ENERGY AUDIT REPORT

SUBMITTED

TO

AMET UNIVERSITY, KANATHUR

AUGUST 2017

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2. SUMMARY STATEMENT

As required by AMET University, Kanathur, Chennai, Energy and Power Quality Audit team had undertaken CO_2, Relative humidity, electrical power quality and harmonic measurements at various locations on 09th August 2017.

The summary of the information is as follows:

The audit was carried out from 10.00 am to 4.30 pm with the help of Indoor air quality meter, Thermal Imager and Power Quality Analyzer.

2.1.1 Summary of Air Quality Measurements:

Indoor air quality (IAQ) refers to the quality of the air inside buildings as represented by concentrations of pollutants and thermal (temperature and relative humidity) conditions that affect the health and performance of occupants it has become one of the most important issues of environment and health worldwide considering the principle of human rights to health that everyone has the right to breathe healthy indoor air.

With the help of Indoor Air Quality meter (Extech EA80), CO_2 level, relative humidity, dry bulb and wet bulb temperatures can be measured. Using Thermal Imager, the heat penetrations in air conditioned rooms can be identified.

The measurements are carried out based on the protocol given by Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India and the norms are discussed briefly in the subsequent sections.

Indoor air quality test was carried out at 20 locations of the institution. Carbon-di-oxide levels are within the ASHRAE 55-1992 limit in the outdoor and indoor. The halls in which air-conditioning systems are running are prone to high CO_2 accumulation. The values slightly deviate from the standards by 4% and 7% in A/C rooms. The reasons are discussed in detail and comments for better operational standards are presented.

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<table>
<tr><td colspan="4">Standard Level of CO_2</td><td colspan="2"><500 ppm (ASHRAE)</td></tr>
<tr><td colspan="4">Standard Level of Relative Humidity</td><td colspan="2">30 – 60 % (ASHRAE)</td></tr>
<tr><td colspan="4">Standard Level of Temperature</td><td colspan="2">26 - 30°C ±3°C (ASHRAE)</td></tr>
<tr><th colspan="2">Location</th><th>CO_2 Level (ppm)</th><th>Relative Humidity (%) (RH)</th><th>Temperature (°C)</th><th>Comments & Recommendation</th></tr>
<tr><th colspan="6">A – Block</th></tr>
<tr><td colspan="2">Ground floor (Near office)</td><td>380</td><td>68.5</td><td>30.9</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td rowspan="3">First floor</td><td>Open area (Near Chemistry)</td><td>300</td><td>67</td><td>30.6</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>AF-2</td><td>410</td><td>67.8</td><td>32.9</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Open area (Near Physics)</td><td>355</td><td>69.5</td><td>29.9</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td rowspan="3">Second floor</td><td>Open area</td><td>305</td><td>66.9</td><td>30.3</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>DEAN-EEE (Open area)</td><td>320</td><td>66.9</td><td>31.8</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>GMDSS Class room(A/C)</td><td>520</td><td>61.8</td><td>20.9</td><td>Temperature is within the limits. CO_2 & RH value exceeds the limit</td></tr>
<tr><td></td><td>Class room(A/C)</td><td>535</td><td>62.1</td><td>21.6</td><td>Temperature is within the limits. CO_2 & RH value exceeds the limit</td></tr>
<tr><td rowspan="3">Third Floor</td><td>Open area</td><td>300</td><td>66.7</td><td>32.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Open area</td><td>290</td><td>66</td><td>32.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Deptt. Naval Arch. Class room</td><td>340</td><td>66</td><td>33.6</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
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<table>
<tr><th colspan="6">F – Block</th></tr>
<tr><td colspan="2">Ground floor</td><td>320</td><td>62</td><td>29.8</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>First floor</td><td></td><td>290</td><td>60.5</td><td>33</td><td>Within the limits</td></tr>
<tr><td rowspan="2">Second floor</td><td>Open area</td><td>285</td><td>63.3</td><td>32.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>F21</td><td>375</td><td>63.3</td><td>32.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td rowspan="2">Third floor</td><td>Near Mechanical</td><td>310</td><td>66.7</td><td>33.1</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Open area</td><td>295</td><td>62</td><td>30</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td rowspan="3">Fourth floor</td><td>Near Deptt. of Petroleum Engg.</td><td>290</td><td>69.7</td><td>31.7</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>F-48</td><td>350</td><td>64.5</td><td>33.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Open area</td><td>305</td><td>65</td><td>36.5</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><th colspan="6">B – Block</th></tr>
<tr><td rowspan="3">Ground floor</td><td>Open area</td><td>290</td><td>60.5</td><td>31.7</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Laboratory</td><td>320</td><td>66.7</td><td>31</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Library</td><td>310</td><td>68.9</td><td>29</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td rowspan="2">Second floor</td><td>Corridor - 1</td><td>305</td><td>63</td><td>30.8</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
<tr><td>Corridor – 2</td><td>300</td><td>64</td><td>30.6</td><td>CO_2&Temperature are within the limits. RH value exceeds the limit</td></tr>
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Third floor	Corridor – 1	295	65.2	35.8	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor - 2	310	65	29.8	CO_2&Temperature are within the limits. RH value exceeds the limit
C – Block					
Ground floor	Open area	290	63.3	28.9	CO_2&Temperature are within the limits. RH value exceeds the limit
First floor	Open area	290	72	30.1	CO_2&Temperature are within the limits. RH value exceeds the limit
Second floor	C-8 Drawing Hall	340	70.4	30.6	CO_2&Temperature are within the limits. RH value exceeds the limit
Third floor	Corridor - 1	295	71.5	31	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor – 2	295	72.2	31	CO_2&Temperature are within the limits. RH value exceeds the limit
Fourth floor	Physical Education hall	350	63	39.2	CO_2&Temperature are within the limits. RH value exceeds the limit
D – Block (Nautical Science Block**)**					
Ground Floor	Entrance	310	65.2	30.1	CO_2&Temperature are within the limits. RH value exceeds the limit
First floor	Corridor - 1	310	68.9	30.5	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor – 2	315	69	30.5	CO_2&Temperature are within the limits. RH value exceeds the limit
Second floor	Open area	310	69.2	31.3	CO_2&Temperature are within the limits. RH value exceeds the limit
Third floor	Corridor - 1	305	70.2	31.3	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor – 2	301	69.3	31.6	CO_2&Temperature are within the limits. RH value exceeds the limit

Fourth floor	Corridor - 1	305	67	31.4	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor – 2	307	66.8	32.1	CO_2&Temperature are within the limits. RH value exceeds the limit
	Corridor - 3	310	64.9	32.1	CO_2&Temperature are within the limits. RH value exceeds the limit

2.1.2 Summary of Energy Measurements

The summary statements of the measurements are as follows:

(i) The measurements were undertaken using mainly **Fluke 435 three phase Power Quality Analyzer. Power Quality Analyzer CA 8332 was also used to record the measurements for some of the individual equipment. The instruments are IEC 61000-4-30 Class –A compliant**.

(ii) The instrument was configured for operation in logger mode with the recording sample time of 5 seconds.

(iii) The following parameters were recorded **and the summary data (the 5 seconds data averaged approximately over 40 seconds) are provided in this section**

(a) Average 3 phase voltage,

(b) Average 3 phase RMS Currents and fundamental currents

(c) Frequency

(d) Active power in kW

(e) Reactive power in kVAR

(f) Apparent power in kVA

(g) Power factor

(h) Active energy in kWh

(i) Reactive energy in kVARh

(j) Apparent energy in kVAh

(k) % current THD and the individual odd harmonics up to 15^{th}.

(iv) These recordings are undertaken for the incomer and also for the individual feeders.

(v) The parameters (a) to (j)- all the relevant electrical data including the voltage and current THDs are provided in page 1/2 of the data set and all the voltage and current related data including the harmonic currents are provided under sheet 2 /2.

(vi) **It was also found that 100 kVAR capacitors were connected always to the main supply system.**

(vii) The recordings are taken with fixed capacitor bank (100kVAR) connected. The corresponding I_{THD}-s are found to be in the range

Recommendations:

i) The major energy consumption is due to the light, fan, water heater and Air conditioner. A sample calculation of replacing these components has been shown in the 3.11 **BLOCK WISE ENERGY OBSERVATIONS**.

ii) By replacing the conventional Flurescent lamp into LED tube light , the energy consumption can be reduced .

iii) Similarly by replacing the conventional fan into BLDC fan , enegy can be saved. And also the payback period calculation has been included in 3.11

iv) The rating of the transformer is 630kVA and hence has large over capacity. The maximum kVA permitted is 450kVA.

v) Transformers consume constant iron losses irrespective loading; presently it is corresponding to 630 kVA.

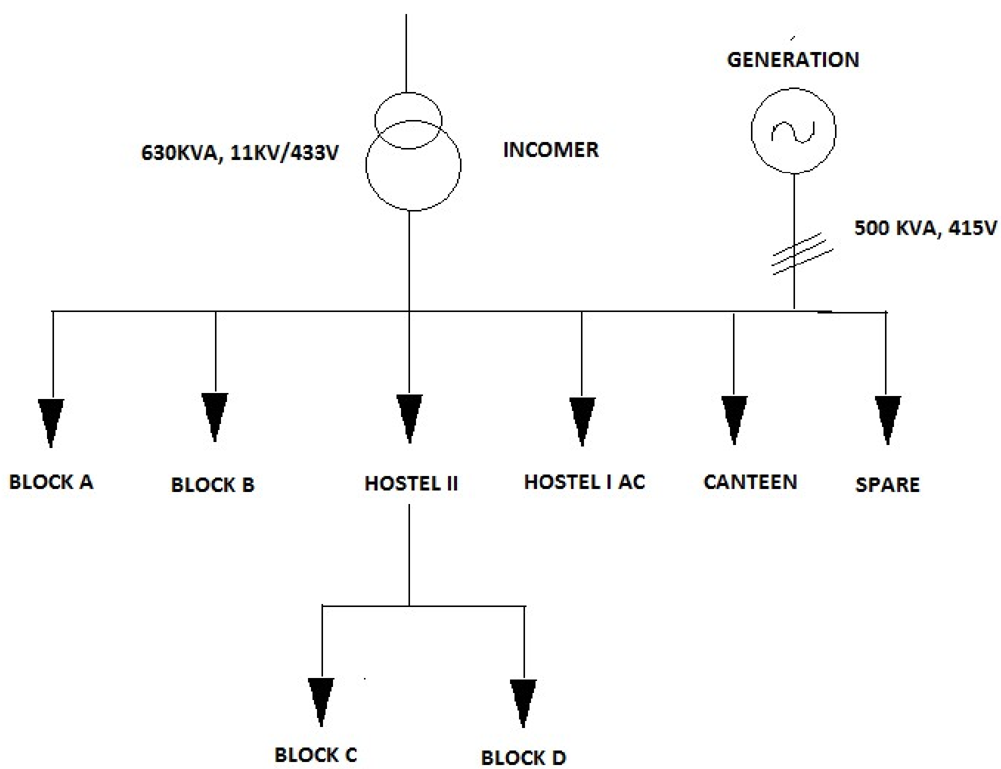
vi) Maintenance (electrical panel board and installation area) needs major improvement.

vii) No Protective devices were available in the EB room

viii) An Supervisor may be appointed to look after the maintenance and for continuous logging and maintaining electrical data considering various sophisticated electrical equipment which are used in the institution.

2.2 OVERALL SINGLE LINE DIAGRAM

OVERALL SINGLE LINE DIAGRAM



3. SUMMARY DATA

3.1 TOTAL INCOMER

3.1.1 Basic Electrical Parameters (from 11:07 to 11:23 averaged over 20 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
227.13	676.67	676.00	49.97	0.18	0.81	421.08	186.40	460.62	0.91	0.92	1.54	4.18	1.50	0.67	1.67
227.42	669.17	669.00	49.97	0.24	0.81	417.82	182.13	456.00	0.91	0.92	1.53	4.24	4.50	1.83	4.83
227.61	664.67	664.33	49.97	0.24	0.81	414.85	182.48	453.38	0.91	0.92	1.56	4.23	7.17	3.17	8.00
227.58	656.50	655.67	49.98	0.25	0.80	409.87	179.67	447.68	0.91	0.92	1.59	4.25	10.83	4.83	11.83
227.32	659.17	658.67	49.97	0.24	0.81	410.45	181.55	448.95	0.91	0.92	1.56	4.22	14.83	6.50	16.17
227.21	663.00	662.67	49.96	0.17	0.67	412.25	183.53	451.40	0.91	0.91	1.57	4.21	18.83	8.17	20.50
227.34	660.50	659.67	49.96	0.18	0.71	411.90	180.30	449.85	0.91	0.92	1.56	4.25	22.83	10.17	24.83
227.19	671.67	671.00	49.96	0.19	0.72	420.23	179.87	457.33	0.92	0.92	1.56	4.20	26.83	11.83	29.33
227.21	674.17	673.33	49.97	0.20	0.74	421.37	181.40	459.02	0.92	0.92	1.50	4.17	30.17	13.17	33.00
227.05	677.00	676.00	49.97	0.13	0.47	421.62	184.58	460.50	0.91	0.92	1.51	4.23	33.83	14.83	37.00
227.04	670.83	670.00	49.97	0.12	0.40	417.90	182.88	456.38	0.91	0.92	1.54	4.22	37.83	16.50	41.33
227.02	674.83	674.67	49.97	0.15	0.43	419.18	186.87	459.15	0.91	0.92	1.57	4.17	41.83	18.50	45.83
227.03	673.67	673.33	49.97	0.13	0.39	418.42	186.52	458.33	0.91	0.92	1.55	4.18	45.50	19.83	49.67
227.10	670.83	670.33	49.97	0.20	0.39	419.02	180.43	456.53	0.92	0.92	1.46	4.31	49.50	21.83	54.17
226.59	685.17	684.33	49.95	0.19	0.44	424.45	189.22	465.00	0.91	0.91	1.48	4.17	53.83	23.50	58.67
226.57	690.83	690.00	49.95	0.20	0.60	427.97	191.05	468.88	0.91	0.91	1.53	4.02	57.83	25.50	63.17
226.41	695.17	694.67	49.95	0.08	0.47	428.77	195.72	471.48	0.91	0.91	1.56	4.03	62.50	27.50	68.33
226.33	693.67	693.00	49.95	0.17	0.51	427.03	197.25	470.62	0.91	0.91	1.55	4.01	67.17	29.50	73.50
226.42	689.67	689.33	49.95	0.25	0.57	427.62	189.70	468.00	0.91	0.91	1.50	4.15	72.50	31.83	79.33
226.64	685.17	684.67	49.95	0.24	0.49	426.20	186.42	465.43	0.91	0.92	1.48	4.18	78.50	34.50	85.67
226.83	681.83	681.33	49.96	0.21	0.69	424.43	185.57	463.32	0.91	0.92	1.53	4.14	83.17	36.50	90.83
226.67	686.50	686.33	49.95	0.24	0.73	426.75	187.87	466.35	0.91	0.92	1.48	4.15	87.17	38.33	95.33

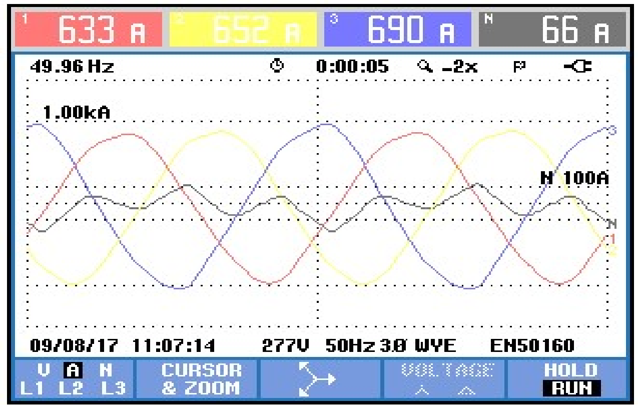
226.45	691.17	690.67	49.93	0.19	0.76	426.62	194.40	468.93	0.91	0.91	1.43	4.18	91.83	40.50	100.50
226.24	692.67	692.00	49.92	0.39	0.67	423.82	201.02	469.45	0.90	0.90	1.50	4.08	96.17	42.33	105.00
226.00	697.17	696.67	49.92	0.36	0.67	427.42	199.90	472.22	0.90	0.91	1.50	4.02	100.83	44.67	110.33
225.31	715.50	715.33	49.91	0.34	0.75	435.97	206.68	482.82	0.90	0.91	1.46	3.93	104.33	46.33	114.33
224.91	725.67	725.67	49.90	0.37	0.79	440.38	211.98	489.12	0.90	0.90	1.47	3.86	107.50	47.83	117.67
225.62	706.17	705.67	49.90	0.33	0.66	435.43	194.30	477.27	0.91	0.91	1.51	4.02	109.83	48.83	120.33

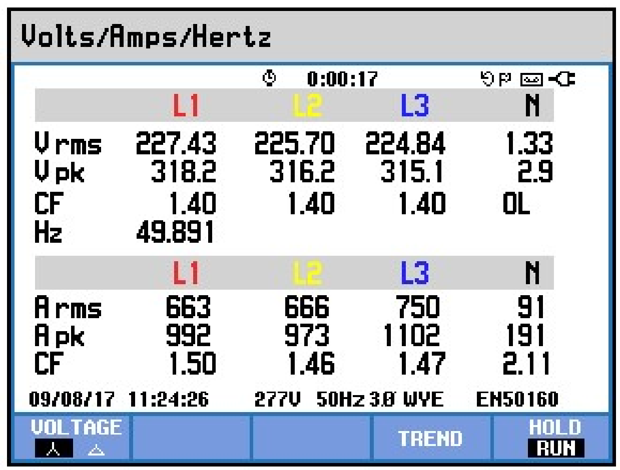
3.1.2 Incomer Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
676.00	4.18	28.27	2.58	17.41	1.79	12.07	0.57	3.85	0.29	1.98	0.20	1.35	0.13	0.87	0.10	0.70
669.00	4.24	28.38	2.61	17.43	1.85	12.40	0.61	4.10	0.29	1.92	0.21	1.40	0.12	0.79	0.10	0.67
664.33	4.23	28.08	2.56	17.01	1.80	11.96	0.55	3.62	0.30	1.96	0.22	1.44	0.11	0.75	0.10	0.66
655.67	4.25	27.89	2.60	17.02	1.74	11.38	0.51	3.31	0.31	2.01	0.22	1.41	0.13	0.82	0.11	0.70
658.67	4.22	27.79	2.59	17.06	1.73	11.41	0.53	3.47	0.31	2.03	0.21	1.37	0.12	0.77	0.11	0.75
662.67	4.21	27.87	2.61	17.31	1.71	11.31	0.48	3.20	0.31	2.02	0.22	1.44	0.11	0.75	0.11	0.72
659.67	4.25	28.05	2.63	17.34	1.74	11.45	0.52	3.45	0.30	2.00	0.22	1.42	0.11	0.73	0.10	0.68
671.00	4.20	28.17	2.67	17.88	1.72	11.56	0.51	3.41	0.32	2.11	0.21	1.41	0.12	0.77	0.10	0.67
673.33	4.17	28.09	2.57	17.30	1.80	12.09	0.55	3.69	0.31	2.09	0.21	1.38	0.12	0.83	0.10	0.66
676.00	4.23	28.56	2.53	17.10	1.91	12.90	0.60	4.08	0.30	2.05	0.20	1.34	0.13	0.89	0.09	0.62
670.00	4.22	28.27	2.56	17.16	1.84	12.34	0.55	3.71	0.30	2.03	0.21	1.40	0.13	0.84	0.10	0.65
674.67	4.17	28.13	2.54	17.14	1.78	11.99	0.48	3.26	0.30	2.05	0.21	1.38	0.12	0.82	0.09	0.63
673.33	4.18	28.14	2.53	17.00	1.80	12.13	0.50	3.38	0.30	2.01	0.21	1.41	0.12	0.77	0.10	0.65
670.33	4.31	28.89	2.53	16.97	2.18	14.59	0.67	4.47	0.27	1.82	0.22	1.50	0.16	1.05	0.11	0.70
684.33	4.17	28.54	2.52	17.23	1.96	13.39	0.58	3.93	0.27	1.81	0.22	1.49	0.14	0.94	0.10	0.70

