Fuji Electric

Innovating
Energy Technology

PID control for dummies: Everything you need to know

Temperature control White Book

PID Control for Dummies is designed for those looking for a better understanding of PID control without getting bogged down in complex technical concepts.

Whether you're a technician or a student in the field of instrumentation, this article is intended as a resource to guide you towards knowledge of the pid controller.

You'll learn about the origins of PID control, how it works, the importance of PID control in different industries, and tips for optimizing your process.

Key points

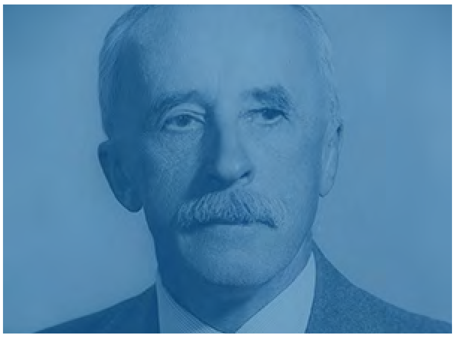
- The **PID controller** controller is an integral part of the control system in many industries and applications.
- The main purpose of a PID controller is to compare a setpoint value with the measurement during the process, in order to minimize error
- The right settings for your PID temperature controllers can have a major impact on your process performance.
- Getting an explanation of the terms **PID**, on/off, proportional band, derivative, integral, loop, setpoint and many other related concepts, will enable you to harness the full power of your PID system.

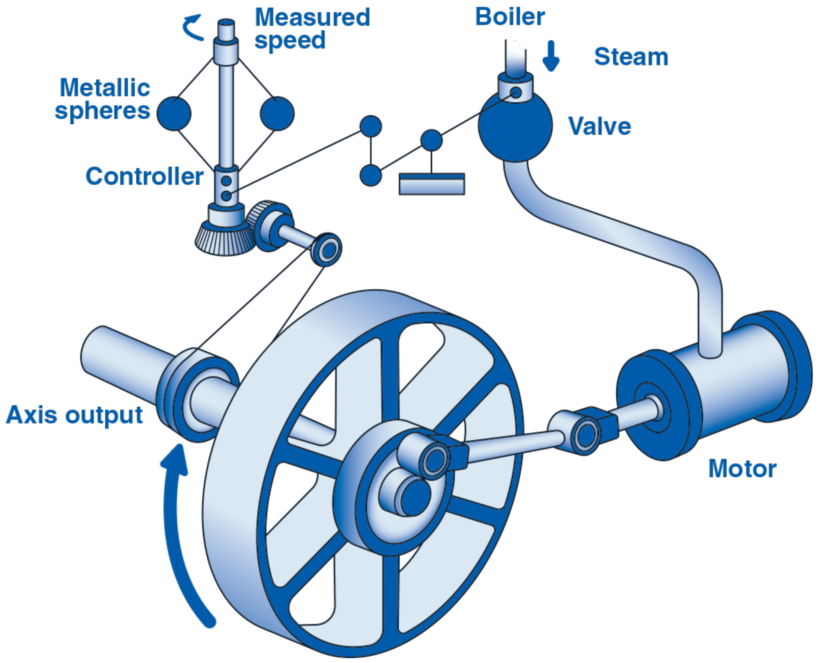
History of the PID controller

It's difficult to discuss **PID control** without touching on its history. At the beginning of the 20th century, **Nicolas Minorsky** observed that ships were unable to maintain a constant course despite the continuous efforts of the piloting staff.

Mr. Minorsky then developed a solution to the need: the use of an automatic controller, which, by exploiting deviations between the desired direction and the actual course, could adjust the rudder to ensure smoother navigation.

This was the basis for the birth of PID control, and its effect on industrial process control has been major.

