AN1007

Thyristors Used As AC Static Switches and Relays

Introduction

Since the SCR and the triac are bistable devices, one of their broad areas of application is in the realm of signal and power switching. This application note describes circuits in which these thyristors are used to perform simple switching functions of a general type that might also be performed non-statically by various mechanical and electromechanical switches. In these .pplications, the thyristors are used to open or close a circuit completely, as opposed to .pplications in which they are used to control the magnitude of average voltage or energy being delivered to a load. These latter types of application are covered in detail in Application Note AN1003.

Static Ac Switches

Normally Open Circuit

The circuit of Figure 20.1 provides random (anywhere in half-cycle) fast turn-on (<10µs) of AC power loads and is ideal for applications with a high duty cycle. It eliminates completely the contact sticking, bounce, and wear associated with conventional electromechanical relays, contactors, etc. As a substitute for control relays, thyristors can overcome the differential problem; that is, the spread in current or voltage between pickup and dropout because thyristors effectively drop out every half-cycle. Also, providing resistor R$_1$ is chosen correctly, the circuits are operable over a much wider voltage range than is a comparable relay. Resistor R$_1$ is provided to limit gate current (I$_{GTM}$) peaks. Its resistance plus any “contact” resistance (R$_C$) of the control device and load resistance (R$_L$) should be just greater than the peak supply voltage divided by the peak gate current rating of the triac. If R$_1$ is made too high, the triacs may not trigger at the beginning of each cycle, and “phase control” of the load will result with consequent loss of load voltage and waveform distortion. For inductive loads, an RC snubber circuit, as shown, is required. However, a snubber circuit is not required when an alternistor is used.

To better understand a typical static switch circuit, the following analysis can be made.

Figure 20.2 circuit operation occurs when switch S$_1$ is closed, the triac, thyristor Q$_1$ will initially be in the blocking condition. Current flow will be through load R$_L$, S$_1$, R$_1$, and gate to MT1 junction of the thyristor. When this current reaches the required value of I$_{GT}$, the MT2 to MT1 junctions will switch to the conduction state and the voltage from MT2 to MT1 will be V$_T$. As the current approaches the zero crossing, the load current will fall below holding current turning the triac (Q $_1$) device off until it is refired in the next half cycle. Figure 20.3 illustrates the voltage waveform appearing across the MT2 to MT1 terminals of Q1. It should be noted that the maximum peak value of current which S1 will carry would be 25 mA since Q1 has a 25 mA maximum I$_{GT}$ rating. Additionally, there will be no arcing of a current value greater than 25 mA when opening S1 when controlling an inductive load. It is important to note that the triac (Q1) is operating in Quadrants I and III, the more sensitive and most suitable gating modes for triacs. The voltage rating of S1 (mechanical switch or reed switch) must be equivalent to or greater than line voltage applied.

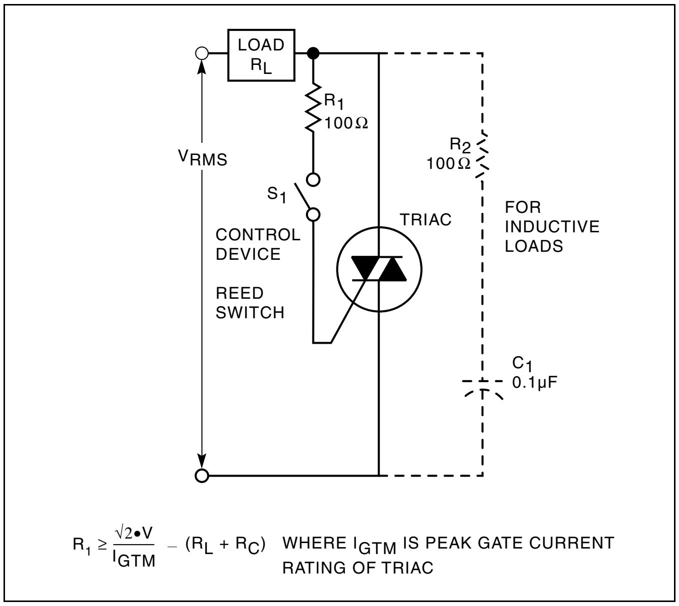

Figure 20.1 Basic Triac Static Switch

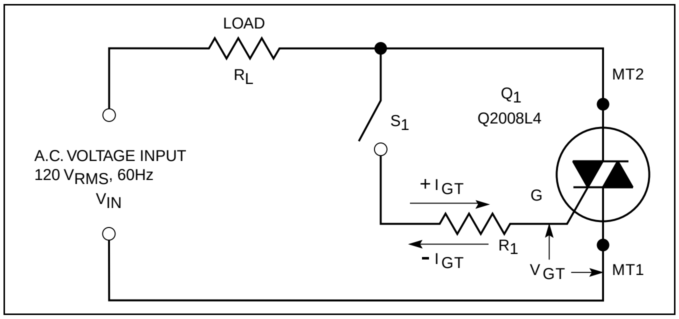

Figure 20.2 Analysis of Static Switch

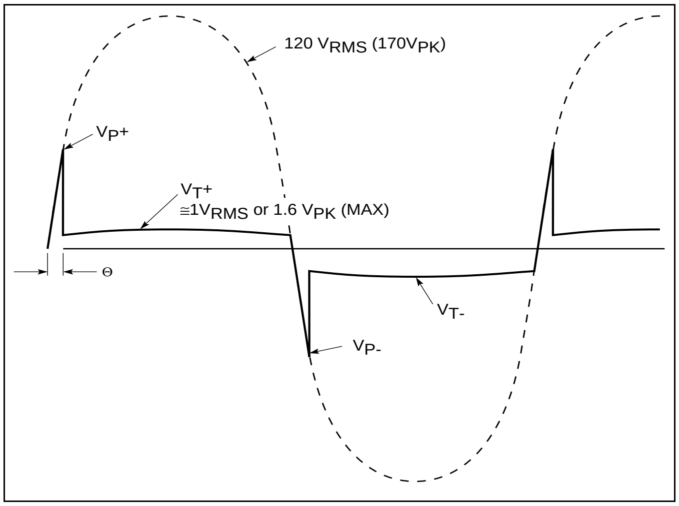

Figure 20.3 Waveform Across Static Switch

A typical example would be in the application of this type circuit for the control of 5 amp resistive load with 120V RMS input voltage. Choosing a value of 100 Ohms for R1 and assuming a typical value of 1.0 Volt for the gate to MT1 (V_{GT}) voltage, we can solve for V_P by the following:

$$V_P = I_{GT}\,(R_L + R_1) + V_{GT}$$

Note: RC is not included since it is negligible.

