ENERGY AUDIT REPORT OF

PADMASHRI Dr. VITHALRAO VIKHE PATIL
COLLEGE OF ENGINEERING,
VILAD GHAT, AHMEDNAGAR.

PREPARED BY

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“A Mission made programme can be created for energy conservation. We have to set yearly target of saving twenty five billion units per year from the present 3.2 billion units, so that we can wipe out the existing shortage within the next four years”

Dr. APJ Abdul Kalam
Ex. Hon. President of India
Address at National Energy Awards Function,
Dec.15, 2005

ACKNOWLEDGEMENT

Power quality, Energy audit cell of DR.B.E. Kushare consulting cell Nasik, places sincere gratitude to Management of PADMASHRI Dr. VITHALRAO VIKHE PATIL COLLEGE OF ENGINEERING, VILAD GHAT, AHMEDNAGAR all board of directors , secretary , technical Directors , All institute Principals , Heads of the Department and officers

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ABBREVIATION

Symbol	Abbreviation
A	Ampere
V	Volts
KV	Kilo volts
KVA	Kilo volt ampere
KVAR	Kilo volt ampere reactive
KW	Kilo watts
MD	Maximum demand
%THD	Percentage Total harmonic distortion
% THDv	Percentage voltage Total harmonic distortion
% THDi	Percentage current Total harmonic distortion
% TIHDv	Percentage voltage Total inter harmonic distortion
% TIHDi	Percentage current Total inter harmonic distortion
Voltage sag	Reduction in RMS voltage from 90% to 10% for the time period from 10 msec. to 1 min.
Voltage swell	Increase in RMS voltage from 110% to 180% for the time period from 10 msec. to 1 min.
Transient	Sudden non power frequency change in the voltage or current from steady state.
%Vunb	Percentage voltage unbalance factor
%Iunb	Percentage current unbalance factor
KF	Crest factor
%U2,U3,……….,U50	Percentage individual voltage harmonics from 2 order to 50 order
%I2,I3,……….,I50	Percentage individual current harmonics from 2 order to 50 order
Max.val.	Maximum value of the parameter over the measurement period
Avg. val.	Average value of the parameter over the measurement period
Min.val.	Minimum value of the parameter over the measurement period

EXECUTIVE SUMMARY:

PADMASHRI Dr. VITHALRAO VIKHE PATIL COLLEGE OF ENGINEERING, Is one of the leading Engineering College in Maharashtra. Energy audit of lighting system, Air conditioning system, Product pumping system ,Air compressor , Computers and other office load, transformers, reactive power management was carried out. After conduction of detailed Audit of various Utilities and analysis of performance of various Equipments, various Energy conservation opportunities are identified and Energy conservation measures are recommended for each ECO with economic analysis .The various finding of Energy audit with suggested Energy conservation measures and Pay back analysis for each type of load in summarised in following section.

LIGHTING SYSTEM: After detailed illumination audit , various Energy conservation opportunities were identified and following Energy conservations measures are recommended. Summary of energy saving in illumination is tabulated in following section.

Recommended value of Watts/Sq.meter/100 lux are tabulated in following table

TABLE 10.2 Target lux/W/m² (W/m²/100lux) values for maintained illuminance on horizontal plane for all room indices and applications:

Room Index	*Commercial lighting. (Offices, Retail stores etc.) & very clean industrial applications, Standard or good colour rendering. Ra: 40-85*	*Industrial lighting (Manufacturing areas, Workshops, Warehousing etc.) Standard or good colour rendering. Ra: 40-85*	*Industrial lighting installations where standard or good colour rendering is not essential but some colour discrimination is required. Ra: 20-40*
5	53 (1.89)	49 (2.04)	67 (1.49)
4	52 (1.92)	48 (2.08)	66 (1.52)
3	50 (2.00)	46 (2.17)	65 (1.54)
2.5	48 (2.08)	44 (2.27)	64 (1.56)
2	46 (2.17)	42 (2.38)	61 (1.64)
1.5	43 (2.33)	39 (2.56)	58 (1.72)
1.25	40 (2.50)	36 (2.78)	55 (1.82)
1	36 (2.78)	33 (3.03)	52 (1.92)

Ra : Colour rendering index

Summary of total Energy saving in lighting

Sr. No.	Energy conservation measures	Energy saving per Year In KWH	Energy cost Saving per Year in Rs	Investment Rs	Pay back period Year	%ROI
1	Replacement of 1XTL36/40W Watt lamps with copper /Low loss/EB ballast by 20 _TL LED type lamp in same Light Fixture	42268.32	486931.00	437800.00	0.899 years or 10.789 months	111.222
2	Replacement of PLL2X36/4X36 mirror light fixtures by 2 feet X 2 Feet 36W LED panel Light fixture	4032.00	46448.64	60200.00	1.29 years or 15.552 months	77.157
Total Rs		46300.32	533379.60	498000.00	0.933 years or 11.204 months	107.104

Power consumption reduction in lighting after Implementation of recommended Energy conservation measures

Sr. No.	Recommended Energy conservation Measures	Reduction in power consumption in KW
1	Replacement of 1XTL36 /40wWatt lamps with copper /Low loss /EB ballast by 20 TL LED type lamp in same Light Fixture	23.056
2	Replacement of PLL2X36/4X36 mirror light fixtures by 2 feet X 2 Feet 36W LED panel Light fixture	0.232
Total power consumption reduction in KW		23.288

Revised lighting load = 17.108 KW

Existing connected load considered for replacement with LED lights =40.396 KW

% Reduction in lighting load = 57.629 %

Specifications of proposed LED lights :

1)LED TL 20 W Linear LED lamp , 1200MM length , Color temperature : 5500Degree Kelvin , CRI :85 , Input voltage range :90-300V , Lumen out put :1760

2) 36W , 2 Feet X 2 Feet Recesses mounted light fixtures centre light Armstrong , Input voltage Range :90-300V , Power factor :0.95 , CRI =85 , Color Temperature : 6500 Degree Kelvin, Lumen output : 3280

3) 12 W T5 LED lamp Color temperature : 5500Degree Kelvin , CRI :85 , Input voltage range :90-

Recommended LED light fixture Makes:

1) SYSKA
2) PHIPLIPS
3) WIPRO
4) OSRAM

TRANSFORMER:

Energy Saving potential by maintenance of RMS voltage near 400Volts :

RMS voltage variation is on Higher side and increases to 450 Volts .Higher RMS voltage results into increase in power consumption of pumps and lamps in addition to accelerated ageing of Equipments leading to premature failure .Recommended to maintain RMS Voltage near 400V .Present transformer is of 250KVA 11KV/0.433KV , Dyn11 , ONAN transformer and it is not possible to maintain RMS voltage within recommended limit .Recommended to replace existing transformer by New transformer with 250KVA , 11KV/0.415KV , ONAN , Dyn11, with OLTC +RTCC +AVR as per provided specifications

Energy saving potential by maintenance of RMS voltage near 400 Volts = 0.05x525273 = 26263.65KWH

Energy cost saving potential considering Energy cost of Rs 11.52 per year = Rs 11.52 x 26263.65 = Rs 302557.248

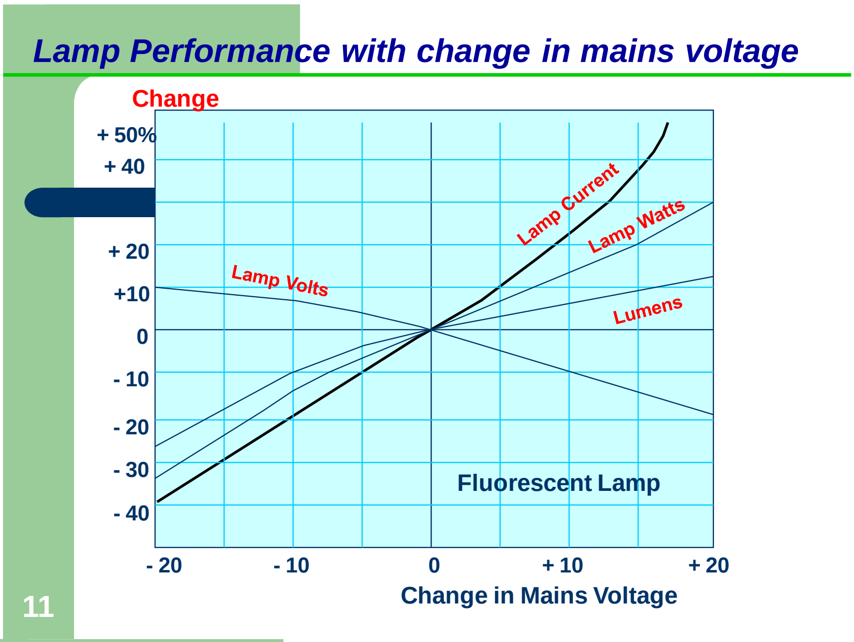
Investment :Cost of New 250KVA transformer :Rs 425000.00

Payback period:1.4046 years or 16.856 Months

%ROI = 71.189

INPUT VOLTAGE VARIATIO	% OF REDUCTION IN BREAKDOWN POSSIBLE	APPROX POWER SAVING POSSIBLE
380-420 Volts	No reduction in breakdown of electrical equipments	No requirement of stabilizer
380-440 Volts	Upto 20% reduction in breakdown of electrical equipments	Up to 5%
380-460 Volts	Upto60% reduction in breakdown of electrical equipments	Up to 7%
380-470 Volts	Upto 80% reduction in breakdown of electrical equipments	Up to 10%

Effect of Voltage on lamp performance for florescent lamps are indicated by following characteristics:



EFFECT OF VOLTAGE ON POWER CONSUMPTION OF LAMPS

Particulars	10% lower voltage	10% higher voltage
Fluorescent lamps		
Light output	Decreases by 9 %	Increases by 8 %
Power input	Decreases by 15 %	Increases by 8 1%
HPMV lamps		
Light output	Decreases by 20 %	Increases by 20 %
Power input	Decreases by 16 %	Increases by 17 %
Mercury Blended lamps		
Light output	Decreases by 24 %	Increases by 30 %
Power input	Decreases by 20 %	Increases by 20 %
Metal Halide lamps		

ADEQUATE REACTIVE POWER MANAGEMENT:

Fixed compensation provided .

There is over compensation .Inadequate reactive power compensation results into increase in MD and transformer loading and branch circuit losses .Recommended to install 150KVAR , 7% detuned RTPFC panel for adequate reactive power compensation .

Benefits of adequate reactive power compensation per Year :Rs88138.41

Cost of 150 KVAR , 7% detuned RTPFC panel : Rs 277500.00

Pay back period : 3.148 Years or 37.78 months

% ROI = 31.761

AIR CONDITIOING SYSTEM:

Existing Air conditioning system Description:

.Performance analysis of each Split, ducted and packaged air conditioner was carried out and detailed measurements and analysis with recommendations are listed in performance evaluation of particular section.

Summary of Energy conservation potential in Air conditioners.

S.No.	Energy Conservation Measures	Energy Saving potential per Year in KWH	Energy cost saving per year considering Energy cost of Rs	Investment Rs	Pay back period	% ROI
1	Increase in temperature set point of room air conditioners from existing to 26 degree centigrade	10957.17	126226.501	-	-	-
2	Switching OFF room air conditioners 30 minutes before conclusion of office hours	14868.00	171279.36	-	-	-
Total		25825.17	297505.80			

SUMMARY OF OUTCOME

Sr. No	Energy conservation Measures	Energy saving per year KWH	Amount saved/year Rs.	Investment required (Rs.)	Payback period.	% ROI	Implementation
1	Replacement of 1XTL36/40W Watt lamps with copper /Low loss/EB ballast by 20 _TL LED type lamp in same Light Fixture	42268.32	486931.00	437800.00	0.899 years or 10.789 months	111.222	Short term
2	Replacement of PLL2X36/4X36 mirror light fixtures by 2 feet X 2 Feet 36W LED panel Light fixture	4032.00	46448.64	60200.00	1.29 years or 15.552 months	77.157	Short term
3	Replacement of Existing transformer with new transformer with250KVA, 11KV/0.415KV , ONAN Dyn11 OLTC +RTCC +AVR	26263.65	302557.248	425000.00	1.4046 years or 16.856 months	71.189	Mid term
4	Adequate reactive power management by installation 0f 150KVAR , 7% detuned RTPFC panel	-	88138.41	277500.00	3.148 years or 37.78 months	31.761	Mid term
5	Increase in temperature set point of room air conditioners from existing to 26 degree centigrade	10957.17	126226.501	-	-	-	Immediate
6	Switching OFF room air conditioners 30 minutes before conclusion of office hours	14868.00	171279.36	-	-	-	Immediate
Total		98389.14	1221581.0	1200500.0	0.981 years or 11.792	101.778	

NO INVESTMENT SAVING

Sr. No	Energy conservation Measures	Energy saving per year KWH	Amount saved/year Rs.	Implementation status
1	Increase in temperature set point of room air conditioners from existing to 26 degree centigrade	10957.17	126226.501	Immediate
2	Switching OFF room air conditioners 30 minutes before conclusion of office hours	14868.00	171279.36	Immediate
Total		25825.17	297505.90	

Total cost of Electricity during last year = Rs 6050917
% of no investment Energy saving =4.9167 %
% Energy saving with and without investment =20.188%

CHAPTER – 1

INTRODUCTION

CHAPTER – 1

1.0 GENERAL

PADMASHRI Dr. VITHALRAO VIKHE PATIL COLLEGE OF ENGINEERING, Is one of the leading Engineering College in Maharashtra.

With the increasing energy cost and the commitment towards sustainable development, the management of the organization is always proactive towards energy conservation. The management in the same direction provided opportunity to our cell to conduct energy, power quality audit, to identify various opportunities for Energy saving in HVAC, Lighting and Compressed air system, Pumps etc. Detailed Energy audit was carried out in area with following objectives.

1.1 OBJECTIVE OF ENERGY AUDIT

- To undertake energy audit to identify the various energy conservation opportunities (ECO's) such as Lighting system , HVAC pumping ,transformer and computer systems, Water pumps ,Compressed Air system ,reactive power management by conducting field measurement, detailed analysis and suggest energy conservation measures to reduce energy consumption with detailed techno-economic analysis .
- To establish benchmark values for energy consumption.
- To identify the areas of energy saving with no investment and with investment.
- To prioritize distinct areas identified for energy saving depending upon saving potential, skills and time frame for execution, investment cost, payback etc.
- To study energy monitoring system required for effective monitoring of energy consumption and analysis of energy efficiency.
- To identify energy consumption of various major equipments.
- Attempt fine-tuning of certain parameters aimed at saving power.

1.2 SCOPE OF ENERGY AUDIT

To study the energy consumption analysis of the building such as lighting, water pumping, motor, reactive power management, HVAC and other areas.

1.2.1 ELECTRICAL ENERGY

1. To study electrical energy metering, monitoring and control systems are existing in the both units and to recommend the suitable system for future monitoring.
2. To study the monthly power factor, maximum demand, working hours, load factors etc for reference period along with monthly electricity consumption and to establish scope for optimization of load factor through detailed load management study.
3. To recommend a specific rationalization/optimization programmed based on measurement of power factors at various PCC points, existing capacitor systems and its maintenance, automatic/manual control required etc.
4. To undertake the detail motor load assessment on all the motors above 5HP to study the loading patterns of the motors to identify the oversized and undersized motors.
5. To study water pumping system.
6. To undertake Illumination audit of all the section including lux measurement with the help of lux meter to recommend the specific plan for energy conservation.
7. Comparison of actual level of illumination with recommended level of illumination for various activities.
8. Study of efficiency of existing lamps and ballast used.
9. Study of voltage profile of all feeders.
10. Identification of energy conservation opportunities of lighting systems.
11. Performance evaluation of Window, split, Ducted and Packaged Air conditioners.
12. Performance Evaluation of Chillers, AHUs.
13. Performance Evaluation by FAD , Leak test on Air Compressors , optimization of compressor pressure setting.
14. Performance Evaluation of Water pumps, primary, secondary and Condenser pumps.
15. Recommend immediate low cost / no cost energy conservation measures.

16. Recommend medium term energy conservation measures.
17. Recommend long-term energy conservation measures.
18. Evaluation, Implementation and monitoring: To identify, evaluate and prioritize energy saving opportunities through above into short, mid and long term time basis depending upon investments, quantum of savings, skills and time required for implementation etc. To recommend a time bound action plan for implementation of accepted measures.

1.3 METHODOLOGY:

FOLLOWING METHODOLOGY WAS FOLLOWED DURING ENERGY AUDIT

1. Held preliminary discussion with Production and maintenance in charge and his team to understand electric supply distribution network feeding power to various institute and energy consumption pattern of various utilities, energy accounting system and various energy management systems employed for energy conservation.
2. Gathered all relevant data related to conduction of detailed energy audit pertaining to electrical system, connected load, monthly energy bills, single line diagram of distribution system, HVAC system, Water distribution system.
3. Detailed Measurement was conducted with the help of various instruments and expert staff. The various equipments used during measurements are advanced power quality analyzer HIOKI-3196, lux meter and clamp on meter.
4. On the basis of measurement result and data collected performance of room wise lighting system, motor driven system and street light are calculated.
5. Recommendations are given based on techno economic analysis to reduce energy consumption.
6. Cost benefits analysis on account of improved efficiency is done.

The various equipments used during measurements are listed in table 1.0

TABLE 1.0: INSTRUMENTION USED DURING ENERGY AUDIT

Sr. No	Instrument	Specifications
1.	Advanced power quality analyzer	HIOKI 3196, Japan, 8 channel, four for voltage and 4 for currents, facility of measurement of 180 electrical parameters and different wiring configuration. Sampling frequency 6M samples per second. Facility of voltage sag, swell, flicker, harmonics, inter-harmonics, transients and all other electrical parameters.
2.	Clamp on meter	0-1200KW 0-600V AC 0-800V DC 0-2000A, current AC/DC
3.	Lux meter	0-10,000 lux level, non contact type
4	Digital Clamp on Earth tester	
5	Ultra Sonic Flow meter	
6	Digital clamp ON leakage meter	
7	Anneaometer	
8	IR camera	
9	IR thermometer	

1.4 ENERGY SCENCE

Primary energy sources used for Air conditioning and Ventilation , Compressed Air system , lighting , Pumps and in office area.. Major part of connected load is Air conditioning , laboratory Equipments

1.5 ENERGY: SOURCES AND UTILIZATION

ELECTRICAL ENERGY: The main source of power for the press is through 11 KV HT Supply of incoming supply

1.6 ENERGY METERING, MONITORING AND CONTROL SYSTEM-EXISTING STATUS

Electricity: The electrical energy consumption of plant is measured on 11KV HT TOD Meter

CHAPTER 2
ENERGY CONSERVATION OPPORTUNITIES IN MOTOR DRIVEN SYSTEMS
(OBSERVATION, FIELD TRIALS, ANALYSIS AND KEY RESULT AREAS)

2.1 ENERGY CONSERVATION OPPORTUNITIES IN MOTOR DRIVEN SYSTEMS

INTRODUCTION

Motor driven system consists of Electrical power supply, the electric motor, the motor control and a mech.anical transmission system. There are several ways to improve the system efficiency. The cost effective way is to check each component of the system for an opportunity to reduce electrical losses. Poor power distribution within a facility is common cause of energy losses.

Electric Motors consume 70% of total electricity used in the industrial sector. Majority of motive loads use squirrel cage induction motor as a driving element, because of low capital, maintenance costs and rugged design. Electric motors are used to provide motive power to equipment such as compressor, pumps, blowers etc that finds application in industry. It is important that the industrial user defines his need accurately to enable proper selection of motor for a particular application. When selecting a motor for any application, the following points should be considered.

- Process requirements: Flow, automatic/non automatic control, variable speed etc.
- Technical aspects: Breakdown torque, startup torque, duty load cycle and operating conditions.
- Electrical system requirement
- Availability, reliability, inventory and maintenance.
- Price of motor

The general observation in the industry is that motors of higher rating than is required for given applications are used because of several reasons, which result into under loading of motors. Good knowledge of process parameters and better understanding of plant power system can help in reducing the over sizing of motor without loss of reliability. Rewinding of the motors results into poor energy efficiency, which leads to more energy consumption and energy costs. Therefore improvement of efficiency of motor must be part of any comprehensive energy, conservation effort. Load losses and hence efficiency of any motor varies in accordance with motor loads. For operating loads in the range of 60%-100% rated load, the reduction in motor efficiency is not very significant but the power factor drops considerably on further reducing the load, both power factor and efficiency decrease and the effect is significant at very low loads.

Motor performance is also affected considerably by service conditions such as voltage, frequency, and voltage unbalance across the motor terminal and % total voltage harmonic distortion.

RECOMMENDATIONS:

The power supply is one of the major factors affecting the operation and maintenance of an electrical motor driven system. To get better performance from motor it is necessary to operate all motors.

- Within tolerance of ±10% of rated voltage.
- Operation from a sinusoidal voltage supply.
- Operation within a tolerance of ±5% frequency.
- Operation within a voltage unbalance of 1% or less.

Operation of motors at other than usual service conditions may result in consumption of additional energy. Nameplate values for current, power factor, efficiency and torque are based on operation at rated voltage and frequency. Using motor at a different voltage will change its performance.

2.2 EFFECT OF VOLTAGE VARIATIONS

The effect of voltage variations on motor operation are

EFFECT OF REDUCED VOLTAGE

- Increase in operating temperature
- Reduction in starting torque
- Reduction in running torque

EFFECT OF INCREASED VOLTAGE

- Decrease in power factor
- Increase in starting and running torque
- Increase in starting current

2.3 EFFECT OF UNBALANCED VOLTAGE

The effect of voltage unbalance between phase voltages is more serious. The current unbalance will be in the order of six times the voltage unbalance. The effects on the motors are reduced efficiency and increased operating temperature. For voltage unbalance above 1% it is necessary to de-rate motor as a square of unbalance and motor operation above 5% unbalance is not recommended. The locked motor torque and breakdown torque are decreased when voltage is unbalanced. If voltage unbalance is extremely severed the torque might not be adequate for the application.

FREQUENCY VARIATIONS: Motor currents, torque, efficiency, power factor and speed are all affected by frequency.

2.4 EFFECT OF HARMONIC VOLTAGE DISTORTION

The efficiency of electric motors designed for sinusoidal conditions when operated on distorted voltage results into decrease in efficiency and increase in temperature rise. Induction motor operation above 5% total voltage harmonic distortion is not recommended as per IEEE STD 519-1992.

Even a modest improvement in the energy efficiency of the motor driven systems can produce significant energy savings.

IMPORTANT NOTE: When employing electric motors for air moving equipment, it is important to remember that performance of fans and blowers is governed by certain rules. For centrifugal loads even a minor change in the motor speed translates into significant saving in energy.

2.5 ENERGY SAVING OPPORTUNITIES IN ELECTRIC MOTORS

- The main opportunities for energy saving in electric motors are
- Stopping idle or redundant running of motors
- Matching motor with driven load
- Improving drive transmission efficiency
- Use of energy efficient motors
- Improvement in motor systems

2.6 ENERGY SAVING OPPORTUNITIES BY MOTOR DRIVE MAINTENANCE AND ALIGNMENT

Operation of a motor is affected by maintenance; simple and regular maintenance and inspection will not only provide longer motor life but can also save on operating costs.

- Temperature: The most important factor affecting life of a motor is temperature of the insulation. Increasing the insulation temp. by 10^{o}C will reduce the motor life by half. Ensure motors are well ventilated.
- Dirt: If screens, filters or air vents become clogged motors may overheat and eventually fail.
- Moisture: Intermittent use or standby motors are prone to the problems with moisture in the windings. The windings insulation resistance measurement is a good indicator of the presence of moisture. Remedial action should be considered if the insulation resistance is less than 1 Mohm per KV.
- Greasing: Over greasing of antifriction bearings increase friction-causing bearings to overheat and motor losses to increase and is the most common cause of bearing failure.
- Vibration: A noticeable increase in motor drive vibration is an indication of trouble-checks should be made of mounting bolts, shaft alignment, and bearings. Vibration can be difficult problem to resolve and increases motor losses.
- Starting: Excessive starting is a prime cause of motor failure through overheating from high starting currents the motor should not exceed more than 150 start seconds a day.

2.9: CONCLUSION OF MOTOR LOADING AND INPUT POWER QUALITY ANALYSIS

1 Average value of % Voltage unbalance factor is less than 1% recommended by NEMA MG standard. There is no need to carry out De-rating of motors.

3 RMS Voltage variation is up to 450 Volts .Over and under voltage results into increase in power consumption of motors .With present transformer off load tap changer it is not possible to adjust RMS voltage near 400 Volts .

Water pumps:

Following Water pumps are installed to meet raw water requirement of campus:

12.5HP mono block : 1 Nos.: Operational schedule 9.00AM to 5.00PM

5 HP Submersible Pump :2 Nos.

3HP Monoblock Pump :1 Nos.: 24 Hours .

Recommendations :

Recommended to install water level controller for Auto operation of water pumps to avoid wastage of water and Energy .

Recommended to operate water pumps during off peak period i.e.10PM to 6.00AM to take benefit of TOD tariff rates .

