POWER QUALITY IMPROVEMENT BY COMPENSATED LED LIGHTING SYSTEM

Y. Santhosh [1] , T. Manmadharao [2] , T. Amit kumar [3]
[1]Assistant professor, Dept. Of EEE, AITAM, Tekkali, Andhrapradesh
[2]Assistant professor, Dept. Of EEE, AITAM, Tekkali, Andhrapradesh
[3]B.E Student, Dept. Of EEE, SITAM, Vizianagaram

Abstract: In this project we are designing a led lightning system such that It could consume less power, but in desirable cost at flexible range of Specification. A part from led lightning system, we are providing led lightning System with compensation, such that where ever this light was used This product was capable of saving about 15 to 20 watts of power Consumed by other loads where it is used per light. In this project power factor compensation was provided in a such way Using static compensators, it will adjust the power factor to unity, To reduce effective apparent power drawn by the source. It has a wide scope of applications for industrial sectors, where reactive Loads are more, also small scale industries. It has an adverse effect on industries, because industries are charged for KVA Tariff system (i.e.), so if the reactive power compensation was not done correctly then it leads to consumption of excessive apparent power as a result more electricity bill.

Keywords: Power quality improvement (PQI), Light emitting diode (LED), Power factor (PF), Alternating current (AC), Direct current (DC), Volt ampere reactor (VAR).

1. Introduction

One of the important consideration of electrical energy was consumption of active power and compensation of reactive power, in this power quality improvement project we are improving power factor of the load. As we know that most of the industries are capable of compensating reactive power in range of KVAR i.e. they were unable to compensate reactive power exactly.

Apart from exact compensation , most of the small scale industries are operating their industries during morning session and they shutdown in night session, i.e. during night session the transformer was operating for lightning load ,at that condition transformer has power factor range from 0.15-0.25 (lpf) .

During this condition additional reactive power consumption was required, this compensation was provided with led light as a result , when light was turned on compensation also turned on, so as to reduce the electricity bill.

Power factor:

Power factor may be defined as the ratio of active power and apparent power. In an AC circuit, there is generally a phase difference between voltage and current is called the power factor of the ac circuit.

It is a measure of how the current is being capable to convert into useful work output and a good indicator on the effect of the load current on the efficiency of the supply system.

Power Factor gives a measure of how effective the real power utilization of the system is. It is a measure of distortion of the line voltage and the line current and the phase shift between them . Power factors range from zero (0) to unity (1). With a typical power factor being between 0.8 and also equal to unity. The power factor can also be leading or lagging depending on whether the load is usually capacitive or inductive in nature

Effect of electric loads on power factor :

There are three types of electric loads on power factor such as Resistive, capacitive, Inductive loads. In resistive load the voltage and current peaks coincide with each other and therefore in phase and the power factor is unity.

Inductive loads require a magnetic field to operate with an inductive load the current waveform is lagging behind the voltage waveform. Therefore, the voltage and current peaks are not in phase.

The capacitor current leads (instead of lags) the voltage because of the time , It takes for the dielectric material to charge up to full voltage from the charging current. Therefore, it is said that the current in a capacitor leads the voltage.

2. Rectifier unit

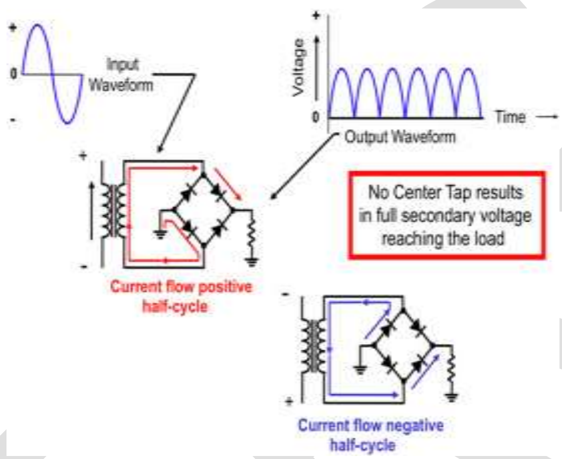
Definition:

A rectifier is a circuit that is used for converting AC supply into unidirectional DC supply. This process of converting alternating current (AC) to direct current (DC) is also called as rectification. These bridge rectifiers are available in different packages as modules ranging from few amperes to several hundred amperes. Mostly in bridge rectifier circuits, semiconductor diode is used for converting AC since it allows the current flow in one direction only (Unidirectional device).

