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IN THIS ISSUE

PUTTING THE PLC IN CONTROL

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The Programmable Logic Controller (PLC) has continued to gain popularity over conventional relay logic systems. The performance and cost advantages of the PLC has made it beneficial, even in applications where it is replacing only six relays.

In process control it is often required to adjust a process input to match a desired process output. In simple applications this can be achieved with an **open loop** controller. In this style of control there is no feedback of the output to the controller. If we consider say an electric room heater with a variable power setting it is possible to adjust the output, but the temperature of the room will depend on outside influences. The external ambient temperature and wind speed will directly influence the steady state temperature. If the power is set at a point that matches the power required to maintain the desired temperature it may take a considerable time for the room to reach that temperature because of the need to heat the contents of the room.

Hitachi PLCs provide high performance and significant cost advantages.

The next step in this example is to provide an **on / off** controller, as provided by a thermostat. The maximum power of the heater can be high enough to provide rapid warm up and it is then controlled within a temperature band determined by performance of the thermostat. There will always be some cycling of the temperature.

Putting the PLC in control
(continued from page 1)

In some processes it is not possible to use the **on / off** control. A motor drive is a typical example. What is required is the ability to match the actual output of the controlled device to the desired output in a manner that compensates for disturbances to the process. To achieve this a **proportional, integral, derivative** closed loop controller is used.

Control elements

To control any process it must be possible to measure the desired result. Typical examples of this would be: temperature, speed, current and weight. Using a PLC as the logic part of the control system we need to convert the variable to be measured / controlled into a form that can be recognised by the PLC. The normal signal formats are 0 - 10 volts, 4 - 20 mA and pulse. To provide signals in this format a transducer is often required to interface between the PLC and the process variable. In selecting a suitable transducer the accuracy and response time must be compatible with the overall performance requirement.

Given that the PLC can now monitor the process it needs to be able to provide an output in a suitable format to vary the controlled device. The normal output signal formats are the same as the input formats.

Mathematics

Given that we now have a system that can monitor the process and control it, the PLC has to be given the required instructions to correctly vary the output in response to variations. The PLC allows proportional, integral or derivative control as well as any combination of these. To select the appropriate technique we need to know what the control requirements are. These include: the desired level of the input variables, the permissible dead-band or the amount the variable can change before the output needs to be varied and what is the range over which the inputs and outputs are expected to operate. The system response must also be known. It is common for overshoot to occur as there is usually a delay between the

