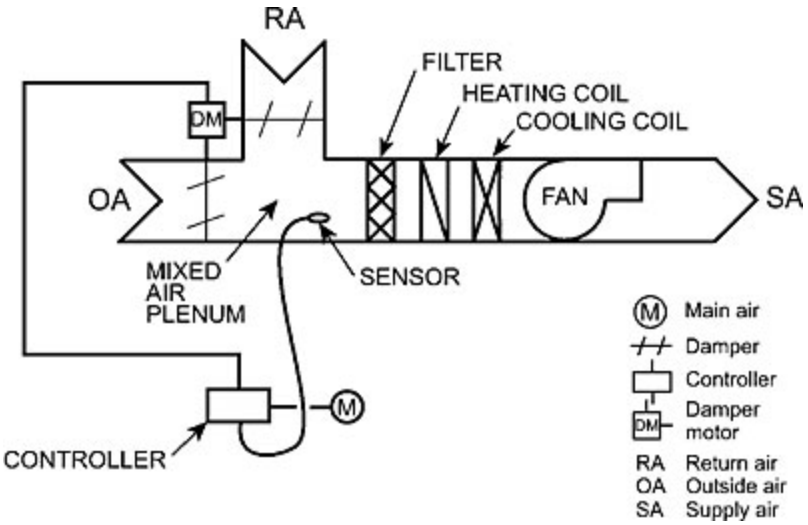
Building HVAC Control Systems – Very Brief Introduction

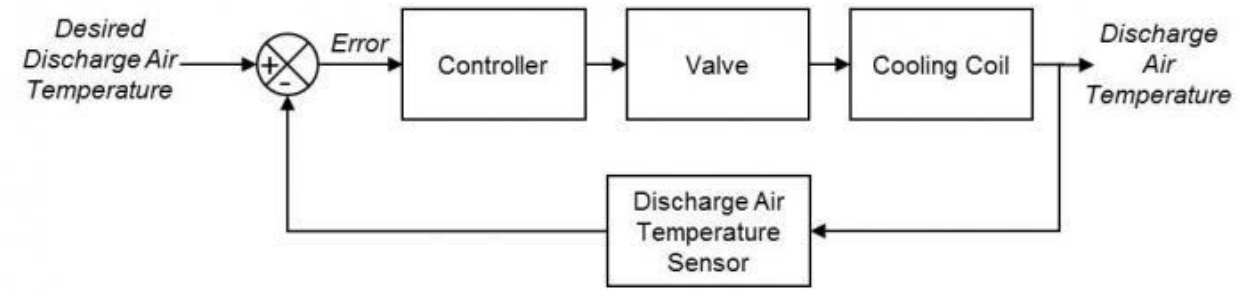


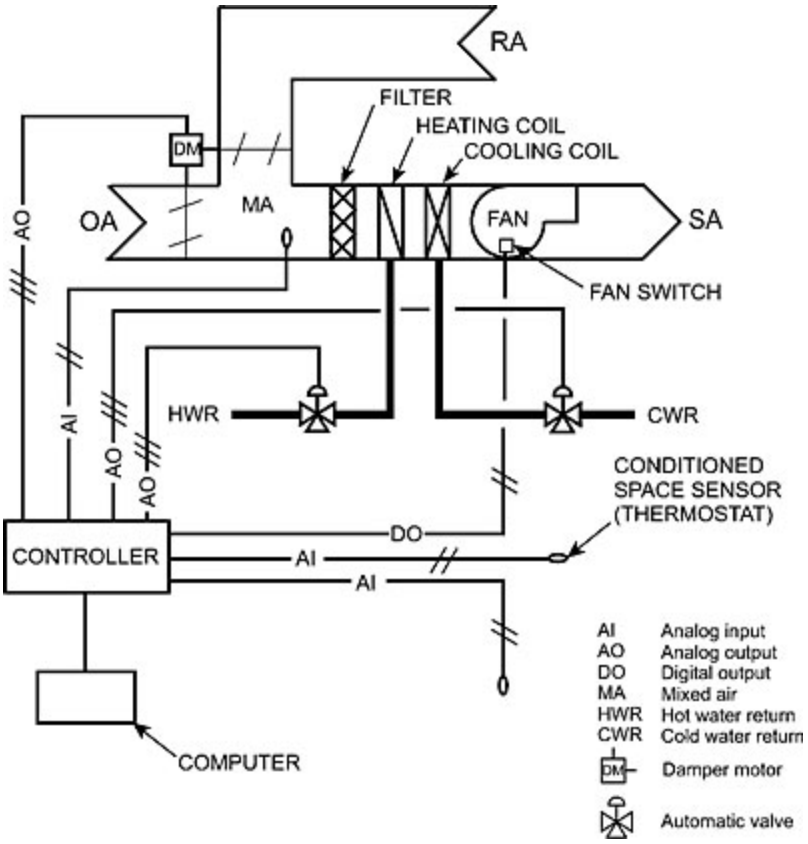
Damper Control System with Mixed-Air Temperature Sensor

