Temperature control utilizing SSR

Solid State Relay's (SSR) input side is electrically isolated from its output side using semiconductor components. The SSR is composed of a low current control input side and a high current load side, whereby the relay provides an electrical I/O isolation of several thousand volts. When current flows through the LED on the input side, it emits light which is detected by a trigger circuit after passing through a silicon resin. The trigger circuit acts like a small triac device and is used to trigger the gate of a larger triac that switches the load.

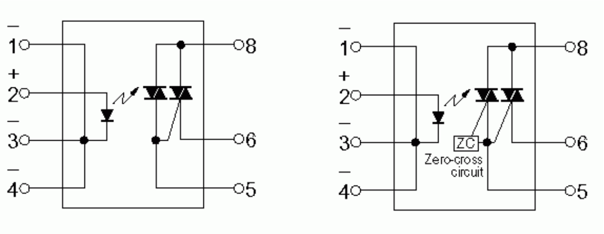

Figure 1: Electrical circuit of AQ-H relay

Like an electromechanical relay, the SSR is an all-or-nothing relay. However, semiconductor relays with a Triac (SSR) or MOSFET (PhotoMOS) output offer the following advantages compared to electromechanical relays:

- Contact reliability
- Long lifetime
- Low control current
- High switching frequency
- Noiseless operation
- No contact arcs
- Shock resistance

Even though semiconductor relays cannot always be applied in exactly the same manner as electromechanical relays, when the application requires switching of AC voltages and some of the mentioned advantages, SSR is an ideal choice. As noted before, Solid State Relays use a triac as the output stage. A triac is a four-layer diode with three terminals which can conduct current from anode to cathode and vice versa. It is non-conductible until a current pulse of about 50 mA (referenced to the cathode) is applied to its gate. After the gate is triggered, the triac conducts the load current till the current drops below a certain level. Therefore a triac device can handle only AC loads where current and voltage naturally become zero (e.g. every half cycle of the sine wave).

Due to this behaviour, SSRs lend themselves perfectly to applications where AC loads have to be switched repeatedly without creating noise. A typical application example is temperature control in which the SSR switches a heater or a fan to reach or prevent a certain temperature level.

A simple comparator circuit can be used to control the temperature, but it is better to use a Schmitt trigger to stabilize switching operation when the temperature reaches the trigger value. A Schmitt trigger is a bistable multivibrator with upper and lower treshold values. When the signal reaches the upper treshold value V_h, the output of the Schmitt trigger alternates. The output will remain in this state until the input signal drops below the lower treshold value V_l. The level of the output depends on the supply voltage of the circuit. This behaviour can be seen in Figure 2.

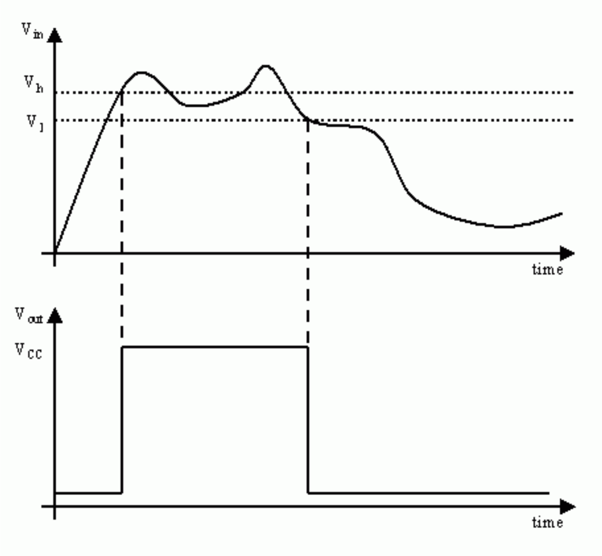

Figure 2: Behaviour of Schmitt trigger

Instead of using operational amplifiers or integrated circuits the Schmitt trigger can also be realized with discrete transistors. The circuit is shown in Figure 3. If there is no input voltage V_{in}, the transistor T_1 is in the off-state. Because of the voltage divider R_1 and R_2, there is current to the base of transistor T_2; it operates in the saturation region and current flows through T_2 and R_E. If the input voltage V_{in} exceeds the threshold value V_h (V_{RE} + V_{BE}) current flows through T_1 and the voltage drop across the voltage divider R_1 and R_2 gets lower, reducing the base current of T_2 and voltage drop across R_E.

This makes it easier for transistor T_1 to reach the saturation region so that now T_1 carries current and T_2 is in off-state. Consequently the output voltage V_{out} changes from low level to high level. If the input voltage drops below the lower threshold value V_l, the transistor T_1 turns off and by regenerative action T_2 turns on forcing the output voltage V_{out} to proceed to its lower level determined by the voltage drop across R_E and the saturation voltage V_{CESat} of T_2.

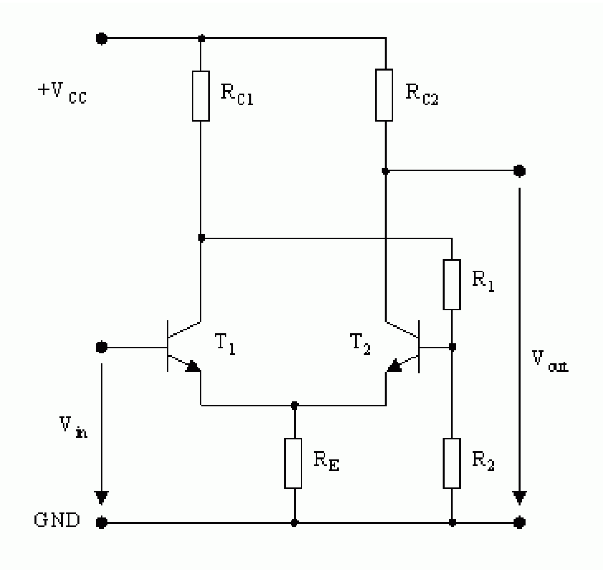

Figure 3: Schmitt trigger circuit

For the input signal of the Schmitt trigger a voltage divider consisting of a resistor and a thermistor can be used. Make sure the thermistor (e.g. NTC or PTC) has a good thermal coupling to the ambient and that current through the voltage divider does not affect the accuracy of temperature measurement. By connecting the temperature dependent voltage divider or bridge circuit to the input of the trigger, the output voltage reflects the temperature and can be used to control the temperature with a heater or a fan. Since heaters and fans are operated from the AC mains network, galvanic isolation may be necessary when actuating the load. Due to the number of operations and noiseless switching, SSRs are the ideal choice.

Panasonic Electric Works offers the AQ-H relay, a small outline Solid State relay in a DIP8 package which can carry currents up to 1.2 A; they also offer zero cross switching (e.g. AQH3213). All AQ-H relays have an I/O isolation of 5000 VAC and a typical control current of 5 mA. Combined with the unlimited life time of semiconductor devices, they are suitable for switching motors, solenoids, valves, lamps, heaters or fans in industrial or home appliance applications.

Part No.	On-state RMS current	Type
AQH0213	0.3 A	Zero-cross
AQH0223	0.3 A	Non zero-cross
AQH1213	0.6 A	Zero-cross
AQH1223	0.6 A	Non zero-cross
AQH2213	0.9 A	Zero-cross
AQH2223	0.9 A	Non zero-cross
AQH3213	1.2 A	Zero-cross
AQH3223	1.2 A	Non zero-cross