



# PID Controllers

---

BY LUKE MCGILL



# Table of Contents

---

- Introduction
- History
- Theory
- Utilization
- Conclusion
- Questions



# Introduction

---

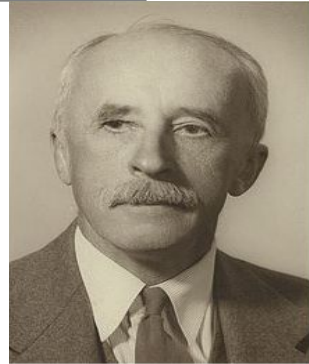
- A control system is a set of mechanical or electronic devices that regulates other devices or systems by way of control loops.
- Control systems are used to enhance production, efficiency and safety
- PID is type of closed loop controller



# History

---

- 1922
  - Nicolas Minorsky
  - Theoretical analysis and first proposed application
- 1933
  - Taylor Instrument Company
  - First pneumatic controller with a fully tunable proportional component
- 1940
  - Taylor Instrument Company
  - Developed the first PID pneumatic controller with a derivative action
- 1942
  - Ziegler and Nichols tuning rules were introduced so that engineers were able to find and set the appropriate parameters of PID controllers



# History cont.

- 1950s
  - Automatic PID controllers were widely adopted for industrial use

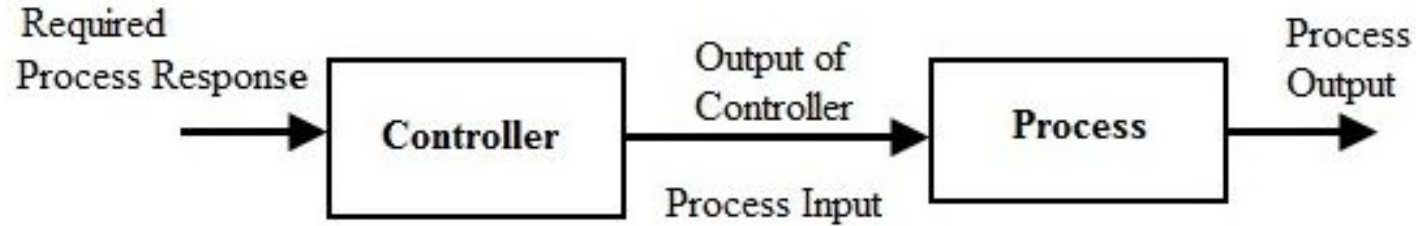




# Theory

---

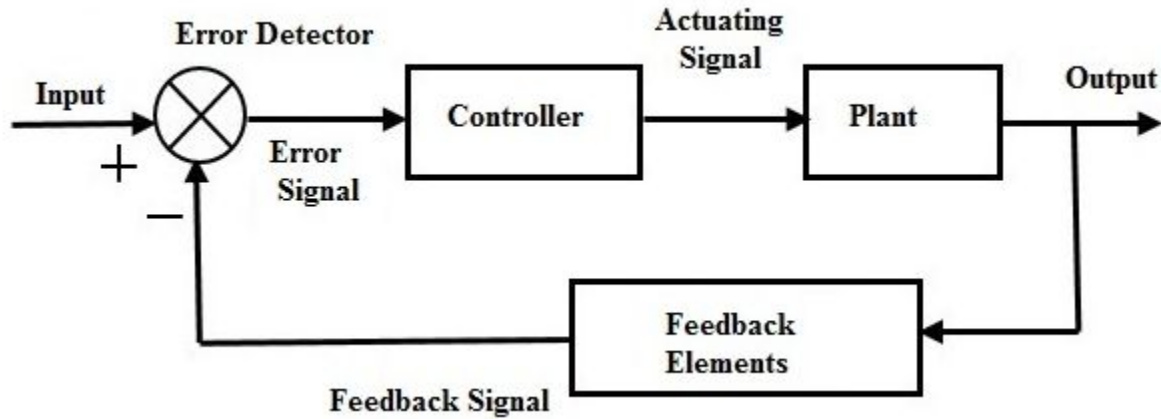
- Open loop control system





# Theory cont.

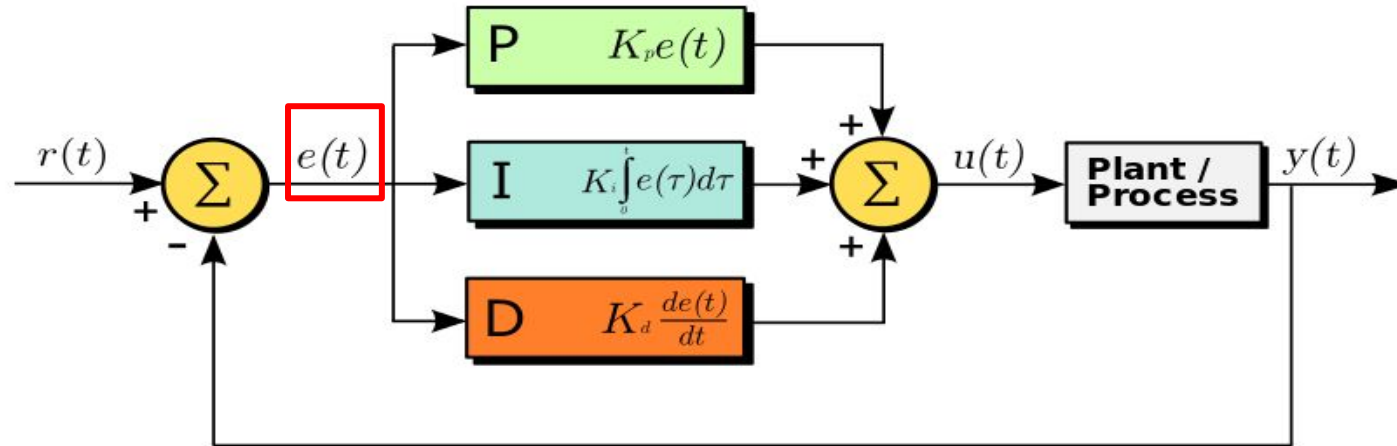
- Closed loop control system



# Theory cont.



- The PID compares desired output with measured output
- $e(t)$  is called the error signal
- $e(t) = r(t) - v(t)$

