Energy Audit Report of

BITS Pilani – Hyderabad Campus

By

ZENITH ENERGY

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September-2023

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I. ACKNOWLEDGEMENT

Zenith Energy Services (P) Limited (ZESPL) appreciate the keen interest shown by the management of "BITS Pilani Hyderabad Campus" in conducting energy audit of BITS Pilani Hyderabad Campus.

For

Zenith Energy Services (P)

Limited, Hyderabad.

II. ENERGY AUDIT TEAM

Name of the Member	Qualification	Role in the Project
Mr. D.S.R.Krishna	Accredited Energy Auditor	Head of Department
Mr. Guru Sri Charan Upparapalli	Sr. Energy Engineer	Team Coordinator
Mr. Faisal Ashraf	Energy Engineer	Team Member
Mr. Harris Mohammad Mir	Energy Engineer	Team Member

III. EXECUTIVE SUMMARY

Zenith Energy Services (P) Limited has been entrusted with carrying out in Energy Audit of **BITS Pilani Hyderabad Campus**. In order to carry out the assignment a team as conducted a detailed site survey from Zenith Energy has visited to conduct audit.

During the audit it was observed that at the main incomer are maintaining good power factor 0.998 with a capacitor bank of 3000 kVAR for each transformer.

In this report highlights the Phase to Neutral Voltage profile, Phase to Phase Voltage profile, Current profile, Power profile, power factor profile, energy consumption and % Total Hormonic Distortions of Voltages and currents of each building.

1. INTRODUCTION

1.1. General Details

Birla Institute of Technology and Science, Pilani Hyderabad campus stands as a beacon among India's premier technical and science institutes of higher learning. It was established by Birla Institute of Technology and Science, Pilani (Rajasthan) known to many as BITS Pilani, as one of its campuses in the year 2008. BITS, Pilani is one of India's top technical and science Deemed to Universities established under Sec. 3 of the UGC Act and was also recognized by the Ministry of Education (Department of Higher Education), Government of India, New Delhi as an Institution of Eminence (IOE) vide Gazette Notification No. 11-9/2019-U.3(A)Pt. dated 14th October 2020. Accredited with an 'A' grade by NAAC, BITS Pilani has consistently delivered top-notch technical education since its inception.

The primary motive of BITS Pilani is to "train young men and women able and eager to create and put into action such ideas, methods, techniques and information". Over the years, BITS Pilani has provided the highest quality technical education to students from all over India admitted on the basis of merit. Its graduates may be found throughout the world in all areas of engineering, science and commerce. BITS Pilani symbolizes the maturing of Indian technical ability and "can-do" entrepreneurial spirit, especially as derived from the private sector. BITS Pilani's mission is to advance knowledge and educate students in science, technology, and other areas of scholarship that will best serve the nation and the world in the 21st century.

BITS Pilani is committed to generating, disseminating, and preserving knowledge, and to working with others to bring this knowledge to bear on the world's great challenges. BITS is dedicated to providing its students with an education that combines rigorous academic study and the excitement of discovery with the support and intellectual stimulation of a diverse campus community.

BITS Pilani Hyderabad Campus is built amidst lush greenery picturesque at Jawahar Nagar, Kapra Mandal, Medchal-Malkajgiri District, Hyderabad (Telangana) surrounded by natural beauty and with state-of-the-art infrastructure spreading over 200 acres of land. The BITS Pilani Hyderabad Campus is offering degrees at all three-tiers, namely, Integrated First Degree, Higher Degree and Ph.D. Modern laboratories, well-furnished classrooms, state-of-the-art Library, lecture theatre complexes, Telepresence Classrooms, Seminar Halls, Student Activity Centre, Auditorium, Amphitheatre, Playgrounds and modern ICT infrastructure, Dining Halls, Cafeteria, round the clock medical facility, and other teaching, research and recreational facilities, all come together to make BITS Pilani, Hyderabad campus a well-equipped campus.

Around 1500 bright minds are admitted every year into first degree, higher degree and doctoral programmes of the Institute through an entrance test conducted by BITS, Pilani. Being a campus of BITS Pilani, its Hyderabad Campus also follows the same curriculum,

teaching methodologies and educational practices of its' parent campus. BITS, Pilani, Hyderabad campus is fully residential, housing over 5500 students, around 270 faculty members and 285 technical and support staff. The teaching faculty brings with them extensive research, teaching and industry experience to offer comprehensive education to the students.

Campus life is vibrant and stimulating. Student calendars are filled with a healthy mix of extracurricular activities through various clubs and departments. There is a culture of freedom coupled with a holistic environment for multidimensional growth of a student personality. Over the past few years, students have been placed at multinational companies, government organizations, and research institutes across the globe. The students of the campus are truly ready to become the innovators of tomorrow.

1.2. Scope of Study

The scope of work includes a detailed study for energy conservation options of various energy sources like electricity or nay fossil fuels and recommends actions for reducing the same. The broad scope of the study is as follows.

- Average, minimum and maximum power by transformers
- Power factor analysis
- Current profile of each transformer.
- Blowers' Specific energy consumption and ways to reduce the same
- Specific energy Consumption of the pumps above 15 HP and ways to reduce the same

1.3. Energy Audit instruments used

The following instruments are used for power recording of 24 Hrs for each block

- 3-Phase power Analyser-ALM-31
- 3-Phase power Analyser- ALM-20
- Flow Meter
- Anemometer
- Pressure Gauges
- Thermal Imager

2. ELECTRICAL BILLS

The electricity bills for collected from the facility from September 2022 to August 2023. The Facility has the contract demand of 2500kVA from the Southern Power Distribution company of TS Limited. The detailed Bill analysis is as follows:

Table 1. Month wise Electricity Consumption (2022-2023) for Buildings of BITS

S. No	Bill Month	CMD	Recorded Demand (kVA)	Billed Maximum Demand (KVA)	Energy Consumption (kVAh)	Energy Consumption (kWh)	Power Factor (PF)	Demand Charges (INR)	Net Bill
1	Sep-22	2500	2044.0	2044	733525	732310	0.998	970900	6925370
2	Oct-22	2500	1825.0	2000	802600	801725	0.999	950000	7468667
3	Nov-22	2500	1853.0	2000	731380	730785	0.999	950000	6889225
4	Dec-22	2500	1903.0	2000	749885	749435	0.999	950000	7037844
5	Jan-23	2500	1525.0	2000	671750	671345	0.999	950000	6403502
6	Feb-23	2500	1802.0	2000	798185	796015	0.997	950000	7438362
7	Mar-23	2500	2160.0	936	388885	387945	0.998	444600	3585864
8	Apr-23	2500	2698.0	2698	1048808	1044963	0.996	6933100	9278856
9	May-23	2500	2573.0	2573	1107437	1103348	0.996	1256850	10248971
10	Jun-23	2500	2296.0	2269	915200	911330	0.996	1077775	8510539
11	Jul-23	2500	1718.0	2000	692716	691547	0.998	950000	6566559
12	Aug-23	2500	2607.0	2607	893479	889528	0.996	1289150	8553102
	Max		2698.000	2698.000	1107437.000	1103347.500	0.999	6933100	10248971.220
	Min		1525.000	936.000	388885.000	387945.000	0.996	444600	3585863.800
	Average		2083.667	2093.917	794487.500	792522.917	0.998	1472697.917	7408905.040

2.1. Solar Roof Top Power Plant

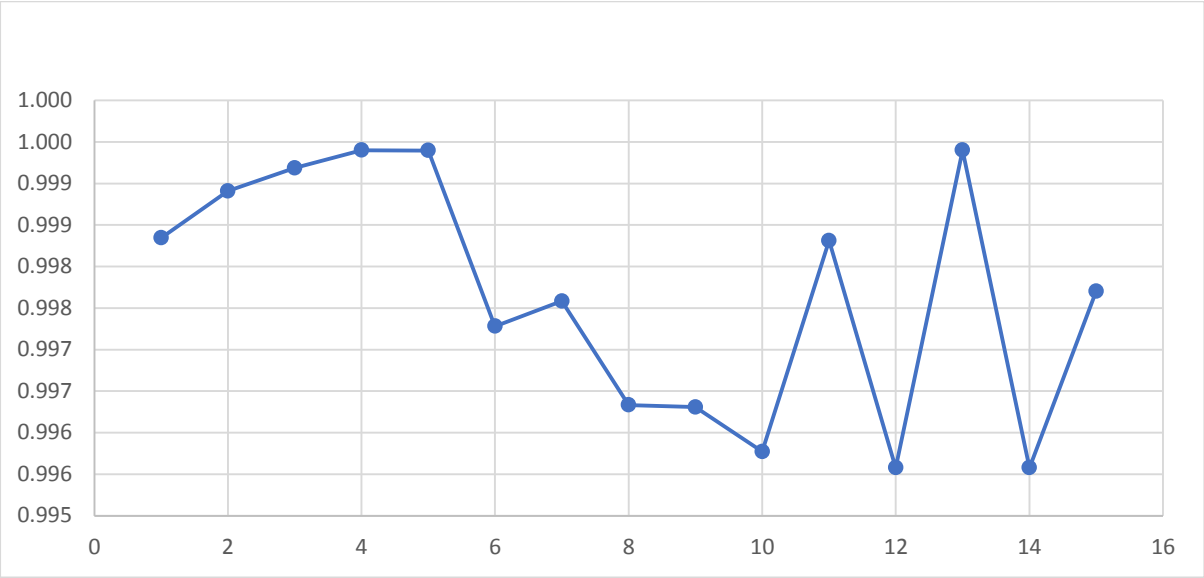
Solar Roof Top Power Plant has been installed in the facility. The capacity of the solar plant is 947.7 kWp. The detailed generation is as follows

Table 2. Solar Roof Top Plant Generation

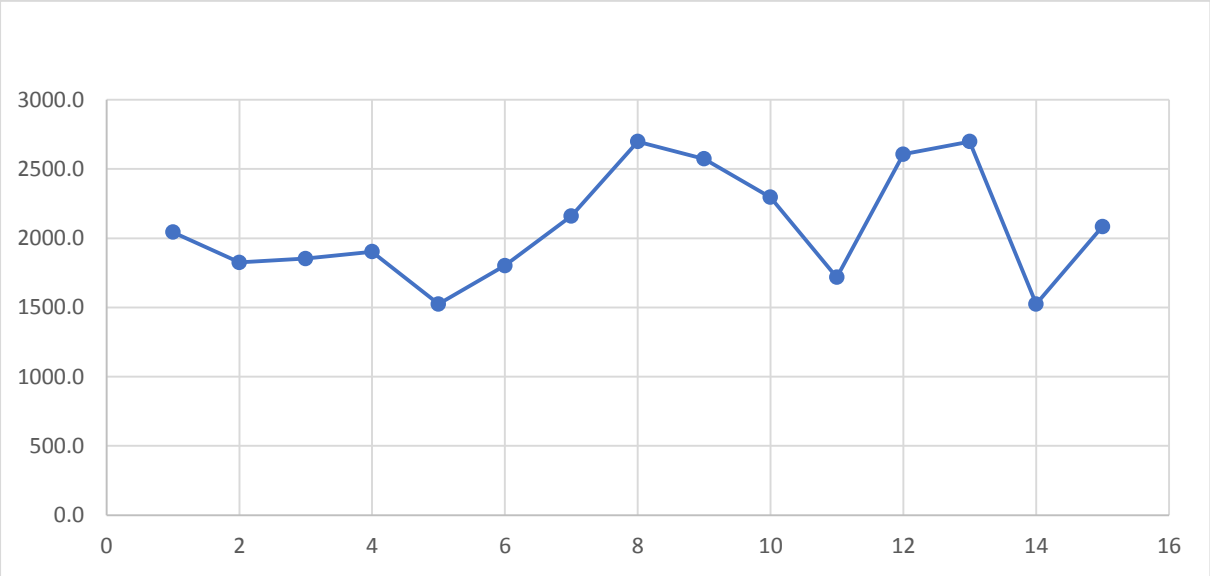
Plant Capacity:		947.7 kWp		
S. No	**Month**	**IR**	**Generation**	**PR**
1	Sep-22	129.96	99392	80.70
2	Oct-22	165.28	118233	75.48
3	Nov-22	166.06	117385	74.59
4	Dec-22	156	105321	71.24
5	Jan-23	183.29	127182	73.22
6	Feb-23	194.54	127068	68.92
7	Mar-23	183.31	120838	69.56
8	Apr-23	169.81	139591	86.74
9	May-23	174.76	131131	79.18
10	Jun-23	160.07	120713	79.57
11	Jul-23	110.41	88304	84.39
12	Aug-23	149.71	118411	83.46

2.2. Observations

1. The bill detailed tabulated above are from September 2022 to August 2023.
2. During the period the peak demand of 2698 kVA is observed in the month of April 2023 where minimum demand of 1525 is recorded in the month if January-2023.
3. During the period the peak consumption of 1107437 kVAh is recorded in May 2023 and Minimum Consumption of 388885 kVAh.
4. The average Power Factor of 0.998 is observed in the period.
5. Though the contract demand is 2500 kVA it is observed that demand limit has crossed in 3 months.



PF Graph



Recorded Demand

3. ELECTRICAL SYSTEMS

3.1. Introduction

The incoming to the facility is 33kV line supplied from southern power distribution company of TS Limited which is being stepped down to the 11kV using a 5 MVA Transformer which is located in the 33kV Substation in the campus. There are two transformers of 5 MVA Capacity installed in the 33kV Substation out of which one is being used and other is in standby.

3.2. IEEE STANDARD 519-2014

The electrical system harmonic limits as per "IEEE519-2014, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems". The standards of voltage and current distortions are given in the following tables.

Table 3: IEEE standards 519-2014 Voltage distribution limits

Bus voltage *V* at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \leq 1.0$ kV	5	8
1 kV $< V \leq$ 69 kV	3	5
69 kV $< V \leq$ 161 kV	1.5	2.5
161 kV $< V$	1	1.5

Table 4: IEEE standards 519-2014 Current Harmonics limits

Maximum Harmonic Current Distortion in Percent of IL						
Individual Harmonic Order (Odd Harmonics)						
ISC/IL	**<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 DC offset, e.g., half-wave converters are not allowed.						
*All power generation equipment is limited to these values of current distortion, regardless of Actual ISC/IL.						
Were ISC=maximum short-circuit current at PCC. IL=maximum demand load current (fundamental frequency component) at PCC. TDD=Total Demand Distortion. PCC =Point of Common Coupling.						

3.3. List of Transformers

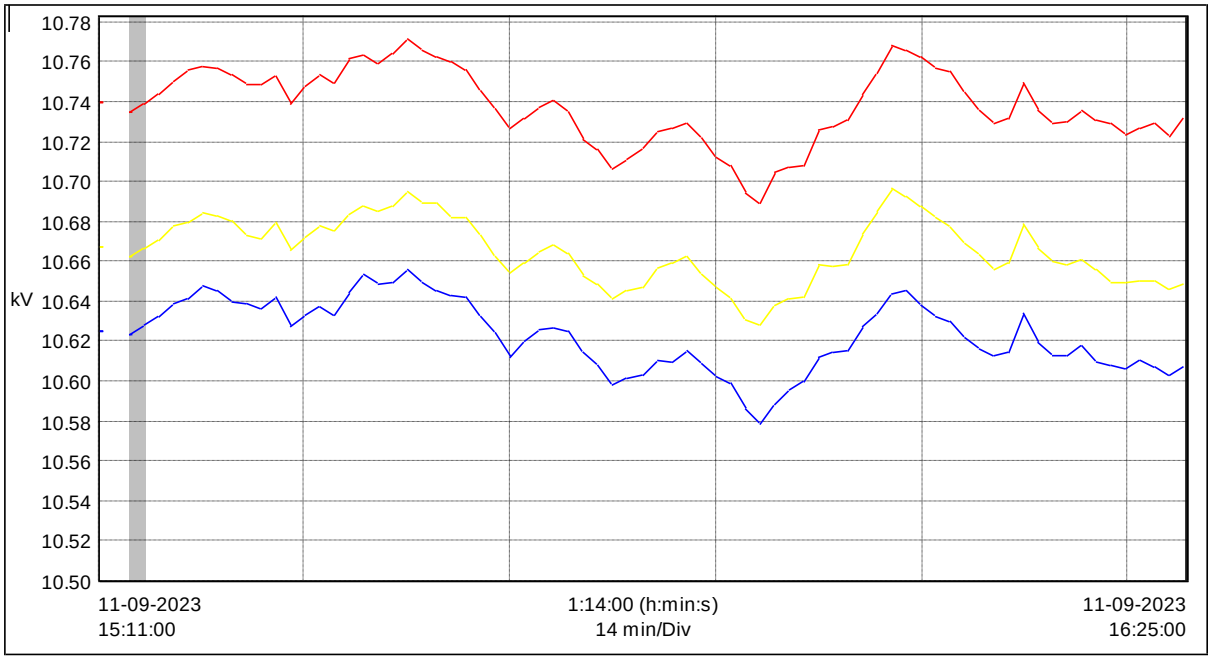
Total of 8 substations equipped with 15 transformers are present in the campus for the distribution of the electricity to various blocks in the campus. The details of the Transformers and Locations are mentioned below.

S.NO	DESCRIPTION	CAPACITY	QUANTITY
I	33KV SUBSTATIONS	33KV/11 KV	
	TRANSFORMERS	5MVA	2
II	ELECTRICAL SUBSTATION-1	11KV/415V	
	TRANSFORMERS	2000KVA	2
III	ELECTRICAL SUBSTATION-2	11KV/415V	
	TRANSFORMERS	500KVA	2
IV	ELECTRICAL SUBSTATION-3	11KV/415V	
	TRANSFORMERS	500KVA	2
V	SUBSTATION @AUDITORIUM	11KV/415V	
	TRANSFORMERS	1000KVA	1
VI	ELECTRICAL SUBSTATION-1A		
	TRANSFORMERS	400 KVA	2
VII	ELECTRICAL SUBSTATION-3A		
	TRANSFORMERS	1000 KVA	2
VIII	ELECTRICAL SUBSTATION-4		
	TRANSFORMERS	1600 KVA	2

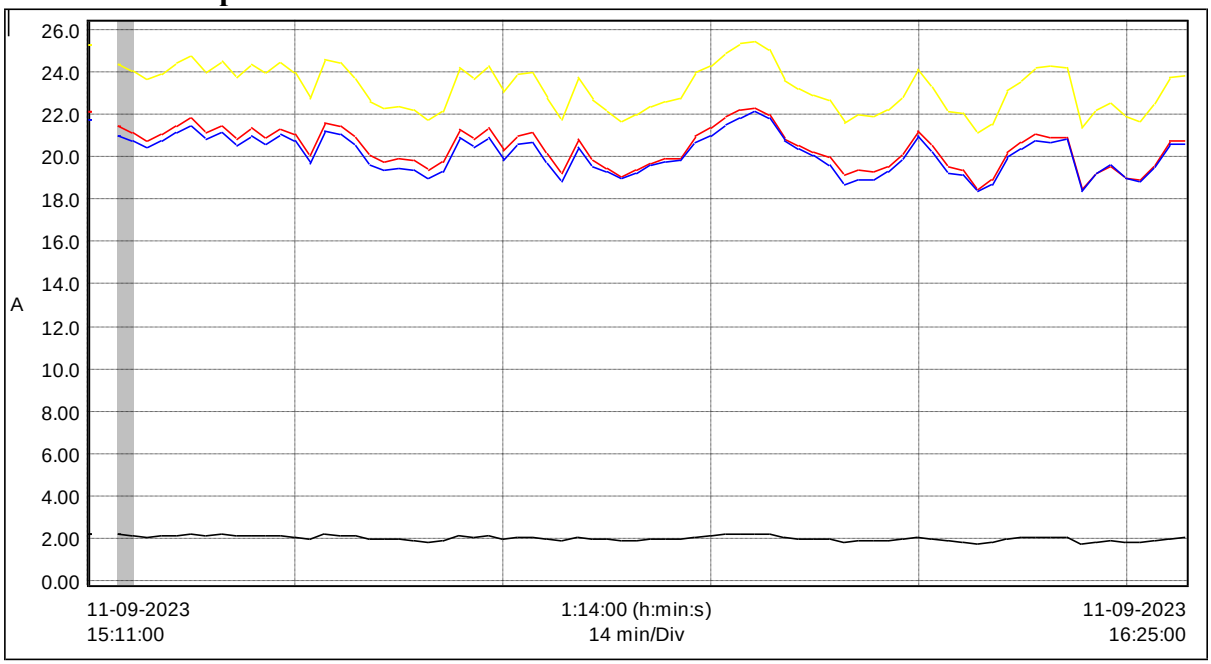
3.4. Transformer Analysis

3.4.1. Electrical Substation 1 Transformer-1 Primary

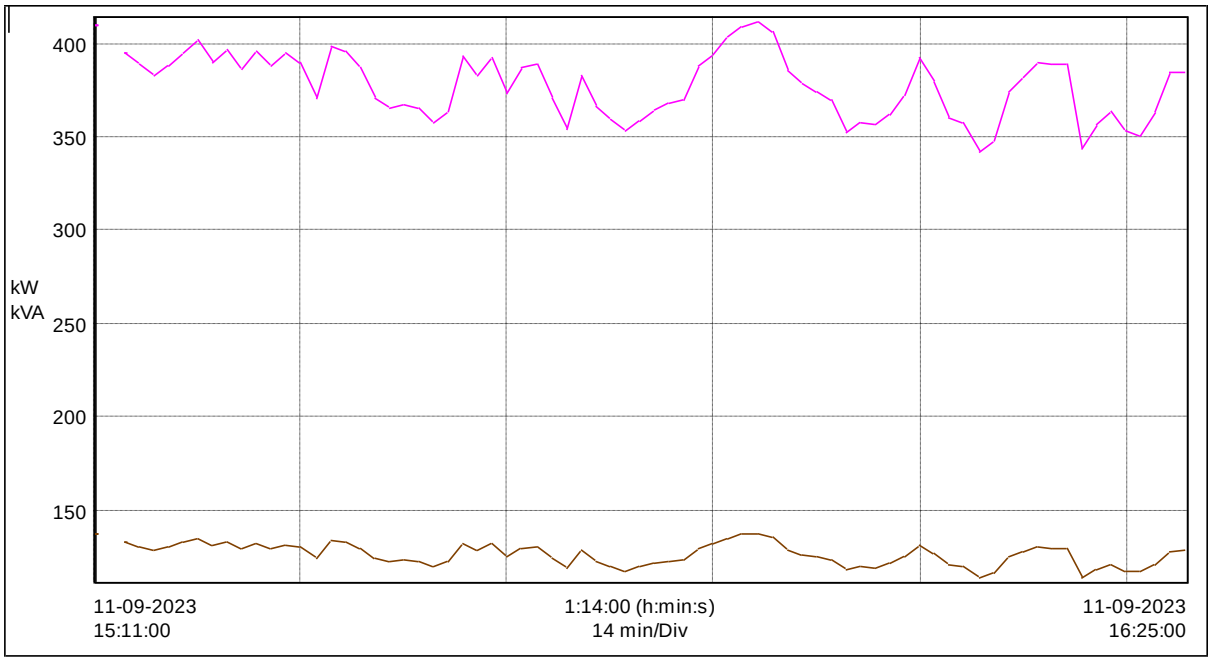
3.4.1.1.Voltage Profile



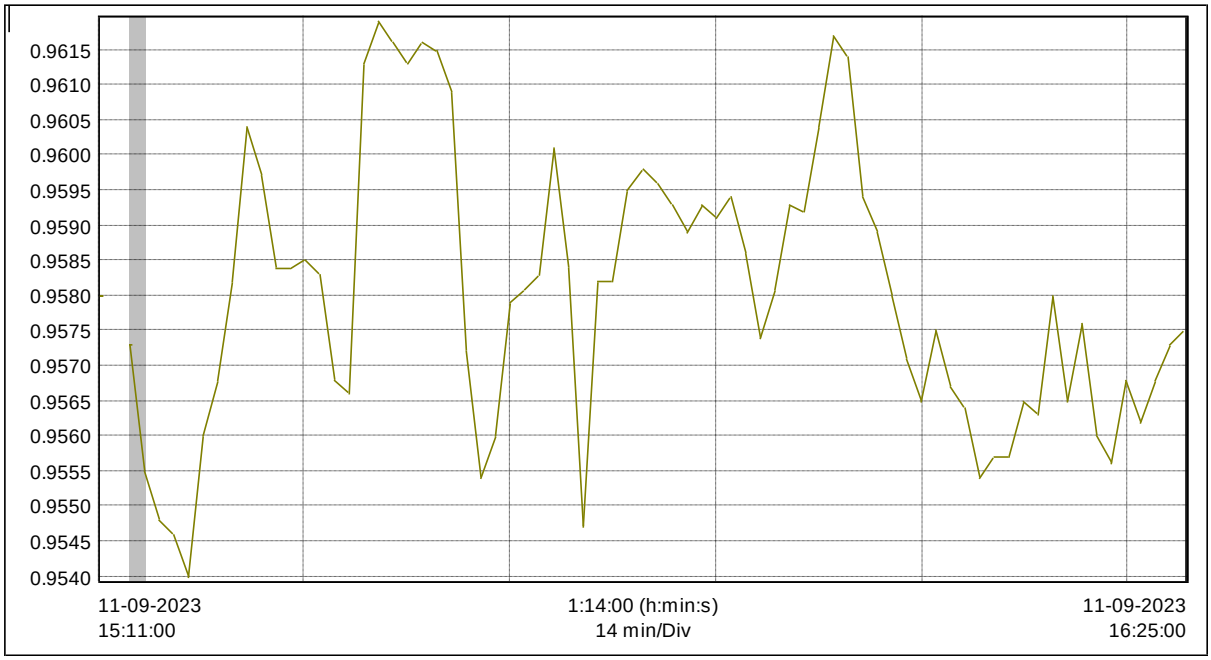
3.4.1.2.Current profile



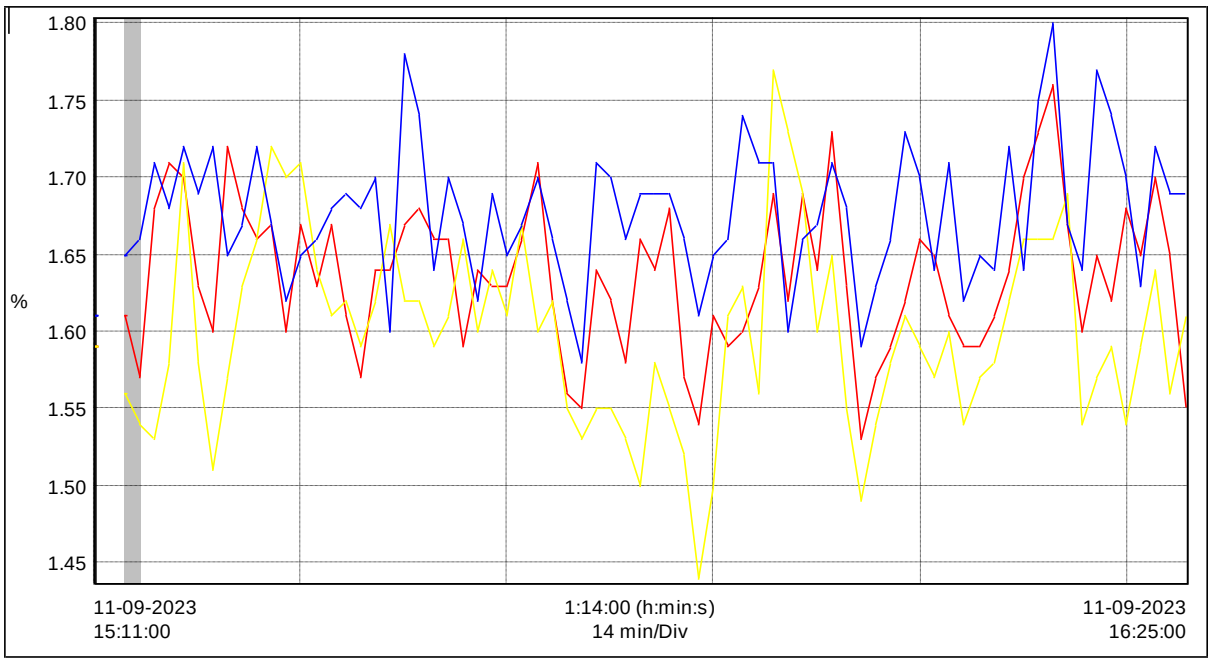
3.4.1.3.Power Profile



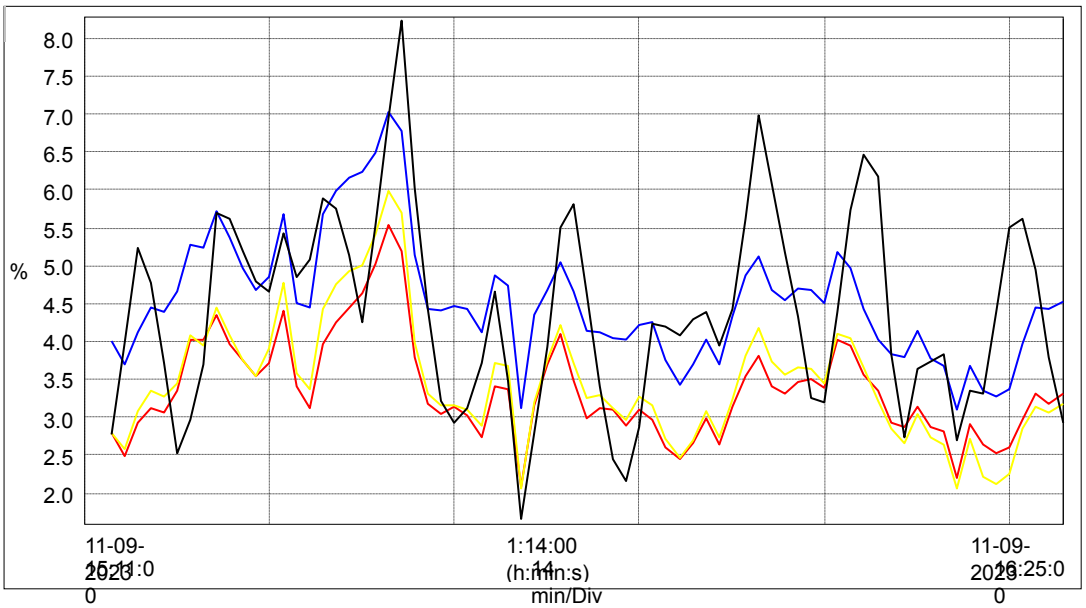
3.4.1.4.Power factor



3.4.1.5. Phase to Phase Total Hormonic distortions (%UTHD)



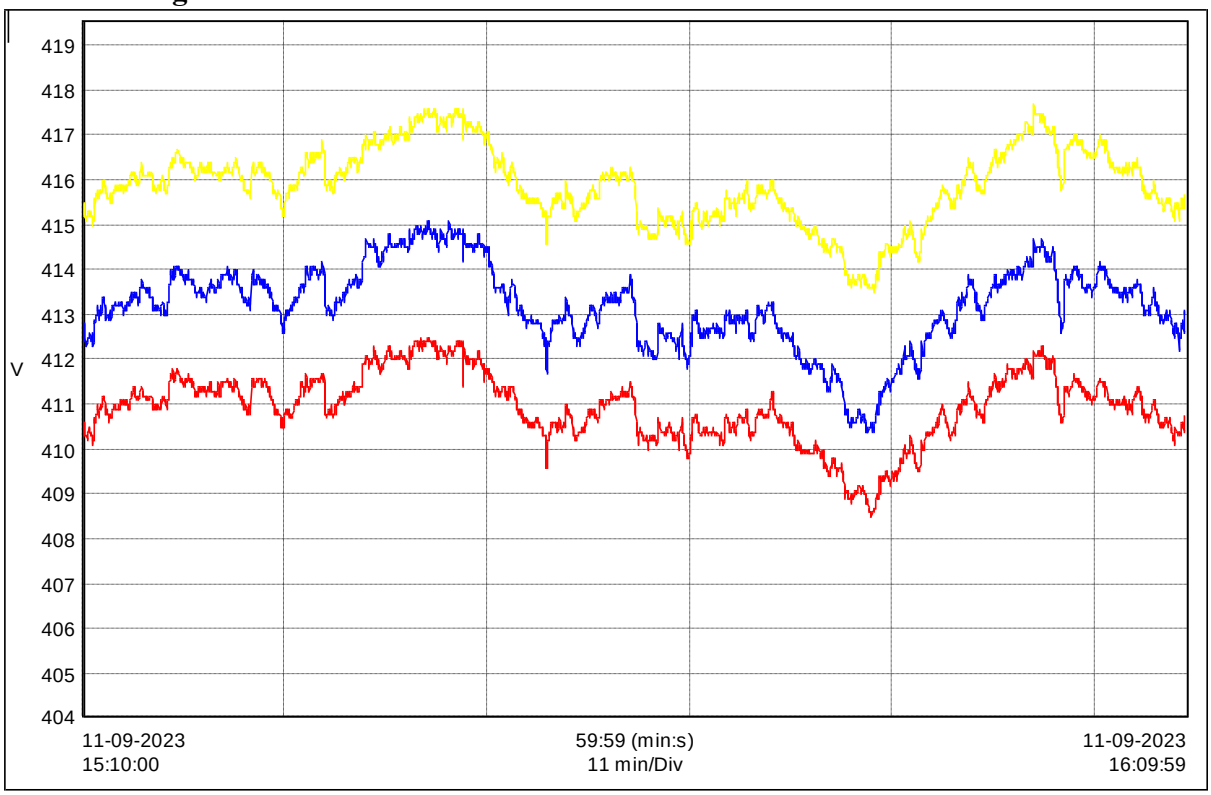
3.4.1.6.Current Harmonic Distortions



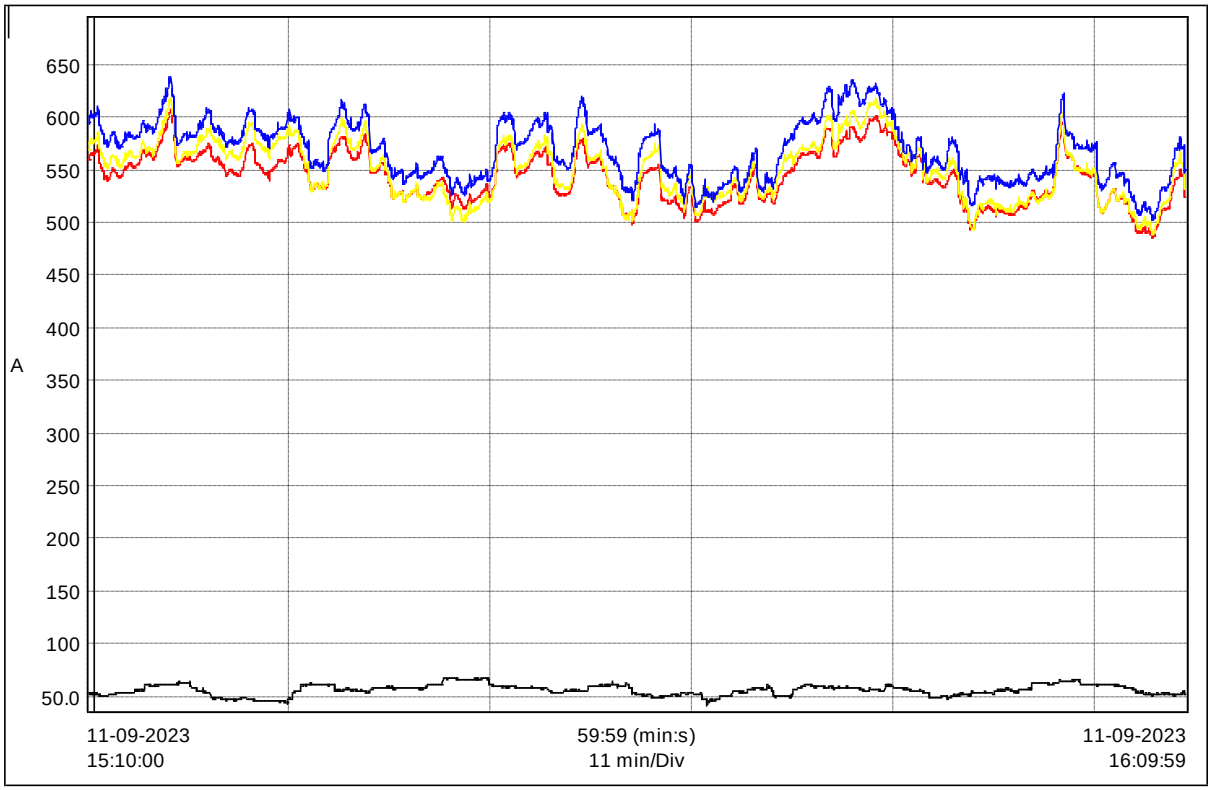
	Average	Minimum	Maximum	UoM
Voltage				
U12	10.74	10.68	10.78	kV
U23	10.67	10.62	10.71	kV
U31	10.62	10.57	10.66	kV
Current				
I1 (1 min)	20.5	18.51	22.33	A
I2 (1 min)	23.34	21.18	25.51	A
I3 (1 min)	20.22	18.38	22.17	A
IN (1 min)	2.011	1.765	2.236	A
Active Power				
P1	121.1	109.1	131.5	kW
P2	135.9	123.1	147.8	kW
P3	120.7	109.7	132.1	kW
PT	377.7	341.8	411.4	kW
Apparent Power				
S1	126.8	114.6	137.7	kVA
S2	143.1	130	155.9	kVA
S3	124.4	113.2	136.1	kVA
ST	394.3	357.8	429.7	kVA
Power Factor				
PF1	0.955	0.951	0.961	
PF2+ (1 min)	0.95	0.945	0.956	
PF3+ (1 min)	0.97	0.967	0.972	
PFT+ (1 min)	0.958	0.954	0.962	
Total Harmonic Distortion				
U12-THD (1 min)	1.64	1.53	1.76	%
U23-THD (1 min)	1.6	1.44	1.77	%
U31-THD (1 min)	1.677	1.58	1.8	%
I1-THD (1 min)	3.285	1.66	5.72	%
I2-THD (1 min)	3.162	1.32	5.99	%
I3-THD (1 min)	4.25	2.39	7.05	%
IN-THD (1 min)	3.74	0.58	8.23	%

3.4.2. Electrical Substation 1 Transformer 1 Secondary

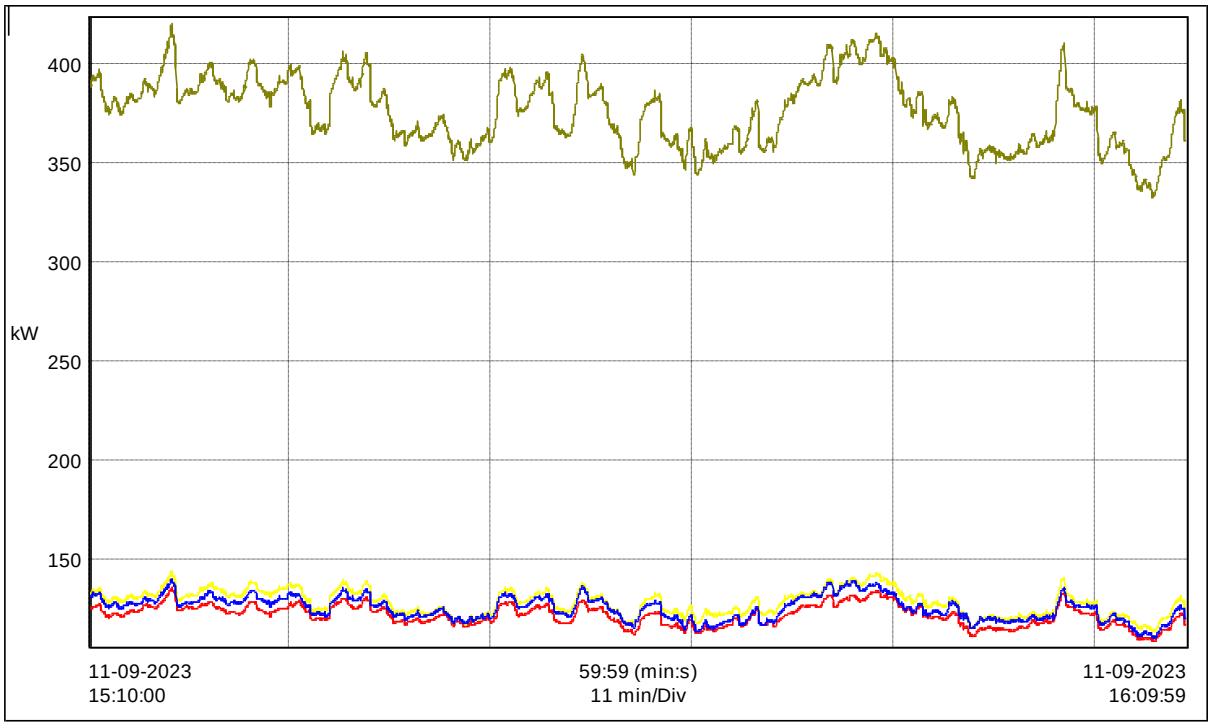
3.4.2.1.Voltage Profile



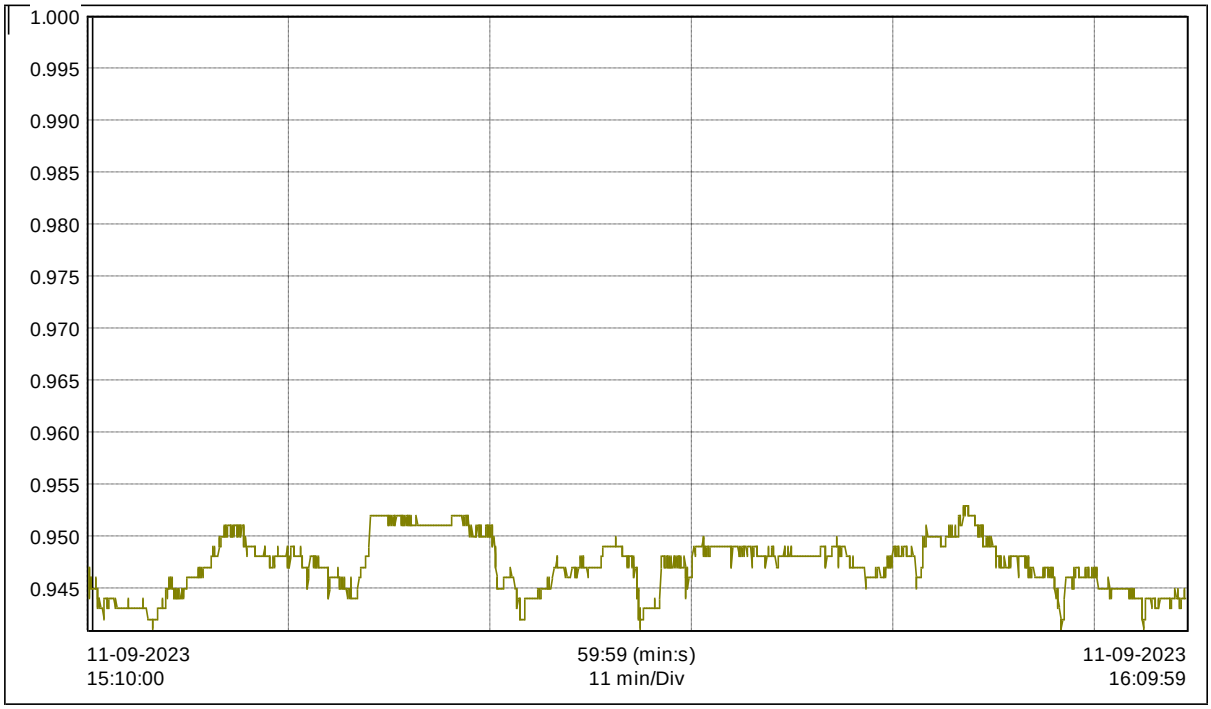
3.4.2.2.Current Profile



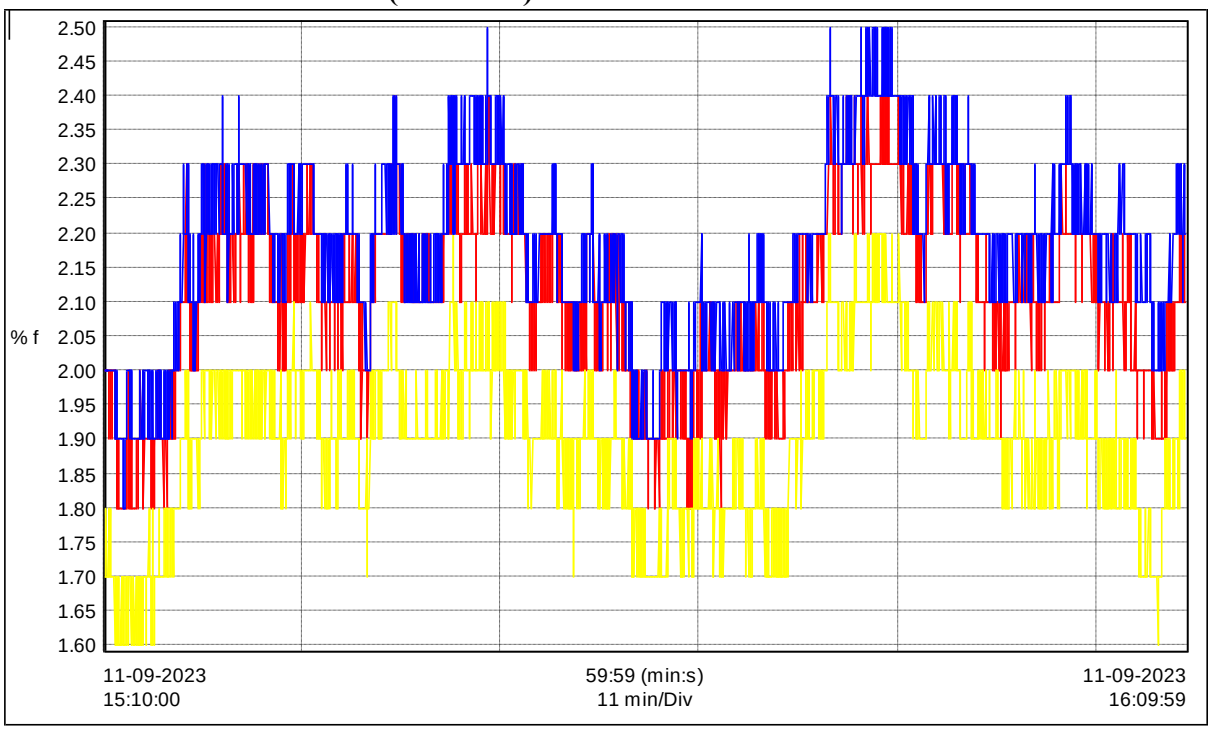
3.4.2.3.Power Profile



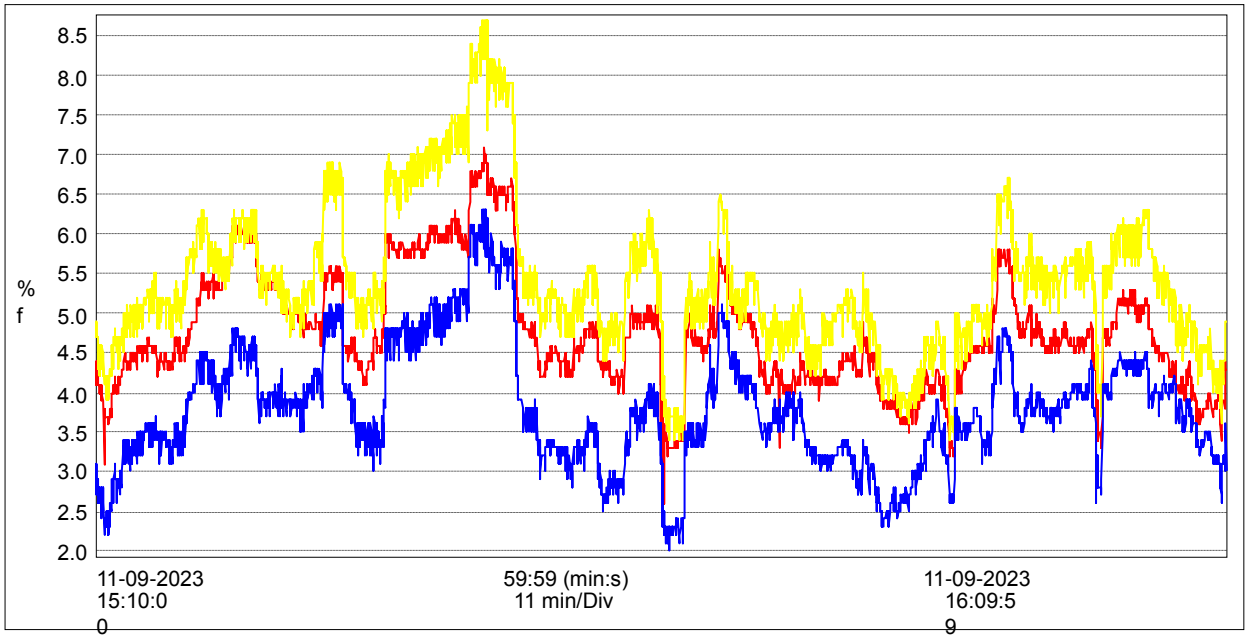
3.4.2.4.Power factor



3.4.2.5.Phase to Phase THD (%UTHD)



