Consultancy Services for the Plant Audit in various Pump Stations and Reservoirs (OP18REFCS03)

Technical Report for Cherry-inline Pump Station

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GHD Ply Ltd.

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Executive Summary

Cherry-inline Pump Station has six (8) pumps (6 booster pumps and 2 storage pumps). Based on preliminary assessment on historical corrective and preventive intervention records, significant degradation has been observed for pumps, which experienced high frequency of failure on bearing and coupling components. Statistically, it is evident from the time series data in the period from 2014 to 2018 on power consumption and production that more power has been incurred while the availability of the pump system is less.
Based on the results of testing, reliability, and life cycle cost analysis, GHD recommends to execute a set of preventive intervention program that involves periodic replacement of pump components and frequent inspection/testing to collect historical data sufficient to estimate the reliability of pumps and the system. The intervention program can be done in the first year of the next 5 years preventive intervention plan that are reflected in the optimal time window shown along with the impact curves.
Furthermore, GHD recommends Maynilad that optimal time window to execute the intervention program shall take into consideration of network analysis which will enable Maynilad to set priorities to perform intervention program not only for Pagcor station but also for other stations. In addition, Maynilad might consider to combine intervention programs of a group of stations as it will be also optimal when preparing the bid.

Contents

Chapter 1

Data and Analysis

1.1 Fire protection and safety (FDAS) audit

1.1.1 Fire alarm and detection system

No fire alarm detection system was installed in this PS.

1.1.2 Lighting protection system

There is a lightning protection system installed for this in line booster. The strike counter has not registered a single strike. The bare copper wire connecting the lightning arrester to the ground is already dark and corroded.

a - Lightning arrester rod b - Sticke counter c - Bare copper wire

Figure 1.1: Protective devices.

1.1.3 Ground-Fault circuit interrupter (GFCI) or electric leakage circuit breaker (ELCB) or Residual circuit devices (RCD)

1.1.3.1 Data and analysis

No ground fault circuit interrupter (GFCI) or earth leakage Circuit breaker (ELCB) protection was installed in the panel this PS.

1.1.3.2 Recommendations

Refer to the conceptual design in Chapter **??**

1.1.4 Electrical safety and protective devices

The pump room is only manned by one person. The old pump room was not maintained and not organized. Staying inside the pump room poses danger to the operator because of the open wiring and exposed live parts. There is only entrance and exit.

1.1.4.1 Data and analysis

Facts obtained from inspection are presented in Table 1.1 with indicative figures for each devices presented in Figure 1.2.

Table 1.1: Protective devices.

Item	Visual Check	Status	Remarks
1	Evacuation Plan	0	
2	Fire Extinguishers	0	Pump Station Is Not Equipped With All Of The Standard Safety Features And Equipment
3	Fire Exits	0	
4	Fire Hose Cabinet	0	
5	Fire Sprinkler System	0	
6	Emergency Exit Signages	0	
7	Emergency Lights	0	
8	PPE Cabinet	0	

1.2 Visual inspection on electrical assets

Results of the visual inspection are reflected in the database that describes also the Asset Registry. Highlights of the outcome for this station are shown in Table 1.3 with visual images shown in Figure 1.3.

1.3 Short circuit calculations and evaluation

1.3.1 Short circuit calculation

Short circuit calculation (SCC) has been done using the software ETAP version 16.2 under following considerations:

- **Available MVA Short Circuit**: Utility supplying normal power to the PS via a 34.5 KV line is MERALCO. The maximum projected fault is to be requested by the owner from the utility. In the calculation, 500MVA available short circuit was used;
- **Transformer**: The SCC was based on a 3 x 50kVA transformer feeding the transfer switch going to the motors. Transformer impedance used in the calculation is per standard impedance in the absence of data;
- **GENSET**:
  - Emergency power will be supplied by 1 Genset, rated at 110 kVA feeding the transfer switch;
  - The result of the short circuit value of the generator sets is slightly lower than the short circuit fault value produced on the bus during normal power mode. Subtransient value of the generator should be provided for a more accurate calculation.
- **Length of wires and cables**: Actual measured length of wires and cables.

Table 1.2: Protective devices.

Item	Description	Status	Findings During Inspection	Remarks
1	Rusty Hinge On Door	0	-Broken Hinge Of The Door	-Unsafe -Door Will Not Be Aligned And Hard To Close - Small Animals May Get Inside
2	Unmaintained Door	0	-Rusty Door Opening - Room Not Secure -Evidence Of Not Observing Cleanliness	-Unsafe -Operator Is Staying Inside The Room -Unclean Environment
3	Ladder	0	- Unprotected Ladder Going To Reservoir -Tree Leaves Blocking The Ladder	-Unsafe -People Climbing Should Be Protected By Cage When Climbing -Leaves Can Retain Water Adding To Slippage
4	Outdoor Stairs	0	- No Hand Rail	-Unsafe -Possible Slipping Of Operator When Going Up The Steps Specially After Rain Pour Or When There Is Drizzle
5	Water Inside Struture	0	- Water Ponding Inside The Structure	-Unsafe -Water Can Be Breeding For Mosquitos If Not Drained
6	Defective Lighting Fixture	0	-Lighting Fixture Is Without Bulb (Not Functioning)	-Unsafe - Can Be A Source Of Fire When Ignited And Not Stored Properly. -Room Where The Operator Stays Is Not Well Lit During The Night
7	Old Structure	0	- Room Was Disorganized With A Lot Of Materials And Devices Stored Inside The Room Where The Operator Stays.	-Unsafe - Can Be A Source Of Fire When Ignited And Not Sored Properly.
8	Hanging Wires	0	- Wires From The Room Were Not Harnessed Or Inside Conduit	-Unsafe - Exposed Wires Still With Power And Can Be A Source Of Fire Hazard.
9	Hanging Wires	0	- Wires From The Room Were Not Harnessed Or Inside Conduit. -Visible Deterioration Of Wires	-Unsafe - Exposed Wires Are Still With Power And Can Be A Source Of Fire Hazard.
10	Hanging Wires	0	- Wires From The Room Were Not Harnessed Or Inside Conduit -Visible Deterioration Of Wire Insulation	-Unsafe - Still With Power And Can Be A Source Electrocution And Of Fire Hazard.

Calculation has been done for both One Phase and Three Phase of short circuit current. Results of the calculations are summarized in Table 1.4. Figure 1.4 and Figure 1.5 represent the graphical representation of Nodes and Links as well as associated values.

The values of SCC shown in the table indicates the followings:

- the values of the FAULT observed to be lower than the values of the protective devices. This infers that the existing protective devices are capable to protect the assets.

1.3.2 Evaluation of protective devices and bus bars

It can be interpreted from the results of the SCC that

- the protective devices and bus bars are still provided adequate level of services and performed per applied standards;

(a - Rusted hinge door)

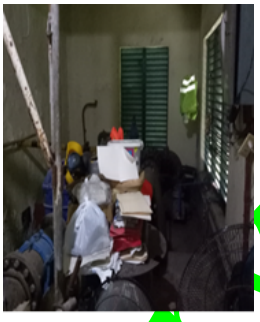
(b - Broken door)

(c- Unprotected ladder)

(d - Stair with handrail)

(e - Water ponding)

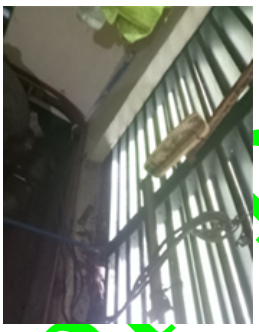
(f - Defective lighting)



(g - Disorganized room)

(h - Hanging wire 01)

(i -Hanging wire 02)



(j -Hanging wire 02)

Figure 1.2: Electrical safety

- there is no undersized electrical components.

1.4 Voltage drop calculation

Voltage drop calculation (VDC) has been conducted in compliance with the code (PEC 2017 ARTICLE 2.15.1.2(A)(1)(b)FPN NO.2) which states the following

- Conductors for feeders, as defined in Article1.1, sized to prevent a voltage drop exceeding 3% at the farthest outlet of power, heating and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5% , will provide reasonable efficiency.

Results of the VDC is presented in Table 1.5

It can be interpreted from the values of the calculation that the VDC is within the limits defined in the applied standard.

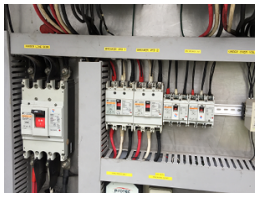
Table 1.3: Highlights of visual inspection - Electrical assets

Item	Categories	Asset name	Model	Branch	Status	CS	Remarks
1	Main switch/Switch board				0		
2	Distribution transformer	150 Kva Transformer (Utility Supply))			1	1	
3	Maynilad owned Load Break Switch (LBS)				0		
4	Power cables				1	1	Not visually observed
5	MCC	Moulded Case Circuit Breakers	Bw400Eag, Bw125Jag	Fuji,		1	
	MCC	Uninterruptible Power Supply					
	MCC	Variable Frequency Drive	Vlt Aqua Drive	Danfoss			
	MCC	Miniature Circuit Breakers		Fuji, Schneider			
	MCC	Magnetic Contactors	Sc-N2S				
6	Capacitor bank				0		
7	TVSS	Surge Protection Device		Protec	1	1	
8	Power meter	Kilowatthour Meter	V-62S	Canadian General Elect.	1	1	
9	Filter and Reactors	Harmonic Filter, 70Amps	Vlt	Danfoss	1	1	
10	Instrument Transformer	Current Transformers			1	1	
11	Electrical Protective Relays				1	1	
12	Motors and Switches					1	
13	Transfer Switch	Manual Transfer Switch	Bw400Eag	Fuji	1	1	
14	Uninterruptible power system (UPS) and batteries						
15	Distribution panel boards and associated appurtenances						
16	Ground-fault circuit Interrupter (GFCI) or Electric leakage circuit breaker (ELCB) or Residual Circuit Devices (RCD)						
17	Emergency Generator	Silent Diesel Generator110Kva/88Kw, 220/440V, 60Hz	Hgc-80	Hexagen	1		
18	Building Service and Distribution						
		Lightning Arrester With Counter	Cdr-401	Cirprotec	1		

1.5 Load flow study

The load flow study (analysis) has been conducted per applied standard. Following Terms are important in the study, thus being extracted from the Philippines Distribution Code for ease of readers.

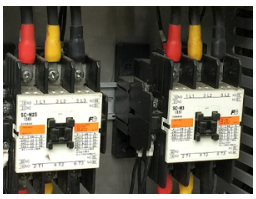
- **Active Power**: The time average of the instantaneous power over one period of the electrical wave, measured in watts (W) or multiples thereof. For AC circuit or Systems , it is the product of the root-mean –square (RMS) or Effective value of the voltage and the RMS value of the in-phase component of the current. In a three phase system, it is the sum of the Active Power of the individual phases;
- **Apparent Power**: The product of the root-mean –square (RMS) or Effective value of the current and root –mean –square of the voltage. For AC circuit Systems, it is the square root of the sum of the squares of the Active Power and Reactive power, measured in volt-amperes (VA) or multiples thereof;
- **Reactive Power**: The component of the electrical power representing the alternating exchange of stored energy (inductive or capacitive) between sources and loads or between two systems, measured in VAR, or multiples thereof. For AC circuits or systems, it is the product of the RMS voltage and the RMS value of the quadrature component of alternating current. In a three phase system, it is the sum of the Reactive power of the individual



(a - Circuit Breaker)

(b - Loose breaker)

(c- Filters)



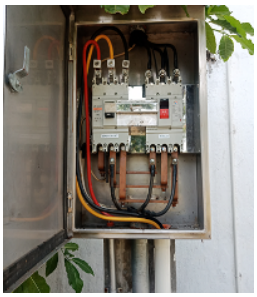
(d - Magnetic contactor)

(e - Light arrester)

(f - Current Transformer)

(g - GENSET house)

(h - Mounted transformer)



(i -MTS)

(j -Panel board)

(k -Surge protection devices)

(l -Kilowatt meter)

Figure 1.3: Existing electrical assets

phases;

- **Harmonics (THD)**: Harmonics shall be defined as sinusoidal voltage and currents having frequencies that are integral multiples of the fundamental frequency.

1.5.1 Analysis based on design

The analysis has been conducted under the assumption of the Alerting Setting shown in Table 1.6. Results of the analysis are shown in the diagram (refer to Figure 1.6) with all details summarized in tabular forms (refer to the Appendix)

As can be seen from the figure, parameter values are all acceptable. However, there is an indication in pink color for VFD1, inferring that this asset might have reached the marginal setting, but not critical. It is recommended that this asset shall be closely monitored. The conclusion on this asset will be validated together with the analysis on the Power Quality which is in subsection 1.8.

Summaries on the results are also shown in Table 1.7, Table 1.8, and Table 1.9.

It is concluded from this analysis that all parameter values are within the acceptable ranges.

Table 1.4: Short circuit calculation - results

Item	Description	SCC (kA)	kAIC & CB (kA)	CS	IT	Remarks
A.	Three Phase			1	1	
1	3 X 50 Kva Transformer-Secondary	2.479	-	1	1	Protection Via Fuse Provided By Utility
2	Transfer Switch	2.418	18	1	1	Acceptable
3	Main Mccb 250A 460	2.418	18	1	1	Acceptable
				1	1	
4	Feeder Mccb-1 100A (30HP Motor)	2.391	8	1	1	Acceptable
5	Feeder Mccb-2 100A (30HP Motor) Alternate	2.391	8	1	1	Acceptable
6	Motorized Opening Valve Supply 1	2.391	8	1	1	Acceptable
7	Motorized Opening Valve Supply 2	2.391	8	1	1	Acceptable
8	Motor1 -30Hp	0.143	-	1	1	Protection Via Vfd
9	Motor2-30 Hp	-	-	1	1	Alternate
B	Single Phase					
1	MCCB 30A	2.041	2.5	1	1	Acceptable
2	Dry Type Transformer 2.5 kVA	0.411	-	1	1	Protection Via Upstream Mccb
3	MCB 32A Ups (Lump 3)	0.3964	2.5	1	1	Acceptable
4	MCB 32A Light & Conv Outlet (Lump 4)	0.394	2.5	1	1	Acceptable
5	MCB 32A For Meter (Lump 5)	0.394	2.5	1	1	Acceptable

Table 1.5: Voltage drop calculation - results

Item	From	To	Wire Size mm^2	I Ampe	L m	R Ω/305 m	X Ω/305 m	Vd	%Vd	Remarks
1	Pole Mounted Transformer 50Kva,3 Φ	Ats Panel	250	425	15.52	0.048	0.027	2.06	0.0043	Within Limits
2	MTS Panel	Ecb 250A	250	425	7	0.048	0.027	0.929	0.0019	Within Limits
3	ECB 30A, 2P	Dry Type Transformer 2.5Kva	5.5	40	4.2	1.2	0.063	1.324	0.0055	Within Limits
4	Dry Type Transformer 2.5Kva, 1Φ	UPS Panel	5.5	40	4	1.2	0.063	1.261	0.0053	Within Limits
5	MCCB 100A, 3P	30Hp Motor	30	115	10	0.2	0.057	1.357	0.0028	Within Limits
	Pole mounted to 30 HP motor							3.417	0.71	Within Limits

1.5.2 Analysis based on measured data from the PQA

Analysis has been conducted for the overall system (referherein as MAIN), for Feeder to motor with VFD1 and VDF2, respectively. The detailed reports were obtained from the analytical software (refer to Appendix) with highlights presented in Figure 1.7, Figure 1.8, and Figure 1.9.

Following conclusions can be derived from the reports

- For the overall system, the maximum loading reached about 54 (A) (Figure 1.7), which is lower than the theoretical values (63.8 A)obtained from ETAB software (Figure 1.6). This indicates that actual parameter values are within the acceptance range;
- For the VFD1, the maximum loading reached about 54 (A) (Figure 1.8), which is lower than the theoretical values (33.9 A)obtained from ETAB software (Figure 1.6). This indicates that actual parameter values are not within the acceptance range;
- For the VFD2, the maximum loading reached about 32 (A) (Figure 1.9), which is lower than the theoretical values (33.9 A) obtained from ETAB software (Figure 1.6). This indicates that actual parameter values are within the acceptance range.

From this analysis, it is recommended that continuous monitoring on VFD1 shall be implemented to ensure that the loading is not going to exceed the limit. Furthermore, continuity test on VFD shall be conducted to determine the probable issue.

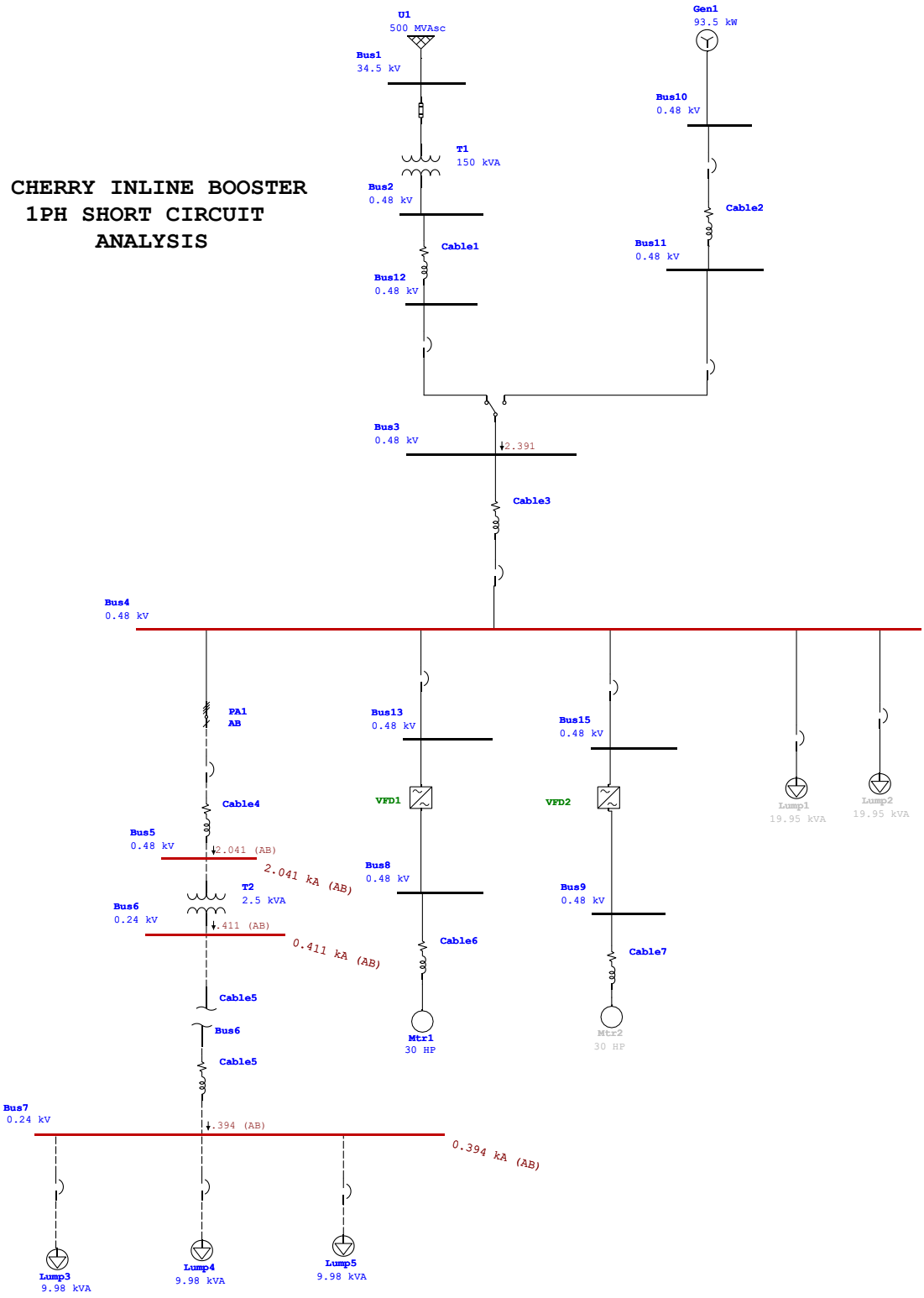


Figure 1.4: One Phase SCC

1.6 Protection coordination study

In protection coordination study, the protective devices nearest to the FAULT shall trip first and the remaining of the protective devices shall not be affected. The results were obtained from the ETAB software and shown in Table 1.10, Table 1.11, and Table 1.12.

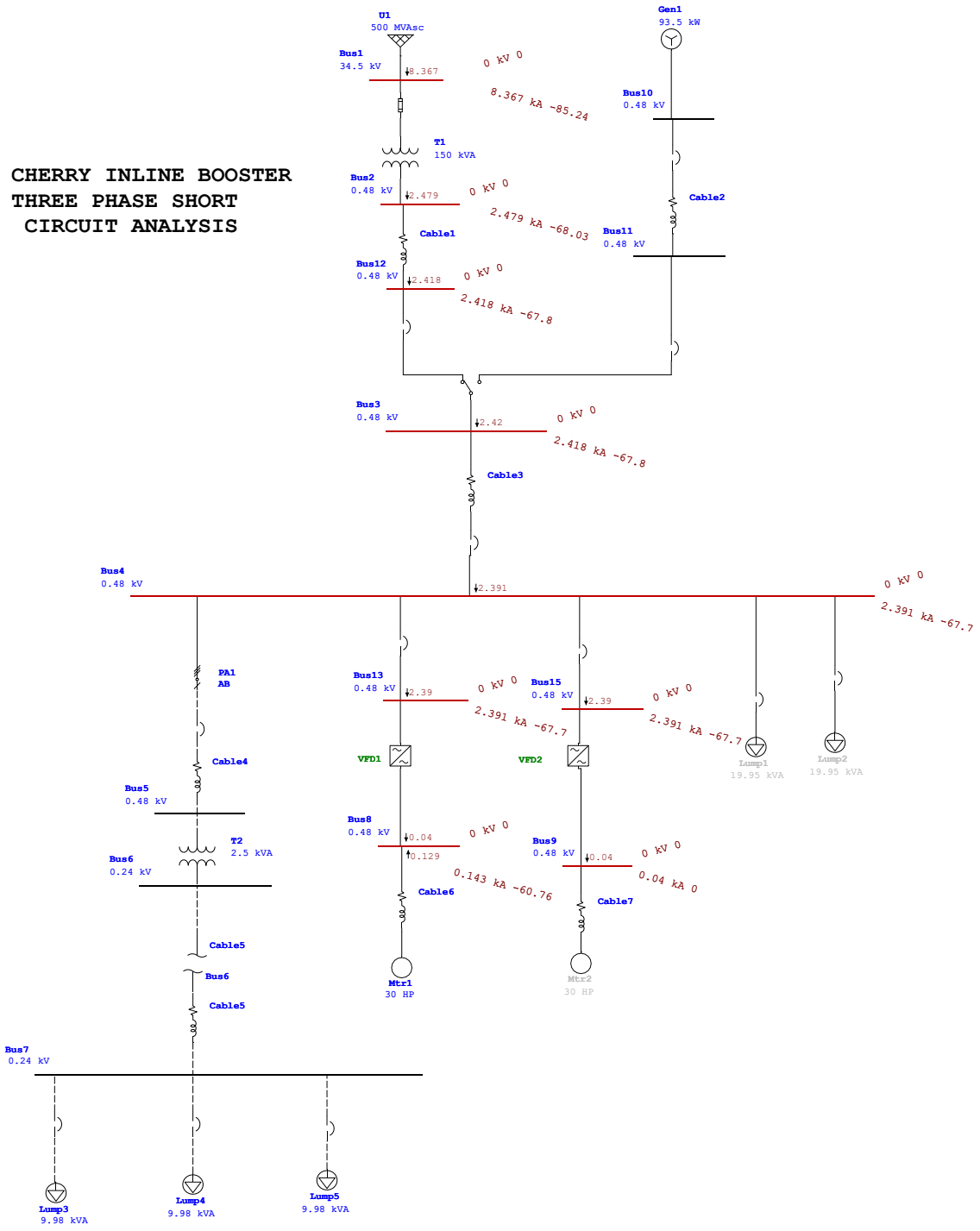


Figure 1.5: Three Phase SCC

Further illustration of the coordination is shown in Figure 1.10.

As can be seen from the tables and the figure, there is a mis-coordination at the instantaneous region. Following conclusions can be realized.

- All trip devices are fixed and can not be adjusted. Hence coordination is deemed to be partial since all branch breaker TCC curves crossed the TCC curve of Main breaker on the instantaneous region.
- No ground fault protection provided due to the type of breaker supplied. However , this is allowed under the Philippine Electrical Code;

Table 1.6: Alert setting

% Alert Settings		
	Critical	**Marginal**
Loading		
Bus	100.0	95.0
Cable	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	105.0	102.0
UnderVoltage	95.0	98.0
Generator Excitation		
OverExcited (Q Max.)	100.0	95.0
UnderExcited (Q Min.)	100.0	

Table 1.7: Summary of total generation, loading, and demand

	MW	Mvar	MVA	% PF
Source (Swing Buses):	0.050	0.030	0.058	86.24 Lagging
Source (Non-Swing Buses):	0.000	0.000	0.000	
Total Demand:	0.050	0.030	0.058	86.24 Lagging
Total Motor Load:	0.030	0.016	0.034	88.48 Lagging
Total Static Load:	0.019	0.012	0.023	85.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.001	0.002		
System Mismatch:	0.000	0.000		

Number of Iterations: 2

Table 1.8: Bus loading

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus1	34.500										0.058	86.2	1.0	
Bus2	0.480			0.000							0.057	87.1	70.1	
Bus3	0.480										0.057	87.1	70.1	
Bus4	0.480		0.005	0.003	0.019	0.012					0.057	87.1	70.1	
Bus8	0.480		0.025	0.013							0.028	89.2	34.7	
Bus9	0.480													
Bus12	0.480										0.057	87.1	70.1	

* Indicates operating load of a bus exceeds the bus critical limit (100.0% of the Continuous Ampere rating).
# Indicates operating load of a bus exceeds the bus marginal limit (95.0% of the Continuous Ampere rating).

Following is recommendation:

- main breaker should be of adjustable and electronic type.

1.7 Harmonic study

Harmonic study has been conducted under the following basics

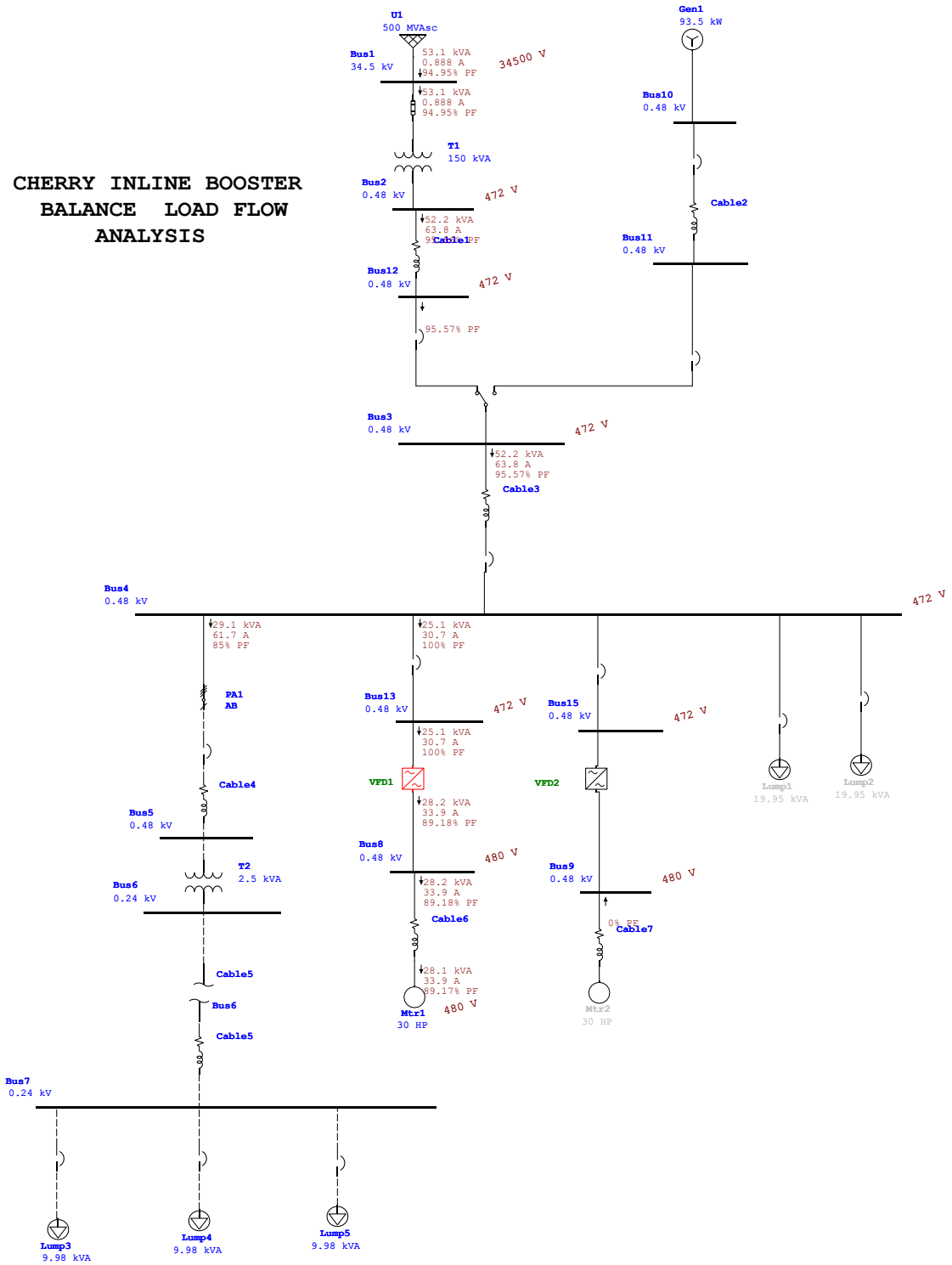


Figure 1.6: Load flow analysis

- Harmonics shall be defined as sinusoidal voltage and currents having frequencies that are integral multiples of the fundamental frequency;
- The total harmonic distortion (THD) shall be defined as the ratio of the RMS value of the harmonic content to the RMS value of the fundamental quantity, expressed in percent;
- PHILIPPINE DISTRIBUTION CODE sets the THD of the voltage at any user system to not exceed 5% during normal operating conditions.

Table 1.9: Branch loading

CKT / Branch		Cable & Reactor			Transformer				
		Ampacity (Amp)	Loading Amp		Capability (MVA)	Loading (input)		Loading (output)	
ID	Type			%		MVA	%	MVA	%
Cable1	Cable	302.68	70.10	23.16					
Cable3	Cable	302.68	70.10	23.16					
T1	Transformer				0.150	0.058	38.9	0.057	38.0

* Indicates a branch with operating load exceeding the branch capability.

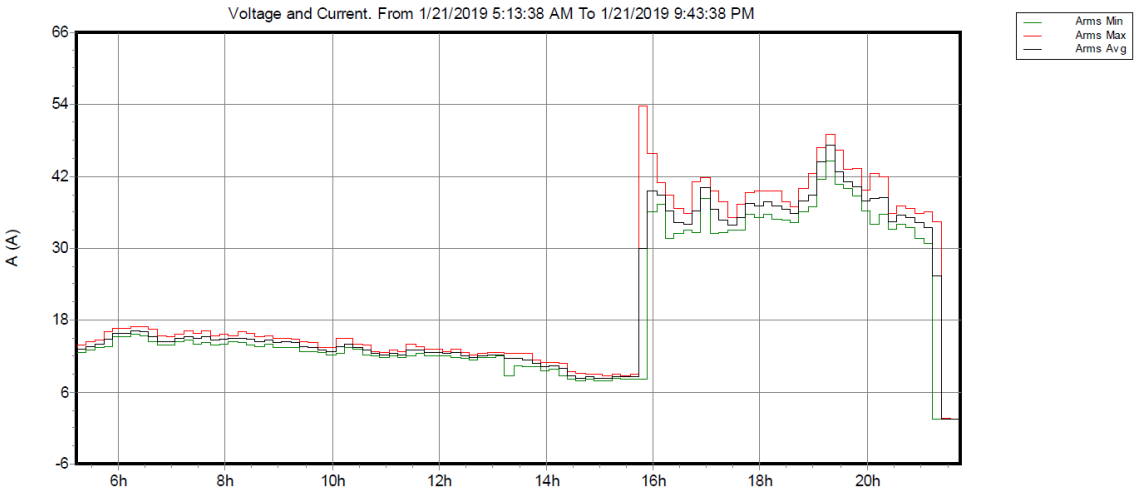


Figure 1.7: Main: 250 Amperes

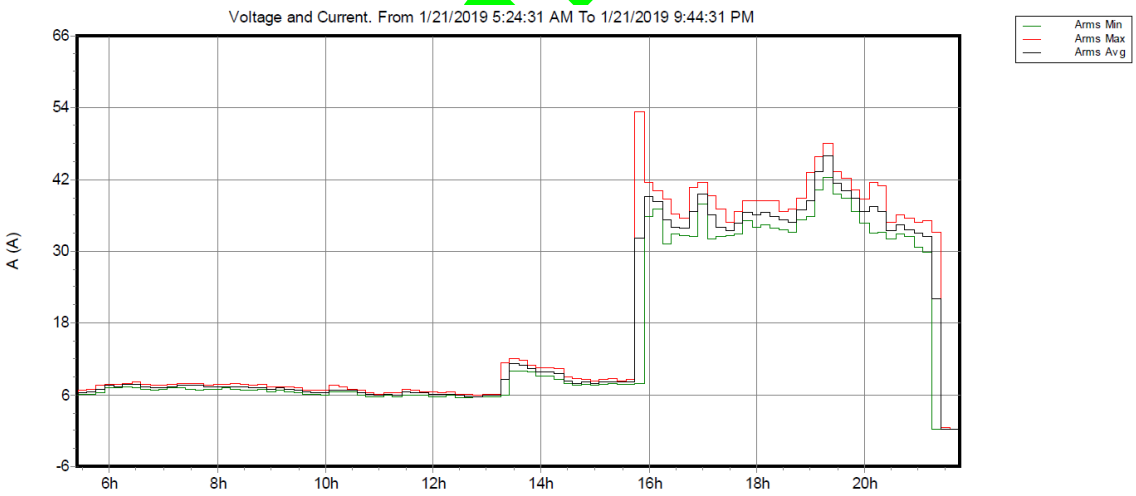


Figure 1.8: Feeder: VFD-1 for 30 HP motor

1.7.1 As per design

Results of the study as per design are shown in Figure 1.11, Figure 1.12, and Figure 1.13

It can be seen from the figures that there are a number of distortions, which are connected to bus 4. It is notable to observe that the percentage of the THD is 4.96%, which is very close to the margin of 5%.

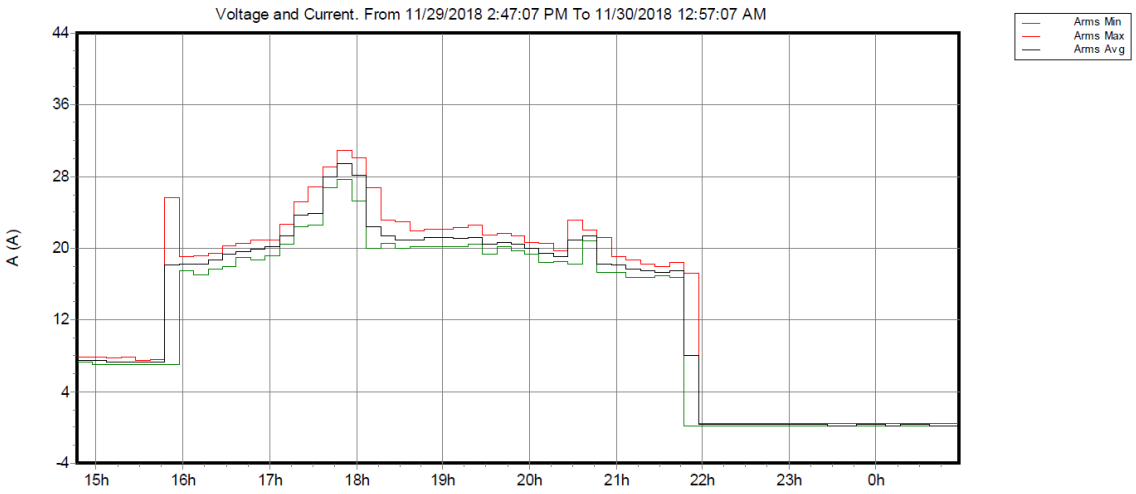


Figure 1.9: Feeder: VFD-2 for 30 HP motor

Table 1.10: Protective Device Settings - Low Voltage Circuit Breaker with Thermal-Magnetic Trip Device

LVCB ID	Manufacturer	Breaker		Thermal		Magnetic (Inst.)	
		Model	Size	Setting	Trip (Amps)	Setting	Trip (Amps)
CB4	Fuji Electric	BW400EAG	250	Fixed	250	Fixed	8 xIn
CB9	Fuji Electric	BW125JAG	100	Fixed	100	Fixed	8 xIn
CB10	Fuji Electric	BW125JAG	100	Fixed	100	Fixed	8 xIn
CB11	Fuji Electric	BW32SAG	32	Fixed	32	Fixed	8 xIn
CB12	Fuji Electric	BW32SAG	32	Fixed	32	Fixed	8 xIn
CB1	Fuji Electric	BW400EAG	250	Fixed	250	Fixed	8 xIn

Table 1.11: Cable-circuit breaker coordination

Items	Protective Device			Cable Protection				Max Fault 3Ph-Amps	Reference kV
	Location	ID	Type	Pickup Limit	Ampacity	Damage Curve	Condition		
Cable1	Load	CB1	TM-Magnetic TM-Thermal	- Pass	- Pass	Pass Pass	Trip curve protects the damage curve Therm. Trip 250 A is within 302.7 A = Ampacity Therm. Trip 250 A is within max. limit of 302.7 A = Ampacity x 100% Trip curve protects the damage curve	2418	0.48
Cable3	Load	CB4	TM-Magnetic TM-Thermal	- Pass	- Pass	Pass Pass	Trip curve protects the damage curve Therm. Trip 250 A is within 302.7 A = Ampacity Therm. Trip 250 A is within max. limit of 302.7 A = Ampacity x 100% Trip curve protects the damage curve	2391	0.48

1.7.2 Per actual

Results of the study based on the PQA are presented in Figures 1.14, 1.15, 1.16, 1.17, 1.18, and 1.19

Table 1.13 shows also the summary of the study, in which the min, average, and max values are presented along with the limit of 5%.

It can be interpreted from the table that values Main and VFD1 infer that there might be a

Table 1.12: MCCB coordination

Zone		Stream		Max Fault		Ref.	Coord.	Amp Range		Condition
ID	type	up PD	down PD	type	Amp	kV	status	From	To	
Bus4	Bus	CB4	CB9	3Ph	2391	0.48	Alert	2000	2000	Miscoordination, the time gap is smaller than 0.001 sec margin at I=2000 A, Plot Ref. kV=0.48
				L-G			Warning			L-G fault coordination is not possible.
			CB11	3Ph	2391	0.48	Alert	2000	2000	Miscoordination, the time gap is smaller than 0.001 sec margin at I=2000 A, Plot Ref. kV=0.48
				L-G			Warning			L-G fault coordination is not possible.
			CB12	3Ph	2391	0.48	Alert	2000	2000	Miscoordination, the time gap is smaller than 0.001 sec margin at I=2000 A, Plot Ref. kV=0.48
				L-G			Warning			L-G fault coordination is not possible.
			CB10	3Ph	2391	0.48	Alert	2000	2000	Miscoordination, the time gap is smaller than 0.001 sec margin at I=2000 A, Plot Ref. kV=0.48
				L-G			Warning			L-G fault coordination is not possible.

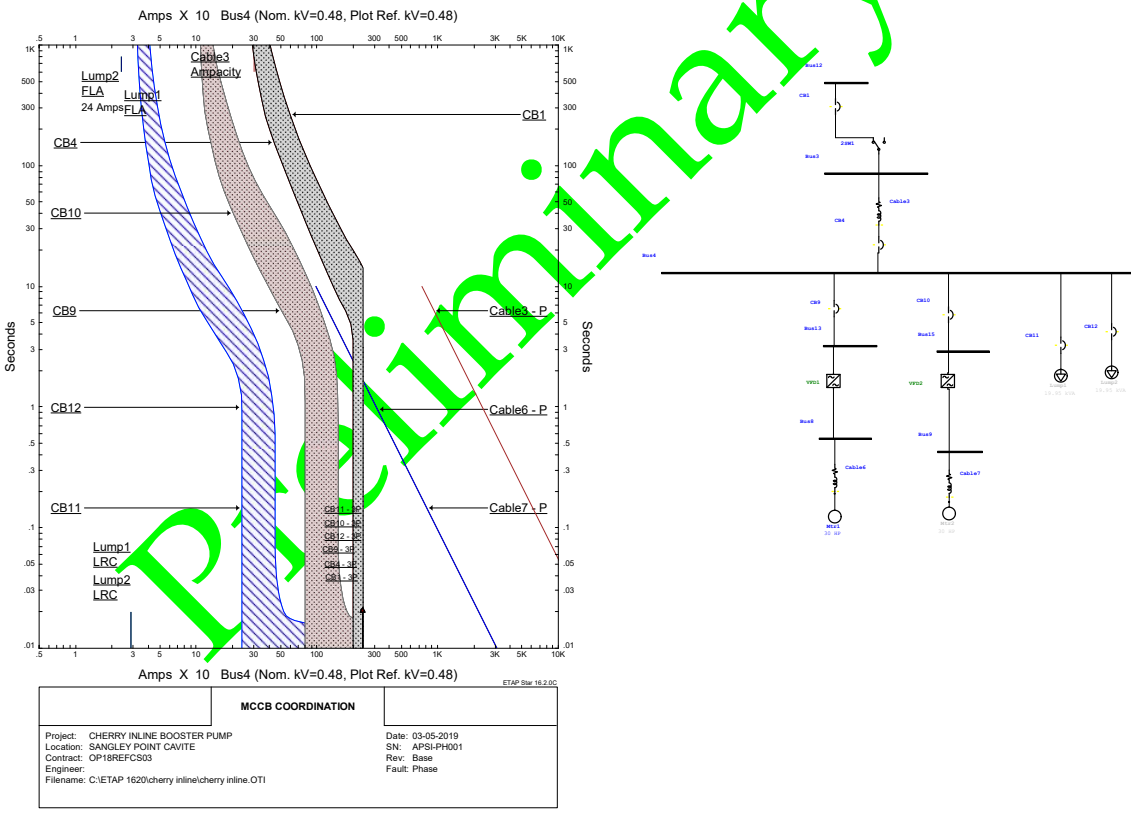


Figure 1.10: Coordination plot

concern, particularly for the harmonic orders of 3rd, 5th, and 7th being dominant registers. This might cause heating on the equipment.