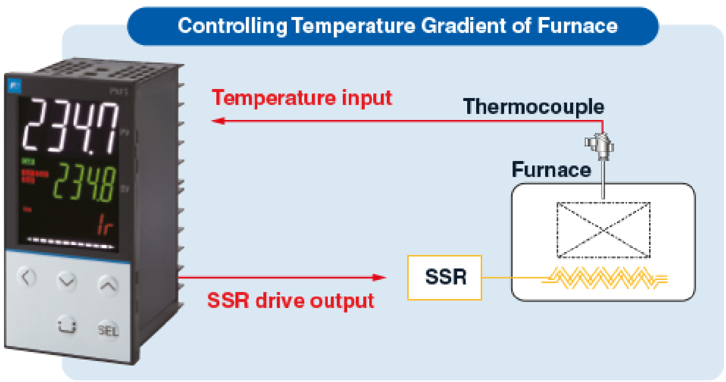


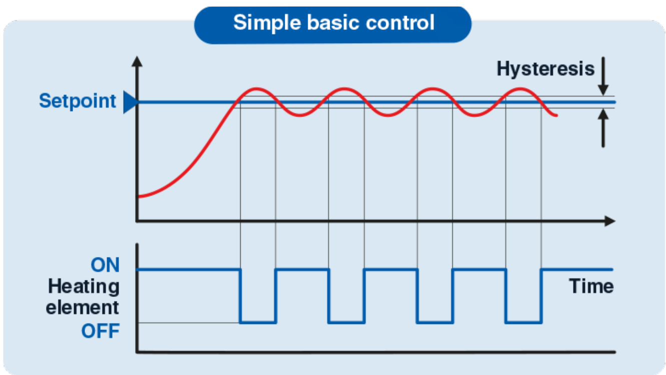


The operating principle

To easily understand how a **PID controller** works, let's consider a simple and common example of a control loop - a pottery kiln.

The temperature inside the oven must be maintained at a constant **setpoint** , say 800°C.

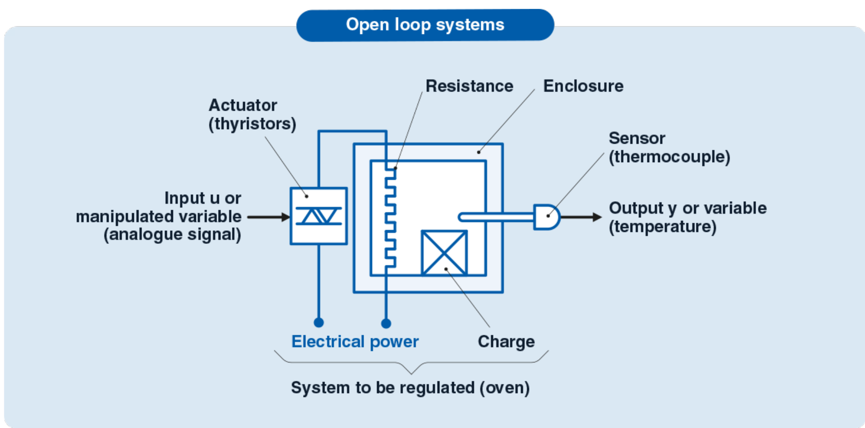




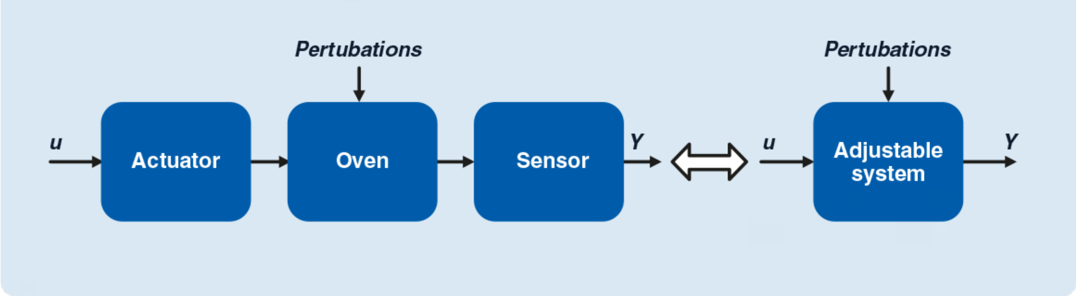
Instead of a simple all-or-nothing control system (the oven is either on or off), the temperature controller PID will maintain this temperature constant to avoid any deviation that could deteriorate the quality of the product inside the oven.

Here's how it works.

The start of the **control process** involves a thermocouple temperature sensor which monitors the **temperature** inside the furnace.

