Using TP, DZC, & Analog Outputs

Watlow Anafaze controllers provide open collector outputs for control. The controller's output form is a 5 VDC gate control signal known as switched DC or a TTL output. The output is a sinking output meaning that when ON it returns the PID output terminal to controller common in reference to the +5 VDC terminal of the controller. These outputs normally control the process using solid state optically isolated relays.

Open collector outputs can be configured to drive a serial digital-to-analog converter (Serial DAC) or dual digital-to-analog converters (Dual DAC) which, in turn, can provide 0 to 5 Vdc, 0 to 10 Vdc or 4 to 20 mA control signals to operate field output devices.

Methods of control

On/Off

When on/off control is used, the output is on or off depending on the difference between the set point and the process variable. PID algorithms are not used with on/off control. The output variable is always off or on (0 or 100 percent). When set point is achieved, the output is turned off. When the temperature moves away from set point by the value of spread or hysteresis, the output is turned back on to drive the process to set point.

Time Proportioning Mode - TP

With time proportioning (TP) outputs, the PID algorithm calculates an output between 0 and 100 percent, which is represented by turning on an output for that percent of a fixed, user-selected time base or cycle time.
The cycle time is the time over which the output is proportioned, and it can be any value from 1 to 255 seconds. For example, if the output is 30 percent and the cycle time is ten seconds, then the output will be on for three seconds and off for seven seconds.

TP is a version of control form for duty cycling of relays, mercury relays, or contactors in order to provide closer control of electrical heaters than ON/OFF control will provide. This is known as proportioning the ON versus the OFF duty cycle time for a given period of time known as Cycle Time. The standard Cycle Time range for Watlow Anafaze controllers is 1-255 seconds. The general rule is that the shorter the cycle time the closer the control will be, but there are limits. Another general rule is the shorter the cycle time the longer the heater life will be.

Cycle times for electrical relays, mercury relays, and contactors may range from 10 to 60 seconds. Average times in use are cycle times of 10 to 20 seconds. The larger the load the longer the cycle time must be to avoid unnecessary wear of the contacts.

Solid State Relay (SSR) due to no moving parts can use cycle times of 1-5 seconds without any problems as to life expectancy of the SSR. Since the SSR will turn on and off at the zero point of the AC sine wave, the minimum time resolution is 0.0166 seconds. The output level of the Watlow Anafaze controllers has a range of 100.0%, thus the required cycle time to provide a one cycle resolution would be 17 seconds. This would give the finest resolution of the AC power, but this is not necessary, as the thermal mass of the load will not normally require this level of control resolution. When the cycle time period is set for 1 second, the control resolution requires a change of 1.7% of the control output to see a change in the number of ON versus OFF power cycles. A cycle time of 2 seconds will give a control resolution of 0.9% for a change in the power cycles. The Watlow Anafaze recommended cycle time for SSR applications of 3 seconds would give a control resolution of 0.55% for change in the power cycles.

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The overall effect as to the PID control is that for a given Proportional Band (Pb) parameter, the shorter the time cycle, the greater the temperature input change must be to effect a change in the AC power cycles.

Example: With a Pb of 58°F using a 1 second cycle time, the PV must change by 1.0°F in order to make a one cycle change in the AC power cycle. Using a 3 second cycle time, it is only required for the PV to change by 0.3°F to effect a one cycle change in the AC power cycle.

With the shortest time cycle of 1 second, at a 50% control level, there would be 30 ON cycles of 60 Hz power and 30 OFF cycles. At 2% output level there would be 1 cycle ON and 59 OFF. At 98% there would be 59 cycles ON and 1 OFF

TP is also used for time proportioning of solenoid valves for providing pulse control of gas valves of burner systems as well as water valves for water cooling systems. Cycle times of 10 to 20 seconds are normal.

TP is used for control of heaters that are called resistive heating elements. These are called resistive as the load presents itself as a resistive load to the power controller. A resistive heater will have a small change of "cold resistance" to heat resistance normally less then 2 times. The cold inrush current at startup conditions is limited to a nominal value that is tolerated by the electrical relays and SSR. Nichrome heating elements is a good example of resistive heating elements. These elements are used in many styles of heater elements such as cartridge, circulation, strip, tubular, radiant, mica strips and some styles of quartz heaters.

