PID Controllers summary

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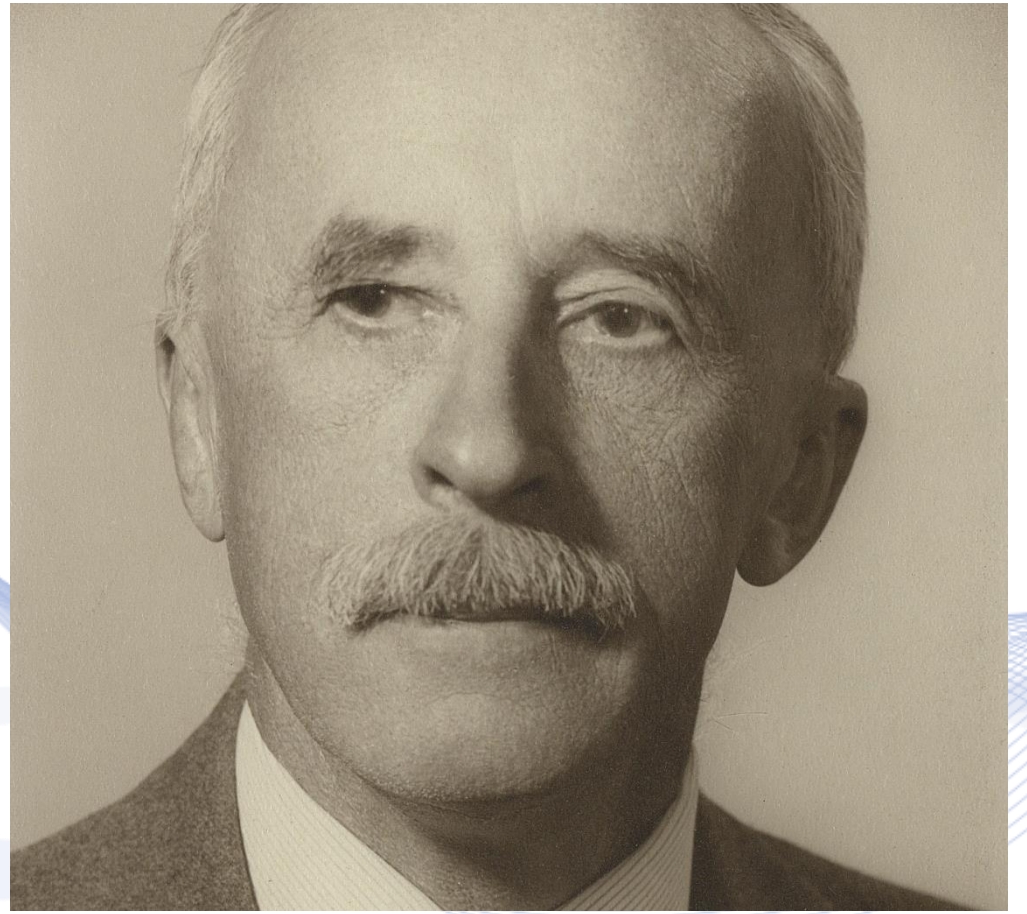
Artificial Intelligence & Information Analysis Lab

PID CONTROLLERS

- **Origins**
- Definition
- Controller operation
- Structure
- Equations and constants
- Control parameters
- PID in real life: Drone control
- Simulations
- Conclusion

Origins



The initial idea came from the analysis of the helmsman of a ship when **Nicolas Minorsky** was working for the US Navy.

With studies in mathematics at the University of Nancy, he was an applied scientist known for this first application proposal of PID controllers

