Application Note: 112
Dimming Methods

Dimming

Dimming is the process of controlling the amount of electrical power supplied to a light source. The four most popular methods for dimming lighting loads are described below and cover 0-10Volt dimming & PWM (Pulse Width Modulation) dimming, Forward-Phase (usually referred to as “Triac” or Incandescent Dimming) and Reverse-Phase (usually referred to as ELV or Electronic Low Voltage Dimming).

Dimming Methods

0-10V Dimming (-RD at the end of an EPtronics Part Number)
This method can use a number of devices to control the dimming. EPtronics latest products all have UL Class 2 isolated dimming and can be wired as Class 2 or Class 1 circuit. Label will state: Isolated Class 2 Dim suitable for Class 1 or Class 2 circuit

- EPtronics 0-10V Dimmable LED Drivers use CCR (Constant Current Reduction) based on the input signal level to achieve dimming. EPtronics latest fixed output current LED Drivers products provide 0-10V Linear Dimming 1% – 100% with Dim to Zero at ≤1.0V Dim.
- EPtronics programmable LED Drivers provide Programmable 0-10V Linear or LOG Dimming 1% – 100% with programmable minimum dim and programmable Dim to Zero YES/NO.

Dimmer Types

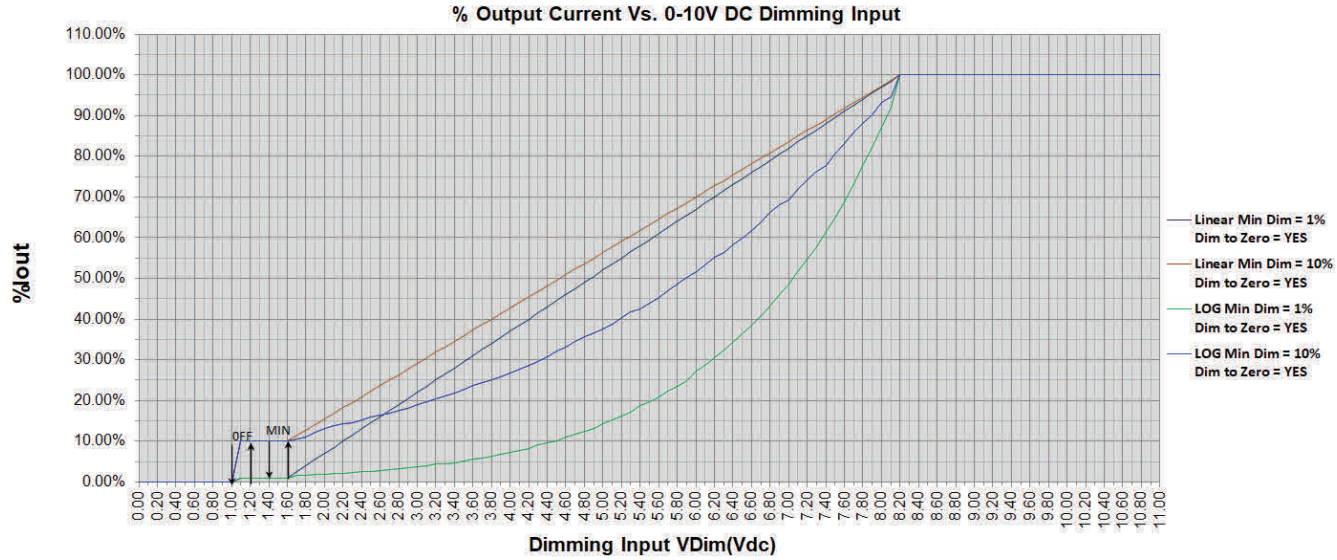
- 0-10V Controller - outputs 0 to 10V control as either a current sink, or a current source.
- 0-10V Wall Dimmer - uses a passive current sinking dimmer to sink ~5mA off a 0-10V input from an LED Driver.
- Potentiometer - For EPtronics drivers a 50K Ohm 2- terminal connection is recommended.

