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Dimming LEDs

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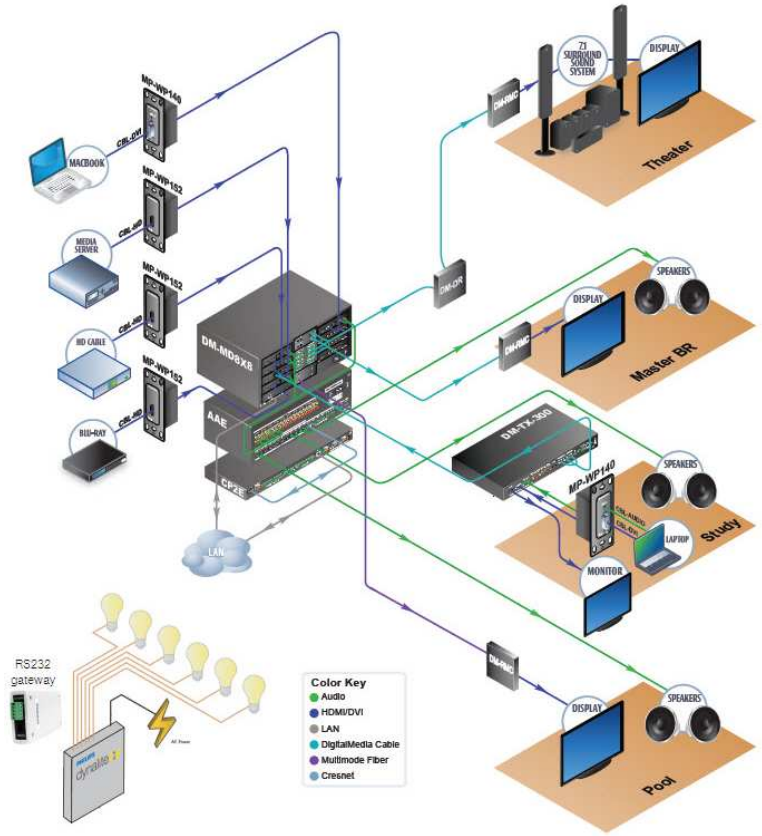
March, 2015



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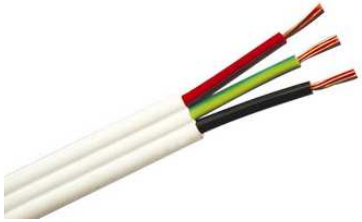
Agenda

- Retrofit LED solutions
- Leading Edge dimmers
- Trailing Edge dimmer
- LED constant current Drivers
- DALI/1-10VDC controls
- DMX512

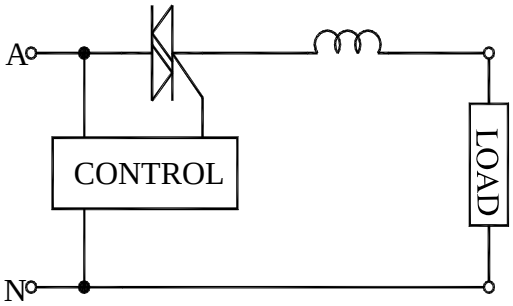
Retrofit

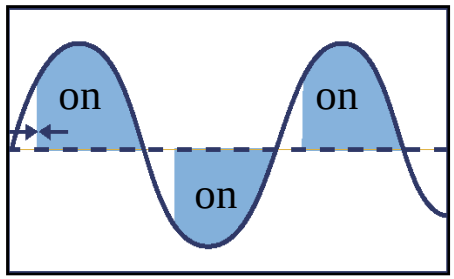


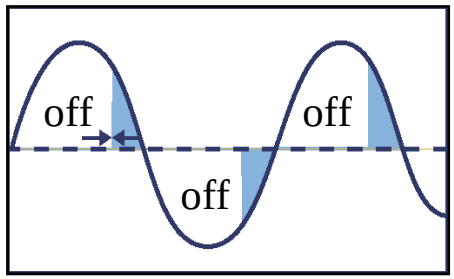
- AS3000 dictates that traditional MR16 50W lamps have transformer per lamp.
- This is not suitable for retrofit LEDs. Typical retrofit LEDs are 7-10W in power consumption.
- Electronic transformers have minimum load requirements of 20W.
- Result is you need 3 LED retrofits per electronic transformer to even switch reliably.
- Dimming performance is non linear & poor.

Leading Edge Phase Control

- Most traditional form of dimmer
- Simple, cost effective and efficient
- Used with resistive and inductive loads
- Examples:
  - Incandescent / Mains Voltage
  - Low Voltage fittings with inductive transformers
  - Some LV fittings with electronic transformers
- Most popular form of dimming