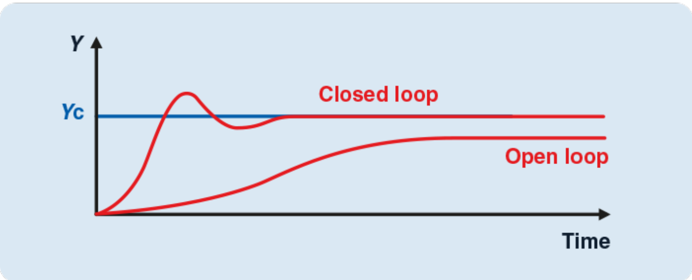


Equivalent function diagram

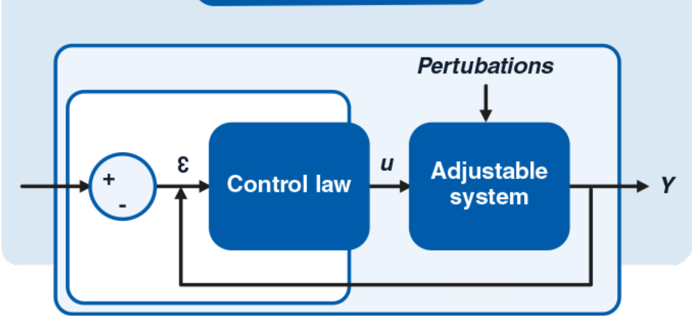


This **temperature measurement** is compared with the temperature **setpoint** (800°C in this example).

System response in open and closed loops

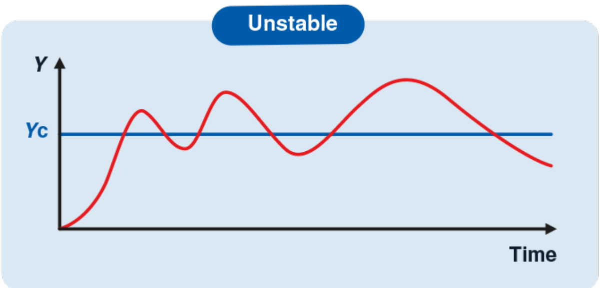


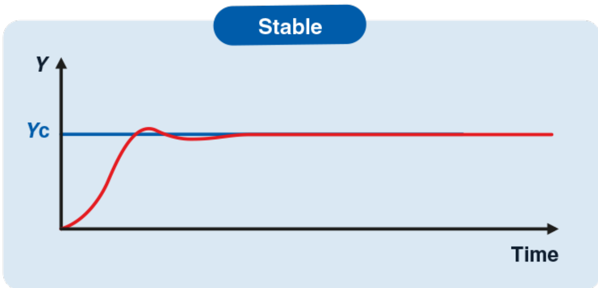
Closed loop system



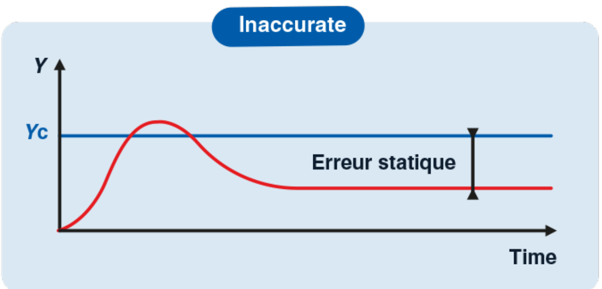
The **difference** between these two **values**, called an **error**, is sent to the **PID controller**, which formulates a **correction action** on the output to mitigate this error.

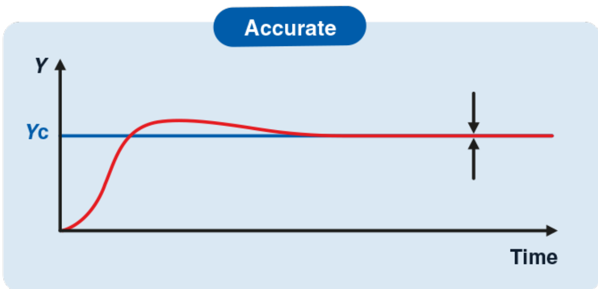
Quality of a good control system: Stability