TABLE 2.2: EFFECTS OF VOLTAGE AND FREQUENCY VARIATION ON MOTOR PERFORMANCE

Variation	Starting & Running torque	Synchronous Speed	% Slip	Full load Speed	Full load Efficiency	Full load Power factor	Full load Current	Starting Current	Temp. rise Full-load	Max. Overload Capacity	Magnetic Noise no-load On particular
Voltage variation 120%	Increase 44%	No change	Decrease 30%	Increase 1.5%	0-6 % decrease	Decrease 5-15 points	Increase 12%	Increase 20%	Increase 5-6^{o}C	Increase 44%	Noticeable increase
110% voltage	Increase 21%	No change	Decrease 17%	Increase 1%	Slight decrease	Decrease 5-15 points	Increase 2-4%	Increase 10-12%	Increase 3-4^{o}C	Increase 21%	Increase slightly
Functions of voltage	$(voltage)^2$	Constant	———	Synchronous speed slip	----	---	---	Voltage	---	$(voltage)^2$	---
90% voltage	Decrease 19%	No change	Increase 23%	Decrease 1.5%	Decrease 2 points	Increase 5 points	Increase 10-11%	Decrease 10-12%	Increase 6-7^{o}C	Decrease 19%	Decrease slightly
Freq. Variation: 100% Freq.	Decrease 10%	Increase 5%	Practically No change	Increase 5%	Slight increase	Slight increase	Decrease slightly	Decrease 5-6%	Decrease slightly	Decrease slightly	Decrease slightly
Function of Frequency	———	Frequency	------	Synchronous speed slip	----	---	----	———	----	---	---
95% Freq.	Increase 11%	Decrease 5%	Practically No change	Decrease 5%	Slight decrease	Slight decrease	Increase slightly	Increase 5-6%	Increase slightly	Increase slightly	Increase slightly
1% Unbalance	Slight decrease	Slight decrease	----	Slight decrease	2%	5-6% decrease	1.5%	Slight decrease	2% decrease	---	---
2% Unbalance	Slight decrease	Slight decrease	---	Slight decrease	8% decrease	7% decrease	3% increase	Slight decrease	8% increase	---	---

CHAPTER – 3

ENERGY CONSERVATION OPPORTUNITIES IN LIGHTING AREA

(Observations, Field Trials, Analysis and Key Result Areas)

3.0 ENERGY SAVING OPPORTUNITIES IN LIGHTING AREA:

Press general lighting is provided by use of , 2XPLL36 W, 250W Metal halide High bay ,400 W HPMV , 4X54W T5 ,1XTL36W , 2XTL36 W , 1XT5 28 W , 2XT5 28 W , 2X18W CFL and 1X18W Down lighter , 250.For street lights 250W HPSV SON T , 150W Metal halide ,250W Metal halide street light fixtures are used. 1XTL36 W Tube light fixtures are used in some of the places to provide indirect lighting . In all office areas mirror optics luminaries are used for recess as well as surface mounted tube light fixtures .CFL down lighters are provided in passages , lobbies , cabin , .Light are controlled by switched and there is no timer based as well as occupancy sensor based control . Energy audit of lighting was carried out by measurement of illumination level with lux meter and Lighting load assessment was carried out to identify the areas for Energy saving in lighting area.

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Average illumination	Light fixture	Hours	Remark
Civil Department					
Toilet Physical Handicap	90, 120, 34	81	1 X TL 36W CU=01	4	
Engineering Geology Lab	**187, 130, 108, 70, 80, 228, 400, 365**	**196**	**1 X TL 40W CU=3W, 01(N/W)**	**4**	**Less than reco.**
Server Lab	**157, 180, 302, 87, 73, 130, 98, 82**	**139**	**1 X TL 40W CU=2W, 01(N/W), 1 X TL 36W CU=01**	**8**	**Less than reco.**
Passage	149, 219, 110, 198, 76	150	1 X TL 36W CU=04, 1 X TL 36W EB=4	12	
Engineering Mechanics Lab	**84, 97, 72, 152, 135, 116, 108, 160, 160, 180, 175**	**130**	**1 X TL 40W CU=02, 1 X TL 36W EB=4**	**RARE USE**	**Less than reco.**
Survey Lab	**125, 64, 57, 45, 296, 40, 160**	**113**	**1 X TL 40W CU=02**	**RARE USE**	**Less than reco.**
Environmental Engineering LAB	**80, 40, 392, 215, 75, 200, 110, 60, 110, 202, 54, 45, 60**	**127**	**1 X TL 40W CU=04, 1 X TL 36W EB=02**	**8**	**Less than reco.**
Computer Lab	**214, 112, 137, 111, 205, 222, 120, 204, 128, 77**	**153**	**1 X TL 36W CU=02, 1 X TL 40W CU=4W, 1(N/W),**	**8**	**Less than reco.**
PG Research Lab	**98, 231, 177, 201, 111, 213**	**172**	**1 X TL 36W CU=01, 1 X TL 40W CU=3W, 1(N/W),**	**4**	**Less than reco.**

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Average illumination	Light fixture	Hours	Remark
PG Computer Lab	**56, 70, 121, 682, 190**	**224**	**1 X TL 40W CU=03, 1 X TL 36W CU=02**	**8**	**Less than reco.**
Research Lab Inside	**91, 78, 129, 381, 216**	**179**	**1 X TL 40W CU=06,**	**8**	**Less than reco.**
Transportation Eng Lab	**129, 112, 121, 83, 123**	**114**	**1 X TL 36W EB=03, 1 X TL 40W CU=3**	**8**	**Less than reco.**
Civil HOD cabin	**150, 270, 34, 53, 125, 88, 215, 140**	**134**	**1 X TL 36W EB=03, 1 X TL 40W CU=1**	**8**	**Less than reco.**
Meeting Hall	**95, 140, 250, 200, 160, 259, 265**	**196**	**1 X TL 36W EB=01, 1 X TL 40W CU=2**	**RARE USE**	**Less than reco.**
2nd Floor					
Class Room	**126,245,143,254,104**	**174**	**1 X TL 36W EB=01, 1 X TL 40W CU=1, 1 X TL 36W CU=01**	**RARE USE**	**Less than reco.**
Class Room FE Div A	**128,201,167,103**	**150**	**1 X TL 36W EB=03, 1 X TL 40W EB=03**	**RARE USE**	**Less than reco.**
Class Room -105	465, 398, 345, 310, 555, 249	387	1 X TL 36W EB=01, 1 X TL 36W cu=01	6	**Less than reco.**
Class Room - 104	**256, 280, 210, 247, 105, 250, 357**	**244**	**1 X TL 40W CU=03,**	**6**	**Less than reco.**
Microprocessor LAB	**205, 150, 450, 110**	**229**	**1 X TL 40W CU=01**	**8**	**Less than reco.**
Electronics Department					
HOD Cabin	270, 152, 300, 118, 420, 324, 249, 98	241	1 X TL 36W CU=01, 1 X TL 40W CU=1W,	3	
Class Room Near HOD cabin	**74, 220, 149, 169, 154**	**153**	**1 X TL 40W CU=02**	**6**	**Less than reco.**
Electronics LAB	**50, 77, 109, 100, 251, 109, 89, 118, 122, 57**	**108**	**1 X TL 36W CU=5**	**RARE USE**	**Less than reco.**
Power Electronics LAB	**114, 104, 147, 550, 70, 224, 126, 170**	**188**	**1 X TL 36W CU=04, 1 X TL 36W EB=1**	**4**	**Less than reco.**
Microwave Communication Lab	**80, 90, 72, 40, 100, 79, 120, 145, 95**	**91**	**1 X TL 40W CU=03W, 1N/W,**	**4**	**Less than reco.**
Basic Electronics	**168, 135, 250, 325, 316, 140, 172, 233, 130**	**207**	**1 X TL 40W CU=4**	**4**	**Less than reco.**
Digital Electronics	**232, 331, 263, 264, 358**	**289**	**1 X TL 36W EB=4,**	**RARE USE**	**Less than reco.**
Advanced Computing Lab	**142, 105, 59, 60, 70, 98, 127, 180, 138, 152**	**113**	**1 X TL 40W CU=4, 1 X TL 36W CU=2**	**8**	**Less than reco.**

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.e illu.	Light fixture	Hours	Remark
Microcontroller Lab	**30, 82, 72, 25, 30, 40, 105, 117, 62, 103, 56, 56, 114**	**68**	**1 X 36W CU=04**	**Rare Use**	**Less than reco.**
Basic lab	**115, 67, 152**	**111**	**1 X TL 36W CU=2W, N/W=02,**	**8**	**Less than reco.**
Computer LAB	**170, 210, 245, 150, 140**	**183**	**1 X TL 36W EB=03W, 1N/W**	**8**	**Less than reco.**
Class Room - 126D	**90, 134, 130, 137, 100, 22**	**102**	**1 X TL 40W EB=03, 1 X TL 36W EB=01W, 01(N/W),**	**8**	**Less than reco.**
Physics Department	148, 718, 704, 746, 264, 407, 228	459	1 X TL 36W EB=1, 1 X TL 40W CU=4,	Rare Use	-
Dark Room	**40, 26, 55, 60**	**45**	**1 X TL 40W CU=4**	**6**	**Less than reco.**
Projector Lab	**171, 300, 160**	**210**	**1 X TL 40W EB=2, 1 X TL 40W CU=01,**	**Rare Use**	**Less than reco.**
DSP Microcontroller	**250, 100, 252, 127, 90, 168, 77, 915, 383**	**262**	**1 X TL 36W EB=1, 1 X TL 40W CU=2, 1 X TL 36W CU=1**	**2**	**Less than reco.**
A & D Technique Lab	115, 613, 700, 700, 118	449	1 X TL 40W CU=4	8	-
Basic Electronics Lab	230, 502, 350, 429, 331	368	1 X TL 36W CU=1, 1 X TL 40W CU=1	8	-
Process Instrumentation	234, 193, 292, 209, 168, 520, 480	299	1 X TL 36W CU=1, 1 X TL 40W CU=2	8	-
Class Room-207	120, 142, 70, 98, 117, 430, 317, 366, 410, 43	211	1 X TL 40W CU=2,	**Rare Use**	-
Class Room-207 A	**366, 410, 43**	**273**	**1 X TL 40W CU=1W, 1(N/W)**	**Rare Use**	**Less than reco.**
Computer LAB	**39, 129, 18, 107, 36, 110, 404,**	**120**	**1 X TL 40W EB=4,**	**8**	**Less than reco.**
Sensor Transducer LAB	401, 443, 230, 378, 180, 377, 230	319	1 X TL 40W EB=4W, 02 N/W,	8	-
Prof. Laware Cabin	**120, 250, 219, 124**	**178**	**1 X TL 40W CU=1, 1 X TL 40W CU=1,**	**4**	**Less than reco.**
Dept Library	**72, 49, 123**	**81**	**1 X TL 40W EB=01,**	**8**	**Less than reco.**
Mechanical Department					
SE (mech..) A Div	240, 332, 202, 294, 340, 320, 210, 315	281	1 X TL 40W CU=01, 1 X TL 36W EB=02,	Rare Use	-
SE (mech..) B Div	205, 328, 407, 285, 300, 302	304	1 X TL 40W CU=01, 1 X TL 36W EB=02,	Rare Use	-
TE (mech.) A Div	329, 274,255	286	1 X TL 36W CU=1W, 2(N/W),	Rare Use	-

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.illu.	Light fixture	Hours	Remark
TE (mech.) B Div	**230, 150, 191, 280, 416, 214**	**246**	**1 X TL 36W CU=03,**	**Rare use**	**Less than reco.**
Class Room-115	440, 364, 460, 104, 210	315	1 X TL 40W CU=03, 1 X TL 36W EB=01	**Rare use**	-
Class Room-116	208, 470, 470, 403	387	1 X TL 40W EB=03,	**Rare use**	-
Open Area Class A	480, 315	397	1 X TL 40W CU=02, 1 X TL 40W EB=02,	8	-
Class Room 107	130, 200, 500, 189, 185	440	1 X TL 40W CU=02, 1 X TL 36W EB=02,	**Rare use**	-
118-A	602	602	1 X TL 40W CU=01W, 1(N/W), 1 X TL 36W EB=02,	6	-
Class Room -119	71, 233, 170, 520, 480, 870	390	1 X TL 40W EB=02	Rare use	-
Research Center (PhD)	155, 422, 456, 425, 334, 374, 300, 350	352	1 X TL 40W CU=01, 1 X TL 36W CU=15,	6	-
Drawing Hall	344, 182, 177, 290, 377, 400, 123, 332, 279, 166	267	1 X TL 40W CU=10, 1 X TL 36W CU=6,	4	-
Drawing Hall Office	378, 340	359	1 X TL 40W CU=6,	8	-
Metrological Lab	**85, 108, 79**	**91**	**1 X TL 40W CU=8,**	**6**	**Less than Rec.**
Material Science Lab	**126, 299, 308, 316, 101**	**230**	**1 X TL 36W CU=01, 1 X TL 40W CU=2W, 1N/W**	**5**	**Less than Rec.**
IC Engine Lab	**245, 360, 79, 71, 156, 96**	**167**	**1 X TL 40W CU=5w, 01(N/W),**	**2**	**Less than Rec.**
Refrigeration & Air Conditioning LAB	**175, 80, 62, 50, 145, 268, 77**	**122**	**1 X TL 40W CU=5,**	**2**	**Less than Rec.**
PG Computer Lab	**65, 127, 46, 31, 88, 159, 57, 147**	**90**	**1 X TL 40W CU=2,1 X TL 36W EB=01**	**8**	**Less than Rec.**
Theory Machine Lab	89, 226, 730, 348, 283, 117	298	1 X TL 36W CU=3,	8	-
PG Lab	720	720	1 X TL 36W EB=01, 1 X TL 36W CU=01	8	-
015D LAB	**213, 200**	**206**	**1 X TL 36W CU=07,**	**8**	**Less than Rec.**
Metrology LAB	122, 140, 212, 375, 1296	429	1 X TL 40W CU=04,	8	-
Fluid Mechanics LAB	293, 279, 427, 908, 1469, 340	619	1 X TL 40W CU=03, 1 X TL 40W EB=1,	8	-

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.illu.	Light fixture	Hours	Remark
Dept Of Mathematics	**72, 155, 125, 486, 147, 413**	**233**	**1 X TL 36W EB=05,**	**Rare use**	**Less than Rec.**
Heat Transfer Lab	**154, 60, 74, 152, 56, 246**	**127**	**1 X TL 40W CU=02,**	**Rare use**	**Less than Rec.**
Dynamic Machine Lab	**159, 84, 109, 162**	**128**	**1 X TL 40W CU=02, 1 X TL 36W EB=1,**	**6**	**Less than Rec.**
CAD/CAM/CAE Lab	**55, 62, 52, 88, 58**	**63**	**1 X TL 40W CU=02, 1 X TL 36W EB=2**	**4**	**Less than Rec.**
Computer Lab-10	**204, 87, 170, 136, 167, 170, 157, 140, 118**	**149**	**1 X TL 36W=2, 1 N/W, 1 X 40W CU=5,**	**4**	**Less than Rec.**
Computer Lab-21	**142, 105, 78, 92, 285, 135, 30**	**124**	**1 X TL 40W CU=01, 1 X TL 36W CU=01, 1 X TL 36W EB=01**	**4**	**Less than Rec.**
Pune University Exam Control Room	**278, 150, 125, 220, 128**	**180**	**1 X TL36W EB=2, 1 X TL 40W EB=02**	**8**	**Less than Rec.**
Class Room-20	-		1 X TL 40W CU=01, 1 X TL 36W CU=04,	3	-
Class Room-19	-		1 X TL 40W CU=5	3	-.
Computer Lab-2	**102, 109, 185, 90, 150, 52, 37, 194, 111, 134, 62**	**114**	**1 X TL 36W EB=4, 1 X TL 40W CU=02,**	**6**	**Less than Rec.**
Central Computing Faculty	**285, 107, 387, 136, 202, 195, 230, 280, 62, 299, 22, 54, 136**	**184**	**MIRROR 2 X PLL 36W=11**	**6**	**Less than Rec.**
			Workshop		
Workshop office	**214, 145, 109, 177, 142, 104, 186**	**153**	**1 X TL 36W EB=1, 1 X TL 40W CU=02,**	**4**	**Less than Rec.**
FITTING shop-1	**175, 253, 235, 224, 215, 234, 296, 300, 172, 292**	**239**	**1 X TL 40W CU=02,**	**4**	**Less than Rec.**
Carpentry Shop	**215, 234, 296, 300, 172, 292**	**251**	**1 X TL 36W CU=2**	**4**	**Less than Rec.**
Sheet metal Shop	**192, 75, 250, 70, 102**	**138**	**1 X TL 40W CU=02, 1 X TL 36W EB=01,**	**4**	**Less than Rec.**
Machine Shop	**280, 192, 225, 305, 352, 205, 286, 237, 324, 334, 217, 160, 157, 115**	**242**	**1 X TL 40W CU=12,**	**4**	**Less than Rec.**
Canteen	110, 120, 170	133	1 X TL 40W CU=2, 1 X TL 36W CU=1	8	-
Xerox	301, 250	275	1 X TL 40W CU=07,	8	-

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.illu.	Light fixture	Hours	Remark
Electrical Department					
Electrical Machine LAB-1	**83, 104, 130, 128, 145, 140, 330, 404, 240, 109, 114**	**152**	**1 X TL 36W CU=02 , 1 X TL 36W EB=4**	**4**	**Less than Rec.**
Class Room-133	**182, 78, 129, 120, 55, 31, 60**	**93**	**1 X TL 36W CU=01 , 1 X TL 36W EB=1, 1 X TL 40W CU=1,**	**Rare use**	**Less than Rec.**
Class Room-132	No Lights				-
Class Room-131	225, 280, 530, 330, 252	323	1 X TL 36W EB=02,	3	-
A & D 130A	**191, 108, 170, 140**	**152**	**1 X TL 36W EB=01W, 01(N/W)**	**3**	**Less than Rec.**
HVE Testing LAB	111, 640, 281, 129	290		3	-
129, Basic Electrical Lab	95, 260, 365, 250, 702	334	1 X TL 36W EB=02, 1 X TL 40W CU=01W, 01(N/W)	3	-
CS LAB, 129A	**220, 191, 337**	**249**	**1 X TL 36W EB=03, 1 X TL 36W CU=1,**	**3**	**Less than Rec.**
Passage			1 X TL 36W EB=4,	8	-
HOD Cabin	**47, 48, 205, 140, 175**	**123**	**1 X TL 36W EB=2, 1 X TL 36W EB=2,**	**4**	**Less than Rec.**
Class Room 220	209, 187, 560, 880, 990	565	1 X TL 36W EB=4,	3	**Less than Rec.**
Class Room 220A	907, 1946, 285	1046	1 X TL 36W EB=3	3	**Less than Rec.**
Prof, S.A Markad Cabin	**198, 105, 86, 48, 97, 67, 150, 84**	**105**	**1 X TL 36W EB=5**	**3**	**Less than Rec.**
Seminar Hall	**92, 108, 142, 104, 68, 70, 75**	**94**	**1 X TL 36W EB=5,**	**Rare use**	**Less than Rec.**
Library	**153, 42, 150, 91, 140, 185, 156, 164, 128, 250, 234, 275, 314**	**175**	**1 X TL 36W EB=3, 28W CFL=01**	**4**	**Less than Rec.**
B.T Bangar Office	**54, 142, 84, 69, 41**	**78**	**1 X TL 36W CU=2,**	**3**	**Less than Rec.**
Digital Library	**106, 150, 95, 95, 118**	**113**	**1 X TL 36W CU=2,**	**3**	**Less than Rec.**
Xerox Periodical Section	**137, 80**	**108**	**1 X 40W CU=01, 1X TL 36=2W, 1N/W,**	**3**	**Less than Rec.**
Study Room	200,234,215,136,321, 432	256	1 X 40W CU=9	3	-

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.	Light fixture	Hours	Remark
IT Department					
Network Lab	**104, 47, 47, 43, 120, 27, 107, 128**	**78**	**1 X 40W CU=01(N/W), 1X TL 36CU=03,**	**6**	**Less than Rec.**
Programming Lab	**103, 29, 35, 75, 86, 136, 97, 120, 88**	**85**	**1 X 36W CU=4,**	**5**	**Less than Rec.**
Information System Lab	**115, 94, 127, 107, 155, 80, 165, 122, 214**	**131**	**1 X 40W CU=4**	**4**	**Less than Rec.**
Operating System Lab	**90, 42, 92, 76, 50, 118, 114**	**83**	**1 X 40W CU=3, 1 X TL 36W CU=01,**	**8**	**Less than Rec.**
HOD Cabin	**66, 125, 275, 88, 138**	**138**	**1 X TL 36W CU=03,**	**8**	**Less than Rec.**
Tutorial Room	**85, 97, 102, 97, 115, 98**	**99**	**1 X TL 36W CU=03,**	**6**	**Less than Rec.**
Project LAB	**136, 100, 134, 95, 141, 88, 89, 115, 67**	**99**	**1 X TL 36W CU=05,**	**4**	**Less than Rec.**
NEW ENGG BUILDING					
Principal Office	681, 550, 450, 550, 670	580	MIRROR 2 X PLL 36W CU=5	4	-
Principal PA Cabin	**142, 91, 99**	**110**	**MIRROR 2 X PLL 36W CU=2**	**4**	**Less than Rec.**
Vice Principal	**140, 213, 290, 110, 140, 159, 92, 111**	**157**	**MIRROR 2 X PLL 36W CU=2, 1 X TL 36W CU=01,**	**4**	**Less than Rec.**
Pantry	159, 92, 111	121	1 X TL 36W CU=01,	4	-
Board Room	132, 427, 545, 240, 564, 530, 520	422	MIRROR 2 X PLL 36W CU=10	4	-
Register Office	262, 302, 230, 113	227	MIRROR 2 X PLL 36W CU=2	4	-
Training & Placement	529, 528, 530, 510	524	MIRROR 2 X PLL 36W CU=4	4	-
Waiting Room	390, 126, 275, 147, 455	278	MIRROR 2 X PLL 36W CU=3	4	-
General office	78, 80, 100, 116, 220, 153, 142, 160, 151, 202, 241, 210, 284, 301	174	1 X TL 36W CU=10W, 1N/W,	4	-
Form Feeling Center	**62, 78, 73, 89, 122, 160**	**97**	**1 X TL 36W CU=4**	**6**	**Less than Rec.**
Ground Floor Passage	280, 508, 214, 495, 380, 470, 595	420	1 X TL 36W CU=11W, 1N/W	8	-
New Library	**173, 228, 175, 89, 133, 586, 142, 559, 260, 278, 240, 92, 45, 188, 295**	**232**	**1 X TL 36W CU=11W, 1N/W**	**8**	**Less than Rec.**

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av. Illu.	Light fixture	Hours	Remark
Library Student Section room	186, 219, 594, 390, 331, 425, 932, 2390, 325, 181, 160	557	1 X TL 36W CU=19, 01N/W	8	-
Agriculture collage					
Principal Office	**315, 172, 144, 209**	**210**	**1 X TL 36W CU=3**	**3**	**Less than Rec.**
Pantry	284, 230, 261	258	1 X TL 36W CU=1	4	-
Administrative Office	298, 310, 250, 506, 288	330	1 X TL 36W CU=4	8	-
Student Lobby	308, 415, 519, 215, 410, 208	345	1 X TL 36W CU=3	6	-
Staff room	283, 300, 298, 140, 245	253	1 X TL 36W CU=3	8	-
Computer Room	232, 313, 215, 223, 261	248	1 X TL 36W CU=5	8	-
Girls Common Room	597, 429, 135	387	1 X TL 36W CU=5	4	-
Girls Toilet	560, 275	418	1 X TL 36W CU=2	8	-
Seminar Room	**125, 125, 84, 100, 77, 158, 166, 195**	**128**	**1 X TL 36W CU=5**	**3**	**Less than rec.**
Department of Agriculture Extensional room	**130, 54, 143, 45, 138, 158, 64, 108**	**105**	**1 X TL 36W CU=6**	**6**	**Less than rec.**
Passage	-	-	1 X TL 36W CU=4	8	-
First Floor					
NCC & NSS room	121, 124, 360	201	1 X TL 36W CU=1	4	-
Class Room -1	-	-	1 X TL 36W CU=1	2	-
Class Room -2	-	-	1 X TL 36W CU=1	2	-
Class Room -3	-	-	1 X TL 36W CU=1	3	-
Department Soil & Science Agriculture	489, 1425, 746, 1098, 1202	991	1 X TL 36W CU=4	3	-
Department Animal & Science Dairy	**146, 220, 127, 190, 75**	**151**	**1 X TL 36W CU=3W, 1N/W,**	**2**	**Less than rec.**
Department Pathology	-	-	1 X TL 36W CU=5	2	-
Department of Horticulture	-	-	1 X TL 36W CU=5	2	-
Reading Room	-	-	1 X TL 36W CU=10,	6	-
Botany	211, 536, 438, 559, 277, 239, 108, 90, 175	293	1 X TL 36W CU=4,	4	-

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av. Illu.	Light fixture	Hours	Remark
Department Of Agriculture Engineering	-	-	1 X TL 36W CU=03,	6	-
First Floor Passage	-	-	1 X TL 36W CU=8,	8	-
Gents Toilet	-	-	1 X TL 36W CU=2,	8	-
Girls Toilet	-	-	1 X TL 36W CU=2	8	-
Agronomy	-	-	1 X TL 36W CU=8,	4	-
Museum	166, 160, 169, 171, 219, 130	169	1 X TL 36W CU=4,	3	-
Boy's Common room	-	-	1 X TL 36W CU=3,	4	-
MBA AND MCA COLLAGE					
Ground Floor					
Library	**102, 155, 184, 180**	**155**	**1 X TL 36W CU=1,**	**6**	**Less than rec.**
Reading Room	**141, 119, 108, 117, 162, 63, 27, 100, 75**	**101**	**1 X TL 40W CU=14**	**6**	**Less than rec.**
Pantry	2040, 1047	1543	1 X TL 36W CU=1,	4	
Class Room	**101, 118, 90, 98, 91, 108, 86, 75**	**96**	**1 X TL 40W CU=4**	**3**	**Less than rec.**
Board Room	**150, 200, 181, 200**	**182**	**MIRROR 2 X 36W CU=03,**	**3**	**Less than rec.**
Passage	**138, 200, 171, 167, 178, 130, 216, 151**	**169**	**1 X TL 36W CU=7,**	**8**	**Less than rec.**
Director Room	**138, 200, 171, 167, 178, 136, 216, 151**	**169**	**MIRROR 2 X 36W CU=06,**	**6**	**Less than rec.**
Toilet			1 X TL 36W CU=01,	6	-
Main Office	**90, 107, 123, 218, 277, 135, 142, 168, 154, 157, 202, 130, 107, 79, 24, 217, 114, 132, 515, 297**	**169**	**1 X TL 40W CU=02, 1 X TL 36W CU=10,**	**8**	**Less than rec.**
Computer Lab 1 & 2	**111, 84, 115, 147, 258, 82, 126, 137, 255, 118, 82, 133**	**133**	**1 XTL 40W CU=6,**	**6**	**Less than rec.**
Class-4	**70, 146, 83, 90, 70, 114**	**96**	**1 X 40W CU=02,**	**3**	**Less than rec.**
General Store	**132, 21, 8**	**53**	**1 X 40W CU=01,**	**3**	**Less than rec.**
Computer LAB 3 & 4	**125, 205, 75, 77, 120, 134, 70, 132**	**117**	**1 X TL 36W CU=5,**	**6**	**Less than rec.**
Exam control room	**96, 150, 99, 92**	**110**	**1 X TL 40W CU=02,**	**6**	**Less than rec.**

Table 3.0: Area wise illumination level and Light Fixture details.