$$V_P = .025\,(24 + 100) + 1.0 = 4.1 \text{ volts}$$

Additionally the turn-on angle is

$$\theta = Sin^{-1}\frac{4.1}{170V_{PK}} \qquad [\theta = 1.4°]$$

The power lost by the turn-on angle is essentially zero. The power dissipation in the gate resistor is very minute. A 100 Ohm, 1/4 watt rated resistor may safely be used. The small turn-on angle also ensures that no appreciable RFI is generated.

The relay circuit of Figures 20.1 and 20.2 has several advantages in that it eliminates contact bounce, noise, additional power consumption by an energizing coil, and can carry an inrush current of many times its steady state rating.

The control device (S1) indicated can be either electrical or mechanical in nature. Light-dependent resistors and light- activated semiconductors, optocoupler, magnetic cores, and magnetic reed switches are all suitable control elements. Regardless of switch type chosen, it must have a voltage rating equal to or greater than the peak line voltage applied. In particular, the use of hermetically sealed reed switches as control elements in combination with triacs offers many advantages. The reed switch can be actuated by passing DC current through a small winding around it or by the proximity of a small magnet. In either case, complete electrical isolation exists between the control signal input, which may be derived from many sources, and the switched power output. Long life is assured the triac/reed switch combination by the minimal volt-ampere switching load placed on the reed switch by the triac triggering requirements. The thyristor ratings determine the amount of load power that can be switched.

Normally Closed Circuit

With a few additional components, the thyristor can provide a normally closed static switch function. The critical design portion of this static switch is a clamping device to turn off/eliminate gate drive and maintain very low power dissipation through the clamping component plus have low by-pass leakage around the power thyristor device. In selecting the power thyristor for load requirements, gate sensitivity becomes critical to maintain low power requirements. Either sensitive SCRs or sensitive logic triacs must be considered which limits the load in current capacity and type. However, this can be broader if an extra stage of circuitry for gating is permitted.

Figure 20.4 represents an application using a normally closed circuit driving a sensitive SCR for a simple but precise temperature controller. The same basic principle could be applied to a water level controller for a motor or solenoid. Of course, SCR and diode selection would be changed depending on load current requirements.

A mercury-in-glass thermostat is an extremely sensitive measuring instrument, capable of sensing changes in temperature as small as 0.1°C. Its major limitation lies in its very low current handling capability for reliability and long life, contact current should be held below 1 mA. In the circuit of Figure 20.4, the S2010LS2 SCR serves as both current amplifier for the Hg thermostat and as the main load switching element.

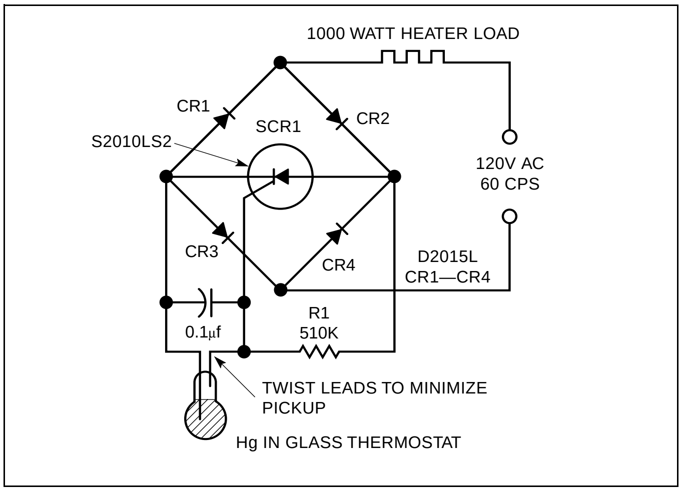

Figure 20.4 Normally Closed Temperature Controller

With the thermostat open, the SCR will trigger each half cycle and deliver power to the heater load. When the thermostat closes, the SCR can no longer trigger and the heater shuts off. Maximum current through the thermostat in the closed position is less than 250 µA RMS.

Figure 20.5 is an all solid state, optocoupled, normally closed switch circuit. By using a low voltage SBS triggering device, this circuit can turn on with only a small delay in each half cycle and also keep gating power low. When the optocoupled transistor is turned on, the gate drive is removed with only a few milliamps of by-pass current around the triac power device. Also by use of the 2N4991 and 0.1 µF, less sensitive triacs and alternistors can be used to control various types of high current loads.

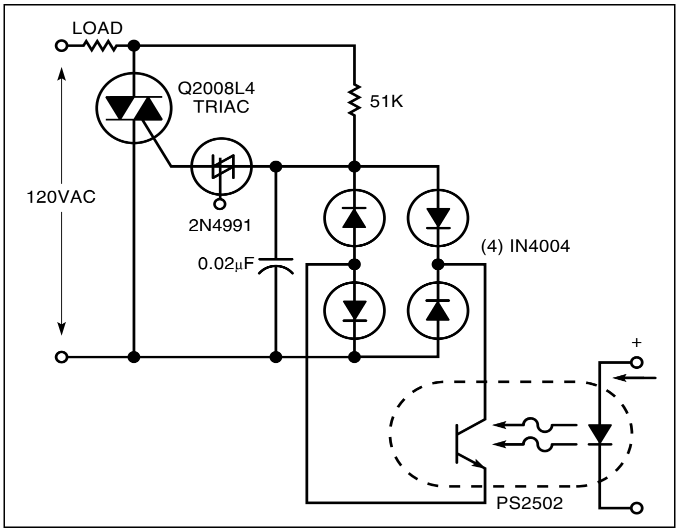

Figure 20.5 Normally Closed Switch Circuit

Optocoupled Driver Circuits

Random Turn-On, Normally-Open

There are many applications which use optocouplers to drive thyristors. The combination of a good optocoupler and a triac or alternistor makes an excellent, inexpensive solid state relay. The optocoupler manufacturers supply application information which is not always best for application of the power thyristor. A standard circuit for a resistive load is shown in Figure 20.6.

