CCFL Characteristics

Cold Cathode Fluorescent Lamps (CCFL) are used as white-light sources to backlight liquid crystal displays (LCDs). CCFLs offer many desirable features, but they also have unique characteristics that must be considered to maximize their usefulness. This application note describes some of these unique CCFL characteristics.

Introduction

Cold Cathode Fluorescent Lamps (CCFLs) are sealed glass tubes filled with inert gases. When a high voltage is placed across the tube, the gases ionize creating ultraviolet (UV) light. The UV light, in turn, excites an inner coating of phosphor, creating visible light. CCFLs have many desirable features, including:

- Excellent white light source
- Low cost
- High efficiency (electrical power in, to light out)
- Long life (>25K hours)
- Stable and predictable operation
- Brightness can be easily varied
- Light weight

CCFLs have some unique characteristics that must be considered for maximizing their efficiency, life span, and usefulness. This application note describes some of these CCFL characteristics. Note that the data shown here was collected on a particular CCFL, and that the specific data will change based on the CCFL model used in an application. The general trends described here, however, apply to all CCFLs.

Temperature Dependence

The operating characteristics of CCFLs are strongly influenced by temperature, as shown in **Figures 1**, **2**, and **3**. At cold temperatures, lamp brightness drops significantly (see **Figure 1**) and the voltage required to initially strike (i.e., turn on) the lamps rises significantly (see **Figure 2**). As illustrated in **Figure 3**, the lamp exhibits a self-heating characteristic, which directly affects the lamp brightness after the lamp is struck.