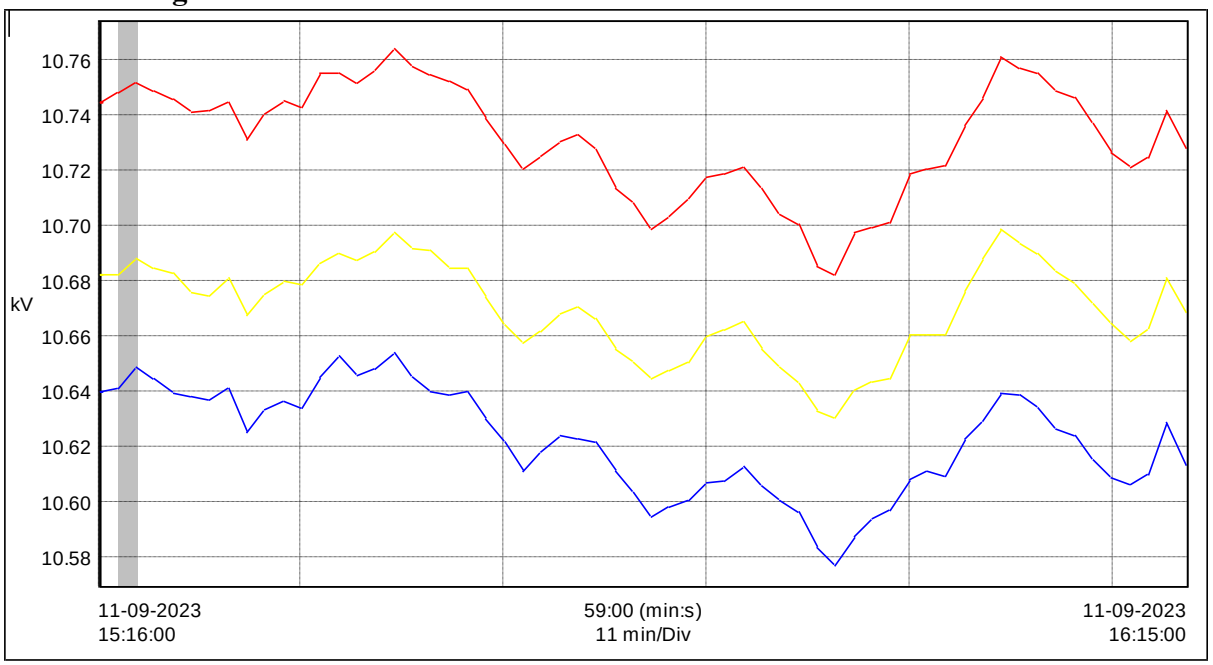
3.4.2.6.Current Harmonic Distortions



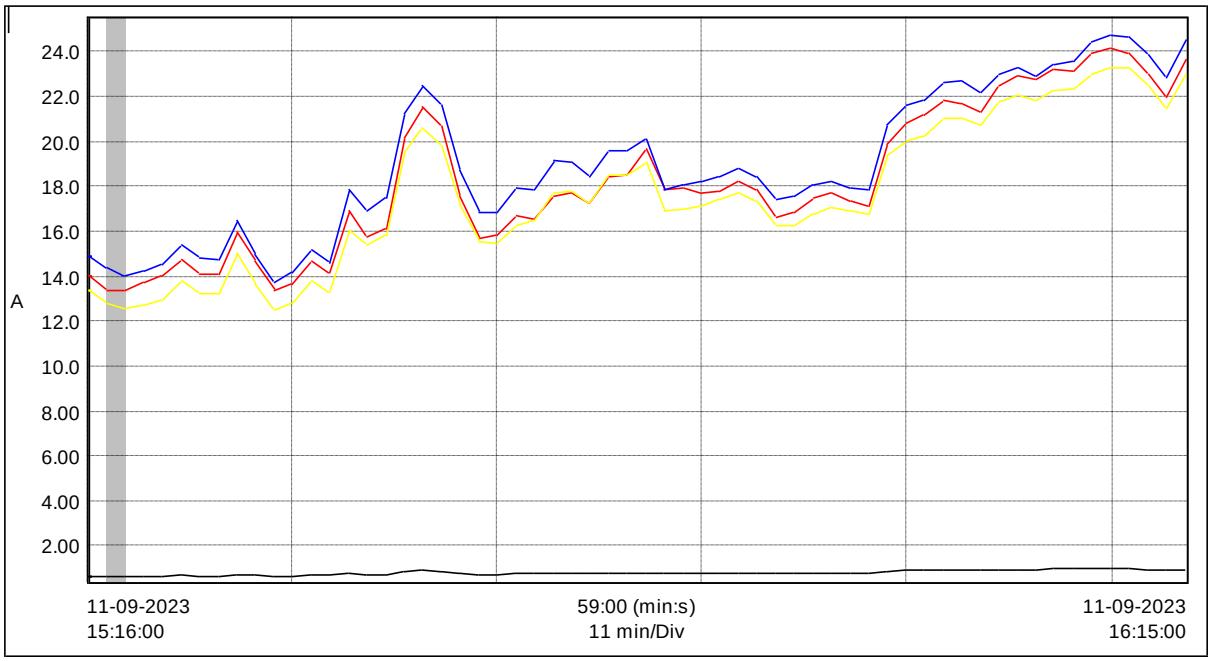
Parameter	Avg	Min	Max	UoM
Voltage				
U12 rms	410.9	406.7	414.2	V
U23 rms	415.9	410.5	419.4	V
U31 rms	413.2	404.2	417	V
Current				
A1 rms	544.6	482.6	653.4	A
A2 rms	551.3	486.4	672	A
A3 rms	569.5	498.6	689.3	A
AN rms	57.15	42.24	68.48	A
Active Power				
P1 (W)	122.1	108.9	136.2	kW
P2 (W)	128.4	113.7	144.2	kW
P3 (W)	125.6	110.3	140.6	kW
PT (W)	376.1	333	421	kW
Apparent Power				
S1 (VA)	127.9	114.4	142.9	kVA
S2 (VA)	133.7	118.7	150.2	kVA
S3 (VA)	135.4	119.7	152.1	kVA
ST (VA)	397	352.9	445.1	kVA
Power Factor				
PF1	0.955	0.949	0.959	
PF2	0.96	0.955	0.966	
PF3	0.927	0.916	0.938	
PFT	0.947	0.941	0.953	
Total harmonic Distortion				
A1 THDf	4.76	2.6	7.1	% f
A2 THDf	5.43	3.4	8.7	% f
A3 THDf	3.81	2	6.3	% f
U12 THDf	2.107	1.8	2.4	% f
U23 THDf	1.902	1.6	2.2	% f
U31 THDf	2.178	1.8	2.5	% f

3.4.3. Electrical Substation 1 Transformer 2 Primary

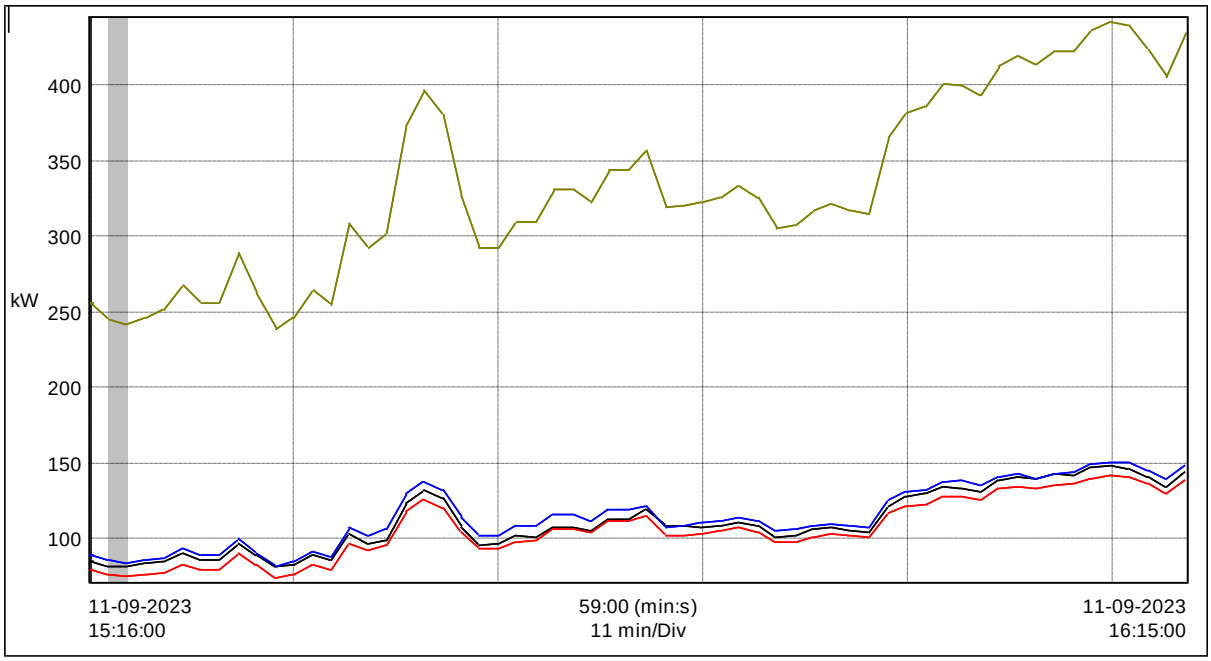
3.4.3.1.Voltage Profile



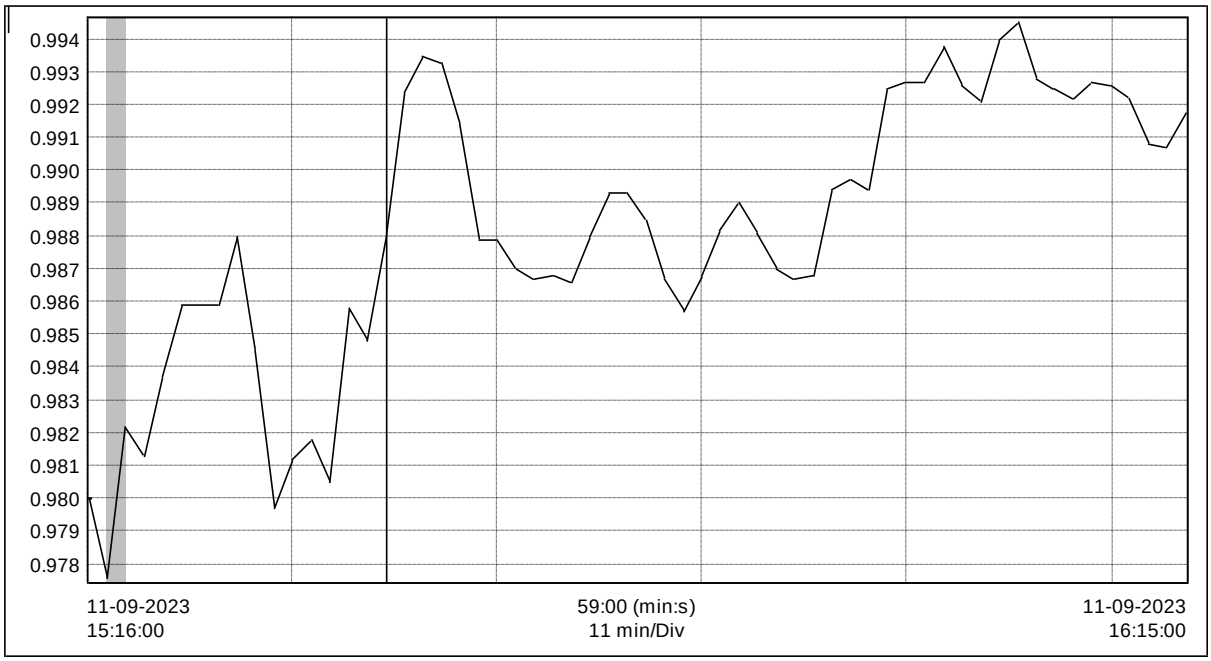
3.4.3.2.Current Profile



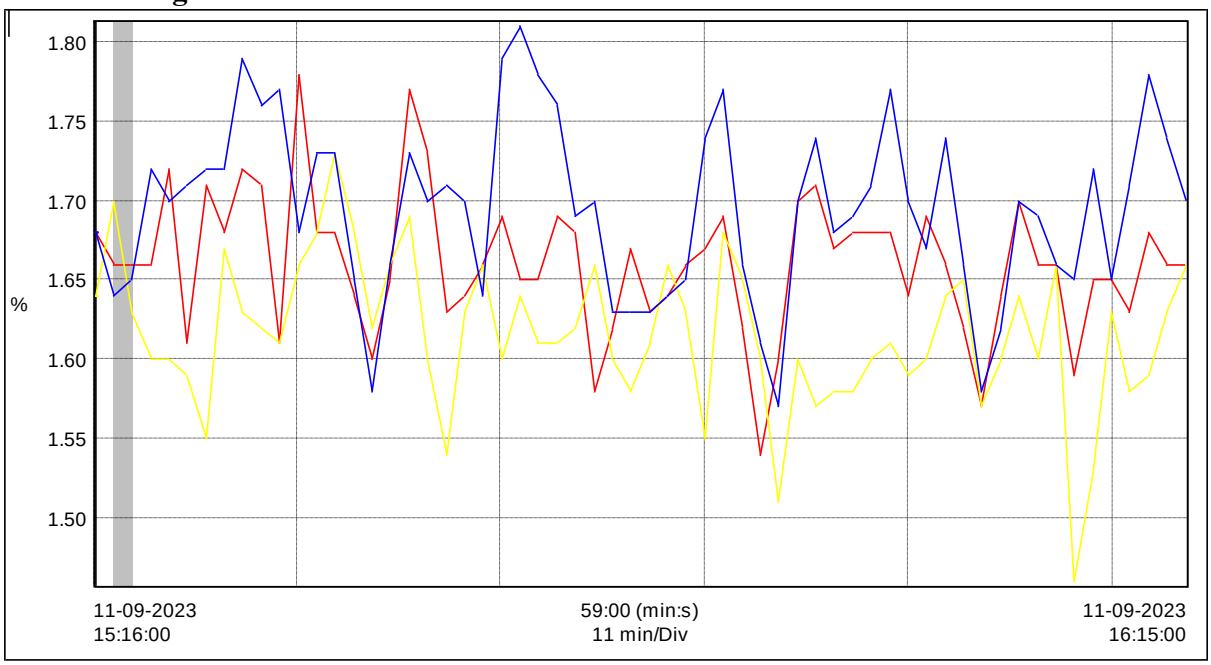
3.4.3.3.Power Profile



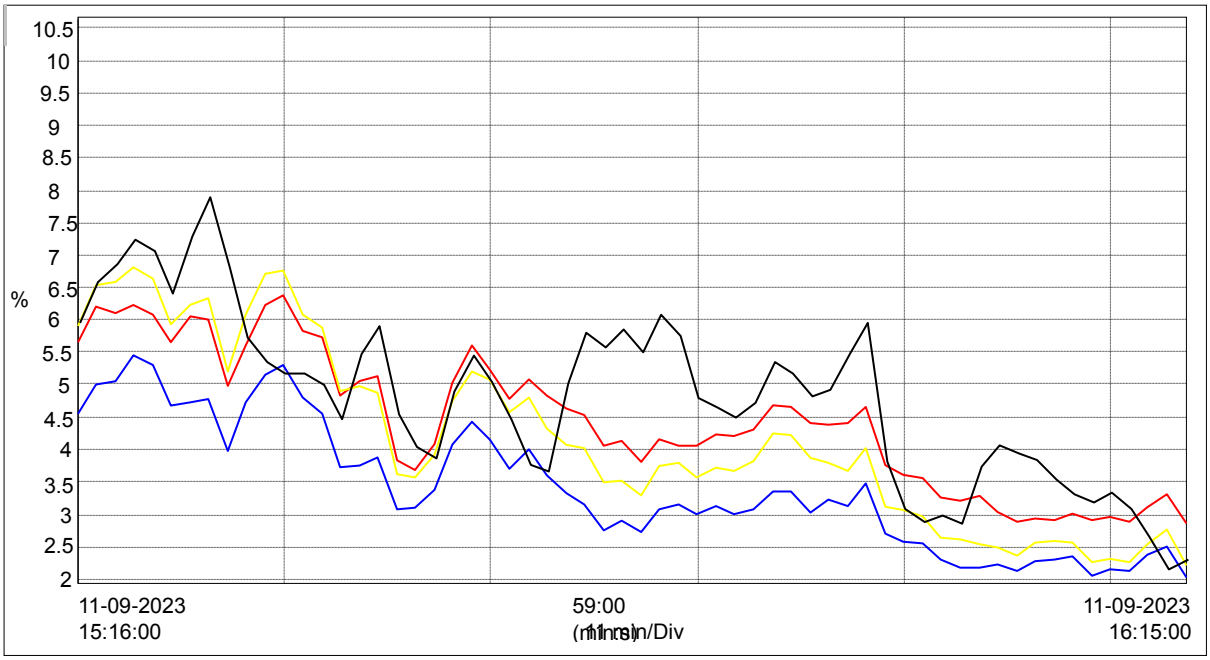
3.4.3.4.Power Factor



3.4.3.5.Voltage harmonics



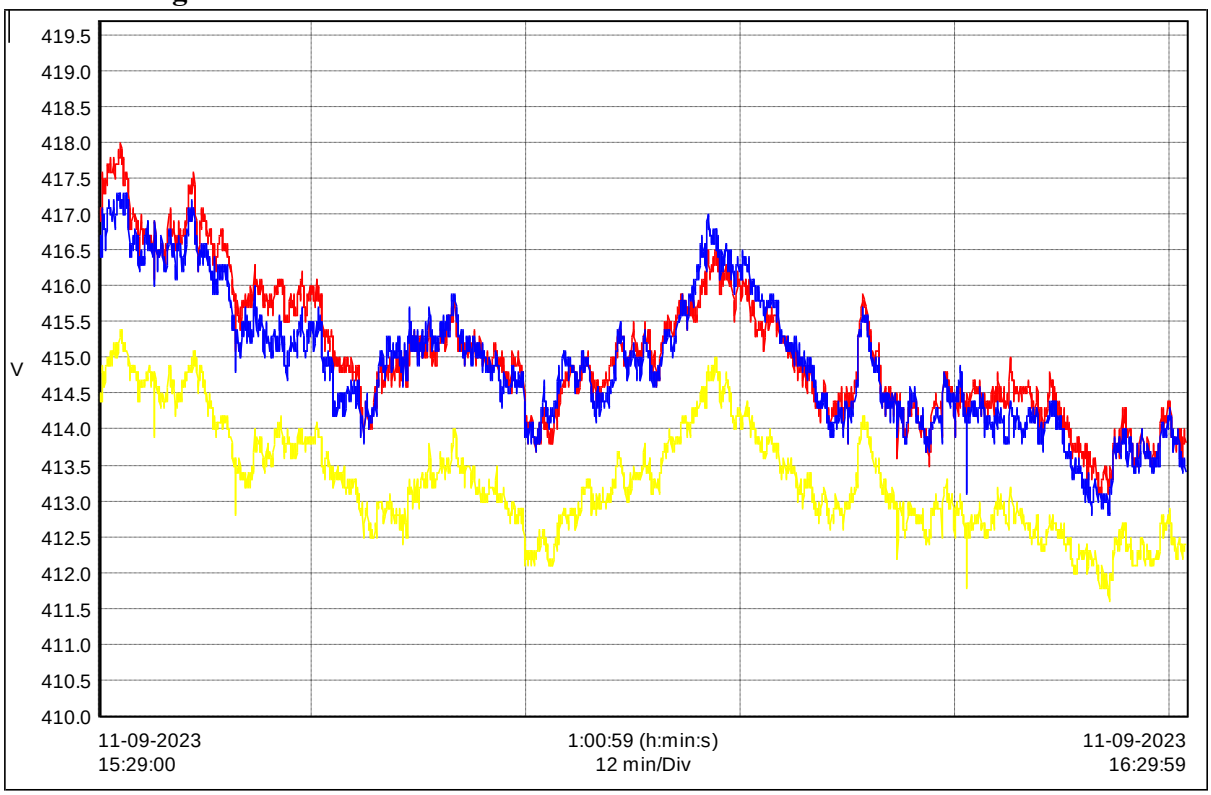
3.4.3.6.Current Harmonics



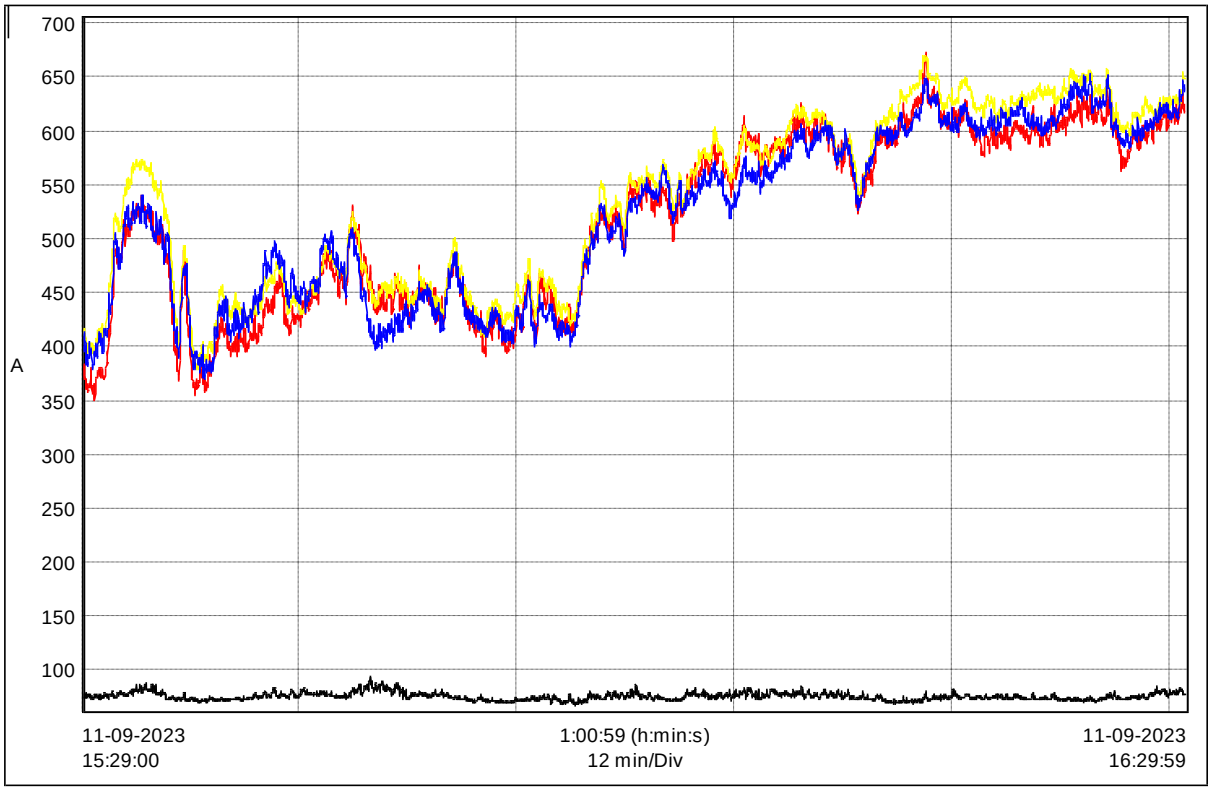
Parameter	Avg	Min	Max	UoM
Voltage				
U12 (1 min)	10.73	10.68	10.77	kV
U23 (1 min)	10.67	10.62	10.71	kV
U31 (1 min)	10.62	10.57	10.66	kV
Current				
I1 (1 min)	18.53	12.78	24.81	A
I2 (1 min)	17.92	11.69	24.02	A
I3 (1 min)	19.26	13.1	25.31	A
IN (1 min)	0.83	0.614	1.052	A
Active Power				
P1 (1 min)	111.8	81.72	148.7	kW
P2 (1 min)	106.8	75.17	142	kW
P3 (1 min)	115.5	82.57	150.9	kW
PT (1 min)	334.1	239.5	441.7	kW
Apparent Power				
S1 (1 min)	112.8	83	149.7	kVA
S2 (1 min)	108.1	76.71	142.9	kVA
S3 (1 min)	117	84.66	152.4	kVA
ST (1 min)	337.9	244.4	445	kVA
Power Factor				
PFT+ (1 min)	0.988	0.978	0.995	
Total Harmonic Distortion				
U12-THD (1 min)	1.661	1.54	1.78	%
U23-THD (1 min)	1.616	1.46	1.73	%
U31-THD (1 min)	1.695	1.57	1.81	%
I1-THD (1 min)	4.28	2.72	6.41	%
I2-THD (1 min)	3.82	2.04	6.82	%
I3-THD (1 min)	3.16	1.92	5.46	%
IN-THD (1 min)	5.30	3.09	7.97	%

3.4.4. Electrical Substation 1 Transformer 2 Secondary

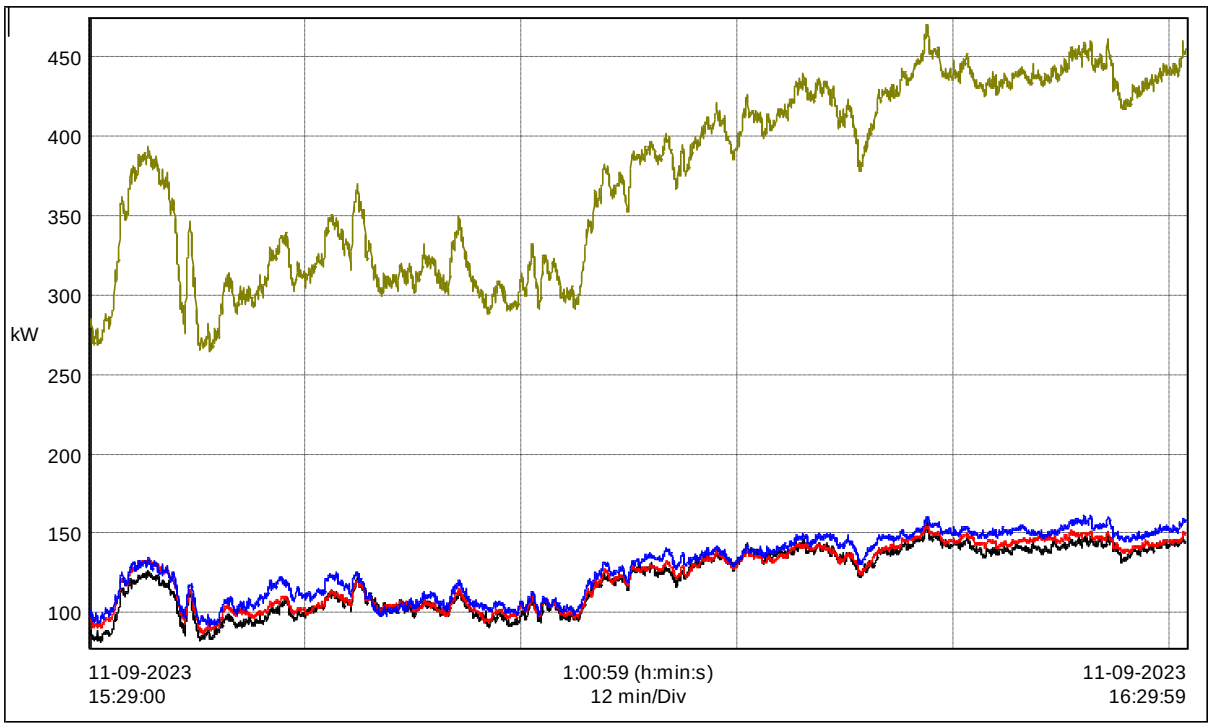
3.4.4.1.Voltage Profile



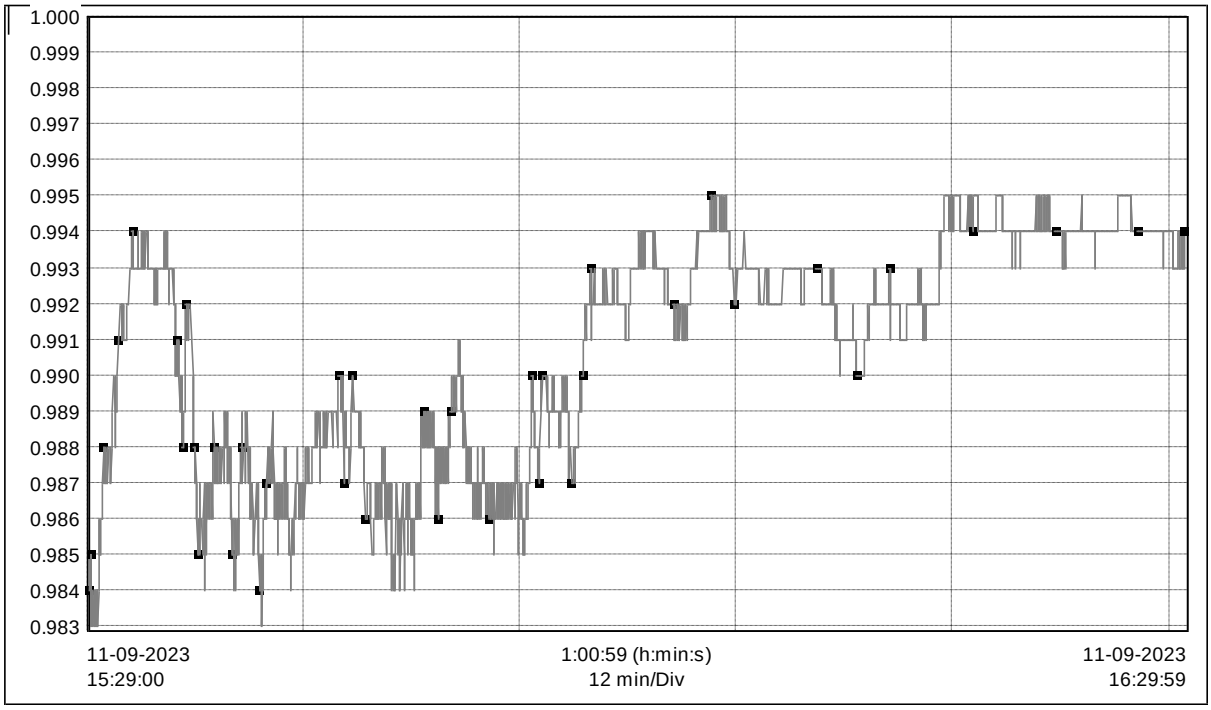
3.4.4.2.Current Profile



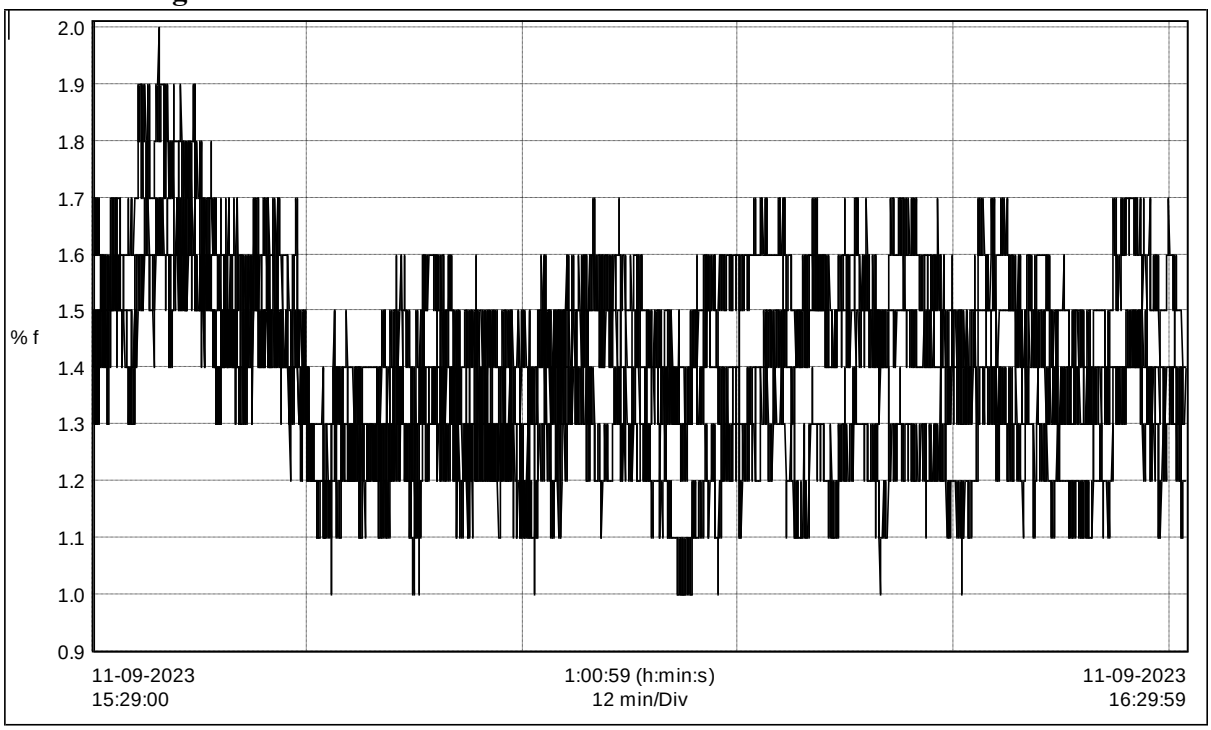
3.4.4.3.Power Profile



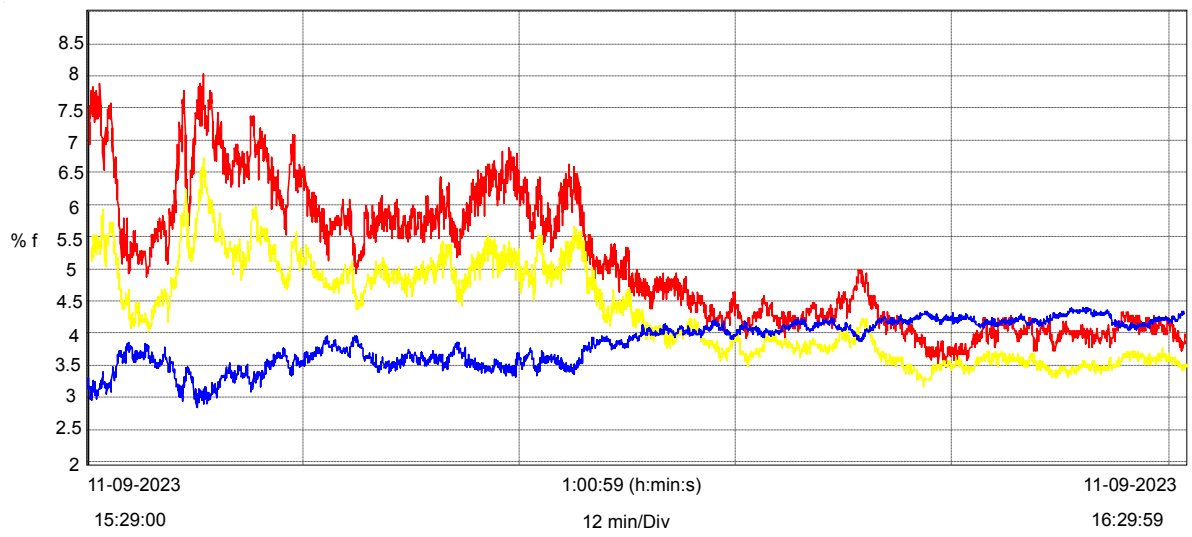
3.4.4.4.Power Factor



3.4.4.5.Voltage Harmonics



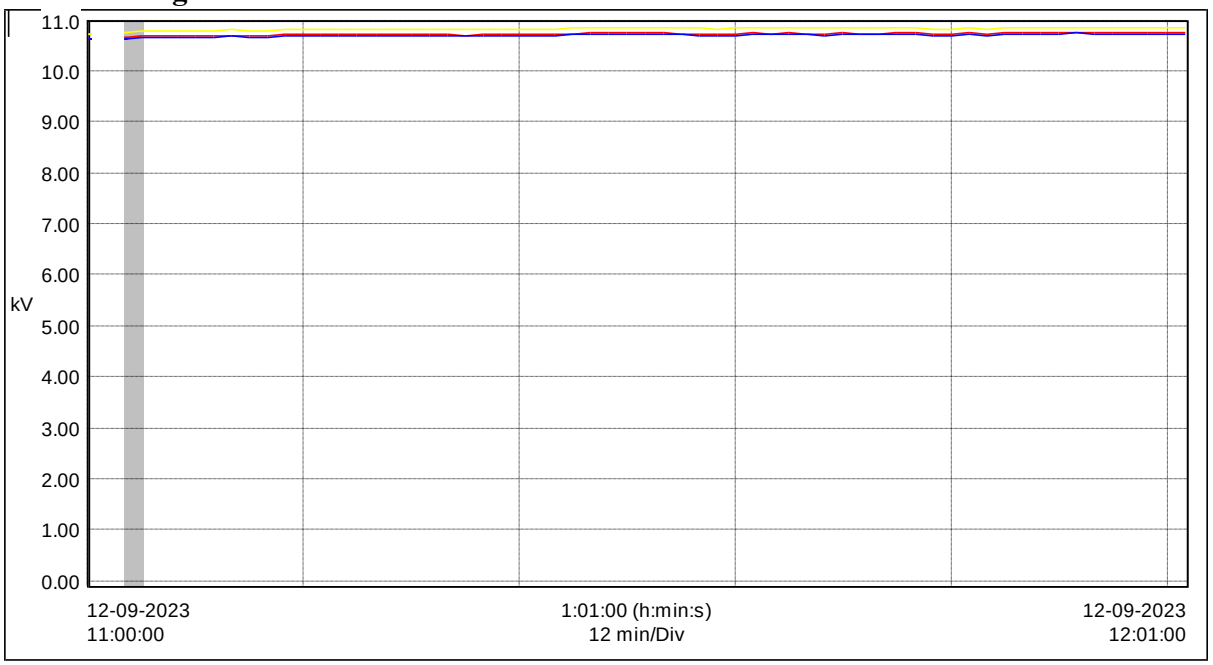
3.4.4.6.Current harmonics



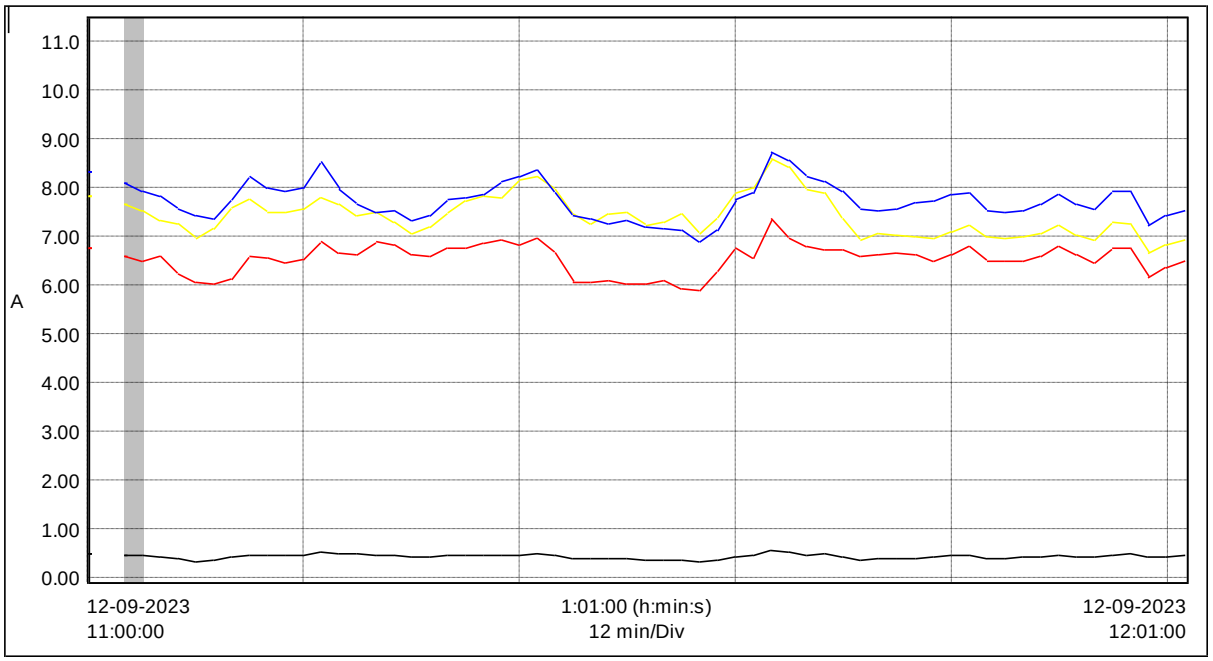
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 rms	415.1	405	419.6	V
U23 rms	413.3	398.8	417.2	V
U31 rms	414.9	398.1	419.3	V
Current				
A1 rms	524.5	342.4	691.8	A
A2 rms	541.9	367.4	700.2	A
A3 rms	526	358.4	688	A
AN rms	76.2	67.84	94.08	A
Active Power				
P1 (W)	121.1	81.62	157.2	kW
P2 (W)	123.7	87.44	154.5	kW
P3 (W)	128.8	91.66	161.6	kW
PT (W)	373.6	265.5	470.9	kW
Apparent Power				
S1 (VA)	122.6	83.5	159	kVA
S2 (VA)	124.1	88.08	155	kVA
S3 (VA)	130.1	93	162.8	kVA
ST (VA)	376.9	268.9	474.8	kVA
Power Factor				
PF1	0.987	0.975	0.994	
PF2	0.996	0.992	0.999	
PF3	0.989	0.98	0.994	
PFT	0.991	0.983	0.995	
Total Harmonic Distortion				
A1 THD	4.87	3.12	8.01	% f
A2 THD	4.25	3.04	6.7	% f
A3 THD	2.78	3.00	4.41	% f
U12 THD	1.406	1.1	1.7	% f
U23 THD	1.535	1.2	2	% f
U31 THD	1.285	1	1.7	% f

