

BEYOND

SMART CITIES

BUILDING AUTOMATION & CONTROL SYSTEM

CEM REFRESHER TRAINING

KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP

ENERGY MANAGEMENT SPECIALIST CURRICULUM

CERTIFIED BUILDING AUTOMATION SPECIALIST

CBAS

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CONTROL ALGORITHMS

FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN

Control Algorithms

What is PID Control?

PID Controls

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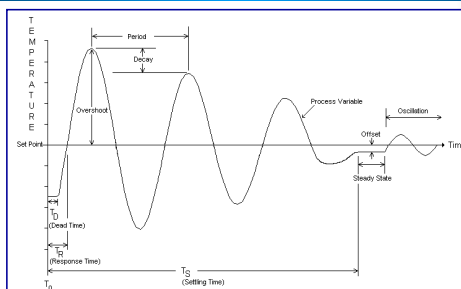
WHAT IS A PID CONTROLLER?

- ✓ The term PID stands for proportional integral derivative and it is one kind of device used to control different process variables like pressure, flow, temperature, and speed in industrial applications. In this controller, a control loop feedback device is used to regulate all the process variables.
- ✓ PID controllers are found in a wide range of applications for industrial process control. Approximately 95% of the closed-loop operations of the industrial automation sector use PID controllers. PID stands for Proportional-Integral-Derivative. These three controllers are combined in such a way that it produces a control signal. As a feedback controller, it delivers the control output at desired levels. Before microprocessors were invented, PID control was implemented by the analog electronic components. But today all PID controllers are processed by the microprocessors.

CONTROL ALGORITHMS

- ✓ PID Controls
 - P is proportional
 - I is integral
 - D is derivative
- ✓ Controls are usually P, PI or PID
- ✓ PID is considered the best of this group
- ✓ Newer control algorithms are:
 - Fuzzy logic
 - Learning systems
 - Self-optimizing systems

PID CONTROLS



PID CONTROLS

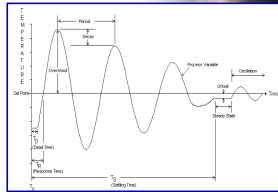
Loop Definitions

Stability	Stable if process doesn't show continuing trend away from setpoint or continuous oscillation following an upset in either load or setpoint
Response Time	Time required for PV to reach SP following a step change in mode or setpoint
Overshoot	The amount the PV goes beyond the SP following a change in load or setpoint
Offset	The amount of constant error existing between PV and SP once the process reaches steady state
Settling Time	Time required for process to reach steady state following a change in load or setpoint
Steady State	Condition that exists in closed loop system when the control variable (CV) equals a constant value and no oscillation occurs

PID CONTROLS +

Proportional Gain:

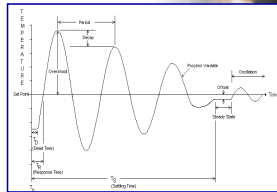
(responds to size of offset) Defines the amount of change in controller output signal for a given change in the difference between PV and SP (error). Changes control loop output by an amount proportional to change in error. Adjusts outcome to obtain stability. Any particular setpoint can be maintained exactly for one and only one load -- an offset will exist for all other loads. Determine gain value at which offset and overshoot are within a usable range.



PID CONTROLS

Integral Gain

- Output of controller affected by error signal integrated (summed) over time
- Compensates for load changes and eliminates offset
- Controller continues to change as long as an error persists
- Decrease PG when introducing IG into the system



PID CONTROLS +

Derivative Gain

- ☑ Output of controller affected by the rate of change of error (how fast)
- ☑ Speeds up output action when fast load changes occur
- ☑ Reduces response time
- ☑ Adds stability
- ☑ Can produce significant correction before magnitude of error becomes too large - acts like a "shock absorber"
- ☑ Anticipates error and initiates early corrective action
- ☑ May saturate controller when very fast load changes or noise measurements are encountered
- ☑ Only systems with very rapid response requirements (ex. pharmaceuticals, laboratories, steam valves etc.) should consider the derivative mode

PID CONTROLS

CONTROL MODE	PURPOSE	ERROR DETECTIONS
PG	Reacts to Change	Detects SIZE of Error
IG	Reduces/Eliminates Offset	Averages Error over TIME
DG	Senses High Rate Load	Detects RATE of change of error

$$CV \text{ (adjustable)} = \left\{ \left(\frac{PG}{1000} \times \text{error} \times \text{action} \right) + \left(\frac{IG}{1000} \int \text{error} dt \times \text{action} \right) + \left(\frac{DG}{1000} \times \frac{d(\text{error})}{dt} \times \text{action} \right) \right\} + \text{bias}$$

REVIEW CONTROLS

1. List advantages and disadvantages of pneumatic controls.
2. Why is DDC so popular?
3. What does the term "direct acting" mean?
4. The difference between the setting at which a controller operates to one position and the setting at which it changes to the other is known as the:
A) Throttling range B) Offset C) Differential D) Control point
5. What is the flow rate of 16°C water through a control valve with a flow coefficient of 0.01 and a pressure difference of 100 kPa?
A) 0.1 LPS B) 0.2 LPS
C) 0.6 LPS D) 0.4 LPS