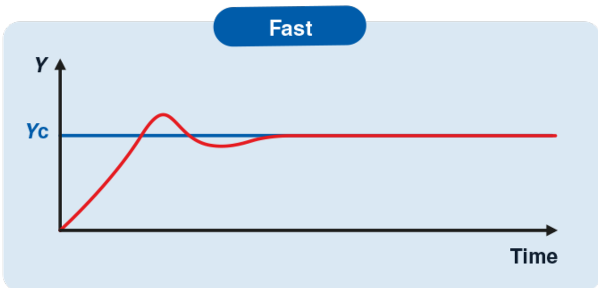


Quality of a good control: Accuracy



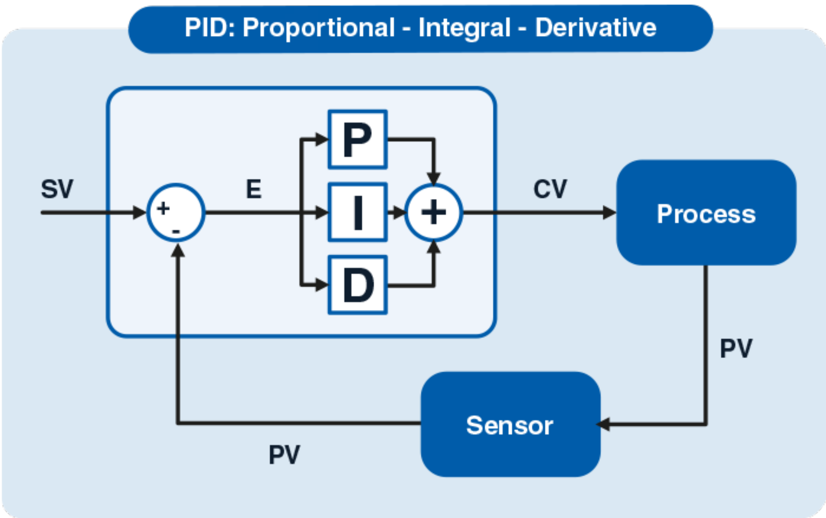


Quality of good control: Speed



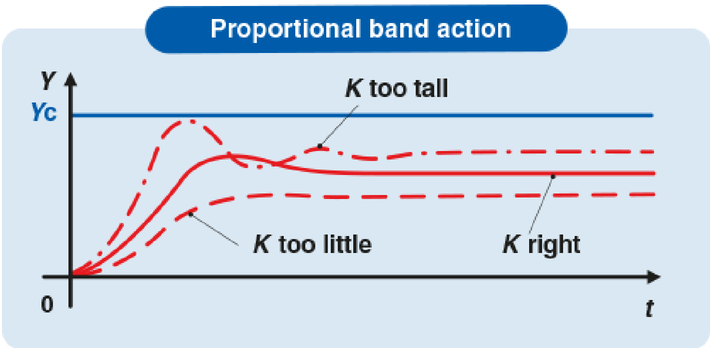
This correction is the product of three functions or quantities:

Proportional (P), Integral (I) and Derivative (D) together form the acronym PID (Proportional Integral Derivative).



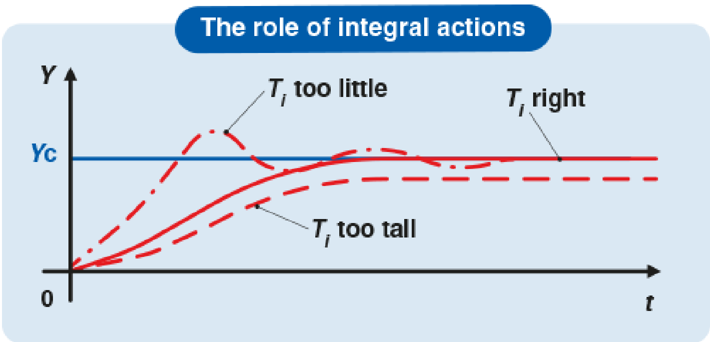
Proportional (P)

The proportional band action is equivalent to multiplying the error by a proportional coefficient (Kp). This action adjusts the controller output to be proportional to the error. So, if the error or disturbance is large, the correction will be equally large, and vice versa.



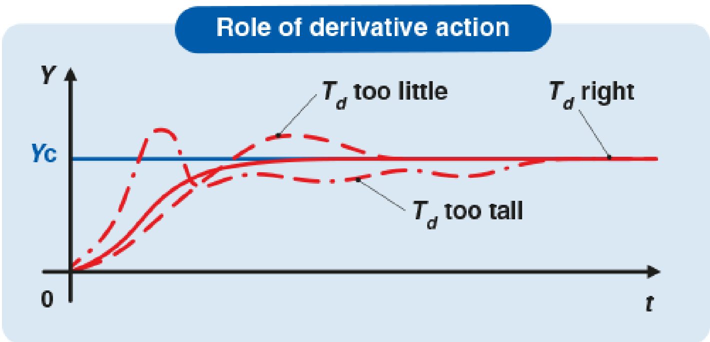
Integral (I)

Integral action aims to eliminate persistent error by accumulating past errors and integrating them over time. This action brings the system progressively closer to the setpoint by adjusting the output according to the integrated error. The integral coefficient (Ki) determines the influence of this component.



