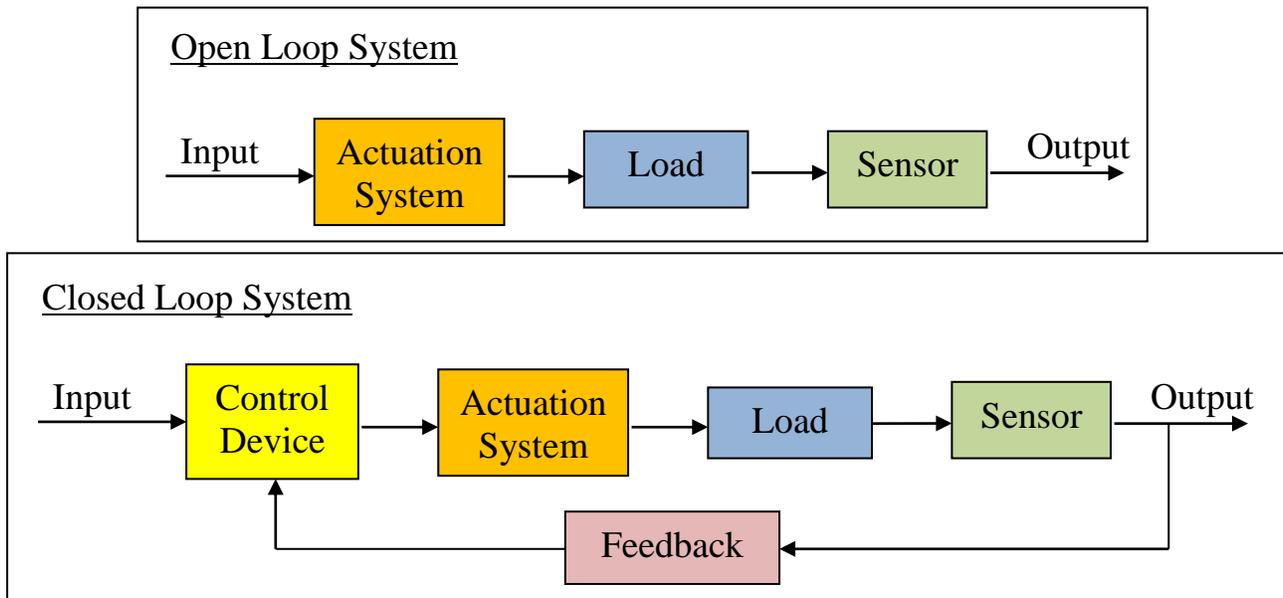


ME 4710 Motion and Control

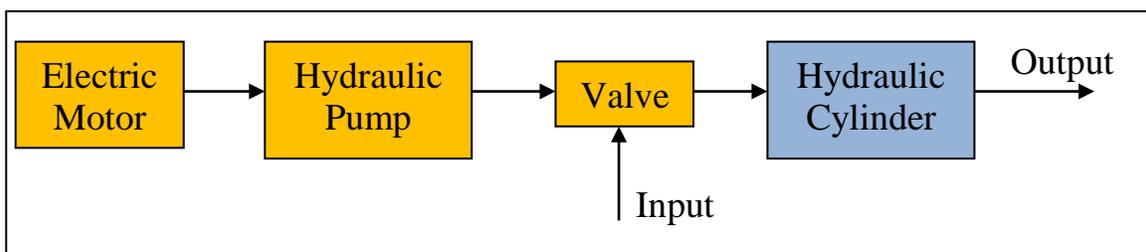
Introduction to Motion Control

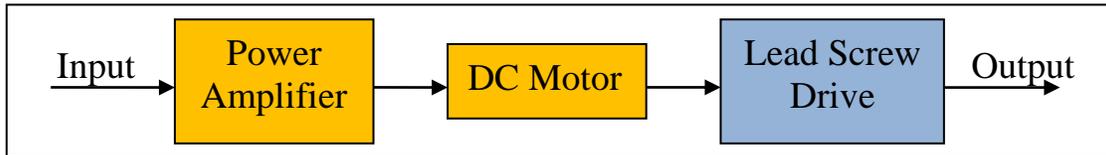
The basic job of a motion control system is to control the *position, velocity and/or acceleration* of some load. A motion control system consists of an *actuation system*, a *sensor* (or sensors), and, if required, a *control device*. In an *open loop* system, a *command* is sent directly to the *actuation system* to move the load, and a *sensor* is used to *measure* the response. In a *closed loop* system, a *command* is made to the *controlling device* that, in turn, *commands* the *actuation system* to move the load. *Feedback* is used to automatically correct for response errors. The responses of open and closed loop systems can be *very different*.



Actuation Systems

An *actuation system* contains the necessary components to *move the required load*. In general, these systems convert *chemical* or *electrical* forms of power into *mechanical power* to complete the task. Examples include *engines, electric motors, pumps, hydraulic motors, air compressors, signal and power amplifiers, electrical solenoids, hydraulic and pneumatic cylinders, and valves*. Examples of *electro-hydraulic* and *electro-mechanical* actuation systems are shown below.





Sensors

Sensors are used to *monitor the behavior* of the system. They should provide *accurate* and *timely measurements* of important variables within the system. Examples include *strain gages*, *pressure gages/transducers*, *force gages/transducers*, *flow meters*, *limit switches*, *potentiometers*, *linear variable differential transformers (LVDT)*, *accelerometers*, *tachometers*, *encoder wheels*, *thermocouples*, and *resistance temperature detectors (RTD)*.

Sensors can be used to measure the *position*, *velocity*, and *acceleration* of the load; however, additional sensors may be used to measure other important variables in the system. In an *electro-hydraulic* actuation system, for example, there can also be feedback of the *valve spool position* and *fluid pressure* and *flow rate*. In an *electro-mechanical* system, there can also be feedback of the *motor speed*. The use of *additional sensors* and *feedback loops* makes the system more complicated and costly, but it may *increase system performance* if properly designed.

Control Device

The *control device* may have *analog circuits*, *digital circuits*, or both. In either case, the control device must have the ability to form *differences* (or sums), *amplify*, *integrate*, and *differentiate* to behave as our control loop design requires. Analog circuits depend heavily on the use of *operational amplifiers* (called Op-Amps). Digital control devices are implemented using microprocessors either in a *PC-based* system, a *microcontroller*, or a program logic controller (*PLC*). *PLC's* are very commonly used in industrial control applications requiring *continual operation*. PC-based control devices are more commonly used in *testing*, *development*, and *research* environments.

Analog-to-digital (*A/D*) and digital-to-analog (*D/A*) *converters* are required for digital control devices to interface with analog processes and sensors. Two important characteristics of these converters are *speed* and *resolution*. The *raw speed* of the converter and the *number of channels* it supports determines its *effective speed*. In some systems, *each channel* of data has

its own *dedicated* converter, while in others a *single converter* is *shared* by *multiple channels* using a multiplexer. *Resolution* is determined by the *number of bits* used in the conversion process. The *quantization error* for a converter using n bits in the conversion process is

$$e_Q = \frac{V_{\max} - V_{\min}}{2^n - 1}$$

Here, $V_{\max} - V_{\min}$ represents the *maximum voltage range* of the converter. It is important to use the *full range* of the converters and use *enough bits* to provide the desired resolution.