3.4.5. Electrical Substation 1A Transformer 1 Primary

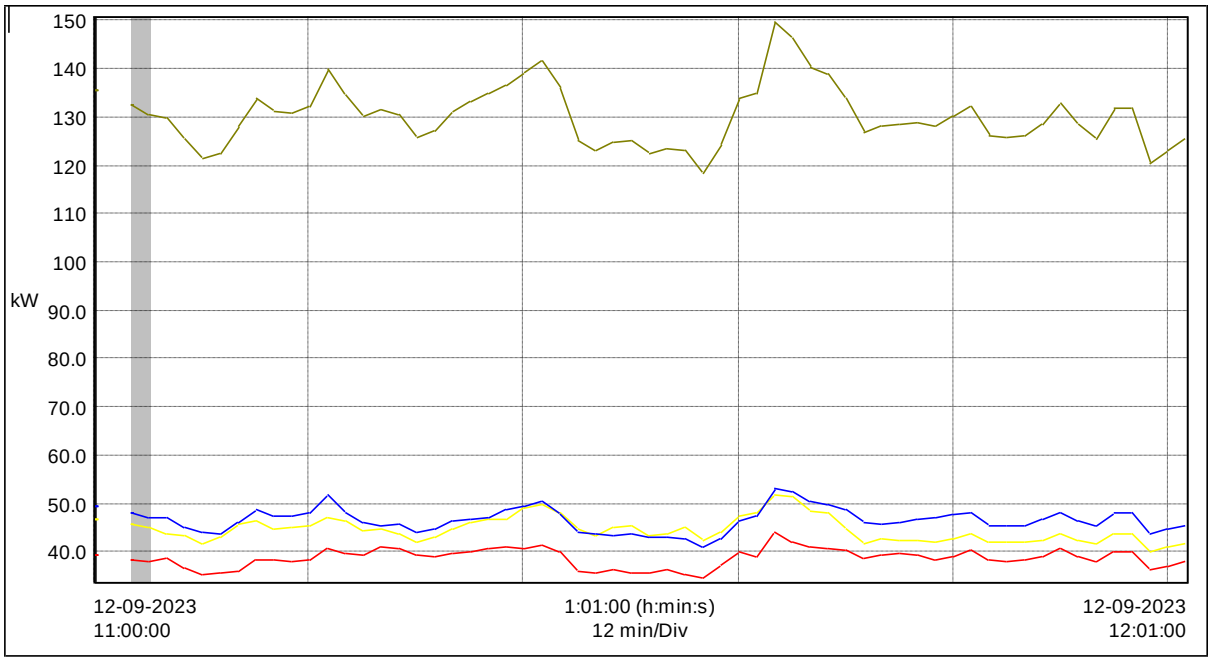
3.4.5.1.Voltage Profile



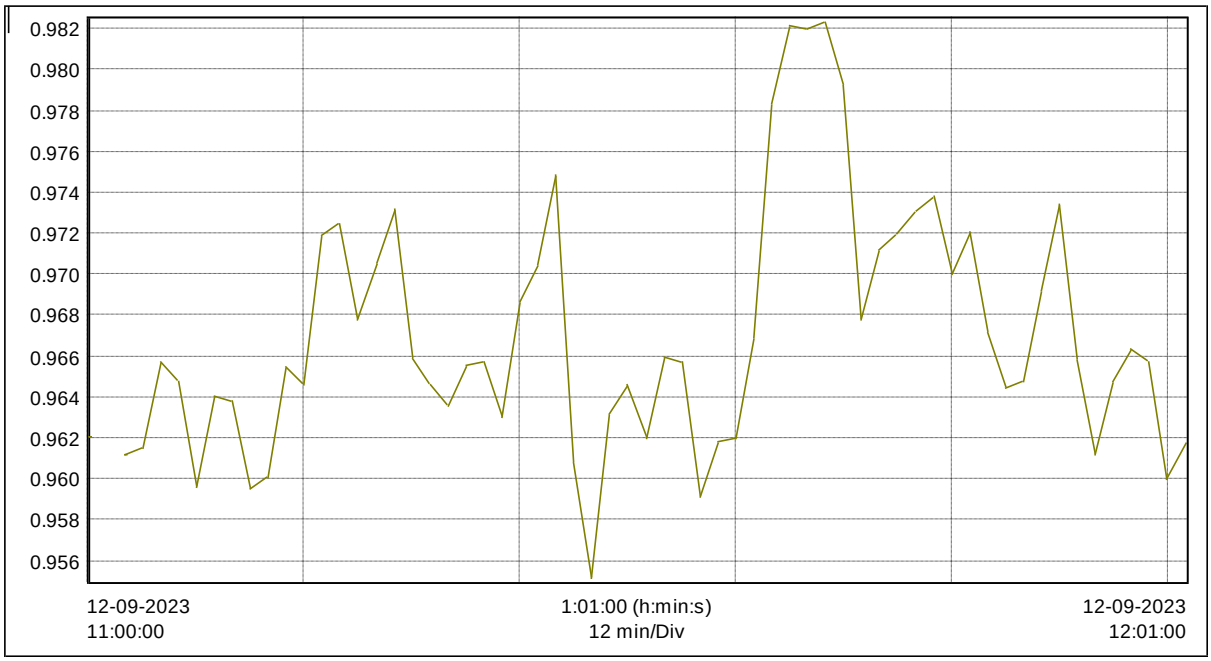
3.4.5.2.Current Profile



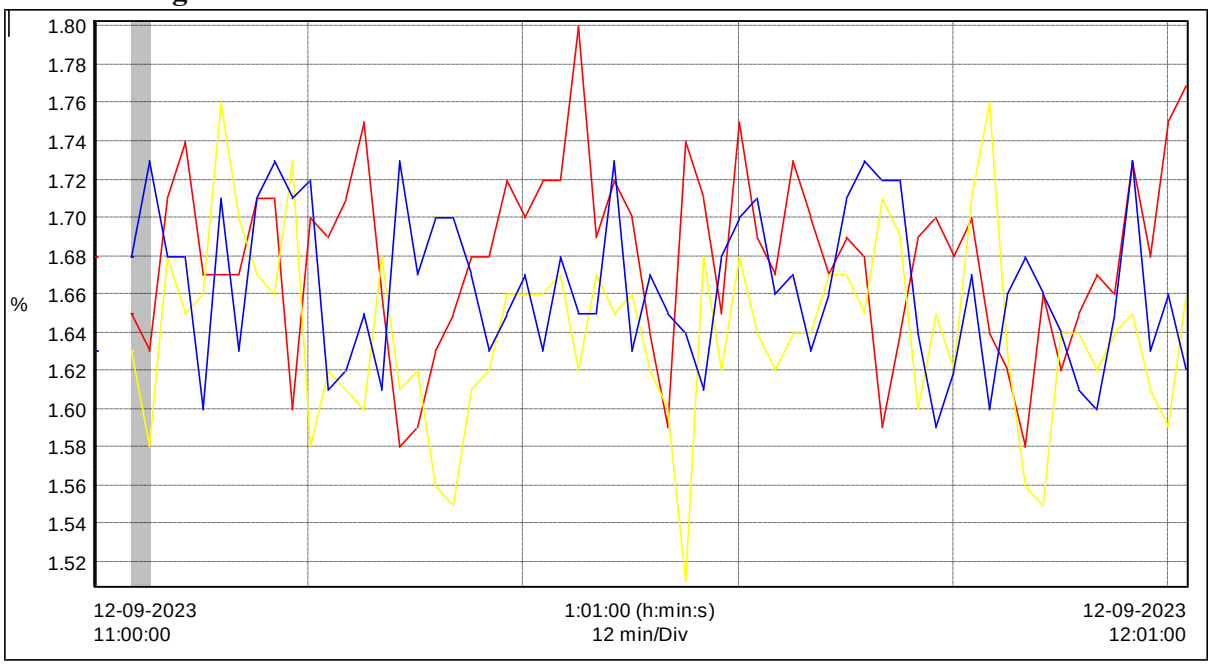
3.4.5.3.Power Profile



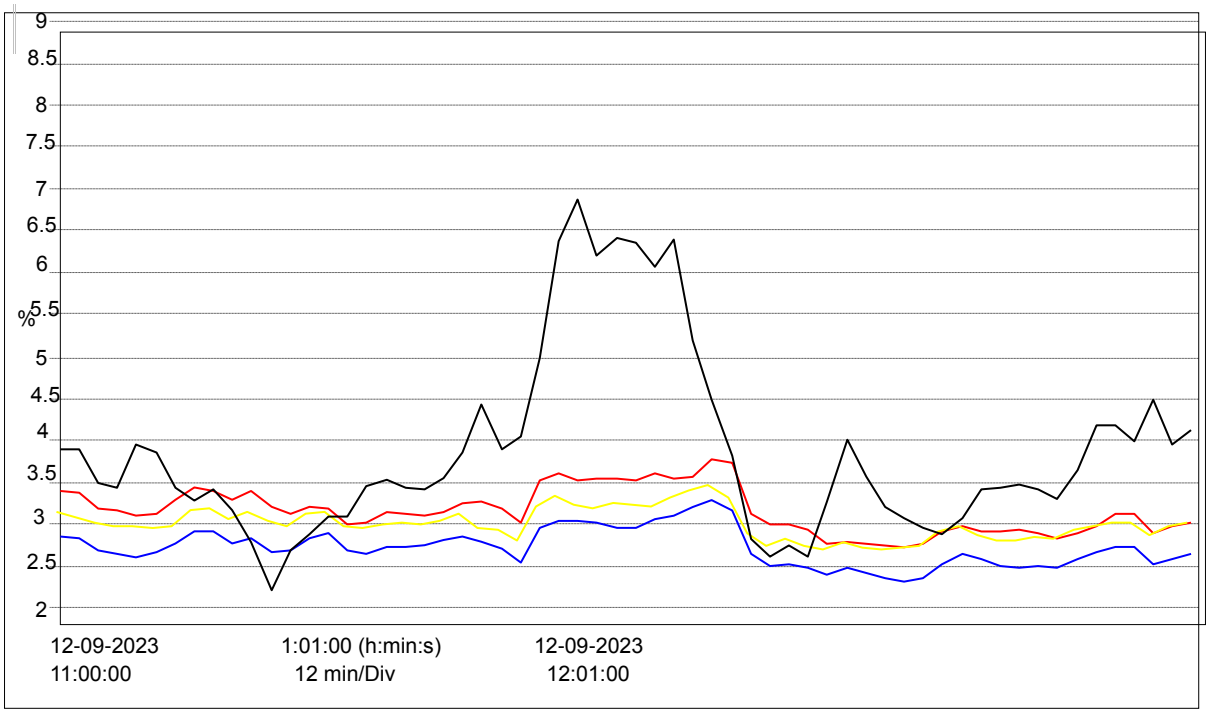
3.4.5.4.Power Factor



3.4.5.5.Voltage Harmonics



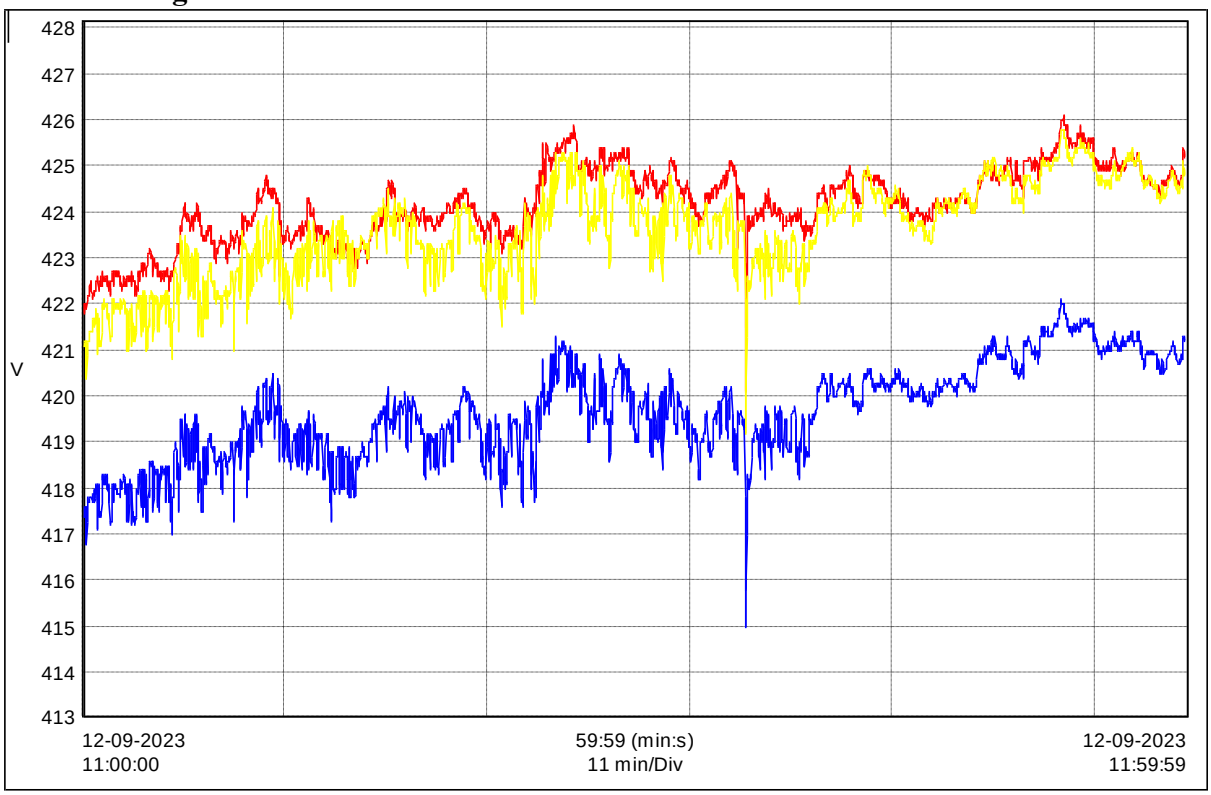
3.4.5.6.Current Harmonics



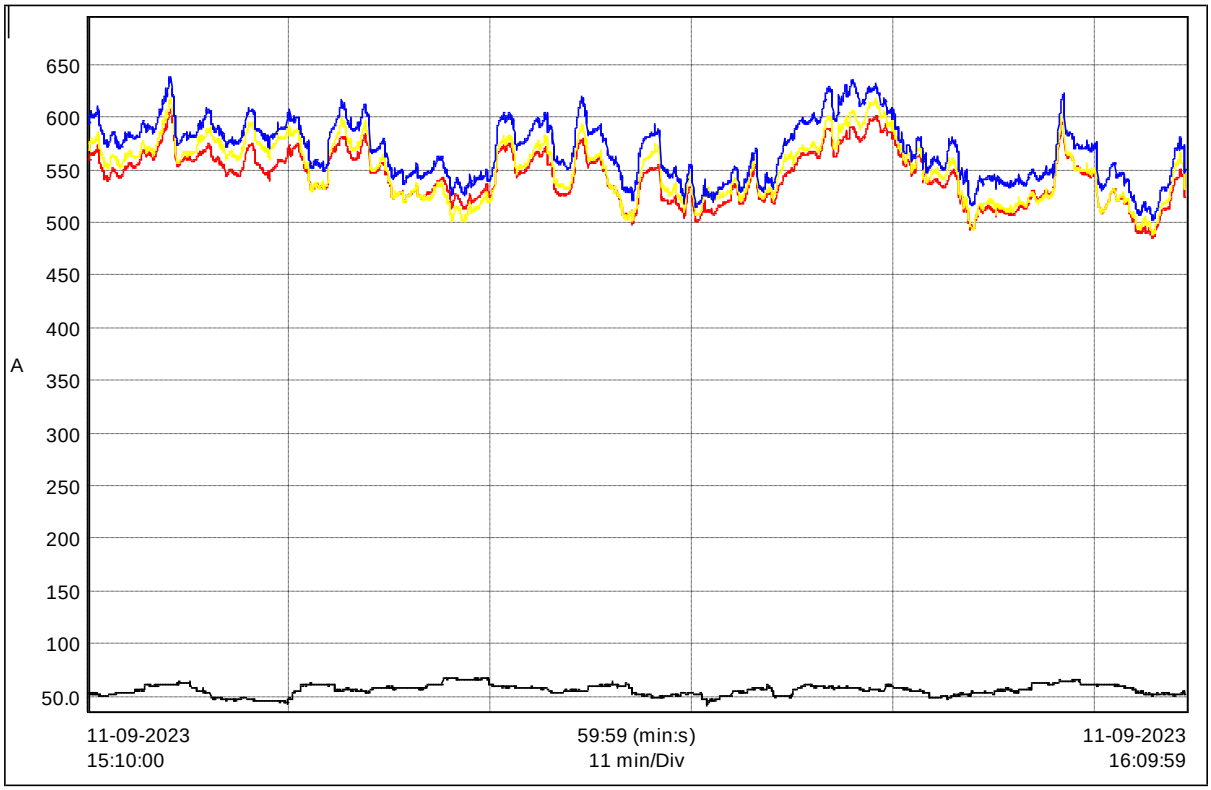
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 (1 min)	10.74	10.63	10.78	kV
U23 (1 min)	10.84	10.73	10.88	kV
U31 (1 min)	10.71	10.61	10.76	kV
Current				
I1 (1 min)	6.548	5.68	9.863	A
I2 (1 min)	7.425	6.548	11.38	A
I3 (1 min)	7.737	6.733	11.13	A
IN (1 min)	0.431	0.282	0.782	A
Active Power				
P1 (1 min)	38.86	34.92	44.19	kW
P2 (1 min)	44.74	40.2	52.08	kW
P3 (1 min)	46.71	41.05	53.35	kW
PT (1 min)	130.3	118.4	149.6	kW
Apparent Power				
S1 (1 min)	112.8	83	149.7	kVA
S2 (1 min)	108.1	76.71	142.9	kVA
S3 (1 min)	117	84.66	152.4	kVA
ST (1 min)	337.9	244.4	445	kVA
Power Factor				
PF1	0.955	0.949	0.959	
PF2	0.96	0.955	0.966	
PF3	0.927	0.916	0.938	
PFT	0.947	0.941	0.953	
Total Harmonic Distortion				
U12-THD	1.68	1.58	1.8	%f
U23-THD	1.64	1.51	1.76	%f
U31-THD	1.664	1.59	1.73	%f
I1-THD	2.57	2.05	3.3	%f
I2-THD	2.9	2.44	3.58	%f
I3-THD	2.8	2.18	3.68	%f
IN-THD	4.19	2.3	6.81	%f

3.4.6. Electrical Substation 1A Transformer 1 Secondary

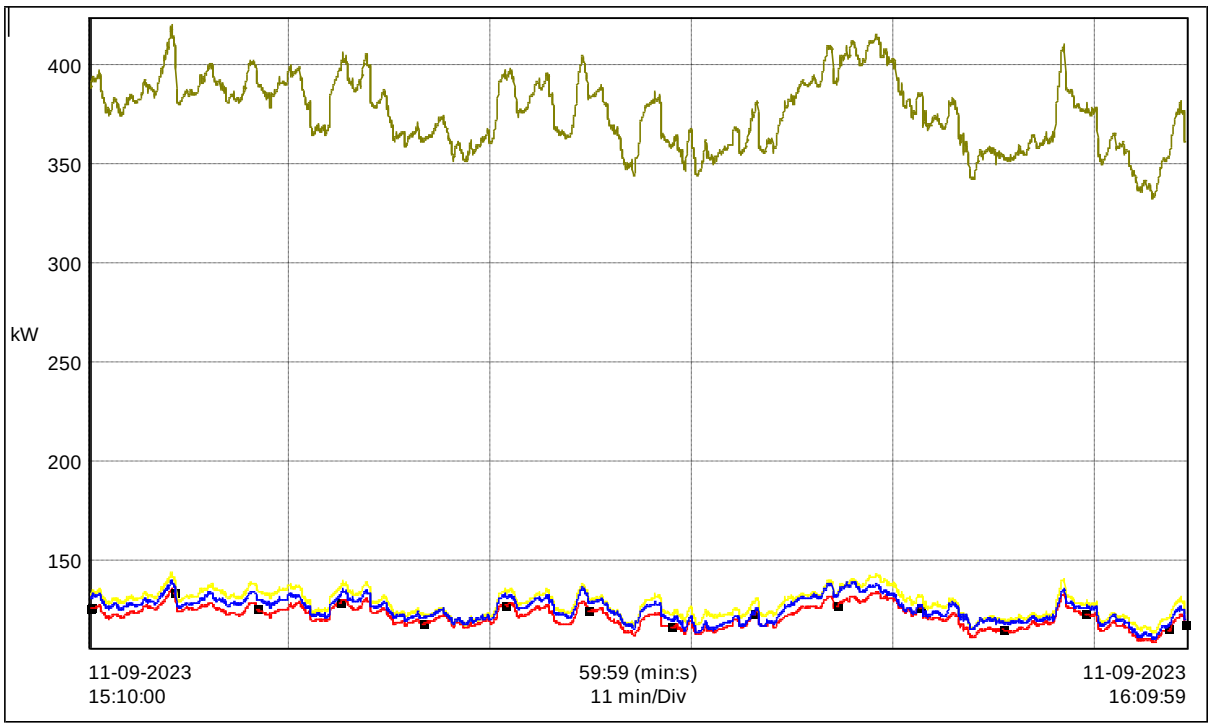
3.4.6.1.Voltage Profile



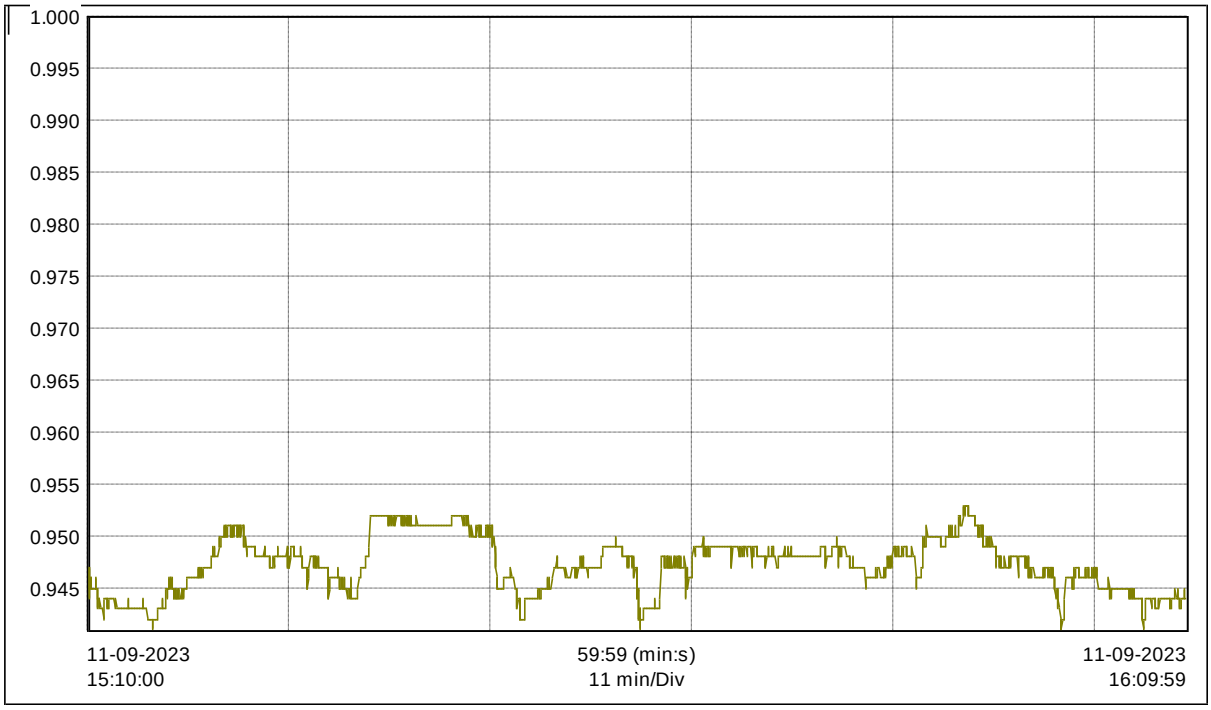
3.4.6.2.Current Profile



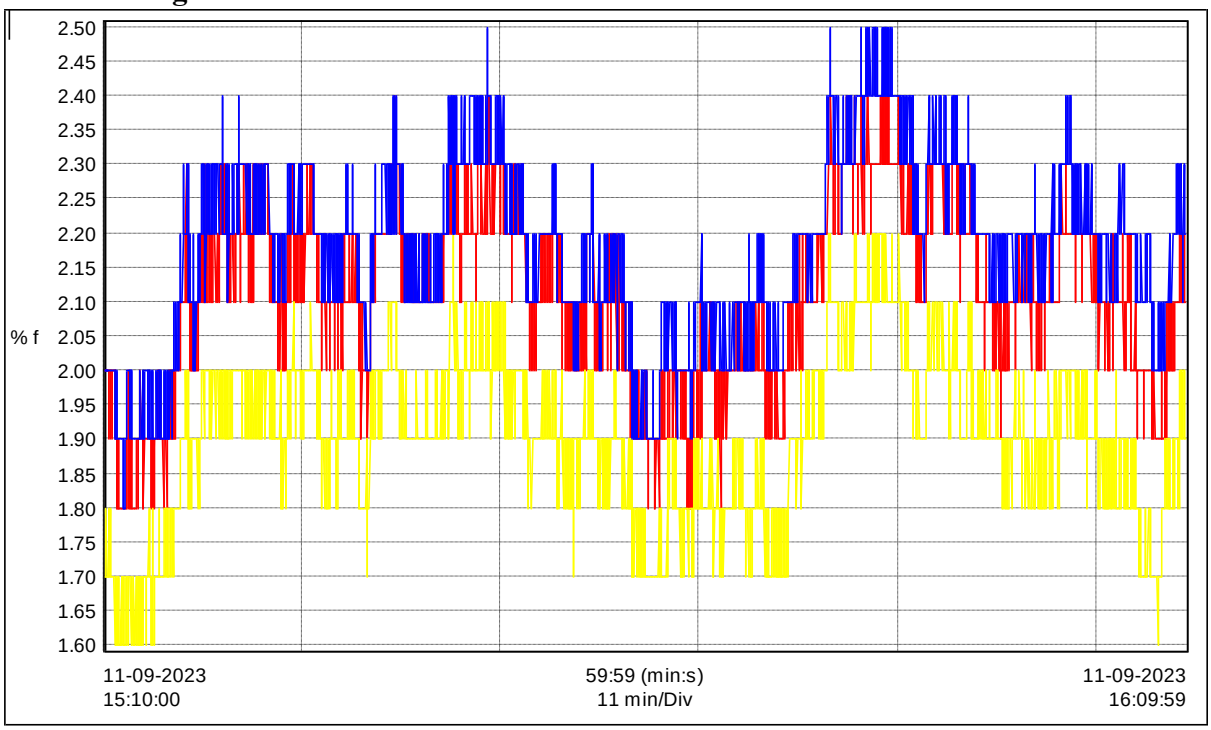
3.4.6.3.Power Profile



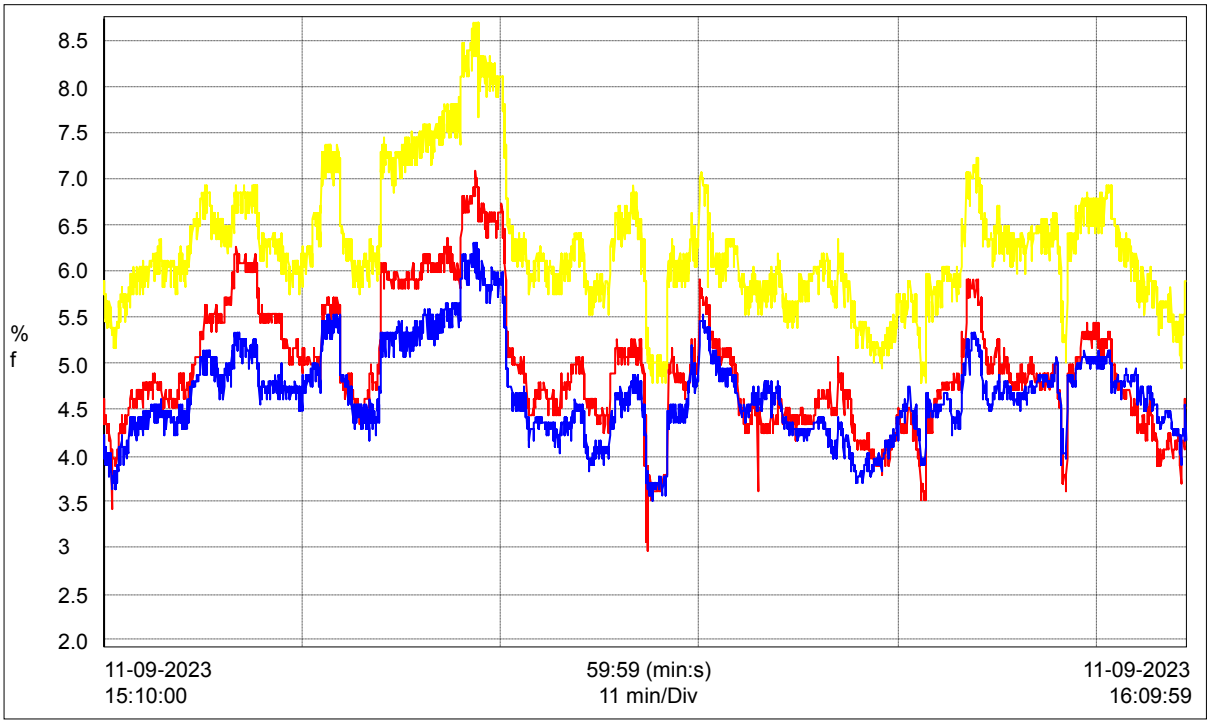
3.4.6.4.Power Factor



3.4.6.5.Voltage Harmonics



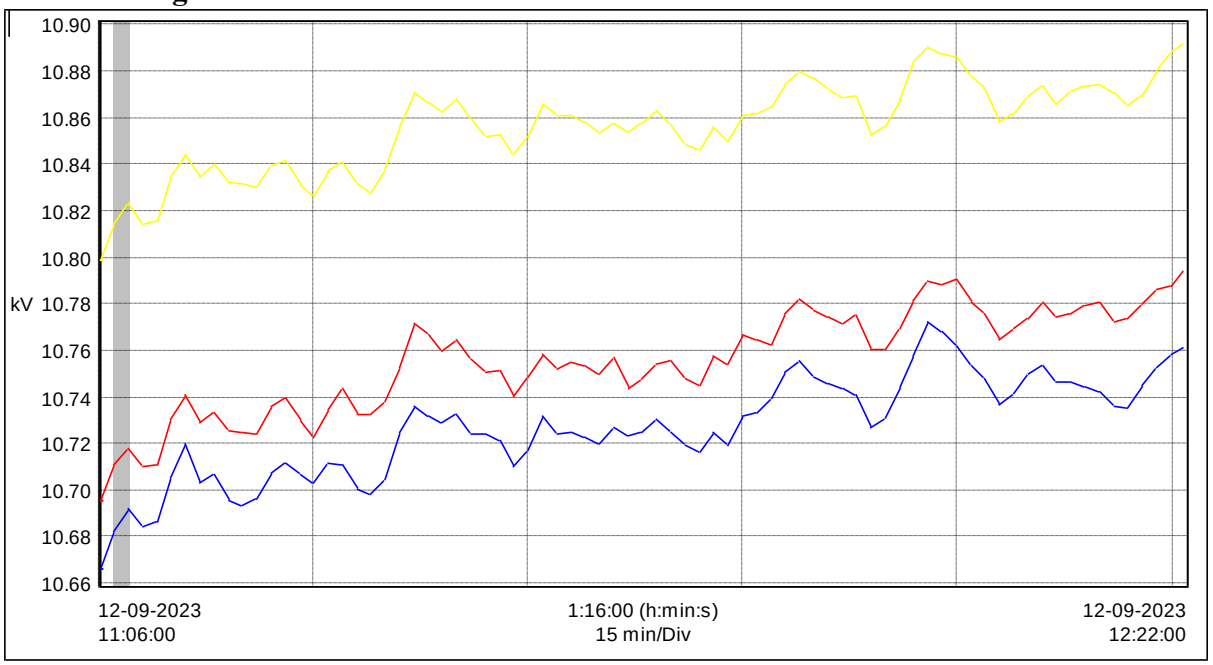
3.4.6.6.Current Harmonics



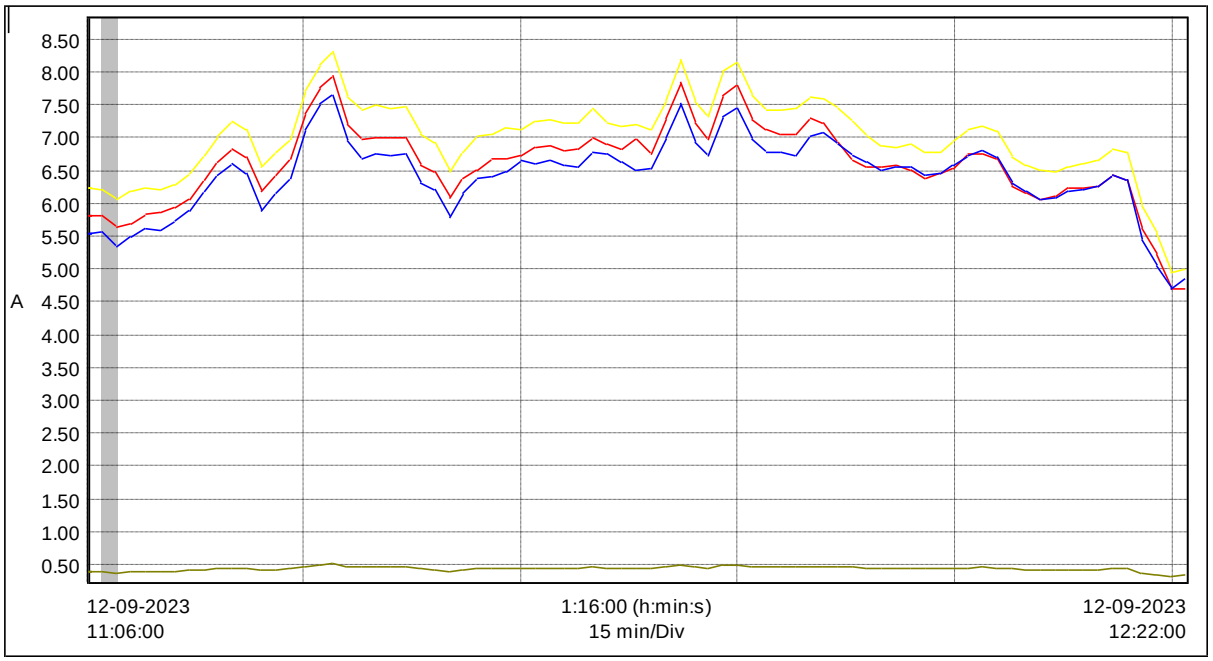
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 rms	424.2	418.5	428	V
U23 rms	423.6	417	427.6	V
U31 rms	419.7	413.2	423.7	V
Current				
A1 rms	544.6	482.6	653.4	A
A2 rms	551.3	486.4	672	A
A3 rms	569.5	498.6	689.3	A
AN rms	57.15	42.24	68.48	A
Active Power				
P1 (W)	122.1	108.9	136.2	kW
P2 (W)	128.4	113.7	144.2	kW
P3 (W)	125.6	110.3	140.6	kW
PT (W)	376.1	333	421	kW
Apparent Power				
S1 (VA)	127.9	114.4	142.9	kVA
S2 (VA)	133.7	118.7	150.2	kVA
S3 (VA)	135.4	119.7	152.1	kVA
ST (VA)	397	352.9	445.1	kVA
Power factor				
PF1	0.955	0.949	0.959	
PF2	0.96	0.955	0.966	
PF3	0.927	0.916	0.938	
PFT	0.947	0.941	0.953	
Total Harmonic Distortion				
A1 THD	5.06	2.96	7.1	% f
A2 THD	6.66	4.85	8.7	% f
A3 THD	4.95	3.54	6.3	% f
U12 THD	5.06	2.96	7.11	% f
U23 THD	6.66	4.85	8.72	% f
U31 THD	4.95	3.54	6.31	% f

