utilisation of the equipment. For example, machine tool equipment manufacturers provide for a motor rated for the full capacity load of the equipment ex. depth of cut in a lathe machine. The user may need this full capacity rarely, resulting in under-loaded operation most of the time. Another common reason for under-loading is selection of a larger motor to enable the output to be maintained at the desired level even when input voltages are abnormally low. Finally, under-loading also results from selecting a large motor for an application requiring high starting torque where a special motor, designed for high torque, would have been suitable.

A careful evaluation of the load would determine the capacity of the motor that should be selected. Another aspect to consider is the incremental gain in efficiency achievable by changing the motor. Larger motors have inherently higher rated efficiencies than smaller motors. Therefore, the replacement of motors operating at 60 – 70 % of capacity or higher is generally not recommended. However, there are no rigid rules governing motor selection; the savings potential needs to be evaluated on a case-to-case basis. When downsizing, it may be preferable to select an energy-efficient motor, the efficiency of which may be higher than that of a standard motor of higher capacity.

Improving the Motor Loading by Operating in Star Mode

For motors, which consistently operate at loads below 40 % of rated capacity, an inexpensive and effective measure might be to operate in star mode. A change from the standard delta operation to permanent star operation involves re-configuring the wiring at terminal box and resetting of the over current relay.

Operating in the star mode leads to a voltage reduction by a factor of '$\sqrt{3}$'. Motor is electrically downsized by $1/3^{rd}$ in star mode operation, but performance characteristics as a function of load remain unchanged. For example if a motor is rated for 15 kW in delta mode, its derated capacity is 5kW in star mode. Thus, full-load operation in star mode gives higher efficiency and power factor than partial load operation in the delta mode. However, motor operation in the star mode is possible only for applications where the torque-to-speed requirement is lower at reduced load.

As speed of the motor reduces in star mode this option may be avoided in case the motor is connected to a production facility whose output is related to the motor speed. Further in star mode the motor loading should not be allowed to cross derated capacity. For example in above case of 15 kW delta connected electric motor, should not be loaded above 5 kW when delta to star switchover takes place.

For applications with high initial torque and low running torque needs, automatic Star-Del-Star converters are also available, which help in load following de-rating of electric motors after initial start-up.

MOTOR DATA SHEET FOR PROCUREMENT

(Required Technical input)

1. Rated output
2. Rated three phase voltage
3. Rated Supply frequency
4. Frame size
5. Stator and Rotor insulation class
6. Degree of protection
7. Type of Enclosure
8. Rated service factor
9. Rated duty
10. Moment of inertia
11. Weight
12. No load current
13. No load loss
14. Full load copper loss
15. Winding Resistance for Stator/Rotor windings value
16. Full load slip
17. Rated RPM
18. Number of poles
19. Thermal curves of motor
20. Type of mounting
21. Motor dimensional drawing
22. Type and Routine test certificates as per BIS / IEC standards
23. Insulation resistance value
24. Vibration values at full load

9 EARTHING REQUIREMENTS FOR ELECTRICAL INSTALLATIONS (*CEIG STANDARDS/ IS 3043*)

9.1 PURPOSE/PRIMARY REQUIREMENTS

- The object of earthing is to limit the potential between the non-current carrying parts of the installation and between these parts and earth to a safe value under all conditions of normal and abnormal system operation.
- Effective earthing in an electrical installation is extremely important for the safety of the operating personnel as well as proper system operation. This means that the touch and step potential should be minimized.
- **The primary requirements among other considerations of a good earthing system are that the impedance to ground should be as low as possible. In large substations it should not exceed one ohm and in small substations five ohms.**
- Earthing should conform to the requirements of Indian Electricity Rules 1956 and IS3043(Code of Practice for Earthing).
- Earthing system mainly consists of earth conductors, earth bus and earth electrodes
- The size of the earthing conductor should be determined as per IS3043/1987.

9.2 SUBSTATION EARTHING

- The poles and metal frame work, supporting pins of AB switch, DO fuse / HG fuse should be earthed effectively with 25 x 3mm copper or its equivalent GI wire.
- **The earth leads of lightning arresters should be of 25 x 3 mm copper or its equivalent GI and should be taken as directly as possible along the structure and suitably secured. It should not be used for earthing any other components.**
- The AB switch operating down rod, support insulator pins, stay clamps, etc should be earthed with No. 8 SWG copper or its equivalent GI wire.

- There should be a minimum of three earth electrodes in the yard (without transformer), one exclusively for lightning arrester and the remaining two for connecting the earth leads of structure and other metallic parts.
- The earthing of the fence should be done at two places covering all lacings, particularly below overhead line.
- **The metallic parts of the transformer not intended as conductors and the frames of the generators/motors/capacitors and the metallic body of the HC switchgears/ MV switch boards / control panels and other power consuming apparatus should be earthed by two separate and distinct earth connections. The earthing leads should be of adequate size as per the Annexure-C.**
- In case of outdoor type transformer with bushings, a copper strip looping between the top cover and tank of the transformer should be provided to avoid fault current passing through the fastening bolts and provide a current carrying path in case there is a flash-over of the bushing. Such loops are not necessary for cable-box type transformers, where there are no bushings.
- The neutral of the transformer/generator should be earthed by not less than two separate distinct earth connections. The earth leads should be of adequate size as per the Annexure-D.
- Suitable link Should be provided in the neutral earthing lead to temporarily interrupt the neutral connection for the purpose of testing or locating a fault. Such link should be strategically positioned to facilitate easy removal without disturbing the earth leads.

9.3 SINGLE TRANSFORMER (HV/MV) MV GENERATOR

- The body of the transformer/generator should be earthed by two leads to earth.
- There may be one separate and independent earth electrode for one of the neutral earthing leads of the transformer/generator. The second neutral earth lead may be connected to another earth electrode, to which other leads except the one meant for lightning arrester are connected.

9.4 MULTI TRANSFORMERS (HV/MV) / MV GENERATOR

- One of the two neutral earth leads of each of the transformers may be taken to a separate earth electrode.
- The second neutral earth lead of each of the transformers can be connected directly to the common neutral earth electrode.

9.5 SINGLE AND MULTI-TRANSFORMERS (HV/MV) / HV GENERATORS

The neutral of each of the transformers should be earthed by not less than two separate and distinct connections with earth having its own earth electrode.

9.6 SWITCHGEARS

- The draw-out circuit breaker should be earthed so that earth continuity is maintained in the draw out position by suitable sliding type earth.
- If any potential transformer is provided in circuit breaker, it should also be earthed by sliding earth or short length of braided tape. Long coiled and loose earth connections must be avoided.
- Each switch-fuse and fuse switch in the main switch board should be provided with separate earth connections. An earth bus of adequate size should be run and earth wire of the switches connected thereto. Both ends of the earth bus should be earthed.
- Each distribution fuse board, MCB DB, isolator, starter and controlling & regulating apparatus should be earthed effectively.

9.7 GENERAL

- The armour of the cables and cable glands should be effectively earthed at both terminations.
- The metal casing or metallic covering containing or providing electric supply lines for apparatus should be earthed. The metallic conduits should be earthed by using clamps.
- All portable apparatus should be earthed by three pin or four pin plugs as the case may be. The third pin of the three-pin socket and the fourth pin of the four-pin socket should be connected to earth.
- Generally, a copper of 25 mm × 3 mm (minimum) or its equivalent must be run throughout
    - the installation as main earth bus. All the earth wires other than neutral and lightning arrester earth should be connected to it, the earth bus in turn should be connected to two or more earth electrodes.
- The minimum size of the earth wire is 10SWG and earth wire must be protected from mechanical damage.
- Earth wire should never be used as neutral.
- In highly corrosive areas, the earth wire should be suitably protected by use of sleeves or using insulated conductors.
- All earth connections in the straight run can be bolted, riveted, welded or brazed above ground surface. However, below ground all connections should be vibration free brazed or

welded. The earthing system should be mechanically robust and joints should be capable of retaining low resistance even after the passage of fault current. Earth leads or earth bus should not be connected to water mains.