Types of Rectifiers:
Rectifiers are classified into a variety of configurations as shown in below figure. Depends on factors like type of supply, bridge configuration, control nature, components used, etc these rectifiers are classified. Majorly rectifiers are classified into single phase and three phase rectifier and these are further classified into uncontrolled, half controlled and full controlled rectifiers. Let us see in brief about some of these types of rectifiers.

Single Phase Uncontrolled Rectifiers
This type of rectifiers uses the uncontrolled diode for rectifying the input AC supply. At the output terminals of this rectifier, power becomes constant and changes of its magnitude or value depend on load requirement is not possible.

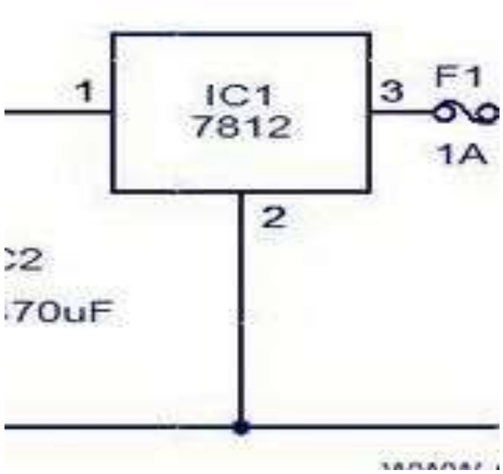
Full Wave Bridge Rectifier
Using the same secondary voltage, this bridge rectifier can produce almost double the output voltage as compared with full wave center-tapped transformer rectifier. During the positive half of the input AC diodes D1 and D2 are forward biased and D3 and D4 are reverse biased. Thus load current flows through D1 and D2 diodes. During the negative half cycle of the input diodes D3&D4 are forward biased and D1&D2 are reverse biased. Therefore load current flows through D3&D4 diodes.



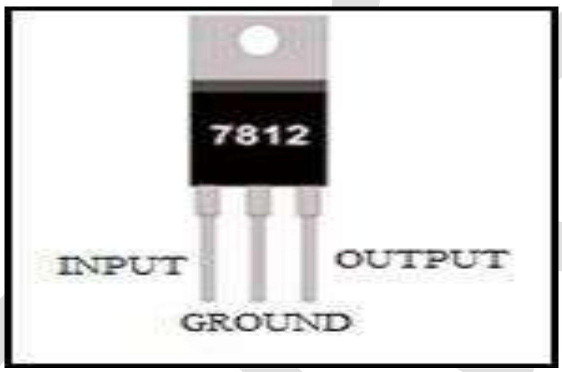
Transformers:
Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection and with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level.

Working Principle of Transformer
The working principle of transformer is very simple depends upon Faraday's law of electromagnetic induction. Actually, mutual induction between two or more winding is responsible for transformation action in an electric transformer.

Voltage regulator:
7812 is a famous IC which is being widely used in 12V voltage regulator circuits. Truly speaking it is a complete standalone voltage regulator. We only need to use two capacitors, one on the input and second one on the output of 7812 in order to achieve clean voltage output and even these capacitors are optional to use.
To achieve 12V, 1A current, 7812 should be mounted on a good heat sink plate. Thanks to the transistor like shape of 7812 which makes it easy to mount on a heat sink plate. 7812 has built in over heat and short circuit protection which makes it a good choice for making power supplies.



In electronics markets, 7812 is sold under various names such as 7812a, 7812act, 7812t and lm7812. All of them are almost identical with a little to no differences at all. 7812 input voltage range is 14V to 35V. Exceeding the voltage range may damage the IC. Given bellow is 7812 pin diagram to make the pin out connections clear in case you want to do some experiments.

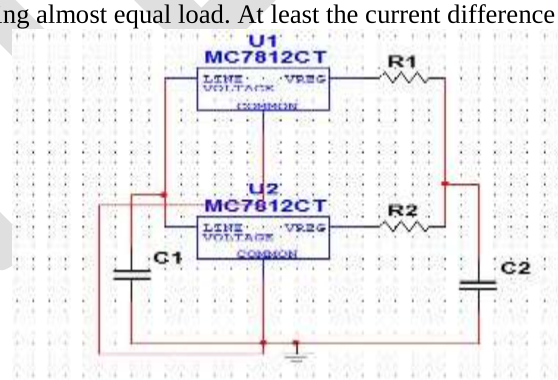


If you hold upside down (pins up) and the IC number is facing you then the left pin will be the voltage regulator output, the center pin will be ground and the right pin will be the voltage input pin. Under my experience, the maximum safe current you can get from one 7812 IC is 1A.