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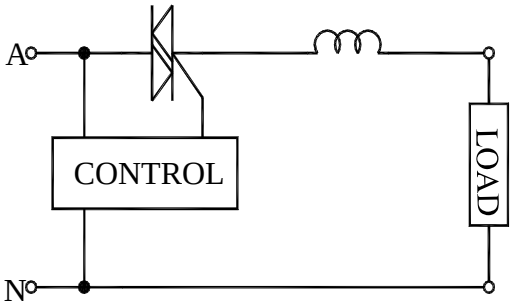
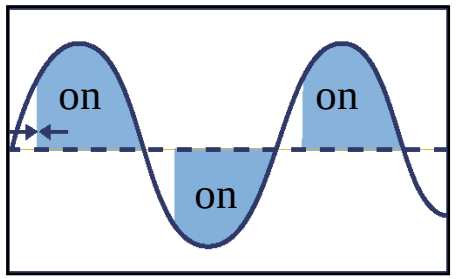
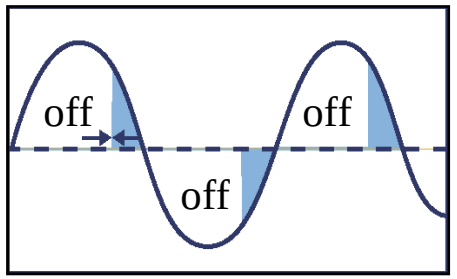
Leading Edge Phase Control

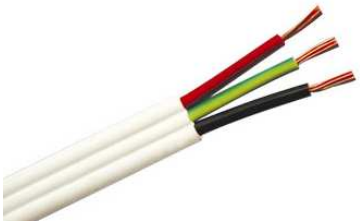
- Series inductor used to create “rise time” to avoid incandescent lamps singing when dimmed.
- Typical stage & studio dimmers have 400uS rise time.
- Philips Dynalite “Big Box” have 200uS rise time
- Philips Dynalite Din Rail have in the order of 30uS rise time
- The larger the rise time, the better performance for incandescent lamps but worse for LEDs.
- This is also true for MR16 lamps utilising electronic transformers.



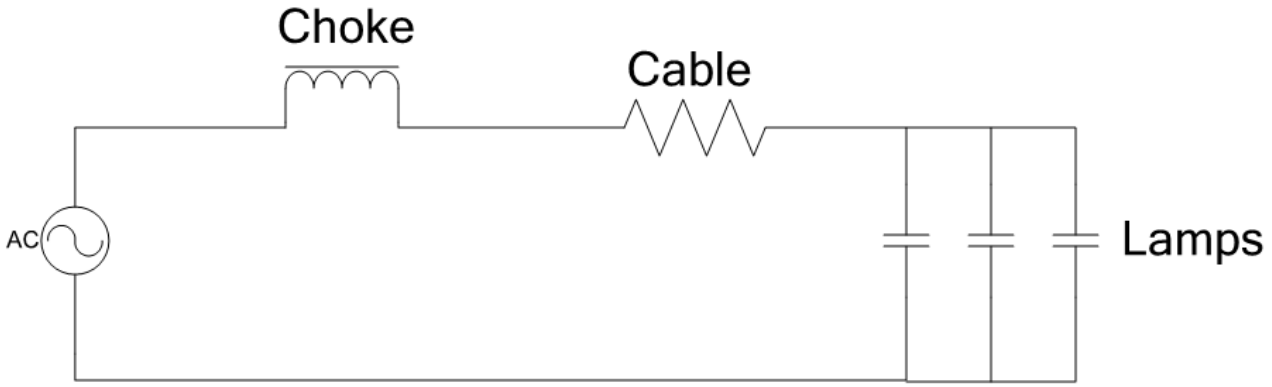




Typical Leading Edge Dimming



- Typical dimming scenario above can be electrically modelled as below.



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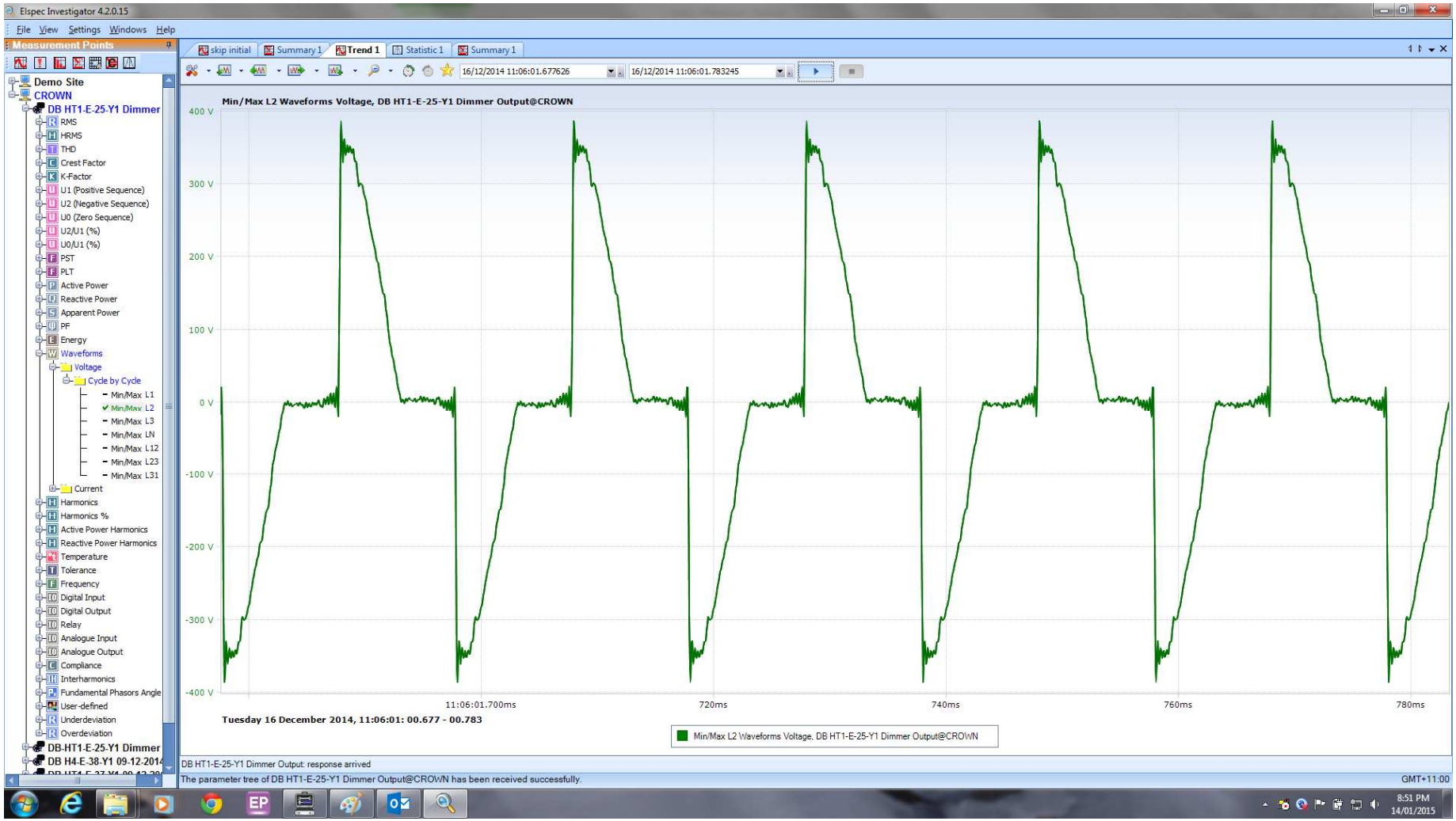
Typical Ringing exhibited by leading edge dimming into capacitive loads



