ECT
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An Introduction to the Use of MATLAB in the Design and Simulation of Advanced Process Control Systems

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UKPRN: 10089771

Agenda

1	Welcome and Introduction
2	What is Process Control
3	Advanced Process Control
4	Building a Process Model from Data
5	Using MATLAB to Simulate an MPC Controller
6	Conclusion and Q&A



Introduction – Presenter

Dr. Hadi Harb



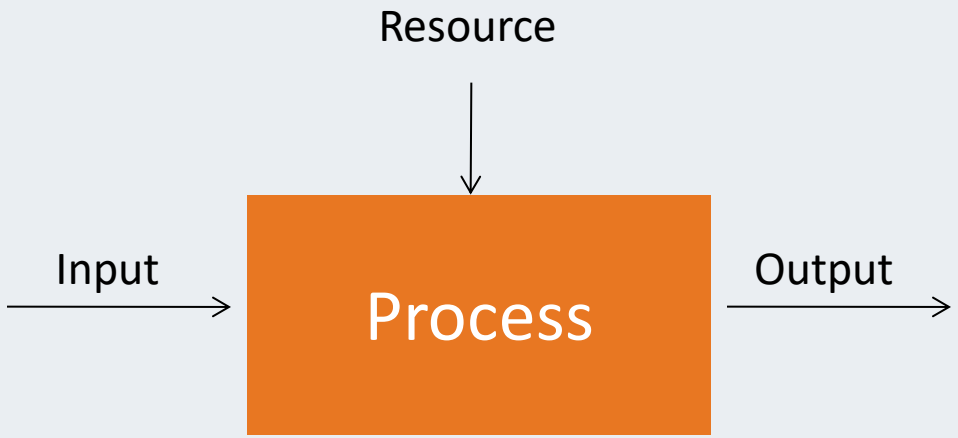
- Dr Hadi Harb has more than 20 years of experience in the development and management of Artificial Intelligence and Audio Signal Processing projects.
- Hadi holds a MEng (2000) in electrical-electronic engineering. He earned his MSc in 2001 and PhD in 2004 both in computer science from the Institut National des Sciences Appliquées INSA Lyon, and the Ecole Centrale de Lyon respectively.
- In 2005 he co-founded and managed Ghanni, a company specialized in multimedia content recommendation and identification. His focus in on the application of AI techniques to solve real world problems.
- Hadi teaches units within EIT's Professional Certificates of Competency, Advanced Diplomas and Master of Engineering degrees.

What is Process Control?

What is Process Control?

Process

A process is an operation that uses resources to transform inputs into outputs.



What is Process Control?

Process

Dynamics and properties of the process

Sensors

Measure temperature, pressure, mass, flow and level typically

Final Control Elements

Valves and pumps typically

The Controller

A person, a switch, a single loop controller, or DCS / PLC system (Distributed Control System / Programable Logic Controller)

What is Process Control?

Process Control is the act of

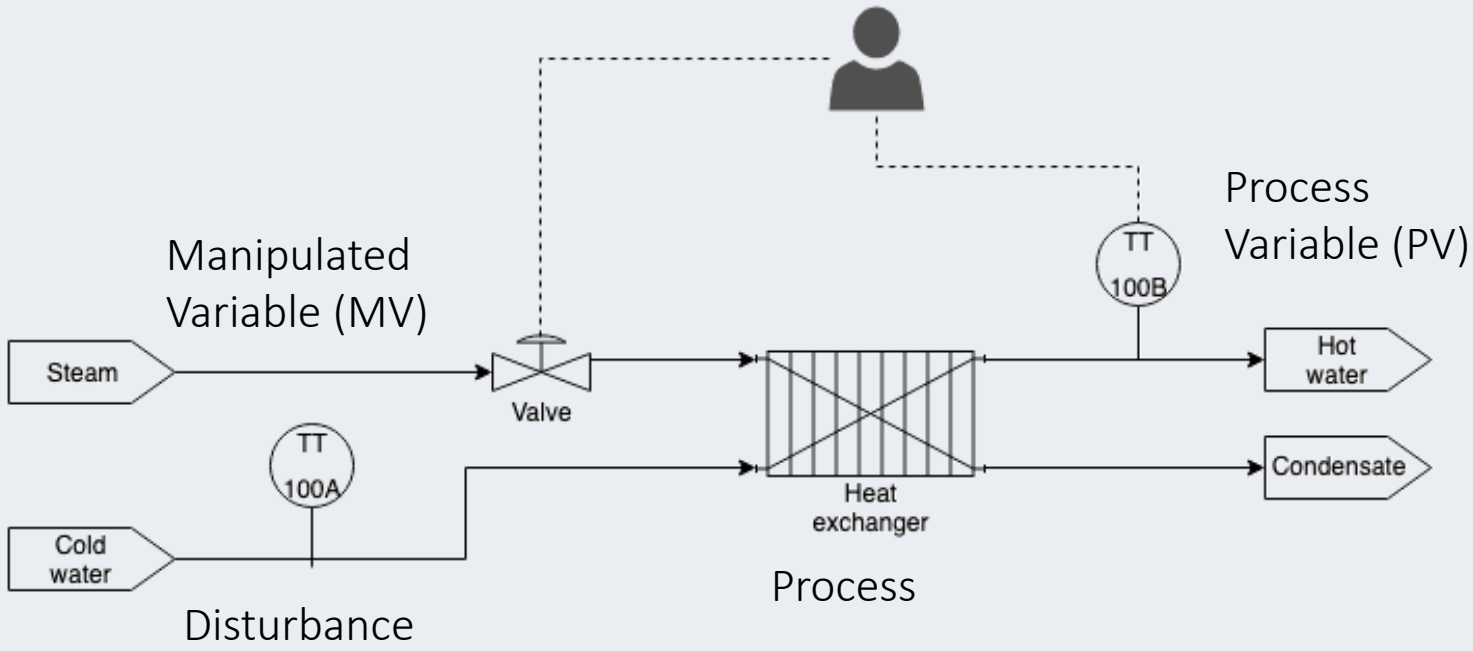
Controlling a final control element

To change the **manipulated variable**

To maintain the **process variable** at a desired **set point**

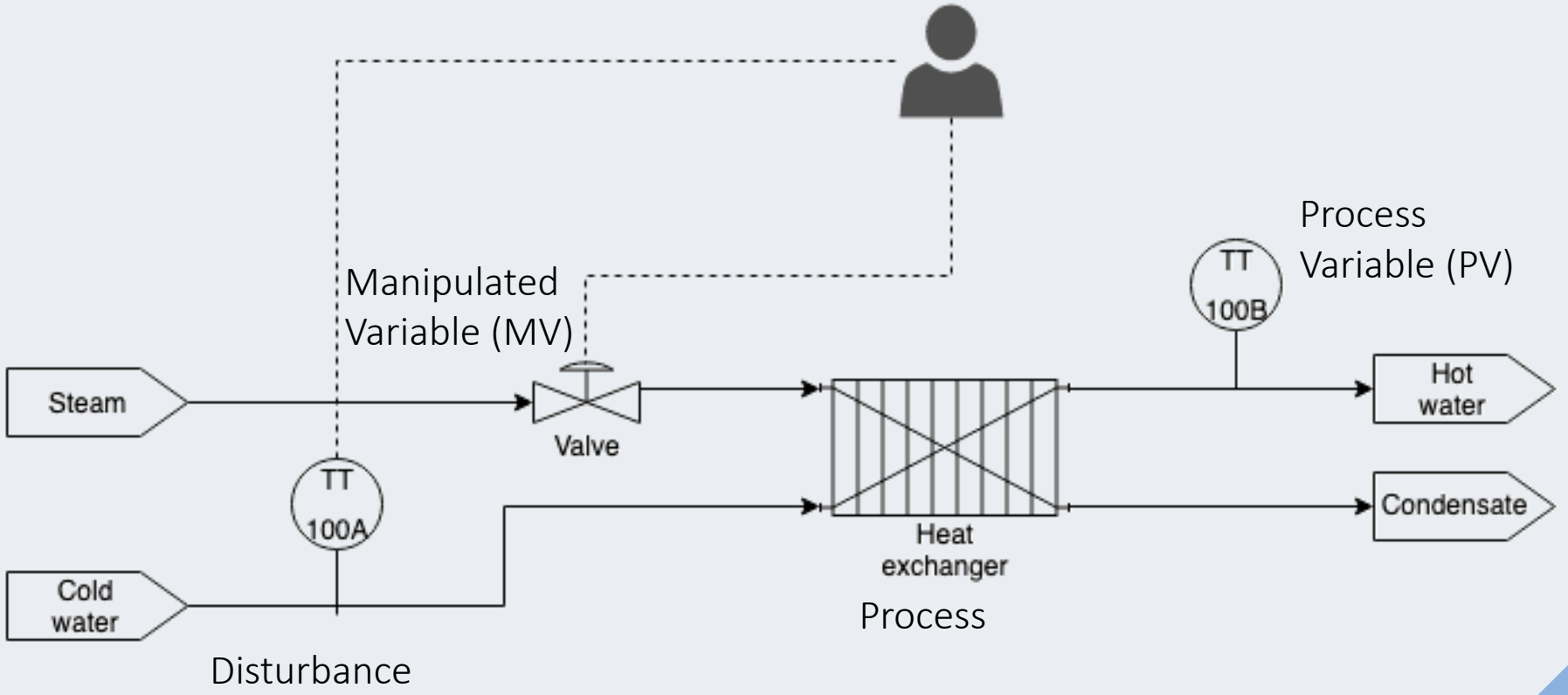
What is Process Control?

