

Design and Implementation of the Controller for the selected systems
VA1 – project guide (sample)

1. Differential equation
2. Laplace transform -> transfer function $G_s(s)$
3. System analysis (time response overview, frequency response overview, stability, etc.)
4. Controller design (use 2-3 methods of design, comparison of methods)
5. Result: algorithm (script, function, etc) + (1-2) xA4 paper from each example

Software: MATLAB/Simulink, Python, C/C++

Example:

1. Differential equation

$$0.5y''' + 4y'' + 0.5y' + 2y = 6u' + 3u$$

2. Laplace transform \rightarrow transfer function $G_s(s)$

$$G_s(s) = \frac{L\{y(t)\}}{L\{u(t)\}} = \frac{Y(s)}{U(s)}$$

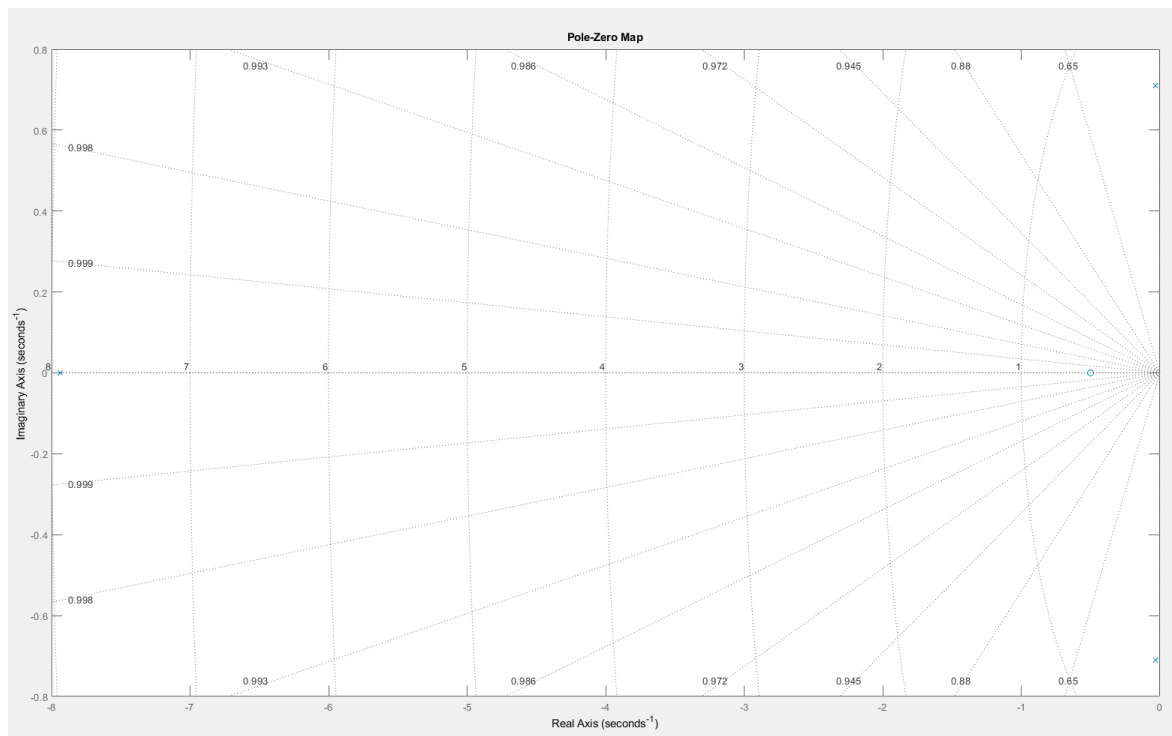
$$L\{0.5y'''(t) + 4y''(t) + 0.5y'(t) + 2y(t)\} = L\{6u'(t) + 3u(t)\}$$