Recommendation shall be realized together with the recommendation from the study of Power Quality Analysis (refer to subsection 1.8)

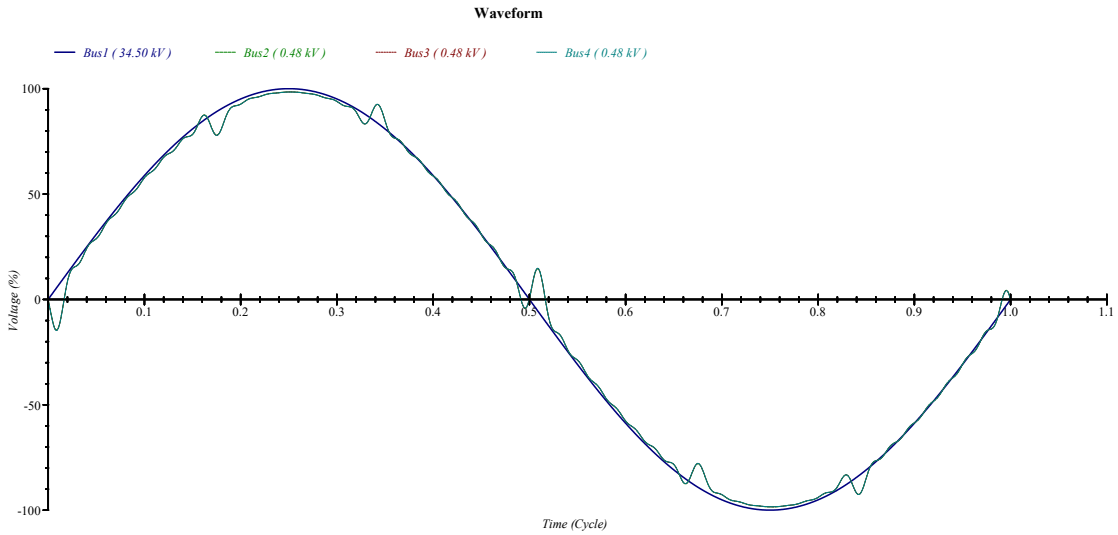


Figure 1.11: Bus wave form

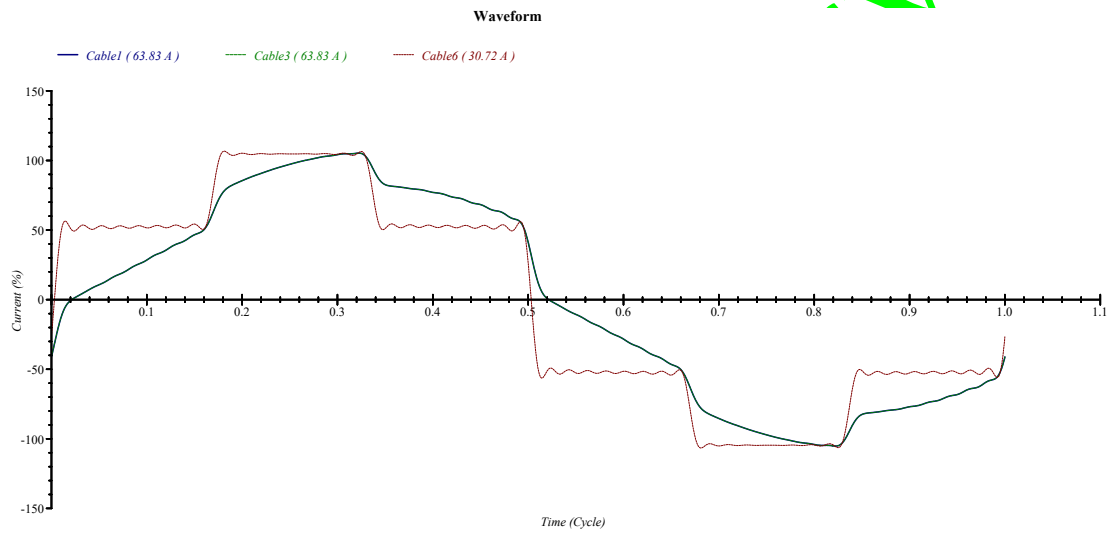


Figure 1.12: Cable waveform

Table 1.13: Harmonic study

Total Harmonic Distortion (%)	Phase	Minimum	Average	Maximum	Limits (5%)	Remarks
Main 250A (Load side)	AB	1.44	3.36	3.90	5	Within Limits
	BC	1.27	2.56	2.86		
	CA	1.53	3.36	3.90		
VFD-1	AB	3.22	3.36	3.90	5	Within Limits
	BC	2.89	3.01	3.37		
	CA	3.22	3.36	3.90		
VFD-2	AB	2.11	2.20	2.68	5	Within Limits
	BC	1.63	1.68	1.97		
	CA	2.11	2.20	2.68		

1.8 Power quality analysis

The Power Quality Analysis (TQA) has been conducted on the Main system, VFD1, and VFD2 of this PS. The Power Quality Analyzer used is FLUKE 430-II. Figure 1.20 shows the analyzer

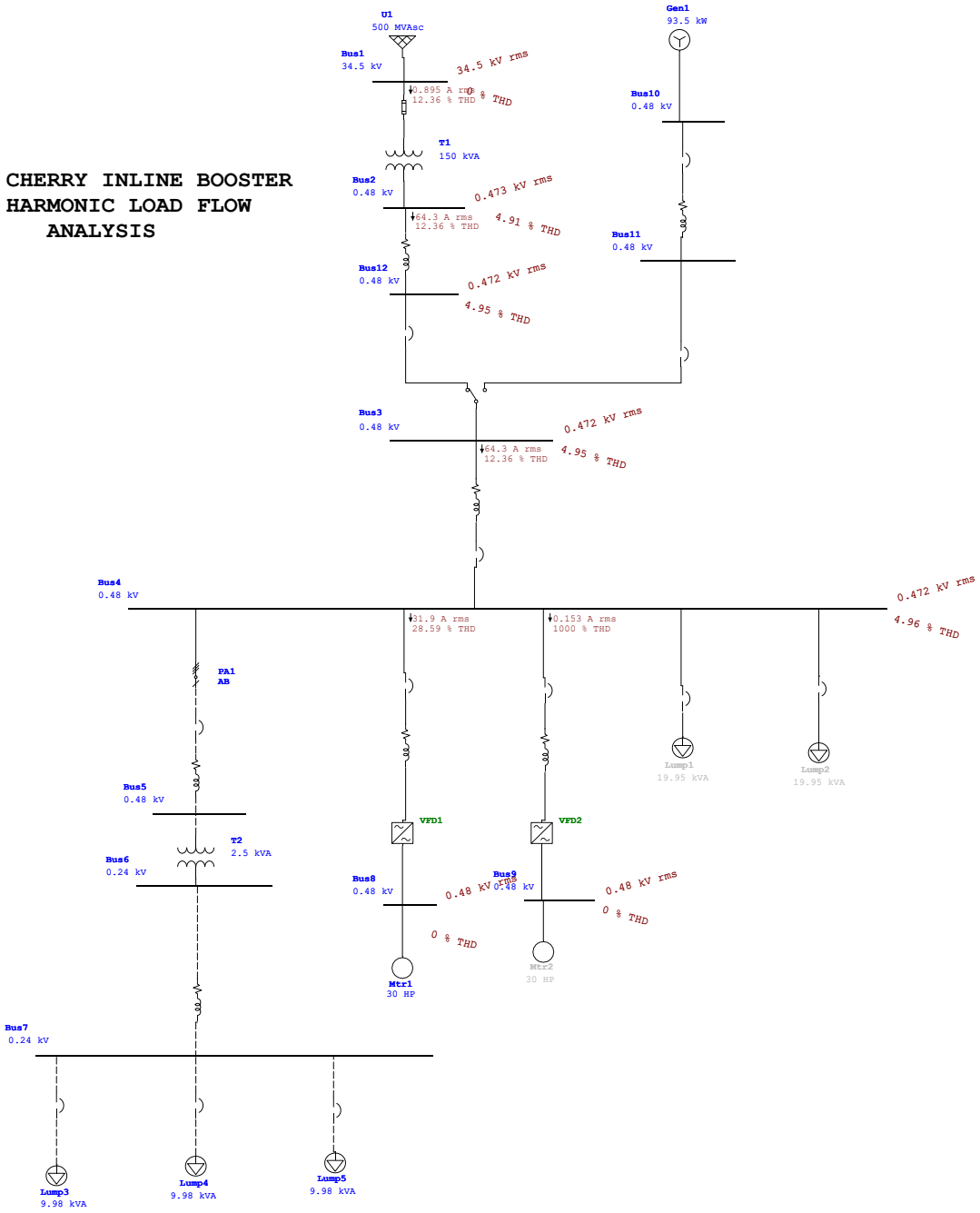


Figure 1.13: Load flow

during the course of measurement for the station.

1.8.1 Objectives and expected outcomes

The preliminary objectives and expected outcomes from this analysis are

- Record the voltage and current profile on the load side of Circuit Breaker with the recording interval set every five (10) minutes;
- Record power profile (KW, KVA, KVAR) on the load side of Circuit Breaker with the recording interval set every ten (10) minutes.
- Record Total Harmonic Distortion (THD);

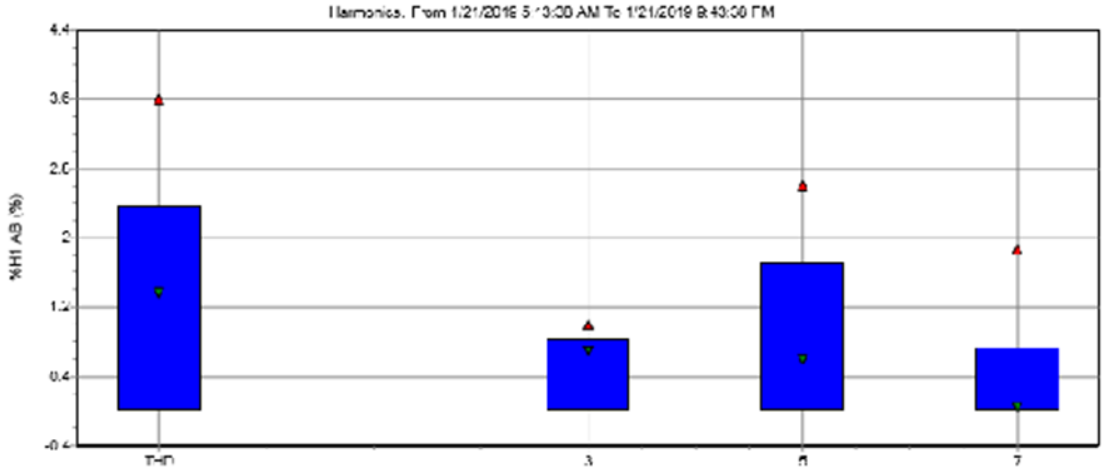


Figure 1.14: Voltage harmonic - AB

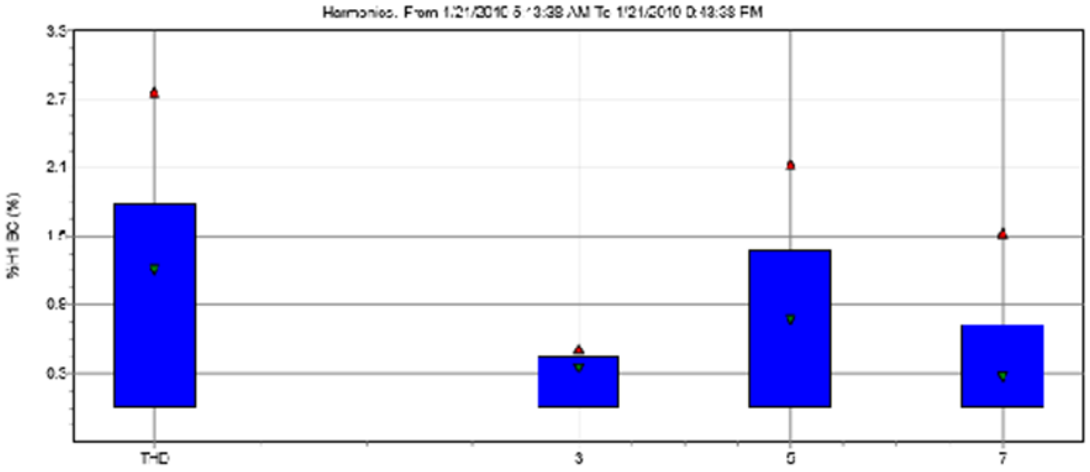


Figure 1.15: Voltage harmonic - BC

- Record Values of Short Duration Voltage Variation that will exceed the limit set by Philippine Distribution code;
- Record values of Long Duration Voltage Variation that will exceed the limit set by the Philippine Distribution Code;
- Record values of Frequency Variation that will exceed the limit set by Philippine Distribution code;
- Record Transient voltage Surge defined by PDC and using Computer Business Equipment Manufacturer's Association(CBEMA) and Information Technology Industry Council (ITIC) Curve International Standard;
- Compute for Voltage Unbalance and compare it on the Voltage unbalance limit set by PDC;
- Recommendations.

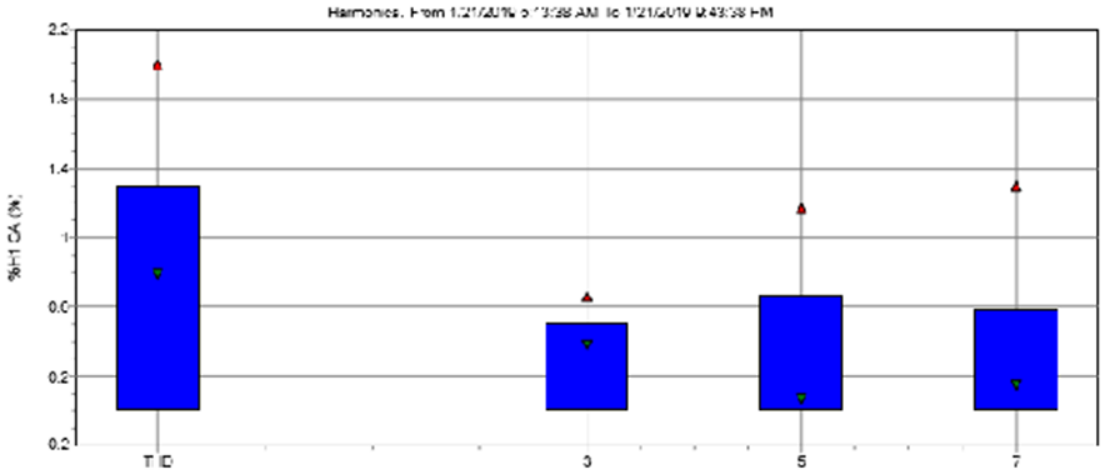


Figure 1.16: Voltage harmonic - CA

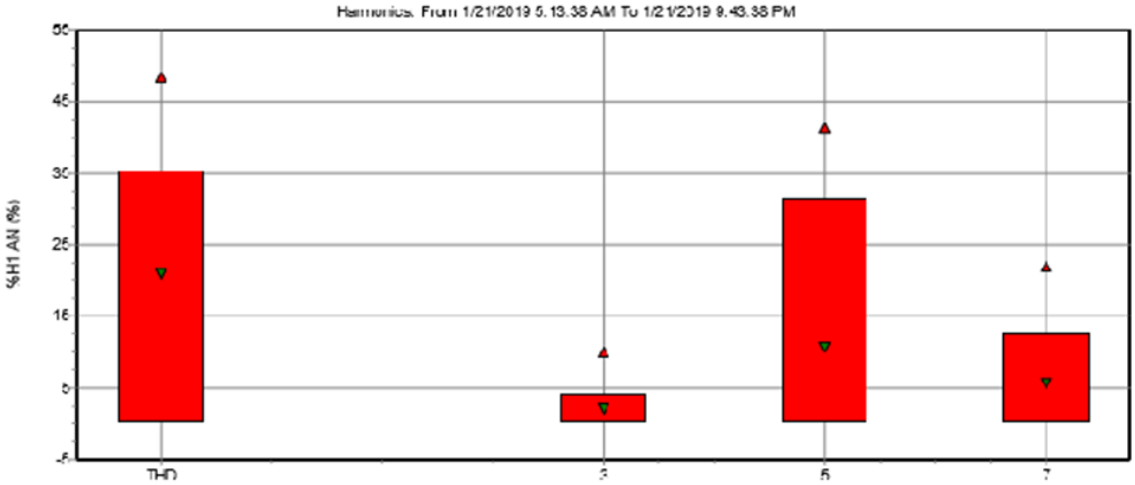


Figure 1.17: Current harmonic -AB

1.8.2 Basic

The assessments made in this report are in accordance to IEEE Standard 1159-1995 "IEEE Recommended Practice for Monitoring Electric Power Quality".

The Philippine Distribution Code was used as the local reference for power quality standards. According to the Philippine Distribution Code, a power quality problem exists when at least one of the categories in the tables of following sections is present during the normal operation of the electrical system

1.8.3 Results

Any values outside these limits are noted in the report. Values within the limits are considered to be within safe operating range.

1.8.3.1 RMS Voltage compliance

The steady-state rms voltage must remain within the range of 90.00% to 110.00%.

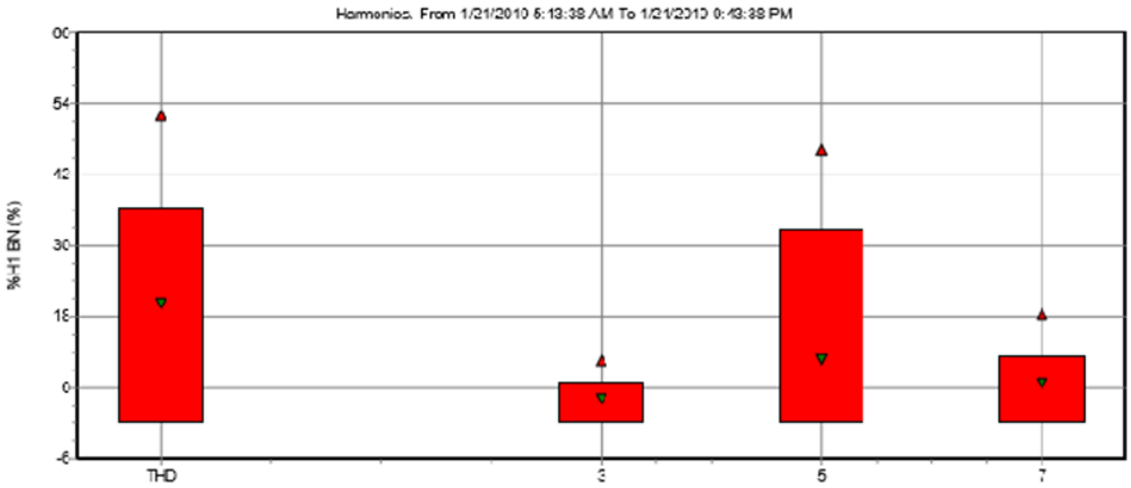


Figure 1.18: Current harmonic -BC

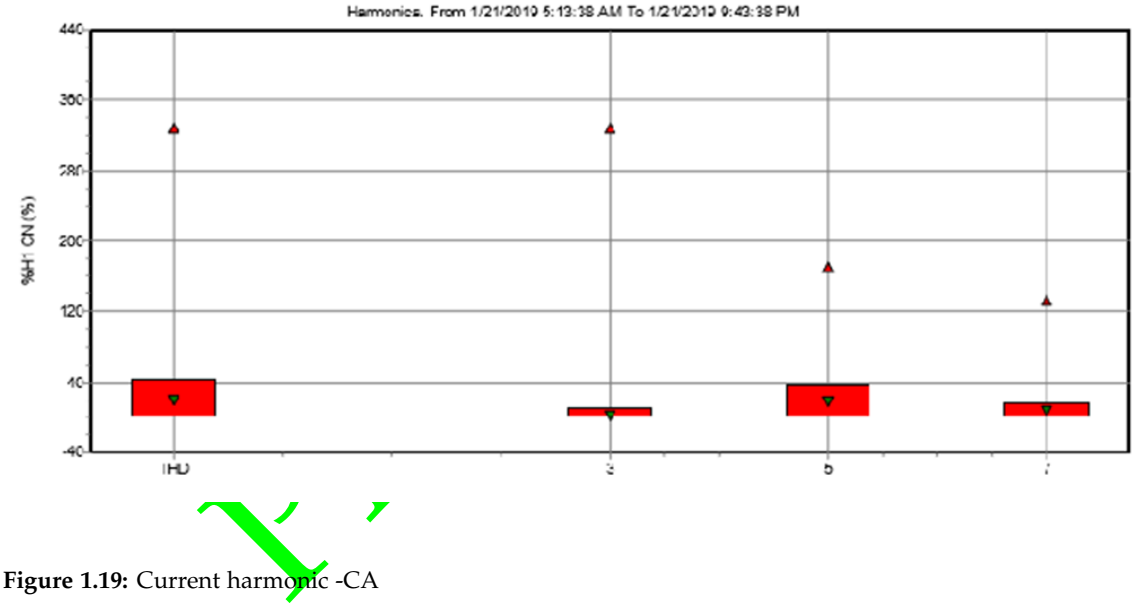


Figure 1.19: Current harmonic -CA

- Over Voltage – if the RMS value of the voltage is greater than or equal to 110% of the nominal value
- Under Voltage – if the RMS value of the voltage is less than or equal to 90% of the nominal voltage

Results are shown in Table 1.14.

1.8.3.2 Voltage unbalance compliance

Voltage Unbalance shall be defined as the maximum deviation from the average of the three phase voltages divided by the average of the three phase voltages expressed in percent. The maximum voltage unbalance at the connection point of any user, excluding the voltage unbalance passed on from the grid shall not exceed 2.5% during normal operating conditions.

Results are shown in Table 1.15.

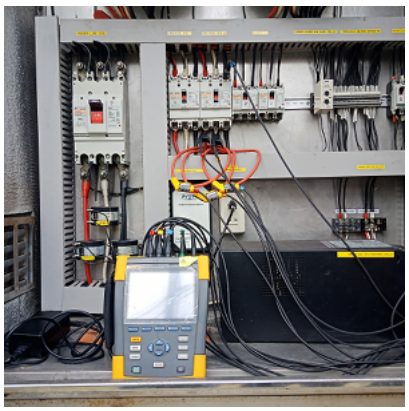


Figure 1.20: Power quality analyzer plugging during measurement

Table 1.14: Power quality - RMS Voltage compliance

RMS VOLTAGE (460 VOLTS)	Phase	Minimum	Average	Maximum	Limits	Remarks
Main 250A (Load side)	AB	449.94	465.3	474.84	±10% (414-506V)	Within Limits
	BC	457.72	471.4	477.32		
	CA	449.94	465.3	474.84		
VFD-1	AB	449.68	460.18	474.76	±10% (414-506V)	Outside Limits
	BC	387.66*	408.04	468.34		
	CA	449.68	460.18	474.76		
VFD-2	AB	455.48	466.18	474.70	±10% (414-506V)	Within Limits
	BC	463.28	470.61	477.76		
	CA	455.48	466.18	474.70		

* Should be cause for concern. Value reached voltage limitation. The incident was recorded on 1/21/2019, 8:214:31PM

Table 1.15: Power quality -Voltage unbalance

Voltage unbalance	Phase	Minimum	Average	Maximum	Limits (%)	Remarks
Main 250A (Load side)		1.15	0.87	0.35	2.5	Within Limits
VFD-1		9.64	7.85	0.91	2.5	Outside limits
VFD-2		1.14	0.63	0.43	2.5	Within Limits

1.8.3.3 Current unbalance compliance

Results are shown in Table 1.16 with note that the current unbalance should not exceed 10%.

Table 1.16: Power quality -Current unbalance

Current unbalance	Phase	Minimum	Average	Maximum	Limits (%)	Remarks
Main 250A (Load side)	AB	0.30	0.70	2.30	$\leq$ 10%	Within Limits
	BC	0.40	0.70	0.80		
	CA	0.10	0.50	1.50		
	Overall	1.15	1.20	2.68		
VFD-1	AB	1.33	1.60	2.57	$\leq$ 10%	Outside Limits
	BC	-0.27	-0.70	-0.73		
	CA	-1.07	-0.90	-1.83		
	Overall	3.40	3.88	4.60		
VFD-2	AB	0.50	-0.23	0.90	$\leq$ 10%	Within Limits
	BC	-0.20	-0.23	-0.30		
	CA	-0.30	-0.33	-0.60		
	Overall	2.18	1.36	2.83		

1.8.3.4 Harmonic - THD compliance

Results are shown in Table 1.17 with the following notes:

- Harmonics shall be defined as sinusoidal voltage and currents having frequencies that are integral multiples of the fundamental frequency;
- The total harmonic distortion (THD) shall be defined as the ratio of the RMS value of the harmonic content to the RMS value of the fundamental quantity, expressed in percent;
- PHILIPPINE DISTRIBUTION CODE sets the THD of the voltage at any user system to not exceed five percent (5%) during normal operating conditions.

Table 1.17: Power quality -Harmonic THD compliance

THD compliance	Phase	Minimum	Average	Maximum	Limits (%)	Remarks
Main 250A (Load side)	AB	1.44	3.36	3.90		
	BC	1.27	2.56	2.86	$\leq$ 5%	Within Limits
	CA	1.53	3.36	3.90		*
VFD-1	AB	3.22	3.36	3.90		
	BC	2.89	3.01	3.37	$\leq$ 5%	Within Limits
	CA	3.22	3.36	3.90		*
VFD-2	AB	2.11	2.20	2.68		
	BC	1.63	1.68	1.97	$\leq$ 5%	Within Limits
	CA	2.11	2.20	2.68		*

* Probable problem as the harmonic at 3rd, 5th, and 7th orders were register dominent. This might cause heating on equipment

1.8.3.5 Harmonic - TDD compliance

Results are shown in Table 1.18 with the following notes:

- The Total Demand Distortion (TDD) shall be defined as the ratio of the RMS value of the harmonic content to the RMS value of the rated or maximum fundamental quantity, expressed in percent;
- PHILIPPINE DISTRIBUTION CODE sets the TDD of the current at any user of the system to not exceed five percent (5%) during normal operating conditions.

It is important to note that the values obtained for the THD (refer to previous sections) might declare the parameter values within the limits. However, the overall conclusion shall be derived together with the TDD compliance as the values of the TDD coming from the asset while the THD values coming normally from the sources.

Table 1.18: Power quality -Harmonic TDD compliance

TDD compliance	Phase	Minimum	Average	Maximum	Limits (%)	Remarks
Main 250A (Load side)	AB	4.98	15.38	39.19		
	BC	5.24	15.77	41.65	$\leq$ 5%	Outside limits
	CA	4.94	15.38	194.09		
VFD-1	AB	2.42	15.14	45.33		
	BC	2.51	15.65	46.45	$\leq$ 5%	Outside limits
	CA	2.30	15.12	193.54		
VFD-2	AB	17.88	19.76	46.72		
	BC	18.62	20.69	45.28	$\leq$ 5%	Outside limits
	CA	18.36	20.59	73.81		

In this situation, results of TDD are significant higher than the limit of 5%, indicating a certain degree of probability that there is an existing issue.

1.8.3.6 100% Power frequency (HZ) compliance

Results are shown in Table 1.19 with the following notes:

- A nominal fundamental frequency of 60HZ, PHILIPPINE DISTRIBUTION COCE set an acceptable limit of 59.7 HZ. for low frequency and 60.3 hz for high frequency.

Table 1.19: Power quality -Harmonic TDD compliance

Frequency	Phase	Minimum HZ	Average HZ	Maximum HZ	Limits HZ	Remarks
Main 250A (Load side)		59.71	60.07	60.30	59.7-60.3	Within Limits
VFD-1		59.71	60.10	60.30	59.7-60.3	Within Limits
VFD-2		59.68	60.06	60.30	59.7-60.3	Within Limits

1.8.3.7 Power factor

Results are shown in Table 1.20 with the following notes:

- The ideal situation is a cos phi or DPF equal or close to 1. Utilities may charge additional cost (penalty when var readings are high because they need to provide apparent power (VA, kVA) that does not include both var and W).

Table 1.20: Power quality -powerfactor

Power factor	Phase	Minimum	Average	Maximum	Limits	Remarks
Main 250A (Load side)		0.86	0.92	0.93	>0.85	Within Limits
VFD-1		0.75	0.89	0.90	>0.85	Outside limits
VFD-2		0.21	0.92	0.92	>0.85	Outside limits

1.8.3.8 Flicker

Results are shown in Table 1.21 with the following notes:

- A measuring period of 2 hours (Plt) is useful when there may be more than one interference source with irregular working cycles and for equipment such as welding machines. Plt $\leq$ 1.0 is the limit used in standards like EN15160;
- The 10 min (Pst) uses a longer measuring period to eliminate the influence of random voltage variations.

Table 1.21: Power quality -powerfactor

Flicker	Parameter	Minimum	Average	Maximum	Limits	Remarks
Main 250A (Load side)	Plt	0.194	0.192	0.183	<=0.80	Within Limits
	Pst	0.262	0.261	0.237	<=1.0	Within Limits
VFD-1	Plt	0.257	0.711	1.829	<=0.80	Outside limits
	Pst	0.365	1.62	4.186	<=1.0	Outside limits
VFD-2	Plt	0.202	0.185	0.195	<=0.80	Within Limits
	Pst	0.239	0.234	0.325	<=1.0	Within Limits

1.8.4 Conclusion and Recommendations

- In general the most efficient way to troubleshoot electrical systems, is to begin at the load and work towards the building's service entrance. Measurements are taken along the way to isolate faulty components or loads;
- Monitoring up to a period of one week is recommended to perform a quality check That allows you to obtain a good impression of power quality;

- According to IEEE 519. "Most motor loads are relatively tolerant of harmonics". However, IEEE 519-1992 states further that, "Even in the case of the least susceptible equipment, harmonics can be harmful. Harmonics, can cause dielectric thermal or voltage stress, which causes premature aging of electrical insulation. A major effect of harmonic voltages and currents in rotating machinery (induction and synchronous) is increased heating due to iron and copper losses at the harmonic frequencies. The harmonic components thus affect the machine efficiency, and can also affect the torque developed";
- In the case of this station, the total demand distortion is outside the limits set in the Philippine Distribution Code. From the application perspective, we're most concerned with the maximum harmonic current levels, and the impact they have on the distribution system. This makes TDD a much more useful metric for power inverter distortion;
- Voltage unbalance causes high unbalanced currents in stator windings resulting in overheating and reduced motor life. As in the case of VFD1, voltage deviation which is outside limit were recorded. Check cause of voltage unbalance which is often caused by current unbalance;
- Crest Factor – A high crest factor value for current was recorded to signify a distorted current waveform. A CF of 1.8 or higher means high waveform distortion. This can be attributed on the current drawn by the rectifier;

Main	VOLTAGE		CURRENT	
Phase	MIN	MAX	MIN	MAX
A	1.41	1.44	1.42	3.27
B	1.41	1.43	1.39	2.87
C	1.41	1.43	1.4	7.22

- Since a filter is already in place (73A VLT, Advance Harmonic Filter AHF005) when the measurements were taken and current harmonics is still high, consider a one week monitoring to validate the values. A second filter may be considered to properly address the 3rd, 5th and 7th harmonics. An active filter (cancellation of all harmonics) can be considered altogether.

1.9 Grounding system study

The study has been conducted in accordance with the ITP. Some of representative pictures during measurement are shown in Figure 1.21.

Results of the study are shown in Table 1.22 with the following note:

- The resistance between the main grounding electrode and ground should be no greater than five ohms for large commercial or industrial systems and 1.0 ohm or less for generating or transmission station grounds unless otherwise specified by the owner. (Reference ANSI/IEEE Standard 142)

1.10 Electrical system design and analysis

1.10.1 Basics

In accordance with Article 1.3 Electrical Plans and specifications of the Philippine Electrical Code 2017 Edition, Electrical design analysis shall be included and submitted separately together with the electrical plans. These includes the followings:

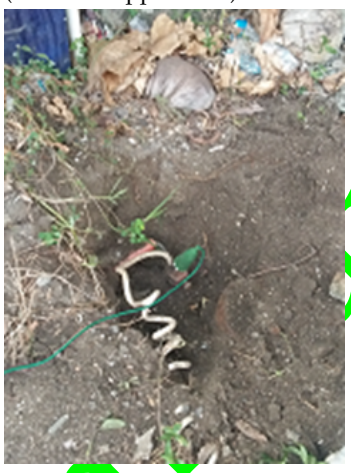
1. Branch circuits, sub-feeders, feeders, busways, and service entrance;
2. Types, ratings, and trip settings of overload protective device;
3. Calculation of voltage drops;

(a - Voltage -LA post)

(b - Bare copper wire)

(c - Ground resistance measure)

(d - Voltage measure - MTS)



(e - Ground pod connection)

(f - Voltage on BCW)

(g - Voltage on rod)

Figure 1.21: Grounding system measurement

4. Calculation of short circuit current for determining the interrupting capacity of overcurrent protective device for residential, commercial and industrial establishment;
5. Protection coordination of overcurrent protective devices;
6. ARC-flash Hazard Analysis to determine the required personal protective equipment (PPE).

ARC flash Hazard Analysis is required and is intended for concerned parties to be informed and made aware of the importance of personal protective equipment (PPE) and its type for the

Table 1.22: Ground system measurement results

Locations	Asset/Room	Resistance	Findings	Recommendations	Effects	Risks
Lightning Arrester Post	Test Point 1 Bare Copper Wire	1.24 Ω	Within The 5 Ω Limit As Per Nfpa And Ieee Standards	(1)Check Tightness Of Connection Of Bcw To Ground Rod (2) Grounding System Electrical And Mechanical Connections Should Be Free Of Corrosion. (3) Replace Bcw For Better Conductivity.	None	None
Mts Equipment Ground	Test Point 2 Bare Copper Wire	7.2 V	Measured Voltage In The Bare Copper Wire	Check And Trace Where The Voltage Is Coming From And Correct The Connection	Danger To Personnel And Damage To Equipment If Not Immediately Corrected	Health And Safety Risks For Facilities And Personnel And Damage To Equipment Or Accessories
Mts Equipment Ground	Test Point 2 Ground Rod	8.2 V	Same As Mts Equipment	Same As Mts Equipment	Same As Mts Equipment	Same As Mts Equipment
Genset	Test Point 3 Bare Copper Wire	NA	Connected To Grounding Busbar Of Mts	Same As Mts Equipment	(1) Unwanted Voltage Maybe Present On Non-Current Carrying Metal Objects (2) Equipment Might Be Damaged During A Fault Condition	(1) Incorrect Operation Of Overcurrent Device With Ground Fault Protection (2) Health And Safety Risks For Facilities And Personnel

flash hazard risk category determined by the analysis (refer to Table 1.23).

Table 1.23: ARC flash hazard risk categories and PPE ratings (Appendix H, PEC 2017)

Risk CAT.	Range of calculated incident energy [cal/cm^2]	Minimum Ppe Rating [Cal/Cm^2]	Clothing Required
0	0 < E ≤1.2	N/A	4.5-14.0 Oz/Yd2Untreated Cotton
1	1.2 < E ≤ 4	4	Flame Retardant (Fr) Shirt And Pants
2	4 < E ≤ 8	8	Cotton Underclothing Plus Fr Shirt And Pants
3	8 < E ≤ 25	25	Cotton Underclothing Plus Fr Shirt, Pants, Overalls Or Equivalent
4	25 < E ≤40	40	Cotton Underclothing Plus Fr Shirt, Pants, Plus Double Layer Switching Coat And Pants Or Equivalent
5	40 < E ≤ 100	100	Cotton Underclothing Plus Fr Shirt, Pants, Plus Multi-Layer Switching Suit Or Equivalent

1.10.2 Results

Results are briefly presented in the following subsections. Details reports generated by the software are enclosed as part of the Appendix of this report (can also be an electronic files)

1.10.2.1 Branch circuits, sub-feeders, feeders and service entrance

Figure 1.22 shows the SLD with values associated with each nodes and links.

1.10.2.2 Types, ratings, and trip settings of overload protective device

Types, ratings, and trip settings of overload protective devices are shown in Table 1.24

1.10.2.3 Calculation of voltage drops

1.10.2.4 Calculation of short circuit current 3-PHASE & 1-PHASE

Table 1.26 and Table 1.27 show summaries of results on short circuit and monentary duty, respectively.

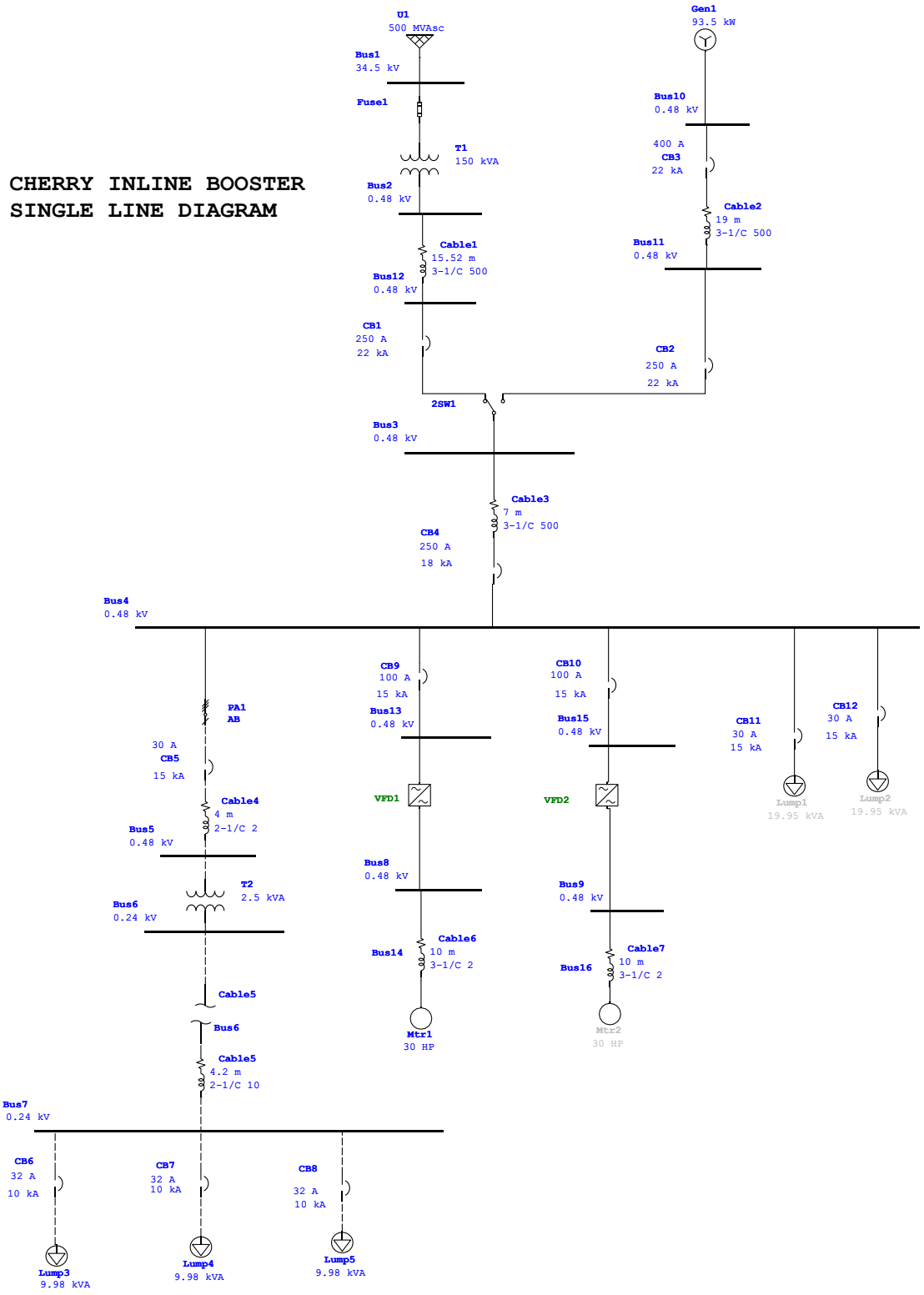


Figure 1.22: Single line diagram

1.10.2.5 Protection coordination of overcurrent protective devices

Results of study on protection coordination are presented in subsection 1.6. With reference to the coordination plot shown in Figure 1.10, it is remarked that partial coordination only for the main and feeder breakers. TCC of feeders crosses the TCC of enclosed circuit breaker upstream of the feeders.

Table 1.24: Protective Device Settings - Low Voltage Circuit Breaker with Thermal-Magnetic Trip Device

LVCB ID	Manufacturer	Breaker		Thermal		Magnetic (Inst.)	
		Model	Size	Setting	Trip (Amps)	Setting	Trip (Amps)
CB4	Fuji Electric	BW400EAG	250	Fixed	250	Fixed	8 xIn
CB9	Fuji Electric	BW125JAG	100	Fixed	100	Fixed	8 xIn
CB10	Fuji Electric	BW125JAG	100	Fixed	100	Fixed	8 xIn
CB11	Fuji Electric	BW32SAG	32	Fixed	32	Fixed	8 xIn
CB12	Fuji Electric	BW32SAG	32	Fixed	32	Fixed	8 xIn
CB1	Fuji Electric	BW400EAG	250	Fixed	250	Fixed	8 xIn

Table 1.25: Voltage drop summary

Item	From	To	Wire Size, Mm^2	I	Length Meters	R Ω/305M	X Ω/ 305M	Vd	%Vd	Remarks
1	Pole Mounted Transformer 50Kva,3Φ	Ats Panel	250	425	15.52	0.048	0.027	2.06	0.43	Within Limts
2	Mts Panel	Ecb 250A	250	425	7	0.048	0.027	0.929	0.19	Within Limts
3	Ecb 30A, 2P	Dry Type Transformer 2.5Kva	5.5	40	4.2	1.2	0.063	1.324	0.55	Within Limts
4	Dry Type Transformer 2.5Kva, 1Φ	Ups Panel	5.5	40	4	1.2	0.063	1.261	0.53	Within Limts
5	Mccb 100A, 3P	30Hp Motor	30	115	10	0.2	0.057	1.357	0.28	Within Limts
	Pole Mounted To 30 Hp Motor							3.417	0.71	Within Limits

Table 1.26: Momentary duty Summary

1/2 Cycle - 3-Phase, LG, LL, & LLG Fault Currents

Prefault Voltage = 100 % of the Bus Nominal Voltage

Bus		3-Phase Fault			Line-to-Ground Fault			Line-to-Line Fault			*Line-to-Line-to-Ground		
ID	kV	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.	Real	Imag.	Mag.
Bus1	34.500	0.695	-8.338	8.367	0.695	-8.338	8.367	7.221	0.602	7.246	6.874	4.771	8.367
Bus2	0.480	0.927	-2.299	2.479	0.000	0.000	0.000	1.991	0.803	2.147	1.991	0.803	2.147
Bus3	0.480	0.913	-2.239	2.418	0.000	0.000	0.000	1.939	0.791	2.094	1.939	0.791	2.094
Bus4	0.480	0.907	-2.212	2.391	0.000	0.000	0.000	1.916	0.786	2.071	1.916	0.786	2.071
Bus8	0.480	0.070	-0.125	0.143	0.083	-0.032	0.089	0.108	0.061	0.124	-0.136	-0.057	0.148
Bus9	0.480	0.040	0.000	0.040	0.040	0.000	0.040	0.000	0.035	0.035	-0.020	-0.035	0.040
Bus12	0.480	0.913	-2.239	2.418	0.000	0.000	0.000	1.939	0.791	2.094	1.939	0.791	2.094
Bus13	0.480	0.907	-2.212	2.391	0.000	0.000	0.000	1.916	0.786	2.071	1.916	0.786	2.071
Bus15	0.480	0.907	-2.212	2.391	0.000	0.000	0.000	1.916	0.786	2.071	1.916	0.786	2.071

All fault currents are symmetrical (1/2 Cycle network) values in rms kA.
* LLG fault current is the larger of the two faulted line currents.

1.10.2.6 Arc-flash Hazard Analysis

1.10.3 Recommendations

According to the results of the Arc Flash Analysis, Cotton underclothing plus FR shirt, pants, plus multi-layer switching suit or equivalent should be worn when opening the cover of the MCC. Arc flash Boundary (AFB) is about 30.6 feet (9.33 meters). Contributors to the arc flash are the motor loads and the VFD's.

An Arc flash label (refer to Figure 1.24) should be placed on the MCC as per requirement of the Philippine Electrical code.

Table 1.27: Momentary duty Summary

3-Phase & 1-Phase Fault Currents: (Prefault Voltage = 100 % of the Bus Nominal Voltage)

Bus		Device			Momentary Duty					Device Capability		
ID	kV	ID	Ckt #	Type	Symm. kA rms	X/R Ratio	M.F.	Asymm. kA rms	Asymm. kA Peak	Symm. kA rms	Asymm. kA rms	Asymm. kA Peak
Bus4	0.480	Bus4		Bus	2.391	2.4	1.073	2.567	4.314			
Bus5	0.480	Bus5		Bus	2.041	2.3	1.064	2.172	3.630			
Bus6	0.240	Bus6		Bus	0.411	1.0	1.001	0.412	0.604			
Bus7	0.240	Bus7		Bus	0.394	0.9	1.001	0.394	0.574			

Method:→IEEE - X/R is calculated from separate R & X networks.

