AND9199/D

Guidelines for Use of LED Shunts

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APPLICATION NOTE

Introduction

LED shunts are multipurpose devices which are used in critical lighting applications to manage LED failures. In a typical LED lighting application there is a string of LEDs. Without LED shunts in place, an open circuit failure will cause an entire string of LEDs to go dark. This concept is illustrated in Figure 1.

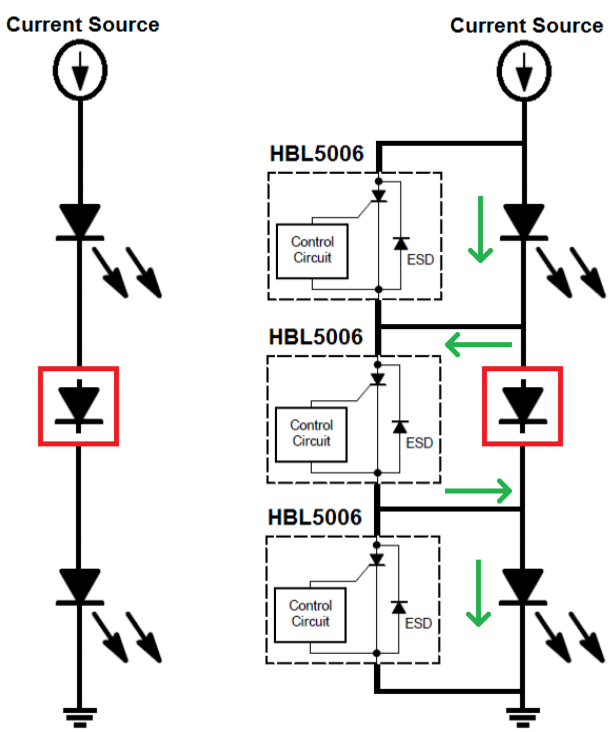

Figure 1. After an LED open circuit failure the entire string goes dark unless LED shunts are used.

Some applications require that the failure of an LED is detected and signaled. In these cases the LED shunts are necessary to present a single failure signature to detection circuitry whether the LED has failed short or open. This signal can be used for diagnostics or to switch in a backup LED. An example of this is shown in Figure 2. For more details about this example please see design note DN05066.