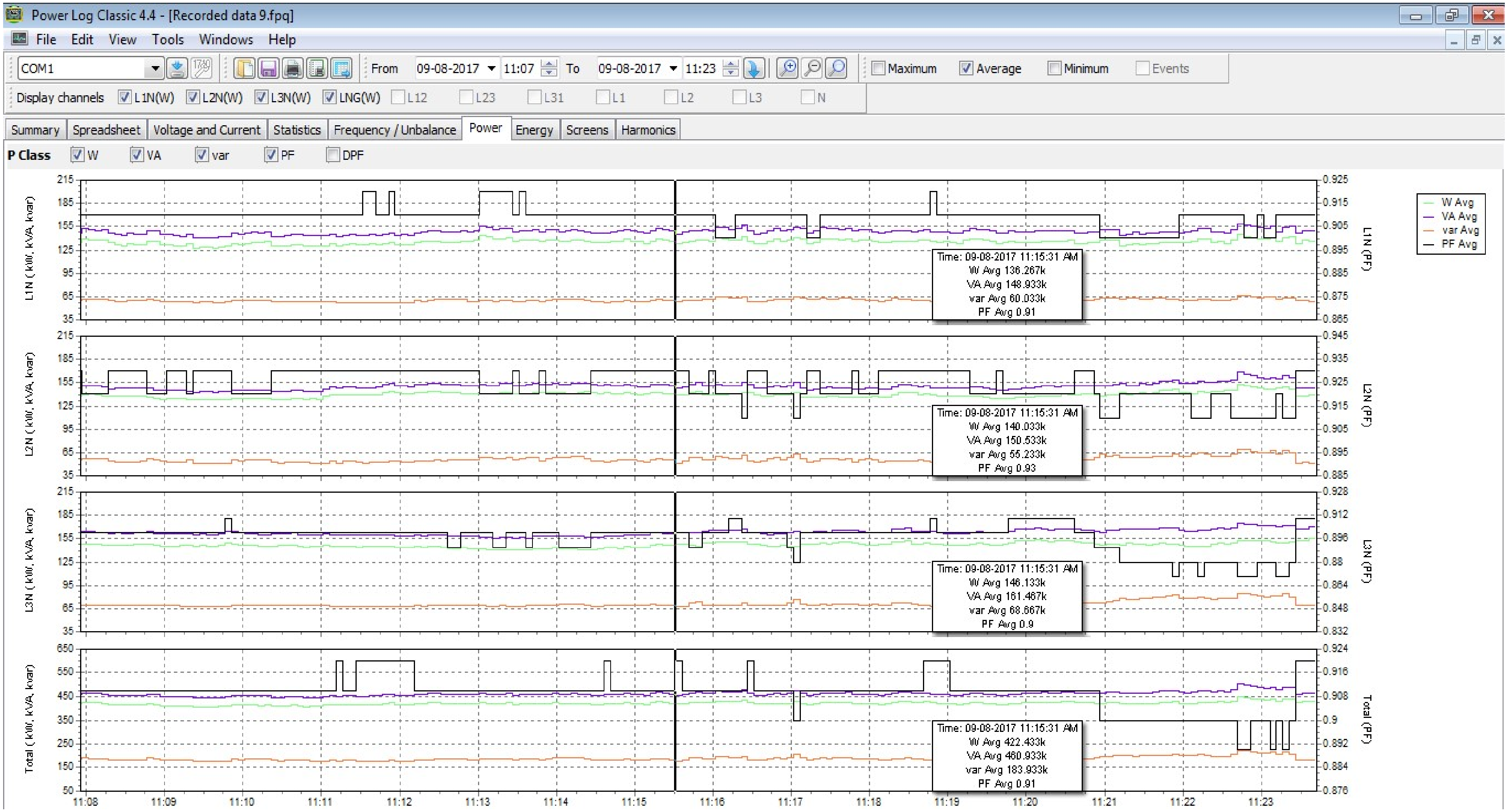
690.00	4.02	27.73	2.48	17.10	1.72	11.88	0.49	3.35	0.29	1.97	0.21	1.41	0.11	0.78	0.09	0.62
694.67	4.03	27.95	2.48	17.24	1.74	12.05	0.47	3.23	0.29	2.00	0.20	1.38	0.12	0.86	0.09	0.59
693.00	4.01	27.81	2.48	17.18	1.76	12.17	0.50	3.44	0.28	1.95	0.20	1.35	0.12	0.81	0.10	0.68
689.33	4.15	28.62	2.48	17.12	1.95	13.46	0.60	4.10	0.28	1.91	0.20	1.34	0.13	0.91	0.10	0.71
684.67	4.18	28.62	2.51	17.20	1.94	13.32	0.60	4.08	0.28	1.88	0.22	1.47	0.12	0.83	0.11	0.73
681.33	4.14	28.18	2.53	17.26	1.76	11.98	0.55	3.75	0.29	2.00	0.21	1.40	0.12	0.78	0.10	0.69
686.33	4.15	28.47	2.50	17.18	1.83	12.58	0.57	3.90	0.29	1.96	0.21	1.43	0.12	0.81	0.10	0.71
690.67	4.18	28.85	2.47	17.07	1.96	13.56	0.64	4.43	0.28	1.95	0.20	1.37	0.12	0.84	0.12	0.82
692.00	4.08	28.24	2.49	17.20	1.85	12.79	0.55	3.81	0.27	1.88	0.19	1.30	0.14	0.93	0.11	0.78
696.67	4.02	28.03	2.48	17.27	1.82	12.68	0.55	3.83	0.27	1.85	0.19	1.32	0.13	0.88	0.10	0.71
715.33	3.93	28.08	2.41	17.23	1.89	13.50	0.55	3.97	0.25	1.79	0.18	1.27	0.12	0.85	0.09	0.66
725.67	3.86	28.02	2.41	17.45	1.87	13.59	0.56	4.06	0.24	1.73	0.17	1.22	0.12	0.83	0.09	0.64
705.67	4.02	28.33	2.55	17.99	1.77	12.48	0.57	4.00	0.26	1.84	0.18	1.28	0.12	0.86	0.09	0.66

3.1.3 SCREEN SHOTS AT INCOMER

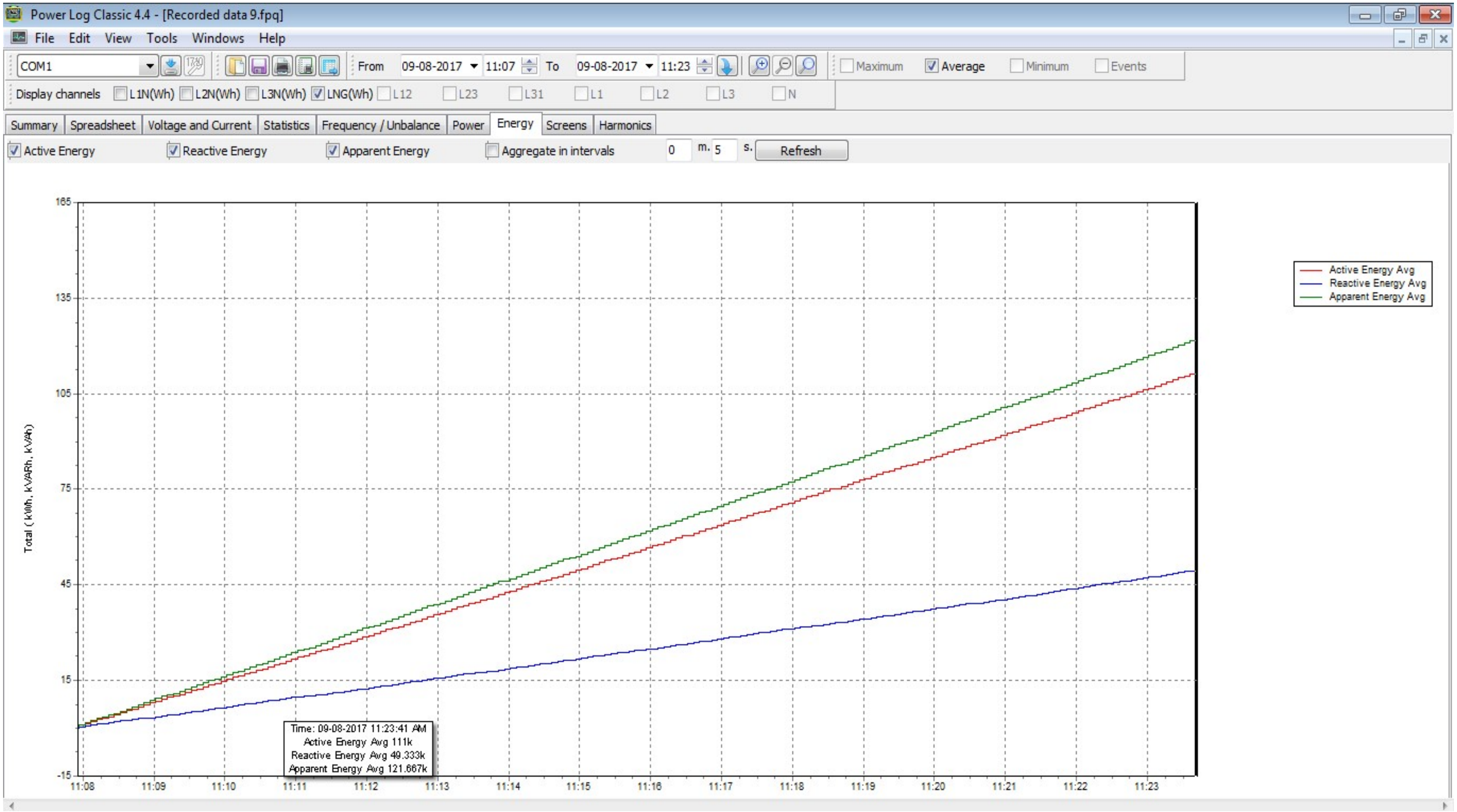




3.1.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.1.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.2 HOSTEL II

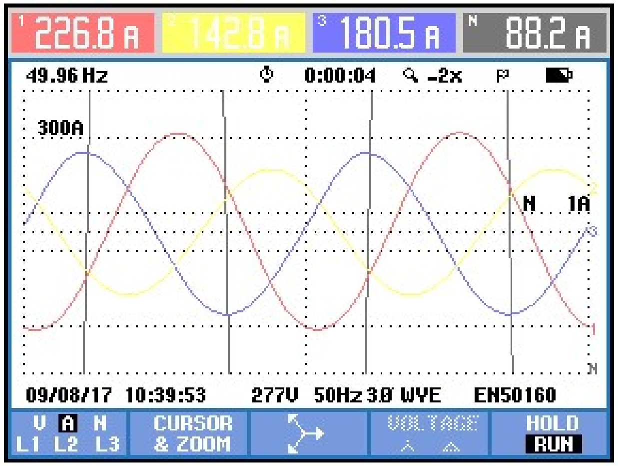
3.2.1 Basic Electrical Parameters (from 11:41 to 11:51 averaged over 20 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD -s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
226.60	181.68	181.50	49.90	0.28	0.46	41.29	116.13	123.35	0.34	0.34	1.41	3.81	0.15	0.40	0.45
226.59	182.90	182.67	49.89	0.25	0.51	41.88	116.75	124.13	0.35	0.34	1.41	3.91	0.45	1.20	1.30
226.66	182.75	182.50	49.89	0.22	0.50	41.81	116.72	124.09	0.35	0.34	1.42	3.90	0.70	2.00	2.15
226.49	181.62	181.43	49.89	0.18	0.48	41.31	116.00	123.23	0.34	0.34	1.44	3.82	1.10	3.00	3.15
226.04	181.05	180.80	49.87	0.23	0.49	40.78	115.48	122.58	0.34	0.34	1.40	3.79	1.45	4.10	4.35
225.70	181.72	181.47	49.86	0.23	0.48	40.69	115.81	122.85	0.34	0.34	1.36	3.79	1.85	5.20	5.55
225.86	176.85	176.63	49.85	0.24	0.49	40.56	112.48	119.66	0.35	0.34	1.44	3.91	2.25	6.30	6.75
225.85	177.85	177.60	49.84	0.23	0.46	41.03	113.02	120.32	0.35	0.34	1.43	3.94	2.65	7.40	7.90
226.07	176.95	176.77	49.83	0.20	0.46	40.99	112.52	119.84	0.35	0.34	1.44	3.84	3.00	8.40	8.90
226.16	173.72	173.57	49.84	0.19	0.46	39.80	110.65	117.70	0.34	0.34	1.44	3.77	3.30	9.30	9.90
225.92	172.78	172.57	49.85	0.23	0.44	39.39	109.96	116.91	0.34	0.34	1.44	3.81	3.70	10.40	11.00
226.01	172.45	172.23	49.86	0.19	0.41	39.21	109.83	116.73	0.34	0.34	1.47	3.77	4.10	11.40	12.15
226.38	172.12	171.90	49.88	0.18	0.44	39.43	109.74	116.72	0.34	0.34	1.44	3.84	4.40	12.35	13.15
226.41	172.38	172.20	49.91	0.19	0.46	39.42	109.96	116.91	0.34	0.34	1.44	3.84	4.80	13.40	14.25
226.74	172.55	172.40	49.92	0.22	0.49	39.13	110.38	117.20	0.34	0.33	1.42	3.70	5.20	14.50	15.40
227.07	172.85	172.63	49.94	0.29	0.48	39.54	110.61	117.55	0.34	0.34	1.43	3.73	5.60	15.60	16.55
227.06	171.75	171.57	49.95	0.35	0.52	39.36	109.89	116.81	0.34	0.34	1.42	3.74	6.00	16.80	17.85
226.87	171.02	170.83	49.95	0.42	0.58	39.56	109.20	116.23	0.35	0.34	1.46	3.80	6.45	18.00	19.15

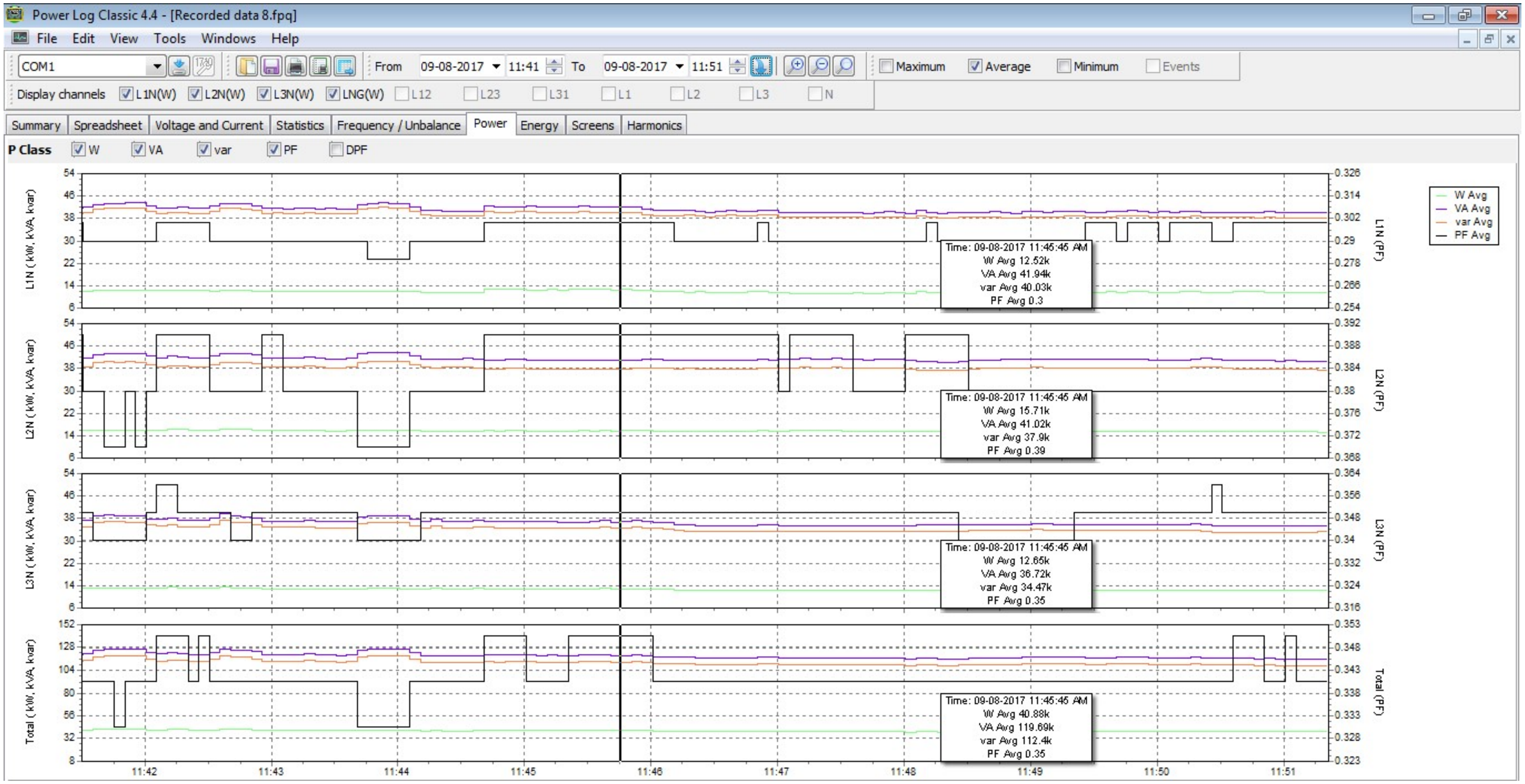
3.2.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
181.50	3.81	6.91	2.58	4.68	0.99	1.80	0.24	0.44	0.08	0.15	0.07	0.13	0.05	0.09	0.04	0.07
182.67	3.91	7.14	2.63	4.79	0.97	1.77	0.24	0.43	0.08	0.14	0.08	0.14	0.05	0.10	0.04	0.08
182.50	3.90	7.11	2.61	4.77	0.96	1.76	0.23	0.43	0.08	0.15	0.08	0.14	0.05	0.10	0.04	0.07
181.43	3.82	6.92	2.59	4.69	0.97	1.77	0.24	0.43	0.08	0.15	0.07	0.13	0.05	0.09	0.04	0.07
180.80	3.79	6.85	2.53	4.57	0.98	1.77	0.24	0.43	0.09	0.15	0.07	0.13	0.05	0.09	0.04	0.07
181.47	3.79	6.88	2.56	4.64	0.99	1.80	0.25	0.46	0.08	0.15	0.08	0.14	0.06	0.10	0.04	0.07
176.63	3.91	6.91	2.72	4.80	0.79	1.39	0.14	0.25	0.09	0.16	0.08	0.14	0.05	0.08	0.04	0.06
177.60	3.94	7.00	2.82	5.01	0.82	1.45	0.13	0.23	0.09	0.15	0.08	0.14	0.05	0.08	0.03	0.06
176.77	3.84	6.78	2.83	5.00	0.83	1.47	0.14	0.24	0.08	0.14	0.08	0.14	0.05	0.08	0.03	0.06
173.57	3.77	6.54	2.70	4.68	0.84	1.46	0.16	0.28	0.09	0.15	0.08	0.14	0.05	0.09	0.04	0.06
172.57	3.81	6.57	2.70	4.66	0.85	1.47	0.17	0.28	0.09	0.16	0.08	0.14	0.05	0.09	0.04	0.07
172.23	3.77	6.50	2.69	4.62	0.86	1.48	0.17	0.28	0.09	0.16	0.08	0.13	0.05	0.09	0.04	0.07
171.90	3.84	6.60	2.69	4.63	0.84	1.44	0.17	0.28	0.09	0.16	0.08	0.13	0.05	0.08	0.04	0.07
172.20	3.84	6.61	2.69	4.62	0.85	1.46	0.17	0.29	0.09	0.15	0.08	0.13	0.05	0.09	0.04	0.07
172.40	3.70	6.38	2.64	4.54	0.86	1.49	0.17	0.29	0.09	0.15	0.08	0.13	0.05	0.09	0.04	0.07
172.63	3.73	6.44	2.68	4.62	0.88	1.52	0.17	0.29	0.09	0.15	0.08	0.14	0.05	0.09	0.04	0.06
171.57	3.74	6.41	2.66	4.57	0.88	1.50	0.18	0.30	0.09	0.15	0.08	0.14	0.05	0.09	0.04	0.06
170.83	3.80	6.49	2.69	4.60	0.87	1.48	0.17	0.30	0.09	0.15	0.08	0.14	0.05	0.08	0.04	0.06