The figure above shows a Damper Control Subsystem for a basic single-zone system. It illustrates four basic components:

1. The sensor in the plenum senses the mixed-air temperature and sends a signal to the controller.
2. The controller receives information from the sensor and sends the appropriate air pressure or electrical power signal to the actuator. The actuator is the damper motor.
3. The actuator positions the controlled device to regulate the air. The damper motor modulates the two air dampers.
4. The 'controlled device' is the return air (RA) and outside air (OA) dampers, which modulate to regulate the temperature of the air in the mixed air plenum.

Any feedback control system works this way – there is a sensor that provides feedback as to how successful the controller has been at modulating (controlling) the required quantities. Here is a feedback control block diagram that describes the feedback control process of a cooling coil in the single zone ventilation system shown on the next page.





Single Zone DDC (Direct Digital Control) System

Wiring from sensors carry input signals to the controller. Other wires from the controller carry output signals to operate the damper and valve actuators to open, close, or modulate them under the proper conditions. The sensors are electronic devices and the damper and valve actuators are electrically operated.

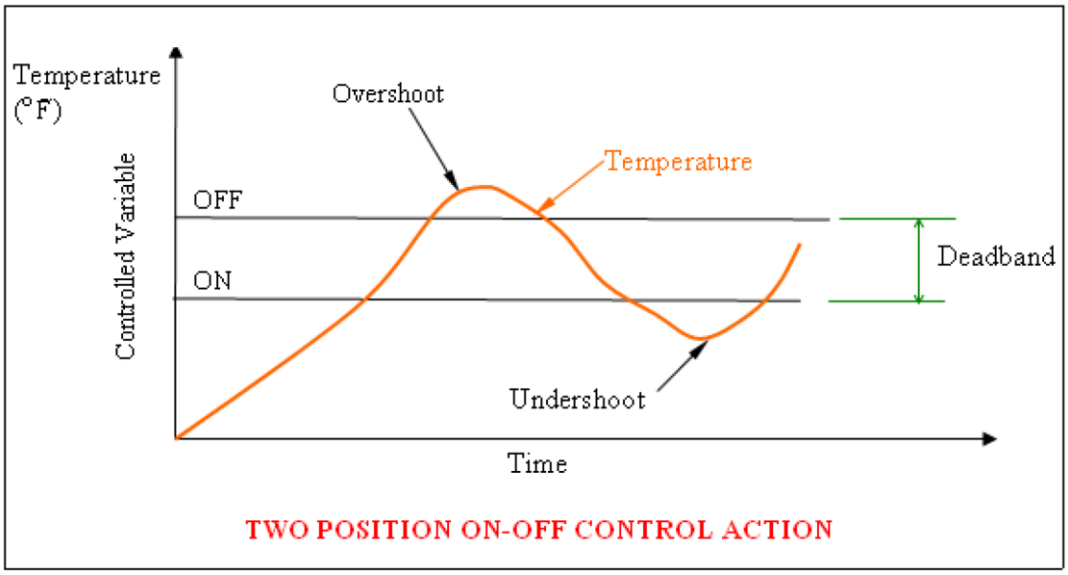
The controller sends and receives two kinds of electronic signals to the actuators, and from the sensors:

1. Digital (on or off).
   - DO: Digital output signal.
   - DI: Digital input signal.
2. Analog (varying). The varying psi branch signal in a pneumatic control signal is an example of an analog signal.
   - AO: Analog output signal.
   - AI: Analog input signal.

A computer communicates with the controller to receive, store, and process data. The computer is programmed to direct the controller so that it produces a desired sequence of operations. The computer can also be use to send commands to the controller, such as changing set points.