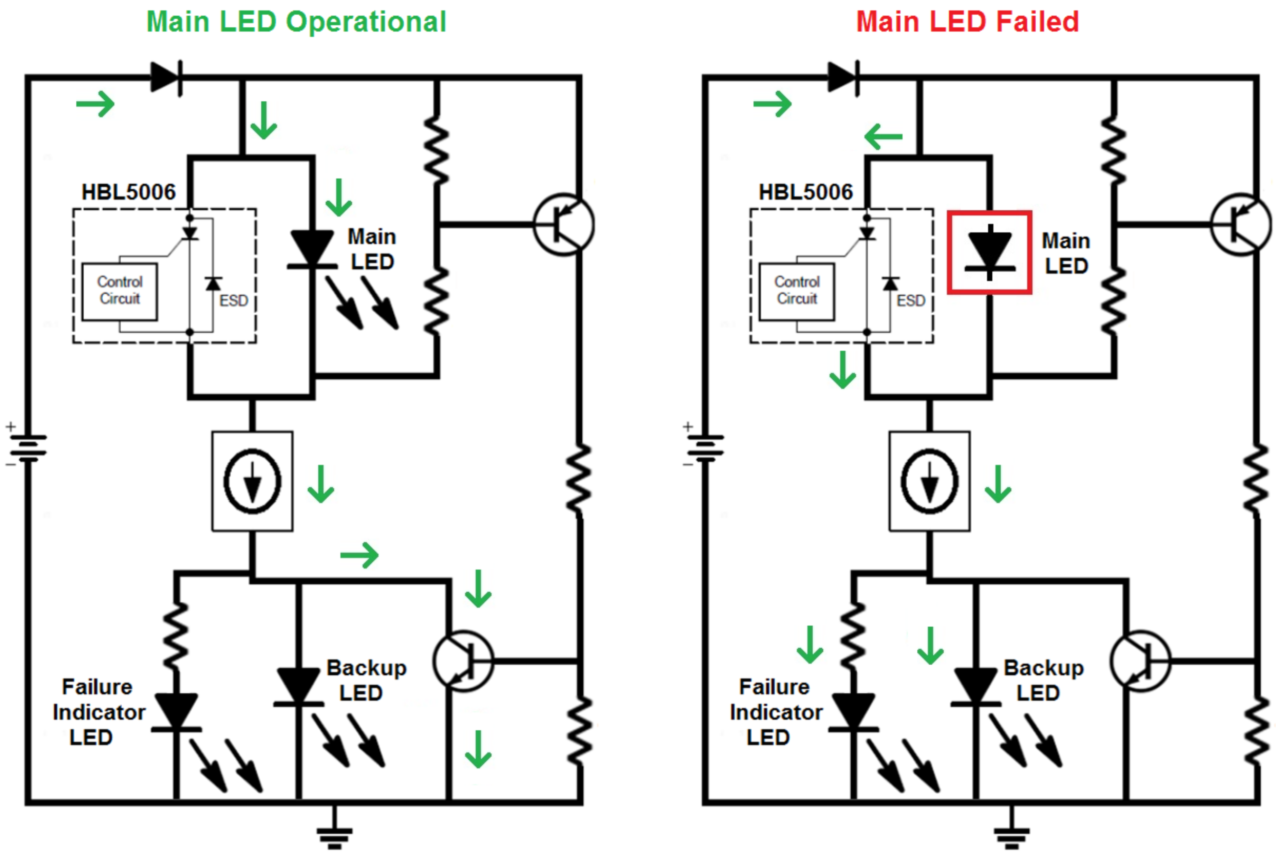

Figure 2. Failure detector circuit for critical lighting applications with backup LED and failure indicator LED. See Design Note DN05066 for more details.

LED shunt datasheets provide important specifications which are relevant to the lighting circuit designer. The shunts are engineered with wide clearances and tight tolerances. These allow them to be designed in without approaching various limits for voltage, current, and power dissipation.

This application note serves as a guide to explain LED shunt datasheet parameters and how the lighting circuit designer should take them into account. Figure 3 provides a general I−V characteristic that illustrates the datasheet parameters discussed below.

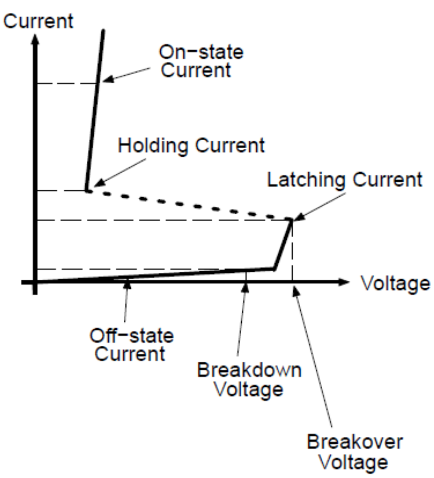

Figure 3. An example of I−V characteristics for an LED shunt.

Maximum On−State Current and θ_{JA}

The maximum junction temperature is either 150 or 175°C. The maximum on−state current is a guide to maintain the shunt in its specified operating temperature range. It is always specified with an ambient temperature of 25°C.

The maximum current must de−rated for environments in which the temperature is greater than 25°C. This can be done using the θ_{JA} parameter listed in the datasheet. θ_{JA} depends on the amount of heat sinking available. The lighting circuit designer should provide generous heat sinking to the LED shunt.

An example of the use of the θ_{JA} equation is shown below:

$$T_{Junction} = T_{Ambient} + (I_{Shunt})(V_{Shunt})(\theta_{JA})$$

For example, consider an HBL5006P2T5G (SOD−923) application where the maximum ambient temperature is 50°C, the desired current is 100 mA, and the heat sinking area is 2−layer, 50 mm^2 per layer, 1 oz. Cu, FR4. The equation becomes:

$$T_{Junction} = 50^{o}C + (0.1)(1.3)(360) = 96.8^{o}C$$

It is important to note that the heat sinking may need to be distributed disproportionately among the pins to provide the specified thermal performance. This is due to the internal construction of the shunts.

In the case of the NUD4700, the majority of the heat sinking for the NUD4700 should be provided for its large underside pad. For HBL5006, it should be provided on pin 2 (next to the LED cathode). The HBL1015 and HBL1025 are symmetrical, bidirectional devices which should be mounted with equal heat sinking on the pins. Whether pin 2 is connected to heat sinking or not is not critical for the HBL1015 and HBL1025.