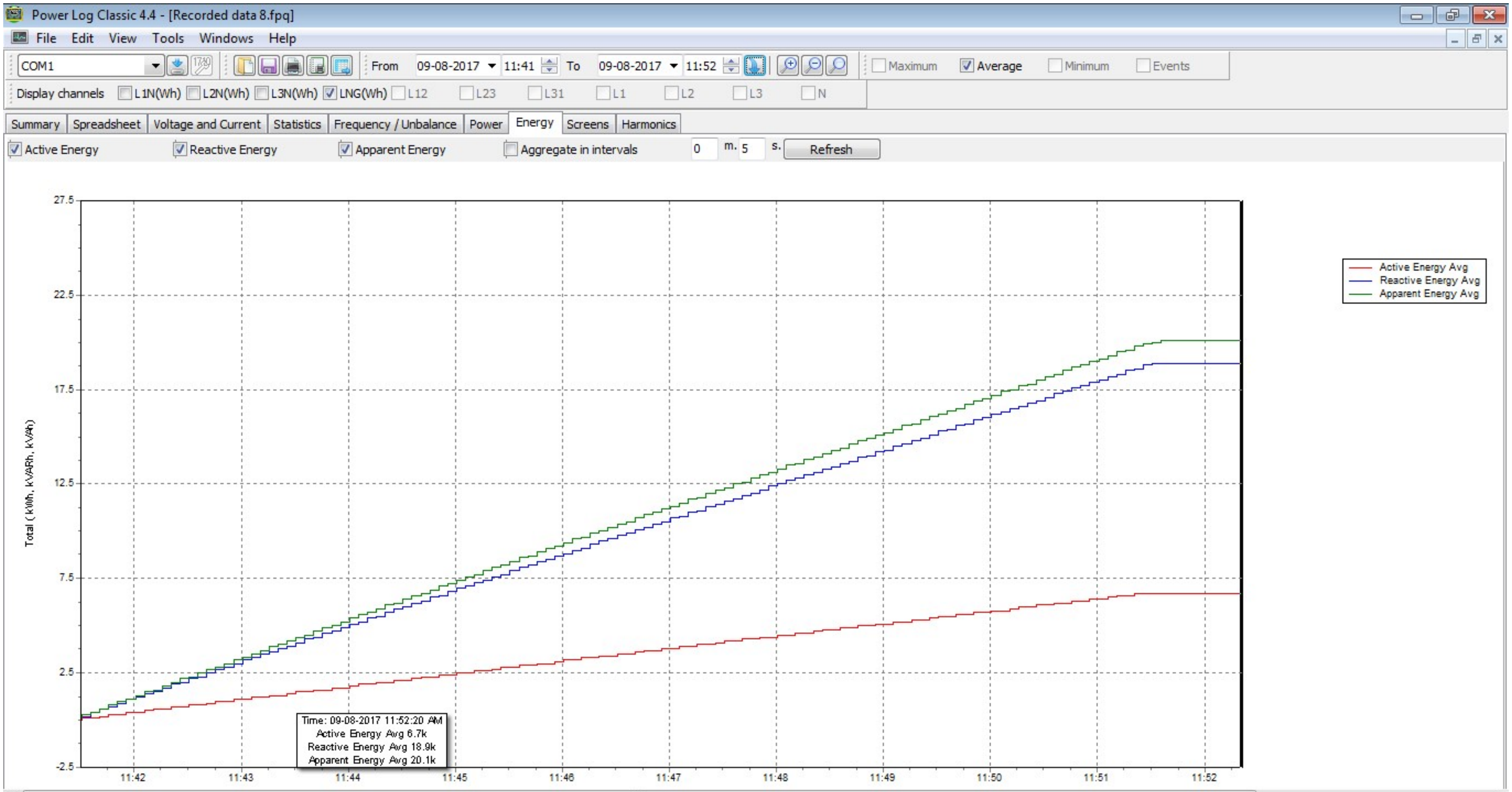
3.2.3 SCREEN SHOT OF CURRENT AT HOSTEL II



3.2.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.2.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.3 BLOCK A

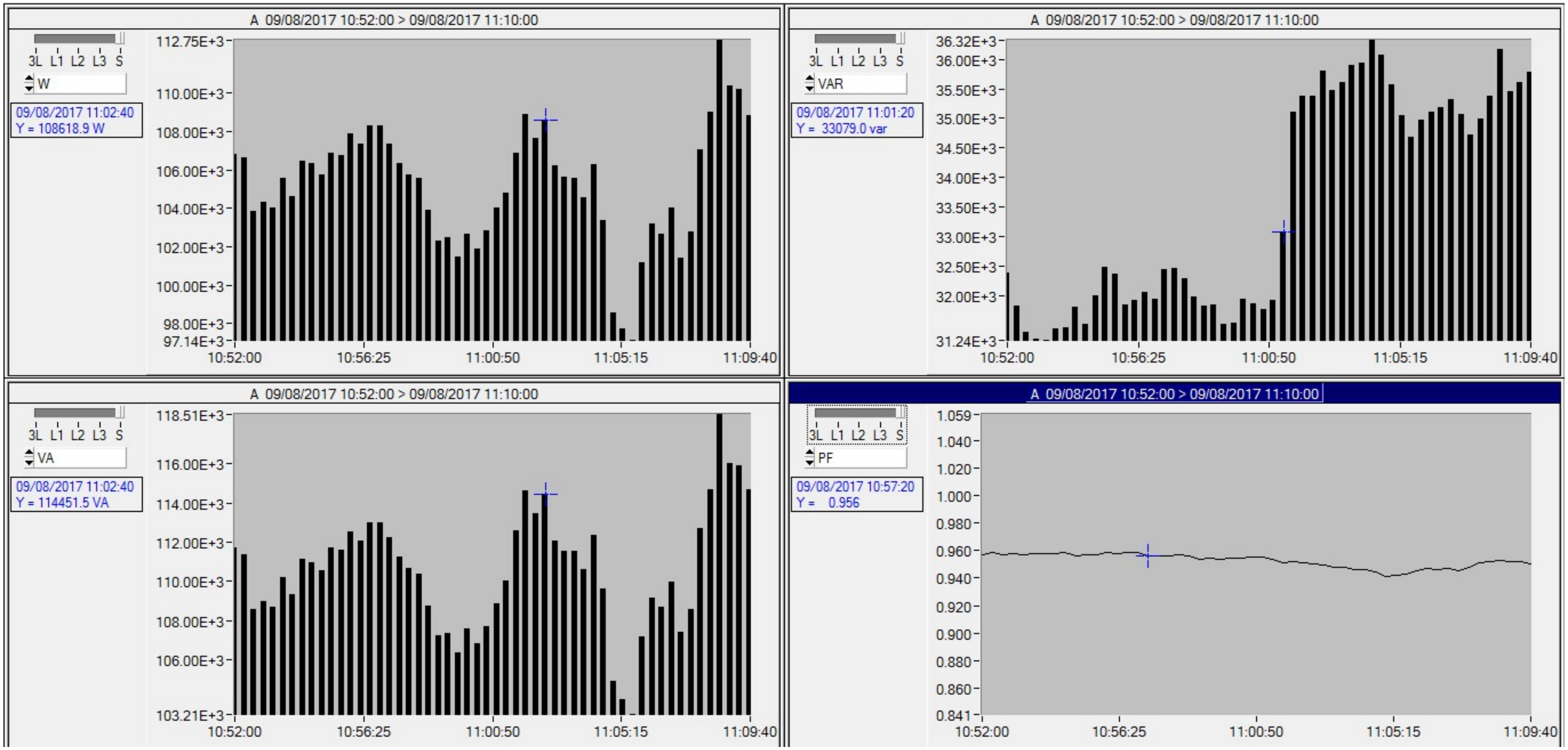
3.3.1 Basic Electrical Parameters (from 10:52 to 11:09 averaged over 40 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in %-age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
227.29	162.00	161.76	49.98	0.13	9.80	105.77	31.86	110.53	0.96	1.29	4.67	0.59	0.18	0.61
227.08	160.29	160.06	49.97	0.10	9.77	104.64	31.31	109.29	0.96	1.31	4.69	2.33	0.70	2.43
227.42	161.82	161.59	49.98	0.17	11.60	105.81	31.59	110.47	0.96	1.30	4.62	4.09	1.22	4.27
227.64	162.84	162.56	50.01	0.13	12.50	106.45	32.28	111.29	0.96	1.29	4.86	5.86	1.76	6.12
227.83	164.53	164.30	50.01	0.17	12.37	107.86	31.94	112.53	0.96	1.29	4.68	7.65	2.29	7.99
228.04	163.86	163.58	50.02	0.13	10.17	107.34	32.28	112.17	0.96	1.30	4.82	9.44	2.83	9.86
228.21	160.44	160.23	50.04	0.13	9.57	105.07	32.03	109.92	0.96	1.28	4.74	11.21	3.36	11.71
228.19	156.14	155.86	50.04	0.10	10.47	102.09	31.63	106.97	0.95	1.22	5.02	12.92	3.89	13.51
228.91	156.23	155.99	50.02	0.13	9.83	102.45	31.85	107.36	0.95	1.30	4.94	14.63	4.42	15.29
228.82	160.87	160.62	50.01	0.20	11.43	105.23	33.37	110.47	0.95	1.21	4.81	16.36	4.96	17.11
228.59	166.38	166.11	50.00	0.13	12.33	108.40	35.52	114.15	0.95	1.27	4.69	18.16	5.55	19.00
228.84	162.61	162.36	50.00	0.07	13.03	105.81	35.66	111.71	0.95	1.30	4.82	19.94	6.14	20.87
228.63	161.51	161.22	49.98	0.13	11.67	104.74	36.11	110.85	0.95	1.29	4.96	21.69	6.74	22.73
228.48	151.66	151.36	49.97	0.23	11.10	97.81	35.10	104.02	0.94	1.24	4.96	23.36	7.34	24.50
228.21	158.17	157.91	49.96	0.30	12.87	102.35	35.09	108.33	0.95	1.22	4.54	25.03	7.92	26.28
228.13	158.67	158.44	49.94	0.27	11.53	102.72	35.03	108.65	0.95	1.26	4.68	26.75	8.50	28.09
227.80	168.60	168.47	49.94	0.13	10.60	109.60	35.51	115.31	0.95	1.26	4.48	28.52	9.09	29.96
227.96	168.87	168.64	49.93	0.20	8.67	109.80	35.62	115.54	0.95	1.28	4.37	30.36	9.68	31.90

3.3.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A
161.76	4.67	7.55	2.92	4.72	1.22	1.98	0.44	0.72	0.22	0.36	0.18	0.29
160.06	4.69	7.51	2.99	4.78	1.29	2.06	0.48	0.76	0.22	0.36	0.17	0.27
161.59	4.62	7.47	2.91	4.70	1.19	1.92	0.46	0.74	0.26	0.41	0.18	0.29
162.56	4.86	7.89	3.07	4.99	1.18	1.91	0.43	0.70	0.26	0.42	0.19	0.31
164.30	4.68	7.69	3.00	4.93	1.17	1.92	0.41	0.68	0.24	0.40	0.17	0.27
163.58	4.82	7.89	3.01	4.93	1.21	1.98	0.42	0.69	0.23	0.38	0.19	0.31
160.23	4.74	7.60	2.98	4.77	1.27	2.03	0.44	0.71	0.28	0.45	0.17	0.27
155.86	5.02	7.83	3.19	4.97	1.14	1.78	0.30	0.47	0.30	0.47	0.18	0.28
155.99	4.94	7.71	3.02	4.71	1.24	1.94	0.42	0.66	0.32	0.50	0.20	0.31
160.62	4.81	7.72	3.10	4.98	1.21	1.94	0.38	0.61	0.33	0.53	0.16	0.25
166.11	4.69	7.79	2.91	4.84	1.22	2.03	0.44	0.74	0.28	0.46	0.20	0.33
162.36	4.82	7.83	3.01	4.89	1.28	2.07	0.44	0.72	0.29	0.47	0.19	0.31
161.22	4.96	7.99	2.97	4.78	1.33	2.15	0.42	0.68	0.32	0.52	0.19	0.30
151.36	4.96	7.50	2.89	4.37	1.37	2.07	0.40	0.61	0.37	0.55	0.19	0.29
157.91	4.54	7.18	2.74	4.33	1.22	1.93	0.42	0.67	0.32	0.51	0.12	0.19
158.44	4.68	7.41	2.73	4.33	1.29	2.04	0.38	0.60	0.34	0.55	0.16	0.25
168.47	4.48	7.55	2.64	4.46	1.28	2.15	0.41	0.69	0.30	0.51	0.10	0.17
168.64	4.37	7.36	2.66	4.48	1.40	2.36	0.49	0.82	0.29	0.49	0.12	0.21

3.3.3 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.4 BLOCK B

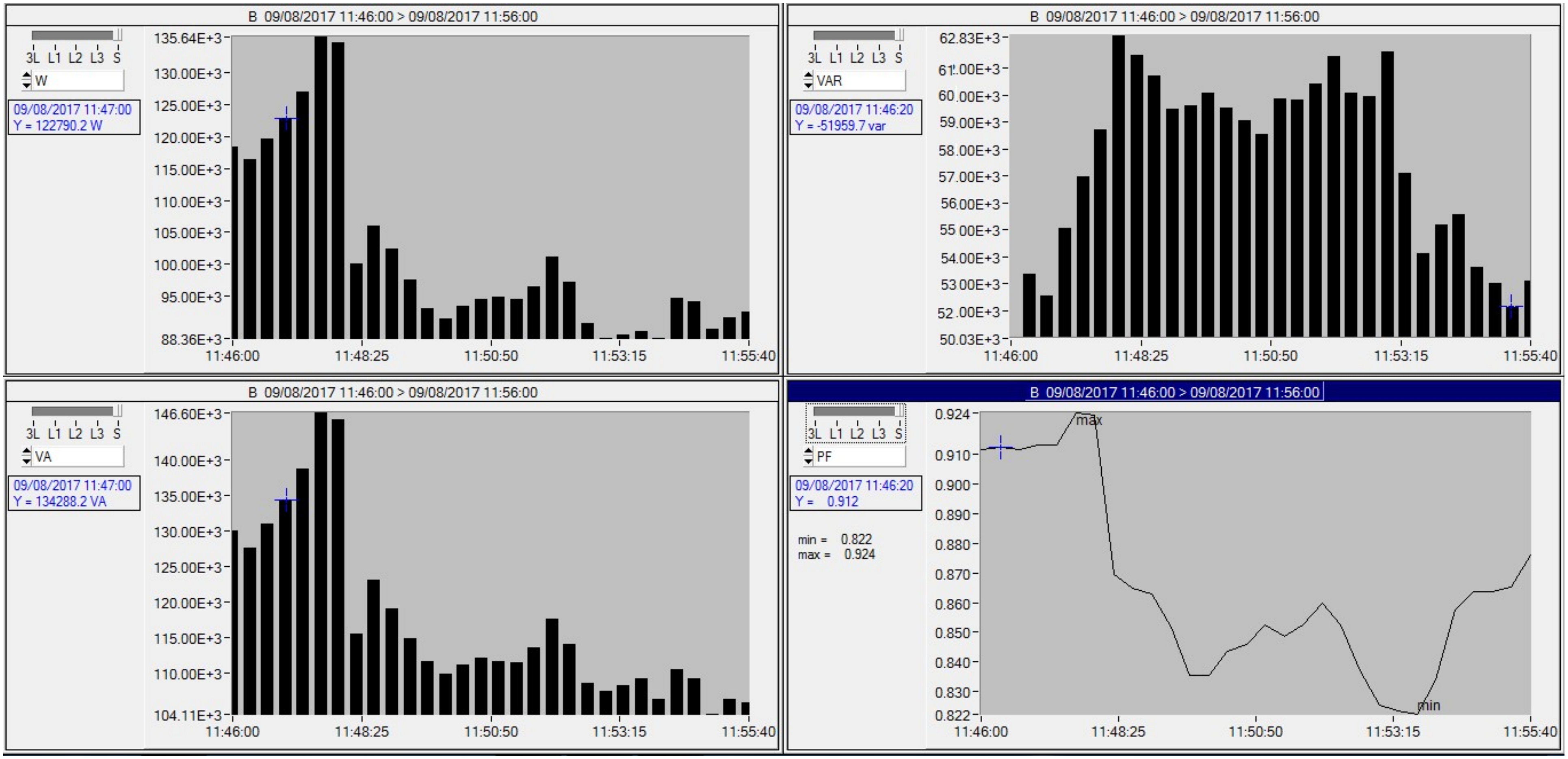
3.4.1 Basic Electrical Parameters (from 11:46 to 11:55 averaged over 40 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in %-age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
225.69	191.11	191.07	49.92	0.27	4.93	118.16	52.58	129.46	0.91	1.24	5.43	0.65	0.29	0.71
224.86	207.23	207.16	49.91	0.23	5.33	128.45	54.61	139.87	0.92	1.23	4.64	2.71	1.19	2.97
225.27	189.37	189.16	49.90	0.23	9.97	113.62	57.44	127.99	0.89	1.26	5.48	4.77	2.12	5.23
225.79	169.90	169.64	49.90	0.17	8.73	97.68	60.31	115.13	0.85	1.29	6.24	6.45	3.12	7.19
226.16	163.42	163.12	49.91	0.13	8.13	93.13	59.87	110.92	0.84	1.28	6.31	8.00	4.12	9.05
226.44	165.04	164.80	49.92	0.07	7.47	95.25	58.87	112.15	0.85	1.28	6.06	9.58	5.10	10.91
226.34	166.84	166.49	49.91	0.13	5.53	96.28	59.55	113.33	0.85	1.30	5.76	11.20	6.10	12.81
226.60	159.12	158.70	49.91	0.17	6.97	88.96	61.30	108.20	0.82	1.21	6.47	12.70	7.10	14.62
226.67	159.57	159.20	49.93	0.23	4.53	92.41	56.74	108.55	0.85	1.24	6.31	14.22	8.09	16.43
226.73	154.76	154.54	49.93	0.20	6.30	91.33	52.14	105.32	0.87	1.23	6.82	15.75	8.98	18.21

3.4.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A
191.07	5.43	10.38	3.30	6.31	1.90	3.63	1.18	2.25	0.12	0.23	0.46	0.87
207.16	4.64	9.60	3.00	6.20	1.61	3.33	0.82	1.70	0.10	0.21	0.31	0.64
189.16	5.48	10.17	3.63	6.72	1.69	3.17	1.12	2.07	0.16	0.28	0.36	0.66
169.64	6.24	10.60	4.33	7.36	1.64	2.79	1.08	1.83	0.17	0.28	0.27	0.45
163.12	6.31	10.30	4.22	6.89	1.82	2.97	1.28	2.09	0.22	0.36	0.37	0.60
164.80	6.06	9.98	4.00	6.59	1.88	3.09	1.36	2.23	0.24	0.40	0.41	0.68
166.49	5.76	9.56	3.82	6.34	1.72	2.87	1.09	1.81	0.19	0.31	0.24	0.41
158.70	6.47	10.26	4.26	6.75	1.93	3.07	1.37	2.17	0.20	0.32	0.40	0.64
159.20	6.31	10.04	4.08	6.49	1.98	3.15	1.31	2.09	0.21	0.34	0.41	0.66
154.54	6.82	10.54	4.48	6.92	2.09	3.23	1.56	2.41	0.23	0.36	0.52	0.81

3.4.3 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.5 CANTEEN

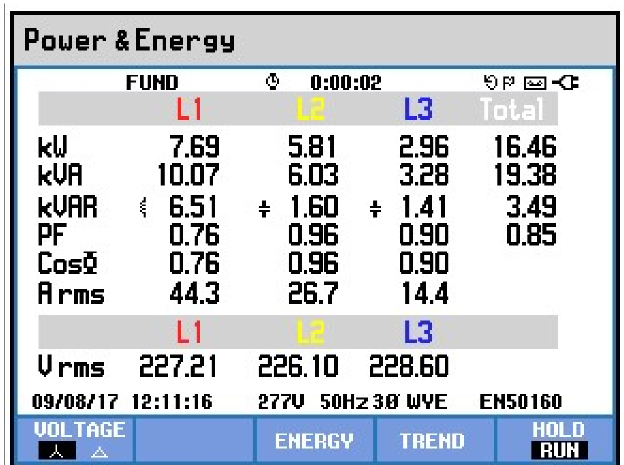
3.5.1 Basic Electrical Parameters (from 12:04 to 12:10 averaged over 20 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
226.64	30.73	30.70	50.03	0.38	0.61	17.03	2.01	20.86	0.82	0.82	1.41	1.97	0.06	0.01	0.08
226.71	30.65	30.63	50.02	0.41	0.61	16.99	2.02	20.82	0.81	0.82	1.39	1.92	0.18	0.03	0.23
226.66	30.18	30.17	50.03	0.44	0.63	16.71	2.00	20.50	0.81	0.82	1.37	2.04	0.29	0.03	0.36
226.84	29.90	29.90	50.04	0.38	0.61	16.53	1.93	20.32	0.81	0.81	1.34	2.06	0.43	0.05	0.53
227.14	30.05	30.03	50.02	0.31	0.61	16.64	1.91	20.45	0.81	0.81	1.48	2.02	0.59	0.07	0.73
226.97	29.75	29.73	50.00	0.37	0.60	16.45	1.72	20.24	0.81	0.81	1.47	2.06	0.76	0.08	0.93
226.78	33.18	33.00	49.99	0.41	0.63	17.20	3.75	21.91	0.79	0.79	1.43	2.19	0.92	0.13	1.13
226.74	33.68	33.67	49.97	0.40	0.65	18.47	-1.59	22.89	0.81	0.81	1.47	2.03	1.09	0.18	1.37
226.78	32.62	32.57	49.95	0.44	0.67	17.88	-0.47	22.06	0.81	0.81	1.42	2.07	1.25	0.21	1.56
226.83	29.45	29.40	49.96	0.47	0.65	16.54	1.23	20.00	0.83	0.83	1.42	2.36	1.39	0.23	1.73
226.76	28.48	28.47	49.97	0.52	0.64	16.43	-3.43	19.34	0.85	0.85	1.38	2.43	1.55	0.26	1.92
226.85	30.32	30.27	49.98	0.47	0.63	17.08	0.31	20.57	0.83	0.84	1.46	2.56	1.72	0.30	2.13

