KEITHLEY
A Tektronix Company

Application Note Series

Number 3212

Avoiding Inrush Current when Testing High Power LEDs with Series 2260B Power Supplies

Light-emitting diodes (LEDs) are quickly becoming an attractive lighting source due to a variety of benefits they offer over the traditional incandescent and fluorescent light bulbs. LEDs have a very long lifespan; they are highly efficient with very low power consumption; they do not contain mercury and are environmentally friendly.

Unlike an incandescent bulb where the lighting source is a filament made of a resistor that lights up when heated, an LED is a two-terminal, semiconductor device that emits visible light when current flows through the device. A diode turns 'on' at a characteristic voltage, V_d, in the forward bias operating region when an avalanche of electrons and electron holes start to recombine. One of the properties of an LED during this recombination process is the release of energy in the form of photons causing the LED to illuminate. The I-V characteristic of a diode in the forward bias region is depicted below, where V_d is the on-voltage of the diode.

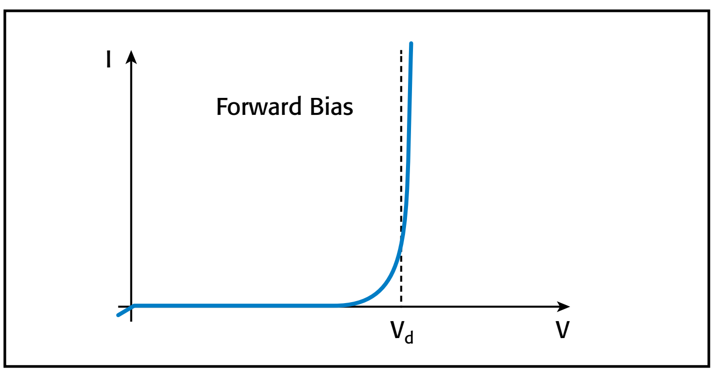
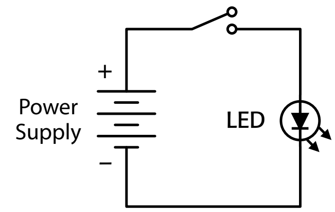
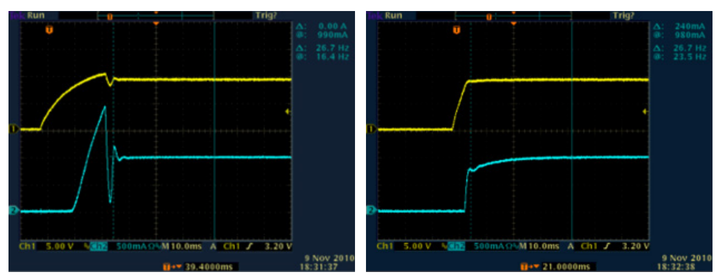


Figure 1. Typical I-V curve of a diode.

Although LEDs can be driven either with voltage or current, current is the preferred method as opposed to voltage used in lighting incandescent bulbs. One reason is brightness. LED brightness is proportional to its drive current. As the I-V curve indicates, a small change in voltage results in large variations in current that will lead to drastic and undesirable variation in LED brightness. In addition, temperature and aging can cause V_d to drift over time. Again, this small voltage drift will likely cause unwanted current variations. Furthermore, driving LEDs with excessive amounts of current can result in irreversible damage and lead to much shorter lifetimes. Thus, regulating the drive current at appropriate levels in LEDs is critical.

A common phenomenon that overstresses LEDs is the inrush current. An LED can be modeled as a parallel R-C network; thus, the device is instantaneously a short circuit when a voltage is applied across the device's terminals. The instantaneous short circuit results in an inrush current , a short duration, startup current that is a much greater magnitude than the LED's steady state operating current. For example, introducing an LED to an energized circuit or "hot switching" the LED will lead to dangerous inrush current magnitudes. The circuit to the right shows that when the switch is open, the voltage at the power supply is maintained at the rated voltage of the LED. As soon as the switch closes, the charge stored at the output of the power supply and the wires flows rapidly into the LED until the power supply starts to regulate. The transient current peak is shown by the blue line in the oscilloscope view in ***Figure 2 (a)***.





(a) (b)

Figure 2. LED turn on voltage (yellow) and current (blue) waveforms when powered by a power supply in the traditional constant voltage (CV) mode (Figure 2a) and the constant current (CC) mode (Figure 2b).

The Keithley Series 2260B Power Supplies feature a constant current (CC) mode beyond the traditional programmable constant voltage (CV) mode. When a supply operates in the CV mode, the voltage is regulated while the current may vary. Unlike traditional powers supplies, the Series 2260B power supplies can be put in a constant current mode independent of the load value. This results in the behavior captured on the oscilloscope in ***Figure 2a***. When the power supply is operating in the CC mode, the current is regulated and supplied to the load while the voltage output may vary. This mode eliminates the need for external controlling circuitry and simplifies the approach to "soft start" a LED. The power supply itself is capable of keeping the current input to the LED under control until the LED reaches the on-voltage as shown in ***Figure 2b***. Removing the possibility of transient inrush current prevents the LED from related damages.

The following example illustrates the steps, both front panel and remote operation, to configure a Series 2260B Power Supply for current limiting, CC high speed priority mode. The example sets the supply's output voltage to 10V and the current limit to 5A.

Front Panel Operation

STEP 1. Set the power supply to CC high speed priority mode

1. Press in the function key. The function key will light up, and the display will show **F-01** on the top line.
2. Rotate the voltage knob to change the F setting to **F-03** (V-I mode slew rate select).
3. Rotate the current knob to set the **F-03** setting to **1** for CC high speed priority.
4. Press in the voltage knob to save the configuration setting. **ConF** will be displayed on the bottom display line when successful.
5. Press the function key again to exit the configuration settings. The function key light will turn off.

STEP 2. Set the output voltage and current limit

6. Press in the voltage knob to highlight specific digits, then turn the voltage knob to adjust the digits until **10.00V** is displayed.
7. Press in the current knob to highlight specific digits, then turn the current knob to adjust the digits until **5.00A** is displayed.

STEP 3. Turning on the output

8. Press the output key. The output key becomes illuminated the when the output is on.

Remote Operation

The following SCPI commands perform the same actions as the steps listed in the front panel operation section.

```
*RST
:OUTP:MODE CCHS
:SOUR:VOLT 10.0
:SOUR:CURR 5.0
:OUTP ON
```

Keithley Instruments' Series 2260B Power Supplies make testing LEDs safe and easy.

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