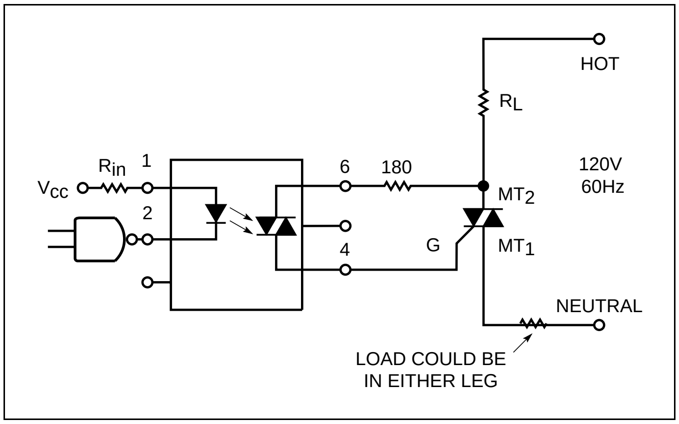

Figure 20.6 Optocoupled Circuit for Resistive Loads (Triac or Alternistor)

A common mistake in this circuit is to make the series gate resistor too large in value. A value of 180Ω is shown in a typical application circuit by optocoupler manufacturers. The 180Ω is based on limiting the current to 1 Amp peak at the peak of a 120V line input. This is good for protection of the optocoupler output triac, as well as the gate of the power triac on a 120V line; however, it must be lowered if a 24V line is being controlled, or if the R_L (resistive load) is 200 watts or less. This resistor limits current for worst case turn-on at the peak line voltage, but it also sets turn-on point (conduction angle) in the sine wave, since triac gate current is determined by this resistor and produced from the sine wave voltage as explained in Figure 20.2 of this application note. The load resistance is also important, since it can also limit the amount of available triac gate current. In most 120V applications with loads greater than 200 watts, and optocouplers from Quality Technologies or Siemens with optocoupler output triacs which can handle $1.7A_{pk}$ (I_{TSM} rating) for a few microseconds at the peak of the line, a 100Ω gate resistor would be a better choice. For loads less than 200 watts, the resistor can be dropped to 22Ω. Remember, if the gate resistor is too large in value, the triac will not turn on at all or not turn on fully which can cause excessive power dissipation in the gate resistor, causing it to burn out. Also the voltage and dv/dt rating of the optocoupler's output device must be equal to or greater than the voltage and dv/dt rating of triac or alternistor it is driving.

Figure 20.7 offers a circuit with a dv/dt snubber network included. This is a typical circuit presented by optocoupler manufacturers.

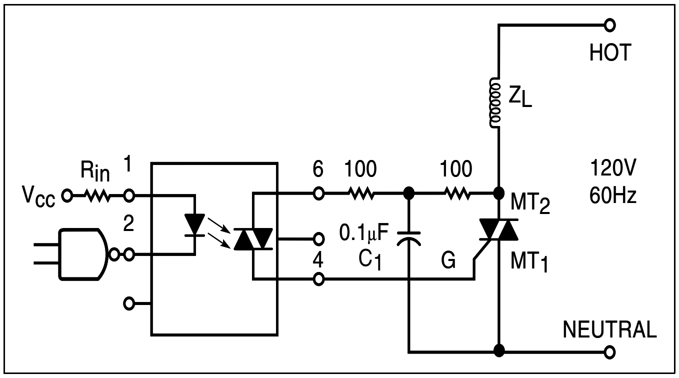

Figure 20.7 Optocoupler Circuit for Inductive Loads (Triac or Alternistor)

This clever "T" circuit hinges around one capacitor to increase dv/dt capability to either the optocoupler output triac or the power triac. The sum of the two resistors then forms the triac gate resistor. Note: both resistors should then be standardized and lowered to 100Ω. Again, this sum resistance needs to be low, allowing as much gate current as possible without exceeding the instantaneous current rating of the opto output triac or triac gate junction. By having 100Ω for current limit in either direction from the capacitor, the optocoupler output triac and power triac can be protected against di/dt produced by the capacitor. Of course, it is most important that the capacitor be connected between proper terminals of triac. For example, if the capacitor and series resistor are accidentally connected between the gate and MT2, the triac will turn on from current produced by the capacitor, hence, loss of control.

For low current (mA) and/or highly inductive loads, it may be necessary to have a latching network (3.3KΩ + 0.047µF)connected directly across the power triac. The circuit in Figure 20.8 illustrates the additional latching network.

In this circuit, the series gate resistors have been increased to 180Ω each, since a 240V line is applied. Also, note that the load is placed on the MT1 side of the power triac to illustrate that load placement is ***not*** important for the circuit to function properly.

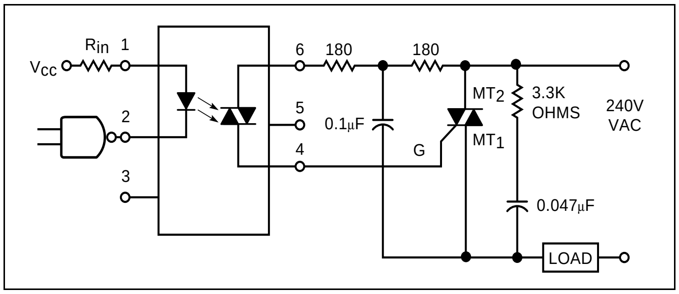

Figure 20.8 Optocoupler Circuit for Lower Current Inductive Loads (Triac or Alternistor)

It should be also noted, that with standard U.S. residential 240V home wiring, both sides of the line are hot with respect to ground (no neutral). Hence, for some 240V line applications, it will be necessary to have a triac switch circuit in both sides of the 240V line input.

If an application requires back-to-back SCRs instead of a triac or alternistor, the circuit shown in Figure 20.9 may be used.