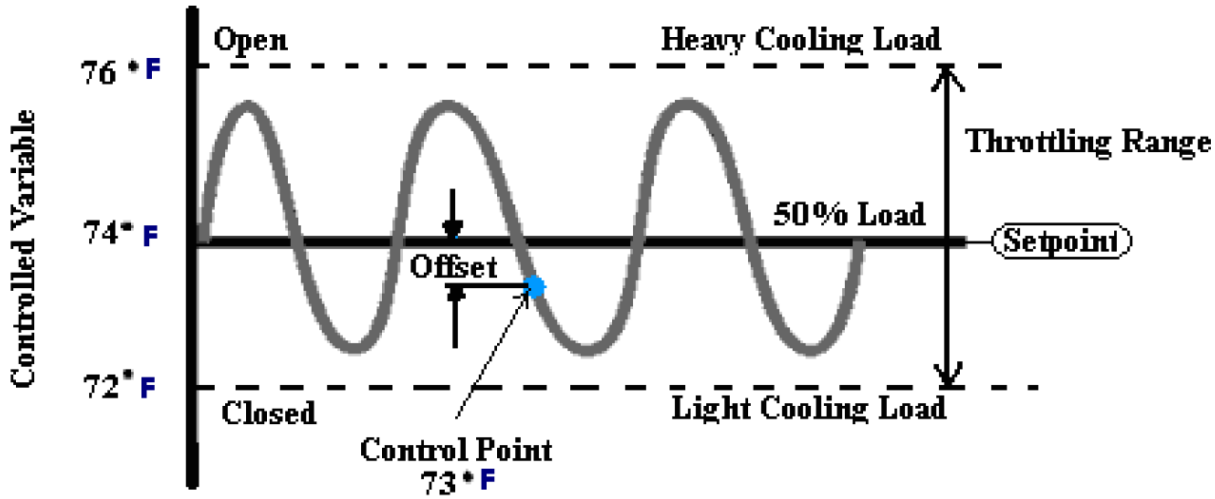
The common types of control are:

- On/Off Control.
  When the room is too cold the heater turns on fully-blast.
  When the room is too warm the heater turns off completely.



TWO POSITION ON-OFF CONTROL ACTION

- Proportional Control (or PID control)
  When the room is 3°C too cold the heater turns 100% on.
  When the room is 2°C too cold the heater turns 75% on.
  When the room is 1°C too cold the heater turns 50% on.
  When the room is 0°C too cold/warm the heater turns 25% on.
  When the room is 1°C too warm the heater turns 0% on.



PROPORTIONAL CONTROL ACTION

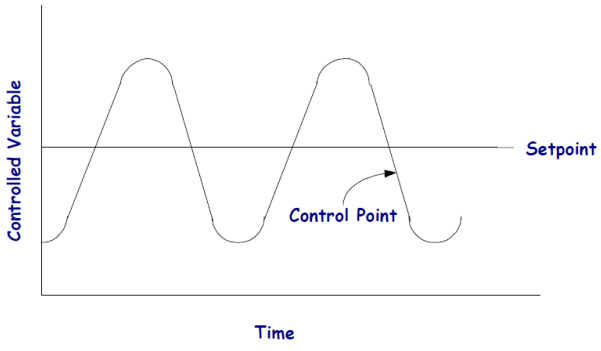
In the figure, we can see that even though the setpoint is 74°F, the temperature doesn't stay constant. It rises and falls, wasting energy and mechanical cooling, and causing uncomfortable temperature swings.

Setpoint: Setpoint is the desired condition of a variable that is to be maintained, such as temperature. The setpoint is an instruction to the control loop and corresponds to a specified value of the controlled device, usually half travel. In figure above the setpoint is 74°F. A room that needs relative humidity to be at 50% RH, or an air handler duct pressure that is to be 2.0 inches of water column (500 Pa) is examples of setpoints.

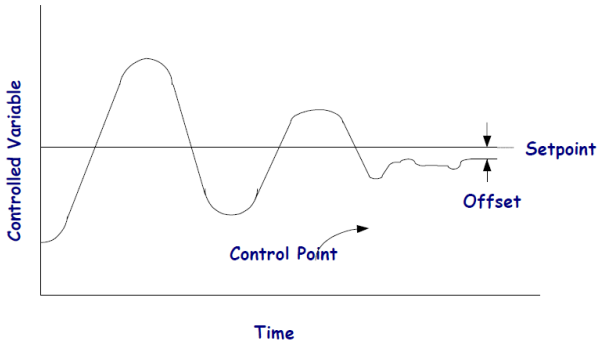
Control Point: The value of the measured variable at any given moment is called the control point. The control point is the actual temperature being sensed. The control point (temperature) may not be on the setpoint, but instead may be above or below it. Systems operate to maintain the setpoint, plus or minus some acceptable limits called differential (two-position or on/off control) or throttling range (proportional control). Simply stated, setpoint is what you want, while control point is what you get. In the example below, the setpoint is 74°F (23°C), and the control point is at 73°F and varying.

Offset: Offset is the amount away from setpoint, or the difference between the setpoint and the control point. In the example above, the offset is approximately 1°F.

Stability is tendency of a system to find a steady control point after an upset.
Instability is tendency for oscillations to grow.



UNSTABLE SYSTEM UNDER PROPORTIONAL CONTROL



A STABLE SYSTEM UNDER PROPORTIONAL CONTROL