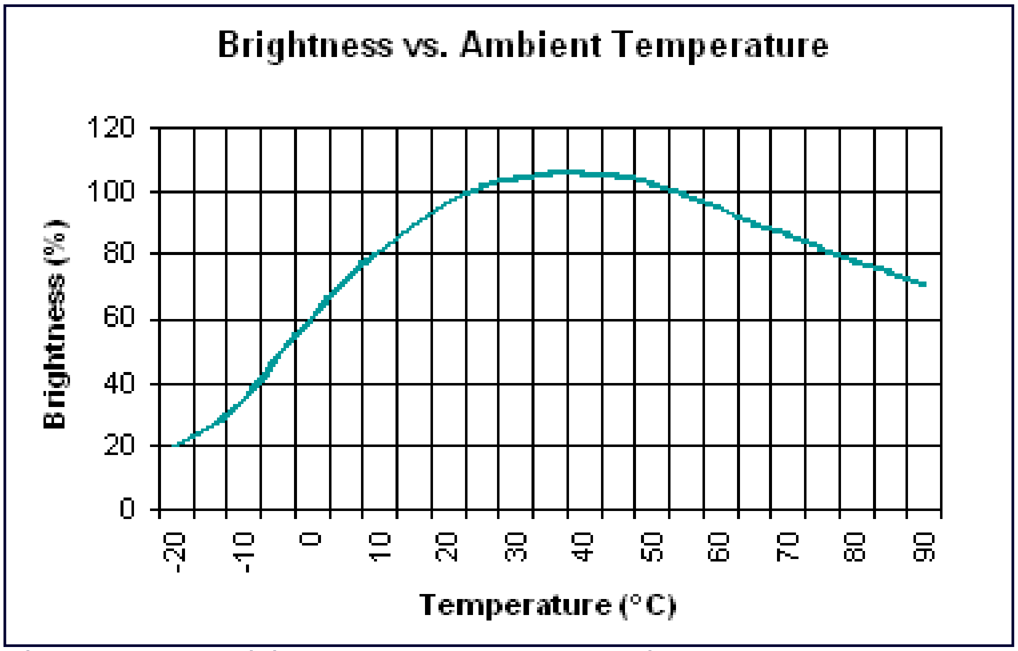

Figure 1. Lamp-Brightness Temperature Dependence

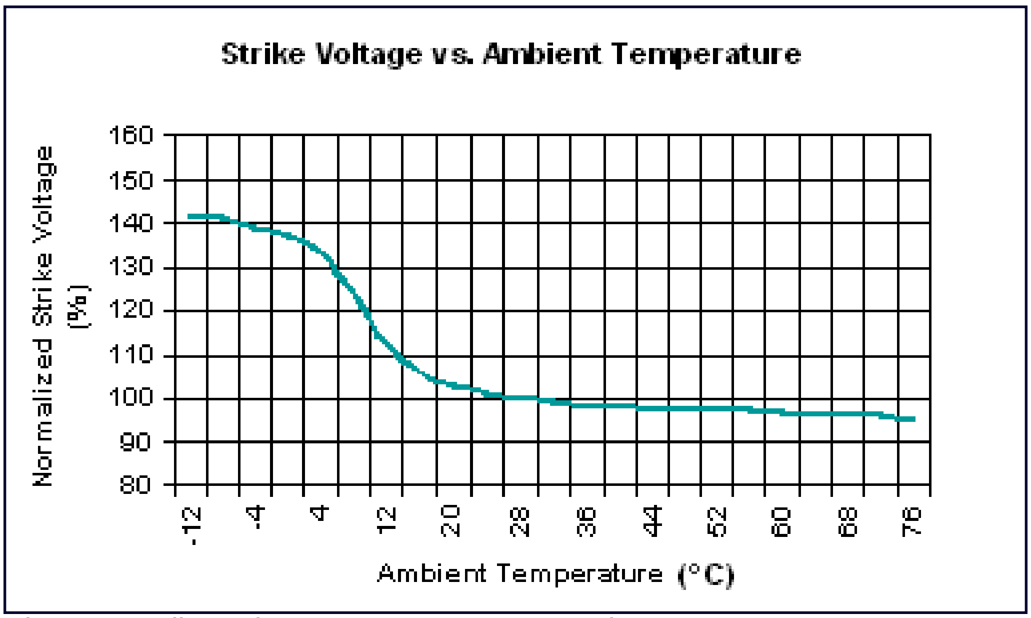

Figure 2. Strike Voltage-Temperature Dependence

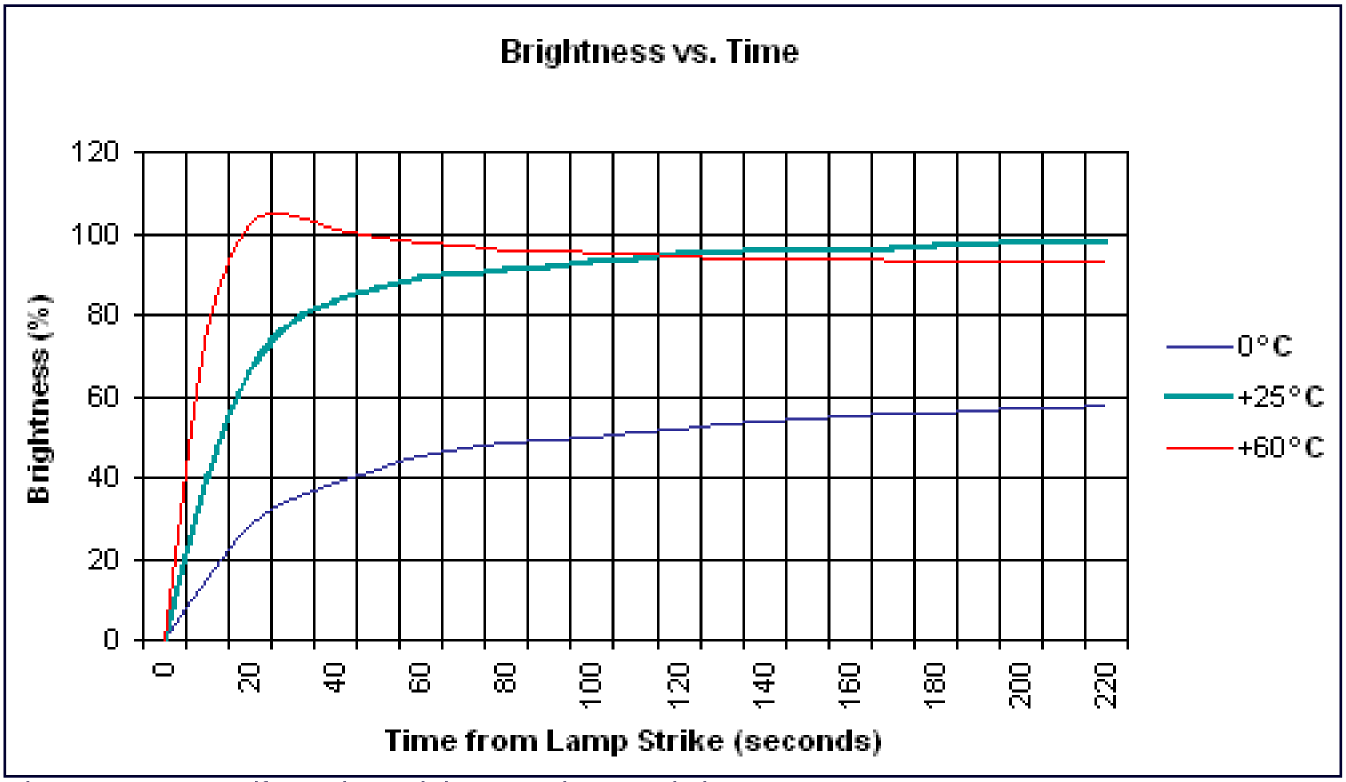

Figure 3. Lamp Self-Heating Brightness Characteristic

Lamp Current

CCFL efficiency is greatly affected by the current waveform driving the lamp. Sinusoidal waveforms provide the greatest efficiency. Conversely, nonsinusoidal waveforms with large crest factors are not efficient CCFL drivers. **Figure 4** shows two current waveforms with approximately the same RMS current. Although the high-crest-factor waveform has the same RMS current as the sinusoidal waveform, its current excursions beyond the sinusoidal waveform's 150% peak level do not generate additional light, only heat. This means that the electrical power-in to light-out efficiency is greatly reduced in a system operating with a high-crest-factor waveform.

DC offset is another waveform that must be considered when using CCFLs. To reduce the possibility of mercury migration within the lamp, lamp waveforms must have minimal DC offset.

CCFLs are designed to operate at a particular rated current, typically in the 3mARMS to 8mARMS range. **Figure 5** shows that decreasing the lamp current reduces the lamp brightness, and increasing the current increases the brightness. Note that this relationship is not linear for higher currents. Near the nominal-rated operational current, the lamp's brightness changes in relation to lamp current at almost a 1:1 ratio; at higher currents, however, this ratio drops to lower than 1:3. It is, consequently, important to operate the lamp near its rated current, because operation very far above that rate will reduce lamp life. Also, in multiple-lamp applications such as LCD TVs and LCD PC monitors, it is important to keep the lamps near the same current (i.e., brightness) level in order to provide uniform light diffusion across the entire LCD panel. In these multiple-lamp applications, the individual lamp-current levels and waveforms must be accurately monitored and tightly controlled, otherwise it is likely that the lamps will exhibit varying levels of brightness.