- The earth wires or earth bus should not be laid over the floor. They should be supported and protected against any probable mechanical damage.
- Copper strips when connected to aluminium strips should be properly tinned at the connection.
- Aluminium leads should not be directly buried in ground.

9.8 EARTH ELECTRODES

- ✓ Earth electrode is a conductor embedded in the earth used for maintaining ground potential on conductors connected to it and for dissipation of earth current conducted to it.
- ✓ The earth electrodes may be GI pipe electrode or plate electrode or cast iron pipe electrode.
- ✓ The earth electrodes should be well packed with powdered charcoal/mix upto the level of connections.
- ✓ The earth electrodes must be 3 metres from one another and 1.5 metres from buildings.
- ✓ Earth troughs and or concrete cover slab should be provided for earth electrodes.
- ✓ Earth troughs should be of adequate size of not less than 46 cm x 46 cm (18” x 18”) to facilitate easy working at earth connections at each earth electrode. The cover also should not rest on earth pipe.
- ✓ The earth pipe should be centrally provided to facilitate handling at earth connections.
- ✓ Double clamp arrangement with central through bolt for connecting the earth leads should be provided. The double clamp should be fixed to the main pipe. No reducer pipe need be employed.
- ✓ The clamps provided should make full contact with the earth pipe and the earth leads to ensure very low resistance.
- ✓ Each earth lead should be connected individually to the earth clamp. Each connection should be always visible for easy examination.
- ✓ Each earth electrode should be identified permanently by engraving on the inner side of the trough walls by wet cement with reference to earth leads connected to it.

ANNEXURE-C

Equipment Body Earthing Conductor Size (Transformers, Motors, Generators, Switchgears)

Rating of Equipment in kVA	Bare copper	Aluminium PVC insulated	Galvanized Iron conductor
Up to 5	10 SWG	10 sq mm	7/22
5 to 15	10 SWG	16 sq mm	6 SWG
15 to 50	8 SWG	16 sq mm	25 × 1.5 mm
51 to 75	6 SWG	25 sq mm	25 × 1.5 mm
75 to 100	6 SWG	35 sq mm	25 × 3 mm
101 to 125	4 SWG	50 sq mm	25 × 6 mm
126 to 150	25 × 1.5 mm	70 sq mm	25 × 6 mm
151 to 200	25 × 1.5 mm	70 sq. mm	40 × 5 mm
201 and above	25 × 3 mm	185 sq. mm	50 × 6 mm

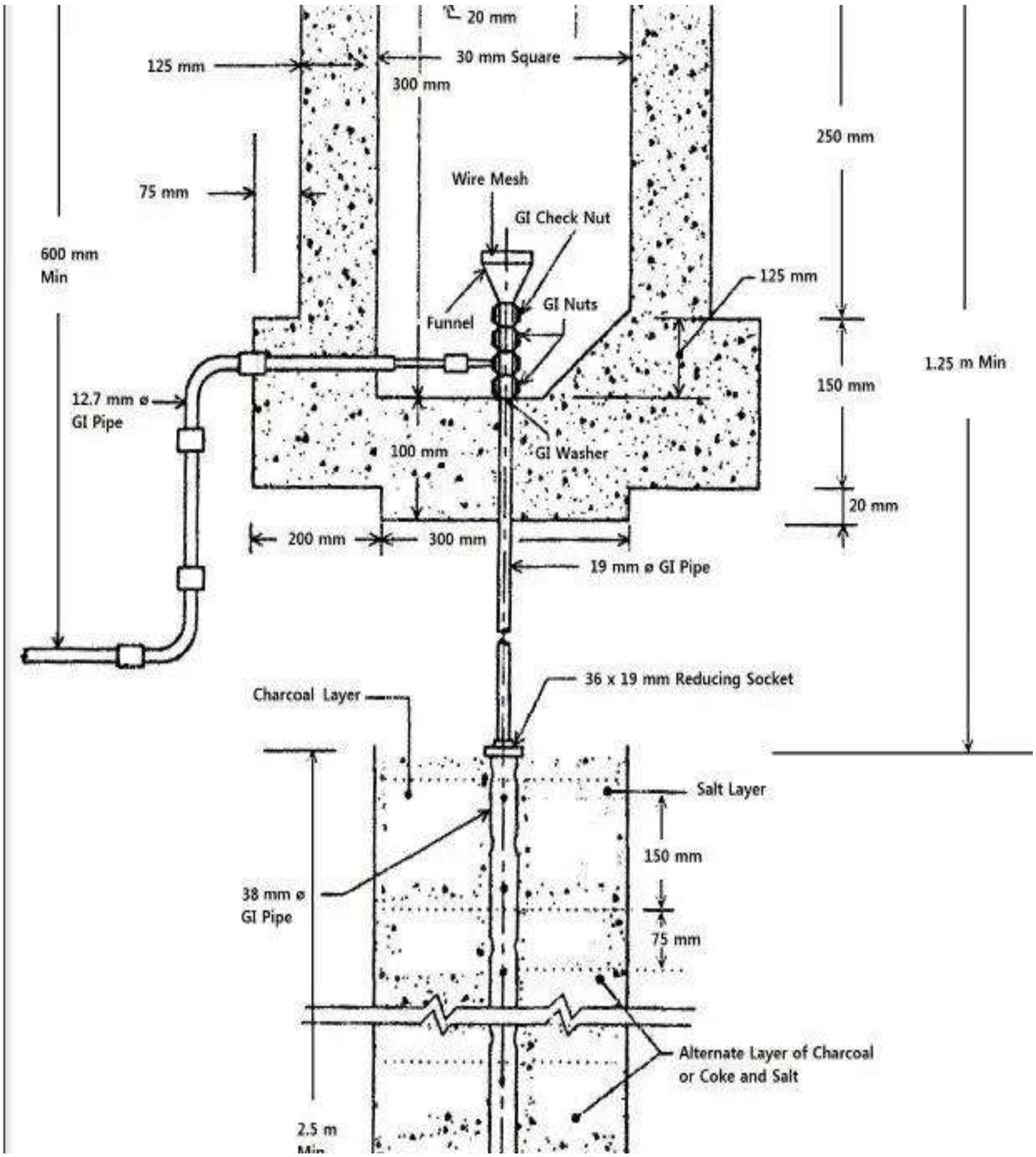
ANNEXURE-D

Transformers/Generators Neutral Point Earthing Conductor Size

Transformer/Generator Rating kVA	Electrolytic Bare copper	Single Stranded Aluminium Conductor PVC insulated	Galvanized Iron Conductor
50 kVA and below	8 SWG	16 sq mm	25 × 3 mm
75	6 SWG	25 sq mm	40 × 6 mm
100	4 SWG	35 sq mm	40 × 6 mm
150	25 mm × 1.5mm	70 sq mm	40 × 6 mm
200	25 mm × 3 mm	95 sq mm	40 × 6 mm
250	25 mm × 3 mm	150 sq mm	40 × 6 mm
300	25 mm × 3 mm	225 sq mm	40 × 6 mm
500	25 mm × 6 mm	300 sq mm	40 × 6 mm
750	40 mm × 6 mm	2 × 225 sq mm	Above 500 kVA only copper or Aulminium to be used
800	40 mm × 6 mm	-----	---------
1000	50 mm × 6 mm		
1250	60 mm× 6 mm		
1600	80 mm × 6 mm		
2000	60 mm × 10 mm		
2500	75 mm × 10 mm		

Above 750kVA size of earth lead to be determined as per IS 3043

TYPICAL PIPE EARTHING ARRANGEMENT



9.8.1 Observations and Recommendations

- The equipment body earthing were not carried out as per the standard practices adopted by the IS 3043 (code of practice for earthing).