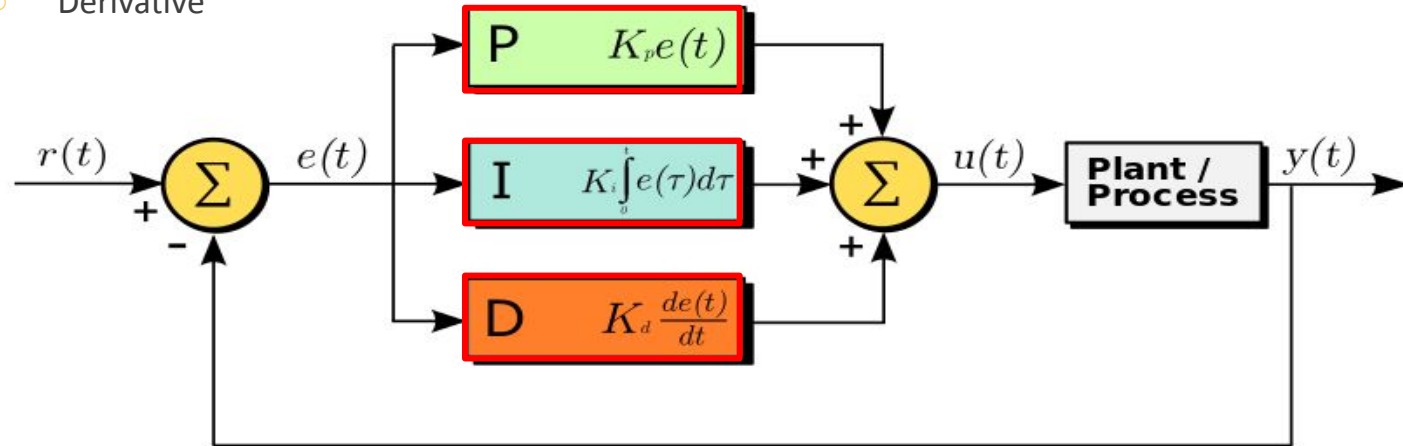




# Theory cont.



- PID has three terms
  - Proportional
  - Integral
  - Derivative

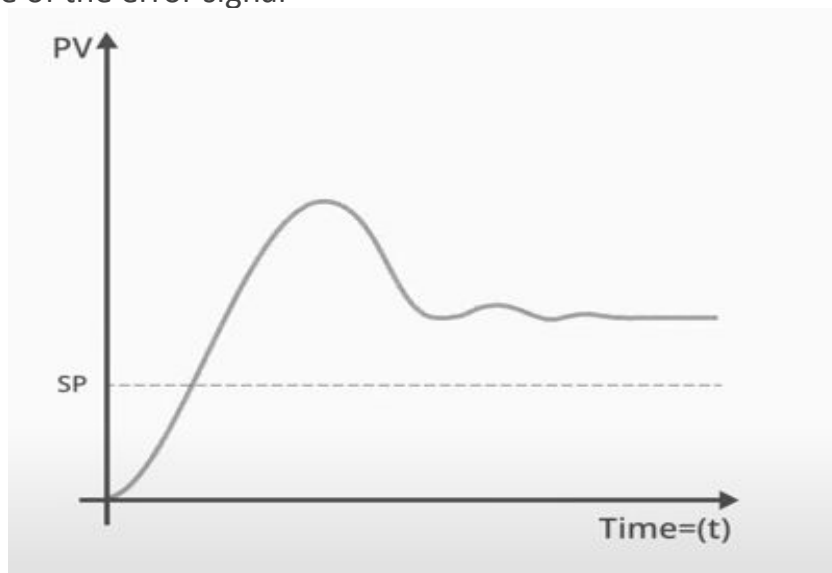




# PID Terms

- Proportional term  $K_p$ 
  - Proportional to magnitude of the error signal

$$K_p \times e(t)$$

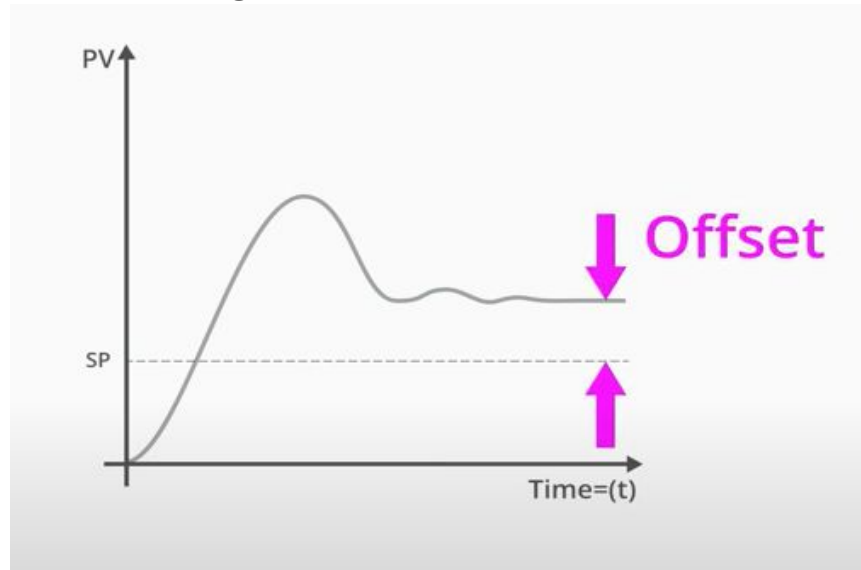




# PID Terms

- Proportional term  $K_p$ 
  - Proportional to magnitude of the error signal

$$K_p \times e(t)$$

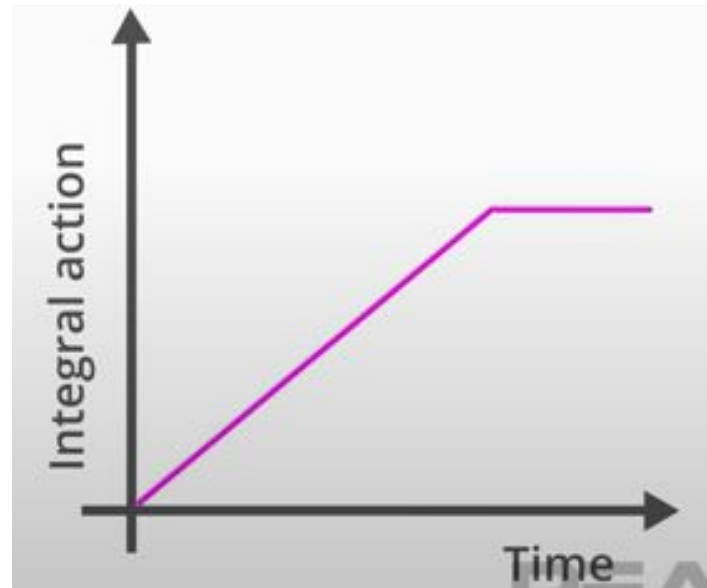




# PID Terms

- Integral term  $K_i$

