MODULATING POSITIONAL CONTROL

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Most engineers think that a modulating actuator is one that accepts 0-10 Vdc or 0(4)-20mA modulating signal and even many manufacturers designate their actuators in a similar manner. The other type of actuator called a 2-position actuator is assumed to be suitable for on/off application only, but nothing could be farther from the truth.

Like how well a car is driven is not dependent on the car alone but on the driver also, in the same way a controller plays an important role in deciding the operational characteristics of an actuator.

Before going in to details it is important to understand a few control basics.

Control Basics

There are four basic elements of a control loop:

i) The process to be controlled

ii) A sensor that measures the condition of the process or factor affecting the process

iii) A controller that decides whether or not the process or factor affecting process condition is acceptable

iv) An actuator or controlled device that applies a corrective action to the process.

A sensor is used to convert a measured variable to a signal used by the controller. A controller compares this value to a preset value, set-point, and produces an output proportional to the difference between the two and sends it to an actuator to change the process parameters.

Commonly used terms in a control loop/systems

- Controlled variable – the property that is to be controlled, such as temperature, relative humidity or pressure.
- Control point – the current value of the controlled variable measured by sensor
- Set-point – the desired value of the controlled variable
- Error – the difference between the set-point and the control-point
- Controlled device – the device used to vary the process conditions
- Controller – the device that compares the input from the sensor with the set point and determines a response for corrective action through controlled device.
- Sensor – the device used to measure changes in the process property through changes in its output. A sensor translates a physical property such as temperature, pressure, humidity or flow-rate, into an electrically or mechanically measurable signal.

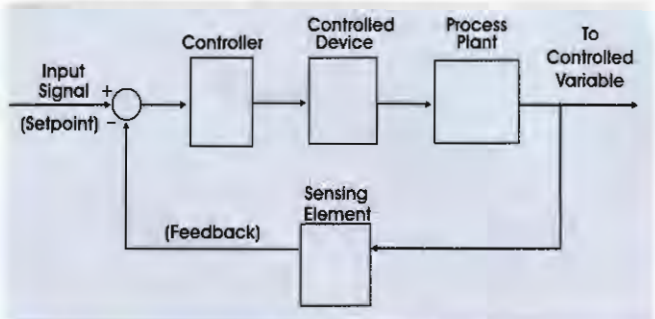

Figure 1 : Block Diagram of a Control Loop.

Modulating Control

In modulating control the output of a controller is continuously variable, i.e., it can have any value between 0-100%. 0-10Vdc and 0(4)-20mA are most common modulating control signals. In a truly modulating signal the difference between two adjacent values is infinitesimal, but due to practical limitations a signal with a resolution of 1% or better is often acceptable.

The term resolution defines the number of steps possible between 0-100% of signal value and is very important when using microprocessors. Microprocessors being digital devices cannot generate true analog or modulating signals. Their output is always in discrete steps, however, it is possible to achieve a very high resolution to imitate a true modulating signal. The concept often used is of pulse-width modulation (PWM) where the output is switched at a high frequency and the ratios between the on-time and off-time is varied to achieve average output imitating a modulating signal.

Unlike pneumatic controls where air pressure signal is also used to operate the controlled device, electronic

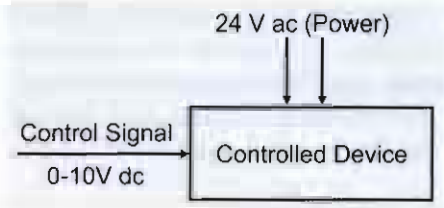

Figure 2: P&I diagram of a control system.

control signals are of very low power, incapable of powering a controlled device, and are therefore, used for reference only. Power is supplied separately to drive the controlled device, as shown in *Figure 2*.

Each electric controlled device has a built-in electronic circuit to regulate the power based on the control signal value. The power output regulation is simple when the output is also modulating like voltage, current frequency etc. regulating motor speed or light intensity, but it requires suitable modification when the desired output is positional.

Modulating Positional Control

In modulating positional control the positioning of the actuator is expected to be proportional to the control signal, i.e., actuator at 50% position for 50% control signal.