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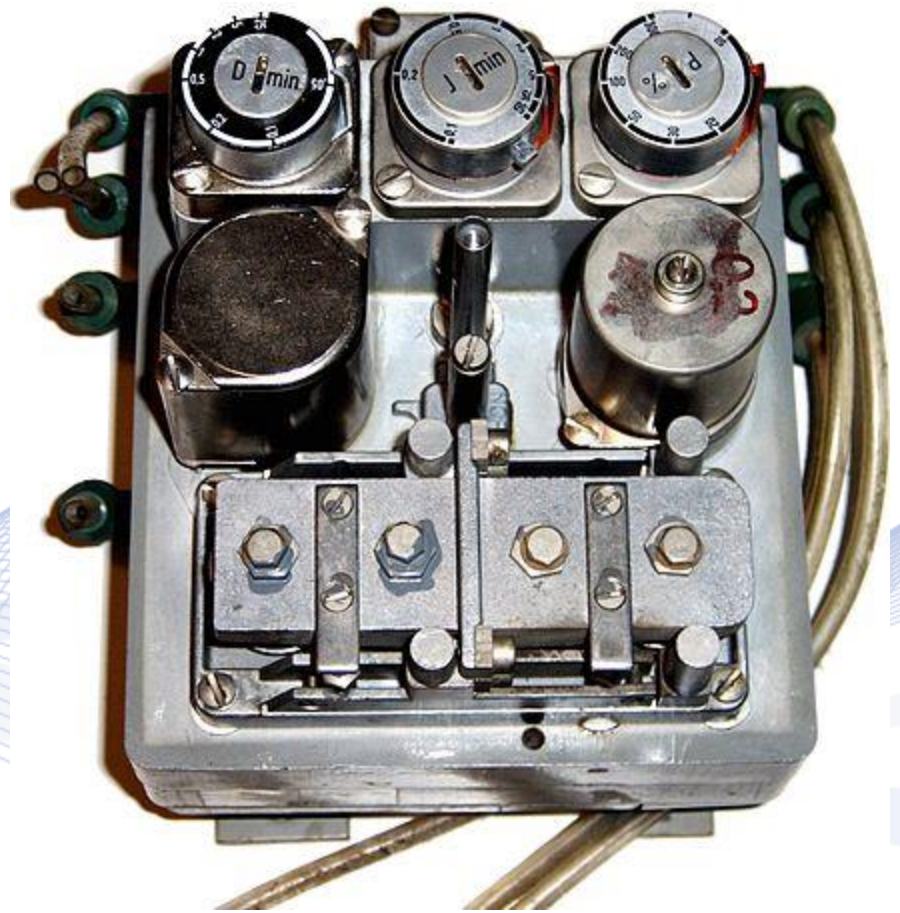
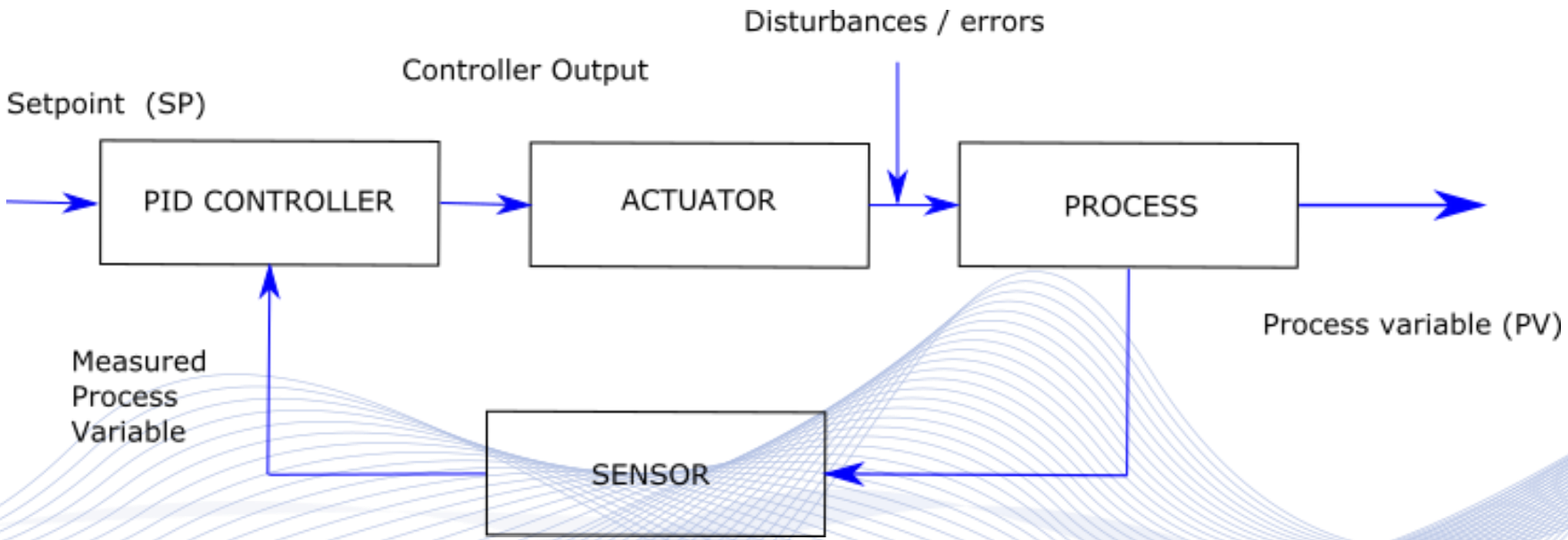
Definition

A **PID controller** is a combination of variables which main function is supervising different process, configuring and programming them.

It is used in **automatic programming architectures**, becoming one of the most important tools in this sector.



Definition


Disturbances / errors
Controller Output
Setpoint (SP)
PID CONTROLLER
ACTUATOR
PROCESS
Process variable (PV)
Measured
Process
Variable
SENSOR

