help desk

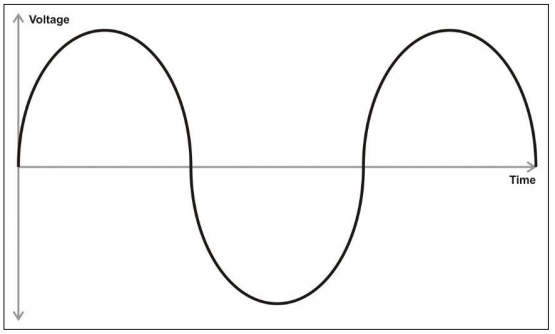
Edgy Dimming | By Wayne Howell

"Why are my LED downlights flickering?" is an oft repeated question on the Help Desk. That apparently simple question has a huge number of potential answers ranging from control signal compatibility to dimming technology. And the answer requires an understanding of the underlying dimming technologies . . .

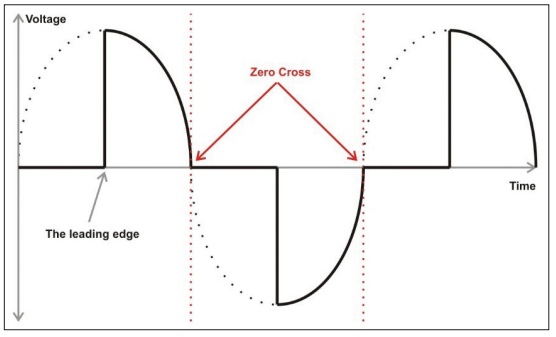
LEDs cannot be dimmed by simply varying the voltage, so some form of modulation is required. The modulation technique depends on whether the power source is AC or DC.

AC DIMMING - LEADING EDGE

The concept of electronic dimming of a light started by modifying the AC waveform. In the UK, the mains voltage is approximately 230VAC at 50Hz. The diagram below shows the AC waveform, which repeats 50 times per second and crosses the x-axis 100 times per second, which is called the zero cross.



The first type of dimming used a technique called leading edge dimming. An electronic device called a Silicon Controlled Rectifier (SCR) is used to define the point in the AC waveform at which the power to the lamp is switched on (called the leading edge).



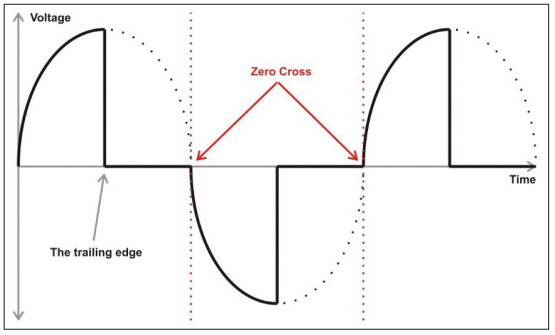
The SCR automatically switches off at the zero cross, so the percentage of the mains cycle between the leading edge and the zero cross defines the intensity of the lamp. This form of dimming actually causes the lamp to flash on and off at a frequency of 100Hz. When used with incandescent lamps, the eye's persistence of vision and the thermal inertia of the lamp mean that no flicker is perceived.

With LED lamps the situation is more difficult. The eye's persistence of vision still covers the 100Hz flicker, even though an LED lamp responds much more quickly than incandescent. However, LED lamps really dislike the leading edge. Many contain electronics that need a stable voltage before the light output is defined. The almost vertical leading edge simply causes the LED lamp to flicker on every leading edge. Conclusion: Don't try to use leading edge dimmers with LED lamps.

AC DIMMING - TRAILING EDGE

Trailing edge dimming was the next innovation in AC dimming. As the name suggests, it is the switch-off point that is modulated.

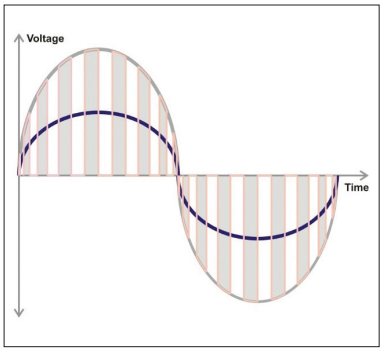
As shown in the drawing above, the power to the lamp switches on automatically at the zero cross and the power is switched off at the trailing edge.



This technique requires more complex circuitry using MOSFETS or IGBT devices, but has the benefit of being much friendlier to LED lamps. As the power starts at a low voltage, the electronics in the LED lamp have time to stabilise. LED circuitry can switch off instantly at the trailing edge - leading to stable and flicker-free dimming. There are still limitations: the LED lamp will rarely dim below 5% to 10%, but will switch without flicker. Conclusion: Trailing edge dimmers work with most LED lamps.

AC DIMMING - SINE WAVE

Sine wave dimming is a technique whereby the AC waveform is chopped and then reconstituted to produce a new AC waveform of lower voltage. The quality of the reconstituted AC is very dependent upon the sophistication (and so cost) of the electronics used.



Wayne Howell is the CEO of Artistic Licence, the lighting controls company that he founded in 1988. Wayne invented Art-Net and is actively involved in the ESTA technical standards programme.