Leading Edge

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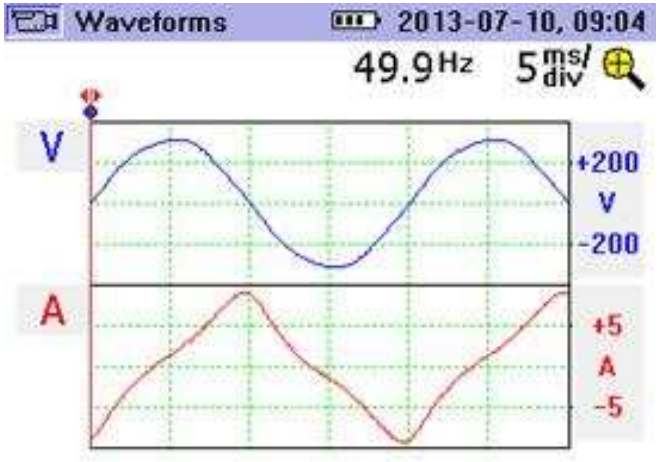
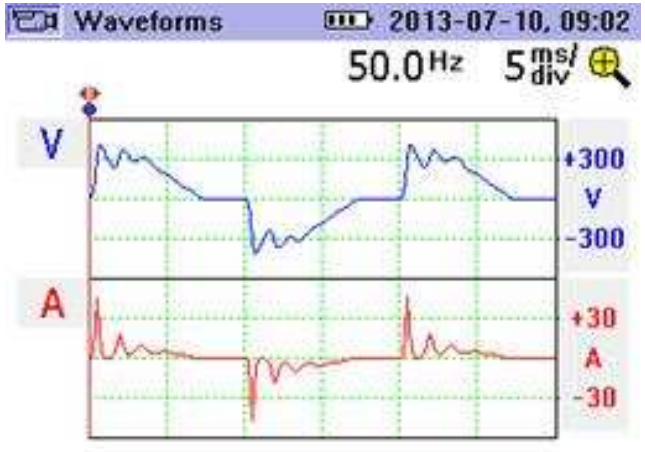
LED – Dimming – How badly it can go wrong….

- Typical high power LEDS fitted to leading edge dimmer. Quantity of over 30 lamps running at 100%. All is well. Note poor power factor



- Dimmer is set to 70%. The capacitive LEDs with influence from inductive choke & series circuit resistance create a tuned RLC ring circuit with the step voltage from the dimmer creating a ring overshoot 100 times per second. Most of these LEDs failed within 2 minutes.
- Peak Voltage -450V, Peak Current 42.5A



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LED – Leading Edge Solutions.

