LED Lighting

is now the dominant technology for illumination in machine vision applications. The reasons for this are very compelling. The advantages over older technologies such as high frequency fluorescent and fibre optic include:

- Small physical size
- Very safe - low voltage, low power, solid state
- No glass, so suitable for the food industry
- Very stable output
- Fast pulsing

The range of LED Lighting modules and techniques and the number of manufacturers is now huge, so that there is a solution for almost all applications.

However, there is one area of the implementation of LED Lighting that has been neglected by engineers, which can result in a reduction in performance and system reliability. The electrical supply used to drive LED Lighting is often an off-the-shelf DC PSU often with a series resistor to attempt to prevent the lighting from being damaged by variations in supply voltage.

LEDs are essentially current driven devices. If a constant current electrical supply is maintained the intensity of LEDs is very stable and there is much less variation in output intensity due to temperature.

Contrast the steep voltage/intensity curve with the linear relationship between current and intensity in Figure 1. LEDs are extremely sensitive to changes in voltage, resulting in large changes of intensity. Even a very small change, such as 10mV, can result in a doubling of intensity.

Reliability

The MTBF of LED lighting is very good, typically over 100K hours. This compares very favourably with the older technologies, where the MTBF is typically around 4K hours.

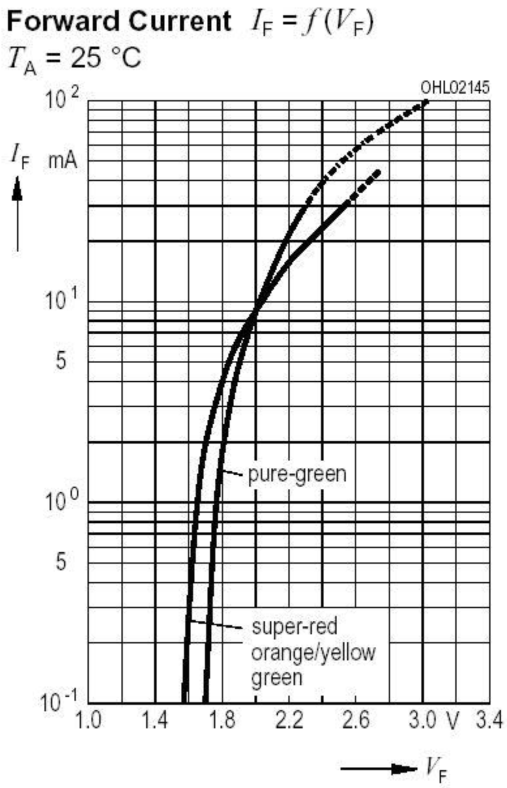
However the reliability of many LED lighting installations has been compromised.

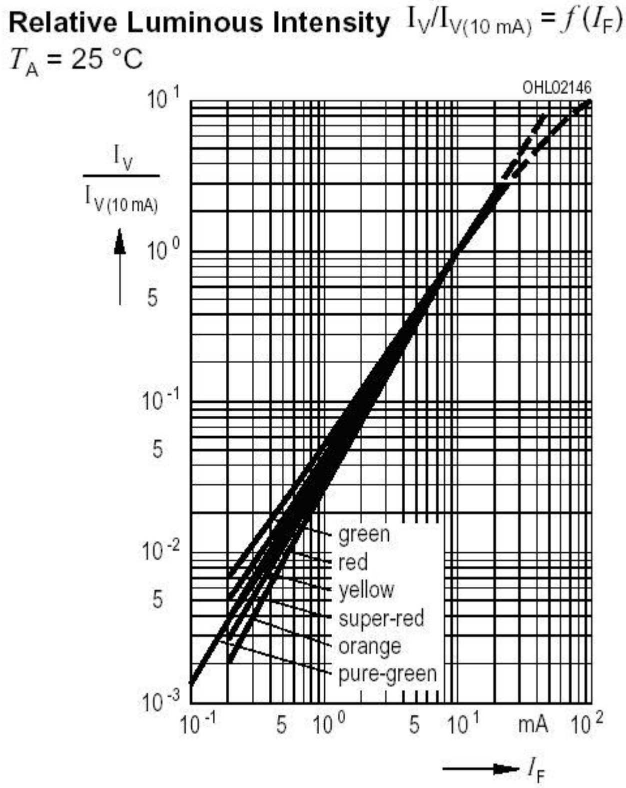
LED manufacturers are continually improving their products, with the emphasis on higher efficiencies and lower forward voltage. Often the minimum forward voltage of LEDs is not specified, as this is not tested during manufacture and is decreasing over time. Users who drive LED lighting from a voltage source may find that the reduction in forward voltage results in systems where the LED Lighting is being continuously overdriven and the reliability compromised. This situation won't occur with a current supply as the maximum allowed current is tightly controlled and is an explicit parameter on LED data sheets.

The "on" time of an LED is the critical parameter in its MTBF. By pulsing LEDs, so they are only on when required, the "on" time is reduced and the MTBF dramatically increased. Pulsing can also be used to negate the reduction in MTBF caused by overdriving LEDs for higher brightness.

Temperature has an exponential effect in reducing LED lifetimes. Even running an LED at an ambient temperature of 40oc, the MTBF is halved compared to running at 25oc.

Variation of Brightness with Voltage





The right hand graph shows how light output varies with current, for the LS-3340 range from Osram. The response is nearly linear and the output can be easily controlled using currents from 0.2mA to 20mA.