If you need more power then there are a few ways

More than one 7812 can be used in parallel in order to achieve more than 1A current but output voltage of each 7812 can slightly vary resulting in unbalanced load on all of them. This can result in load balancing issues and can damage the IC carrying most current.

However there is a way to overcome this problem. I have given bellow a schematic diagram in which two 7812 ICs are attached together and both of them are carrying almost equal load. At least the current difference is not too much to damage any IC.



Please note that in this circuit diagram, I have used resistors for load balancing purpose so the output of this voltage regulator circuit may slightly inaccurate. Both resistors should be minimum 15 Watt or above.

If you don't find such resistors in your area then you can make them using 32 gauge or thinner copper wire. This parallel 7812 circuit will provide 12V and approximately 2A current. You can increase number of 7812 but each additional 7812 will require a resistor on its output.

Where this voltage regulator was most widely used integrated circuit in most of electronics circuits, because of more versatile and easy to incorporate in printed circuit board.

Electrical Characteristics (LM7812)

Refer to the test circuit, -40°C < T_J < 125°C, I_O = 500 mA, V_I = 19 V, C_I = 0.33 µF, C_O = 0.1 µF, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_O	Output Voltage	T_J = +25°C	11.5	12.0	12.5	V
		I_O = 5 mA to 1 A, P_O ≤ 15 W, V_I = 14.5 V to 27 V	11.4	12.0	12.6	
Regline	Line Regulation(12)	T_J = +25°C, V_I = 14.5 V to 30 V		10	240	mV
		T_J = +25°C, V_I = 16 V to 22 V		3	120	
Regload	Load Regulation(12)	T_J = +25°C, I_O = 5 mA to 1.5 A		11	240	mV
		T_J = +25°C, I_O = 250 mA to 750 mA		5	120	
I_Q	Quiescent Current	T_J = +25°C		5.1	8.0	mA
ΔI_Q	Quiescent Current Change	I_O = 5 mA to 1 A		0.1	0.5	mA
		V_I = 14.5 V to 30 V		0.5	1.0	
$\Delta V_O/\Delta T$	Output Voltage Drift(13)	I_O = 5 mA		-1		mV/°C
V_N	Output Noise Voltage	f = 10 Hz to 100 kHz, T_A = +25°C		76		µV
RR	Ripple Rejection(13)	f = 120 Hz, V_I = 15 V to 25 V	55	71		dB
V_{DROP}	Dropout Voltage	I_O = 1 A, T_J = +25°C		2		V
R_O	Output Resistance(13)	f = 1 kHz		18		mΩ
I_{SC}	Short-Circuit Current	V_I = 35 V, T_J = +25°C		230		mA
I_{PK}	Peak Current(13)	T_J = +25°C		2.2		A

3. LED lighting module

Led lightning system:

Energy-saving solutions have been becoming increasing essential in recent years because of environmental issues such as climate change and global warming. Environmental problems are very important issues and these problems are largely caused by the excessive use of energy.

A light accounts for approximately20 percent of the world’s total energy consumption; thus the related studies of an energy efficient lighting system have been done by various researchers around the world.

The invention of a light emitting diode (LED) is expected to significantly alleviate the energy consumption of a light, because the LED lighting device consumes 50 percent of the energy consumption compared to the fluorescent lighting device.

Recently, an intelligent lighting control system using various sensors and communication modules are actively studied and developed in both university and industry. The intelligent lighting control system can reduce energy consumption as automatically controlling the intensity of illumination through situation awareness, such as awareness of user movement or brightness of surroundings. The technical report from the U.S. Department of Energy shows that about 15 percent of total energy consumption can be reduced through light control according to user's living pattern.