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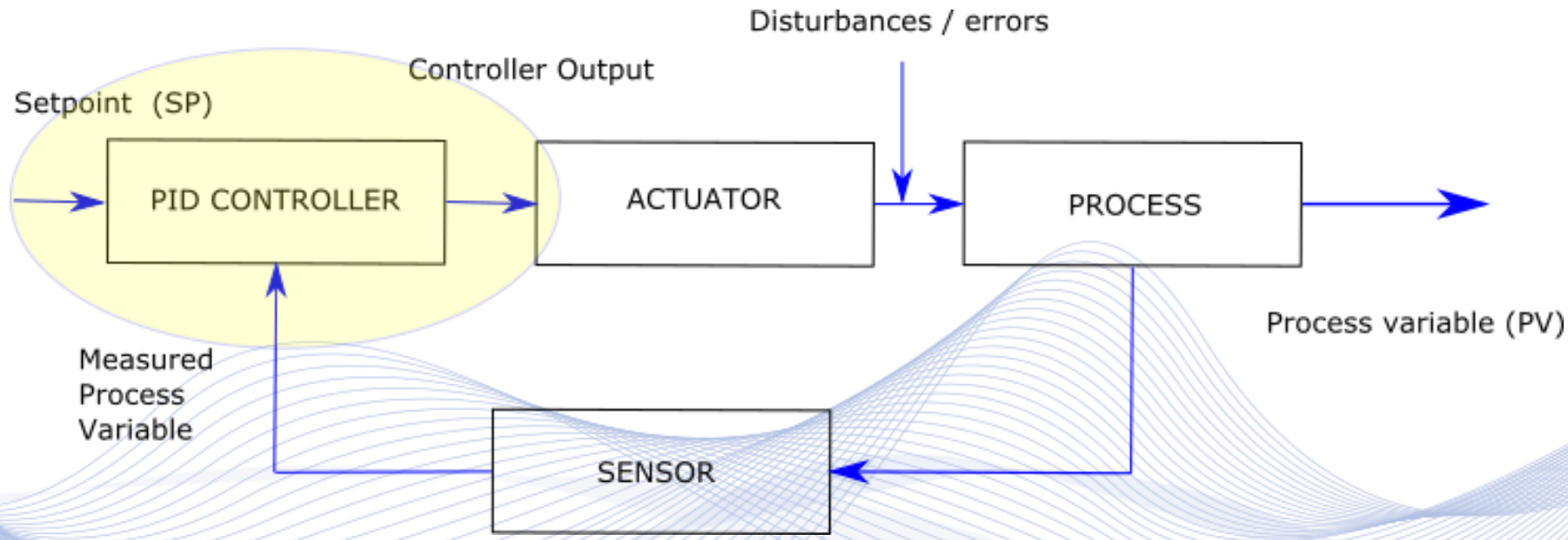
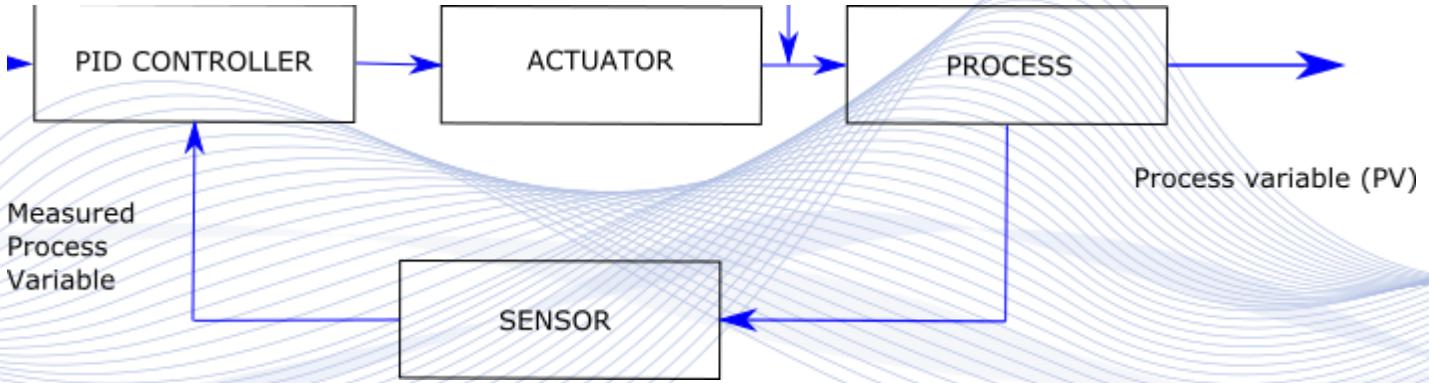
Controller Operation



Controller Operation

It’s the step where we obtain the **final product** after changing the original one. Also, it can be compared again with the original, if the **sensor** detects that it’s necessary.