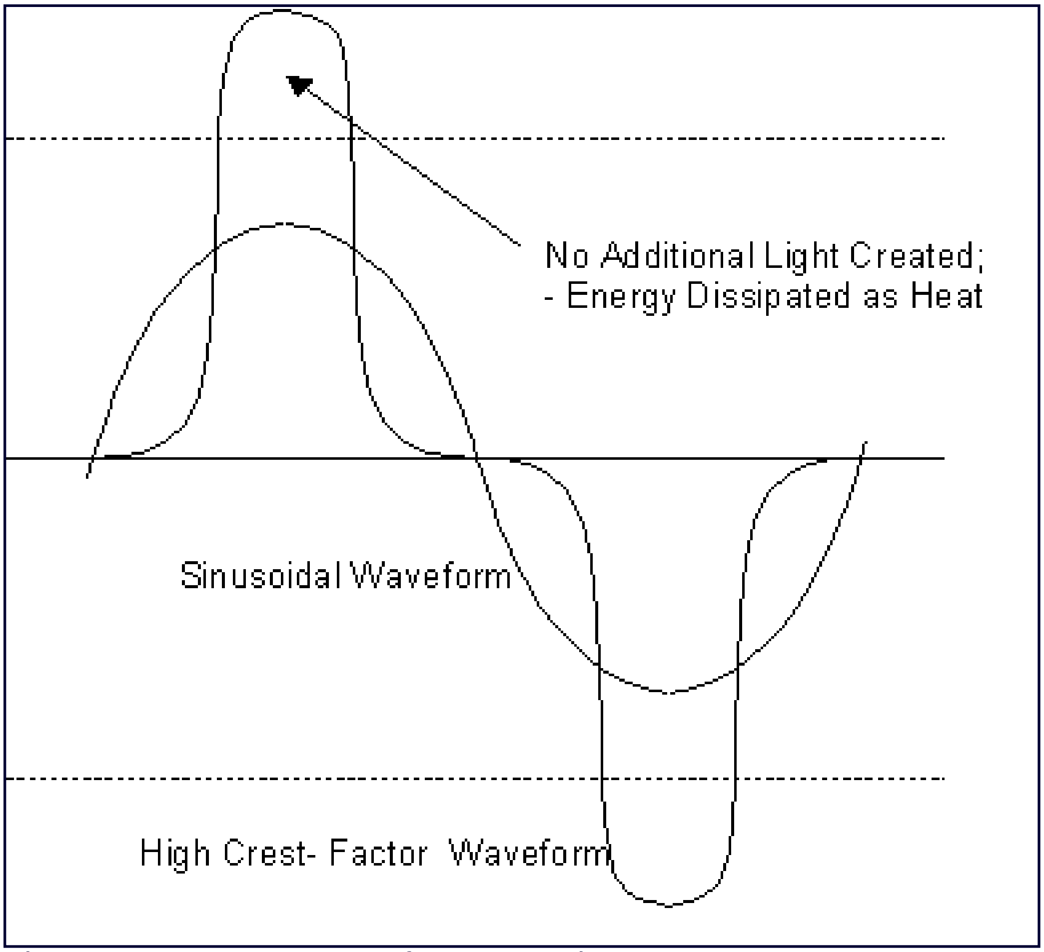

Figure 4. Lamp Current-Waveform Comparison

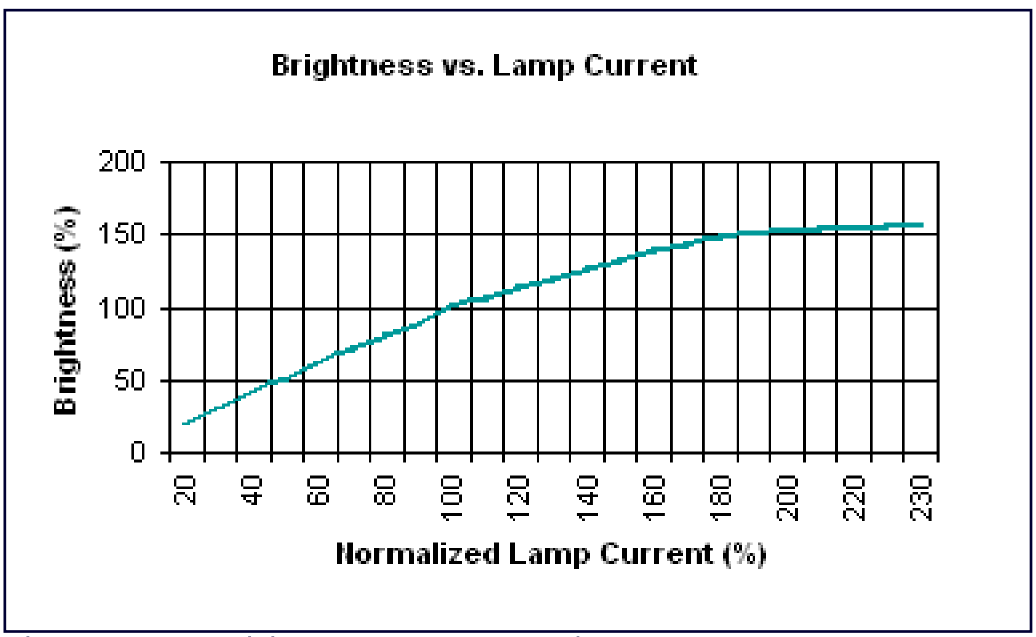

Figure 5. Lamp Brightness-Current Dependence

Lamp Voltage

The CCFL operating and strike voltages required for optimal performance vary with lamp length and diameter. **Figure 6** shows how the operating voltage increases with lamp length. Smaller diameter lamps require higher operating voltages.

An unusual characteristic of CCFLs is that they exhibit ’negative resistance,‘ which means that lamp voltage drops as current increases (see **Figure 7**). Negative resistance can vary between individual lamps, causing the lamps to have different currents at any particular voltage level. In multiple-lamp applications, therefore, the most uniform lamp performance will be achieved by providing individual transformers and current control for each lamp.

