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Light Dimming

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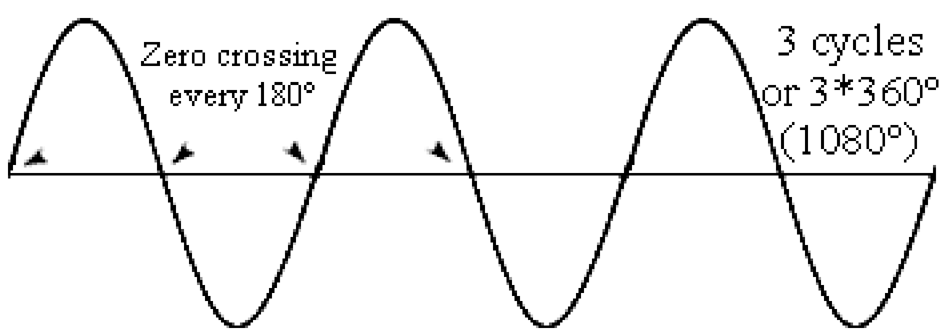
Phase controlled dimming is a method of providing AC power to a load only during certian phases of the AC cycle.

The following is a sine wave. Power is supplied by power companies in the form of AC current, in a sine wave. This is so that the power companies can raise and lower the voltage of the power by placing passive transformers throughout the grid. They need high voltages for one main reason: They could send 240 Volts AC down the line at 3,000 amps for 20-30 homes and businesses, or they can send 2,400 Volts AC at 300 amps. Given that they would have to buy, install and maintain nearly ten times the amount of copper wiring for the first example, it is less expensive to buy, install and maintain smaller wire, and many transformers. Furthermore there's something about the 'skin effect' of AC current along transmission lines, but I'll leave that investigation up to you.



You will note that there are three complete AC cycles in the above sine wave. Each time the AC line equals the neutral or ground line, we say the AC has 'Zero Crossed". This is important to know when we look at SCRs and TRIACs.

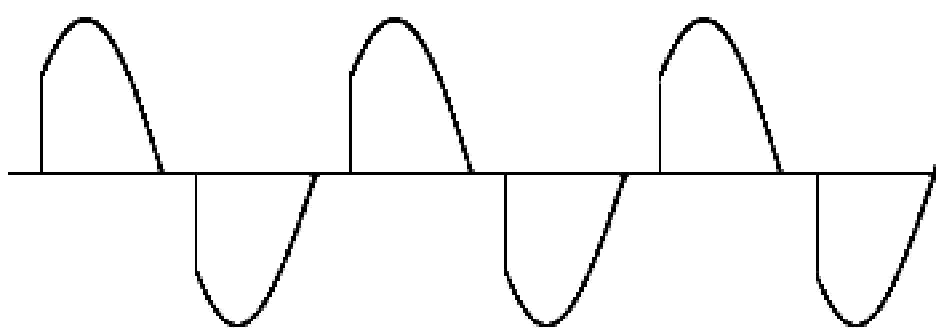
A **Silicon Controlled Rectifier (SCR)** can be thought of as a device which is either on or off. Furthermore, once turned on, it will only turn off when there is no current flowing through it. It has three terminals, and schematically looks just like a diode with an extra wire coming off the anode. This extra wire is the gate, and requires very little current to switch the SCR on. An SCR will only conduct current one way, so if the current changes polarity, it will turn off, since it won't allow any current to flow.

A **TRIAC**[1] schematically resembles two SCRs, back to back with only one gate coming from one anode. This will allow AC operation, but every time the current changes polarity, the triac will turn off unless the gate is held high.

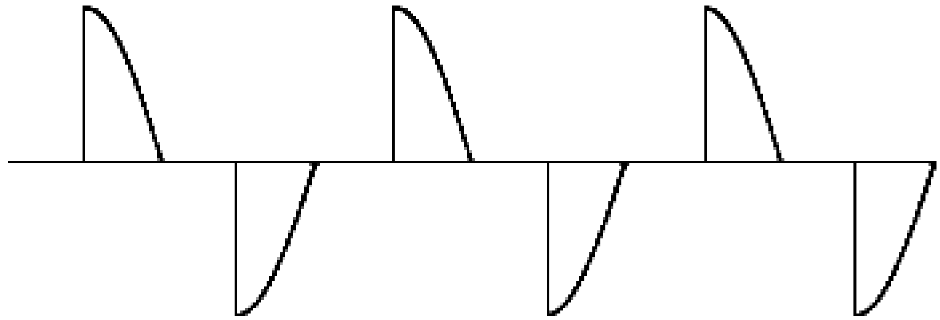
Phase Control, in this context, refers to allowing only portions of the AC cycle to go through the load. It is usually performed with a TRIAC, or two back to back SCRs. You will find that at the higher currents (10A and up) two SCRs cost less than a similarily rated TRIAC. From this point on, I will refer to only the TRIAC, but everything will also apply to the SCR based design.