Closed Loop Control



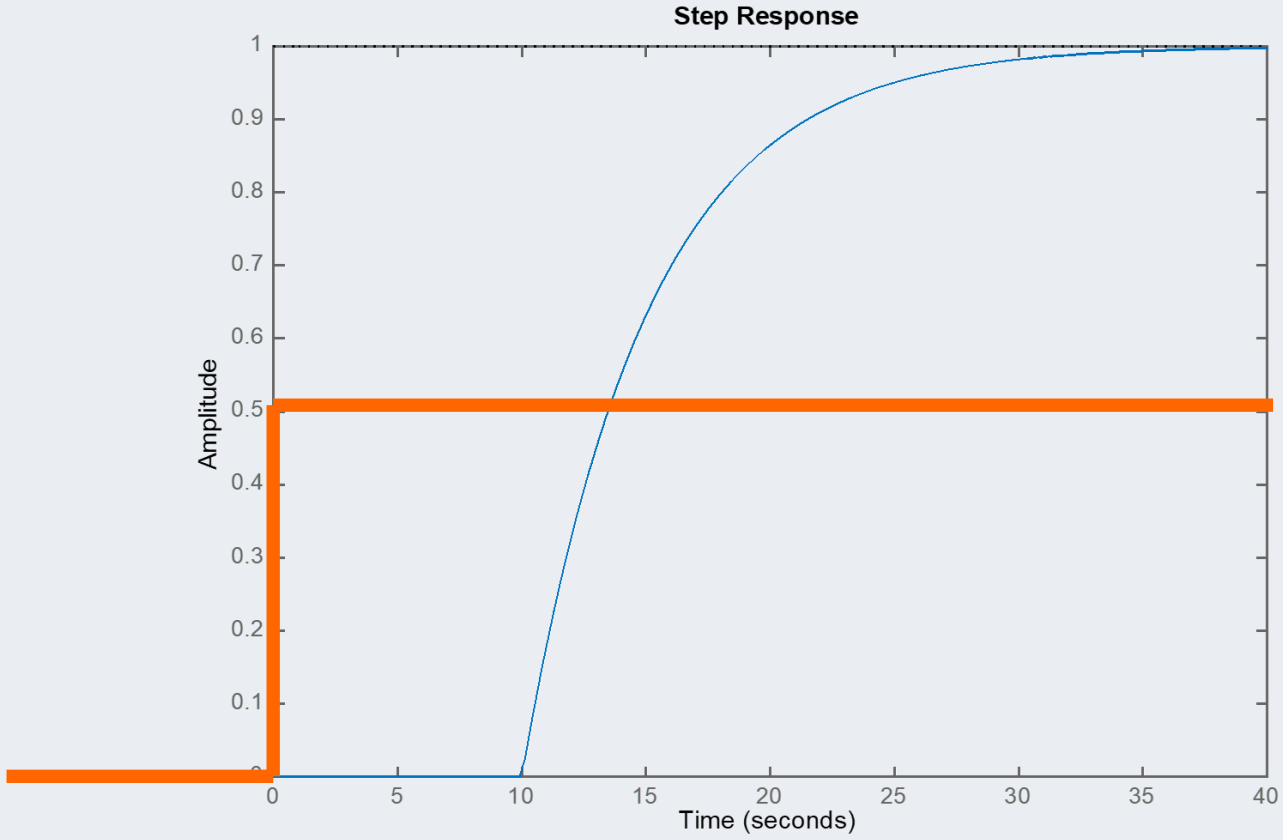
What is Process Control?

Open Loop Control



Modelling

- FOPDT: First Order Plus Dead Time
  - What is the gain?
  - What is deadtime?
  - What is the time constant?



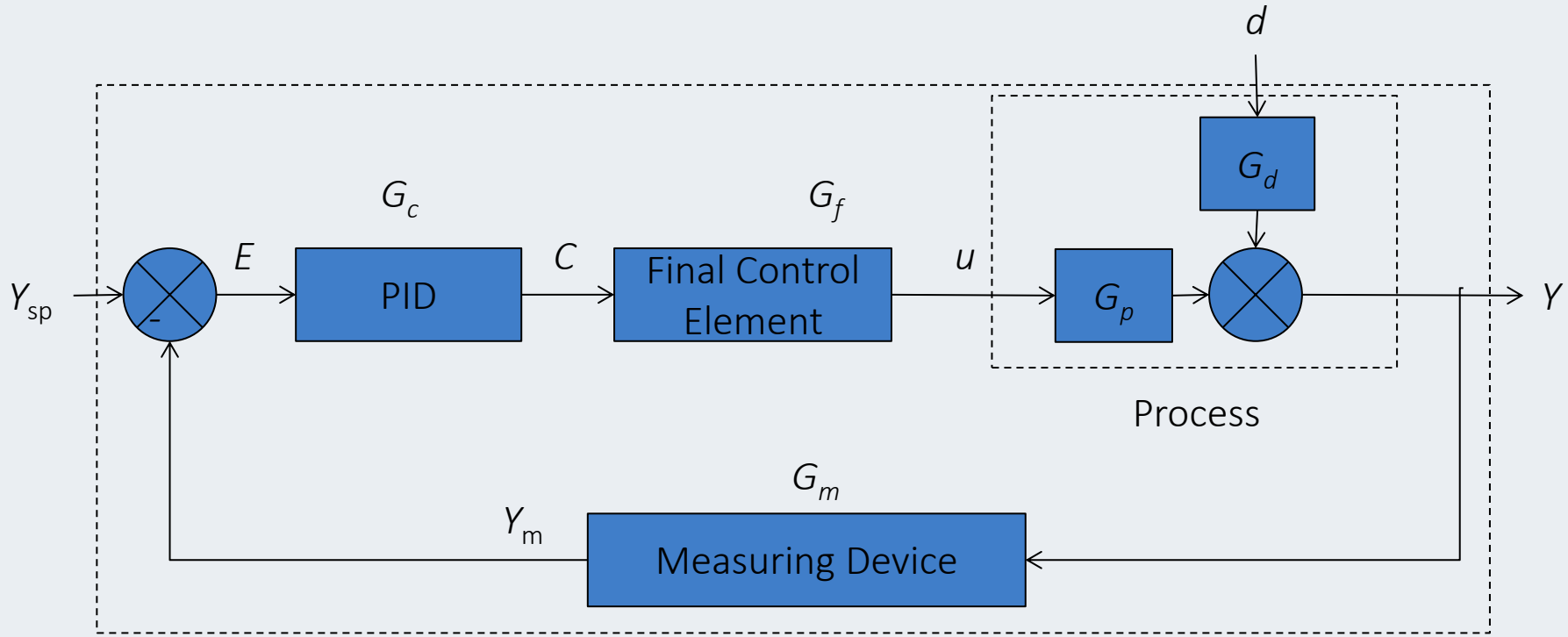
Modelling

- Bump test
  - Put the controller in manual
  - Change its output by a %
  - Record the PV
  - Estimate the gain, deadtime and time constant