- DDLE801 Purpose built LED dimmer
- Active load per channel
- Still need to de-rate channels
- Superior mains tracking

- DMAL120F Active Load
- Suppresses circuit ringing
- Provides load when thyristor tuned off to discharge capacitors in LEDs.
- Also suitable for trailing edge dimmers

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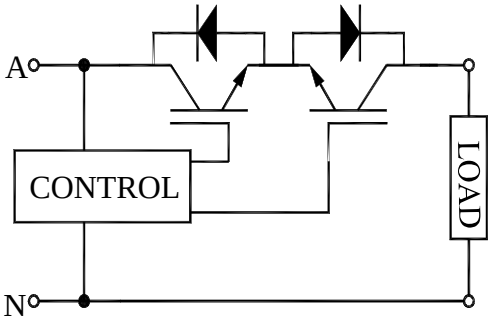
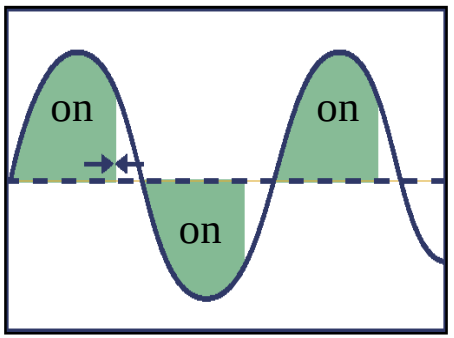
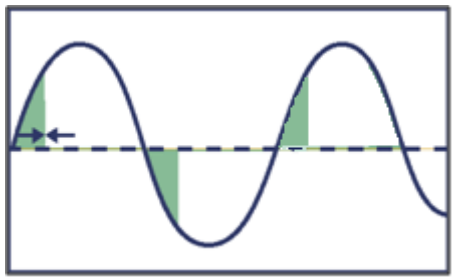
Trailing Edge Phase Control

- Rise time controlled by Sine Wave
- Suitable for capacitive and resistive loads only
- Examples:
  - Incandescent/Mains Voltage
  - LV fittings with electronic transformers
- Not as common as leading edge phase control
- Major Benefit –quieter or more silent dimming
- Uses MOSFETS as dimming devices which are more frail to current & voltage surge when compared with thyristors.







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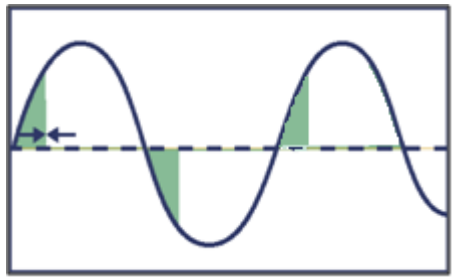
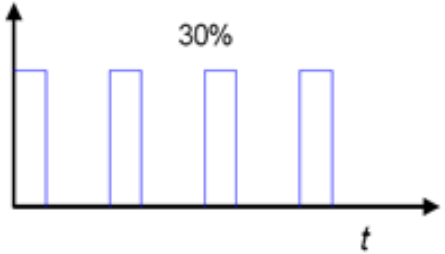
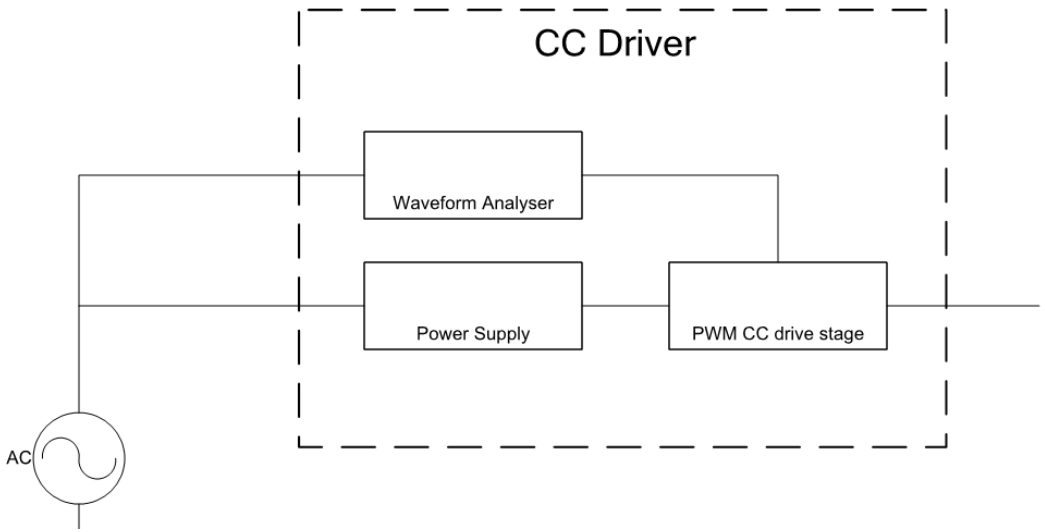
Constant Current Drivers – Phase Control





- Many drivers available typically Osram, Diginet, Meanwell.
- Later generation have lower capacitance & can be suitable for both leading & trailing edge dimming.
- Far better performance on trailing edge.
- Are prone to mains disturbance (flicker, harmonics)
- Typically LED current is between 350 & 700mA

Constant Current Drivers – Phase Control



- Challenge for the driver is to have enough energy at low levels to keep the power supply alive without creating increased capacitance.
- Waveform analyser has to allow for both leading & trailing edge.
- Some manufacturers such as Tridonic allow Trailing edge only.

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Constant Current Drivers – DALI

- Many drivers available typically Philips, Osram, Diginet, Meanwell.
- Far better performance than phase control.
- Are not prone to mains disturbance (flicker, harmonics) due to fixed mains supply
- Typically LED current is between 350 & 700mA
- Bottom end dimming performance is far superior.
- Generally more linear in dimming response.

