

Power Efficient Electronic Ballast

Monica Parmanand¹, Aniket Chavan¹, Anuj Sathe¹, Monica Mane¹, Mr. Pramod Bhavarthe²

¹Pursuing B.E., Department of Electronics, PVPPCOE, Sion, Mumbai, India

²Asst. Professor, Department of Electronics, PVPPCOE, Sion, Mumbai, India

ABSTRACT:

Electronic ballast is basically a choke without a starter. It is a device used for stabilizing current in an electric circuit i.e. in a tube lamp supply circuit. It provides just the required amount of voltage to start the lamp by regulating the current. It is made to replace the conventional choke in fluorescent lamps as it has more advantage in lifetime operation. It has higher efficiency since it uses the power semiconductor devices with better switching methods. The main component is Ballast Controller IC IR2156. Also, PFC IC L6562 is used to manage the power factor correction while achieving high efficiency over a wide load range. Electronic Ballast, in short, is a device made to increase efficiency, thereby reducing electricity bill. There have been other projects made related to Electronic ballast but without the use of Ballast Control IC. By using IC IR2156, the efficiency can be increased greatly. The ballast being made is primarily for T8 40W tube.

Keywords: Ballast, Fluorescent lamps, Power-factor-correction, high frequency, efficiency

I. INTRODUCTION

In the world where electrical energy is such an important factor in human life, it is necessary to find out ways to save it. The increasing electrical costs calls for a more thorough research in producing electrical equipments which will help us to consume less and less electrical energy. One such main device responsible for consuming electricity is Ballast. The two types of Ballast are Magnetic and Electronic Ballast. Magnetic ballast is core-and-coil electromagnetic ballast. They operate on the line frequency of 60Hz. Electronic ballast is a device which overcomes the shortcomings of the Magnetic ballast. These ballasts operate on the high line frequency of 20-60 kHz, suffering half the power loss as that of Magnetic ballast. Increasing the operating frequency has varied advantages. The lamp efficiency increases by 10-15% when the lamp operates at a frequency above 20 kHz. High frequency operation also results in significant weight loss of the ballast and it increases the performance of the lamp. The lamp starts easily and eliminates flickering effect as well as noise. In the basic circuit of ballast, first 50Hz ac is converted to dc and then it is converted from dc to high frequency ac. This rectification results in introduction of harmonics, which further result into poor input power factor. To correct this, a Power-Factor-Correction IC L6562 is used. This IC has a highly linear multiplier consisting of a special circuit which is able to reduce AC input current distortion or decrease harmonics. Electronic ballast also consists of Ballast control IC IR2156 which is high voltage half-bridge gate driver with programmable oscillator and state diagram.

II. DESIGN AND IMPLEMENTATION

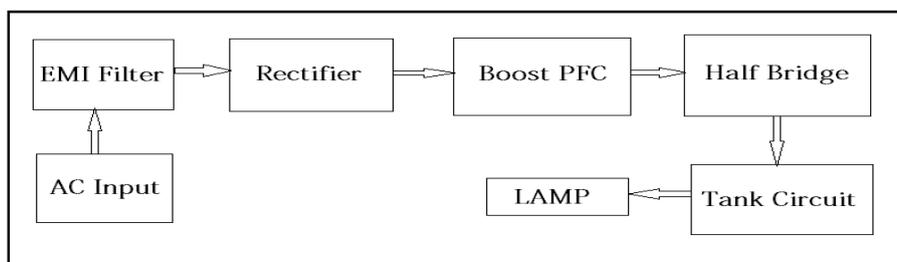


Figure 1. Block Diagram of the project

Electronic ballast circuit must perform the basic functions like providing high strike voltage across the lamp's electrodes and then when the lamp gets on, it must maintain a constant current while operating in steady state^[8]. As the operating frequency of the lamp is increased, the amount of current required to produce the same amount of light is reduced compared to the line frequency, thus increasing its efficiency.