Location	Illumination level	Av.illu.	Light fixture	Hours	Remark
Girls Common room	85, 132, 146	121	1 X TL 40W CU=1	6	-
Boys Common room	164, 76, 140	127	1 X TL 40W CU=1	6	-
Class Room-5	**266, 165, 88, 130,**	**163**	**1 X TL 40W CU=4**	**2**	**Less than rec.**
First floor					
Faculty Room	115, 160, 121, 207, 213	145	1 x TL 36W CU=02,	3	-
Class Room-1	**124, 224, 57, 36, 416, 116, 135**	**158**	**1 X TL 36W CU=04,**	**3**	**Less than rec.**
Battery Room	224, 305	265	1 X TL 40W CU=01,	8	-
Seminar Hall-2	**23, 79, 45, 80, 123, 135, 28**	**74**	**1 X TL 40W CU=05,**	**4**	**Less than rec.**
Seminar Hall-1	**198, 115, 119, 25, 55, 20, 130**	**95**	**1 X TL 40W CU=04W, 01N/W,**	**4**	**Less than rec.**
Gents Toilet			1 X TL 40W CU=02	8	-
Girls Toilet			1 X TL 40W CU=03	8	-
Junior And Senior Collage					
Principal Office	**185, 205, 164**	**187**	**1 X TL 40W CU=02, 1 X TL 36W CU=1,**	**6**	**Less than rec.**
Administrative Office	164, 490, 195, 280, 575	341	1 X TL 40W CU=03, 1N/W,	8	-
Department computer science	**150, 160, 97, 47, 96, 50, 45**	**93**	**1 X TL 40W CU=03,**	**6**	**Less than rec.**
Computer Lab=5	262, 323, 200, 230, 427	289	1 X TL 40W CU=01, 1 X TL 36W CU=1,	6	-
CAP Assessment	**196, 202, 169, 66, 112, 92**	**140**	**1 X TL 40W CU=02,**	**8**	**Less than rec.**
Class Room-10	285, 230, 454, 247, 270	297	1 X TL 40W CU=02	8	-
Faculty Room-1	407, 195, 235	304	1 X TL 40W CU=01W, 1N/W,	8	-
Faculty Room-2	480, 195, 235	303	1 X TL 40W CU=02	8	-
Last room	**185, 244, 170, 240**	**210**	**1 X TL 40W CU=02**	**8**	**Less than rec.**
Seminar HALL	640, 445, 463, 157, 350, 651	451	MIRROR 4 X 36W=10	8	-
Passage			1 X TL 40W CU=02	8	-

Table 3.0: Area wise illumination level and Light Fixture details.

Engineering College					
Boys hostel	Total rooms	Illumination Level	Illumination Average	Light fixture	Hrs
Hostel-A					
Rooms	60	97, 252, 120, 122	148	1 x TL 36W EB=2	10
Toilets	6	67,45,89	67	1 x TL 36W EB=3	10
HOSTEL-B					
ROOMS	60	285, 133, 81, 286, 144, 301, 503	248	1 X TL 36W CU=2	10
TOILETS	6	67,45,77,89	70	1 x TL 36W EB=2	10

Girls Hostel					
Kaveri					
Rooms	55	135, 91, 345, 109, 40	144	1 X TL 36W CU=02,	10
Toilets	5	99, 135, 41, 73	87	1 X TL 40W CU=2	10
NEW BUILDING-1	28	134, 157, 165, 162	155	12W CFL=3, PL 20W=02,	10
Toilets	4	98, 178, 65	113	1 X TL 36W CU=02,	10
NEW BUILDING-2	28	143,234,167,149	173	12W CFL=3, PL 20W=02,	10
Toilets	4,5,9,12,13	87,45,98	77	1 X TL 36W CU=02,	10

5. RECOMMENDED ILLUMINATION LEVELS AND GLARE INDEX

5.1 The levels of illumination and glare index recommended for the different areas in educational institutions are given below:

Areas	*Illumination (Lux)*	*Limitation of Glare Index*
a) Classrooms	300	16
b) Lecture rooms (including Demonstration areas)	300	16
c) Reading rooms	150 to 300	19
d) Laboratories	300	16
e) Corridors	70	—
f) Libraries	300	16
g) Auditorium		
i) Hall	70	—
ii) Foyer	70	—
	150	—
iii) Stage area	300	16
h) Gymnasiums	150	—
j) Cafeterias	100	—
k) Staff Rooms	150	—

3.2: ENERGY CONSERVATION OPPORTUNITIES IN LIGHTING AREA where 1XTL36W Cu / 1XTL 40W Cu/1XTL 36W EB/ 1XTL 40W EB/ 28W CFL/ Mirror 2X36W PLL/ Mirror 4X36W PLL surface mounted Light Fixtures are used for Illumination:

Table: 3.2: Total Number of 1XTL36W Cu / 1XTL 40W Cu/1XTL 36W EB/ 1XTL 40W EB/ 28W CFL/ Mirror 2X36W PLL/ Mirror 4X36W PLL light Fixtures.

0 to 4 Hours (Rare Use)							**4 to 8 Hours**							**8 to 12 Hours**		
Lighting Fixture	1XTL 36W CU	1XTL 40W CU	1XTL 36W EB	1XTL 40W EB	28W CFL	Mirror 2X36W PLL	**Lighting Fixture**	1XTL 40W CU	1XTL 36W CU	1XTL 36W EB	1XTL 40W EB	Mirror 2X36W PLL	Mirror 4X36W PLL	**Lighting Fixture**	1XTL 36W CU	1XTL 36W CU EB
Working	123	132	71	12	1	1	**Working**	141	146	28	24	17	10	**Working**	4	4
Not Working	6	6	1				**Not Working**	7	37	2	2			**Not Working**		
Total	129	138	72	12	1	1	**Total**	148	183	30	26	17	10	**Total**	4	4

3.3: ENERGY CONSERVATION IN LIGHT FIXTURES

Table 3.3: Energy conservation by replacement of 1XTL36 /1XTL40 Watt lamps with copper ballast /Low loss/EB by 20 W T8 LED type lamp in same Light Fixture(4 Hours of Use per Day)

Sr. No	Description	
1	Total power consumption of 138 number of 1XTL40W light fixtures with copper choke , 12 number with Electronic ballast , 179 Number of 1XTL36 W with copper choke , and 72 number with Electronics Ballast	138X54+12X42+179X50 +38X72/1000 =7.452+0.504+8.95+2.736= 19.642 KW
2	Total power consumption number of 411 number 20 W TL LED lamp in same Fixture	411X20/1000 = 8.22 KW
3	Power consumption reduction by replacement of 1XTL40/36 Watt lamps with copper/low loss /EB ballast by 20 T8 LED type lamp in same Fixture.	11.422 KW
4	Energy saving per year considering 4 hours operation per day and 360 days in year	11.422X4X360 = 16447.68 KWH
5	Total energy cost saving/year considering energy cost Rs 11.52 / KWH including demand charges and Electricity Duty	Rs11.52x16447.68= Rs 189477.2736
6	Total cost of 20 W LED TL lamps to be used in same light fixture	Rs 550x401 = Rs 220550.00
7	Payback period	1.163 years or 13.967 months
8	% Return on investment	85.91

Table 3.4: Energy conservation by Replacement of Mirror PLL2X36 Light fixtures by 2 feet X 2 feet 36W LED Panel Light fixture(4 Hours Use)

Sr. No	Description	
1	Total power consumption 1 number PLL2X36 W mirror light fixtures	76X1/1000 = 0.076KW
2	Total power consumption of 01 number 36W 2 feet X 2 Feet LED panel Light fixture.	36X1/1000 = 0.036KW
3	Power consumption reduction by replacement of Total power consumption of Mirror PLL2X36 and 4XPLL36 light fixtures by 2 feet X 2 feet 36 W LED panel Light Fixtures .	0.040KW
4	Energy saving per year considering 4 hours operation per day and 360days in year	0.040X4X360 = 57.60KWH
5	Total energy cost saving/year considering energy cost Rs 11.52/ KWH	Rs11.52X57.60= Rs663.552
6	Total cost of 36W , LED 2 feet X 2 feet Panel fixtures.	Rs2150X1 = Rs 2150.00
7	Payback period	3.24 years or 38.88 months
8	%ROI	30.862

Table 3.5: Energy conservation by replacement of 1XTL36 /1XTL40 Watt lamps with copper ballast /Low loss/EB by 20 W T8 LED type lamp in same Light Fixture(6 Hours of Use per Day)

Sr. No	Description	
1	Total power consumption of 148 number of 1XTL40W light fixtures with copper choke , 26 number with Electronic ballast , 183 Number of 1XTL36 W with copper choke , and 30 number with Electronics Ballast	148X54+26X42+183X50 +30X38/1000 =7.992+1.092+9.15+1.14= 19.374 KW
2	Total power consumption number of 387 number 20 W TL LED lamp in same Fixture	387X20/1000 = 7.74 KW
3	Power consumption reduction by replacement of 1XTL40/36 Watt lamps with copper/low loss /EB ballast by 20 T8 LED type lamp in same Fixture.	11.634 KW
4	Energy saving per year considering 6 hours operation per day and 360 days in year	11.634X6X360 = 25129.44 KWH
5	Total energy cost saving/year considering energy cost Rs 11.52 / KWH including demand charges and Electricity Duty	Rs11.52x25129.44= Rs 289491.1488
6	Total cost of 20 W LED TL lamps to be used in same light fixture	Rs 550x387 = Rs 212850.00
7	Payback period	0.735 years or 8.823 months
8	% Return on investment	136.00

Table 3.6: Energy conservation by Replacement of Mirror PLL2X36/PLL4X36 Light fixtures by 2 feet X 2 feet 36W LED Panel Light fixture(6 Hours Use)

Sr. No	Description	
1	Total power consumption 17 number PLL2X36 W and 10 Number of 4XPLL36 W mirror light fixtures	76x17+152x10/1000 = 1.292 +1.52 = 2.812KW
2	Total power consumption of 27 number 36W 2 feet X 2 Feet LED panel Light fixture.	36X27/1000 = 0.972KW
3	Power consumption reduction by replacement of Total power consumption of Mirror PLL2X36 and 4XPLL36 light fixtures by 2 feet X 2 feet 36 W LED panel Light Fixtures .	1.84 KW
4	Energy saving per year considering 6 hours operation per day and 360days in year	1.84 X6X360 = 3974.40KWH
5	Total energy cost saving/year considering energy cost Rs 11.52/ KWH	Rs11.52X3974.40= Rs45785.00
6	Total cost of 36W , LED 2 feet X 2 feet Panel fixtures.	Rs2150X27 = Rs 58050.00
7	Payback period	1.267 years or 15.214 months
8	%ROI	78.871

Table 3.7: Energy conservation by replacement of 1XTL36 /1XTL40 Watt lamps with copper ballast /Low loss/EB by 20 W T8 LED type lamp in same Light Fixture(10 Hours of Use per Day)

Sr. No	Description	
1	Total power consumption of 4 Number of 1XTL36 W with copper choke , and 4 number with Electronics Ballast	4X50 +4X38/1000 =0.352 KW
2	Total power consumption number of 8 number 20 W TL LED lamp in same Fixture	8X20/1000 = 0.160 KW
3	Power consumption reduction by replacement of 1XTL40/36 Watt lamps with copper/low loss /EB ballast by 20 T8 LED type lamp in same Fixture.	0.192 KW
4	Energy saving per year considering 10hours operation per day and 360 days in year	0.192 X10X360 = 691.20 KWH
5	Total energy cost saving/year considering energy cost Rs 11.52 / KWH including demand charges and Electricity Duty	Rs11.52x691.20= Rs 7962.624
6	Total cost of 20 W LED TL lamps to be used in same light fixture	Rs 550x8 = Rs 4400.00
7	Payback period	0.552 years or 6.630 months
8	% Return on investment	180.96

Table 3.8:Summary of total Energy saving in lighting

Sr. No.	Energy conservation measures	Energy saving per Year In KWH	Energy cost Saving per Year in Rs	Investment Rs	Pay back period Year	%ROI
1	Replacement of 1XTL36/40W Watt lamps with copper /Low loss/EB ballast by 20 _TL LED type lamp in same Light Fixture	42268.32	486931.00	437800.00	0.899 years or 10.789 months	111.222
2	Replacement of PLL2X36/4X36 mirror light fixtures by 2 feet X 2 Feet 36W LED panel Light fixture	4032.00	46448.64	60200.00	1.29 years or 15.552 months	77.157
Total Rs		46300.32	533379.60	498000.00	0.933 years or 11.204 months	107.104

Table 3.9: Power consumption reduction in lighting after Implementation of recommended Energy conservation measures

Sr. No.	Recommended Energy conservation Measures	Reduction in power consumption in KW
1	Replacement of 1XTL36 /40wWatt lamps with copper /Low loss /EB ballast by 20 TL LED type lamp in same Light Fixture	23.056
2	Replacement of PLL2X36/4X36 mirror light fixtures by 2 feet X 2 Feet 36W LED panel Light fixture	0.232
Total power consumption reduction in KW		23.288

Revised lighting load = 17.108 KW
Existing connected load considered for replacement with LED lights =40.396 KW
% Reduction in lighting load = 57.629 %

Specifications of proposed LED lights :

1)LED TL 20 W Linear LED lamp , 1200MM length , Color temperature : 5500Degree Kelvin , CRI :85 , Input voltage range :90-300V , Lumen out put :1760

2) 36W , 2 Feet X 2 Feet Recesses mounted light fixtures centre light Armstrong , Input voltage Range :90-300V , Power factor :0.95 , CRI =85 , Color Temperature : 6500 Degree Kelvin, Lumen output : 3280

3) 12 W T5 LED lamp Color temperature : 5500Degree Kelvin , CRI :85 , Input voltage range :90-

Recommended LED light fixture Makes:

5) SYSKA
6) PHIPLIPS
7) WIPRO
8) OSRAM

Street lighting technology comparison

Light technology	Life time	Lumens per watt	Color temperature	CRI (color rendering index)	Ignition time	considerations
Incandescent light	1.000 - 5.000	11 - 15	2.800K	40	instant	very inefficient, short life time
Mercury vapor light	12.000 - 24.000	13 - 48	4.000K	15 - 55	up to 15 min	very inefficient, ultraviolet radiation, contains mercury
Metal halide light	10.000 - 15.000	60 - 100	3.000-4.300K	80	up to 15 min	high maintenance UV radiation, contains mercury and lead, risk of bursting at the end of life
High pressure sodium light	12.000 - 24.000	45 - 130	2.000K	25	up to 15 min	low CRI with yellow light, contains mercury and lead
Low pressure sodium light	10.000 - 18.000	80 - 180	1.800K	0	up to 15 min	low CRI with yellow light, contains mercury and lead
Fluorescent light	10.000 - 20.000	60 - 100	2.700-6.200K	70 - 90	up to 15 min	UV radiation, contains mercury, prone to glass breaking, diffused non-directional light
Compact fluorescent light	12.000 - 20.000	50 – 72	2.700-6.200K	85	up to 15 min	low life / burnout, dimmer in cold weather (failure to start), contains mercury
Induction light	60.000 - 100.000	70 – 90	2.700-6.500K	80	instant	higher initial cost, limited directionality, contains lead, negatively affected by heat
LED light	50.000 - 100.000	70 - 150	3.200-6.400K	85 - 90	instant	relatively higher initial c

CHAPTER -4

POWER QUALITY AUDIT FINDINGS AND RECOMMENDATIONS

CHAPTER -4

POWER QUALITY AUDIT FINDINGS AND RECOMMENDATIONS

4.1 NEED OF POWER QUALITY AUDIT

There are several important reasons to conduct power quality audit. The various reasons are:

To avoid financial loss due to process disruption: - The various cost of disruption is a) Lost work: The product or service is not generated for a period of time until the recovery is complete. The various cost related to lost work are idled labor, lost production hence lost profits, overtime labor and premium charges, overtime operating cost, late delivery fees. b) Cost of repair of the damaged equipment: - The various costs involved in repairing of damaged equipment due to power quality problem are repair, cost of labor, cost of replaced spare parts, cost of replacement part availability. c) Cost of recovery: - Cost involved in recovery of secondary equipment failures, recovery of labor inefficiency. d) Cost of scrap and product quality: - The various cost involved are replacement value of scrap (BOM value + labor value, product lost profit margin and rework costs. e) Miscellaneous cost: - The various miscellaneous costs are customer's dissatisfaction, lost business, avoided customers due to longer lead time, fines and penalties etc.

Considering the huge financial losses related to a power quality event causing process disruption to industry, it is necessary to monitor power quality to provide cost effective solution to avoid financial losses. The various effects of power quality event on equipment and process operation include mis-operation, damage, process disruption, and other anomalies.

4.2 IMPACT OF POWER QUALITY PROBLEMS ON THE OPERATIONS OF VARIOUS EQUIPMENTS

The growing percentage of sensitive equipments and process downtime due to power quality problems has pointed out an incompatibility between the tolerances of electronics appliances to power disturbances and the expected electric environment. Power quality audit helps to study various power quality problems present in electric supply distribution system and to take appropriate remedial actions. With a better understanding of the electrical environment, end users can request improvements in the tolerance of electrical appliances to power quality disturbances to ensure electrical power system compatibility. In order to mitigate these power quality anomalies a statistical knowledge base of frequency, voltage profiles as a function of time of the day is required. The harmonics present in the electrical distribution are undesirable for the operation of various equipments. They cause frequent failure of equipments due to excessive heating, over loading of transformers and cables, malfunctioning of electronic equipments and increase in line loss etc.

Some symptoms caused by power quality include:

- Malfunction of equipment.
- Frequent system reboots becoming necessary.
- High failure rate of electronic systems.
- Overheating of transformers, cables, motors and capacitor banks.
- A.C coil contactor disengagement and tripping of ASD's.
- Inaccuracy of testing and measuring equipment.
- Light dimming or blinking.

The level of power quality required is that level which will result in proper operation of equipment at a particular facility. It is the susceptibility of end use equipment that defines the necessary level of power quality. The various power quality problems with their characteristics are tabulated in Table 8.0

4.3 RESULTS OF POWER QUALTIY ANALYSIS

Power quality analysis was conducted at various feeders .The result of power quality analysis conducted for various positions of tap of the distribution transformer is presented below.

4.4:Power Quality Analysis at Main LT incomer

Table 4.0: Power Quality Analysis at Main LT incomer

Parameter	**CH1**			**CH2**			**CH3**		
	Max.	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**
RMS VOLTAGE (V)	451.61	436.14	416.29	443.6	429.05	408.49	448.62	434.1	413.25
RMS CURRENT (A)	133.84	75.67	46.02	134.46	76.42	37.87	117.88	53.22	34.77
RMS VOLTAGE AVG.(V)	447.94	433.09	412.79	---	---	---	---	---	---
RMS CURRENT AVG.(A)	120.95	68.44	41.74	---	---	---	---	---	---
ACTIVE POWER (KW)	90.1	47.81	26.03	---	---	---	---	---	---
REACTIVE POWER (KVAR)	22.77 Cap	13.77 cap	0.03 Cap	---	---	---	---	---	---
APPARENT POWER (KVA)	92.19	51.28	31.54	---	---	---	---	---	---
POWER FACTOR	0.997 Lead	0.91848 Lead	0.825 Lead	---	---	---	---	---	---
K.F.	3.19	1.6	1.11	3.79	1.42	1.1	4.03	1.95	1.22
%Vunb	1.26	0.978	0.6	---	---	---	---	---	---
%Iunb	48.47	24.735	6.99	---	---	---	---	---	---
%VTHD	2.9	1.32	0.58	2.47	1.27	0.59	3.1	1.39	0.54
%ITHD	32.66	13.08	5.44	22.92	10.71	5.01	28.62	14.94	7.17

Table 4.1: Individual Voltage Harmonic Distortion in Volts at Main LT incomer

Harmonic Order	**CH1**			**CH2**			**CH3**		
	Max.	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**
2	1.51	0.44	0.24	1.67	0.35	0.14	1.35	0.43	0.25
3	2.53	1.52	0.78	2.57	1.52	0.79	3.01	1.67	0.8
5	12.13	3.82	0.18	8.61	3.26	0.15	12.06	4	0.24
7	6.11	3.02	0.79	6.77	3.37	0.76	8.12	3.45	0.25
9	1.86	0.51	0.05	0.94	0.28	0.05	1.58	0.39	0.08
11	1.84	0.73	0.12	1.49	0.68	0.04	0.76	0.34	0.05
13	0.64	0.24	0.02	0.58	0.24	0.04	0.5	0.2	0.01
15	0.47	0.14	0.01	0.6	0.09	0.01	0.55	0.11	0.01
17	0.7	0.12	0.01	0.83	0.13	0.01	0.92	0.17	0.02
19	0.93	0.2	0.03	0.99	0.16	0.02	1.03	0.21	0.02
21	0.82	0.09	0.01	0.83	0.11	0.02	0.85	0.13	0.01
23	0.64	0.2	0.02	0.67	0.23	0.01	0.83	0.27	0.02
25	0.77	0.19	0.01	0.74	0.24	0.02	0.64	0.22	0.02
27	0.29	0.14	0.02	0.31	0.13	0.01	0.4	0.11	0.01
29	0.3	0.11	0.01	0.31	0.1	0.01	0.37	0.09	0.02
31	0.68	0.18	0.01	0.48	0.15	0.01	0.6	0.18	0.02
33	0.3	0.08	0.01	0.48	0.13	0.01	0.49	0.13	0.01
35	0.57	0.17	0.01	0.86	0.2	0.02	1.07	0.2	0.01
37	0.91	0.19	0.02	0.85	0.2	0.02	0.65	0.17	0.02
39	0.44	0.13	0.02	0.48	0.11	0.01	0.38	0.1	0.01
41	0.41	0.1	0.01	0.43	0.11	0.01	0.39	0.1	0.01
43	0.42	0.13	0.01	0.35	0.11	0.01	0.28	0.08	0.02
45	0.45	0.1	0.01	0.44	0.13	0.03	0.4	0.09	0.01
47	0.58	0.13	0.01	0.92	0.18	0.01	1.19	0.19	0.01
49	1.14	0.19	0.01	0.82	0.16	0.02	0.71	0.13	0.01

Table 4.2: Individual Current Harmonic Distortion in Ampere at main LT incomer

Harmonic Order	CH1			CH2			CH3		
	Max.	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**
2	4.65	1.28	0.69	4.73	1.41	0.76	4.17	1.06	0.44
3	21.22	6.21	1.56	9.93	4.74	1.74	8.66	3.46	0.65
5	21.03	6.45	1.19	12.1	3.65	0.12	13.23	4.28	0.26
7	12.84	4.72	0.99	8.09	3.77	0.99	11.12	5.02	1.13
9	3.48	0.63	0.07	3.18	1.1	0.1	2.57	1.05	0.27
11	2.75	0.97	0.08	2.48	0.89	0.08	2.01	0.76	0.06
13	1.76	0.58	0.02	1.75	0.6	0.07	1.5	0.53	0.11
15	1.23	0.5	0.11	1.29	0.35	0.08	1.11	0.45	0.17
17	1.34	0.23	0.01	1.23	0.14	0.02	1.22	0.13	0.01
19	1.03	0.21	0.02	1.21	0.14	0.01	1.1	0.15	0.02
21	0.85	0.13	0.01	0.9	0.13	0.02	0.82	0.1	0.01
23	0.63	0.21	0.03	0.59	0.18	0.02	0.78	0.21	0.01
25	0.5	0.15	0.01	0.58	0.16	0.01	0.46	0.16	0.01
27	0.44	0.1	0.01	0.26	0.08	0.01	0.29	0.12	0.02
29	0.16	0.05	0.01	0.19	0.06	0.01	0.29	0.06	0.01
31	0.37	0.11	0.02	0.22	0.06	0	0.32	0.08	0.01
33	0.18	0.05	0.01	0.22	0.05	0	0.29	0.08	0.01
35	0.33	0.08	0	0.26	0.08	0	0.6	0.13	0.01
37	0.34	0.08	0	0.39	0.07	0.01	0.28	0.08	0.01
39	0.17	0.05	0.01	0.16	0.05	0	0.18	0.04	0
41	0.14	0.04	0.01	0.15	0.04	0.01	0.21	0.04	0
43	0.15	0.05	0.01	0.13	0.04	0	0.14	0.04	0.01
45	0.12	0.03	0	0.18	0.05	0.01	0.22	0.04	0
47	0.26	0.05	0.01	0.22	0.05	0	0.46	0.07	0
49	0.23	0.06	0	0.27	0.06	0.01	0.19	0.05	0

4.5:Power quality analysis at main LT incomer :

- RMS Voltage variation is between 408.49 V to 451.61V.RMS voltage variation is Higher considering Utilization voltage range of Equipments .Higher RMS voltage results into increase in power consumption of Motors and Lamps in addition to accelerated ageing leading to premature failure .
- Average value of % Total voltage harmonic distortion is less than 5% limit recommended by IEEE 519-1192 standard for general distribution system below 69KV.
- Average value of % Individual voltage harmonic distortion of all order are less than 3% limit recommended by IEEE 519-1992 standard for general distribution system below 69KV .
- Average % Voltage unbalance factor is 1.26% which is slightly higher than 1% limit recommended by NEMA MG standard .
- Average %Current unbalance factor is higher.
- Average value of % Total current harmonic distortion is higher than 5% limit recommended by IEEE 519-1192 standard for general distribution system below 69KV for ISC/IL ratio less than 20
- Average %Individual current harmonic distortion of 3, 5,7 th order is more than recommended limit by IEEE 519-1992 standard.
- Reactive power management is inadequate .There is over compensation .Over compensation results into increase in MD and transformer loading and losses. Over compensation is due to fixed capacitors connected at various locations which remains in circuit even during night when load reduces .Recommended to provide timer based capacitor logic to switch off capacitors automatically after conclusion of college hours.

