Hoffman Controls
Engineering Bulletin

900/902/903/905 Series
SCR Control Systems

To: All Customers

Re: Engineering/Application of 900 Series SCR Type Controllers for Power Modulation of Resistive Heating Elements

Hoffman Controls Corp. was the first manufacturer to develop a UL Recognized Power Controller for modulating energy proportionally to electric resistant heating elements in the mid 1960s.

General

This Bulletin is descriptive of 900/902/903 Series products only.

All of the controllers up to that time were designed to accomplish this function by utilizing two SCR (Silicon Controlled Rectifiers) "back to back" for the positive (+) and negative (–) side of the sine wave. As a result, the term "SCR" has continued to identify the type of controller herein described, even though most UL listed products use a "Triac". Hoffman Controls Corp. developed the first "Triac" controller, eliminating the redundant requirement of two power devices in favor of a single device that could control both the positive and negative cycles. As a result, the Triac thus improved the reliability of performance and life of the controller.

Misconceptions have continued to prevail about the method of proportionally controlling energy of resistive heating elements (loads). Contrary to one's understanding, many are not knowledgeable as to the actual control method that is used for this type product.

Controlling Resistive Loads

In applications where resistive loads are being controlled, the voltage and current are at unity; that is, the voltage and current wave forms cross Zero together where no voltage or current flows. It is necessary and imperative that the control engage the resistive load at "Zero Crossing". To connect the load at other than "Zero Crossing" on restive loads would create "Electrical Noise" (DVDT). This would cause an unacceptable electrical disturbance that would be intolerable even in industrial and commercial environments.

Contacts are energized or de-energized at random (other than at "Zero Crossing"). This condition can be observed by the arcing that occurs when the contactor opens or closes.

Proportional control of the load is accomplished by "sampling" a quantity of sine waves and connecting a percent of them to the load over a time base (defined period of time). The typical time base for controlling the temperature (heating air) for environmental applications is nominally 5-seconds. This time base provides 300-full sine wave cycles (60 cycles X 5-seconds), or 600-half sine wave cycles. Since the Triac does not distinguish positive or negative cycles, opportunity for obtaining any quantity of half cycles during the time base from 1-to-600 is available. This 1 in 600 resolution provides very precise control of the load every 5-seconds. The proportional quantity of cycles of energy connected to the load during the time base thus provide an extremely accurate and responsive performance for controlling energy. This type of control does not cause "inrush" of current.

The control can respond and reset itself for proportionally furnishing the appropriate amount of energy every 5-seconds; selectively determining how many cycles (of the 600 available) will be connected to the load, and how many will not. The control continues to increase the amount of connected cycles as the error increases from set point. This means that at set point, the SCR delivers no cycles connected to the load. At the end of the span, the controller delivers all of the 600-half cycles to the load. The starting point (set point) is commonly called the "Zero", the range of the modulation is commonly called the "Span".

Controlling Inductive Loads

Unlike resistive (heating) loads, inductive loads make it necessary to protect the triac from large voltage surges. Inductive loads are "phase proportioned" because current and voltage of the motor are out of phase. (Current falls to zero at a differnt time than voltage does). Filtering circuitry is designed into the controller to diminish the electrical noise. The precise control of each half wave, however, increases the harmonics and electrical noise generated by the firing of the Triac at other than “Zero Crossing”. Phase proportioning is not a suitable design for controlling resistive heating elements. The above description is included in this information to clearly identify the distinction between the two designs.

Application of SCRs

The 901-D Series Low Voltage Logic functions to provide the intelligence for connecting the appropriate load for each 5-second time base. The Triac receives a pulse from the logic to connect the line voltage to the load at the next “Zero Crossing”, for single or three phase applications.

Three phase loads may be connected in a “Delta” or “Wye” configuration. When the controller is connected in the “Line”, the Triac must be rated at the rated anticipated line current for the heating element. When the Triacs are connected “Inside the Delta”, they need only to be rated at the single phase current rating of each single phase leg of the Delta. The actual current in each three phase line outside the Delta will be a multiple of 1.732 of the current in the Delta (the square root of 3 = 1.732). Conversely, if the three phase line current is known, the current rating of the phases inside the Delta can be determined by dividing the line current by 1.732.

When inductive Triac control devices are used, the life of a controller is dependent on abuse. The Triac designed control precludes any surge when the load is connected to the line. The resistive load is switched at “Zero Voltage and Current”; thus no stress is imposed on the controller. Excessive ambient temperatures and external electrical impulses are the only known causes that cause failure of the device other than an inherent defect within the device itself. SCR devices have continued to function satisfactorily from the original conception of the semiconductor Triac.

Signal Inputs

In selecting the thermostatic input, care should be given to select an appropriate input signal that can be responsive to a change in signal error within seconds. The 906 Series Thermistor Thermostats that sense temperature directly are designed to recognize a 1°F change in 19 seconds.

When inputs are used other than the thermistor signal, care must be given to select a responsive sensing device or the function of the SCR will be compromised. Time constants of the input signal devices used should be in the 20 to 40 second per degree Centigrade time constant range if satisfactory control is to be achieved.

135 Ohm inputs are not recommended if the signal is pneumatic driven. (Pneumatic pressure driven devices generally require 2 to 4 minutes to respond to a 1°C change in temperature.)

Technical Assistance

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