Analog Outputs

For analog outputs, the PID algorithm calculates an output between 0 and 100 percent. This percentage of the analog output range can be applied to an output device via a Dual DAC or a Serial DAC.

Phase Angle SCR using Analog Outputs

Silicon Controlled Rectifiers (SCR) are a form of solid state control of the voltage phase cycle of the 50/60 Hz power providing proportional load current control. An ANALOG output control signal for is used by the SCR control unit. The analog proportional signal may be 0-20 mA DC, 4-20 mA DC, 0-5, 1-5 or 1-10 VDC which will proportionally control a phase angle fired SCR AC power controller. This provides proportional control from minimum to maximum of the AC load current.

The main purpose for using the SCR phase angle fired final control element is the feature of having current limiting to avoid high inrush current due to cold start conditions. Heaters that have a high ratio change of cold resistance to heat resistance such as 20:1require current limiting to avoid damaging the final control unit as well as the heater. Tungsten elements, some forms of quartz heaters, silicon carbide, molybdenum, and graphite heaters have high changes in the cold to heat resistance, or change in resistance due to aging requiring current limiting at startup cold conditions.

The SCR uses a coil transformer for measuring the output current in order to provide a signal to the current limiting circuit that is adjustable as to the level of current it will limit.

The SCR can be use for very close proportional control resolution of high current loads. For example with the control output range of 100.0% of the Watlow Anafaze controllers using a 4-20 mA DC supplied via a Dual DAC control signal with a 200 Amp SCR, the output AC load current resolution could be as little as ±2.5 amps. This depends on the actual zero and span setting as well as control resolution of the SCR, but the controller could provide proportional control resolution of ±2.5 amperes with a full span of 200 amps.

SCR are also used for transformer applications to decrease supply voltage for molybdenum, graphite or any heating elements.

Distributive Zero Control - DZC

With DZC outputs, the PID algorithm calculates an output between 0 and 100 percent, but the output is distributed on a variable time base. For each AC line cycle, the controller decides whether the power should be on or off. There is no fixed cycle time since the decision is made for each line cycle. When used in conjunction with a zero crossing device, such as a solid state relay (SSR), switching is done only at the zero crossing of the AC line, which helps reduce electrical noise.

Using a DZC output should extend the life of heaters. Since the time period for 60 Hz power is 16.6 ms, the switching interval are very short and the power is applied uniformly. DZC should be used with SSRs. Do not use DZC output for electromechanical relays.

The combination of DZC output and a solid state relay can inexpensively approach the effect of analog phase-angle fired control. Note, however, DZC switching does not limit the current and voltage applied to the heater as phase-angle firing does.

This very fine control resolution of one AC cycle provides for very close temperature control of fast reaction heater applications and provides for a very big increase in heater life.

The DZC control output for use with SSR is to be used only with resistive heating elements such as Nichrome heating elements. These elements are used in many styles of heater elements such as cartridge, circulation, strip, tubular, radiant, mica strips and some styles of quartz heaters.

The DZC control output is also used for the input signal to the Dual DAC in order to provide analog output control signals.

The DZC control output for use with SSR is not to be used with high resistive change types of heaters such as Tungsten elements with a cold start low resistance state. The power limiting feature of the Watlow Anafaze controllers is only a duty cycle power limiting function not a current limiting function. Each ON cycle will have full voltage output with full load current capacity available for that cycle based on the resistance of the heater.

Do not use DZC to control solenoid valves.

Do not use DZC to control heating elements with high resistive cold to heat change. The cold resistance startup values of these types of heaters are small enough to cause a failure of the SSR due to very high current startup loads.

Three-Phase Distributed Zero Crossing (3P DZC)

This output type performs exactly the same function as DZC except that the minimum switching time is three AC line cycles. This option is selected when using three-phase heaters with three-phase power solid state switching relays.

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