- Most of the motors' enclosures were not earthed

- All the three standby Generators body and neutral grounding were improperly done

- Earth electrodes were not looped properly.

- Earth conductors' sizes are quite inadequate and do not conform to national standards.

- There is no proper identification for the earth pits.

- Could not locate earth resistance values routine measurement records.

- Earth pits location distance from buildings are not meeting the requirements.

- The grounding / Earthing system has to be properly maintained, as a whole, in the premises, through proper installations, identifications and periodical maintenance. This requires complete refining of the existing grounding system to conform to the standards' requirements from safety perspectives and to ensure better reliability. We have provided guide lines in this chapter as per CEIG norms and code of practice for earthing. Corrective actions may be taken accordingly.

- Should Mallow International require technical assistance to execute this, we could extend our support to get it practically done as per the norms. The implementation part requires materials assessment, labour requirements, estimation of time duration for correction and cost evaluation. All these could be done during shut down time only.

10 LIGHTNING PROTECTION

OBSERVATIONS AND RECOMMENDATIONS:

- The height of the Air terminal is lower than the tallest chimney.
- There is only one 50 sq. mm copper cable connected from the Lightning arrester to the Earthing system located below the steel structural tower over which the arrester is installed. If this cable connection gets loosened or gets open circuited, the total lightning protection will be lost for the entire premises.

- Other equipment body earth is also connected to the Lightning arrester grounding arrangement.

- The height of the present air terminal should be increased at least by “2 metres” above the top surface of the tallest chimney.

- One more parallel cable of same size (50sq mm) should be run from the top of the air terminal base to another new earth pit (to be installed). This new cable should be connected to a different point at the base of the air terminal and not to the same point where the present cable is connected.

- The additional earth lead (from other equipment) that is presently connected to the Lightning protection grounding system should be isolated and must be shifted elsewhere. Only the Lightning protection earth cable alone is to be retained (dedicated earthing for lightning protection)

- New additional (Qty-1no) earth pit has to be installed and the new cable is to be connected to this earthing arrangement. Also, the existing earth electrode has to be interconnected with the new electrode using the 50 sq mm cable bit of short length.

Enclosed the Extracts of frequently referred Lightning Arrester standards for reference:

Fig-1: IEC 62305 (International Standard) that indicates the Lightning arrester earth cable minimum size.

Fig-2: IEC 62305-3 that indicates the lightning arrester earthing arrangement resistance allowable limit**.**

Fig.3: NFC-17-102: French standard for Lightning Arrester that indicates the minimum height requirement of Lightning Arrester over the nearby object.

Fig.4: IEC62305-3 that indicates the minimum requirements of Lightning Arrester Earth pits

Fig-1: IEC 62305 (International Standard) that indicates the Lightning arrester earth cable minimum size.

Table 6 – Material, configuration and minimum cross-sectional area of air-termination conductors, air-termination rods, earth lead-in rods and down-conductors[a]

Material	Configuration	Cross-sectional area mm²
Copper, Tin plated copper	Solid tape	50
	Solid round[b]	50
	Stranded[b]	50
	Solid round[c]	176
Aluminium	Solid tape	70
	Solid round	50
	Stranded	50
Aluminium alloy	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round[c]	176
Copper coated aluminium alloy	Solid round	50
Hot dipped galvanized steel	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round[c]	176
Copper coated steel	Solid round	50
	Solid tape	50
Stainless steel	Solid tape[d]	50
	Solid round[d]	50
	Stranded	70
	Solid round[c]	176

[a] Mechanical and electrical characteristics as well as corrosion resistance properties shall meet the requirements of the future IEC 62561 series.

[b] 50 mm² (8 mm diameter) may be reduced to 25 mm² in certain applications where mechanical strength is not an essential requirement. Consideration should in this case, be given to reducing the spacing between the fasteners.

[c] Applicable for air-termination rods and earth lead-in rods. For air-termination rods where mechanical stress such as wind loading is not critical, a 9,5 mm diameter, 1 m long rod may be used.

[d] If thermal and mechanical considerations are important then these values should be increased to 75 mm².

Fig-2: IEC 62305-3 that indicates the lightning arrester earthing arrangement resistance allowable limit.

IS/IEC 62305-3 : 2010

- the electrical continuity between the various parts is made durable in accordance with 5.5.3,
- their dimensions are at least equal to that specified in Table 6 for standard down-conductors.

Piping carrying readily-combustible or explosive mixtures shall not be considered as a down-conductor natural component if the gasket in the flange couplings is not metallic or if the flange-sides are not otherwise properly bonded.

NOTE 1 Metal installations may be clad with insulating material.

b) the metal of the electrically-continuous reinforced concrete framework of the structure;

NOTE 2 With prefabricated reinforced concrete, it is important to establish interconnection points between the reinforcing elements. It is also important that reinforced concrete contains a conductive connection between the interconnection points. The individual parts should be connected on-site during assembly (see Annex E).

NOTE 3 In the case of pre-stressed concrete, attention should be paid to the risk of causing unacceptable mechanical consequences, due either to lightning current or as a result of the connection to the lightning protection system.

c) the interconnected steel framework of the structure;

NOTE 4 Ring conductors are not necessary if the metal framework of steel structures or the interconnected reinforcing steel of the structure is used as down-conductors.

d) the facade elements, profile rails and metallic sub-constructions of facades, provided that

- their dimensions conform to the requirements for down-conductors (see 5.6.2) and that for metal sheets or metal pipes thicknesses shall be not less than 0,5 mm,
- their electrical continuity in a vertical direction conforms to the requirements of 5.5.3.

NOTE 5 For more information, see Annex E.

5.3.6 Test joints

At the connection of the earth-termination, a test joint should be fitted on each down-conductor, except in the case of natural down-conductors combined with foundation earth electrodes.

For measuring purposes, the joint shall be capable of being opened with the aid of a tool. In normal use it shall remain closed.

5.4 Earth-termination system

5.4.1 General

When dealing with the dispersion of the lightning current (high frequency behaviour) into the ground, whilst minimizing any potentially dangerous overvoltages, the shape and dimensions of the earth-termination system are the important criteria. In general, a low earthing resistance (if possible lower than 10 Ω when measured at low frequency) is recommended.

From the viewpoint of lightning protection, a single integrated structure earth-termination system is preferable and is suitable for all purposes (i.e. lightning protection, power systems and telecommunication systems).

Earth-termination systems shall be bonded in accordance with the requirements of 6.2.

NOTE 1 The conditions of separation and bonding of other earth-termination systems are usually determined by the appropriate national authorities.

NOTE 2 Serious corrosion problems can occur when earthing systems made of different materials are connected to each other.

Fig.3: NFC-17-102: French standard for Lightning Arrester that indicates the minimum height requirement of Lightning Arrester over the nearby object.

NFC-17-102.pdf 21

Level of protection I^{++} : the roof is protected at level I^{+} with an ESEAT having a radius of protection reduced by 40% compared to values given in 5.2.3.2 to achieve a complete protection of equipments on the roof against direct lighning strikes.