3.4.7. Electrical Substation 1A Transformer 2 Primary

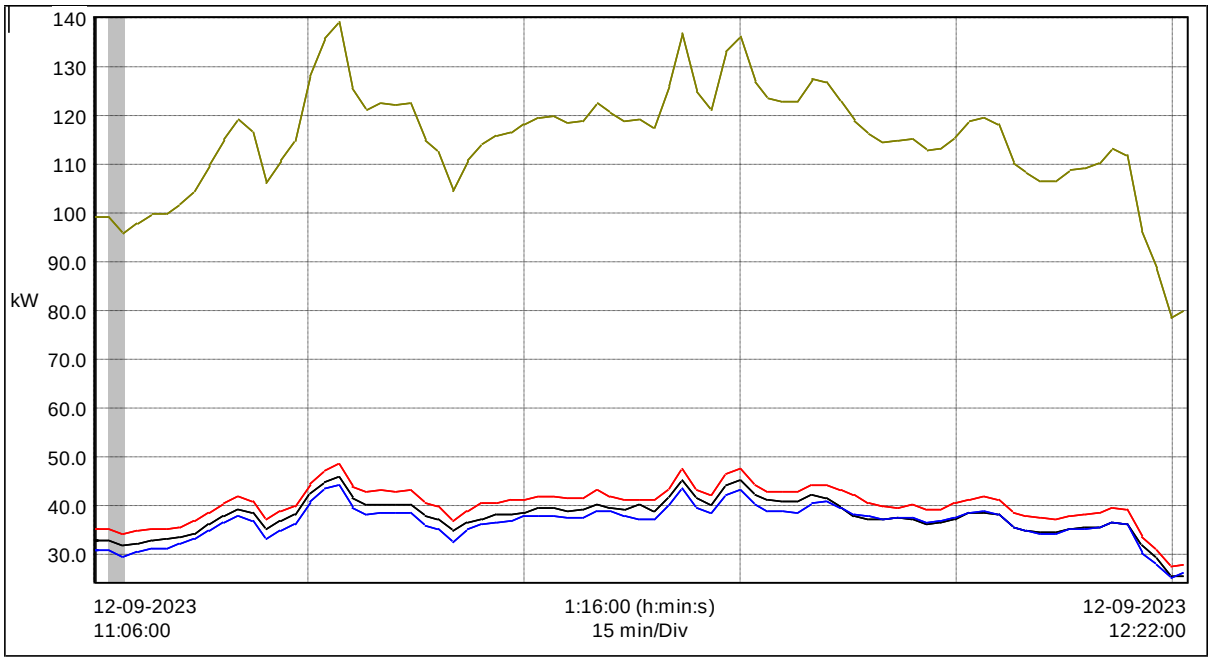
3.4.7.1.Voltage Profile



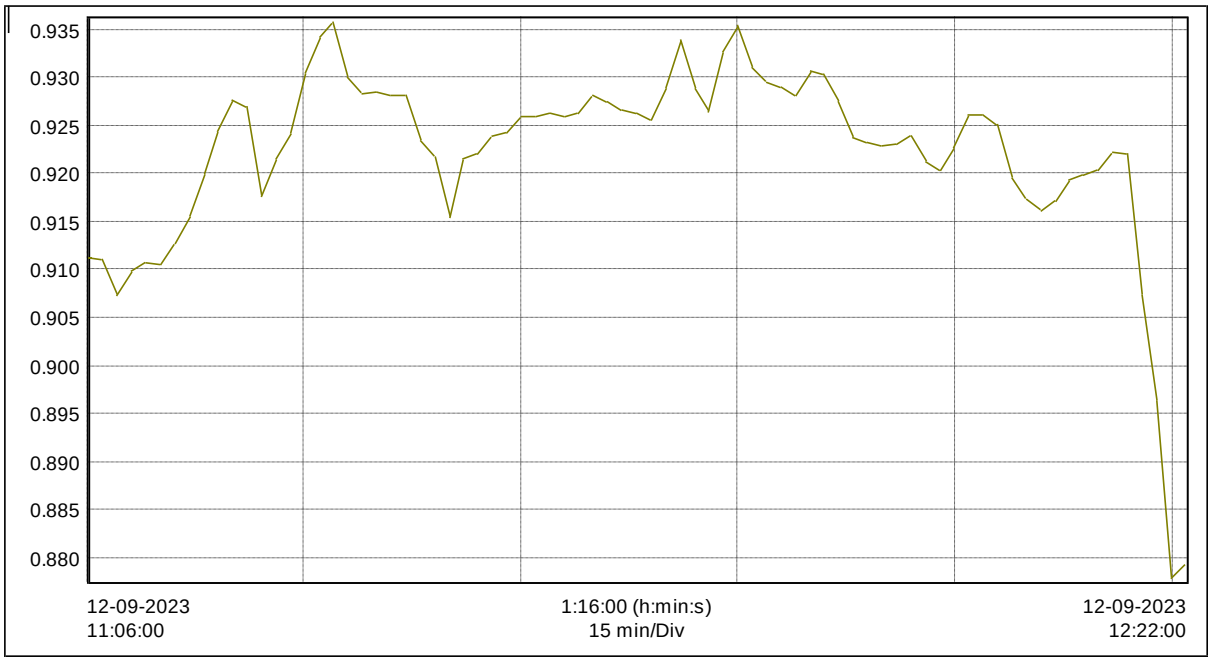
3.4.7.2.Current Profile



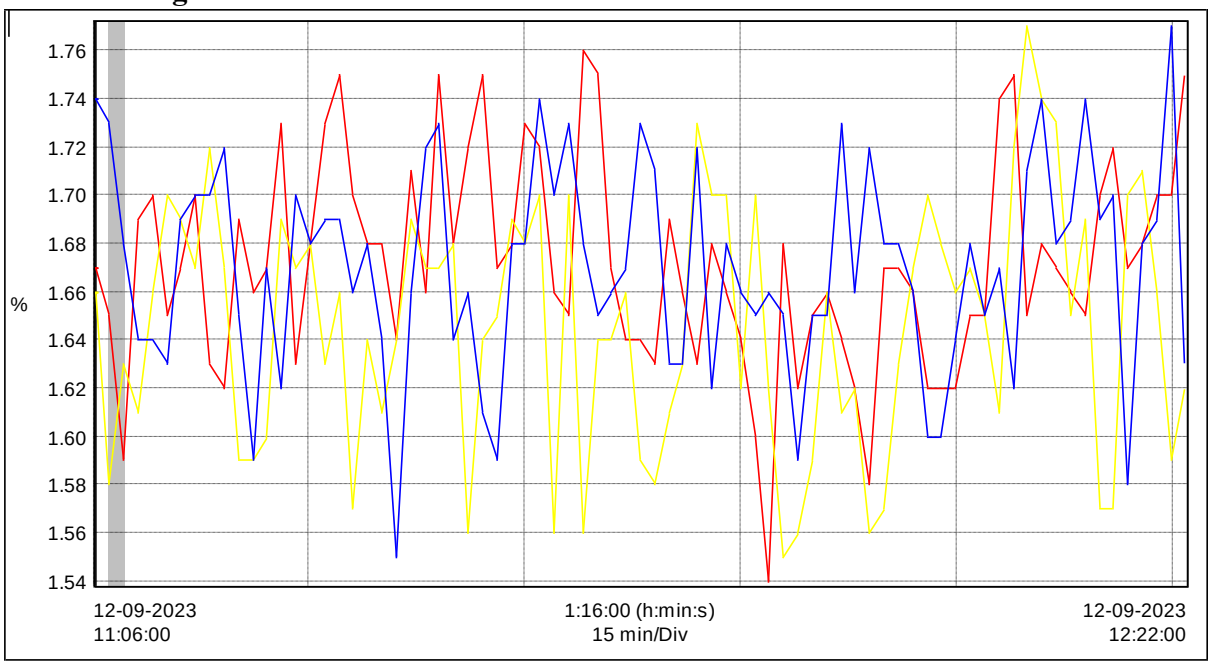
3.4.7.3.Power Profile



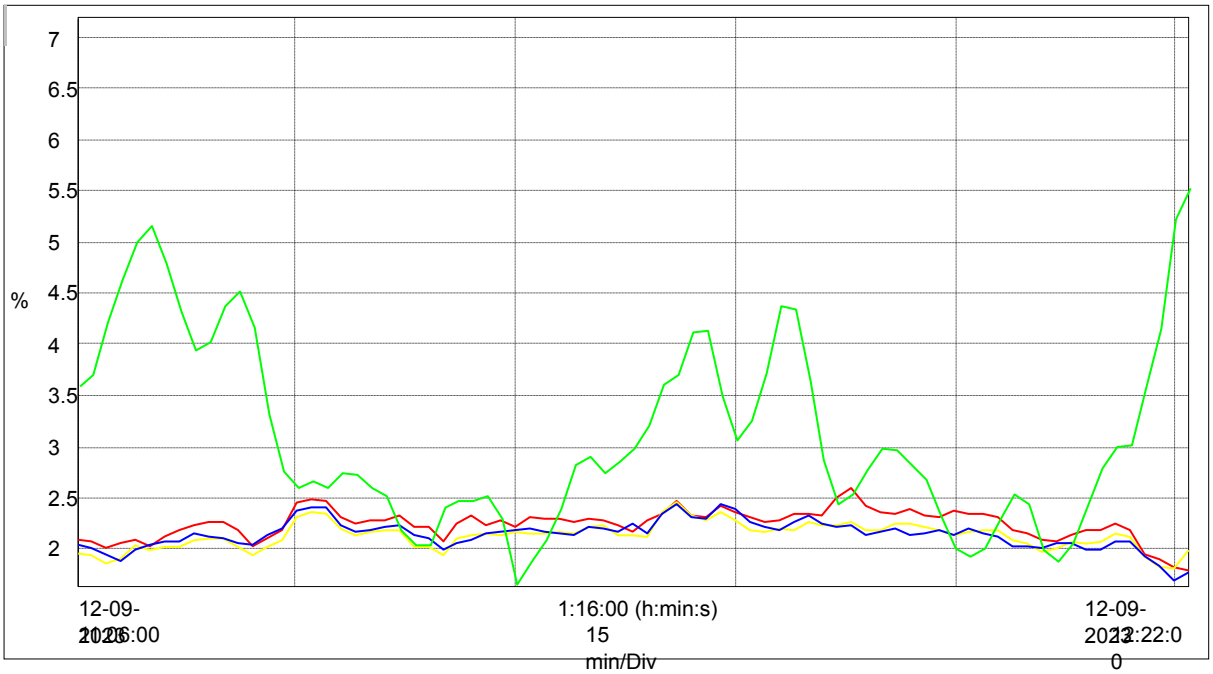
3.4.7.4.Power factor



3.4.7.5.Voltage Harmonics



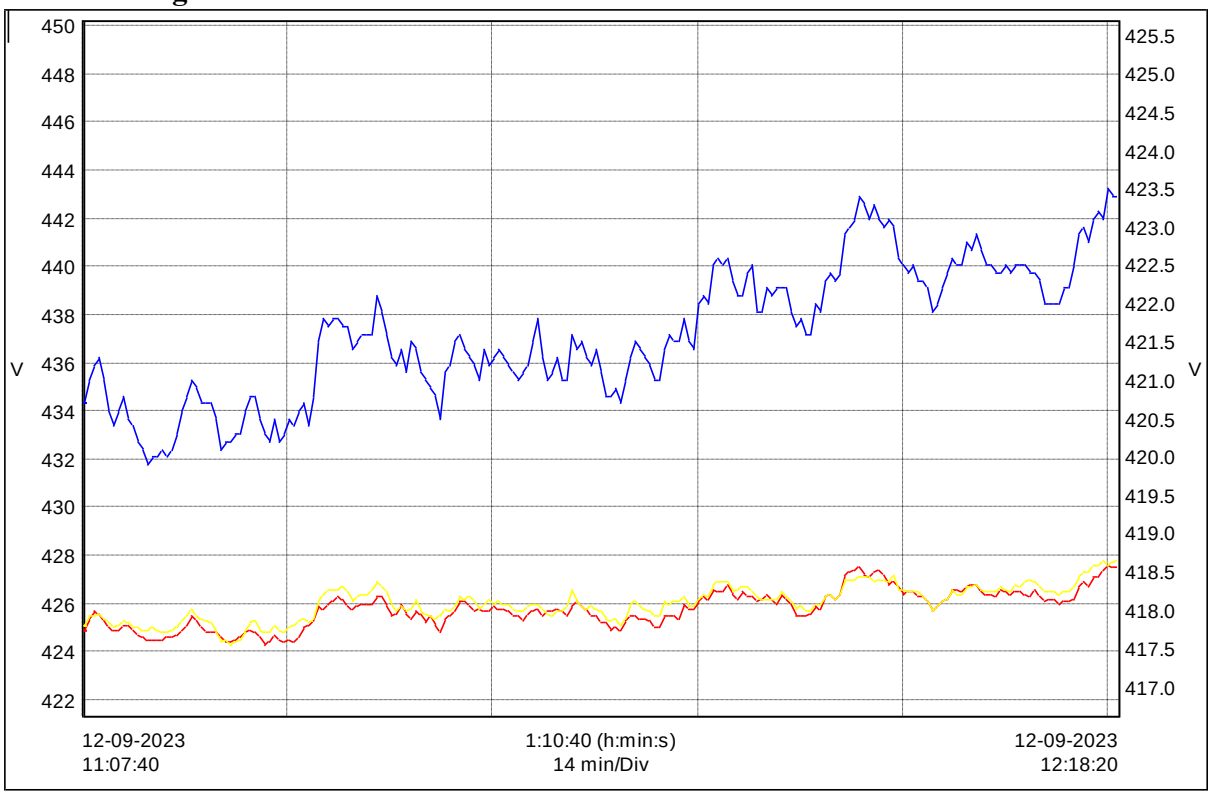
3.4.7.6.Current Harmonics



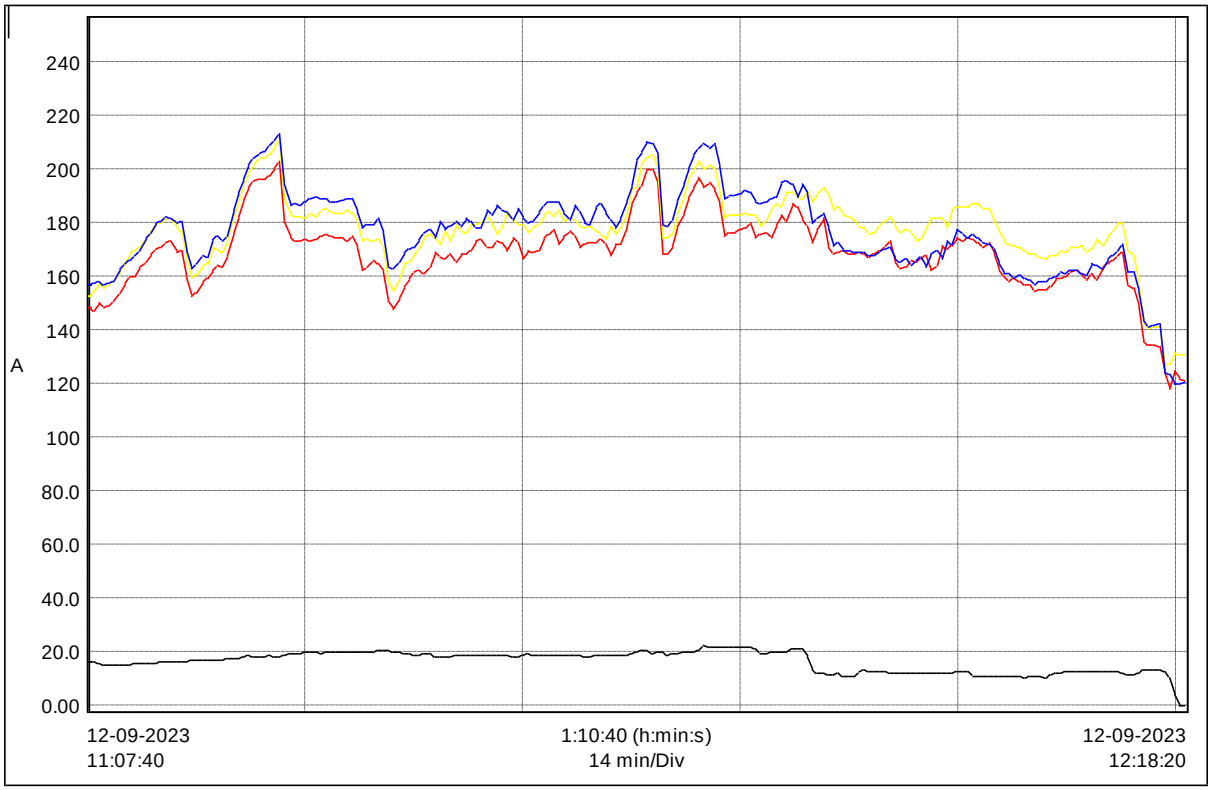
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	10.76	10.7	10.8	kV
U23	10.86	10.8	10.89	kV
U31	10.73	10.67	10.77	kV
Current				
I1	6.637	4.552	8.283	A
I2	7.023	4.762	8.756	A
I3	6.463	4.391	8.016	A
IN	0.449	0.315	0.541	A
Active Power				
P1	37.92	25.57	46.11	kW
P2	40.39	27.62	48.58	kW
P3	36.76	25.54	44.49	kW
PT	115.1	78.73	139.2	kW
Apparent Power				
S1	40.96	29.2	49.17	kVA
S2	43.38	30.88	51.61	kVA
S3	40.33	29.59	47.96	kVA
ST	124.7	89.67	148.7	kVA
Power Factor				
PF1	0.925	0.872	0.939	
PF2	0.93	0.894	0.941	
PF3+	0.91	0.863	0.927	
PFT+	0.922	0.878	0.936	
Total Harmonic Distortion				
U12-THD	1.672	1.54	1.76	%f
U23-THD	1.646	1.55	1.77	%f
U31-THD	1.67	1.55	1.77	%f
I1-THD	2.25	1.66	2.6	%f
I2-THD	2.2	1.65	2.59	%f
I3-THD	2.1	1.51	2.45	%f
IN-THD	3.03	1.92	5.33	%f

3.4.8. Electrical Substation 1A Transformer 2 Secondary

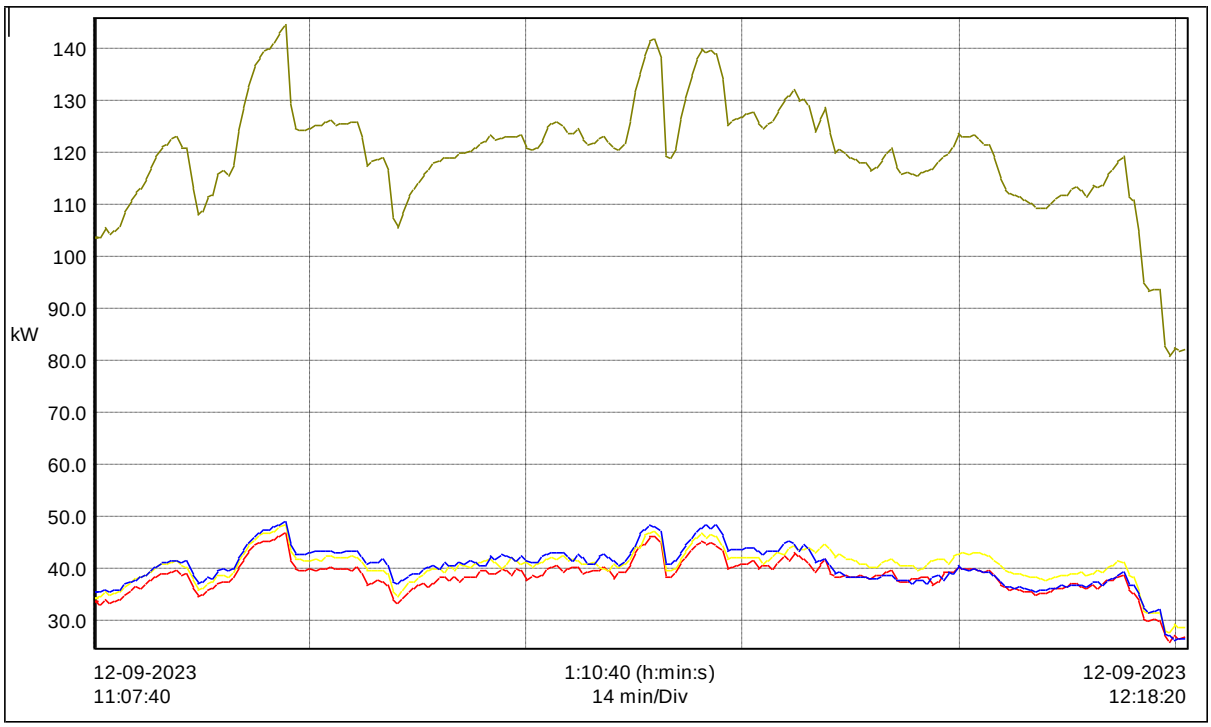
3.4.8.1.Voltage Profile



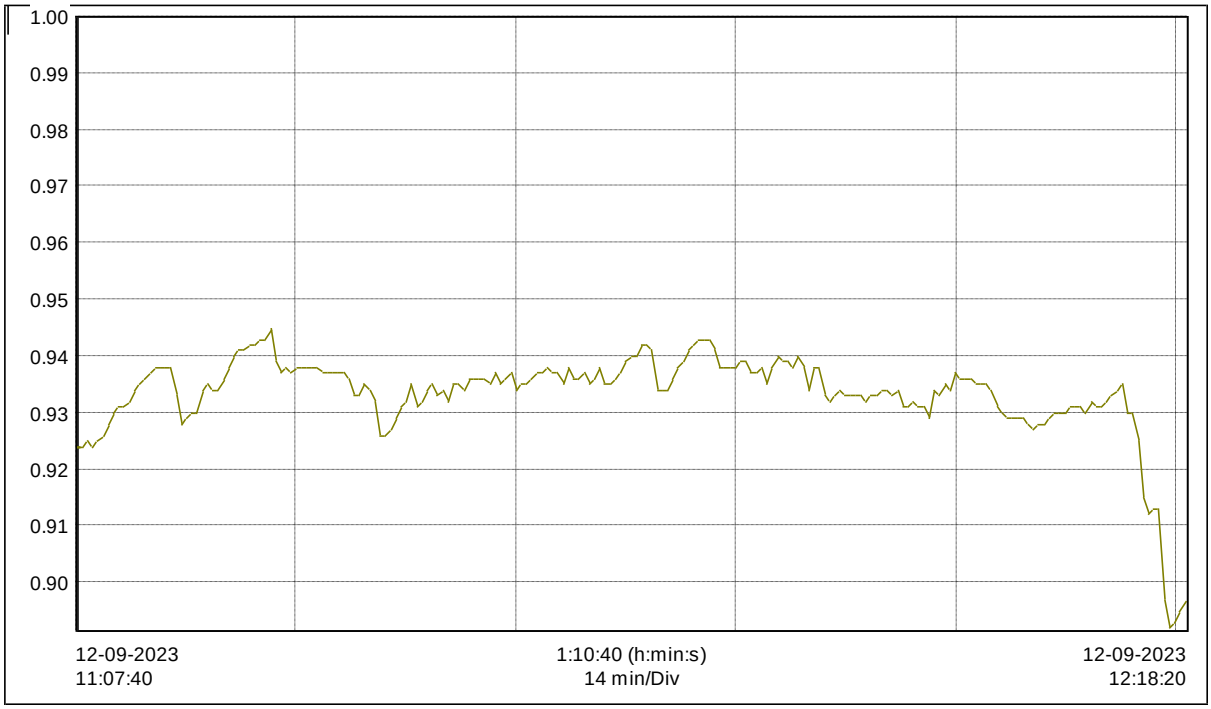
3.4.8.2.Current Profile



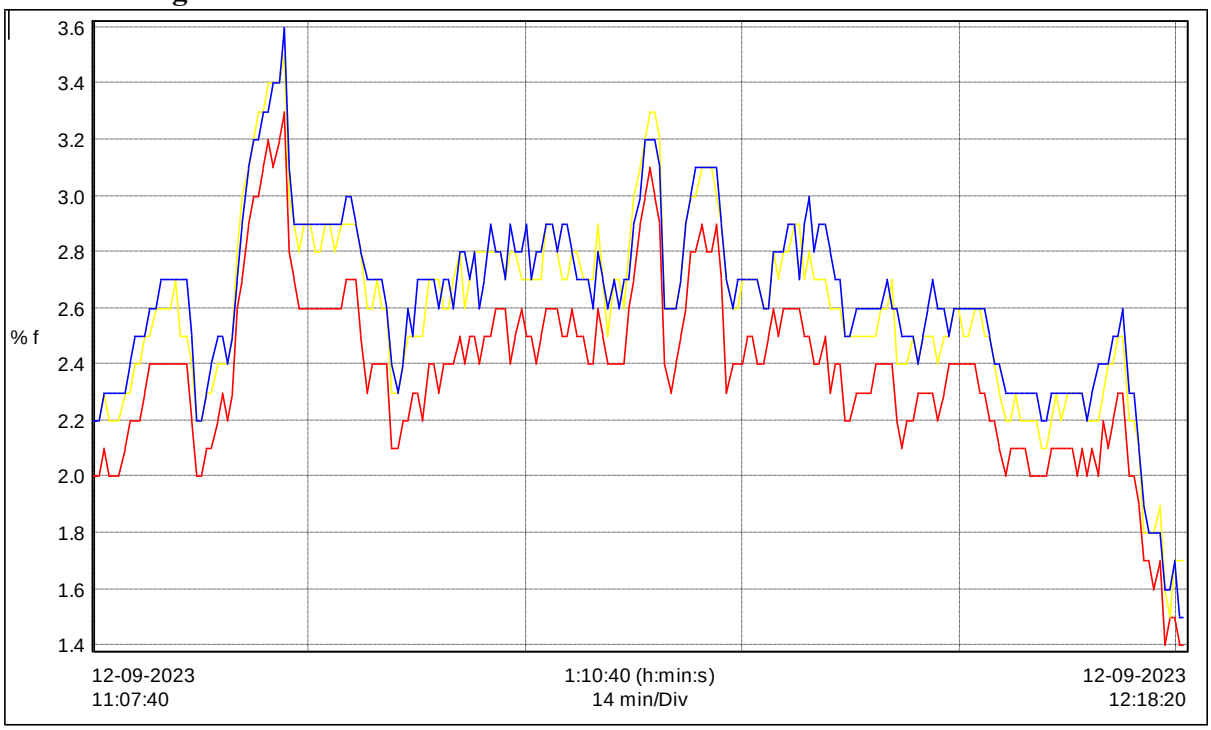
3.4.8.3.Power Profile



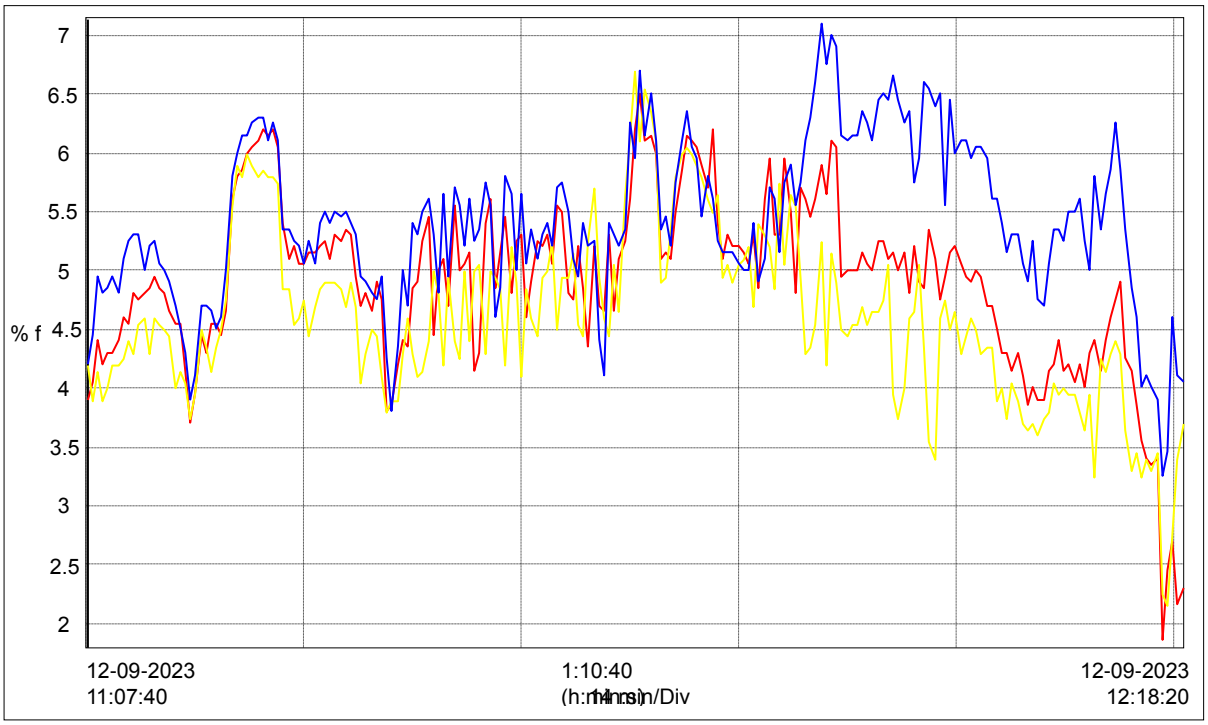
3.4.8.4.Power Factor



3.4.8.5.Voltage harmonics



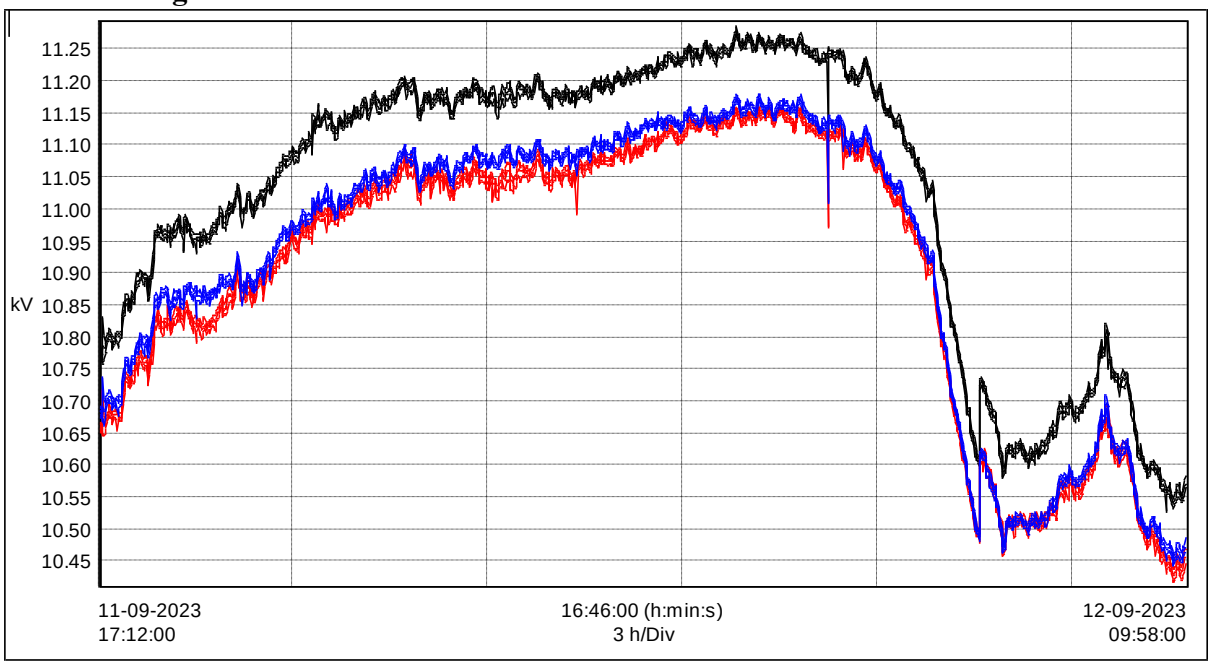
3.4.8.6.Current Harmonics



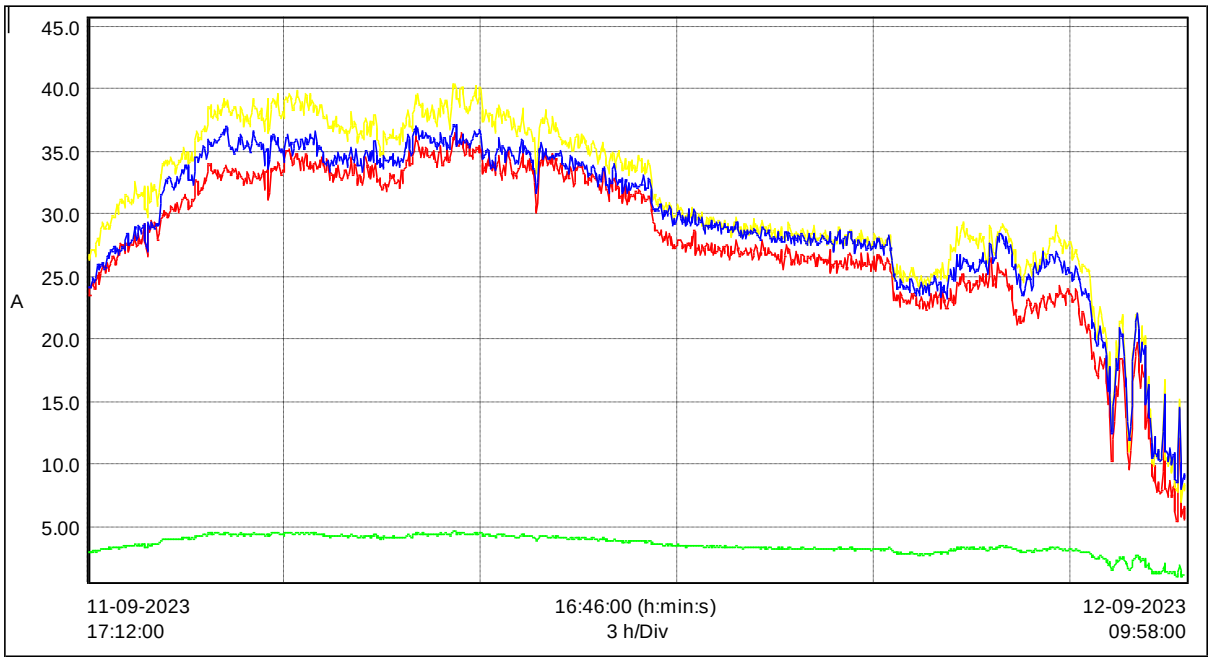
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 rms	425.8	421.4	429.7	V
U23 rms	426	421.7	429.9	V
U31 rms	421.6	416.7	425.6	V
Current				
A1 rms	169.4	111	254.5	A
A2 rms	178.1	115	235	A
A3 rms	177.7	112	241.5	A
AN rms	16.69	0	22.6	A
Active Power				
P1 (W)	38.68	25.95	47.06	kW
P2 (W)	40.68	27.79	48.62	kW
P3 (W)	40.49	26.27	49.17	kW
PT (W)	119.9	81.01	144.8	kW
Apparent Power				
S1 (VA)	41.83	29.37	50.13	kVA
S2 (VA)	43.49	31.23	51.43	kVA
S3 (VA)	42.95	29.16	51.73	kVA
ST (VA)	128.3	90.72	153.3	kVA
Power Factor				
PF1	0.924	0.873	0.938	
PF2	0.934	0.888	0.945	
PF3	0.942	0.9	0.951	
PFT	0.933	0.892	0.945	
Total harmonic Distortion				
A1 THDf	3.81	1.9	6.51	% f
A2 THDf	5.78	2.1	6.71	% f
A3 THDf	5.38	3.4	7.16	% f
U12 THDf	2.372	1.4	3.3	% f
U23 THDf	2.589	1.5	3.5	% f
U31 THDf	2.628	1.5	3.6	% f

3.4.9. Electrical Substation 2 Transformer 2 HT

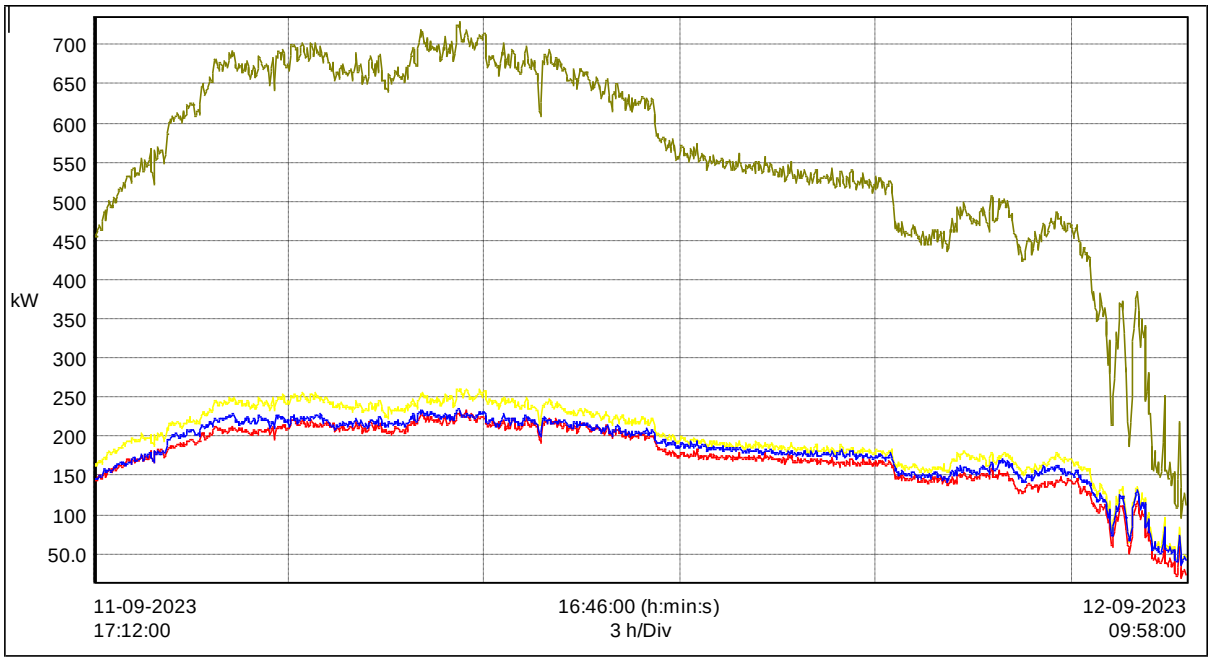
3.4.9.1.Voltage Profile



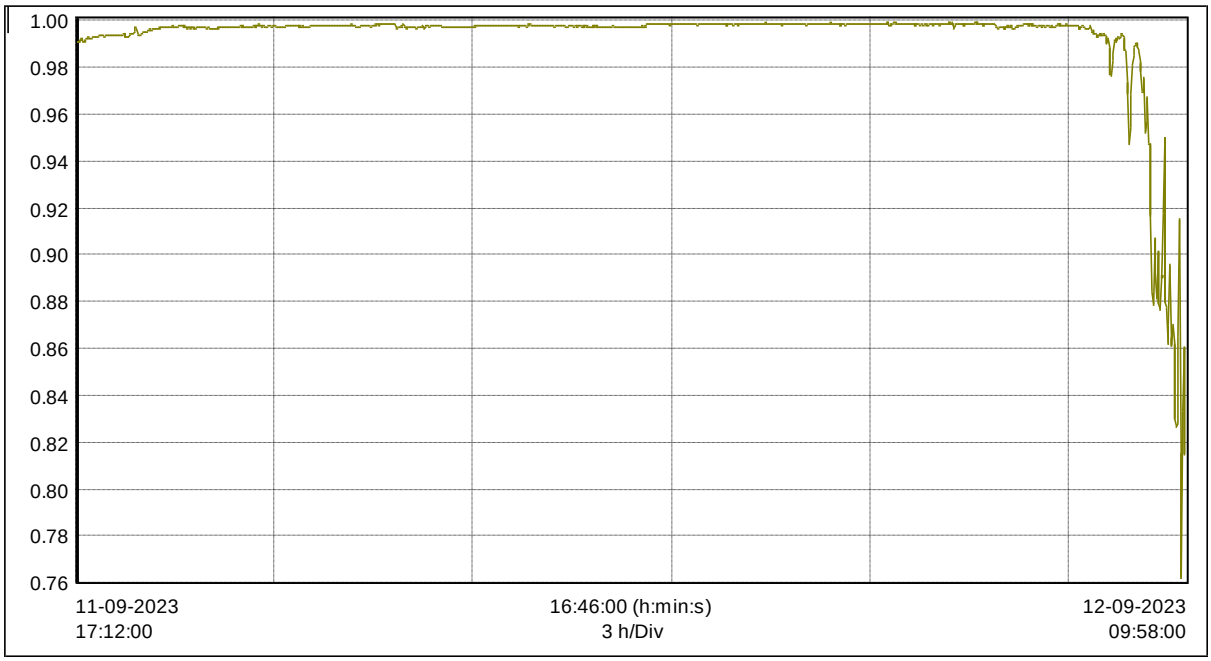
3.4.9.2.Current Profile



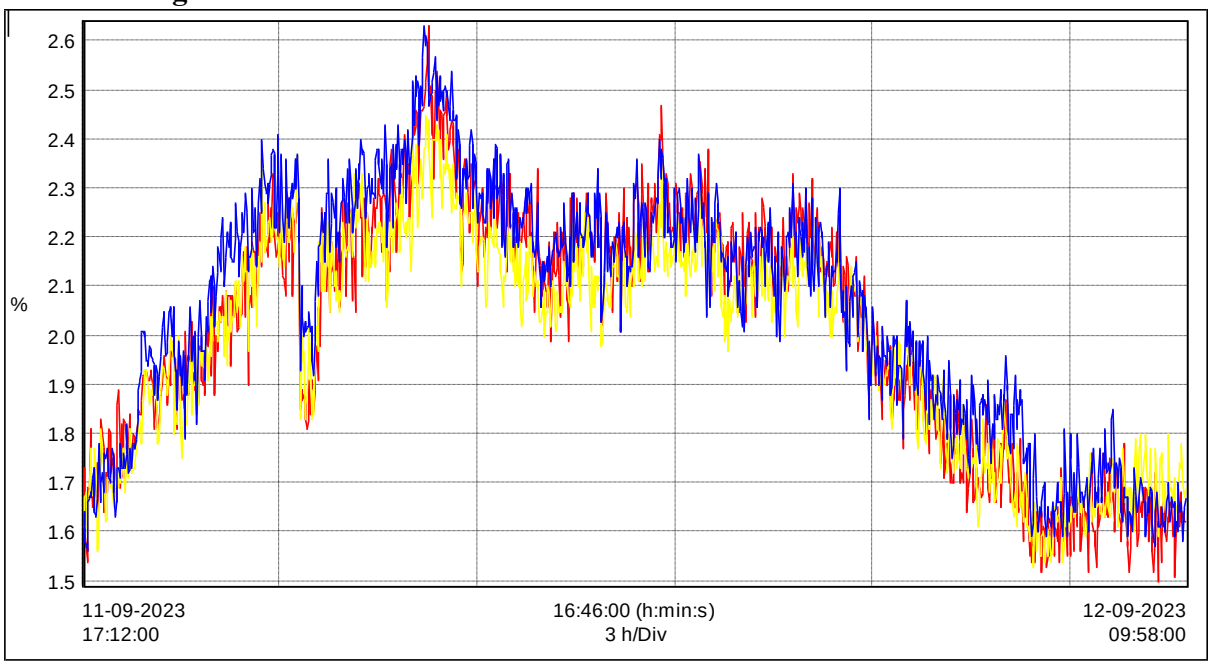
3.4.9.3.Power Profile



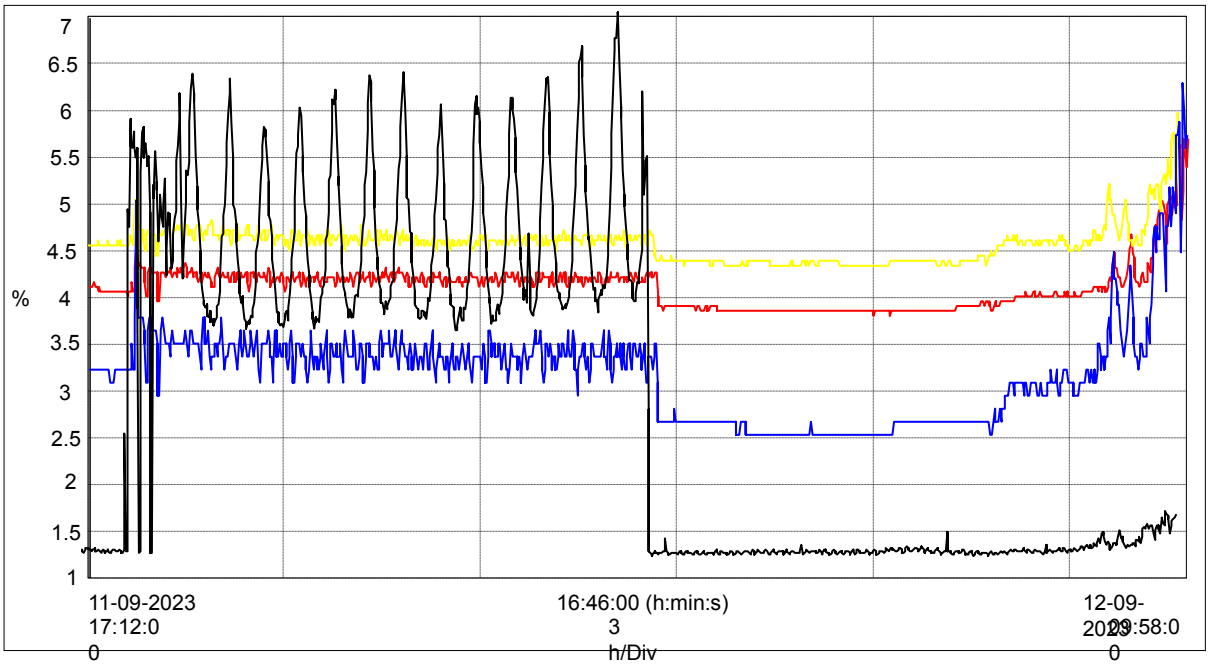
3.4.9.4.Power Factor



3.4.9.5.Voltage harmonics



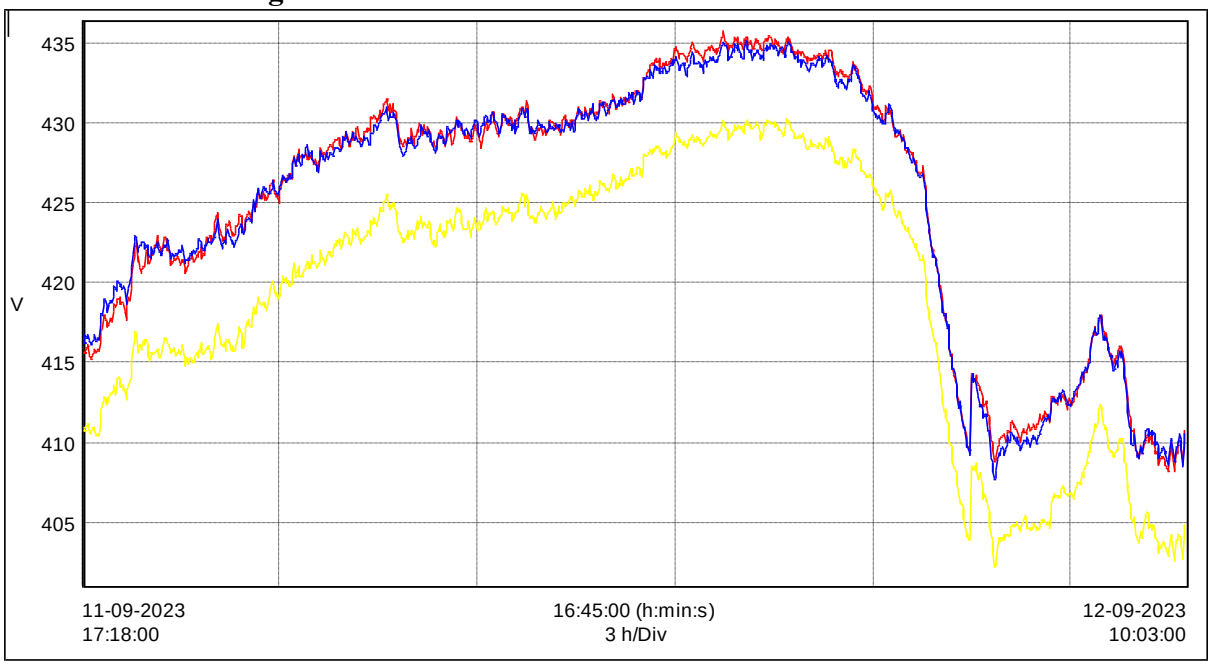
3.4.9.6.Current harmonics



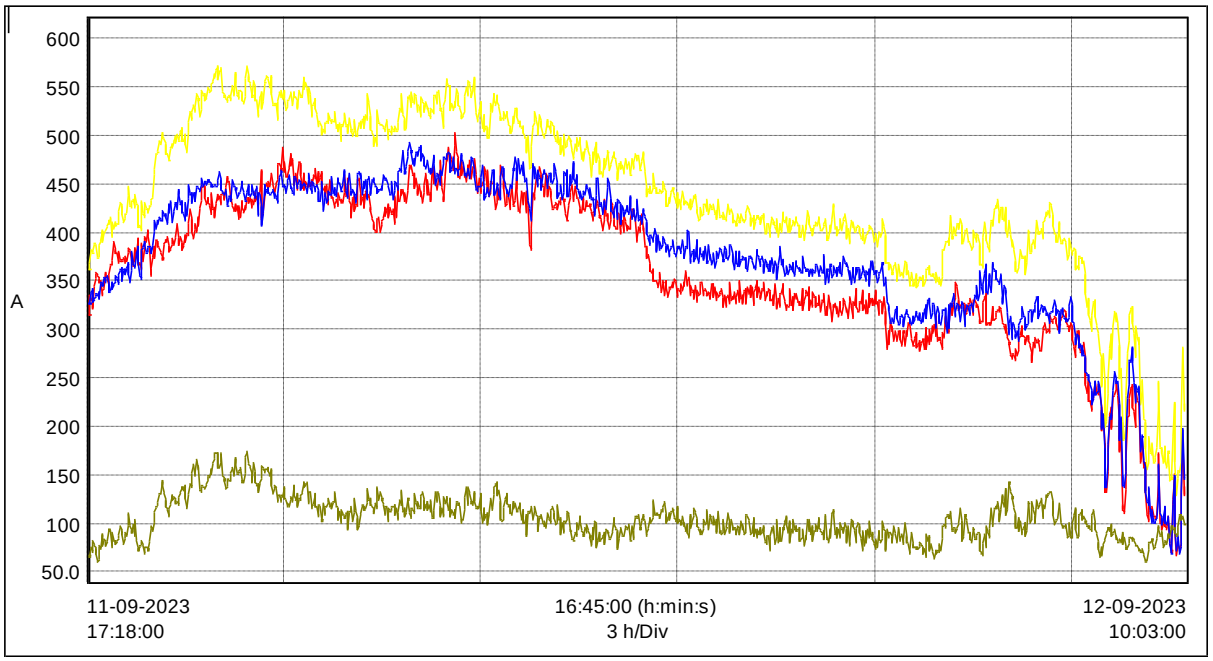
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	11.03	10.53	11.29	kV
U23	10.91	10.42	11.16	kV
U31	10.93	10.44	11.18	kV
Current				
I1	28.61	4.829	41.84	A
I2	31.71	6.224	45.28	A
I3	30.07	7.162	42.97	A
IN	3.709	1.001	5.192	A
Power Factor				
PF1+	0.99	0.598	1	
PF2+	0.996	0.886	1	
PF3+	0.993	0.76	1	
PFT+	0.993	0.763	0.999	
Active Power				
P1	175.8	21.2	233	kW
P2	198.6	38.12	261.9	kW
P3	184.1	36.78	235.2	kW
PT	558.4	96.09	728.8	kW
Apparent Power				
S1	176.6	32.87	233.4	kVA
S2	199.1	42.92	262.6	kVA
S3	184.8	48.19	235.7	kVA
ST	560.5	126	730.7	kVA
Total Harmonic Distortion				
U12-THD	2.018	1.5	2.63	%f
U23-THD	1.99	1.53	2.45	%f
U31-THD	2.059	1.56	2.63	%f
I1-THD	4.31	3.72	5.72	%f
I2-THD	5.81	4.32	6.11	%f
I3-THD	3.94	2.56	6.32	%f
IN-THD	4.15	1.35	7.03	%f