$$K_i \int_0^t e(\tau) d\tau$$

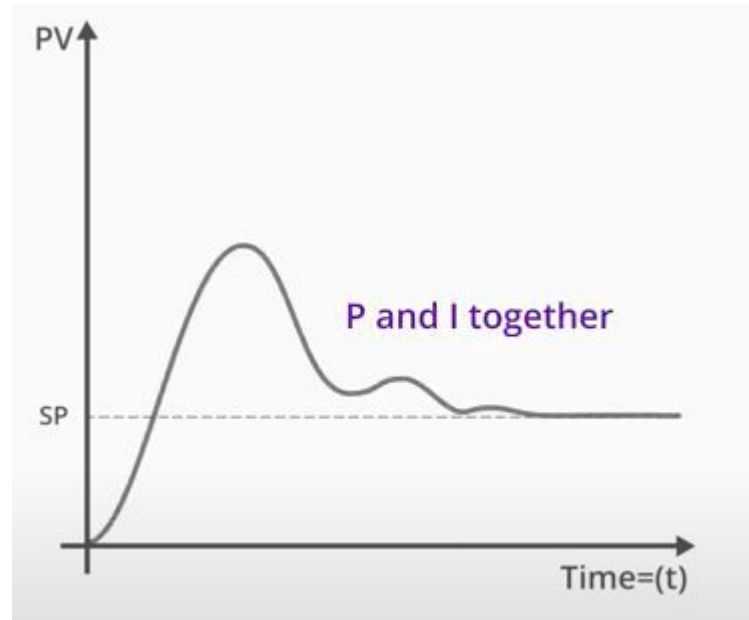




# PID Terms

- Integral term  $K_i$

$$K_i \int_0^t e(\tau) d\tau$$

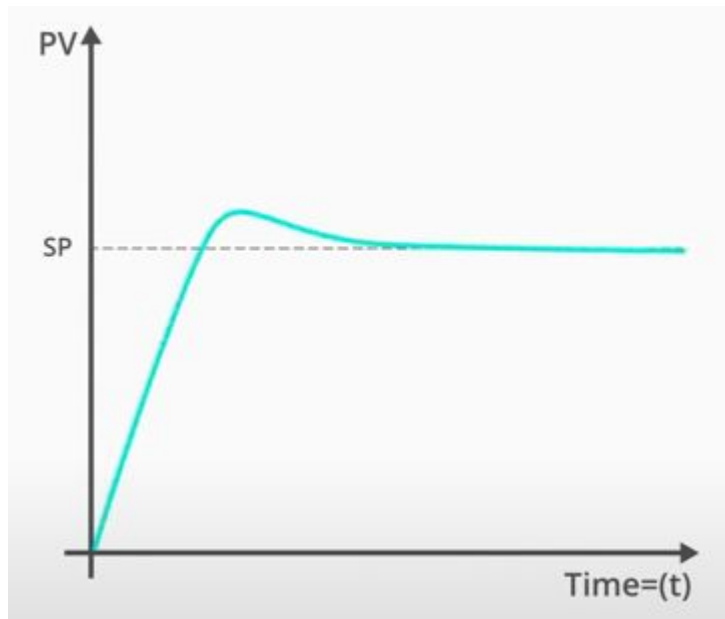




# PID Terms

- Derivative  $K_d$

$$K_d \frac{de(t)}{dt}$$





# Tuning

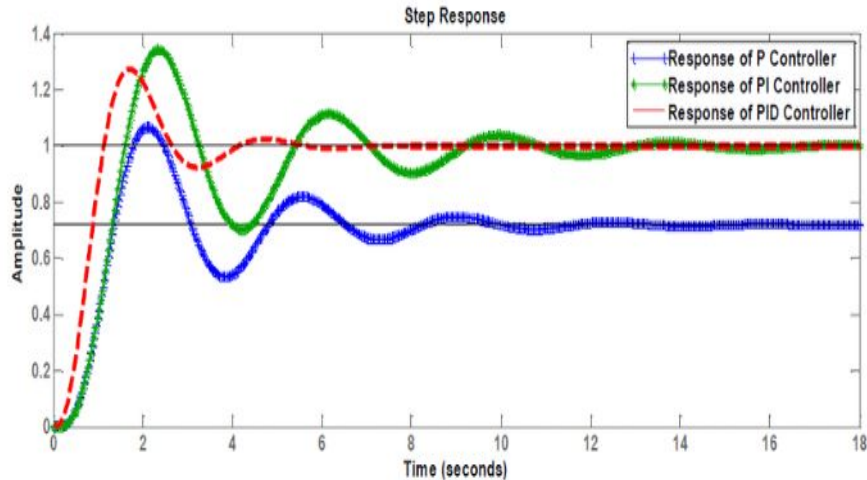
---

- Adjust constants  $K_p$ ,  $K_i$ ,  $K_d$
- PID term tuning can differ vastly between processes and applications
- Can be tuned by trial and error, observing output response