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Special Drivers – DALI

- Great demand for “Tunable White” or RGB control.
- Tunable white used to enhance retail experience or replicate sun light (circadian rhythm) for office tenancy applications.
- One DALI address can have both intensity & colour selection controls.
- Part of DALI IEC 62386.
- Known as extension 209 or “type 8” control.

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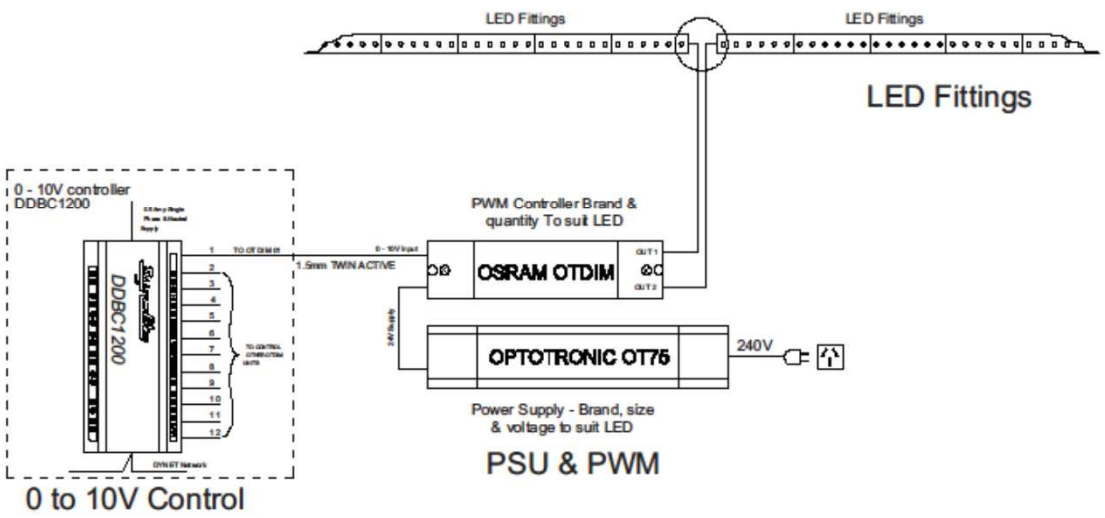
LED 1(0) to 10v Control - Schematic

Typical LED Control - using 0 to 10v control from Lighting Control System



- Be wary as many controls follow fluorescent ballast standard of 1-10VDC & will not fully extinguish LEDs.
- Far better performance than phase control.
- Are not prone to mains disturbance (flicker, harmonics) due to fixed mains supply
- Be wary with SELV & ELV interfaces (DDMC802 with ballast card)

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DMX512

- **D**igital **M**ultiple**X** communications protocol used mainly to control stage lighting
- Method for controlling single controlling source to multiple locations
- Uses RS-485
- Considered ‘Entertainment Technology’
- Useful for colour changes in LED control.
- Useful for large or dynamic control requirements as it is a very fast protocol controlling 512 channels.
- Many Dynalite devices compatible with DMX – transmit or receive.
- Preferred method of interface with Philips Color Kinetics.

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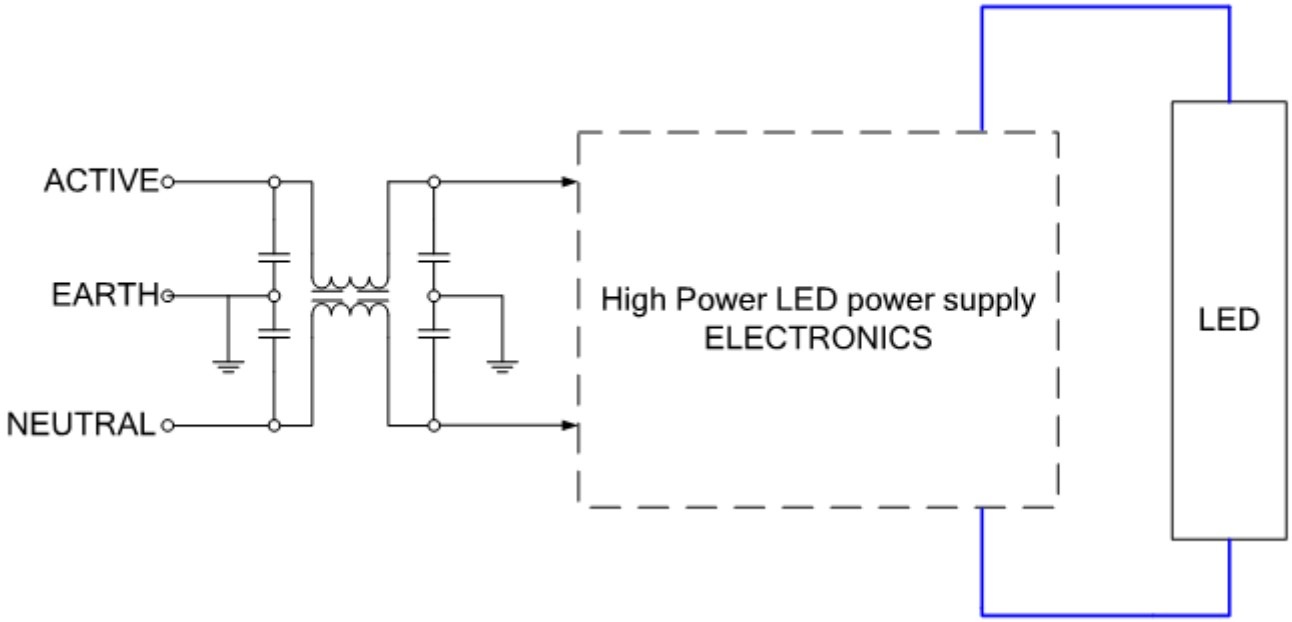
RCD & Electronic Power Supplies



- Electronic Ballast operate at high frequency requiring an input filter to minimise noise injection into mains supply (EMC compliance). Typical of 1mA per power supply.
- Higher current in Active-Earth path cause active neutral imbalance & therefore false tripping of RCD.