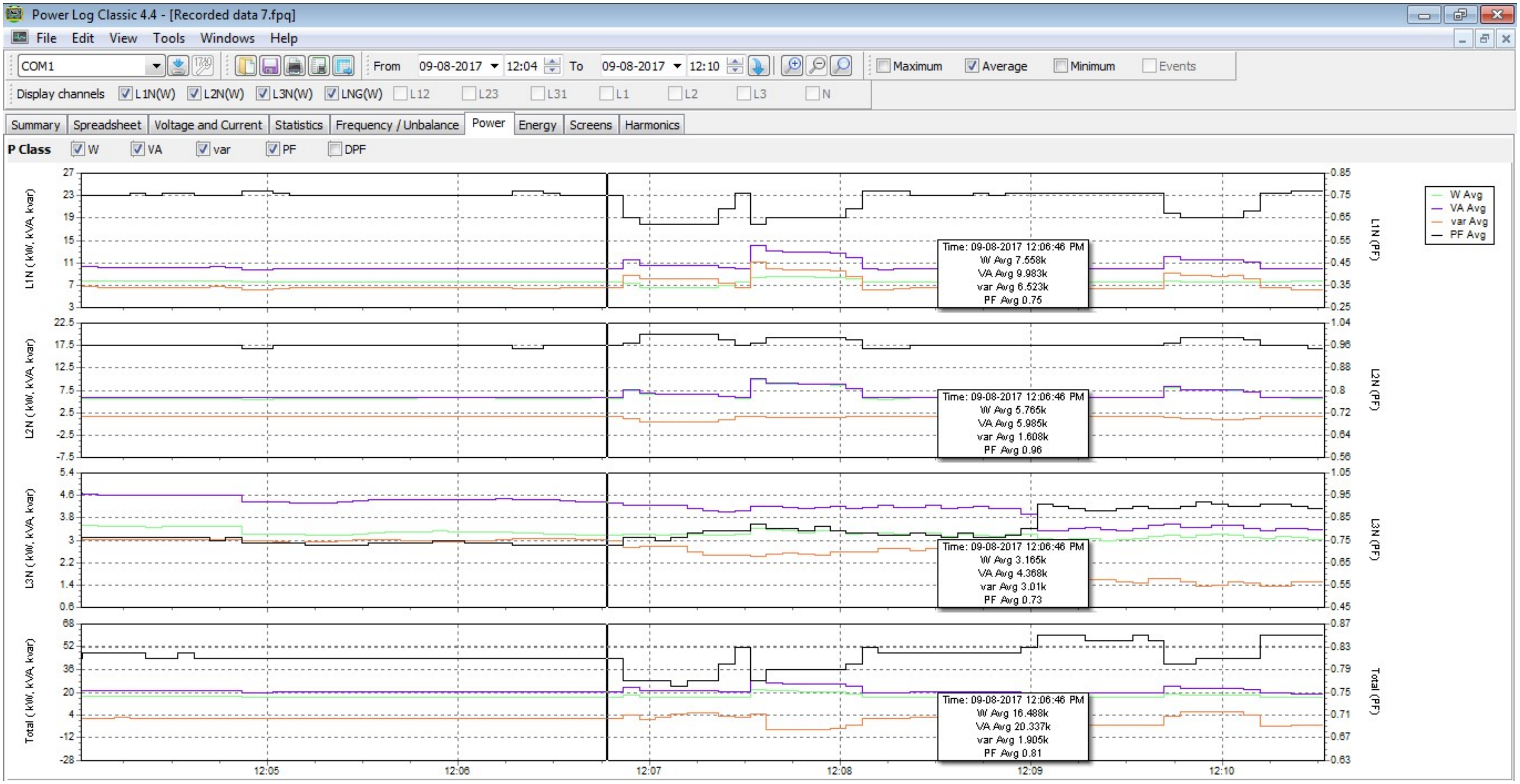
3.5.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
30.70	1.97	0.60	0.64	0.20	0.35	0.11	0.32	0.10	0.14	0.04	0.09	0.03	0.05	0.02	0.05	0.01
30.63	1.92	0.59	0.65	0.20	0.36	0.11	0.32	0.10	0.14	0.04	0.09	0.03	0.05	0.02	0.05	0.01
30.17	2.04	0.62	0.70	0.21	0.36	0.11	0.32	0.10	0.14	0.04	0.09	0.03	0.05	0.02	0.05	0.01
29.90	2.06	0.62	0.73	0.22	0.35	0.10	0.33	0.10	0.14	0.04	0.09	0.03	0.06	0.02	0.05	0.01
30.03	2.02	0.61	0.74	0.22	0.37	0.11	0.34	0.10	0.14	0.04	0.09	0.03	0.06	0.02	0.05	0.01
29.73	2.06	0.61	0.76	0.23	0.36	0.11	0.34	0.10	0.15	0.04	0.09	0.03	0.06	0.02	0.05	0.01
33.00	2.19	0.72	0.83	0.27	0.39	0.13	0.34	0.11	0.16	0.05	0.11	0.04	0.07	0.02	0.06	0.02
33.67	2.03	0.68	0.80	0.27	0.33	0.11	0.33	0.11	0.15	0.05	0.10	0.03	0.06	0.02	0.05	0.02
32.57	2.07	0.67	0.81	0.26	0.33	0.11	0.34	0.11	0.15	0.05	0.10	0.03	0.06	0.02	0.06	0.02
29.40	2.36	0.69	0.87	0.25	0.35	0.10	0.36	0.10	0.16	0.05	0.10	0.03	0.07	0.02	0.06	0.02
28.47	2.43	0.69	0.93	0.26	0.37	0.10	0.35	0.10	0.17	0.05	0.11	0.03	0.07	0.02	0.06	0.02
30.27	2.56	0.77	0.91	0.28	0.37	0.11	0.35	0.10	0.17	0.05	0.11	0.03	0.07	0.02	0.06	0.02

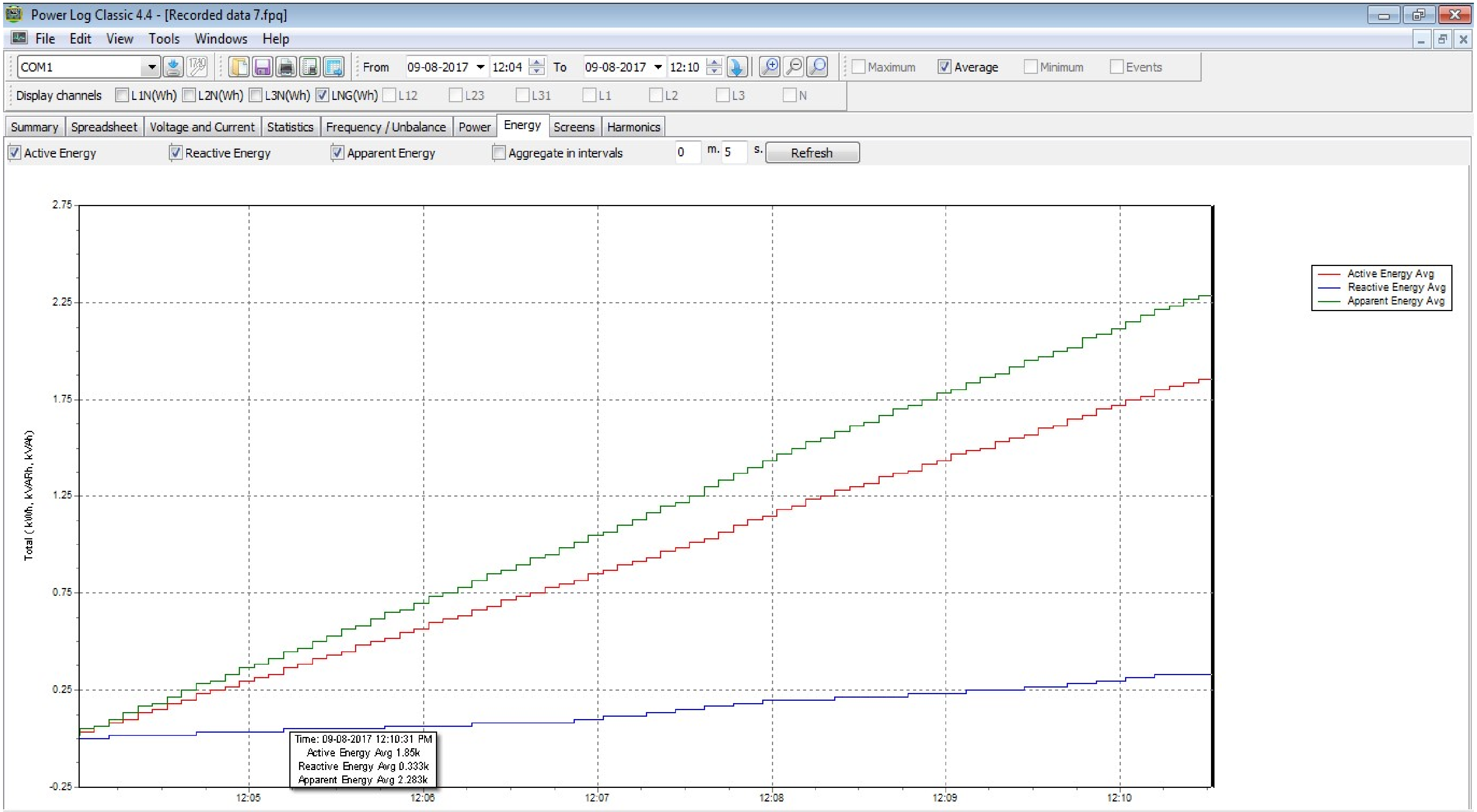
3.5.3 **SCREEN SHOT OF POWER AT CANTEEN**



3.5.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.5.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.6 BLOCK A – UPS

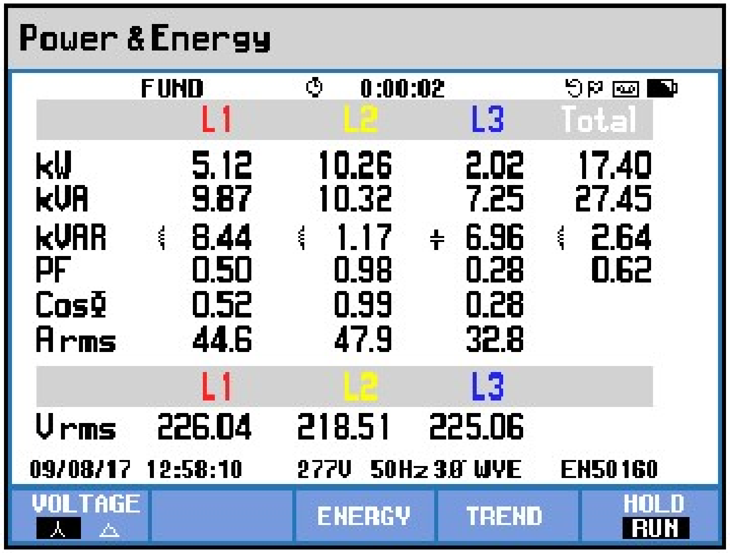
3.6.1 Basic Electrical Parameters (from 12:49 to 12:57 averaged over 20 seconds)

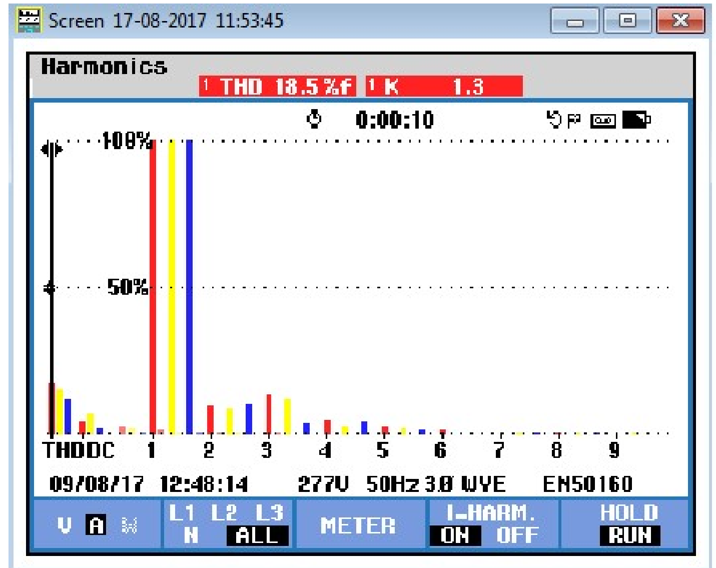
Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
226.86	37.40	36.67	49.91	0.37	1.86	14.73	-4.01	24.99	0.58	0.59	3.57	17.39	0.06	-0.01	0.08
226.70	37.50	36.83	49.92	0.38	1.88	14.74	-4.02	25.05	0.58	0.59	3.57	17.35	0.16	-0.04	0.27
226.61	37.47	36.73	49.93	0.38	1.89	14.70	-3.96	25.02	0.58	0.59	3.57	17.27	0.26	-0.07	0.43
226.49	37.58	36.80	49.95	0.39	1.94	14.61	-3.75	25.06	0.57	0.59	3.55	17.22	0.38	-0.10	0.65
226.28	40.03	39.33	49.96	0.39	1.52	16.46	-3.29	26.72	0.60	0.62	3.52	16.43	0.53	0.01	0.89
222.45	41.75	41.00	49.95	0.24	1.39	17.43	0.88	27.49	0.62	0.64	3.32	15.21	0.69	0.17	1.16
222.76	41.78	41.10	49.94	0.16	1.45	17.37	2.61	27.44	0.63	0.64	3.23	15.24	0.87	0.19	1.43
223.50	41.58	40.93	49.96	0.25	1.35	17.42	2.68	27.41	0.63	0.64	3.24	15.32	1.03	0.22	1.69
223.30	41.92	41.20	49.99	0.28	1.33	17.41	2.39	27.60	0.62	0.63	3.22	15.16	1.18	0.24	1.93
223.79	39.47	38.80	50.01	0.26	1.57	15.98	-0.40	26.03	0.61	0.62	3.26	16.25	1.32	0.26	2.14
224.25	37.53	36.83	50.03	0.19	1.88	14.54	-3.45	24.79	0.58	0.59	3.29	17.28	1.46	0.29	2.39
224.04	37.60	36.87	50.03	0.16	1.87	14.57	-3.39	24.83	0.58	0.59	3.31	17.27	1.61	0.33	2.63
224.01	37.85	37.10	50.03	0.15	1.89	14.55	-3.19	24.95	0.57	0.59	3.31	17.16	1.73	0.36	2.84
223.96	37.53	36.83	50.03	0.18	1.86	14.54	-3.35	24.79	0.57	0.59	3.31	17.28	1.88	0.38	3.08
223.75	37.80	37.10	50.01	0.18	1.89	14.51	-3.15	24.90	0.57	0.59	3.28	17.21	2.01	0.41	3.33

3.6.2 Currents with Harmonics

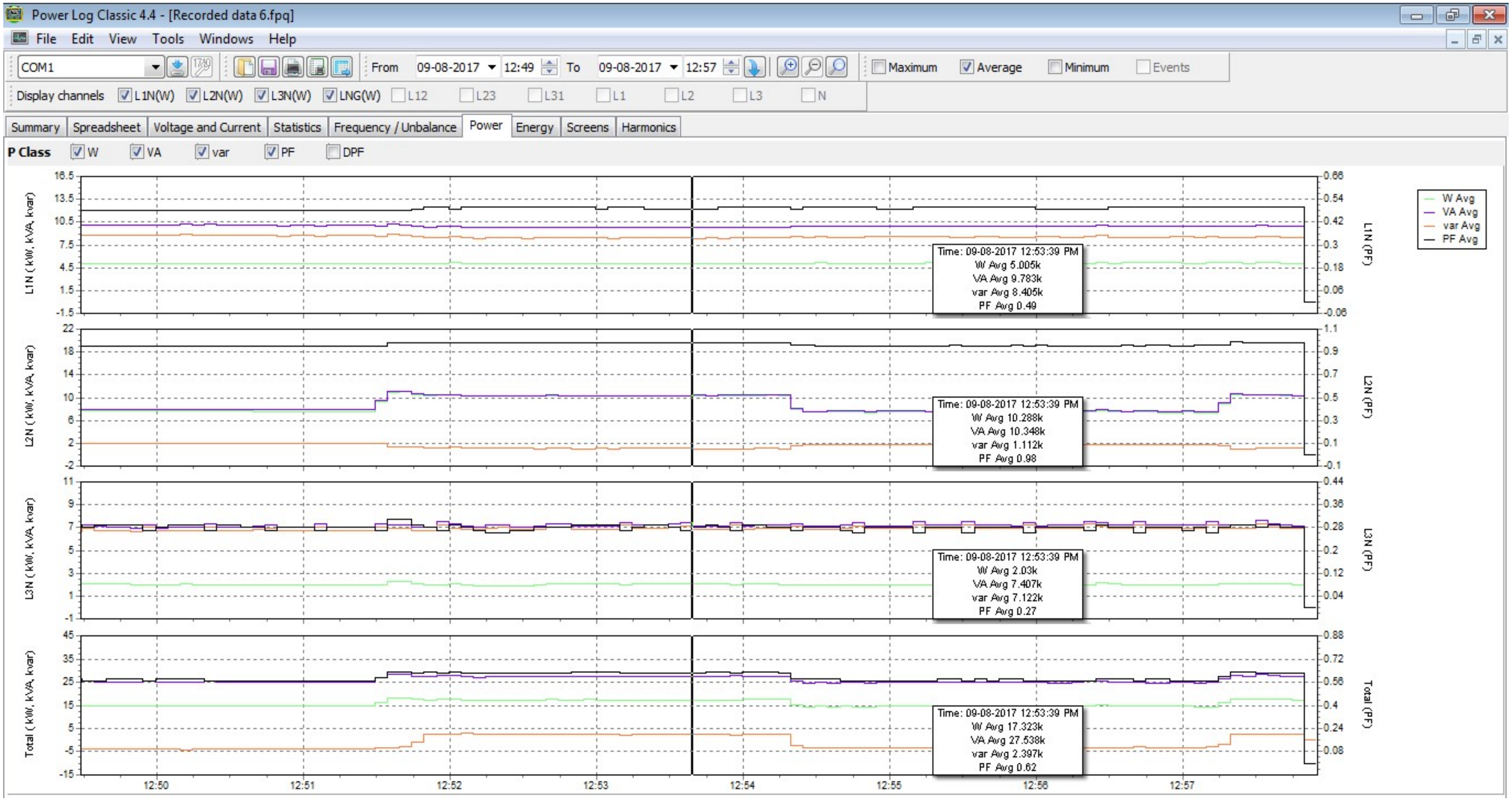
Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
36.67	17.39	6.38	11.46	4.20	2.24	0.82	0.68	0.25	0.51	0.19	0.43	0.16	0.21	0.08	0.15	0.06
36.83	17.35	6.39	11.45	4.22	2.25	0.83	0.69	0.25	0.51	0.19	0.43	0.16	0.21	0.08	0.15	0.06
36.73	17.27	6.34	11.47	4.21	2.25	0.83	0.68	0.25	0.51	0.19	0.43	0.16	0.20	0.07	0.15	0.05
36.80	17.22	6.34	11.44	4.21	2.26	0.83	0.68	0.25	0.51	0.19	0.43	0.16	0.20	0.07	0.15	0.05
39.33	16.43	6.44	10.42	4.07	2.09	0.82	0.60	0.23	0.46	0.18	0.38	0.15	0.18	0.07	0.14	0.05
41.00	15.21	6.24	9.71	3.98	1.98	0.81	0.54	0.22	0.42	0.17	0.35	0.14	0.16	0.07	0.13	0.05
41.10	15.24	6.26	9.75	4.01	1.96	0.80	0.52	0.22	0.42	0.17	0.35	0.14	0.16	0.07	0.13	0.05
40.93	15.32	6.27	9.80	4.01	1.98	0.81	0.53	0.21	0.42	0.17	0.35	0.14	0.16	0.07	0.13	0.05
41.20	15.16	6.25	9.75	4.02	1.95	0.80	0.52	0.21	0.42	0.17	0.36	0.15	0.17	0.07	0.13	0.05
38.80	16.25	6.28	10.63	4.10	2.04	0.79	0.59	0.23	0.47	0.18	0.39	0.15	0.18	0.07	0.14	0.05
36.83	17.28	6.37	11.56	4.26	2.14	0.79	0.65	0.24	0.51	0.19	0.43	0.16	0.21	0.08	0.15	0.06
36.87	17.27	6.37	11.60	4.28	2.14	0.79	0.64	0.24	0.51	0.19	0.42	0.15	0.21	0.08	0.15	0.06
36.83	17.29	6.37	11.61	4.28	2.13	0.78	0.65	0.24	0.52	0.19	0.42	0.15	0.21	0.08	0.15	0.06
37.10	17.21	6.39	11.57	4.29	2.12	0.79	0.64	0.24	0.51	0.19	0.42	0.16	0.21	0.08	0.15	0.06
38.23	16.78	6.41	11.13	4.25	2.07	0.79	0.62	0.24	0.49	0.19	0.41	0.16	0.20	0.08	0.15	0.06