Protective device duty is calculated based on total fault current

For 1-Phase 3-Wire systems (fed from center-tap transformers), the calculated momentary duty for panel's main and feeder protective devices are based on max. of 1-pole and 2-pole faults.

* Indicates a device with momentary duty exceeding the device capability•

Table 1.28: Incident Energy Summary

Bus			Total Fault Current (kA)		Arc-Flash Analysis Results			
ID	Nom. kV	Type	Bolted	Arcing	FCT (cycles)	Incident E (cal/cm²)	AFB (ft)	Energy Level
# Bus1	34.500	Open Air	8.367	8.367	6.000	17.683	11.54	Level D
Bus2	0.480	Open Air	2.479	1.711	6.000	0.426	0.89	Level A
Bus3	0.480	MCC	2.418	1.950	6.000	0.736	1.11	Level A
Bus4	0.480	MCC	2.391	1.642	1662.737	169.313	30.61	>Max.
# Bus8	0.480	MCC	0.143	0.143	6.000	0.017	0.18	Level A
# Bus9	0.480	MCC	0.040	0.040	6.000	0.005	0.09	Level A
Bus12	0.480	Switchboard	2.418	1.930	6.000	0.462	1.05	Level A
Bus13	0.480	MCC	2.391	1.932	6.000	0.728	1.11	Level A
# Bus14	0.480	Other	0.144	0.144				
Bus15	0.480	MCC	2.391	1.932	6.000	0.728	1.11	Level A
# Bus16	0.480	Other	0.040	0.040				

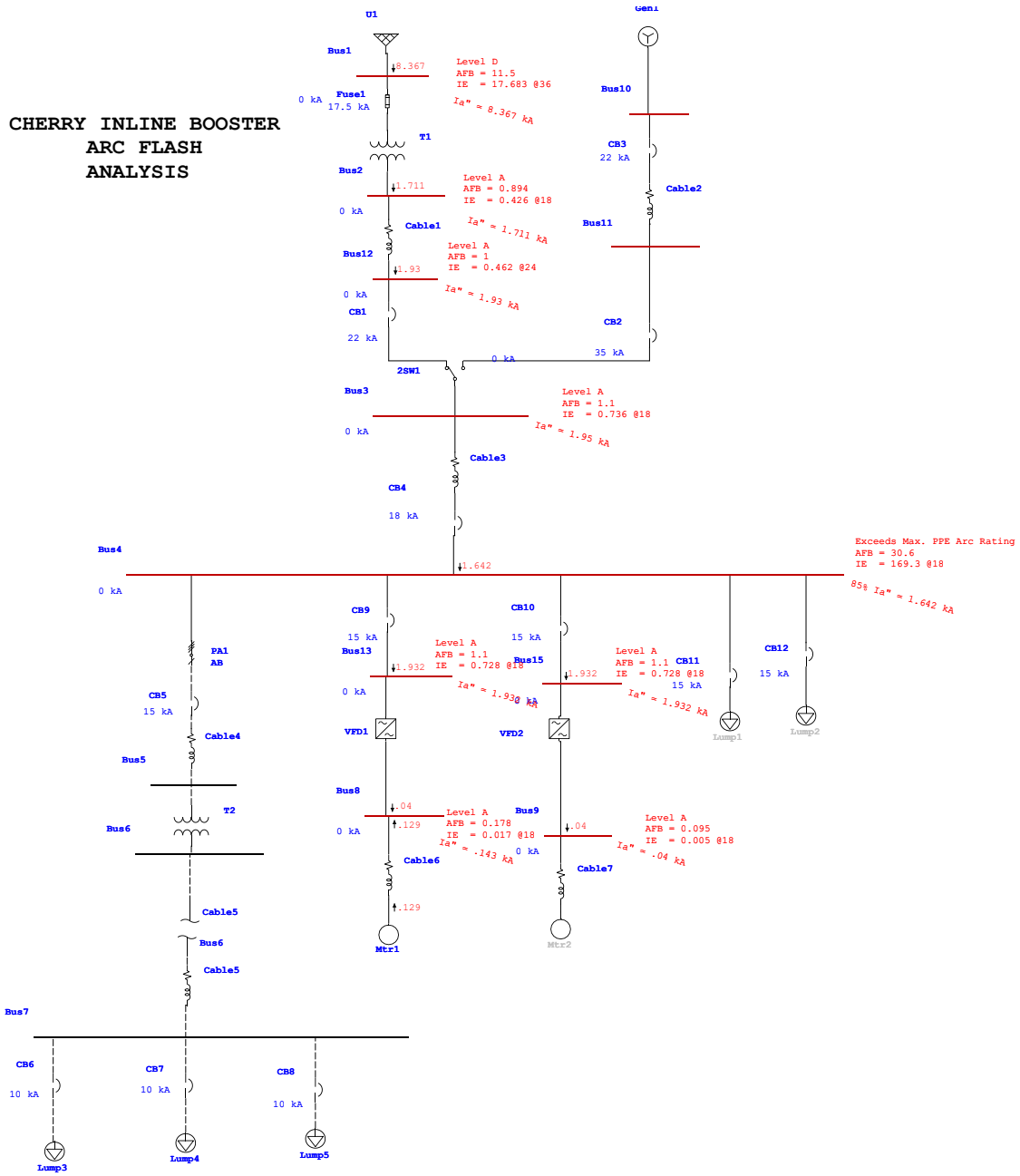


Figure 1.23: ARC flash analysis

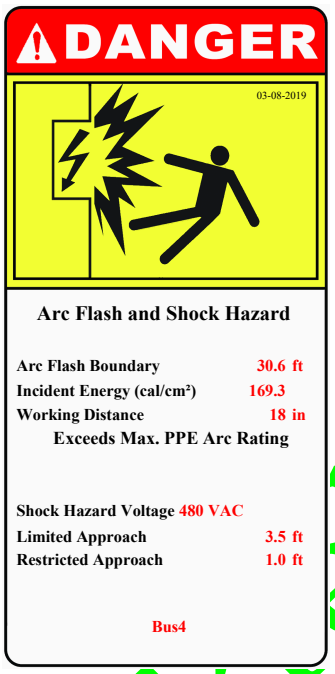


Figure 1.24: Cable waveform

Appendix A

Load Flow Analysis

Instrument Information

Model Number	435-II
Serial Number	41183106
Firmware Revision	V05.04

Software Information

Power Log Version	5.4
FLUKE 430-II DLL Version	1.2.0.13

General Information

Recording location	MAIN 250AMPS BREAKER
Client	MAYNILAD CHERRY IN LINE
Notes	Naval Base, Heracleo Alano Sangley Point Cavite City

Measurement Summary

Measurement topology	3-element delta mode
Application mode	Logger
First recording	1/21/2019 5:13:38 AM 688msec
Last recording	1/21/2019 9:43:38 PM 688msec
Recording interval	0h 10m 0s 0msec
Nominal Voltage	460 V
Nominal Current	250 A
Nominal Frequency	60 Hz
File start time	1/21/2019 5:03:38 AM 688msec
File end time	1/21/2019 9:43:38 PM 688msec
Duration	0d 16h 40m 0s 0msec
Number of events	Normal: 0 Detailed: 0
Events downloaded	No
Number of screens	1
Screens downloaded	Yes
Power measurement method	Unified
Cable type	Copper
Harmonic scale	%H1
THD mode	THD 40
CosPhi / DPF mode	DPF

Scaling

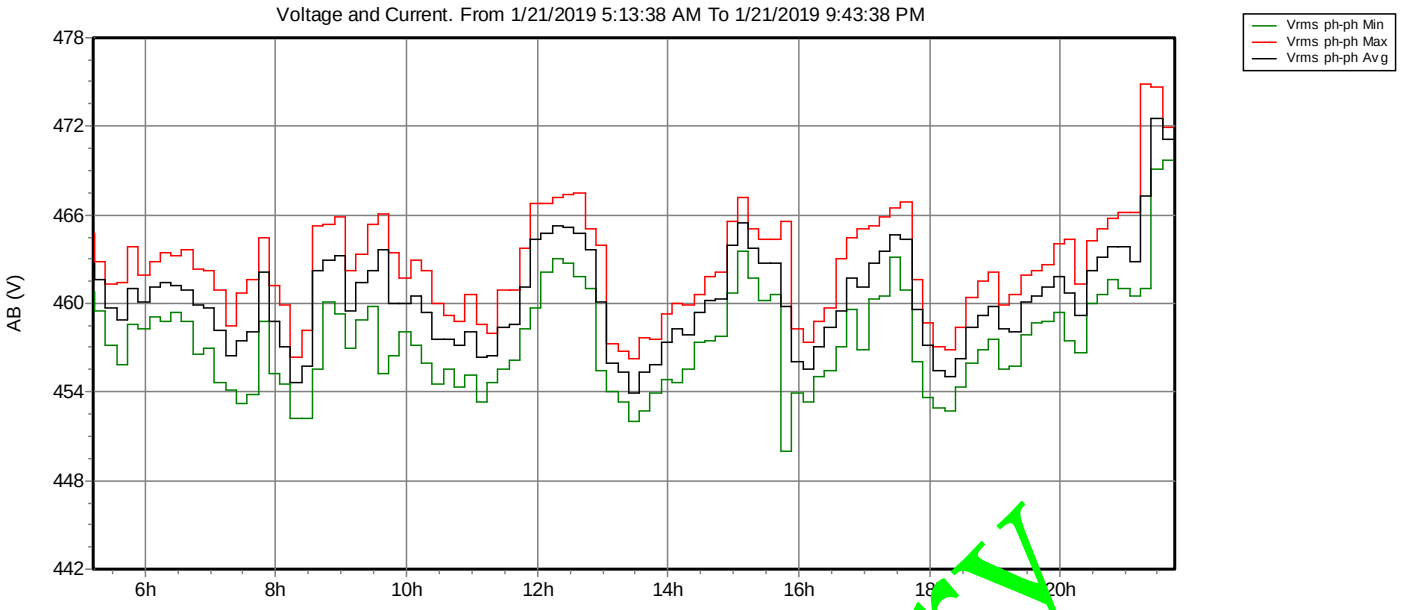
Phase:	
Current Clamp type	i430Flex
Clamp range	N/A
Nominal range	250 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1
Neutral:	
Current Clamp type	i430Flex
Clamp range	N/A
Nominal range	250 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1

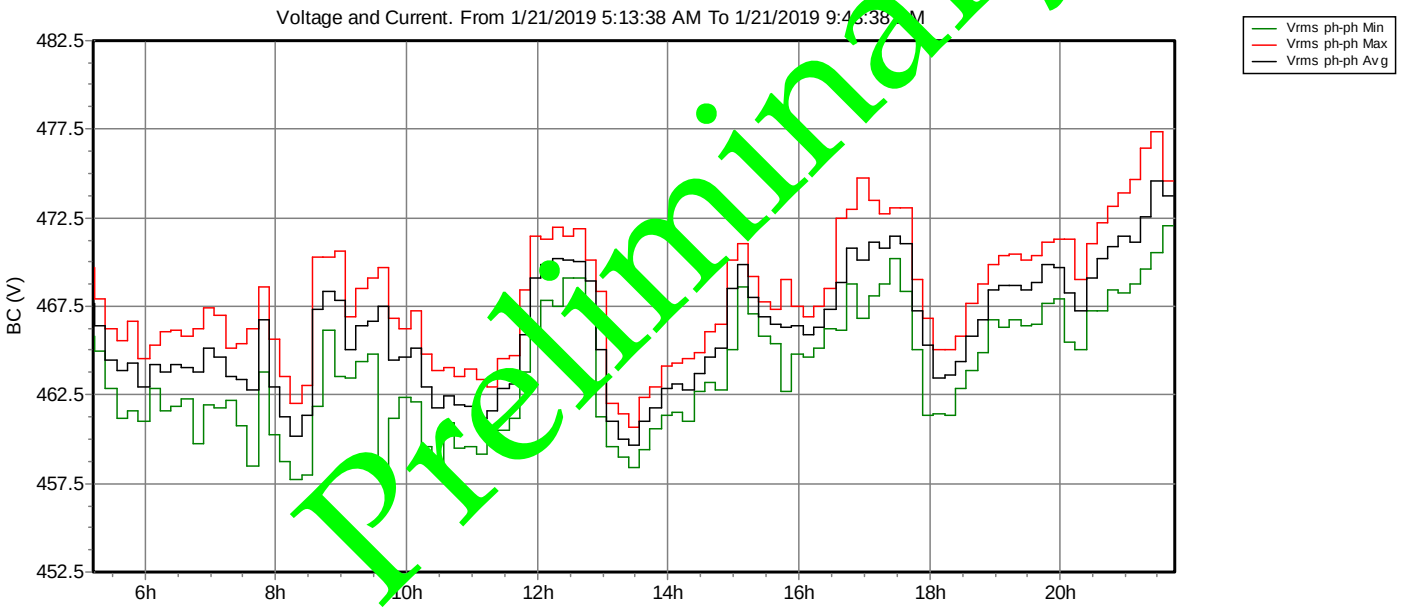
Recording Summary

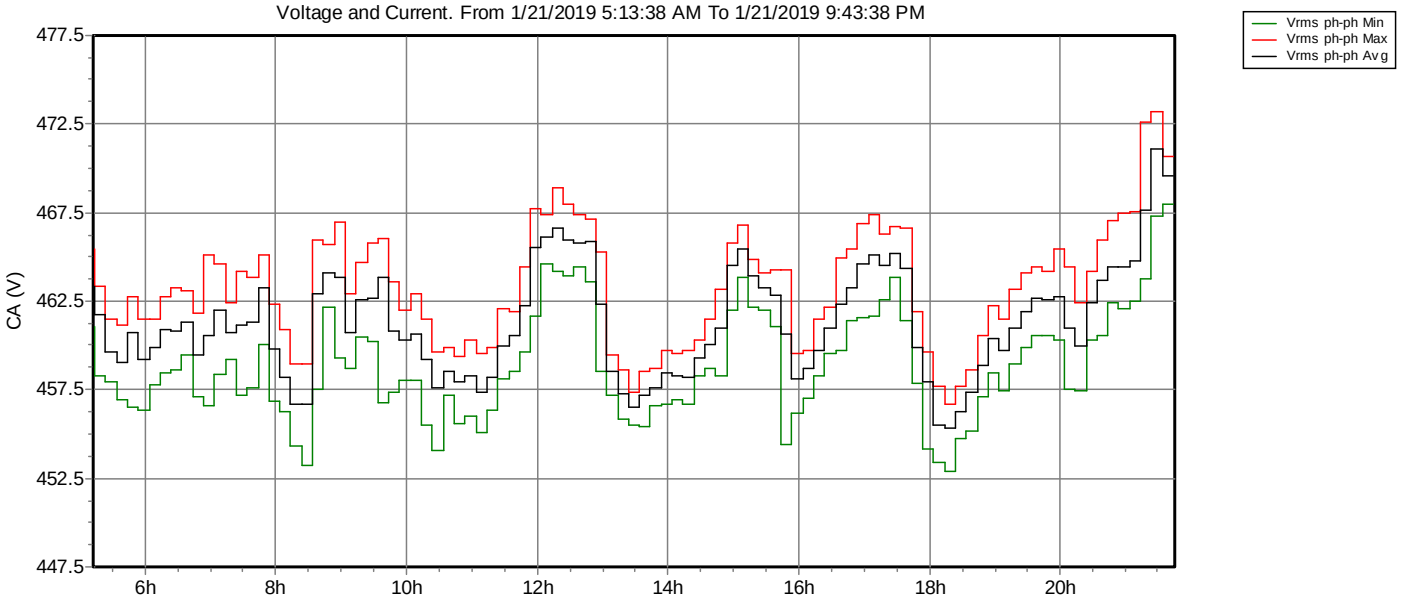
RMS recordings	100
DC recordings	0
Frequency recordings	100
Unbalance recordings	100
Harmonic recordings	100
Power harmonic recordings	100
Power recordings	100
Power unbalance recordings	0
Energy recordings	100
Energy losses recordings	0
Flicker recordings	100
Mains signaling recordings	100

Events Summary

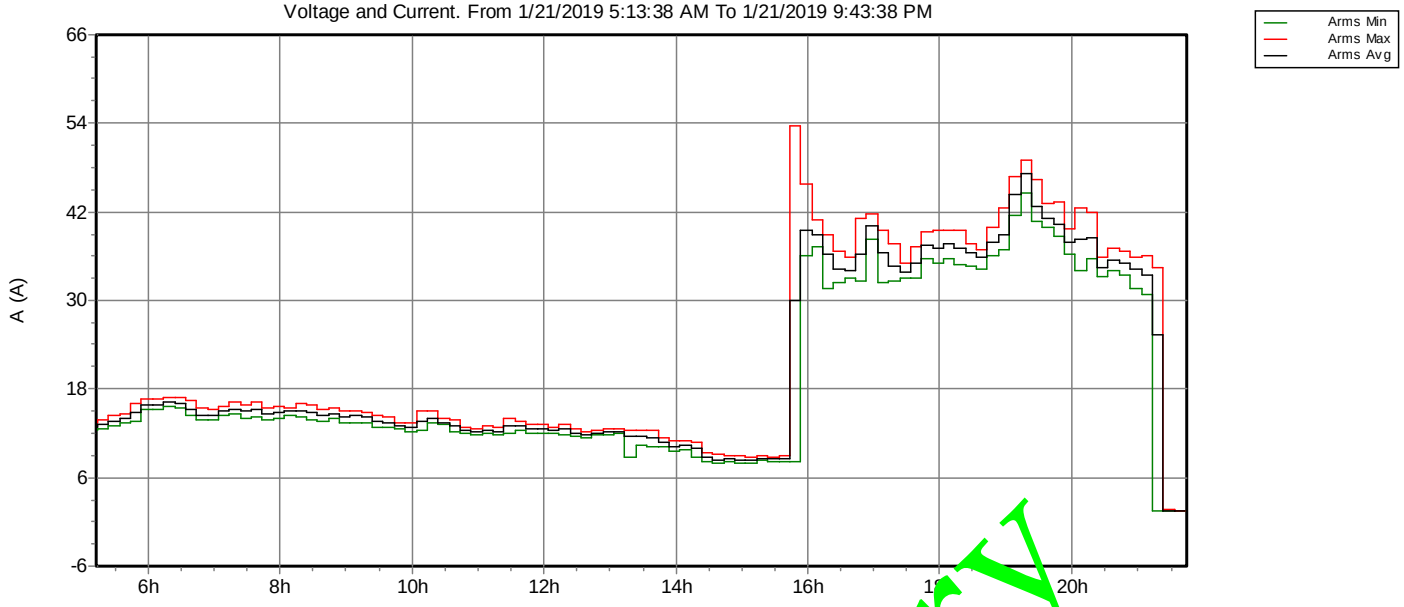
Dips	0
Swells	0
Transients	0
Interruptions	0
Voltage profiles	0
Rapid voltage changes	0
Screens	1
Waveforms	0
Intervals without measurements	0
Inrush current graphics	0
Wave events	0
RMS events	0



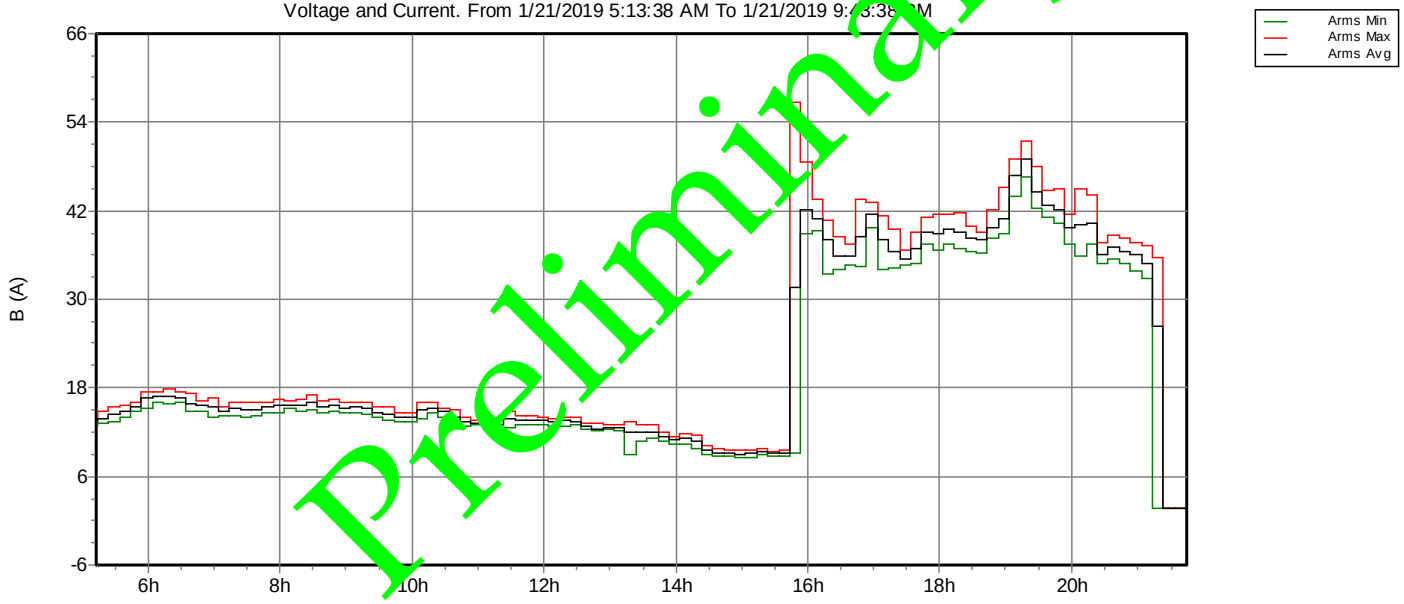




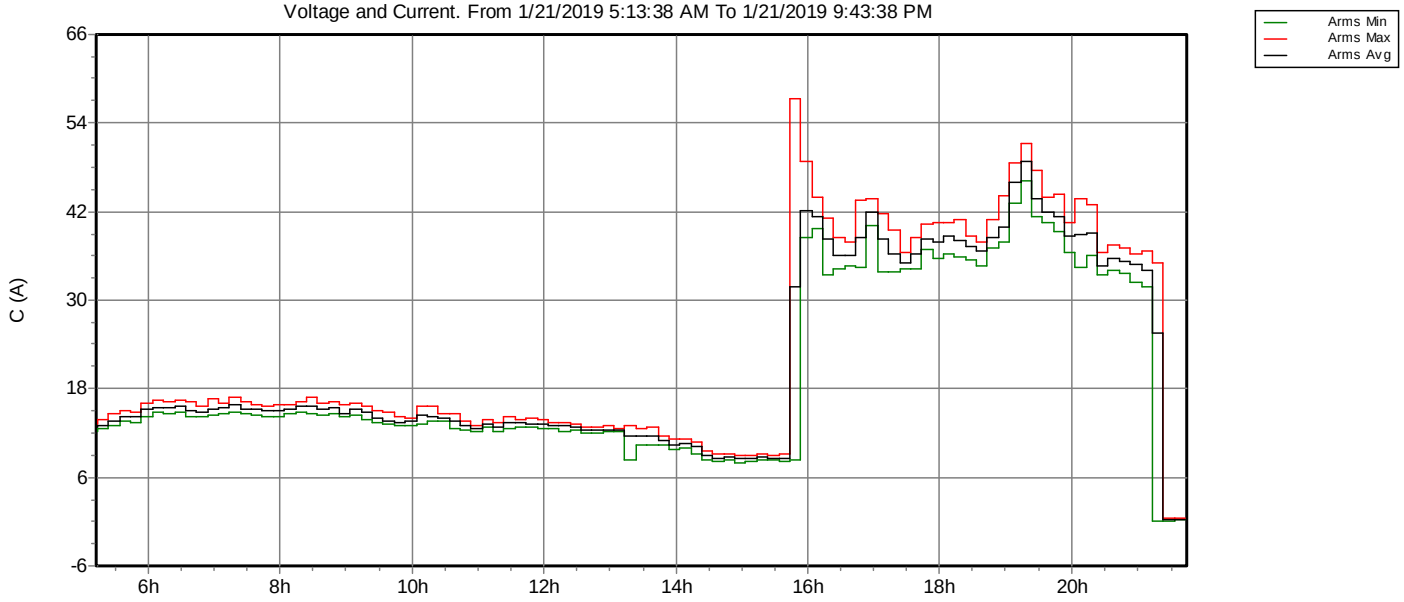
Voltage and Current. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



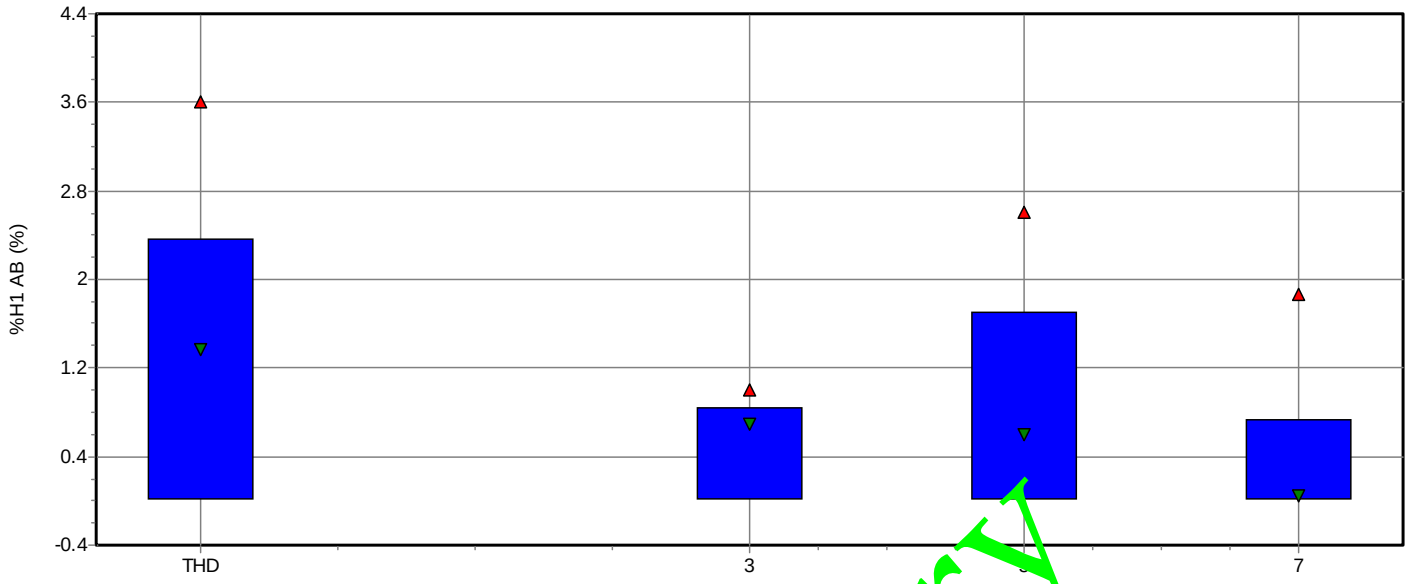
Voltage and Current. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



Voltage and Current. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



Harmonics. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



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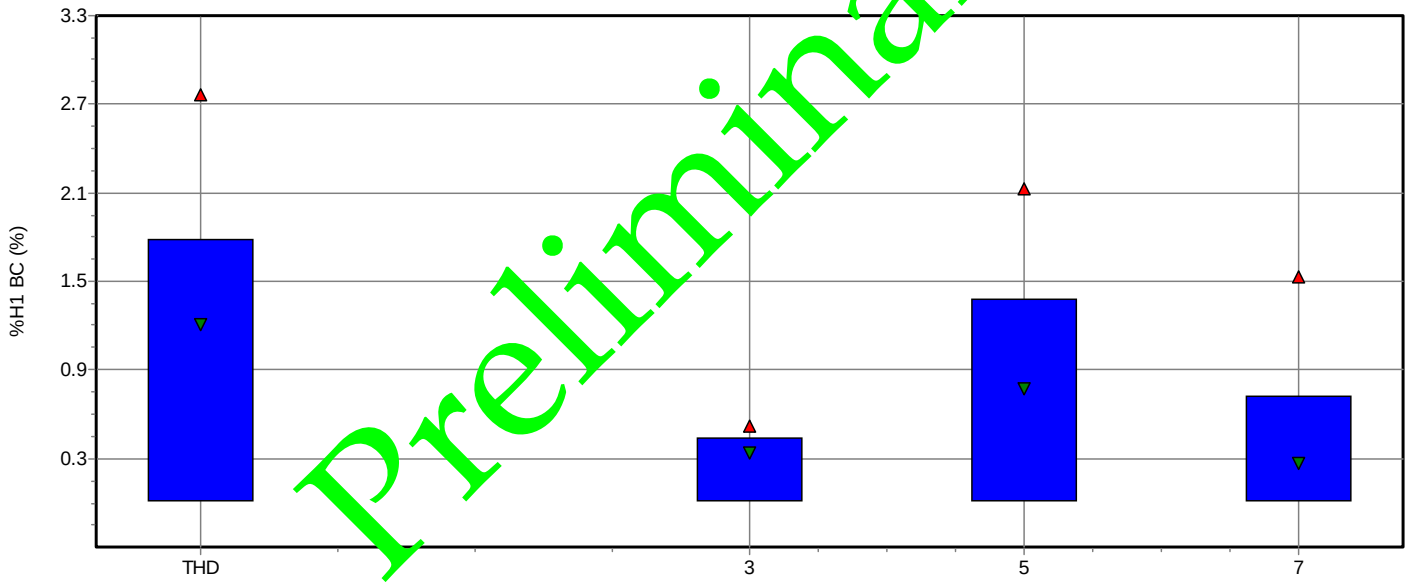

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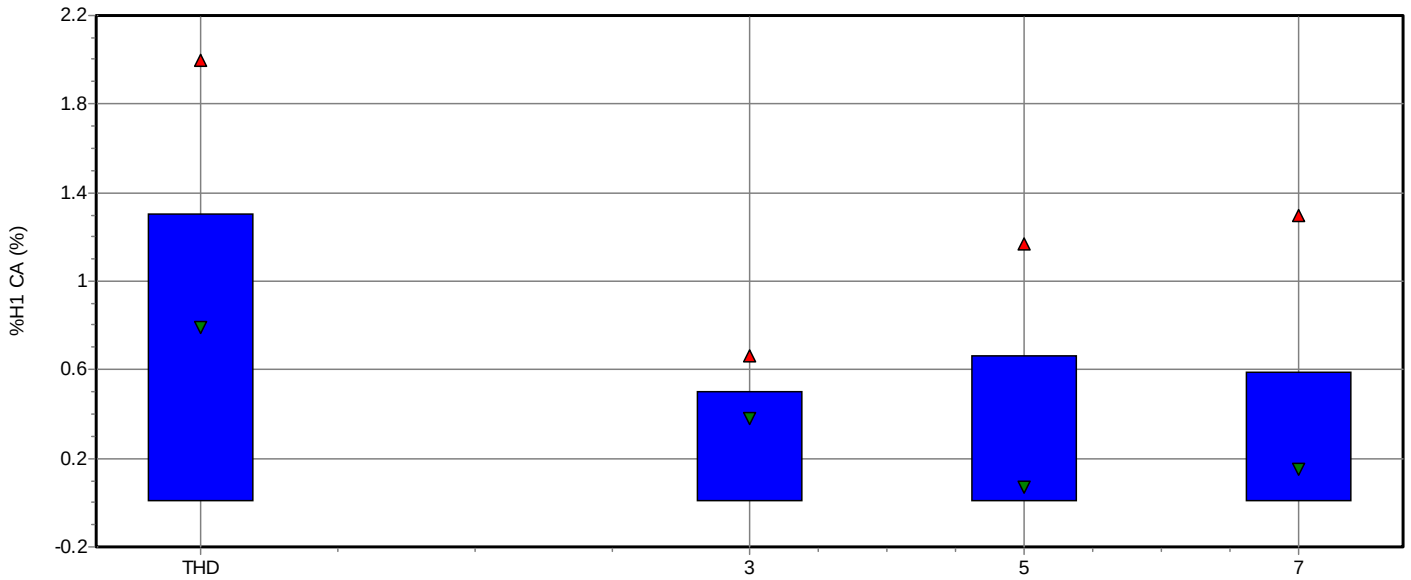

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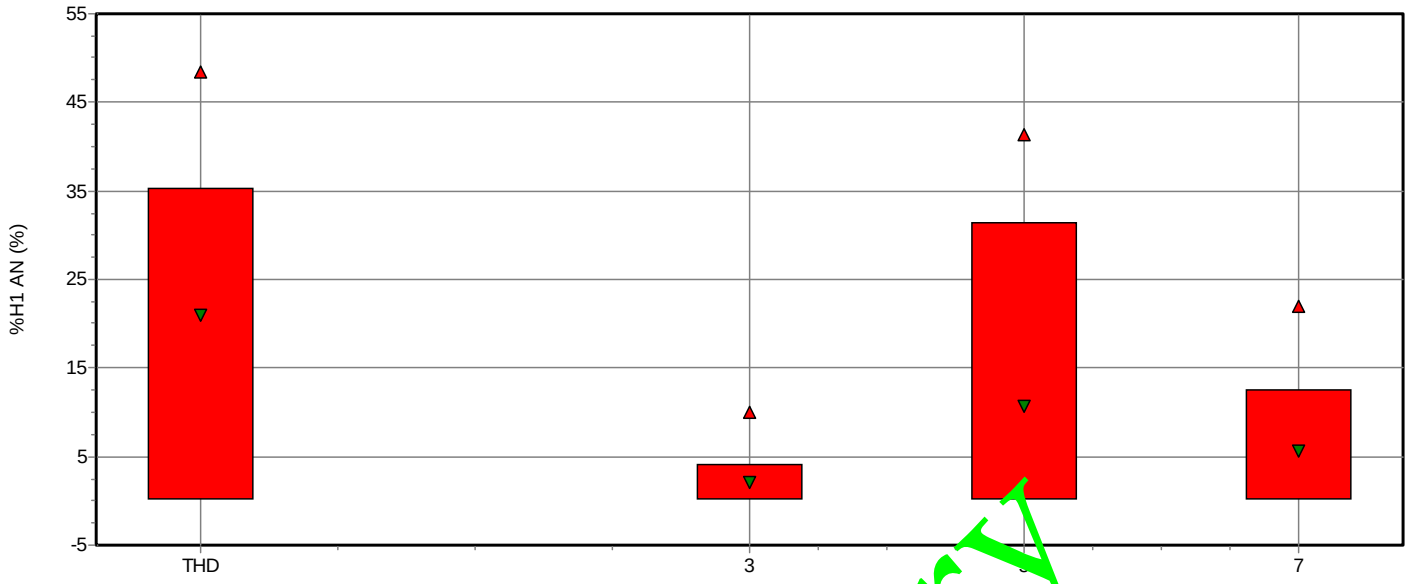

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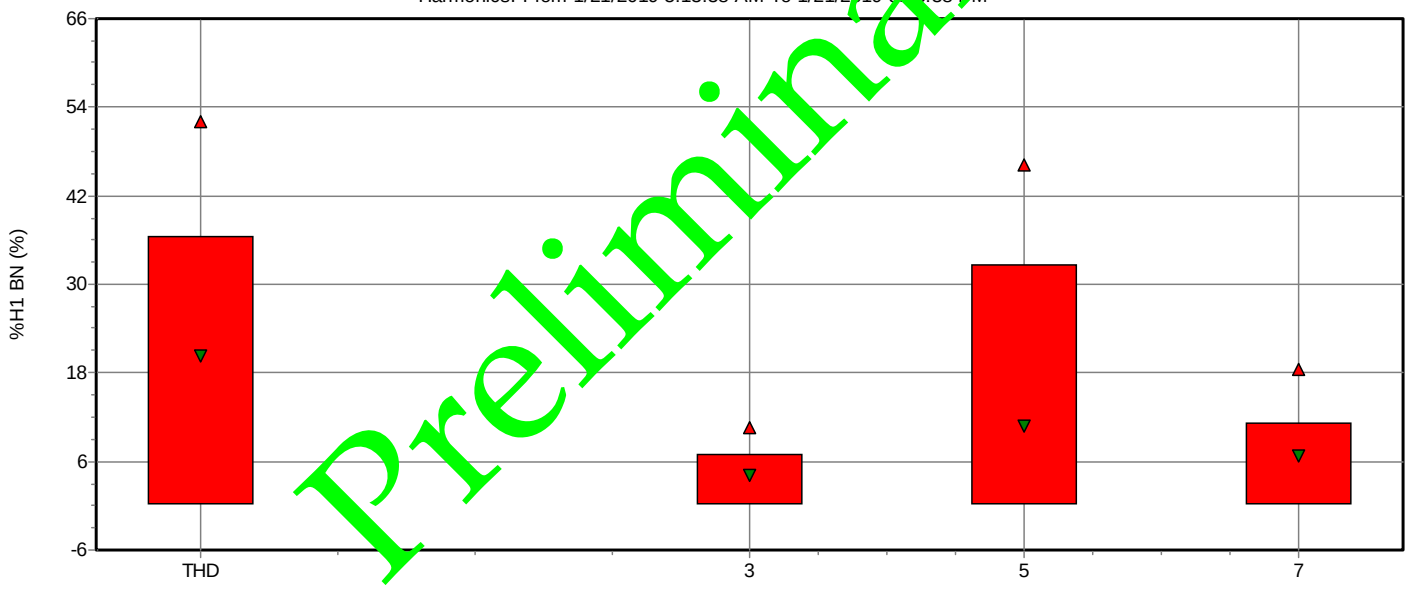
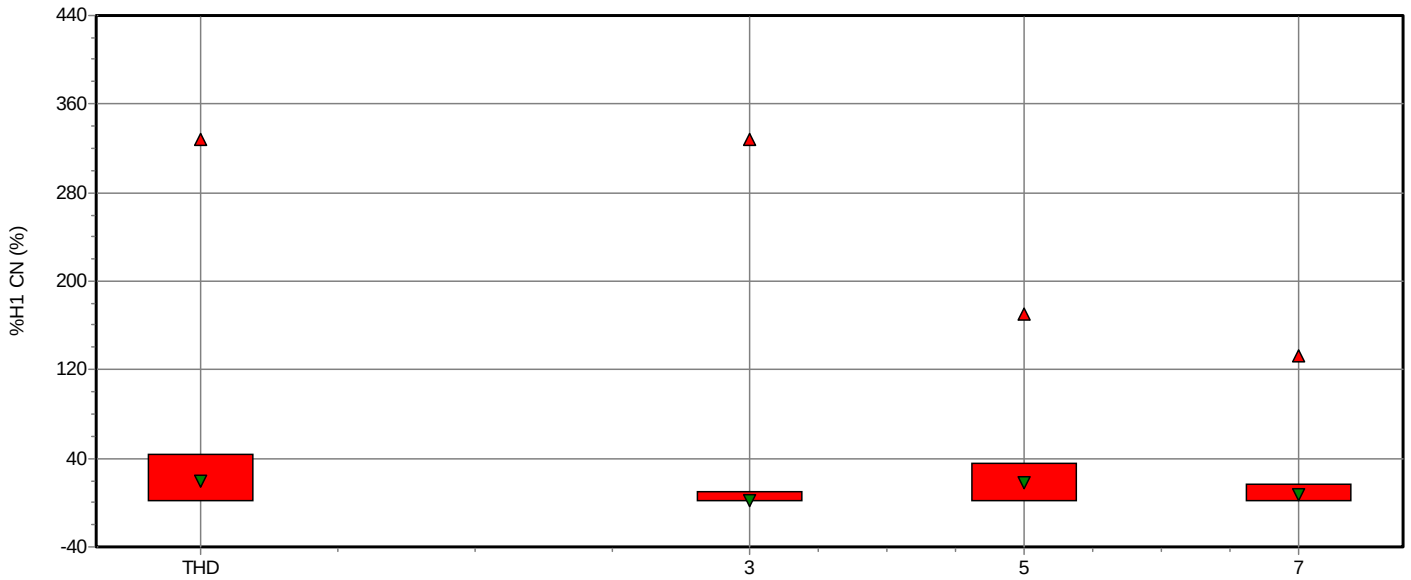
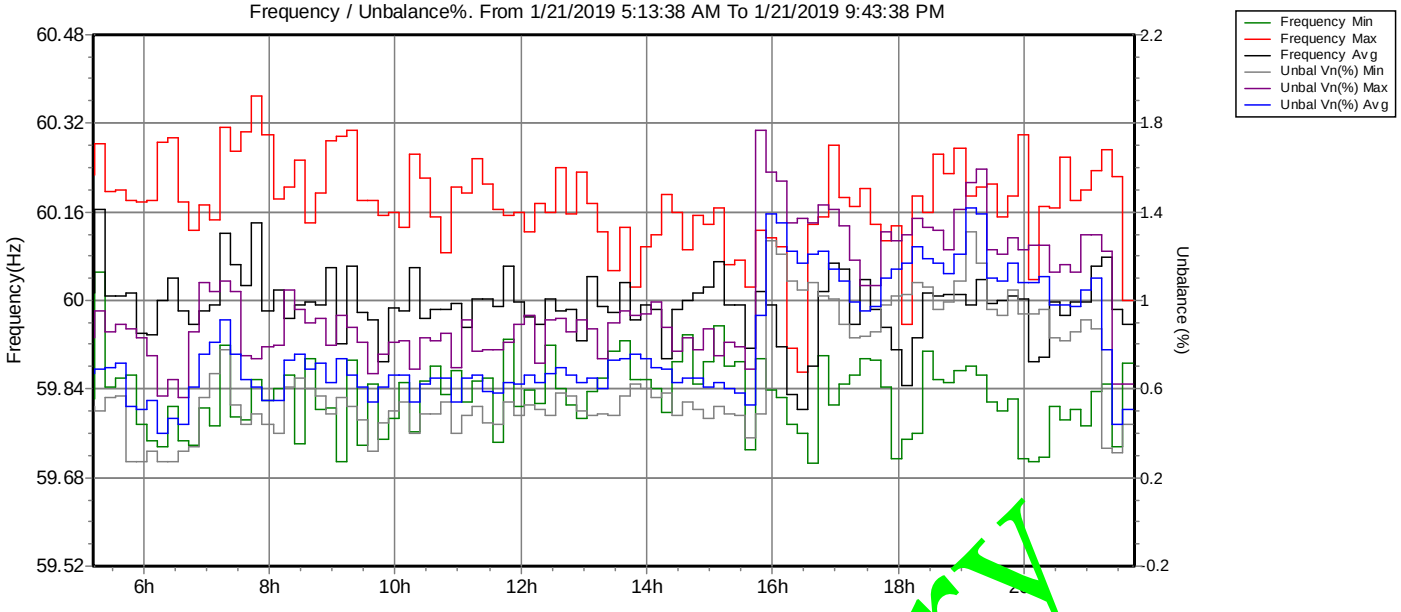