$$Y(s) = \left[\frac{Ke^{-st_0}}{\tau s + 1} \right] X(s)$$

PID Control

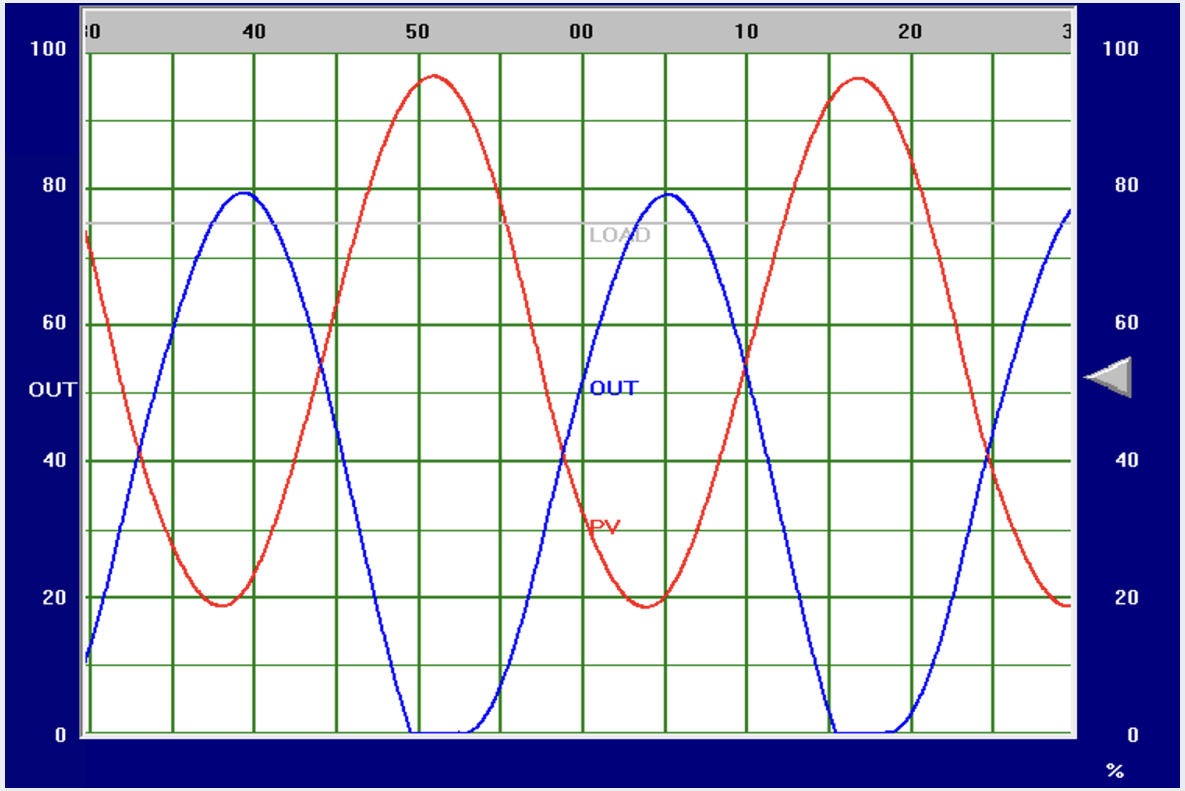
PID Controllers



Closed Loop Equivalent

Problems with PID control

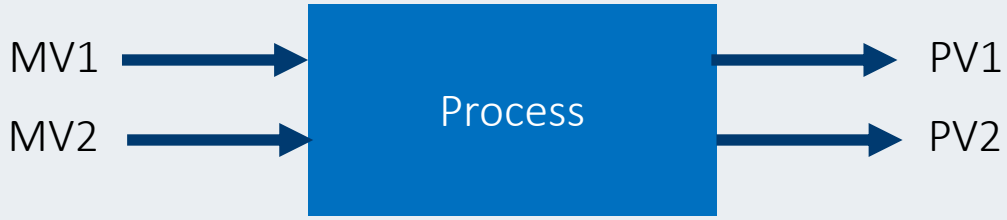
- Single variable
- Long dead time effect



Advanced Process Control

Advanced Process Control

- MIMO



Advanced Process Control

- Transfer Matrix to represent a MIMO system

```
s = tf('s')
h11 = (5)/(0.52*s+1);
h21 = (1.5)/(0.17*s+1);
h12 = (5)/(0.52*s+1);
h22 = (-1.55)/(0.17*s+1);
H = [h11 h12; h21 h22]
```

H =

From input 1 to output...

$$\frac{5}{0.52\,s + 1}$$

$$\frac{1.5}{0.17\,s + 1}$$

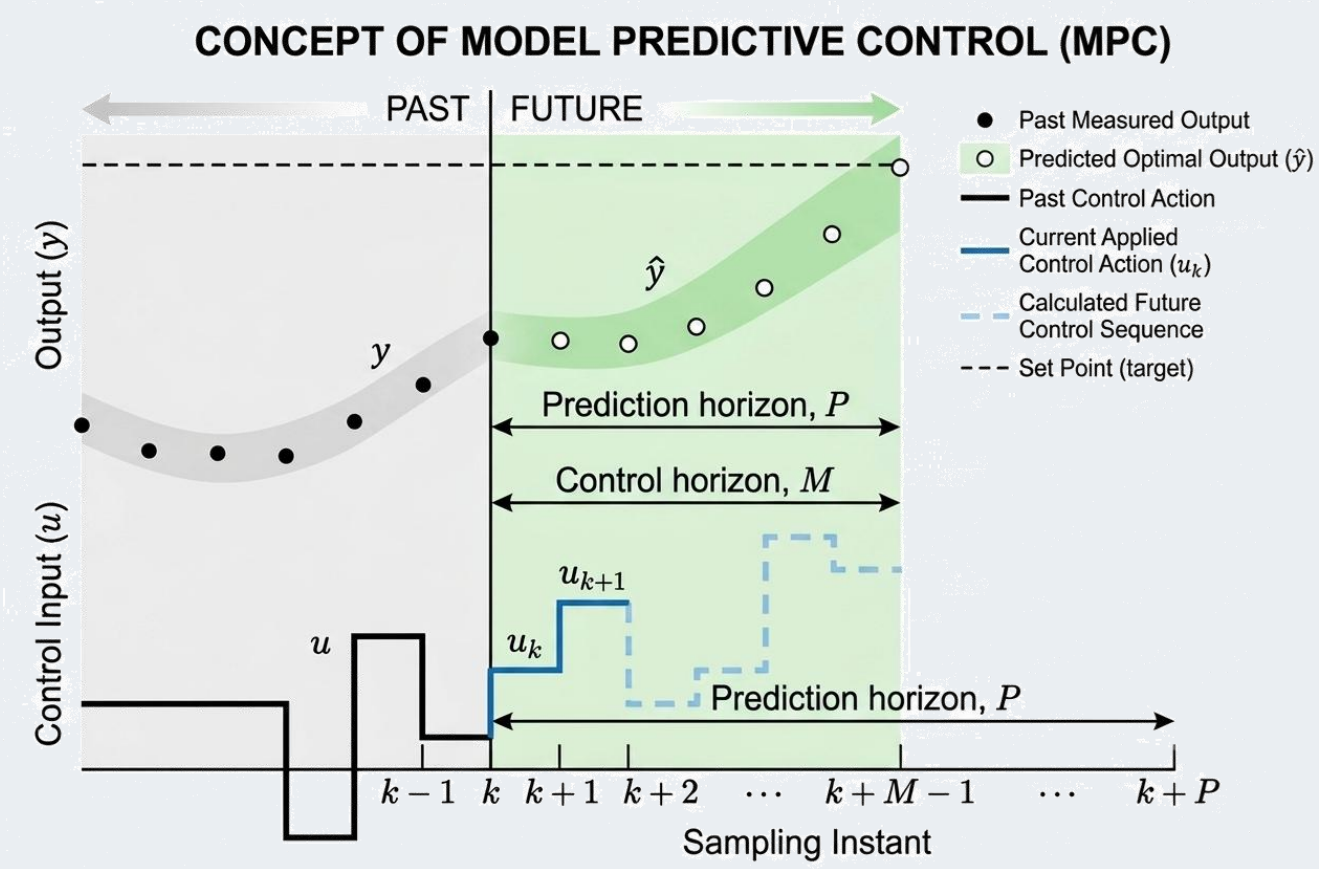
From input 2 to output...

$$\frac{5}{0.52\,s + 1}$$

$$\frac{-1.55}{0.17\,s + 1}$$

Model Predictive Control (MPC)

