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Power Quality Audit in SAPC

K.Sathiyasekar[1], N.Ravikumar[2], R.Kamalakannan[3], G.Vignesh[3], E.Visithra[4], T.Sacriyas[5]

Professor, Department of EEE, S.A. Engineering College, India [1],

Assistant Professor, Department of EEE, S.A. Engineering College, India [2,3],

UG Scholar, Department of EEE, S.A. Engineering College, India [3,4,5]

ABSTRACT: This paper is mainly focus on the power quality audit conducted at S.A.Polytechnic College, Thiruverkadu. Nowadays we are facing many power quality issues like voltage sag, voltage swell, harmonics, interruption, unbalance, voltage surges, flickering,etc.These problems results in energy loss in electrical machines like motor,generator,data loss, improper operation of sensitive equipments stoppage, increase in occurance of resonance,over heating of cables and all electrical equipments, reduction in life of equipment. Fluke 435 is used to measure the power quality issues which is user interactive. It helps to predict, prevent and measures the power and rectifies the energy losses due to harmonics, unbalance,etc.

KEYWORDS: Harmonics, Power quality analyzser, neutral current, voltage sag, and voltage swell, energy loss

I INTRODUCTION

Power quality plays a vital role in utility system. Poor power quality leads to loss and malfunction of the electrical equipment. In most of the Africa, especially in Nigeria they not have pure power supply there will be some loss due to the power quality disturbances. [1]Firstly, power quality means that the electricalnetwork or grid's ability to provide or supply a stable power. [2]It is defined as provision of voltages and system design so that user of electric power can utilized electric energy from the distribution system successfully, without interference on interruption.[3]. It is also defined as the variation in voltage and current from alternating sinusoidal waveform.[4].The power quality can be defined as the problem taking place in voltage,current or frequency deviations that results in energy losses in electrical equipments, improper function of sensitive equipment.[5],[6].The power quality deals with the Continuity of the supply and quality of voltage. [7].For economic operation of power system the power quality should be maintained properly. The power quality problems are mainly due to the nonlinear loads, power electronic components like Diodes, transistors, computers, CFCL, motors, transformers, etc.

The various power quality issues are

- Voltage sag
- Voltage swell
- Transients
- Harmonics
- Unbalance
- Interruption
- Flickering

Voltage sag

Voltage sag means the dip or reduction in normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for the time period of 0.5 cycles to 1 minute. The voltage sag is commonly occurs inside the buildings like institutions, residential, hospitals, etc. In residential the voltage sag is mainly due to the starting of refrigerator, air conditioning motors and mixer grinder.

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II. CAUSES OF VOLTAGE SAG

Voltage sag is mainly due to

- starting of the huge motors
- non-linear loads
- faults in transmission lines
- line to ground fault
- lightning
- transformer enerzing
- sudden load change or excessive loads
- laser and copiers
- arc welding machines

Impacts of voltage sag

The voltage sag results in

- loss of efficiency in rotating machines
- malfunction of sensitive equipments
- tripping of relays and circuit breakers
- voltage sag indication in homes
- Lights blinks

- Motors speed reduces and comes to actual speed
- Computers reboot unexpectedly
- Automated devices stop suddenly

Voltage swell

Voltage swell is also called as “voltage surge”. It is defined as the sudden increase in voltage from its normal value for the time period more than one cycle less than few seconds.

Causes of voltage swell

- Lighting is the major cause of voltage swell
- Sudden removal of loads
- Turning off power electronic devices
- Deenergization of huge loads
- Single line to ground fault
- Effects of voltage swell
- The voltage swell results in
- Data loss
- Overheating
- Breakdown of the electrical components

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Harmonics

Harmonics is the multiples of fundamental frequency ie 50Hz or 60Hz.It is also defined as the deviation in voltage or current from its normal form. There are two kinds of harmonics namely odd and even order harmonics.The odd order harmonics that affects the power system equipments than even order harmonics.

Causes of harmonics

The non-linear loads like

- arc welding machines
- Rectifiers
- DC motors
- Arc furnaces
- Uninterrupted power supplies(UPS)
- Switched Mode Power Supplies(SMPS)
- Adjustable speed drives
- Household appliances

Impacts of harmonics

- Chance for occurrence of resonance
- Overheating of cables
- Energy loss
- Electromagnetic interference with communication systems
- Reduces the life period of the electrical equipment

Unbalance

Unbalance is nothing but losing the balance condition. There are two types of unbalance occurs in power system namely,

- voltage unbalance and
    - Current unbalance Transient

It is defined as the sudden rise in voltage or current from is actual value.