Light emitting diode:

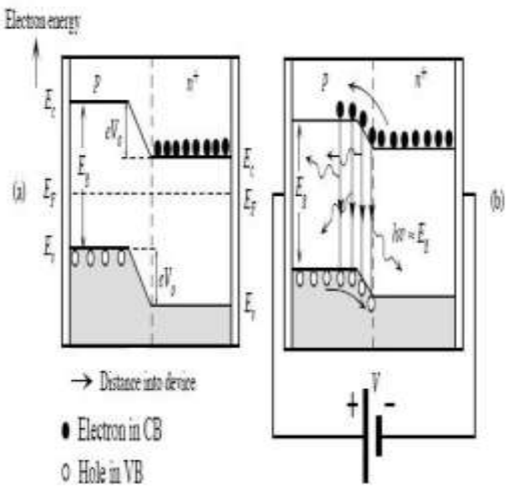
A light emitting diode (LED) is a two lead semiconductor light source. It is ap-n junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

Light emitting diode:

A light emitting diode (LED) is a two lead semiconductor light source. It is ap-n junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level and releases energy in the form of a photon.

Theory:

A Light emitting diode (LED) is essentially a p-n junction diode. When carriers are injected across a forward-biased junction, it emits incoherent light. Most of the commercial LEDs are realized using a highly doped n and a p Junction.



To understand the principle, let's consider an unbiased p-n junction (Figure1 shows thep-n energy band diagram). The depletion region extends mainly into the p-side. There isa potential barrier from Ec on the n-side to the Ec on the p-side, called the built-in voltage,V0.

This potential barrier prevents the excess free electrons on the n+ side from diffusing into the p side. When a Voltage V is applied across the junction, the built-in potential is reduced from V0to V0 – V.

This allows the electrons from the n+ side to get injected into the p-side. Since electrons are the minority carriers in the p-side, this process is called minority carrier injection. But the hole injection from the p side to n+ side is very less and so the current is primarily due to the flow of electrons into the p-side. These electrons injected into the p-side recombine with the holes. This recombination results in spontaneous emission of photons (light). This effect is calledinjection electroluminescence. These photons should be allowed to escape from the device with out being reabsorbed.

LED Materials:

An important class of commercial LEDs that cover the visible spectrum are the III-V ternary alloys based on alloying GaAs and GaP which are denoted by GaAs1-yPy. In GaAlP is an example of a quaternary III-V alloy with a direct band gap.

The LEDs realized using two differently doped semiconductors that are the same materials called a homo junction. When they are realized using different band gap materials they are called . A hetero structure LED is brighter than a homo Junction LED.

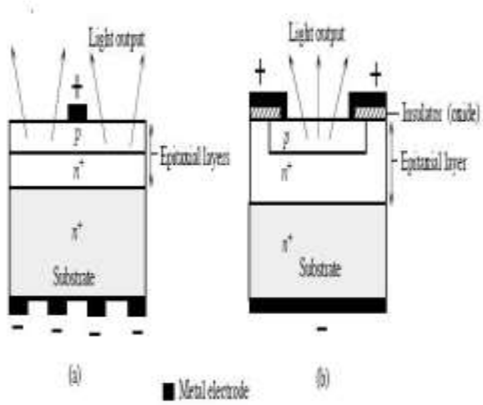
LED Structure:

The LED structure plays a crucial role in emitting light from the LED surface. The LEDs are structured to ensure most of the recombination takes place on the surface by the following two ways.

• By increasing the doping concentration of the substrate, so that additional Free Minority charge carriers electrons move to the top, recombine and emit light at the
surface.

• By increasing the diffusion length $L = \sqrt{D\tau}$, where D is the diffusion coefficient and τ is the carrier life time. But when increased beyond a critical length there is a
chance of re-absorption of the photons into the device.

The LED has to be structured so that the photons generated from the device are emitted without being reabsorbed. One solution is to make the p layer on the top thin, enough to create a depletion layer. Following picture shows the layered structure. There are different ways to structure the dome for efficient emitting.



Lifetime and failure:

Solid state devices such as LEDs are subject to very limited wear and tear if operated at low currents and at low temperatures. Many of the LEDs made in the 1970s and 1980s are still in service in the early 21st century. Typical lifetimes quoted are25,000 to 100,000 hours, but heat and current settings can extend or shorten this time significantly.