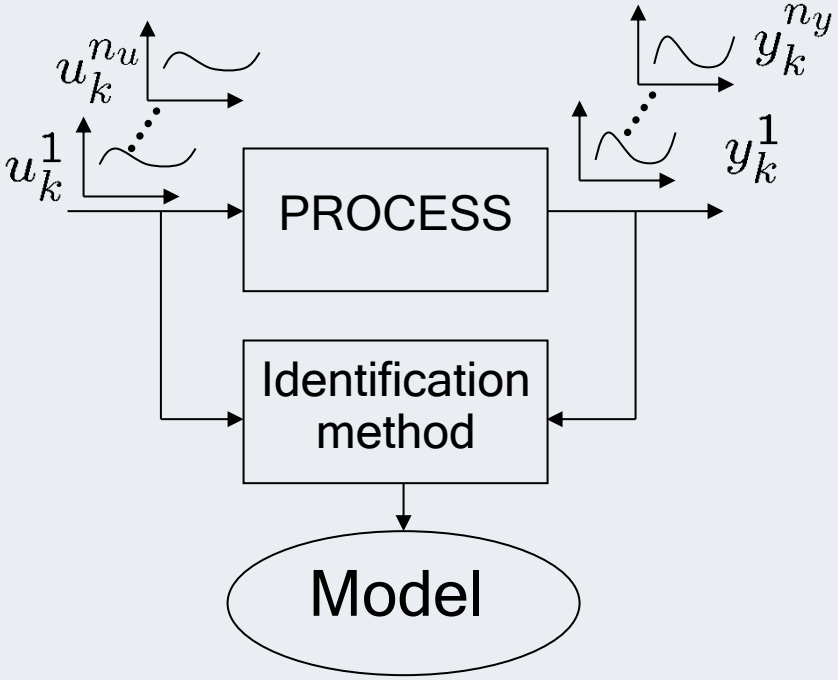
- The concept



Building Process Model From Data

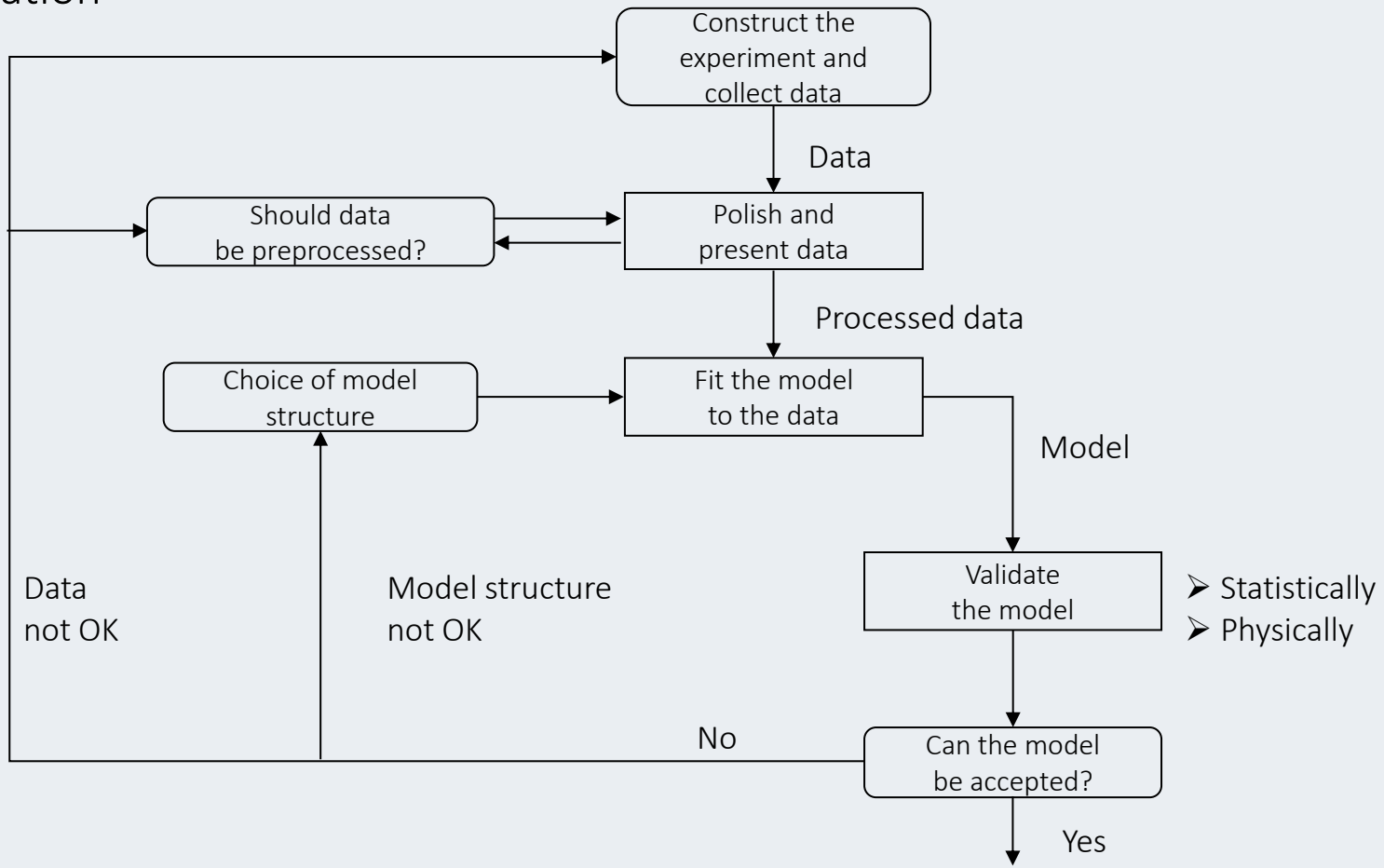
Model Predictive Control (MPC)

- Model Identification



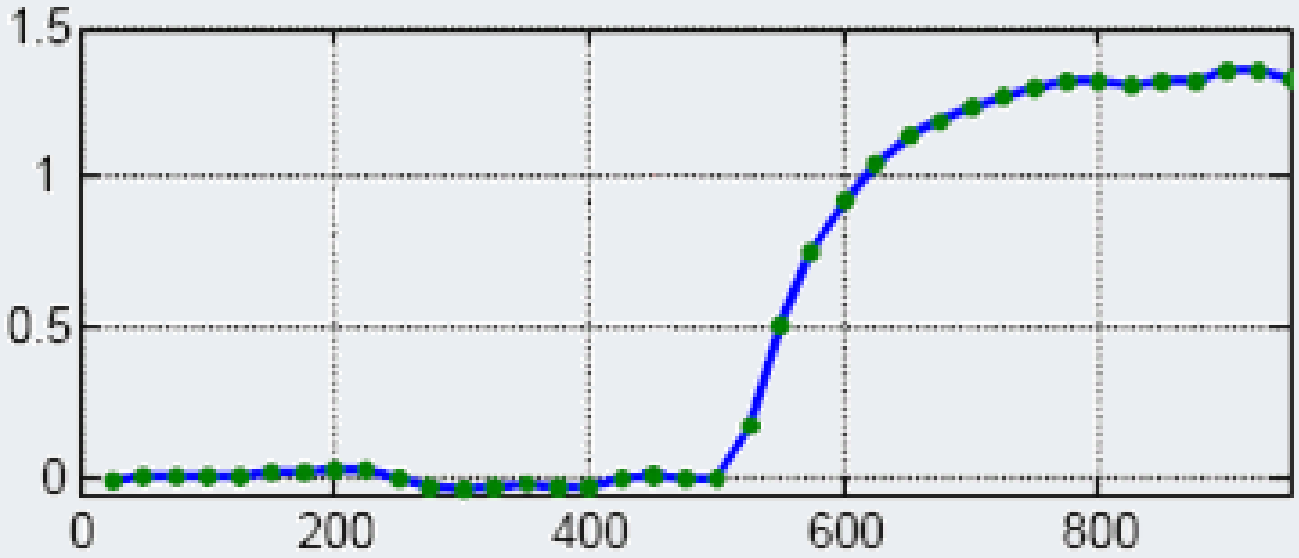
Model Predictive Control (MPC)