Causes of transient
Internal causes

- Capacitance switching
- Ferro resonance
- arcing ground External cause
- Lightning

Impacts of transient

- Shorter lamp life
- Equipment damage

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- PC crashes with memory loss
- Data processing errors

Noise

Noise means that the unwanted electrical signal in power system

Causes of noise

- Improper grounding
- Electromagnetic interference
- Arc welding
- Effects of noise in power system
- Loss of data
- Disturbances on sensitive equipment
- Data processing errors

Reduction of power factor

Increase in the reactive power of the load in relation to its active power

Causes of low power factor

- Addition of excessive capacitive or inductive loads
- fault in capacitor filters or compensation system

Effects of low power factor

- Increased operating cost
- Penalty charges in electricity bill

III. POWER QUALITY MONITORING

 The power quality disturbances affects the quality of power and results in loss. In order to avoid these kinds of problems the power quality monitoring is very important. Power quality monitoring provides the required data about the power quality disturbances .It can be used to determine the need for mitigation equipment and problems can be detected easily before causing widespread damage.

 FLUKE 435-II POWER QUALITY ANALYSER

 It is also called as" Energy Loss Calculator". In order to measure the power quality issues fluke 435-II series is used. It is also used to measure the rms voltage, rms current, load, total harmonic distortion, power factor, efficiency and reliability of an equipment .The fluke 435 is a user interactive device, which is mainly used for three phase system over single phase system. It measures the cost of energy wasted due to power Quality problems

- By using dc clamp AC and DC Input to electronic devices are measured
- Efficiency of an inverter
- Energy loss calculation
- Measures three phase and neutral voltage and current

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III. POWER MEASUREMENT IN S.APOLYTECHNIC COLLEGE

The Dharma Naidu Educational and Charitable Trust started By Thiru.D.Sudharssanam, M.L.A in 1992. Initially it was named it as S.A. Polytechnic after few years it was changed to S.A.Polytechnic College, as per G.O MS No.62dt.13-03-2002.It was started during the academic year 1996-97 with 180 students at annanagar. Later it was shifted to Sundarasolavaram, Chennai-77 during 1997-98 with 300 students. Now the count was increased to 1500.

We conduct the power quality audit in that college to measure the PQ issues and the energy loss to reduce the electricity bill.

Fig.1 Fluke 435-II Power analyzer

The main advantage of the meter over other power quality measuring instrument is that it provides very accurate values and waveforms. On comparing with other instruments fluke PQ analyser his efficient and reliable. We can connect this equipment with transformer, generator. By using the power logger software we can get the output response of the electrical equipment in terms of readings and waveform as well.

Applications of Fluke 435-II PQ analyser

- Energy monetization
- Energy assessment
- Front line Troubleshooting
- Long term analysis
- Load studies
- Detailed loss Analysis
- Unbalance Analysis

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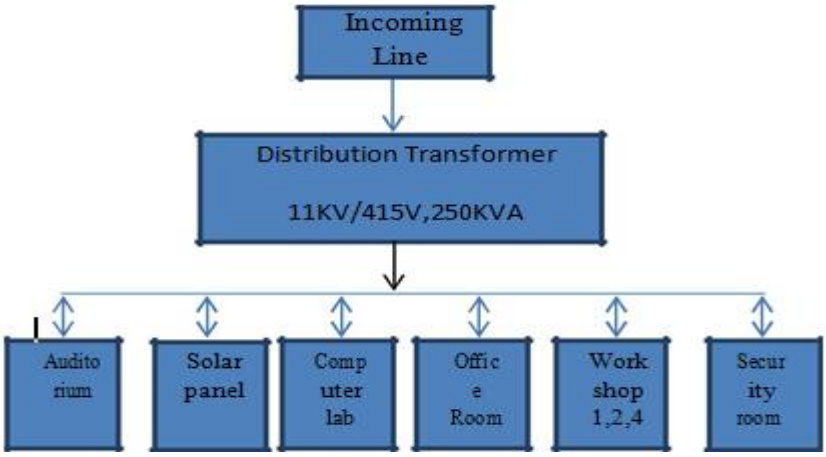