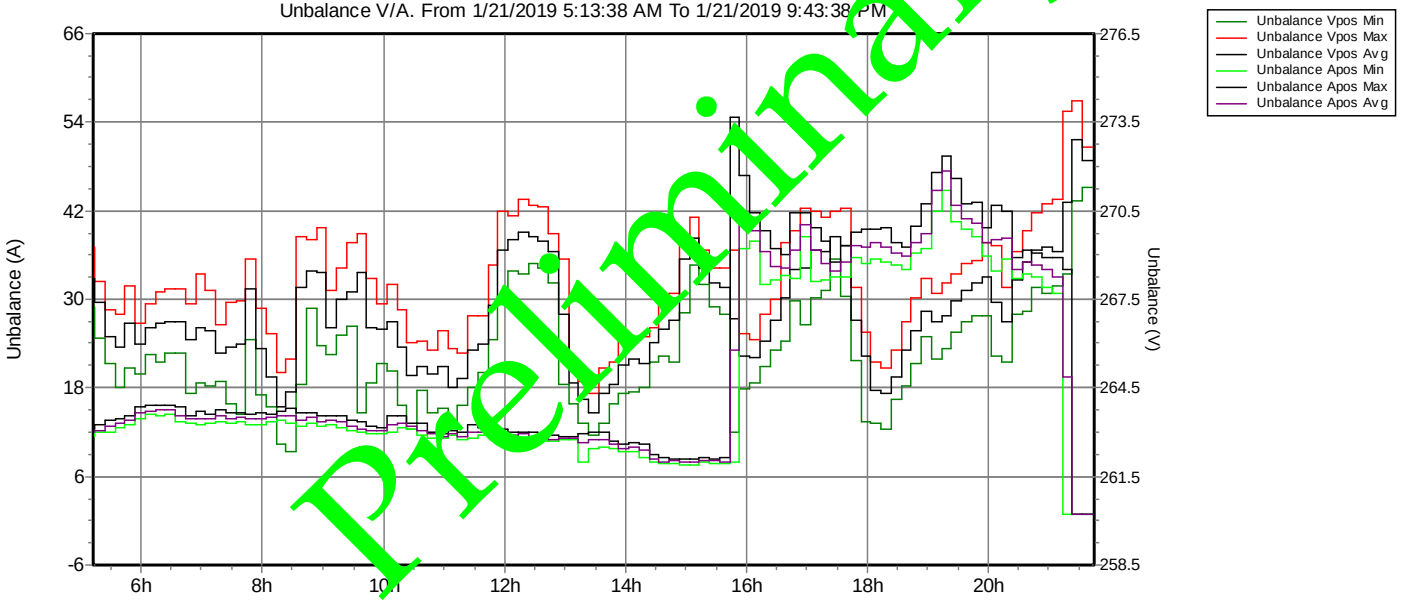
Harmonics. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



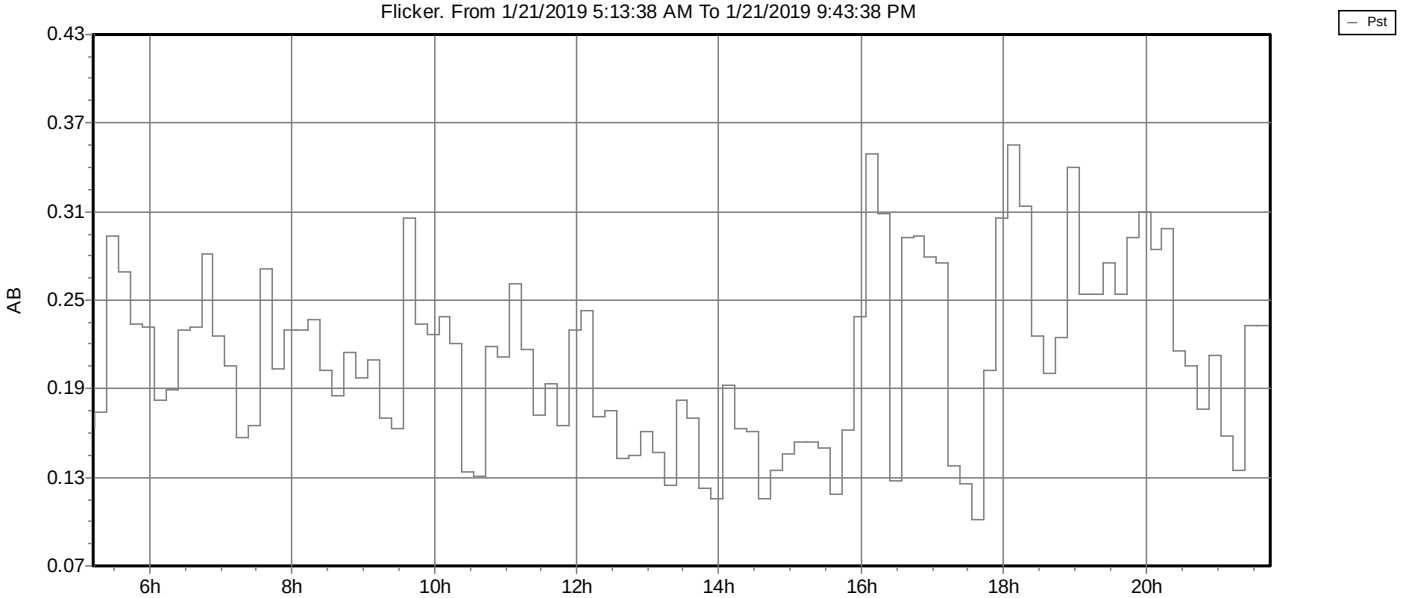
Frequency / Unbalance%. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



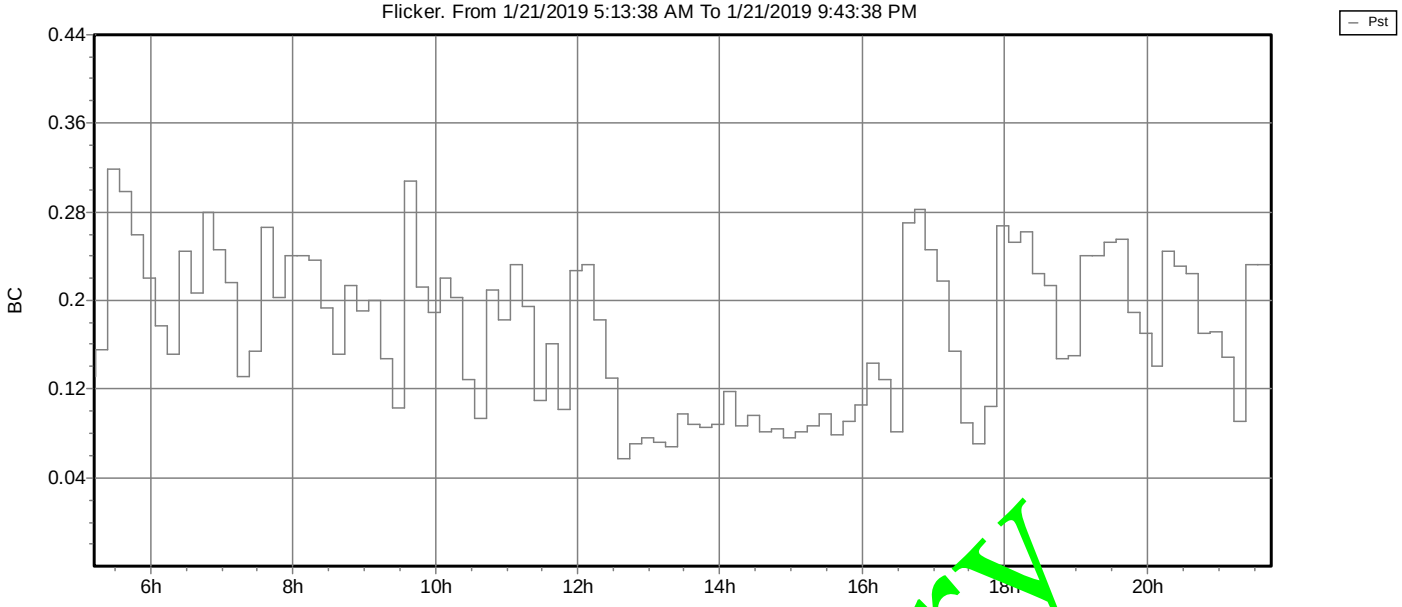
Unbalance V/A. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



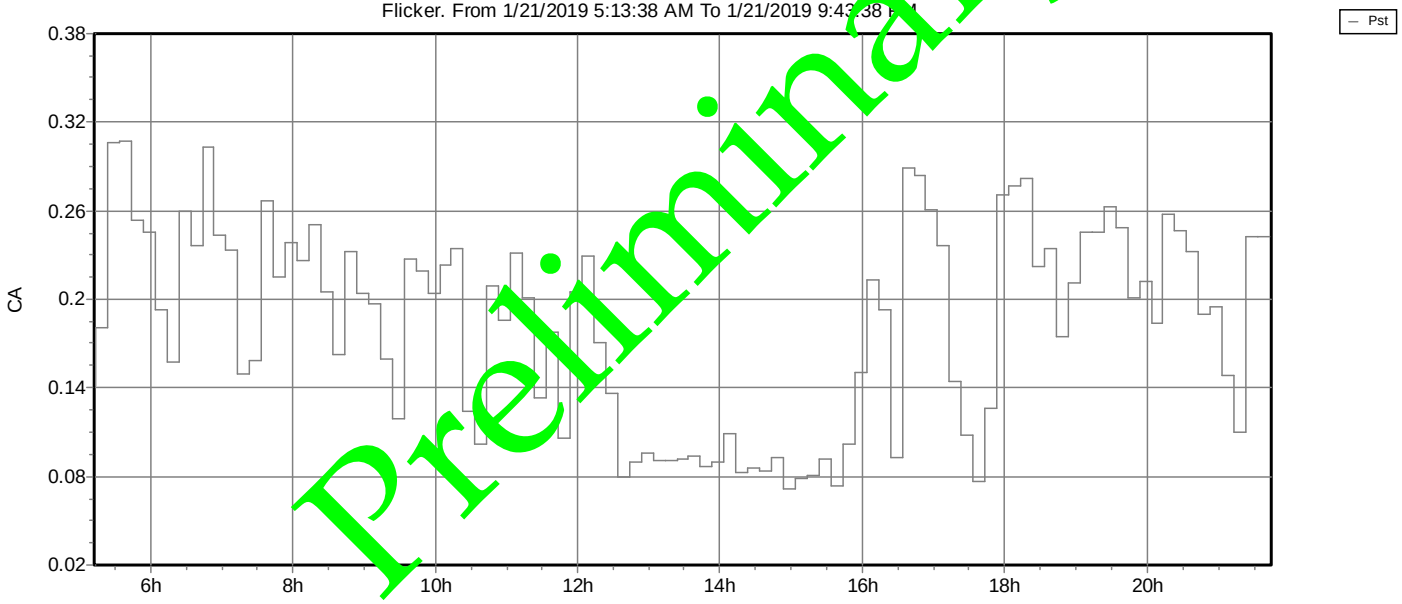
Flicker. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



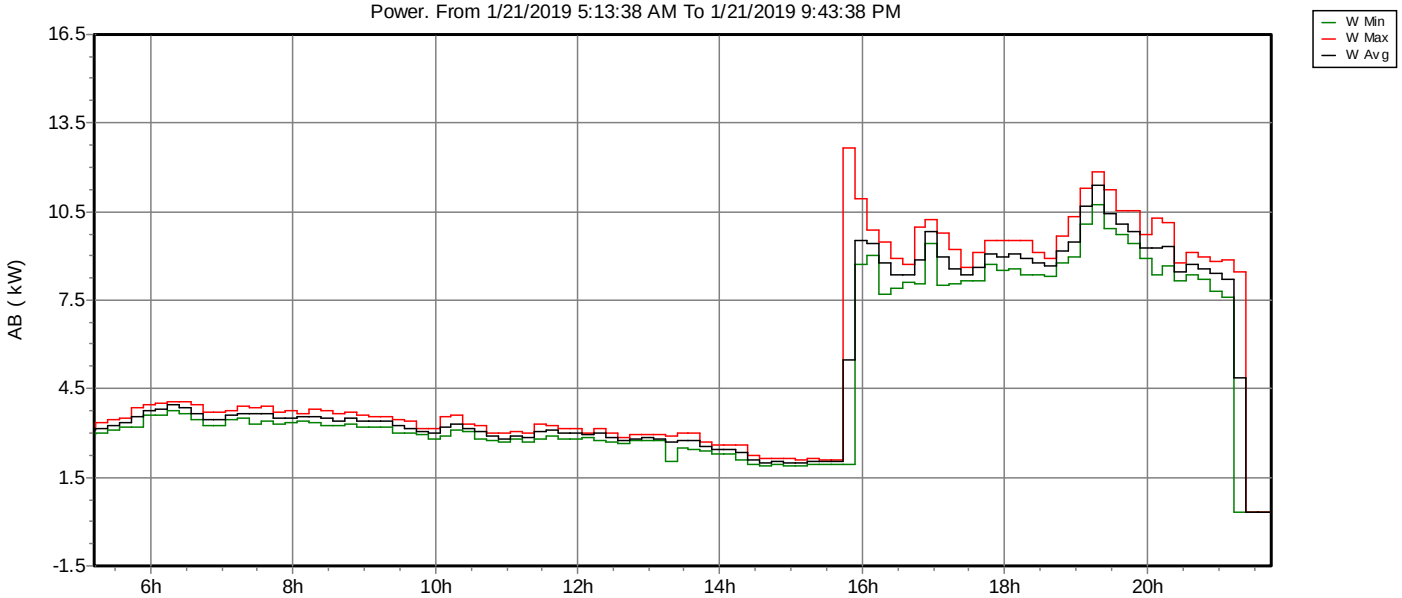
Flicker. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM

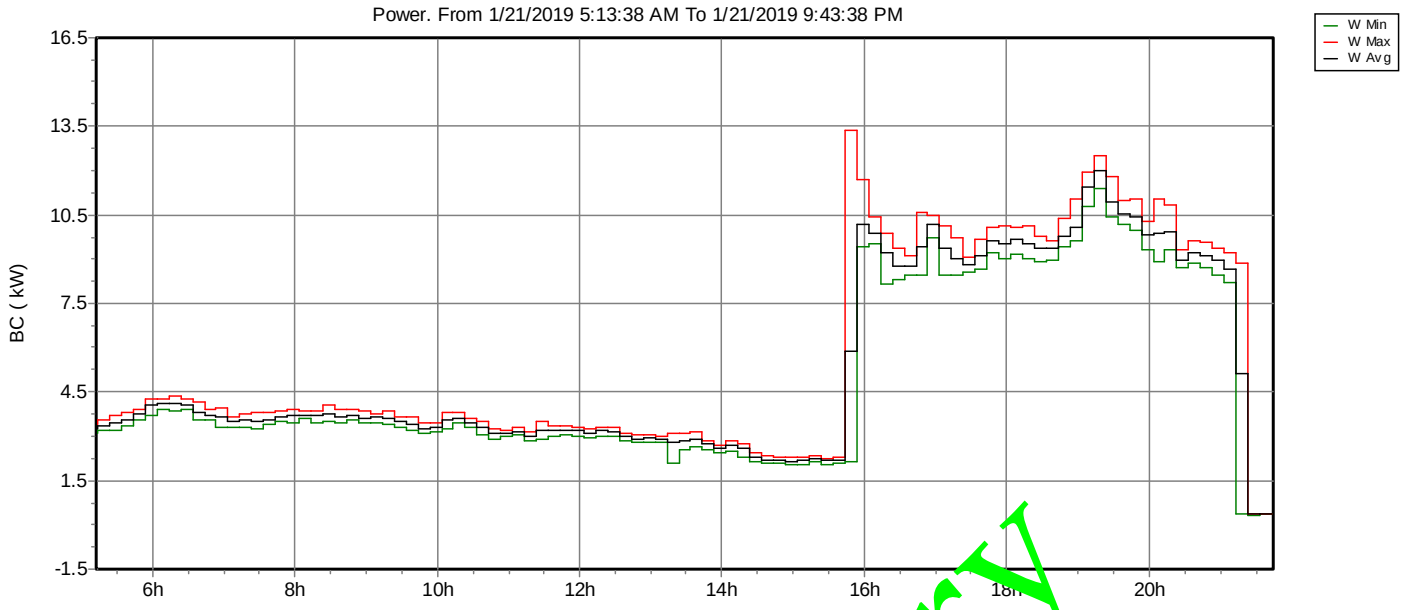


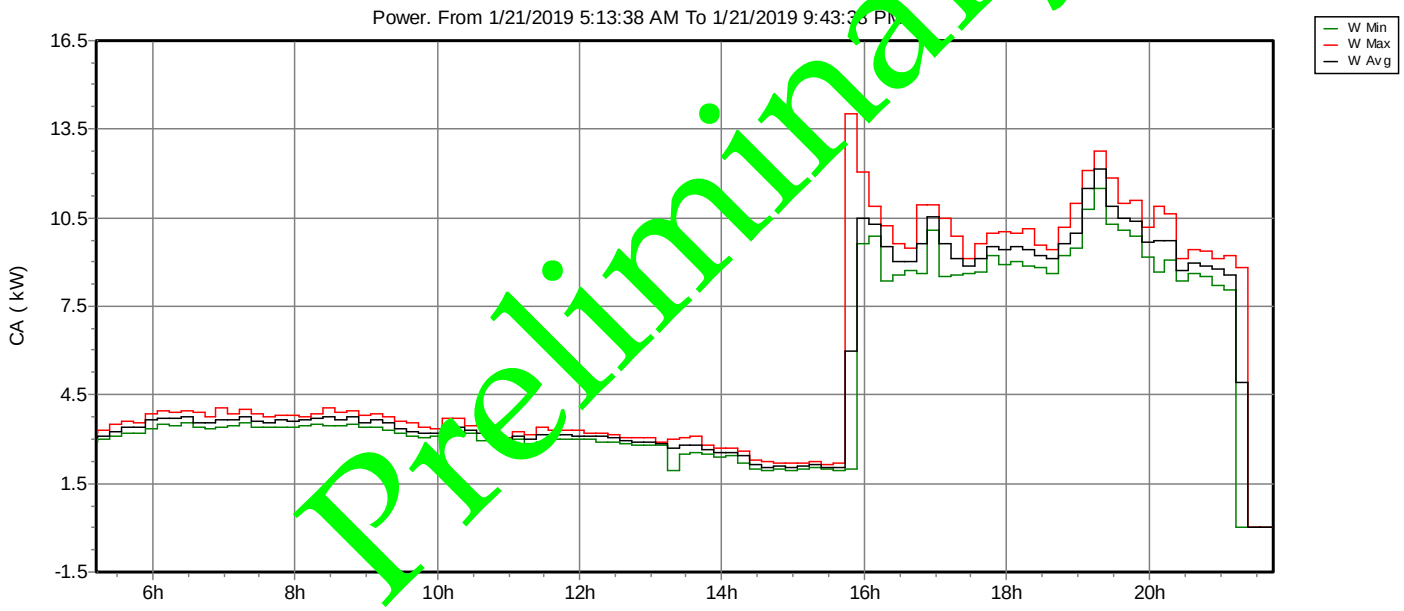
Flicker. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM

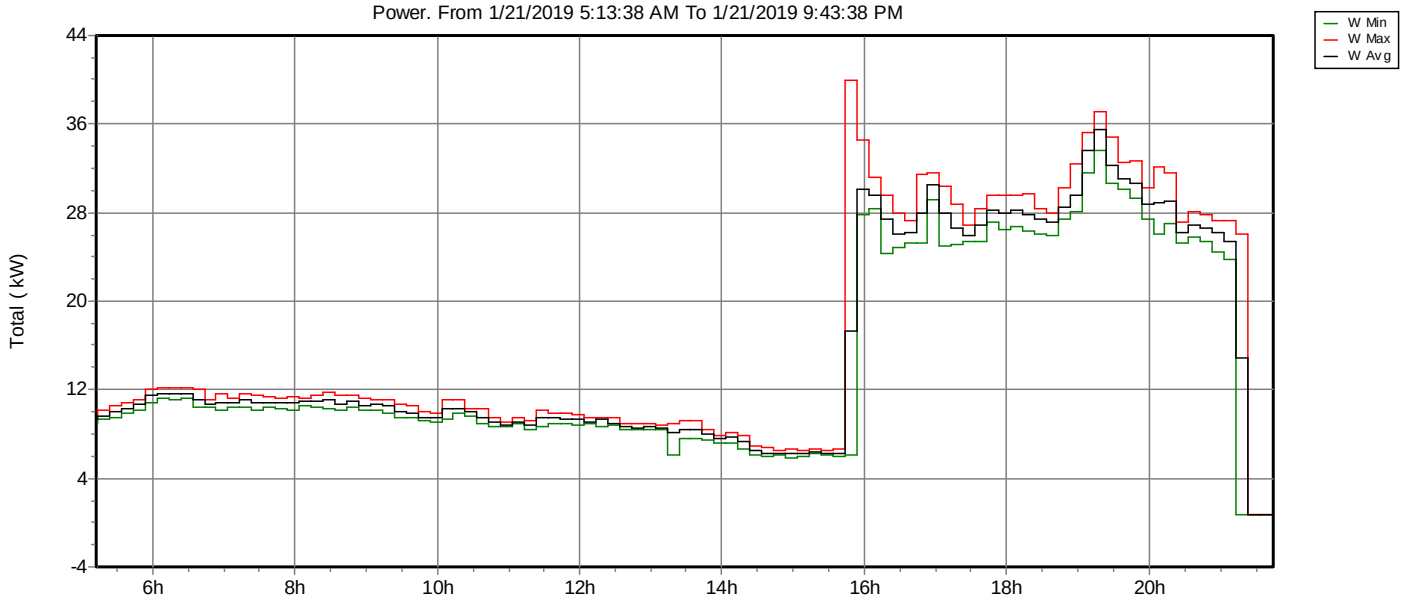


Power. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM

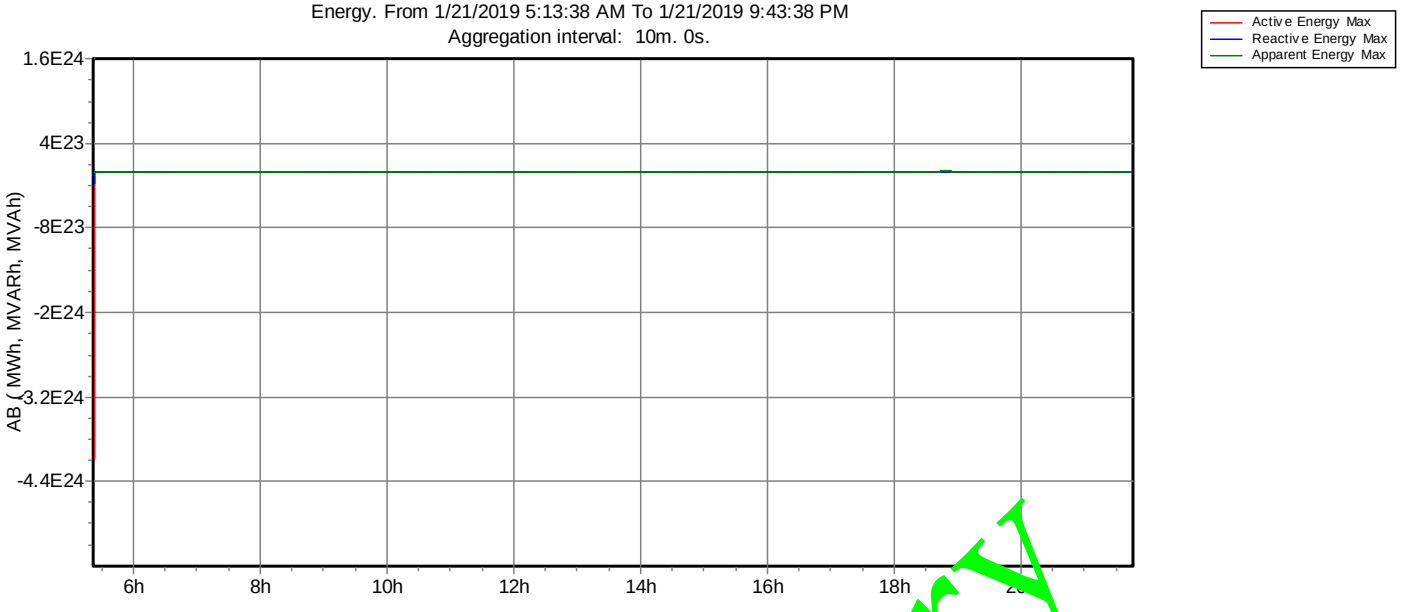








Energy. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM
Aggregation interval: 10m. 0s.



Energy. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM
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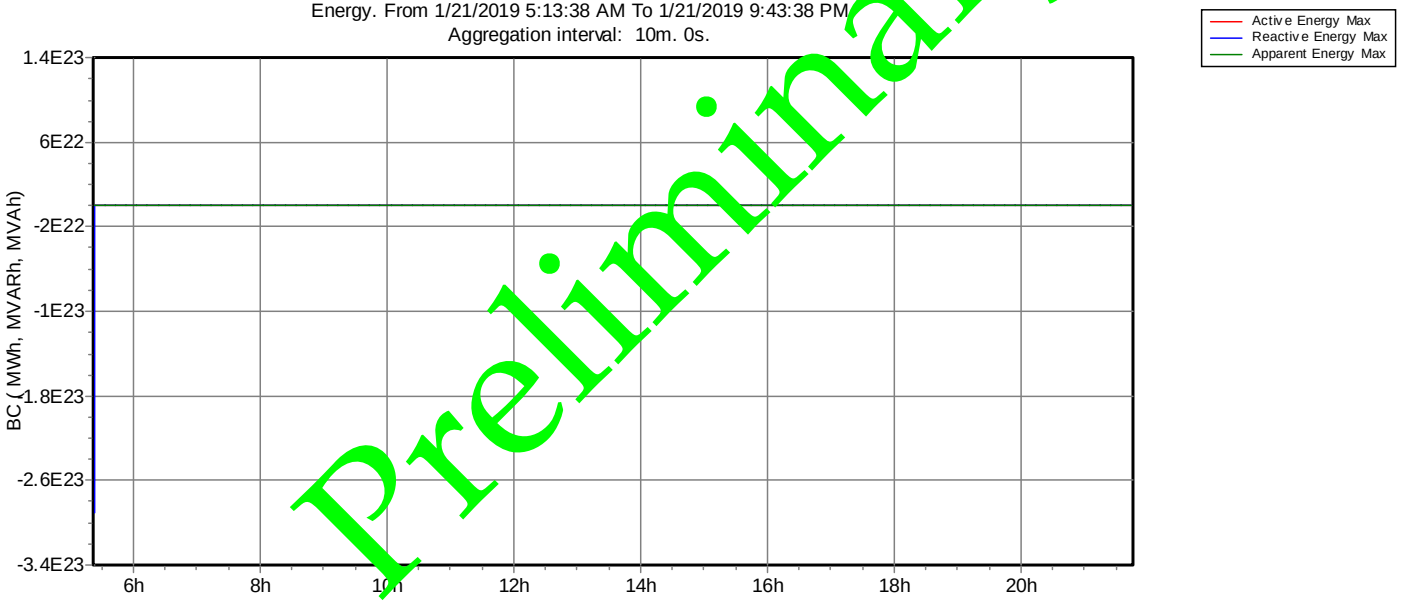

Energy. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM
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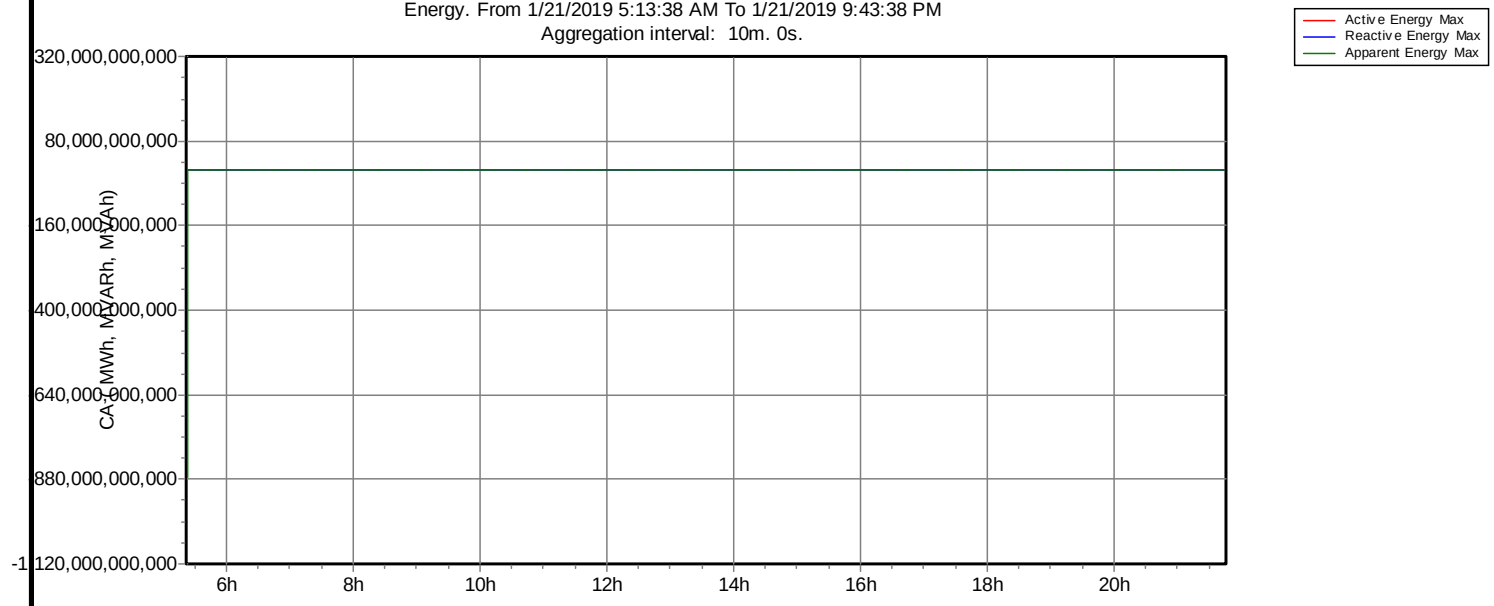

Energy. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM
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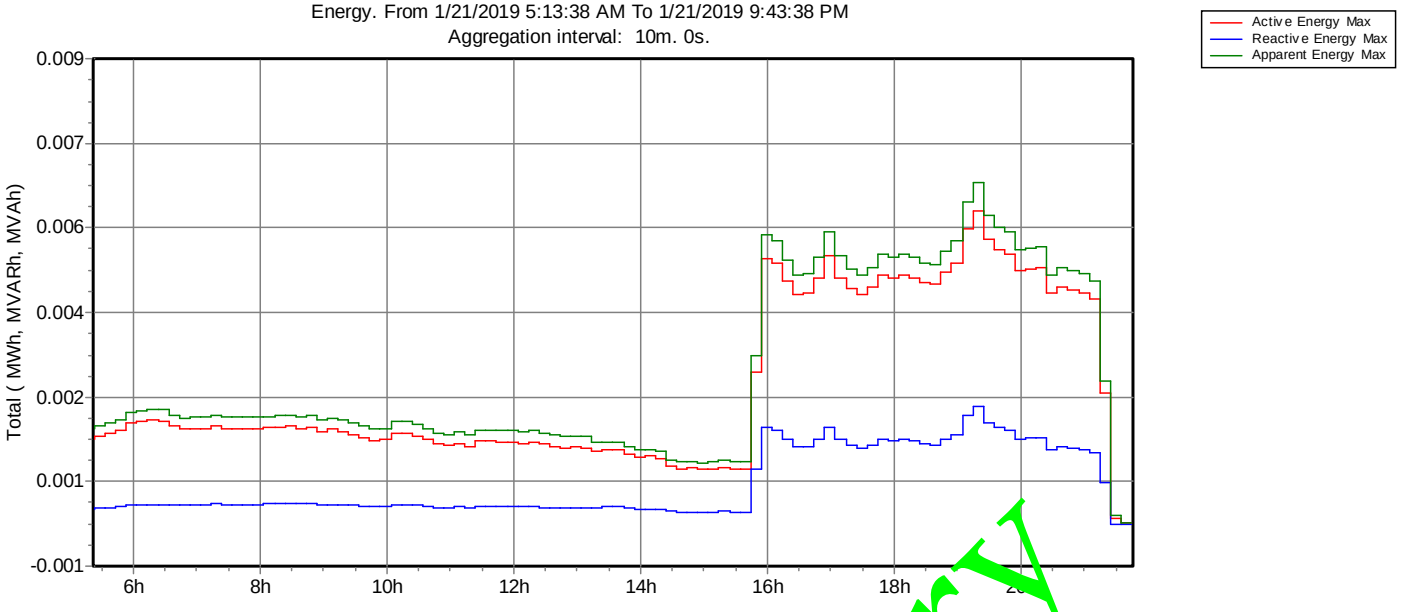
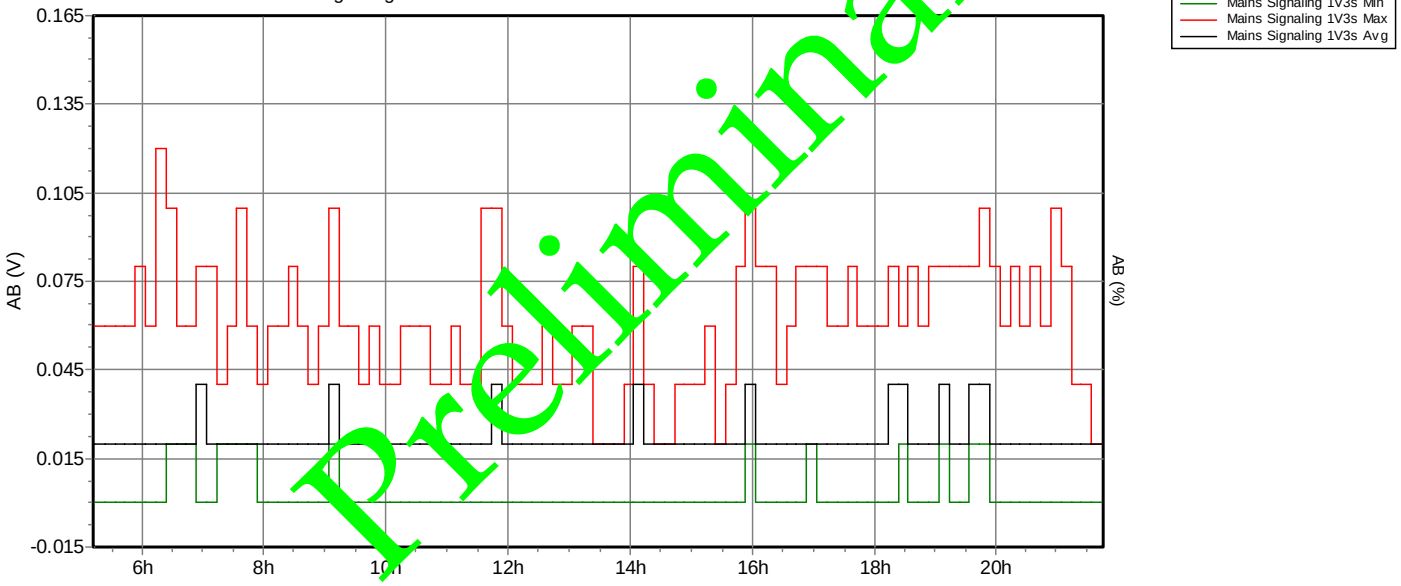
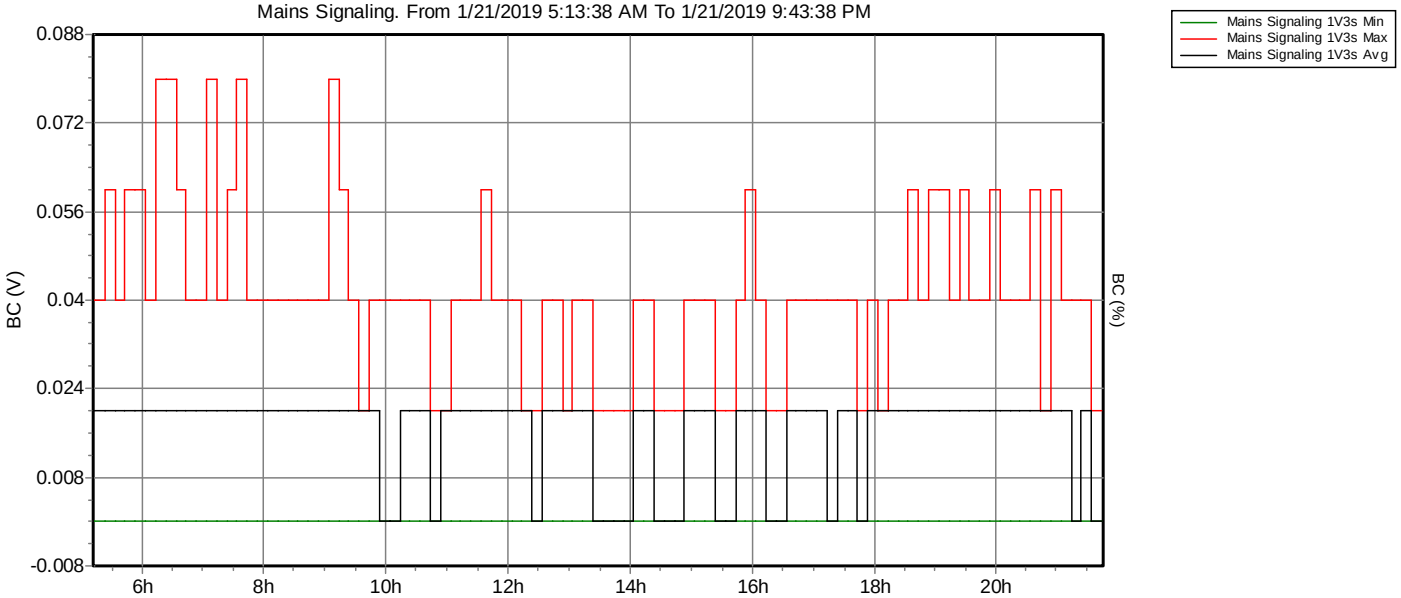


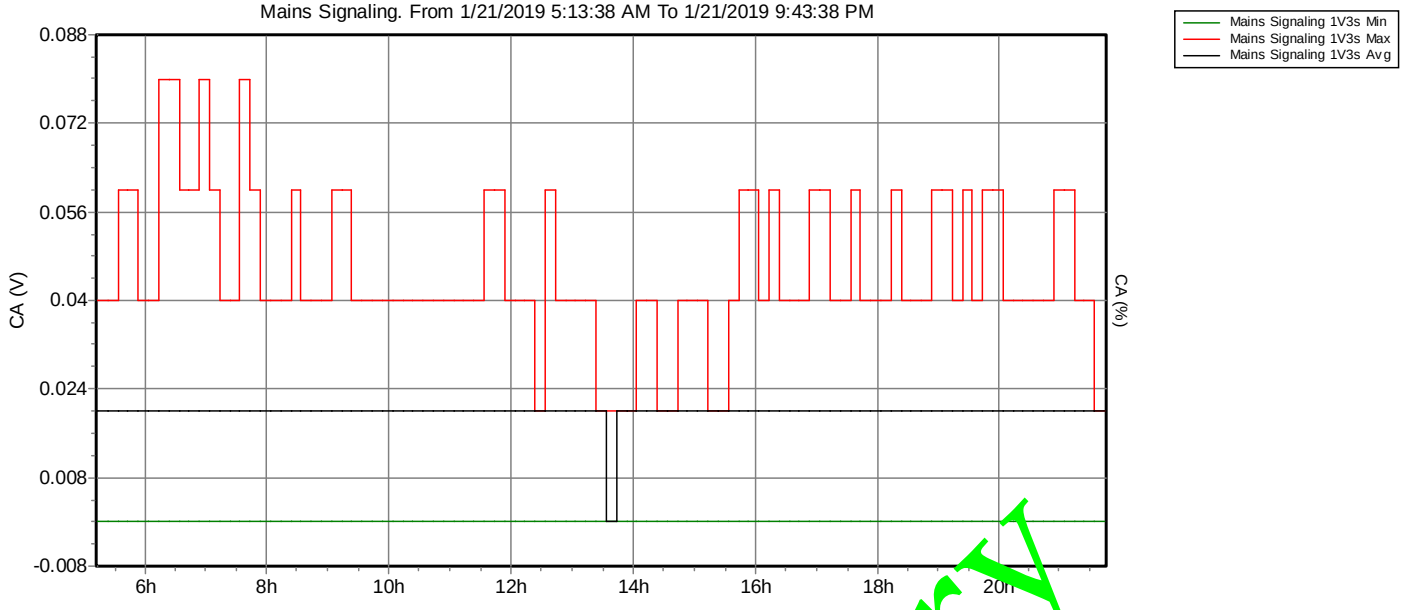
Mains Signaling. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



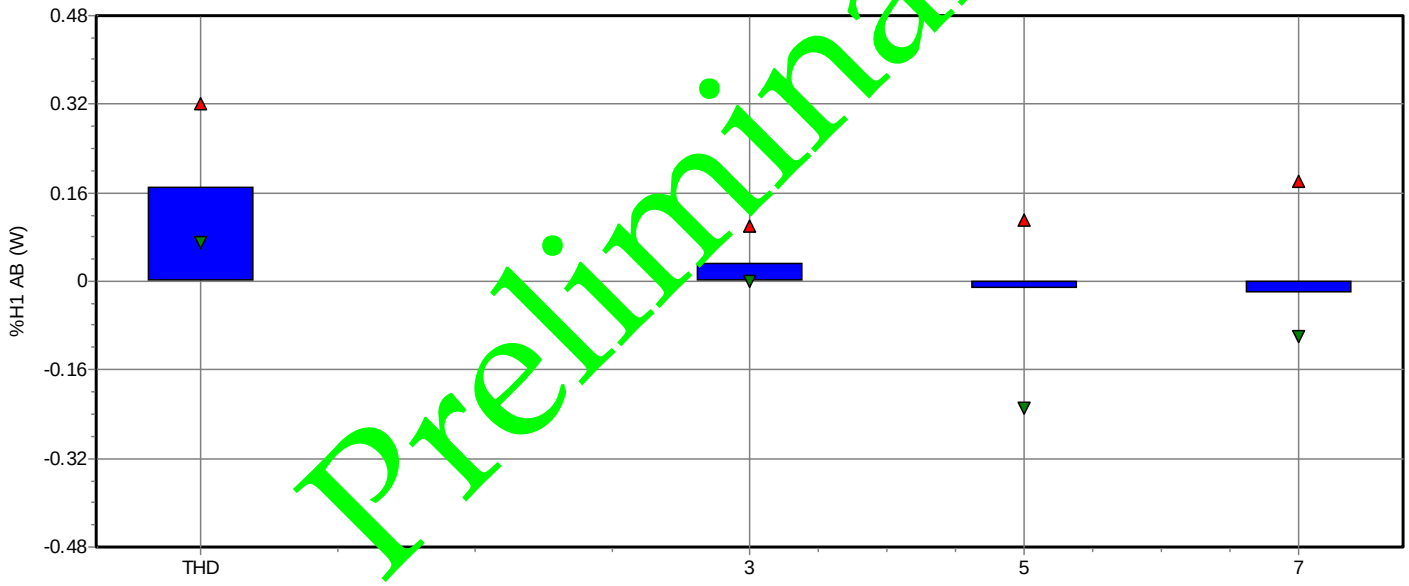
Mains Signaling. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