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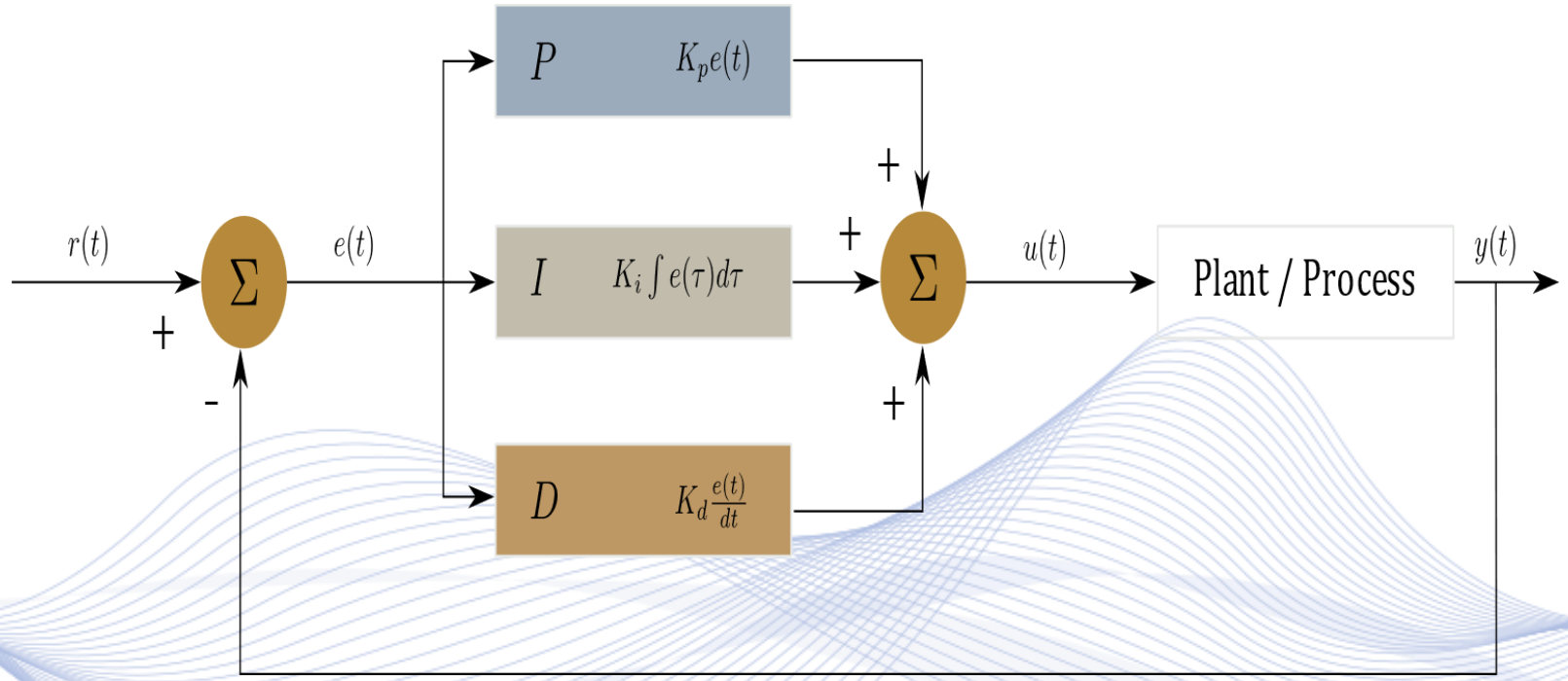
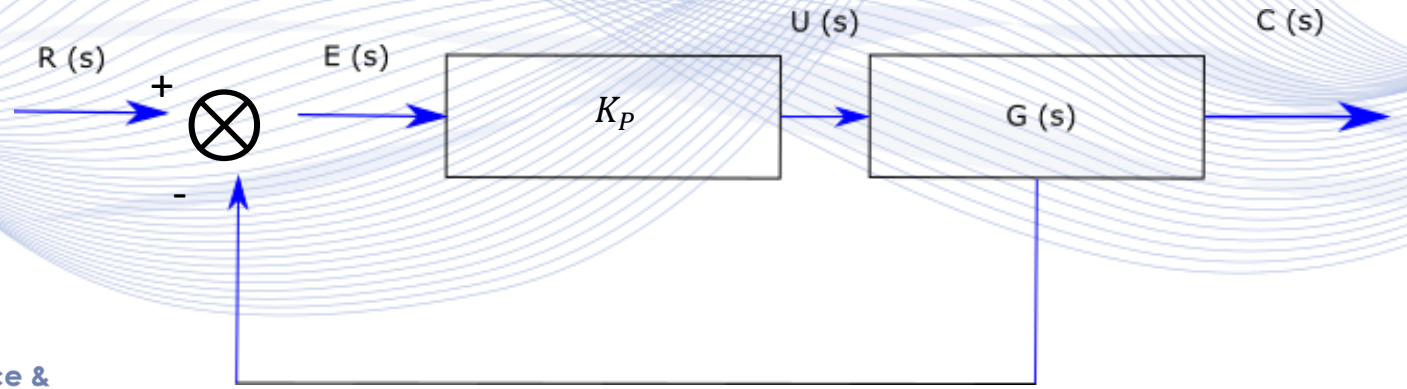
PID Controller Structure



Structure

Proportional controller function (P) → To reduce the error in the system.

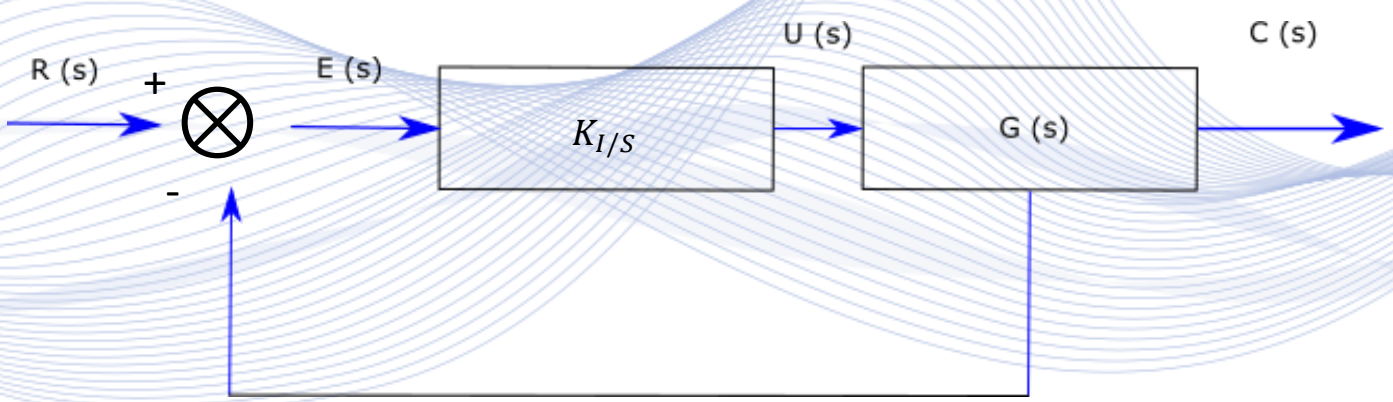
Manipulated variable → It's used in every step for keeping the constant value of our measured variable. This manipulated variable has a proportional relation with the error. It has a fast reaction; it only works if there is any existing error, and it doesn't get completely the setpoint. It will be full obtained in the next step.