The most common symptom of LED (and diode laser) failure is the gradual lowering of light output and loss of efficiency. Sudden failures, although rare, can also occur. Early red LEDs were notable for their short service life. With the development of high power LEDs the devices are subjected to higher junction temperatures and higher current densities than traditional devices. This causes stress on the material and may cause early light Output degradation. To quantitatively classify useful lifetime in a standardized manner it has been suggested to use the terms L70 and L50, which is the time it will take a given LED to reach 70% and 50% light output respectively.

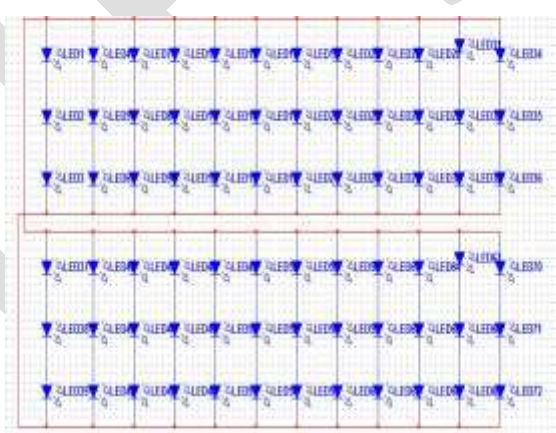
LED performance is temperature dependent. Most manufacturers' published ratings of LEDs are for an operating temperature of 25 °C (77 °F). LEDs used outdoors, such as traffic signals or in pavement signal lights, and that are utilized in climates where the temperature within the light fixture gets very high, could result in low signal intensities or even failure.

Lightning network module design:

The important aspect of design of network module was to make a model in which these led’s are connected in a such topology ,it should satisfy the input voltage specifications.

Since the led diode are practically conducted ,if the applied voltage was greater then the forward cut in voltage , so when these diodes are connected in series, the cut in voltages are the sum of connected diodes.

LED’s are practically modeled as a resistor and voltage source in series with resistor and, the magnitude of voltage source acts as the forward cut in voltage for the diode.



Schematic of 3 diodes are connected in series

As shown in the above figure , the diodes are connected in series ,the forward cut in voltage of diode was ~3v i.e when 3 diodes are connected in series ,then the total cut in voltage was ~9v.

When ever the voltage applied to the branch of 3 series connected diodes are supplied the input voltage greater then the equivalent forward cut in voltage~9v the branch of diode conducts.

Here in this lightning module design ,we are applying 12v as input to a branch of diodes ,total 24 parallel branches are connected in series to achieve a good lightning and with less quantity of power.

Lightning module data sheet

Absolute Maximum Ratings(Ta=±25℃)

PARAMETER	Green	Orange	Gap Red	HI-EFF	Yellow	GaAlAs	Blue	UNIT
Reverse Voltage Per Segment or D.P.	5	5	5	5	5	5	5	V
Average Forward Current (IF)	25	25	25	25	25	30	50	mA
Peak Forward Current Per Segment Or Dp	200	200	200	200	200	200	200	mA
Power Dissipation	85	85	85	85	85	100	120	mW
Operating Temperature Range	-35℃~+80℃							
Recomend Storage Temperature Range	-35℃~+80℃							
Lead Solder Temperature(4mm From Body) 260℃for3sec								
Life:100000H								

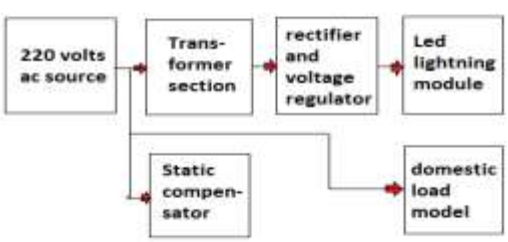
4. Power quality improvement

Power quality:

Power quality improvement is a process in which the effective power drawn by the load was been reduced by using some sort of methods like power factor improvement, maximum efficiency operation. While dealing with maximum efficiency operation, if the electrical load was operated in maximum efficiency so that load was utilized fully When dealing with the power factor improvement, in this process the excessive reactive power required was been supplied by an alternative source called as capacitor.

When capacitor was used such that reactive power required by inductive load was equal to reactive power supplied by capacitor then , load does not consumes reactive power from supply so the effective apparent power required was reduces.