3.4.10. Electrical Substation 2 Transformer 2 Secondary

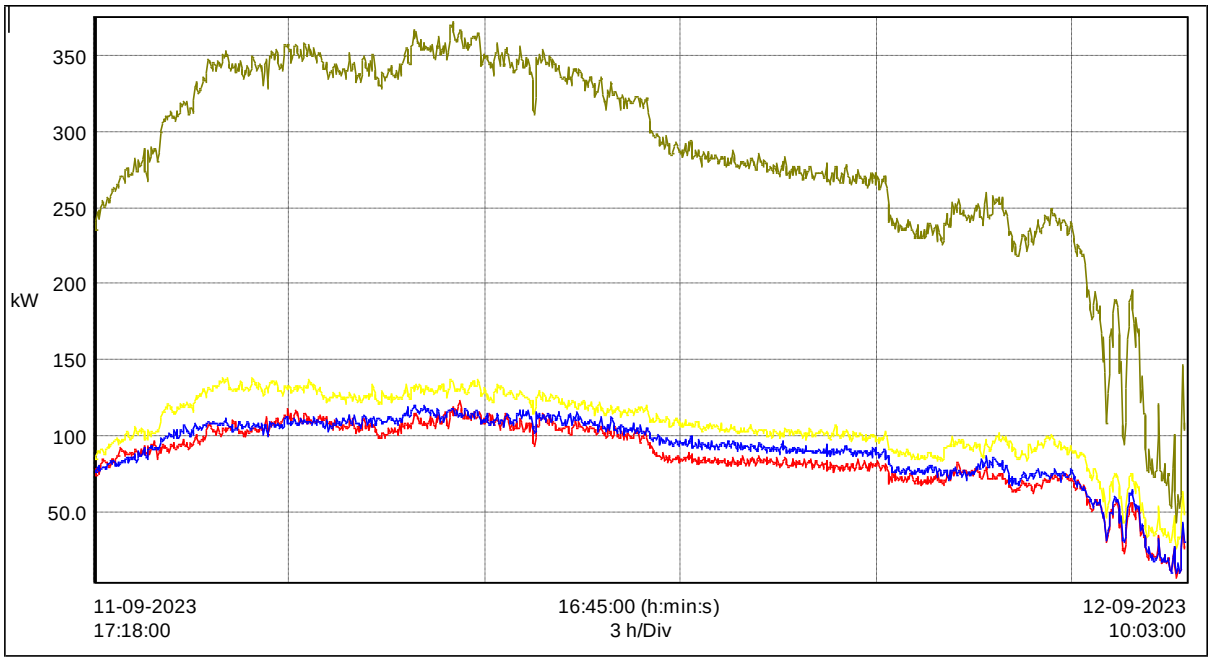
3.4.10.1. Voltage Profile



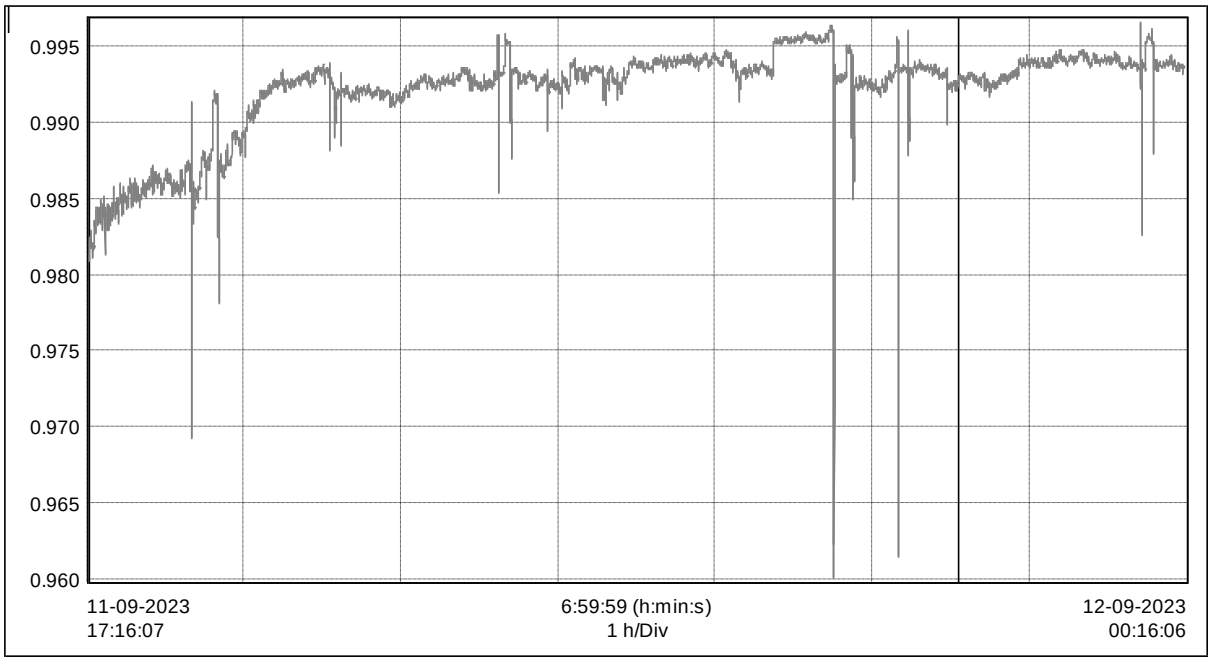
3.4.10.2. Current Profile



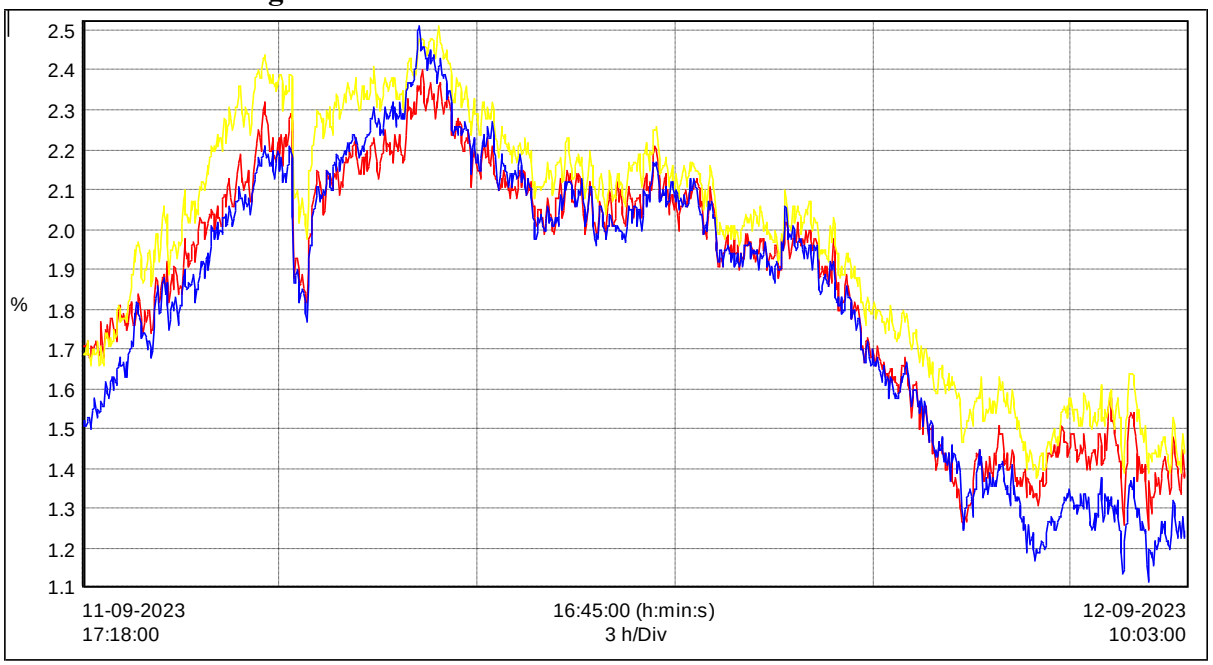
3.4.10.3. Power Profile



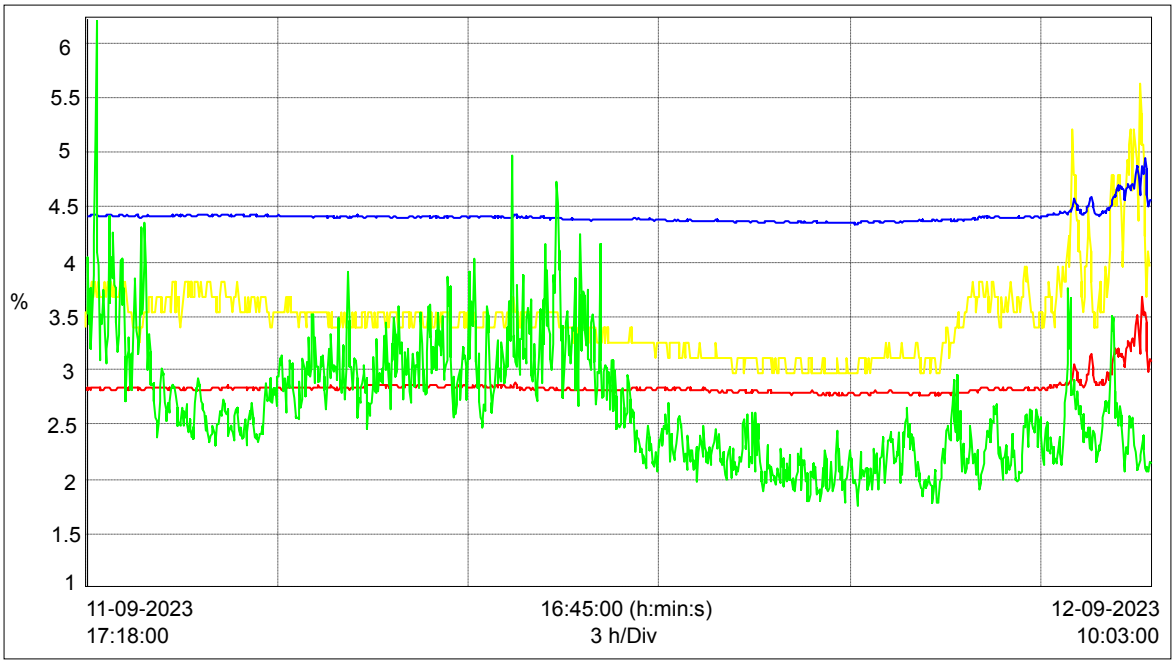
3.4.10.4. Power Factor



3.4.10.5. Voltage Harmonics



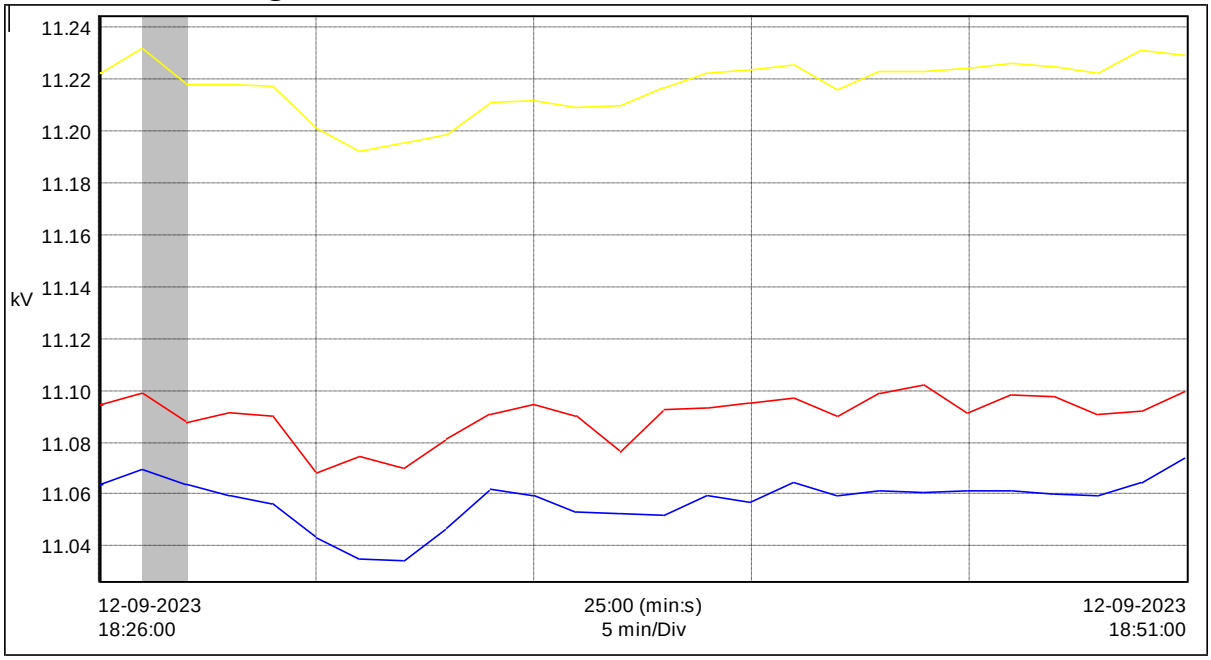
3.4.10.6. Current Harmonics



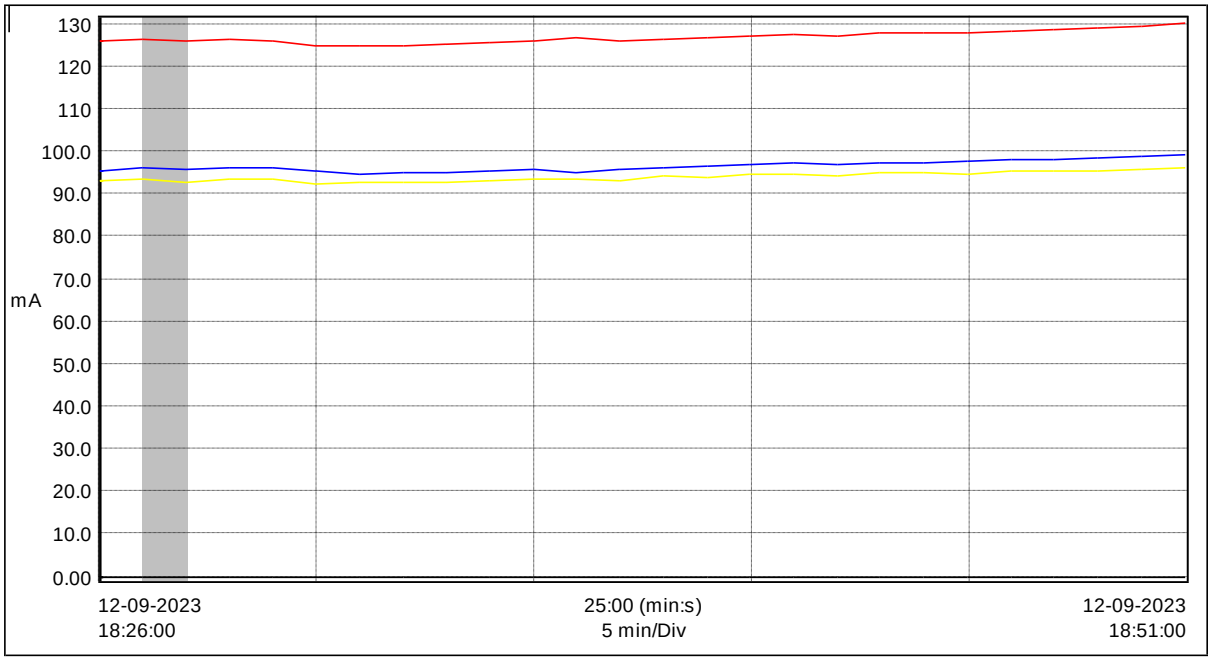
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	425.3	406.8	436.1	V
U23	419.5	401.4	430.7	V
U31	425.1	407.3	435.5	V
Current				
I1	370	62.43	543.6	A
I2	447.1	115.3	616.3	A
I3	386.3	61.24	579.7	A
IN	65	32.2	81.6	A
Active Power				
P1	86.99	7.073	122.9	kW
P2	106.7	25.91	138.5	kW
P3	91.53	9.796	120.7	kW
PT	285.3	42.77	372.5	kW
Apparent Power				
S1	88.04	15.76	124	kVA
S2	107.3	30.2	139.1	kVA
S3	92.36	16.3	121.5	kVA
ST	287.7	62.78	375.3	kVA
Total Harmonic Distortion				
U12-THD	1.871	1.25	2.4	%
U23-THD	1.973	1.38	2.51	%
U31-THD	1.836	1.12	2.51	%
I1-THD	3.09	2.51	3.72	%
I2-THD	4.28	2.95	5.61	%
I3-THD	4.03	4.45	4.91	%
IN-THD	3.14	1.79	6.20	%

3.4.11. Electrical Substation 3A Transformer 1 Primary

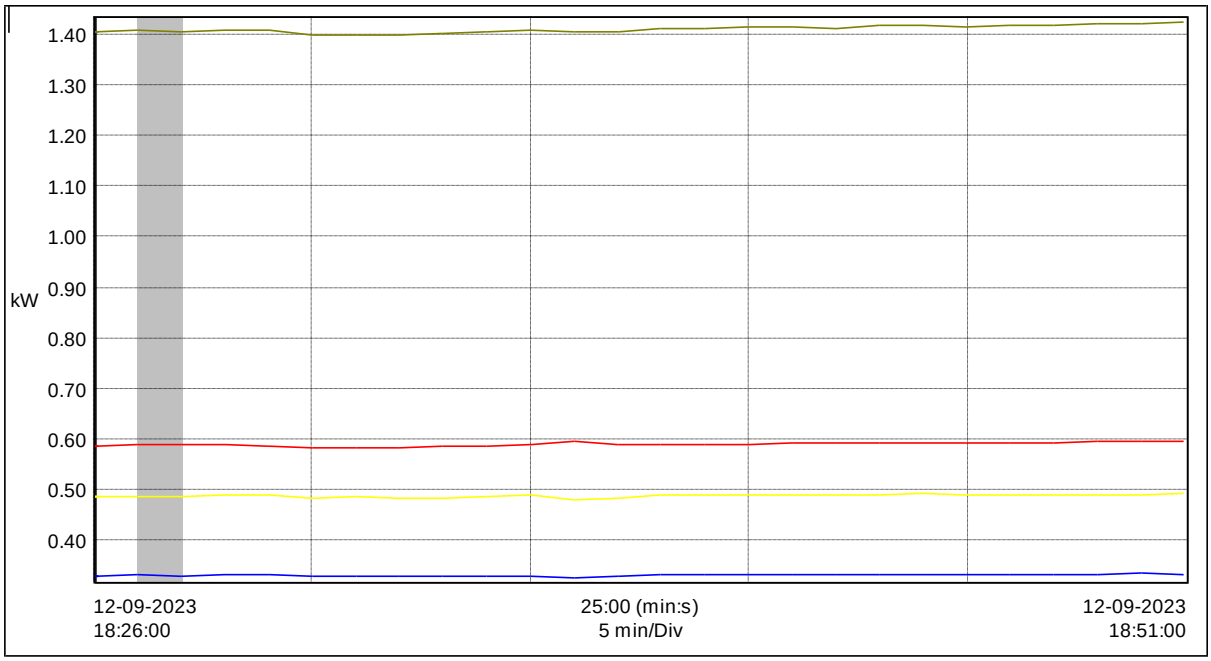
3.4.11.1. Voltage Profile



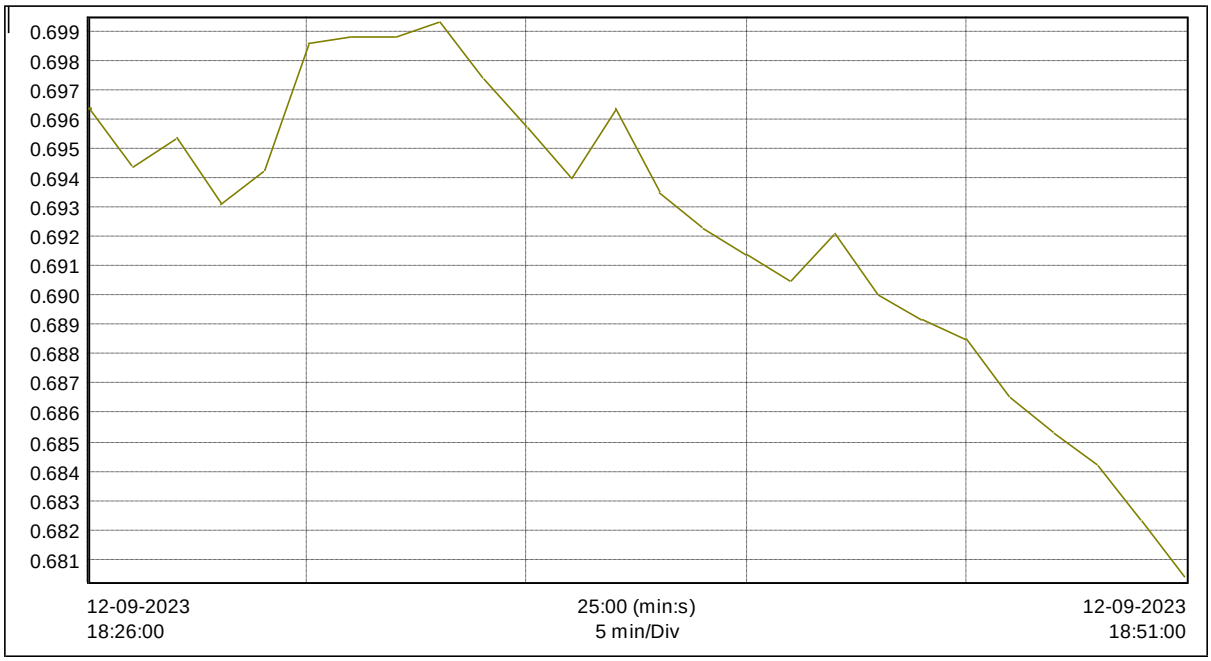
3.4.11.2. Current Profile



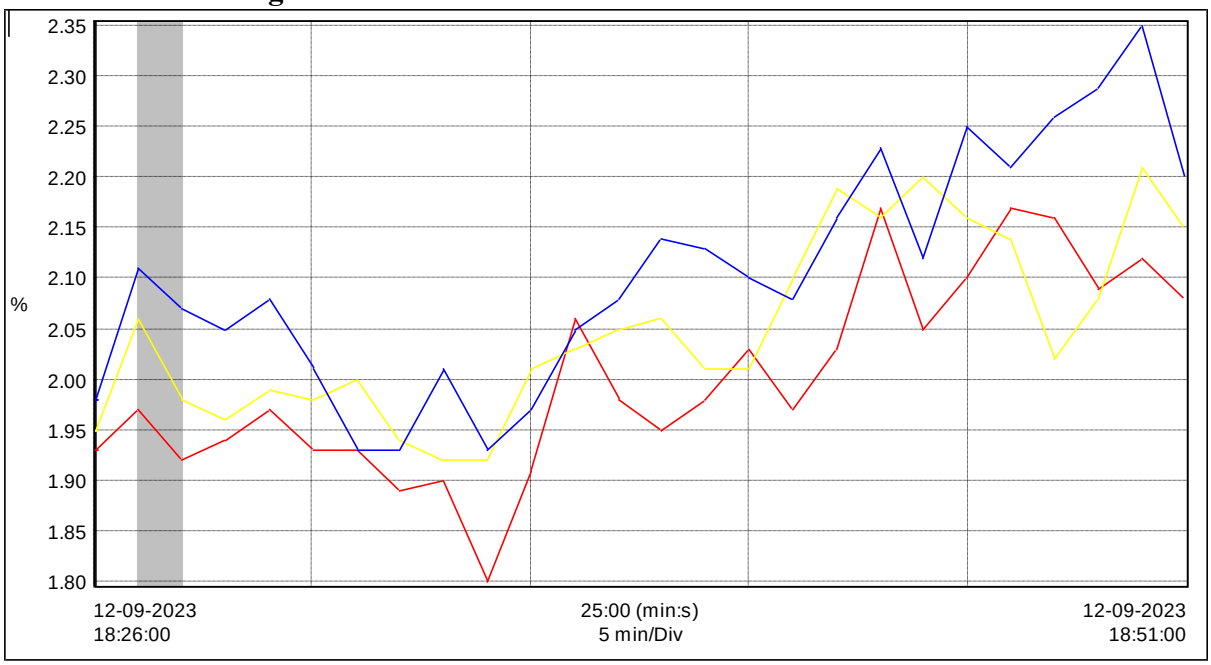
3.4.11.3. Power Profile



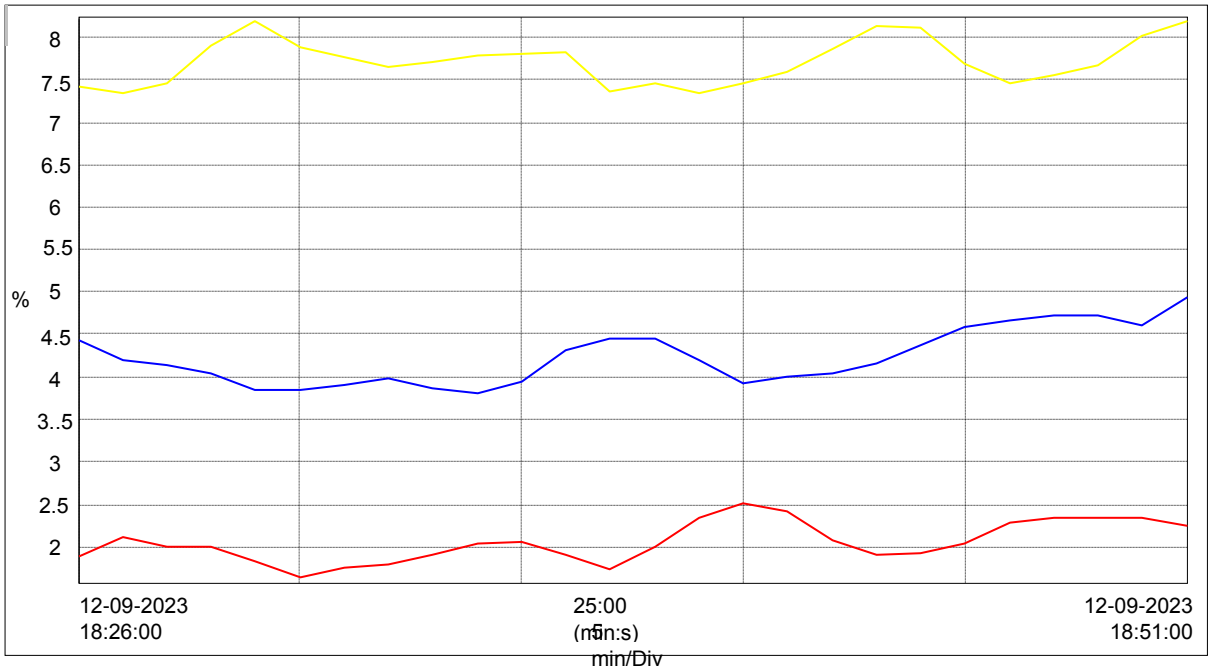
3.4.11.4. Power Factor



3.4.11.5. Voltage Harmonics



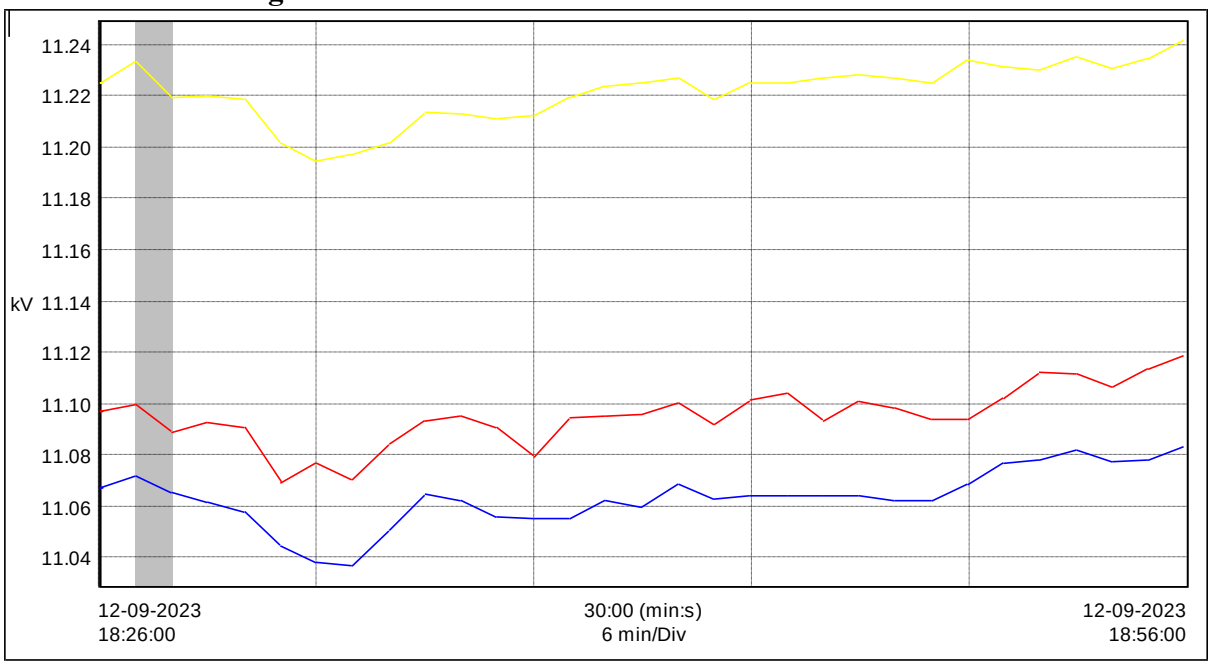
3.4.11.6. Current harmonics



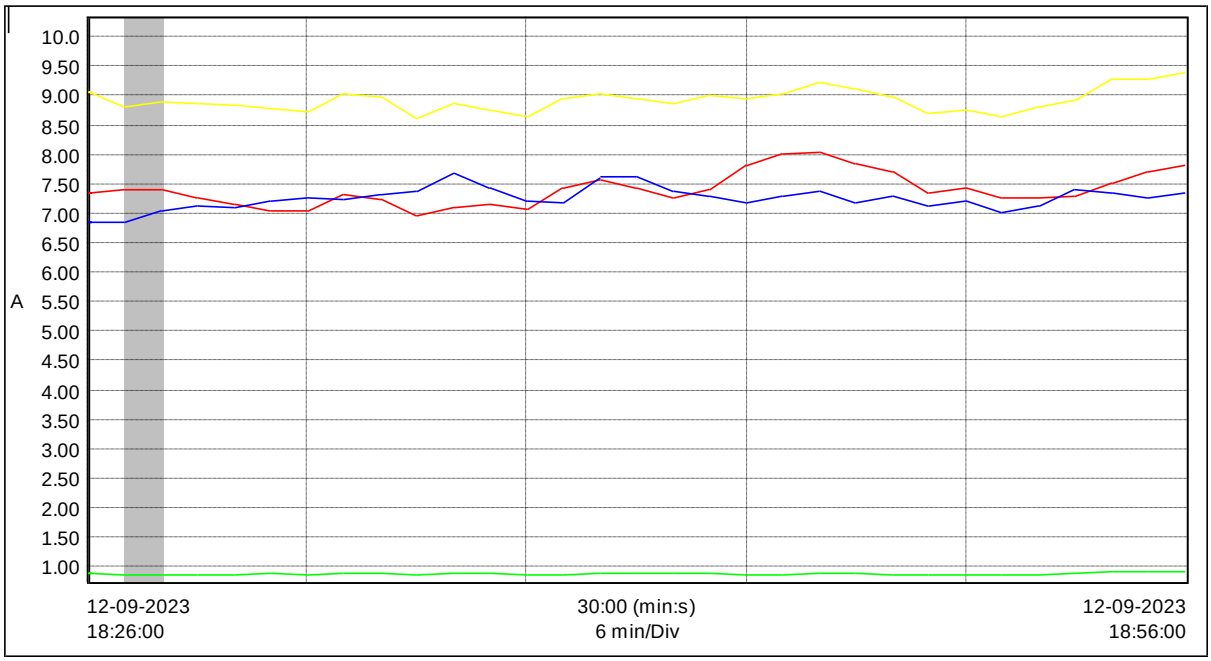
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	11.09	11.05	11.11	kV
U23	11.22	11.19	11.24	kV
U31	11.06	11.03	11.08	kV
Current				
I1	0.127	0.124	0.131	A
I2	0.094	0.091	0.097	A
I3	0.097	0.094	0.1	A
IN	0	0	0	A
Active power				
P1	590.5	584	597	W
P2	488.8	482	494	W
P3	332.2	328	335	W
PT	1.411	1.399	1.424	kW
Apparent Power				
S1	811.1	796	832	VA
S2	602.6	591	617	VA
S3	625.2	612	644	VA
ST	2.039	2.002	2.093	kVA
Power Factor				
PF1+	0.728	0.717	0.735	
PF2+	0.811	0.801	0.819	
PF3+	0.531	0.518	0.54	
PFT+	0.692	0.68	0.699	
Total Harmonic Distortion				
U12-THD	2.001	1.8	2.17	%
U23-THD	2.049	1.92	2.21	%
U31-THD	2.105	1.93	2.35	%
I1-THD	2.43	2.37	2.5	%
I2-THD	8.03	7.9	8.2	%
I3-THD	4.73	4.63	4.9	%
IN-THD	---	NA	NA	%

3.4.12. Electrical Substation 3A Transformer 2 Primary

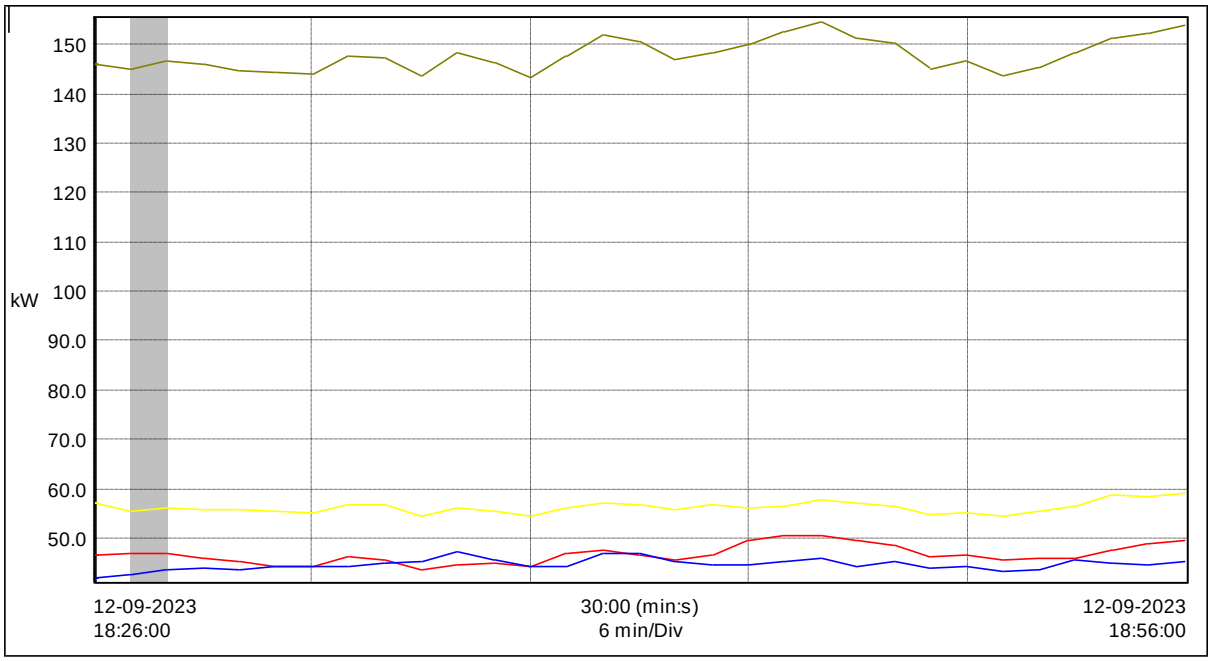
3.4.12.1. Voltage Profile



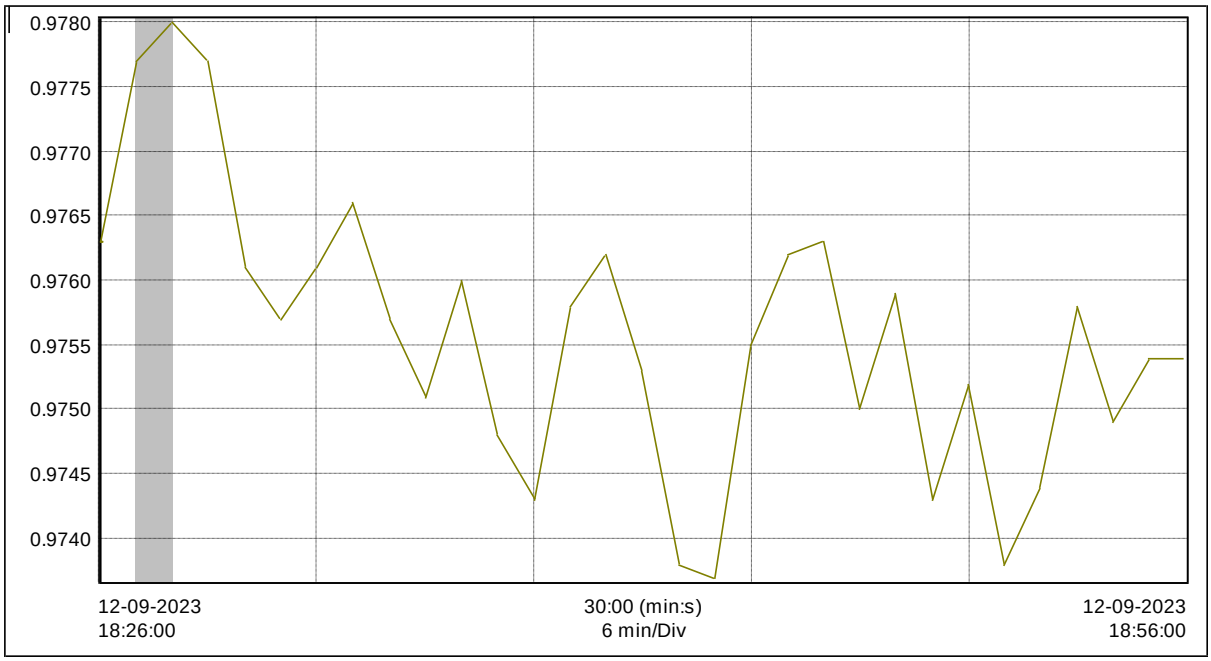
3.4.12.2. Current Profile



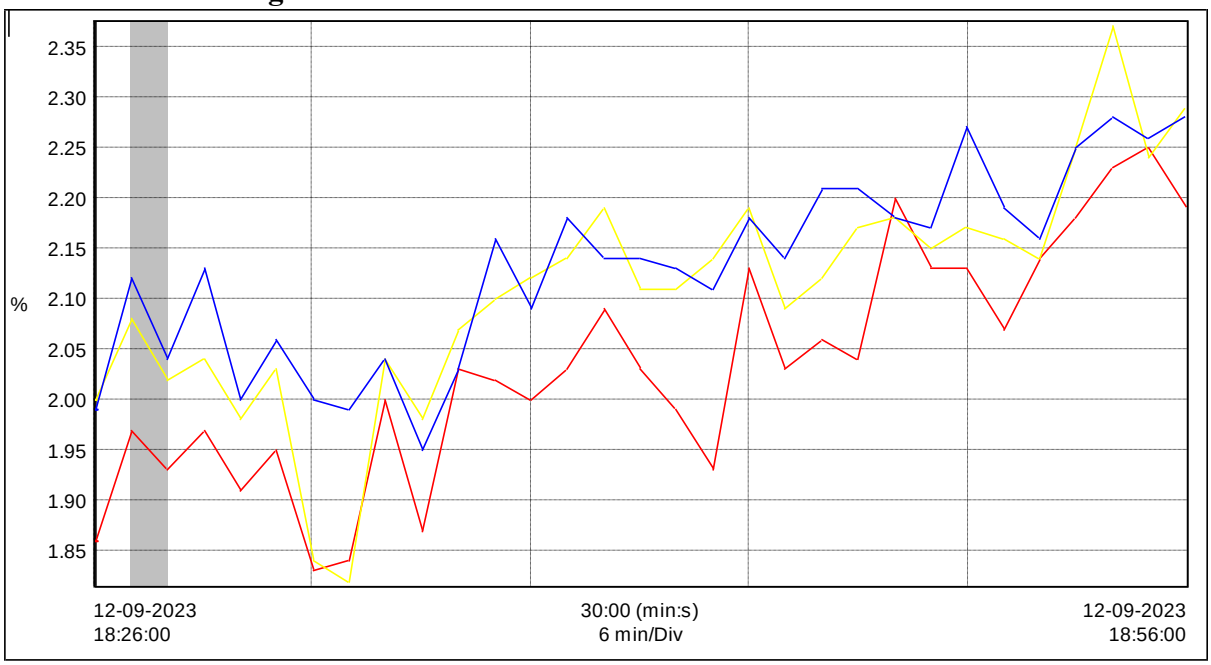
3.4.12.3. Power Profile



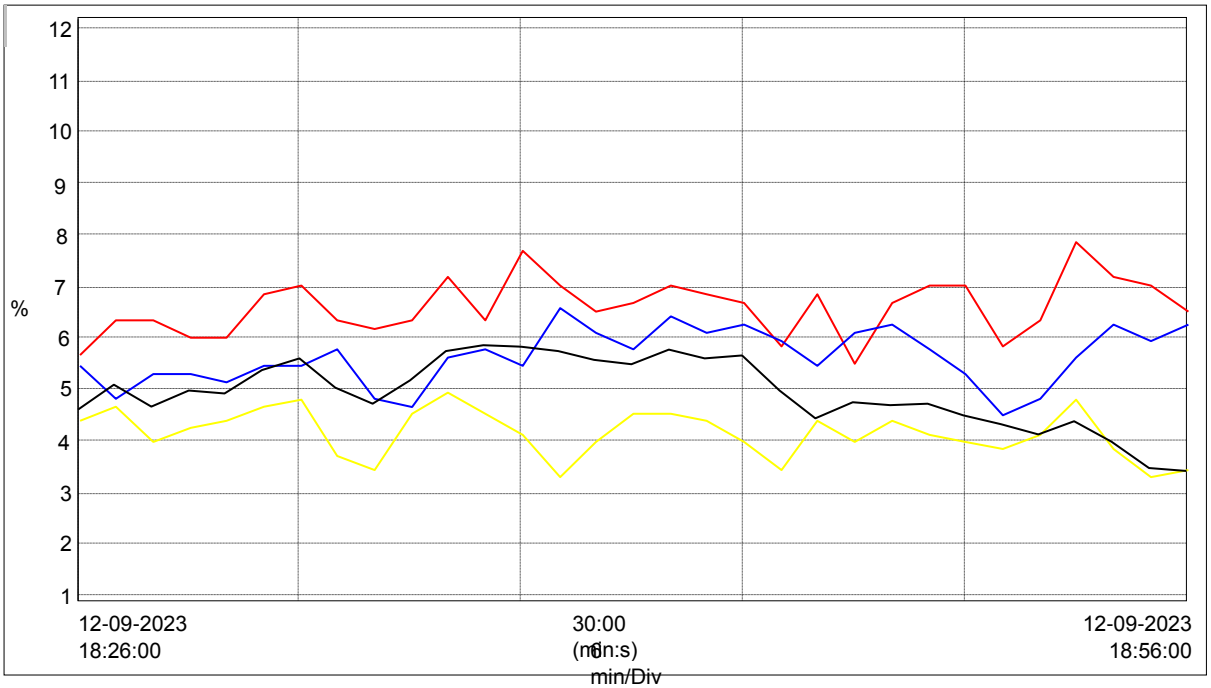
3.4.12.4. Power factor



3.4.12.5. Voltage Harmonics



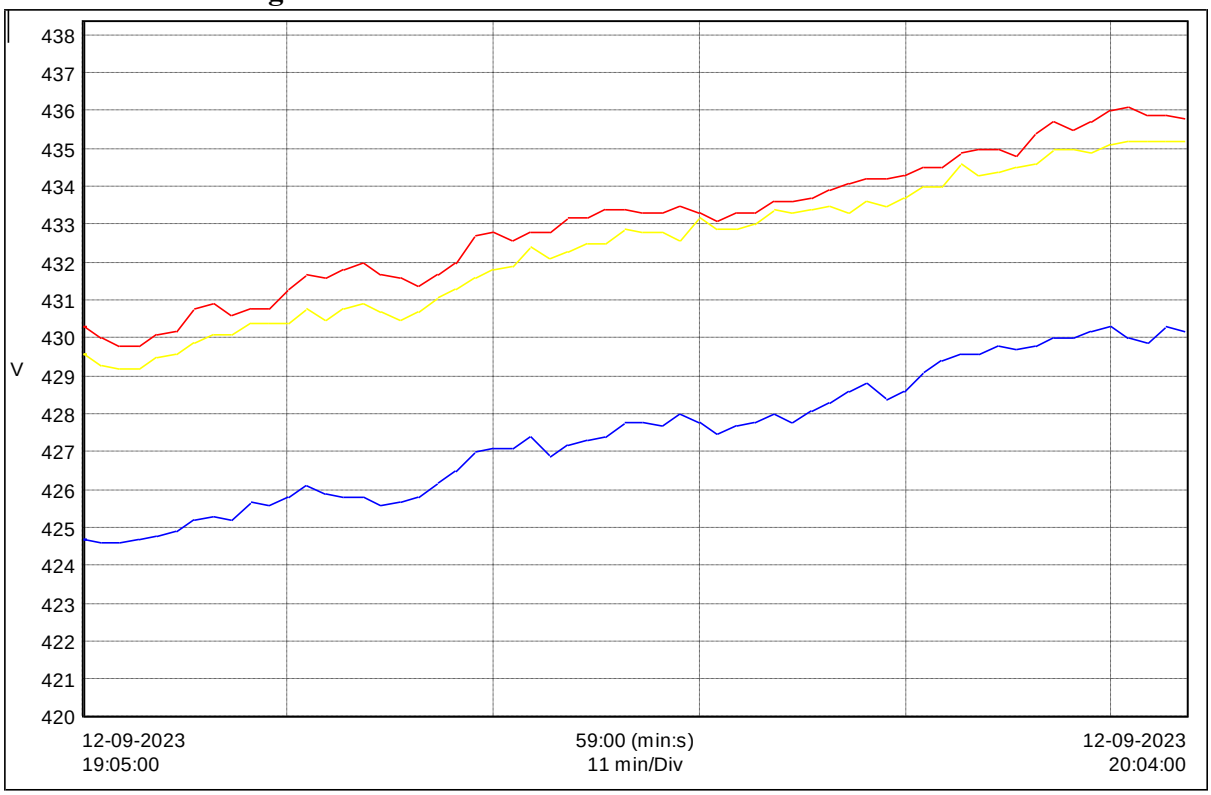
3.4.12.6. Current Harmonics



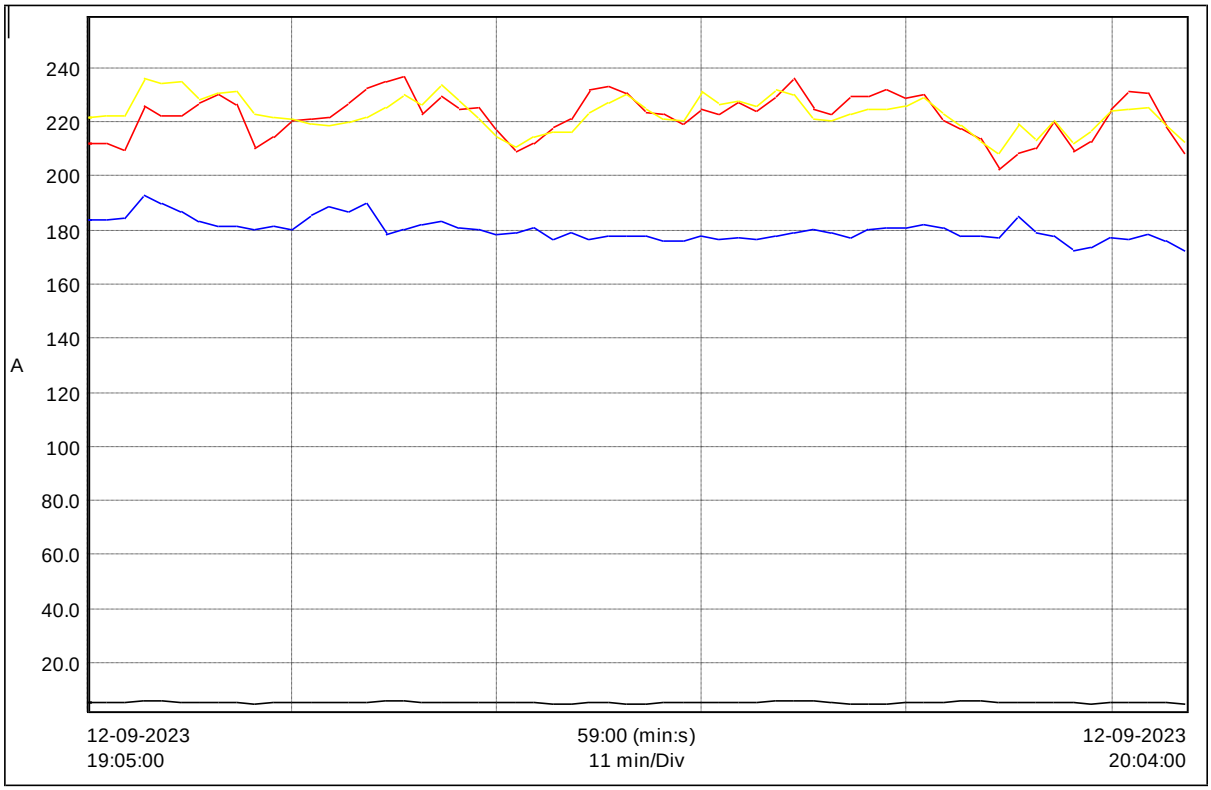
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	11.1	11.05	11.13	Kv
U23	11.22	11.19	11.25	kV
U31	11.06	11.03	11.09	kV
Current				
I1	7.422	6.76	8.892	A
I2	8.937	8.312	10.24	A
I3	7.269	6.669	8.297	A
IN	0.886	0.824	0.984	A
Active Power				
P1	46.81	43.81	50.74	kW
P2	56.36	54.5	59.3	kW
P3	44.77	42.2	47.2	kW
PT	147.9	143.4	154.5	kW
Apparent Power				
S1	47.63	44.73	51.25	kVA
S2	57.55	53.75	60.35	kVA
S3	45.75	44.09	49.54	kVA
ST	150.9	143.8	157.4	kVA
Power factor				
PF1+	0.988	0.984	0.995	
PF2+	0.985	0.978	0.993	
PF3+	0.951	0.946	0.962	
PFT+	0.976	0.974	0.978	
Total Harmonic Distortion				
U12-THD	2.033	1.83	2.25	%
U23-THD	2.107	1.82	2.37	%
U31-THD	2.132	1.95	2.28	%
I1-THD	4.77	3.84	7.92	%
I2-THD	3.15	2.64	4.98	%
I3-THD	3.78	3.24	6.5	%
IN-THD	4.66	3.75	5.8	%