5.2.4 Materials and dimensions.

All materials should comply with EN 50164-2

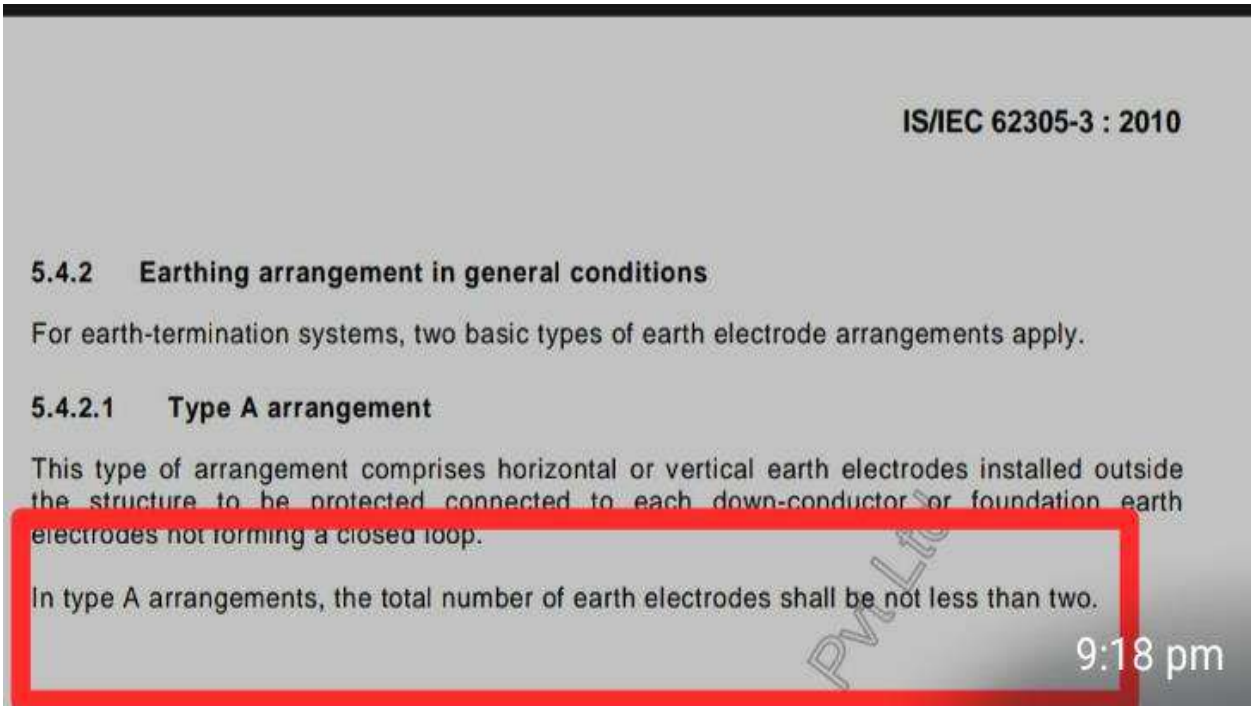
5.2.5 Installation

The top of the ESEAT shall be installed at least 2 m over the area that it protects, including aerials, refrigerating towers, roofs, tanks, etc.

When designing the ESESystem, it is recommended to take into account the architectural spots that are adequate to place an ESEAT. These locations are high structural points like:

- rooms on the terraces;
- ridge;
- masonry or metallic chimneys.

Fig.4: IEC62305-3 that indicates the minimum requirements of Lightning Arrester Earth pits



IS/IEC 62305-3 : 2010

5.4.2 Earthing arrangement in general conditions

For earth-termination systems, two basic types of earth electrode arrangements apply.

5.4.2.1 Type A arrangement

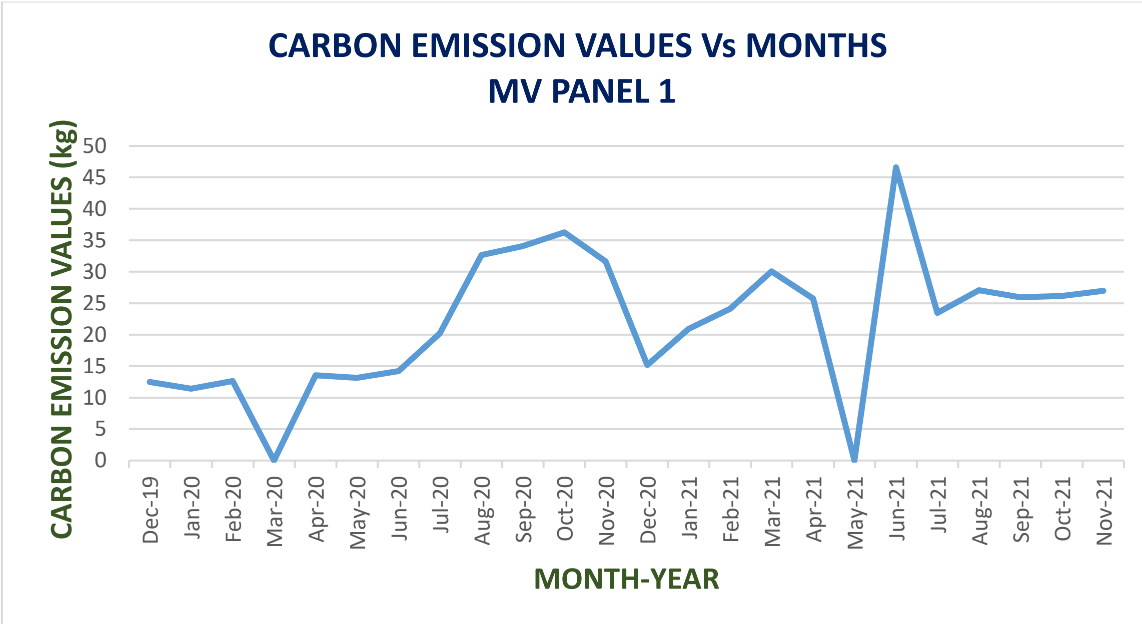
This type of arrangement comprises horizontal or vertical earth electrodes installed outside the structure to be protected connected to each down-conductor or foundation earth electrodes not forming a closed loop.

In type A arrangements, the total number of earth electrodes shall be not less than two.