- Model Identification



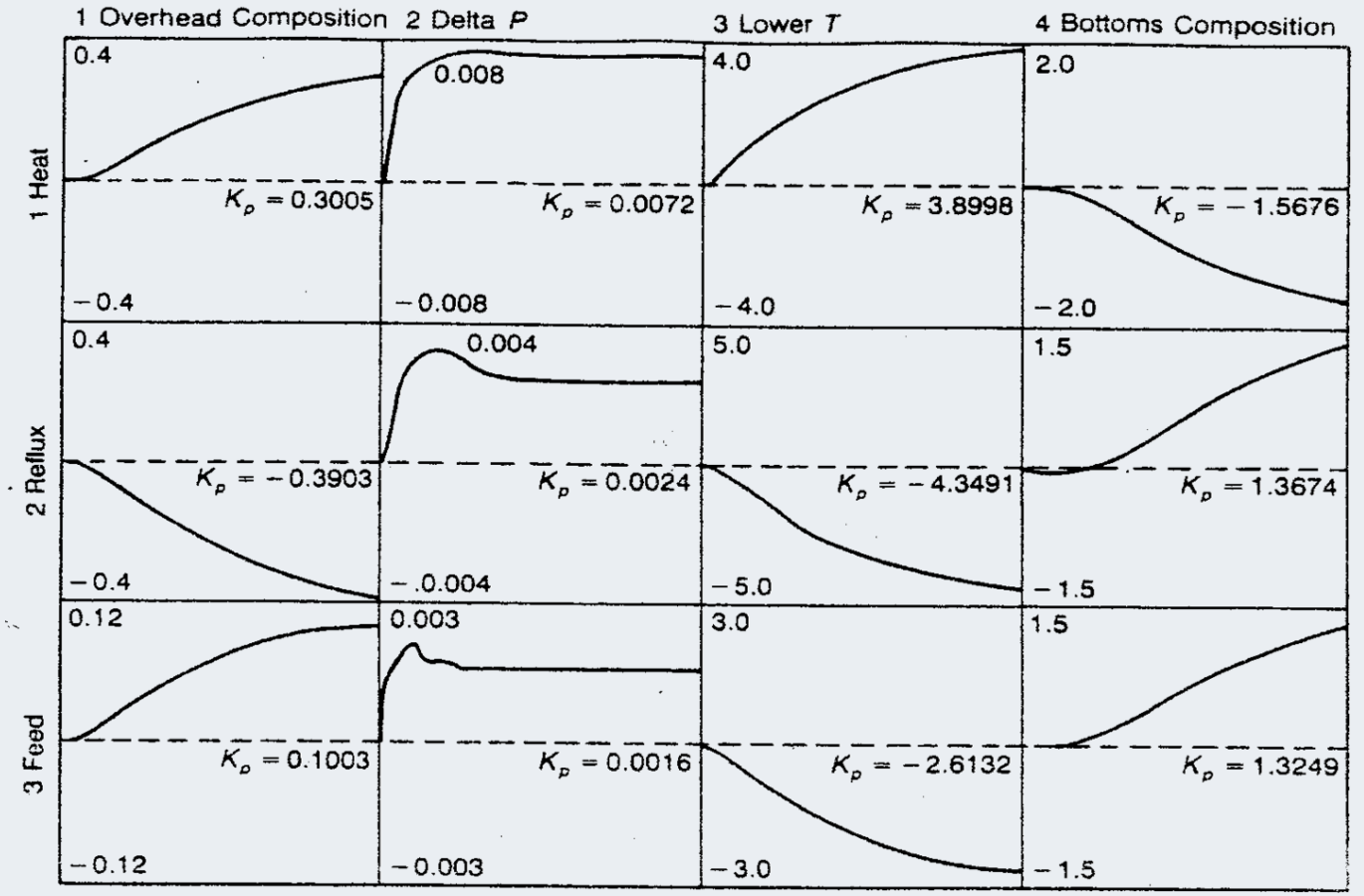
Model Predictive Control (MPC)

- Model Identification: typical response is a FOPDT



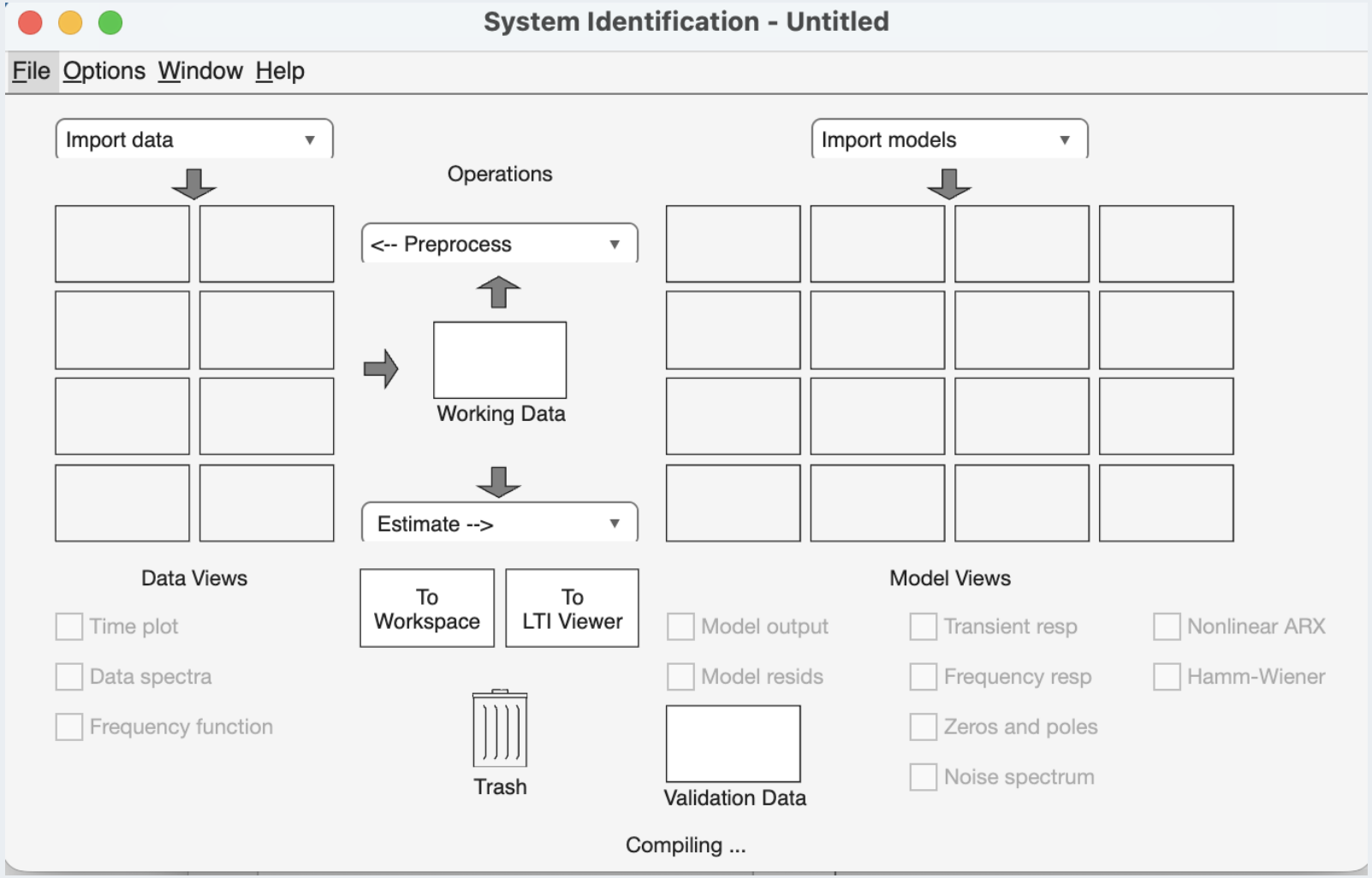
Model Predictive Control (MPC)

