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RESEARCH ARTICLE

RECYCLING OF BALLASTIC CIRCUIT TO FORM A NIGHT LAMP

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Abstract

This paper presents a single-stage high-frequency full-bridge electronic ballast circuit of a scrap CFL is reused for luminance LCD projector systems. The studied electronic ballast is found to have high conversion efficiency due to its single-stage circuit with zero-voltage switching features. A high-power factor can be achieved by using developed single-stage topology. The operation principles and design considerations are analyzed and discussed in detail. The night lamp circuit presented in this paper uses a serviceable electronic circuit enclosed in a base of 11-watt or 15-watt CFL.

Introduction:-

Compact fluorescent lamp (CFL): “A compact fluorescent lamp (CFL), also called compact fluorescent light, energy-saving light, and compact fluorescent tube, is a fluorescent lamp designed to replace an incandescent lamp; some types fit into light fixtures formerly used for incandescent lamps. The lamps use a tube which is curved or folded to fit into the space of an incandescent bulb, and compact electronic ballast in the base of the lamp” [1] as shown in Fig 1.

“Compared to general-service incandescent lamps giving the same amount of visible light, CFLs use one-fifth to one-third the electric power, and last eight to fifteen times longer. Like all fluorescent lamps, CFLs contain mercury, which complicates their disposal” [1]

Fig.1:- Practical view of CFL.

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History:
“The parent to the modern fluorescent lamp was invented in the late 1890s by Peter Cooper.” [12] “Edmund Germer, Friedrich Meyer, and Hans Spanner patented a high-pressure vapor lamp in 1927.” [12] “George Inman later teamed with General to create a practical fluorescent lamp, sold in 1938 and patented in 1941.” [12] “The first fluorescent bulb and fixture were displayed to the general public at the 1939 New York World's Fair.” [2]
“The helical (three-dimensional spiral) CFL was invented in 1976 by Edward Hammer, since the design was costly so it did not get much reorganization. In 1995, helical lamps, manufactured in China, became commercially available. Since that time, their sales have steadily increased. In 1980, Philips introduced its model SL, which was a screw-in lamp with integral magnetic ballast. In 1985 Osram started selling its model EL lamp, which was the first CFL to include electronic ballast.” [10]

Construction
There are two types of CFLs:
a. Integrated
b. Non-integrated lamps.

Integrated lamps are single units which combines the tube and ballast. Integrated CFLs can be easily retrofitted into standard light fixtures which reduces the cost of converting fluorescent.

“Non-integrated CFLs have the ballast mounted directly into the luminaire, and only the lamp bulb is replaced at its end of life. Since the ballasts are placed in the light fixture, they are more sophisticated and has a longer life compared to the integrated ones.” [13]

Non-integrated CFL housings can be both more high-priced and complex. They are of two types of tubes:
1. “A quad-pin tube designed for electronic ballast or conventional ballast with an external starter.” [3]
2. “A bi-pin tube designed for conventional ballast. A bi-pin tube has an integrated starter which negates the requirement for external heating pins but has drawbacks which causes compatibility issues with new electronic ballasts.” [12].
A. Components
CFLs have two main parts, magnetic or electronic ballast and a gas-filled tube (also called bulb or burner).

“The combination of magnetic ballasts with electronic ballasts have has solved the issue of flickering and slow starting usually associated with fluorescent lighting, and has led to the development of smaller lamps directly interchangeable with more sizes of incandescent bulb” [17] as shown in Fig.2.

“Electronic ballasts are tiny circuit boards with rectifiers, a filter capacitor and usually two switching transistors. The input AC current is first rectified to DC. Then the rectified DC is converted to extremely high frequency AC by the transistors, connected as a resonant series DC to AC inverter. This is then applied to the lamp tube. Since the resonant converter tries to stabilize lamp current (and light produced) over a range of input voltages, standard CFLs does not work well in dimming applications and special lamps are required.” [17].

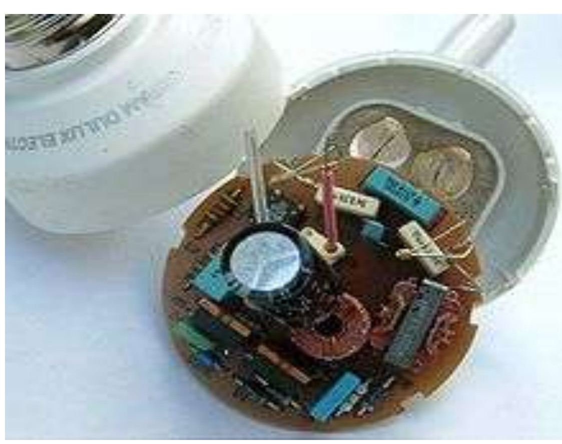

Fig.2:- An electronic ballast and permanently attached tube in an integrated CFL.

