

How a Dimmer Works

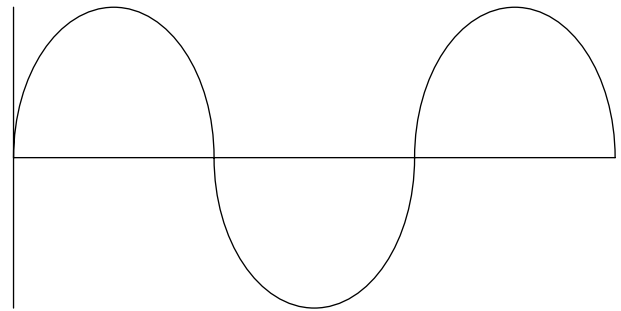
Principles of Dimming

There are several types of dimmers generally available. Those employing triac or thyristor devices operate in a very similar fashion. These are used for resistive, and inductive loads, such as incandescent, cold cathode and low voltage (inductive) lamp sources. Note that not all electronic transformers used for low voltage lamps are suitable for dimming by triac or thyristor dimmers. Specialist electronic transformers (for example those manufacturing by IBL Lighting and Mode Electronics) are required.

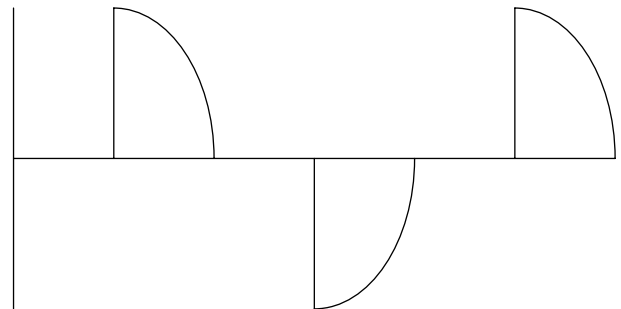
Triac and Thyristor Dimmers

Triacs and thyristors are similar components; a triac is essentially two thyristors combined in one package. Thyristors tend to be more expensive but more robust. Triacs have the advantage that they are less likely to “half wave” on failure and so the opportunity for headache induced (50Hz) flickering and subsequent damage to transformers is greatly reduced. Furthermore, when triacs are over-rated, they offer a technically more elegant solution than thyristors.

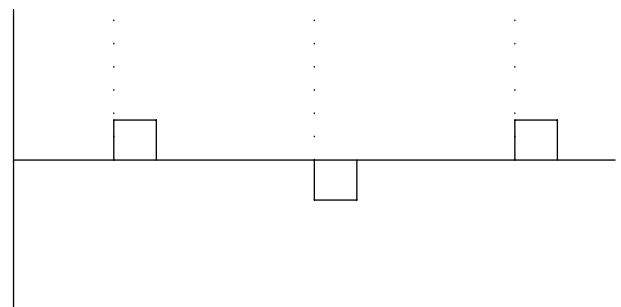
Both act as high-speed switches and in a dimmer are used to control the amount of electrical energy passing to a lamp. They do this by ‘chopping’ the sinusoidal mains voltage waveform. A trigger or firing pulse dictates at what point the device starts to conduct. The later the device is fired the later it starts to conduct and hence less power is transmitted to the lamp.



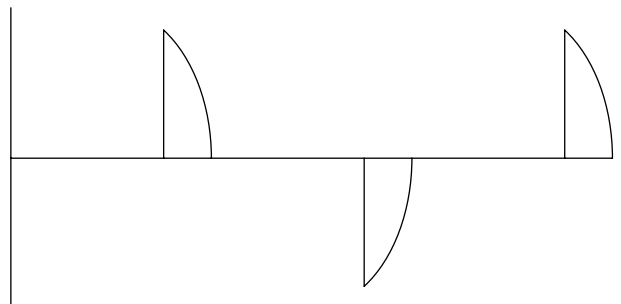
Normal Mains voltage Supply - Full power to load



A “chopped” waveform at a dimmed level - Reduced power to load



The Trigger Pulse of a “hard fired” dimmer

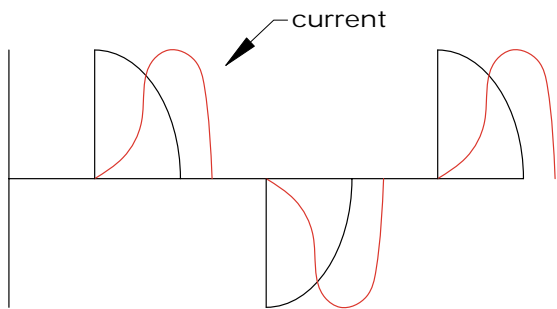


A “chopped” waveform with later firing of device. Greatly reduced power to load

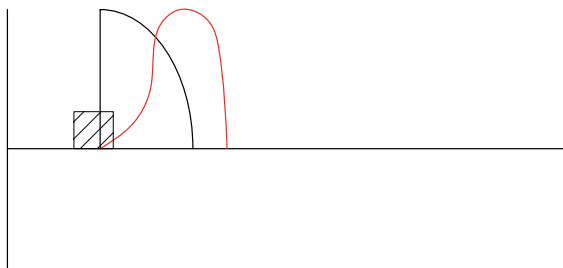
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Inductive loads