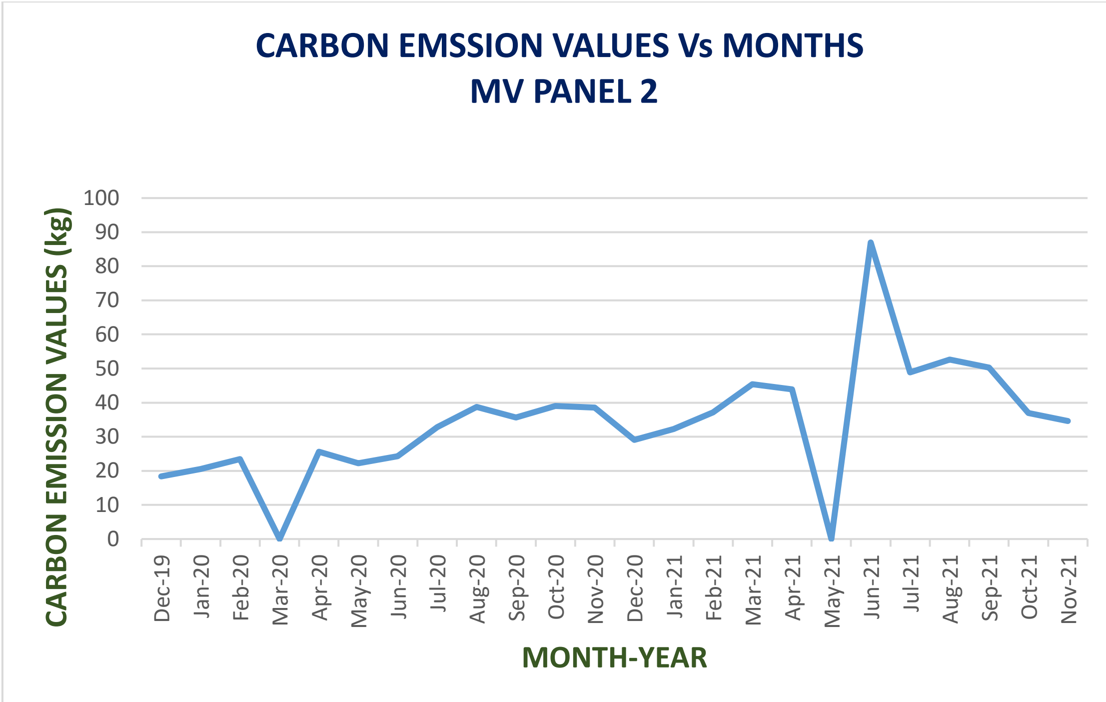
9:18 pm

11 CARBON EMISSION TREND

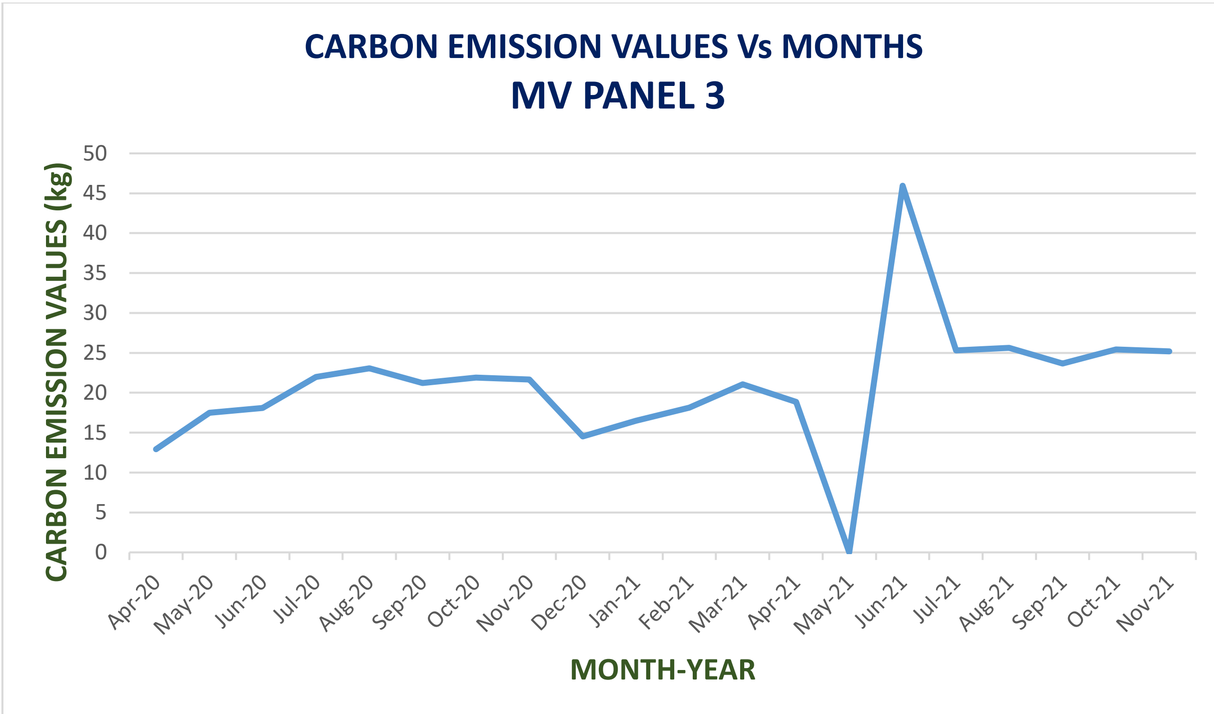
MV PANEL 1		
Month	**Units consumed**	**Carbon Emission Values**
Nov-21	32906.8	26.983576
Oct-21	31911.2	26.167184
Sep-21	31646.8	25.950376
Aug-21	32996.8	27.057376
Jul-21	28594.4	23.447408
Jun-21	56821.6	46.593712
May-21		0
Apr-21	31372.8	25.725696
Mar-21	36680.4	30.077928
Feb-21	29423.2	24.127024
Jan-21	25488.4	20.900488
Dec-20	18507.6	15.176232
Nov-20	38549.6	31.610672
Oct-20	44232.8	36.270896
Sep-20	41530.4	34.054928
Aug-20	39837.2	32.666504
Jul-20	24656.8	20.218576
Jun-20	17313.2	14.196824
May-20	16032	13.14624
Apr-20	16519.2	13.545744
Mar-20		0
Feb-20	15401.2	12.628984
Jan-20	13891.2	11.390784
Dec-19	15207.2	12.469904



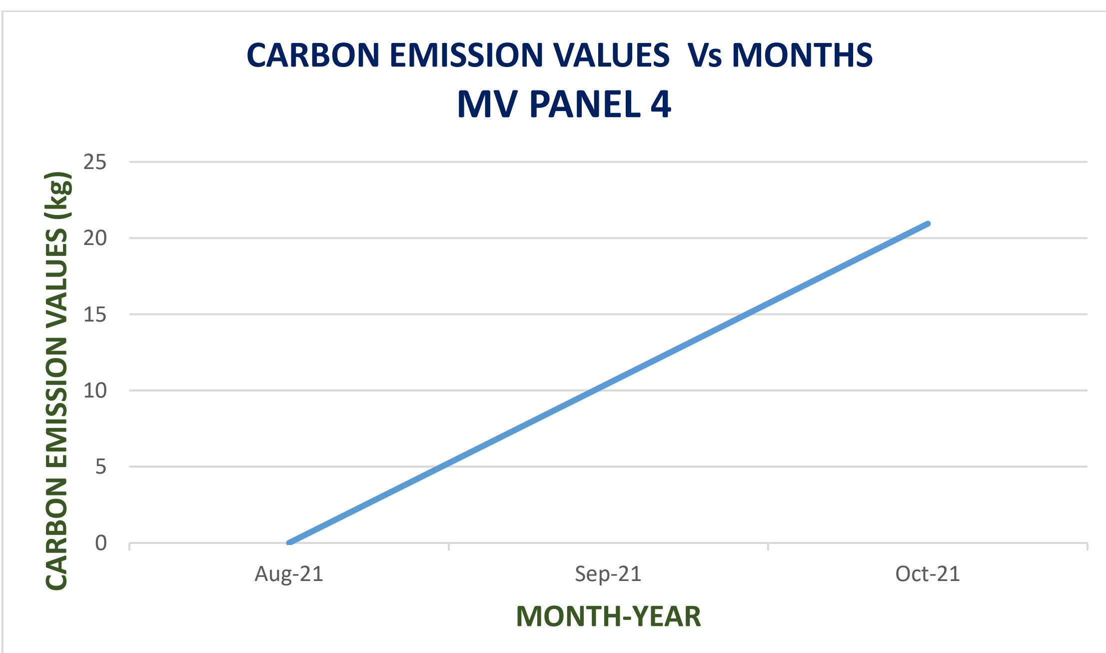
MV PANEL 2		
Month	**Units consumed**	**Carbon Emission Values**
Nov-21	42196.2	34.600884
Oct-21	45016.8	36.913776
Sep-21	61297.8	50.264196
Aug-21	64203.6	52.646952
Jul-21	59577.6	48.853632
Jun-21	106074	86.98068
May-21		0
Apr-21	53524.2	43.889844
Mar-21	55332.6	45.372732
Feb-21	45274.8	37.125336
Jan-21	39328.2	32.249124
Dec-20	35514	29.12148
Nov-20	47018.4	38.555088
Oct-20	47590.8	39.024456
Sep-20	43432.4	35.614568
Aug-20	47295.6	38.782392
Jul-20	40086	32.87052
Jun-20	29640	24.3048
May-20	27125.6	22.242992
Apr-20	31244	25.62008
Mar-20		0
Feb-20	28575.2	23.431664
Jan-20	25089.6	20.573472
Dec-19	22411.6	18.377512