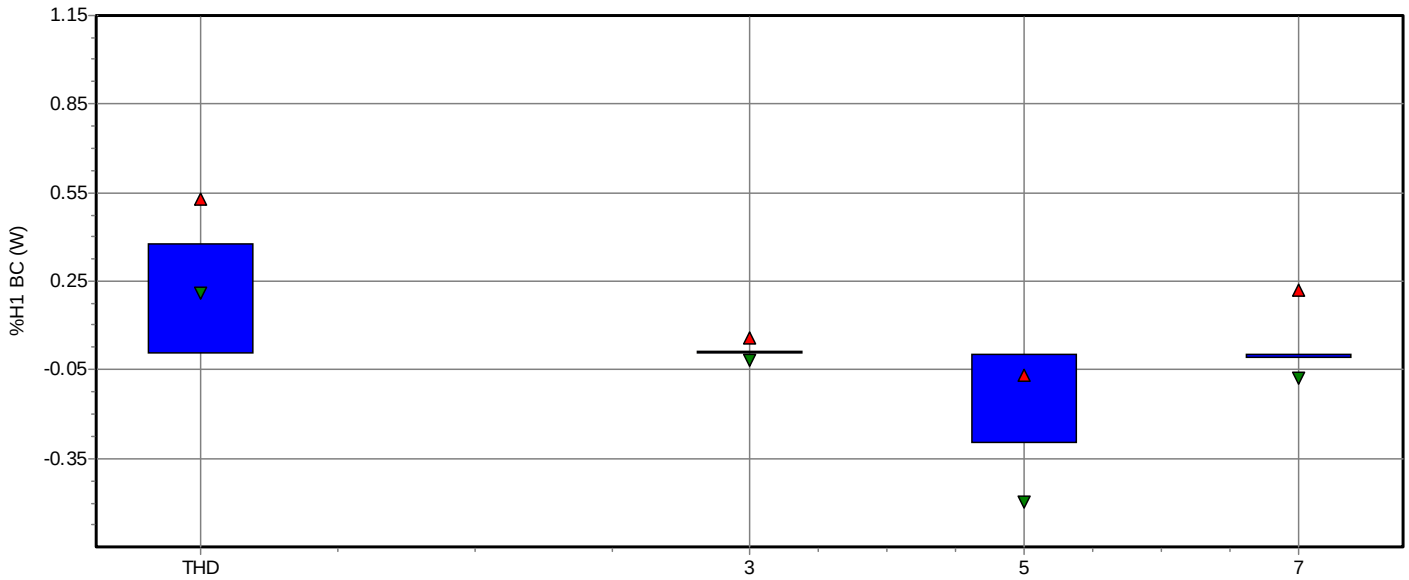
Mains Signaling. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



Power Harmonics. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM

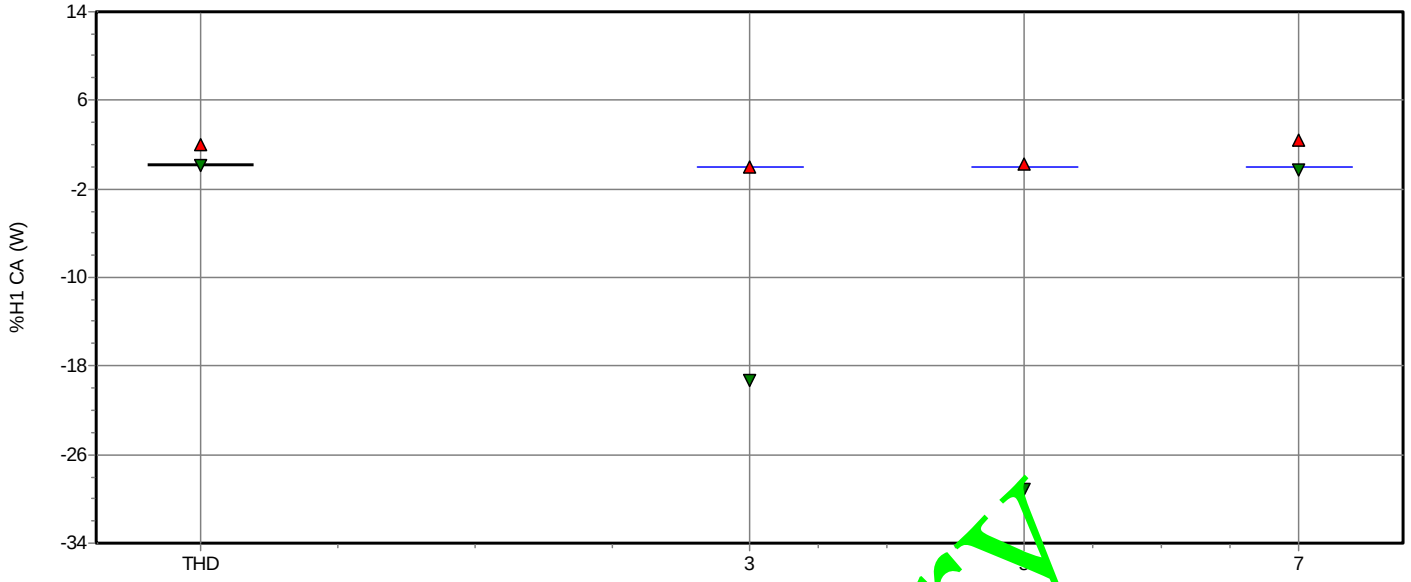


Power Harmonics. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM

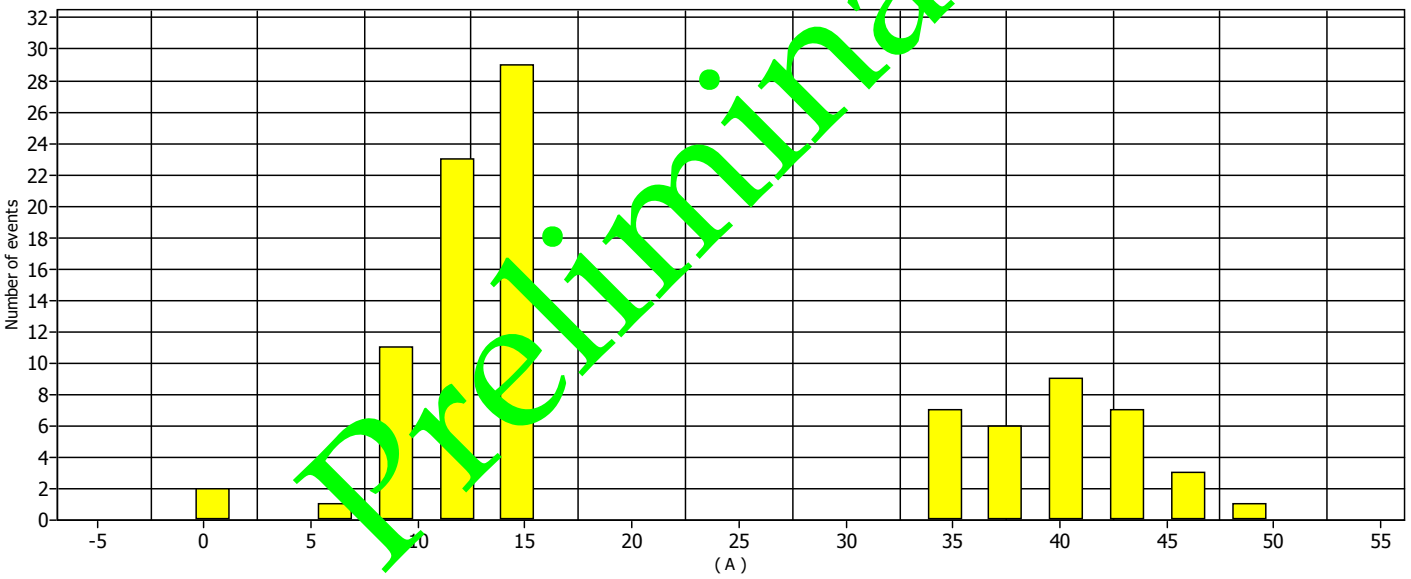


N -- FLUKE 430-II (COM15) 250A,3P,FUJI.fpqo

Power Harmonics. From 1/21/2019 5:13:38 AM To 1/21/2019 9:43:38 PM



Arms - C - Maximum



Instrument Information

Model Number	435-II
Serial Number	34843110
Firmware Revision	V05.04

Software Information

Power Log Version	5.4
FLUKE 430-II DLL Version	1.2.0.13

General Information

Recording location	FEEDER VFD-1
Client	MAYNILAD CHERRY IN LINE PUMP STATION
Notes	Naval BAse, Heracleo Alano Sangley Point Cavite City

Measurement Summary

Measurement topology	3-element delta mode
Application mode	Logger
First recording	1/21/2019 5:24:31 AM 13msec
Last recording	1/21/2019 9:44:31 PM 13msec
Recording interval	0h 10m 0s 0msec
Nominal Voltage	460 V
Nominal Current	100 A
Nominal Frequency	60 Hz
File start time	1/21/2019 5:14:31 AM 13msec
File end time	1/21/2019 9:44:31 PM 13msec
Duration	0d 16h 30m 0s 0msec
Number of events	Normal: 1 Detailed: 2
Events downloaded	No
Number of screens	1
Screens downloaded	Yes
Power measurement method	Unified
Cable type	Copper
Harmonic scale	%H1
THD mode	THD 40
CosPhi / DPF mode	DPF

Scaling

Phase:	
Current Clamp type	i430Flex
Clamp range	N/A
Nominal range	100 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1
Neutral:	
Current Clamp type	i430Flex
Clamp range	N/A
Nominal range	100 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1

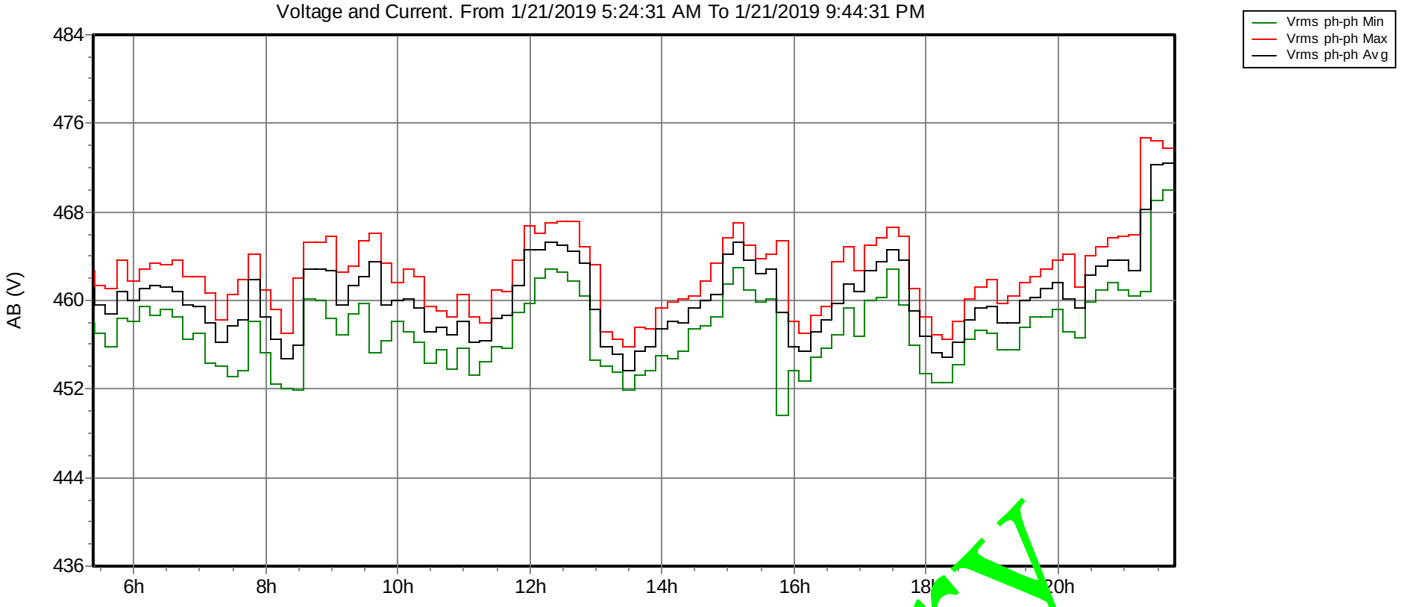
Recording Summary

RMS recordings	99
DC recordings	0
Frequency recordings	99
Unbalance recordings	99
Harmonic recordings	99
Power harmonic recordings	99
Power recordings	99
Power unbalance recordings	0
Energy recordings	99
Energy losses recordings	0
Flicker recordings	99
Mains signaling recordings	99

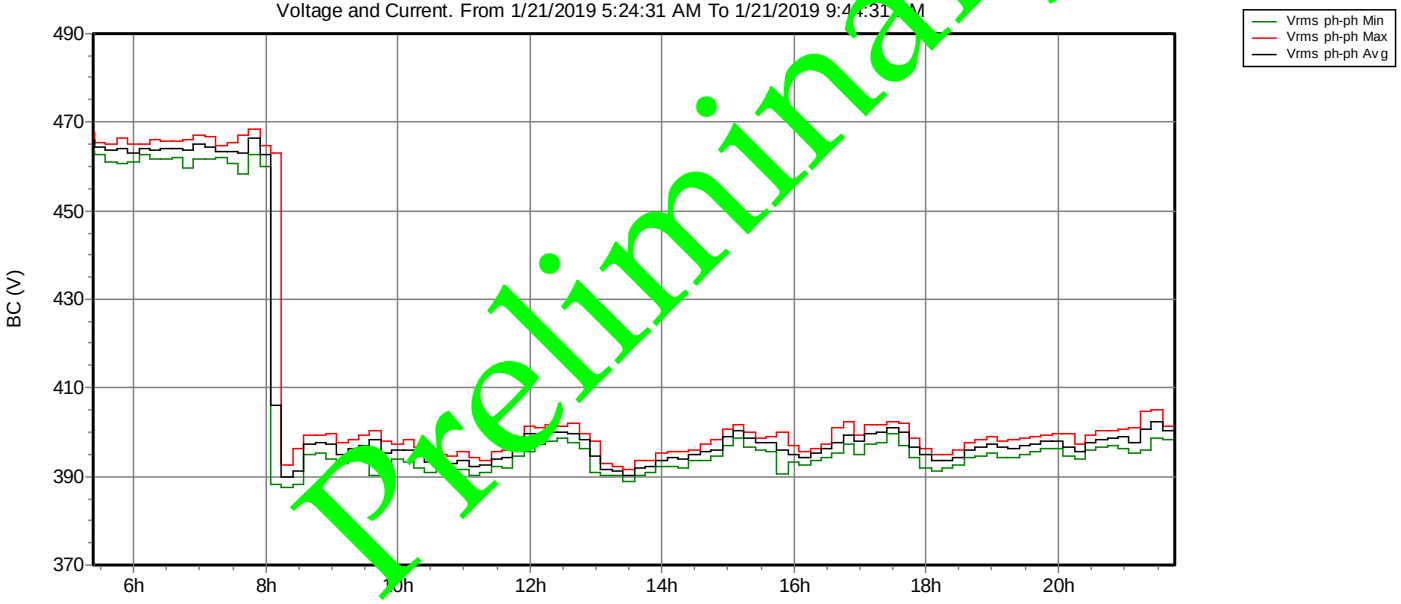
Events Summary

Dips	0
Swells	0
Transients	0
Interruptions	0
Voltage profiles	0
Rapid voltage changes	0
Screens	1
Waveforms	0
Intervals without measurements	0
Inrush current graphics	0
Wave events	0
RMS events	0

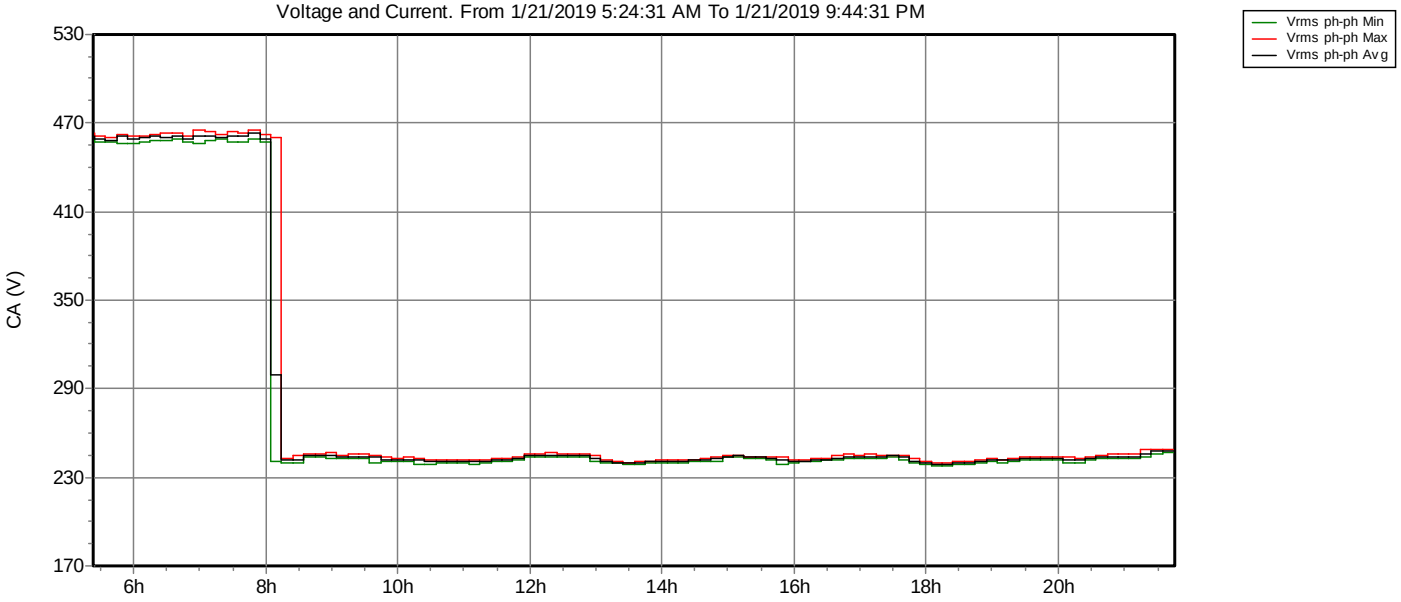
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



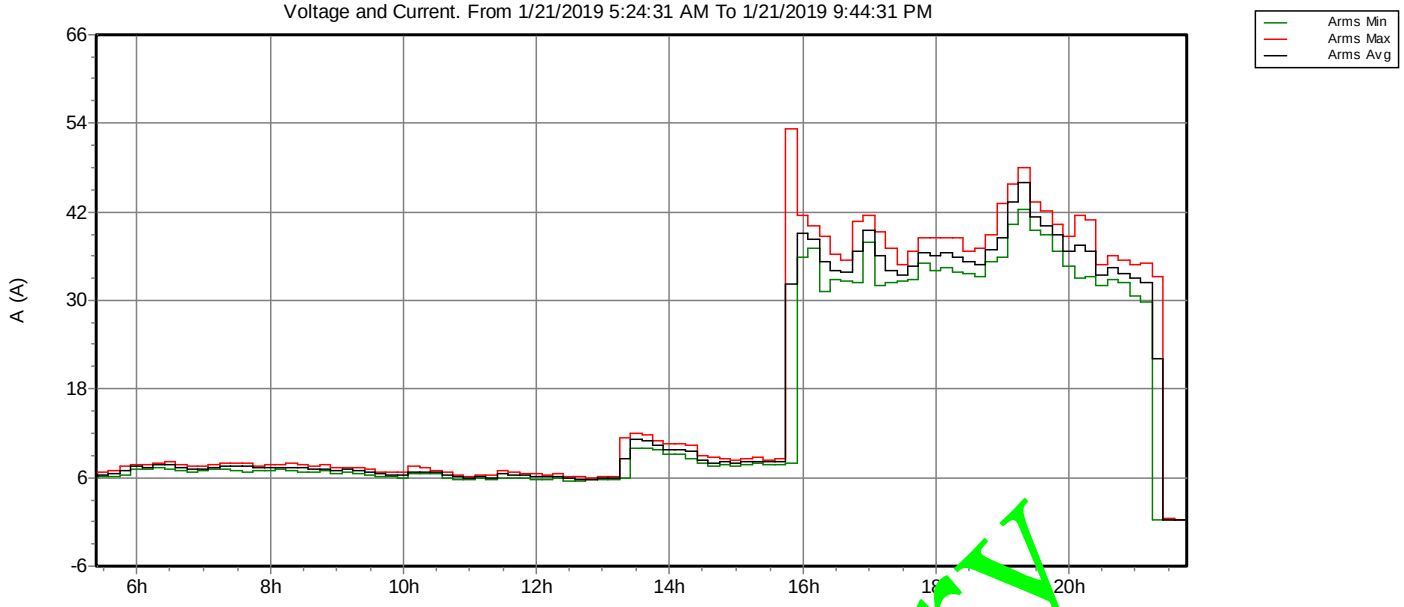
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



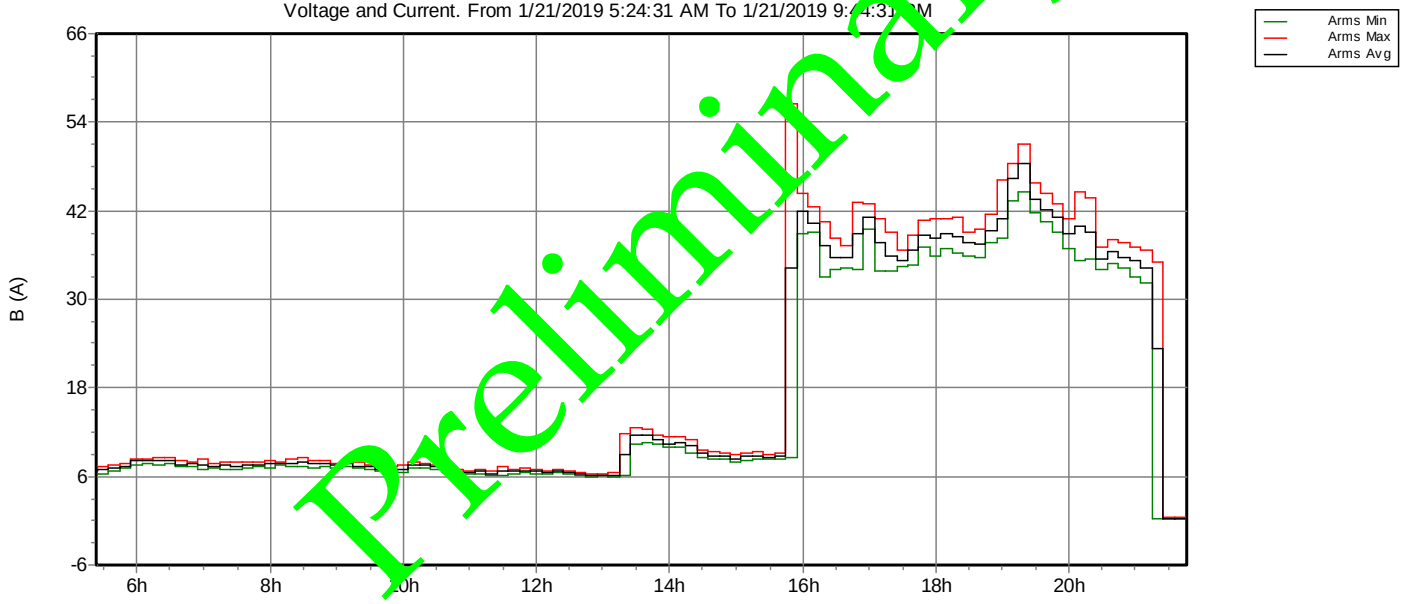
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



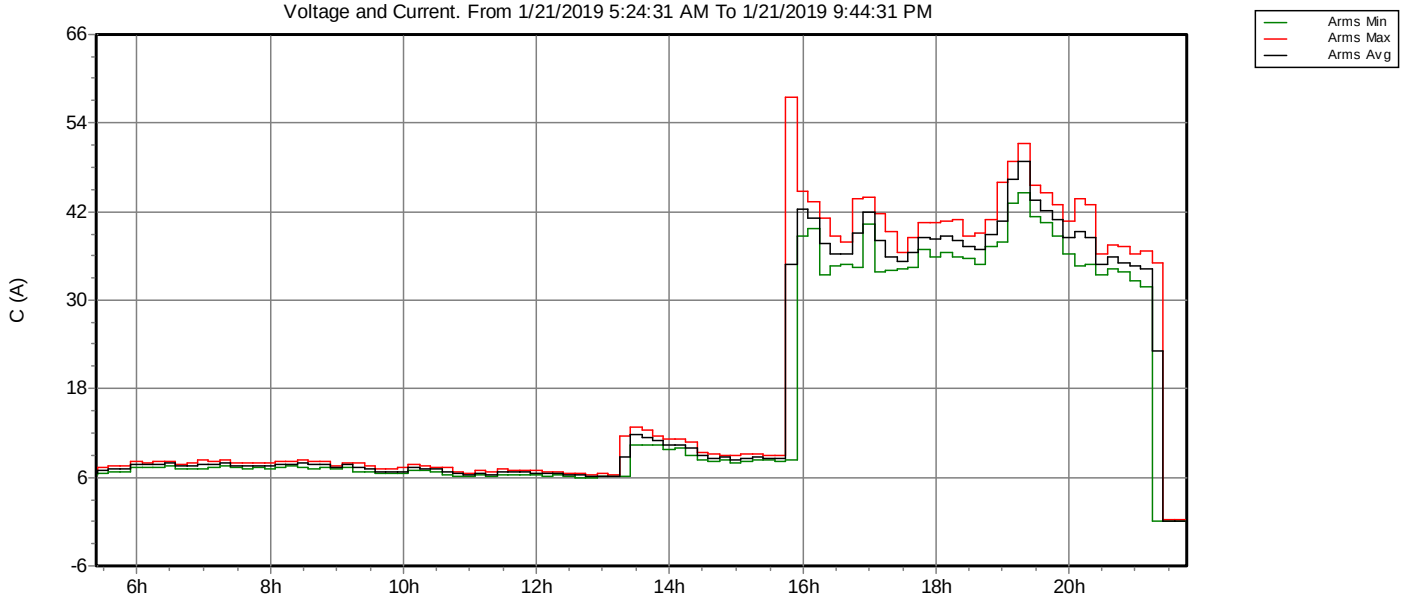
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



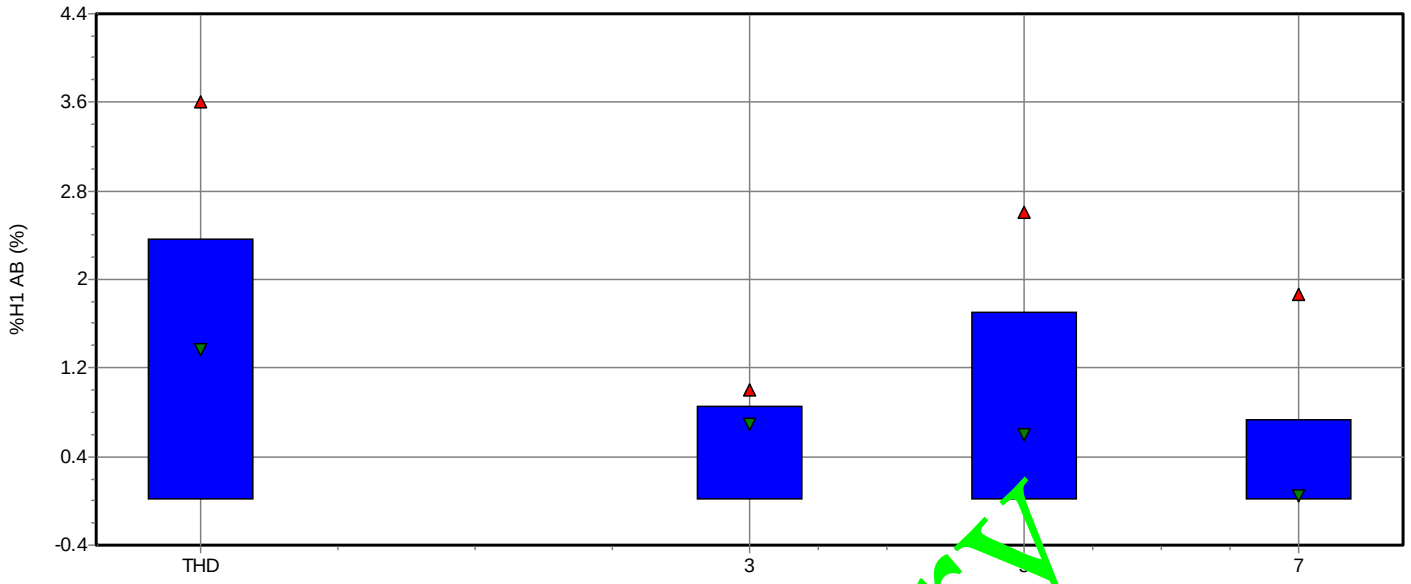
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



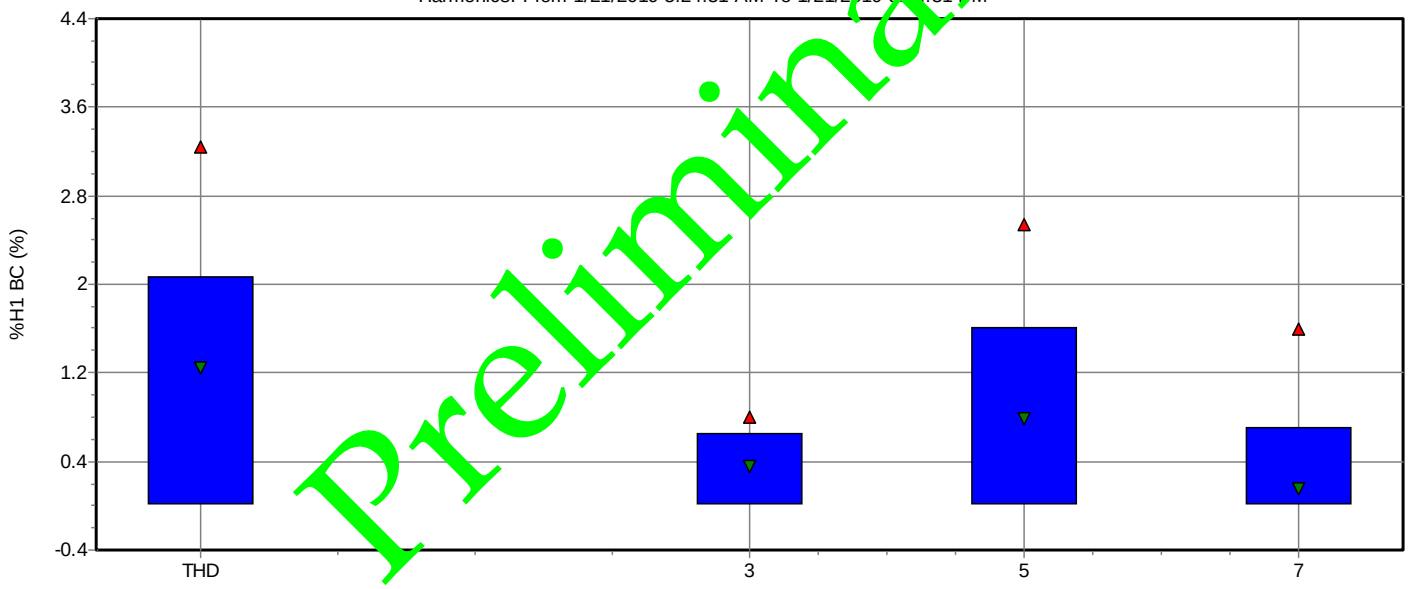
Voltage and Current. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



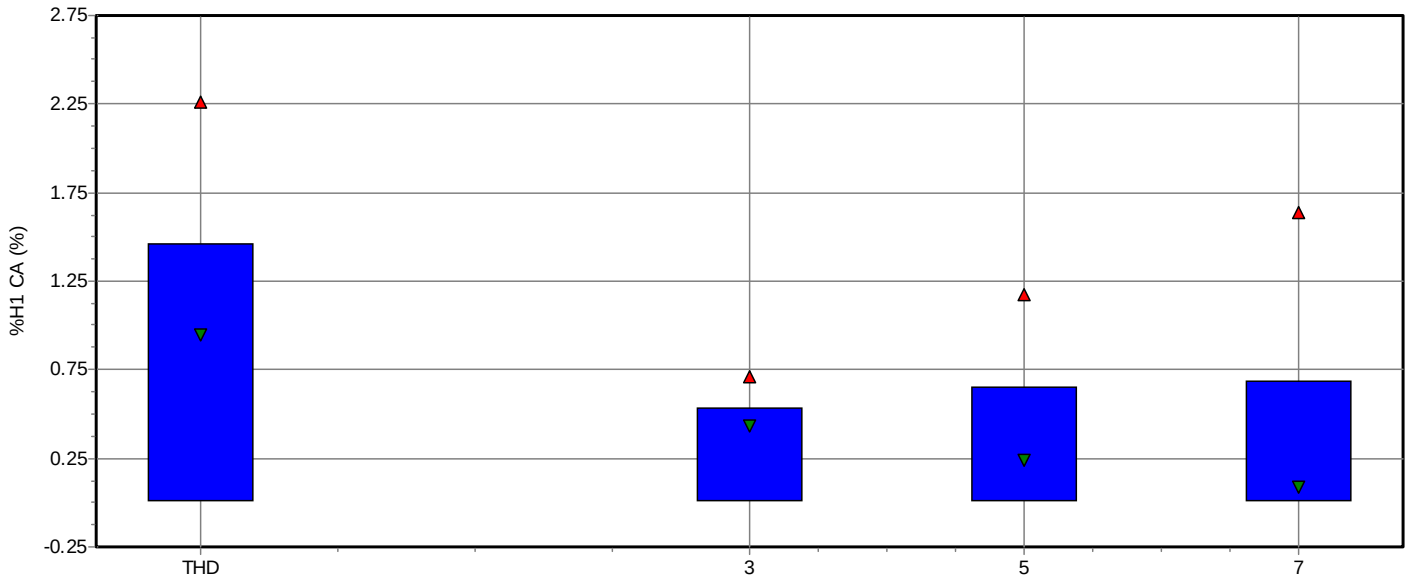
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



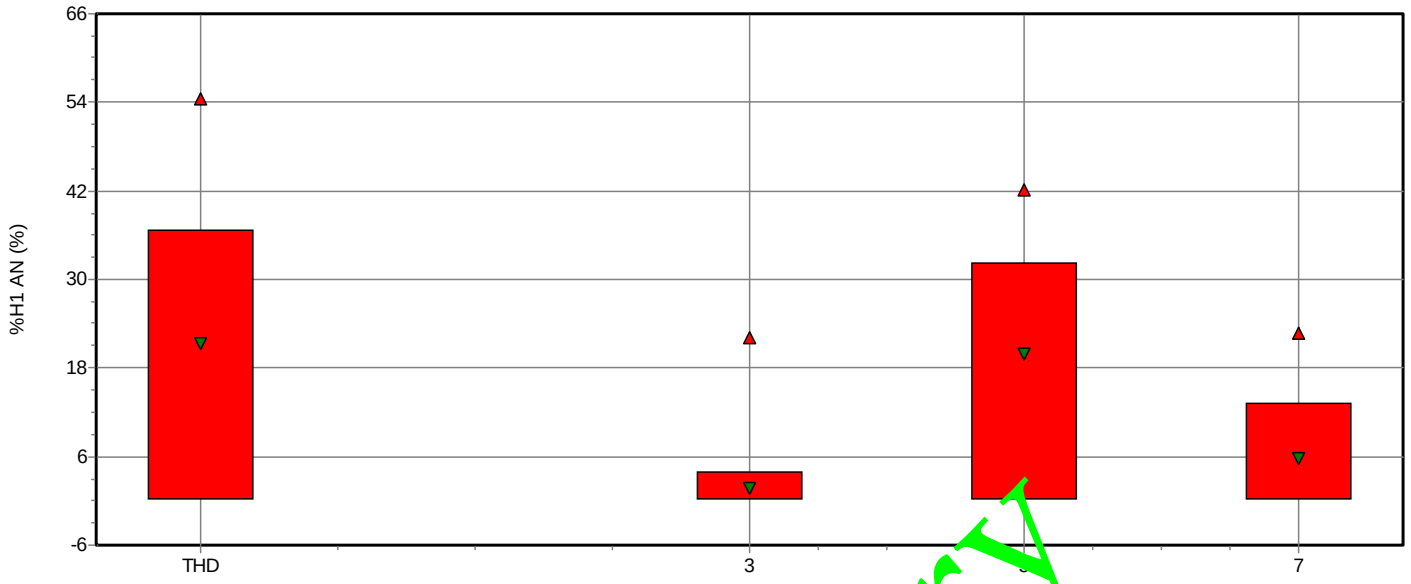
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



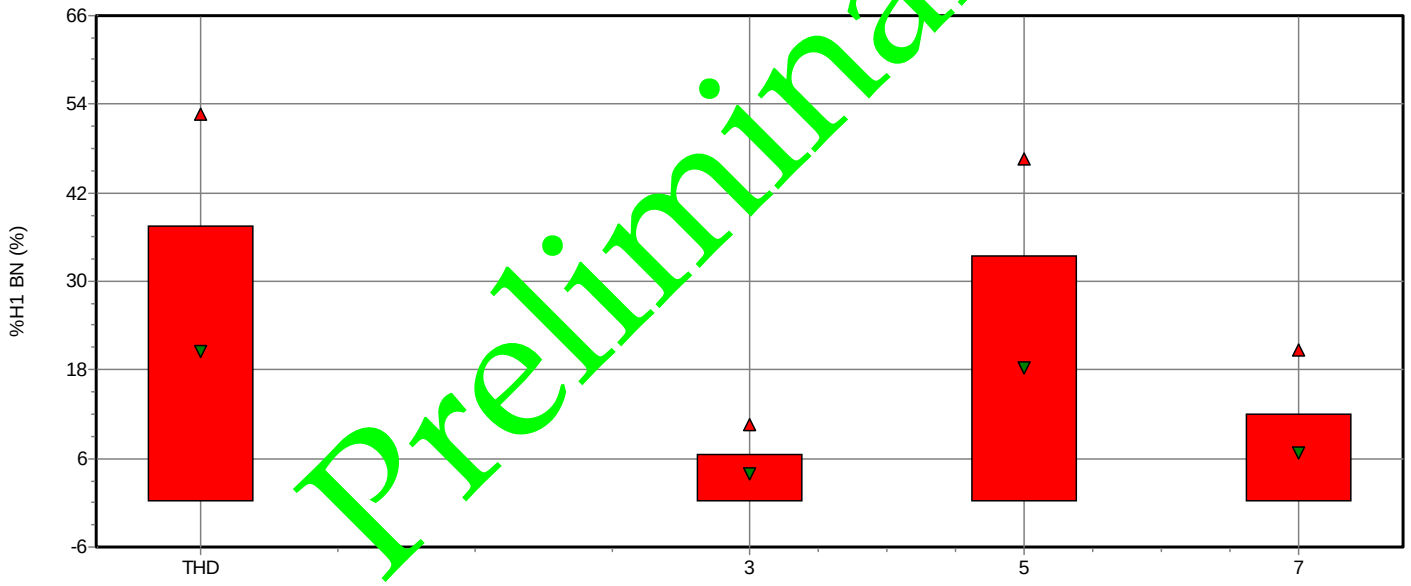
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



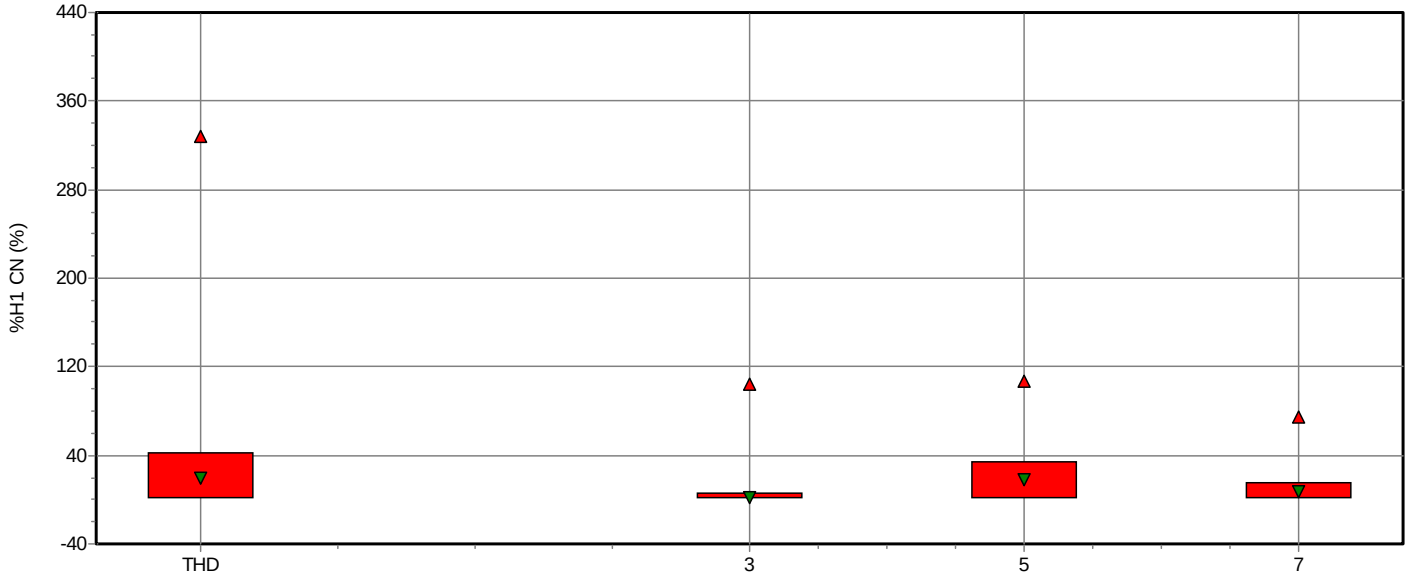
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



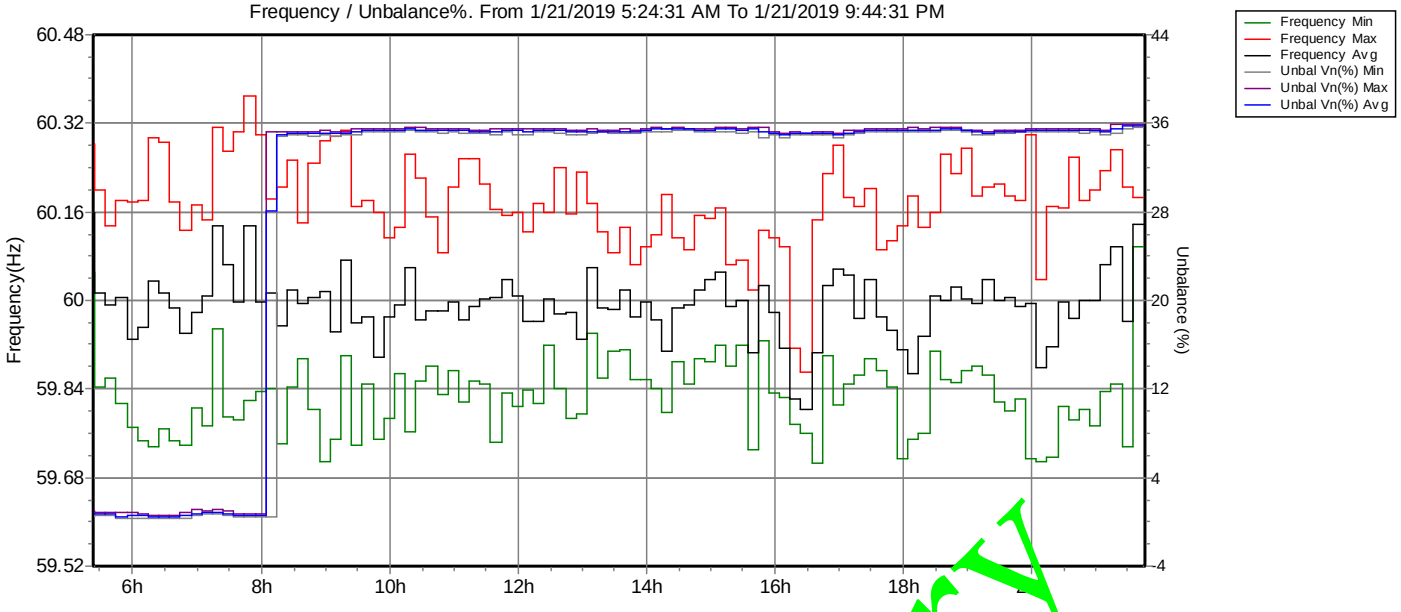
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