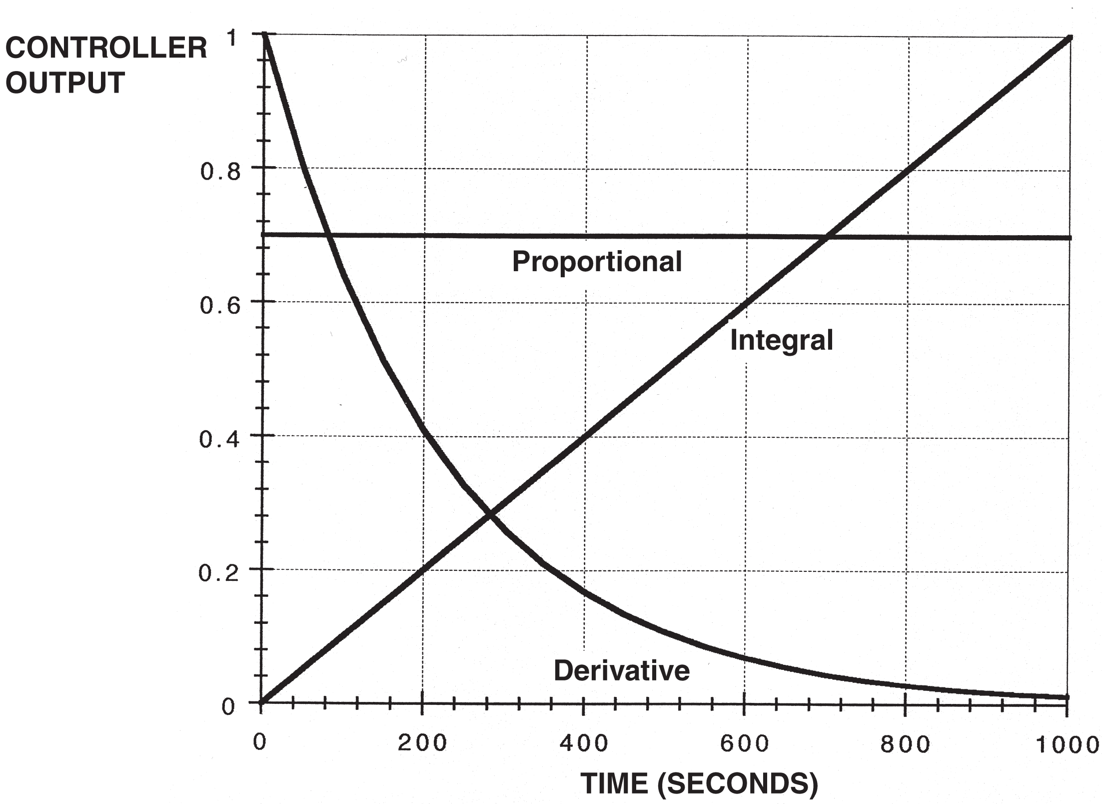


Figure 1. Controller output with step disturbance

Mathematics
(continued from page 2)

adjustment of a variable and the change of the output. In some cases even if the controlled device is shut-off it still delivers an output. Heaters are a typical example of this, as they can store heat in their own mass and still deliver it with no external power applied.

If a process has a rapid response to changes, proportional control can be used. The error or difference between the desired setting and the actual value is determined by the system gain as some error is required to provide the compensating output. If there is a delay in the system response overshoot will occur and the system can become unstable. The higher the gain the greater the overshoot. To slow the control response a degree of integration of the input can be applied. This means that the longer an error is present the greater the signal to the controlled device but the initial response is slowed and the measured variable is given time to respond.

Some processes exhibit the opposite characteristic in that a small but quick change in measured value may require a quick response from the controlled device if a large process fluctuation is to be prevented. This problem can be resolved by using derivative control which responds to the rate of change of the measured variable. The quicker the measured item changes the higher the correction to the controlled device.

Basic outputs

The response of the controller to a step disturbance is shown in **figure 1 (Page 2)**. This is the signal being applied to the controlled device, not the process output. The response curves of each basic style of control is shown. In practice it is common to use a combination of these.

The results

There will always be some error between the desired set point and the actual process output and a time delay, while the system responds to a disturbance. In **figure 2** below two response curves to a step disturbance are shown. Curve ‘A’ shows the process output approaching but never quite reaching the required level.
This response is typical of a proportional control system.
The final error and response time will be influenced by the