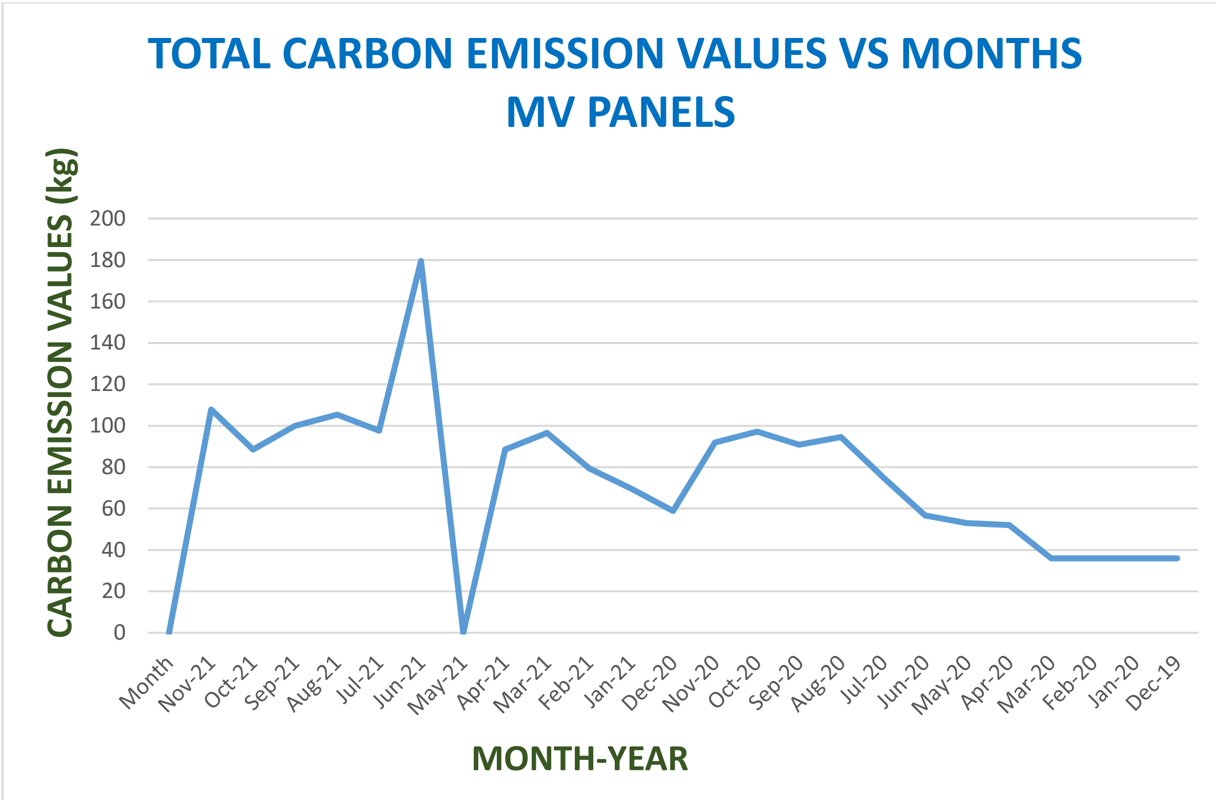
MV PANEL 3		
Month	**Units consumed**	**Carbon Emission Values**
Nov-21	30728.4	25.197288
Oct-21	31032	25.44624
Sep-21	28851.6	23.658312
Aug-21	31249.8	25.624836
Jul-21	30848.4	25.295688
Jun-21	56033.4	45.947388
May-21		0
Apr-21	23018.4	18.875088
Mar-21	25681.2	21.058584
Feb-21	22102	18.12364
Jan-21	20133.2	16.509224
Dec-20	17740	14.5468
Nov-20	26400	21.648
Oct-20	26707.2	21.899904
Sep-20	25866	21.21012
Aug-20	28130	23.0666
Jul-20	26825.2	21.996664
Jun-20	22085.2	18.109864
May-20	21360	17.5152
Apr-20	15755.6	12.919592



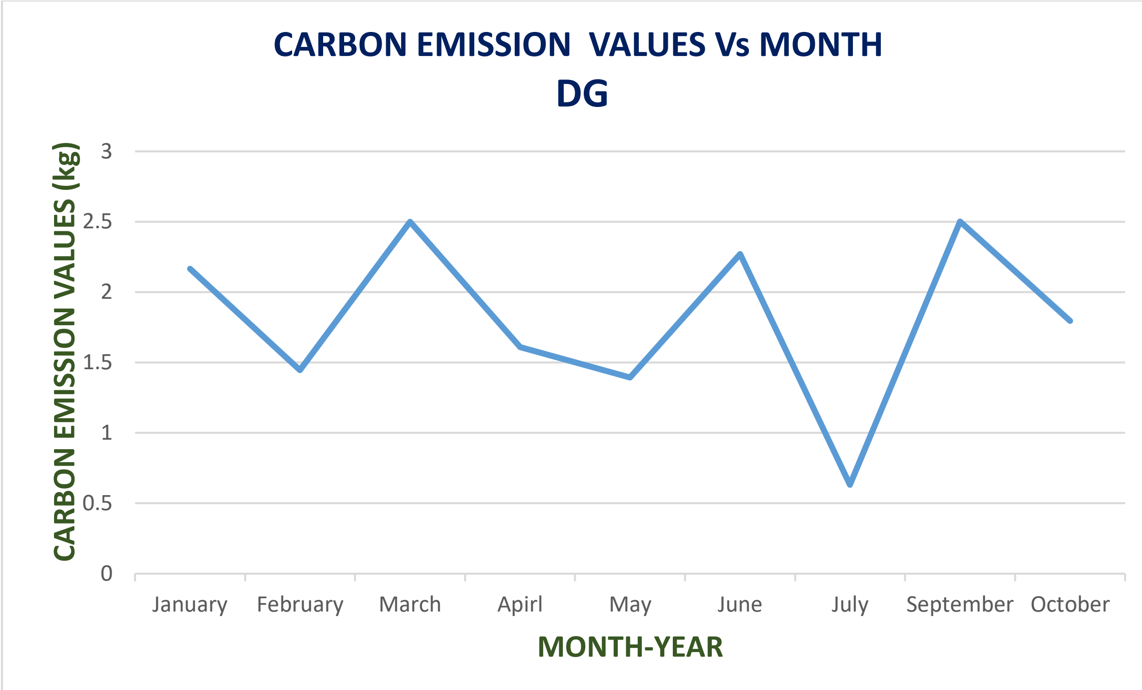
MV PANEL 4		
Month	**Units consumed**	**Carbon Emission Values**
Oct-21	25543.7	20.945834
Aug-21	0	0



Total Carbon Emission Values					
Month	**Carbon Emission Values MV 1**	**Carbon Emission Values MV 2**	**Carbon Emission Values MV 3**	**Carbon Emission Values MV 4**	**Total Carbon Emission Values**
Nov-21	26.98358	34.60088	25.197288	20.945834	107.7276
Oct-21	26.16718	36.91378	25.44624	0	88.5272
Sep-21	25.95038	50.2642	23.658312		99.87288
Aug-21	27.05738	52.64695	25.624836		105.3292
Jul-21	23.44741	48.85363	25.295688		97.59673
Jun-21	46.59371	86.98068	45.947388		179.5218
May-21	0	0	0		0
Apr-21	25.7257	43.88984	18.875088		88.49063
Mar-21	30.07793	45.37273	21.058584		96.50924
-Continued from previous page -					
Feb-21	24.12702	37.12534	18.12364		79.376
Jan-21	20.90049	32.24912	16.509224		69.65884
Dec-20	15.17623	29.12148	14.5468		58.84451
Nov-20	31.61067	38.55509	21.648		91.81376
Oct-20	36.2709	39.02446	21.899904		97.19526
Sep-20	34.05493	35.61457	21.21012		90.87962
Aug-20	32.6665	38.78239	23.0666		94.5155
Jul-20	20.21858	32.87052	21.996664		75.08576
Jun-20	14.19682	24.3048	18.109864		56.61149
May-20	13.14624	22.24299	17.5152		52.90443
Apr-20	13.54574	25.62008	12.919592		52.08542
Mar-20	35.99062	0.029512			36.02013
Feb-20	35.96684	0.029493			35.99633
Jan-20	35.94142	0.029472			35.97089
Dec-19	35.916	0.029451			35.94545