Figure 2 Block diagram

Fig.2 The block diagram shows the voltage distribution of S.A .Polytechnic College. The entire load is divided into six sections as:

- Auditorium and Electrical lab -This block incudes various types of electrical machines like rotating motors and generators.
- Workshop –there are four workshop which have polishing machines, tensile tester, ac Induction motors, Abrushion machines, sensitive drilling and horizontal milling machines.etc.
- Solar panel –Two solar panels are available in that college
- Office Room – various loads like computers, printers, lights and fans are available
- Computer lab –AutoCAD lab, Multimedia lab and BCS lab contains many computers and ups as well
- Security room.

The Power Quality measurement is done at the main HT/LT panel, where the power enters into the main panel. Fluke 435 is connected to the main HT panel in order to measure the power. By power on the meter, initially it ask to do some setup after that it records the voltage, current, THD, power, power factor for each 0.25 sec and gives response curve as well.

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Fig.3.connection diagram of fluke 435-II with HT/LT side of the distribution transformer

RESULTS

TABLE.1: Values recorded by Fluke 435-II power analyzer

Parameters to be recorded	R phase	Y phase	B phase	Neutral
Vrms(star)	231.15	232.40	240.13	0.39
Vrms(Delta)	402.68	407.52	409.34	
Arms	**21.4**	**31.0**	**9.5**	**30.6**
Afund	18.3	30.0	9.5	28.7
HZ	49.94			
KW	3.89	6.45	0.39	Total:10.64
PF	0.82	0.9	0.16	0.69
Volt THD%f	2.4	2.2	1.2	24.2
Amp THD%f	57.1	13.4	17.4	43.2

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TABLE.2: Values recorded by Fluke 435-II power analyzer

Parameters to be recorded	R phase	Y phase	B phase	Neutral
Vrms(star)	232.38	231.05	234.47	0.71
Vrms(Delta)	404.88	403.55	404.09	
Arms	29.2	51.9	23.7	28.2
Afund	27.0	51.9	23.1	23.6
HZ	49.971			
KW	5.62	10.51	5.32	Total:21.52
PF	0.86	0.88	0.98	0.85
Volt THD%f	1.7	1.8	1.2	46.3
Amp THD%f	42.7	11.8	18.7	84.2

The table 1 and 2 gives the reading which was taken on 1st day. It clearly explains that, at initial condition the load demand was very less. After 30min to 1 hour the load demand was increased due to turning on various electrical motors.

TABLE.3: Values recorded by Fluke 435-II power analyzer

Parameters to be recorded	R phase	Y phase	B phase	Neutral
Vrms(star)	235.51	237.68	231.50	0.88
Vrms(Delta)	408.93	401.18	404.64	
Arms	33.6	19.0	37.3	23.0
Afund	31.6	19.0	36.4	18.4
HZ	49.916			
KW	6.88	3.89	8.23	Total:18.90
PF	0.84	0.92	0.95	0.87
Volt THD%f	2.2	1.6	1.4	54.2
Amp THD%f	43.0	19.6	10.6	61.5

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TABLE.4: Values recorded by Fluke 435-II power analyzer

Parameters to be recorded	R phase	Y phase	B phase	Neutral
Vrms(star)	235.65	235.10	235.78	0.77
Vrms(Delta)	409.80	406.29	406.72	
Arms	37.6	27.3	21.6	32.6
Afund	32.8	29.9	21.6	25.1
HZ	49.967			
KW	9.15	6.65	5.16	19.38
PF	0.83	0.97	0.97	0.90
Volt THD%f	1.96	1.21	1.05	1.78
Amp THD%f	2.6	1.8	1.7	1.72

Table 3 and 4 gives the reading which was taken on 2nd day, here also load requirement is very less at the beginning later it was increased due to usage of electric power to start the electrical machines, air conditioner in computer labs,etc.