3.6.3 SCREEN SHOTS OF POWER AND HARMONICS AT BLOCK A

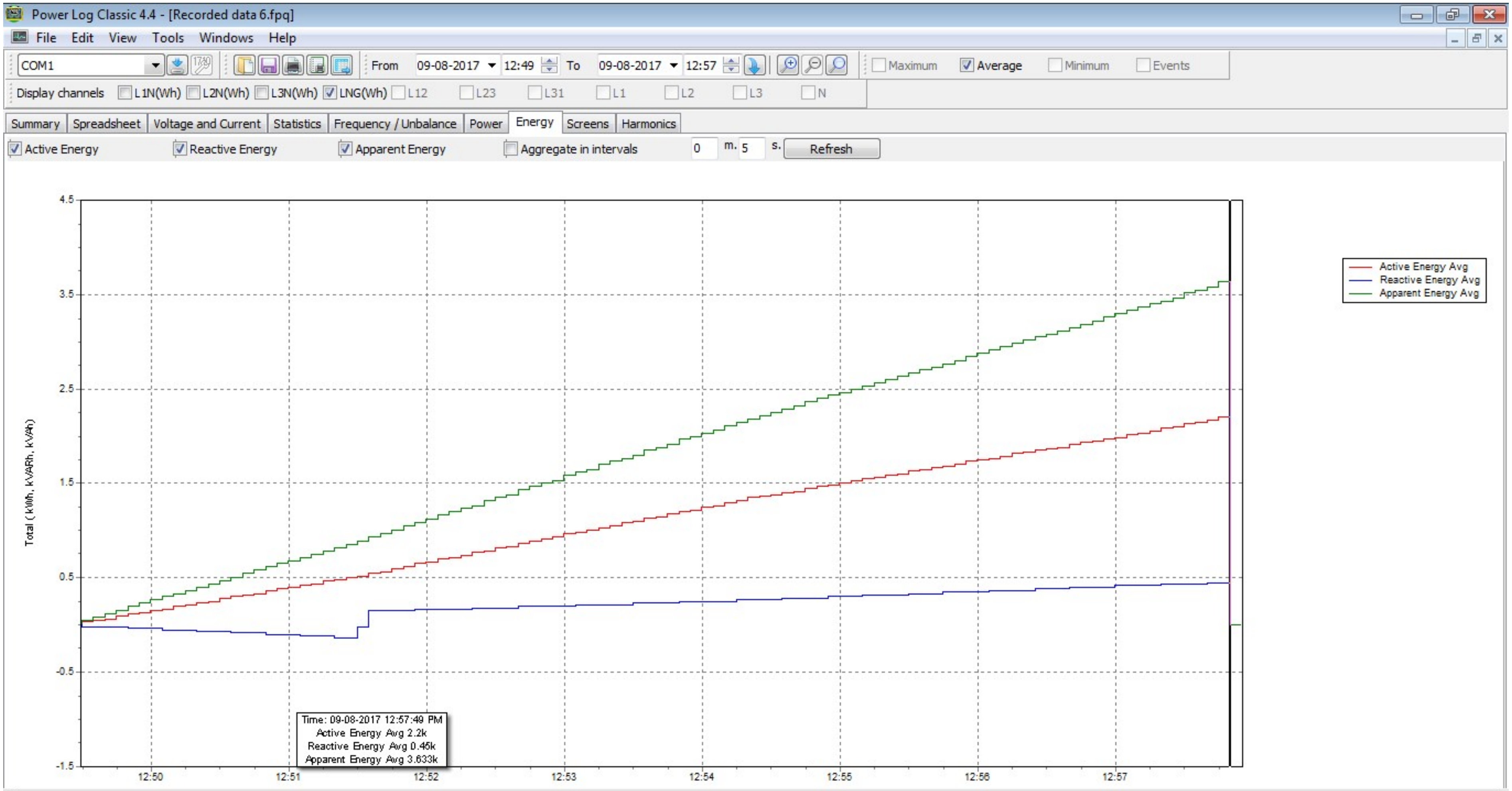




3.6.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.6.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.7 BLOCK B UPS

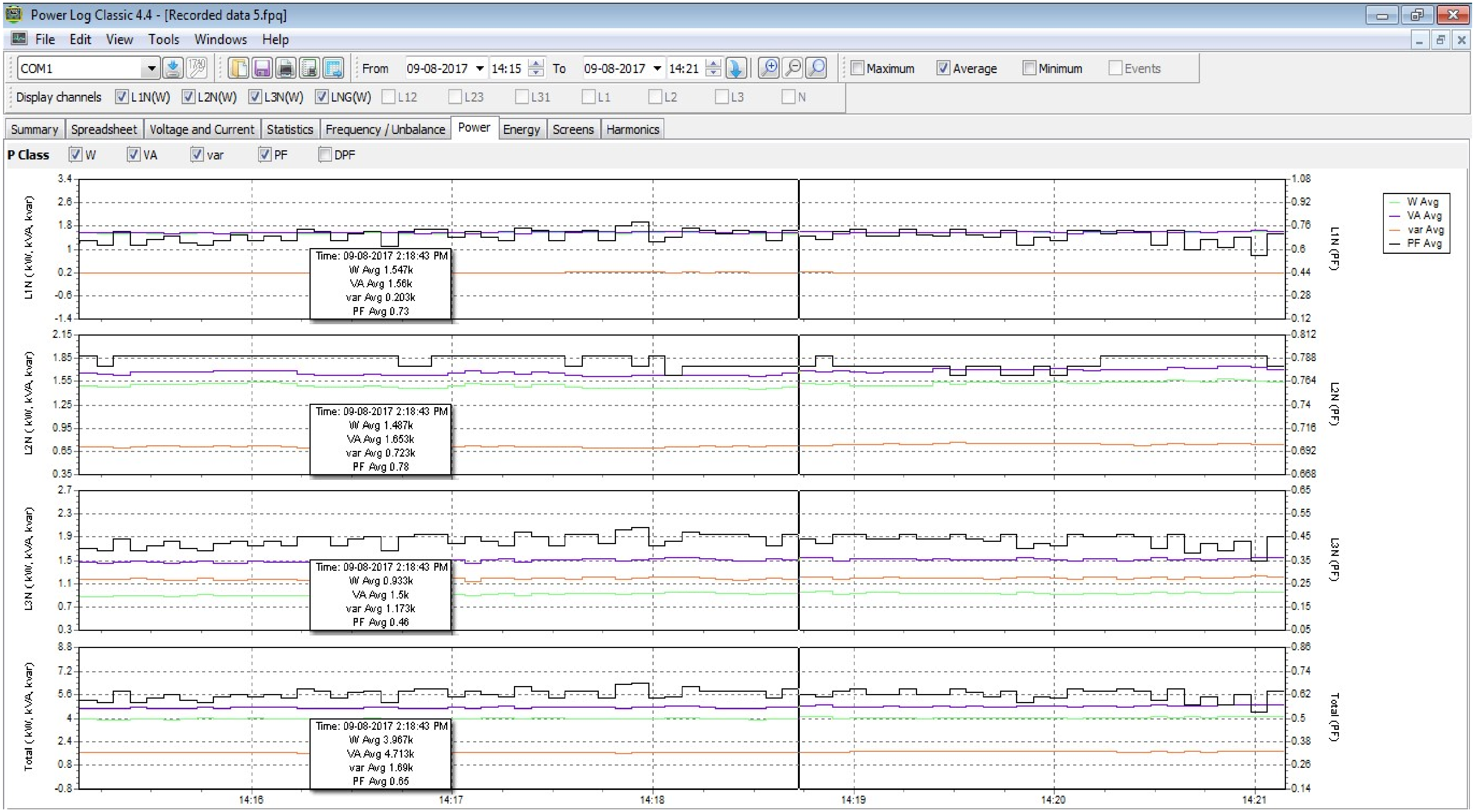
3.7.1 Basic Electrical Parameters (from 14:15 to 14:21 averaged over 20 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
217.60	11.30	7.23	49.94	0.80	3.82	3.97	1.71	4.73	0.59	0.84	2.50	39.98	0.02	0.00	0.02
217.78	10.95	7.20	49.94	0.79	3.80	3.95	1.68	4.70	0.61	0.84	2.46	40.07	0.05	0.02	0.05
218.44	10.52	7.17	49.95	0.69	3.85	3.95	1.67	4.69	0.64	0.84	2.51	39.68	0.07	0.03	0.08
218.17	9.98	7.13	49.96	0.65	3.61	3.93	1.66	4.67	0.65	0.84	2.50	39.66	0.10	0.03	0.12
217.70	9.83	7.13	49.97	0.72	3.47	3.92	1.68	4.67	0.66	0.84	2.45	39.79	0.15	0.07	0.17
218.22	9.83	7.30	49.97	0.46	3.29	4.01	1.69	4.76	0.66	0.84	2.40	39.36	0.18	0.07	0.22
217.56	10.45	7.20	49.97	0.47	3.14	3.96	1.68	4.71	0.62	0.84	2.45	40.71	0.22	0.10	0.25
217.33	10.53	7.30	49.97	0.88	3.09	4.00	1.74	4.76	0.61	0.84	2.48	40.23	0.25	0.10	0.32
217.43	10.72	7.37	49.97	0.84	3.17	4.03	1.76	4.80	0.63	0.84	2.41	40.21	0.28	0.13	0.35
217.23	10.53	7.33	49.96	0.52	3.24	4.01	1.74	4.76	0.63	0.84	2.31	40.06	0.32	0.13	0.38
217.61	11.02	7.40	49.95	0.45	3.30	4.07	1.76	4.84	0.61	0.84	2.34	40.32	0.37	0.17	0.43

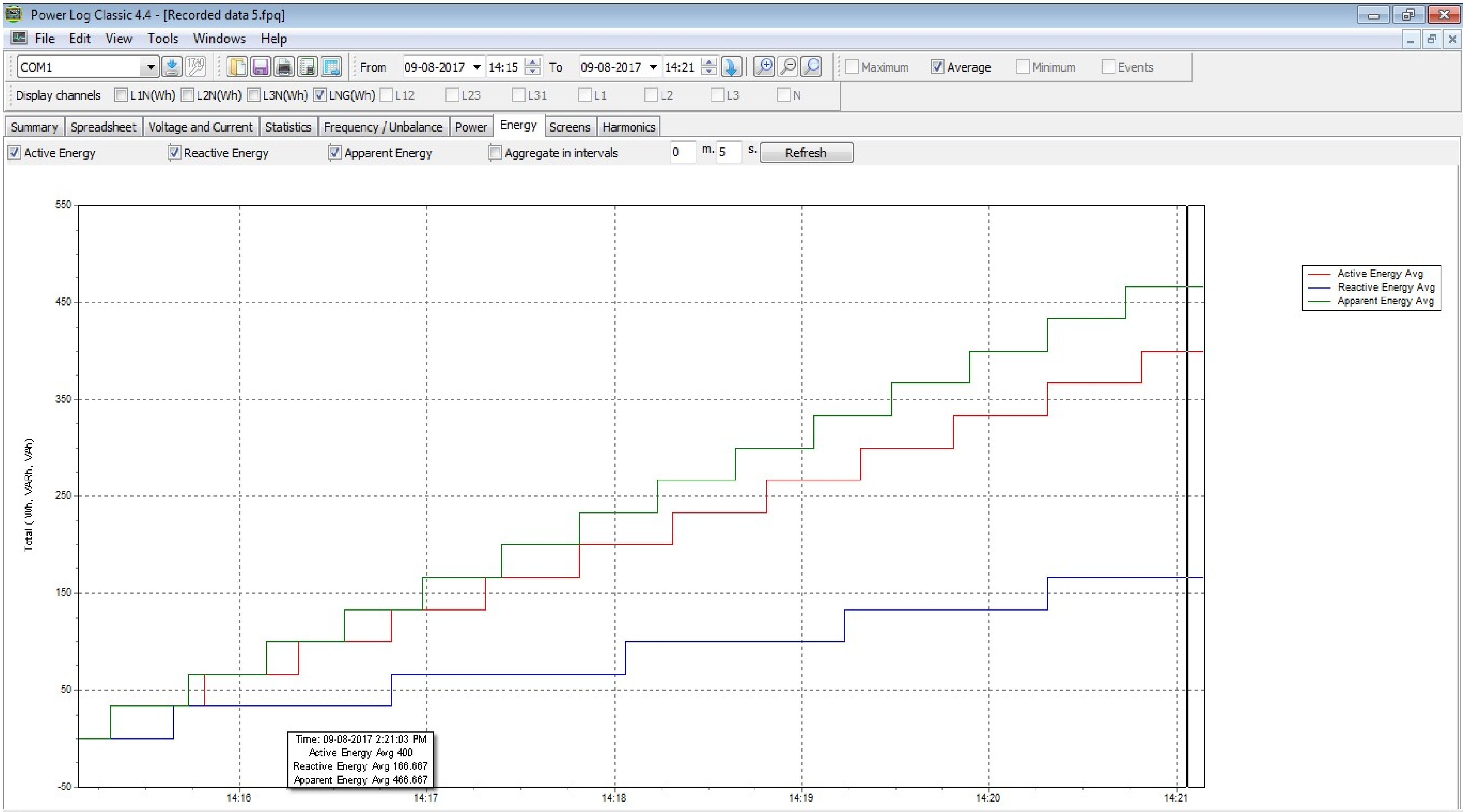
3.7.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD -s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
7.23	39.98	2.89	26.61	1.93	10.04	0.73	3.11	0.23	1.05	0.08	0.69	0.05	0.52	0.04	0.40	0.03
7.20	40.07	2.89	26.70	1.92	10.16	0.73	3.21	0.23	1.12	0.08	0.76	0.05	0.57	0.04	0.45	0.03
7.17	39.68	2.84	26.76	1.92	10.20	0.73	3.20	0.23	1.02	0.07	0.65	0.05	0.51	0.04	0.38	0.03
7.13	39.66	2.83	26.73	1.91	10.19	0.73	3.20	0.23	1.01	0.07	0.62	0.04	0.48	0.03	0.36	0.03
7.13	39.79	2.84	26.79	1.91	10.20	0.73	3.15	0.22	0.98	0.07	0.60	0.04	0.47	0.03	0.34	0.02
7.30	39.36	2.87	26.82	1.96	10.25	0.75	3.25	0.24	1.03	0.08	0.69	0.05	0.53	0.04	0.40	0.03
7.20	40.71	2.93	26.58	1.91	10.03	0.72	3.12	0.22	1.04	0.07	0.64	0.05	0.48	0.03	0.39	0.03
7.30	40.23	2.94	26.60	1.94	10.03	0.73	3.12	0.23	1.08	0.08	0.63	0.05	0.49	0.04	0.40	0.03
7.37	40.21	2.96	26.66	1.96	10.06	0.74	3.12	0.23	1.07	0.08	0.65	0.05	0.51	0.04	0.40	0.03
7.33	40.06	2.94	26.76	1.96	10.20	0.75	3.21	0.24	1.10	0.08	0.71	0.05	0.55	0.04	0.43	0.03
7.40	40.32	2.98	26.61	1.97	10.02	0.74	3.10	0.23	1.07	0.08	0.73	0.05	0.55	0.04	0.43	0.03

3.7.3 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.7.4 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.8 BLOCK C INCOMER

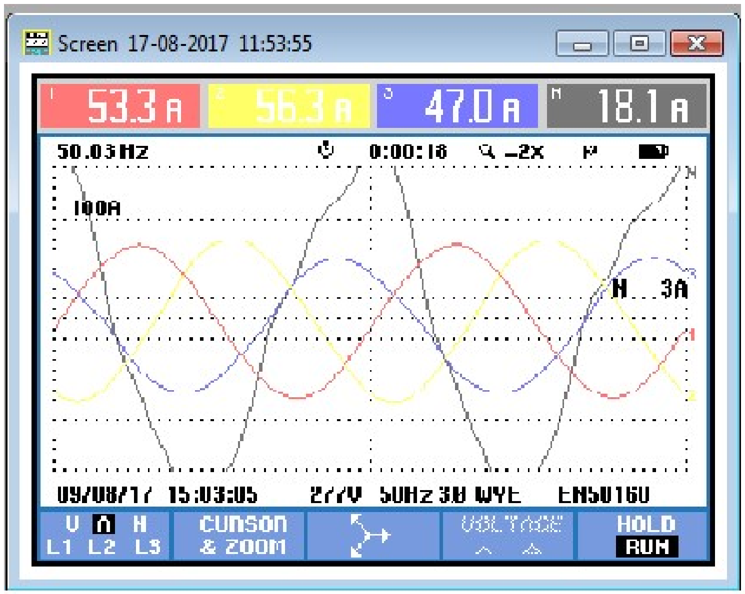
3.8.1 Basic Electrical Parameters (from 14:56 to 15:01 averaged over 20 seconds)

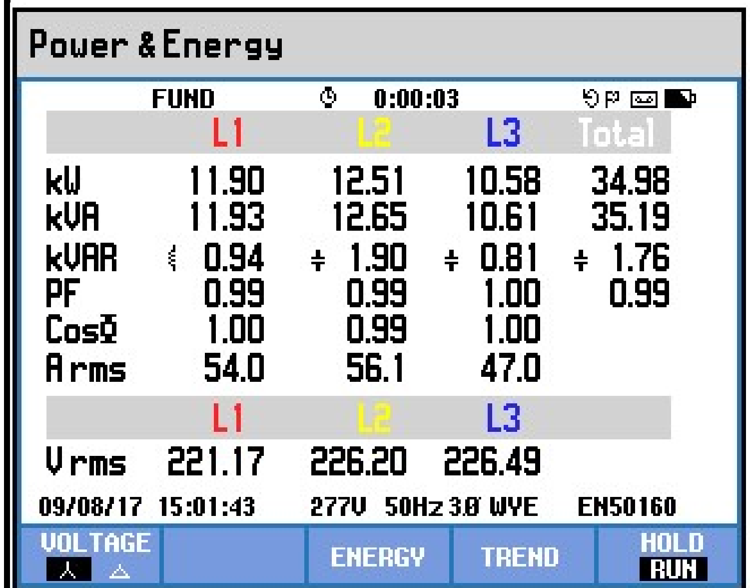
Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
223.83	50.15	50.07	49.95	0.19	0.95	33.35	2.26	33.60	0.99	0.99	3.77	2.86	0.12	0.00	0.12
223.82	50.03	49.97	49.95	0.24	0.89	33.27	2.26	33.53	0.99	0.99	3.77	2.90	0.35	0.03	0.35
223.92	50.40	50.30	49.95	0.29	0.94	33.51	2.30	33.77	0.99	0.99	3.78	2.91	0.58	0.03	0.58
223.95	50.67	50.60	49.95	0.31	1.01	33.71	2.27	33.97	0.99	0.99	3.78	2.90	0.87	0.07	0.87
224.25	50.63	50.60	49.95	0.31	1.12	33.74	2.24	33.99	0.99	0.99	3.79	2.90	1.20	0.08	1.20
224.34	50.65	50.60	49.95	0.28	1.17	33.73	2.20	33.99	0.99	0.99	3.81	2.89	1.52	0.10	1.53
224.33	50.90	50.80	49.97	0.26	1.17	33.97	1.64	34.17	0.99	1.00	3.85	2.91	1.85	0.12	1.87
224.47	53.43	53.40	49.98	0.24	1.52	35.69	1.74	35.91	0.99	0.99	3.99	3.05	2.20	0.13	2.20
224.37	52.78	52.70	49.99	0.19	1.42	35.24	1.65	35.44	0.99	0.99	3.95	3.00	2.48	0.15	2.50
224.81	52.45	52.33	49.99	0.26	1.41	35.09	1.69	35.29	0.99	0.99	3.84	2.82	2.77	0.17	2.80