Note: Most controllers and dimmers cannot get to 0V. EPtronics min dim occurs at <1.0V Dim to handle this.

Summary of 0-10V EPtronics Dimming

- Controls current to LED's via CCR method.
- Fixed output constant current LED drivers dim to 1% at ≤1.6Vdim and dim to zero at ≤1.0V Dim.
- Programmable LED Drivers dim to %Min Dim programmed at ≤1.6Vdim and if selected dim to zero at ≤1.0V Dim
- Better energy efficacy.
- Color of light could change as LED's are current dependent for color

EPtronics Typical 0-10V Dimming curve: Programmable Drivers (Fixed will be per Linear 1% Min Dim curve)



Application Note: 112
Dimming Methods

PWM (Pulse Width Modulation) Can be use with EPtronics –RD 0-10V Dimmable Drivers, Vpulse 0-9V @ >2KHz.
This method can use a number of devices to control the dimming. EPtronics latest products all have UL Class 2 isolated dimming and can be wired as Class 2 or Class 1 circuit. Label will state: Isolated Class 2 Dim suitable for Class 1 or Class 2 circuit

- EPtronics standard "-RD" products can be dimmed using positive PWM dimming. Vpulse must be 0-9V @ ≥ 2KHz. The longer the positive duty cycle the brighter the output. Typical PWM duty cycles are 5-90% and must be >2KHZ frequency.
- EPtronics 0-10V Dimmable LED Drivers use CCR (Constant Current Reduction) based on the duty cycle of the PWM input signal to achieve dimming. EPtronics latest fixed output current LED Drivers products provide Linear Dimming 1% – 100% with Dim to Zero at ≤ 5% Duty cycle.
- EPtronics programmable LED Drivers provide Programmable 0-10V Linear or LOG Dimming 1% – 100% with programmable minimum dim and programmable Dim to Zero YES/NO.

Summary of EPtronics PWM dimming
- Controls current to LED's via CCR method
- Better energy efficacy.
- Color of light could change as LED's are current dependent for color
- Light output is non-linear vs. current to LED
- CCR PWM dimming operates the same as 0-10V CCR dimming as explained above except pulse width controls dim level.

AC Line Phase Dimming (-TL, -TE or -LE at the end of an EPtronics Part Number)
Requires a Leading edge (Triac/Incandescent) or Trailing edge (ELV) dimmer to change input voltage via phase cut. The resulting chopped wave has less energy than the AC line. Since these types of dimmers connect directly between AC source and AC input of LED Driver they are very popular and easy to use. They typically require no additional wiring so are good for retrofit and residential applications.

Forward Phase: Referred to as Leading Edge, Triac or Incandescent Dimming
Also commonly known as "Triac Dimming", "SCR Dimming", and forward-phase control dimming, Forward Phase dimming control is the most common form of phase dimming. It uses a silicon device, usually an SCR or a Triac, to turn the mains waveform on part way through its cycle. By varying the point at which the waveform turns on, we can alter the amount of power delivered to the load.

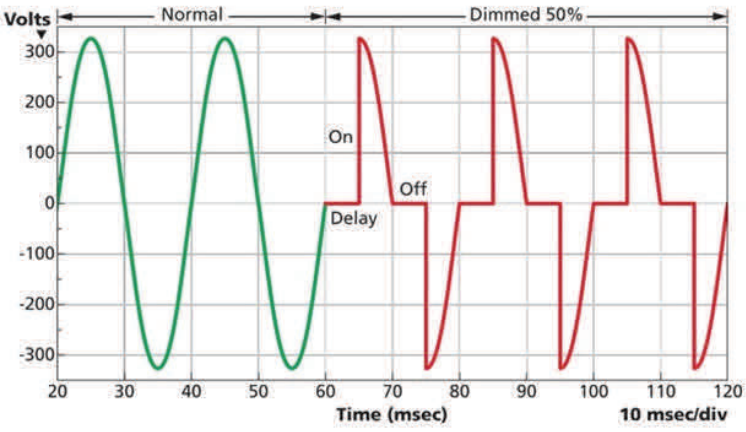
The first solid-state phase control dimmers employed SCRs and Triacs for switching. The electrical characteristics of these devices require that the unwanted power be cut from the start or leading edge of each half power cycle as show in figure 3. The very rapid switch-on time of SCRs and Triacs produces very low losses however the rapid current increase produces unwanted Electromagnetic Interference (EMI), radiated from the load circuits and harmonic distortions in the supply mains. To reduce these problems, a substantial inductor is incorporated into the dimmer circuit to slow the rate of current increase.