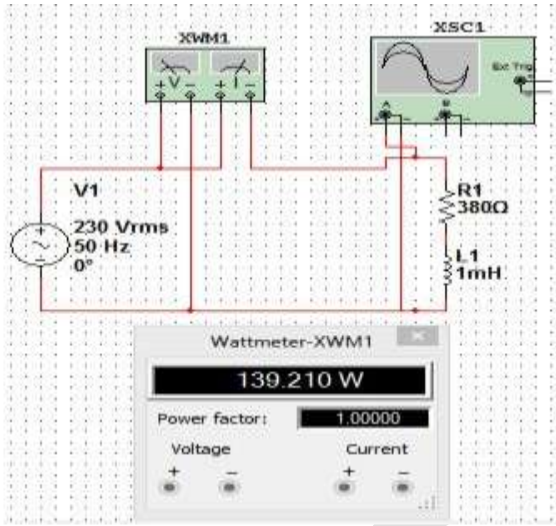
It has an adverse effect on industries, because industries are charge for KVA Tariff system (i.e.), so if the reactive power compensation was not done correctly then it leads to consumption of excessive apparent power as a result more electricity bill.



Block Diagram

Before proceeding to practical circuit implementation, a simulated model was been developed and analysis was done, this analysis was made by using MULTI-SIM simulation tool by NATIONAL INSTRUMENTS.

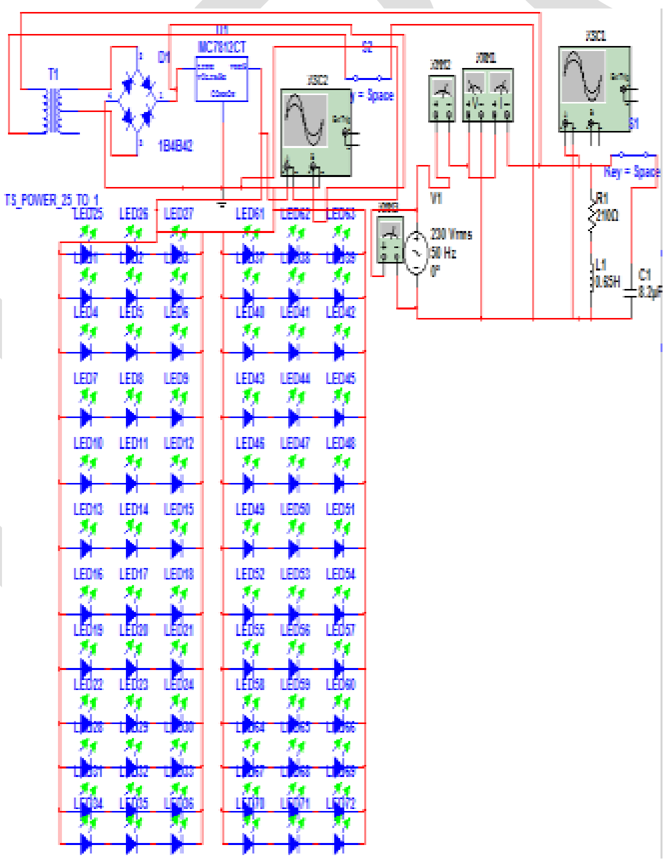
Induction motor load model:



Single phase induction motor model :

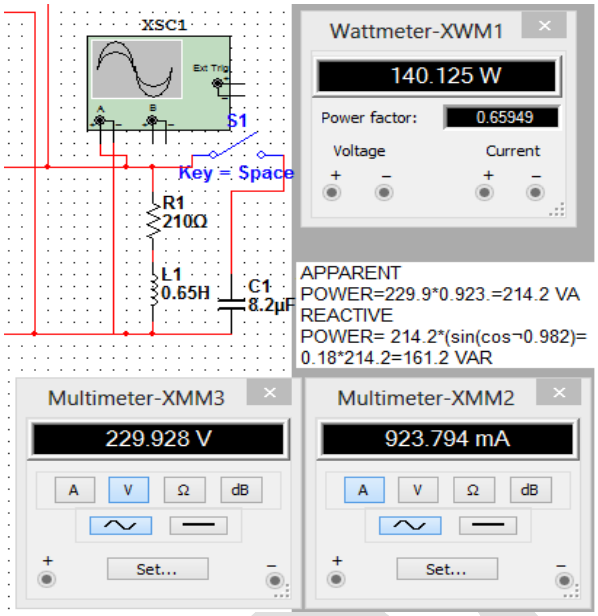
In this simulated model the simulation model of load was analyzed by an R-L circuit neglecting shunt branch parameters and resistance and inductance values are brought with practical methods.
The electrical model of single phase induction motor was replaced with obtained values from practical method of voltmeter ammeter and wattmeter.