Mains Harmonics & Flicker

- Most mains supply is inherently noisy with the loss of sinusoidal current devices & most modern loads being active.
- Most typical current waveforms for LED devices are close to square wave causing huge increases in odd harmonics.
- Power Quality standard is EN50160 which allows for +10/-15% flicker which is suitable for whitegoods. However LED flicker is noticeable at <3% mains flicker. So whilst mains may seem compliant by the outdated standard, much flicker can be observed in retrofit & phase control LEDs.
- Installation may be fine when commissioned but flicker seems to increase after 12-18 months. Typical complaint where the mains tends to increase content of flicker & harmonic distortion. Can be impacted by neighbors migrating to LEDs, Solar invertors, VFD's etc.
- Leading edge dimming of capacitive loads reflects ringing onto the mains This is known as "inter-harmonic" distortion & can be observed impacting 15th harmonic & above when testing with EN50160 test equipment.

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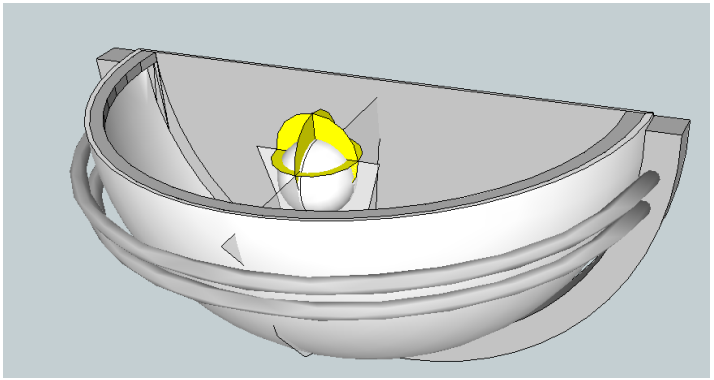
Incandescent 240VAC lamps on TE



- Be wary of installing incandescent lamps on trailing edge dimmers when installed filament up as per typical wall sconce.
- When filament fails, it normally drops onto the incoming connection points creating a huge inrush on the dimmer channel. This is too fast for the fuse to react but will generally cause failure of the mosfets in the dimmer drive stage.

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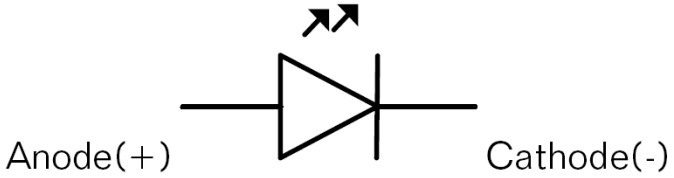
LED Basics

- Light Emitting Diodes (LEDs) are semi-conductor devices that emit photon energy (light) when an electrical current is passed through them.



- LEDs pass current in one direction only, from Anode to Cathode and block current in the reverse direction.
- To produce light a voltage needs to be applied, which exceeds the LED's forward voltage drop (VF) in order for current to flow.
- VF is generally in the range of 0.7 – 4V and varies depending upon the material composition of the LED & LED colour.

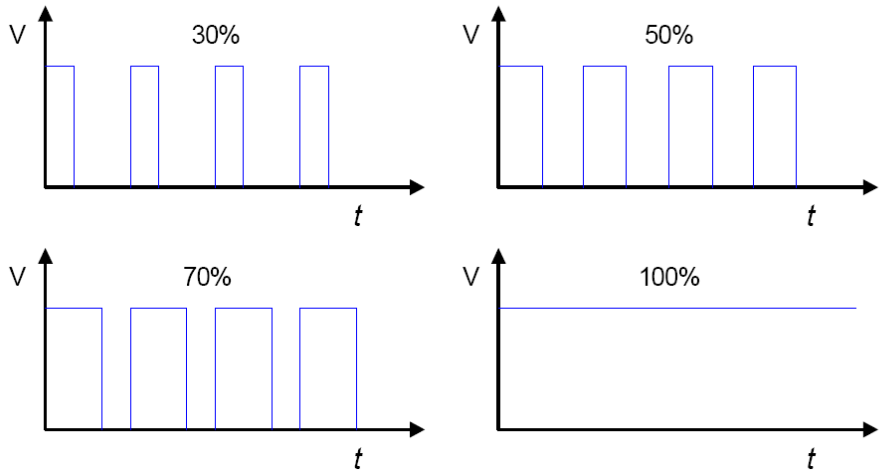
LED Dimming

The most common way of dimming LED is Pulse Width Modulation (PWM).