Derivative (D)

The derived action concerns the rate of change of the error. This predictive action enables the system to react to future events based on observed trends. The derived coefficient (Kd) adjusts the influence of this action for better control.



Setting a PID controller

Setting up a Proportional Integral Derivative **controller** may seem daunting, but it's essential to ensure that your process runs smoothly. Each of the tuning parameters, P, I and D, impacts the way the controller reacts to process **value** variations.

The right **settings** can significantly improve the stability and **performance** of your system.

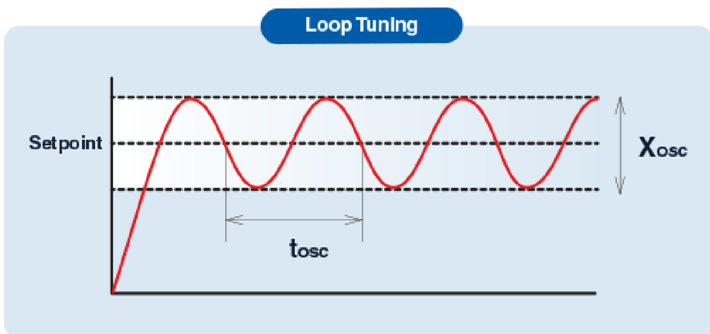
On the other hand, incorrect settings can lead to oscillations, over-excitations and under-reactions, impairing the quality of process control.

Ziegler-Nichols method

The Ziegler-Nichols method is a well-known approach to setting the parameters of a PID controller.

This method consists of making the system or process oscillate by adjusting the proportional gain (Kp) until it reaches the stability limit.

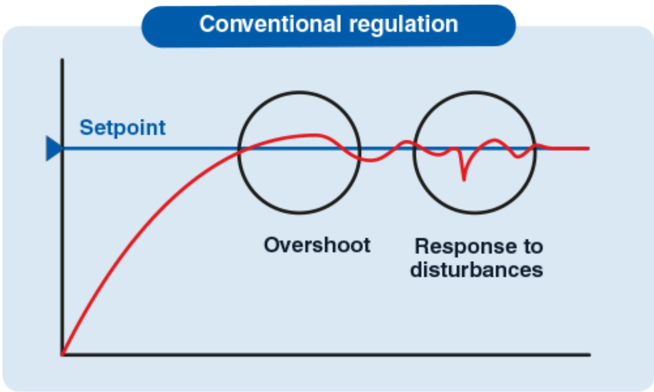
The oscillation period and critical gain are then used to determine the optimum proportional (Kp), integral (Ki) and derivative (Kd) coefficients.