- Model Identification in MIMO

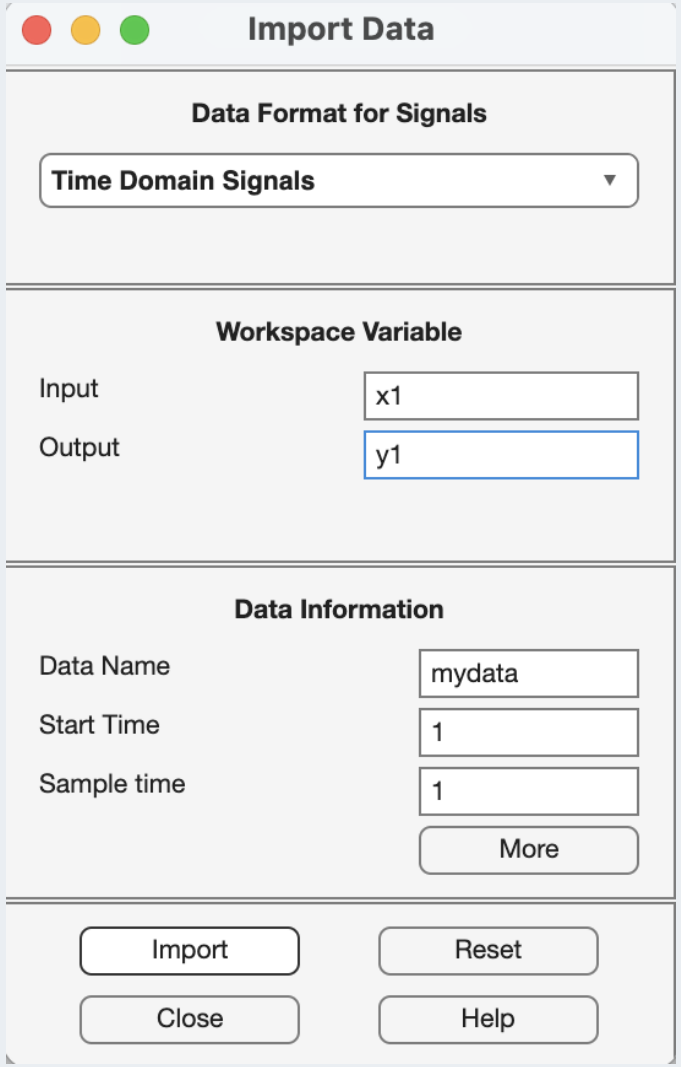


MATLAB for MPC

System Identification



System Identification



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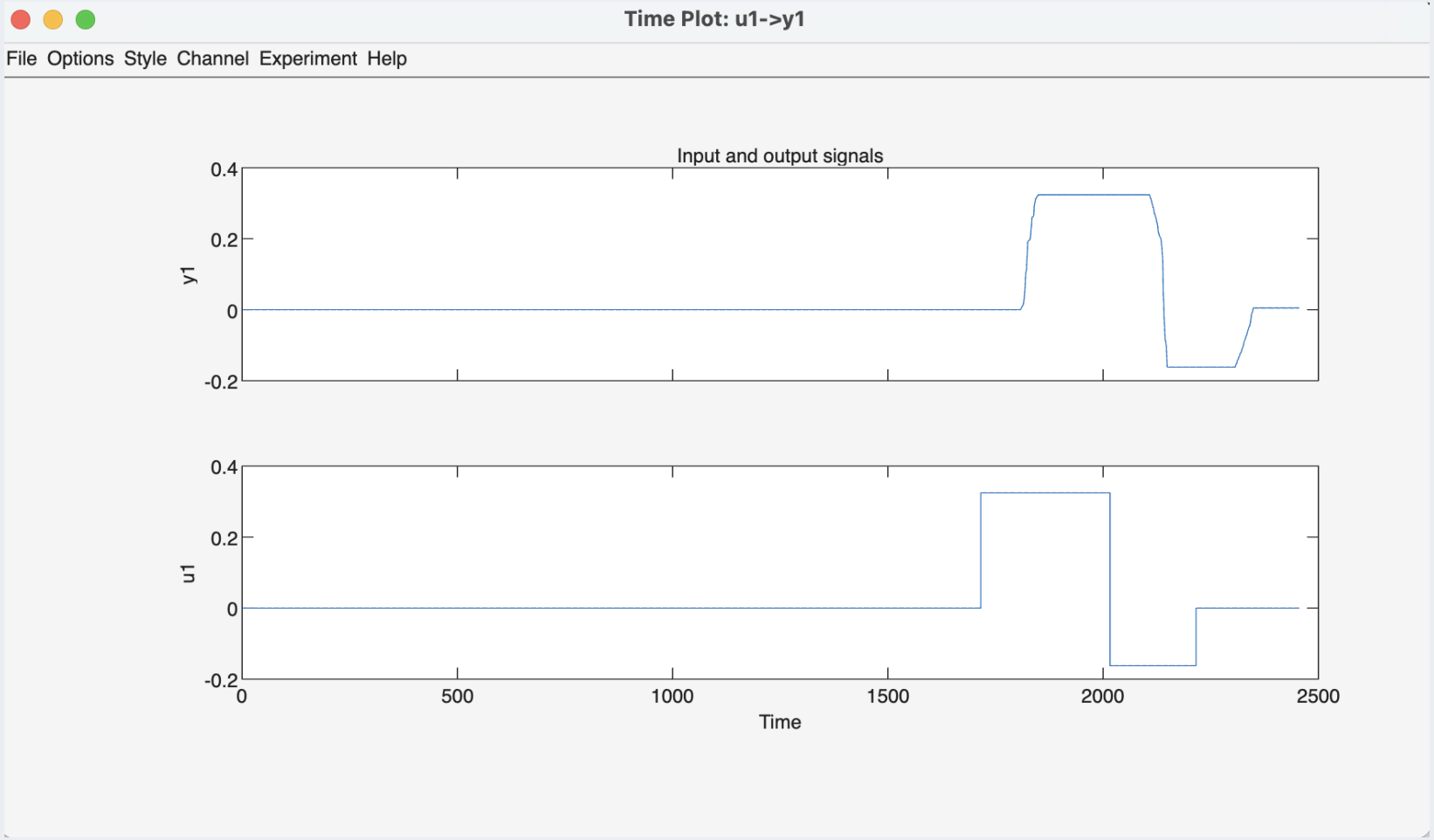
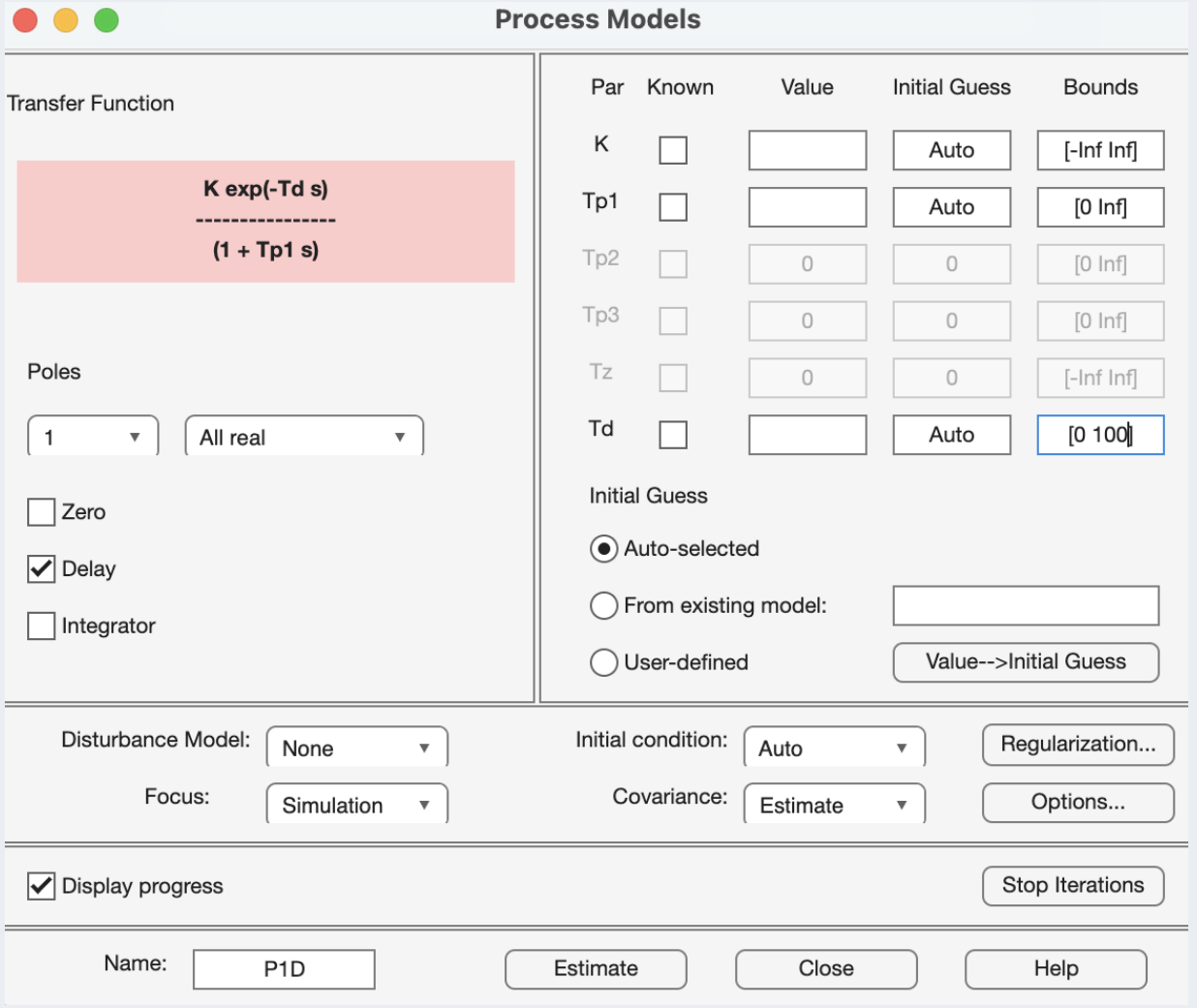
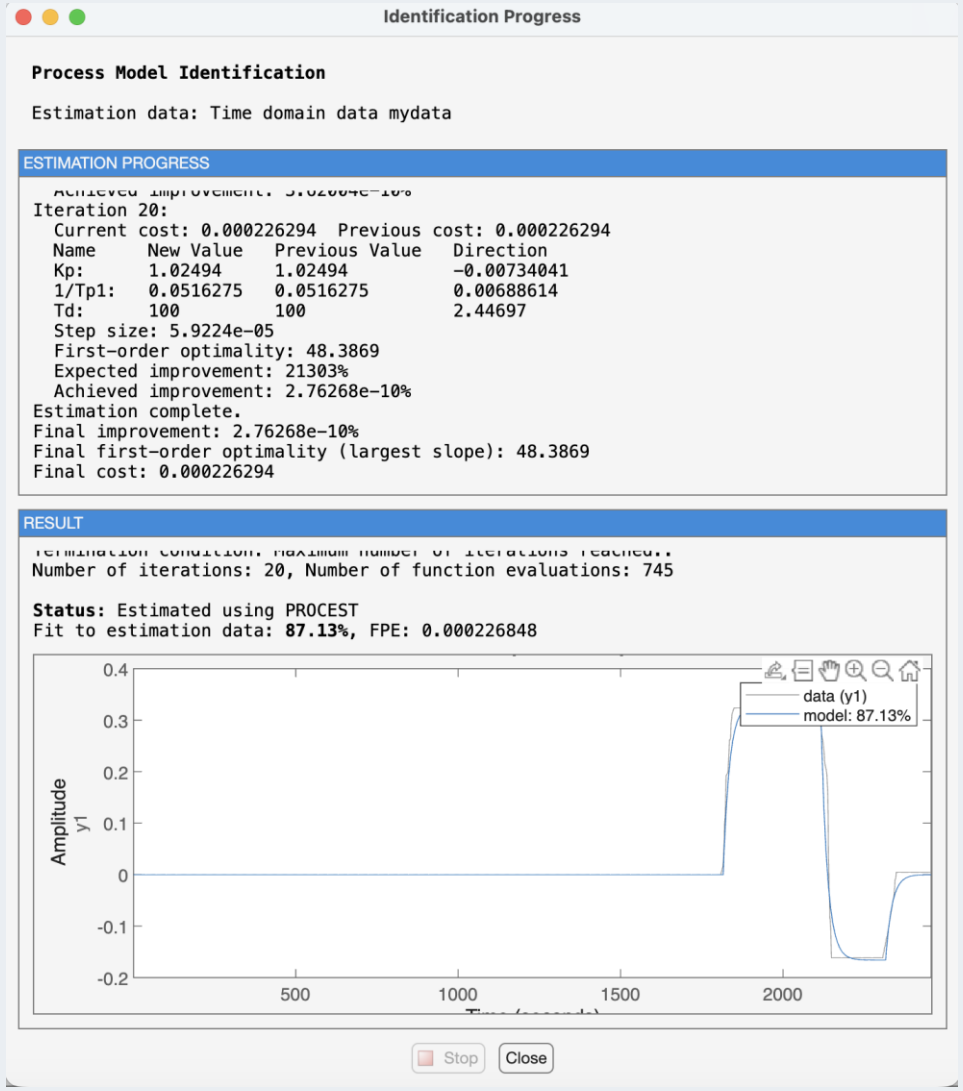