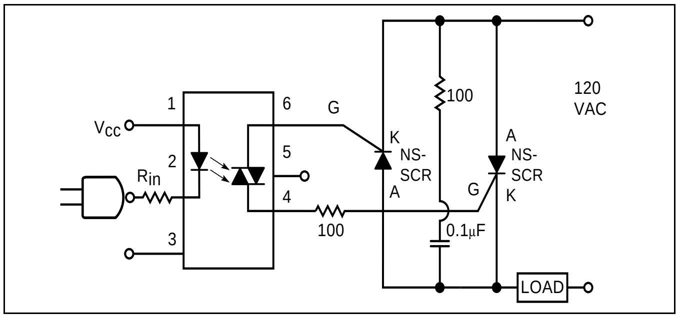

Figure 20.9 Optocoupled Circuit for Heavy Duty Inductive Loads

Again, all the aforementioned application comments and recommendations apply. Notice the snubber network can only be applied across the SCRs as shown. The optocoupler should be chosen for best noise immunity. Also the voltage rating of the optocoupler output triac must be equal to or greater than the voltage rating of SCRs.

Summary of Random Turn-On Relays

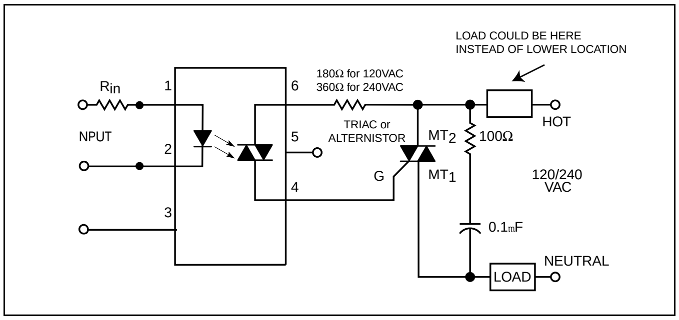

Figure 20.10 Random Turn-On Triac Driver

As shown in Figure 20.10, if the voltage across the load is to be phase controlled, the input control circuitry will have to be synchronized to the line frequency and the trigger pulses delayed from zero crossing each and every half cycle. If the series gate resistor is chosen to limit the peak current through the opto-driver to less than one amp, then on a 120 VAC line the peak voltage is 170 volts, therefore, the resistor is 180Ω. On a 240 VAC line the peak voltage is 340 volts, therefore, the resistor should be 360Ω. These gate pulses are only as long as the device takes to turn on (typically 5 to 6μ seconds), therefore, ¼ watt resistor is adequate.

The triac should be selected for the voltage of the line being used, the current through the load, and the type of load. Since the peak voltage of a 120VAC line is 170 volts you would choose a 200 volt (min.) device. If the application is used in an electrically noisy industrial environment, a 400 volt device should be used. If the line voltage to be controlled is 240VAC with a peak voltage of 340 volts, then use at least a 400 volt rated part or 600 volts for more design margin. Selection of the voltage rating of the opto-driver must be the same or higher than the rating of the power triac. In electrically noisy industrial locations, the dv/dt rating of the opto-driver and the triac must be considered.

The RMS current through the load and main terminals of the triac should be approximately 70% of the maximum rating of the device. However, a 40 Amp triac should not be chosen to control a 1 Amp load due to low latching and holding current requirements. Remember that the case temperature of the triac must be maintained at or below the current vs. temperature curve specified on its data sheet. As with all semiconductors the lower the case temperature the better the reliability. Opto-driven gates normally do not use a sensitive gate triac. The opto-driver can supply up to 1 Amp gate pulses and less sensitive gate triacs have better dv/dt capability. If the load is resistive, okay to use a standard triac. However, if the load is a heavy inductive type, then an alternistor triac is recommended or back to back SCRs as shown in Figure 20.9. A series RC snubber network may or may not be necessary when using an alternistor triac. Normally a snubber network is not needed when using an alternistor because of it's high dv/dt and dv/dt(c) capabilities. However, latching network as described in Figure 20.8 may be needed for low current load variations.

Zero Crossing Turn-On, Normally Open Relay Circuits

When a power circuit is mechanically switched “on” and “off” mechanically, high frequency components are generated that can cause interference problems such as RFI. When power is initially applied, a step function of voltage is applied to the circuit which causes a shock excitation. Random switch opening chops current off, again generating high frequencies. In addition, abrupt current interruption in an inductive circuit can lead to high induced voltage transients.

The latching characteristics of thyristors are ideal for eliminating interference problems due to current interruption since these devices can only turn off when the on-state current approaches zero, regardless of load power factor.

On the other hand, interference-free turn-on with thyristors requires special trigger circuits. It has been proven experimentally that general purpose AC circuits will generate minimum electromagnetic interference (EMI) if energized at zero voltage.

The ideal AC circuit switch, therefore, consists of a contact which closes at the instant when voltage across it is zero and opens at the instant when current through it is zero. This has become known as “zero-voltage switching.”

For applications that require synchronized zero-crossing turn-on, Figure 20.11 circuit is presented, which incorporates an optocoupler with a built-in zero-crossing detector

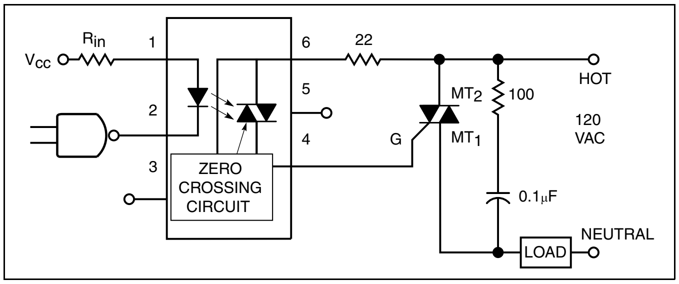

Figure 20.11 Optocoupled Circuit with Zero-Crossing Turn On (Triac or Alternistor)

Also, this circuit includes a dv/dt snubber network connected across the power triac. This typical circuit illustrates switching the hot line; however, the load may be connected to either the hot or neutral line. It also should be noted that the series gate resistor is low in value, 22Ω, which is possible on a 120V line and above, since zero-crossing turn-on is insured in any initial half-cycle.

