Triacs and Diacs

The Triac

The triac is similar in operation to two thyristors connected in reverse parallel but using a common gate connection. This gives the triac the ability to be triggered into conduction while having a voltage of either polarity across it. In fact it acts rather like a "full wave" thyristor. Either positive or negative gate pulses may be used. The circuit symbol for the triac is shown in Figure 1.

Triacs are mainly used in power control to give full wave control. This enables the voltage to be controlled between zero and full power. With simple "half wave" thyristor circuits the controlled voltage may only be varied between zero and half power as the thyristor only conducts during one half cycle. The triac provides a wider range of control in AC circuits without the need for additional components, e.g. bridge rectifiers or a second thyristor, needed to achieve full wave control with thyristors. The triggering of the triac is also simpler than that required by thyristors in AC circuits, and can normally be achieved using a simple DIAC circuit. A simplified triac control circuit is shown in Figure 2. The operation will be explained after introducing the Diac.

The Diac

This is a bi-directional trigger diode used mainly in firing Triacs and Thyristors in AC control circuits. Its circuit symbol (shown in figure 3a) is similar to that of a Triac, but without the gate terminal, in fact it is a simpler device and consists of a PNP structure (like a transistor without a base) and acts basically as two diodes connected cathode to cathode as shown in figure 3b.
The DIAC is designed to have a particular break over voltage, typically about 30 volts, and when a voltage less than this is applied in either polarity, the device remains in a high resistance state with only a small leakage current flowing.

Once the break over voltage is reached however, in either polarity, the device exhibits a negative resistance as can be seen from the characteristic curve in Figure 4.

When the voltage across the diac exceeds about 30 volts (a typical break-over voltage) current flows and an increase in current is accompanied by a drop in the voltage across the Diac. Normally, Ohm's law states that an increase in current through a component causes an increase in voltage across that component; however the opposite effect is happening here, therefore the Diac exhibits negative resistance at break-over.

In the simple power control circuit in Figure 2 the Diac is used to trigger a Triac by the "Phase Control" method. The AC mains waveform is phase shifted by the RC circuit so that a reduced amplitude, phase delayed version of the mains waveform appears across C. As this wave reaches the break over voltage of the Diac, it conducts and discharges C into the gate of the Triac, so triggering the Triac into conduction. The Triac then conducts for the remainder of the mains half cycle, and when the mains voltage passes through zero it turns off. Some time into the next (negative) half cycle, the voltage on C reaches break over voltage in the other polarity and the Diac again conducts, providing an appropriate trigger pulse to turn on the Triac.
By making R a variable value, the amount of phase delay of the waveform across C can be varied, allowing the time during each half cycle at which the Triac fires to be controlled. In this way, the amount of power delivered to the load can be varied.

Note that in practical control circuits using Thyristors, Triacs and Diacs, large voltages are switched very rapidly. This can give rise to serious RF interference, and steps must be taken in circuit design to minimise this. Also as Mains is present in the circuit there must be some form of safe isolation between the low voltage control components (e.g. the Diac and phase shift circuits) and the mains "live" components, e.g. the Triac and load. This can easily be achieved by "Opto-coupling" the low voltage control circuit to the high voltage power control (Triac or SCR) part of the circuit.

Figure 5. The Opto Triac

The materials used in the manufacture of Triacs and SCRs, like any semiconductor device, are light sensitive. Their conduction is changed by the presence of light; that's why they are normally packaged in little chunks of black plastic. However, if an LED is included within the package, it can turn on the high voltage device output in response to a very small input current through the LED. This is the principle used in Opto-Triacs and Opto-SCRs, which are readily available in integrated circuit (IC) form and do not need very complex circuitry to make them work. Simply provide a small pulse at the right time and the power is switched on. The main advantage of these optically activated devices is the excellent insulation between the low power and high power circuits, (typically several thousand volts). This provides safe isolation between the low voltage input and high voltage output.

Testing Thyristors, Triacs and Diacs.

Resistance tests on these devices are of limited use; SCRs and Triacs often operate at mains voltage and when they fail the results can be dramatic. At least the violent blowing of a fuse will be the usual result of a short circuit. Such a fault can be confirmed by measuring the resistance between the two main current carrying terminals of a SCR or Triac. A short circuit in both directions means a faulty component. It is quite possible however, for these devices to be faulty and not show any fault symptoms on an ohmmeter test. They may seem OK at the low voltages used in such meters, but still fail under mains voltage conditions.

The normal method of testing would be the checking of voltages and waveforms if the circuit was operating, or substitution of a suspect part when damage (e.g. blown fuses) is apparent. In many
cases these components will be designated "safety critical components" and must only be replaced using manufacturers recommended methods and components. It is common for manufacturers to supply complete "service kits" of several semiconductor devices and possibly other associated components, all of which must be replaced, since the failure of one power control device can easily damage other components in a way that is not always obvious at the time of repair.

**ANY WORK ON MAINS POWERED CIRCUITS MUST BE DONE WITH THE MAINS SUPPLY FULLY DISCONNECTED AND ANY CHARGE STORING (e.g. CAPACITORS) COMPONENTS DISCHARGED UNLESS THIS IS ABSOLUTELY UNAVOIDABLE**

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**1000W AC Motor Speed Controller**

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This triac based AC motor speed controller circuit is designed for controlling the speed of AC motors like drill machines, fans, vacuums, etc. The speed of the motor can be controlled by changing the setting of P1 potentiometer. The setting of P1 determines the phase of the trigger pulse that fires the triac. The circuit incorporates a self-stabilizing technique that maintains the speed of the motor even when it is loaded.