4.6: Power quality analysis at main DB Panel 1 Engineering

Table 4.3: Power quality analysis at main DB Panel 1 Engineering

Parameter	CH1			CH2			CH3		
	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.
RMS VOLTAGE (V)	450.04	433.85	301.11	442.71	427.57	297.85	449.18	433.79	301.64
RMS CURRENT (A)	89.96	56.61	37.21	83.56	53.71	25.93	51.23	36.06	29.84
RMS VOLTAGE AVG.(V)	447.31	431.74	300.2	---	---	---	---	---	---
RMS CURRENT AVG.(A)	74.92	48.79	30.99	---	---	---	---	---	---
ACTIVE POWER (KW)	43.87	29.65	13.72	---	---	---	---	---	---
REACTIVE POWER (KVAR)	30.18 Cap	20.71 cap	13.21 Cap	---	---	---	---	---	---
APPARENT POWER (KVA)	47.98	36.46	23.21	---	---	---	---	---	---
POWER FACTOR	0.96 Lead	0.81 Lead	0.46 Lead	---	---	---	---	---	---

4.7:Power quality analysis at main DB Panel 1 Engineering :

- RMS Voltage variation is goes up to 450.04V.RMS voltage variation is Higher considering Utilization voltage range of Equipments .Higher RMS voltage results into increase in power consumption of Motors and Lamps in addition to accelerated ageing leading to premature failure .
- Reactive power management is inadequate .There is over compensation .Over compensation results into increase in MD and transformer loading and losses.

4.8:Power quality analysis at Main DB Panel 2 Engineering

Table 4.12: Power quality analysis at Main DB Panel 2 Engineering

Parameter	CH1			CH2			CH3		
	Max.	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**
RMS VOLTAGE (V)	450.2	432.64	331.08	442.53	426.94	373.9	449.39	429.68	20.23
RMS CURRENT (A)	77.16	31.7	6.87	90.38	31.35	6.96	98.19	34.46	7.2
RMS VOLTAGE AVG.(V)	447.37	429.75	241.74	---	---	---	---	---	---
RMS CURRENT AVG.(A)	88.58	32.51	7.01	---	---	---	---	---	---
ACTIVE POWER (KW)	57.83	22.66	4.53	---	---	---	---	---	---
REACTIVE POWER (KVAR)	14.78	5.81	0.95	---	---	---	---	---	---
APPARENT POWER (KVA)	59.2	23.48	4.68	---	---	---	---	---	---
POWER FACTOR	1	0.95	0.85	---	---	---	---	---	---

4.9:Power quality analysis at Main DB Panel 2 Engineering:

- RMS Voltage variation is goes up to 450.04V.RMS voltage variation is Higher considering Utilization voltage range of Equipments .Higher RMS voltage results into increase in power consumption of Motors and Lamps in addition to accelerated ageing leading to premature failure .
- Reactive power management is inadequate .There is under compensation .Under compensation results into increase in MD and transformer loading and losses.

Energy Saving potential by maintenance of RMS voltage near 400Volts :

RMS voltage variation is on Higher side and increases to 450 Volts .Higher RMS voltage results into increase in power consumption of pumps and lamps in addition to accelerated ageing of Equipments leading to premature failure .Recommended to maintain RMS Voltage near 400V .Present transformer is of 250KVA 11KV/0.433KV , Dyn11 , ONAN transformer and it is not possible to maintain RMS voltage within recommended limit .Recommended to replace existing transformer by New transformer with 250KVA , 11KV/0.415KV , ONAN , Dyn11, with OLTC +RTCC +AVR as per provided specifications

Energy saving potential by maintenance of RMS voltage near 400 Volts = 0.05x525273 = 26263.65KWH

Energy cost saving potential considering Energy cost of Rs 11.52 per year = Rs 11.52 x 26263.65 = Rs 302557.248

Investment :Cost of New 250KVA transformer :Rs 425000.00

Payback period:1.4046 years or 16.856 Months

%ROI = 71.189

BUZ Relay PROVIDED Between Conservator And Tank.

1) Silica Gel is OK.
2) Conservator Oil Level = 50%
3) Grass In Transformer Yard.

Observations and recommendations :

During energy audit power quality parameters including all power parameters were monitored for 24 hours and Maximum, average and Minimum loading of transformer is tabulated in following table.

Transformer loading details :

Transformer Rating in KVA	Power factor	Load in KVA	%Loading
250	0.918 Leading	Max:92.19 Avg.:51.28 Min:31.54	36.876 20.512 12.616

Transformer Specifications :

KVA=250
Vhv=11KV
Vlv=433V
Ihv= 13.121A
Ilv= 347.811A
Vector Group : Dyn11
Cooling :ONAN
Off load Tap changer

Proposed Transformer Specifications:

Transformer specifications

Supply of 250 VA, 11KV/0.415KV, copper wound, transformer
with ON LOAD TAP CHANGER + RTCC + AVR with following specifications.

<table>
<tr><td>Sr. No</td><td>Technical parameters</td><td colspan="4">Normal duty distribution transformer specifications</td></tr>
<tr><td>1.</td><td>Rating (KVA)</td><td colspan="4">250 KVA</td></tr>
<tr><td>2.</td><td>No load voltage ratio (KV)</td><td colspan="4">11KV/0.415 KV</td></tr>
<tr><td>3.</td><td>Vector group</td><td colspan="4">Dyn11</td></tr>
<tr><td>4.</td><td>Tapping range</td><td colspan="4">7.5% to –7.5 %</td></tr>
<tr><td>5.</td><td>Tap changer</td><td colspan="4">ON LOAD TAP CHANGER</td></tr>
<tr><td>6.</td><td>Steps</td><td colspan="4">1.25%</td></tr>
<tr><td>7.</td><td>Temperature rise (oil/winding): Ambient 50</td><td colspan="4">50/55°C</td></tr>
<tr><td>8.</td><td>No load loss at rated voltage and frequency</td><td colspan="4" rowspan="2">As per ECBC norms</td></tr>
<tr><td>9.</td><td>Full load loss at principal tap at 75°C</td></tr>
<tr><td>10</td><td>Impedance at 75°C (+10 % to – 10 %)</td><td colspan="4">5% [Sub. To IS Tolerance]</td></tr>
<tr><td>11</td><td>IS no.</td><td colspan="4">IS:2026</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">Insulation level
a) HV (KVP/KVrms)
b) LV (KVP/KVrms)</td><td colspan="2">HV (KVP)</td><td colspan="2">75 kVp</td></tr>
<tr><td colspan="2">LV (KVP)</td><td colspan="2">-</td></tr>
<tr><td rowspan="5">13</td><td rowspan="5">Efficiency at various load/pf(Provide data)
% load/pf 1.00 0.9 0.8
125
100
75
50</td><td>% load</td><td>1.00 p. f.</td><td>0.9 p. f.</td><td>0.8 p. f.</td></tr>
<tr><td>125 %</td><td>98.52%</td><td>98.35</td><td>98.15</td></tr>
<tr><td>100 %</td><td>98.75%</td><td>98.61</td><td>98.44</td></tr>
<tr><td>75 %</td><td>98.97%</td><td>98.85</td><td>98.71</td></tr>
<tr><td>50%</td><td>99.13%</td><td>99.03</td><td>98.91</td></tr>
<tr><td rowspan="5">14</td><td rowspan="5">Regulation at various load/pf(Provide data)
% loading/pf
Regulation
125
100
75
50</td><td>% load</td><td>1.00 p. f.</td><td>0.9 p. f.</td><td>0.8 p. f.</td></tr>
<tr><td>125 %</td><td>1.561%</td><td>4.015%</td><td>4.840%</td></tr>
<tr><td>100 %</td><td>1.219%</td><td>3.193%</td><td>3.859%</td></tr>
<tr><td>75 %</td><td>0.892%</td><td>2.380%</td><td>2.884%</td></tr>
<tr><td>50%</td><td>0.580%</td><td>1.577%</td><td>1.916%</td></tr>
<tr><td>15</td><td>Fitting with transformer
1. Rating and diagram plate
2. Lifting lugs
3. Air release valve
4. Single partitioned conservator with oil filling hole and drain plug
5. Double diaphragm explosion vent
6. 2 Nos. thermometer pockets
7. 2 Nos. earthing terminals
8. Magnetic oil level gauge with LLA contact</td><td colspan="4">1 HV termination: Cable box with disconnection chamber
2 LV termination: Cable box with disconnection chamber

OK</td></tr>
</table>

	9. Top filter valve 10. 2 Nos. silica gel breather 11. Plain oil level indicator 12. Detachable type radiators 13. 4 Nos. bi-directional flat rollers 14. Dial type oil temperature indicator A/T contacts 15. Buchholz relay with two number shut off valve 16. Marshalling box. 17. Bottom drain cum filter valve 18. Oil surge relay for OLTC 19. OLTC with RTCC panel and AVR with PT 20. Termination : 180 Deg orientation	
16	Fitting of RTCC panel 1. Supply of ON indication- 1 Nos. 2. Tap changer in progress indication lamp- 1 Nos. 3. Tap changer indicator digital type –1 Nos. 4. Auto manual switch: 1 Nos. 5. Thermostat for heater (0-60 Deg. C)- 1 Nos. 6. Heater switch; Rotary type: 1Nos. 7. Control supply switches –1 Nos. 8. Raise push button: 1 Nos. 9. Lower push button: 1 Nos. 10. Automatic voltage regulating relay with out LDC- 1 Nos. 11. Fuse for control relay: 1 Nos. 12. Fuse for heater: 1 Nos. 13. Tap changer in progress buzzer: 1 Nos. 14. Strip heater and cubicle illuminating lamps: 1 Nos. 15. PT for AVR-433/110V, CL-3.0, 15VA single phase: 1 Nos. 16. Terminal strip – 1 Nos. 17. Labels for accessories: 1 set 18. Name plate: 1 Nos. 19. Lifting lugs: 2 Nos. 20. Earthing terminal : 2 Nos.	OK

O**observations and recommendations :**

Substation Area:

All lightening arrestors are by passed .Recommended to install lightening arrestors on top most priority .

In substation area there are plants and grass growth .Recommended to keep substation area neat and clean.

Recommended to carry out painting of HT structure .

Apply HT tape at termination at HT bushings .

Transformer is with off load tap changer .

Present tap position is at tap number 2.

Trees near transformer .Recommended to keep area neat and clean.

Transformer LV side NO LV box .Recommended to provide cover to LV side .

No DO fuse with proper fuse size as per peak load conditions or rating of transformer is provided .Copper wire is used .Recommended to use DO fuse of proper rating based on peak load conditions or transformer rated HT current.

No silica gel breather .Recommended to provide silica gel breather to avoid entry of moisture inside transformer tank.

Oil level is ok.

Sand buckets with sand are not provided .Recommended to provide sand bucket with sand .

LT panel Room:

Outgoing cables : 2 Numbers near panel laid on open ground .Recommended to lay cable through cable trench .

Agricultural building 3.5CX120 Sq.mm AYFY cable laid on ground .Recommended to lay cable through trench .

Computer lab.cable from power house 3.5CX120Sq.mmAYFY For agricultural college laid on ground .Recommended to lay cable through cable trench .

Cable trench are without covers .Recommended to provide cover to cable trenches ,

Material stored at back side of panel room.Recommended to keep panel room neat and clean.

NO fixed capacitor or APFC panel is installed at PCC panel.

No rubber mat provided in front of PCC panel .Recommended to provide synthetic mat in front of all panels.

Side cable entry in PCC room is open .Recommended to close side cable entry .

Overhead lines:

Over head line 1: Engg.college , Hostel , staff Quarters

Over head line 2 : MBA , Gym.A Hostel , Bungalows.

Recommended to carry out trimming of tree branches .

Agricultural college :

Earthing is provided to all panels .

No rubber mat provided in front of panels .Recommended to provide synthetic mat in front of all panels .

SMD DB:

No rubber mat provided in front of panels .Recommended to provide synthetic mat in front of all panels

No fire extinguisher is provided .Recommended to provide fire extinguishers .

No multifunction meter is provided .

Panel back side cover is open .Recommended to keep panel covers closed .

SMD DB in front of Computer Lab.:

No rubber mat provided in front of panels .Recommended to provide synthetic mat in front of all panels

No fire extinguisher is provided .Recommended to provide fire extinguishers .

Floor wise DB earthing is provided .

Class Room + Lab: Sufficient day light available

Engineering college :

Electrical building :
Fixed capacitors of10KVAR X2 Numbers are provided .
Specifications of fixed capacitors :
Vn=415V , I=13.9A , 3phase
Make: Madhav Capacitors
Panel Room:
Cable entries are closed .
No rubber mat is provided.
No Fire Extinguishers are provided. Recommended to provide fire extinguishers .
No multifunction meter is provided .
Labs and class rooms:
Sufficient day light is available
IT department :
Computer labs AC are provided .Windows with curtain , sun film applied .
AC filters are clogged .Recommended to carry out regular cleaning of AC filters .
All labs tubes are kept on recommended to switch off tube lights when there is sufficient day light for indoor illumination .
Recommended to carry out regular cleaning of condenser of air conditioners .
Work shop :
Day light is available .
Earthing is provided .
Lathe machines are used only to conduct practical's .
Welding shop : Light were ON. Recommended to switch off lights when not required .
Over head line from IT department to Hostel:
Tree branches are touching line conductors .Recommended to carry out trimming of tree brnches .
Civil Engineering Department :
Server room : AC condenser surfaces are dirty .Filter is clogged .Recommended to carry out regular cleaning of filters and condenser surfaces .
Civil Engg.Computer Lab:
Sun film is applied to window glasses .
Lights kept ON when not required .Recommended to switch off lights .
Panel E&TC , instrumentation Department :
No rubber mat provided in front of panel. Recommended to provide synthetic mat .
No fire extinguisher provided .Recommended to provide fire extinguishers .
No eartthig is provided to incomer PDB
E&TC department :
Computer lab 1 &4 :Air conditioner temperature set point 17 degree centigrade .Recommended to increase temperature set point from 17 to 26 degree Centigrade .
Curtains are provided .
Sun film is applied to window glasses.
AC filters are clogged .Recommended to carry out regular cleaning of filters .
Micro-controller lab:
Air conditioner temperature set point 17 degree centigrade .Recommended to increase temperature set point from 17 to 26 degree Centigrade .
Curtains are provided .
Sun film is applied to window glasses.
Lights are kept ON when not required .Recommended to switch off lights.
Computer lab 126:
All fans and tubes were kept ON .Recommended to switch off fans and tubes when not required .

Sun film applied to window glasses partly .
Central computer Lab.:
No earthing provided to battery rack .Recommended to provide earthing to battery rack .
Dirt and dust accumulation .Recommended to keep area neat and clean.
Rubber mat is not provided .Recommended to provide synthetic mat .
No fire extinguisher is provided .Recommended to provide fire extinguisher .
Mech/Civil Computer Labs:
Sun film provided to window glasses .
AC pipe openings at window .Window kept open .Recommended to close all openings and keep window closed .
Mechanical Department :
Air conditioner temperature set point is 17 Degree centigrade .Recommended to increase temperature set point from 17 degree centigrade to 26 degree centigrade .
Curtains are provided .Sun film applied to window glasses .
Filters of Air conditioners are clogged .Recommended to carry out regular cleaning of filters .
Tubes are kept ON .Recommended to switch off tubes when not required .
PG lab:
Air conditioners temperature set point is 20 degree centigrade .Recommended to increase temperature set point to 26 degree centigrade .
Sun film provided to window glasses.
No door closure is provided .Recommended to install door closure .
Refrigeration and Air conditioning Labs:
Fans and tubes were kept ON .Recommended to switch off fans and tubes when not required .
Instrumentation department :
Computer lab :
Curtains are provided .
Sun film is applied to window glass.
DSP lab:
Lights were kept ON .Recommended to switch off lights when not required .
Sun film provided to window glasses.
Admin Block:
Earthing is provided .
No rubber mat provided .Recommended to provide synthetic mat in front of panel.
No fire extinguisher is provided .Recommended to provide fire extinguishers .
Incoming cable behind admin building laid on ground .Recommended to saddle on wall and provide tray cover .
SMD board :
Earthing connection done on painted surface .Recommended to carry out earth connection after removal of paint .
Library reading Hall :
Sufficient day light .Tubes are kept ON during day .Recommended to switch off tubes during day period .
Admin Digital Lib:
Recommended to close AC pipe openings in wall to avoid infiltration of hot air inside conditioned space .
Hostel Boys A:
No rubber mat is provided .Recommended to provide synthetic mat .
No fire extinguisher is provided near panel. Recommended to provide fire extinguisher .
No earthing is provided .Recommended to provide earth connection .
Floor wise DBs , no lugs are provided .Recommended to provide lugs to avoid loose connection .
DB door were open .Recommended to keep DB doors closed .

Boys Hostel B:
No rubber mat is provided .Recommended to provide synthetic mat .
No fire extinguisher is provided near panel. Recommended to provide fire extinguisher .
Floor wise DBs , no lugs are provided .Recommended to provide lugs to avoid loose connection .
DB door were open .Recommended to keep DB doors closed
Solar Water heaters are provided on terrace of boys and girls hostel and no geysers are provided

CHAPTER -5

REACTIVE POWER MANAGEMENT

5.1 REACTIVE POWER MANAGEMENT

An improvement of power factor can provide both economic and system advantages. The various operational benefits are improved system efficiency, release of system capacity, reduction of power losses and voltage improvement. The energy saving are dependent on

- The percentage reduction in ampere due to additional KVAR
- Motor design, conductor size and conductor length.
- Capacitor watt loss.

REDUCED POWER LOSSES WHEN CAPACITORS ARE LOCATED AT THE LOAD: Since power losses are proportional to the current squared and the current is proportional to the power factor, an improvement in power factor will cause a reduction in system losses and reduced power bills.

% Loss reduction= $100 \times \left(1 - \frac{\text{Original power factor}^2}{\text{Desired power factor}^2}\right)$

5.2:Benefits related with reactive power management

Sanctioned contract demand – 200KVA, 50% OF sanctioned contract demand :100KVA

TABLE 5.1: BENEFITS RELATED TO ADEQUATE REACTIVE POWER MANAGEMENT TO MAINTAIN POWER FACTOR TO UNITY

Month	Billed MD in KVA	P.F	Actual MD At unity power factor	Actual MD recorded in KVA	Difference in billed MD and actual MD at unity Power factor	Reduction in MD charges in Rs	Monthly consumption	Power factor incentives Rs	Additional Power factor incentive Rs by maintain Power factor above 0.996	Monthly bill Rs
JUN-14	136	0.995	135.32	136.00	0.68	129.20	32437	24894.29	7052.10	393790
JUL-14	141	0.991	139.731	141.00	1.269	241.11	44725	24154.97	9522.188	544650
AUG-14	135	0.996	127.488	128.00	7.512	1427.28	49893	36550.21	0.00	578350
SEP-14	157	0.995	156.215	157.00	0.785	149.15	54892	41985.96	0.00	664170
OCT-14	142	0.995	141.29	142.00	0.71	106.50	47399	35654.87	0.00	564090
NOV-14	135	0.990	123.75	125.00	1.25	237.50	46297	25500.03	9848.9696	574910
DEC-14	135	0.980	105.84	108.00	2.16	410.40	38080	12579	14386.444	481060
FEB-15	136	0.986	134.096	136.00	2.00	380.00	45221	22059.36	8467.00	422745.50
MAR-15	165	0.989	163.185	165.00	1.815	344.85	54105	25887.98	10718.76	584219.20
APR-15	170	0.989	168.13	170.00	1.87	355.30	58319	28253.88	12595.305	660155.48
MAY-15	160	0.993	158.88	160.00	1.12	212.80	53905	24933.80	11553.64	582776.48
Total						3994	525273	302454.4	84144.41	6050917
	Average per unit KWH cost Rs 11.52									

Observations and recommendations :
Fixed compensation provided .
There is over compensation .Inadequate reactive power compensation results into increase in MD and transformer loading and branch circuit losses .Recommended to install 150KVAR , 7% detuned RTPFC panel for adequate reactive power compensation .
Benefits of adequate reactive power compensation per Year :Rs88138.41
Cost of 150 KVAR , 7% detuned RTPFC panel : Rs 277500.00
Pay back period : 3.148 Years or 37.78 months
% ROI = 31.761

Specifications of 150KVAR , 7% detuned RTPFC panel:

5.7:Specifications of 7% Detuned 150 KVAR at 415 V RTPFC panel with dual trigger RTPFC relay :

150 KVAR , 7% DETUNED RTPFC PANEL SPECIFICATIONS;

Specifications of 150 KVAR at 415V, 3 Phase , 50 Hz, 7% Detuned harmonic filter reactor , Thyristor Switched RTPFC Panel with following Detailed Specifications :

PANEL SHALL HAVE FOLLOWING MINIMUM FEATURES :

1) Capacitor switching shall be at zero crossing (+/- 3 volt) and shall be smooth and surge less.
2) No electromagnetic contactors / relays/ moving parts shall be used in the switching circuit or in parallel to the switching device .
3) Forced cooling system to thyristors shall be provided.
4) Diagnostic capabilities shall be provided to analyze and indicate the type of fault.
5) Power factor controlling shall be on cycle to cycle basis.
6) The controller shall be capable to work at phase to phase voltage between 200 to 440 volts.
7) Controller shall be 3 phase current & voltage sensing & operating type.
8) Digital controller shall be provided indication of line voltage, and current, power factor, active power, reactive power, apparent power, injected capacitive KVAR, uncompensated capacitive KVAR , CT ratio selected, switching time.
9) LED indication for capacitor bank step switch ON , power factor Lag / lead shall be provided.
10) LT Panel should be type tested at CPRI / ERDA for Short Circuit .
11) Controller should be type tested at NABL Lab.
12) MCB/ HRC Fuse protection shall be suitable for Thyristor Switch.

MICRO PROCESSOR BASED PROTECTIONS TO BE PROVIDED TO THYRISTORISED SWITCHING SYSTEM:

Following protections shall be provided for each Capacitor Feeder.
1) Over voltage protection. 2) Over current protection.
3) Over temperature protection: Internal and External with a separate PT100 input Facility for Thyristor & Reactor of each capacitor feeder.
4) Voltage imbalance protections.
5) Facility of manually operating capacitor bank on first in first out basis.
6)Second Target Power Factor trigger for DG operation to Realize Change Over.

General Technical Specifications For 150 KVAR at 415V, 50Hz, 7% Detuned RTPFC Panel

Sr.No.	Parameters/Details	Specifications
1	Rated Voltage	415V +/-10%
2	Rated Frequency	50Hz,+1.5Hz, -2Hz
3	Rated Output at 415 Volts	150 KVAR+/-5% at rated frequency and Voltage
4	Type	Thyristor Switched Capacitor
5	Configuration	Delta Connected, **525 Volts Rated Capacitors**
6	Number of stages	7
7	Number of Steps	7, Unequal
8	Step Size at 415Volts	5KVAR X1+10KVAR X2 + +25KVARX3+50KVARX1
9	Capacitor Steps required at 525 Volts	7.5KVAR X1+15KVAR X2 + +37.5KVARX3+75KVARX1
10	Protection	Over Current /short Circuit
11	Control	Auto/manual
12	Ambient Conditions	Indoor 10 Deg.C to 40 Deg.C , 60% RH , Non-condensing
13	Primary Protection	320 A, 3P,MCCB With microprocessor based over current , short circuit and earth fault protection release
14	Back up Protection	High Speed semi-conductor Fuse of suitable rating for protection of semiconductor devices in each step .
15	Panel Shell	CRCA Housing with powder coating
16	Panel Finish	RAL 7032
17	Panel Protection Class	IP42
18	Main Bus Bars	Aluminum with current density less than 0.7Amp/Sq.mm
19	Parameter Indication	Voltage , current , power (Real , Reactive) , Power Factor
20	Control Sequence	Programmable by User with FIFO Facility
21	Panel construction	Free Standing
22	Cable Entry	Bottom through cable gland
23	Measuring current input	Three CT with secondary current 5A (Will be Provided by Customer)
24	RTPFC Controller	3 CT sensing , 12 Step, Dual trigger power factor
25	High Speed Fuses	Shall be provided
26	Series Reactors :Detuned Harmonic Filter 7% reactor copper wound with high linearity and Class H insulation at 415 Volts for	Required with low loss
27	Reactor linearity	Linearity :L>=150 LR For current up to 1.73 I1

General Technical Specifications For 150KVAR at 415V, 50Hz, 7% Detuned RTPFC Panel

Sr.No.	Parameters/Details	Specifications
28	Capacitor Type	MPP Heavy Duty type , 525 Volts , loss per KVAR shall be less than 0.2Watt, , max. over current up to 2.2 times rated current .Inrush current :300 Times rated current .Number of annual operations :1,00,000.00
29	Exhaust fan	8 Inch, 3 numbers
30	Panel	CRCA powder coated
31	Application	Indoor
32	Bus Bar Support	SMC/DMC
33	Thyristor PIV	2200V Min.
34	Response Time	Less than 20 m sec
35	Thyristor Stack	SCR –SCR Type
36	Indicating lamps	R,Y,B
37	Analog ammeter with ASS	0-400 A
38	Analog Voltmeter with ASS	0-500V
39	MCB/MCCB rating in each Step	Shall be provided
Special Features Required		
1	Thermal integral switch with temperature sensing and auto Cut OFF of a particular capacitor Feeder in the Event of Temperature Rise . Separate PT100 temperature probe facility to be provided	
2	Fan stoppage alarm with indication by hooter	
3	Smoke detection Feature with interlock with main incomer :In case of smoke incomer should trip	
4	Thermostat to Sense Overall temperature in RTPFC panel and Indication of Over temperature by Hooter .	
Panel Construction Details		
1	Base Channel	75 MM Height and 3mm Thick
2	Load Bearing Frame member	2.00mm
3	Top Cover plate or sheet	1.6mm
4	Bottom cover plate/Gland Plate	1.6mm/3.00mm
5	Side Sheet/walls	1.6mm
6	Circuit breaker compartment door	1.6 mm
7	Other compartment doors/covers	1.6mm
8	Equipment mounting plate	1.6mm

Capacitor Makes : EPCOS/ABB/SCHINEIDER
Thyristor Module :EPCOS/SEMICRON / ABB/SCHINEIDER

CHAPTER 6

ENERGY CONSERVATION OPPORTUNITIES
AIR CONDITIONING
(OBSERVATION, FIELD TRIALS, ANALYSIS AND KEY RESULT AREAS)

CHAPTER -6
MEASURMENT AND ANALYSIS

6.0 FACTORS GOVERNING ENERGY EFFICIENCY OF AIR CONDITIONING SYSTEM

In any commercial buildings power consumption of air conditioning system is major component. Proper design of building, use of energy efficient air-conditioning systems and regular maintenance leads to substantial saving in energy cost.