Holding and Latching Current

The maximum value of holding and latching current determines the minimum LED string current with which the device may be used. For example, for the HBL5006 the holding current is specified as being 40 mA maximum at 25°C. To ensure that the device works properly use this device with an LED string current above 40 mA. Therefore, a current source with a nominal value of 50 mA and a variation of ±10 % would be acceptable. For the NUD4700 the latching current is higher than the holding current so the designer must observe the latching current maximum.

For lower light output than 50 mA DC, consider using pulse width modulation (PWM). If 10 mA, 100% duty cycle produces the light output required, alternatively the circuit could operate with 50 mA, 20% duty cycle. The light output will be the same and it will be possible to use LED shunts in the circuit.

Breakdown Voltage and Shunting Multiple LEDs

It is possible to connect LED shunts around more than one LED. This is done in applications to minimize cost or cover LEDs with high forward voltages. The minimum breakdown voltage determines the maximum LED voltage that can be shunted. Breakdown voltage is defined as the voltage in the off−state while the shunt is conducting 1 mA.

The HBL5006 has a minimum breakdown voltage of 6.2 V. Therefore it may be connected across any amount of LEDs as long as the LED forward voltage is less than 6.2 V. For example, it could be connected across one 3.3 V LED, two 2.2 V LEDs, two 3.0 V LEDs, or one 6.0 V LED. This is illustrated in Figure 4.

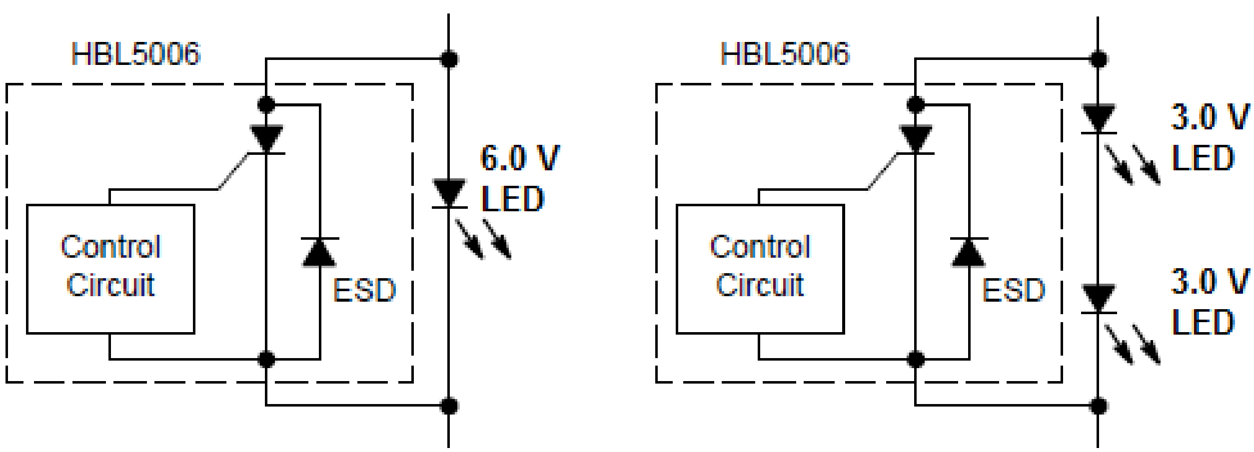

Figure 4. Examples of acceptable configurations for HBL5006. The forward voltage of the LEDs does not exceed the minimum breakdown voltage of the HBL5006 (6.2 V).

The HBL1015 and HBL1025 have even higher minimum breakdown voltages. This allows them to be used with additional LEDs. Figure 5 shows how the HBL1025 with its 11.5 V minimum breakdown voltage can be used with various LED configurations.