  - Can be time consuming and impractical
- Some modern PID controllers have autotuning functionality
  - Sometimes additional tweaking required

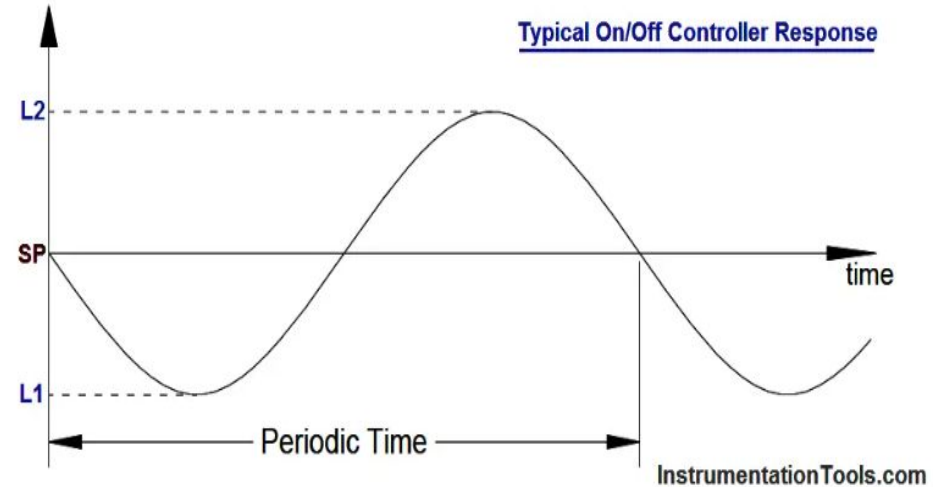


# Why choose a PID controller?

## Typical PID Controller Response



## Typical On/Off Controller Response







# Variations

---

- PID not always necessary
  - P controller
  - PI controller
- Why make a simpler controller?
  - Easy to implement
  - Easy to test and troubleshoot
  - Easy to understand
  - Can save time and money