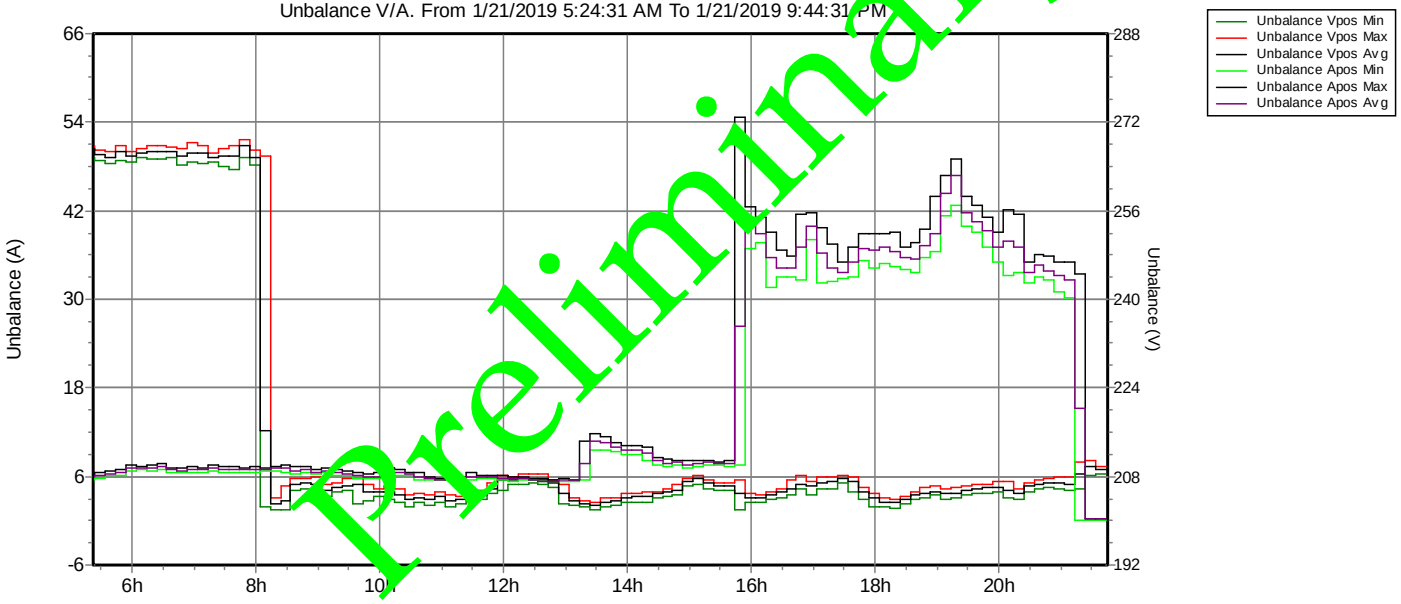
Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



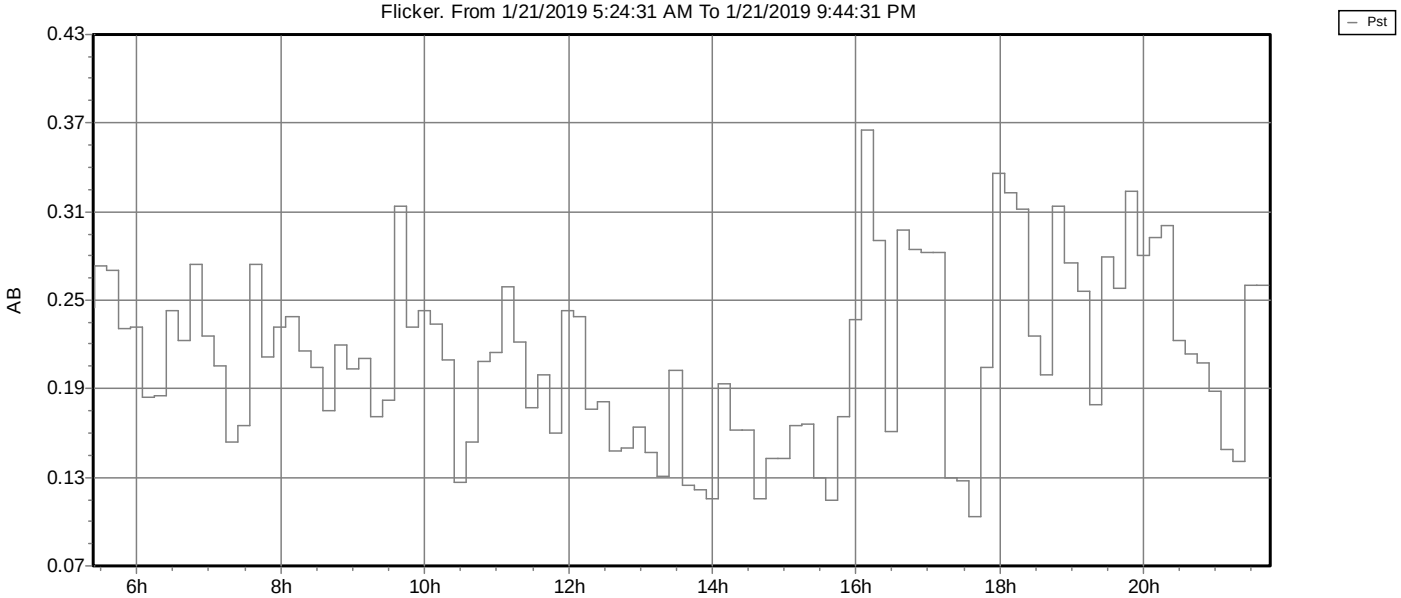
Frequency / Unbalance%. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



Unbalance V/A. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM

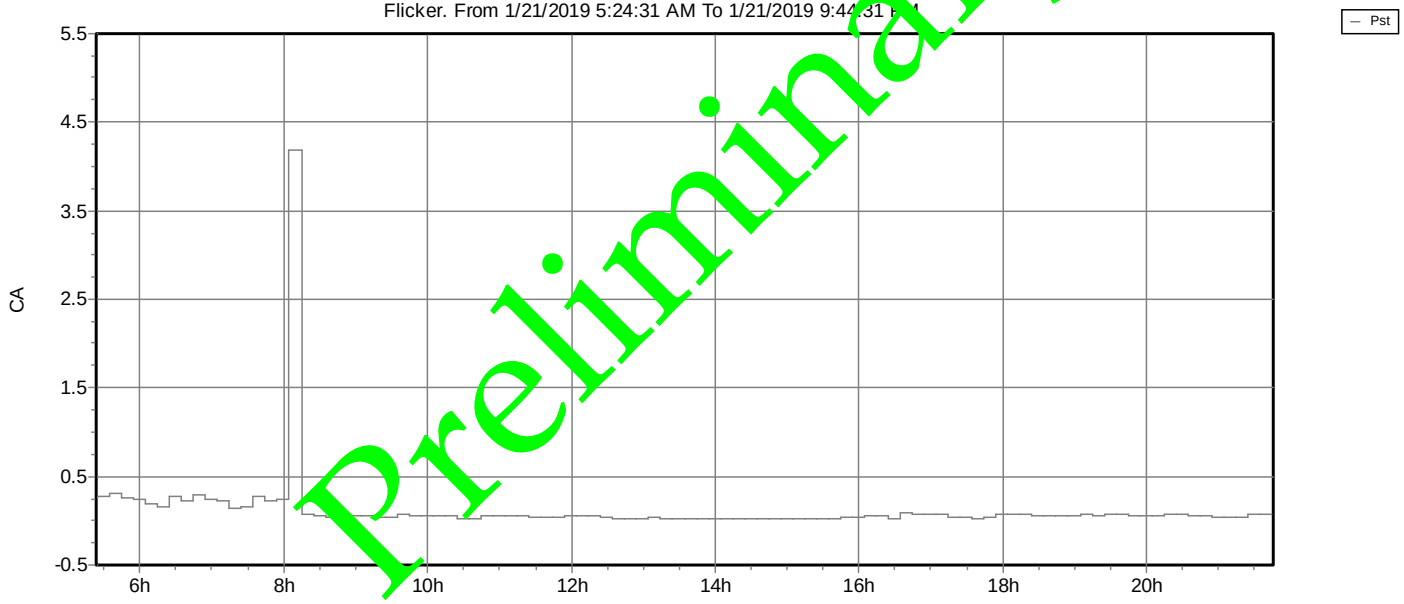


Flicker. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM

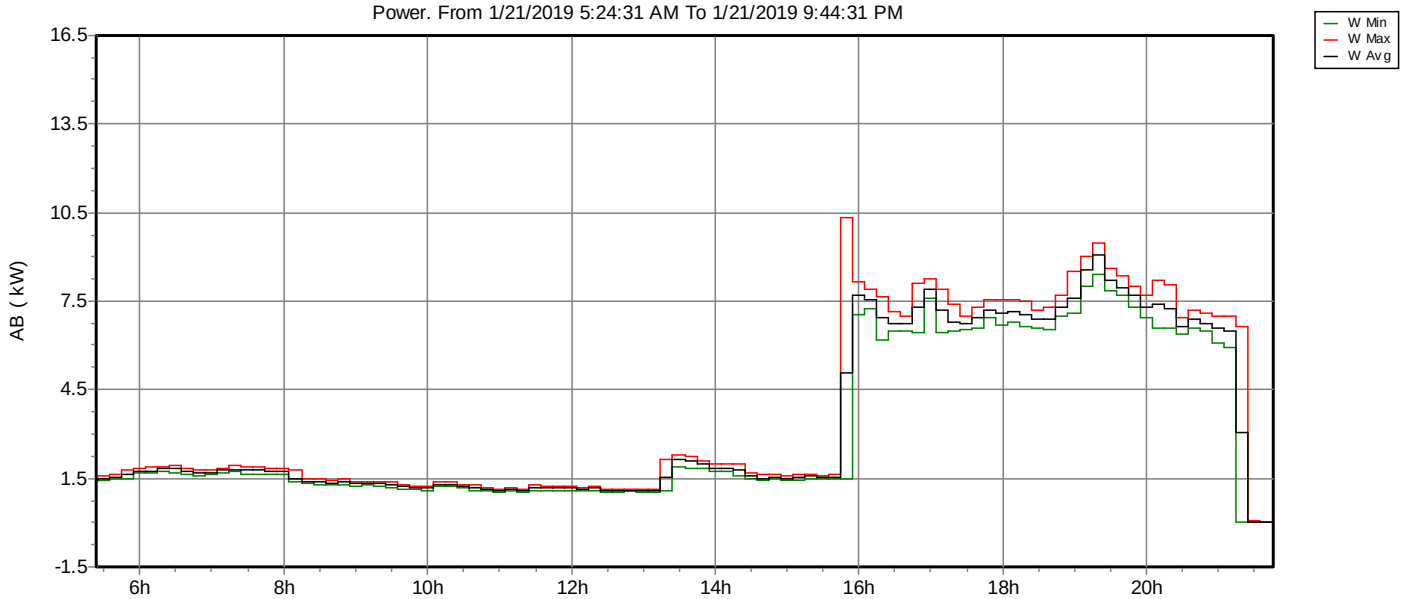


Flicker. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM

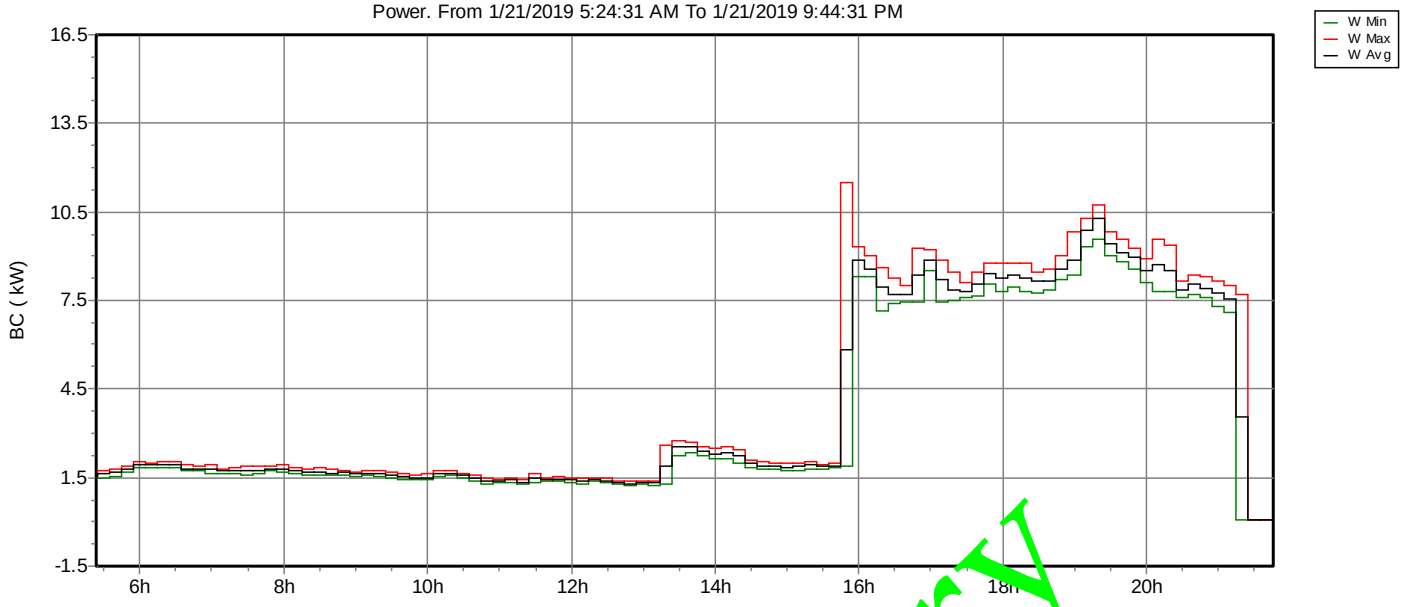
Flicker. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



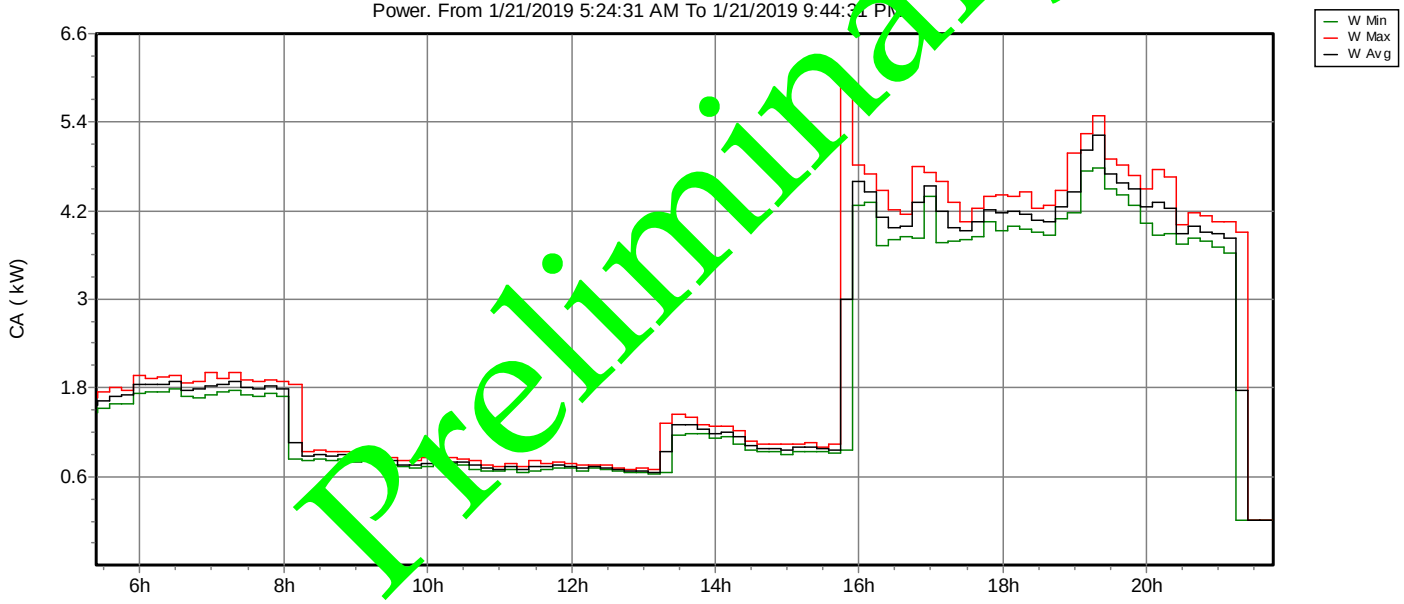
Power. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



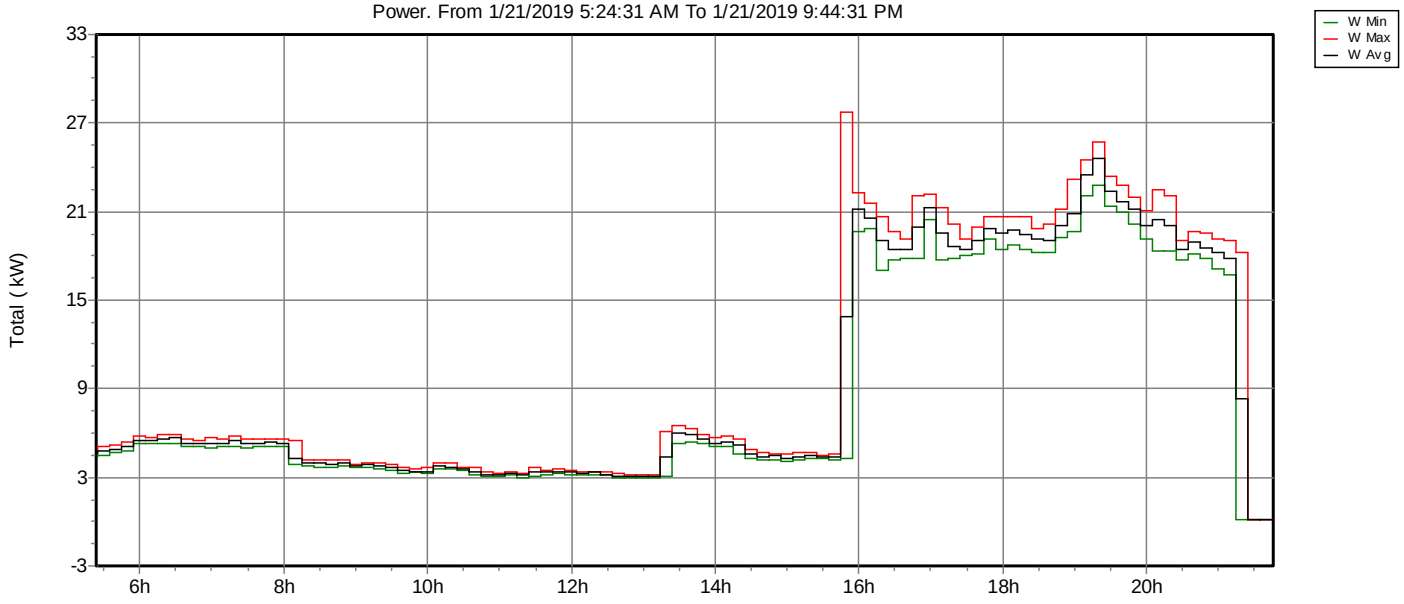
Power. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



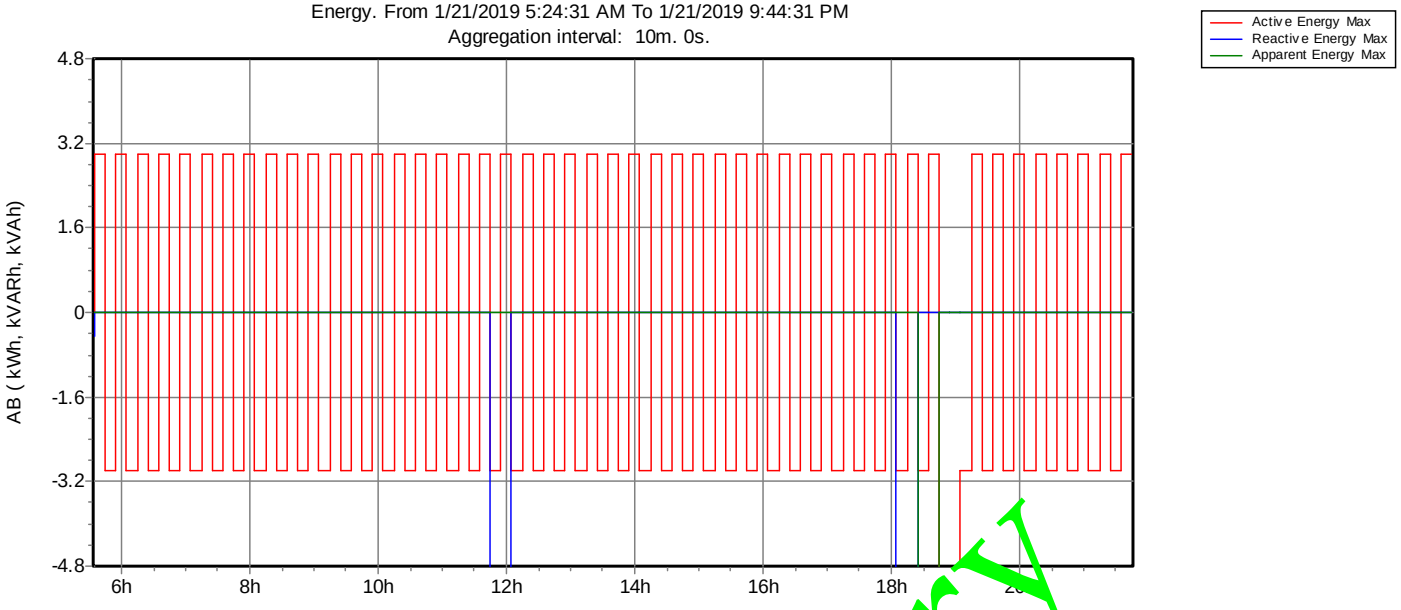
Power. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



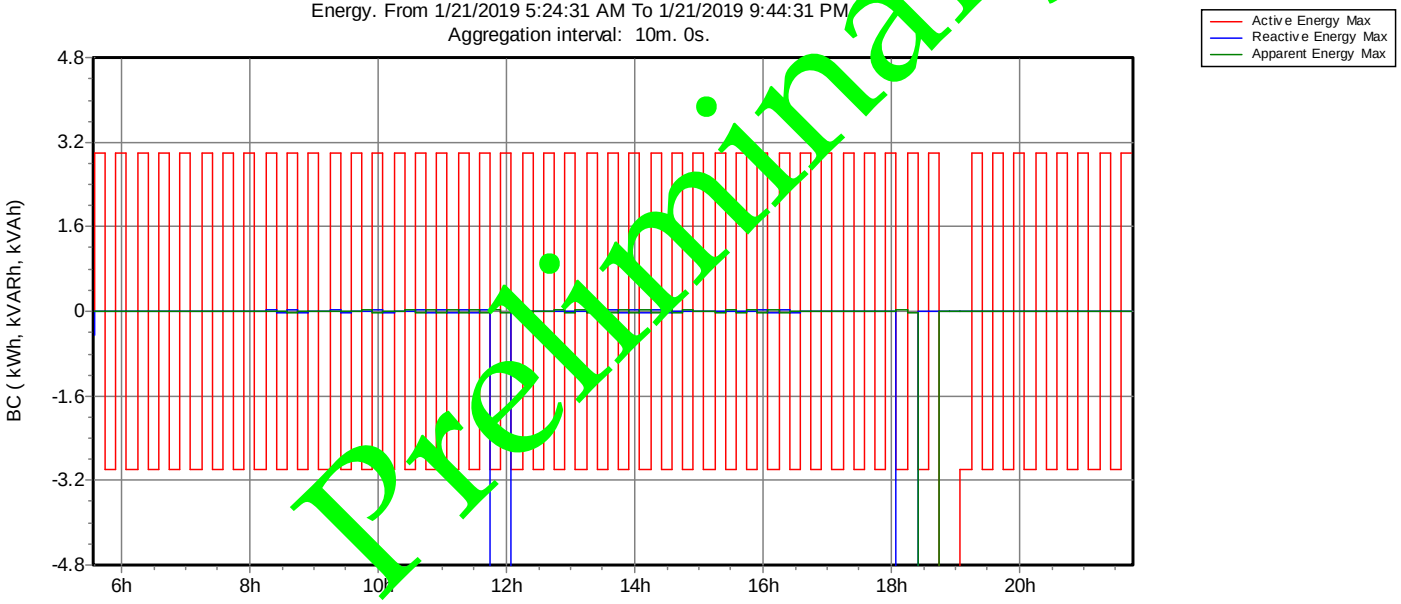
Power. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



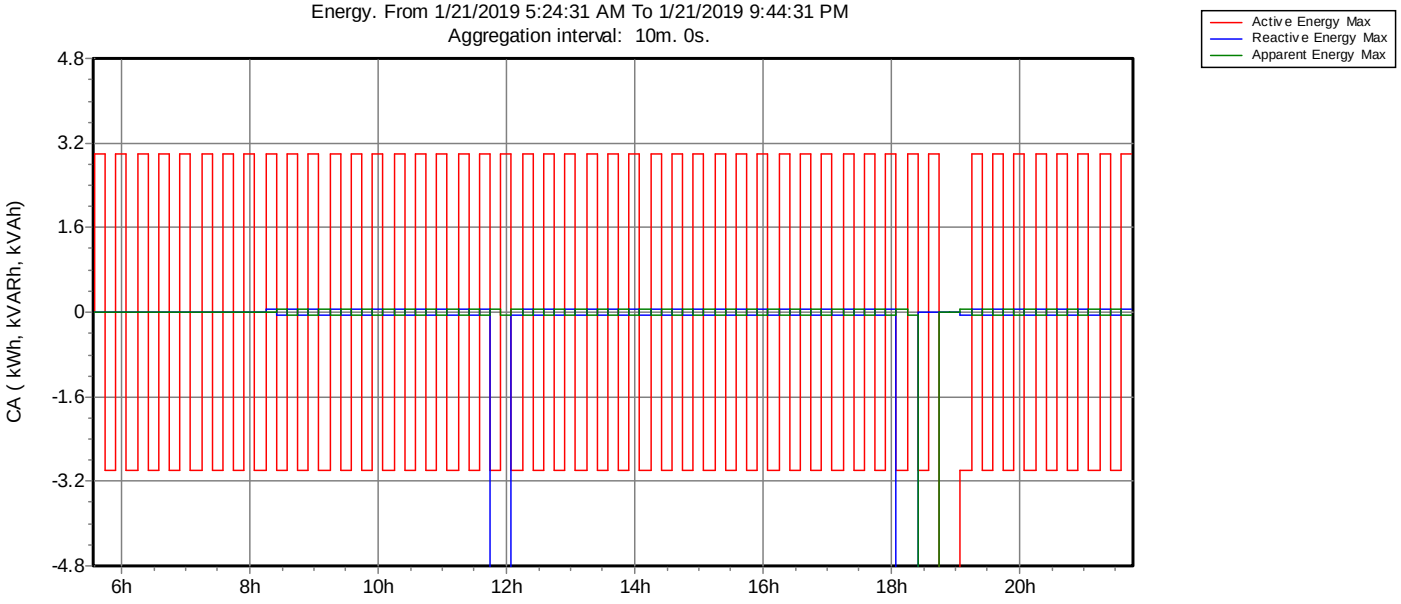
Energy. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM
Aggregation interval: 10m. 0s.



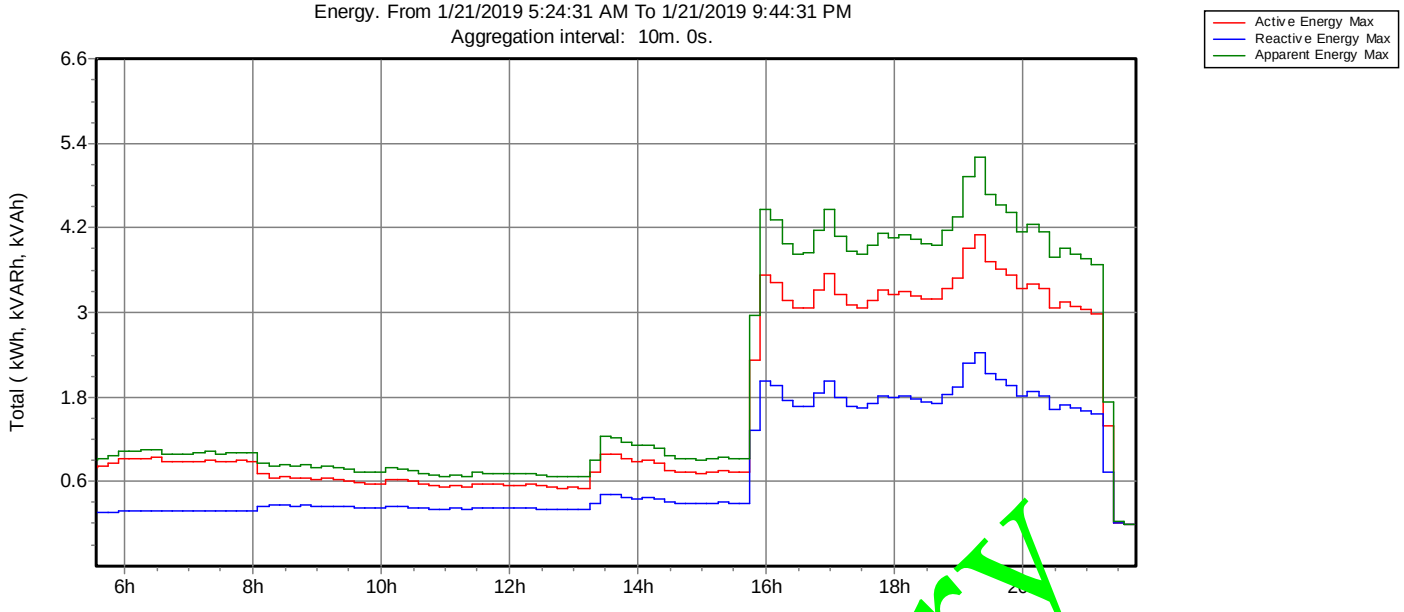
Energy. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM
Aggregation interval: 10m. 0s.



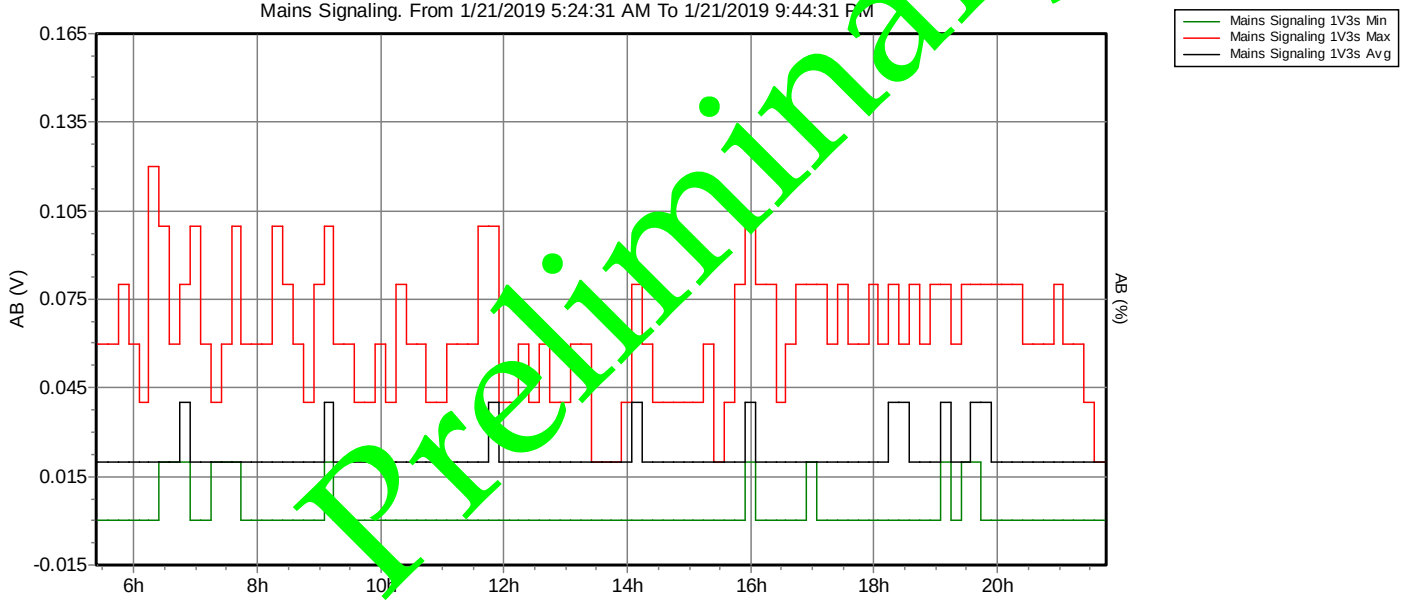
Energy. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM
Aggregation interval: 10m. 0s.



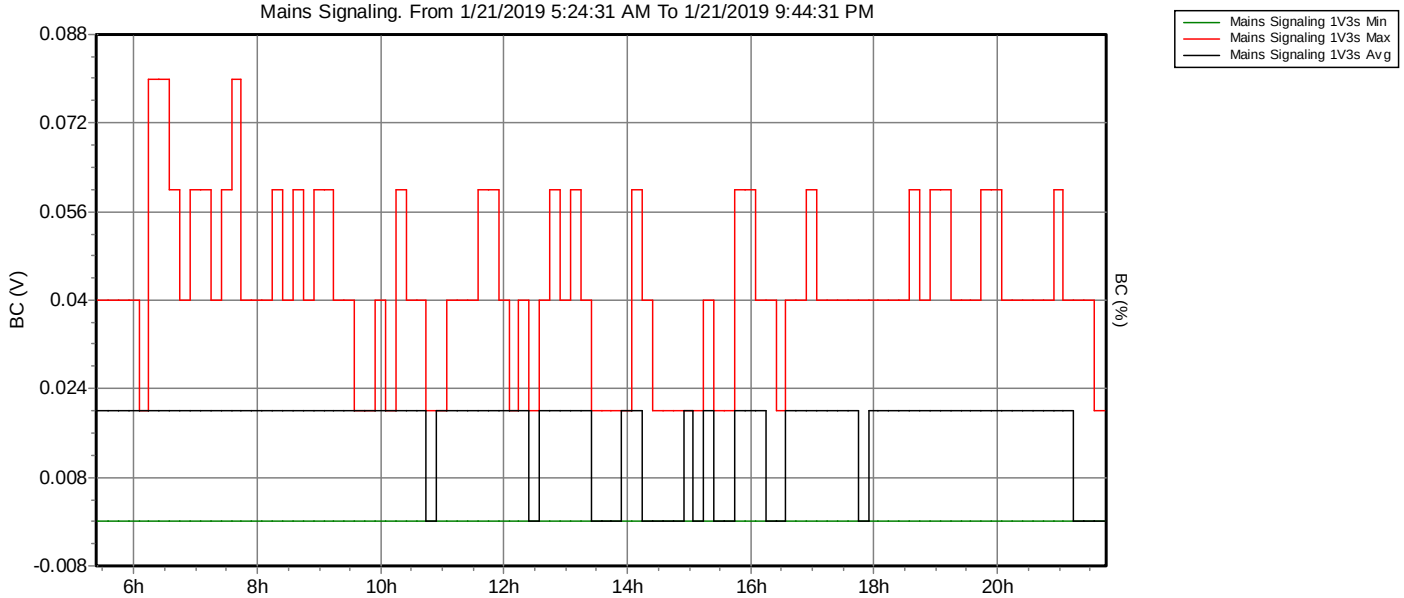
Energy. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM
Aggregation interval: 10m. 0s.



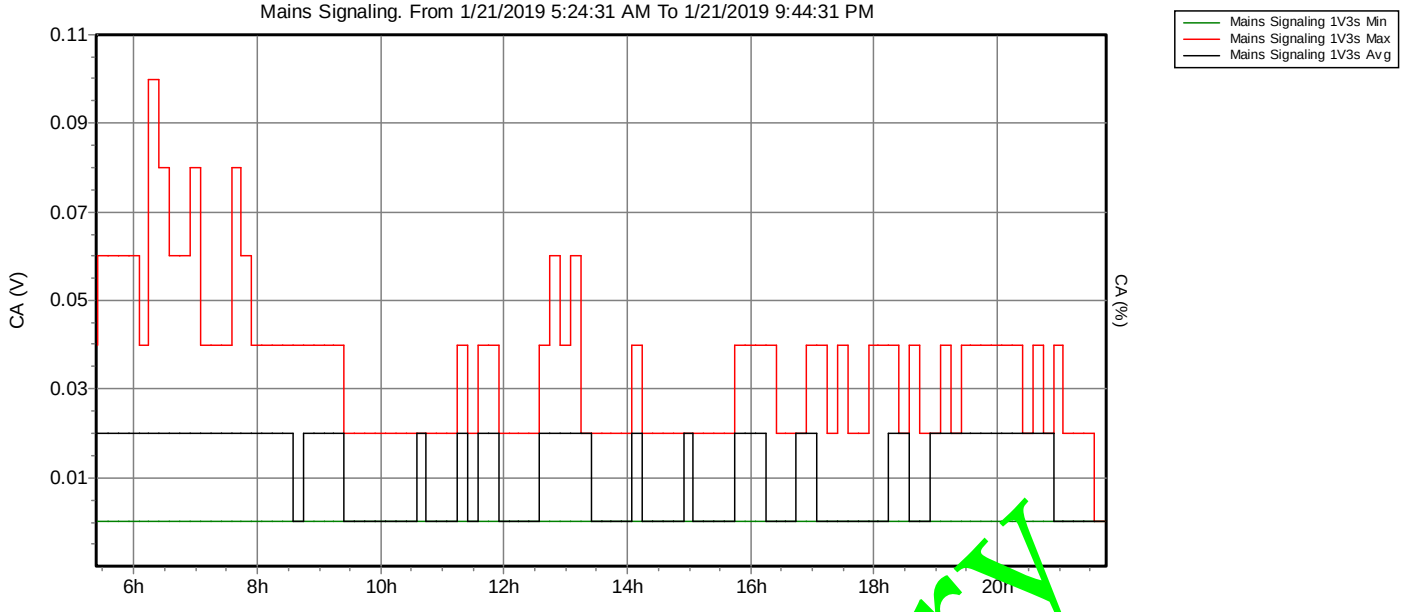
Mains Signaling. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



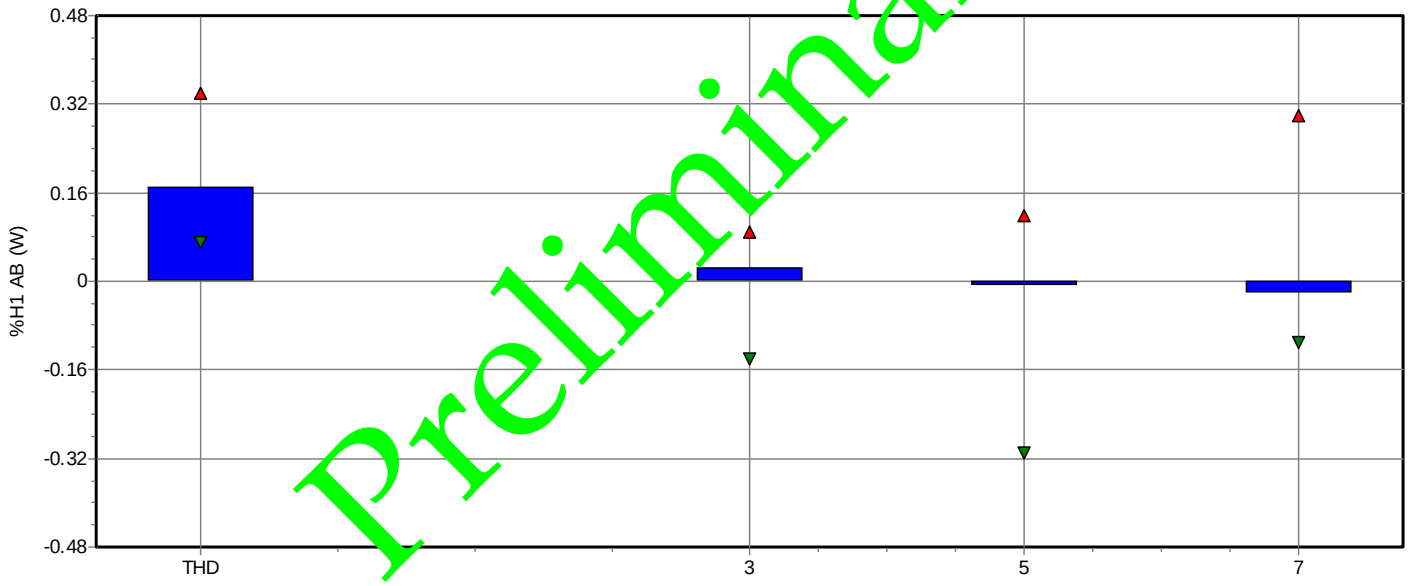
Mains Signaling. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



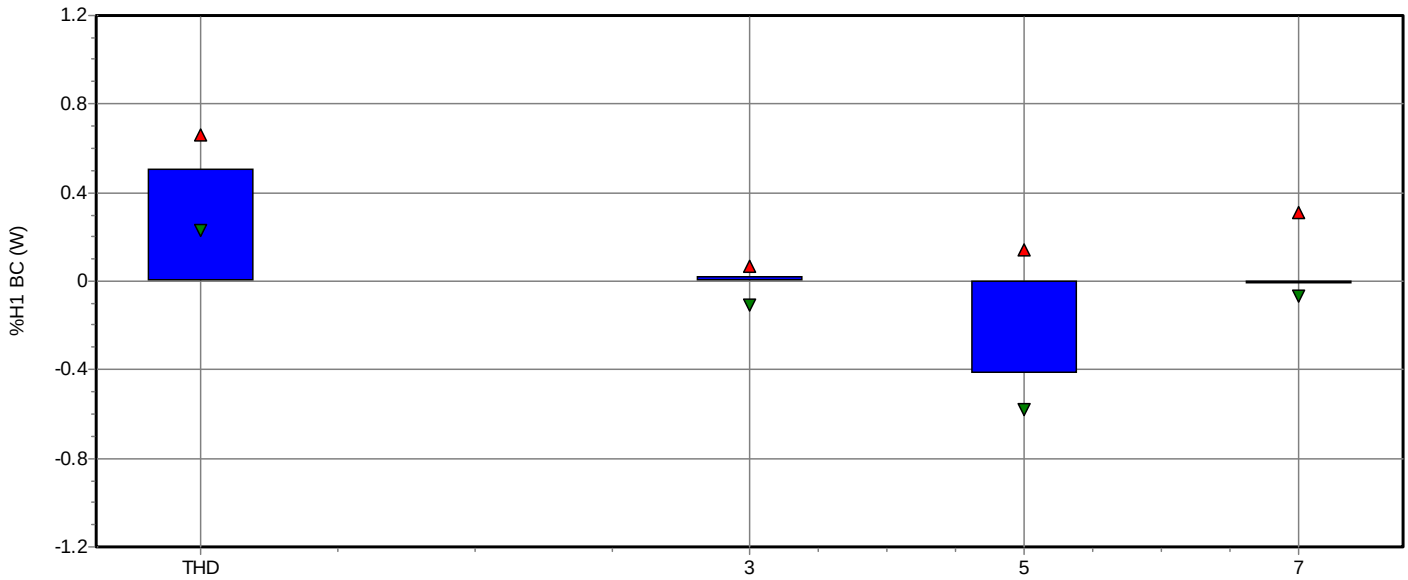
Mains Signaling. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