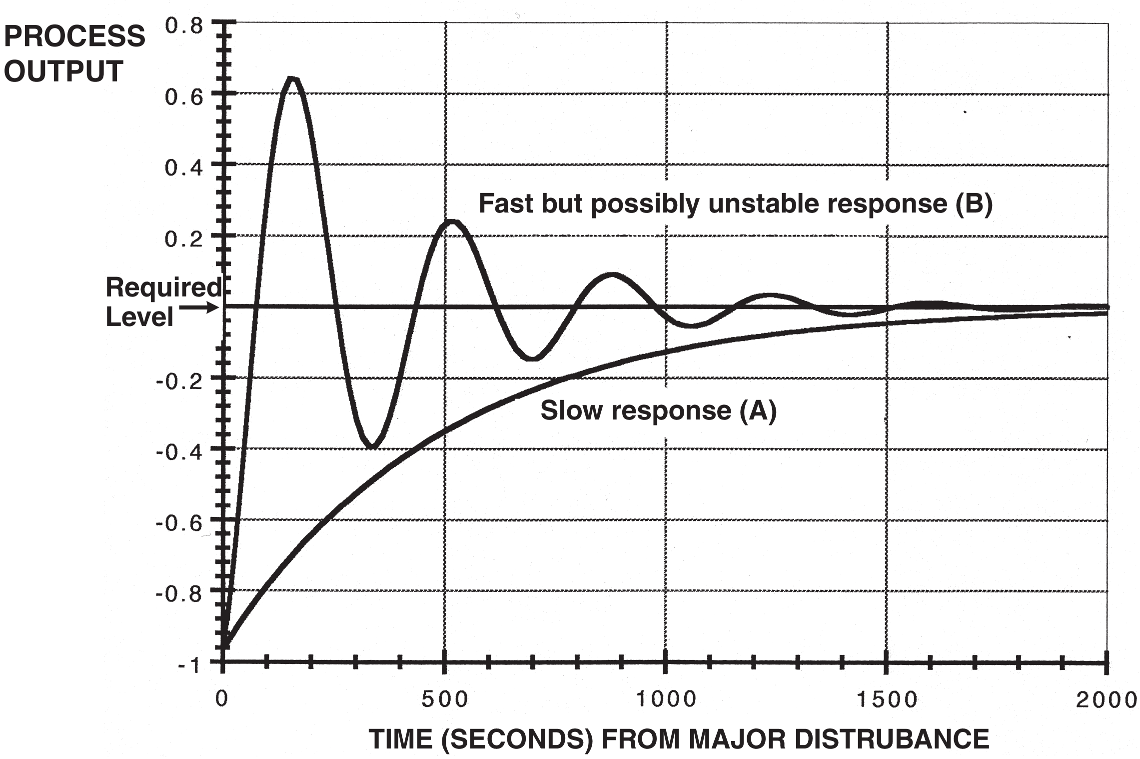


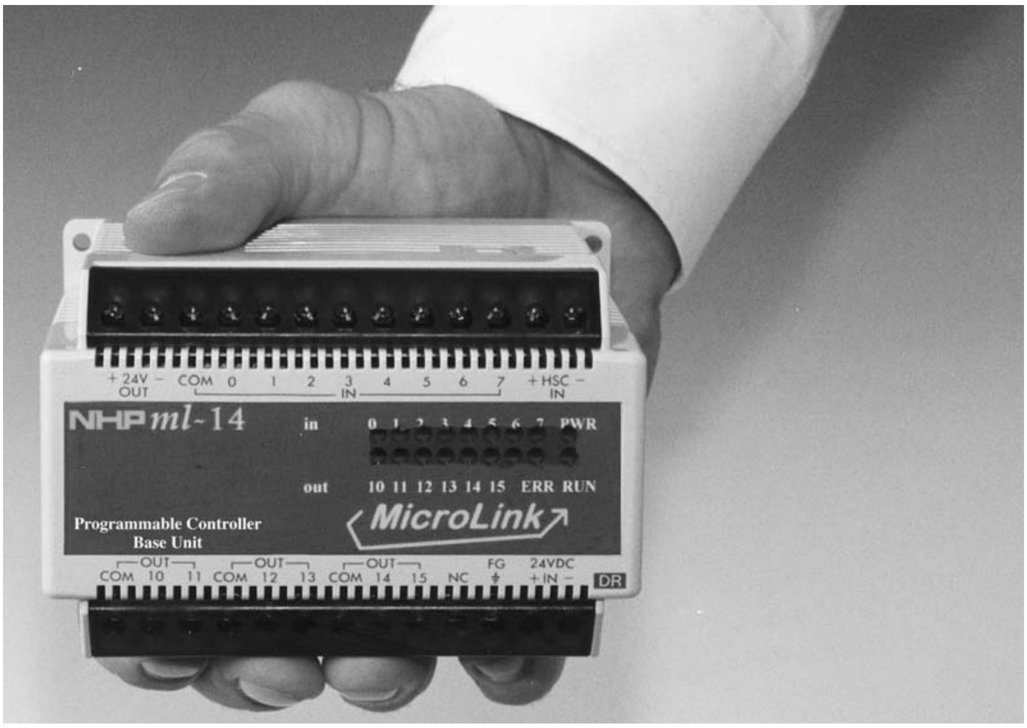
Figure 2. Process output with step disturbance

Results
(continued from page 3)

control system gain. Curve ‘B’ represents a faster responding system but with an oscillation about the desired level. It is possible to have a system where the oscillations do not reduce and the control system is unstable. The time delay between the process output changing and the controller responding is the major cause of the oscillation.

The PLC

The modern PLC allows quite complex control systems to be implemented with many inputs being evaluated at the same time. The relative simplicity of these systems allows even a novice PLC programmer to achieve satisfactory results. Applications that are critical in that they are not tolerant to initial errors (equipment may be damaged) should be left to the experts.



PLCs are now priced and sized to suit even the most simple applications.

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