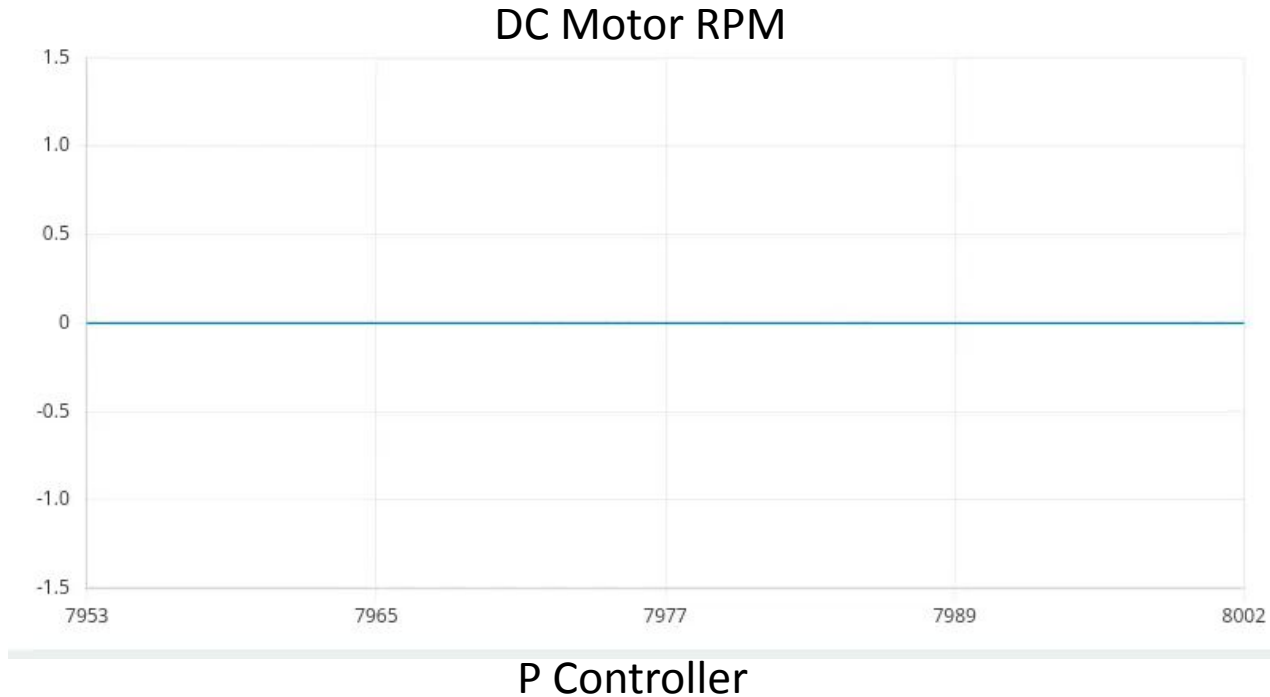
# Utilization

- Widely used in industry, automation, and manufacturing
- Usually digital
- Typically integrated in a PLC or DCS
  - Can still be stand alone devices



