

The Principles Of Dimming

An artificial light source such as a lamp or one or more lamps in a fitting (luminaire) will be specified for a purpose. Often this purpose will need a lot of light but may be too much at other times. This is nothing new, candle lamps used mechanical screens and oil lamps adjustable wicks. Aesthetic, artistic, mood setting, visual comfort, or energy saving are all valid reasons for changing lighting levels, or in other words dimming the lamps.

Dimming an electric lamp is achieved by reducing the current and thereby the power to the lamp. Early dimmers used series resistance but this generates a lot of heat and is inefficient. All modern dimmers use semiconductor technology and digital control with typical losses of less than 2% of full load.

Mains “chopping” or Phase Control

The most widely used form of dimming is phase control. Phase control dimming uses a switching device to “chop” the supply such that only part of each half cycle of the AC mains supply is applied to the load. For the remaining part the switch is open and no power is applied to the load. The amount of power to the load is therefore determined by the phase angle of the AC supply at which the switching occurs and thereby altering the ratio of off to on time from always open, no power, to always closed, full power.

The switching is synchronised to each half cycle to minimise the visual impact of momentarily turning the lamp off. In principle the same average power to the lamp could be achieved by turning off several successive cycles, but this would be easily seen and subjectively annoying.

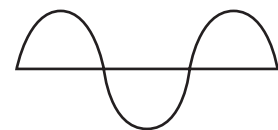
For technical reasons the synchronisation must also be symmetrical with respect to each half cycle, and this is done by using the point at which the AC supply reverses polarity, known as the zero (voltage) crossing point, as the reference to which the switching (or “chopping”) is synchronised.

Leading edge dimming – Triac and thyristor dimmers

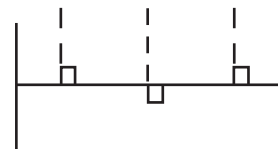
Leading edge dimming is a type of phase control where the turn on at each half cycle is delayed from the zero crossing point so that the first voltage presented to the load after the zero crossing is the rising or “leading” edge of the voltage.

Historically this type of dimmer has been identified with the use of thyristors, notably the SCR (silicon controlled rectifier) and triac. An SCR device is a unidirectional switch, whereas the triac is essentially 2 SCR devices in one package to give bi-directional control. Thyristors have a gate input by which the device is turned on or “triggered” and this gate control signal is variously referred to as the “trigger” or “firing” pulse. A characteristic of thyristor devices is that once turned on they rely on the current through them to remain on and will only turn off when the current falls to near zero, below the “holding” current. The control only needs to turn them on and they will automatically turn off at each half cycle.

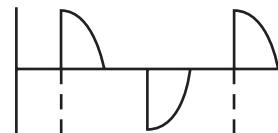
Many electronic transformers appear as a large capacitance. This means the current build up is fast and “leads” the applied voltage increase. This increase will be undesirably amplified when the applied voltage itself is rising quickly as in the case of leading edge dimmers. A common and undesirable consequence is audible noise from the transformer due to component stressing which can lead to premature failure. The preferred dimming choice for these transformers is trailing edge. As a consequence trailing edge dimmers are sometimes called capacitive dimmers and compatible loads symbolised by the letter “C” (the electrical symbol for capacitance).



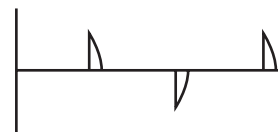
Normal line voltage, full power for the load



Ignition impulse, thyristor and bidirectional triode thyristor



Voltage reduced through adjustment of the phase angle, lower power for the load



Voltage reduced through adjustment of the phase angle, lower power for the load

Trailing edge dimming – Transistor dimmer

Trailing edge dimming is a type of phase control where the turn off at each half cycle is delayed from the zero crossing point so that the last voltage presented to the load after the zero crossing is the falling or “trailing” edge of the voltage. Here the control has to interrupt the load current and is most commonly implemented using transistor technologies and hence is commonly referred to as a transistor dimmer.

Dimming Tungsten lamps

Conventional lamps are near the ideal resistive load and pose little difficulty to either leading or trailing edge dimmers. Dimmers that are designed to exploit this simplicity are often called resistive dimmers and compatible loads designated with the letter “R” (the electrical symbol for resistance).

Dimming Wire-wound transformers for low voltage halogen lamps

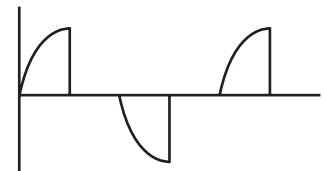
Conventional transformers are inductive in nature. An inductor stores energy when current is flowing and interrupting the current can create consequential high voltages – the basic mechanism of a car ignition coil! This means the most suitable time to turn off the supply to an inductive load is when the current is near zero and so is ideally suited to the natural behaviour of thyristor (leading edge) technology.

But an inductive load means the load current is slow to build up and “lags” behind the applied voltage. This slow build up of current which might otherwise cause a thyristor dimmer to turn off too early is overcome by a technique where the gate input is held on, or “hard fired” until the current builds up. Hard-fired thyristor dimmers are commonly called inductive dimmers and compatible loads symbolised by the letter “L” (the electrical symbol for inductance).

Dimming Electronic transformers for low voltage halogen lamps

The design of electronic transformers varies considerably and the manufacturer’s data must be checked to ensure both that the transformer is designed for dimming and to confirm the compatible dimming control.

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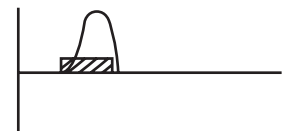
Typical form of voltage in the adjustment of a declining edge



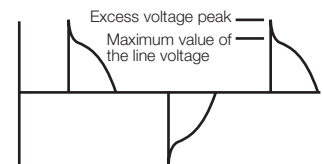
The shapes of the curves of the voltage and current with an inductive load (current is delayed)



Holding current is not reached with a short driving pulse due to the delayed current



The threshold level of the holding current is reached with an extended (“hard-fired”) ignition impulse



The shape of the curve of the output voltage of the adjuster of the bidirectional triode thyristor or thyristor when using a load that has an incompatible electronic transformer