3.4.13. Electrical Substation 3A Transformer 2 Secondary

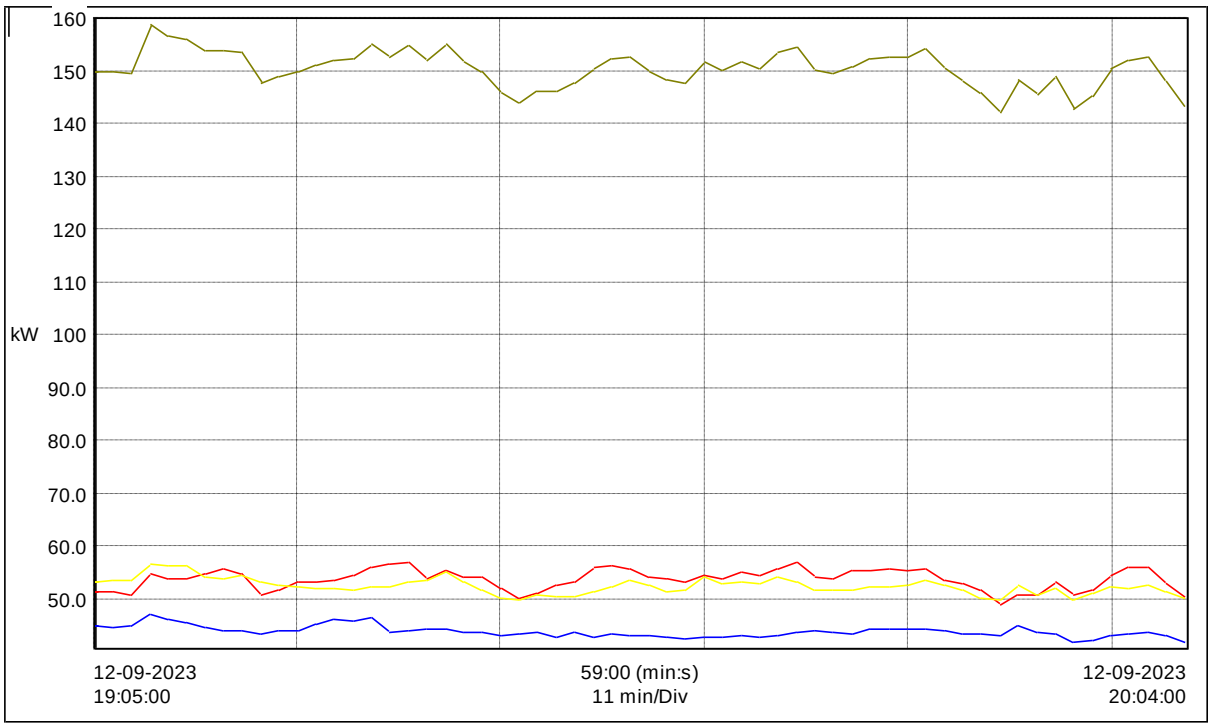
3.4.13.1. Voltage Profile



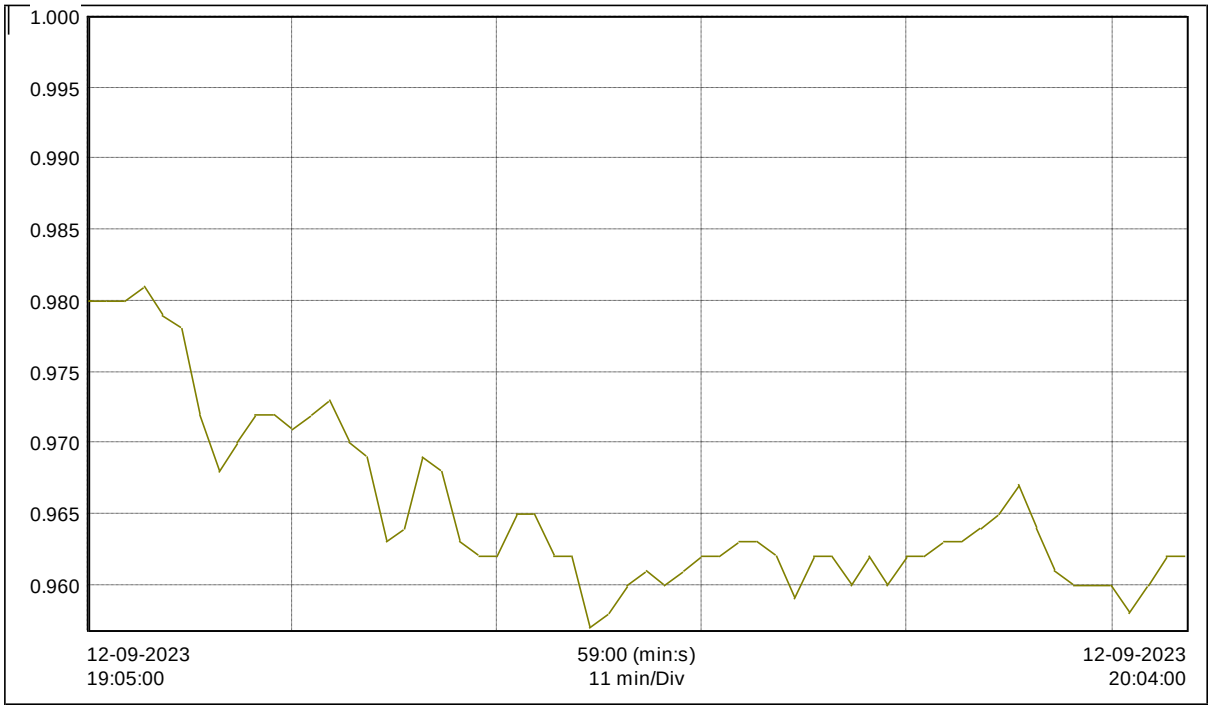
3.4.13.2. Current Profile



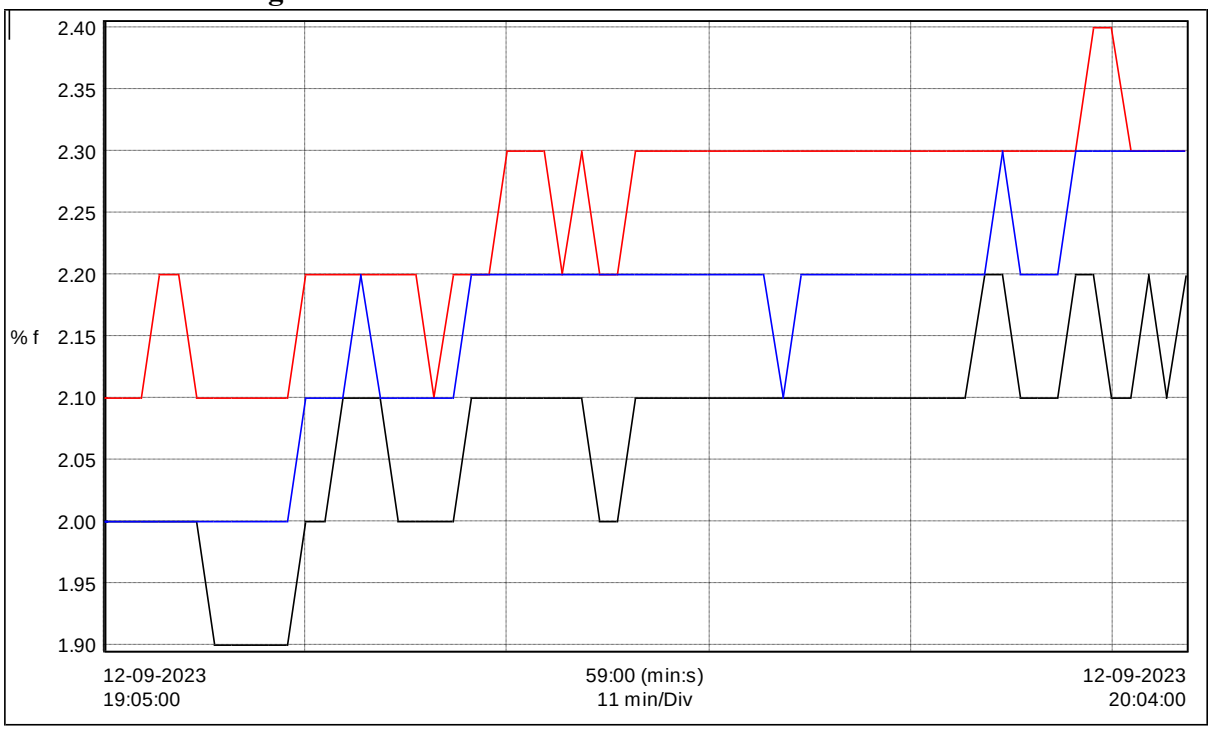
3.4.13.3. Power Profile



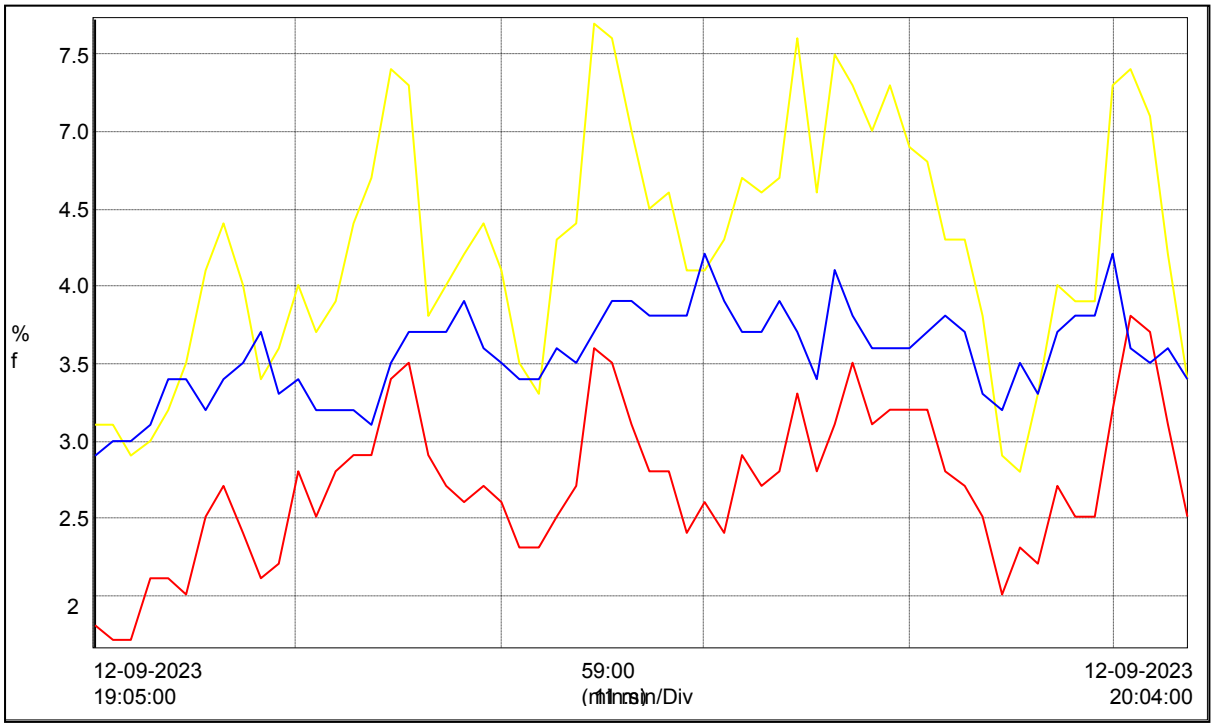
3.4.13.4. Power factor



3.4.13.5. Voltage Harmonics



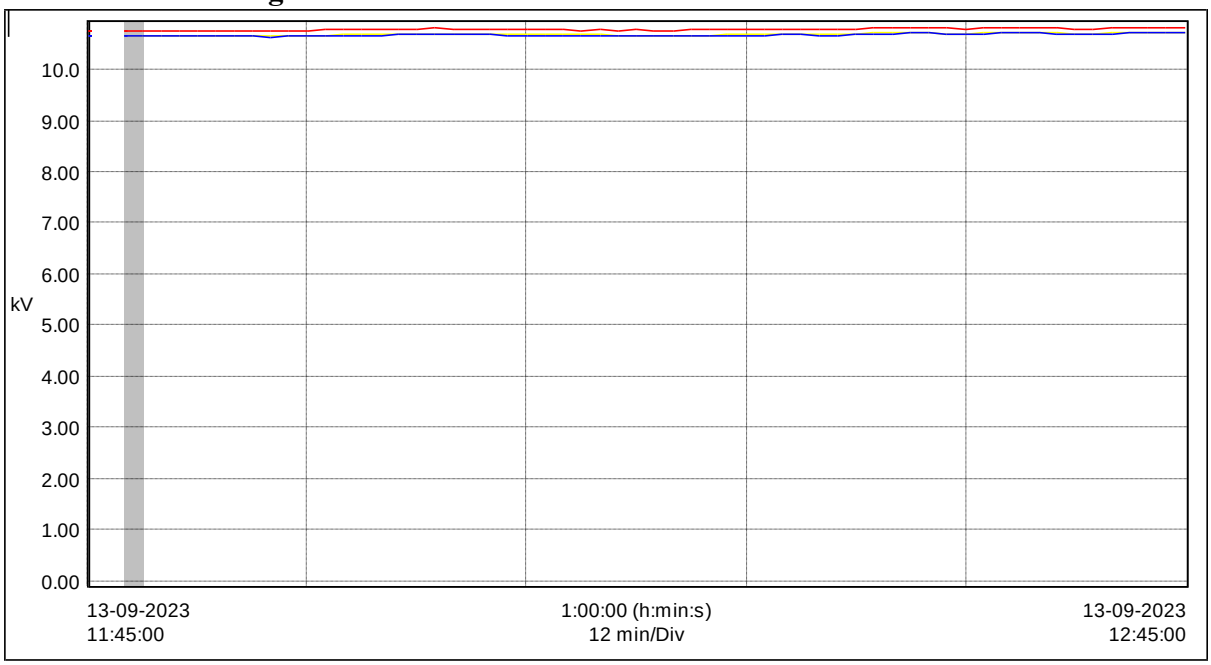
3.4.13.6. Current Harmonics



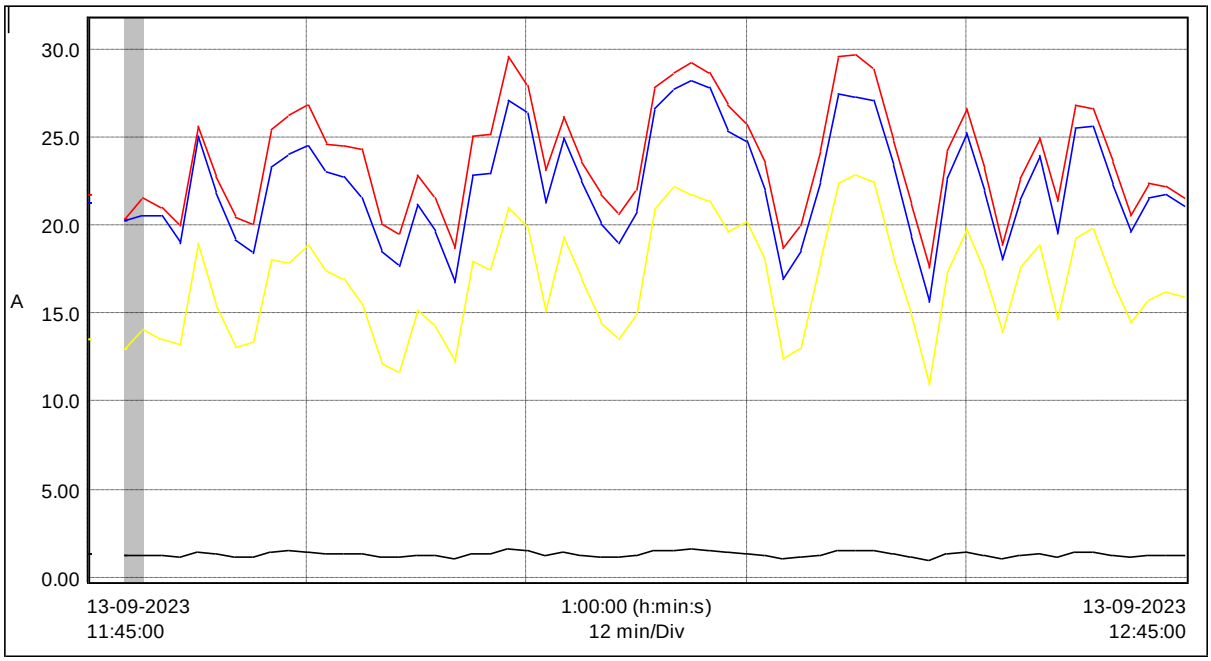
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 rms	433.1	424.5	438.2	V
U23 rms	432.4	423.6	437.4	V
U31 rms	427.5	420.2	432.3	V
Current				
A1 rms	222.6	194.6	256.6	A
A2 rms	223.3	199.4	255	A
A3 rms	180.4	170.2	206.4	A
AN rms	5.632	4.48	7.04	A
Active power				
P1 (W)	53.88	49.2	57.22	kW
P2 (W)	52.62	49.96	56.87	kW
P3 (W)	43.98	41.94	47.22	kW
PT (W)	150.5	142.4	158.9	kW
Apparent Power				
S1 (VA)	54.6	50.06	58.03	kVA
S2 (VA)	55.61	52.22	58.36	kVA
S3 (VA)	45.6	43.9	48.47	kVA
ST (VA)	155.8	147.4	161.9	kVA
Power Factor				
PF1	0.986	0.981	0.996	
PF2	0.946	0.924	0.976	
PF3	0.964	0.954	0.976	
PFT	0.965	0.957	0.981	
Total Harmonic Distortion				
A1 THDf	2.61	1.6	3.7	% f
A2 THDf	6.25	4.8	7.7	% f
A3 THDf	3.56	2.9	4.2	% f
U12 THDf	2.07	1.9	2.2	% f
U23 THDf	2.245	2.1	2.4	% f
U31 THDf	2.162	2	2.3	% f

3.4.14. Electrical Substation 3 Transformer 1Primary

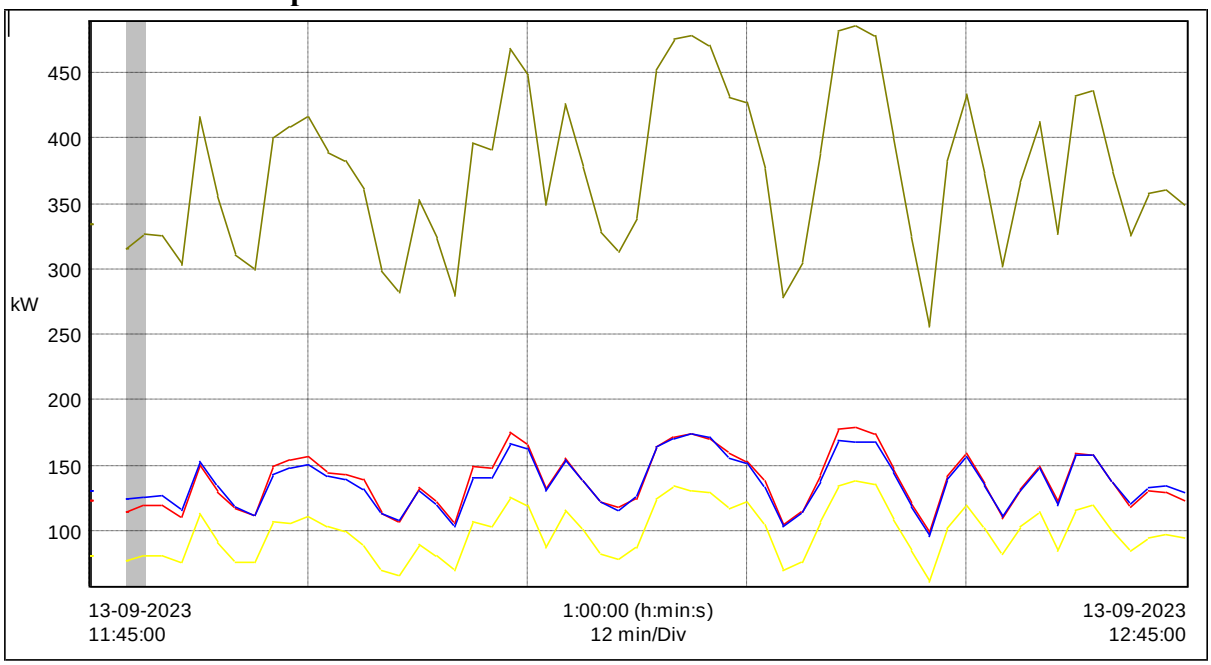
3.4.14.1. Voltage



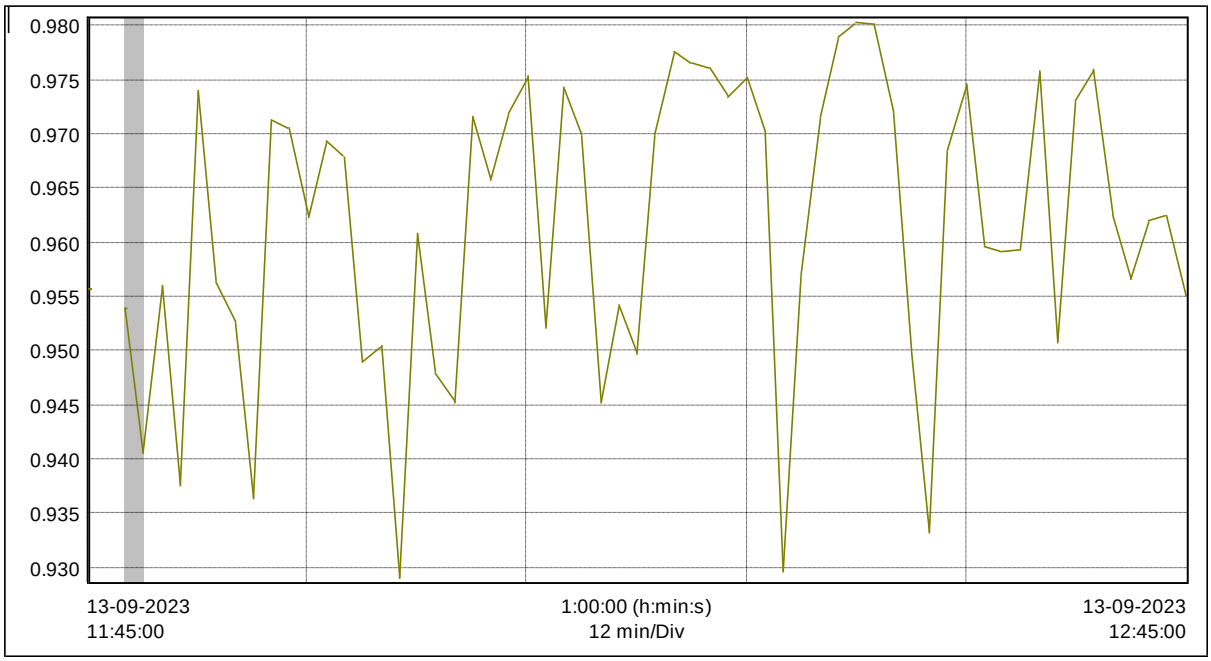
3.4.14.2. Current



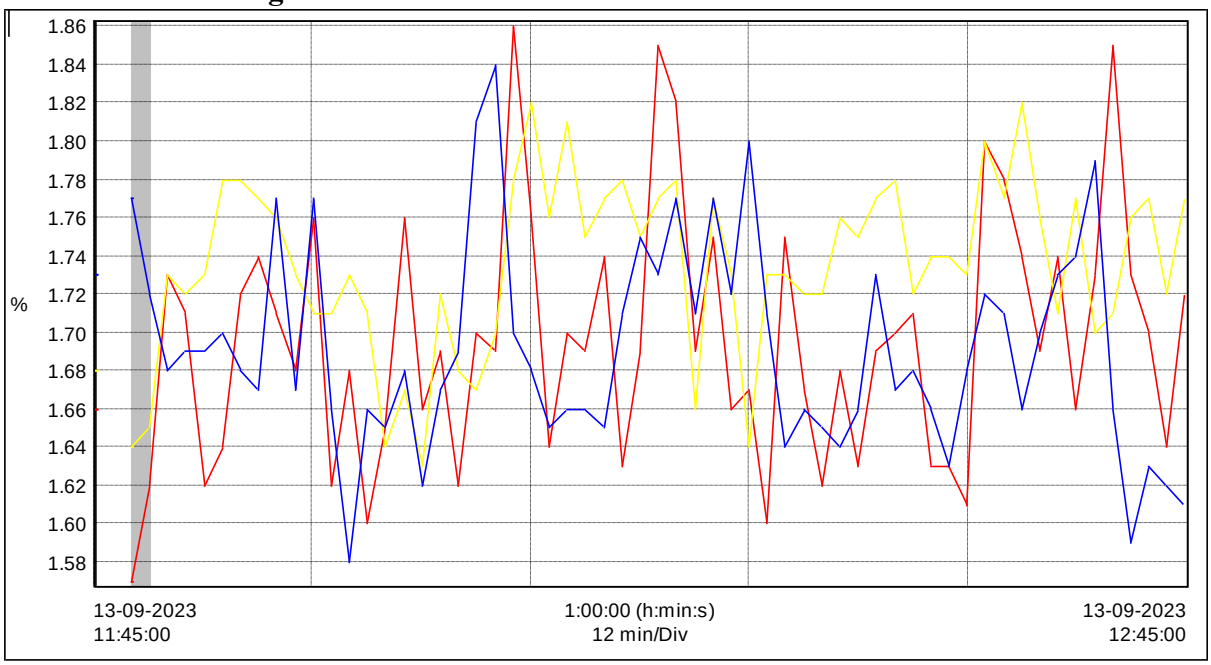
3.4.14.3. Power profile



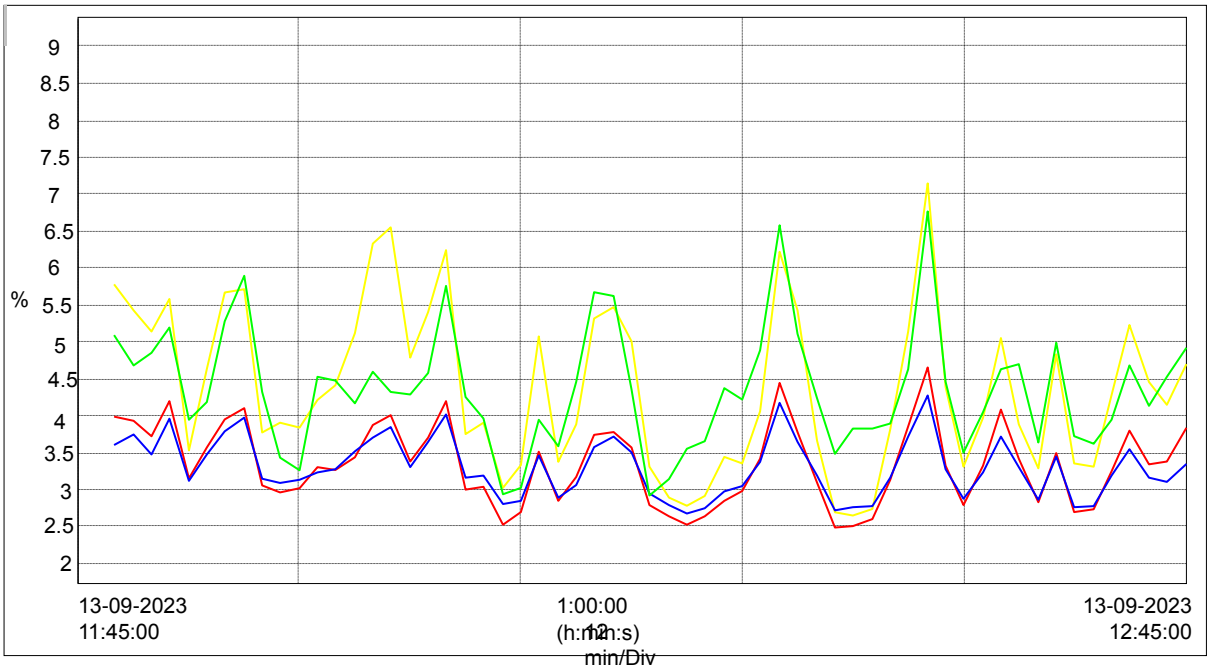
3.4.14.4. Power Factor



3.4.14.5. Voltage Harmonics



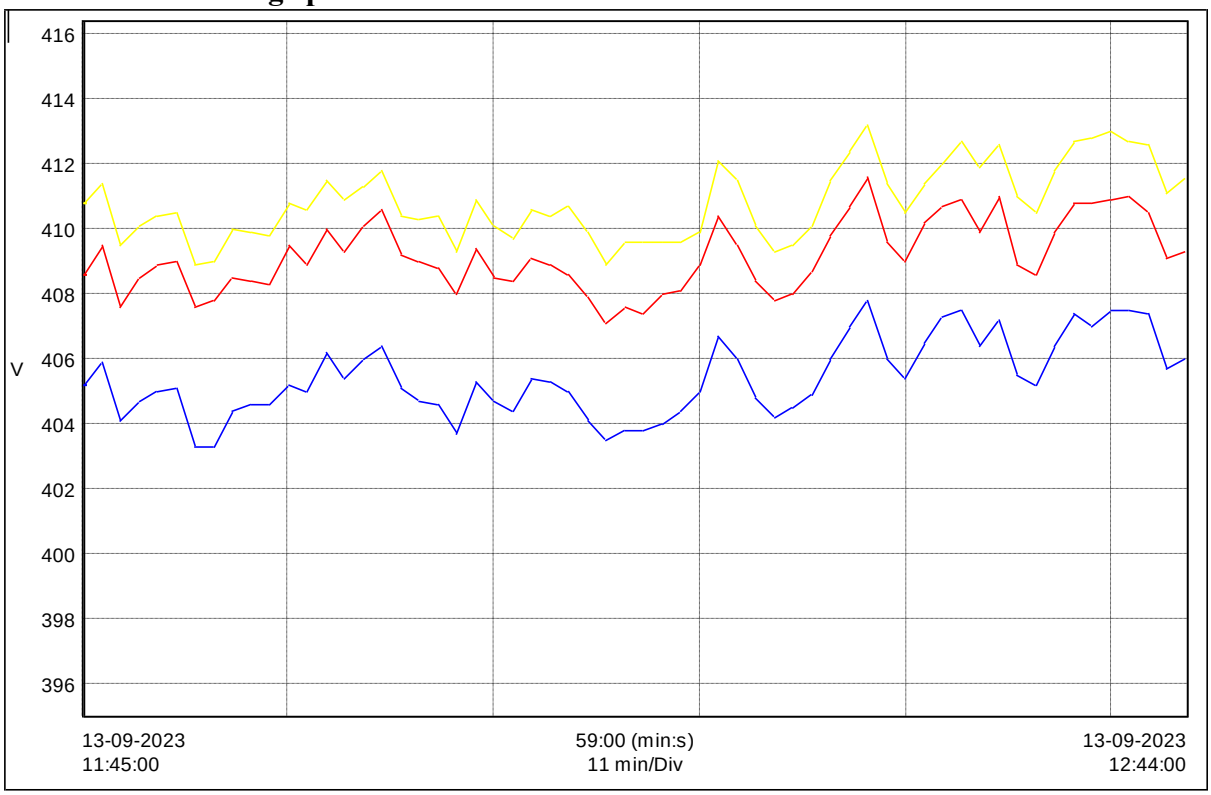
3.4.14.6. Current Harmonics



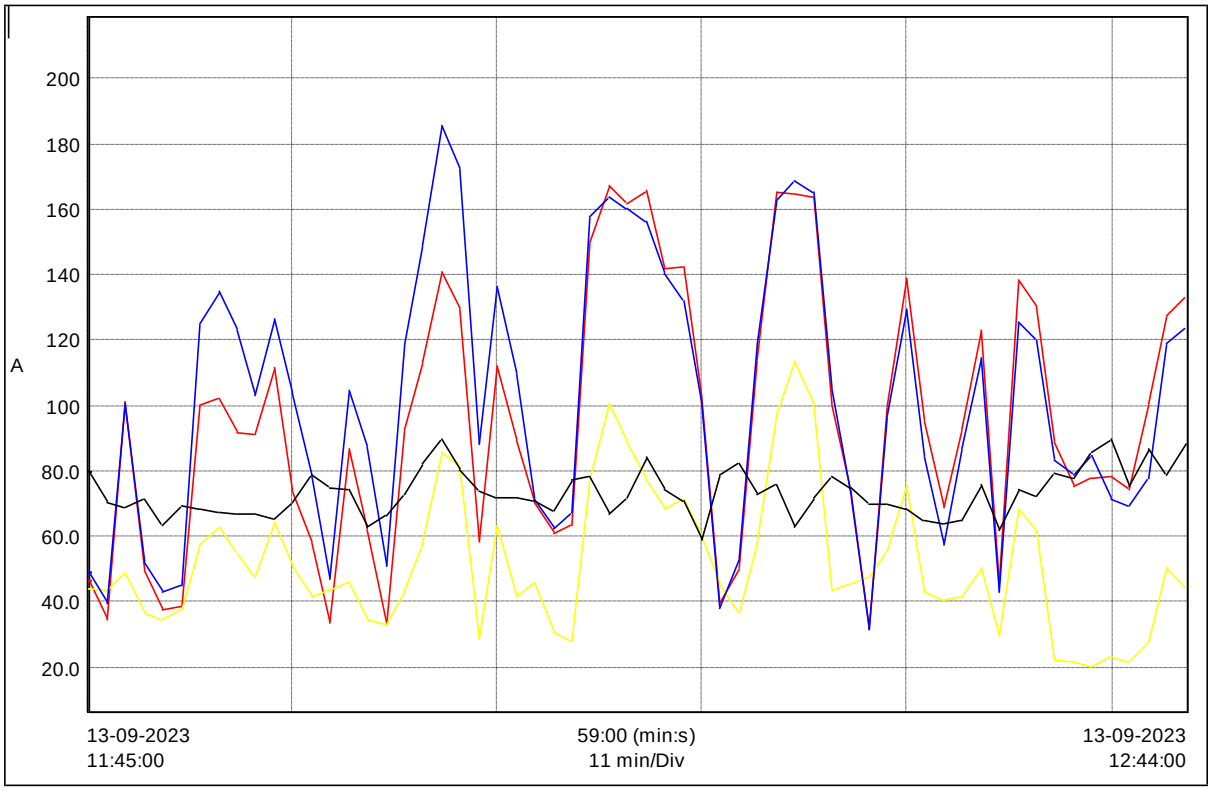
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	10.8	10.76	10.85	kV
U23	10.7	10.65	10.76	kV
U31	10.69	10.64	10.75	kV
Current				
I1	23.99	16.53	31.55	A
I2	17.08	10.04	24.34	A
I3	22.56	14.75	29.41	A
IN	1.328	0.935	1.675	A
Active Power				
P1	138.4	98.78	179.3	kW
P2	99.23	61.77	137.7	kW
P3	137.2	96.23	174.3	kW
PT	374.8	256.8	485.8	kW
Power factor				
PF1+	0.932	0.883	0.967	
PF2+	0.96	0.912	0.983	
PF3+	0.993	0.983	0.998	
PFT+	0.961	0.929	0.98	
Total Harmonic Distortion				
U12-THD	1.695	1.57	1.86	%f
U23-THD	1.734	1.63	1.82	%f
U31-THD	1.692	1.58	1.84	%f
I1-THD	3.38	2.56	4.6	%f
I2-THD	4.71	3.17	7.1	%f
I3-THD	3.02	2.25	4.2	%f
IN-THD	4.78	3.54	6.8	%f