Project model:



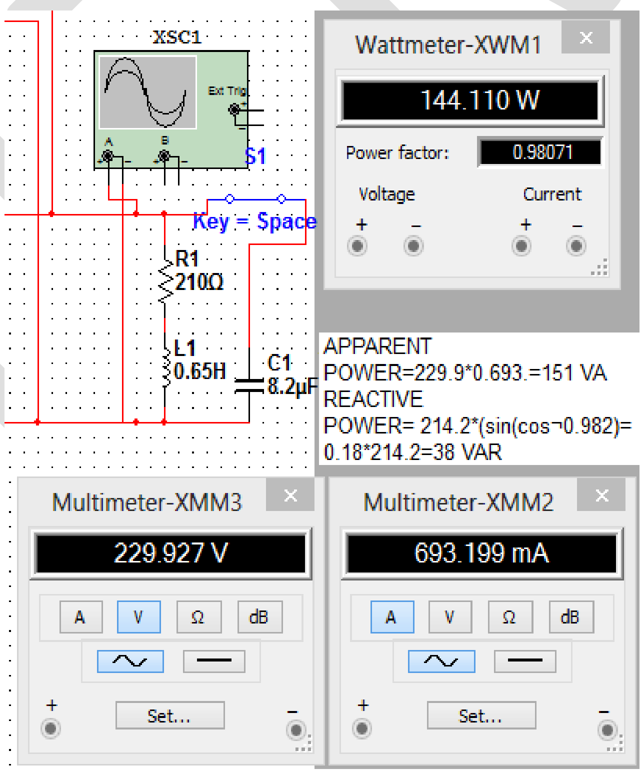
5. Results

Output project model with only load:



This above figure shows when the model was simulated and the results were shown, as shown the apparent power required for model was 214.2 VA

Output with project model with compensator :



The above figure shows when compensator was switched with LED the apparent power reduces.

Conclusion:

The above model results show the output of compensated led lightning system, the difference between with and without compensation we can save about for one led light. The use of led lightning was increased but if it was used with compensation then it saves about 20% of our energy charges as proved above. Even it was more convenient for industrial sectors since; the tariff system used was KVA tariff. As shown above, as increase the number of light , we can save more energy, apart from energy charges is also decreases the cost of equipment required for applications as effective current required reduces. As stated above ,if current required reduces then heat generation in conductor also reduces as a result, the conductor size reduces i.e. cost reduces and also increases in life spam of conductors.

REFERENCES:

[1] R.K.Mukhopashyay and T.Choudhury, S.P. Choudhury, SamiranChoudhuri, F.I.E, Power System for the year 2000 and beyond "Reactive Power Compensation in Industrial Power Distribution System".

[2] Abhinav Sharma, Saleem Khan, Shavet Sharma, ParveenLehana International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-5, June 2013.

[3] S. Tompros, N. Mouratidis, M. Draaijer, A. Foglar, andH. Hrasnica, "Enabling applicability of energy saving applications on the appliances of the home environment," *IEEE Network*, vol. 23, no. 6, pp. 8-16, Nov.- Dec. 2009.

[4] M.-S. Pan, L.-W.Yeh, Y.-A.Chen, Y.-H.Lin, and Y.-C.Tseng, "A WSN-Based Intelligent Light Control SystemConsidering User Activities and Profiles," *IEEE Sensors Journal*, vol. 8, no. 10, pp. 1710- 1721, Oct. 2008.

[5] "NickHolonyak,Jr.2004Lemelson MIT Prize Winner"
(http://web.mit.edu/invent/awinners/aholonyak.html). LemensonMIT Program. Retrieved August 13, 2007.

[6] S. Tompros, N. Mouratidis, M. Draaijer, A. Foglar, and H.Hrasnica, "Enabling applicability of energy saving applications on the appliances of the home environment," *IEEE Network*, vol. 23, no. 6, pp. 8-16,Nov.- Dec. 2009

[7] J. Byun and S. Park, "Development of a self-adapting intelligent system for building energy saving and context-aware smart services, "*Trans. on Consumer Electron.*, vol. 57, no. 1, pp. 90-98, Feb.2011