The various factors governing energy consumption of air-conditioning systems are;

a. **Building design**: Orientation of building plays a key role in the air-conditioning requirement. Excessive use of glass especially on the western side adds high air-conditioning heat loads. Use of materials such as foam concrete, double wall glazing, hollow concrete blocks or foam insulated roofing will help to improve the insulation of building and save energy.
b. **Energy efficient air-conditioning equipments: It is recommended to use the air-conditioning** equipments with the best energy efficiency ratio(EER). Window ACs using rotary compressors are more energy efficient than those with reciprocating compressors. Packaged air-conditioners/ducted splits are available with reciprocating compressor as well as scroll compressors. Scroll compressors are capable of higher EER which leads to saving in energy for higher tonnages Screw and centrifugal equipment are most preferred because of low operating costs. Where heat source such as steam or hot water is available as a by product or economically, absorption type units are a good energy saving choice. Though the initial cost of energy efficient air conditioning unit is high but the energy consumption is less. Considering the life cycle cost, it is always recommended to use energy efficient air conditioning equipments.
c. **Regular Maintenance:** Periodical maintenance helps to ensure efficient operation of air-conditioning equipment. During periodical maintenance it is necessary to carry out cleaning of filters, de-scaling of heat exchangers, lubricating friction point, such as fans, motors and shafts. Setting of indoor temperature at the highest point acceptable to the largest segment of occupants, and shutting off the system when not in use will lead to energy saving.

The performance of given system depends upon the performance of equipment used. The parameters needed to be looked into are:

- Inside and outside design conditions.
- Measured flows and capacities of all the equipment used in the system.
- Comparison of the measured and design capacities.
- Comparison of energy consumption with design values.

Key factors in evaluating and better utilization of the HVAC system are as follows

a. Are there obstructions in the ventilation system?
    i. Do filters, radiator fins or coils need cleaning?
    ii. Are ducts, dampers or passages and screens clogged?
b. Is the wrong amount of air being supplied at various times?
    i. Are dampers stuck?
    ii. Is exhaust or intake volume is too high or too low?
    iii. Are all dampers functioning in the most efficient manners?
c. Can the system exhaust only the area needing ventilation?
d. Can the system intake only the amount required?
e. Can air be recycled rather than exhausted?
f. Can the system be turned OFF at night?
g. Is the temperature is right for the area of use?
h. Can temperature setback be used effectively?
i. Can heat be redirected?
j. Is the proper system is being used?
k. Is there too much or too little ventilation?

l. Can the natural environment be used more effectively?
m. Are doors, windows or other openings letting out valuable heat?
n. Can weather strip, caulking or other leaks be repaired?
o. Can additional insulation be justified/

6.1 EXISTING AIR CONDITIONING SYSTEM DESCRIPTION

.Performance of Chiller was carried out by measurement of pressure drop , inlet temperature , pressure and Electrical power input by power analyzer .Detailed measurement and COP calculation are tabulated with specifications of all A.C. plant equipment in chiller performance evaluation section. AHU are provided floor wise for distribution of cooled air in various areas. Performance of AHU is evaluated by CFM measurement and Power measurement at Each AHU .Performance analysis of each ducted ,RAC and Precision air conditioner was carried out and detailed measurements and analysis with recommendations are listed in performance evaluation of particular section.

6.2: Performance assessment of room air conditioners :

6.2: Performance assessment of room air conditioners

SR NO	AREA	MAKE	TYPE	CAPACITY TR	QTY NOS	TEMP. (DEG C) AMB	GRILL	ROOM	REMARK
	ENGINEERING COLLEGE	VOLTAS	SAC	1.5	1		10	24	OK
1	ELECTRICAL DEPT COMPUTER LAB	VOLTAS	SAC	1.5	2		12,15	23	PMS REQUIRE & OTHER A/C WATER LEAKAGE
2	LIBRARIAN OFFICE	VOLTAS	SAC	2	1		12	26	OK
3	LIBRARY READING HALL	VOLTAS	SAC	2	2	32	15,14	26	REQUIRE PMS
4	IT DEPT NETWORK LAB	VOLTAS	SAC	2	2		12,23	24	ONE A/C COMPRESSOR NOT WORKING ELECTRICAL PROBLEM
5	IT DEPT PROGRAMING LAB	VOLTAS	SAC	2	1		11	24	PMS REQUIRE
6	IT DEPT INFOSYS LAB	VOLTAS	SAC	2	1		23	28	COMP NOT WORKING ELECTRICAL PROBLEM
7	**IT DEPT OSL**	VOLTAS	SAC	2	1		9	25	OK
8	IT DEPT HOD CABIN	VOLTAS	SAC	2	1		12	26	OK
9	IT DEPT TUTORIAL	VOLTAS	SAC	2	1		0	0	NOT IN USE
10	IT DEPT PROJECT LAB	VOLTAS	SAC	2	3		10,11,23	26	ONE A/C COMPRESSOR NOT WORKING ELECTRICAL PROBLEM
11	CIVIL DEPT SERVER ROOM	VOLTAS	SAC	1.5	1		9	25	DOOR KEPT OPEN
12	CIVIL DEPT PG COMP LAB	VOLTAS	SAC	1.5	1		0	0	NOT IN USE
13	CIVIL DEPT COMP LAB	VOLTAS	SAC	1.5	2		10,11	24	OK
14	**MECHANICAL DEPT SOFTWARE LAB**	VOLTAS	SAC	2	3		10,12,24	26	ONE A/C COMPRESSOR NOT WORKING ELECTRICAL PROBLEM
15	MECHANICAL DEPT COMP LAB	VOLTAS	SAC	1.5	4		10,9,11,10	24	DOOR KEPT OPEN
16	STUDENT COUNCILING CENTER	VOLTAS	SAC	2	1	32	12	26	OK
17	MECHANICAL COMP LAB 3	VOLTAS	SAC	1.5	2		10,24	26	ONE A/C REFRIGERANT LEAK
18	MICRO CONTROLLER LAB	VOLTAS	SAC	1.5	2		10,22	24	ONE A/C REFRIGERANT LEAK
19	ELECTRONICS DEPT LAB 124	VOLTAS	SAC	1.5	2		9,10	24	PMS REQUIRE
20	INSTRUMENTATION DEPT DSP LAB	VOLTAS	SAC	1.5	1		11	25	OK
21	**INSTRUMENTATION DEPT COMP LAB**	VOLTAS	SAC	1.5	2		11,14	24	OK
22	MECHANICAL DEPT COMP LAB 4	VOLTAS	SAC	1.5	2	32	12,21	25	ONE A/C REFRIGERANT LEAK
23	MECHANICAL DEPT CAD/CAM LAB	VOLTAS	SAC	1.5	2		10,11	26	OK
24	MECHANICAL DEPT PG ROOM	VOLTAS	SAC	1.5	1		20	27	REFRIGERANT LEAK

25	FORM FILLING CENTER	VOLTAS	SAC	2	1		12	24	DOOR KEPT OPEN
27	ENGINEERING PRINCIPAL OFFICE	VOLTAS	SAC	1.5	1		11	24	OK
	MBA & MCA COLLEGE								
28	**FIRST FLOOR SEMINAR HALL**	VOLTAS	SAC	2	3		12,14,11	26	OK
29	FIRST FLOOR ARC CENTER	VOLTAS	SAC	1.5	1		12	26	OK
30	SECOND FLOOR ARC CENTER	VOLTAS	SAC	1.5	1		12	25	OK
31	THIRD FLOOR ARC CENTER	VOLTAS	SAC	1.5	1		11	26	OK
32	FOURTH FLOOR ARC CENTER	VOLTAS	SAC	1.5	1		22	27	ELECTRICAL PROBLEM
33	DIRECTOR OFFICE	VOLTAS	SAC	1.5	2		9,8	24	OK
34	BOARD ROOM	VOLTAS	SAC	1.5	1		11	25	OK
35	**COMPUTER LAB 1 & 2**	VOLTAS	SAC	2	2		12,12	26	OK
36	COMPUTER LAB 3 & 4	VOLTAS	SAC	2	2		12,14	26	OK
37	JUNIOR COLLEGE COMPUTER LAB	VOLTAS	SAC	2	2	32	12,12	26	OK
38	DEPARTMENT OF COMPUTER SCIENCE	VOLTAS	SAC	2	1		0	0	NOT IN USE

SET TEMPERATURE OF ALL ROOM AIR CONDITIONERS ARE22- 23 DEGREE CENTIGRADE .AS PER REVISED ASHAREE 2008GUIDE LINES IT IS RECOMMENDED TO MAINTAIN ROOM TEMPERATURE TO 25 DEGREE CENTIGRADE .TO MAINTAIN ROOM AIR TEMPERATURE TO 25 DEGREE CENTIGRADE RECOMMENDED TO SET RETURN AIR TEMPERATURE AT 26 DEGREE CENTIGRADE .

6.3:Observations and recommendations :

S.No.	Energy Conservation opportunity	Recommended Energy conservation measures (ECM)
1	Increase in return temperature set point of all room air conditioners from Existing to 26 Degree centigrade .	Recommended to increase return temperature set point from existing to 26 degree centigrade .
2	Switching OFF room air conditioners 30 minutes before conclusion of office hours .	Recommended to switch OFF air conditioners 30 minutes before conclusion of office hours.
3	Cleaning of Air conditioners condenser units	Condenser units of all room air conditioners provided in Admin building , Laboratory , Control room , IOC office are with dirty .Layer of dust causes reduction in heat transfer and working of AC Units for more hours of AC operations leading to increase in power consumption
4	Repair of insulation of Room air conditions copper tubing's near outdoor AC units	Thermal insulation of copper tubing's of many room air conditioners near outdoor units is completely damaged and at other units partially damaged .Recommended to immediately provide insulation to copper tubing's to avoid Energy loss .
5	Application of sun film to window glasses in offices /Labs in air conditioned area .	Air conditioned areas in admin office , Lab, are provided with windows .Window glasses are without sun film leading to heat gain resulting into increase in power consumption .Recommended to apply sun film to all window glasses .
6	Regular cleaning of return AC filters	During Energy Audit it was observed that majority of filters were clogged .Clogging of filter results into decrease in CFM resulting into decrease in cooling and increased operation of air conditioners leading to increase in Energy consumption. For 1Ton air conditioning 400 CFM is required .Recommended to carry out regular cleaning of filters

6.4: Energy saving potential by increase in temperature set point of room Air conditioners from existing to 26 Degree Centigrade :

Temperature set point of all other air conditioners from existing to 26 degree centigrade .Recommended to maintain temperature set point of all Air conditions at 26 degree Centigrade .

Energy saving potential per year by increase in temperature set point from existing to 26 degree Centigrade = ((3 x 0.06 x 1.771) +(2x0.06x 18.48) 12 x360 = (0.31878 + 2.2176) x12x360 = 10957.17 KWH

Energy cost saving per year by increase in temperature set point of room air conditioners to 26 degree centigrade considering Energy cost of Rs11.52per KWH = Rs 11.52 x10957.17= Rs 126226.501

Investment : Nil

6.5: Energy saving potential by switching OFF cabin room air conditioners 30 minutes before conclusion of office Hours and installation of occupancy sensors

Generally room air conditioners are switched off by remote at the time of conclusion off office hours , recommended to switch off room air conditioners in cabins 30 minutes before conclusion off office hours as during 30 minutes times room temperature during evening period when ambient temperature is lower will increase by one degree centigrade .

Total actual power consumption of room Air conditioners provided in cabin areas = 82.6 KW

Energy saving potential by switching off room air conditioners 30 minutes before conclusion off office hours per year = 82.6 x360 x0.5 = 14868 KWH

Energy cost saving per year considering energy cost of Rs 11.52 per KWH = Rs 11.52 x 14868 = Rs 171279.36

Investment: Nil.

Table 6.1:Summary of Energy conservation potential in Air conditioners.

S.No.	Energy Conservation Measures	Energy Saving potential per Year in KWH	Energy cost saving per year considering Energy cost of Rs	Investment Rs	Pay back period	% ROI
1	Increase in temperature set point of room air conditioners from existing to 26 degree centigrade	10957.17	126226.501	-	-	-
2	Switching OFF room air conditioners 30 minutes before conclusion of office hours	14868.00	171279.36	-	-	-
Total		25825.17	297505.80			

CHAPTER NO:7

GROUNDING AUDIT

Chapter No.7:Grounding Audit

7.0:Grounding audit was carried out by Clamp on Earth tester and leakage meter at various points. Results of earth resistance and leakage currents are tabulated in table .

Table 7.0:Grounding Audit

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Earth Pit At Civil Department	0.93	20.1 mA	25 x 3	GI	1
Earth Pit At Mechanical Department	0.68	0.2 mA	25 x 3	GI	1
Computer Lab Ground Floor	**580**	**3.25 mA**	**25 x 3**	**GI**	**1**
Civil-2 Earth pit	**50**	**1.60 mA**	**25 x 3**	**GI**	**1**
Mech.ancal-1 PDB	**400**	**0.25 mA**	**25 x 3**	**GI**	**1**
Civil Department PDB	**106**	**5.10 mA**	**25 x 3**	**GI**	**1**
PG Lab PDB	**NA**	**-**	**25 x 3**	**GI**	**1**
Civil Geology Lab LDB	**OPEN**	**-**	**25 x 3**	**GI**	**1**
Survey Lab LDB	**OPEN**	**-**	**25 x 3**	**GI**	**1**
Computer Lab (Prof.M.P. Wagh) LDB	**125**	**2.70 mA**	**25 x 3**	**GI**	**1**
Civil Geotechnical Lab	**33**	**0 mA**	**6 SWG**	**GI**	**1**
PG LAB LDB (001A)	**440**	**0 mA**	**4 SQ.MM**	**CU**	**1**
Room No (002A) LDB	**OPEN**	**-**	**6 SWG**	**GI**	**1**
Chemistry LAB-(009)	**440**	**-**	**6 SWG**	**GI**	**1**
University Exam Control	**440**	**-**	**6 SWG**	**GI**	**1**

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Room					
Chemical PDB	**OPEN**	**-**	**6 SWG**	**GI**	**1**
Computer LDB-2	**OPEN**	**0.3 mA**	**6 SWG**	**GI**	**1**
ENTC PDB In Front Of computer Lab	**NA**	**-**	**-**	**-**	**-**
Mechanical (010) Computer Lab LDB-1	**153**	**7.15 mA**	**2.5 SQ.MM**	**CU**	**1**
Mechanical (010) Computer Lab LDB-2	0.05	9.40 mA	2.5 SQ.MM	CU	1
CAD/CAM Lab LDB (011)	**75**	**11.7 mA**	**6 SWG**	**GI**	**1**
PG Computer LAB (016, 015A, 015B)	**800**	**4 mA**	**1.5 SQ.MM**	**CU**	**1**
Main Ground Floor (for Civil & Mechanical) Power Switch	1.32	0.6 mA	2.5 SQ.MM	CU	1
Fluid Mechanics LAB LDB	**OPEN**	**-**	**-**	**-**	**-**
IC Engine LAB LDB	**OPEN**	**-**	**-**	**-**	**-**
Material Science Lab LDB	**OPEN**	**-**	**-**	**-**	**-**
Mechanical First Floor (121) LDB	**OPEN**	**-**	**-**	**-**	**-**
Mechanical Class Room - B 118	**OPEN**	**-**	**-**	**-**	**-**

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Main Switch	3.12 Ω	0 mA	2.5 SQ.MM	CU	1
Microwave & Optic Communication	**OPEN**				
109 Power Electronics LAB	**OPEN**				
108 Advance Communication	**24 Ω**	**2.4 mA**	**2.5 SQ.MM**	**CU**	**1**
FE Class Civil (102)	**OPEN**				
2nd Floor Sensor & Transducer LAB	**OPEN**				
Class room (202) LDB	**OPEN**				
Process Instrumentation (206) LDB	**OPEN**				
Medical Instrumentation (203) LDB	**OPEN**				
Project LAB (202 A) LDB	**350**	**0 mA**	**6 SWG**	**GI**	**1**
DSP Microcontroller (201) LDB	**5.8**	**3.1 mA**	**2.5 SQ.MM**	**CU**	**1**
Student Counseling Lab (126) LDB	**OPEN**				
Microcontroller LAB (125)	**44**	**16.2 mA**	**6 SWG**	**GI**	**1**
Basic Electronics LAB (122)	**65**	**0.75 mA**	**2.5 SQ.MM**	**CU**	**1**
Workshop Building					

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Machine Shop					
LT-1	0.086	0 mA	6 SWG	GI	2
LT-2	1.5	0 mA	12 SWG	GI	1
LT-3	0.84	0 mA	6 SWG	GI	1
LT-4	0.98	0.25 mA	12 SWG	GI	1
LT-5	**NA**				
LT-6	**22**	**0 mA**	**6 SWG**	**GI**	**1**
Earth Pit At Machine Shop	**135**	**0.1 mA**	**6 SWG**	**GI**	**1**
Carpentry Shop					
LT-1	**75**	**2.6 mA**	**6 SWG**	**GI**	**1**
LT-2	**OPEN**				
LT-3	2.92	0 mA	6 SWG	GI	1
LT-4	1.3	1.45 mA	6 SWG	GI	1
Earth Pit Carpentry Shop	2.1	1.65 mA	25 x 3	GI	1
Sheet Metal Shop	OPEN	-	-	-	-
Electrical Department					
Electrical Department Main Panel	1.75	0.48 A	2.5 SQ.MM	CU	4
DB-1	0.15	1.80 mA	1.5 SQ.MM	CU	1
DB-2	1	13.4 mA	1.5 SQ.MM	CU	1
DB-3	0.65	14.3 mA	1.5 SQ.MM	CU	1
First Floor					
Toilet-(133) LDB	0.4	16.10 mA	12 SWG	GI	1
Room (132) LDB	**OPEN**				
Basic Electrical Lab-1	**5.3**	**88.4 mA**	**8 SWG**	**GI**	**1**
Basic Electrical	**10.8**	**1.7 mA**	**8 SWG**	**GI**	**1**

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Lab-2					
Second Floor					
Toilet LDB	**OPEN**	**-**	**-**	**-**	**-**
Seminar Hall-222	**OPEN**	**-**	**-**	**-**	**-**
Passage Backside	**500 Ω**	**-**	**-**	**-**	**-**
First Floor Passage	**OPEN**	**-**	**-**	**-**	**-**
Ground Floor LDB-1	**OPEN**	**-**	**-**	**-**	**-**
Ground Floor LDB-2	**OPEN**	**-**	**-**	**-**	**-**
Basement LDB	2.6 Ω	84.2 mA	2.5 SQ.MM	CU	1
Basement PDB	3.2 Ω	82.1 mA	2.5 SQ.MM	CU	1
Security Office PDB	**OPEN**	**-**	**2.5 SQ.MM**	**CU**	**1**
Floor-1 Library Area	**OPEN**	**-**	**2.5 SQ.MM**	**CU**	**1**
IT second Floor Operating System LAB-214	**71**	**1.7 mA**	**2.5 SQ.MM**	**CU**	**1**
Project LAB 211	**OPEN**	**-**	**2.5 SQ.MM**	**CU**	**1**
Networking LAB-217	**OPEN**	**-**	**2.5 SQ.MM**	**CU**	**1**
Electrical Department Earthing Pit	**5.8**	**124 mA**	**25 x 3**	**GI**	**1**
Electrical machine LAB-1 (026)	0.3	0.65 mA	2.5 SQ.MM	CU	1
Electrical machine LAB-2 (026)	0.041	0 mA	2.5 SQ.MM	CU	1
Electrical Machine PDB	0.15	3.95 mA	2.5 SQ.MM	CU	1

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Power House Earthing Pit	**72**	**0.25 mA**	**25 x 3**	**CU**	**1**
Transformer Pit	**17**	**3.25 mA**	**25 x 3**	**CU**	**1**
Agriculture Collage					
Earthing Pit-1	**8.8**	**0.6 mA**	**25 x 5**	**GI**	**1**
Earthing Pit-2	**10.25**	**0.25 mA**	**25 x 5**	**GI**	**1**
Earthing Pit-3	**12**	**0.1 mA**	**25 x 5**	**GI**	**1**
Earthing Pit-4	**9.9**	**0.3 mA**	**25 x 5**	**GI**	**1**
Main PDB-1	2.6	2.20 mA	8 SWG	GI	1
Main Incomer Earthing-1	0.24	0.25 mA	8 SWG	GI	3
Seminar Hall GF-15	0.38	0 mA	8 SWG	GI	1
Training Room Department Of Agri. extension GF-17	0.32	0 mA	8 SWG	GI	
Main PDB-2	0.48	0.2 mA	12 SWG	GI	2
Museum-9 Ground Floor LDB	0.16	0.25 mA	1.5 SQ.MM	CU	1
First Floor					
Class Room - 29	0.16	0.1 mA	1.5 SQ.MM	CU	1
Department Agri Economics-34	0.069	0.20 mA	1.5 SQ.MM	CU	1
Room-21	0.03	0.15 mA	1.5 SQ.MM	CU	1
Room-20	0.122	0.0 mA	1.5 SQ.MM	CU	1
Engineering Office Main Building					
Earth Pit -1	**11.8**	**0 mA**	**25 x 3**	**GI**	**1**
Earth Pit -2	**9.1**	**0 mA**	**25 x 3**	**GI**	**1**
Earth Pit -3	**10**	**0 mA**	**25 x 3**	**GI**	**1**
LDB Earthing Not Connected (worked Pending)					
Boys Hostel					
Earth Pit-1	**28.4**	**0.1 mA**	**25 x3**	**GI**	**1**

LOCATION	RESISTANCE IN OHM	LEAKAGE CURRENT IN MA	SIZE IN MM	MATERIAL	RUN
Earth Pit-2	**29**	**0 mA**	**25 x 3**	**GI**	**1**
Girls Hostel					
Ground Floor PDB	1.4	108 mA	25 x 3	GI	1
Mess LDB	2.6	159 mA	2.5 SQ.MM	GI	1
PIT-1 Wing - A	**47**	**0.27 mA**	**25 x 3**	**GI**	**1**
PDB Wing -B	**23.4**	**1.9 mA**	**25 x 3**	**GI**	**1**
MBA Girls Hostel	**Open**	**-**	**-**	**-**	**-**
Canteen LDB-1	0.5	0.3 mA	1.5 SQ.MM	CU	1
Canteen LDB-2	0.5	1.25 mA	25 x 3	GI	1
Canteen Earthing Pit	0.163	0.6 mA	25 x 3	GI	1

OBSERVATIONS AND RECOMMENDATIONS:

- Earth connections are open at many points .Recommended to check earth connection and provide earth connection on top most priority.
- At many places earth resistance is on higher side .Higher Earth resistance makes earth protection ineffective .Recommended to check and tight Earth connection .Use spring washers and nut bolts with lugs for Earth connections at Equipment side.
- Use Bi-metallic washers when connecting two dissimilar materials.
- It is recommended to carry out regular dosing of earth pits by salted water.

APPENDIX: I
GENERAL ENERGY CONSERVATION RECOMMENDATION

Apart from the various mentioned Energy conservation measures (ECM) there are certain recommendations which will help in near future to increase energy efficiency to reduce energy costs. Change of work culture and good house keeping practices in the organization will lead to 10% energy saving without additional investment.