3.4.15. Electrical Substation 3 Transformer 2 Secondary

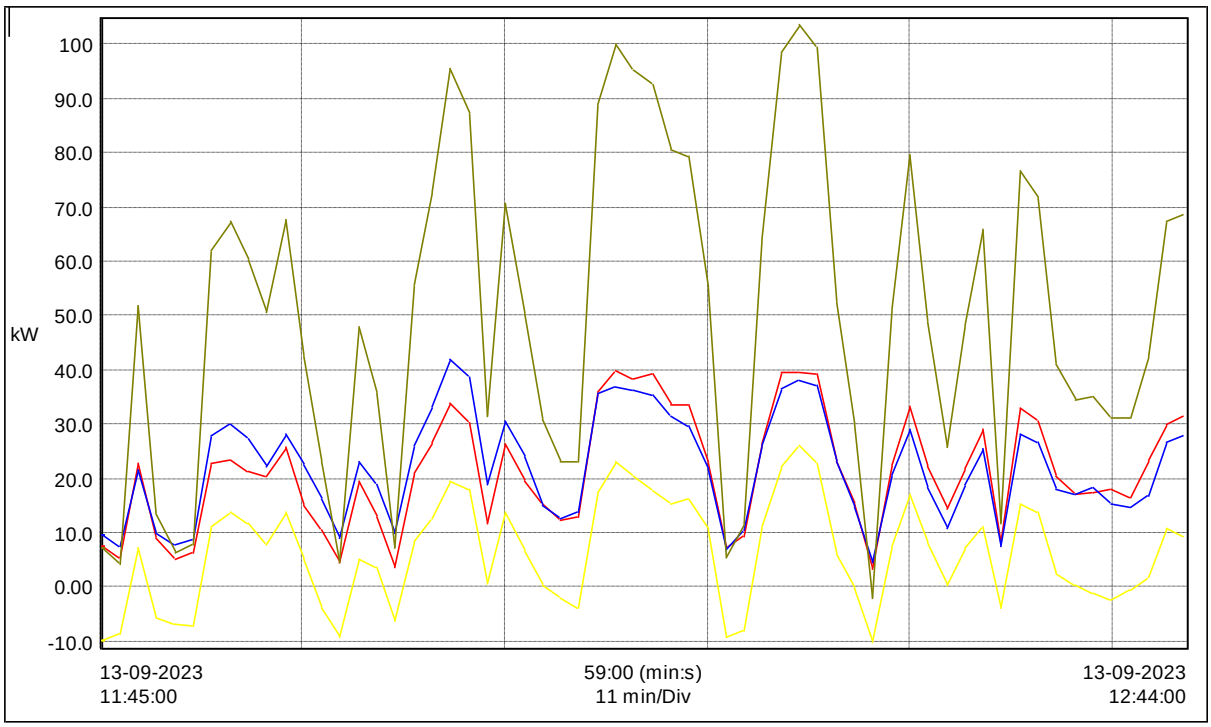
3.4.15.1. Voltage profile



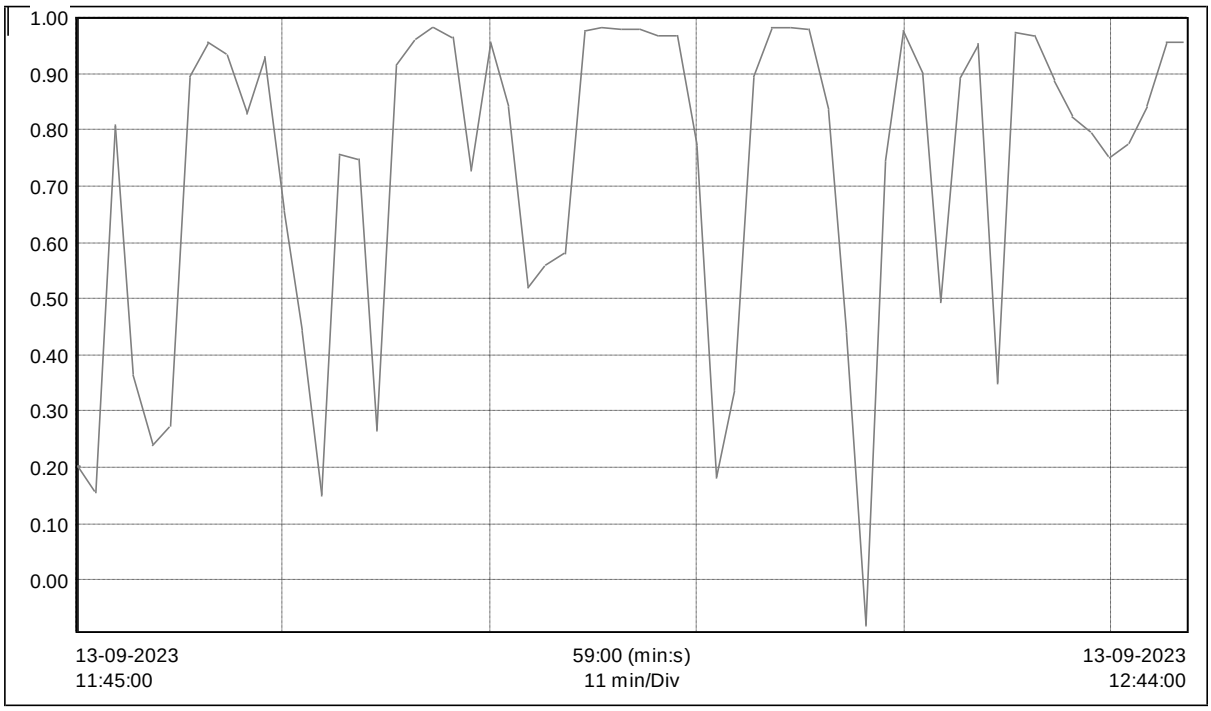
3.4.15.2. Current Profile



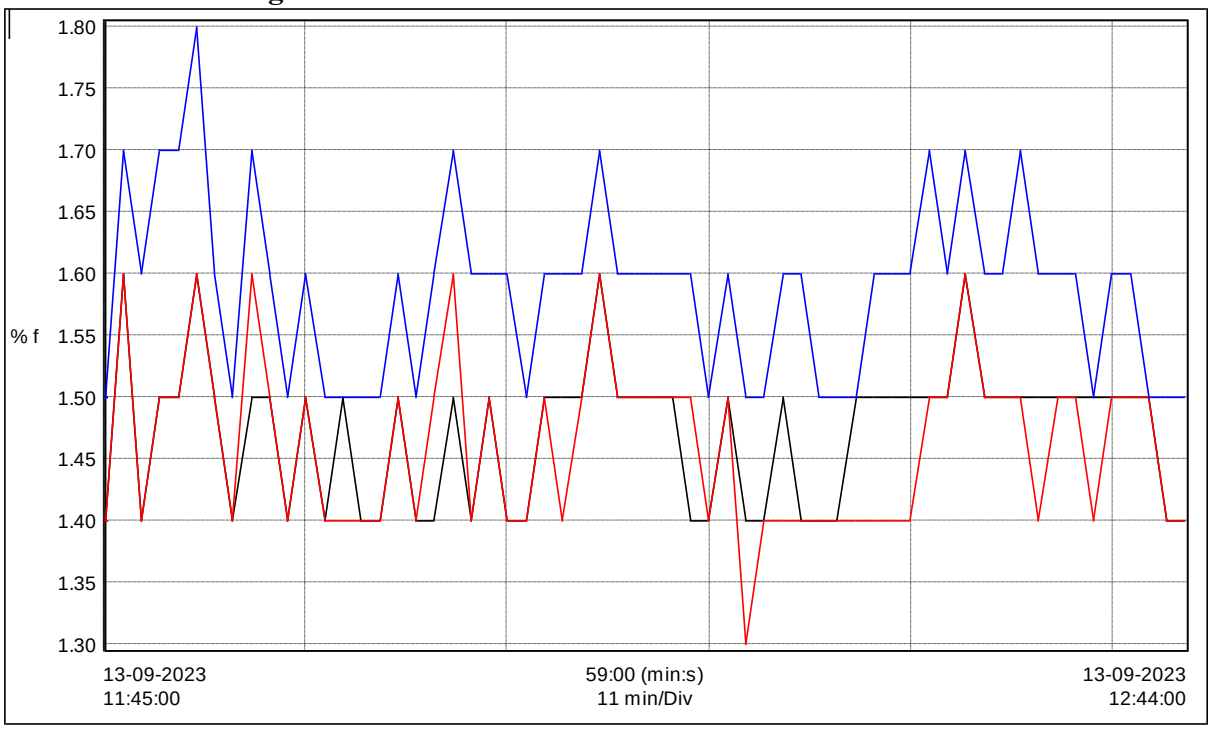
3.4.15.3. Power Profile



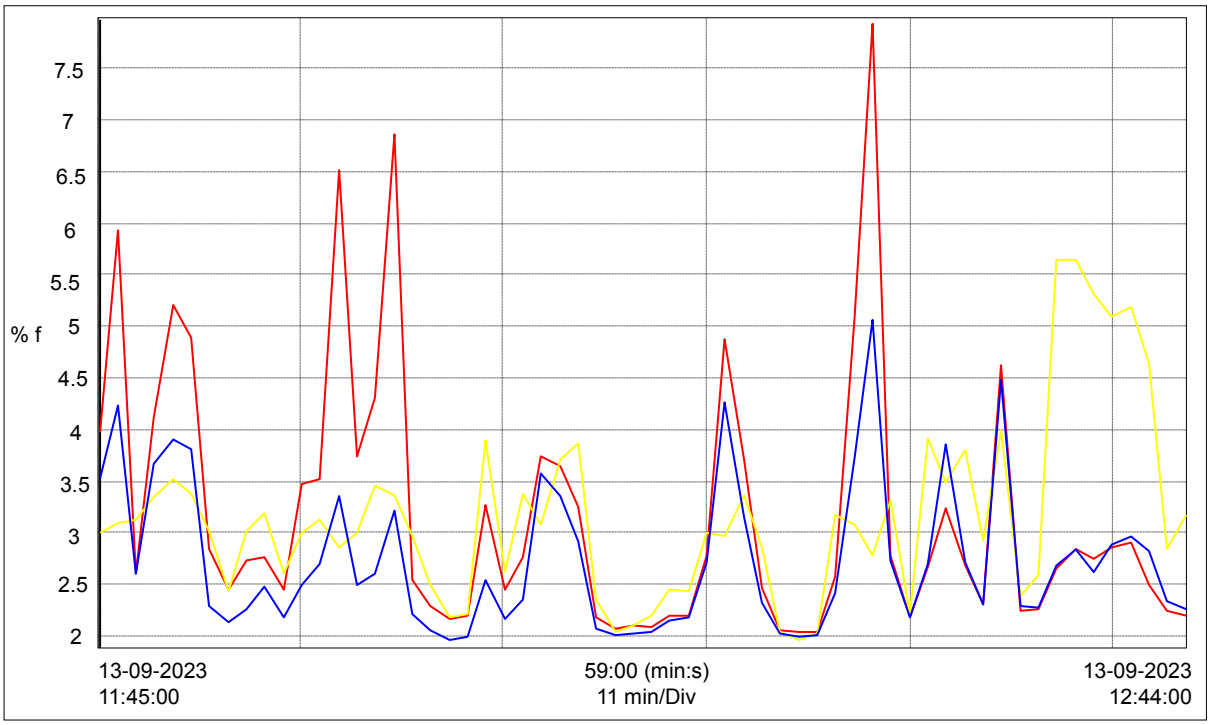
3.4.15.4. Power factor



3.4.15.5. Voltage Harmonics



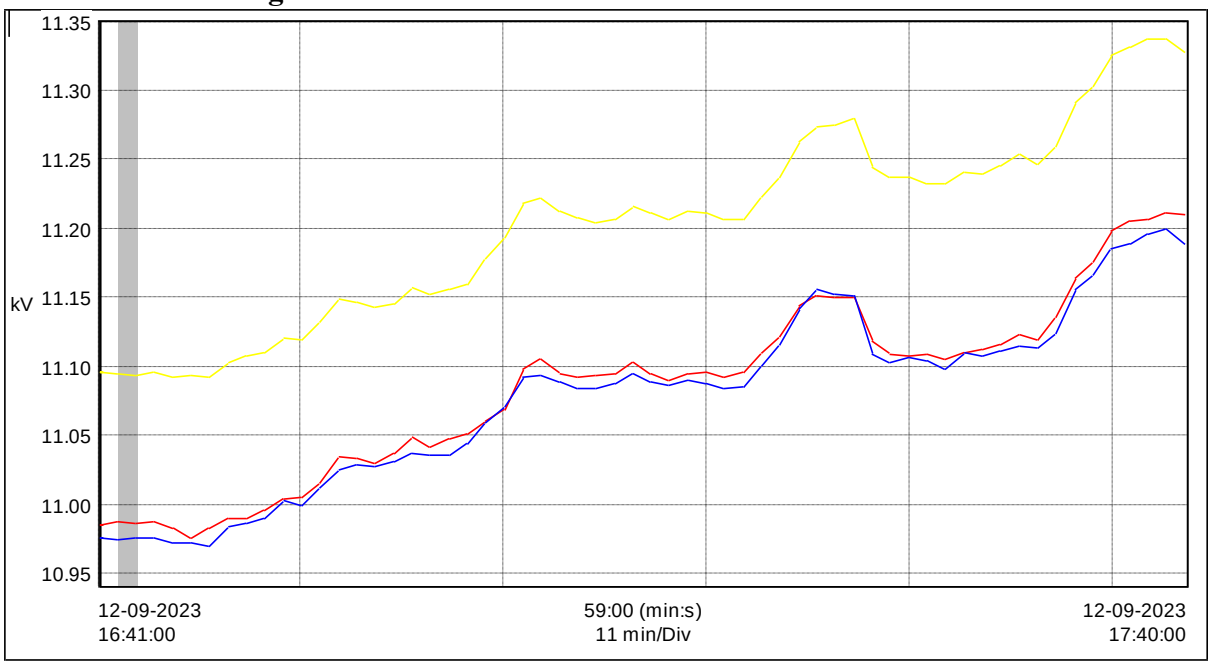
3.4.15.6. Current Harmonics



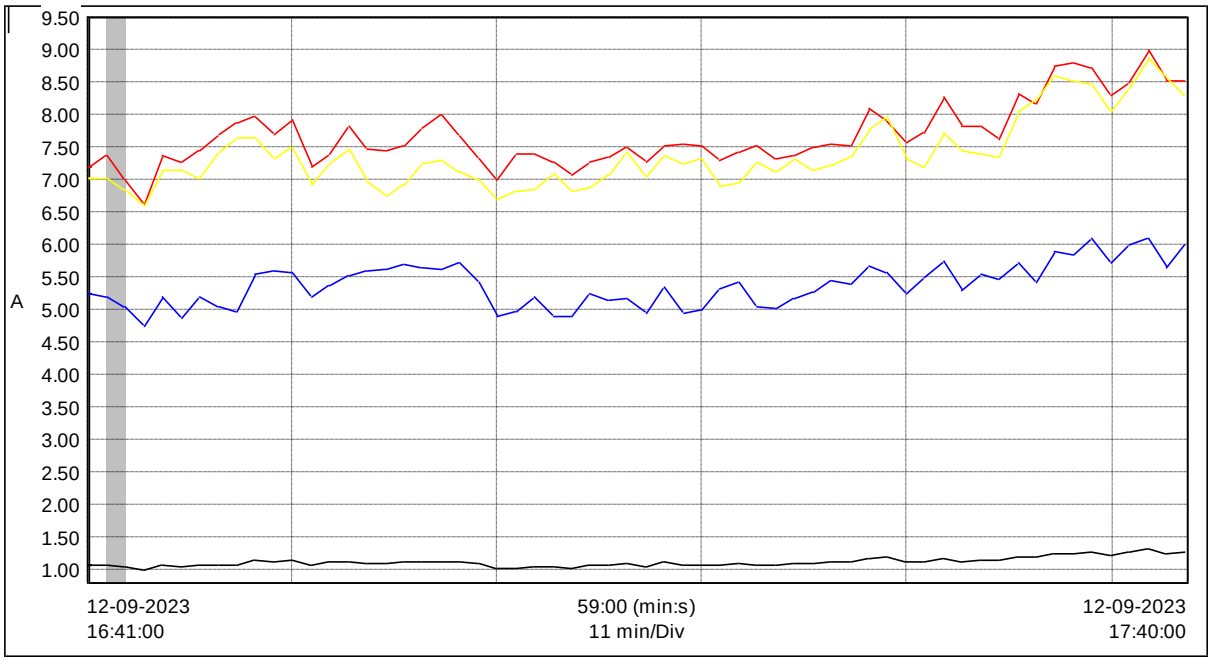
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12 rms	409.2	402.1	414.3	V
U23 rms	410.8	403.6	416.2	V
U31 rms	405.4	395.2	412.3	V
Current				
A1 rms	103.1	19	186	A
A2 rms	56.32	8.5	128	A
A3 rms	109	20.5	217	A
AN rms	17.4	14.3	25.2	A
Active power				
P1 (W)	21.45	3.501	39.84	kW
P2 (W)	6.312	-10.12	26.06	kW
P3 (W)	22.11	4.59	42.08	kW
PT (W)	49.87	-2.026	103.8	kW
Apparent power				
S1 (VA)	23.36	7.84	40.82	kVA
S2 (VA)	12.22	4.846	26.53	kVA
S3 (VA)	23.15	7.368	42.4	kVA
ST (VA)	58.72	26.47	105.4	kVA
Total Harmonic Distortion				
A1 THDf	5.09	2.16	7.97	% f
A2 THDf	4.22	2.11	5.71	% f
A3 THDf	3.92	1.98	5.03	% f
U12 THDf	1.472	1.4	1.6	% f
U23 THDf	1.462	1.3	1.6	% f
U31 THDf	1.587	1.5	1.8	% f

3.4.16. Electrical Substation 4 Transformer 2 Primary

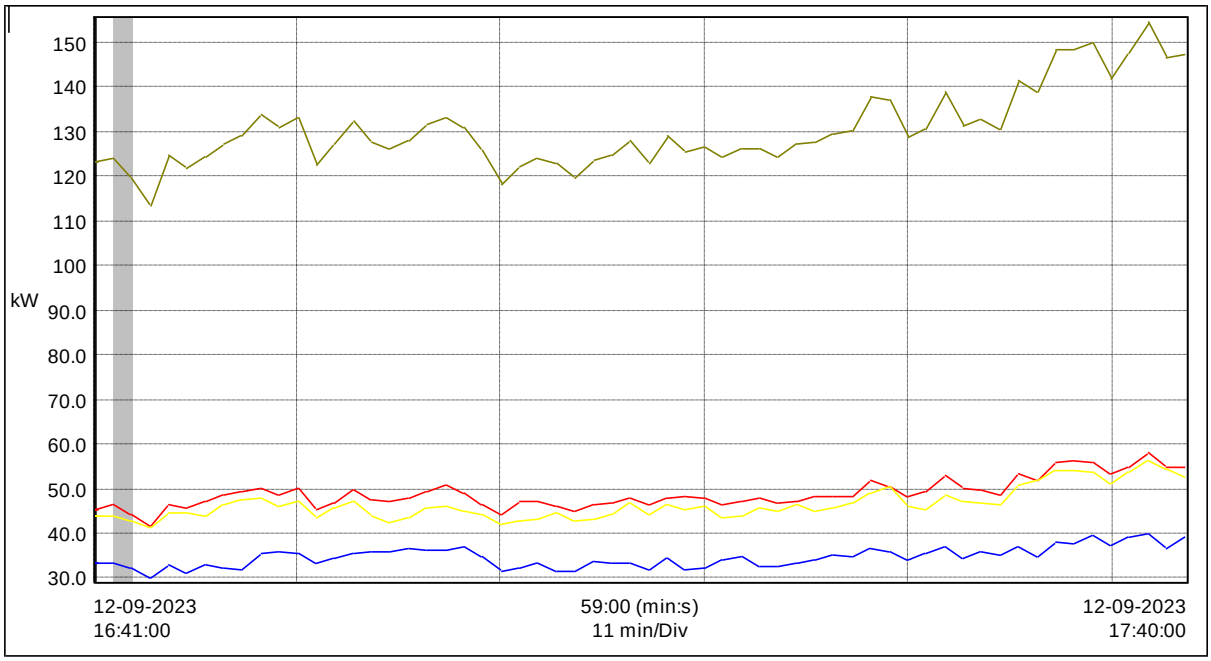
3.4.16.1. Voltage Profile



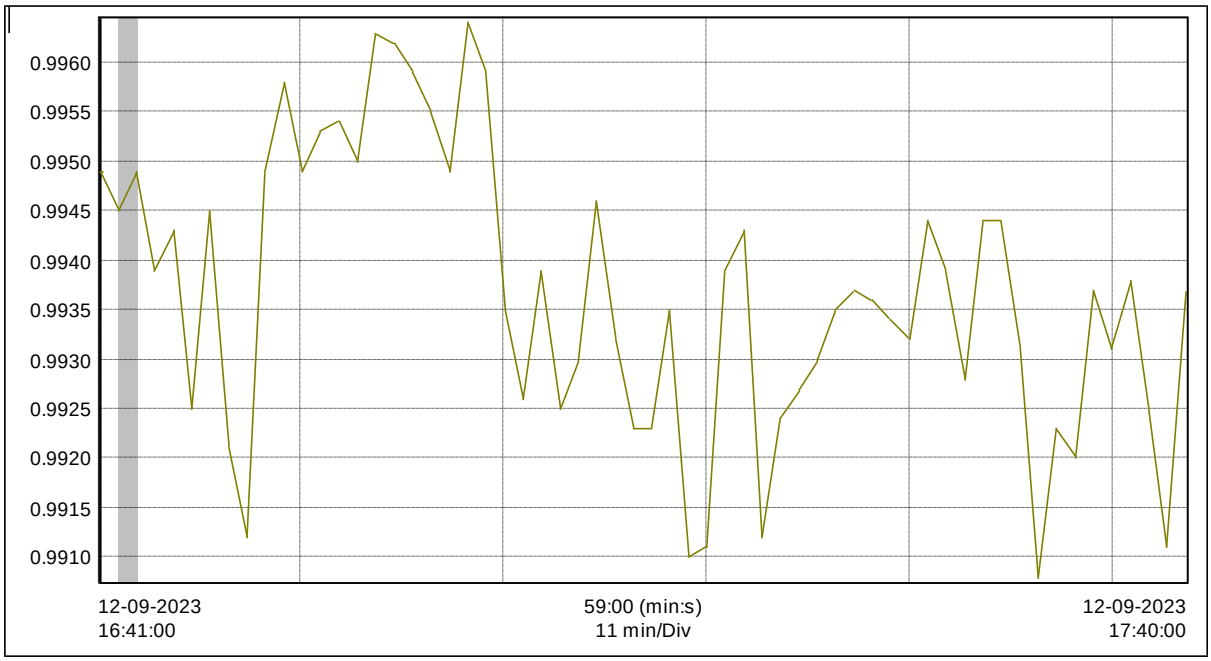
3.4.16.2. Current Profile



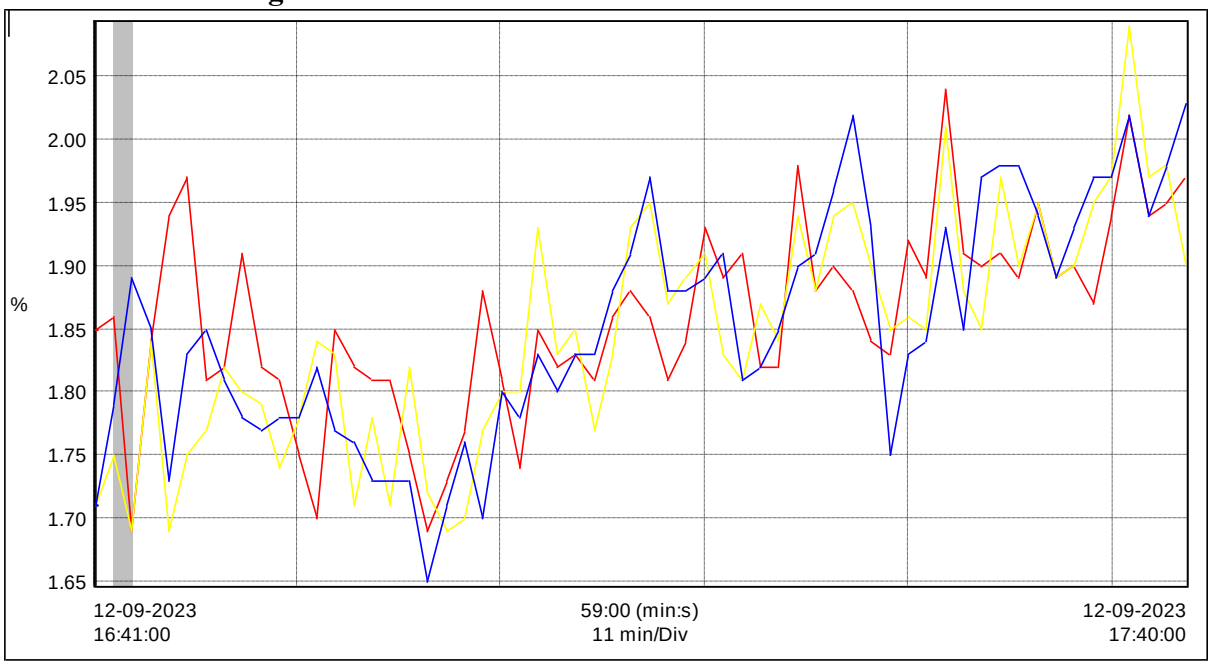
3.4.16.3. Power Profile



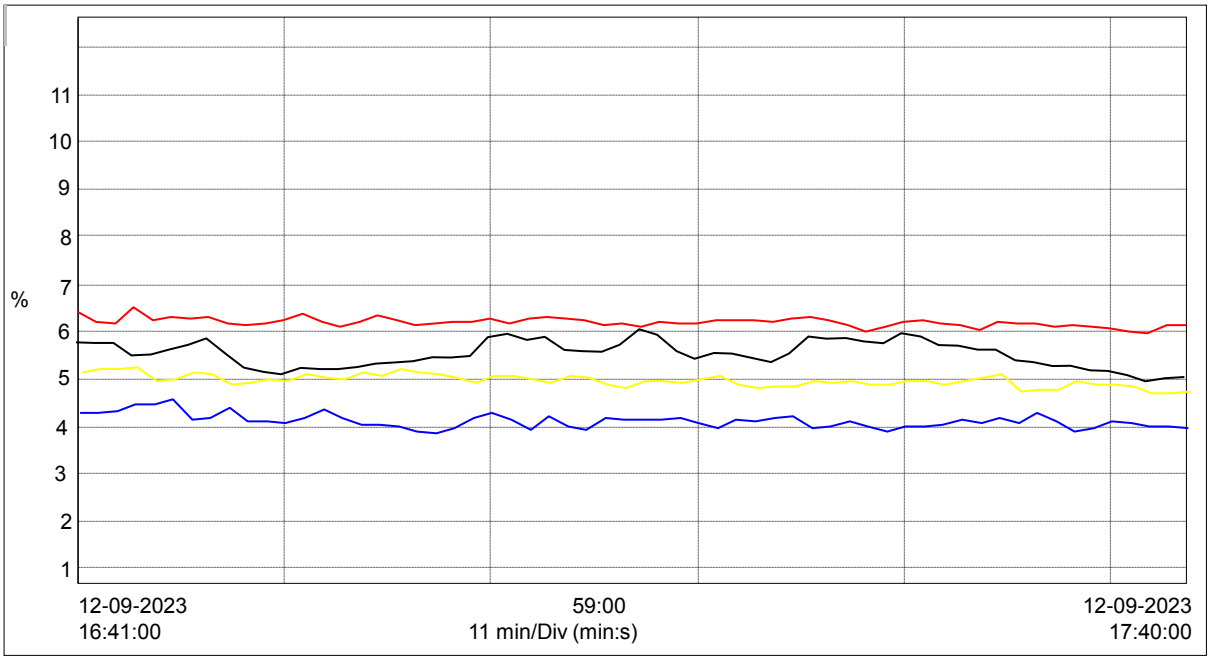
3.4.16.4. Power factor



3.4.16.5. Voltage Harmonics



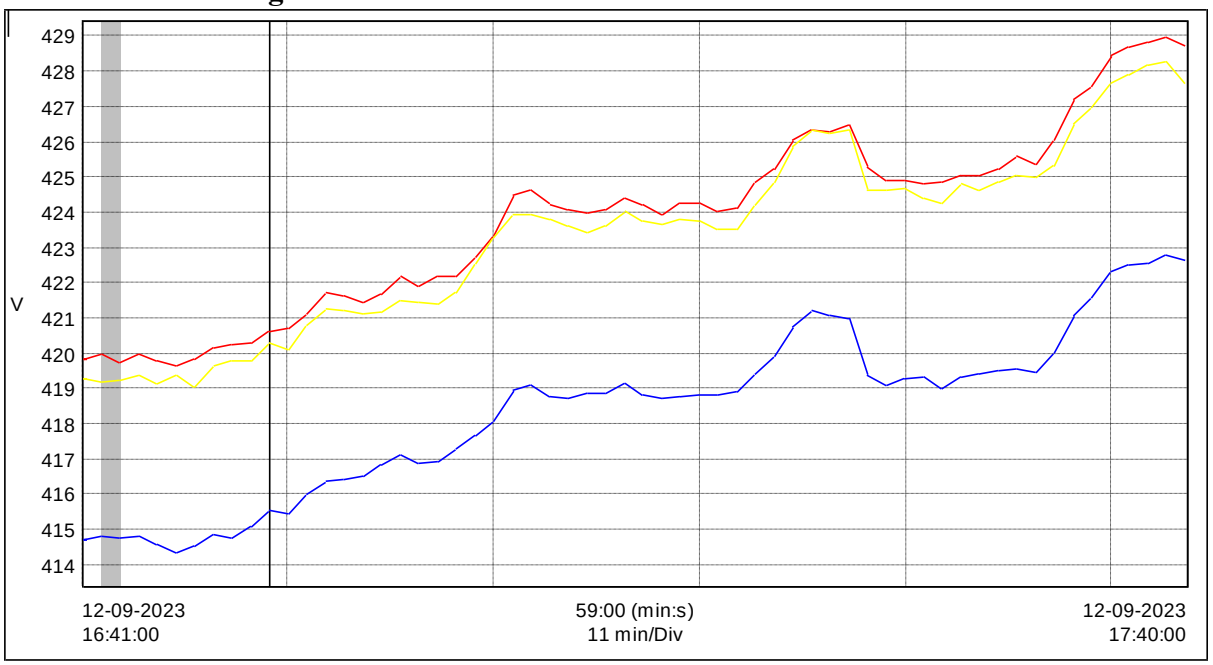
3.4.16.6. Current Harmonics



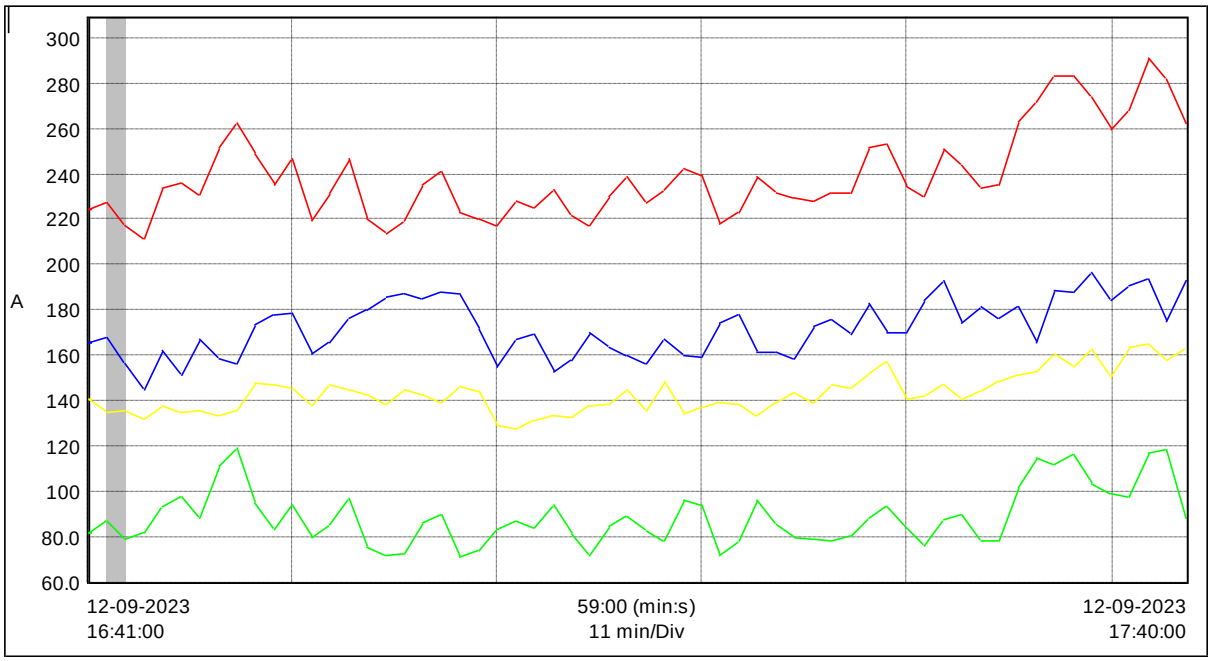
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	11.08	10.96	11.22	kV
U23	11.2	11.07	11.35	kV
U31	11.08	10.94	11.2	kV
Current				
I1	7.715	6.159	9.425	A
I2	7.423	5.92	9.378	A
I3	5.406	4.052	6.953	A
IN	1.135	0.894	1.427	A
Power Factor				
PF1+	0.997	0.993	1	
PF2+	0.989	0.982	0.995	
PF3+	0.996	0.992	1	
PFT+	0.994	0.991	0.996	
Active Power				
P1	49.07	41.87	58.08	kW
P2	46.67	41.46	56.5	kW
P3	34.76	30.32	39.91	kW
PT	130.5	113.7	154.5	kW
Apparent Power				
S1	49.2	42.1	58.22	kVA
S2	47.2	41.76	57.29	kVA
S3	34.92	30.49	40.15	kVA
ST	131.3	114.4	155.7	kVA
Total Harmonic Distortion				
U12-THD	1.859	1.69	2.04	%
U23-THD	1.847	1.69	2.09	%
U31-THD	1.852	1.65	2.03	%
I1-THD	6.06	6.0	6.51	%
I2-THD	5.3	5.46	5.13	%
I3-THD	4.47	4.5	4.5	%
IN-THD	4.68	5.2	6.0	%

3.4.17. Electrical Substation 4A Transformer 2 Secondary

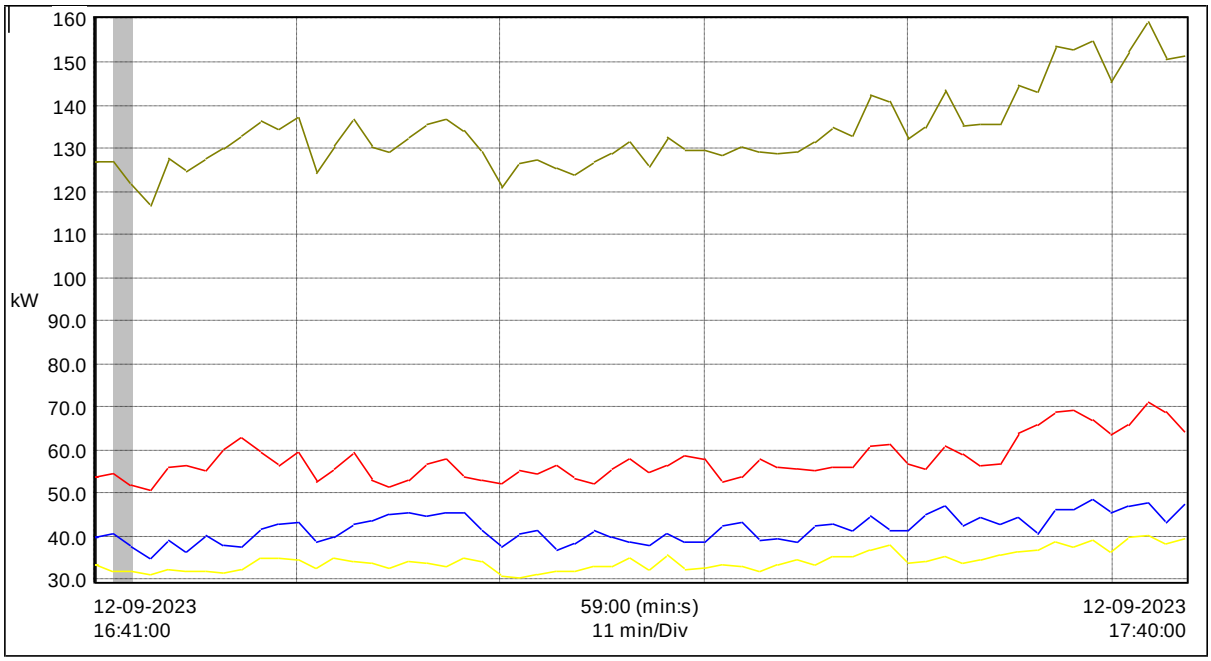
3.4.17.1. Voltage Profile



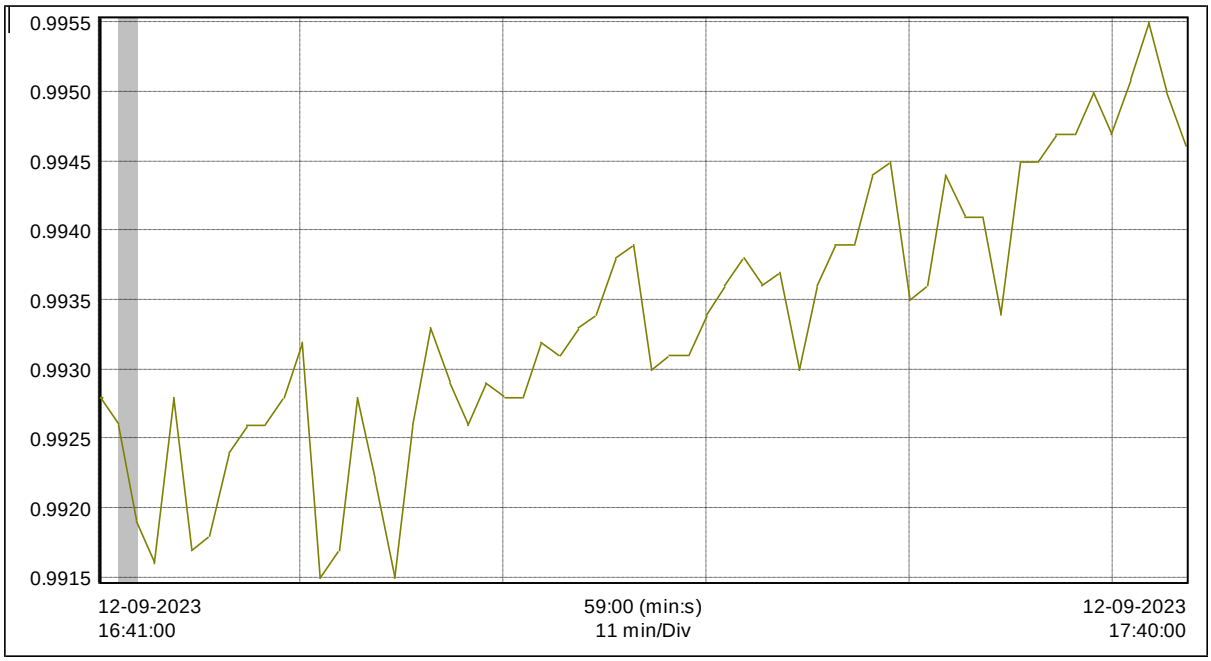
3.4.17.2. Current Profile



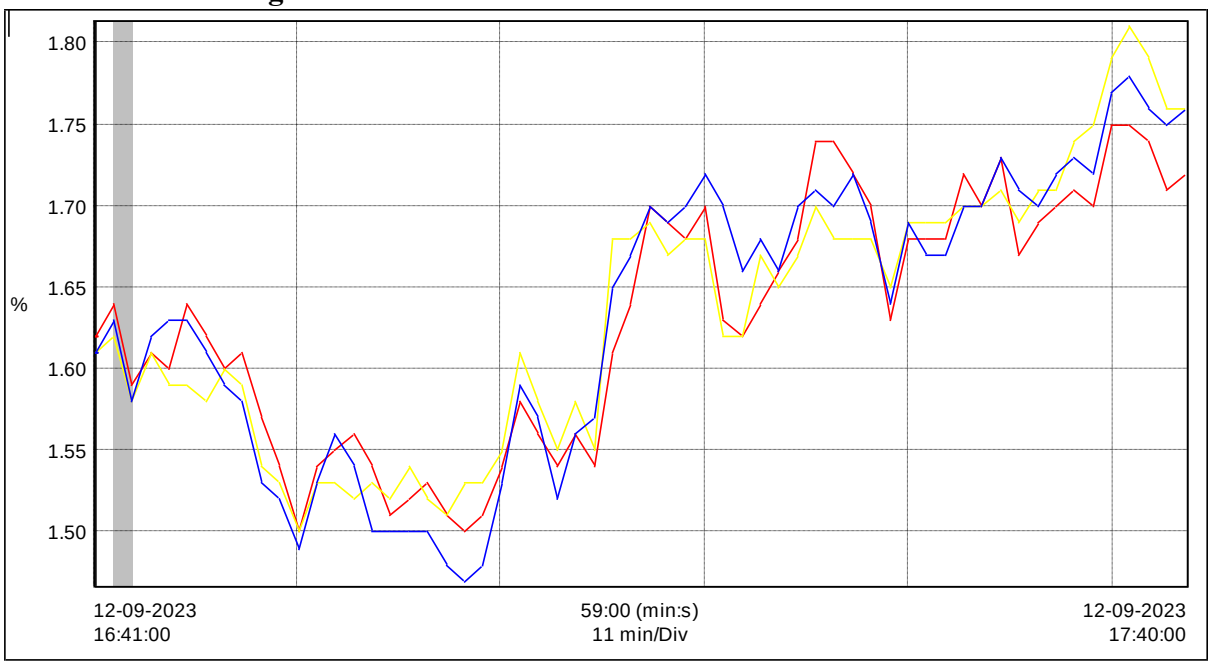
3.4.17.3. Power Profile



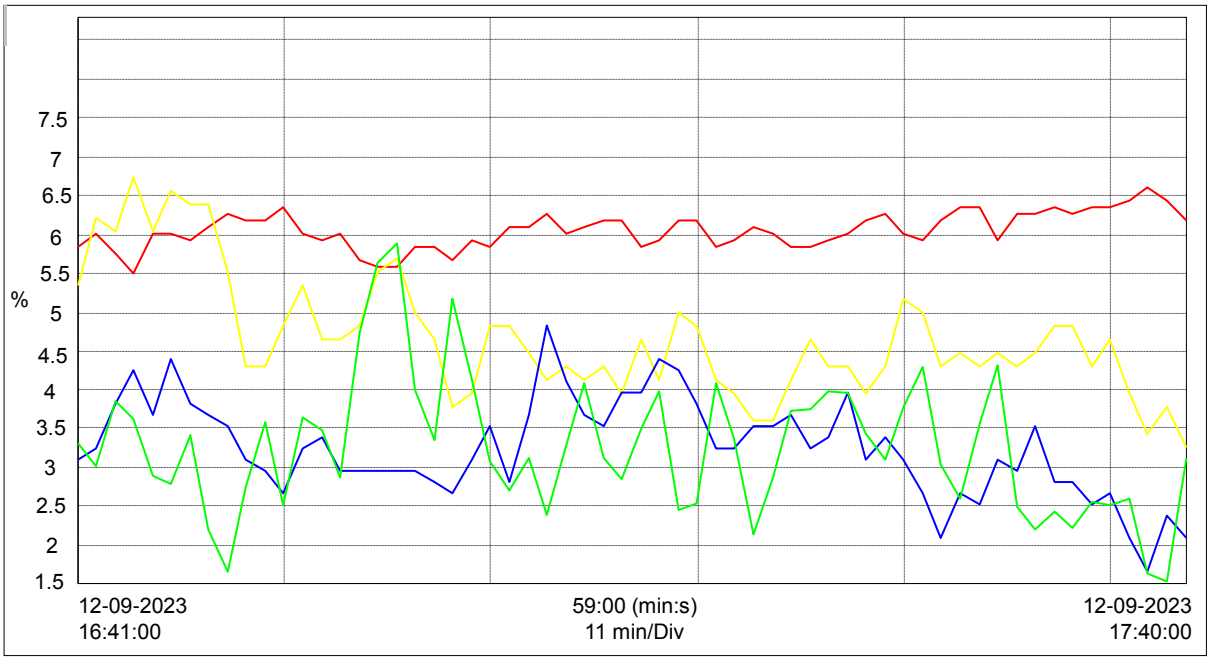
3.4.17.4. Power Factor



3.4.17.5. Voltage Harmonics



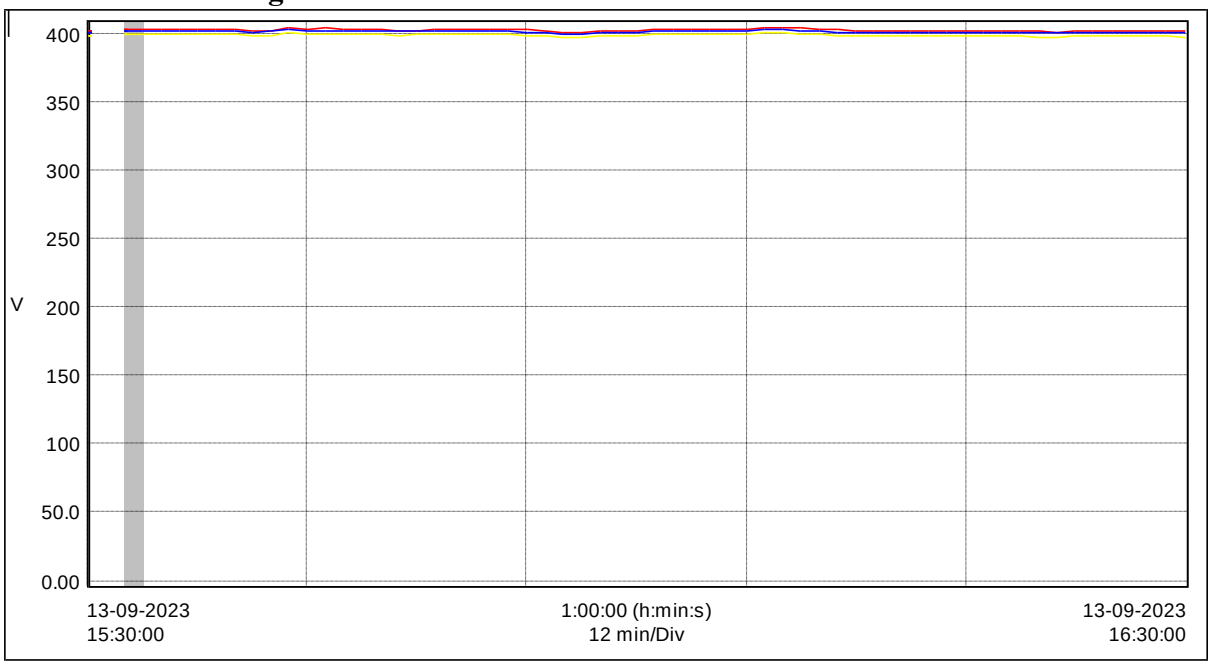
3.4.17.6. Current harmonics



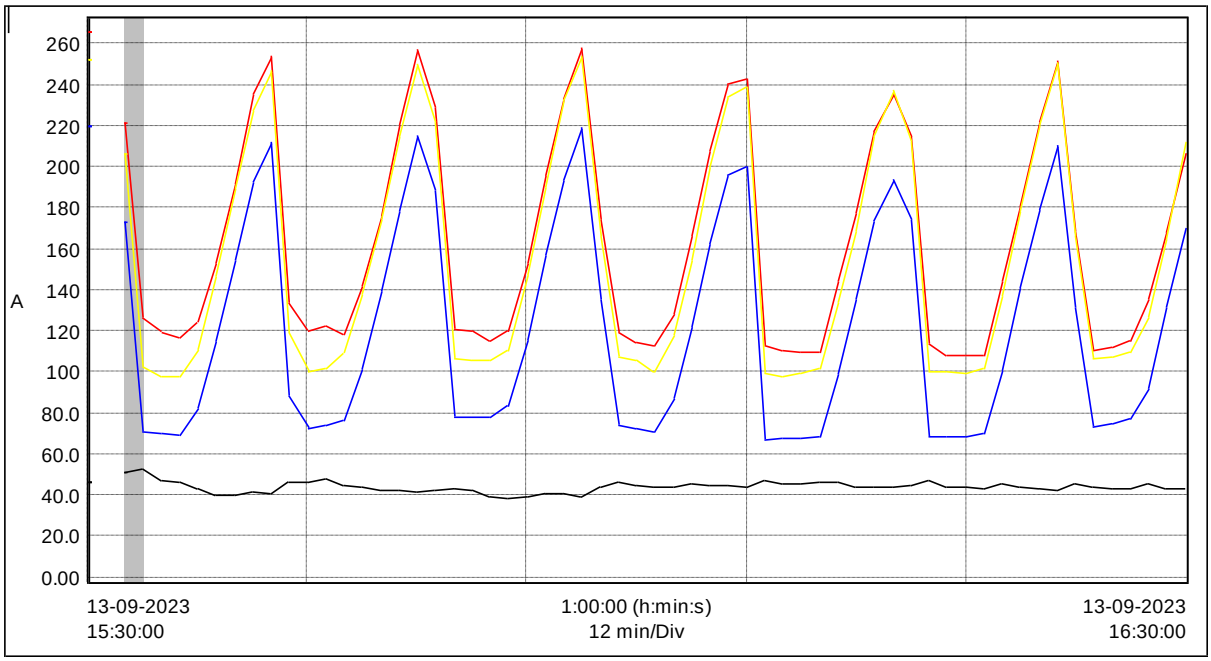
Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	423.8	418.9	429.3	V
U23	423.3	418.1	428.4	V
U31	418.4	413.6	423.1	V
Current				
I1	240.1	194.2	306.8	A
I2	143.8	107	188.7	A
I3	172.7	128.6	215.4	A
IN	32.8	22	41.2	A
Active Power				
P1	57.91	50.79	71.3	kW
P2	34.35	30.65	40.17	kW
P3	41.93	34.92	48.45	kW
PT	134.2	117	159.3	kW
Apparent Power				
S1	58.17	51.02	71.57	kVA
S2	34.66	30.95	40.42	kVA
S3	42.24	35.28	48.68	kVA
ST	135.1	118	160	kVA
Power Factor				
PF1+	0.996	0.994	0.997	
PF2+	0.992	0.985	1	
PF3+	0.992	0.988	0.996	
PFT+	0.993	0.992	0.996	
Total Harmonic Distortion				
U12-THD	1.631	1.5	1.75	%
U23-THD	1.633	1.5	1.81	%
U31-THD	1.633	1.47	1.78	%
I1-THD	4.96	5.54	6.62	%
I2-THD	4.86	3.63	6.7	%
I3-THD	3.17	1.86	4.81	%
IN-THD	3.04	1.5	5.93	%