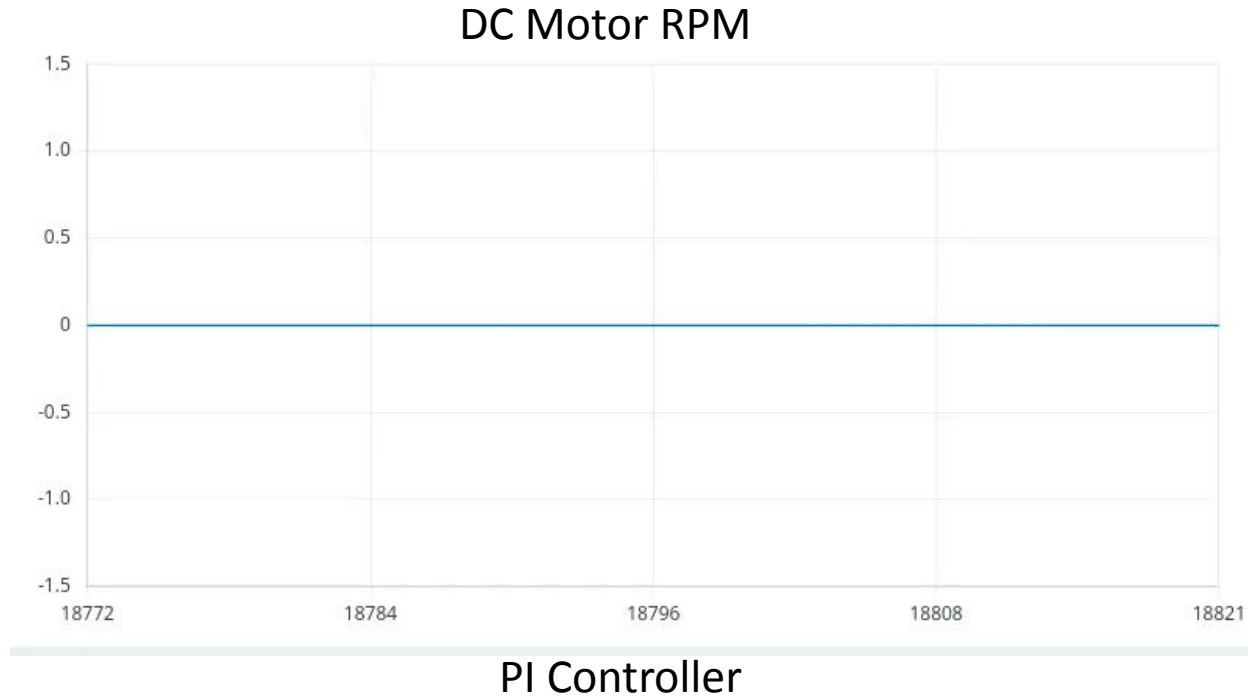


# Using PID in Capstone



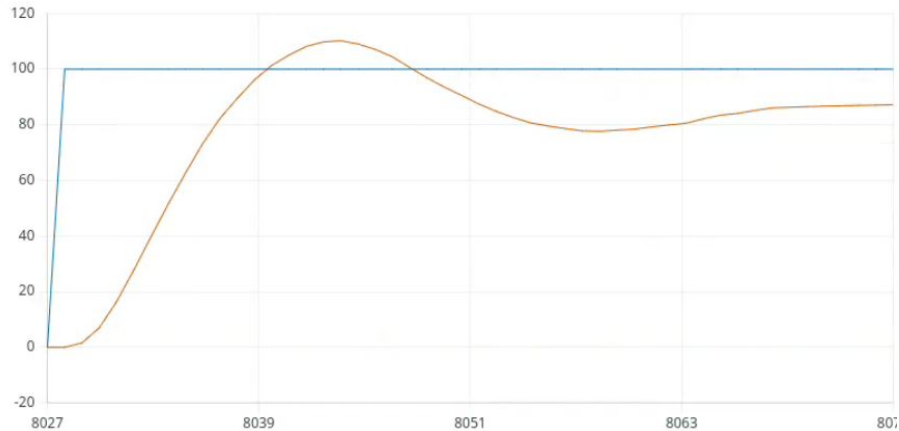


# Using PID in Capstone





# Using PID in Capstone



P Controller



PI Controller



# Conclusion

---

- PID controllers are widely used control method
- Three terms P, I, D
- Can be simple or more sophisticated depending on application
- Used heavily in industry, automation, and manufacturing



# Works Cited

---

- [1] "Pid Controller," Wikipedia, 17-Mar-2023. [Online]. Available: [https://en.wikipedia.org/wiki/PID\\_controller#:~:text=A%20proportional%E2%80%93integral%E2%80%93derivative%20controller,continuously%20calculates%20an%20error%20value](https://en.wikipedia.org/wiki/PID_controller#:~:text=A%20proportional%E2%80%93integral%E2%80%93derivative%20controller,continuously%20calculates%20an%20error%20value). [Accessed: 19-Mar-2023].