Structure

Integral controller function (I) → To eliminate the error from the first step

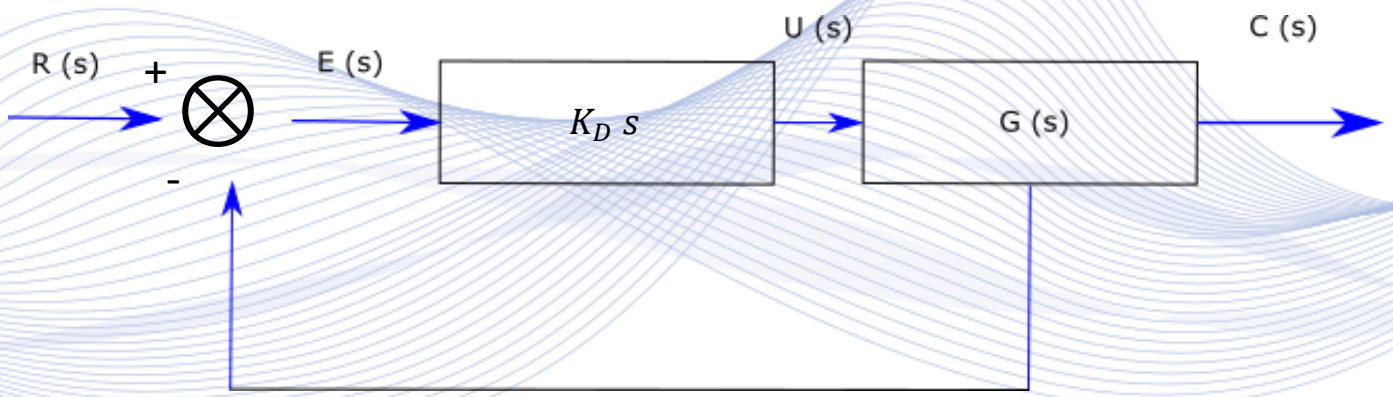
It's related to the integral of the output deviation. It's a slower process than the previous one, but it eliminates the error kept from the first step.



Structure

Derivative controller function (D) → To produce a correction to the error.

In this case, the manipulated variable has a relation with the changing speed of the regulation error. It is not difficult to guess that this step is the fastest one.



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Equations and constants

Equations and the constants that define the universal PID controllers:

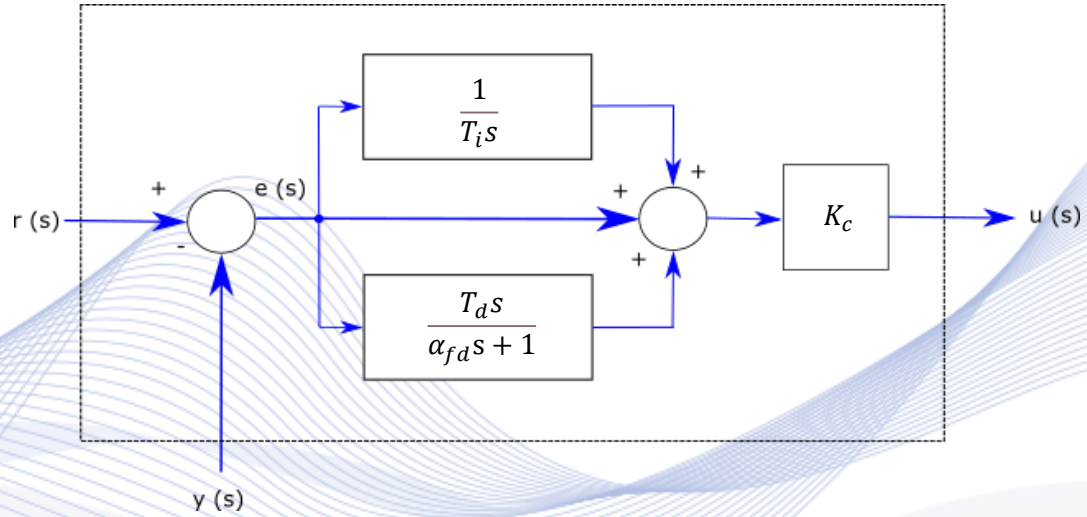
- **Parallel circuit design (Ideal)**
- **Series circuit design.**

There are a big amount of variety PID controllers in the market, because both of the equations have some similarities in terms of characteristics, that make easier the synchronization.

Equations and constants

- Parallel circuit design (Ideal)

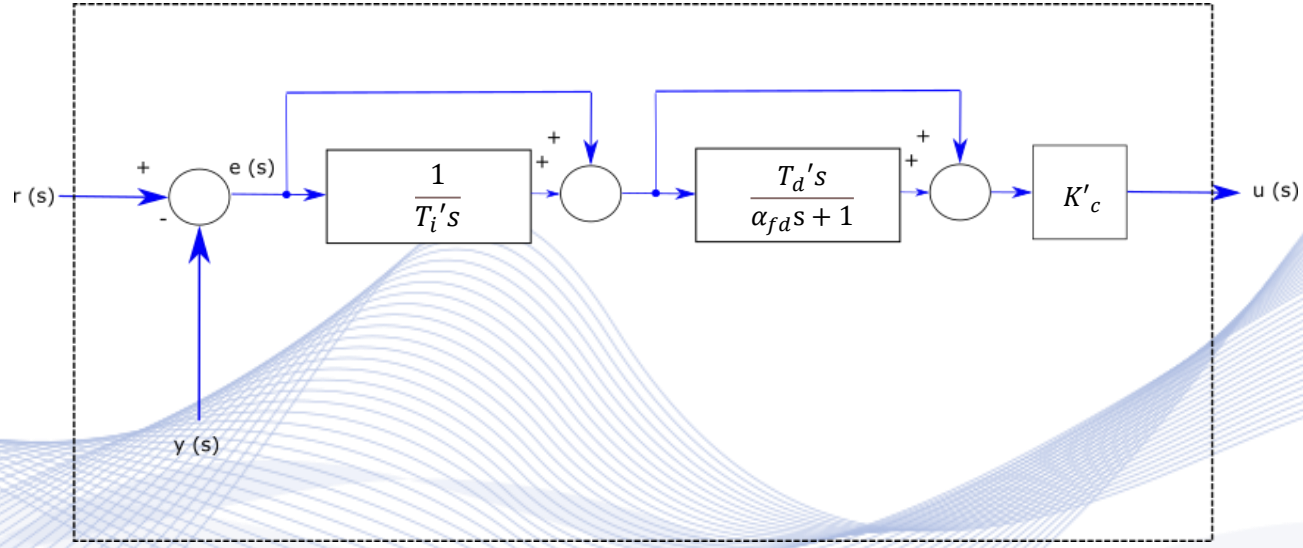
The controllers with this type of structure are based on a non-relation between the derivative and integral actions



Equations and constants

- **Series circuit design**

The controllers with this type of structure are based on a series relation between the derivative and integral actions.