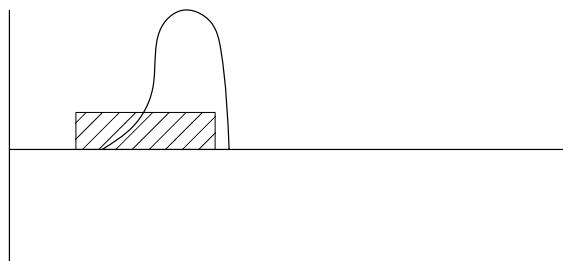
The above examples hold true for mains voltage tungsten loads but low voltage fittings introduce a transformer into the circuit that makes the load more complex. With a mains voltage incandescent lamp, which has a resistive characteristic, the voltage and current waveforms are almost identical. On the other hand, a wire wound transformer is an inductive load and the current tends to lag behind the voltage. Once triggered a triac or thyristor relies on the current flowing through the device to keep it conducting. Should the current fall below the device's threshold level it will turn off and stop conducting. However with an inductive load the current 'lags' behind the voltage so it is possible that the current through the triac will not reach the triacs threshold level before the trigger pulse ends. This results in unacceptable dimming performance. To avoid this, dimmers designed for use with wire wound transformer fed loads use what is known as a hard firing technique. This ensures that the trigger pulse is maintained for a long enough period of time to ensure that the current reaches the device's threshold level.



Voltage and Current waveform for an inductive load. (Current waveform seen trailing the Voltage)



Current threshold level not reached

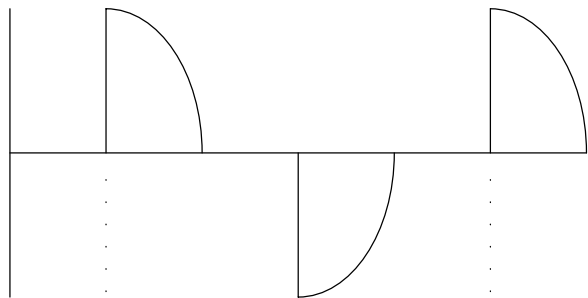


Hard Fired pulse held long enough for current threshold level to be reached

Electronic transformers

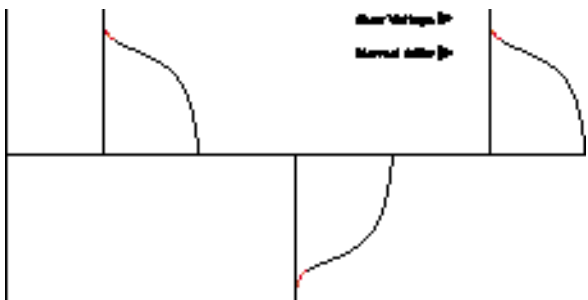
Unlike wire wound transformers, which by their very nature are dimmable, electronic transformers may induce problems and care must be taken when selecting electronic transformers to ensure compatibility with dimmers in a control system.

Almost all dimmers in the UK employ triac or thyristor pair circuitry to control the mains voltage sinusoidal waveform which reduces the energy flow and hence the light output in a lamp.



Typical voltage waveform of triac dimmer with resistive load

A triac dimmer switches the supply on and may be known as a leading edge dimmer. When used with an electronic transformer that has a capacitive nature, an amount of overshoot can occur resulting in higher than normal peak-to-peak voltages.



Triac or thyristor dimmer waveform showing voltage peaks when used with electronic transformers not designed for triac or thyristor dimming.

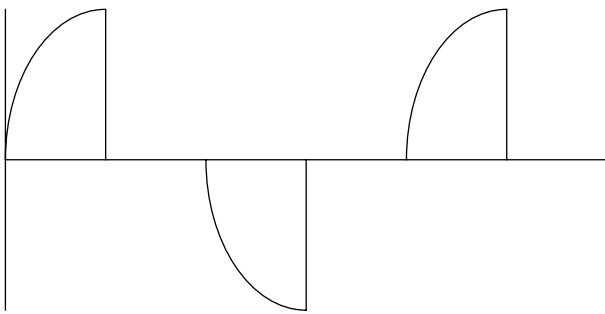
A transformer that has been designed for use with triac dimmers should not produce these peaks. A transformer that is not designed for triac dimming may work but is likely to emit audible noise when dimmed. This noise is usually a symptom of internal stress, which in turn can cause failure of the transformer. This problem will become worse with more fittings on a circuit.