DG		
Month	**Units consumed**	**Carbon Emission Values (kg)**
January	3670	2.1653
February	2450	1.4455
March	4239	2.50101
April	2726	1.60834
May	2361	1.39299
June	3850	2.2715
July	1070	0.6313
September	4240	2.5016
October	3043	1.79537



Reference

Carbon Emission Factor

S. No.	Parameter	Units	Emission Factor
1	Grid Electricity	Kg CO_2/kWh	0.82
2	CPP Electricity		
a)	Coal Fired	Kg CO_2/kWh	1.04
b)	Diesel Fired	Kg CO_2/kWh	0.59
c)	Gas Fired (CC)	Kg CO_2/kWh	0.43
3	Coal(Sub-bituminous)	Kg CO_2/TJ	90600
4	Diesel	Kg CO_2/TJ	69100
5	Furnace oil	Kg CO_2/TJ	71900

For MV panels carbon emission calculations- multiply the units generated each month by the emission factor 0.82 and it gives kg of CO2 produced for the grid electricity consumption.

For DG power carbon emission calculations- multiply the DG units produced by 0.59 and it gives kg of CO2 produced corresponding to diesel consumption.

12 RENEWABLE ENERGY PROPOSAL

PV SOLAR ONGRID PLANT

We have given a proposal for installing a 50 kW (10% of total EB power demand) Solar Photo voltaic grid connected plant at Mallow International to reduce EB consumption as well as to mitigate CO_2 emission effectively:

- Total space required for installation

a) For roof top mounting: **4000 sq ft**

b) For ground level mounting: **5000 sq ft**

- **Total net cost of the project: Rs.25,20,000/- (including 12% GST)**

  Rs.22, 50,00/- (12% GST extra)

(Includes materials, supply & installation without AC interface cable)

- Government Subsidy: Presently not provided for industry
- Time duration for installation: One month
- Monthly EB bill saving: **Rs. 47,000/-**
- Unit Generation per day: **225 units**
- CO2 reduction: **62 tons per year**
- Yearly Generation **75,000 units**
- Life of the plant **25 years**

Cash Flow Statement 50 kw solar power plant

Description	Capacity	UoM	AD	Year
Plant Capacity proposed	50	kWp	2,97,000	1
Total cost of the Plant	22,50,000	INR	1,78,200	2
Rate of Interest	10.5	%	1,06,920	3
Loan tenure	7	years	64,152	4
Generation PLF	18	%	38,491	5
Generation per year	75,000	Units	23,094	6
Life of the plant	25	years	13,856	7
Loan Amount	15,75,000	70		
Equity	6,75,000	30		
Accelerated Depreciation allowed	40	%		
Income tax slab considered	30	%		
EMI for 22.5 lakhs /Monthly Rs. 37936.00				

[1] EMI has been considered as yearly payment.

[2] Generation per KW has been considered as 4.5 Units/kWp

[3] At present Accelerated depreciation is allowed for solar power plant@ 40 % in the same financial year of Investment

S.No	Year	In Flow					Out Flow				
		Generation	Present EB Tariff	Income from Generation	Tax Savings Thorugh AD*	Total Earnings	O & M Expenses	ROE 12 %	EMI for Loan	Total Expenses	Net Earnings
1	2021	75000	7.0	525000	297000	822000	0	0	455232	455232	366768
2	2022	75000	7.0	525000	178200	703200	0	0	455232	455232	247968
3	2023	75000	7.0	525000	106920	631920	0	0	455232	455232	176688
4	2024	75000	7.0	525000	64152	589152	0	0	455232	455232	133920
5	2025	75000	7.0	525000	38491	563491	0	0	455232	455232	108259
6	2026	75000	7.0	525000	23094	548094	33750	0	455232	488982	59112
7	2027	75000	7.0	525000	13856	538856	34763	0	455232	489995	48862
8	2028	75000	7.0	525000		525000	35805	0		35805	489195
9	2029	75000	7.0	525000		525000	36880	0		36880	488120
10	2030	75000	7.0	525000		525000	37986	0		37986	487014
11	2031	67500	7.0	472500		472500	39126	0		39126	433374

12	**2032**	**67500**	**7.0**	**472500**		**472500**	**40299**	**0**		**40299**	**432201**
	2033		**0.0**					**0**		**0**	
	2034		**0.0**					**0**		**0**	
13	**2035**	**67500**	**9.0**	**607500**		**607500**	**41508**	**0**		**41508**	**565992**
14	**2036**	**67500**	**9.0**	**607500**		**607500**	**42753**	**0**		**42753**	**564747**
15	**2037**	**67500**	**9.0**	**607500**		**607500**	**44036**	**0**		**44036**	**563464**
16	**2038**	**67500**	**9.0**	**607500**		**607500**	**45357**	**0**		**45357**	**562143**
17	**2039**	**67500**	**9.0**	**607500**		**607500**	**46718**	**0**		**46718**	**560782**
18	**2040**	**67500**	**9.0**	**607500**		**607500**	**48119**	**0**		**48119**	**559381**
19	**2041**	**67500**	**9.0**	**607500**		**607500**	**49563**	**0**		**49563**	**557937**
20	**2042**	**67500**	**9.0**	**607500**		**607500**	**51050**	**0**		**51050**	**556450**
21	**2043**	**67500**	**9.0**	**607500**		**607500**	**52581**	**0**		**52581**	**554919**
22	**2044**	**67500**	**9.0**	**607500**		**607500**	**54159**	**0**		**54159**	**553341**
23	**2045**	**67500**	**9.0**	**607500**		**607500**	**55784**	**0**		**55784**	**551716**
24	**2046**	**67500**	**9.0**	**607500**		**607500**	**57457**	**0**		**57457**	**550043**
25	**2047**	**67500**	**9.0**	**607500**		**607500**	**59181**	**0**		**59181**	**548319**
						14814213				**0**	**10720714**

13 SUMMARY OF OBSERVATIONS AND RECOMMENDATIONS

- ✓ The measurements carried out on all the medium voltage panels in the power room indicate high values of current distortions (THD- Total Harmonic Distortion). Limits for these distortions stipulated by the relevant standards are attached in this report. Obviously, it is seen that the measured values exceed well beyond the acceptable limit namely 8%.
- ✓ As a cross check, the readings of distortions on LT services at LT CT meters were taken on a different day and were also found much higher.
- ✓ Presently TANGEDCO impose penalty charges in the EB bill for all the HT consumers who exceed the distortion limits. however, for the LT consumers there is no issue. Such high distortions will produce overheating, energy loss and nuisance tripping.
- ✓ The distortions could be mitigated through installation of appropriate harmonic filters. Solution to correct this issue is not required for Mallow International since the industry is coming under LT service.
- ✓ However, it is recommended to prevent further aggravation of these distortions while adding future loads (VFDs, UPS or any power electronic devices). While procuring the new equipment, it must be demanded from the manufacturer of the product to submit a test report to show that current THD and voltage THD values are within the acceptable limits as per the attached national and international standards.
- ✓ In all the Medium Voltage panels (MV-1 to 4), generator change over panel, standby generators local panels, the cable gland plates are not provided and the bottom is kept open. If any rat enters inside the energized panel boards from the bottom the cable trench, it could be a major havoc resulting in short circuit and flash over leading to a major interruption and break down. This needs corrective action on priority basis and could be carried out during shutdown.
- ✓ In the entire panel boards, underground cables are not taken through cable glands. This needs corrective action and could be done only during shutdown.
- ✓ Grounding of all the panel boards in power room, generator locations, servo stabilizers, etc., were not done properly and not meeting the safety requirements as per the national

standards. Extracts of grounding requirements are categorically brought out in this report to execute the corrections. This should be carried out during shutdown.