Summary of Zero Crossing Turn-On Circuits

Zero voltage crossing turn on opto-drivers are designed to limit turn on voltage to less than 20 volts. This reduces the amount RFI and EMI generated when the thyristor switches on. Because of this zero turn on, these devices can not be used to phase control loads. Therefore, speed control of a motor and dimming of a lamp can not be accomplished with zero turn on opto-couplers.

Since the voltage is limited to 20 volts or less, the series gate resistor that limits the gate drive current has to be much lower with a zero crossing opto-driver. With typical inhibit voltage of 5 volts an alternistor triac gate, could require 160 ma at -30°C, (5v / .16A = 31 ohm gate resistor). If the load has a high inrush current, then drive the gate of the triac with as much current as reliably possible but stay under the I$_{TSM}$ rating of the opto-driver. By using 22 ohms for the gate resistor, a current of at least 227mA is supplied with only 5 volts, but limited to 909mA if the voltage goes to 20 volts. As shown in Figures 20.12, 20.13, and 20.14 a 22 ohm gate resistor is a good choice for various zero crossing controllers.

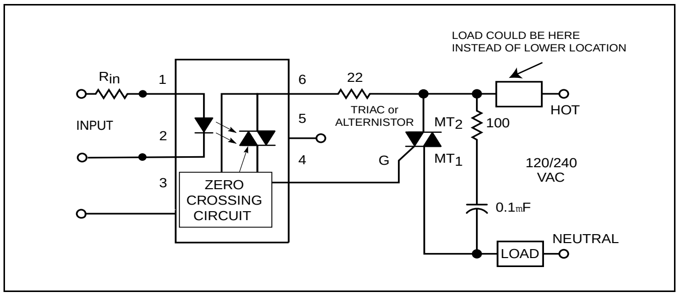

Figure 20.12 Zero Crossing Turn-On Opto Triac Driver

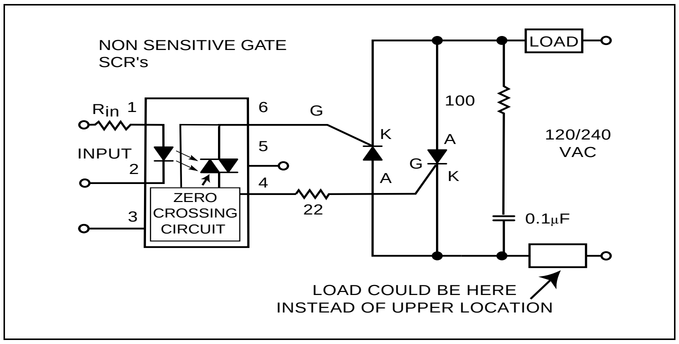

Figure 20.13 Zero Crossing Turn-On Non Sensitive SCR Driver

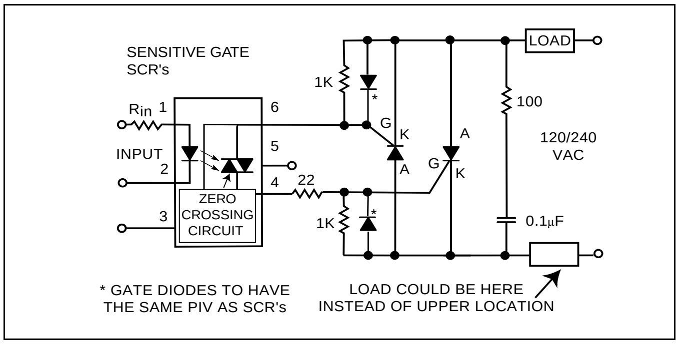

Figure 20.14 Zero Crossing Turn-On Opto Sensitive Gate SCR Driver

Typical Solid State Controller Circuit Using Zero Switching

The CA3059 zero-voltage switch is a monolithic integrated circuit used primarily as a trigger circuit for the control of thyristors. The multistage circuit employs a diode limiter, a threshold detector, a differential amplifier, and Darlington output driver to provide the basic switching action. The DC supply voltage for these stages is supplied by an internal zener-diode-regulated power supply that has sufficient current capability to drive external circuit elements, such as transistors and other integrated circuits. This built-in power supply provides unique solutions to many application problems. An important feature of the CA3059 is that the trigger pulses developed by this circuit can be applied directly to the gate of a silicon controlled rectifier (SCR) or a triac. A built-in fail-safe circuit inhibits the application of these pulses to the thyristor gate circuit in the event that the external sensor for the integrated-circuit switch should be inadvertently opened or shorted.

Basic Circuit Operation

Figure 20.15 shows a functional block diagram of the CA3059 integrated-circuit zero-voltage switch. Any triac that is driven directly from the output terminal of this circuit should be characterized for operation in the Quadrant I and Quadrant IV triggering modes, i.e., with positive gate current (current flows into the gate for both polarities of the applied AC voltage).

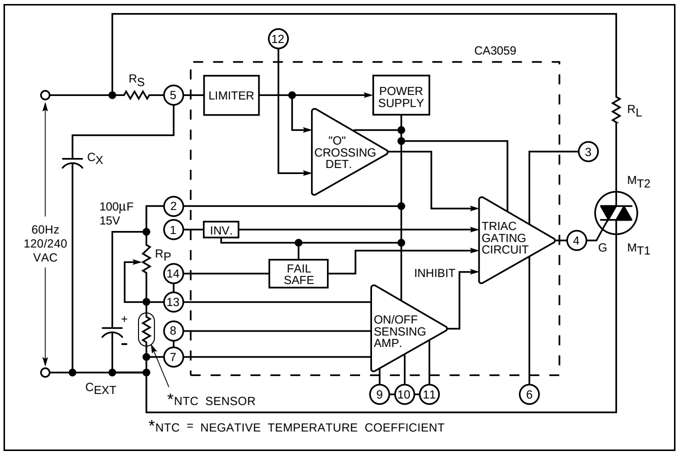

Figure 20.15 Zero-Switching Heat Controller

AC Input Voltage (volts) 50/60 or 400 Hz	Series Resistor R_S(kΩ)	Power Rating R_S(watts)
24	2	0.5
120	10	2
208/230	20	4
277	25	5

The limiter stage of the CA3059 clips the incoming AC line voltage to approximately plus and minus 8 Volts. This signal is then applied to the zero-voltage-crossing detector which generates an output pulse during each passage of the line voltage through zero. The limiter output is also applied to a rectifying diode and an external capacitor that comprise the DC power supply. The power supply provides approximately 6 Volts as the V_{CC} supply to the other stages of the CA3059. The on/off sensing amplifier is basically a differential comparator. The triac gating circuit contains a driver for direct triac triggering. The gating circuit is enabled when all the inputs are at a high voltage, i.e., the line voltage must be approximately zero Volts, the sensing-amplifier output must be "high", the external voltage to terminal 1 must be a logical "1", and the output of the fail-safe circuit must be "high."