3.8.2 Currents with Harmonics

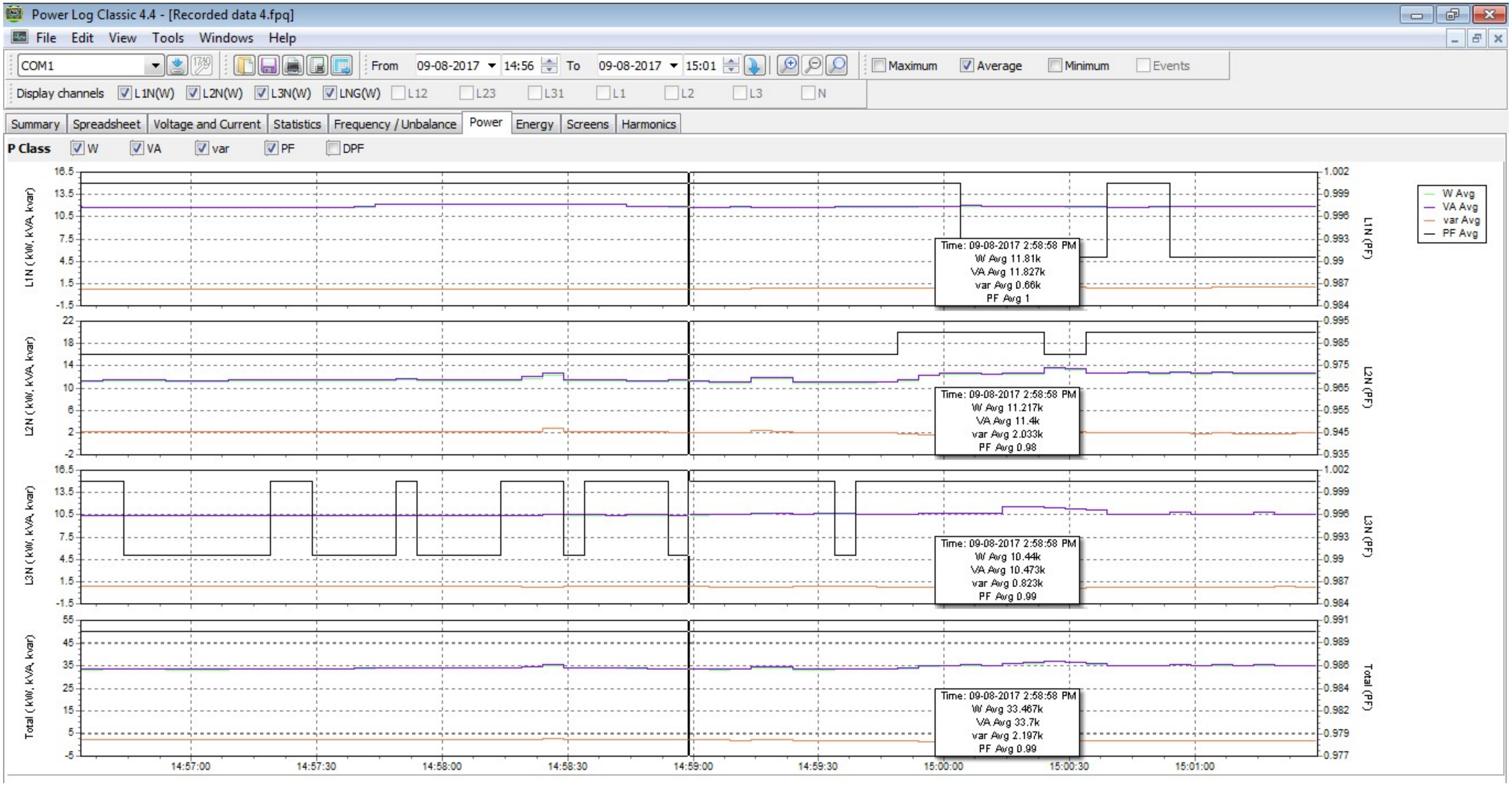
Av. of three line currents (fund.)in A	Av. Of three I THD -s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
50.07	2.86	1.43	1.80	0.90	0.88	0.44	0.34	0.17	0.14	0.07	0.06	0.03	0.03	0.02	0.04	0.02
49.97	2.90	1.45	1.81	0.90	0.89	0.44	0.34	0.17	0.14	0.07	0.06	0.03	0.03	0.01	0.04	0.02
50.30	2.91	1.46	1.80	0.90	0.89	0.45	0.34	0.17	0.14	0.07	0.06	0.03	0.03	0.02	0.04	0.02
50.60	2.90	1.46	1.80	0.91	0.89	0.45	0.34	0.17	0.14	0.07	0.06	0.03	0.03	0.02	0.04	0.02
50.60	2.90	1.47	1.78	0.90	0.88	0.44	0.34	0.17	0.13	0.07	0.06	0.03	0.03	0.02	0.04	0.02
50.60	2.89	1.46	1.76	0.89	0.84	0.42	0.33	0.17	0.13	0.07	0.06	0.03	0.03	0.02	0.04	0.02
50.80	2.91	1.48	1.84	0.94	0.82	0.41	0.32	0.16	0.13	0.07	0.06	0.03	0.03	0.02	0.04	0.02
53.40	3.05	1.63	1.98	1.06	0.91	0.49	0.33	0.18	0.12	0.06	0.06	0.03	0.03	0.02	0.04	0.02
52.70	3.00	1.58	1.99	1.05	0.92	0.48	0.34	0.18	0.12	0.06	0.06	0.03	0.04	0.02	0.04	0.02
52.33	2.82	1.47	1.79	0.93	0.85	0.44	0.34	0.18	0.14	0.07	0.06	0.03	0.03	0.02	0.04	0.02

3.8.3 SCREENSHOTS AT BLOCK C INCOMER

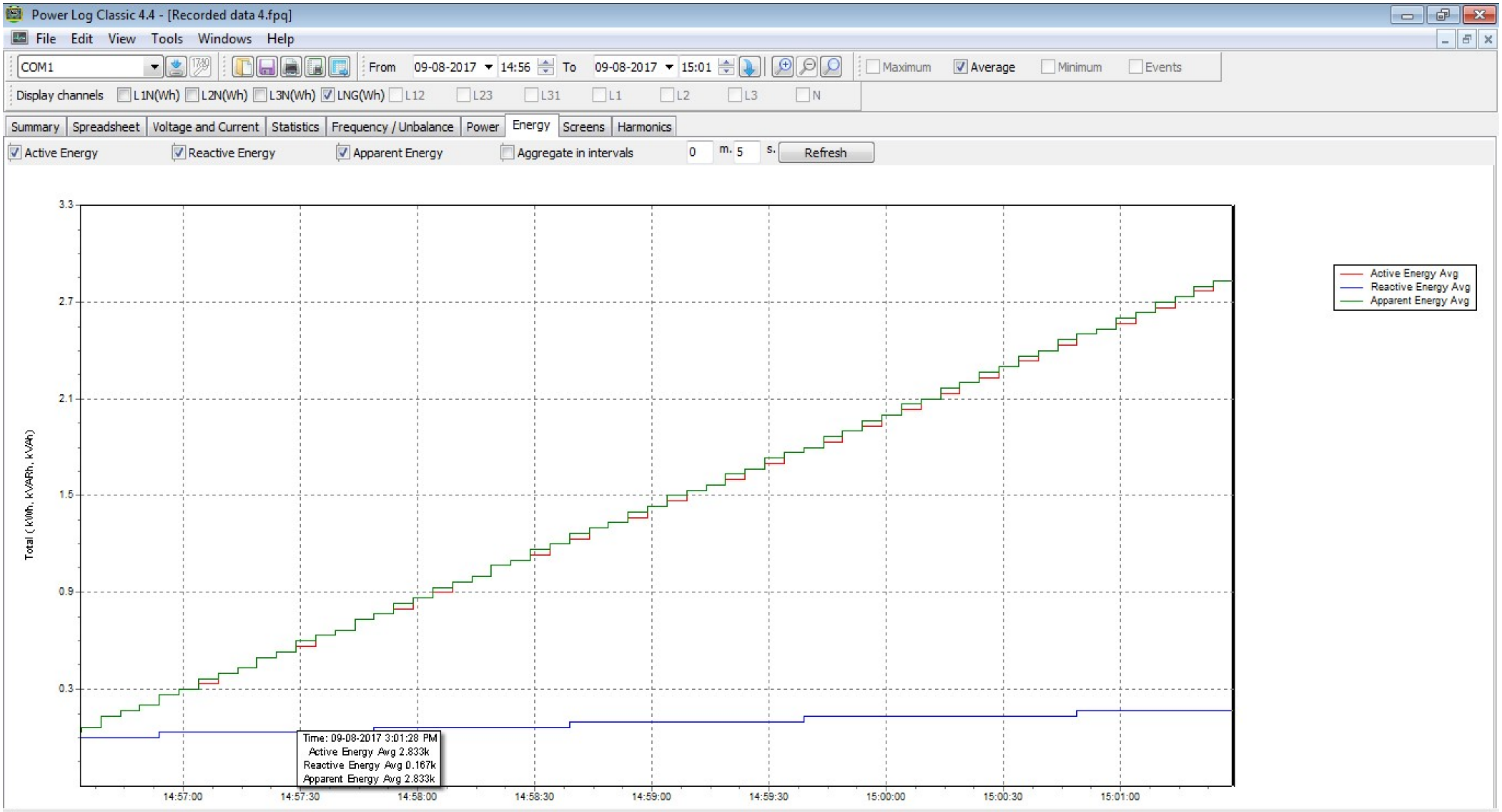




3.8.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.8.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.9 BLOCK D

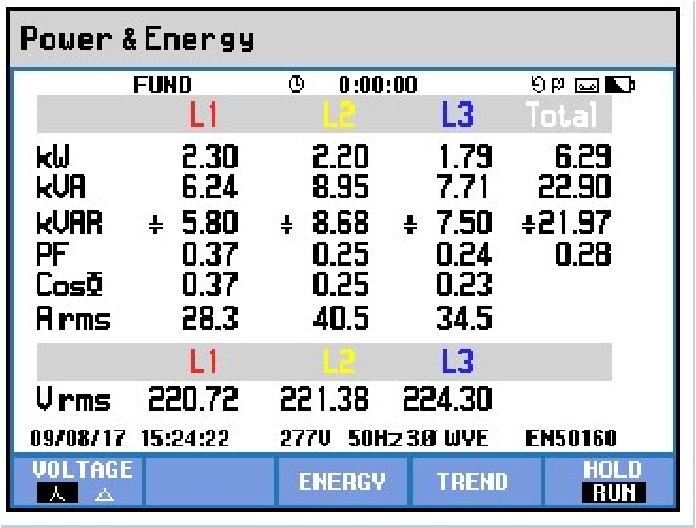
3.9.1 Basic Electrical Parameters (from 15:18 to 15:21 averaged over 20 seconds)

Av . Of Three phase Voltages in V	Av. Of three line currents in A	Av. Of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
220.93	33.40	33.30	49.86	0.47	0.87	5.65	21.31	22.09	0.26	0.26	2.89	3.05	0.02	0.07	0.08
221.01	33.72	33.63	49.85	0.49	0.90	5.82	21.50	22.32	0.27	0.26	2.95	3.04	0.05	0.23	0.23
221.30	33.25	33.17	49.87	0.45	1.00	5.76	21.22	22.03	0.27	0.26	2.90	3.09	0.10	0.37	0.38
221.10	34.73	34.63	49.89	0.33	1.13	6.40	22.00	22.96	0.28	0.28	3.12	3.69	0.15	0.55	0.57
221.27	36.25	36.10	49.92	0.27	1.22	7.13	22.81	23.94	0.30	0.30	3.35	4.22	0.22	0.77	0.80
221.44	36.25	36.10	49.93	0.17	1.78	7.11	22.83	23.94	0.30	0.30	3.39	4.26	0.28	1.00	1.03

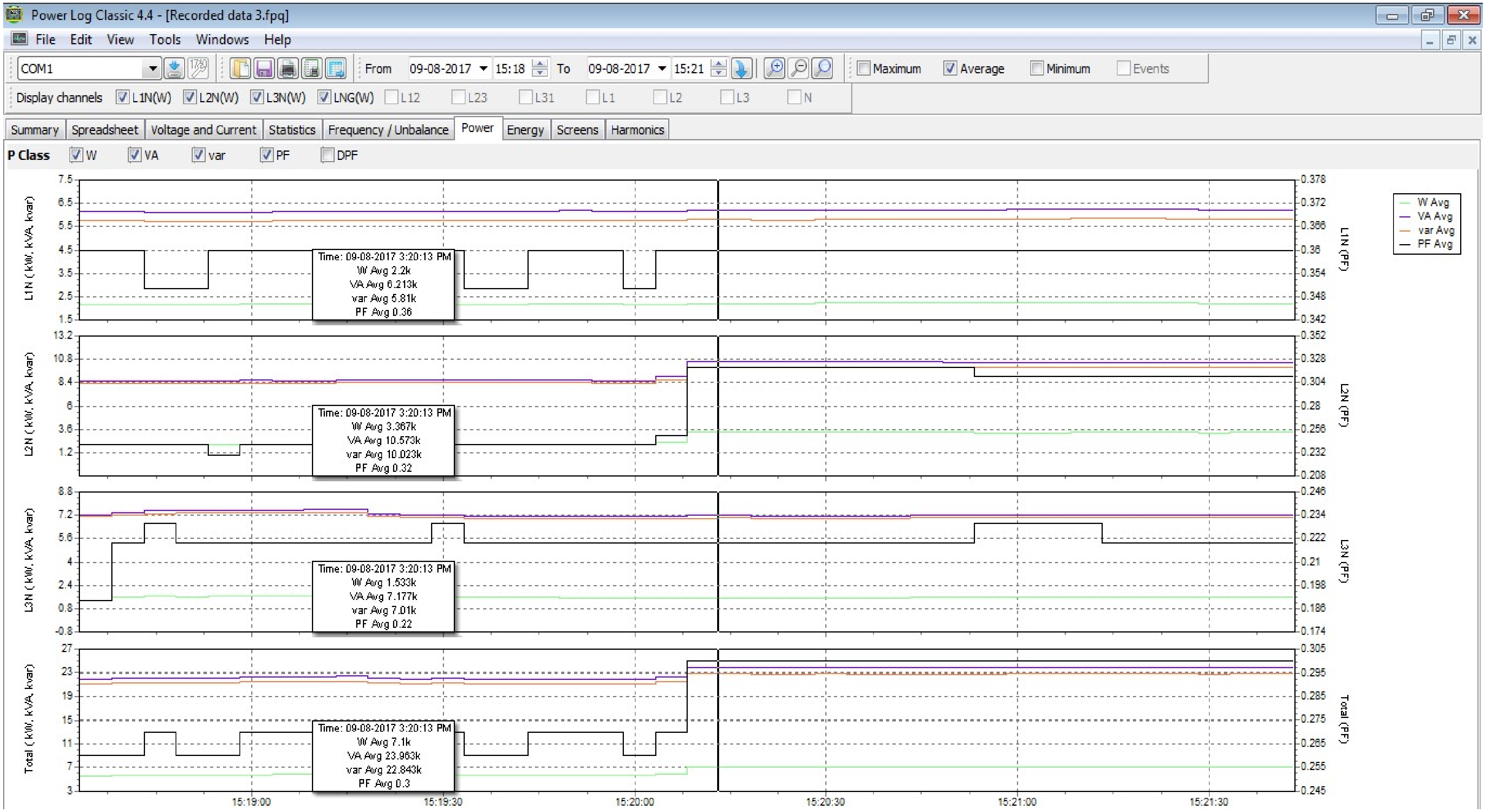
3.9.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD-s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
33.30	3.05	1.01	1.71	0.57	0.78	0.26	0.32	0.11	0.13	0.04	0.06	0.02	0.06	0.02	0.05	0.02
33.63	3.04	1.02	1.70	0.57	0.80	0.27	0.32	0.11	0.12	0.04	0.06	0.02	0.06	0.02	0.05	0.02
33.17	3.09	1.02	1.69	0.56	0.81	0.27	0.32	0.11	0.13	0.04	0.06	0.02	0.06	0.02	0.05	0.02
34.63	3.69	1.29	2.39	0.84	0.84	0.29	0.23	0.08	0.13	0.05	0.07	0.03	0.05	0.02	0.05	0.02
36.10	4.22	1.52	3.10	1.12	0.98	0.35	0.19	0.07	0.14	0.05	0.10	0.04	0.05	0.02	0.05	0.02
36.10	4.26	1.54	3.12	1.12	1.05	0.38	0.21	0.07	0.14	0.05	0.10	0.03	0.04	0.02	0.06	0.02

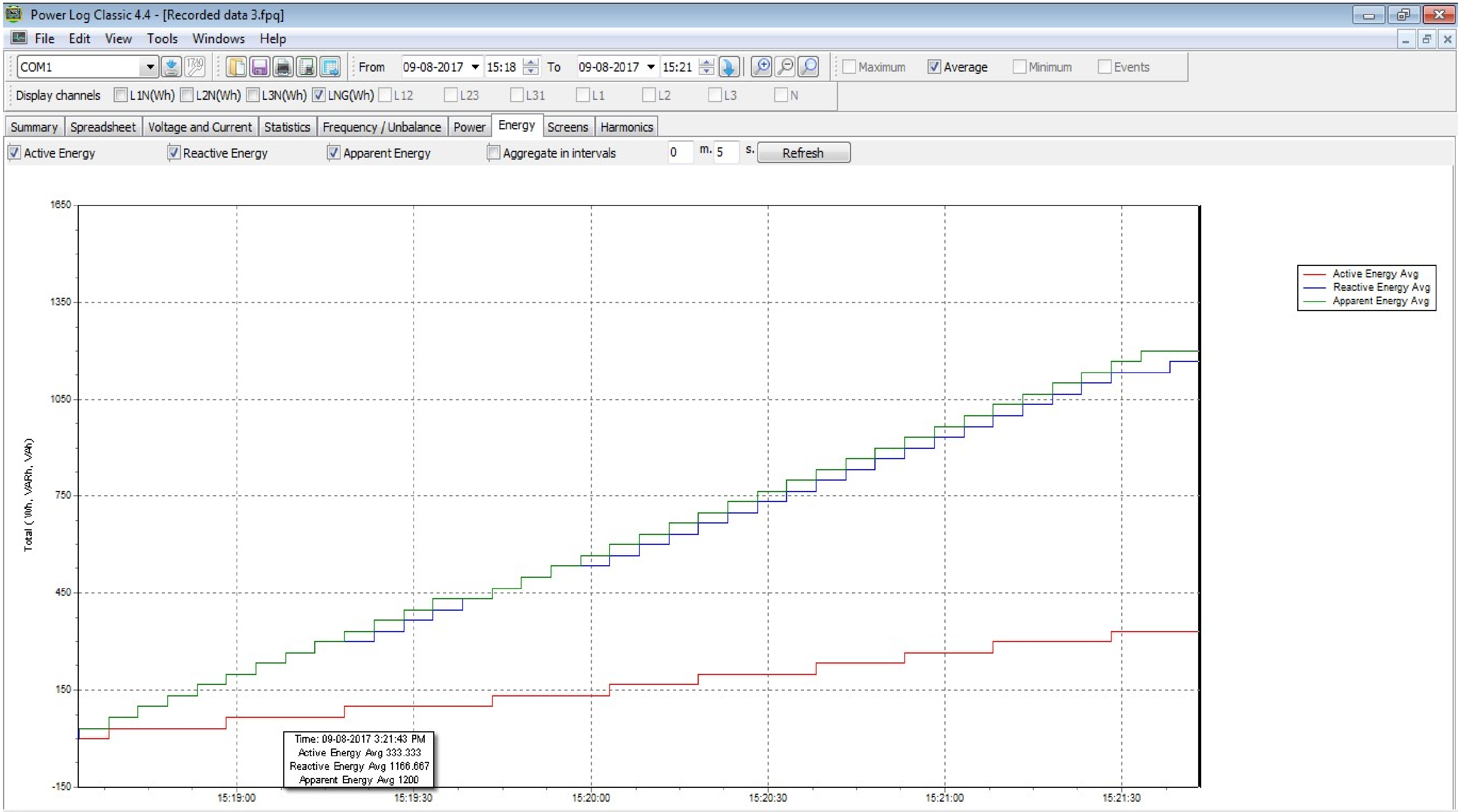
3.9.3 SCREENSHOT AT BLOCK D



3.9.4 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.9.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.10 BLOCK F

SEPERATE LT

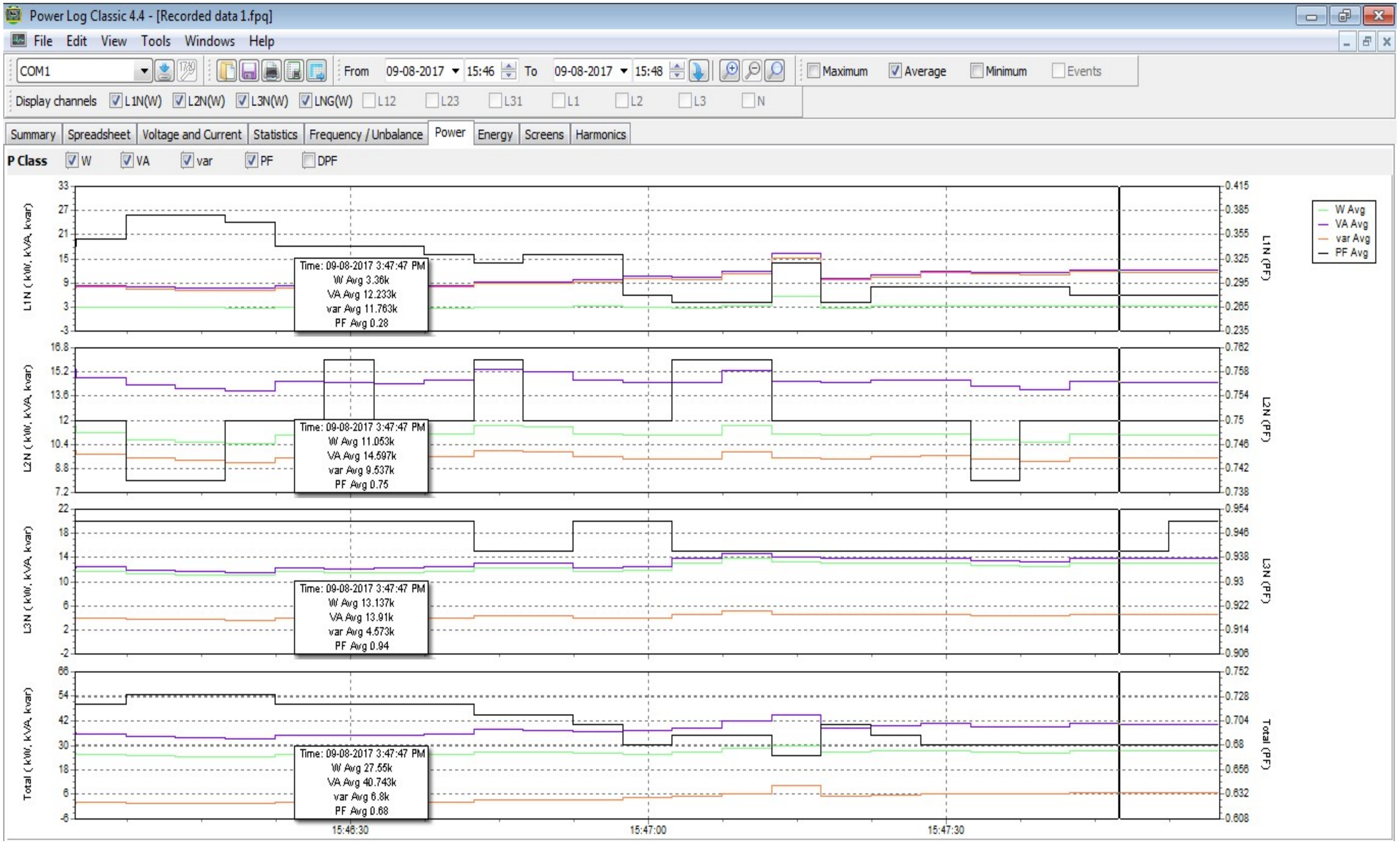
3.10.1 Basic Electrical Parameters (from 15:46 to 15:48 averaged over 30 seconds)

