

Compact Fluorescent Lighting

Introduction

Compact fluorescent light bulbs (or CFL's) are a technology which has been around for many years now and is still very underutilized in today's world, especially with the way that the prices of these bulbs have dropped over the years. If every home in America replaced just one incandescent bulb with a compact fluorescent it would save enough energy to light over 2.5 million homes for one year. It would also prevent greenhouse gas emissions that would roughly be the equivalent of 800,000 cars [1]. Compact fluorescent bulbs use only a third (if not less) of the energy used by an incandescent bulb while providing the same amount of light. These bulbs last for roughly ten years compared to an incandescent bulb's lifetime of only around six months. CFL's generate about 70% less heat, which makes them safer around the home and will also somewhat cut down on air conditioning cost. Compact fluorescents also fit in the same sockets which you would now be using for an incandescent, so replacement is as easy as changing a light bulb.

Background

The visible light from a compact fluorescent lamp is produced through chemical means by the mixing of three phosphors on the inside of the lamp. These phosphors give off a certain amount of light when it becomes exposed to ultraviolet radiation, which is released by mercury atoms as they are bombarded by electrons. The flow of electrons inside these bulbs is produced through an arc between two electrodes at the ends of the tube.

An important part of any type of compact fluorescent lighting system is the ballast. This ballast will provide the initial high voltage which is required to create the starting arc as well as limiting the current to prevent the lamp from self-destructing. There are several different types of ballasts available for compact fluorescent lamps; electromagnetic or electronic, either of which and could be attached directly to the lamp or separately wired. Some of these systems also contain features which will improve your power factor, reduce harmonic distortions, eliminate radio interference, and some can even provide constant illumination during brownouts. A diagram of a typical compact fluorescent light is shown in Figure 1.

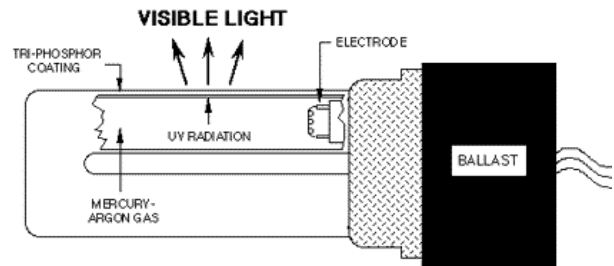


Figure 1: Diagram of a Typical Fluorescent Light Bulb

Electromagnetic ballasts have been around for many years. These ballasts work with a wire-wound core used to limit the amount of current drawn by the lamp. This type of ballast will typically consume an additional 15% to 25% of the lamp wattage, producing heat as a waste product of this extra energy usage. There have been more energy efficient magnetic ballasts developed recently through improved materials and manufacturing processes, but these tend to be slightly larger and more expensive than standard ballasts.

Many types of magnetic ballasts use the same default 60 Hz frequency supplied by the utility grid. Some of the more recently developed ballasts are smaller, lighter, and more energy efficient than high frequency electronic ballasts. These newer ballasts use transistors to boost the prior input frequency of 60 Hz to within the frequency range of 25 to 40 kHz. These high frequency lights offer advantages of improved overall efficiency, reduced noise, and an increased lamp life. The disadvantage of these ballasts is that they are more likely to cause electromagnetic interference and tend to be more susceptible to damage from spikes in the supply voltage and other transients. Many newer electronic ballasts, however, now are available with built in filtering and protection circuits to reduce or eliminate these types of problems.

Case Study

Since a 100W incandescent will produce approximately the same amount of light as the CFL's, a sample calculation comparing two different commercially available 23 W compact fluorescent light bulbs to a 100 W incandescent bulb was performed. Some basic information associated with the individual bulbs is shown below in Table 1.

Table 1: Spec Comparison between CFL's and Incandescent

	CFL 1	CFL 2	Incandescent
Power (W)	23	23	100
Guaranteed Lifetime (hrs)	7,000	10,000	1,000
Initial Cost (\$)	\$4.94	\$4.22	\$0.40
Bulbs Over 10 Year Lifetime	1.57	1.10	10.96

The packages of the bulbs containing the specifications obtained are shown below as Figure 2.



Figure 2: Packages of CFL 1 and CFL 2 Respectively

Assuming an electric cost of \$0.12 per kWh and the light is used for 3 hours per day, the simple payback and savings over the lifetime of the bulb will be calculated. The capital cost based only upon the number of bulbs needed over the 10 year period is calculated by multiplying the number of bulbs used over 10 years by the cost of a single bulb. CFL 1, for example would be $1.57 * \$4.94 = \7.76 . The energy savings annually is then determined by multiplying the number of hours the bulbs would be in use over the 10 years (1,096 hours) by the power consumed by each bulb (23 W for the CFL's and 100 W for the incandescent). The capital costs and lifetime energy savings are shown below in Table 2.

Table 2: Simple Payback Calculation Results

	CFL 1	CFL 2	Incandescent
Capital Cost (\$)	\$7.76	\$4.62	\$4.38
Energy Savings (kWh)	25.2	25.2	109.6

Based upon this, it is known that either CFL would save 84.4 kWh per year ($109.6 - 25.2$) and this 84.4 kWh per year multiplied by

the \$0.12 per kWh electricity cost results in a savings of \$10.13 per year. Taking the difference in initial cost for both of the CFL's and then dividing this by the annual savings will yield the simple payback. For CFL 1: $\$4.54 / \$10.13 = 0.448$ years or 5.4 months and for CFL 2: $\$3.82 / \$10.13 = 0.377$ years or 4.5 months. This result means that a CFL would pay for itself over an incandescent bulb in as little as 4.5 months, which is an extraordinary payback. If we would then want to figure out the total savings that a CFL would provide over an incandescent bulb over the 10 year lifetime the calculation for this is shown below:

CFL 1 compared to incandescent

$7000 / 1000$ hour life = saves 7 lamps at $\$0.4 = \2.80

Energy savings $7000 \text{ hrs} \times (100 - 23 \text{ watts saved}) = 539 \text{ kWh}$ over life @ $\$0.12 / \text{kWh} = \64.68

Total Savings = \$67.48 - \$4.94 = \$62.54

CFL 2 compared to incandescent

$10000 / 1000$ hour life = saves 10 lamps at $\$0.4 = \4.00

Energy savings $10000 \text{ hrs} \times (100 - 23 \text{ watts saved}) = 770 \text{ kWh}$ over life @ $\$0.12 / \text{kWh} = \92.40

Total Savings = \$96.40 - \$4.22 = \$92.18

References

End Notes

- [1] Energy Star, "Compact Fluorescent Light Bulbs" [Online Document]. [cited 2007 April 2]. Available HTTP: http://www.energystar.gov/index.cfm?c=cfls.pr_cfls
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- [4] CFL 'real' data, "Engineering Economics of Advanced Power Systems" [Online Document] 2007 March [cited 2007 April 2]. Available HTTP: http://users.rowan.edu/~jansson/spring07/advpowersys/sc_hedule.html