Checklist and tips for energy efficiency in electrical utility

1. Correct P.F. to unity under rated load conditions to take maximum benefit of power factor incentive.
2. Set transformer taps at optimum setting
3. Check utility KWH meter reading with your own TOD meter. Install TOD meter at incomer and get it calibrated.
4. Shut off unnecessary computers, printers and copiers when not is use.
5. Tune up the HVAC control system (heating/ventilation/air conditioning)
6. Eliminate or reduce heat generation in air conditioned area.
7. Use appropriate thermostat settings of air conditioners and water coolers.
8. Clean air conditioner coils periodically and comb mashed fins.
9. Check air conditioners filters on a regular basis and clean/change if necessary.
10. Seal leakages in air conditioned area.
11. Switch off air conditioners one hour before the end of office hours.
12. Waste and Waste water
    a. Recycle water, particularly for uses with less critical quality requirements.
    b. Fix water leaks
    c. Test and underground water leaks.
    d. Eliminate continuous overflow at water tanks.
    e. Promptly repair leaking toilets.
    f. Use water restrictors on faucets, showers etc.
    g. Use self closing type faucets in restrooms.
    h. Use the lowest possible hot water temperature.
    i. Use instant water geysers in place of storage type.
13. Managing Lighting Energy: Inefficiencies in lighting systems may be due to a number of factors
    a. Lighting power density is too high.
    b. Lights being left ON when not required.
    c. Lights poorly located.
    d. Inefficient luminaries.
    e. Inefficient lamps.
    f. Inefficient ballasts.
    g. Poor maintenance of lamps and luminaries
    h. Dark and dirty room surfaces.
14. Energy Management opportunities
    a. Switch off unnecessary lights
    b. Remove redundant fixtures
    c. Fixtures re-lamping
    d. Fixtures de-lamping
    e. Fixtures modification or replacement
    f. Cleaning light fixtures, lamp reflectors and room surfaces regularly to maintain better level of illumination

g. Luminaries of higher space to height ratio.
h. Higher reflectance surfaces of the room
i. Selective switching
j. Task oriented lighting.
k. Consider lowering the fixtures to enable using less of them
l. Consider day lighting and sky lighting.
m. Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
n. Use task lighting and reduce background illumination.
o. Utilize daylight for indoor illumination which leads to the reduction of daytime consumption of energy attributable to illumination system.

15. The six basic rules for energy efficient lighting

Rule 1: Use the most efficient light source suitable.
Rule 2: Use the lamp light output efficiently.
Rule 3: Maintain lighting equipment in good order.
Rule 4: Use well designed energy effective lighting schemes.
Rule 5: Integrate daylight with electric lighting system and use control system.
Rule 6: Consider effect of surrounding décor

16. Miscellaneous

a. Meter any un-metered utilities.
b. Shut down spare, idling equipment
c. Diffused glass shall not be used for windows and ventilators. Plain glass should be used.
d. Ventilator and window lower seal position in all upcoming new buildings should be at height of work plane.
e. Color of class rooms and hotel rooms for ceiling and wall should be white or fluorescent.
f. Use reflectors (add on type) for bare tube lights in all areas.
g. Classrooms and lab windows should be kept open to allow entry of daylight for indoor illumination which will offer maximum saving during day by keeping tube lights OFF.

Appendix 1: Best practices for maintenance of earthing installation **:**

Reference : IS3043 and other earthing standards

Nature of Earthing Resistance

The earthing resistance of an electrode is made up of:

a) Resistance of the (metal) electrode,

b) Contact resistance between the electrode and the soil, and

c) Resistance of the soil from the electrode surface outward in the, geometry set up for the flow of current outward from the electrode to infinite earth.

Soil Resistivity

- The resistance to earth of a given electrode depends upon the electrical resistivity of the soil in which it is installed.
- The type of soil largely determines its resistivity
- Earth conductivity is, however, essentially electrolytic in nature and is affected, by the moisture content of the soil and by the chemical composition and concentration of salts dissolved in the contained water.
- Grain size and distribution, and closeness of packing **are** also contributory factors since they control the manner in which the moisture is held in the soil.
- Many of these factors vary locally and some seasonally
- It should also be noted that soil temperature has some effect but is only important near and below freezing point, necessitating the installation of earth electrodes at depths to which frost will not penetrate.
  It is, therefore, recommended that the first meter of any earth electrode should not be regarded as being effective under frost conditions.
- Following types of soil in the order of preference given:
- Wet marshy ground
- Clay, loamy soil, arable land, clayey soil, clayey soil or loam mixed with small quantities of sand;
- Clay and loam mixed with varying proportions of sand, gravel and stones;
- Damp and wet sand, peat.
- Care should be taken to avoid a site kept moist by water flowing over it (for example, the bed of a stream) as the beneficial salts may be entirely removed from the soil in such situations.
- Bentonite or similar material may be used to advantage in rocky terrain.
- Where holes are bored for the insertion of vertical electrodes or where strip electrodes are laid radially under shallow areas of low resistivity overlaying rock strata, bentonite packing will increase the contact efficiency with the general mass of ground.

Effect of Moisture Content on Earth Resistivity –

- Moisture content is one of the controlling factors in earth resistivity.
- It will be seen from Fig. that above about 20 per- cent moisture, the resistivity is very little affected, while below 20 percent the resistivity increases very abruptly with the decrease in moisture content.
- A difference of a few percent moisture will therefore, make a very marked difference in the effectiveness of earth connection if the moisture content falls below 20 percent.
- The normal moisture content of soils ranges from 10 percent in dry seasons to **35** percent in wet seasons, and an approximate average may be perhaps 16 to 18 percent.
- earth electrodes driven directly in the beds of rivers or mountain streams may present very high resistance to earth.
- If the water is relatively pure, it will be high resistivity and unless the soil contains sufficient natural elements to form a conducting electrolyte, the abundance of water will not provide the soil with adequate conductivity.

- The value ‘of high moisture content in soils is advantageous in increasing the solubility of existing natural elements in the soil, and in providing for the solubility of ingredients which may be artificially introduced to improve the soil conductivity.

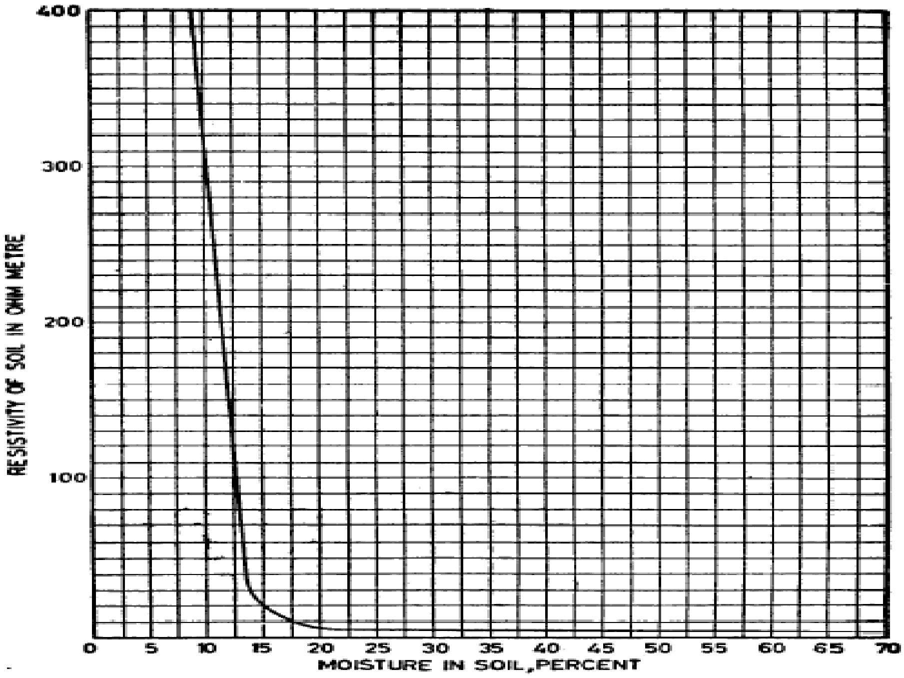


FIG. 9 VARIATION OF SOIL RESISTIVITY WITH MOISTURE CONTENT

Effect of Temperature on Earth Resistance :

- The temperature coefficient of resistivity for soil is negative, but is negligible for temperatures above freezing point.
- At about 20°C, the resistivity change is about 9 percent per degree Celsius.
- Below 0°C the water in the soil begins to freeze and introduces a tremendous increase in the temperature coefficient, so that as the temperature becomes lower the resistivity rises enormously.
- It is, therefore, recommended that in areas where the temperature is expected to be quite low, the earth electrodes should be installed well below the frost line.
- Where winter seasons are severe, this may be about 2 meters below the surface, whereas in mild climates the frost may penetrate only a few centimeters or perhaps the ground may not freeze at all.

Artificial Treatment of Soil –

- Multiple rods, even in large number, may sometime fail to produce an adequately low resistance to earth.
- This condition arises in installations involving soils of high resistivity.
- The alternative is to reduce the resistivity of the soil immediately surrounding the earth electrode.
- To reduce the soil resistivity, it is necessary to dissolve in the moisture, norm- ally contained in the soil, some substance which is highly conductive in its water solution. The most commonly used substances are sodium chloride (NaCl), also known as common salt, calcium chloride (Ca Cls), sodium carbonate (NasCOs), copper sulphate (CuSO,), salt, and soft coke, and salt and charcoal in suitable proportions.
- With average or high moisture content, these agents form a conducting electrolyte through-out a wide region surrounding the earth electrode.
- Approximately 90 percent of the resistance between a driven rod and earth lies within a radius of about two meters from the rod.
- This should be kept in mind when applying the agents for artificial treatment of soil.
- The simplest application is by excavating a shallow basin around the top of the rod, one meter in diameter and about30 cm deep, and applying the artificial agent in this basin.
- The basin should subsequently be filled several times with water, which should be allowed each time to soak into the ground, thus carrying the artificial treatment, in electrolyte form, to considerable depths and allowing the artificial agent to become diffused throughout the greater part of the effective cylinder of earth surrounding the driven rod.

Curve flattens off at about 5 percent salt content and a further increase in salt gives but little decrease.
The effect of salt will be different for different kinds of soil and for various moisture contents but the curve will convey an idea of how the soil conductivity can be improved.
Decreasing the soil resistivity- causes a corresponding decrease in the resistance of a driven earth electrode.

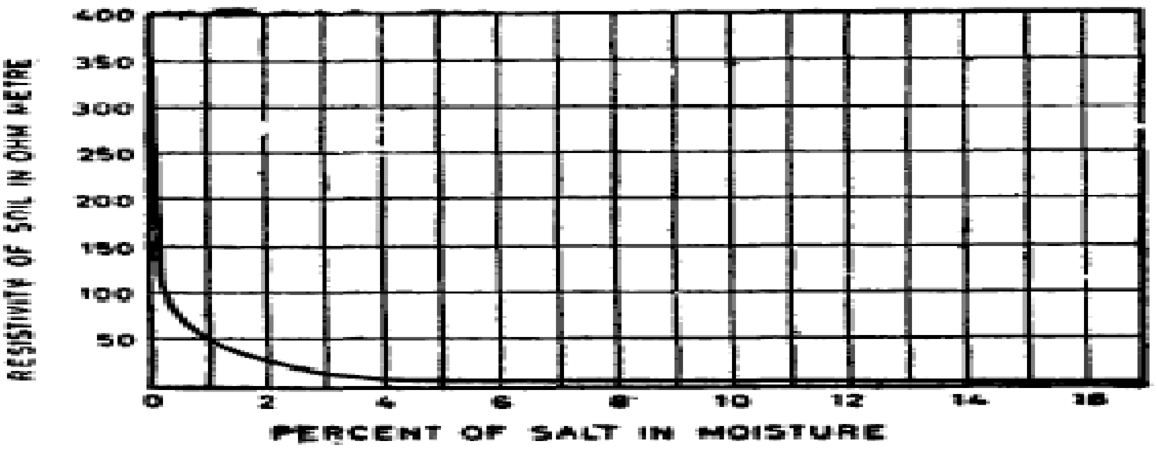


FIG. 10 VARIATION OF SOIL RESISTIVITY WITH SALT (Nacl) CONTENT, CLAY SOIL HAVING 3 PERCENT MOISTURE

- In close texture soils, the artificial treatment may be effective over a period of many years.
- However, it is recommended that annual or biannual measurements of earth resistivity should be made to find out if additional treatment is needed.
- In using artificial treatment, the possible corrosive effect of the salt on the driven rods and connections should be considered.

EFFECT OF SHAPE OF EARTH ELECTRODE ON ELECTRODE RESISTANCE:

- With all electrodes other than extended systems, the greater part of the fall in potential occurs in the soil within a few feet of the electrode surface, since it is here that the current density is highest.
- To. obtain a low overall resistance the current density should be as low as possible in the medium adjacent to the electrode, which should be so designed as to cause the current density to decrease rapidly with distance from the electrode.
- This requirement is met by making the dimensions in one direction large compared with those in the other two, thus a pipe, rod or strip has a much lower resistance than a plate of equal surface area content is expressed in percent by weight .
- The resistance is not, however, inversely proportional to the surface area of the electrode.
- Where the resistance of a single plate is higher than the required value, two or more plates may be used in parallel and the total resistance is than inversely proportional to the number employed, provided that each plate is installed outside the resistance area of any other.
- This normally requires a separation of about 10 m but for sizes of plate generally employed, a separation of 2 m is sufficient to ensure that the total resistance will not exceed the value obtained from the above formula by more than 20 percent.
- The use of coke breeze as an infill is not recommended as it may result in rapid corrosion not only of the electrode itself but also of cable sheaths, etc, to which it may be bonded.
- Plate electrodes shall be buried such that its top edge is at a depth not less than 1. 5 m from the surface of the ground.
- However, the depth at which plates are set should be such as to ensure that the surrounding soil is always damp.
- It is apparent that the resistance diminishes rapidly with the first few feet of driving, but less so at depths greater than 2 to 3 *m* in soil of uniform resistivity.

- A number of rods or pipes may be connected in parallel and the resistance is then practically proportional to the reciprocal of the number employed so long as each is situated outside the resistance area of any other.
- In practice, this is satisfied by a mutual separation equal to the driven depth.
- Little is to be gained by separation beyond twice the driven depth.
- A substantial gain is effected even at 2 m separation.
- Pipes may be of cast iron of not less than 100 mm diameter, 2-5 to 3 m long and 13 mm thick.
- Such pipes cannot be driven satisfactorily and may, therefore, be more expensive to install than plates for the same effective area.
- Alternatively, mild steel water-pipes of 38 to 50 mm diameter are sometimes employed. These can be driven but are less durable than copper rods.
- Driven rods generally consist of round copper, steel-cored copper or galvanized steel 13, 16 or 19 mm in diameter from 1 220 to 2 440 mm in length.

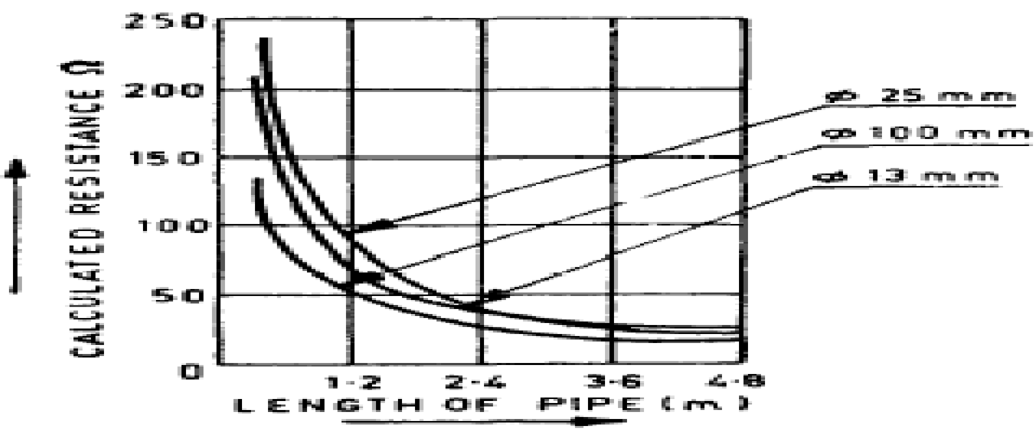


FIG. 11 EFFECT OF LENGTH OF PIPE ELECTRODE ON CALCULATED RESISTANCE FOR SOIL RESISTIVITY OF 100 Ω m (ASSUMED UNIFORM)

- Except in special conditions, a number of rods in parallel are to be preferred to a single long rod.
- Deeply driven rods are, however, effective where the soil resistivity decreases with depth or where substrata of low resistivity occur at depths greater than those with rods, for economic reasons, are normally driven.
- In such cases the decrease of resistance with depth of driving may be very considerable
- In cases where impenetrable strata or high-resistivity soil occur at relatively small depths, considerable advantage may result from driving rods at an angle of about 30° to the horizontal, thus increasing the length installed for a given depth.

Selection of Metals for Earth-Electrodes-

- **Although** electrode material does not affect initial earth resistance, care should be taken to select a material that is resistant to corrosion in the type of soil in which it will be used.
- Tests in a wide variety of soils have shown that copper, whether tinned or not, is entirely satisfactory.

Maintenance of Earthing installation:

The effective performance of earthing installation is reduced by soil conditions ,lightening currents , corrosion and physical damage .It is necessary to regularly measure Earthing resistance to monitor earthing installation performance by fall of potential method or clamp meter .

Appendix :II :Testing of Earthing Installation (Source :Engineering Educators):

The measurement of ground resistances can only be accomplished with specially designed equipment. Most instruments use the fall of potential principal of alternating current (AC) circulating between an auxiliary electrode and the ground electrode under test. The reading is ohms and represents the resistance of the ground electrode to the surrounding earth. Several testing equipment manufacturers have recently introduced clamp-on ground resistance testers .

Ground Resistance Testing Principle (Fall of Potential – 3 Point Measurement)

The potential difference between rods X and Y is measured by a voltmeter, and the current flow between rods X and Z is measured by an Ammeter .

By Ohm’s Law E = IR or R + E / I

Position of Auxiliary Electrodes on Measurements:

The goal in precisely measuring the resistance to ground is to place the auxiliary current electrode Z far enough from the ground electrode under test so that the auxiliary potential electrode Y will be outside of the effective resistance area of both the ground electrode and the auxiliary current electrode. The best way to find out if the auxiliary potential rod Y is outside the effective resistance areas is to move it between X and Z and to take a reading at each location. If the auxiliary potential rod Y is in an effective resistance area by displacing it the readings taken will vary noticeably in value. Under these conditions, no exact value of the resistance to ground may be determined.

On the other hand, if the auxiliary potential rod Y is located outside of the effective resistance areas (figure X), as Y is moved back and forth the reading variation is minimal. The readings taken should be relatively close to each other, and are the best values for the resistance to ground X. the readings should be plotted to ensure they lie in a “plateau” region The region is often referred to as the “62% area”.

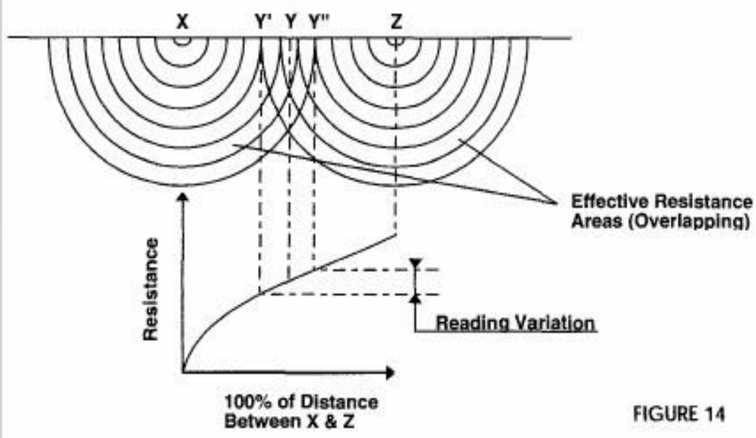


FIGURE 14

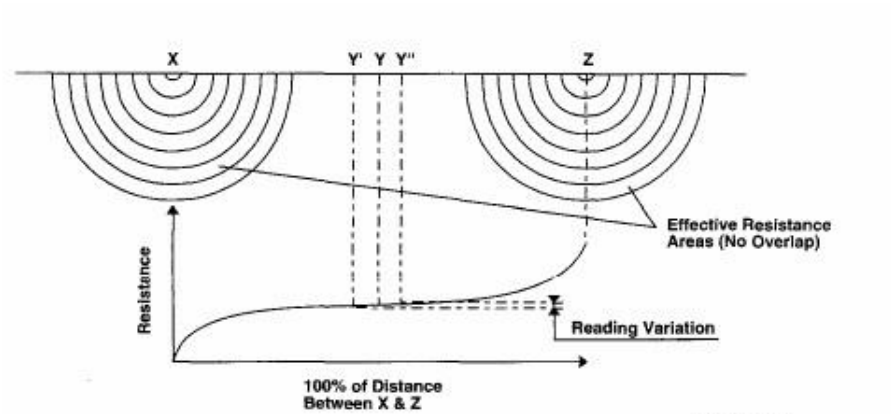


FIGURE 15

Measuring Resistance of Ground Electrodes (62% Method)

The 62% method has been adopted after graphical consideration and after actual test. It is the most accurate method but is limited by the fact that the ground tested is a single unit.

This method applies only when all three electrodes are in a straight line and the ground is a single electrode, pipe, or plate as in Figure

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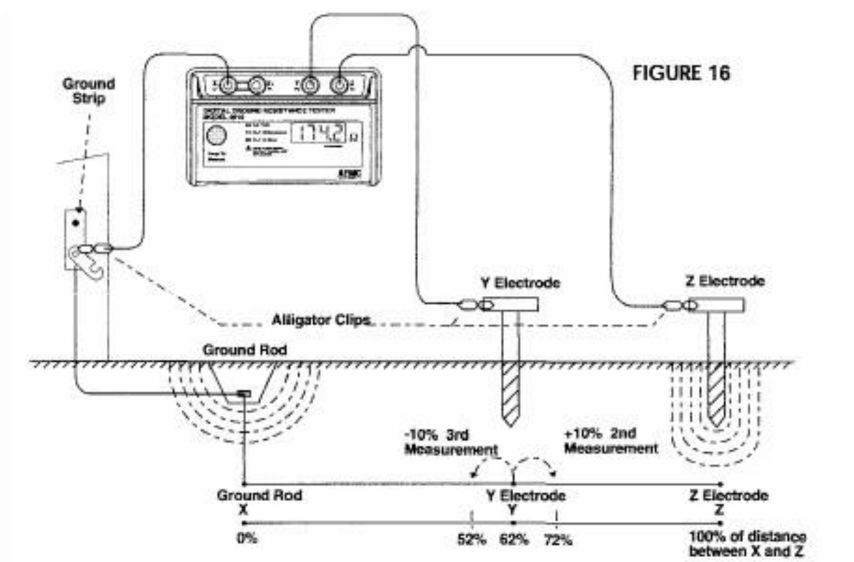


FIGURE 16

Consider Figure 17, which shows the effective resistance areas (concentric shells) of ground electrode X and of the auxiliary current electrode Z. The resistance areas overlap. If readings were taken by moving the auxiliary potential electrode Y towards either X or Z, then reading differentials would be great and one could not obtain a reading within a reasonable band of tolerance. The sensitive areas overlap and act constantly to increase resistance as Y is moved away from X.

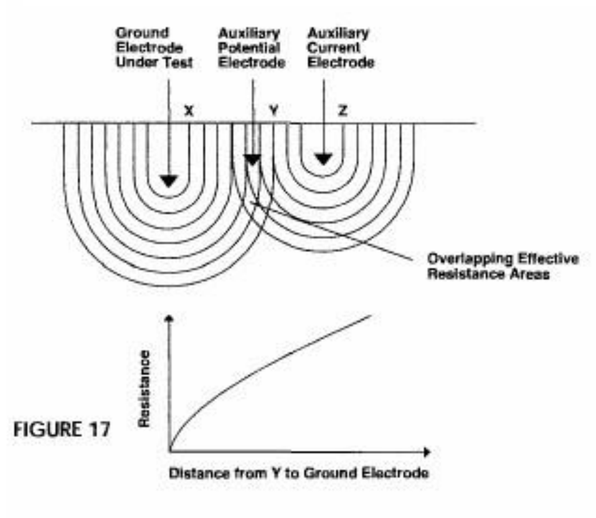


FIGURE 17

Now consider Figure 18, where the X and Z electrodes are sufficiently spaced so that the areas of effective resistance do not overlap. If we plot the resistance measured we find that the measurements level off when Y is placed at 62% of the distance from X to Z and that the readings on either side of the initial Y setting (62%) are most likely to be within the established tolerance band. This tolerance band is defined by the user and expressed as a percent of the initial reading +/- 2%, +/-5%, +/-10% etc.

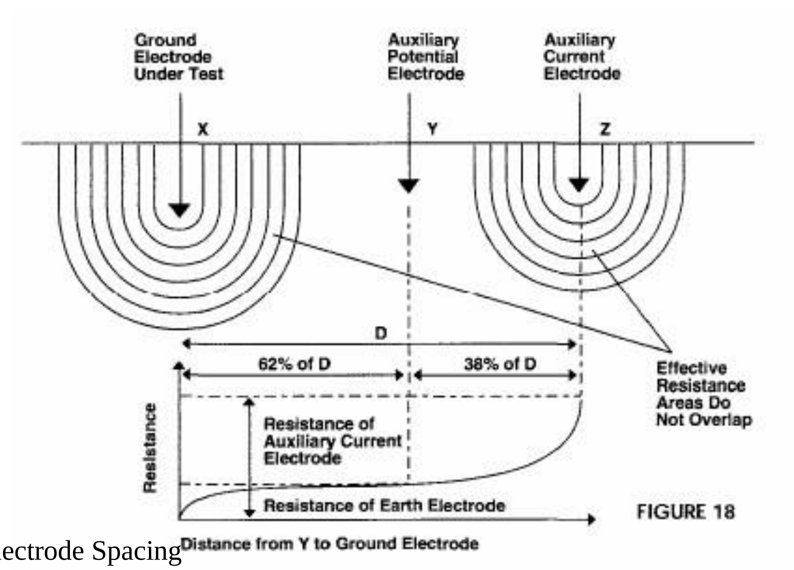


FIGURE 18

Auxiliary Electrode Spacing

No definite distance between X and Z can be given, since this distance is relative to the diameter of the rod tested, its length, the homogeneity of the soil tested, and particularly, the effective resistance areas. However, an approximate distance may be determined from the following chart which is given for homogenous soil and an electrode of 1" in diameter (for a diameter of ½" reduce the distance by 10%).