System Identification



System Identification



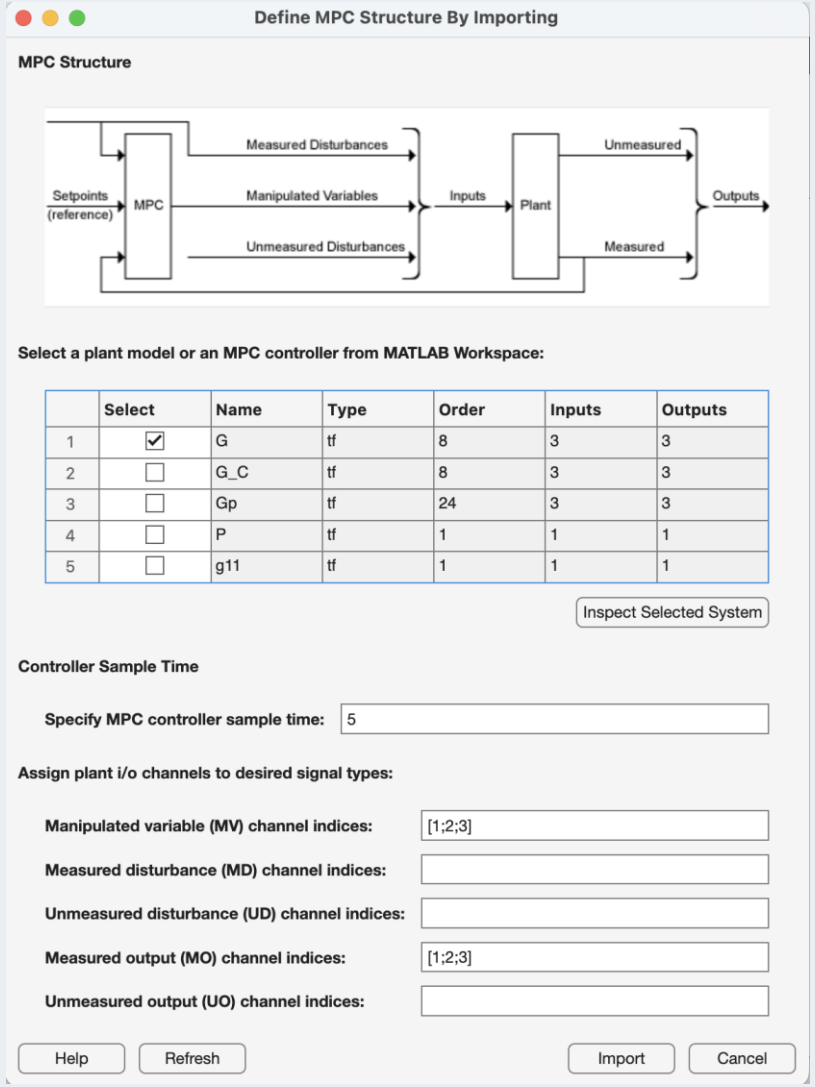
MPC In MATLAB

- Introduce the model

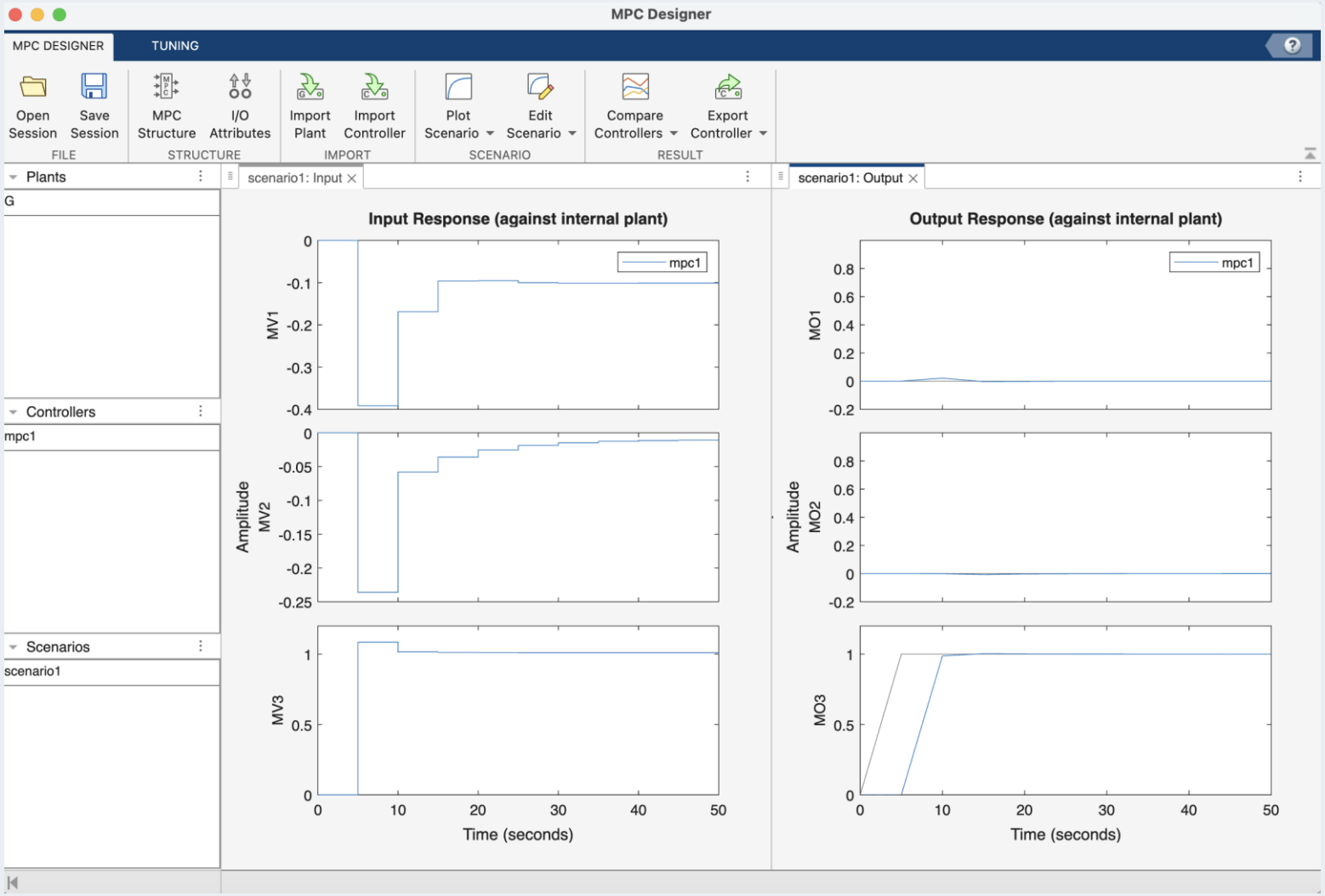
```
>> s = tf('s');
g11 = 1/(20*s+1);
g21 = -0.2/(100*s+1);
g31 = 0.1/(20*s+1);
g12 = 0;
g22 = 1/(5*s+1);
g32 = 0;
g13 = 0.1/(1*s+1);
g23 = 2*s/(10*s^2+11*s+1);
g33 = 1/(2*s+1);
G = [g11 g12 g13; g21 g22 g23; g31 g32 g33];
```