IV. RESPONSE CURVE

Voltage versus time

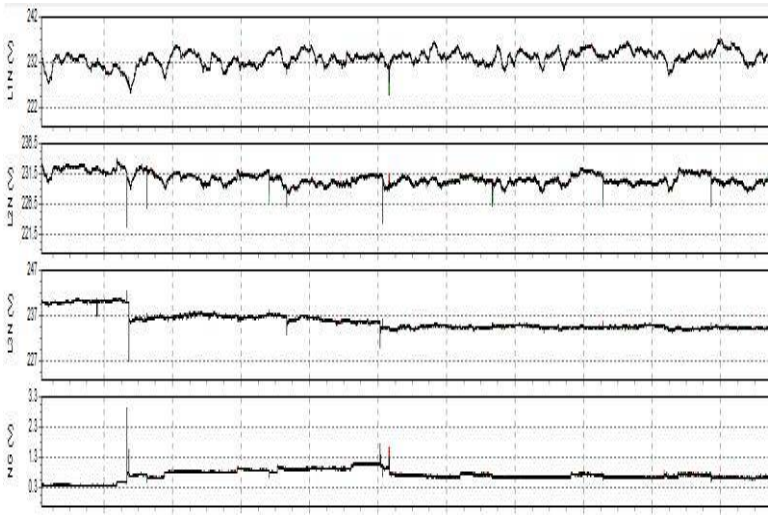

Fig.4 response curve of voltage versus time

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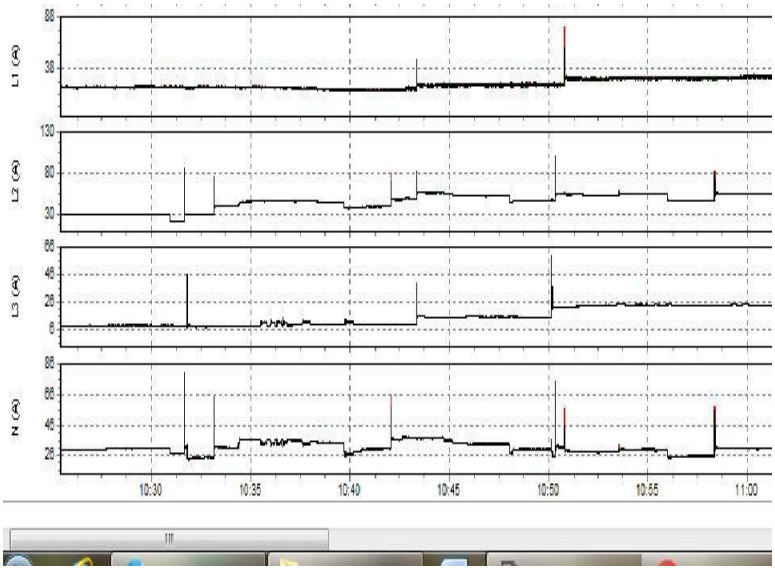
T his curve gives the detail about the voltage in each phases of the three phase system and neutral voltage also. In first phase and second phase the voltage is nearly 232V,in third Phase the voltage is about 238V.Some amount of voltage is available in neutral is about 0.3V.From the graph we observed that there will be some voltage drop which is due to sudden turning on loads.



F ig.5 response curve of phase current versus time The above waveform explains the current flow in each phase and neutral. Though the current in each phase is low, the neutral current is very high. This clearly explains that there is a problem in some electrical equipment. The neutral current is increasing with respect to the time.

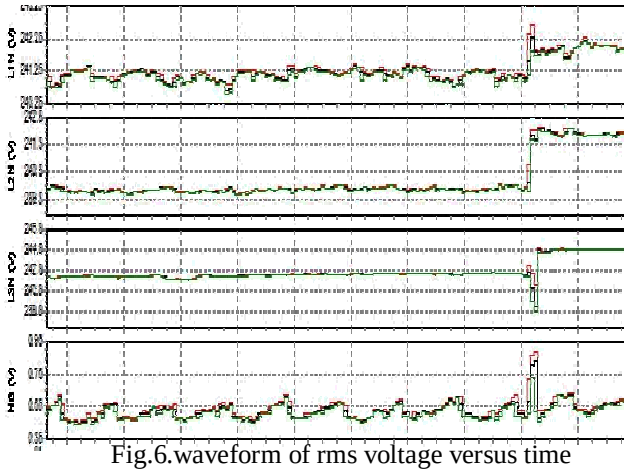


Fig.6.waveform of rms voltage versus time

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This waveform gives the rms voltage in each phase and neutral.

