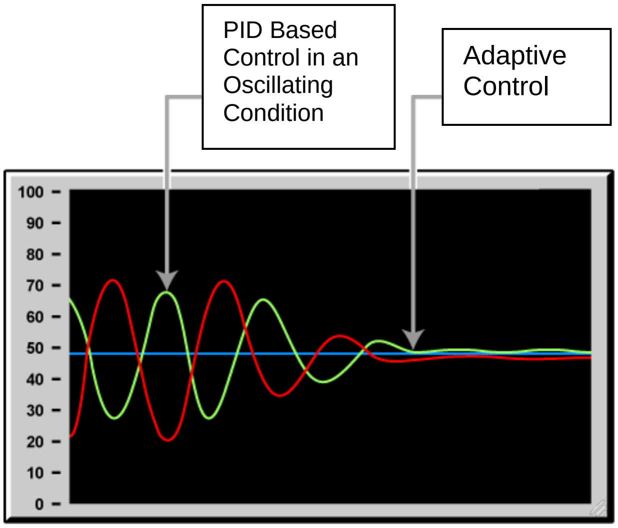
Adaptive Control for APOGEE Building Automation



Description

The APOGEE® Automation System controller family includes Adaptive Control, based upon the Model-Free Adaptive (MFA®) Control software developed by Cybosoft®.

Adaptive Control is a sophisticated closed loop control algorithm that auto-adjusts to compensate for mechanical system/load/seasonal changes – it provides more efficient, robust, fast, and stable control than traditional Proportional, Integral, Derivative (PID) control. Adaptive Control achieves superior performance in a dynamic, non-linear system compared to PID in terms of response time and holding steady state, while minimizing error, oscillations and actuator repositioning.

The MEC, MBC, and PXC Compact series controllers (with firmware Rev. 2.7 or greater) all come standard with Adaptive Control.

Features

- Continuously adapts to changes in system characteristics and can easily handle
  - non-linear loops
  - complex applications such as multi-output supply air temperature control
- Model free – faster response since no complex modeling of process is required
- More consistent control results
- Reduced training requirements, improved staff productivity, and less chance for human error.
- Adjusts automatically to seasonal and mechanical characteristic changes – no seasonal adjustments
- Saves energy due to better tuned loops
  - Reduced cycling
  - Reduced offset from setpoint
- Increased life expectancy of valve and actuators
  - Reduces cycling-induced wear and tear
  - Reduces repair, replacement, and maintenance costs of end devices

Background on PID

PID is a “fixed” controller. This means it must be tuned to be optimal for static or fixed conditions. When conditions change, the operating performance will no longer be optimal. Therefore, PID is a compromise for variable/non-linear conditions. Variable conditions are common and could include:

- Seasonal and load changes
- Process delays
- Noisy process signals

- Heating – cooling changeover
- Other non-linearities

Adaptive Control is designed to adapt to system changes and non-linearities and eliminate the compromises of PID.

How Adaptive Control Works

Adaptive Control is based on CyboSoft's patented Model Free Adaptive (MFA®) control software, which is a multi-layer neural network-based control program. Adaptive Control is not a PID based "auto – tuner" and does not utilize Proportional, Integral, Derivative (PID) technology in any way.

Model Free Adaptive control technology is inherently very easy to configure and commission. The neural network technology allows controllers to learn, remember, and improve performance.

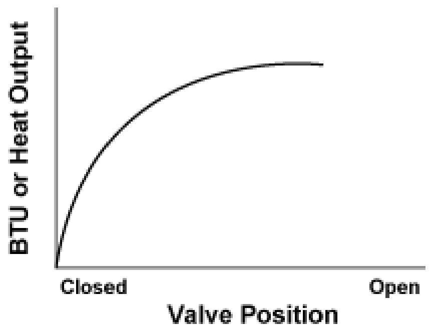
Adaptive Control continuously measures performance, its response times, and setpoint error measurements. The neural network dynamically adjusts to new operating conditions and continues to re-compute its performance, creating a "learned memory" that continues to improve and adapt.

By constantly adapting to conditions, Adaptive Control provides consistent control performance, year-round.

Real World Examples

#1 The non-linear steam valve.

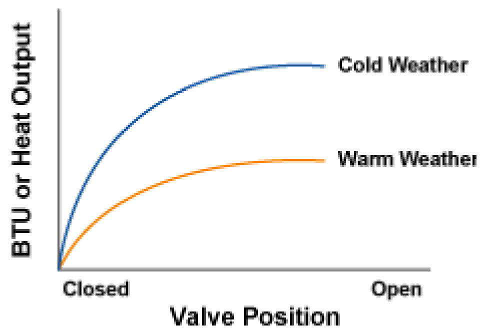
Particularly with steam valves, when the valve nears the closed position, small changes in valve position result in large changes in coil discharge temperature, while when the valve nears the open position, a change in valve position will result in very little change in discharge temperature. This is an example of a non-linear process.



The standard practice is to tune the temperature loop to work well with the valve near the middle of its range. The result is that when there is a light heating load, the valve nears the closed position, and the loop oscillates trying to maintain setpoint – the PID gains are too big. When the heating load is high, the valve nears the open position, and loop response is very sluggish – the PID gains are too small. Adaptive Control dynamically "adapts" to the changing characteristics providing smooth control throughout the entire valve range. The same situation often occurs with non-linear damper control.

#2 The hot-water reset problem.

This is a very common energy-saving strategy - setting the supply hot water temperature down when it is warm outside - but it can play havoc with the performance of the temperature loops. In warm weather, the lower supply water temperature causes less change in coil discharge temperature for a given valve position change than when the water is hotter in cold weather.



PID loops are typically tuned for one condition (usually the season when the system was commissioned) so when the other season arrives, the control can become either oscillatory or sluggish – because the PID gains are wrong. Adaptive Control handles this situation superbly and automatically, limiting actuator motion while maintaining the required set points without oscillation.

#3 Varying discharge air temperature sensor time constant

The time constant of the discharge air temperature sensor for a VAV air handler varies constantly with the varying velocity of the air. PID gains are optimal for only one velocity. This can result in either sluggish or oscillatory air temperature control at other air velocities. Adaptive Control overcomes this limitation by automatically adjusting to give optimal control for all air velocities.