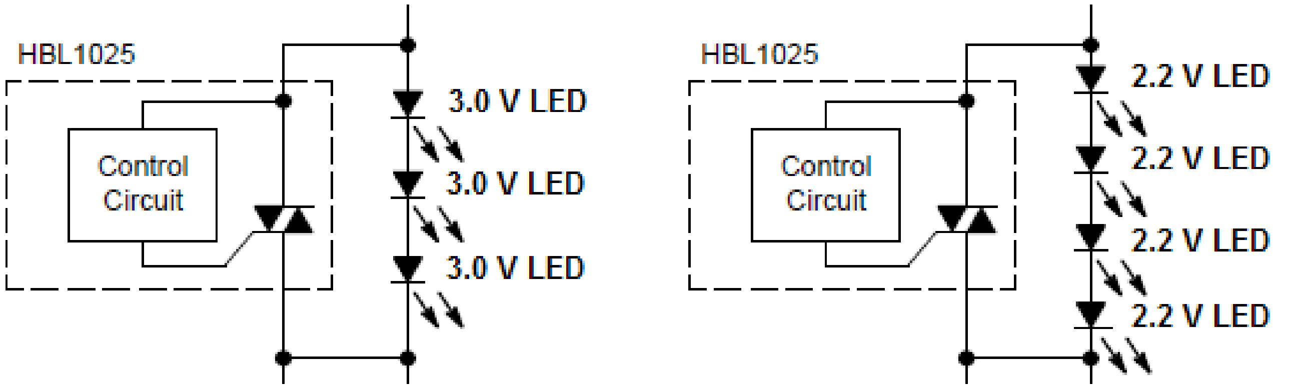

Figure 5. One HBL1025 can cover LED strings with forward voltages up to 11.5 V

Breakover Voltage

The breakover voltage is the voltage required to make the shunt switch from the off−state to the on−state. It is important to ensure that the supply voltage can make the shunts breakover. For example, with HBL5006 the maximum breakover voltage is 8.0 V. If this voltage is not available, it is possible that the shunt will not switch from the off−state to the on−state when an LED fails.

The lighting circuit designer must also be aware that some situations require that there be breakover voltage for more than one shunt at the same time. In Figure 6, two LEDs have failed as open circuits. When the power to the circuit is switched, both LED shunts need to breakover at the same time. Therefore, the supply voltage must be:

Supply Voltage > (Breakover Voltage) x 2 + (LED Forward Voltage) x 2 + (Current Source Voltage)

For Figure 6 the equation becomes:

Supply Voltage > (8.0 V) x 2 + (3.0) x 2 + (1.0)
Supply Voltage > 23 V

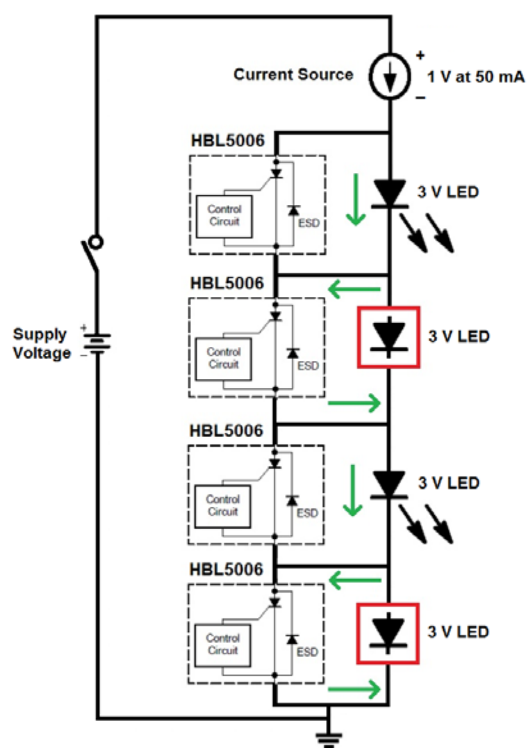

Figure 6. Adequate supply voltage must be provided for cases in which multiple LEDs have failed.

This supply voltage requirement is also present while PWM dimming, since PWM will essentially cut the power to the LEDs momentarily.

On−State Voltage

This specification is the voltage the shunt will carry after an LED has failed in an open circuit condition. This parameter is important for junction temperature calculations. It is also important for ensuring the power supply or linear LED driver will not have any issues due to the change in load voltage. Consider a circuit that uses HBL5006 shunts versus HBL1015 shunts as shown in Figure 7. There will be less voltage dropped across the current source when using the HBL1015.