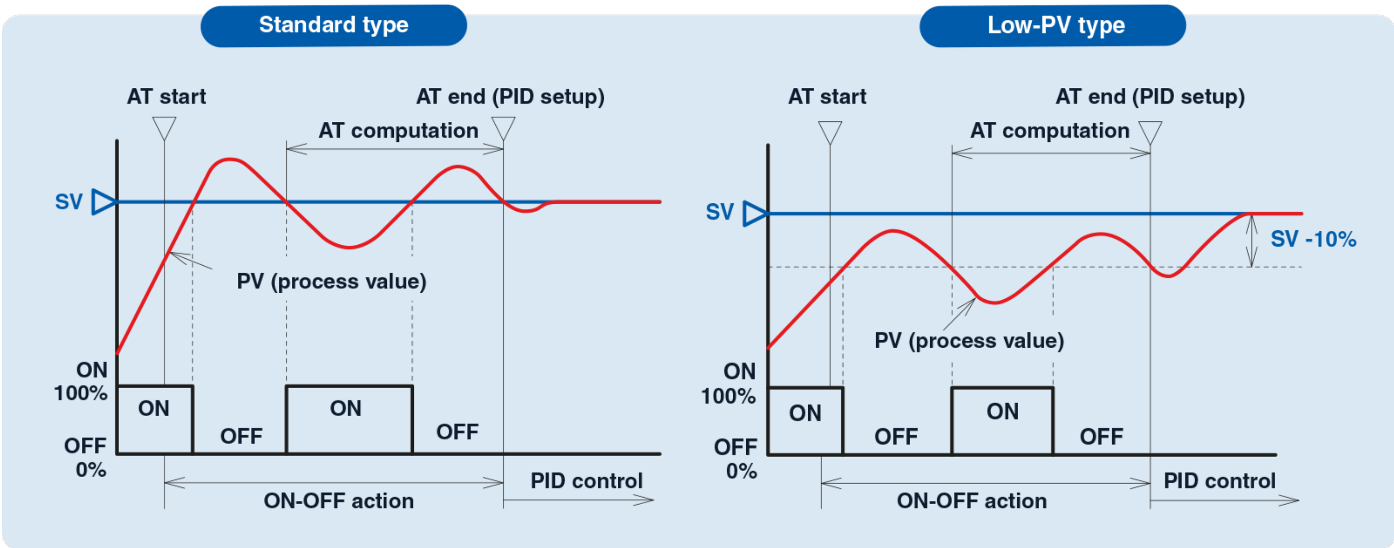


While this method is convenient for initial setting of PID parameters, it is important to note that optimization of the control system may require further adjustments. These adjustments will depend on the desired response and specific process constraints.

PID control limits

If your **system** has inherent instability, or **other** prevailing problems such as delays, disturbances, external pressures, etc., then a **P, I, D controller** can only temper them, not eliminate them completely. It is sometimes useful to redesign the process.





PID control FAQs

What is a closed loop in PID control?

In a **closed loop**, information on the current state of the process is constantly fed back to the PID controller. It uses this information to correct its output, thus keeping the process as close as possible to the setpoint. This mechanism considerably improves the precision of process variable management, enabling tighter control and greater stability. In addition, closed-loop systems effectively counteract external disturbances, minimizing unwanted fluctuations.

What does all-or-nothing mean in regulation?

All-or-nothing refers to a control mode in which the system is either 100% on or completely off. There are no intermediate operating levels.

What are the disadvantages of On/Off control compared with PID control?

1 - Lack of precision:
Unlike PID control, which finely adjusts power to achieve and maintain the desired temperature, On/Off control operates only in extreme states (100% on or off). This method tends to generate a temperature overshoot before stabilizing, creating fluctuations rather than the stability obtained with PID control.

2 - Temperature oscillations:
On/Off operation leads to greater temperature oscillations around the setpoint. This fluctuation can be detrimental to processes requiring fine, constant temperature control.

3 - Equipment wear and tear:
The frequent switching on and off of equipment with On/Off control places greater stress on mechanical and electrical components, potentially reducing their lifespan compared to the smoother operation permitted by PID control.

4 - **Energy consumption:**

Although On/Off control may appear more energy-efficient due to periods of inactivity, frequent on/off cycles can actually lead to higher energy consumption over the long term, particularly in cases where the system consumes a lot of energy at start-up. PID control, thanks to its precise adjustment, tends towards optimized energy consumption.

5 - **Response to disturbances :**

On/Off control can be less effective in the face of sudden process disturbances (e.g. a door opening in an air-conditioned room), as it can only respond by switching on or off, whereas PID control can proportionally adjust the energy applied to quickly counterbalance the disturbance.

In short, On/Off control can be adapted for simple, less demanding applications. However, for precise and efficient temperature control, particularly in industrial environments or for critical processes, PID control offers significant advantages in terms of stability, energy efficiency and equipment protection.

What is the proportional band in PID control?

The **proportional band** is the range of values within which the controller switches from its off state to its full power state (and vice versa) in a proportional control. It is the part of PID control that reacts according to the deviation between the desired value and the actual value. The greater the deviation, the greater the correction.

What is the integral band in PID control?

The **integral band** is the part of the PID control that accumulates over time. If the deviation persists, however small, this correction will continue to increase until the deviation is corrected.

What is the derivative in PID control?

The **derivative action** in PID control is the part that reacts to the speed of change of the deviation. It tries to predict the future of this deviation and to make a preventive correction to minimize too rapid variations.

Where can PID controllers be used?

PID controllers are widely used in various industries such as the **pharmaceutical industry**, the food industry (e.g. **bakery ovens** or **pizza ovens**), the automotive industry (e.g. **paint booths**), in laboratories (e.g. **automotive materials testing**), in special machines such as packaging machines or **plastics processing**, in particular for :

- Temperature control
- Fluid flow and velocity control
- Level monitoring
- Pressure regulation

And many other **temperature control**.

Don’t let the complexity of PID control stop you!

At Fuji Electric, our **temperature control industrial** experts are ready to help you select the ideal **PID controllers** for your systems. We will assist you during controller commissioning to fine-tune parameter settings.

Whether you’re a seasoned professional or a novice in the field, our team is here to turn PID control into a controllable, high-performance asset for your business.

GET A QUOTE

DISCOVER THE PID CONTROLLER RANGE >

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