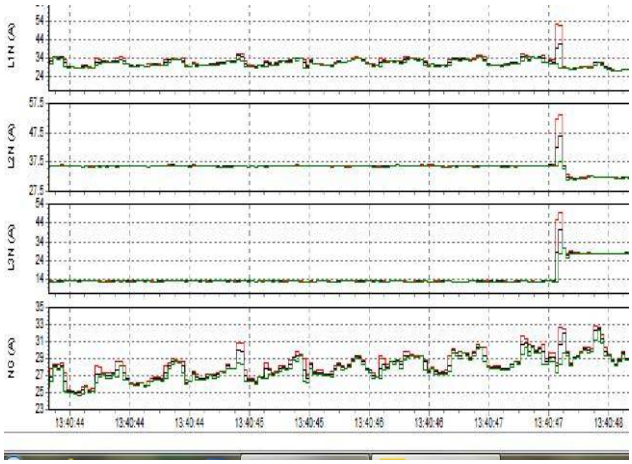
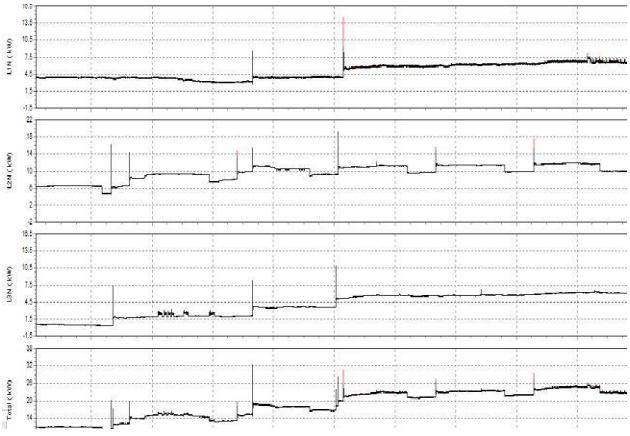


Fig.7.waveform of rms current versus time

The above waveform gives the rms current of each phases.



This graph shows the total power consumed by the electrical equipments that is total load demand of that college. The maximum load demand is 32KW.At initial the power consumed in each phase is very less and later the power requirement is slightly increased from 15KW to 32KW.During summer season may be the load demand increases as per the requirement.

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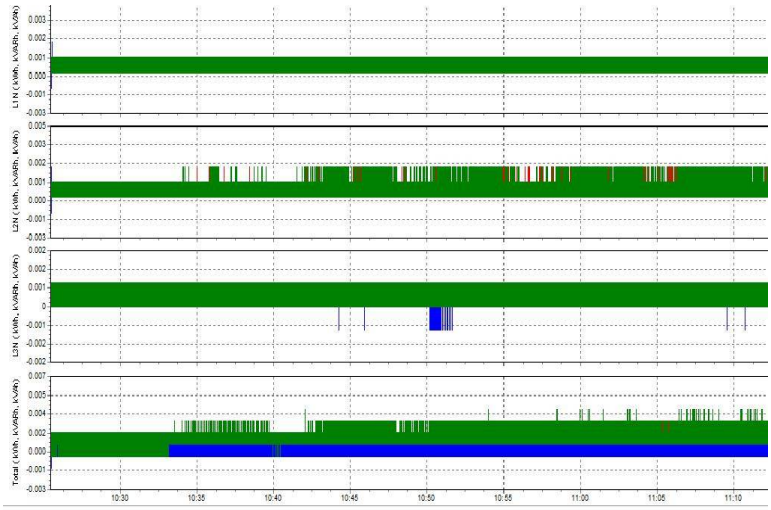

Fig.9.waveform of energy versus time

This gives information about the energy consumption of S.A.polytechnic College and also gives the real and reactive power in each phase.

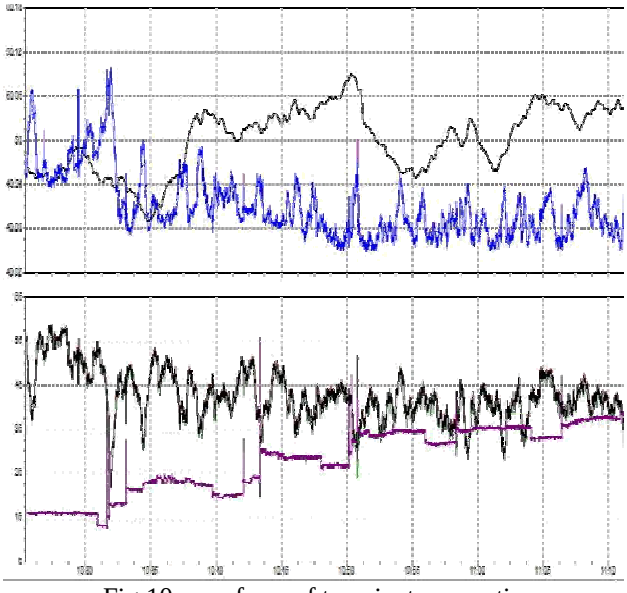

Fig.10.waveform of transient versus time

This three phase wave explains that the transient is recorded. At 13:40 there is a sudden increase in voltage and current. This clearly explains that the transient may occur due to switching on and off electrical machines.