MPC In MATLAB

- Load the model in MPC

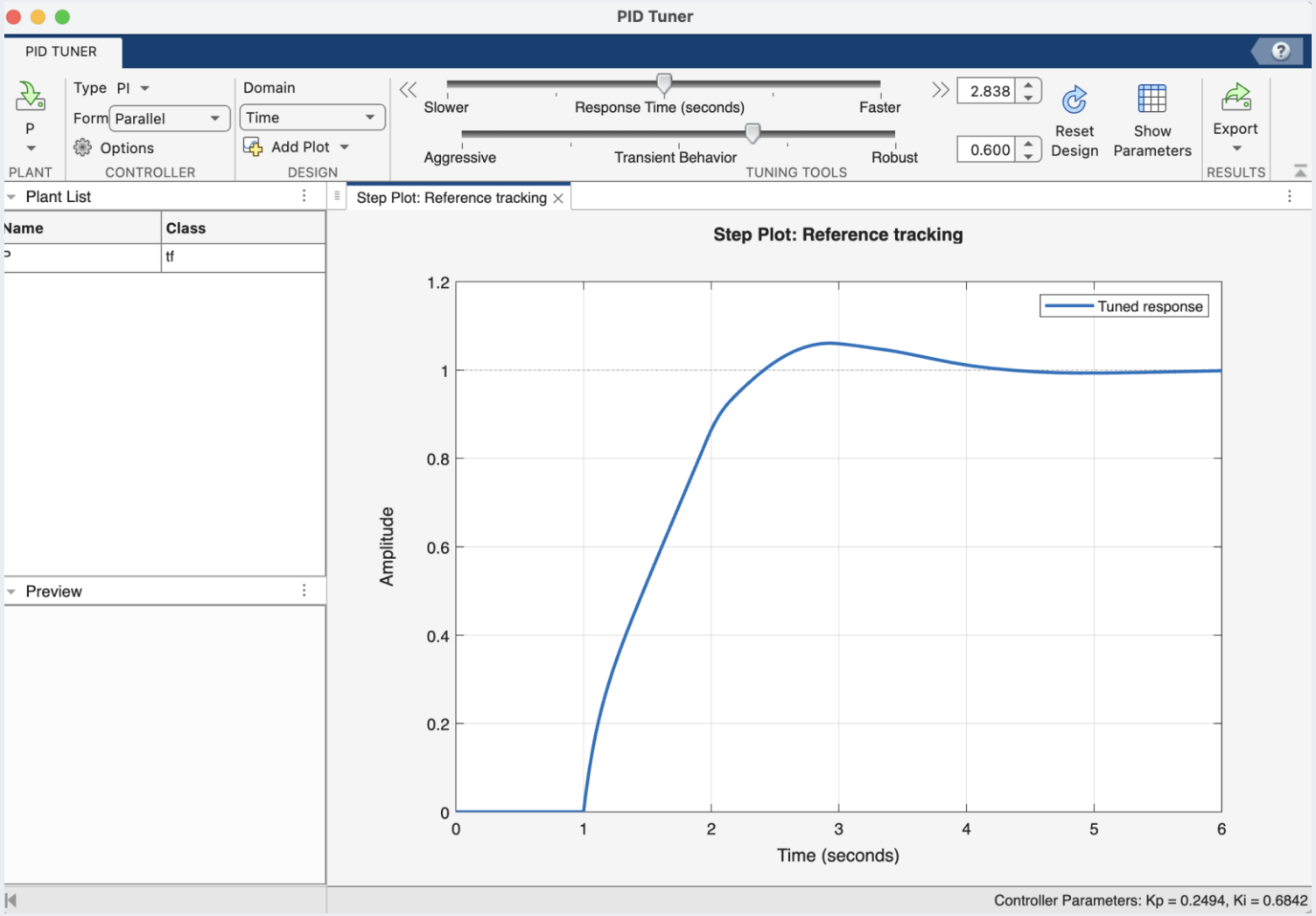


MPC In MATLAB



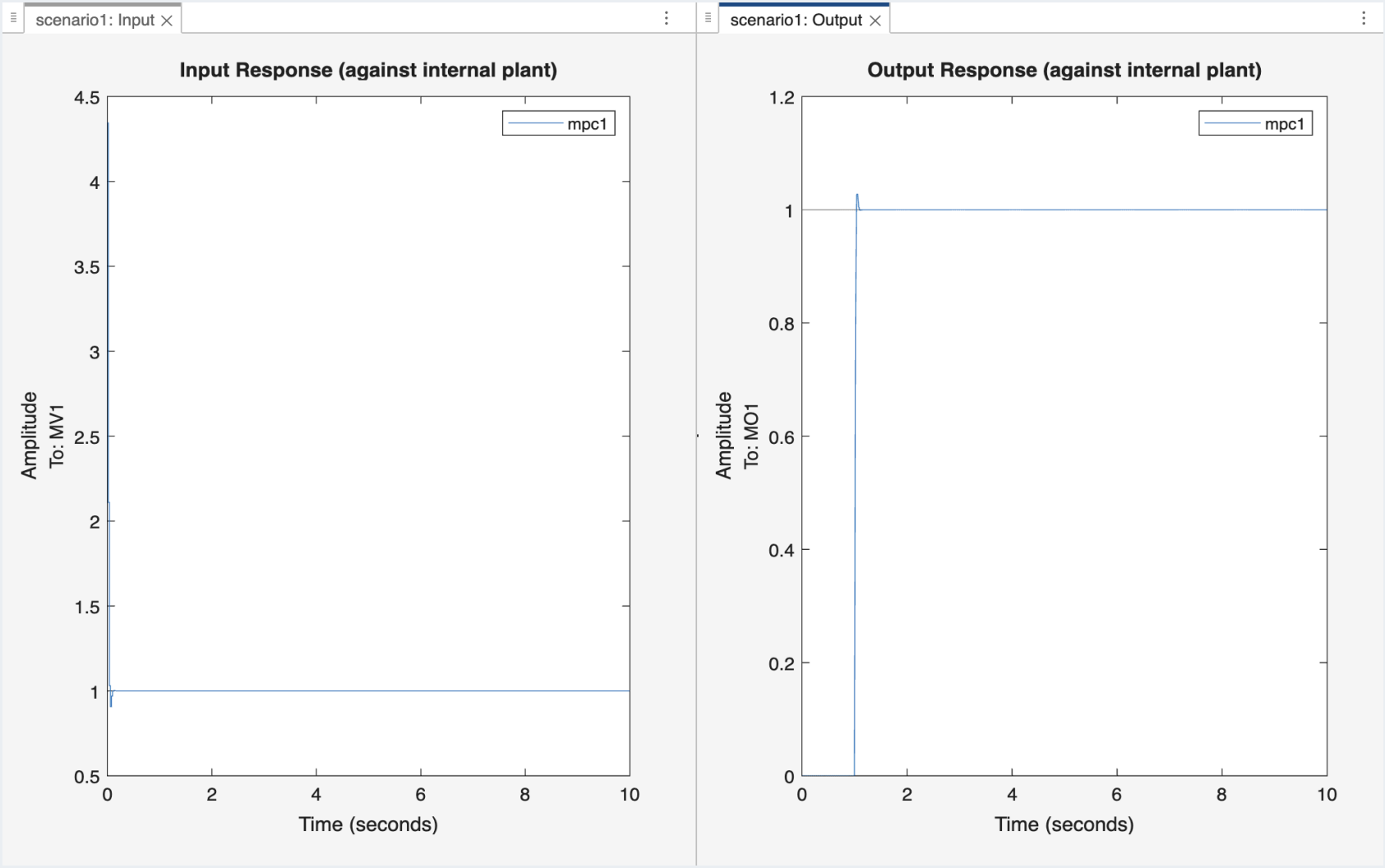
PID vs MPC

- PID



PID vs MPC

- MPC



Conclusion

- MPC is suitable when:
  - The process is difficult to control (delays)
  - There are multiple variables that interact (MIMO)
  - There is a potential to create models for:
    - The process dynamics
    - The disturbances
    - The setpoints
  - There are strict constraints on the inputs and outputs
- Challenges:
  - Computational costs and tuning complexity
  - Dependence on the model

Thank You!

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Bachelor of Engineering (Honours) in Electrical Engineering	September 2026, February 2027
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Master of Science (Industrial Automation and Instrumentation Control)	October 2026, February 2027

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