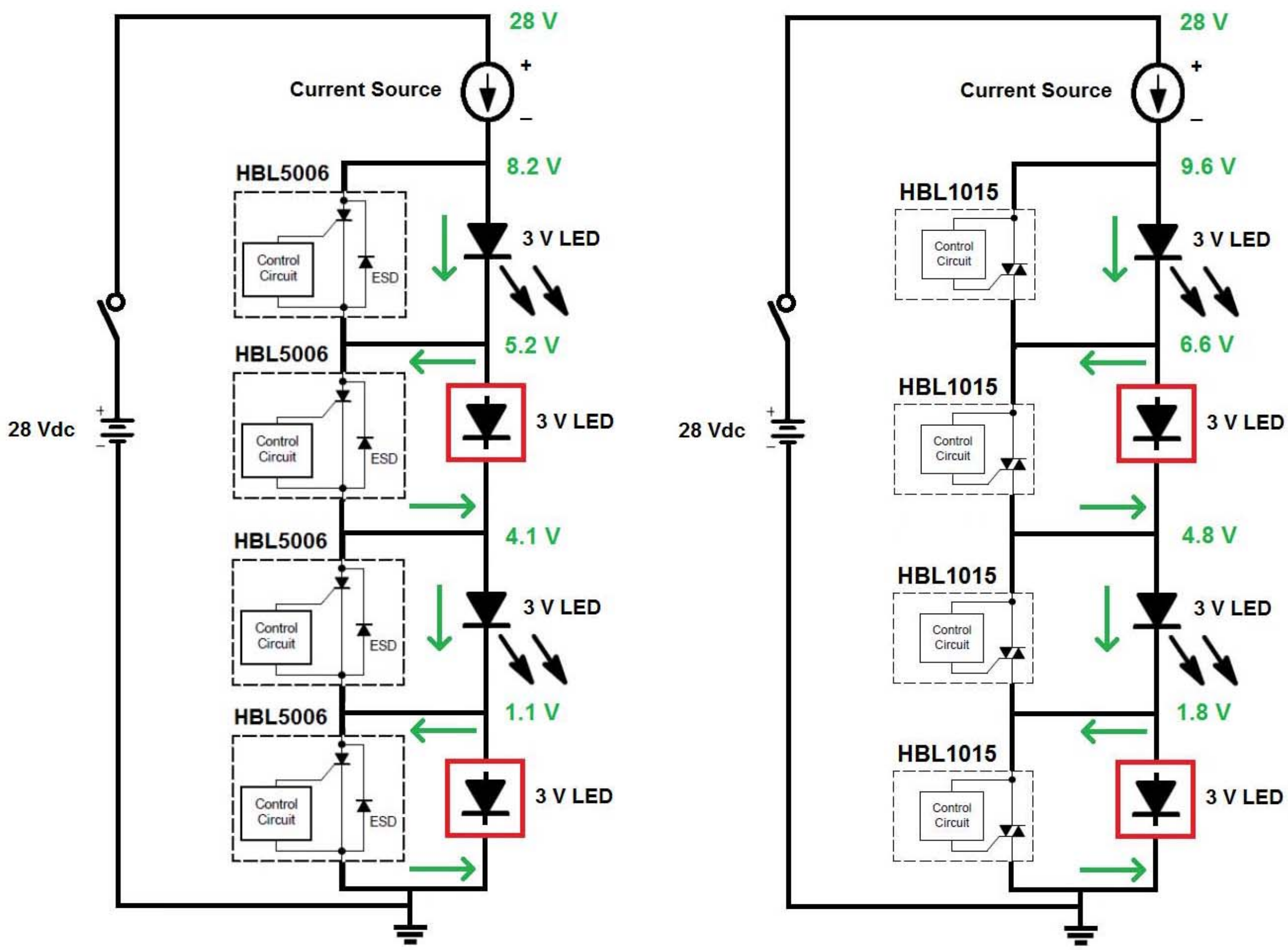

Figure 7. The HBL1015 has a higher on−state voltage. Therefore the voltage over the current source is not as high as it is in the HBL5006 case.

For applications involving LED failure detection, it is desirable that an LED open circuit failure appear like a short circuit failure. In those cases, it is important that the on−state voltage be distant from the LED voltage so that the two signals can be distinguished by the control circuitry. For example, the HBL5006 with a typical on−state voltage of 1.1 V would be better matched to a 2.2 V LED than the HBL1015 with a typical on−state voltage of 1.8 V.

Off−State Current

This is a leakage current specification. ON Semiconductor LED shunts have off−state currents that are orders of magnitude below the current conducted by LEDs, so generally this parameter requires minimal attention from the lighting circuit designer.

Summary

This application note has explained the parameters designers must keep in mind when using LED shunts. They are multipurpose devices which serve uses from string continuity insurance to the presentation of a single failure signature for an LED.

PUBLICATION ORDERING INFORMATION

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