The lifespan of a CFL is very small (approximately 10,000 hours). In the case of an unserviceable CFL, the filament might have reached the end of its life, but the possibility of the electronic ballast in the bottom of the CFL to be still in perfect working conditions are high. So, this ballast circuit can be used for many applications, one such application is making Night Lamp from scrap CFL.

Following are the parts which together forms Night lamp:

Coil from an old Ballast circuit:
"Electrical ballast is a device intended to limit the amount of current in an electric circuit. A very commonly used example is the inductive ballast used in fluorescent lamps. It limits the current through the tube, which if not regulated, can rise to destructive levels due to the tube's negative resistance characteristic." [1]

Ballasts limit the current through an electrical load. These are most often used when a load presents a negative power supply. The ballast ensures the proper functioning of tf the device by restricting excess amounts of current. "An Electronic ballast uses solid state electronic circuits to provide the required starting and operating electrical conditions to power discharge lamps. An electronic ballast can be lighter and smaller than a similar magnetic one." [4] The ballast may be sealed with a resin to safeguard the internal circuitry and components from moisture and vibration. A magnetic ballast can be very noisy because it produces a line-frequency hum by vibration of the transformer laminations and hence the electronic ballast is a lot quieter.

SMPS topology are what electronic ballasts are often based on. First the input power gets rectified and then gets chopped at a high frequency. Electronic ballasts supply power to the lamps at high frequencies of about 20,000 Hz or higher, rather than the mains frequency of 50 - 60 Hz

1. This ballast circuit contains an inductor that can be easily detached from the ballast circuit and used as a coil in the night lamp.
2. **Fixed resistors: "A fixed resistor is** commonly used f**or simple, low-powered loads such as a neon lamp or LED. B**ecause the resistance of the ballast resistor is large and hence it dominates the current in the circuit, even in the face of negative resistance introduced by the CFL." [13]
3. **Self-variable resistors: "Some ballast resistors have the property of increasing in resistance as** current through them increases and decreasing in resistance as current decreases. Physically, some such devices are often built quite like incandescent lamps. These devices are sometimes called *barretters.* Self-variable resistors have the property that can lead to more precise current control than merely choosing an appropriate fixed resistor. The power lost in the resistive ballast is also reduced because a smaller portion of the overall power is dropped in the ballast compared to what might be required with a fixed resistor." [13]
4. **Snubber: A snubber is a device used to suppress ("snub") some phenomenon, such as:**
   - Voltage transients in electrical systems.
   - Pressure transients in fluid systems.
   - Excess force or rapid movement in mechanical systems

"Snubbers are frequently used in electrical systems with an inductive load where the sudden interruption of current flow leads to a sharp rise in voltage across the current switching device, in accordance with Faraday's law.

The snubber used here is RC snubber. A simple snubber uses a small resistor (R) in series with a small capacitor (C). This combination can be used to suppress the rapid rise in voltage across a circuit by limiting the rate of rise in voltage (dV/dt) across the circuit. The voltage across a capacitor cannot change instantaneously, so a decreasing transient current will flow through it for a small fraction of a second, allowing the voltage across the switch to increase more slowly when the switch is opened. Determination of voltage rating can be difficult owing to the nature of transient waveforms and may be defined simply by the power rating the snubber components and the application. RC snubbers can be made discretely and are also built as a single component." [14]

5) Rectifier: "A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction to direct current (DC), which flows in only one direction. The process is known as rectification. There are basically two types of rectifiers." [4]

i) Half Wave rectifier: "In half wave rectification of a single-phase supply, either the positive or negative half of the AC wave is passed while the other half is blocked. Because only one half of the input waveform reaches the output, mean voltage than full-wave rectifiers, and much more filtering is needed to eliminate harmonics of the AC frequency from the output. Rectifiers yield a unidirectional but pulsating direct current; half-wave rectifiers produce far more ripple is lower. Half-wave rectification requires a single diode in a single-phase supply, or three in a three-phase supply. Rectifiers yield a unidirectional but pulsating direct current; half-wave rectifiers produce far more ripple than full-wave rectifiers, and much more filtering is needed to eliminate harmonics of the AC frequency from the output." [15]

ii) Full-wave rectifier: "A full-wave rectifier as shown in Fig 3 converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to DC (direct current) and yields a higher mean output voltage. Two diodes and a center tapped transformer, or four diodes in a bridge configuration and any AC source (including a transformer without center tap), are needed. Single semiconductor diodes, double diodes with common cathode or common anode, and four-diode bridges, are manufactured as single components." [15]

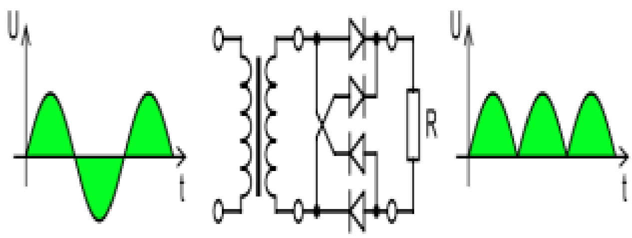

Fig. 3:- Bridge rectifier: a full-wave rectifier using 4 diodes.