APPENDIX :III LED LAMP SELECTION GUIDE

LEDs have many advantages over conventional lighting including longer life, energy efficiency, durability, improved performance at cold temperatures, directional light emission, instant on at full output, rapid on-off cycling capability without detrimental effects, dimming and control capability, opportunity for color tuning, and minimal non visible radiation (ultraviolet and infrared radiation). However, several important factors should be considered before selecting the appropriate light source. This article aims to help consumers select the appropriate LED lighting for a particular application. Choosing the Best Product .

Choosing the Best Product There are a number of factors that should be considered before choosing LED lights. Choosing the best option for a specific application will likely include evaluating:

- Lumen output.
- Color quality and appearance.
- Energy use and luminous efficacy.
- Light distribution and angle of view .
- Rated life vs. operational time Life-cycle cost .
- Dimming characteristics, flicker, and audible noise .
- Compatibility with new or existing luminaries and building systems

Lumen Output: Lumen is the rate at which a source produces light. The light output is the total amount of light emitted by the source in all directions per unit time. Higher lumens correspond to brighter light while lower lumens correspond to dimmer light. The selected LED light should be capable of providing enough light to achieve the proper lighting level required. 1 Color Quality and Appearance Objects are not inherently colored, but rather reflect different proportions of radiant energy. Thus, if the light incident on a surface changes, the apparent color of the object may change. Depending on the light source, this shift can be small or large. Color of LED lights is typically characterized using the correlated color temperature (CCT) and color rendering index (CRI) metrics.

Correlated Color Temperature (CCT) :The correlated color temperature is the absolute temperature (in °K) of a blackbody whose chromaticity most nearly resembles that of the light source. Lamps with a CCT rating below 3200°K are usually considered warm sources, whereas those with a CCT above 4000°K are usually considered cool in appearance. Temperatures in between are considered neutral in appearance. Warm lights are usually used for indoor application whereas cool light is used for outdoors and industrial application. Figure 1 shows the CCT of various light sources.

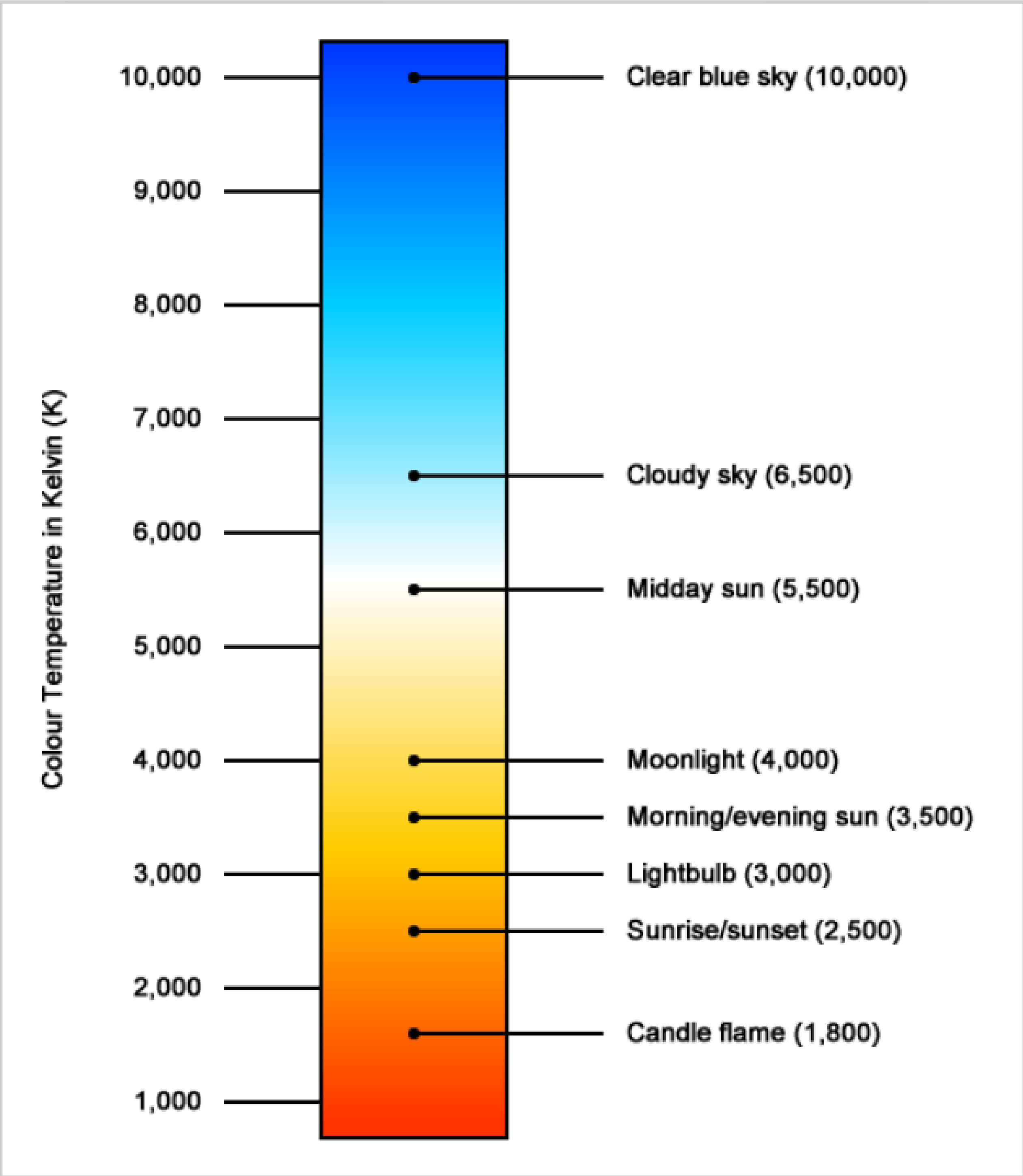


Figure 1 – Correlated Color Temperature Chart

Color rendering index (CRI) : The color rendering index measures the ability of a light source to render colors, compared to either incandescent reference sources if warm in color, or daylight reference sources if cooler in color. At the maximum CRI value of 100, the colors of objects would be seen as they would appear under an incandescent or daylight spectrum of the same CCT. In general, a minimum CRI of 80 is recommended for interior lighting, with CRIs of 90 or higher indicating excellent color rendering. ENERGY STAR requires that qualified fixtures have lamps with CRI above 80. The CRI has been found to be inaccurate for RGB (red, green, blue) LED systems because it's poor at predicting the quality of the appearance of saturated color objects, and doesn't correspond well to human perception of color quality. Hence, CCT and CRI together give only an approximate figure for selecting and matching lamp colors. A number of new color-rendering metrics have been proposed in recent years, but none have been widely adopted as of yet. In the meantime, color rendering of LED products should be evaluated in person and in the intended application if possible.

Energy Use and Luminous Efficacy: Luminous efficacy is a measure of how efficient a light source produces visible light and is the ratio of the light output of a lamp (lumens) to its active power (watts). LED lamps have higher luminous efficacy when compared to other lighting technologies. While buying lamps consumers should pay more attention to the luminous efficacy i.e. amount of light the lamp produces per watt than the actual wattage of the lamp. Lamps with higher lumens per watt have higher efficiency. Table 1 shows the luminous efficacy comparison of different lighting technologies.

Light Distribution and Angle of View: The way in which the light is spatially distributed is an important criterion as this determines the luminous intensity (the quantity of visible light that is emitted in unit time per unit solid angle). It is also important to consider the pattern created by the light, such as the sharpness of beam edges. While this LED specification may not be important for some applications like interior lighting, it is of great importance for others like exterior and perimeter lighting**.**

Rated Life vs. Operational Life : The average rated life of a lamp is determined by the number of hours at which half of the lamps in a large sample are likely to fail and half are likely to survive. LED lamps usually have a rated life of more than 25,000 hours. But, the light intensity of LED lamps decreases gradually with time and it is important to consider the operational life as well when selecting a LED lamp. Operational life can be expressed in terms of lumen maintenance or the ability of a lamp to retain its light output over time. Greater lumen maintenance means a lamp will remain brighter longer. The useful lifetime estimates for LED lighting products are typically given in terms of the expected operating hours until light output has diminished to 70% of initial levels (denoted L70 life). The recommended lumen maintenance requirements for different useful lifetime claims are given in Table 2.

Table 2 - Recommended lumen maintenance requirements

L_{70} lifetime claim (hrs.)	Minimum lumen maintenance at 6,000 hours (%)
25,000	91.8
35,000	94.1
50,000	95.8

Life-cycle Cost :LED technology is in its infancy and is costly compared to other lighting technologies. However, it is important to consider the life-cycle cost of LED lamps when deciding to purchase a particular lighting technology. LEDs can yield an attractive return on investment when energy and maintenance savings are included. LED products are typically more expensive on a first-cost basis, but prices continue to fall as performance improves. Maintenance cost savings is an important factor for the adoption of LED technology. Companies and municipalities are adopting LED lights as these will allow them to improve service levels and reduce costs. Lower maintenance costs come from the exceptionally long life of LED powered luminaries. Payback periods for these luminaries range from 1- 3 years depending on labor costs and the nature of applications. The most significant energy and maintenance savings are realized from lights used in stairwells, emergency lights, etc. that remain switched on 24 X 7. For outdoor lights that need cherry pickers and trucks to replace, the maintenance savings are substantial and breakeven is achieved quickly. For safety and security applications like slippery floors in manufacturing or processing companies, perimeter lighting etc. the failure of a light can have unacceptable consequences. For these applications, the long lifespan of LED technology makes it the best choice.

Dimming/Flicker: Certain lighting applications require dimming capability. The type of dimmers, dimming range, and type of dimming also plays a major part in selecting the lamps. Many LEDs face problems with visual flicker when full on or at any point during dimming. Buyers should be aware of these characteristics before buying the LED lamps. It is also recommended that the consumer be aware of the light output frequency and depth of modulation and know if there is color shift during dimming.

Compatibility with new or existing luminaries and building systems: Different lighting technologies often require different accessory components. It is important to know if the product will perform as desired given the type of transformer, type of dimmer, and the connected load. Manufacturers should provide compatibility charts for their products. It is important to know if the new LED light has the same shape and size that of the previous light. A replacement lamp is of little use if it does not fit into an existing luminaries.

INDIAN STANDARDS ON LED PUBSLISHED Following Indian Standards on LED and LED based products have been published.

1) IS No Title 1. 16101 : 2012 General Lighting - LEDs and LED modules – Terms and Definitions

2.) 16102(Part 1) : 2012 Self- Ballasted LED Lamps for General Lighting Services Part 1 Safety Requirements

3) 16102(Part 2) : 2012 Self-Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements

4) 16103(Part 1) : 2012 Led Modules for General Lighting Part 1Safety Requirements

5.) 16103(Part 2) : 2012 Led Modules for General Lighting Part 2 Performance Requirements

6) 15885(Part2/Sec13): 2012 Safety of Lamp Control Gear Part 2 Particular Requirements Section 13 d.c. or a.c. Supplied Electronic Control gear for Led Modules

7)16104 : 2012 d.c. or a.c. Supplied Electronic Control Gear for LED Modules - Performance Requirements

8)16105 : 2012 Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources

9)16106 : 2012 Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products

10) 16107Part 1):2012 Luminaries Performance Part 1 General Requirements

11) 16107-1:2012 Luminaries Performance Part 2 Particular Requirements Section 1 LED Luminaries

12) 16108 : 2012 Photo biological Safety of Lamps and Lamp Systems

Recommended Battery Maintenance Practice :

Protective equipment

Although VRLA cells can vent or leak small amounts of electrolyte, electrical safety is the principal but not the only concern for safe handling. The following minimum set of equipment for safe handling of the battery and protection of personnel shall be available:

a) Safety glasses with side shields, goggles, or face shields, as appropriate.
b) Electrically insulated gloves, appropriate for the installation.
c) Protective aprons and safety shoes.
d) Portable or stationary water facilities in the battery vicinity for rinsing eyes and skin in case of contact with acid electrolyte.
e) Class C fire extinguisher. Note that some manufacturers do not recommend the use of CO_2 fire extinguishers due to the potential for thermal shock.
f) Acid neutralizing agent.
g) Adequately insulated tools.
h) Lifting devices of adequate capacity, when required.

NOTE—Although VRLA cells are designed to minimize electrolyte leakage, neutralize any electrolyte with a bicarbonate of soda mixed with approximately 0.1 kg/L of water or other appropriate neutralizing agents.[3]

Precautions

The following protective procedures shall be observed:

a) Use caution when working on batteries because they present a shock and arcing hazard.
b) Check the voltage to ground (ac and dc) before working around the battery. If the voltage is other than anticipated, or is considered to be in an unsafe range, do not work on the battery until the situation is understood and/or corrected. Wear protective equipment suitable for the voltage.
c) Prohibit smoking and open flame, and avoid arcing in the immediate vicinity of the battery.
d) Provide adequate ventilation, and follow the manufacturer’s recommendations during charging.
e) Ensure unobstructed egress from the battery work area.
f) Avoid the wearing of metallic objects such as jewelry while working on the battery.
g) Ensure that work area is suitably illuminated.
h) Follow the manufacturer’s recommendations regarding cell orientation.
i) Follow the manufacturer’s instructions regarding lifting and handling of cells.

Uninterruptible power system (UPS) or other systems might not be equipped with an isolation transformer. In addition to dc voltage, an ac voltage might also be present. Lack of an isolation transformer may provide a direct path to ground of the dc supply to the UPS. This can substantially increase the electrocution and short-circuit hazards.

Procedures:

The following safety procedures should be observed:

g) Restrict all unauthorized personnel from the battery area.

h) Keep the battery clear of all tools and other foreign objects.

i) Avoid static build up by having personnel contact ground periodically while working on batteries.

j) Do not remove the pressure relief valves without the battery manufacturer's approval.

k) Inspect and test instrumentation for safe working condition.

Maintenance :

General

Proper maintenance will prolong the life of a battery and will aid in assuring that it is capable of satisfying its design requirements. A good battery maintenance program will serve as a valuable aid in determining the need for battery replacement. The users must consider their particular application and reliability needs if maintenance procedures, other than those recommended in this document, are used. Battery maintenance should be performed by personnel knowledgeable of batteries and the safety precautions involved.

Inspection:

All inspections should be made under normal float conditions if possible. Readings should be taken in accordance with the manufacturer's instructions. All measurements and observations should be recorded for future comparisons.

Monthly

A monthly general inspection should include a check and record of the following:

a) Overall float voltage measured at the battery terminals.

b) Charger output current and voltage.

c) Ambient temperature.

d) The condition of ventilation and monitoring equipment.

e) Visual individual cell/unit condition check to include

    Cell/unit integrity for evidence of corrosion at terminals, connections, racks, or cabinet.

    General appearance and cleanliness of the battery, the battery rack or cabinet, and battery area, including accessibility.

    Cover integrity and check for cracks in cell/unit or leakage of electrolyte.

f) Excessive jar/cover distortion.

g) DC float current (per string). This should be measured using equipment that is accurate at low (typically less than 1 A) currents.

Quarterly

A quarterly inspection should include the items and a check and record of the following (values recorded and observations made should be compared with initial inspection values):

a) Cell/unit internal ohmic values
b) Temperature of the negative terminal of each cell/unit of battery
c) Voltage of each cell/unit

Yearly and initial:
The yearly inspection and the initial installation should check and record of the following:

Cell-to-cell and terminal connection detail resistance of entire battery

AC ripple current and/or voltage imposed on the battery

Special inspections

If the battery has experienced an abnormal condition (such as a severe discharge, overcharge, or extreme high ambient temperature), an inspection should be made to assure that the battery has not been damaged. Include the requirements for the yearly inspection.

Corrective actions

Immediate:
The following items indicate conditions that should be corrected before the next general inspection:

a) If connection resistance readings obtained are more than 20% above the installation value or above a ceiling value established by the manufacturer, or if loose connections are noted, re-torque and retest. If terminal corrosion is noted, clean the corrosion and check the resistance of the connection. If retested resistance value remains unacceptable, the connection should be disassembled, cleaned, reassembled, and retested
b) When cell/unit internal ohmic values deviate by a significant amount from either the installation value or from the average of all connected cells/units, additional actions are needed .
c) If any electrolyte is found, determine source and institute corrective action. Clean excessive dirt on cells or connectors when noted. Remove any electrolyte seepage on cell covers and containers with a bicarbonate of soda solution (or other neutralizing agent) 0.1 kg to 1 L of water. Do not use hydrocarbon-type cleaning agents (oil distillates) or strong alkaline cleaning agents, which may cause containers and covers to crack or craze. Use extreme care when cleaning battery systems to prevent ground faults .
d) When the float voltage, measured at the battery terminals, is outside of its recommended operating range, the charger voltage should be adjusted. The out-of-range condition may have been caused by a defective charger and may need to be investigated. The recommended operating range may be affected by temperature .

Routine:

The following items indicate conditions that, if allowed to persist for extended periods, can reduce battery life. They do not necessarily indicate a loss of capacity. Therefore, the corrective action may be accomplished before the next quarterly inspection, provided that the battery condition is monitored at regular intervals:

a) If any cell/unit voltage is below its respective critical minimum voltage as specified by the manufacturer, corrective action should be given . Do not charge at rates above the manufacturer’s recommendation for the specific ambient temperature involved.
b) When cell temperatures deviate more than 3 °C from each other during a single inspection, determine the cause and correct. If sufficient correction cannot be made, contact the manufacturer for allowances that must be taken.

Pre test requirements

The following list defines the activities and data required before initiating a discharge test,

a) If an equalizing charge is specifically recommended by the manufacturer as a normal periodic maintenance event, verify that it has been completed more than 3 days and less than 30 days before the start of the test.
b) Check all battery connections and ensure that all resistance readings are correct for the system
c) Read and record the float voltage of each cell/unit just before the test.
d) Read and record the temperatures of several battery cells/units to determine an average battery temperature (suggest 10% or more cell/units).
e) Read and record the battery terminal float voltage.
f) Measure and record individual cell/unit internal ohmic values before the test.
g) Take adequate precautions (such as isolating the battery to be tested from other batteries and critical loads) to ensure that a failure will not jeopardize other systems or equipment.

Do's

- ✓ While installing the batteries please refer to the supplier's technical manual.
- ✓ It is advisable to install batteries in an isolated environment.
- ✓ Maintain Proper Ventilation in the battery room.
- ✓ Turn off the power supply before maintenance.
- ✓ Use only insulated tools during Installation & Commissioning.
- ✓ Metal watches, jewelry should not be worn while handling batteries.
- ✓ Turn off the charger before attempting to connect leads to the battery to avoid sparks.
- ✓ Check all sides of battery for cracks, dents, leaking or swelling in the battery case and lid.
- ✓ Check that all vent caps are in place (flush) and do not appear to be elevated. If found elevated gently tap the vent back in place, mark the vent with an "R" with a permanent marker. If it elevates again during charging or operational use, dispose the battery
- ✓ Tighten the battery terminals according to recommended torque values given by the manufacturer to ensure all inter-cell connections are proper.
- ✓ Maintain Optimum gap between each battery in the rack for better heat dissipation.
- ✓ Maintain the appearance, safety, cleanliness & temperature of battery room as per the recommendations of manufacturer for better service life of the battery.
- ✓ Adequate safety measures are to be taken in the Battery room to alert, prevent and extinguish fire. It is important to use application specific equipment for the purpose. The safety equipments are to be periodically maintained and a separate record to be maintained thereof.
- ✓ There is no protection available for individual battery. It is a source of abundant energy that can go uncontrolled. Adequate care is to be taken to avoid short circuit of cells. Electrical spark from battery can cause serious injury to the personnel. Ensure all personnel protection system while working on Battery.
- ✓ Battery needs to be discharged & charged periodically (at least quarterly) for better performance and life.
- ✓ **THE VRLA TECHNOLOGY IS OPERATED WITH LIMITED VOLUME OF ELECTROLYTE WHICH IS IMMUNE TO DE-GENERATION IST ORIGINAL CAPACITY IN PHASED MANNER. THE BATTERY LIFE IS DETERMINED ON THE BASIS OF THE CAPACITY UTILIZATION. SERVICED LIFE SHOULD NEVER BE COMPAIRED & MATCHED TO THE DESIGN LIFE. IT IS RECOMMANDED TO REPLACE THE VRLA BATTERIES AT EVERY 3 TO 4 YEARS INTERVAL AS A PRECAUTION TO AVOID THERMAL RUNAWAY RESULTING IN DISASTROUS FIRE.**
- ✓ Keep only essential personnel in the area while disconnecting and removing the battery.

DONT’s

- Do not lay tools or metal parts on top of batteries, falling of which across the terminal can cause short circuit and uncontrolled current flow leading to spark blast etc.
- Do not expose batteries to direct sunlight.
- Do not use batteries of different capacities or make in one battery string.
- Do not replace only part of the battery bank. If the system permits one or two defective batteries can be removed by adjusting the DC bus voltage accordingly, **to be carried out by UPS OEM only.**
- Do not install batteries close to any heat generating equipment.
- Do not overcharge the batteries.
- Do not smoke, cause a flame or spark in the immediate vicinity of the batteries.
- Do not charge a damaged or frozen battery.
- Batteries are to be replaced within the life span specified, in considerations of de-rating factors.

Why Batteries fail?

- High or uneven temperature.
- Inaccurate float charge voltage.
- Loose inter-cell link or connection.
- Loss of electrolyte due to drying out or damaged case.
- Lack of maintenance, aging

How Battery lead to Fire:

- Short circuit at battery terminals.
- Hydrogen gas production from batteries.
- Thermal runaway.
- Extreme temperature.
- Wrong polarity connection.

General Tips for Safety & Protection

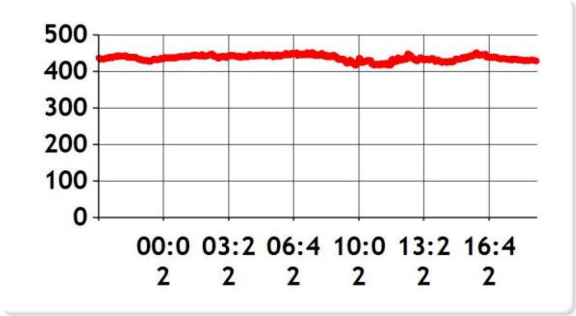
- Ensure all protection devices are functional to prevent overcharge or short circuit.
- Check Mains input protection power breaker & protection relay calibration and its functionality.
- Check Emergency stop operation.
- Install Battery Breaker of specified type & rating to protect self & batteries during operations.
- Check the functionality of UPS battery breaker Under Mains fail condition and control wiring & its operation during emergency stop.
- If temperature compensation charging is provided then check the sensor & charging operation by stimulating conditions.
- Boost charging must not be applied to VRLA. This may overcharge the battery as they are not sealed and so may vent gases leading to permanent damage.
- Dispose the battery if vents elevate during charging or any operational use.
- Follow OEM instruction for System startup & shutdown procedure.
- Maintain the battery room temperature in the range of 22^0C to 25^0C.

  The battery capacity gets de rated by 1% for every degree C rise in temperature. (Check OEM spec. for the same.)
- Maintain proper ventilation during charging process.
- Fire monitoring, alerts and protection system must be checked at regular intervals.
- Ensure proper Earthing for battery rack & UPS.

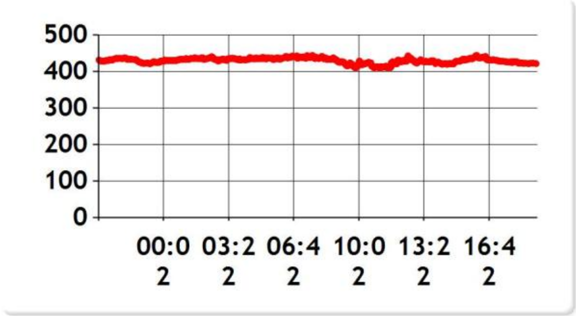
ANNEXURE -II

POWER QUALITY TIME PLOTS

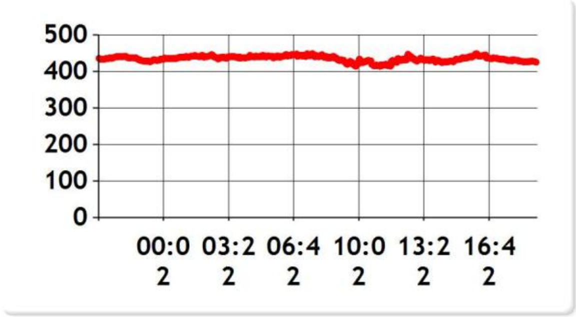
MAIN_LT_INCOMER_ENGINEERING.