This technique dims the LED by supplying the nominal current at a variable duty cycle, which enables a much greater dimming range. 50% brightness is achieved with a 50% duty cycle.

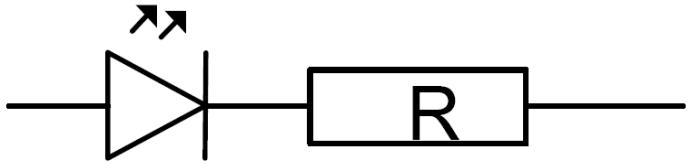
The frequency of the PWM is generally 100 Hz or greater, so that flicker is not discernable by the human eye.

The flicker can be seen in some non-broadcast quality cameras e.g., web cams



LED Voltage Mode

The simplest method of driving an LED is to apply a DC voltage Vs to the LED with a resistor R in series. This will control the current and protect the LED. The forward current (IF) can be controlled by selecting a suitable resistor. Voltage mode LED fittings incorporating integral current regulation circuitry are designed for connection to a nominal voltage supply.

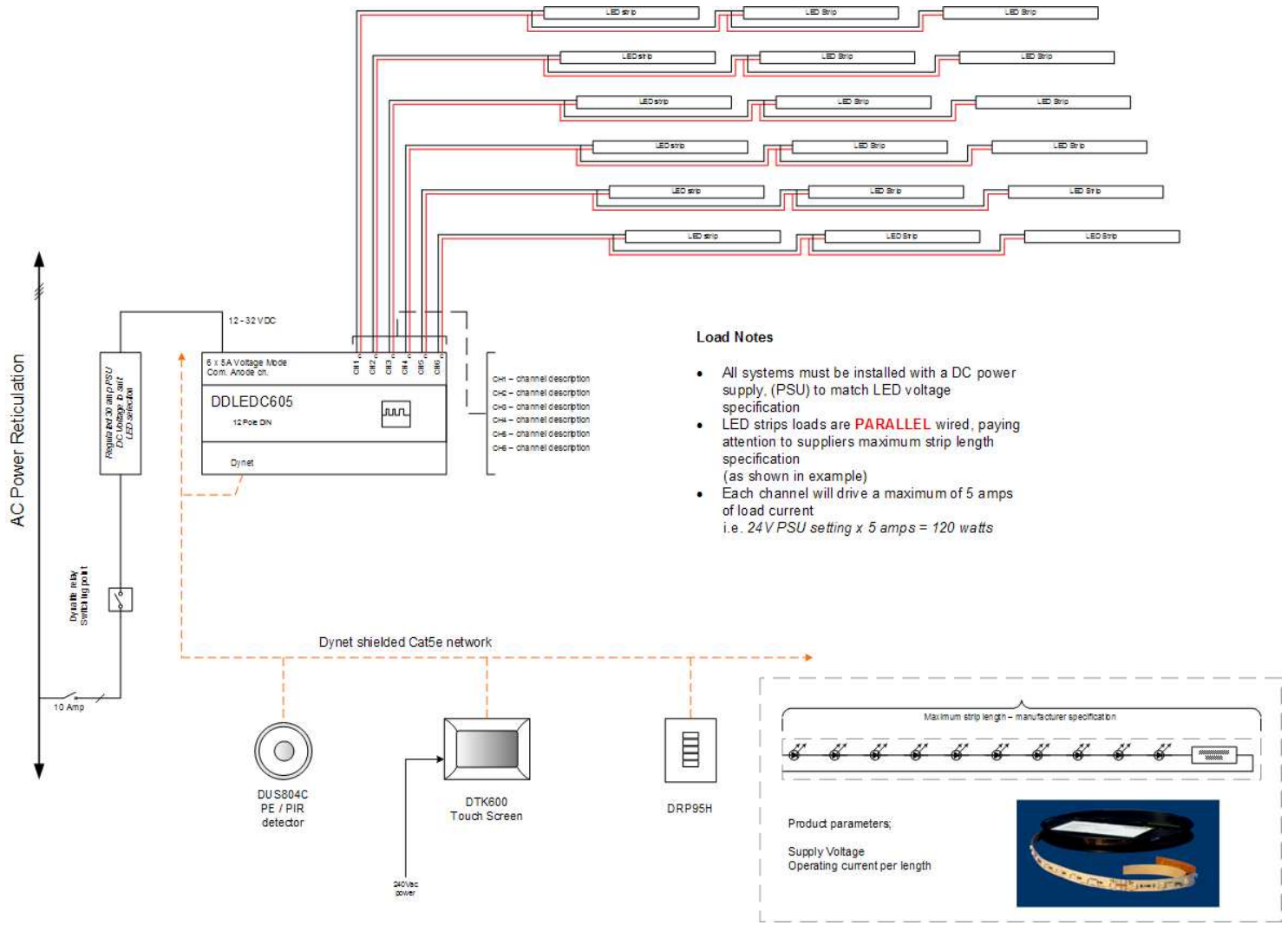


$$I_F = (V_S - V_F)/R$$

i.e.
For a Luxeon® LED to run from a 12V supply at 350mA with a V_F of 3V, it would require a resistor value of:
$R = (V_S - V_F)/I_F = (12 - 3)/0.35 = 25.7$ ohms