The given block diagram explains the working of electronic ballast. The EMI filter blocks the ballast generated noise. The Full wave rectifier converts AC source to DC voltage supply. The Power-Factor-Correction (PFC) circuitry is used for input current control whereas the Ballast controller section provides frequency modulation (normally by PWM) of R-L-C type resonant-output circuit for preheating, igniting and ballasting the lamp^[8].

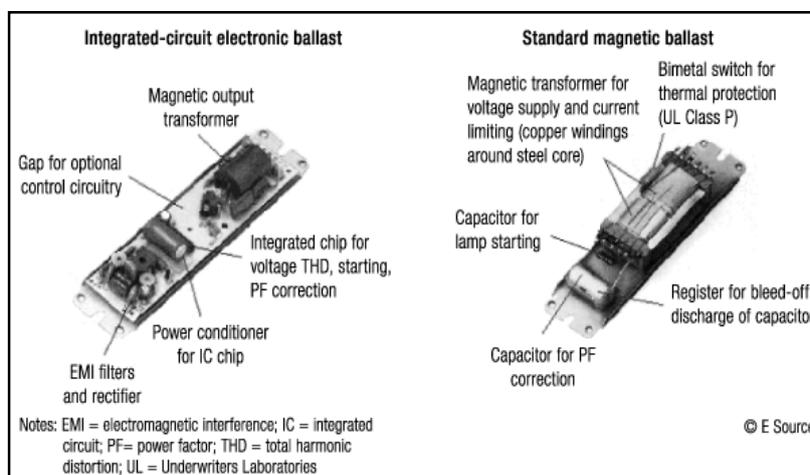


Figure 2. Electronic ballast v/s Magnetic ballast (Image taken from www.google.com)

Since the ballast operates at a higher frequency than the mains, it generates Electromagnetic Interference (EMI) which it transfers back to the supply. The EMI and noise in the system will affect the performance of the electronic device. Thus, to reduce or eliminate this EMI, capacitor, varistor and common mode line filter (ELF-15N007A) is used at the beginning of the circuit. It attenuates the EMI between the line and the device without causing signal degradation. They can withstand high DC currents without filtering performance degradation. At the same time, Varistor will protect the circuit by absorbing the inrush voltage.

Once the signal is filtered, it flows through the rectification stage. Here, the alternating current (AC) main line voltage is changed to a direct current (DC) bus voltage. A full bridge rectifier with ratings 1000V and 1A is used for this process. Filter and rectifier are together combined to decrease the radio frequency interference (RFI) and voltage transients. This combined circuit also produces sinusoidal lamp voltage and current with higher efficiency with the help of self-oscillating resonant higher frequency inverter circuit.

Power factor correction (PFC) is reduction of harmonic content and/or adjusting the phase angle of incoming current. It is usually not compulsory but if used, it reduces the disturbances on the AC and maximizes the real power drawn by power supply from AC line. The CFL lamps draw a non-sinewave current as they do not have a unity power factor. To meet the necessities of power supply, the ballast is provided with power factor correction. When many electronic ballasts are connected to AC mains, wasted electricity, voltage fluctuations etc. takes place due to total peak current. Hence, PFC is required to connect these loads so as to have high power factor and more resistance.

They can be realized using either passive or active methods. Boost converter is generally used for active PFC solutions. It operates on a separate ON and OFF time circuit. The ON time is the time during which the boost inductor is charged and during the OFF time, the stored inductor current flows through the boost diode to the dc bus.

The full operation of electronic ballast circuit is controlled by IR2156. It is ballast controller and high voltage half bridge gate driver with programmable oscillator in one IC. There is a bootstrap diode across the 2 MOSFETs called as fast recovery diode (IN4937) that is used for recovery time and providing high efficiency.

Half bridge circuit consists of 2 MOSFET transistors, resonant inductor, capacitors and diodes. The switching regulator charges electrolytic capacitor that acts as energy reservoir. The MOSFETs are used to achieve stability and reliability. Capacitors and diodes form snubber circuits while the half bridge is oscillating which keeps a check on the rise and fall time at high bridge output. Also, the steady state current is limited by external inductance in current mode drive.