Figure 20.16 shows the position and width of the pulses supplied to the gate of a thyristor with respect to the incoming AC line voltage. The CA3059 can supply sufficient gate voltage and current to trigger most triacs at ambient temperatures of 25°C. However, under worst-case conditions (i.e., at ambient temperature extremes and maximum triggering requirement), selection of the higher current thyristors may be necessary for particular applications.

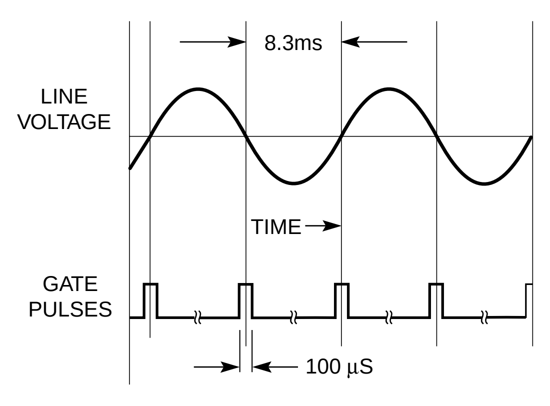

Figure 20.16 Thyristor Gate Signal Timing

Required Thyristor Characteristics Due To Load

The CA3059 is designed primarily to gate a thyristor that switches a resistive load. Because the output pulse supplied by the CA3059 is of short duration, the latching current of the triac becomes a significant factor in determining whether other types of loads can be switched. (The latching-current value determines whether the triac will remain in conduction after the gate pulse is removed.) Provisions are included in the CA3059 to accommodate inductive loads and low power loads. For example, for loads that are less than approximately 4 amperes RMS or that are slightly inductive, it is possible to retard the output pulse with respect to the zero-voltage crossing by insertion of the capacitor C_X from terminal 5 to terminal 7 as shown in Figure 20.15. The insertion of capacitor CX permits switching of triac loads that have a slight inductive component and that are greater than approximately 200 watts (for operation from an AC line voltage of 120 volts RMS). However, for loads less than 200 watts (for example, 70 watts), it is recommended that the user employ the sensitive gate triac with the CA3059 because of the low latching-current requirement of this triac.

For loads that have a low power factor, such as a solenoid valve, the user may operate the CA3059 in the DC mode. In this mode, terminal 12 is connected to terminal 7, and the zero-crossing detector is inhibited. Whether a "high" or "low" voltage is produced at terminal 4 is then dependent only upon the state of the differential comparator within the CA3059 integrated circuit and not upon the zero crossing of the incoming line voltage. Of course, in this mode of operation, the CA3059 no longer operates as a zero-voltage switch. However, for many applications that involve the switching of low-current inductive loads, the amount of RFI generated can frequently be tolerated.

Fail-Safe Feature

As shown in Figure 20.15, when terminal 13 is connected to terminal 14, the fail-safe circuit of the CA3059 is operable. If the sensor should then be accidentally opened or shorted, power is removed from the load (i.e., the triac is turned off). The internal fail-safe circuit functions properly, however, only when the ratio of the sensor impedance at 25°C and potentiometer is less than 4 to 1.

For ratios greater than 4 to 1, for example 100 to 1, the circuit shown in Figure 20.17 may be employed to provide fail-safe operation. In this circuit, transistor Q_1 and diode D_1 are components external to the CA3059. Transistor Q_1 detects the sensor current which maintains this transistor in saturation so that terminal 1 is effectively shorted to terminal 7 through the collector-to-emitter junction of the transistor. Transistor Q_1 provides sufficient current gain to permit operation with a sensor impedance greater than 1 megohm. If the sensor becomes open-circuited, transistor Q_1 turns off, and current then flows into terminal 1, the inhibit terminal of the CA3059, and results in the removal of power to the load. For the shorted-sensor condition, the external diode D_1 conducts and causes the triac to turn off. Diode D_2 compensates for variations in the base-to-emitter voltage of transistor Q_1 with temperature. Terminals 13 and 14 on the CA3059 should not be connected together when the external fail-safe circuit shown in this illustration is employed.

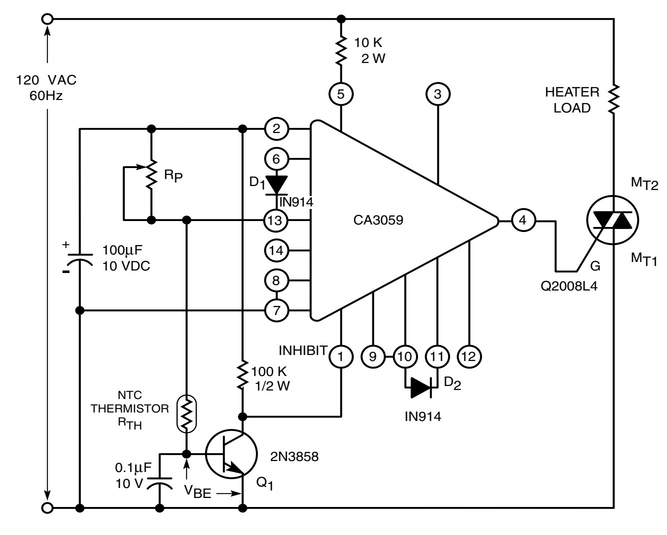

Figure 20.17 Improved Fail-Safe for Zero-Switching Heat Controller

Three Phase Controller

With the growing demand for solid-state switching of AC power in heating controls and other industrial applications has resulted in the increasing use of triac circuits in the control of three phase power. In these power-control circuits the CA3059 integrated-circuit zero-voltage switch can be used as the trigger circuit for the power triacs.