- [2] T. T. Contributor, "What is control system?: Definition from TechTarget," WhatIs.com, 31-Dec-2017. [Online]. Available: <https://www.techtarget.com/whatis/definition/control-system#:~:text=A%20control%20system%20is%20a,of%20industry%20and%20of%20auto>mation. [Accessed: 19-Mar-2023].
- [3] O. Engineering, "What is a PID controller?," <https://www.omega.com/en-us/>, 28-Sep-2022. [Online]. Available: <https://www.omega.com/en-us/resources/pid-controllers>. [Accessed: 19-Mar-2023].
- [4] E. Staff, "On-off Controller Principle," Inst Tools, 27-Nov-2018. [Online]. Available: <https://instrumentationtools.com/onoff-control-principle/>. [Accessed: 19-Mar-2023].
- [5] T. Mortenson, "PID controller explained," The Easiest Way to Learn Industrial Automation, 08-Oct-2022. [Online]. Available: <https://realpars.com/pid-controller/>. [Accessed: 19-Mar-2023].
- [6] Kumar, Vivek & Patra, Ashis. (2016). Analysis of Power Transformer using fuzzy expert and neural network system. [Online] System Response of P,PI& PID Controller tuned with Process Reaction... | Download Scientific Diagram (researchgate.net) [Accessed: 19-Mar-2023].



# Questions?

---