Av . Of Three phase Voltages in V	Av. of three line currents in A	Av. of three line currents (fund.)in A	Frequency Avg	Unbalance Vn Avg	Unbalance An Avg	Active Power Total Avg in kW	Reactive Power Total Avg in kVAR	Apparent Power Total Avg in kVA	Power Factor Total Avg	DPF Total Avg	Av. Of three V THD-s in %-age	Av. Of three I THD-s in % age	Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh
229.65	50.22	50.13	49.98	0.44	0.49	25.17	1.62	34.50	0.73	0.73	2.01	5.82	0.10	0.00	0.13
229.41	52.98	52.83	49.99	0.47	0.46	26.19	2.66	36.37	0.72	0.73	2.04	5.60	0.27	0.02	0.37
229.08	58.38	58.23	50.00	0.49	0.41	27.80	4.87	39.70	0.70	0.71	2.03	5.22	0.45	0.05	0.62
228.97	59.32	59.17	49.99	0.50	0.24	27.54	6.35	40.33	0.69	0.69	1.95	4.95	0.68	0.08	0.95

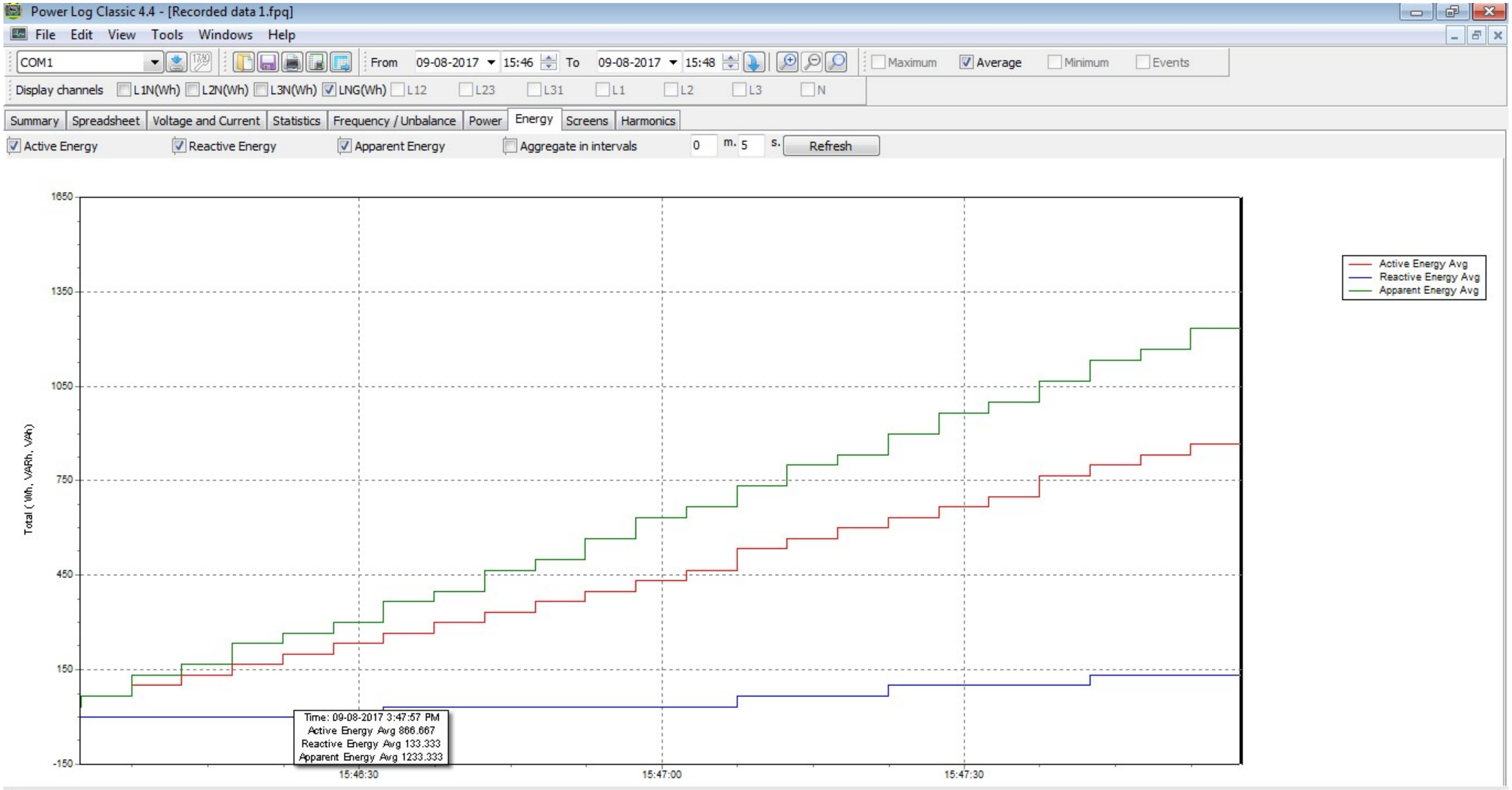
3.10.2 Currents with Harmonics

Av. of three line currents (fund.)in A	Av. Of three I THD -s in %-age	Av. Of three line current harmonics in A	Av. Of three I 3 harmonics in %-age	Av. Of three I 3 harmonics in A	Av. Of three I 5 harmonics in %-age	Av. Of three I 5 harmonics in A	Av. Of three I 7 harmonics in %-age	Av. Of three I 7 harmonics in A	Av. Of three I 9 harmonics in %-age	Av. Of three I 9 harmonics in A	Av. Of three I 11 harmonics in %-age	Av. Of three I 11 harmonics in A	Av. Of three I 13 harmonics in %-age	Av. Of three I 13 harmonics in A	Av. Of three I 15 harmonics in %-age	Av. Of three I 15 harmonics in A
50.13	5.82	2.91	2.25	1.12	0.80	0.40	0.35	0.18	0.24	0.12	0.25	0.12	0.13	0.06	0.08	0.04
52.83	5.60	2.95	2.18	1.15	0.81	0.43	0.35	0.18	0.24	0.13	0.23	0.12	0.11	0.06	0.07	0.04
58.23	5.22	3.03	2.10	1.21	0.80	0.46	0.34	0.19	0.23	0.13	0.21	0.12	0.10	0.06	0.06	0.04
59.17	4.95	2.92	1.84	1.09	0.67	0.40	0.28	0.16	0.17	0.10	0.18	0.10	0.09	0.05	0.06	0.03

3.10.3 Trend curve of Active Power in kW , Reactive power in kVAR and power Factor



3.10.5 Trend curve of Active Energy in kWh , Reactive Energy in kVARh and Apparent Energy in kVAh



3.11 BLOCK WISE ENERGY OBSERVATIONS

The following table represents the energy consumption details at various blocks based on the measurement taken on 09.08.2017 from 11.00am to 4.00pm. The cumulative **energy consumption** taken from each block **basic electrical parameter** tabulation. For calculating total active energy consumption we have assumed the number of working hours and days.

Table 1: BLOCK WISE ENERGY CONSUMPTION DETAILS

BLOCKS	Working Hours (Assumed)	Working Days (per month) (Assumed)	DURATION OF MEASURE MENT IN MINUTES	ENERGY CONSUMED			Active Energy Total (kWh)		
				Active Energy Total Avg in kWh	Reactive Energy Total Avg in kVARh	Apparent Energy Total Avg in kVAh	(for 1 hour)	Per day	Per month
BLOCK F	6	20	3	0.68	0.08	0.95	13.6	81.6	1632.0
BLOCK D	6	20	3	0.28	1	1.03	5.6	33.6	672.0
BLOCK C INCOMER	6	20	5	2.77	0.17	2.8	33.2	199.4	3988.8
BLOCK B UPS	6	20	6	0.37	0.17	0.43	3.7	22.2	444.0
BLOCK A – UPS	6	20	8	2.01	0.41	3.33	15.1	90.5	1809.0
CANTEEN	4	25	6	1.72	0.3	2.13	17.2	68.8	1720.0
BLOCK B	6	20	9	15.75	8.98	18.21	105.0	630.0	12600.0
BLOCK A	6	20	17	30.36	9.68	31.9	107.2	642.9	12858.4
HOSTEL II	8	25	10	6.45	18	19.15	38.7	309.6	7740.0

Total 43464.2 kWh

TOTAL INCOMER	6	20	16	109.83	48.83	120.33	411.9	2471.2	49423.5

RECOMMENDATIONS:

1. Readings taken at various blocks such as electrical parameters, data, waveforms and graphs are explicitly given under each heading.
2. These data are used to calculate the Energy consumption details for various blocks.
3. From the table, it is understand that major loads are in the block A and Block B. The current THD and Voltage THD are well within the standard limits. Energy Conservation opportunites may be identiifed and necessary measures may be taken to conserve energy.
4. Energy Conservation policy may be defined by the university and Energy Conservation slogans may be disseminated to students and staff of the university to conserve energy.

Table 2: CURRENT HARMONIC

Standard value of Current TDD / Max. Harmonic Current Distortion in % of I :					**8%**			
Individual Current Harmonics					**h< 11 : 7% , 11 ≤ h ≤17 : 3.5%, 17 < h ≤ 23 : 2.5 %**			
S.No	**Location**	**Current THD(%)**	**% of 3rd harmonics**	**% of 5th harmonics**	**% of 7th harmonics**	**% of 9th harmonics**	**% of 11rd harmonics**	**Comments and Recommendations**
1	INCOMER	4.3	2.67	2.18	0.67	0.32	0.22	Within the Limit
2	HOSTEL II	3.94	2.83	0.99	0.25	0.09	0.08	Within the Limit
3	Block A	5.02	3.19	1.4	0.49	0.37	0.20	Within the Limit
4	Block B	6.82	4.48	2.09	1.56	0.24	0.52	Within the Limit
5	CANTEEN	2.56	0.93	0.37	0.36	0.17	0.11	Within the Limit
6	Block C	3.05	1.99	0.92	0.34	0.14	0.06	Within the Limit
7	Block D	4.26	3.12	1.05	0.32	0.14	0.1	Within the Limit
8	Block F	5.82	2.25	0.81	0.35	0.24	0.25	Within the Limit

Recommendations:

From the readings taken, it is observed that **Current THD is within the specified Limit** in all the blocks

Table 3: VOLTAGE HARMONIC

Voltage THD Limits :					**≤ 5%**			
Individual Voltage Harmonics Limits					**≤ 3%**			
S.No	**Location**	**Voltage THD(%)**	**% of 3rd harmonics**	**% of 5th harmonics**	**% of 7th harmonics**	**% of 9th harmonics**	**% of 11rd harmonics**	**Comments and Recommendations for Voltage THD**
1	INCOMER	4.25	0.79	0.51	1.07	0.11	0.22	Within the standard Limit
2	HOSTEL II	1.46	0.62	0.51	1.03	0.06	0.21	Within the standard Limit
3	Block A	0.96	5.02	0.17	0.52	1.01	0.07	Within the standard Limit
4	Block B	0.92	6.82	0.2	0.44	0.98	0.09	Within the standard Limit
5	CANTEEN	1.5	0.54	0.59	1.03	0.05	0.26	Within the standard Limit
6	Block C	4	3.49	0.53	0.95	0.27	0.49	Within the standard Limit
7	Block D	3.4	2.93	0.69	0.91	0.19	0.45	Within the standard Limit
8	Block F	2.04	0.36	1.08	1.22	0.04	0.37	Within the standard Limit

Recommendations:

1. From the readings taken, it is observed that **Voltage THD is within the specified Limit** in all the blocks.
2. Also it is to be noted that the Individual Harmonic Limits are not within the limit in BLOCK A BLOCK B and BLOCK C. It may be due to large number of non-linear loads available. Only the Third Harmonics percentage exceeds the standard limit specified by **IEEE 519-1992**. Proper Mitigation techniques such as line reactors, harmonic trap filters or active filters may be used. A brief note on the Harmonic Mitigation by Detuning of the Power factor Capacitor Network is attached in Annexure 6.2.

Table 4: POWER FACTOR & REACTIVE POWER

Limiting Value of Power factor: **0.9**				
S.No	**Location**	**Reactive Power (VAR)**	**Power factor**	**Comments and Recommendation**
1	INCOMER	211980	0.92	Within the Limit
2	HOSTEL II	116750	0.35	Less than the limit
3	Block A	32280	0.96	Within the Limit
4	Block B	61300	0.92	Within the Limit
5	CANTEEN	3430	0.85	Within the Limit
6	Block C	2300	0.99	Within the Limit
7	Block D	22830	0.3	Less than the limit
8	Block F	6350	0.73	Less than the limit

Recommendations:

1. From the readings taken, it is observed that power factor is within limit in all the blocks except in Block D and Hostel II. From the observations, it is also to be noted that, **poor power factor may be due to low load connected** (or most of the loads may be shut down) while taking readings.
2. **Power factor is maintained well at 0.92** at the incomer with 100kVAR Capacitor connected. Even then an operator may be appointed for looking at the power factor and other parameters.

3.12.1 SAMPLE CALCULATION FOR REPLACING FTL WITH LED

In the following we have shown the simple calculation for replacing 100 FTL with 100 LED lights. The total saving in energy is 3400W instead of using FTL. The payback period for LED lights replacement is 9 months.

DESCRIPTION	FTL FITTINGS	**LED FITTINGS**
	40W	**18W**
No. OF FITTINGS	100	**100**
WATTS (LAMP + BALLAST LOSS 12W ONLY)	5200	**1800**
TOTAL WATTS	5200	**1800**
CONSUMPTION UNITS PER DAY	57.200	**19.800**
RUNNING COST PER DAY	363.22	**125.73**
SAVINGS LED INSTEAD OF FTL IN WATTS	3400	
UNITS SAVINGS PER DAY	37.400	
UNITS SAVINGS PER MONTH	**1122.000**	
RUNNING HOURS PER DAY	11	
PRESENT TNEB UNITS COST Rs.	6.35	
COST SAVINGS PER DAY Rs.	237.49	
COST SAVINGS PER MONTH Rs.	**7124.70**	
LED LIGHT FITTING TOTAL EXPENSES Rs. (100*Rs.650)	**65000.00**	
COST RETURN PERIOD IN DAYS	274	
COST RETURN PERIOD IN MONTHS	9.12	
COST RETURN PERIOD IN YEARS	**0.75**	

3.12.2 SAMPLE CALCULATION FOR REPLACING NORMAL FAN WITH BLDC FAN

In the following we have shown the simple calculation for replacing 100 Normal Fan with 100 BLDC fan. The total saving in energy is 4800W instead of using conventional Fan. The payback period for BLDC fan replacement is 32 months.

DESCRIPTION	NORMAL FAN	**BLDC FAN**
	72W	**24W**
No. OF FITTINGS	100	**100**
TOTAL WATTS	7200	**2400**
CONSUMPTION UNITS PER DAY	79.200	**26.400**
RUNNING COST PER DAY	502.92	**167.64**
SAVINGS BLDC INSTEAD OF NORMAL FAN IN WATTS	4800	
UNITS SAVINGS PER DAY	52.800	
UNITS SAVINGS PER MONTH	**1584.000**	
RUNNING HOURS PER DAY	11	
PRESENT TNEB UNITS COST Rs.	6.35	
COST SAVINGS PER DAY Rs.	335.28	
COST SAVINGS PER MONTH Rs.	**10058.40**	
LED LIGHT FITTING TOTAL EXPENSES Rs. (100*Rs.3250)	**325000.00**	
COST RETURN PERIOD IN DAYS	969	
COST RETURN PERIOD IN MONTHS	32.31	
COST RETURN PERIOD IN YEARS	**2.66**	

4. MEASURING INSTRUMENTS

4. FEATURES OF FLUKE 435 SERIES THREE-PHASE POWER QUALITY ANALYZER

Technical Data: The Fluke 434 and 435 three-phase power quality analyzers help one to locate, predict, prevent and troubleshoot problems in three- and single-phase power distribution systems. Troubleshooting is faster with on-screen display of trends and captured events, even while background recording continues. The new IEC standards for flicker, harmonics and power quality are built right in to take the guess work out of power quality.

• **Troubleshoot real-time**: Analyze the trends using the cursors and zoom tools-even while background recording continues	• **Highest safety rating in the industry** :600 V CAT IV/1000 V CAT III rated for use at the service entrance
• **Automatic Transient Mode**: Capture 200 kHz waveform data on all phases simultaneously up to 6 kV	• **Fully Class-A compliant**: Conduct tests according to the stringent international IEC 61000-4-30 Class-A standard
• **Measure all three phases and neutral**: With included four current probes	• **Auto-Trend**: Every measurement you see is always automatically recorded, without any setup
• **System-Monitor**: Up to ten power quality parameters on one screen according to EN50160 power quality standard	• **Inrush mode**: For troubleshooting nuisance circuit breaker tripping
• **View graphs and generate reports**:	• **Logger function**: Configure for any test

With included analysis software	condition with memory for over 400 parameters at user defined intervals
• **Mains signaling**: Measure interference from ripple control signals at specific frequencies	• **Battery Life**: Seven hours operating time per charge on Ni MH battery pack
• **Warranty**: Rugged, handheld troubleshooter with Fluke three-year warranty	

The specifications of the instrument are verified using the "implementation verification" Table 3 as specified in IEC 61000-4-30 2002 chapter 6.2. **Accuracy** is specified in % of reading unless otherwise specified. Specifications are valid for models Fluke 435 and 434 unless otherwise specified.