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Control parameters

When we talk about adjusting the parameters of a PID controller, we are referring to the adjustment of these following a series of specific criteria. This process is called the **tuning criteria**.

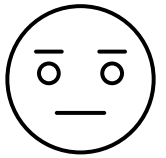
To carry out this procedure, a previous supervision of the system must be carried out, accompanied by the subsequent tuning mentioned in the previous point.

Control parameters

Difficulties

Only one of the parameter sets meets the mentioned specifications.

Several of the sets of parameters meet the specifications, and that is where it is necessary to decide which is better.



There is no set of parameters that agrees with the specifications mentioned.

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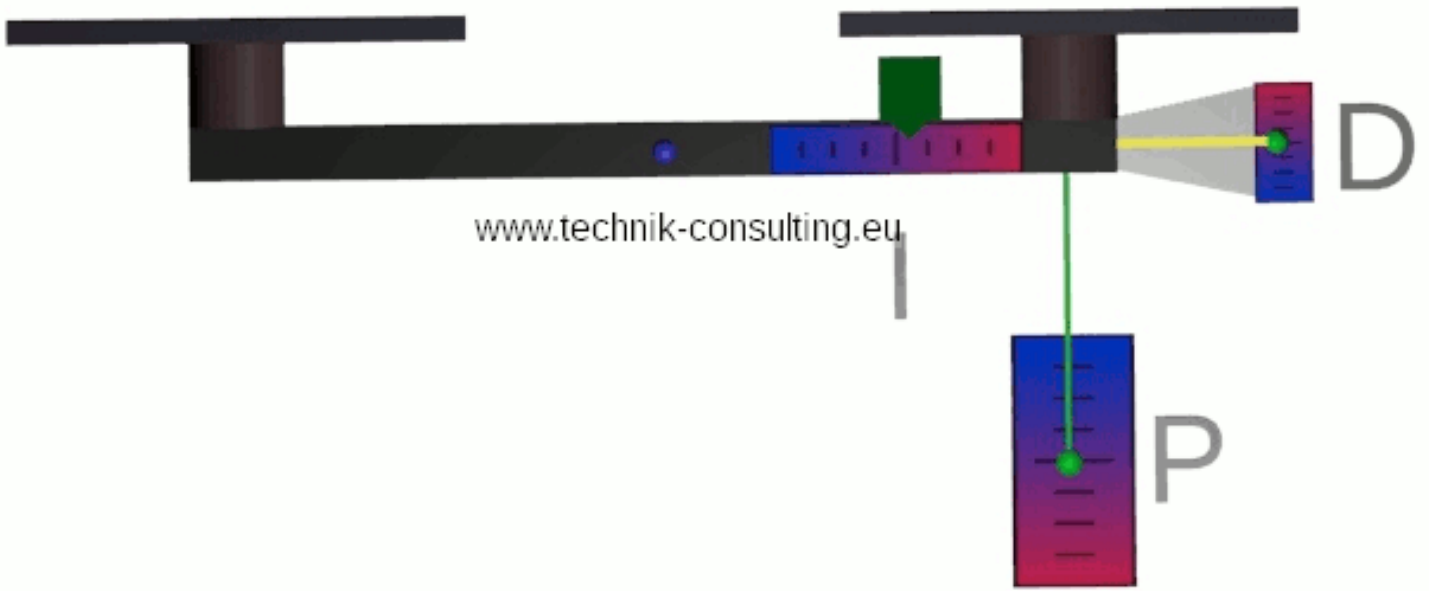
PID in real life: Drone control

PID controller tuning

- Initialize all controller parameters to zero.
- Set the P, I and D parameters.
- Obtain the maximum values so that they cannot be exceeded