In pneumatic controls it is easy to achieve positional control by balancing the variable air pressure signal

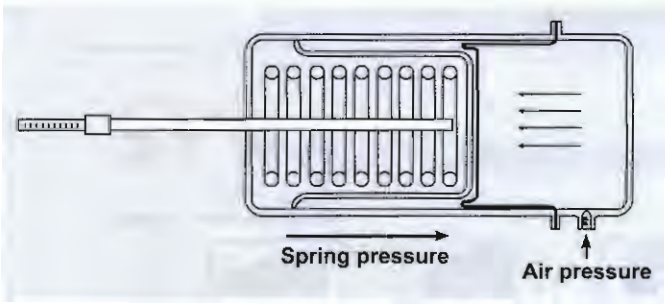

Figure 3 : Pneumatic Actuator.

against a spring. Increase in air pressure pushes the spring back till the spring pressure becomes equal to the air pressure. By knowing the spring characteristics it is possible to work out the actuator position for different air pressures.

With magnetic actuators also it is possible to vary the magnetic force and balance it against the spring pressure to achieve predefined position for a known signal input, however, these are not very often used due to their high cost and low power output.

Electric Actuators

Most of the present day valve or damper actuators use either a dc motor or an ac motor. It is easy to control the speed and/or torque characteristics of a motor by varying voltage, current or frequency but positional control requires positioning of output shaft in response to a modulating signal. To position the output shaft at the desired location the motor has to be stopped in that position and it has to be started again to move it to a new position, whenever required.

In simple terms, the output shaft of an actuator motor is positioned by using following three distinct signals.

- Power for forward movement
- Power for reverse movement
- No power for stopping the motor at the desired position.

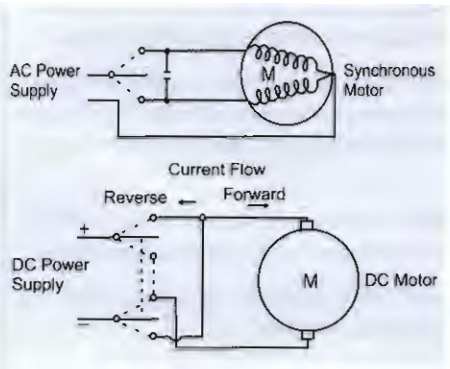

Figure 4 & 5: Internal connection details of synchronous motor

Figures 4 & 5 show the internal connection details of actuator motors

A synchronous ac motor has two windings - one for forward and other for reverse movement. Fixed voltage power is applied to the motor and the direction of rotation is changed by switching the power from one winding to the other.

A dc motor has single winding and the direction of rotation is reversed by changing the direction of current flow.

As described above, to modulate any such electric actuator the final signal to the electric motor has to be a 3-position signal, also called 3-point signal. This signal could either come directly from a controller or a 0-10vdc/4-20mA signal could be converted to a 3-point signal in the actuator itself.

Signal Conversion

Each electric actuator accepting 0-10Vdc or 0(4)-20mA modulating signal has a built-in electronic card to convert modulating signal to 3-point signal. Generally two different concepts are used to convert modulating signal to 3-point signal.

Say the motor has to be positioned proportional to 0-10 Vdc signal then one way is to take 5V as the reference voltage and give pulses to the motor to move it in the forward direction whenever the signal voltage exceeds 5V or in the reverse direction whenever the signal voltage falls below 5V. The pulses are stopped when signal voltage becomes 5V. The on time of the pulse varies according to the difference in magnitude of the control voltage and the reference voltage.

The other way to position an actuator is take actual position feed-back. In such a case, usually, a

potentiometer is connected to the actuator output and a signal is generated to indicate the actuators position. This feedback signal is compared to the input modulating signal and the motor is switched forward or reverse till the feedback signal matches the input control signal.

Importance of Controller

It is worth repeating that in a control loop the controller is the boss, and with a suitable controller it is possible to modulate a 2-position actuator or make a, so called, modulating actuator operate in 2-position mode.

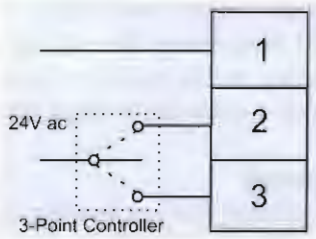

Figure 6 : Modulating operation of a 2-position actuator

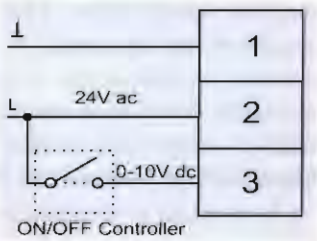

Figure 7 : 2-positon operation of a modulating actuator.

Figure 6 shows how a 3-point controller can be used to modulate a 2-position actuator, whereas *Figure 7* shows how an on/off controller can operate a modulating actuator for 2-position application.