Crystal IS
High Performance UVC LEDs

APPLICATION NOTE:

Duty Cycle Operation of Crystal IS UVC LEDs

August 24, 2015

THIS APPLICATION NOTE SUMMARIZES THE IMPACT OF OVERDRIVING ON LIGHT OUTPUT AND JUNCTION TEMPERATURE OF OPTAN TO-39 LEDS UNDER VARIOUS DUTY CYCLES.

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Introduction

In applications that require a high LED output power, some end users choose to operate LEDs at an elevated current above datasheet specifications. Overdriving the current in this way allows for an increase in light output, but also poses certain risks in performance. Overheating is a common issue that can negatively impact both the light output and lifetime of LEDs.

Applications in fluorescence, which typically require higher light outputs, commonly use pulsed mode operation to more safely overdrive LED current.

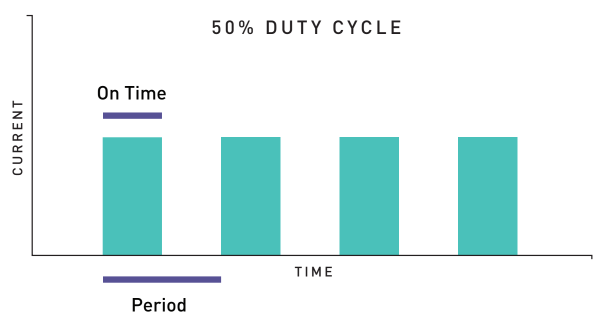
Duty Cycle and Frequency

Due to the instant on-off capability of LEDs, one can quickly turn on and off an LED in a periodic manner. Duty cycle is the percentage in one period in which an LED is turned on; where a period is the total time it takes to complete an on-and-off cycle.

Equation 1: Duty cycle = On time / (On time + Off time) = On time / Period

An LED operating at a 50% duty cycle, for example, would be turned on exactly half of the time and off half of the time. This concept is illustrated in Figure 1.

FIGURE 1



The on time and one period of light emission of an LED being operated at a 50% duty cycle.

The frequency is defined as the number of times the LED is turned on, or cycled, within a second. This is measured in Hertz (Hz), and is inversely proportional to the period (in seconds) as expressed in Equation 2.

Equation 2: Period = 1 / frequency

EXAMPLE

In this example, the design engineer would like a 25% duty cycle at a frequency of 100 Hz. The period as well as the on/off time can be calculated as follows:

1. Period = 1 / frequency = 1 / 100 Hz = 0.01 seconds (s) = 10 milliseconds (ms)

2. Duty cycle = On time / Period
0.25 = On time / 10 ms
On time = 2.5 ms

3. Off time = Period – On time = 10 ms – 2.5 ms = 7.5 ms

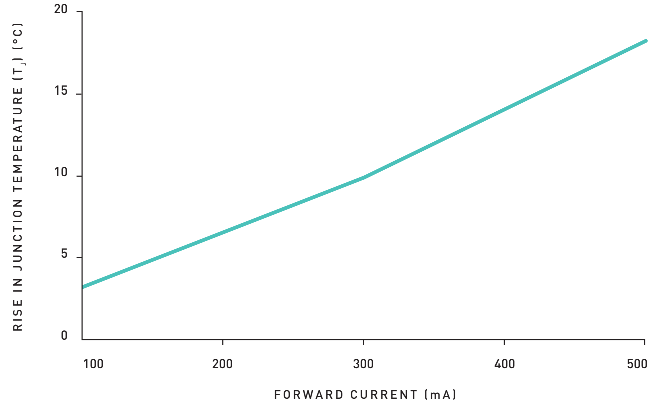
According to the calculations, a 25% duty cycle at a frequency of 100 Hz results in the LED being turned on for 2.5 milliseconds, then off for 7.5 milliseconds, for a period of 10 milliseconds.

Effect of Duty Cycle on Junction Temperature and Light Output

Overdriving or operating the LED at high currents impacts the LED junction temperature, which consequently impacts lifetime and light output. Optan UVC LEDs from Crystal IS were operated under various duty cycle conditions to monitor the impact on junction temperature and light output.

In the first set of experiments, Optan UVC LEDs were operated in pulsed mode without using a heat sink for thermal management. Although not actively cooled, heat from the LEDs is dissipated through natural convection of surrounding air. This experiment evaluated the effect of pulsed current on junction temperature in this natural cooling condition. According to the Crystal IS LED Optan Data Sheet, these LEDs are rated for currents up to 100 mA in the continuous mode. The duty cycle studied in this experiment was 5% at a frequency of 50 Hz, with currents ranging from 100 mA to 500 mA. The results are shown below in Figure 2 and Figure 3.