PID in real life: Drone control



PID Drone control

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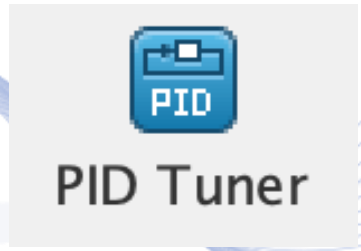
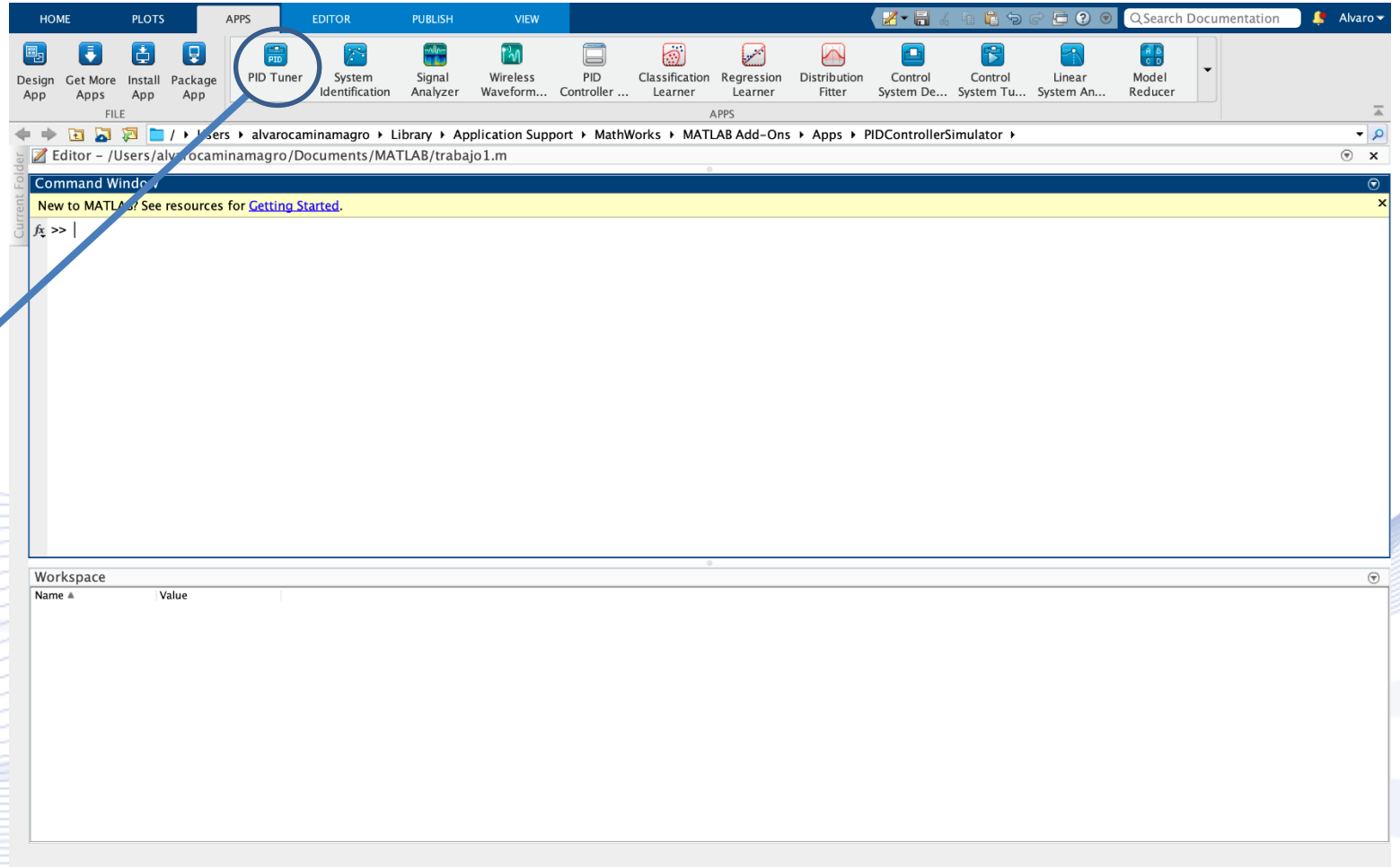
Simulations





Simulations

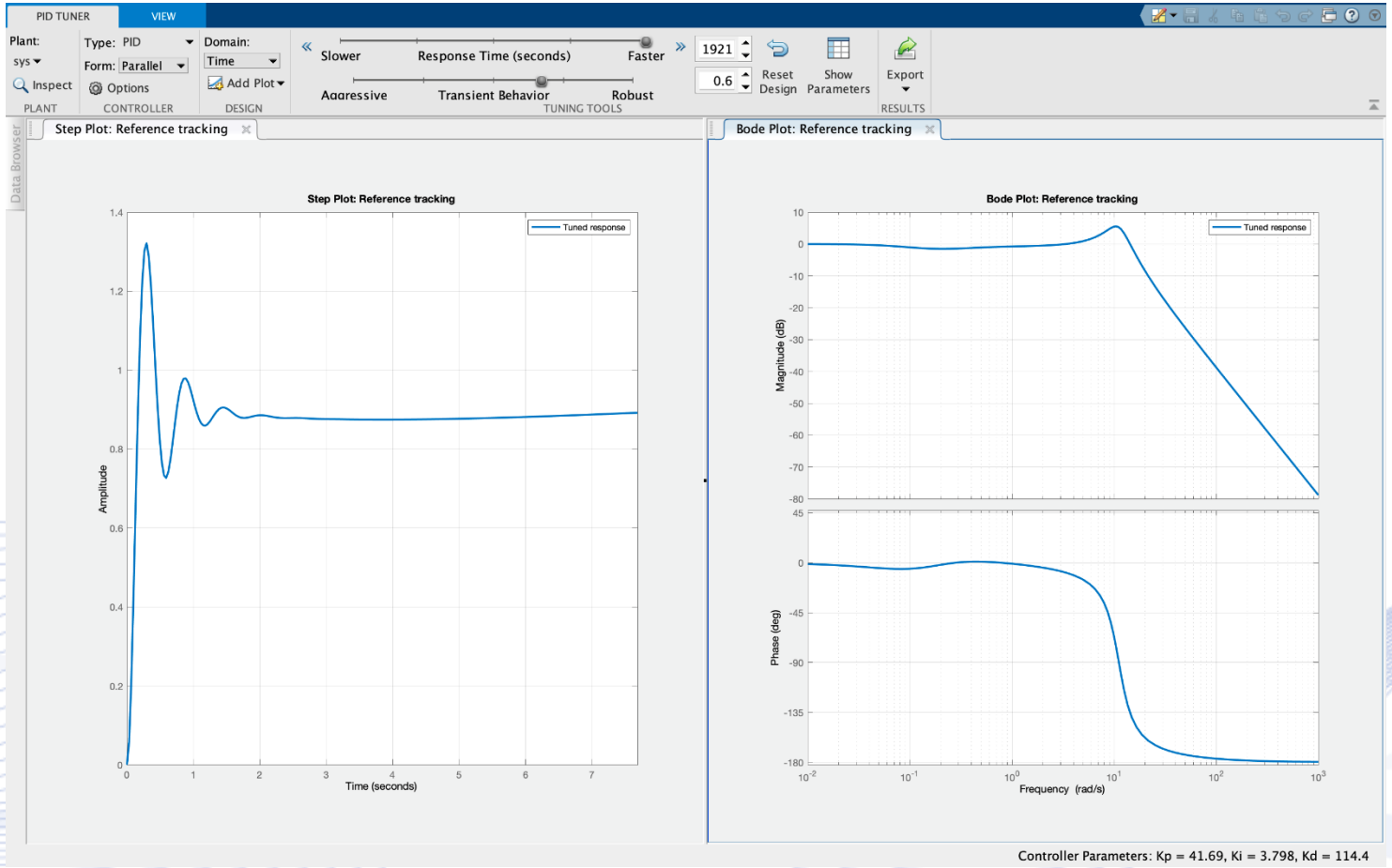
Comparative between slow-medium-fast response time