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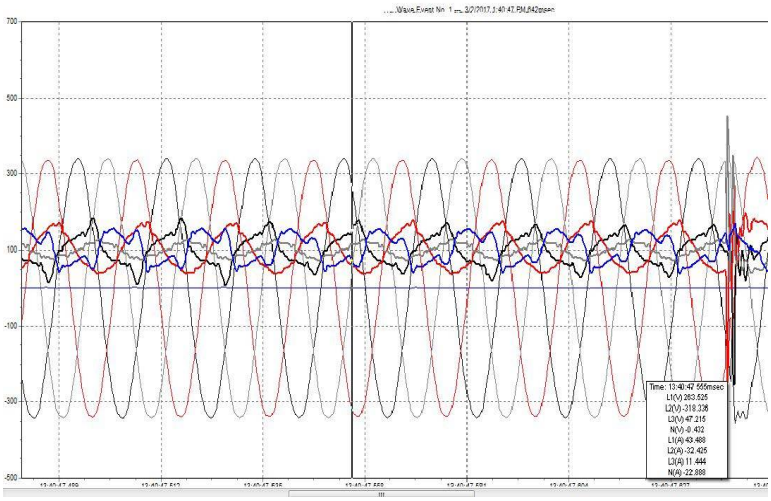

Fig.11.waveform of unbalance versus time

The graph shows the unbalance between each phase. Improper wiring, loose neutral connection causes unbalance.

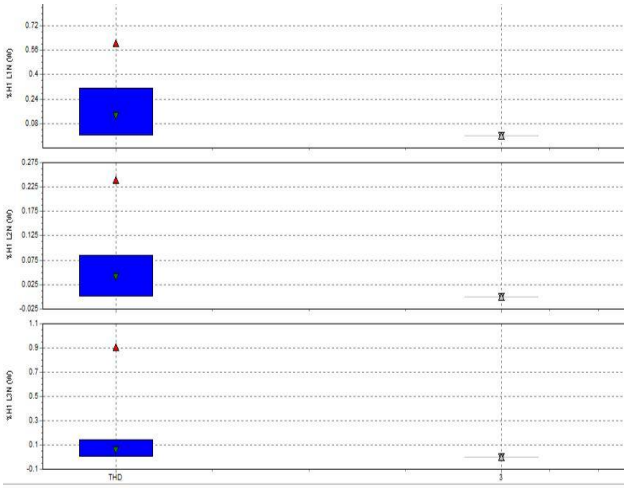

Fig.12 waveform of Total Harmonic Distortion (THD) versus time

Before explaining the graph we have to know what is meant by THD.THD is nothing but the square root of sum of the squares of harmonic component to fundamental component. The graph explains that the THD value is very high at early stage which causes energy loss and also increases the electricity bill.

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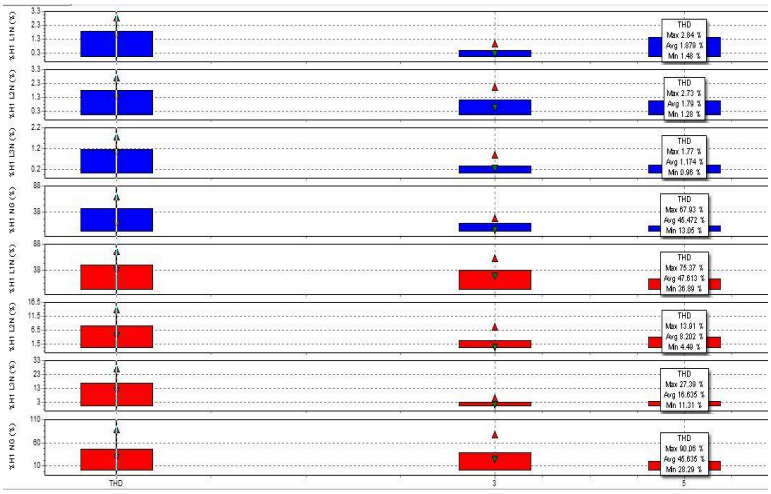