It has real benefits for incandescent lamps as it largely removes audible filament noise. However, it can be problematic with LED lamps - often causing flicker at the switch-on or switch-off points. Conclusion: Sine wave dimmers should be tested with your chosen LED lamps before committing.

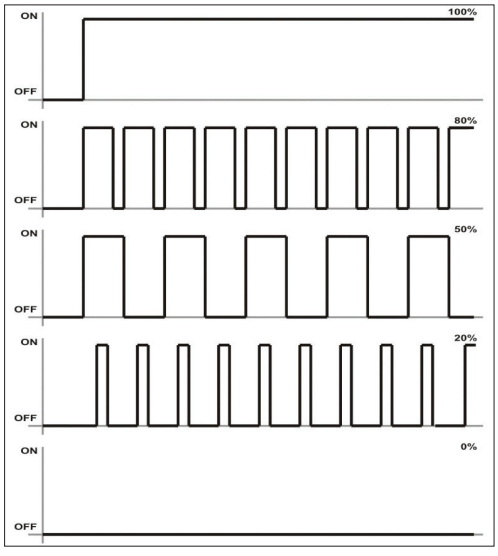
DC DIMMING - CONSTANT VOLTAGE

There are two key techniques used in DC dimming: Constant Voltage and Constant Current - often abbreviated to CV and CC respectively.

Constant voltage dimming is the simplest technique and the lowest cost, but is also the least efficient. It's frequently used for dimming and colour mixing LED tape products which contain current-limiting resistors that convert the constant voltage dimming into the constant current that all LEDs require. In the process, they generate heat - which is why they are not very efficient. That said, their simplicity has led to widespread use.

DC DIMMING - CONSTANT VOLTAGE - PWM

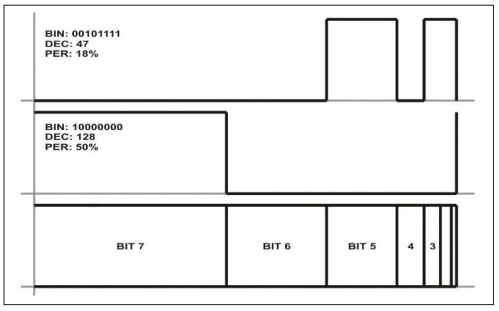
There are several ways in which Constant voltage dimming can be achieved. The best known is Pulse Width Modulation (PWM), a technique similar to the AC dimming schemes in that the ratio of on-time to off-time sets the lamp's intensity as shown in the diagram below.



The frequency of modulation is not set by the mains frequency but is defined by the design. A PWM frequency of at least 1000Hz is required to ensure that no flicker is perceived. Conclusion: Check the modulation frequency is above 1KHz. Otherwise any flicker issues are likely to be related to the control (DMX / DALI / 0-10V) input.

DC DIMMING - CONSTANT VOLTAGE - BAM

Bit Angle Modulation (BAM) is another method of modulating the constant voltage to dim LEDs. BAM uses a pulse train containing the binary intensity value and was invented by Artistic Licence in response to the frivolous patents that exist over PWM. Its key benefit is that the varying pulse widths are less likely than PWM to cause harmonic interference.

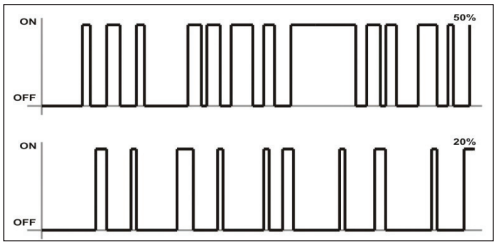


Conclusion: BAM rarely causes flicker so any problems are more likely to be related to the control (DMX / DALI / 0-10V) input.

DC DIMMING - CONSTANT VOLTAGE - RPM

Pioneered by Cypress Semiconductors, Random Pulse Modulation (RPM) is by far the best form of constant voltage dimming. It uses a sequence of random pulses to modulate the constant voltage; the density of the pulses sets the intensity.

The random nature of the control means that there is no flicker. Perhaps more important is that RPM solves the TV camera 'beating' problem. Beating is a term used to describe the phenomenon where two frequencies combine to produce a different frequency. The best-known example is the 'wagon wheel' effect whereby on TV, the wheels of a vehicle appear to stop or rotate backwards. This happens when the wheel is rotating at very nearly the same frequency as the frame rate at which TV is recorded. The same problem can occur when PWM is used to modulate LED on a TV show. If the PWM is close to the TV frame rate (or harmonic thereof) a beating effect is seen as on-screen flicker. RPM ensures this cannot happen.



Conclusion: RPM rarely causes flicker so any problems are more likely to be related to the control (DMX / DALI / 0-10V) input. RPM is the best choice for LEDs that will be viewed on camera.

DC DIMMING - CONSTANT CURRENT

Constant current LEDs don't have an intrinsic current limiter. They simply have a specified current rating such as 350mA or 700mA. For this reason, a constant current LED will be damaged or destroyed if connected to a constant voltage dimmer. Constant current dimming is good for dimming LEDs where long and variable cable lengths are involved. It's also the most efficient as the current is controlled electronically, rather than being wasted as heat in the lamp.

Most constant current dimmers use a form of very high frequency modulation similar to that used in switch mode power supplies. So long as the modulation frequency is above 1KHz, there is little chance of the dimmer being responsible for lamp flicker.