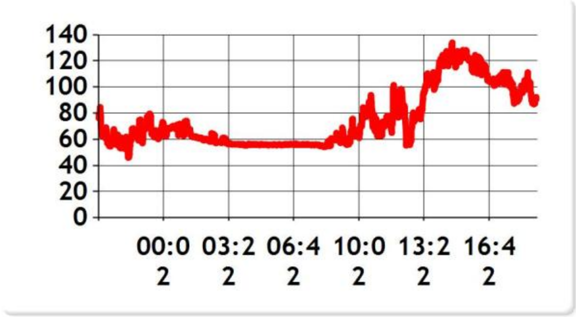
RMS VOLTAGE VARIATION TIME PLOT OF CH1
Max Val. : 451.61 V
Avg. Val. : 436.14 V
Min Val. : 416.29 V



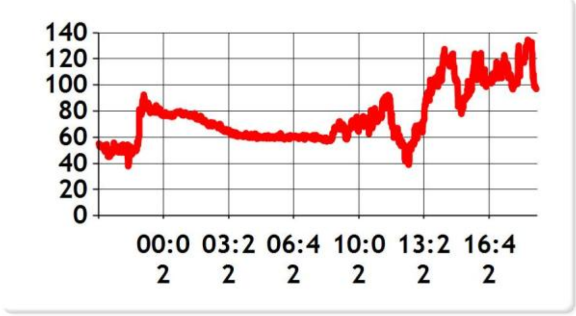
RMS VOLTAGE VARIATION TIME PLOT OF CH2
Max Val. : 443.6 V
Avg. Val. : 429.05 V
Min Val. : 408.49 V



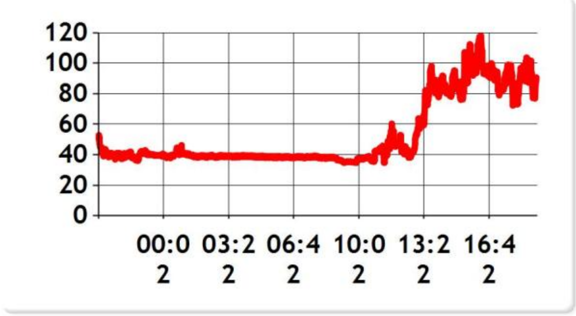
RMS VOLTAGE VARIATION TIME PLOT OF CH3
Max Val. : 448.62 V
Avg. Val. : 434.1 V
Min Val. : 413.25 V



RMS CURRENT VARIATION TIME PLOT OF CH1
Max Val. : 133.84 A
Avg. Val. : 75.67 A
Min Val. : 46.02 A

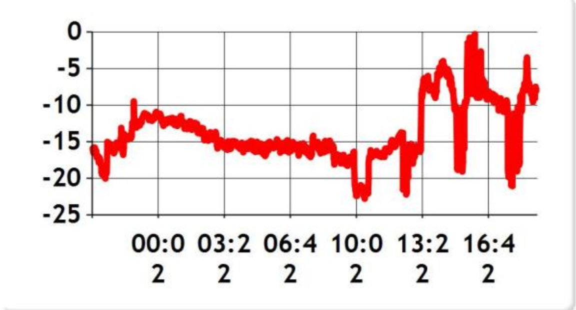


RMS CURRENT VARIATION TIME PLOT OF CH2
Max Val. : 134.46 A
Avg. Val. : 76.42 A
Min Val. : 37.87 A

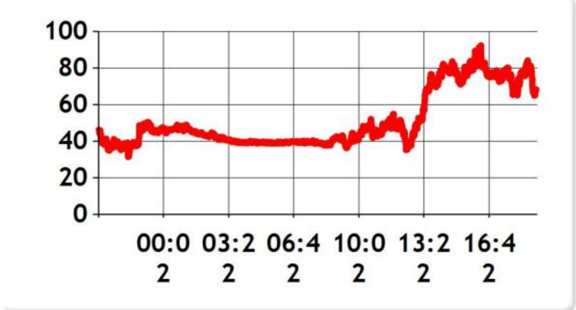


RMS CURRENT VARIATION TIME PLOT OF CH3
Max Val. : 117.88 A
Avg. Val. : 53.22 A
Min Val. : 34.77 A

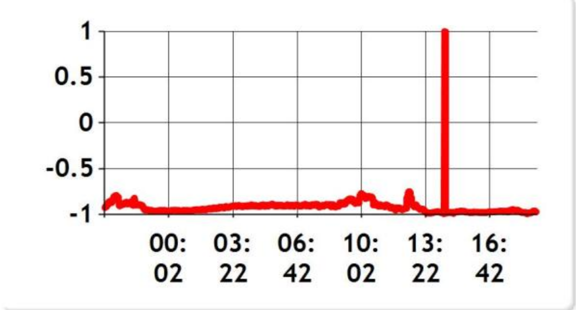
TOTAL ACTIVE POWER VARIATION TIME PLOT
Max Val. : 90.1 KW
Avg. Val. : 47.81 KW
Min Val. : 26.03 KW



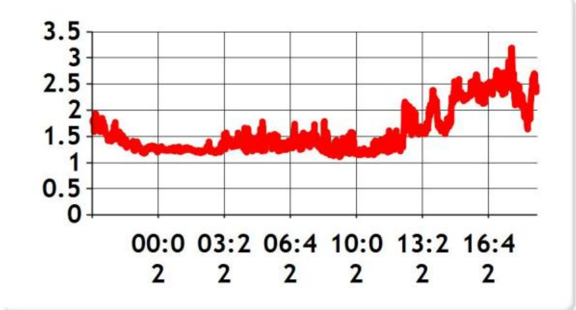
TOTAL REACTIVE POWER VARIATION TIME PLOT
Max Val. : -0.32 KVAR
Avg. Val. : -13.77 KVAR
Min Val. : -22.77 KVAR



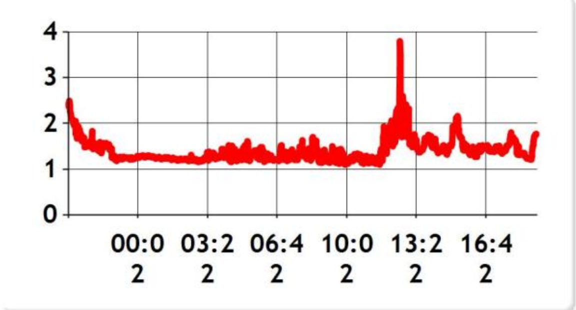
TOTAL APPARENT POWER VARIATION TIME PLOT
Max Val. : 92.19 KVA
Avg. Val. : 51.28 KVA
Min Val. : 31.54 KVA



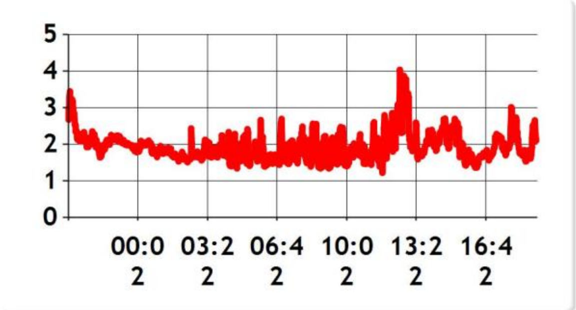
POWER FACTOR VARIATION TIME PLOT
Max Val. : 1
Avg. Val. : -0.92
Min Val. : -0.99



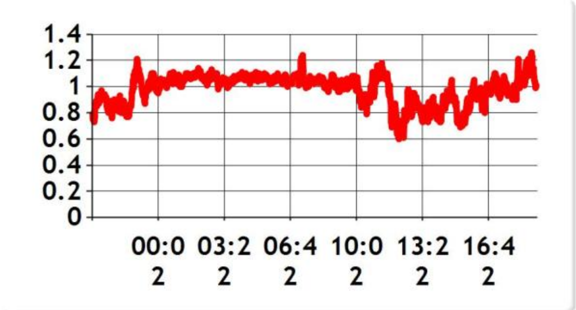
KF FACTOR VARIATION TIME PLOT OF CH1
Max Val. : 3.19
Avg. Val. : 1.6
Min Val. : 1.11



KF FACTOR VARIATION TIME PLOT OF CH2
Max Val. : 3.79
Avg. Val. : 1.42
Min Val. : 1.1



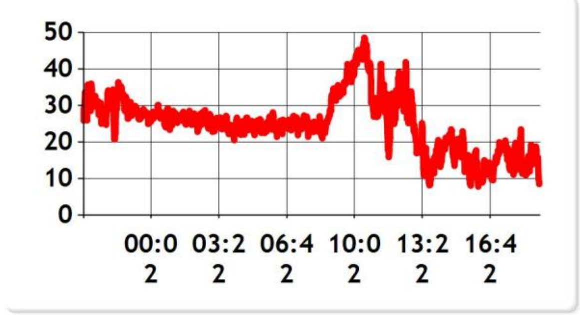
KF FACTOR VARIATION TIME PLOT



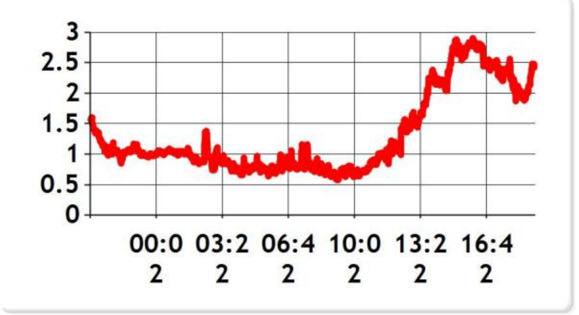
% VOLTAGE UNBALANCE FACTOR

OF CH3
Max Val. : 4.03
Avg. Val. : 1.95
Min Val. : 1.22

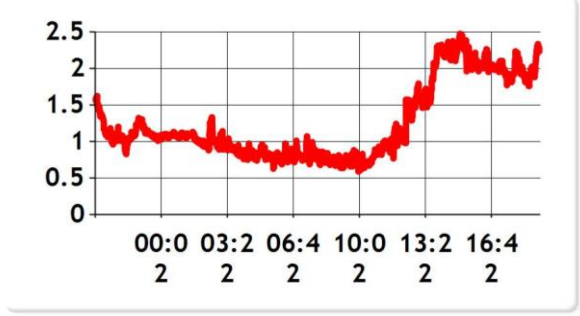
VARIATION TIME PLOT
Max Val. : 1.26
Avg. Val. : 0.98
Min Val. : 0.6



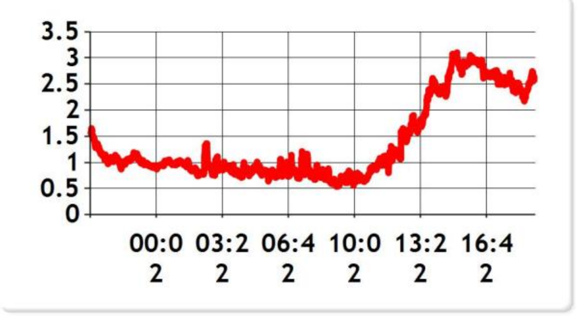
% CURRENT UNBALANCE FACTOR VARIATION TIME PLOT
Max Val. : 48.47
Avg. Val. : 24.73
Min Val. : 6.99



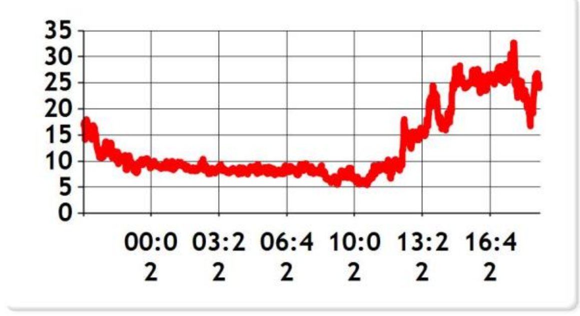
% TOTAL VOLTAGE HARMONIC DISTORTION VARIATION TIME PLOT OF CH1
Max Val. : 2.9
Avg. Val. : 1.32
Min Val. : 0.58



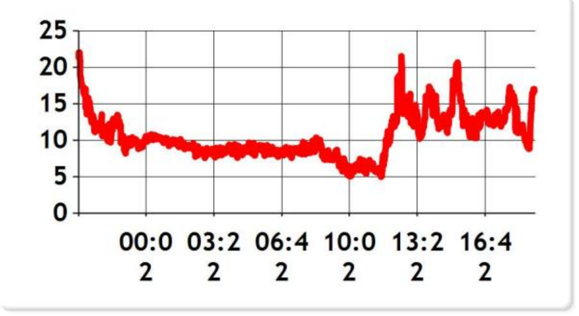
% TOTAL VOLTAGE HARMONIC DISTORTION VARIATION TIME PLOT OF CH2
Max Val. : 2.47
Avg. Val. : 1.27
Min Val. : 0.59



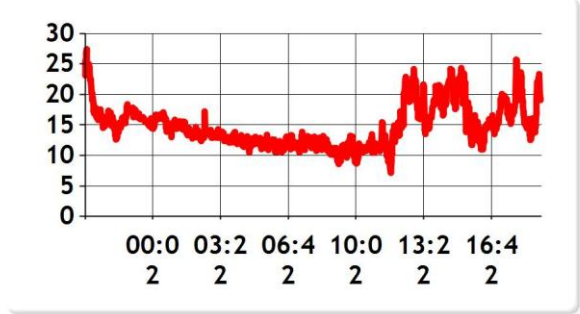
% TOTAL VOLTAGE HARMONIC DISTORTION VARIATION TIME PLOT OF CH3
Max Val. : 3.1
Avg. Val. : 1.389
Min Val. : 0.54



% TOTAL CURRENT HARMONIC DISTORTION VARIATION TIME PLOT OF CH1
Max Val. : 32.66
Avg. Val. : 13.08
Min Val. : 5.44

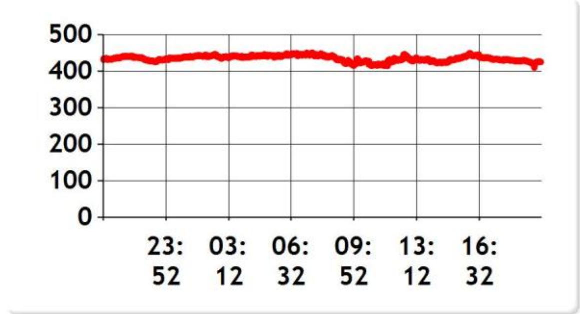


% TOTAL CURRENT HARMONIC DISTORTION VARIATION TIME PLOT OF CH2
Max Val. : 22.92
Avg. Val. : 10.711
Min Val. : 5.01

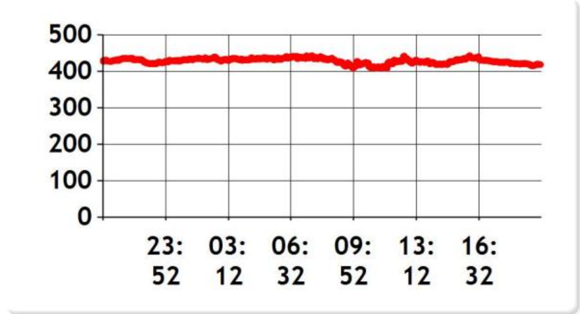


% TOTAL CURRENT HARMONIC DISTORTION VARIATION TIME PLOT OF CH1
Max Val. : 28.62
Avg. Val. : 14.94
Min Val. : 7.17

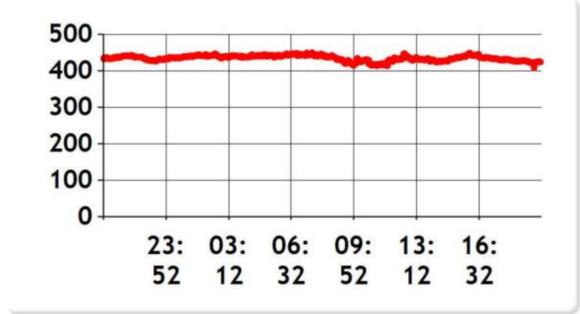
MAIN_DB_PANEL_NO_1_ENGINEERING.



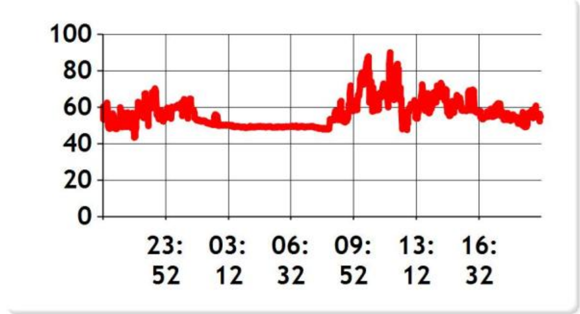
RMS VOLTAGE VARIATION TIME PLOT OF CH1
Max Val. : 450.04 V
Avg. Val. : 433.85 V
Min Val. : 301.11 V



RMS VOLTAGE VARIATION TIME PLOT OF CH2
Max Val. : 442.71 V
Avg. Val. : 427.57 V
Min Val. : 297.85 V



RMS VOLTAGE VARIATION TIME PLOT OF CH3
Max Val. : 449.18 V
Avg. Val. : 433.79 V
Min Val. : 301.64 V



RMS CURRENT VARIATION TIME PLOT OF CH1
Max Val. : 89.96 A
Avg. Val. : 56.61 A
Min Val. : 37.21 A

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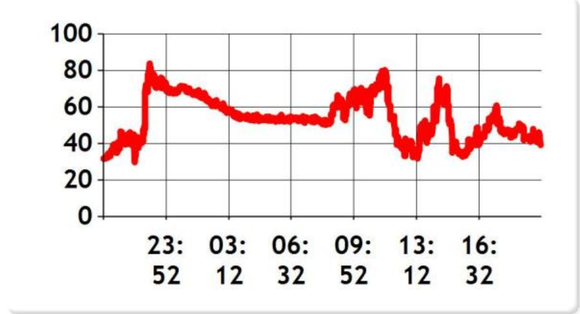

RMS CURRENT VARIATION TIME PLOT OF CH2
Max Val. : 83.56 A
Avg. Val. : 53.71 A
Min Val. : 25.93 A
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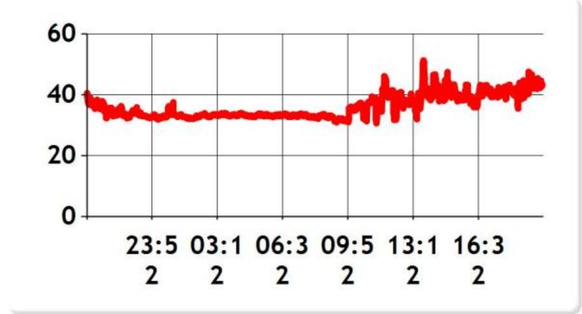

RMS CURRENT VARIATION TIME PLOT OF CH3
Max Val. : 51.23 A
Avg. Val. : 36.06 A
Min Val. : 29.84 A
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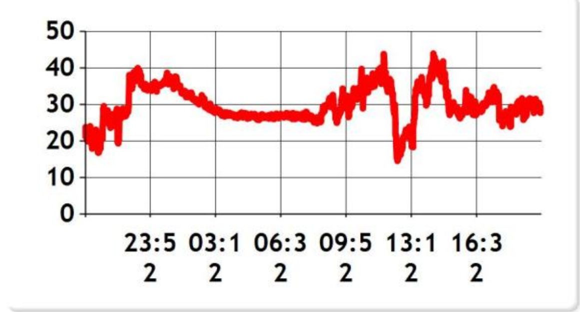

TOTAL ACTIVE POWER VARIATION TIME PLOT
Max Val. : 43.87 KW
Avg. Val. : 29.65 KW
Min Val. : 13.72 KW
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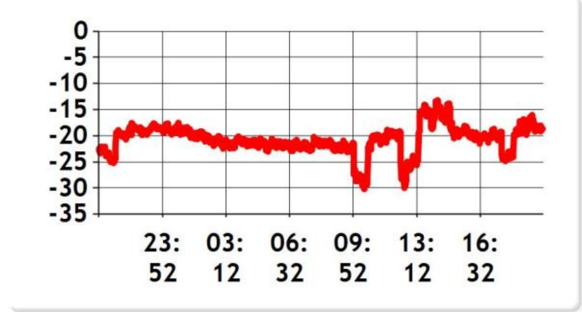

TOTAL REACTIVE POWER VARIATION TIME PLOT
Max Val. : -13.21 KVAR
Avg. Val. : -20.71 KVAR
Min Val. : -30.18 KVAR
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TOTAL APPARENT POWER VARIATION TIME PLOT
Max Val. : 47.98 KVA
Avg. Val. : 36.46 KVA
Min Val. : 23.21 KVA
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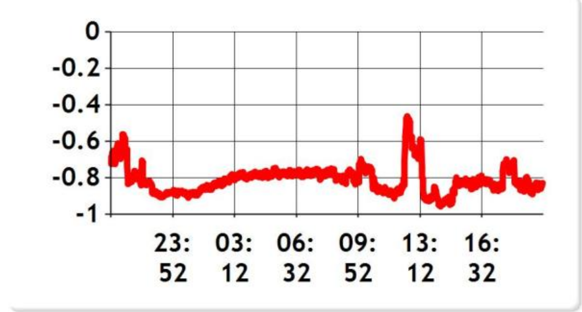

POWER FACTOR VARIATION TIME PLOT
Max Val. : -0.46
Avg. Val. : -0.81
Min Val. : -0.96
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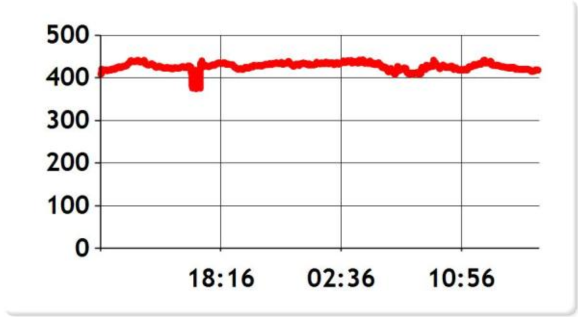
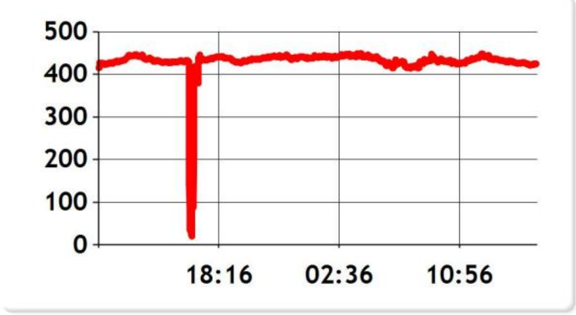
MAIN_DB_PANEL_NO_2_ENGINEERING.

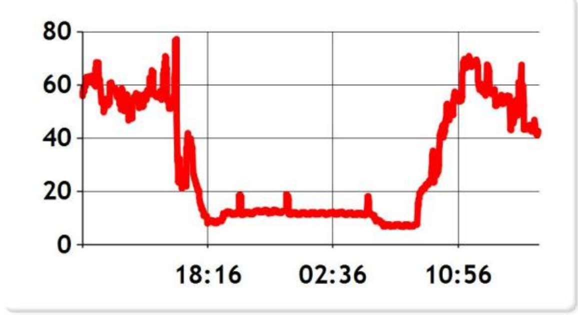
RMS VOLTAGE VARIATION TIME PLOT OF CH1
Max Val. : 450.2 V
Avg. Val. : 432.64 V
Min Val. : 331.08 V



RMS VOLTAGE VARIATION TIME PLOT OF CH2
Max Val. : 442.53 V
Avg. Val. : 426.94 V
Min Val. : 373.9 V

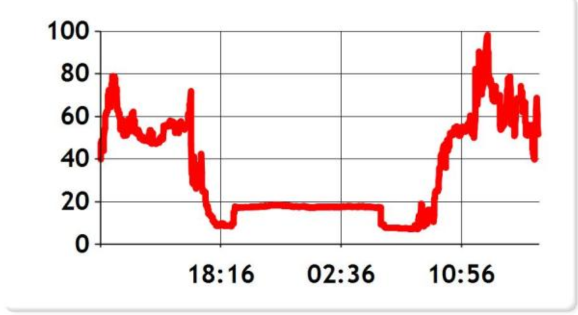


RMS VOLTAGE VARIATION TIME PLOT OF CH3
Max Val. : 449.39 V
Avg. Val. : 429.68 V
Min Val. : 20.23 V

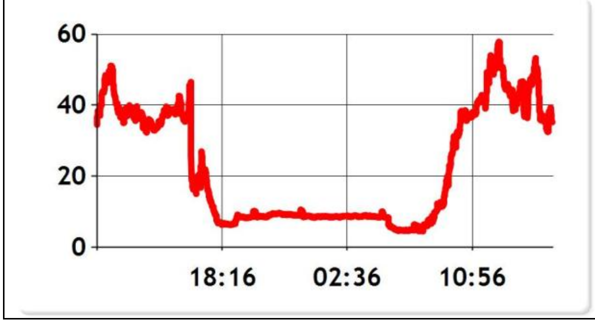


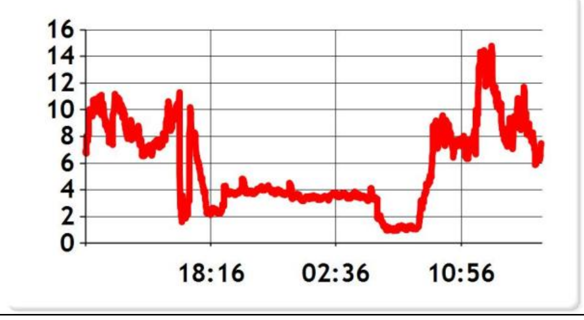
RMS CURRENT VARIATION TIME PLOT OF CH1
Max Val. : 77.16 A
Avg. Val. : 31.7 A
Min Val. : 6.87 A

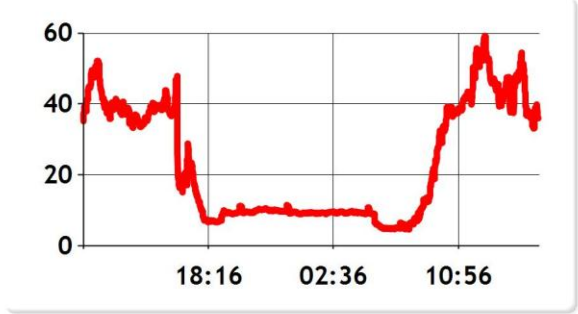
RMS CURRENT VARIATION TIME PLOT OF CH2
Max Val. : 90.38 A
Avg. Val. : 31.35 A
Min Val. : 6.96 A



RMS CURRENT VARIATION TIME PLOT OF CH3
Max Val. : 98.19 A
Avg. Val. : 34.46 A
Min Val. : 7.2 A





TOTAL ACTIVE POWER VARIATION TIME PLOT Max Val. : 57.83 KW Avg. Val. : 22.66 KW Min Val. : 4.53 KW	TOTAL REACTIVE POWER VARIATION TIME PLOT Max Val. : 14.78 KVAR Avg. Val. : 5.81 KVAR Min Val. : 0.95 KVAR
	
TOTAL APPARENT POWER VARIATION TIME PLOT Max Val. : 59.2 KVA Avg. Val. : 23.48 KVA Min Val. : 4.68 KVA	POWER FACTOR VARIATION TIME PLOT Max Val. : 1 Avg. Val. : 0.95 Min Val. : 0.85