Reverse Phase: Referred to as Trailing Edge or ELV Dimming
A trailing edge dimmer uses a more complex circuit than a forward phase dimmer. The simple leading edge circuit can no longer be used because most Triac's cannot be turned off. (Gate turn-off (GTO) Triac's exist, but are far more expensive and less common). To implement a trailing edge dimmer, the switching device turns on as the AC waveform passes through zero, called a zero-crossing detector circuit. After a predetermined time set by the control, the switching device is turned off, and the remaining part of the waveform is not used by the load.
Trailing edge dimmers commonly use a MOSFET (metal oxide semiconductor field effect transistor), as these require almost no control current and are rugged and reliable. They are also inexpensive and readily available at voltage ratings suitable for mains operation. Another option is to use an IGBT (insulated gate bipolar transistor), which combines the advantages of both MOSFET and bipolar transistor. These are generally more expensive than MOSFET's.

Application Note: 112
Dimming Methods

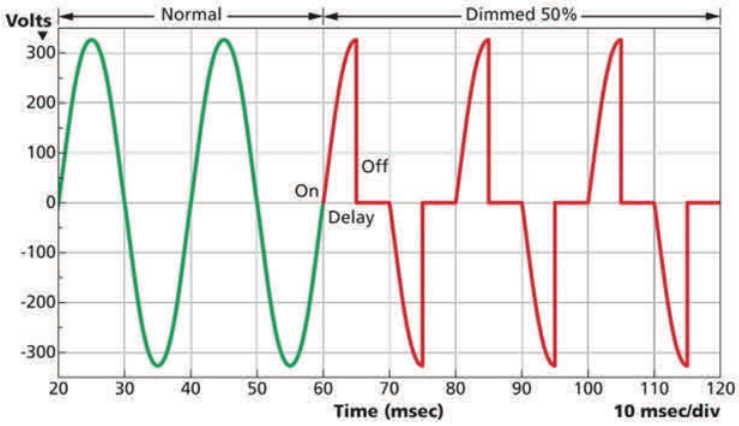
Reverse Phase Control dimmers employ MOSFET's or IGBT's to remove power from the end or trailing edge of each power cycle. The general advantage is that a reverse phase control dimmer will produce less EMI and mains distortion than a forward phase control dimmer. Using IGBT's and MOSFET's to achieve slow turn-on times has enabled the production of phase control dimmers with acceptable EMI and harmonic distortion, without the need for big, heavy inductors. The drawback is higher heat dissipated in the switching devices necessitating thermal control measures, such as heatsinks.

Typical Phase Dimmer Operation



Foward Phase Dimmer Operation: Incandescent or TRIAC

FIGURE: 3



Reverse Phase Dimmer Operation: ELV

FIGURE: 4

Summary of Phase Control Dimmers

- ELV (Electronic Low voltage) - Reverse Phase Dimmer. Developed for use on electronic transformers & switch mode power supplies.
- MLV (Magnetic Low voltage) - Forward Phase that prevents DC in the output. Dimmer Developed for use with AC magnetic transformers.
- Incandescent/Triac - Forward Phase Dimmer. Developed for use on Resistive loads & bulb filaments.
- DALI = Digital Addressable Lighting Interface - Remote controlled phase dimmer capable of either leading or trailing edge phase cut dimming of the AC line.