Fig.13.Waveform of Harmonic component versus time

This output response curve represents the harmonic distortion with respect to time. There will be odd and even order harmonics. The odd order harmonics affects the electrical equipments than even order harmonics. It is observed that the most dominant harmonic is 5^{th} order harmonic, which is mainly due to the computers, air conditioners, single phase loads,etcThe 5^{th} order harmonic create an impact on sensitive equipment to malfunction, energy loss, heating of electrical machines, reduces the life of the equipment.

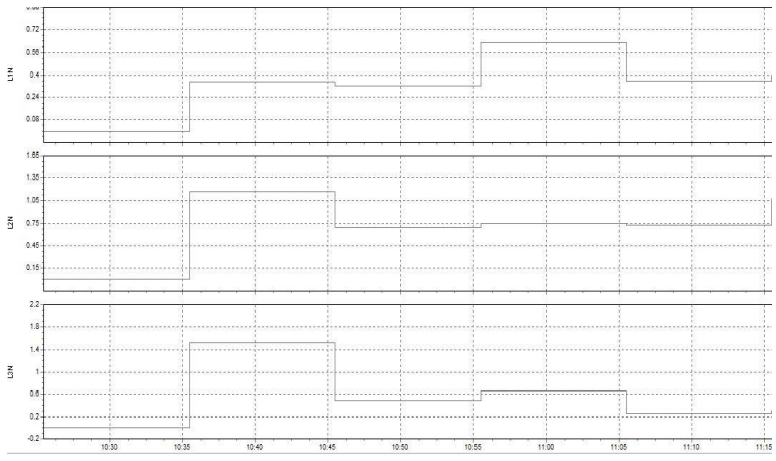

Fig.14.waveform of voltage fluctuations (Flicker) versus time

From the above graph we observed that the voltage is not stable it changes proportionally with respect to time. The waveform explains the line to neutral voltage.

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Observation

Initially the load demand is very less but the neutral current is very high compared to the required current and the power factor in each phase is also very less which clearly shows that there is a problem in some equipment. The leakage voltage is also very high.

After few hours the load is increased by switching on the electrical motors and generator in electrical lab.The entire load demand of that college is very less because there are less number of students so the number of class rooms is less. Due to the small infrastructure the power requirement is also less.

We conducted 5 hours test for 2 days in that college.by conducting the power measurement test we found that there was a problem in the capacitor bank.

They use 4 capacitor banks. Out of these four one is damaged. Due to this the neutral current is very high, it causes energy loss, increases the total harmonic the capacitor distortion level and increases the electricity bill.

The capacitor bank is used to correct the logging power factor in each phase and also regulates the harmonic current flowing through each phase. It also used to correct the load factor to reduce the power loss in the distribution network.

Fluke 435 is records the power factor in each phase and harmonic voltage, harmonic current flows through each phase of the three phase system.Power logger is the software used to records the response curve and stores the harmonic voltage and current for every 0.25sec.

Solutions for the problem

In order to minimise the power Quality problem proper mitigation steps have to be taken mainly used to reduce the penalty bill and electricity bill of the college. Replace the faulted capacitor banks toRodriguez," Grid Converters for Photovoltaic and reduce the harmonic current and neutral current

From that waveform we observed that harmonics is the major power quality.

- In order to reduce the harmonics we can use different types of filters like passive and active filters.
- By adding the line reactor or isolation transformer the harmonic content is reduced.
- By using Static VAR Compensator we can reduce the harmonic as well as voltage sag.
- By increasing the delay time of the 12 or 18 pulse converter THD will be reduced.

V. CONCLUSION

Power Quality Measurement in S.A.Polytechnic was successfully completed. From that analysis we found that the fault in capacitor bank is the major source for the power quality issues like harmonics, voltage sag, low power factor and transient. The 5^{th} order harmonic creates a great impact on the electrical equipment. The power quality issues can be reduced by making proper wiring connection and using tuned filters like active and passive filters. This analysis is wind Power systems"Willey-IEEE Press, 2011.

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