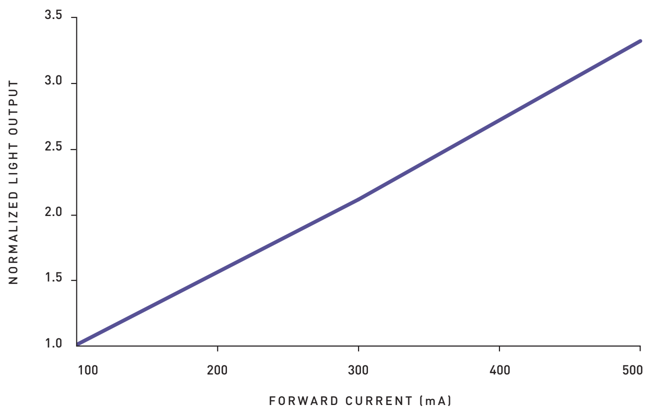
FIGURE 2



Rise in junction temperature versus forward current for a 5% duty cycle at 50Hz.

As Figure 2 shows, the average junction temperature increased with increasing current. In this example, even though no thermal management was employed, the average junction temperature was maintained within an acceptable range. This means that one may be able to control the junction temperature by carefully choosing a duty cycle and frequency of operation.

FIGURE 3



As Figure 3 shows, the light output versus forward current for a 5% duty cycle at 50Hz. Normalized power is relative output power compared to the power in continuous mode operation at maximum rated operating current of 100mA.

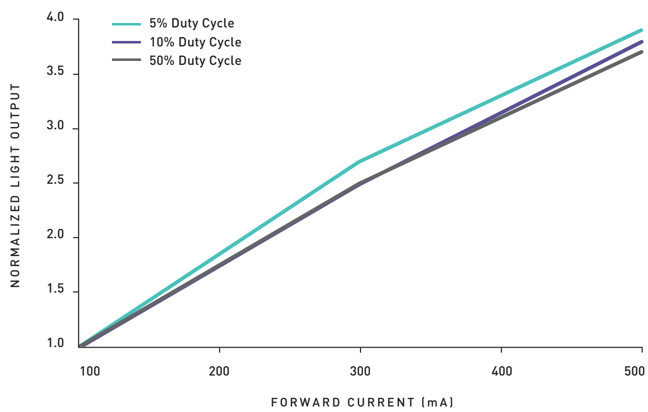
The light output at 300 mA and 500 mA, increased by a factor of 2.1 and 3.3, respectively over the light output at 100 mA. The non-linear relationship between light output and drive current indicates a drop in light emission efficiency at higher currents. This drop in efficiency is mostly due to the increased peak junction temperature for Crystal IS diodes.

For the second set of experiments, the on time was held constant while duty cycle varied. Since on time was kept constant, the frequency was varied.The results are shown in Figure 4 and 5 on the next page.

Overdriving the LED, or increasing the current, achieved an increase in the output power relative to the normalized power at 100 mA. However, the junction temperature of the LEDs was elevated as a function of increased duty cycle and current.

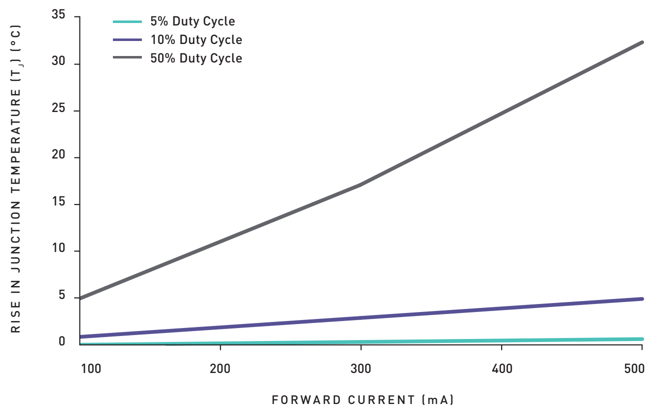
This increased light output at higher currents is especially advantageous in fluorescence applications where the signal strength is directly related to emission intensity.

FIGURE 4



Impact of varied duty cycle on normalized output power, while on time is held constant at 500 µs. Normalized power is relative output power compared to the power in continuous mode operation at maximum rated operating current of 100 mA with the appropriate heat sink.

FIGURE 5



Impact of varied duty cycle on junction temperature, while on time is held constant at 500 µs.

The increased light output enables detection of lower concentration of fluorophores. However, engineers must select the appropriate combination of duty cycle and drive current along with thermal management to minimize increases in junction temperature and maintain LED performance.

Conclusion

Optan UVC LEDs deliver sufficient light output for a majority of spectroscopy applications, however in certain specialized applications higher light output may be required for measurement. This can be achieved by exceeding the maximum-current ratings of UVC LEDs to obtain the desired level of performance. Crystal IS testing indicates that Optan LEDs are capable of withstanding current transients well above the maximum rated continuous current.

However, there are trade-offs that may adversely affect efficiency and long-term reliability. In these cases, Crystal IS recommends that customers perform their own lifetime testing when evaluating the feasibility of a design. It is the customer's responsibility to determine if the trade-offs will be acceptable in the application. Crystal IS does not make any guarantees regarding reliability or performance when using our products outside the published specification limits in our product data sheets. Customers who have questions or concerns about their unique applications are encouraged to contact Crystal IS applications support team (support@cisuvc.com) for technical guidance with respect to product selection and system design.

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We invite you to learn more about our UVC LEDs.

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