Application Note: 112
Dimming Methods

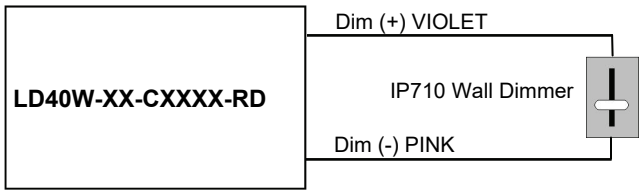
Fixed Output Constant Current -RD 2-Wire 0-10V CCR Dimming Scheme

Parameters	Minimum	Typical	Maximum
Source Current out of 0-10V VIOLET Wire	0mA	—	1.0mA
Absolute Voltage Range on 0-10V (+) VIOLET Wire	-2.0V	—	+15V

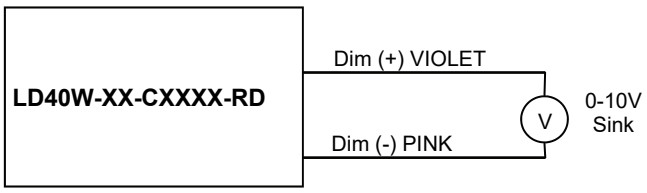
Notes

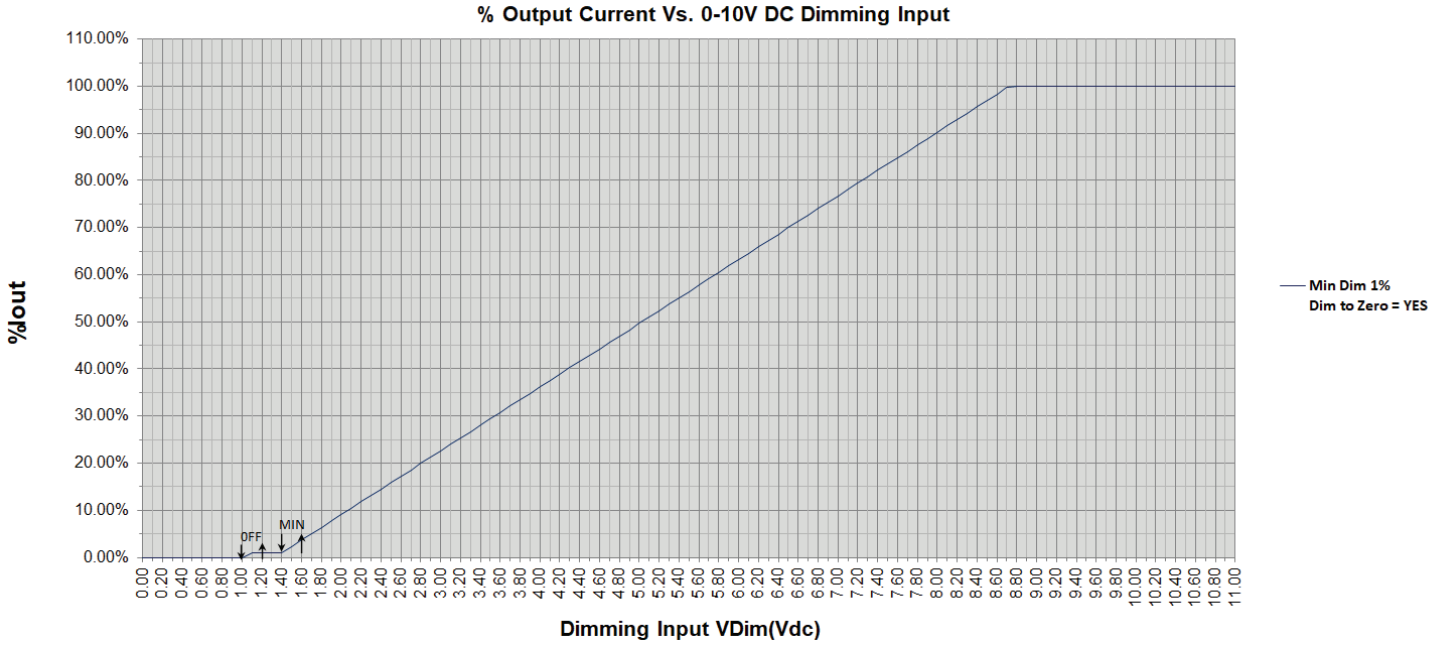
1. -RD 0-10V dimmable version comes with an extra two wires +VIOLET/-PINK on the output side.
2. -RD version is compatible with most 0-10V Wall Slide dimmers and direct 0-10V analog signal. Recommended wall slide dimmer is Leviton IP710 or equivalent
3. -RD 0-10V dimmable version is Dim to Zero @ ~1.00V and 1% Min Dim.
4. -RD 0-10V dimmable version output will be 100% with VIOLET/PINK open and minimum with VIOLET/PINK Shorted.
5. Dimming wires +VIOLET/-PINK must not touch any other wires or damage to LED Driver can occur.