We know that the TRIAC will only turn AC on, but will not turn off until there is no current flow through the device. Well, as luck would have it, AC current sources have a zero crossing two times every cycle, in which there is (read: *should be*) no current flowing. In North America that's 120 times a second, in Europe it's 100 times a second. I will refer from now on only to the North American frequency, but, again, the only difference will be timing.

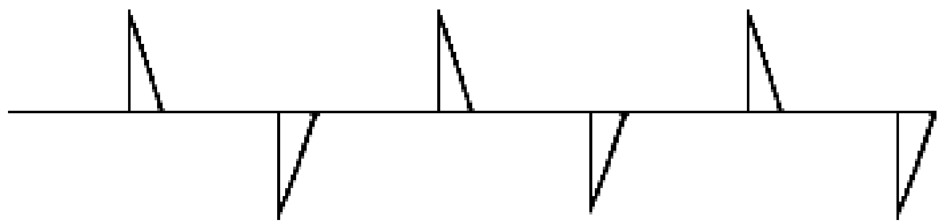
So we know that the TRIAC will turn off 120 times a second, and that we have only the power to turn the TRIAC on. So we decide that if we want less power to be delivered, then we wait until a few mS after each zero crossing, and turn the triac on. This produces this waveform:



If we want to deliver only half the power, we 'fire' the triac between each zero-crossing:



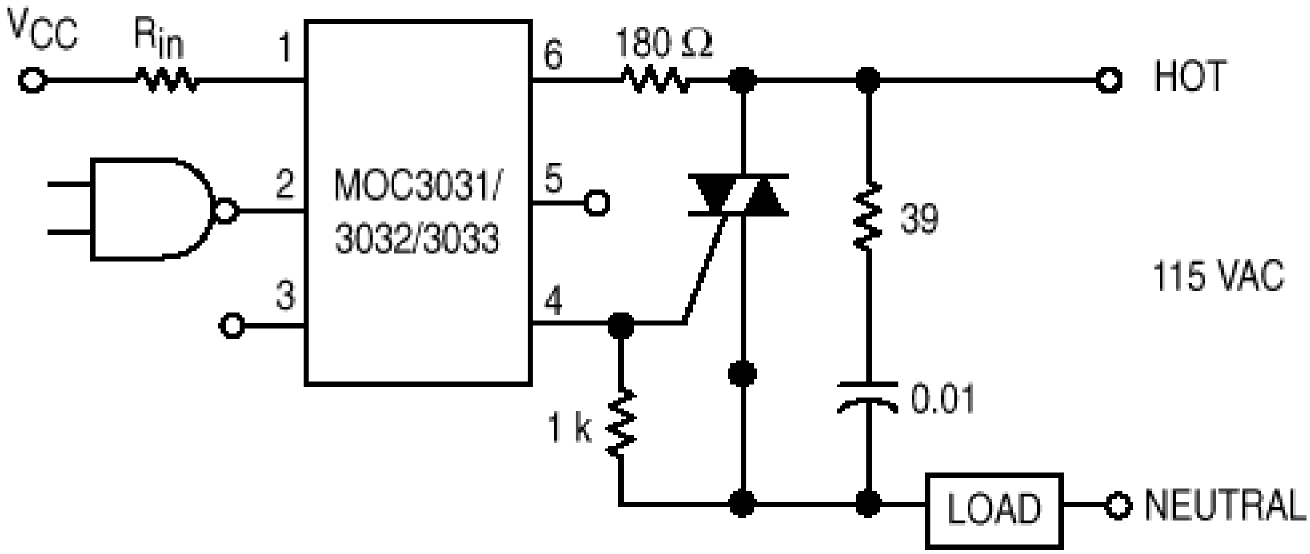
By firing the TRIAC just before each zero crossing, we can see the following:



This is usually used for light dimming because lights are resistive loads, and will not flicker even if they only get voltage spikes as in the last waveform. This method does not work well for inductive loads because they usually require a 'nicer' sine wave than what is shown here, and there may be some inductive kickback current which will not allow the TRIAC to turn off.

I do not have a circuit to post handy, so I am showing one from a Motorola Datasheet.

The following circuit diagram may be found on the Motorola data sheet mmoc3010.pdf which appears to no longer be available. It refers to specific MOC variants, but most MOC30xx variants will work in the same configuration. PLEASE check your data sheets! You may also wish to check out a few other circuits from Texas Instruments' MOC301x data sheet [2]. It has application circuits covering inductive and resistive loads, as well as sensitive and non-sensitive gate triacs.



Please click here or on the diagram for a diagram showing more detailed information, as well as an SCR version. [3]

Next: Using a PIC for Dimming (preliminary source code [4])

NOTES:
1. It appears that 'TRIAC' is a name given by those who first manufactured it. Though TRIAC is always capitalized, I have never seen (and I have searched!) an acronym expansion for it. It is defined as a "Bidirectional gate controlled thyristor similar to an SCR, but capable of conducting in both directions." **Thyrister** is a term used to classify all four layer semiconductor devices. SCRs and triacs are examples of thyristors.
TRIode for AC - a likely candidate submitted by AtariJedi. Thanks!

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