Load Information

LED Voltage Mode



Load Information

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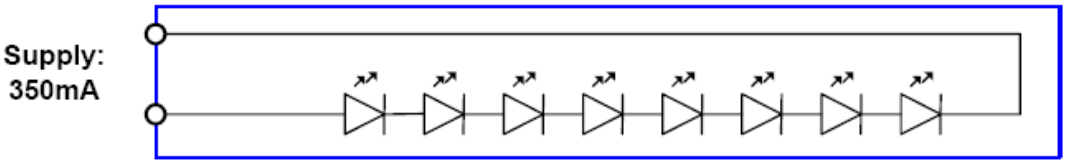
LED Voltage Mode - Considerations

- Dynalite DDLEDC605 has 6 outputs of up to 5 amps with a total load of 20 amps 12 or 24 volt
- It uses PWM to control light level
- Power Supply must be matched to the LED
- Useful for large loads of LED to be controlled together i.e. cove lighting
- Useful where the designer has final say in LED selection and can ensure the product specified is delivered to the project to avoid incompatibility issues.

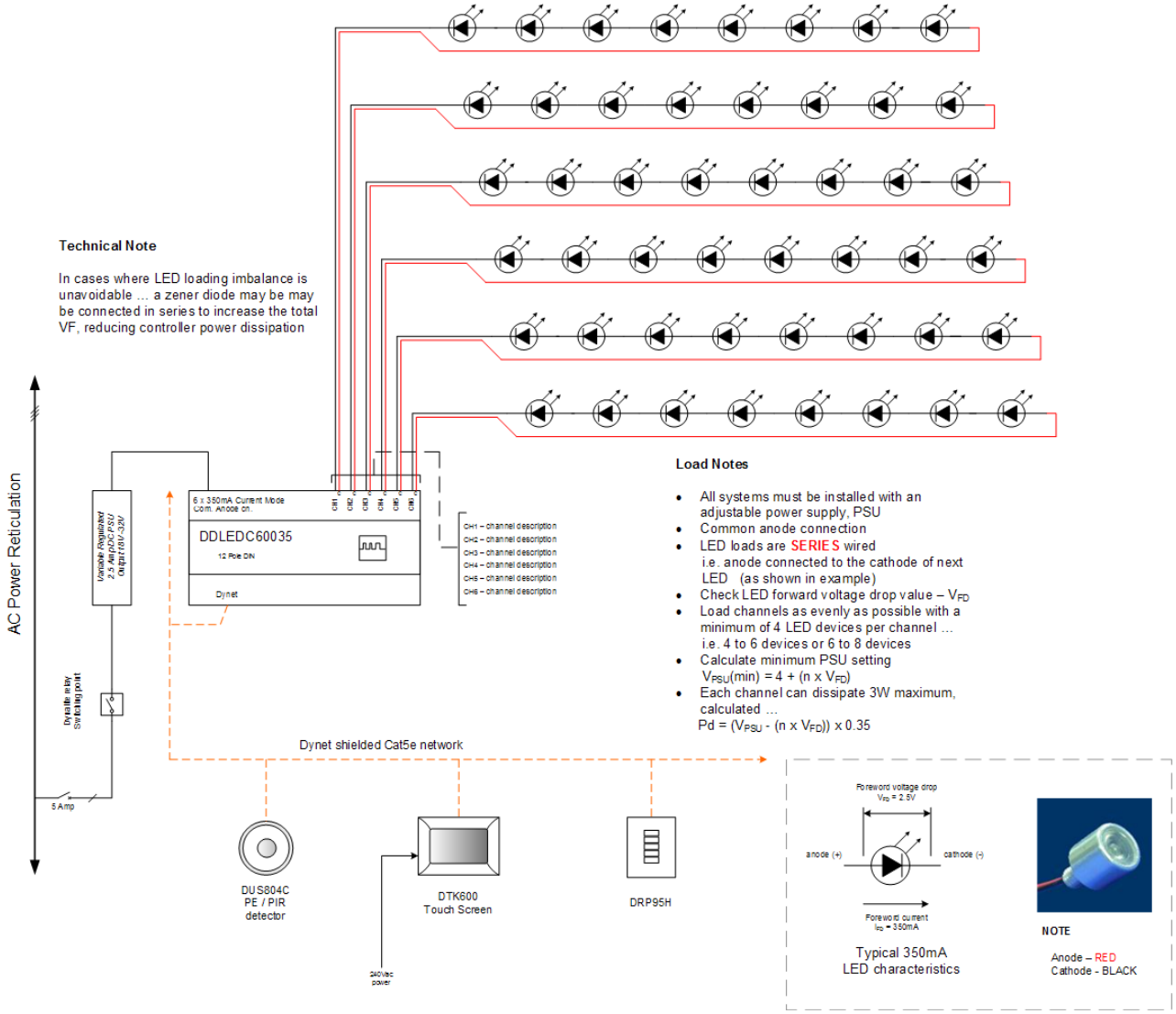
LED Current Mode

Another method of driving an LED is to include a constant current regulator, which eliminates any variations due to inconsistencies in V_F.
Current mode LED fittings have no internal current regulation and therefore must be connected to a constant current supply.
Following is the circuit diagram for a typical current mode LED fitting.



Load Information

LED Current Mode



Load Information

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