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Transistor Dimmer

A number of dimmer manufacturers produce transistor based dimmers which operate in a different fashion to triac dimmers making it compatible with electronic (capacitive) transformers even if they are not designed for dimming applications.

A transistor dimmer switches the supply off and is commonly known as a trailing edge dimmer. By switching the current off the possibility for voltage peaks is eliminated.



Typical voltage waveform of a transistor dimmer

It should be noted that transistor dimmers are suitable for use with electronic (capacitive) transformers and mains voltage incandescent (resistive) lamps, but not with conventional wire wound (inductive) transformers, nor those electronic transformers, which are designed to work with hard firing triac dimmers, such as those, made by IBL Lighting or Mode Electronics.

Adaptive Dimmers

iLight™ has developed an FET (field effect transistor) source controller that solves all the load compatibility problems inherent in loads controlled by both triac and transistor dimmers.

In the iLight™ Adaptive Dimmer, both the voltage and the current are monitored, and this is linked into the CPU which controls the dimmers operating parameters. This control is dynamic and offers several major benefits over conventional dimmers.

These adaptive source controllers will work with resistive, capacitive and inductive loads. They will also detect reactive loads. If a reactive load is connected to the dimmer, it will immediately switch to full on, thus avoiding any possible damage to the gear associated with that circuit. Alternatively, the unit can be configured to switch off, if that is the user preference.

When the adaptive source controller "sees" an inductive load, it adopts a leading edge dimming mode. Furthermore the patented iPROTECT™ circuitry within the source controller can determine if the load is too great for it to cope with. In this case the unit will immediately switch off. However,

in the case where the lamp inrush current is the reason for the overload* the dimmer will attempt to turn on every half cycle. Each time it tries a small amount of energy is transmitted to the lamps. This energy has the effect of warming up the lamp filament. As the temperature rises, so does the resistance of the lamp, thus reducing the current passing through the filament. After several cycles, the filaments will have heated up sufficiently to offer sufficient resistance and so the monitoring circuitry within the source controller will allow full control or illumination of the lamps.

Should the adaptive source controller identify a resistive or capacitive load, then it will adopt a trailing edge dimming methodology. This has the added benefit that the unit will be then totally silent in operation - because trailing edge dimming techniques result in there being no magnetostriction in the suppression chokes (used for RFI (EMC) suppression).

The other major advantage of this technology over conventional dimmers is that the speed of "turn on" can be precisely and dynamically controlled. In entertainment lighting, there is a requirement to be able to flash lights on very quickly. However, when theatrical lamps are turned full on instantly, the filaments suffer thermal shock. This shock reduces the life of the lamp. By optimising the turn on time in a dynamic way, the fastest possible turn on times may be achieved whilst minimising the thermal shock to the lamps and thus dramatically extending lamp life.

Fluorescent Dimming

The method of dimming of fluorescent lamps is dependant on the type of dimmable ballast being used. This is dealt with in great detail in the Section entitled "Load Compatibility".

Note however that there is a vast array of different fluorescent lamps available. As a general rule, only those with 4 pins are dimmable. Furthermore, they must be supplied with ballasts that are electronically dimmable. Whilst there are still some mains voltage dimmable ballasts available, in general terms these are either themselves prohibitively expensive or do not comply with CE directives on EMC, Safety or the Low Voltage Directive. Use of the latter devices within the EU is illegal.

iLight™ has a range of HF Ballast controllers that are compatible with all commercially available dimmable ballasts available in the EU.

As a rule these fall into three types:- The most common units require the mains supply to be switched on or off, and the intensity of the lamp is determined by a control voltage in the range 1->10 volts.

* The inrush current of a cold incandescent lamp at switch on is 17 times greater than the running current, once the lamp has warmed up.

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The second popular ballast is the digital ballast available from Tridonic. These are referred to as DSI ballasts. The primary advantage that these ballasts have over the 1->10-volt units is that they have an internal electronic switch. By using the digital control pair, the power can be switched on/off as part of a control message. This removes the requirement to separately switch the power supply to the ballasts. Finally, there are DALI ballasts. These will become

commercially available in early 2001. In theory these ballasts offer integral controls and scene setting functions. In practice the concept requires a random addressing of each ballast. This would mean that commissioning or maintaining installed systems would be difficult and expensive. Each network is also limited to a maximum of 64 ballasts. It is understood that most ballast manufacturers will be offering units with both 1->10 volt control as well as DALI.