-RD 2-Wire Resistance Dimming Scheme



-RD 2-Wire 0-10V Analog Dimming Scheme





Application Note: 112
Dimming Methods

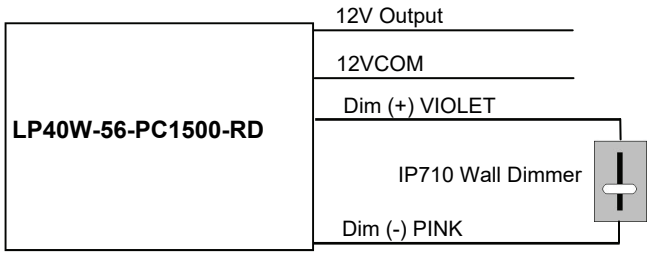
Programmable Output Current -RD 2-Wire 0-10V CCR Dimming Scheme

Parameters	Minimum	Typical	Maximum
12V Auxiliary Output	11V	12.0V	13.0V
12V Auxiliary Output Source Current	0mA	—	200mA
Absolute Voltage Range on 0-10V Input (VIOLET Wire)	-2.0V	—	+15V
Source Current out of 0-10V Input (VIOLET Wire)	0uA	—	250uA
Dim: Class 2 Isolated from AC input and Outputs	2.5kV	—	—

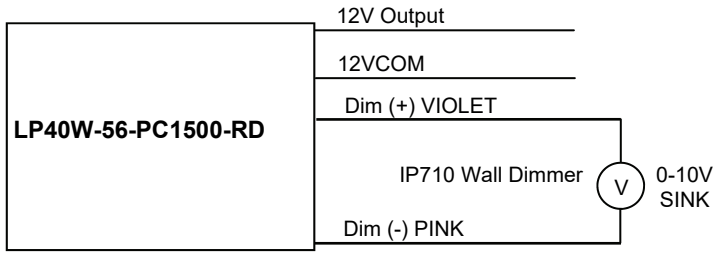
Notes

1. Part comes with 12V auxiliary & 12VCOM. 12V return is connected to 12VCOM. Isolated DIM+, DIM-.
2. Part is compatible with most 0-10V Wall Slide dimmers and direct 0-10V analog signal. Recommended dimmer is Leviton IP710 or equivalent connected between DIM+ VIOLET and DIM- PINK connectors. (Legacy DIM- = GRAY)
3. Output will be 100% with DIM+/DIM- open and Minimum Programmed Value, or OFF with DIM+/DIM- Shorted.
4. Minimum dimming level & Dim to Zero? are programmable with EPtronics LED Driver Interface Programming Tool.

-RD 2-Wire Resistance Dimming Scheme



-RD 2-Wire 0-10V Dimming Scheme



Typical Dimming Curves: Dim to Zero? = YES