The circuit behaves as series LC circuit with own resonant frequency when the power transistor is turned ON. This generates the high voltage required to ionise the medium inside the fluorescent lamp. The lamp current causes ionisation by flowing through the filament. The arc is stuck causing the impedance to drop, increasing the damping across capacitor shifting the resonant frequency to ignite and run the lamp.

III. RESULTS AND DISCUSSION

The electronic ballast is still in development stages. While the implementation of basic ballast for T8 40W tube is successful on dotted board, it is still in process of increasing the efficiency to its optimum value. The first output shows that the current has decreased as compared to the magnetic ballast.

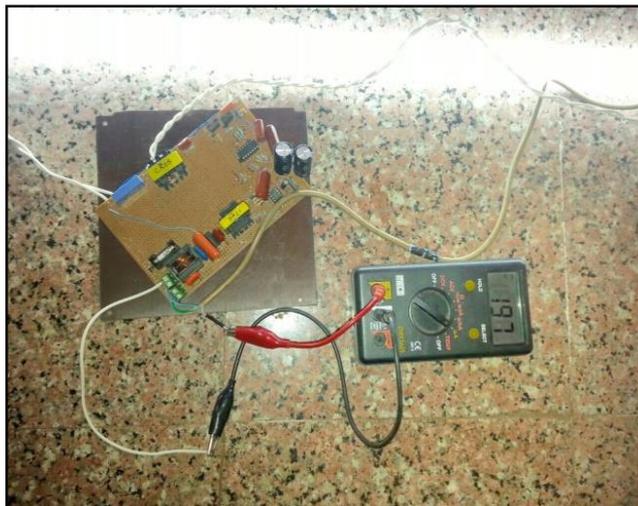


Figure 3. Electronic Ballast current reading



Figure 4. Magnetic ballast current reading

The other readings such as power factor, power, ballast factor etc. are yet to be taken and evaluated.

IV. CONCLUSIONS

An overview of the electronic ballast is presented. A simple lamp is taken for trial and experimental purpose and the results obtained are stated. Electronic ballast has become the need of the hour. It has almost half the power loss when compared to magnetic ballast which makes it useful at every place such as schools, home, offices etc. Along with greater efficiency which eliminates the flicker, it has the ability to drive more lamps than magnetic ballast (4 as compared to 2). Without the core and coil, I^2R losses (generated heat) are minimised as well as it becomes lighter in weight, making it the next gen power saving device.

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REFERENCES

- [1] R.W.Erickson – “Fundamentals of power electronics” New York Chapman and Hall, 1997
- [2] V.B.Borghate, H.M.Suryawanshi, G.A.Dhomane - “Analysis and performance of highly efficient electronic ballast operating at unity-power-factor” *Sadhana Vol 33, Part 5, October 2008*
- [3] IR2156 Ballast Control IC Datasheet, *International Rectifier 2004*
- [4] Spiazzi, G. - “Analysis of High-Power-Factor Electronic Ballast for high brightness light emitting diodes” *Power electronics specialist conference, 2005, IEEE 36th*

- [5] Kazimierczuk, M.K. – “Electronic Ballast for fluorescent lamps” *Power Electronics, IEEE Transactions on Vol.8, Issue 4, Oct 1993*
- [6] Tsai-Fu Wu – “Single stage electronic ballast with dimming feature and unity power factor” *Power Electronics, IEEE Transactions on Vol.13, Issue 3, May 1998*
- [7] Sheryl Colago, Ciji Kurian, V.I.George, Anitha Colago – “The Implications of Fluorescent Lamp Electronic Ballast Dimming” *Scientific Research, Energy and power engg, 2010, 53-64*
- [8] Vivien Delpont – “Microcontrollers simplify Lamp Ballast Design” *Power electronics technology, February 2007*