Controller Parameters

	Tuned
Kp	41.6877
Ki	3.7978
Kd	114.3991
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.124 seconds
Settling time	25.7 seconds
Overshoot	32.2 %
Peak	1.32
Gain margin	Inf dB @ Inf rad/s
Phase margin	30.6 deg @ 10.4 rad/s
Closed-loop stability	Stable



Fast response time

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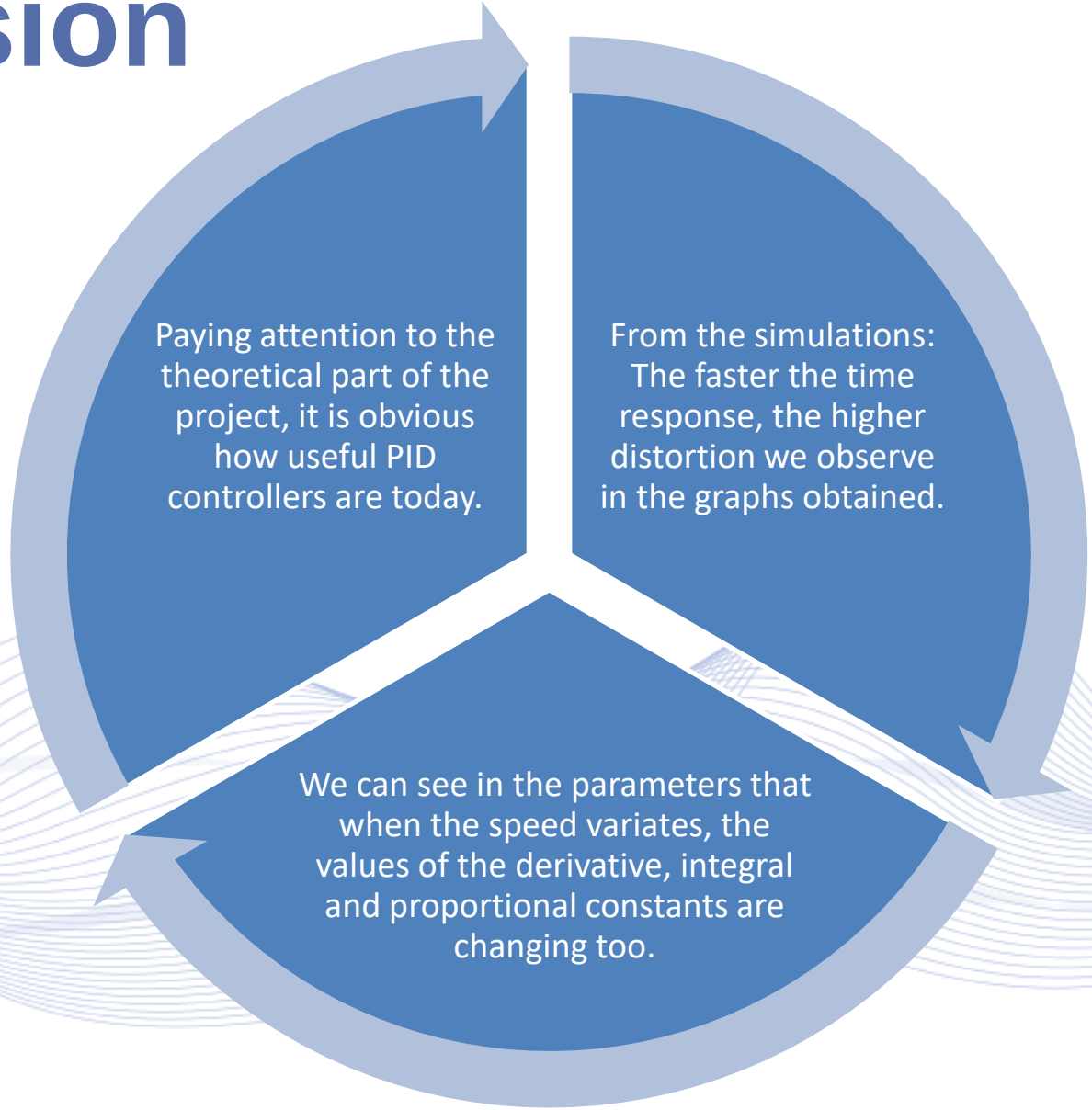
Conclusion


Paying attention to the theoretical part of the project, it is obvious how useful PID controllers are today.
From the simulations: The faster the time response, the higher distortion we observe in the graphs obtained.
We can see in the parameters that when the speed variates, the values of the derivative, integral and proportional constants are changing too.

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Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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