Design Requirements

The following conditions are imposed in the design of the three phase triac control circuits:

(1) The load should be connected in the three-wire configuration with the triacs placed external to the load; either delta or wye arrangements may be used.

(2) Only one logic command signal is available for the control circuits. This signal must be electrically isolated from the three phase power system.

(3) Three separate triac gating signals are required.

(4) Two phases must be turned on for initial starting of the system.

Isolation of DC Logic Circuitry

Isolation of the DC logic circuitry from the AC line, the triac, and the load circuit is often desirable even in many single-phase power-control applications. In control circuits for polyphase power systems, however, this type of isolation is essential, because the common point of the DC logic circuitry cannot be referenced to a common line in all phases. In a three phase system the phases are 120 degrees apart; consequently, all three phases cannot be switched on simultaneously at zero-voltage.

Typical Circuit

For inductive loads, zero-voltage turn-on is not generally required because the inductive current cannot increase instantaneously; therefore, the amount of RFI generated is usually negligible. Also, because of the lagging nature of the inductive current, the triacs cannot be pulse-fired at zero-voltage. There are several ways in which the CA3059 may be interfaced to a triac for inductive-load applications. The most direct approach is to use the CA3059 in the DC mode, i.e., to provide a continuous DC output instead of pulses at points of zero-voltage crossing. This mode of operation is accomplished by connection of terminal 12 to terminal 7, as shown in Figure 20.18. The output of the CA3059 should also be limited to approximately 5 milliamperes in the DC mode by the 750 Ohm series resistor. Use of a logic triac such as the L401E5 is recommended for this application. Terminal 3 is connected to terminal 2 to limit the steady-state power dissipation within the CA3059. For most three phase inductive load applications, the current-handling capability of the L401E5 triac (1.0 ampere) is not sufficient. Therefore, the L401E5 is used as a trigger triac to turn on any other currently available power triac or alternistor that may be used. The trigger triac is used only to provide trigger pulses to the gate of the power triac (one pulse per half-cycle); the power dissipation in this device, therefore, will be minimal.

Simplified circuits using pulse transformers and reed relays will also work quite satisfactorily in this type of application. The RC networks across the three power triacs are used for suppression of the commutating dv/dt when the circuit operates into inductive loads; however, when alternistor power devices are used a snubber network most probably is not necessary.

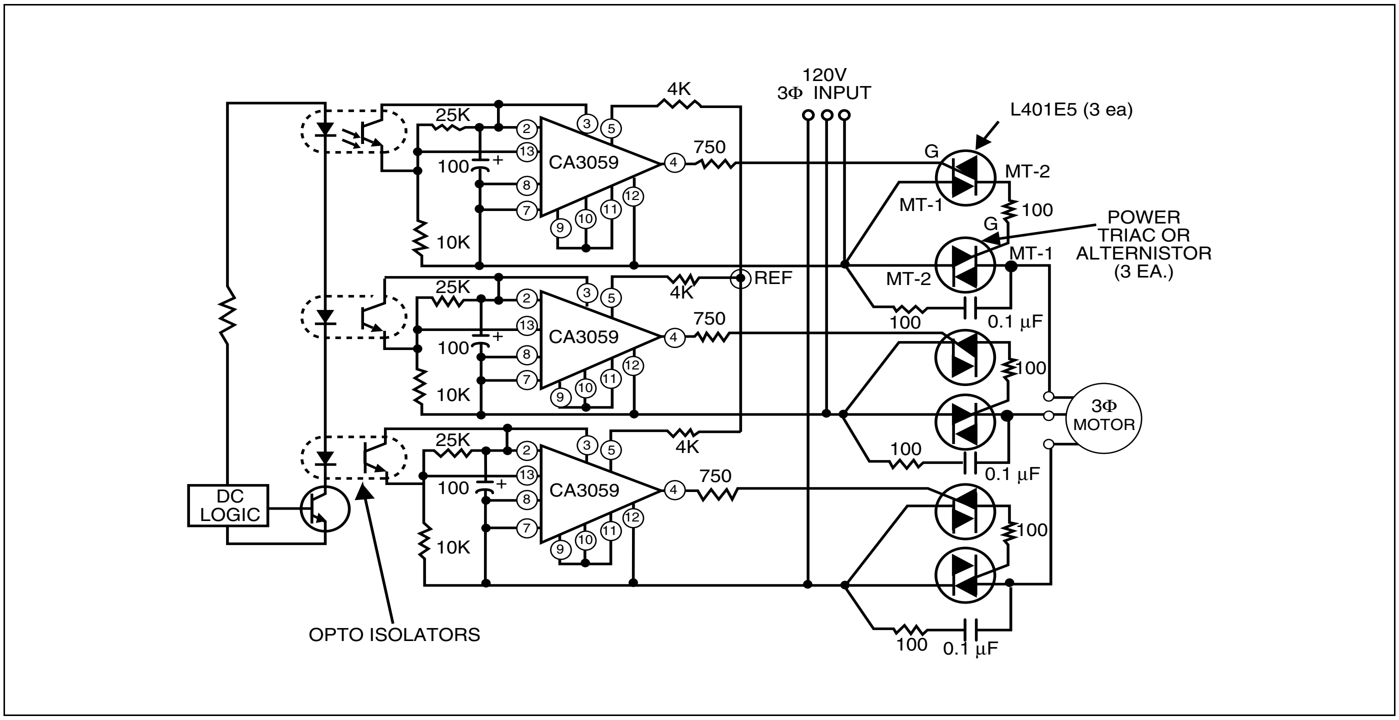

Figure 20.18 Triac Three Phase Control Circuit for a Three Phase Motor Load

Time Delay Relay Circuit

By combining a 555 timer IC with a triac, various time delays of several seconds can be achieved for delayed activation of solid state relays / switches.Figure 20.19 Illustrates a solid state timer delay relay using a sensitive gate Triac and a 555 timer IC. The 555 timer in the time delay mode of operation precisely controls time delay of operation using an external resistor and capacitor as illustrated by the resistor and capacitor combination curves. (Figure 20.20)