Input characteristics

Voltage inputs

- ✓ Number of inputs 4 (3 phases + neutral) dc-coupled
- ✓ Maximum input voltage 1000 Vrms
- ✓ Nominal voltage range 50 V to 500 V according IEC 61000-4-30.Selectable from 1 V to 1000 V.
- ✓ Maximum peak measurement voltage 6 kV
- ✓ Input impedance 4 MΏ//5 pF
- ✓ Bandwidth > 10 kHz, up to 100 kHz for transient display
- ✓ Scaling 1:1, 10:1, 100:1, 1000:1 and variable

Current inputs

- ✓ Number of inputs 4 (3 phases + neutral) dc-coupled
- ✓ Type Clamp on current transformer with mV output
- ✓ Range 1 Arms to 400 Arms with included clamps (i400s/Fluke 434)
- ✓ 30 A to 3000 Arms with included clamps (i430-flex/Fluke 435)
- ✓ 1 Arms to 3000 Arms with optional clamps
- ✓ Input impedance 50 kΏ
- ✓ Bandwidth > 10 kHz
- ✓ Scaling 0.1, 1, 10, 100, 1000 mV/A, variable, i5s and i430-flex

- ✓ Nominal frequency 40 Hz to 70 Hz

Sampling system

- Resolution 16 bit analog to digital converter on 8 channels
- **Maximum sampling speed 200 k Samples /s on each channel simultaneously**
- RMS sampling 5000 samples on 10/122 cycles according IEC 61000-4-30
- PLL synchronization 4096 samples on 10/122 cycles according IEC 61000-4-7

Display modes

Waveform display Available in Scope and Transient mode

Captures 8 waveforms simultaneously

- *Display update rate 5 x per second*
- Up to 10/122 times horizontal zoom
- Cursors: single vertical line showing min, max, average reading at cursor position
- Phasor: Shows real time phasor diagram
- Available in Scope and Unbalance mode
- *Display update rate 5x per second*
- Meter readings Available in Volts/Amps/Hertz, Harmonics, Power and Energy, Flicker, Unbalance and Logger 4 mode
- Auto-Trend graph Available in Volts/Amps/Hertz, Dips and Swells, Harmonics, Power and Energy, Flicker, Unbalance, Inrush,
- Mains Signaling Logger and Monitor mode
- Cursors: single vertical line showing with min, max, average reading at cursor position
- Bar graph Available in Harmonics and Monitor mode
- Event list Available in Dips and Swells, Mains Signaling, Logger and Monitor mode

Measurement modes

- ✓ Scope Vrms, Arms, Vcursor, Acursor, Vfund, Afund, Hz, V phase angles, A phase angles
- ✓ Volts/Amps/Hertz Vrms, Vpk, V Crest Factor, Arms, Apk, A Crest Factor, Hz

- ✓ Dips and swells Vrms ½, Arms ½
- ✓ Captures up to 1000 events with date, time, duration, magnitude and phase identification with programmable thresholds.
- ✓ Harmonics dc, 1 to 50 Harmonic Volts, THD Volt, Harmonic Amps, THD Amps, K Amps, Harmonic Watts, THD Watts, K Watts, Inter harmonic Volts 4, Inter harmonic Amps 4 (relative to fundamental or to total rms).
- ✓ Power and energy Watts, VA, VAR, Power factor, Cos φ/DPF, Arms, Vrms, kWh, kVAh, kVARh, peak demand interval using trend, KYZ revenue meter verification via optional input.
- ✓ Flicker Pst(1min), Pst, Plt, PF5, Vrms ½, Arms ½, Dc, Dmax, TD
- ✓ Unbalance V_{neg}, V_{zero}, A_{neg}, A_{zero}, V_{fund}, A_{fund}, Hz, V phase angles, A phase angles
- ✓ Transients V_{rms}, A_{rms}, V_{cursor}, A_{cursor}
- ✓ Inrush currents Inrush Current, Inrush duration, $A_{rms\ 1/2}$, $V_{rms\ 1/2}$
- ✓ Mains signaling Relative signaling voltage and absolute signaling voltage averaged over three seconds for two selectable frequencies
- ✓ Logger Measures and records up to 100 parameters on all 4 phases simultaneously with selectable averaging time
- ✓ Captures up to 10000 events with date, time, duration, magnitude and phase identification with programmable thresholds
- ✓ System monitor Vrms, Arms, Harmonic Volts, THD Volts, Plt, Vrms ½, Arms ½, Vneg, Hz, dips and swells, unbalance
- ✓ All parameters are measured simultaneously in accordance with EN50160
- ✓ Using Flagging to indicate unreliable readings according IEC61000-4-30

SPECIFICATIONS OF THERMAL IMAGER

Make: Fluke Ti125

IR resolution (FPA size)	160 x 120 FPA Uncooled Micro bolometer
Spectral band	7.5 µm to 14 µm (long wave)
Capture or refresh rate	9 Hz or 30 Hz versions
NETD (Thermal sensitivity)	≤ 0.10 °C at 30 °C target temp (100 mK) 0.10 °C at 30 °C target temp (100 mK)
FOV (Field of view)	22.5 °H x 31 °V
IFOV (Spatial resolution)	3.39 mRad
Temperature measurement range (not calibrated below -10 °C)	-20 °C to +350 °C (-4 °F to +662 °F)
Temperature measurement accuracy	± 2 °C or 2 % (at 25 °C nominal, whichever is greater)

SPECIFICATIONS OF INDOOR AIR QUALITY METER

Make: Extech EA80

Features:

- Checks for Carbon Dioxide (CO_2) concentrations
- Maintenance free dual wavelength NDIR (non-dispersive infrared) CO_2
- CO_2 measurement range: 0 to 6,000ppm
- Temperature measurement range: -4 to 140°F (-20 to 60°C)
- Humidity measurement range: 10 to 95%RH
- Continuous (20,000 sets) or Manual (99 sets) data logging

5. GREEN AUDIT

5.1 Introduction

Indoor air quality (IAQ) refers to the quality of the air inside buildings as represented by concentrations of pollutants and thermal (temperature and relative humidity) conditions that affect the health and performance of occupants.

5.1.1 Causes of Indoor Air Pollution

- Inadequate ventilation
- High temperature and humidity levels

5.1.2 Carbon dioxide (CO2)

CO2 is a colorless, odorless, and tasteless gas. It is a product of completed carbon combustionandthe by-product of biological respiration. ASHRAE states that CO_2concentrations in acceptable outdoorair typically range from 300-500 ppm.

Adverse health effects from CO_2 may occur since it is an asphyxiate gas. The CO_2 levels can be used as a rough indicator of the effectiveness of ventilation, and excessive population density in a structure. CO_2 increases inbuildings with higher occupant densities, and is diluted and removed from buildings based on outdoor air ventilation rates. Therefore, examining levels of CO_2 in indoor air can reveal information regarding occupant densities and outdoor air ventilation rates. High CO_2 levels may indicate a problem with overcrowding or inadequate outdoor air ventilation rates.

5.1.2.1 Carbon Dioxide Poisoning – Symptoms

CO2, a by-product of normal cell function, is removed from the body via the lungs in the exhaled air. Exposure to high levels of CO_2 can increase the amount of this gas in the blood, which is referred toas *hypercapnia*or *hypercarbia*. As the severity of hypercapnia increases, more symptoms rangingfrom headache to unconsciousness appear, and it can also lead to death.

5.1.3 Damp Indoor Environments

Damp indoor environments have been associated with many serious health effects, including asthma,hypersensitivity, and sinusitis. Moisture incursion leading to dampness can result from waterleaksand/or by condensation due to high humidity. Common sources of moisture in buildings include:plumbing; roof and window leaks; flooding; condensation on cold surfaces, e.g., pipe sweating;poorly-maintained drain pans; and wet foundations due to landscaping or gutters that direct water intoor under the building. Water vapor from unvented or poorly-vented kitchens, showers, combustionappliances, or steam pipes can also create conditions that promote microbial growth.Well-designed, well-constructed and well–maintained building envelopes are critical to the prevention andcontrol of excess moisture and microbial growth by avoiding thermal bridges and preventing intrusionby liquid or vapor-phase water. Management of moisture requires proper control of temperaturesand ventilation to avoid high humidity, condensation on surfaces, and excess moisture in materials.

Ventilation should be distributed effectively in spaces, and stagnant air zones should be avoided.ASHRAE recommends relative humidity levels between 30 and 60 percent for optimum comfort. Higher humidity may result in microbial growth. A consistently implemented good-housekeeping plan is essential to eliminate or reduce the microbial growth in the building.

5.1.4 Poor outdoor air quality

The traditional means of dealing with IAQ is through ventilation with outdoor air, but this approach assumes that the outdoor air is cleaner than the indoor air. In many locations and for many contaminants, this is not the case, and insufficiently treated ventilation air can actually make IAQ worse. Poor outdoor air quality includes regionally elevated outdoor contaminant levels, as well as local sources such as motor vehicle exhaust from nearby roadways and contaminants generated by activities in adjacent buildings. Somegreen building programs recommend across-the-board increases in ventilation rates, but such recommendations may be counterproductive in areas with poor outdoor air quality unless accompanied by appropriate and effective increases in filtration and air cleaning.

5.2 Protocol from Central Pollution Control Board

5.2.1 Time of sampling/monitoring

The contaminants concentrations indoors are related with cofactors such as humidity, human activity and air temperature. The time of sampling/monitoring must then be chosen accordingly so as to minimize the influence of the cofactors e.g. when the potential cofactors are expected to be constant and at average level. Such choice of time may not be acceptable or achievable all the time in relation to the overall aims of the investigations. Hence the sampling/monitoring programme must always allow estimate of the range of variations of relevant cofactors.

For Indian scenario, the timing protocols proposed are:

- Residential (morning & evening, one hour in each case)

- Schools / colleges /educational institution (two working hours)
- Offices (two working hours)
- Health care units (morning and evening, one hour in each case)
- Restaurants (two hours in the evening)
- Museums/Historical Buildings (two hours during the visiting hours)
- Industrial establishments (short time or long time during working hours)

Number of samples may be based on the following criterion:

- By means of random numbers
- All corners, central place at all floors
- Building / house orientations
- Pre-dominant wind direction (up-wind and down-wind)
- Depending of the fuel usage
- Income group

5.2.2 Instrumentation Requirement:

For CO_2 measurement: IR based Device – Least count 1ppm

Temperature Measurement: Thermometer, thermo hygrometer - Least count 1°C WBT (As per ASHRAE 55-1992 standards)

Relative humidity – Humidity gauge – Least count -1%/ 30% to 60% for both winter and summer (As per ASHRAE 55-1992 standards)

5.2.3 Instruments used in the present audit:(As per ASHRAE 55-1992 standards)

Indoor Air Quality Meter – Extech Make EA80 Model

- CO_2 range: 0 to 6,000ppm
- Temperature range: -4 to 140°F (-20 to 60°C)
- Humidity range: 10 to 95%RH

Thermal Imager – Fluke Make Ti125 Model

Temperature measurement accuracy	± 2 °C or 2 % (at 25 °C nominal, whichever is greater)

5.3 Measurements

Indoor air quality test was carried out at 20 locations of the institution. With the help of Indoor Air Quality meter (Extech EA80), CO_2 level, relative humidity, dry bulb and wet bulb temperatures were measured. The measured readings are presented in the below table:

Location		CO_2 Level (ppm)	Relative Humidity (%)	Temperature (°C)	Heat Penetration
A – Block					
Ground floor (Near office)		380	68.5	30.9	---
First floor	Open area (Near Chemistry)	300	67	30.6	---
	AF-2	410	67.8	32.9	---
	Open area (Near Physics)	355	69.5	29.9	---
Second floor	Open area	305	66.9	30.3	---
	DEAN-EEE (Open area)	320	66.9	31.8	---
	GMDSS Class room(A/C)	520	61.8	20.9	• Heat generated due to continuous usage of Projector • More heat loads due persons, computers, projectors • Infiltrations
	Class room(A/C)	535	62.1	21.6	
Third Floor	Open area	300	66.7	32.5	---
	Open area	290	66	32.5	---
	Deptt. Naval Arch. Class room	340	66	33.6	Ventilation is not adequate
F – Block					
Ground floor		320	62	29.8	---
First floor	Open area	290	60.5	33	---
Second floor	Open area	285	63.3	32.5	---
	F21	375	63.3	32.5	
Third floor	Near Mechanical	310	66.7	33.1	---
	Open area	295	62	30	---
Fourth floor	Near Deptt. of Petroleum Engg.	290	69.7	31.7	---
	F-48	350	64.5	33.5	• Ventilation is not adequate
	Open area	305	65	36.5	---
B – Block					

Ground floor	Open area	290	60.5	31.7	---
	Laboratory	320	66.7	31	---
	Library	310	68.9	29	---
Second floor	Corridor - 1	305	63	30.8	---
	Corridor – 2	300	64	30.6	---
Third floor	Corridor – 1	295	65.2	35.8	---
	Corridor - 2	310	65	29.8	---
C – Block					
Ground floor	Open area	290	63.3	28.9	---
First floor	Open area	290	72	30.1	---
Second floor	C-8 Drawing Hall	340	70.4	30.6	---
Third floor	Corridor - 1	295	71.5	31	---
	Corridor – 2	295	72.2	31	---
Fourth floor	Physical Education hall	350	63	39.2	More heat penetration due to ceiling
D – Block (Nautical Science Block**)**					
Ground Floor	Entrance	310	65.2	30.1	---
First floor	Corridor - 1	310	68.9	30.5	---
	Corridor – 2	315	69	30.5	---
Second floor	Open area	310	69.2	31.3	---
Third floor	Corridor - 1	305	70.2	31.3	---
	Corridor – 2	301	69.3	31.6	---
Fourth floor	Corridor - 1	305	67	31.4	---
	Corridor – 2	307	66.8	32.1	---
	Corridor - 3	310	64.9	32.1	---

5.4 Observations and comments

5.4.1 CO_2 Levels:

- Carbon-di-oxide levels are within the ASHRAE 55-1992 limit in the outdoor and indoor. For indoor condition, CO_2 level should be less than 500 ppm.
- CO_2 level is observed within the satisfactory level as per standards in open areas.
- In air-conditioned rooms, the CO_2 levels are deviated with respect to the standard limit.
- In air-conditioned class rooms, faculty rooms, laboratory and office the levels of CO_2 are found to be deviated by 4 to 7%.
- It is observed that ceiling fans are also operated simultaneously with air-conditioning units. This affects the return hot air from the room. The hot air gets recirculate in the room due to the operation of fans. The usage of fans may be reduced.

- Damaged insulation layers on the air conditioned pipelines of the outdoor unit may be reconditioned otherwise will leads the more heat loads to air-conditioning units. This will increase the electrical energy required for producing cooling effect.
- ASHRAE recommends relative humidity levels between 30 and 60 percent for optimum comfort.
- Higher humidity level (above 60%) is observed in most of the places in various blocks.
- Natural circulation of air is not sufficient inside the classrooms and laboratory. Hence provisions for natural circulation of air may be arranged.

5.4.3 Ambient Temperature:

- The average ambient temperature in the campus is found to be 31.4°C.
- In air-conditioned rooms the temperature is found to be between 30 to 31°C. This is because of the recirculation of hot air within the room.
- When the room is filled with maximum number of people, the temperature of the room is measured between 30 to 33.5°C. Based on the load in air-conditioning systems, appropriate air-conditioning systems (Capacity based) may be arranged.

5.4.4 Heat Penetration:

- Heat penetration through the windows and door linings is a problem for air-conditioned rooms.
- Dark coloured window screens and Sun films may be provided to minimize heat penetrations.

6. ANNEXURE

6.1 EXTRACTS FROM IEEE 519-1992

CURRENT DISTORTION LIMITS FOR GENERAL DISTRIBUTION SYSTEMS (120V THROUGH 69 000V)

Maximum Harmonic Current Distortion in Percent of I_1						
Individual Harmonic Order /odd Harmonics/						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20	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

Even harmonics are limited to 25% of the odd harmonic limits above.

Current distortions that result in a de offset, e.g., half-wave converters, are not allowed.

*All power generation equipment is limited to these values of current distortion, regardless of action I_{sc} / I_L

Where

I_{sc} = maximum short-circuit current at PCC.

I_L = maximum demand load current (fundamental frequency component) at PCC.

Current Distortion Limits for General Sub transmission Systems (69 001 V Through 161 000 V)

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (odd Harmonics)						
I_{sc}/I_L	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	TDD
<20	2.0	1.0	0.75	0.3	0.15	2.5
20<50	3.5	1.75	1.25	0.5	0.25	4.0
50<100	5.0	2.25	2.0	0.75	0.35	6.0
100<1000	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0

Even harmonics are limited to 25% of the odd harmonic limits above.

Current distortions that result in a de offset, e.g., half-wave converters, are not allowed.

*All power generation equipment is limited to these values of current distortion, regardless of action I_{sc} / I_L

Where

I_{sc} = maximum short-circuit current at PCC.

I_L = maximum demand load current (fundamental frequency component) at PCC.

Voltage Distortion Limits. The recommended voltage distortion limits (see Table 6.1) are concerned with the follow indices:
THD: Table (RSS) Harmonic voltage distortion in percent of nominal fundamental frequency voltage.

The limits listed in Table 6.1 should be used as system design values for the “worst case” for normal operation (conditions lasting longer than one hour). For shorter periods, during start-ups or unusual conditions, the limits may be exceeded by 50%.

6.1 Voltage Distortion Limits

Bus voltage at PCC	Individual voltage Distortion (%)	Total voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001kV through 161kV	1.5	2.5
161.001 kV and above	1.0	1.5

Note: High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

6.2 Write up on Harmonic Mitigation by Detuning of the Power factor Capacitor Network

The purpose of this note is to provide an introduction to the detuned filters to achieve harmonic reduction:

1. Many medium scale industries (and also large ones) receive HT power ; in many cases it is 11kV, 3 phase of appropriate capacity- at PCC(Point of Common coupling).
2. The same is then stepped down to 3 phase 415 V and the same is distributed to the various load centres of the plant from the LT power distribution board.
3. TANGEDCO requires the customers to meet the CEA regulations (included under (ii) of the annexure of the report that the voltage total harmonic distortion (THD_V) must be limited to 5% and current harmonic distortion (THD_I) must be limited to 8% for the HT customers at PCC.
4. THD is defined as the ratio of the vector sum of all the harmonics to the fundamental value- for both voltage and currents - normally expressed in percentage.
5. Due to the increased use of non-linear loads (use of power electronic modulators) harmonics result – to start with harmonic currents are generated due to the switching action of the power electronic devices which when passes in the supply network results in harmonic voltage drop due to the supply line impedance ; this finally result in the distortion of the input voltage itself at PCC as seen by the customers.
6. The voltage distortion on the grid – which is the result of the harmonic currents generated by different consumers - affects even the industries which do not use the harmonic current producing loads.
7. This is the reason why the electricity supplier is mandating the limit of the harmonic figures as under 3.
8. Kongu Engineering college undertakes the measurement of the harmonics of the power system – using power quality analyzers - analysis the measurements and provide suggestions to the Industries to mitigate this problem and achieve the mandated harmonic levels.
9. Normally the following methods are used to address the harmonic issues – (i) provide tuned passive filters (ii) provide detuned filter and (iii) provide the active harmonic filters .
10. The tuned filter achieves the best attenuation figures for a given site. However this requires specifically designed filters for a site and also number of filters for different frequencies. Hence these are not preferred. The active filter filters all the selected harmonics and the same is widely used. The rating of the filter can be selected based on the total RMS harmonic current to be handled. However these are quite expensive and many customers find it difficult to invest in this.
11. The detuned filters do not basically remove the harmonic currents introduced by the switching loads. Normally plants have power factor compensation capacitors . In a harmonic rich environment, these capacitors resonate with the upstream supply transformer reactance and causes amplification of the harmonic currents - different frequencies to different levels - and hence the percentage harmonic currents will be about 8 % to 10 % higher than the situation without the power factor compensation capacitors in circuit. **The detuned filters only removes such amplification of the harmonic currents by detuning the resonance frequency to a value quite away from the significant existing harmonic currents.**
12. Hence it is preferred to provide the detuning for all the pf compensation capacitor banks and eliminate any amplification effect due to the above mentioned phenomenon. This will reduce the sizing of the active filter - required to eliminate the harmonics introduced due to non- linear loads. This can substantially reduce the investment.
13. Detuning is done by retuning the resonance frequency of the combination of Pf compensation capacitor and the system inductance (due to the transformer etc.) to a lower frequency well below the normal existing harmonic frequencies of the system , say 5th (250 HZ) and 7th (350Hz) ; This results in a flattened portion - means no amplification - in the frequency v/s impedance curve for the various harmonic frequencies introduced in the supply system . On the contrary, without

detuning , there will be significant amplification of the normal harmonic currents by a factor up to 5. Refer the following curves for the situation without and with detuning.

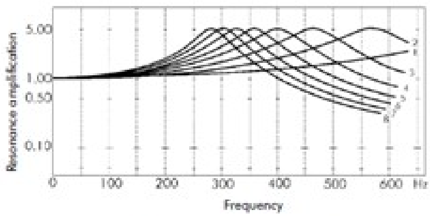


Figure 9 - Resonance curves of different compensators ranging from 50 kvar (curve 1) to 400 kvar (curve 8), operated on a 1 250 kVA transformer (Frako)

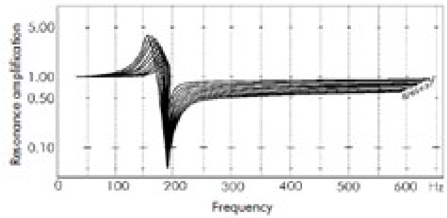
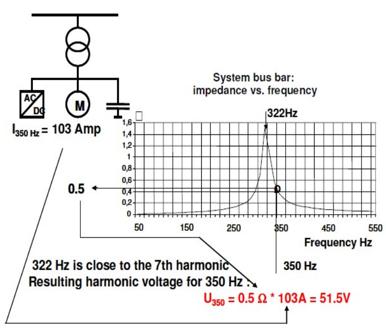
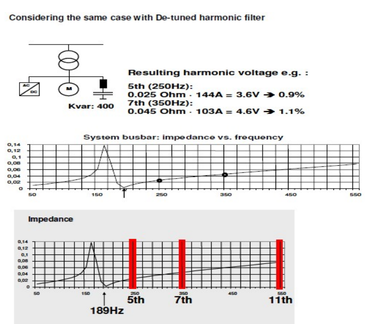
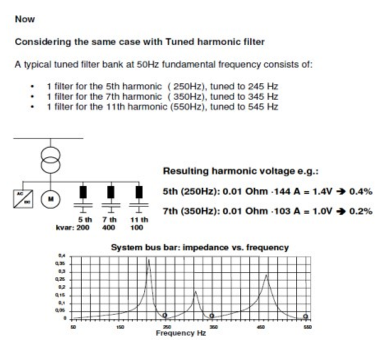


Figure 10 - Resonance curves of different detuned compensators ranging from 50 kvar (curve 1) to 400 kvar (curve 8), operated on a 1 250 kVA transformer (Frako)

14. It is also seen that with **larger and larger compensation capacitor the resonance amplification curve becomes more peaky** in the vicinity of the low frequency harmonics and the resultant amplification is also higher.
15. The following figures provide the relative harmonic voltages for the significant frequencies – (i) without detuning- there will be significant amplification of harmonics due to larger resonance impedance (ii) with detuned filters –**there is no filtering of the harmonics** but amplification of the harmonics is avoided; net result is normally 20% to 30% reduction of the THD as compared to the case without the detuning and (iii) with individual tuned harmonic filters - results in about 90% reduction.
16.







Without Detuning **With Detuning** **With Tuning filter**

17. The typical figures as per the above literature is 12.7 % for case (i), 1.1 % for case (ii) and 0.2% for case (iii)
18. Considering that in general the power systems are now a day's polluted due to energy conservation measures or due to connection of power electronics based equipment in the system –VFD drives, CFL / LED lamps, SMPS based computers , UPS systems etc.- all the new power factor compensation panels, getting ordered, should be compulsorily with the detuning filters instead of with plain capacitors.

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