What are the Methods of Firing SCRs?

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SCR power controllers are designed to deliver the energy needed to maintain a steady, stable temperature in a heater. Today's SCR power controllers feature advanced microprocessor-based firing and control-mode algorithms with diagnostic and communication options to provide more information on your system.

With these devices, the firing method is an important decision to ensure your system operates properly for years to come. This article examines the differences between zero cross and phase-angle firing.

What are SCRs?

SCR is short for silicon controlled rectifier. It is a power controller designed to communicate with an industrial heater in a thermal system and determine when and how much power a heater should be supplied.

SCRs are defined by several characteristics: They are fast-responding devices able to handle high current loads, and they are more efficient compared to some other options. However, these benefits come with challenges too. SCRs are typically bigger devices and require a more complex firing circuit. In addition, SCRs cannot be used at frequencies greater than 60Hz.

When using SCR power controllers, one of the biggest decisions system designers face is what type of control mode to use. Zero cross and phase-angle control are the two options, and it is important to understand the pros and cons of each method before making a choice.

The Methods of Firing SCRs

There are two methods for firing SCR power controllers: Zero cross and phase angle. Not all SCRs can be fired by both methods, and some situations dictate the method required. Typical, traditional heaters are made with Nichrome wire, which supports both zero-cross and phase-angle firing. This gives you flexibility when selecting an SCR for your system.

With that flexibility, it is important to understand the advantages and disadvantages of each firing method. As always, Watlow® representatives are well-versed in each method and can walk you through the options for your specific situation.

Zero Cross

Zero-cross firing is the principle of allowing all or a few sine waves into the heater to create heat. The SCR is commanded on as the electrical sine wave passes through zero potential. By using this timing, no electromagnetic interference (EMI) is created. This allows for a heater load to be finely controlled while limiting a low power factor. This method is ideal for stable resistance heaters, such as Nichrome. However, there are limitations: Voltage and current will be rising and falling, or “in-phase,” and as a result, current limiting is not possible. This is the primary reason why zero cross is not the correct method for controlling variable resistance heaters. Other pros and cons include:

Pros

- Low EMI
- Conducted and radiated
- Fewer components
- Higher calculated Mean Time Between Failures (MTBF)
- No power factor concerns

Cons

- No soft start
- No current limiting
- Not for transformer-coupled loads

Phase Angle

Phase-angle firing is the principle of firing within the sine wave. In this method, every sine wave is used; however, only a portion of that sine wave. For example, if the duty required at time x is 30%, the power controller will not conduct for the first 70% of the sine wave and then conduct for the last 30%. This will result in only 144 volts being delivered to the load on a 480 volt source. This method also causes current to lead voltage, which allows for current limiting. This becomes extremely beneficial with non-linear heater technology such as molybdenum disilicide. Phase-angle firing also creates “harmonics,” which is a common occurrence when conduction begins within a sine wave.

Consider a dimmer switch on a light bulb. If the dimmer switch is set to 50%, you will likely hear the light bulb ringing or buzzing. The element is physically shaking to generate this noise. Harmonics can be either radiated (the kind you can hear) or conducted (sent back through the power line).

Every piece of electronic equipment creates harmonics and can withstand a certain amount of harmonics. That said, devices overwhelmed by harmonics will fail. This means conducted lines need additional technology – chokes, coils, filters, etc. – to eliminate these emissions.

Other pros and cons include:

Pros

- Voltage soft start option
- High hot to cold resistance ratio loads
- “Infinite” resolution within sine wave
- Current limiting
- Great for fast-acting loads

Cons

- Costly
- Complex circuitry, low MTBF
- High harmonic distortion and EMI
- Multiple panel units can cause crosstalk problems
- AC sine wave notching

How Does an SCR Affect the Life of the Heater?

Using an SCR maximizes the life of your heater by maintaining a steady temperature in the heater. By reducing the number of heat-up, cool-down cycles, the heater element is subjected to less oxidation.

Think about the oven in your home. If you set your oven to 400 degrees Fahrenheit, a big relay – a contactor – pulls in, and the element warms up. As the oven reaches 400 degrees, the relay releases and the element begins to cool down. When it warms up, it expands. It shrinks as it cools down. During the heat-up phase, a shell of oxidation, or rust, forms. During the cooling phase, the rust flakes off. Every heat-up, cool-down cycle generates wear and tear on the wire. This reduction of the heater element will result in a shorter life.

This is why SCRs lead to a longer life of the heater. The rapid switch between on and off leads to a more stable temperature, which leads to longer heater life.

Which Method is Right for Your System?

If you are in the market for a power controller, Watlow can help find the best solution for your unique situation. Our experts will ask for details about the system: What it does, what the goals are for the system, what is the desired result? Depending on the application, our team will provide you with potential solutions, such as the ASPYRE® line of SCR power controllers (https://www.watlow.com/products/controllers/power-switching-devices/aspyre-intelligent-power-controller).

Contact Watlow today (https://www.watlow.com/contact-us), and we will find the right solution for your system.