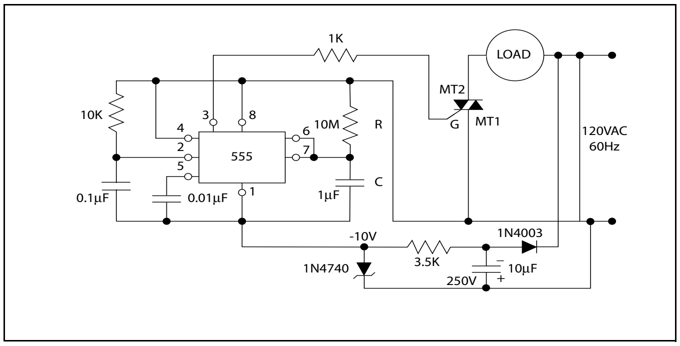

Figure 20.19 555 timer circuit with 10 second delay

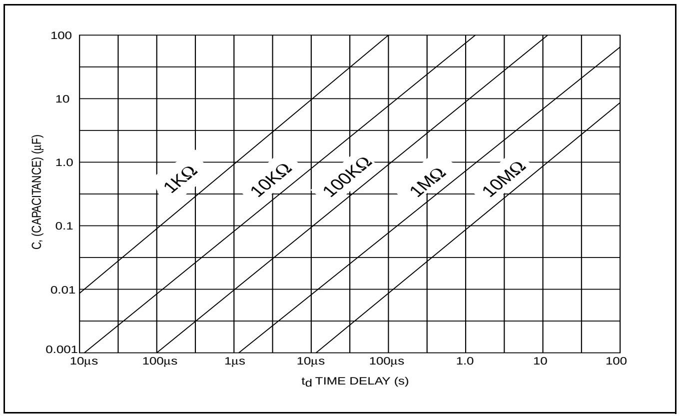

Figure 20.20 Resistor (R) and capacitor (C) combination curves

IR Motion Control

A more complex triac switch is illustrated in an infrared (IR) motion detector controller circuit. Applications for this circuit can be, alarm systems, automatic lighting, auto doorbells, and others.

Figure 20.21 demonstrates an easy to implement automatic lighting system using an infrared motion detector control circuit. A commercially available LSI circuit, HT761XB, from Holtek integrates most of the analog functions. This LSI chip, U2, contains the op amps, comparators, zero crossing detection, oscillators and a triac output trigger. An external RC that is connected to the OSCD pin determines the output trigger pulse width. (Holtek Semiconductor Inc. is located at No.3, Creation Road II, Science-Based Industrial Park, Hsinchu, Taiwan, R.O.C.) Device U1 provides the infrared sensing. Device R13 is a photo sensor that serves to prevent inadvertent triggering under daylight or other high light conditions.

Choosing the right triac depends on the load characteristics. For example, an incandescent lamp operating at 110 volts would require a 200 volt 8 amp triac. Using an 8 amp triac will give sufficient margin to allow for the high current state during lamp burn out. U2 provides a minimum output triac negative gate trigger current of 40ma, thus operating in QII & QIII. This meets the requirements of a 25ma gate triac. Teccor also offers alternistor triacs for inductive load conditions as well.

This circuit has three operating modes (ON, AUTO, OFF), which can be set through the mode pin. While the LSI chip is working in the auto mode the user can override it and switch to the test mode, or manual on mode, or return to the auto mode by switching the power switch. More information on this circuit, such as mask options for the infrared trigger pulse and flash options, are available in the Holtek HT761X General Purpose PIR Controller specifications.

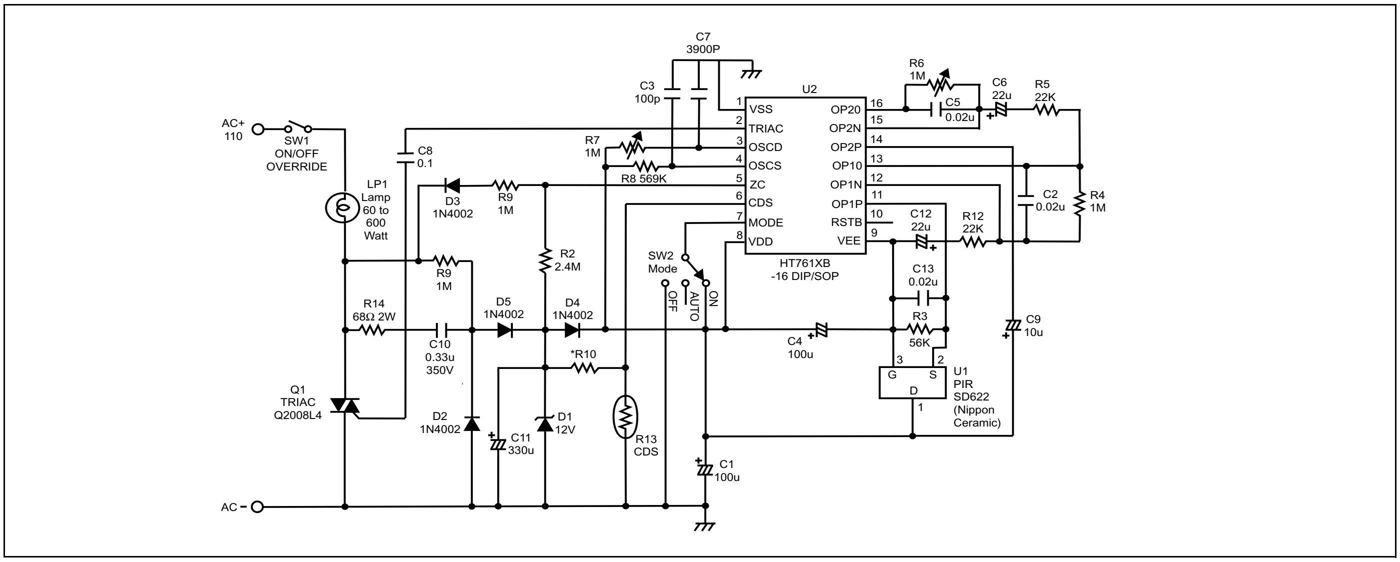

Figure 20.21 I R motion control circuit