6) Light-Emitting Diode: "A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for other lighting. Appearing as practical electronic components in 1962 early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness." [16]

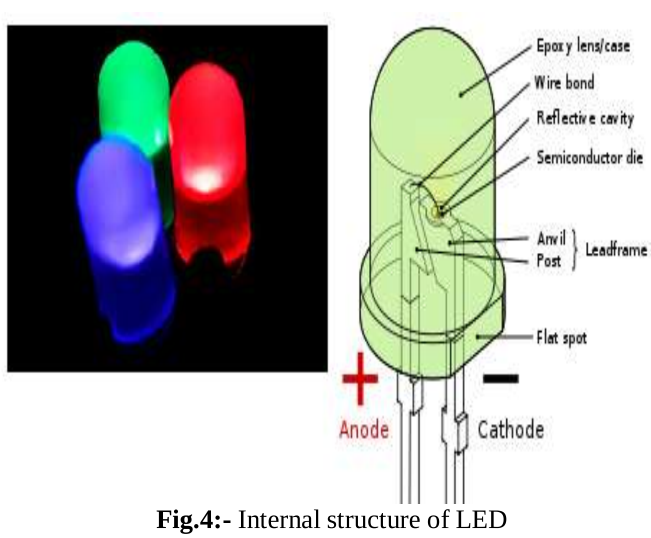

Fig.4:- Internal structure of LED

"When a light-emitting diode as shown in Fig.4, is forward-biased (switched on), 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 gap of the semiconductor. A LED is often small in area (less than 1 mm2), and integrated optical components may be used to shape its radiation pattern. LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs powerful enough for room lighting are relatively expensive and require more precise current and heat management than compact fluorescent lamp sources of comparable output." [16]
The Electronic symbol of LED is represented as shown in Fig.5

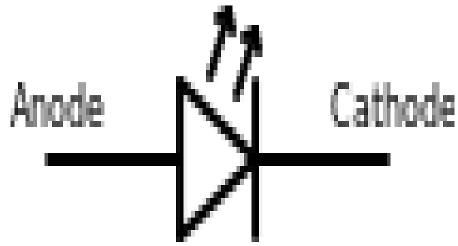

Fig.5:- Symbolic representation of LED.

The night lamp circuit described here uses the serviceable electronic circuit fitted in the base of an 11 or 15 watts CFL.

B. **Circuit Diagram**

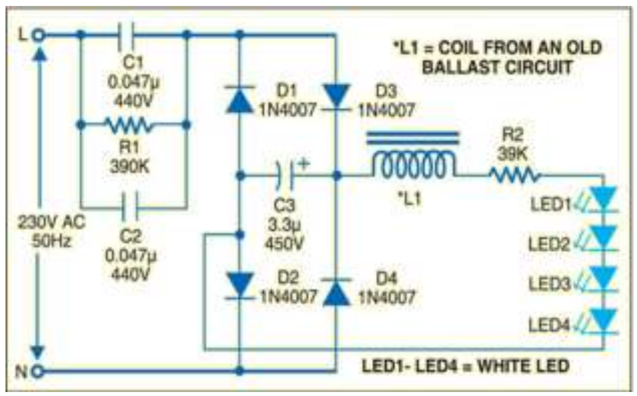

Fig.6:- Circuit Diagram.

Working

As shown in Fig.6, the FWB rectifier consisting of diodes D1(1N4007) through D4(1N4007) converts the AC to DC. Snubber capacitor C1 at the input reduces the line input voltage of 230V to a very low-level AC voltage. Series current-limiting resistor R2 and series inductor coil L1 avoid voltage spikes. Therefore, when we supply the input voltage it gets reduced to approximately 12V which gets distributed in LED equally.

Practical View

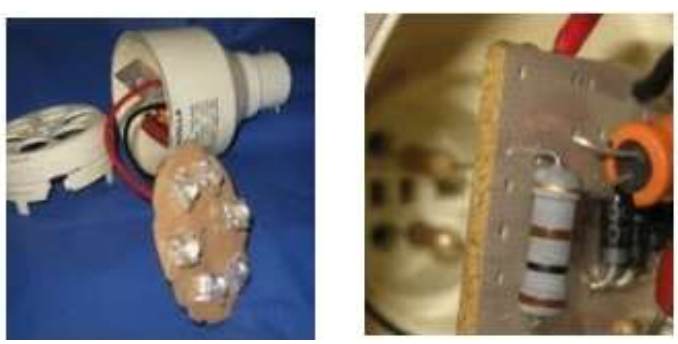

Fig.10:- Internal view of CFL showing ballastic circuit.

Conclusion:-

This paper gives us a systematic and prologue version of how to recycle waste CFL circuitry and make a night lamp. Main aim of this paper is to recycle waste electronic components. It helped us to learn more about the circuitry, system, the rudimentary standards for maximum performance and consolidate information which will help us to make a baseline evolution of our current practices which will go a long way in shaping our knowledge levels and skills.

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