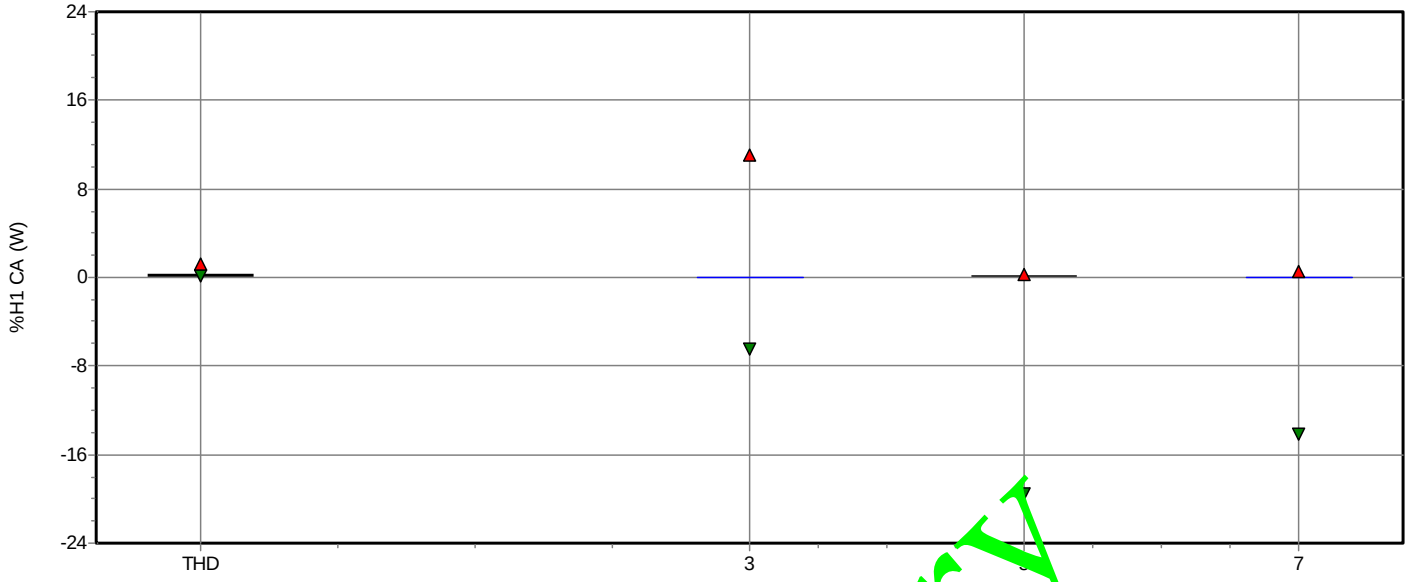
Power Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM

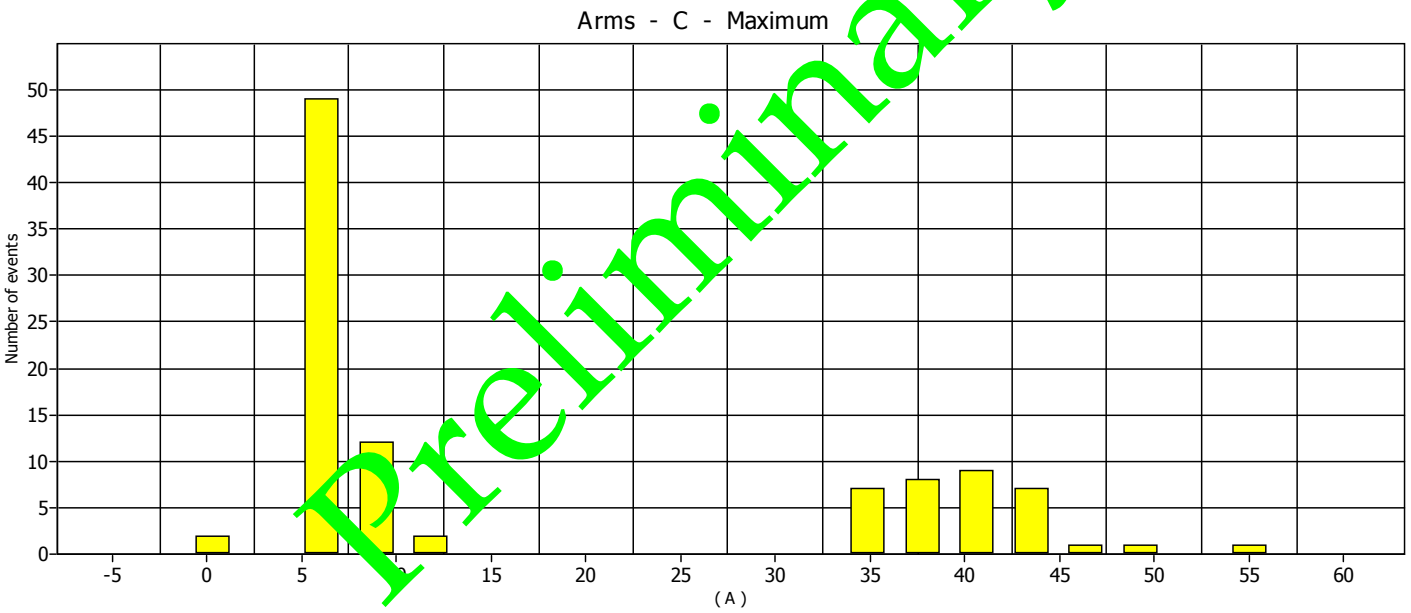


Power Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM



Power Harmonics. From 1/21/2019 5:24:31 AM To 1/21/2019 9:44:31 PM





Instrument Information

Model Number	435-II
Serial Number	41183106
Firmware Revision	V05.04

Software Information

Power Log Version	5.4
FLUKE 430-II DLL Version	1.2.0.13

General Information

Recording location	FEEDER VFD-2
Client	MAYNILAD CHERRY IN LINE PUMP STATION
Notes	Naval Base Heracleo Alano Sangley Point Cavite City

Measurement Summary

Measurement topology	3-element delta mode
Application mode	Logger
First recording	11/29/2018 2:47:07 PM 168msec
Last recording	11/30/2018 12:57:07 AM 168msec
Recording interval	0h 10m 0s 0msec
Nominal Voltage	460 V
Nominal Current	100 A
Nominal Frequency	60 Hz
File start time	11/29/2018 2:37:07 PM 168msec
File end time	11/30/2018 12:57:07 AM 168msec
Duration	0d 10h 20m 0s 0msec
Number of events	Normal: 0 Detailed: 0
Events downloaded	No
Number of screens	1
Screens downloaded	Yes
Power measurement method	Unified
Cable type	Copper
Harmonic scale	%H1
THD mode	THD 40
CosPhi / DPF mode	DPF

Scaling

Phase:	
Current Clamp type	i4[illegible]7F
Clamp range	N/A
Nominal range	100 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1
Neutral:	
Current Clamp type	i430Flex
Clamp range	N/A
Nominal range	100 A
Sensitivity	x10 AC only
Current ratio	1:1
Voltage ratio	1:1

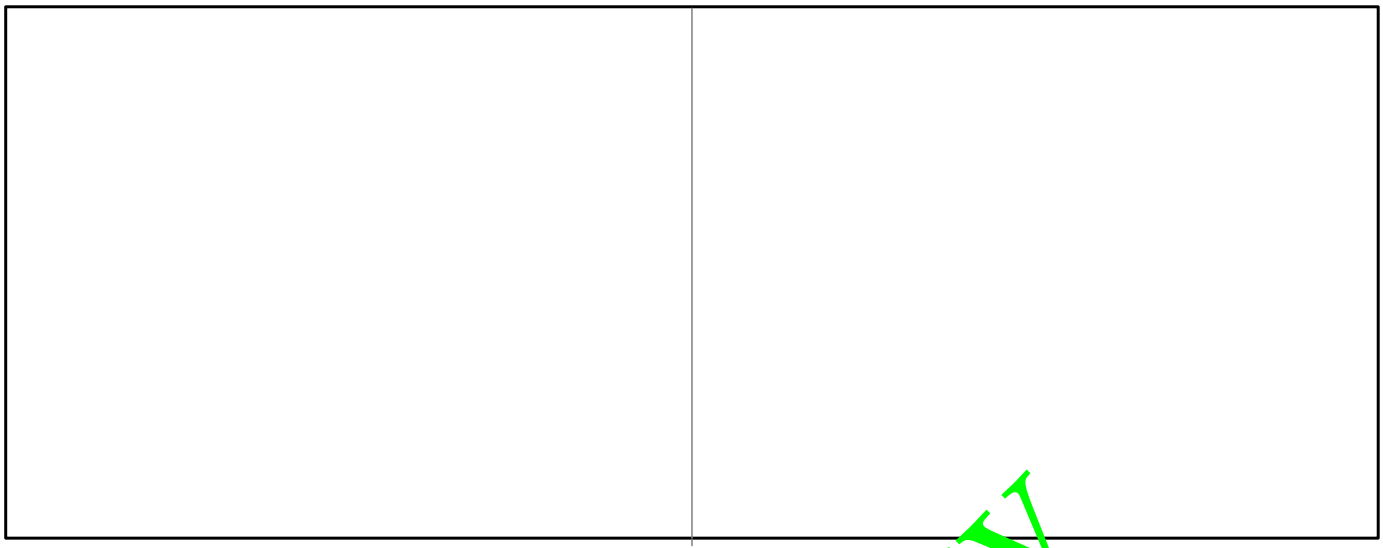
Recording Summary

RMS recordings	62
DC recordings	0
Frequency recordings	62
Unbalance recordings	62
Harmonic recordings	62
Power harmonic recordings	62
Power recordings	62
Power unbalance recordings	0
Energy recordings	62
Energy losses recordings	0
Flicker recordings	62
Mains signaling recordings	62

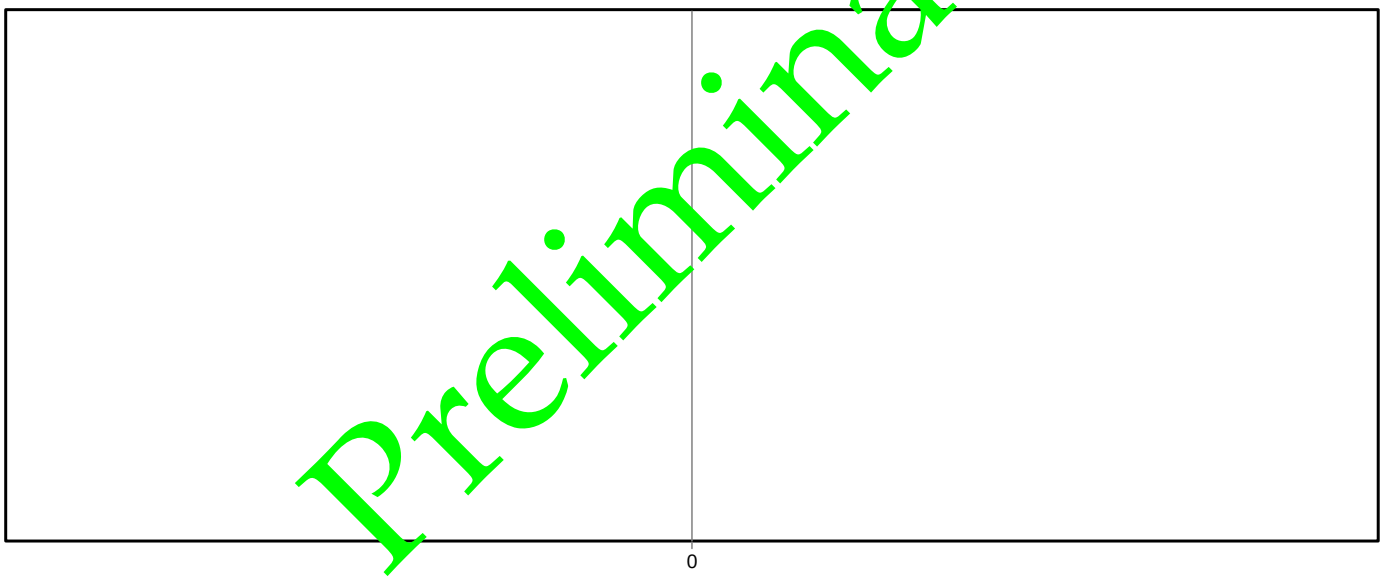
Events Summary

Dips	0
Swells	0
Transients	0
Interruptions	0
Voltage profiles	0
Rapid voltage changes	0
Screens	1
Waveforms	0
Intervals without measurements	0
Inrush current graphics	0
Wave events	0
RMS events	0

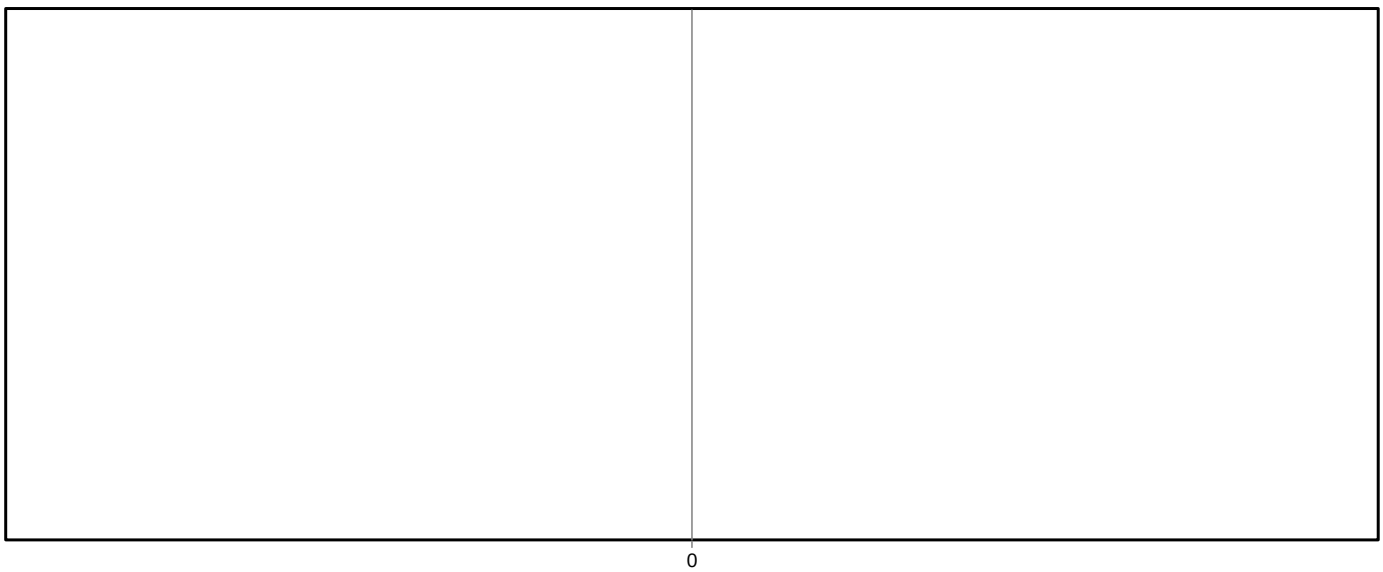
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



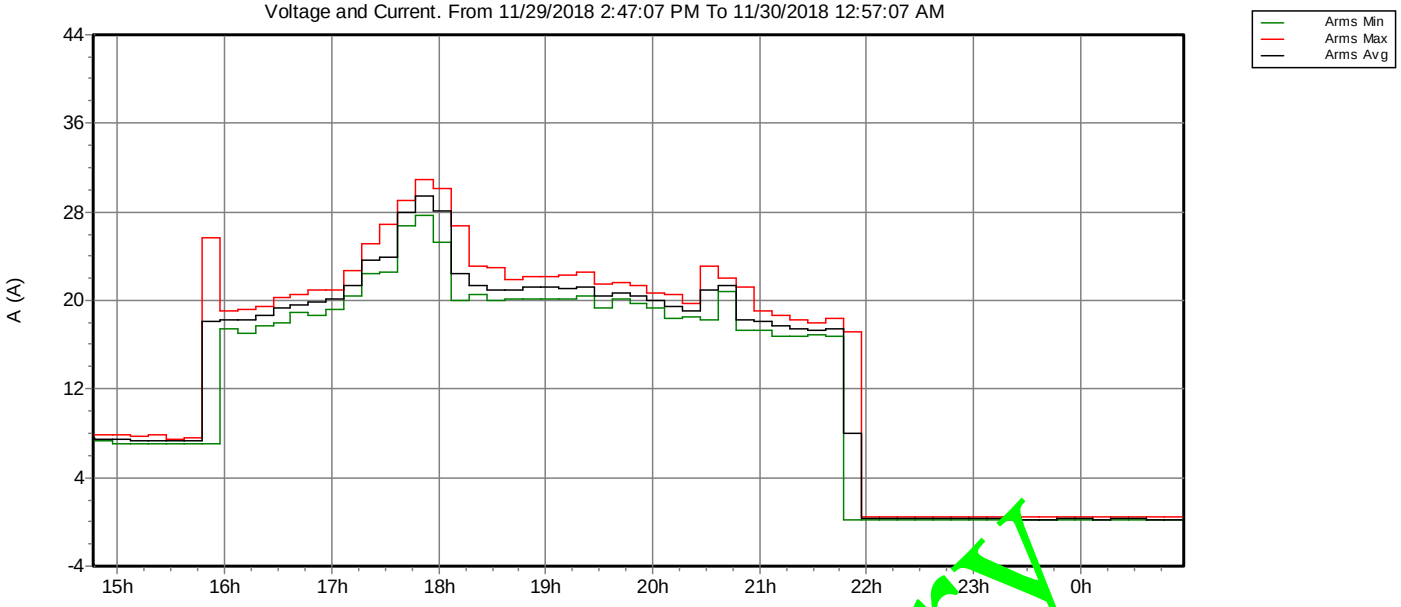
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



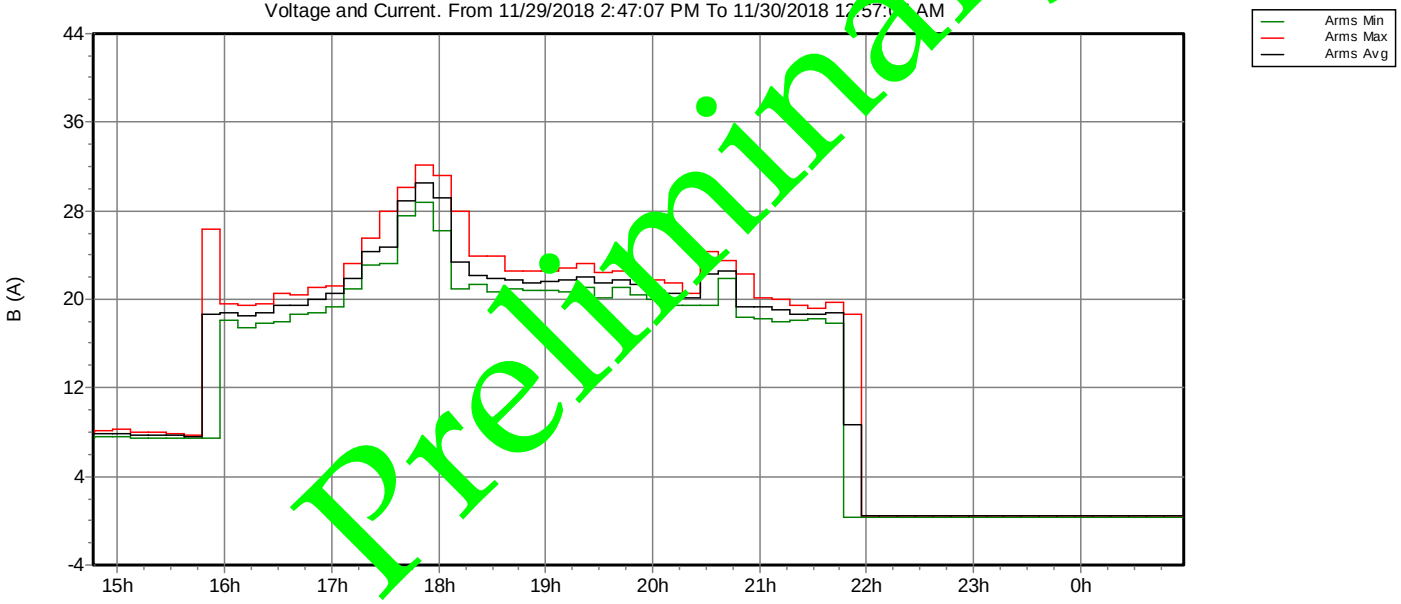
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



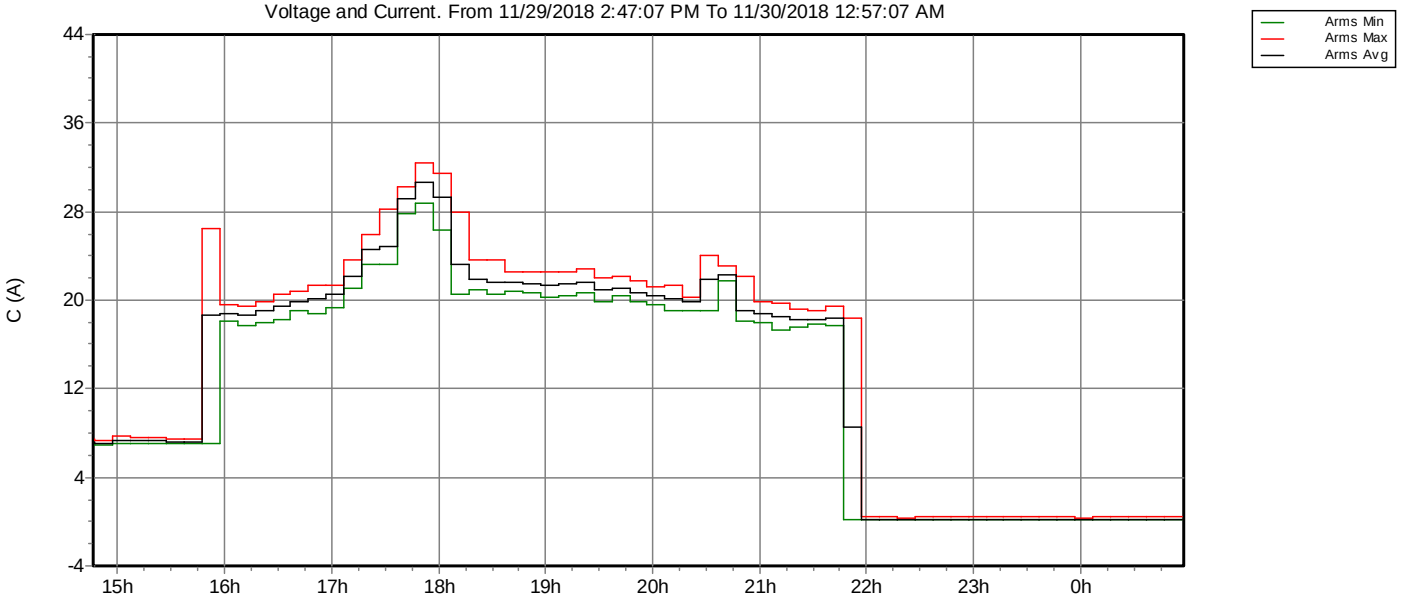
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



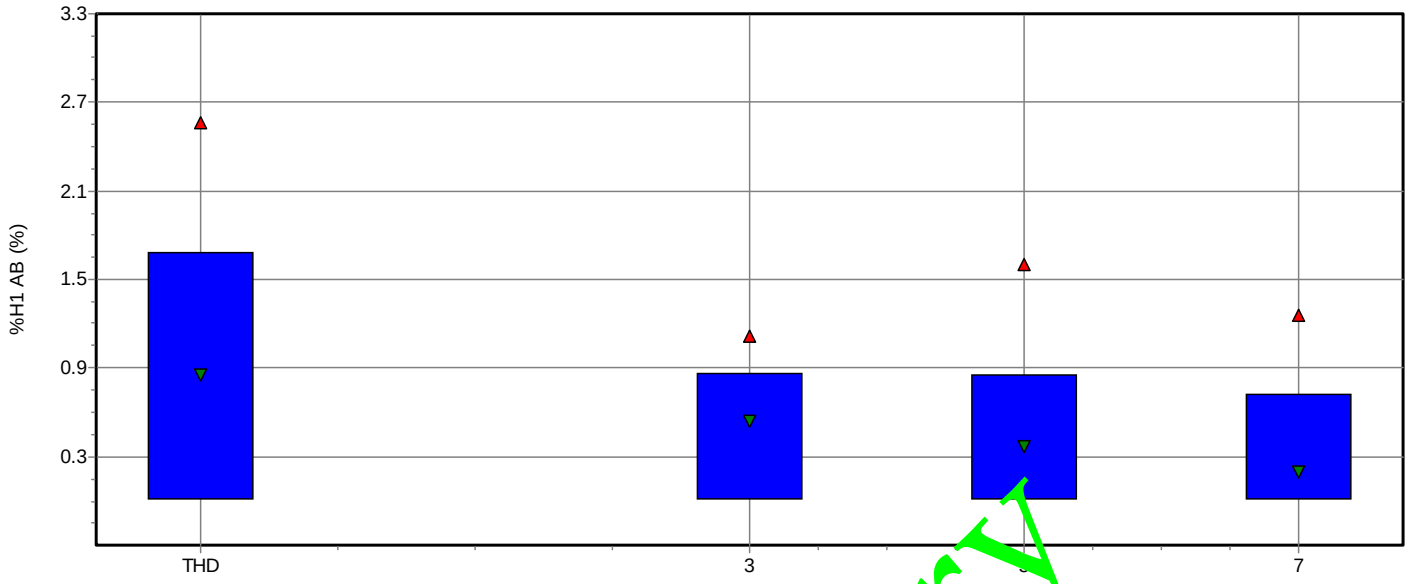
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



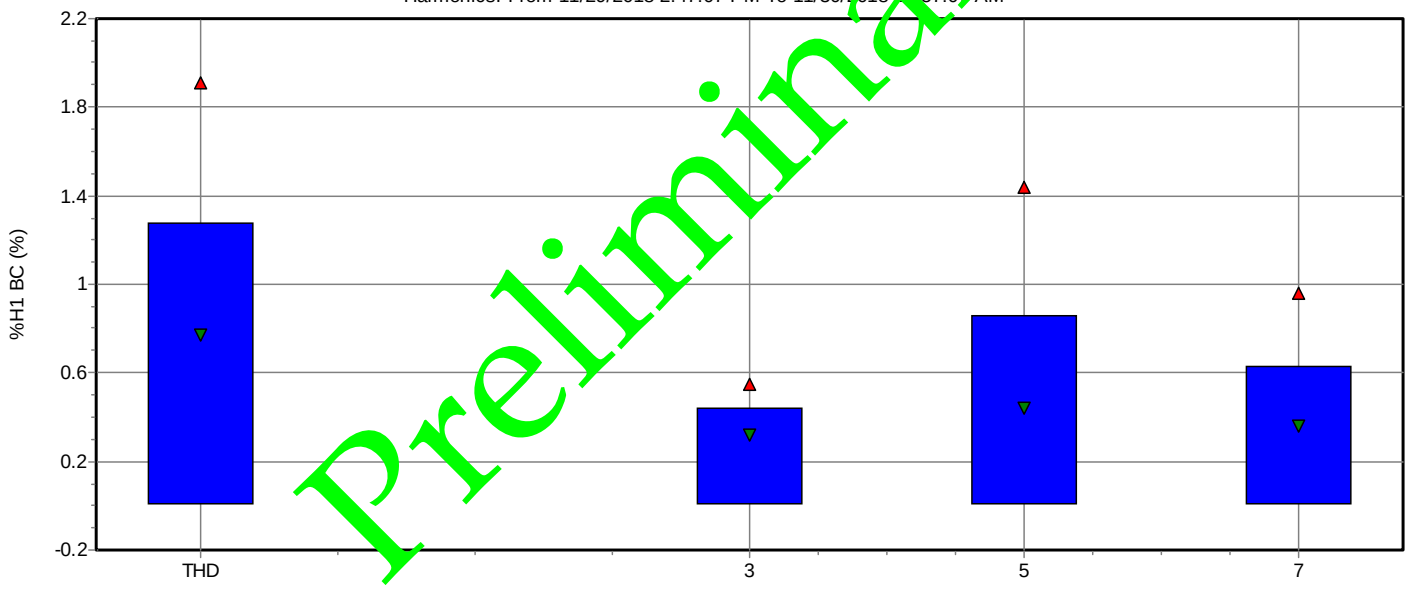
Voltage and Current. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



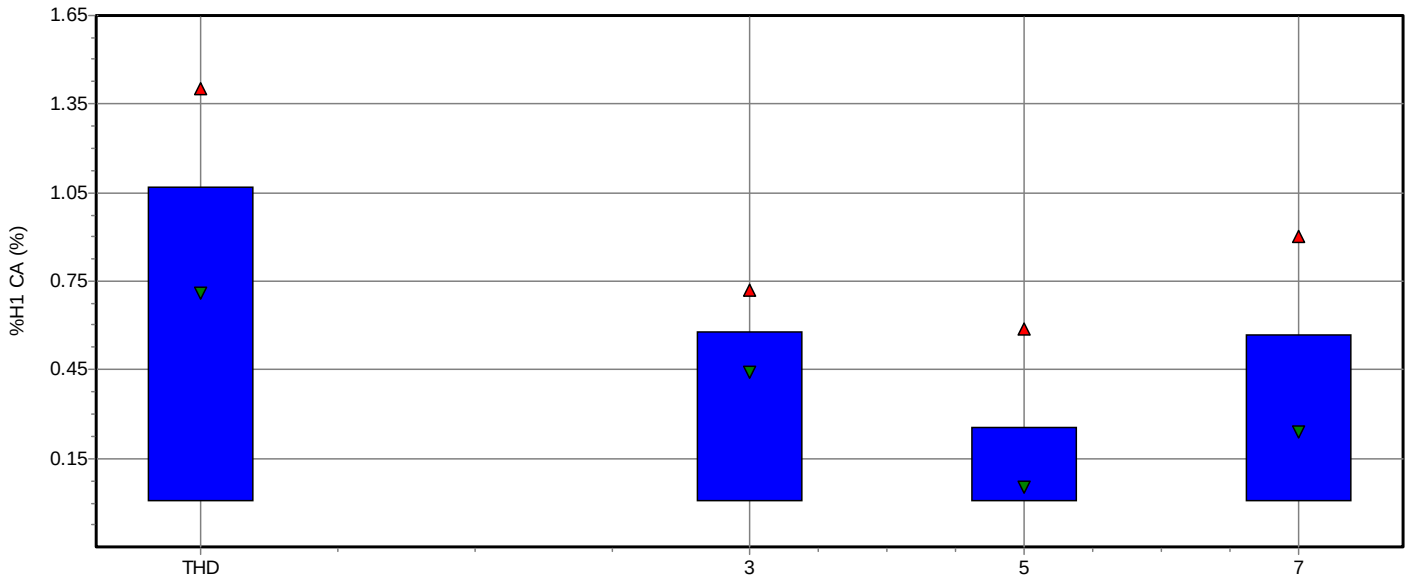
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



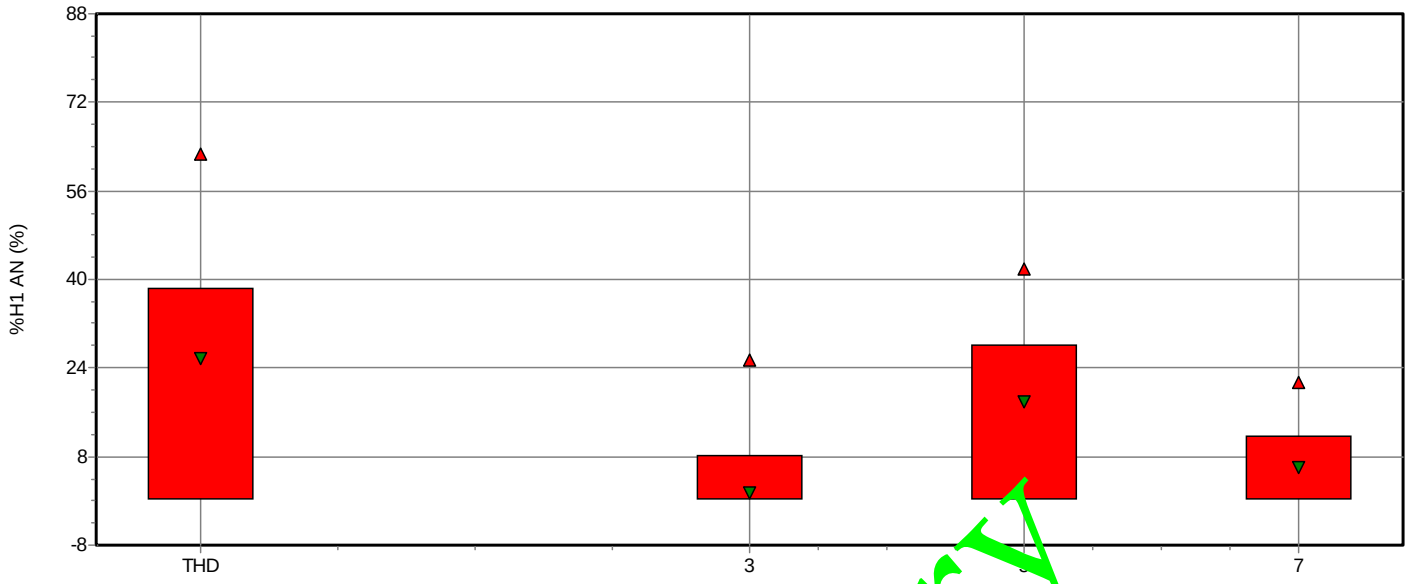
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



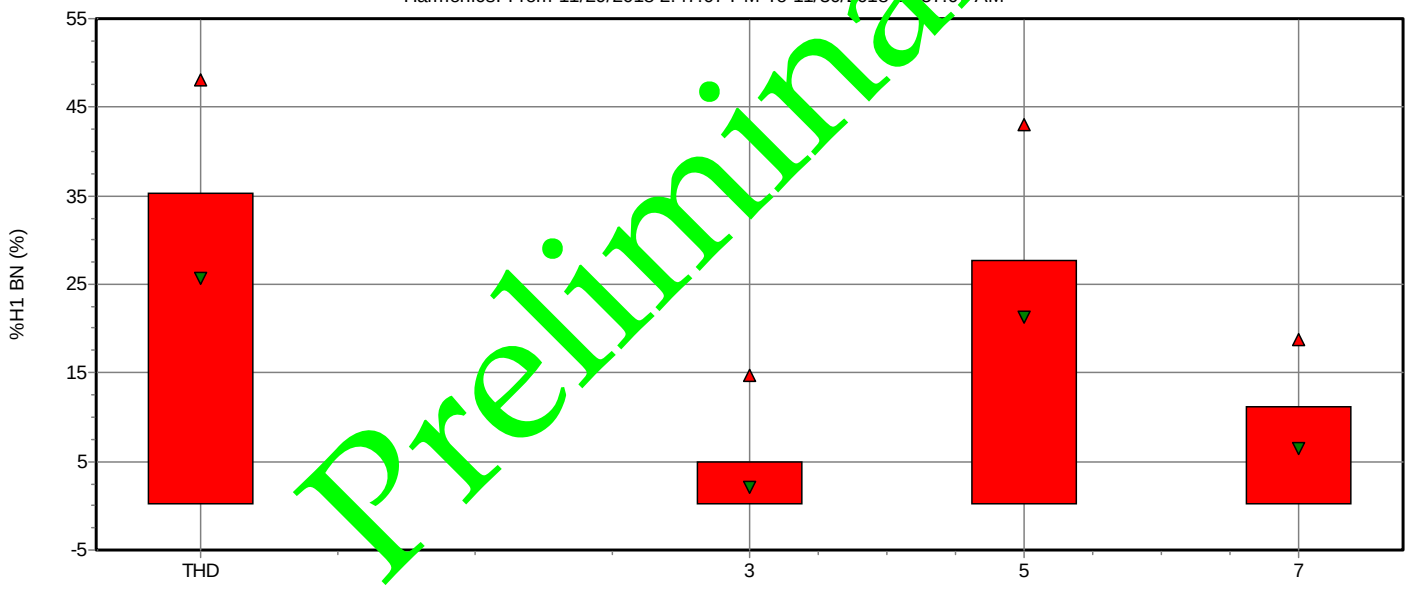
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM



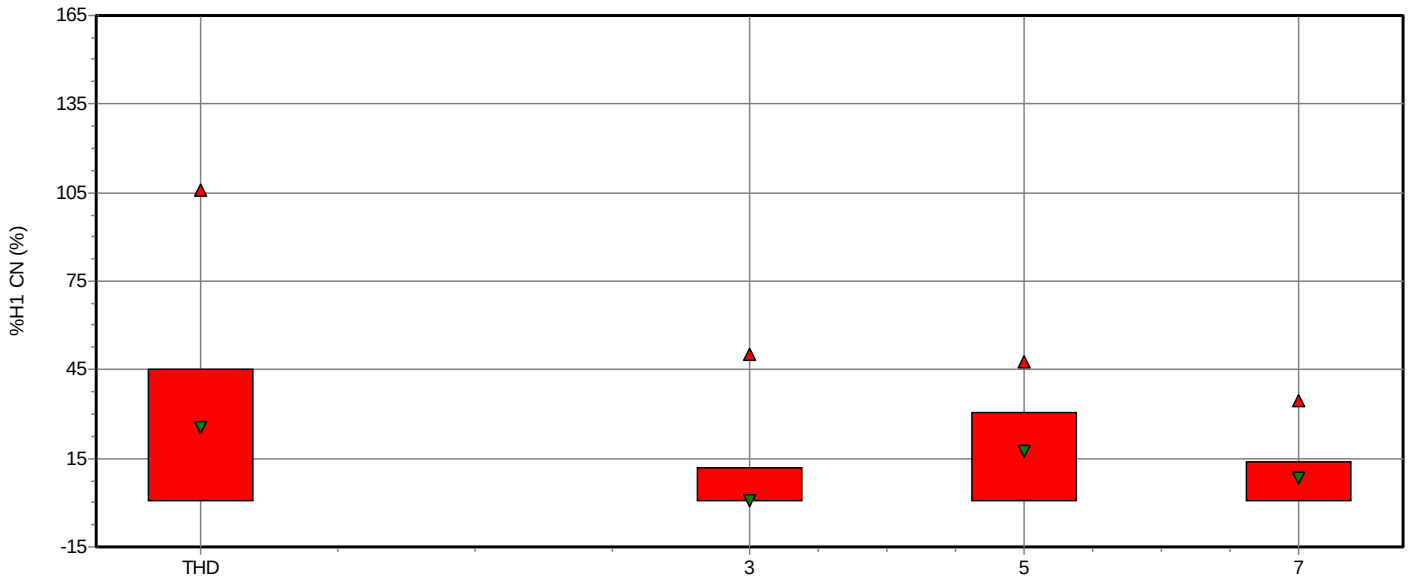
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM

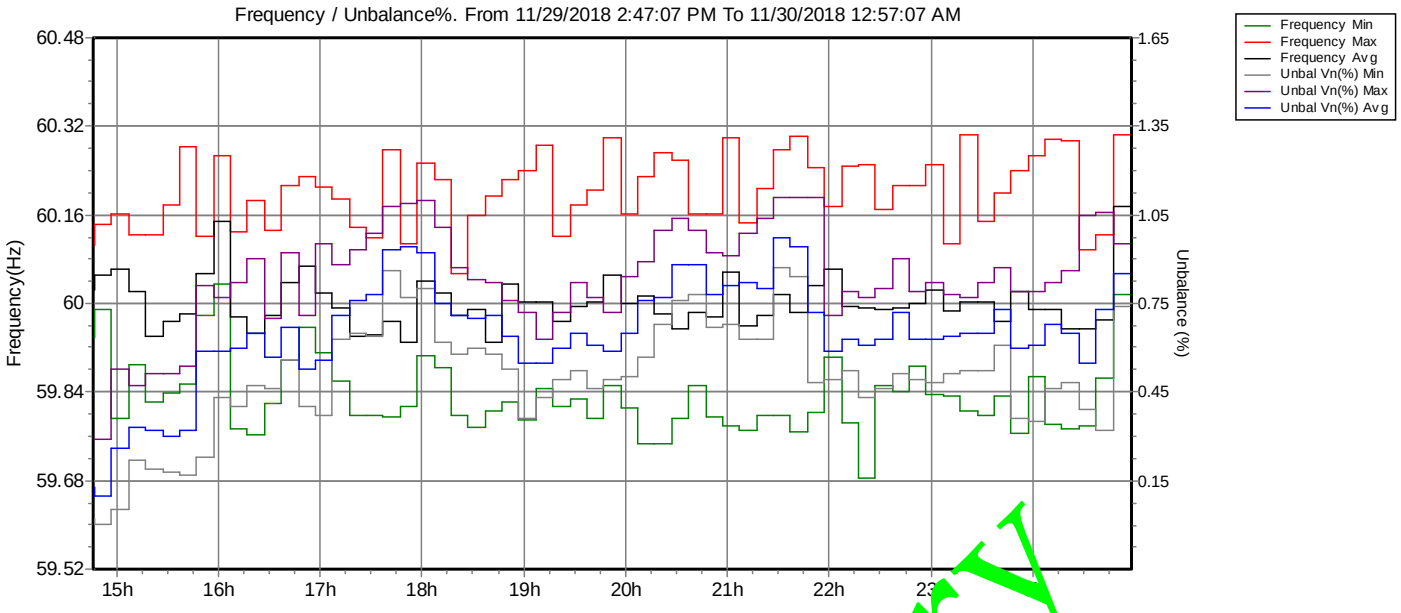


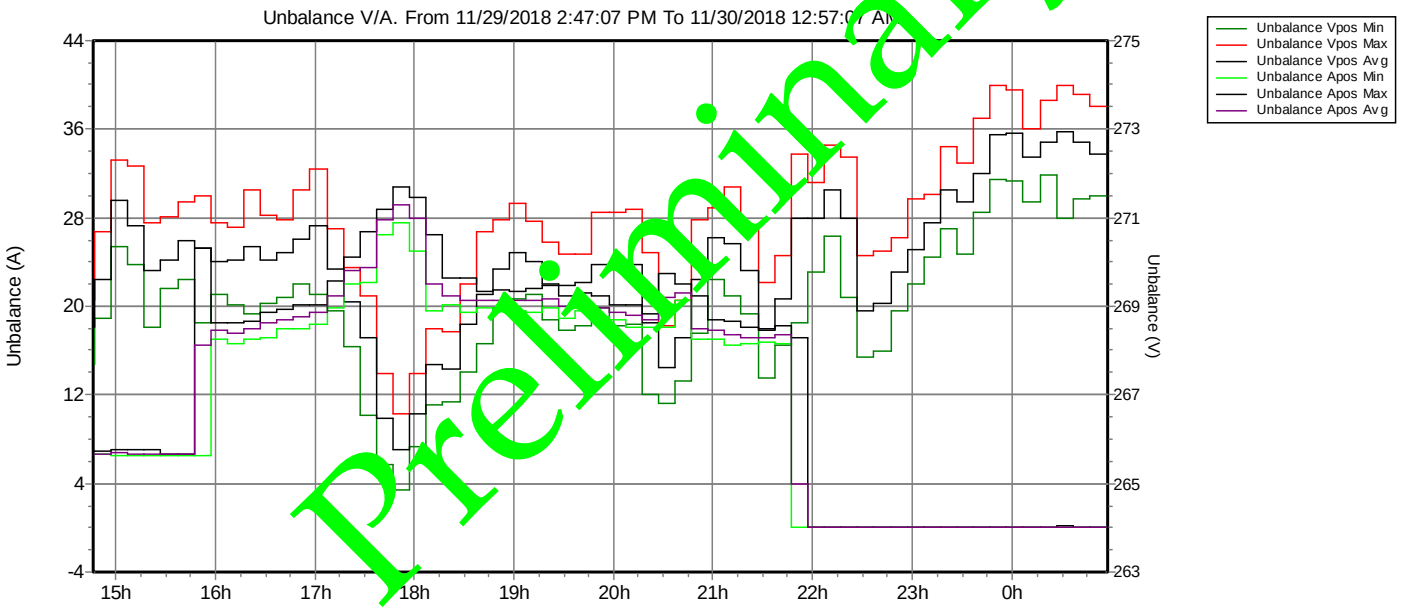
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM

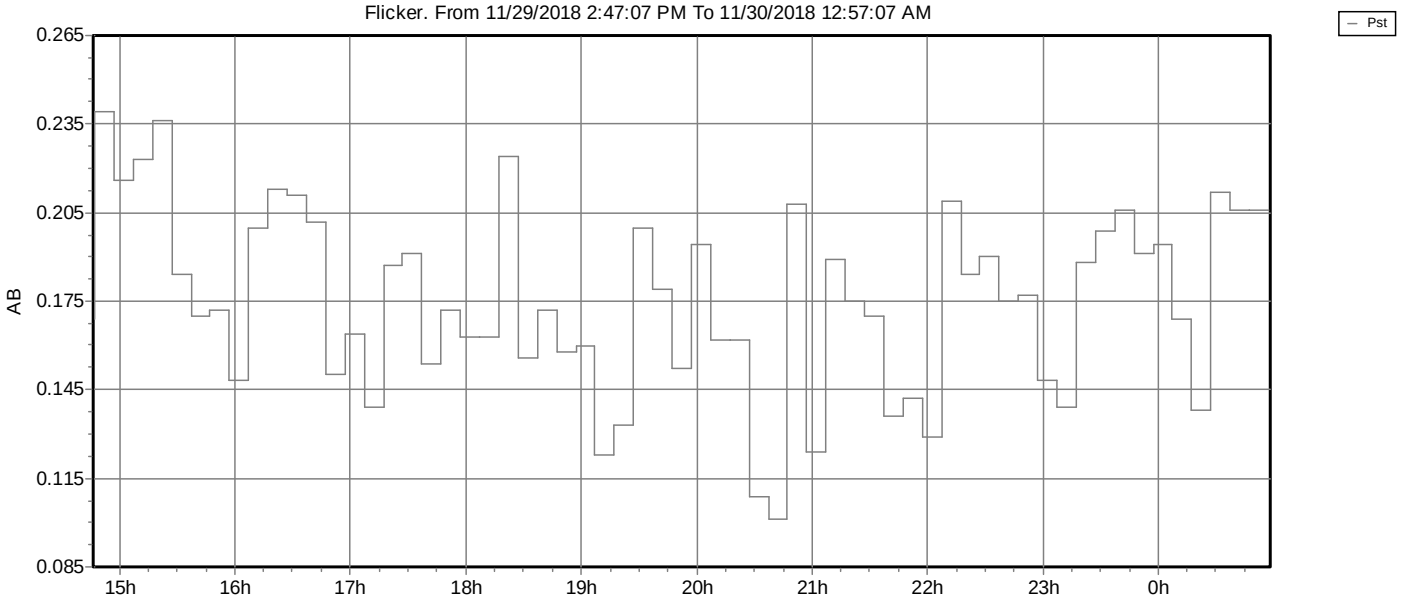


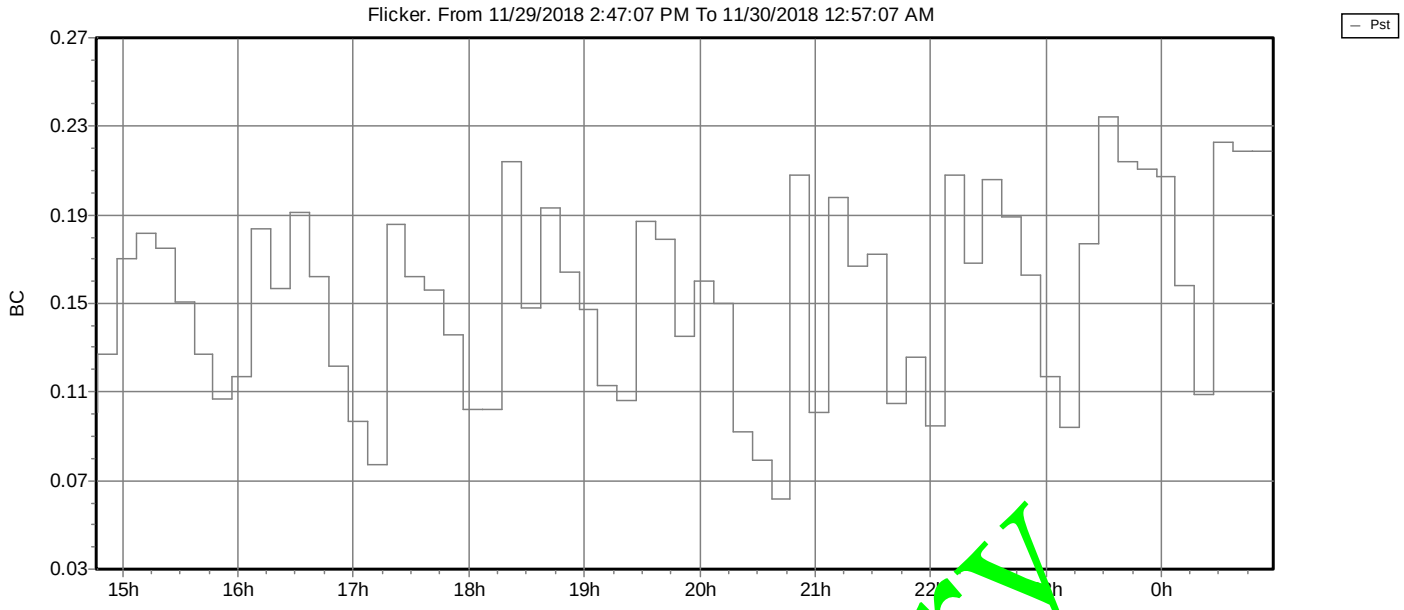
Harmonics. From 11/29/2018 2:47:07 PM To 11/30/2018 12:57:07 AM

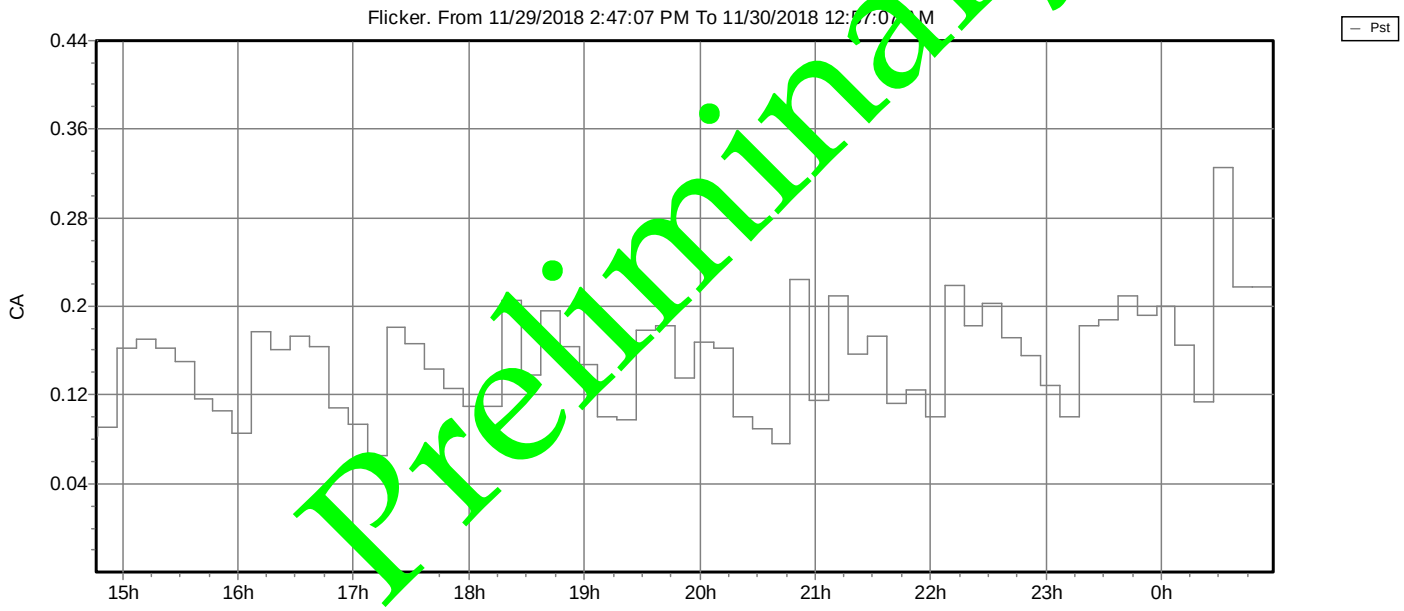


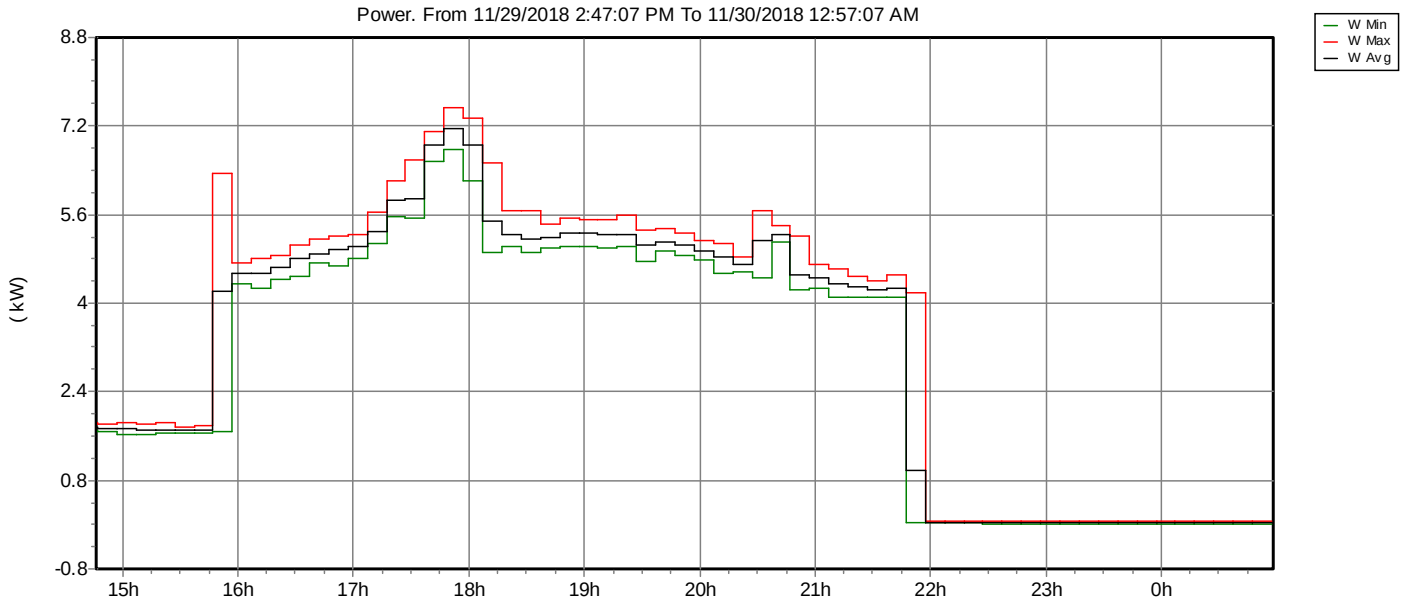


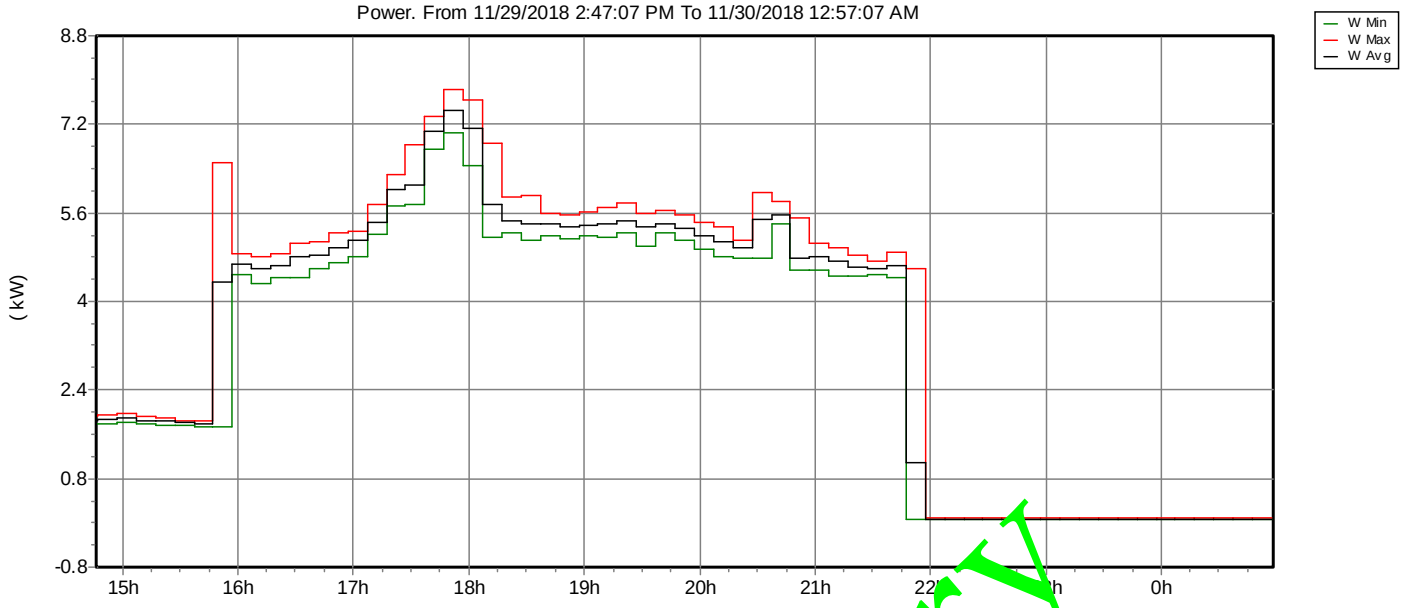


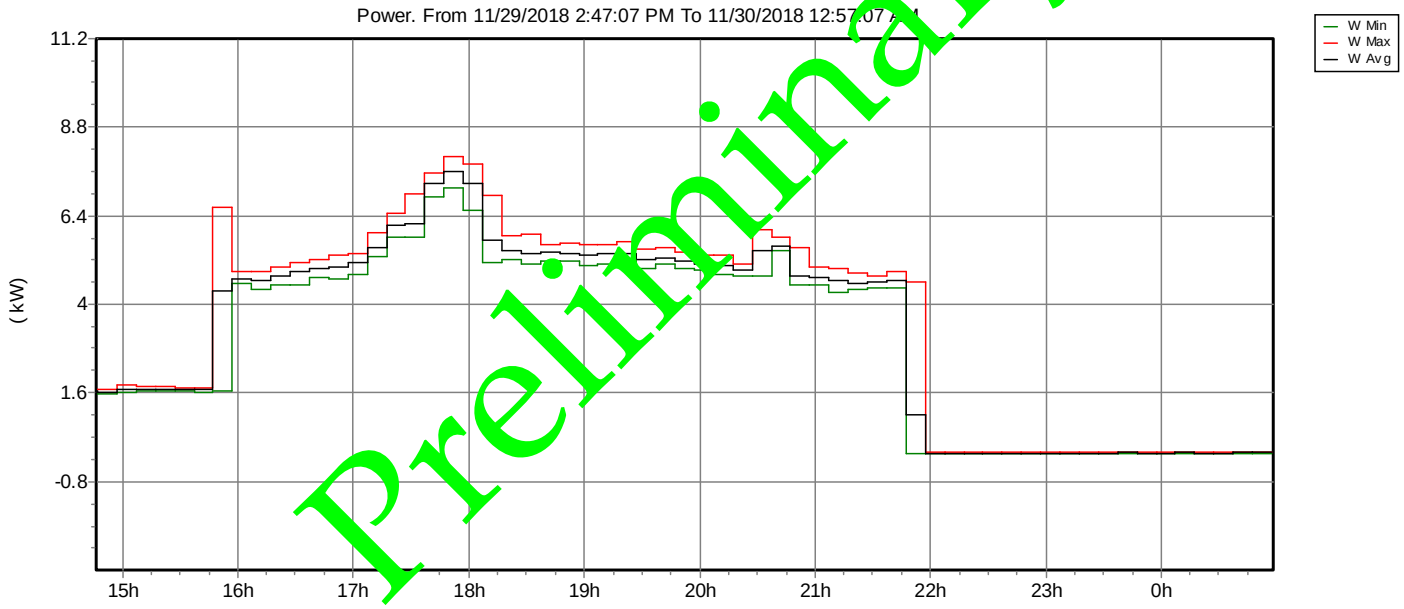


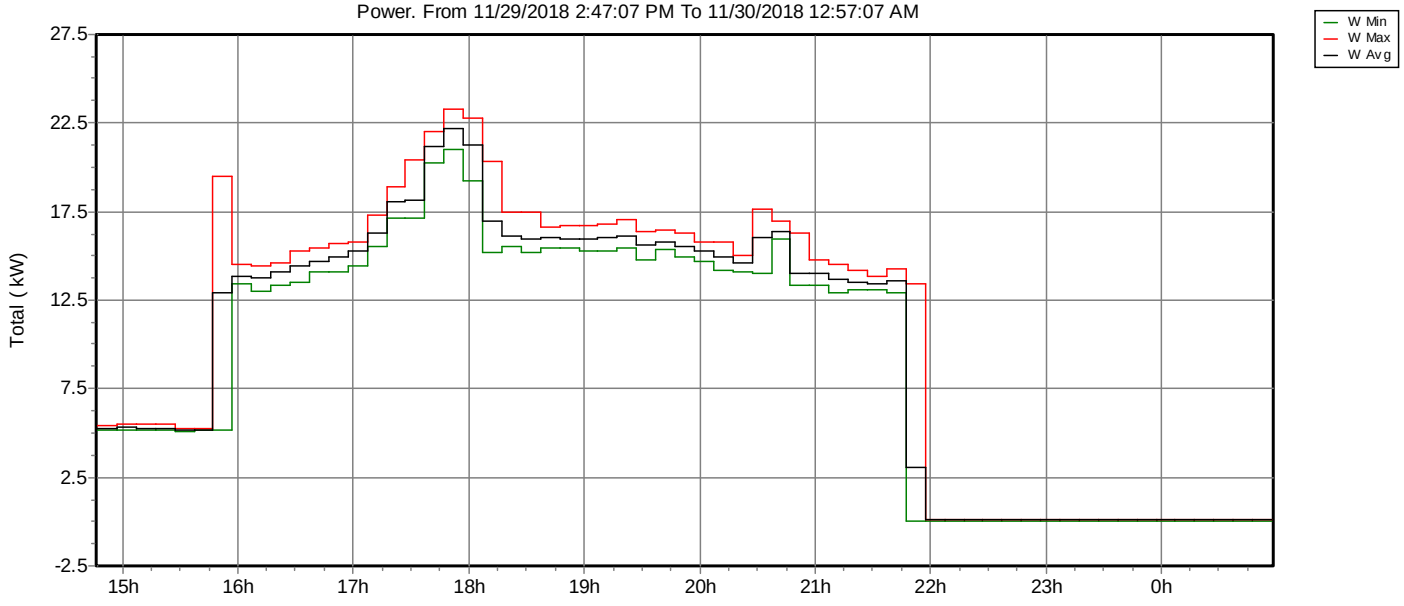


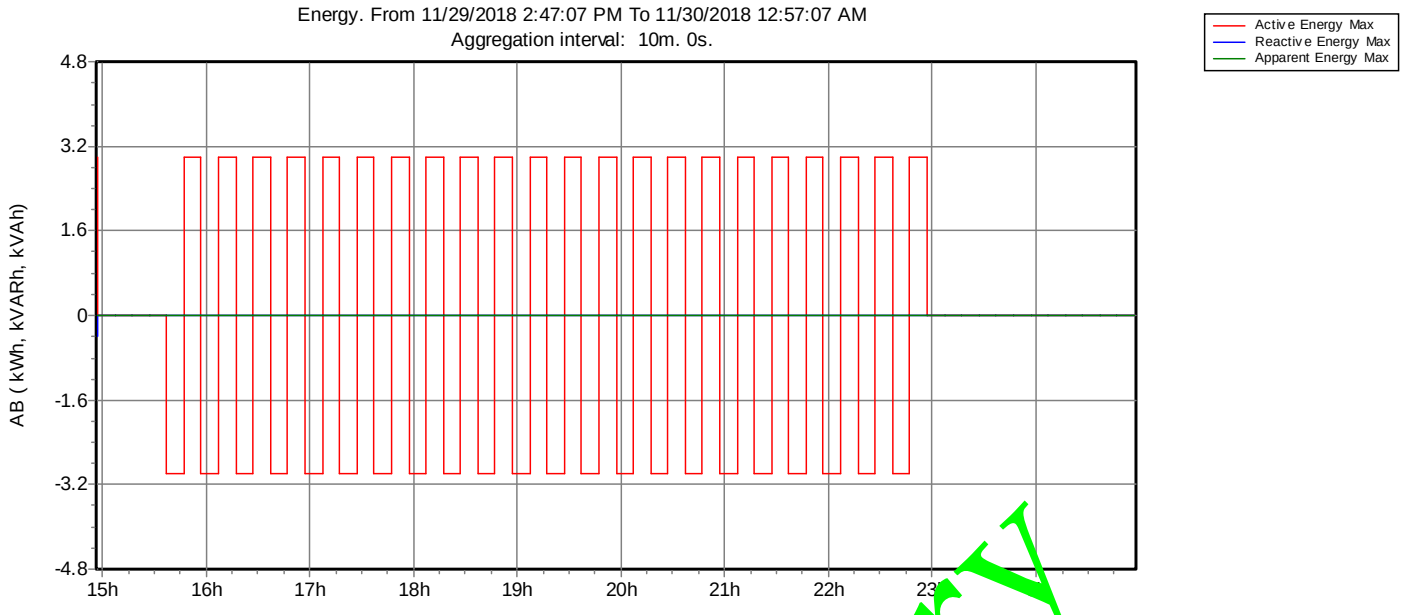


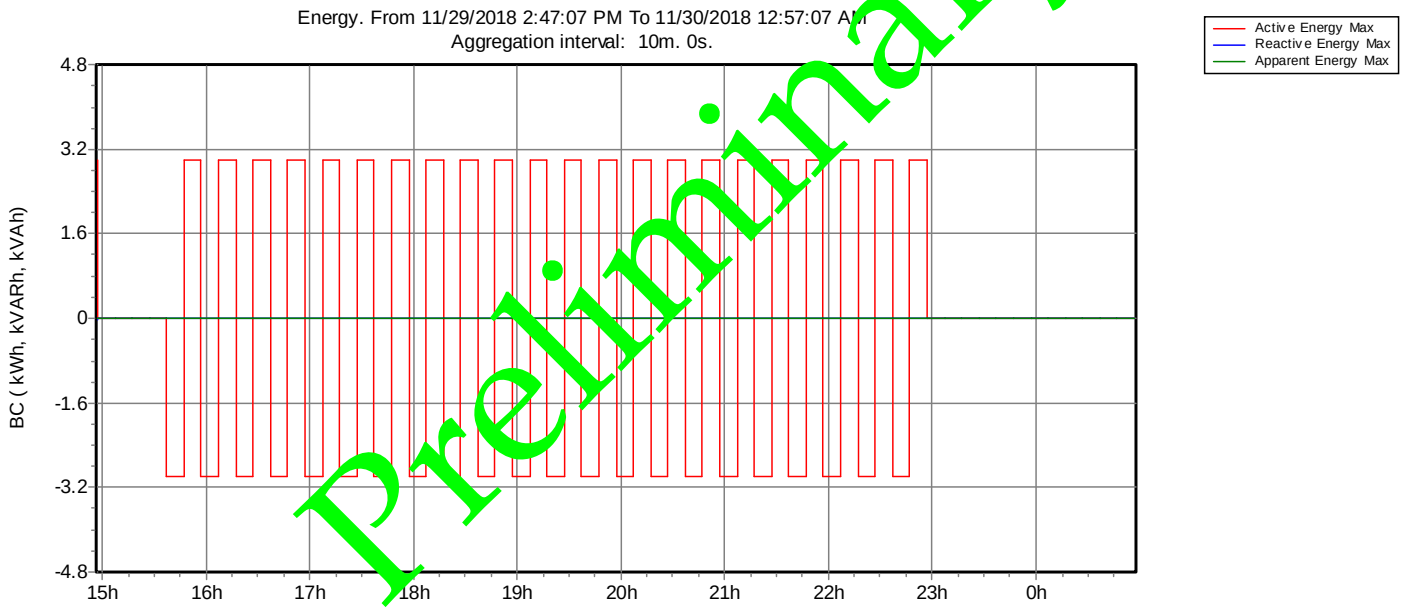


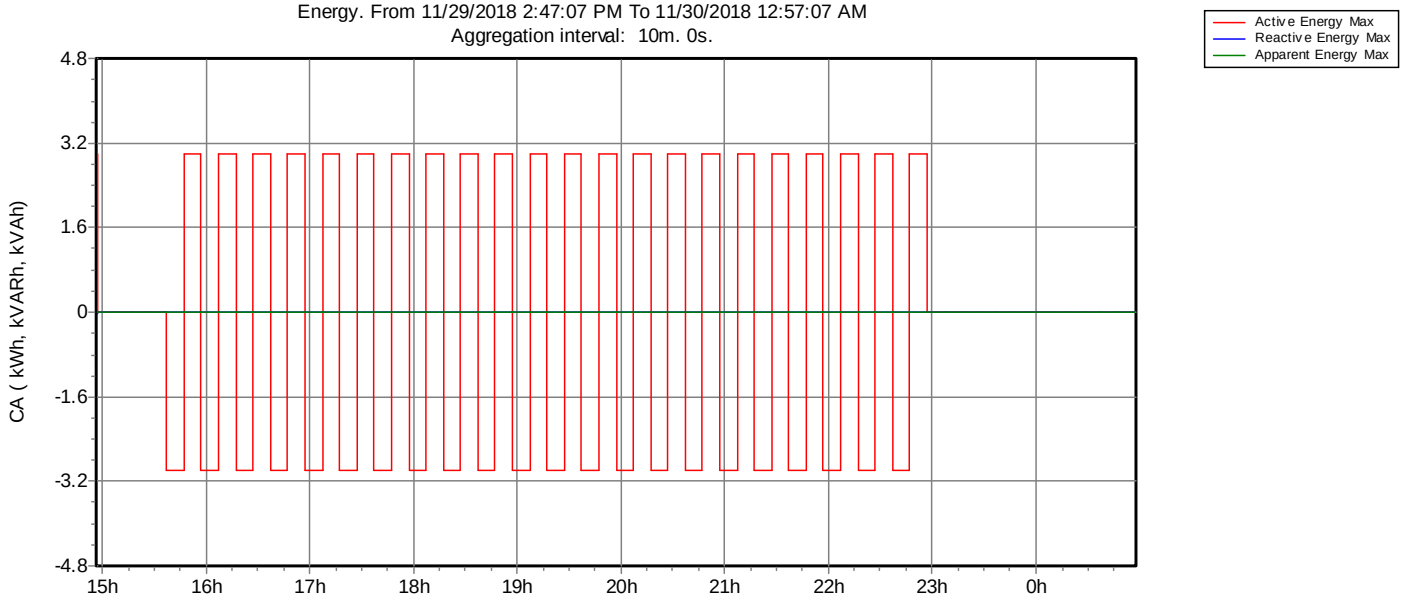


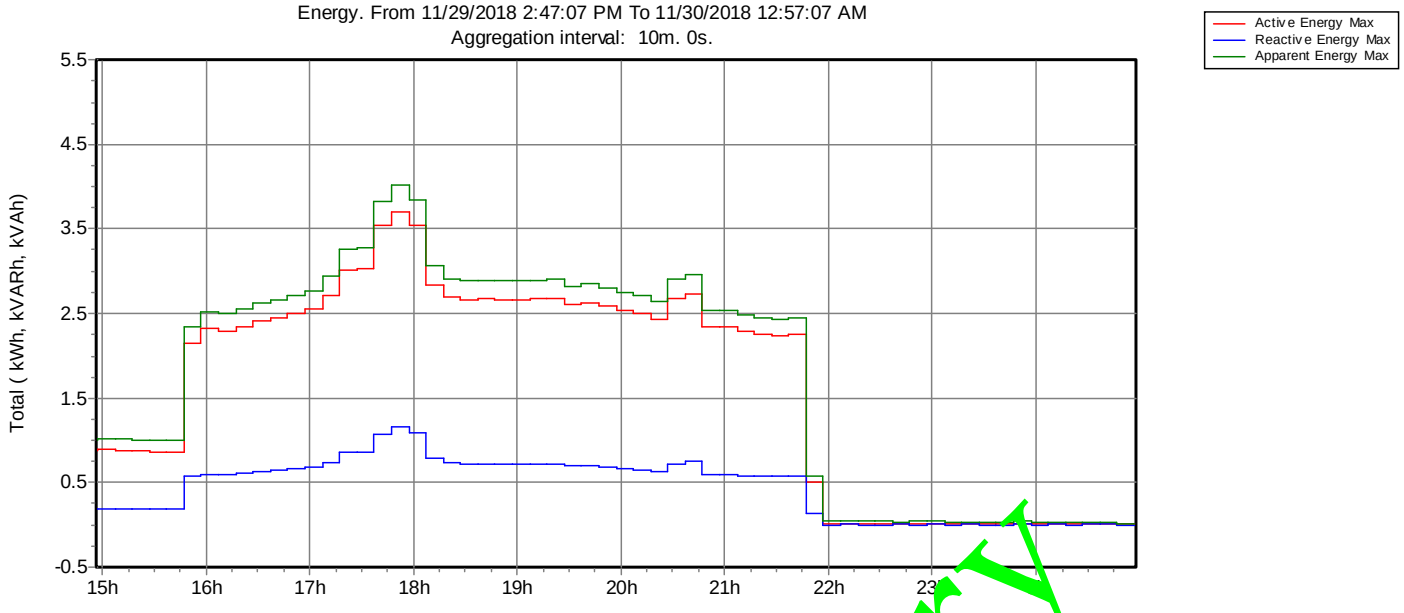


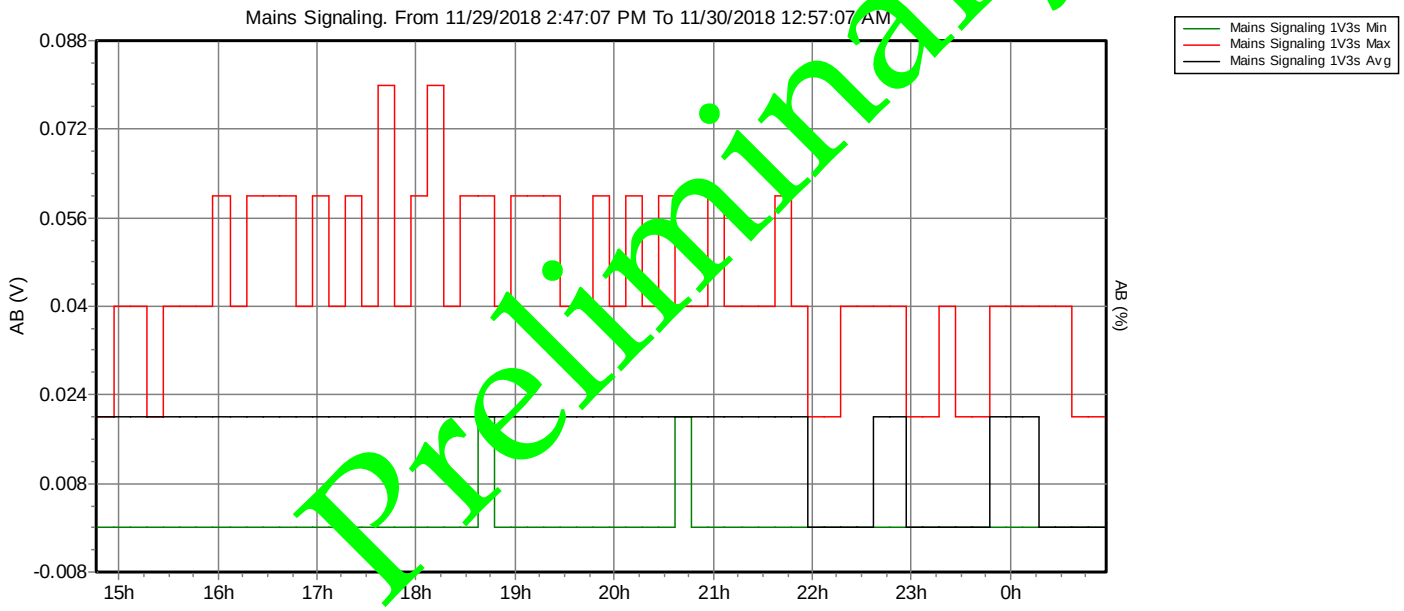


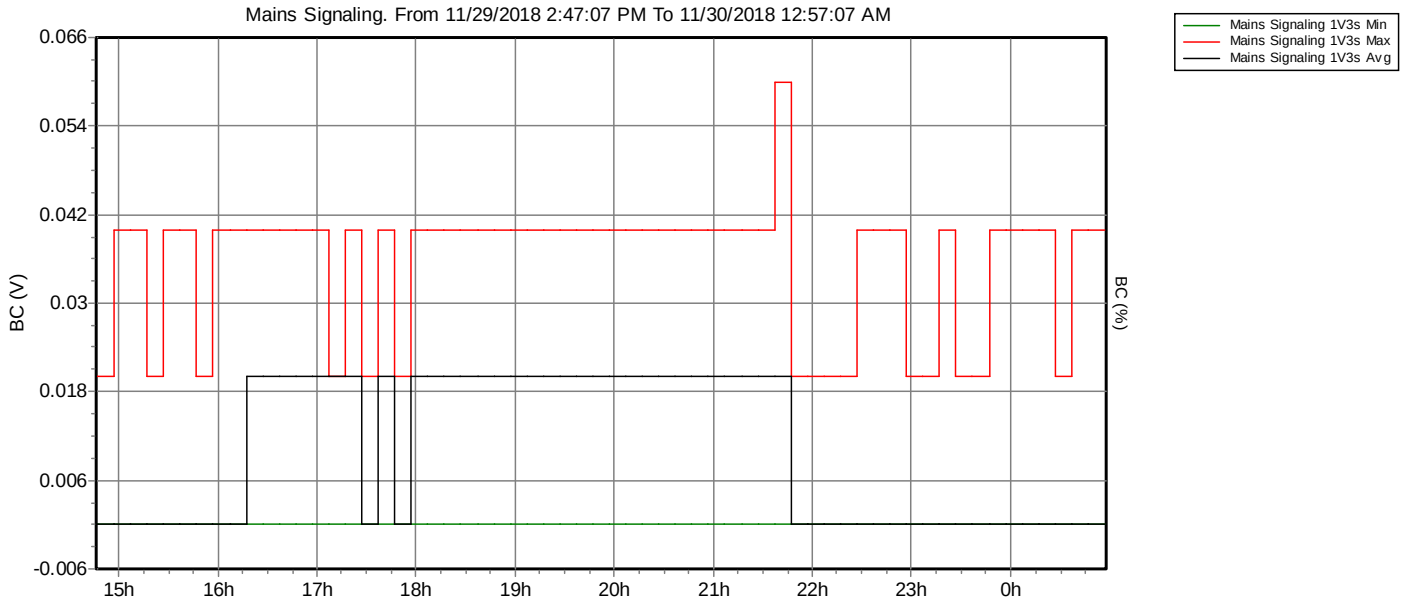


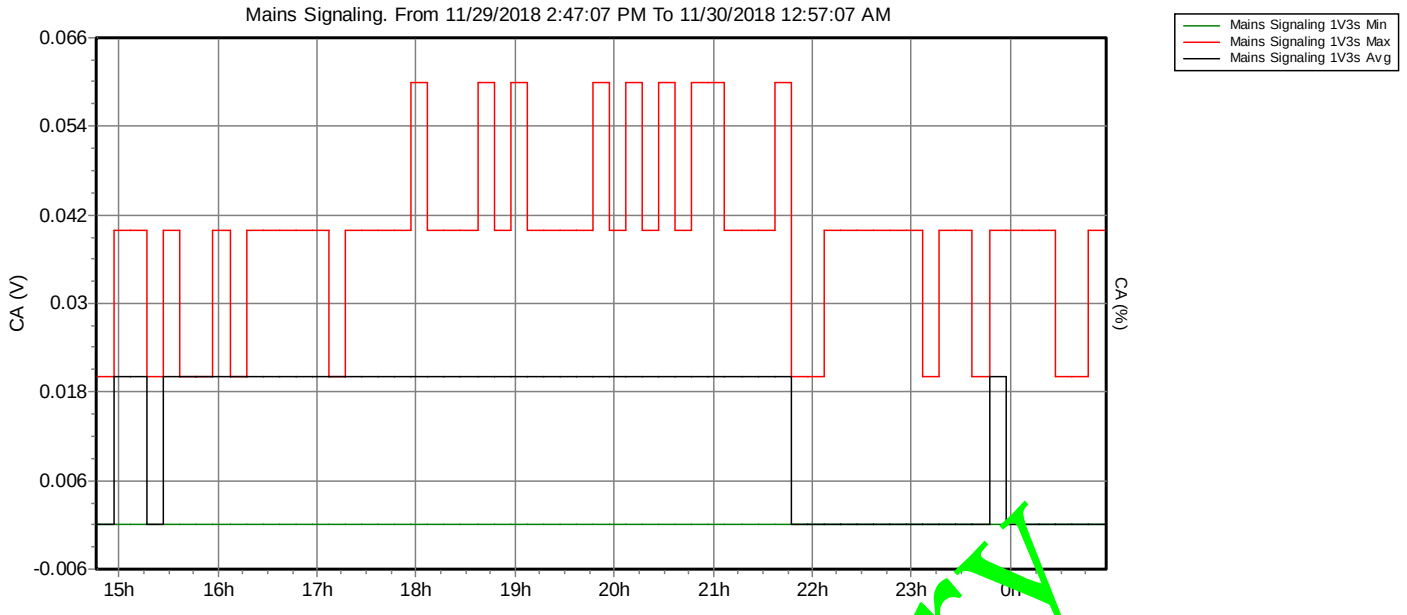


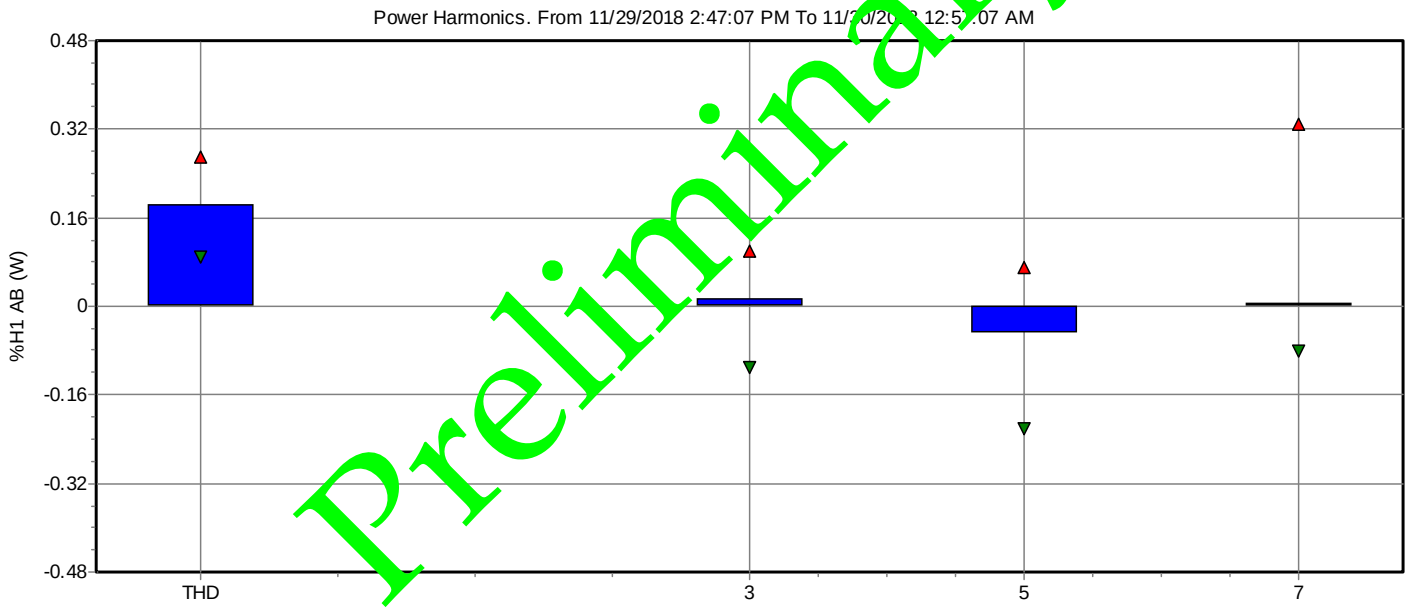


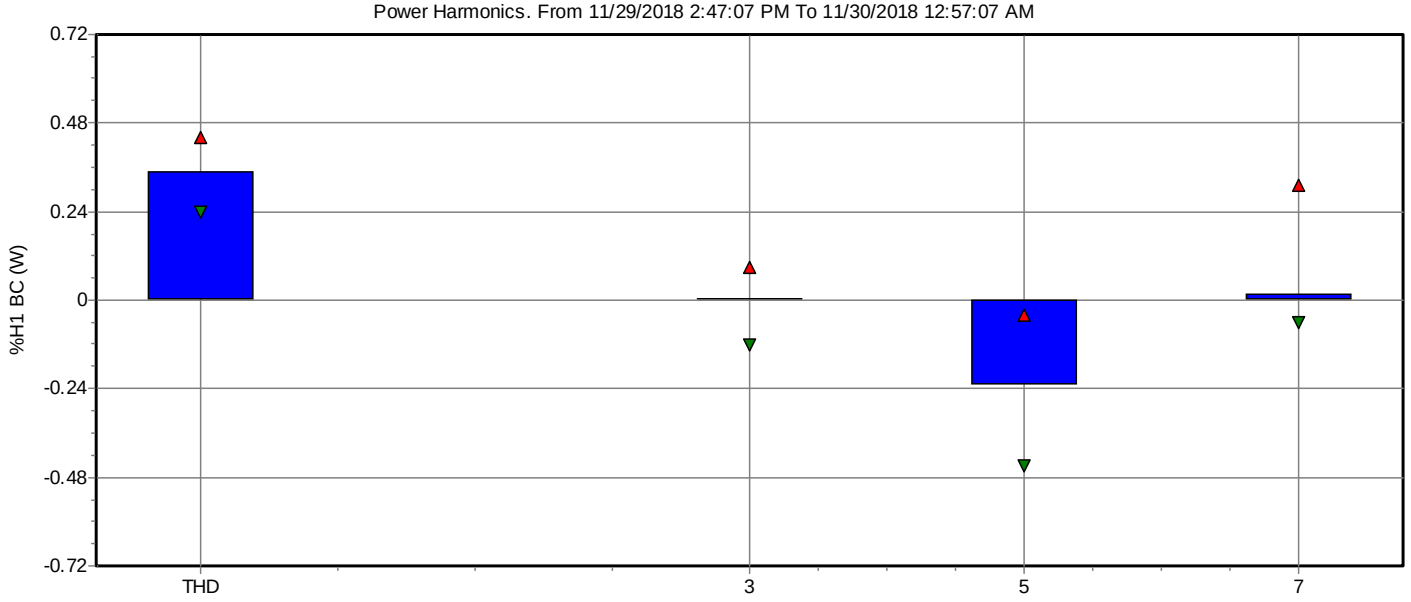












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