3.4.18. Auditorium Transformer

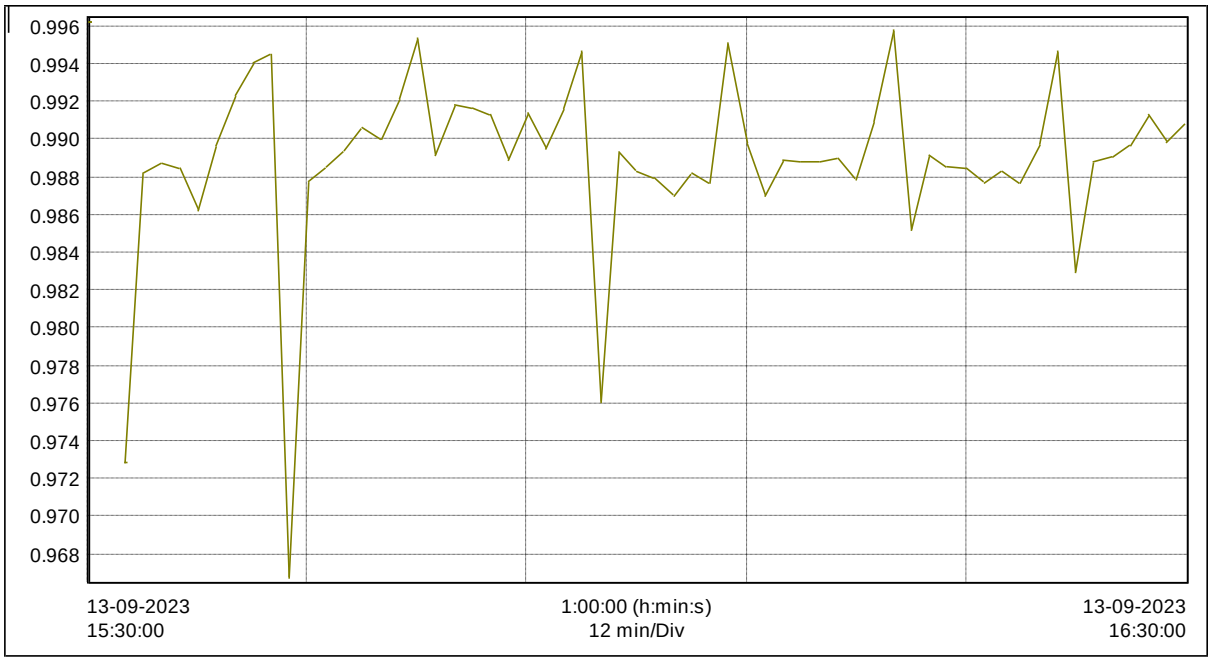
3.4.18.1. Voltage Profile



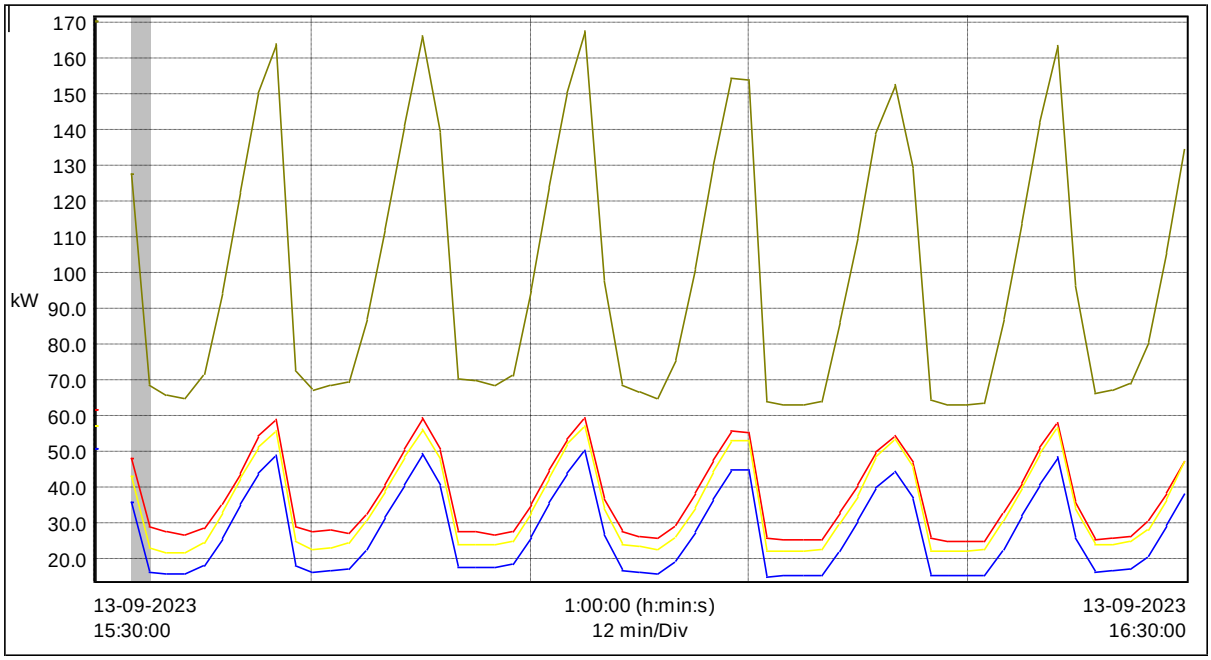
3.4.18.2. Current Transformer



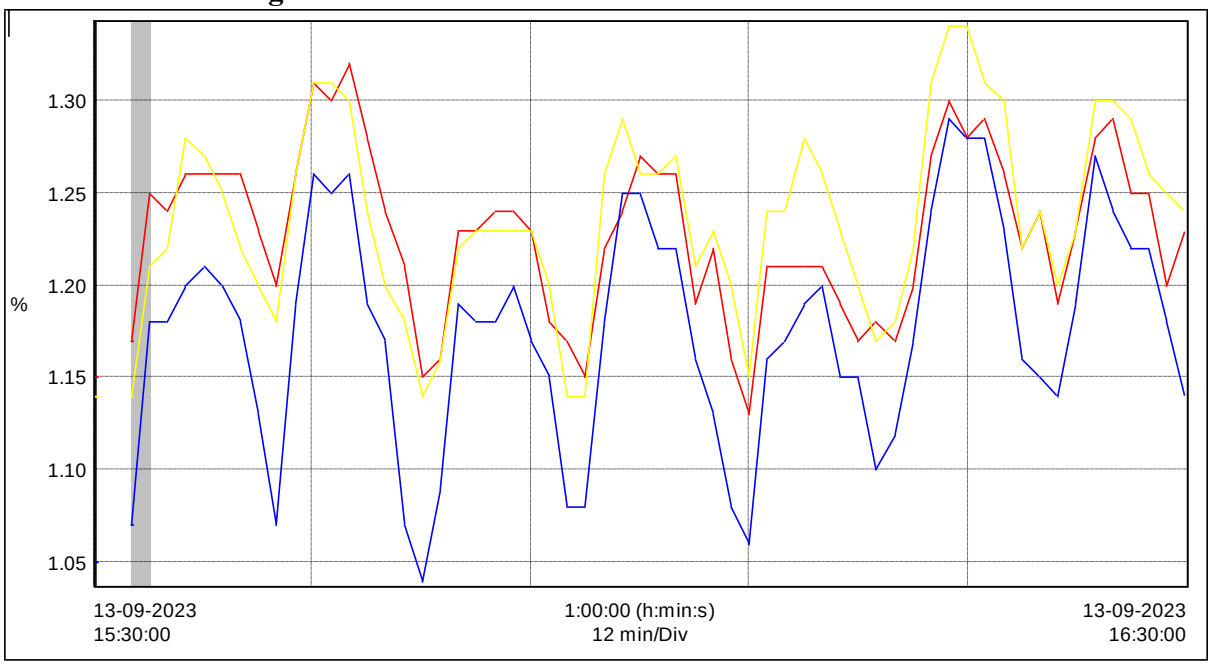
3.4.18.3. Power Factor



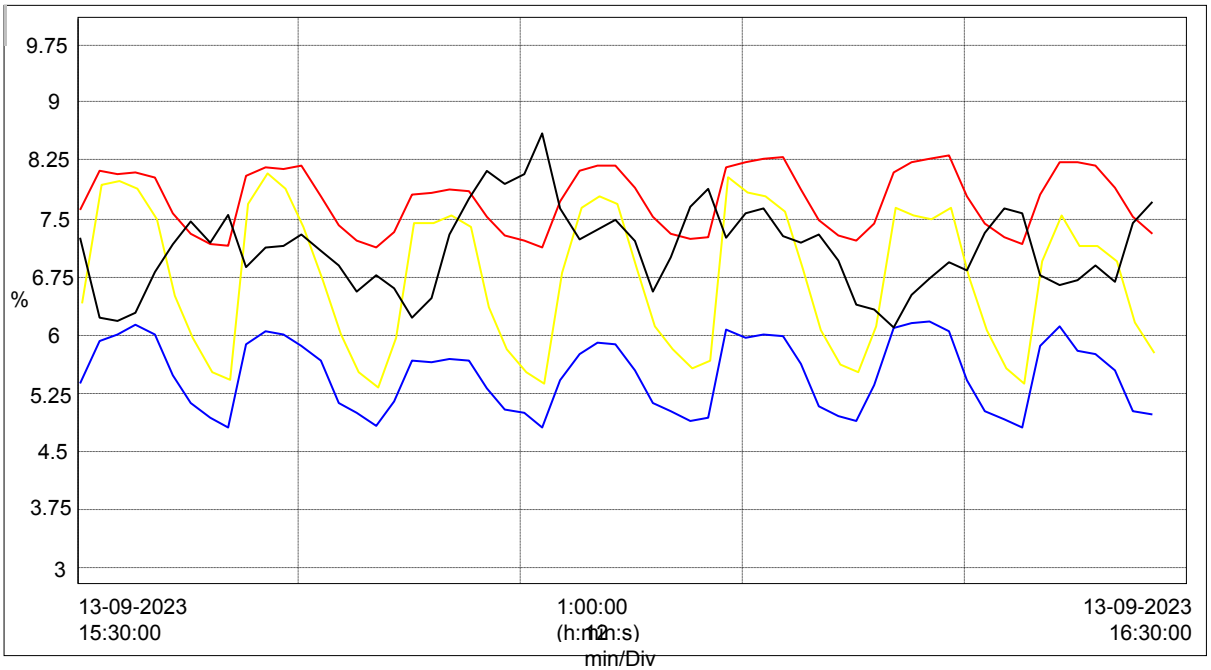
3.4.18.4. Power Profile



3.4.18.5. Voltage Harmonics



3.4.18.6. Current Harmonics



Parameters	AVG	MIN	MAX	UoM
Voltage				
U12	402.9	400.9	405.3	V
U23	399.2	397.3	401.6	V
U31	401.6	399.7	404	V
Current				
I1	172	106.5	270.2	A
I2	165	95.77	259.4	A
I3	132.8	64.45	222.8	A
IN	20.8	16.2	34.6	A
Active Power				
P1	37.7	25.01	61.74	kW
P2	34.9	22.15	57.48	kW
P3	27.63	15.38	51.05	kW
PT	100.2	63.17	170.2	kW
Apparent Power				
S1	37.99	25.22	61.88	kVA
S2	35.21	22.34	57.8	kVA
S3	28.09	15.67	51.32	kVA
ST	101.3	63.91	170.8	kVA
Power Factor				
PF1+	0.993	0.969	0.999	
PF2+	0.992	0.969	0.999	
PF3+	0.983	0.946	0.995	
PFT+	0.989	0.967	0.996	
Total Harmonics Distortion				
U12-THD	1.228	1.13	1.32	%
U23-THD	1.235	1.14	1.34	%
U31-THD	1.173	1.04	1.29	%
I1-THD	7.65	6.99	8.25	%
I2-THD	6.62	8.13	8.11	%
I3-THD	5.55	6.31	6.2	%
IN-THD	6.88	6.15	8.51	%

3.5. SUGGESTIONS & OBSERVATIONS

Voltage Harmonics: From the above Analysis the average voltage.

Total Harmonic Distortion (THD) for voltage are within the limit of 5%.

Current Harmonics: From the above Analysis the average Total Harmonic Distortions (THD) for currents are within the limits (8%) for all the Transformers.

SI. No	Description of Sub Station	Description of Transformer	Primary or Secondary	Load Balance	Voltage Harmonics	Current Harmonics	Neutral Current % (Respect to total current)	PF
I	SUB Station 1	Transformer 1	P	OK	Within Limits	Within Limits	3.1	OK
			S	OK	Within Limits	Within Limits	3.4	OK
		Transformer 2	P	OK	Within Limits	Slightly High	1.4	OK
			S	OK	Within Limits	Within Limits	4.8	OK
II	SUB Station 1A	Transformer 1	P	OK	Within Limits	Within Limits	1.9	OK
			S	OK	Within Limits	Within Limits	3.4	OK
		Transformer 2	P	OK	Within Limits	Within Limits	2.2	OK
			S	OK	Within Limits	Within Limits	3.2	OK
III	SUB Station 2	Transformer 2	P	OK	Within Limits	Within Limits	4.1	OK
			S	OK	Within Limits	Within Limits	5.4	OK
IV	SUB Station 3A	Transformer 1	P	OK	Within Limits	Within Limits	0	OK
		Transformer 2	P	OK	Within Limits	Within Limits	3.7	OK
			S	OK	Within Limits	Within Limits	0.8	OK

SI. No	Description of Sub Station	Description of Transformer	Primary or Secondary	Load Balance	Voltage Harmonics	Current Harmonics	Neutral Current % (Respect to total current)	PF
V	SUB Station 3	Transformer 1	P	OK	Within Limits	Within Limits	2.1	OK
		Transformer 2	S	OK	Within Limits	Within Limits	6.5	OK
VI	SUB Station 4	Transformer 2	P	OK	Within Limits	Within Limits	5.5	OK
	SUB Station 4A	Transformer 2	S	OK	Within Limits	Within Limits	5.9	OK
VII		Auditorium Transformer	S	OK	Within Limits	Within Limits	4.4	OK

4. Pumps

Pump performance parameters such as power input, flow rate and head measurements taken in all possible locations for the Pumps above 15 HP. The electrical data recorded and performance details arrived at on these pumps are given below:

			Auditorium Pumps		
Pump name		UOM	**Pump-1**	**Pump-2**	**Pump-3**
Operating			√	√	X
	Drive Type	-	Motor	Motor	Motor
	Service Area	-	Auditorium	Auditorium	Auditorium
	VFD		No	No	No
Rated	Head	Meter	20	20	20
	Flow	Cu M/Hr	109	109	109
	Motor	kW	11	11	11
	Motor Efficiency	%	91	91	91
	Design Efficiency	%			
Measured Parameters	Suction valve opening	%	100%	100%	Standby
	Discharge valve opening	%	100%	100%	
	Suction Pr. (Ps)	kg/cm2	0.1	0.1	
	Discharge Pr. (Pd)	kg/cm2	2	2	
	Flow (Q)	Cu M/Hr	80	79	
	Total Motor I/P	kW	9.50	10.00	
Evaluated Parameters	% Motor Loading	%			
	Total Head H = Pd - Ps (mtr)	Mtr	19	19	
	Pump Hydraulic Power Ph = Q*H*ρ*g/3600	Kw	4.1	4.1	
	Overall Efficiency η = Ph/P	%	44%	41%	

			Block A Chiller Pumps	
Pump name		UOM	**Pump-1**	**Pump-2**
Pump number (Tag Number)				
Operating			√	√
	Drive Type	-	Motor	Motor
	Service Area	-	Block A	Block A
	VFD		No	No
Rated	Head	Meter	30	30
	Flow	Cu M/Hr	45	45
	Motor	kW	7.5	7.5
	Motor Efficiency	%	90.5	90.5
	Design Efficiency	%		
Measured Parameters	Suction valve opening	%	100%	100%
	Discharge valve opening	%	100%	100%
	Suction Pr. (Ps)	kg/cm2	1.9	1.9
	Discharge Pr. (Pd)	kg/cm2	5.1	5.1
	Flow (Q)	Cu M/Hr	38	33
	Total Motor I/P	kW	7.00	6.20
Evaluated Parameters	% Motor Loading	%	93%	83%
	Total Head H = Pd-Ps (mtr)	Mtr	32	32
	Pump Hydraulic Power Ph =Q*H*ρ*g/3600	kW	3.3	2.9
	Overall Efficiency η = Ph/P	%	47%	46%

5. Blowers

There are total 6 Blowers installed in the facility. Out of which 4 are used for aeration in the Old and New STPs and 2 were installed on the canteen and used as an exhaust for the kitchen.

During the course of audit, we have made measurements of the pressure, velocity of the air and power measurements were made for the installed blowers.

S. No	Parameters	UOM	New STP Blower 1	New STP Blower 2	Centrifugal Blower-1 Canteen	Canteen Blower 2
1	Temperature of the air/gas	^oC	27.00	27.00	27.00	27.00
2	Density of air/Gas,	kg/m^3	1.16	1.16	1.16	1.16
3	Suction Pressure (Pitot)	mm H_2O	-38.00	-38.00	-15.00	-2.65
4	Discharge Pressure (Pitot)	mm H_2O	412.00	421.00	520.00	536.00
8	Velocity of air/gas	m/s	18.00	18.00	19.44	7.10
9	Area of the Duct	m^2	0.03	0.03	0.67	0.01
10	Flow of air/gas	m^3/sec	0.58	0.58	12.96	0.07
		m^3/hr	2090.32	2090.32	46665.19	255.60
		TPH	2421.61	2421.61	54061.03	296.11
		CFM	1230.30	1230.30	27465.73	150.44
12	Rated Power of motor	kW	10.00	10.00	15.00	15.00
13	Actual Power of the motor	kW	9.94	8.90	12.00	11.20
14	Rated Efficiency of the motor	%	89.90	89.90	88.07	88.07
	Input power to Blower		8.9	8.0	10.6	9.9
15	Pressure developed by the Blower		450.00	459.00	535.00	538.65
16	Blower Static Efficiency		51.4	58.6	50.6	54.6

S. No	Parameters	UOM	New STP Blower 1	New STP Blower 2	Centrifugal Blower-1 Canteen	Canteen Blower 2
15	Percentage of Motor loading	%	89.36	80.01	70.46	65.76
16	Specific Energy Consumption	kW/tone	0.00	0.00	0.00	0.04

6. Observations from the Measurements

6.1. Transformers

The overall performance of the transformers is good particularly the voltage levels on both HT and LT sides, equal loading on all the three phases of the Transformers, Power factor levels of each Transformer etc. The observations are as under.

(a) It was observed from the transformers' measurements that average Voltage and Current Harmonics in all the of the transformers are within limits.
(b) In Substation 3A Transformer 1 the Power Factor is on lower side which can be increased by increasing the load on the Transformer.
(c) Check the condition of the earthing of all the Transformers
(d) Ensure that the PF and Harmonic levels guaranteed by the suppliers for the new energy saving equipment being procured (Like LEDs, BLDC Fans etc) are within the permissible limits.
(e) Ensure equal loading in all the three phases to the maximum possible levels.

6.2. Pumps

It was observed that the efficiencies of all the 4 No Chiller pumps are on lower side mainly due to low output (Flow) from the pumps. The reasons for lower efficiency of the pumps are

(a) Choking of Suction strainer
(b) Worn out impeller
(c) Partial opening of suction/discharge valves
(d) Improper functioning of NRV installed in the discharge line

Carrying out Overhauling of the pumps as recommended by the OEM and attending the above issues will improve the efficiency of the pump by a margin of 10 to 12%.

6.3. Blowers

From the measurements it was observed that the efficiency of the blowers is varying from 50 to 60%. Normally the efficiency of blowers will be around 70 to 75%. Since during the measurements the scoop is partially open the efficiency will be slightly lower than the design efficiency. However, the efficiency of the blowers can be slightly increased by carrying out Overhauling of the Blowers as recommended by the OEM.

7. Environment Management Assessment

7.1. Water Management

Seven groundwater recharge points are created across 200 acres of the campus to replenish the groundwater resources. The surface runoff water during monsoon is directed to a designated area and is allowed to infiltrate and percolate into the ground resulting in groundwater recharge. Several other recharge points will be constructed across the campus in the coming years to increase the quantity of groundwater replenishment. All overhead tanks and water coolers within the campus are fitted with floats to shut the water supply and avoid overflow. Apart from the above, the following aspects are also considered for arriving at the best water management:

1. VFD-based hydropneumatics system.
2. Pumps & equipment selected on “best” energy efficiency point.
3. Use of low-flow fixtures.
4. Using treated water with BOD less than 10 ppm and COD less than 50 ppm from STP for flushing and irrigation.

7.2. Different sources of water for the campus

- HMWSSB- Metro water
- In-house Bore well Water
- Outside Tanker water supply (in case of a breakdown in metro water).
- STP-treated water
- Rainwater Harvesting

The details of the eleven bore wells (BW) spread across the campus are given in Table 6.1.

Table 6.1. Details of bore wells within the campus.

S. No	Bore well No	Location	Water Level
1	BW-01	Near Main gate	700 Feet
2	BW-02	Near Valmiki Bhavan	650 Feet
3	BW-03	Near Viswakarma Bhavan	750 Feet
4	BW-04	New C-5 staff quarters	650 Feet
5	BW-05	Near C8 staff quarters	550 Feet
6	BW-06	Near Amul parlour	730 Feet
7	BW-07	Near Volleyball court	600 Feet

8	BW-08	Near Gautham Bhavan	600 Feet
9	BW-09	Near NAB	850 Feet
10	BW-10	Near Mess-1	650 Feet
11	BW-11	Near Labour camp	550 Feet

Twelve water storage facilities spread across the campus to collect the water from the different sources, and subsequently supply for different uses. The storage capacities of these water storage facilities are detailed in Table 6.2.

Table 6.2. Details of water storage facilities within the campus.

S. No	Tank Location	Storage Capacity in Litres
1	Near main cafeteria	70,092
2	Clock Tower	90,000
3	Near PhD Quarter	39,648
4	Near Post Office Gate	64,230
5	Near BITS Coop	3,60,090
6	Near Main Gate	61,058
7	Pooja Ground	1,06,200
8	Gym ground	50,976
9	New Faculty Housing	93,456
10	Plumbing Zone-1	3,50,000
11	Plumbing Zone-2	2,20,000
12	Plumbing Zone-3	7,00,000

The total capacities (in litres) of the different water tanks spread across the campus for distributing water are presented in Table 6.3.

Table 6.3. Storage capacity details of water tanks within the campus.

S. No	Tank details	Storage Capacity in Litres
1	Total capacity of PVC Tanks in Faculty Housing & Medical centre/ Connaught Place (shopping centre)	2,28,000
2	PVC storage facility at the Academic block	15,000
3	Total capacity of RCC underground storage tanks	54,32,000
4	Capacity of OHT on the institute area	2,16,400
5	Capacity of OHT on the housing area	4,31,400
6	Capacity of OHT on the hostel area	5,00,000
7	Treated water storage tank at the STP	1,78,000

Note: PVC – polyvinyl chloride; RCC – reinforced cement concrete; OHT – overhead tank; STP – sewage treatment plant

Every day, approximately 9,50,000 Litres of water is pumped to various storage tanks within the campus. The daily water usage for domestic and flushing purposes is ~8,30,000 Litres. Around 1,20,000 Litres of water is used daily for irrigation requirements within the campus.

7.3. Water Usage Pattern in the Campus:

The total amount of water used in Litres per day (LPD) by the twelve student hostels within the campus are detailed in table below.

S. No	Hostel name	Quantity of water used (LPD)
1	Gandhi Bhavan	15,813
2	Budh Bhavan	28,719
3	Vyas Bhavan	25,438
4	Krishna Bhavan	25,000
5	Ram Bhavan	32,188
6	Shankar Bhavan	29,281
7	Gautham Bhavan	17,030
8	Viswakarma Bhavan	53,188
9	Valmiki Bhavan	26,156
10	Meera Bhavan	25,500
11	Malaviya Bhavan	26,906
12	Ganga Bhavan	13,594

7.4. Storage of harvested rainwater:

Three reinforced cement concrete (RCC) tanks are constructed at three locations within the campus to store the harvested rainwater. The three tanks are as follows:

1. RCC Tank near E block (Capacity approx. 20,000 Liters)
2. RCC Tank near D block (Capacity approx. 20,000 Liters)
3. RCC Tank near Gandhi Bhavan (Capacity approx. 12,000 Liters)

7.5. Daily water consumption:

The details pertaining to daily water consumption within different buildings of the campus are given in Table below.

S. No	Hostel name	For domestic use (LPD)	For flushing use (LPD)	Gross use (LPD)
1	Old & New Academic Blocks	78,500	0	78,500
2	Old Faculty Housing	1,53,000	0	1,53,000
3	New Faculty Housing	1,44,000	80,000	2,24,000

S. No	Hostel name	For domestic use (LPD)	For flushing use (LPD)	Gross use (LPD)
4	Hostels	3,12,811	0	3,12,811
5	Mess-1	25,467	0	25,467
6	Mess-2	24,467	0	24,467
7	Cafeteria	3,000	0	3,000
8	Other food outlets & facilities	9,300	0	9,300
Total		**7,50,545**	**80,000**	**8,30,545**

7.6. Irrigation water Network

Irrigation water for landscape use (to maintain lush green gardens) within the campus is of domestic quality and is sourced from the in- house sewage treatment plant (STP). It has acceptable parameters as per governing standards. An image of the sprinkler irrigation system applying water on to the football field is given as Figure 6.1.

Figure 6.1. Typical sprinkler irrigation system employed in the campus.

7.7. Recycling of water and Sewage treatment plant

Domestic waste generated in the campus at residences, hostels, messes, etc., is segregated at source into dry and wet waste. The biodegradable portion of the waste is then processed to maintain a natural balance in the environment and make optimum utilization of waste available. The two Sewage Treatment Plants (STPs), with a capacity of 600 KLD & 450 KLD each, are working round the clock to treat the sewage generated by campus residents. Recycled water is sourced from the in-house STP for the New faculty quarters for flushing and to the other campus buildings for irrigation. The treated effluent for flushing is obtained

after tertiary treatment at STP. The tertiary treatment is designed to produce treated odourless effluent with acceptable chemical /bacteriological parameters per Telangana pollution control board regulations. The pipeline network for supplying the treated effluent for flushing purposes in the twelve Hostels has been completed and will be in operation shortly. The sludge generated at STP is transferred to the drying bed near STP, used as manure within the campus after drying.

The treated effluent from the STP is currently in use for two purposes:

- Flushing (80,000 LPD)
- Gardening (1,20,000 LPD)

The quality parameters of treated water like BOD, COD, TSS, pH, TDS is carried out periodically through an Annual Maintenance Contract vendor.

A few snapshots of the aeration tank of the STP with 450 KLD capacity are given as Figure 6.2.

Figure 6.2. Aeration tank of the 450 KLD STP

The layout of the 600 KLD STP employing the membrane bed bioreactor (MBBR) technology for the secondary treatment of wastewater is given as Figure 6.3.

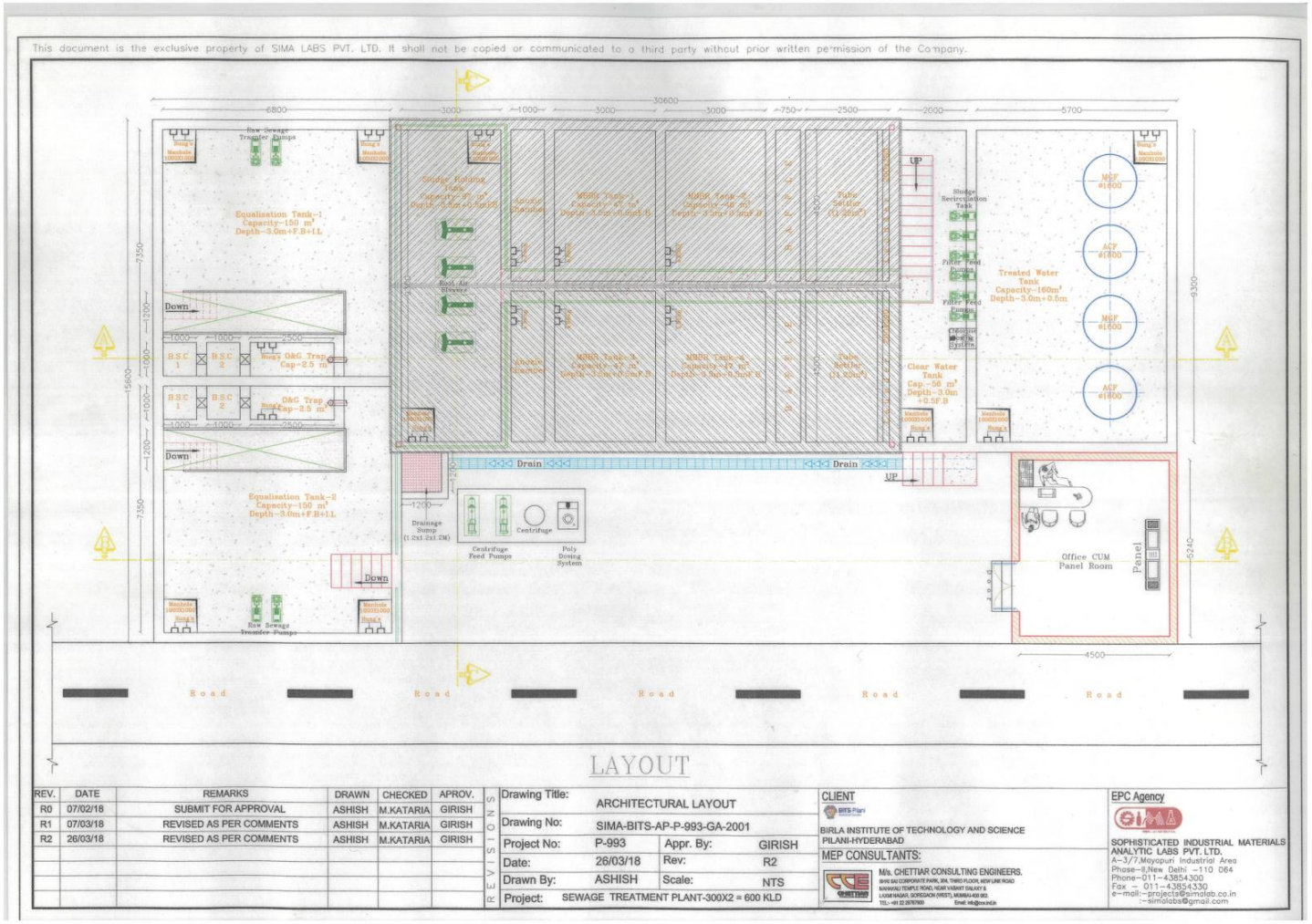


Figure 6.3. Layout of the 600 KLD STP in operation within the campus.

The layout of the 450 KLD STP employing the MBBR technology is given as Figure 6.4.

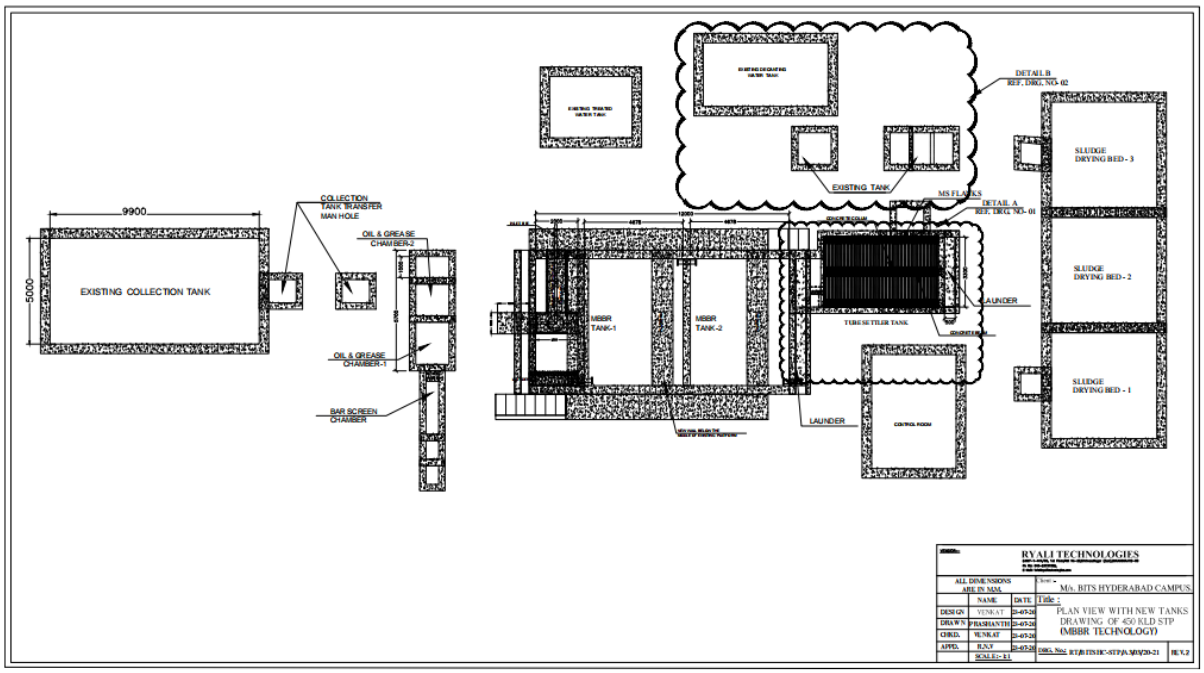


Figure 6.4. Layout of the 450 KLD STP in operation within the campus.

7.8. Best practices in water management:

- ✔ 100 % utilization of reclaimed water for flushing and irrigation
- ✔ Pumps and equipment selected on best energy efficient point.
- ✔ Use of low-flow fixtures to reduce water flow and thereby control in water usage.
- ✔ Insulation of hot water pipes.
- ✔ Master switches installed in each classroom.
- ✔ CRT Monitors being replaced with LCD/LED Monitor
- ✔ Thermostat controlled cooling System
- ✔ New academic Block is equipped with a rainwater management system with channelized drain and pipe network, rainwater holding tank, pumps, and groundwater recharge pits.
- ✔ Rainwater harvesting and recharge pits are provided at numerous locations on the campus.

7.9. Waste Management and Food waste management

The campus has total two messes, and the food preparation is carried out in both. The messes are operated by outsourced agencies. The two agencies operating Messes 1 and 2, respectively are:

1. Aditya Food Management
2. Shakthi's Kitchen

FSSAI license is verified for both. Reverse Osmosis (RO) water is provided to both messes and the RO water testing is carried out periodically by an external agency.

Approximately 5,000 students have daily meals (breakfast, lunch, and dinner) from the two messes. The total food prepared daily is approximately 3,900 to 4,000 kg. Around 1,000 – 1,200 kg is the total food waste generated daily. The original plan was to feed the food waste into the biogas plant (existing) for biogas production. However, the existing biogas plant is currently not in operation. We propose to relocate the same to a new location where a new biogas plant is currently under construction. The food waste is being handed over to a local authorized vendor.

7.10. Biomedical waste management

The following colour-coded bins are adopted for collecting and segregating the biomedical waste generated within the campus: yellow, red, white, and blue. The details of the biomedical wastes collected in the four coloured bins are given below in detail.

Yellow bin:

- Pathological waste.
- Soiled (infectious) waste.
- Medical chemical waste.
- Clinical lab waste.
- Pharmaceutical waste (discarded/expired medicines and drugs).

Red bin:

- Contaminated waste (recyclable).

White (or translucent) bin:

- Sharp materials.

Considering the nature of this hazardous medical waste, puncture-proof, leak-proof, and tamper-proof containers are used. As for disposal, the case is the same as with the biomedical waste falling under the red category. A medical waste shredder is used.

Blue bin:

- Medical glassware waste.

The details of the quantity of biomedical waste collected and segregated from the campus between July and December 2022 are detailed in Table 6.6.

Table 6.6. Month-wise quantity of biomedical waste (all colour-coded bins) collected and segregated.

Year	Month	Quantity of waste collected and segregated (kg)
2022	July	23
	August	19
	September	22
	October	47
	November	54
	December	17

Once collected and segregated, the biomedical waste is disposed to the Pollution Control Board Authorized Agency.

7.11. Electronic waste management

Electronic waste such as computers, telecommunications equipment, consumer electronic devices, solar panels, TVs, monitors, and screens are collected and segregated separately. Once collected and segregated, it is disposed to the Pollution Control Board Authorized Agency. Annual Report on e-waste is being submitted to PCB. LED bulbs are managed under the buy-back system.

7.12. Oil and grease-related waste management

This waste is collected separately and then disposed of through agencies authorized by the Pollution Control Board.

7.13. Plastic and Paper waste management

Currently, no segregation of plastic and paper waste is in practice. The municipality currently collects waste under this category.

7.14. Observations and Future Plans

At present, there are several measures in place to minimize the generation of different types of waste on campus. As the campus undergoes further planned expansion, these measures will evolve to ensure maintenance of the current standards of waste management. Additional measures shall be adopted to meet the requirements of sustainability to ensure reduction, reuse and recycling of the waste generated on campus.

8. GREEN MANAGEMENT

Trees play an important ecological role within the urban environment, as well as support improved public health and provide aesthetic benefits to campuses. In one year, a single mature tree will absorb up to 48 pounds of carbon dioxide from the atmosphere, and release it as oxygen. The amount of oxygen released by the trees of the campus is good for the students and staff in the campus. We need to realize the importance of trees in and around the campus as they significantly contribute towards making the air cleaner for us. The BITS – Hyderabad campus sustains a luxuriant plant diversity ranging from trees, grasses, herbs, shrubs, creepers ornamental plants, palm and seasonal flowers.

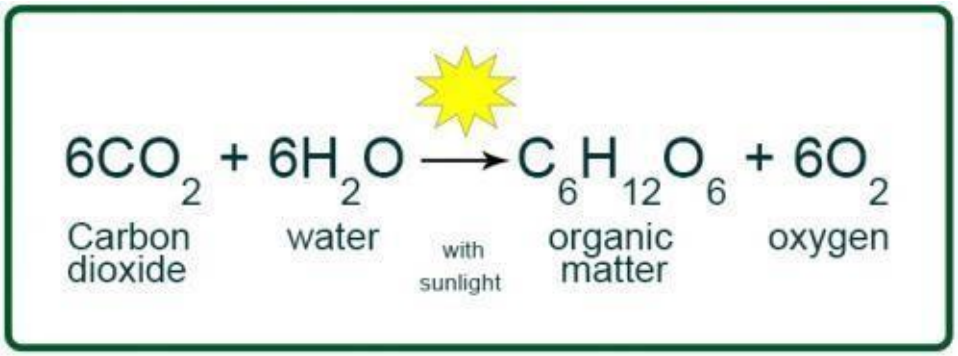
Newly constructed academic blocks of Hyderabad campus show more green cover around them with particular focus on environment.

8.1. Benefits of plants

- Constantly seeing and being around plants helps people feel calmer and more relaxed, thus decreasing levels of stress and anxiety
- Increases occupational health and safety by circulating fresh air
- Reduce the toxicity of the air by neutralizing the carbon-di-oxide
- Enhances the creativity and improve the innovative atmosphere

- It provides more cooling effect during summer seasons
- Overall, it Increases productivity and efficiency in many ways

The ultimate benefit of plants is the air that we breathe. Our ancient Earth likely contained very little free oxygen, but scientists estimate that about 2.5 billion years ago the evolution of photosynthesis, whose by-product was oxygen, was the ultimate cause of the rise of oxygen levels in our atmosphere as shown in Fig. 7.2. Modern levels of oxygen in the atmosphere allow us to breathe easy, thanks to photosynthesis. Today, the levels of oxygen in our atmosphere are not much of a concern, but the rapid rise of carbon dioxide is. However, another benefit of photosynthesis is the absorption



The chemical equation for the process of photosynthesis illustrating the consumption of carbon dioxide and releasing of oxygen as a poduct.

of carbon dioxide from the air which ultimately transforms into carbon (organic matter) stored in plant tissues (Fig. 7.2). If the carbon is stored long-term, such as in trunks of long-lived trees, this process is called "carbon sequestration." Many scientists are looking at ways to use plants to sequester carbon in order to mitigate or defer global warming. Fig. 7.2 shows the chemical equation of photosynthesis showing how six carbon dioxide molecules and six water molecules in the presence of sunlight are converted into one molecule of organic matter and six molecules of oxygen.

8.2. Green Cover Statistics and Analysis

Table 7.1 provides an overview of green cover statistics of Hyderabad campus and other relevant details. Other information such as number and types of indoor and outdoor plants are in the campus. Overall, perspective on the green cover analysis of the campus is given in number for better understanding.

Green Cover Statistics of Hyderabad Campus (in numbers)		
Green Cover Stats	Number of Outdoor Plants: 53035	Number of Ornamental Indoor Plants: 1252
Total campus area: 8,09,370 Sq.m. Green cover: 1,00,000 Sq.m. Green cover (%): 12.40 % Target percentage: 15 % by 2025 Few initiatives: • seasonal plantation being done every year • maintaining existing greenery intact	• Areca palm (Dypsis lutescens) • Golden duranta(Duranta erecta) • Exora (Ixora coccinea) • Indian Copperleaf (Acalypha indica) • Indian shot (Canna indica) • Frangipani (Plumeria) • paperflower(Bougainvillea) • Madras Kanakambaram (Crossandra infundibuliformis) • weeping fig (Ficus) • Hibiscus (Hibiscus rosa-sinensis)	❖ Spider (Chlorophytum Comosum) ❖ Dumb cane (Dieffnbachia Amoena) ❖ ZZ plant (Zamioculcas Zamiifolia) ❖ sweetheart plant (Philodendron) ❖ Dragon tree (Draceaena Marginata) ❖ Croton (Euphorbiaceae) ❖ Rubber plant (Ficus elastica) ❖ Chinese evergreen (Aglaonema modestum) ❖ Ferns (Polypodiophyta)

8.3. Health and Environmental Benefits of Indoor Plants:

Table 7.2 shows the health and environmental benefits of various indoor plants used in Hyderabad campus. The indoor plants are commonly used for their aesthetics benefits but they also have vital role reducing airborne pollution. The right choice of plants can be an excellent way of improving indoor air quality and general health. Local landscape contractor can be contacted for supply and rotation of these plants. VOC stands for Volatile organic compounds, emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects.

Table 7.2. The health and environmental benefits of various indoor plants used in Hyderabad campus

Plants	VOC it removes	Indoor source of VOC's	Plant care
 **Aloe Vera**	Formaldehyde, Trichloroethylene and Benzene	Chemical based cleaners and paints	Easy to grow with enough sunlight
 **Bamboo Plant**	Formaldehyde, Trichloroethylene and Benzene	Paints, Plastics, Wood products etc.	Thrives under low light conditions as well as easy to maintain
 **Chinese Evergreen**	Benzène	Paint	Low maintenance plant that prefers lowlight conditions.
 **English Ivy**	Formaldéhyde, Benzène, Air borne fecal matter particles	Wood, Paper products, Air borne fecal – matter particlesfrom pests	Easy to maintain
 **Parlor Palm**	Purifies indoor air		Easy to maintain

8.4. 7.4. Carbon Foot Print

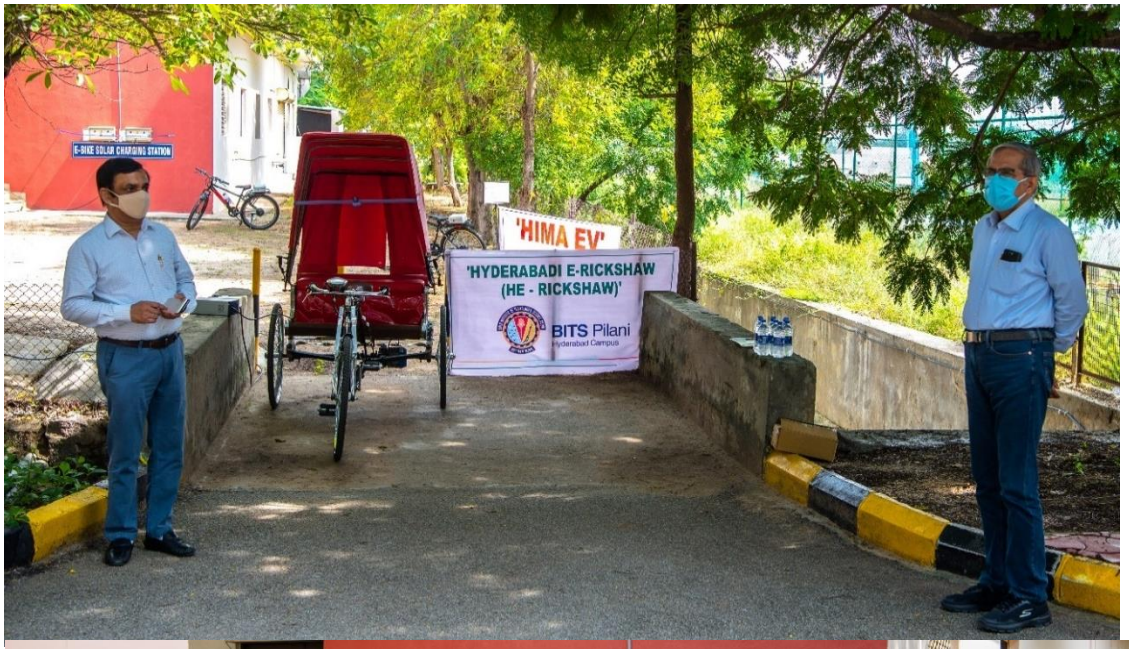
Fossil fuels (such as petrol, diesel) contribute significantly to environmental pollution through emission of greenhouse gases into the atmosphere mainly as carbon dioxide. Vehicular emission is the main source of carbon emission in the campus, hence to document the various means of transportation that is practiced by the university members is important.

April 2023 - Vehicle Movement Data inside Hyderabad Campus (in numbers)	
Four wheelers	9000
Two wheelers	12000
Auto-Rickshaw	2000
Bicycles	18000
Total movement	41,000
Percentage of bi-cycle movement: 44 %. Hence, more cycle movement is encouraged.	
No of electric cars in the campus	
No of electric scooters in the campus	

8.5. Routine Green Initiatives and Practices:

- ✓ Every year university celebrates World Environment Day and World Water Day in the campus. The main focus of these programs is to provide awareness to the students about the importance of the environment, its conservation and sustainable use of environmental resources.
- ✓ Many plants are planted on this kind of occasions every year to increase the green cover in the campus.
- ✓ The campus maintains about 25000 sqm area of landscape with lush green gardens with a rich collection of flora and fauna.
- ✓ Cycle movement encouraged. All students are allowed only to use the Cycles.
- ✓ To minimize the traveling time and distance the hostels are within the premises only.
- ✓ Car Pooling is encouraged.
- ✓ Special charging assistances are provided for EVs and electric scooters.
- ✓ Students are highly discouraged to use any fossil fuel-based vehicles inside the campus. Thereby, major usage of petrol two-wheelers and cars are prevented inside the campus.

8.6. Photos of Various Green Initiatives Implemented in Hyderabad Campus



9. Energy Conservation Measures

9.1. Installation of Demand Controller

Present System

During the Electricity Bill Analysis, it is observed that the three Months the demand has crossed the maximum demand provided by the Electricity board.

Proposed System

It is recommended to Install the Demand Controller and set to 90% so that the non-required loads during the maximum load utilisation.

SI. No	Description	UoM	Values
1	Additional demand used	kVA	378
2	Per kVA Penalty Paid	Rs	950
3	Total Penalty Cost	Rs	359100
4	Demand Controller and Installation Cost	Rs	300000
5	Estimated % Energy Savings after Installation	%	5%
6	Annual Energy Consumption	kVAh	9532595
7	Energy Savings	kVAh	476630
8	Cost of Unit	Rs	8.06
9	Annual Monetary Savings	Rs	4200736
10	Payback	Months	1

The total energy savings with the installation of demand controller will be 476630 kVAh and Annual monetary savings are 42 Lacs. The Cost of Demand Controller including installation will be 3 Lacs and Payback is 1 Month.

9.2. Installation of Energy Management System with condition-based monitoring system

Proposed system

It is proposed to install energy monitoring system powered by IoT and AI in order to increase productivity of the systems installed and increase life cycle and efficiency.

Sl. No	Description	UoM	Values
1	Current Annual Energy Consumption	kVA	9532595
2	Estimated % Energy Savings after Installation	%	3%
3	Annual Energy Savings	kVAh	285978
4	Cost of Unit	Rs	8.06
5	Monetary Savings	Rs	2304981
6	Cost of Energy Management System	Rs	2500000
7	Payback	Months	13

Vendor Details

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