- ✓ Lightning arrester air terminal must be at least 2 m taller than the tallest boiler chimney top surface. One additional 50 sq mm copper cable has to be connected from the top of the air terminal base and brought down to the additional earth pit that is to be provided at the bottom the present steel structure (over which the lightning arrester is mounted). This is the requirement.
- ✓ Extracts of lightning arrester are attached in the report for reference. In the present earth pit, existing at the bottom of the steel tower, the earth connections from other equipment were mixed up with arrester grounding. This should be separated out and shifted elsewhere to other grounding arrangement.
- ✓ The measurements on various motors reveal unbalance currents in RO stage 1 Feed pump, Blower (ETP), Condensate pump (Evaporator section), Cooling Tower pump (Evaporator section), Balance Feed pump (Evaporator section), ETP (UF) Motor, Cooling Tower Fan (Evaporator section), Vacuum Pump (Evaporator section), RO Stage 3 Feed pump. Also, it seems RO stage 1 Feed pump, ETP (UF) Motor and RO Stage 3 Feed pump are getting overloaded.
- ✓ The unbalance and overload will create energy loss and overheating. Monitor these motors for a few days to check the consistency of the prevailing issue before initiating corrective action.
- ✓ **Corrective action:** Check the tightness of the connections at motor and contactor terminals. If everything is ok and the problem still exists, replace the motors with IE3/IE4, if the existing motors are already rewound.
- ✓ Majority of the motors' enclosures are not grounded. This needs correction and must be done during shutdown.
- ✓ It is recommended to provide over voltage and under voltage alarm in the MV panels to ensure that all the motors operate at the optimum voltage values to avoid energy loss.

Under the scope for reaudit (based on the previous audit report)

- ✓ The voltages measured in the panel boards (LT distribution) are maintained in the 400 volts region only. Hence, there is no question of energy wastage due to over voltage and under voltage. The savings obtained on account of maintaining correct voltage could not be quantified.

  - ✓ We are unable to measure the savings due to the V belts replacements.
  - ✓ Under efficiency motors replacement), the motors that are fitted with the VFDs automatically adjust the speed based on the load and the efficiency improves accordingly. Hence inefficiency is ruled out.

- ✓ In MV-1, MV-2 & MV-3 LT CT service connections, excess demand charges were paid for exceeding the permitted maximum demand. We understand that alerting alarms are provided through maximum demand controller in the MV panels to control the demand. Despite this protection if the demand had exceeded, the protection arrangement healthiness needs to be checked.
- ✓ If Mallow International requires our assistance to implement the corrective measures for providing proper earthing for panel boards, motors, cable gland termination, fixing gland plates on all the panel boards, reinstallation of all grounding system, etc., then we could extend our support to complete the work under total shutdown. Before that it is required to assess, in depth, the quantum of work, materials requirements, time duration requirements and submit a quotation. Because this task is labour-intensive.
- ✓ All the grounding arrangements need to be identified.
- ✓ The Diesel Generator sets performance could be improved using additives in fuel and lube oil with the consultation of the manufacturer for performance betterment.
- ✓ The lighting board power supply should be segregated from PDB-3 and should not be mixed up with power loads.
- ✓ 10kVA UPS input power is taken from lighting board. This should be taken from power distribution board only.
- ✓ Renewable Energy power supply (to feed 10% of the total power requirements) proposal is attached with the report to reduce CO_2 emission as well as EB consumption.
- ✓ The defective capacitors are identified in the APFC panels for replacement.
- ✓ The earth electrode resistance has to be measured at least once in a year and a record has to be maintained to ensure safety.

- ✓ We understand that cables feeding power supply to all the panels are of inadequate length to take it through the cable glands. In the future, whenever the cables are laid, a two-metre diameter ring formation of the cable has to be provided at each end of termination to make use of the same in case of any termination failures at any of the ends (source side or load side).
- ✓ We have provided additional guide lines for your reference with regard to the impacts of unbalance, unbalance estimation, motor data sheet to support procurement, motor efficiency classifications, energy efficient motors retrofit examples to evaluate energy savings, motor characteristics, motor rewinding check points, etc.
- ✓ UG cable sizes have to be indicated at the rear side of all the main panel boards, servo stabilizers, generator panel boards, etc.
- ✓ The room air conditioners (quantity two numbers) located in the 160/60 kVA UPS room are maintaining room temperature at 18 deg C. This temperature may be kept at 24 to 25 deg C (recommended comfort level) that will result in energy savings.

KNOW ENERGY MANAGEMENT

NO MONETARY LOSS

NO ENERGY MANAGEMENT

KNOW MONETARY LOSS

Department of Electrical and Electronics Engineering

SARANATHAN COLLEGE OF ENGINEERING

Technical Capabilities

- Impart switch gear training to practicing engineers and contractors.
- Testing of protective relays.
- Testing of CTs.
- Transformer oil BDV test.
- Insulation resistance measurements on motors, generators, transformers, UG cables and insulators.
- Earth resistance measurements.
- Illumination measurements.
- Electrical Power Quality / Energy Auditing
- No load tests on motors (foot mounted) up to 40HP.
- Design and sizing of solar plant ON grid and OFF grid.
- Inspection services for motors at manufacturer premises.


GPS Map
Camera Lite
Karur - Vangal - Nerur Road, Karur, Tamil Nadu 639006, India
Latitude
10.9876515°
Longitude
78.095743°
Local 10:37:43 AM
GMT 05:07:43 AM
Altitude 0 meters
Tuesday, 07-12-2021
Note : Energy Auditing,Mallow International, Unit V


GPS Map
Camera Lite
X3PW+3R8, Karur, Tamil Nadu 639004, India
Latitude
10.98527896°
Longitude
78.09717131°
Local 12:54:43 PM
GMT 07:24:43 AM
Altitude 35.37 meters
Tuesday, 30-11-2021
Note : Energy Auditing,Mallow International, Unit V


X3PW+3R8, Karur, Tamil Nadu 639004, India
Latitude
10.985245183110237°
Longitude
78.09700372628868°
Local 09:34:06 AM
GMT 04:04:06 AM
Altitude 19 meters
Tuesday, 11-30-2021


X3PW+3R8, Karur, Tamil Nadu 639004, India
Latitude
10.985092925839126°
Longitude
78.09691797941923°
Local 09:59:34 AM
GMT 04:29:34 AM
Altitude 31 meters
Monday, 11-29-2021


X3PW+3R8, Karur, Tamil Nadu 639004, India
Latitude
10.984643949195743°
Longitude
78.09696273878217°
Local 09:58:52 AM
GMT 04:28:52 AM
Altitude 29 meters
Monday, 12-06-2021


X3PW+3R8, Karur, Tamil Nadu 639004, India
Latitude
10.98472055979073°
Longitude
78.0973568558693°
Local 11:00:14 AM
GMT 05:30:14 AM
Altitude 24 meters
Tuesday, 12-07-2021