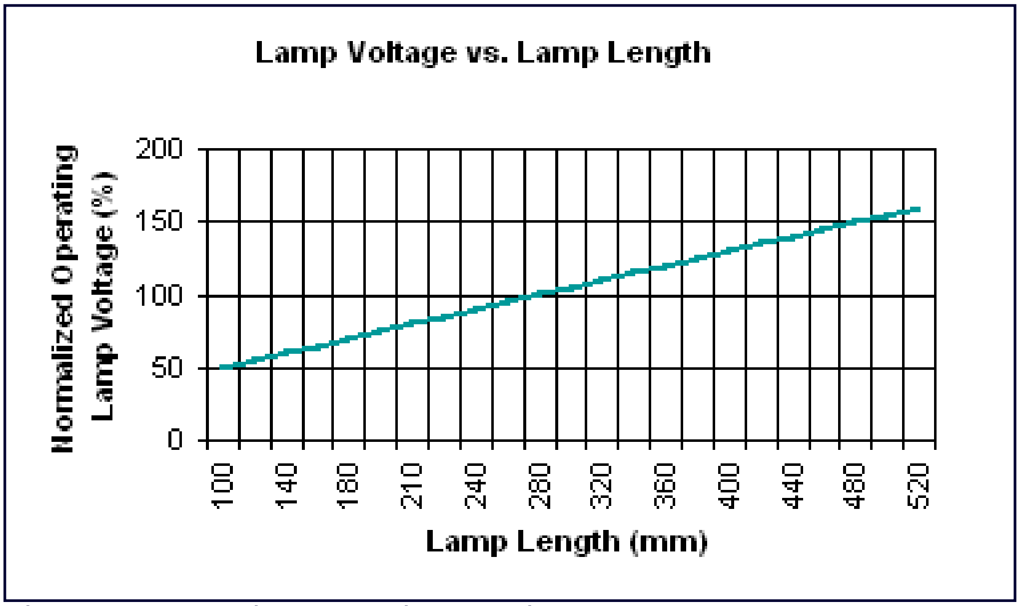

Figure 6. Lamp Voltage-Length Dependence

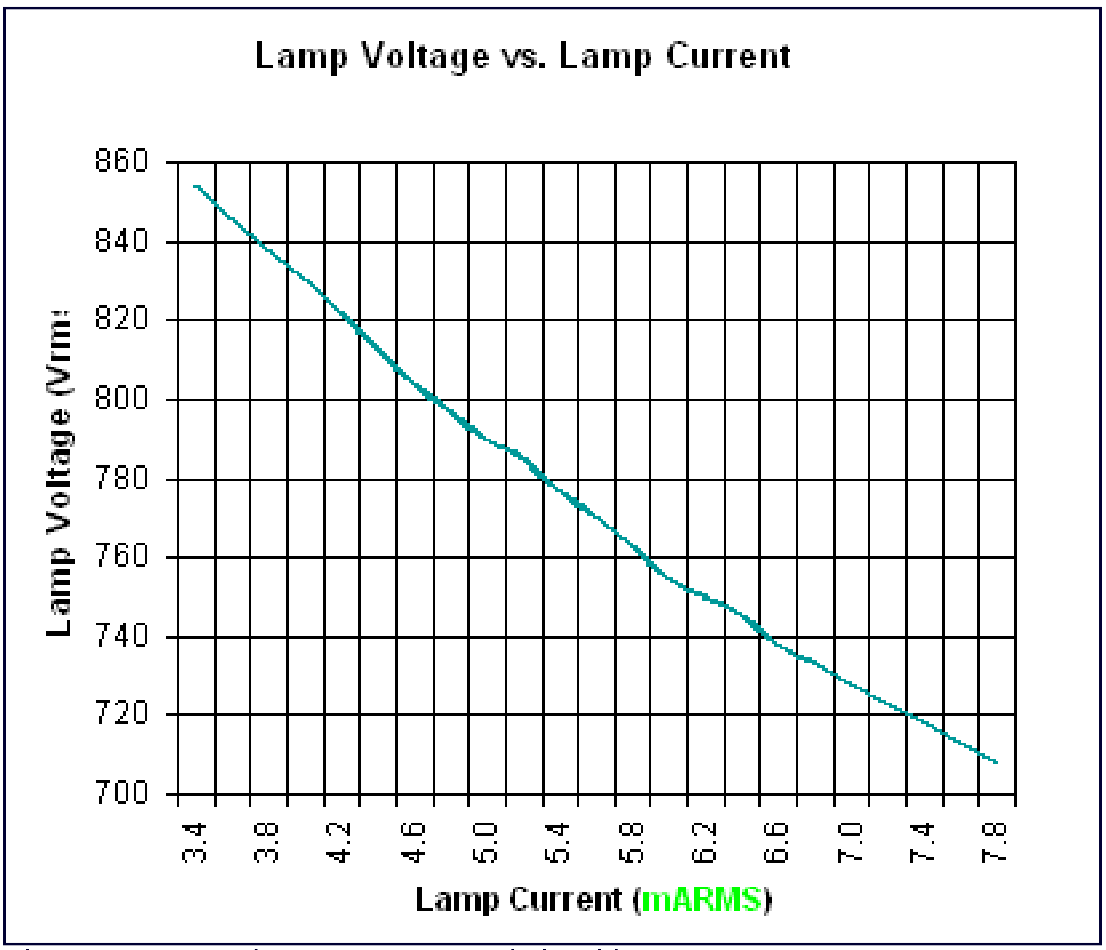

Figure 7. Lamp Voltage-to-Current Relationship

Lamp Striking

To create light, the gases within the CCFLs must first be ionized. Ionization occurs when a voltage, approximately 1.2 to 1.5 times the nominal-rated operating voltage, is placed across the lamp for a few hundreds of microseconds. Before ionization occurs, the impedance across the lamp is in the multimega ohm range; in a typical application, it looks almost completely capacitive. At the onset of ionization, current begins to flow in the lamp, its impedance drops rapidly into the hundreds of kilohms range, and it looks almost completely resistive. To minimize lamp stress, the striking waveforms should be symmetrical, linear sinusoidal ramps without spikes. As noted above, the voltage required to strike a CCFL varies with temperature (see **Figure 2**). The exact timing of the lamp strike is not highly repeatable and can vary ±50%, even under the exact same temperature and biasing conditions.

More Information

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