The left hand graph shows how current (and therefore light output) varies with voltage. The response is not linear and the steepness of the graph shows how difficult it is to control output as the LEDs are very sensitive to small changes in the range of 1.6V to 2.25V. The output from the LS-3340 is typically 45millilumens (mlm). From these graphs, it can be seen that at a supply voltage of 1.4V the output is 0.14mlm and at 1.5V is 3.6mlm, variation by a factor of 26 for a 0.1V change. Osram do not publish graphs of light output against voltage for their LED devices as they recommend that LEDs are driven from a constant current source.

RIP To DIY Controllers

In the early days of LED Lighting, many engineers would put together a DC power supply and series potentiometer for intensity control. All this would have to be put into a small enclosure and then drawn up and documented. The whole exercise could easily take three days to complete, proving very expensive. The worst thing that can happen once a DIY Lighting Controller has been sold is that the customer orders a second one as the whole assembly is uneconomic to produce.

Features such as dynamic intensity control, switching and accurate strobe timing are out of reach as the development cycle is unfeasibly long.

DIY Controllers seem simple in concept but can result in a large hidden cost and a reduction in performance.

LED Lighting Current Controllers

The solution to these problems is an LED Lighting Current Controller. Typically these provide a digitally controlled repeatable constant current output, very accurate pulse timing with variable delay and pulse width and selectable intensity.

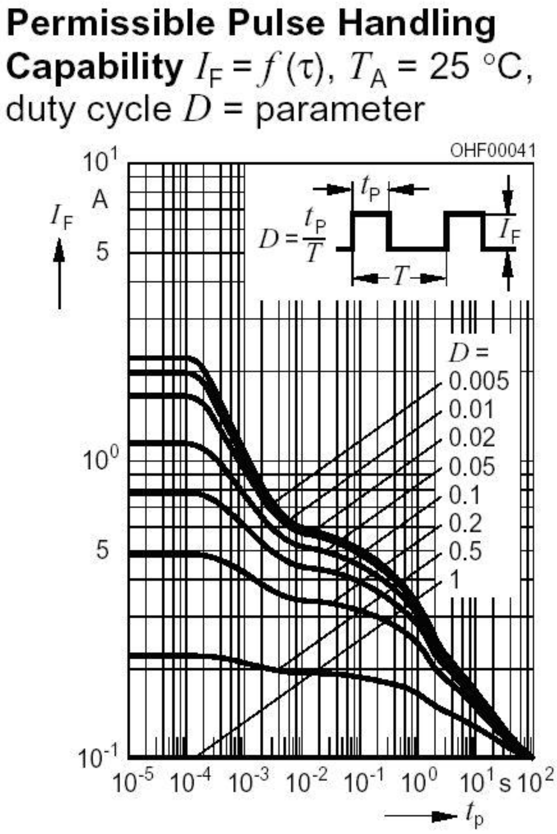
Output current and pulse timing are usually set manually or dynamically from software. Settings are stored in the controller and are non-volatile.

Digital control means that once an output current has been set, it is easy to reproduce the setting in the future. With analogue control, it is common to get the settings nearly right and then not try to improve them further, for fear of making things worse.

Pulses are triggered on an opto-isolated digital input, usually from a PLC, frame grabber or camera. The delay before the pulse fires and the pulse width can both be controlled.

Often two or more views of an object are taken using different lights at different intensities. With an LED Lighting Current Controller it is possible to switch lights on and off and also to switch between several preset intensities.

Pulsing LEDs for Higher Intensity



This graph shows how Osram's SFH 4301 can be driven with high currents when pulsed. The maximum allowed pulse current is plotted against pulse width for a variety of different duty cycles.

At a duty cycle of 1, the SFH 4301 can be driven at its rated current, 100mA. At a duty cycle of 0.5 (50%) the SFH 4301 can be pulsed for 1ms at 200mA (approximately twice as bright).

The SFH 4301 can be pulsed at up to 2.2A for 100us as long as the duty cycle is no greater than 0.005 (one pulse every 20ms).

Advanced Techniques

Once an LED Lighting Current Controller is used, there are lots of advanced lighting techniques that can be used to improve the accuracy of the inspection.

Automatic or manual calibration of the lighting intensity can prevent system degradation over a period of time. Once per day, the lighting is turned on and the average brightness of a known region in the camera's field of view is measured. If the brightness has reduced, which may be due to lighting ageing or a dirty lens, the lighting intensity is increased by a small amount and remeasured until the target brightness is achieved.

Pulsing can be used to increase the brightness of LED Lighting. For example, referring to Insert 2, if a camera has a 1ms exposure every 20ms, then lighting using the SFH 4301 can be pulsed at four times its rated current, giving two iris stops more light compared to constant illumination.

Motion blur can be almost eliminated by strobing the lighting, using a very short pulse from an LED Lighting Current Controller. Within limits (see Insert 2), the brightness of the image can be maintained by overdriving the LED Lighting even though the illumination time is reduced.

Different lights can be switched on for different views of a component. For example, it might be necessary to use a bright on-axis light to check a component feature, then a lower brightness so that an etched legend can be verified and then a backlight to dimensionally check the component. These three lighting schemes can be controlled from a PLC or can be sequenced to change on vertical sync from a camera, so that the three views can be obtained in three frames.

Current Controllers - Every System Should Use One

In conclusion, LED Lighting provides many benefits for machine vision systems, but there are pitfalls. Using an LED Lighting Controller is the way to design reliable and accurate machine vision systems.

Seven Steps To Improving LED Lighting

- Drive LED lighting from a constant current
- Pulse the output at a higher current to get higher intensity
- Reduce the ambient temperature where possible
- Use pulsing to turn the LEDs off when not required to increase the MTBF
- Auto or manually calibrate intensity using feedback from the camera
- Use advanced lighting control techniques
- Use an LED Lighting Current Controller