$$0.5s^3Y(s) + 4s^2Y(s) + 0.5s^1Y(s) + 2s^0Y(s) = 6s^1U(s) + 3s^0U(s)$$

$$[0.5s^3 + 4s^2 + 0.5s^1 + 2s^0]Y(s) = [6s^1 + 3s^0]U(s)$$

$$G_s(s) = \frac{6s + 3}{0.5s^3 + 4s^2 + 0.5s + 2}$$

3. System analysis (time response overview, frequency response overview, stability, etc.)



```
%% Stability
pzmap(G_s)

p_G_s = pole(G_s);
e = 0;

for i = 1:length(p_G_s)
    if p_G_s(i) > 0
        disp('System is not stable!');
        e = 1;
    end
end

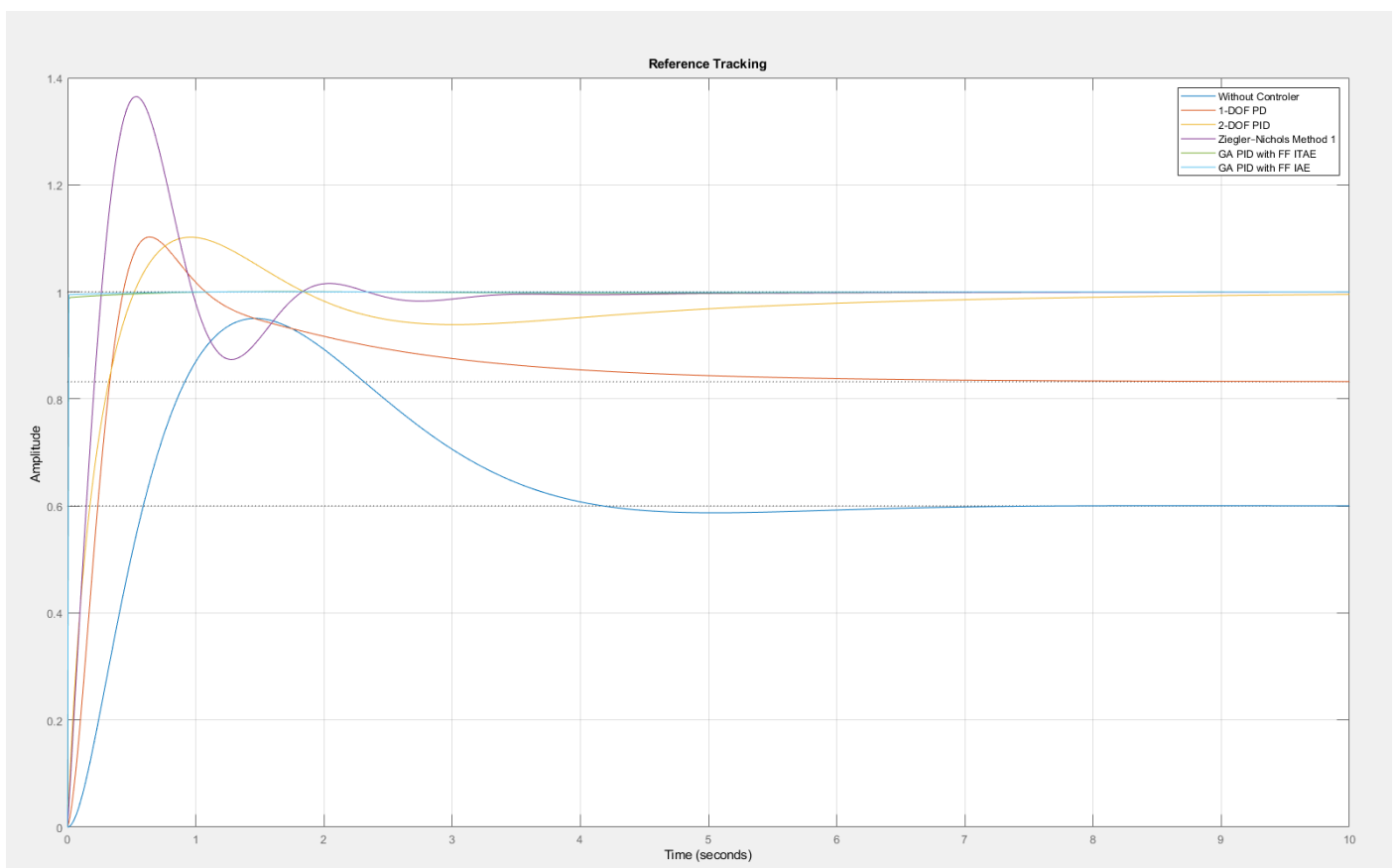
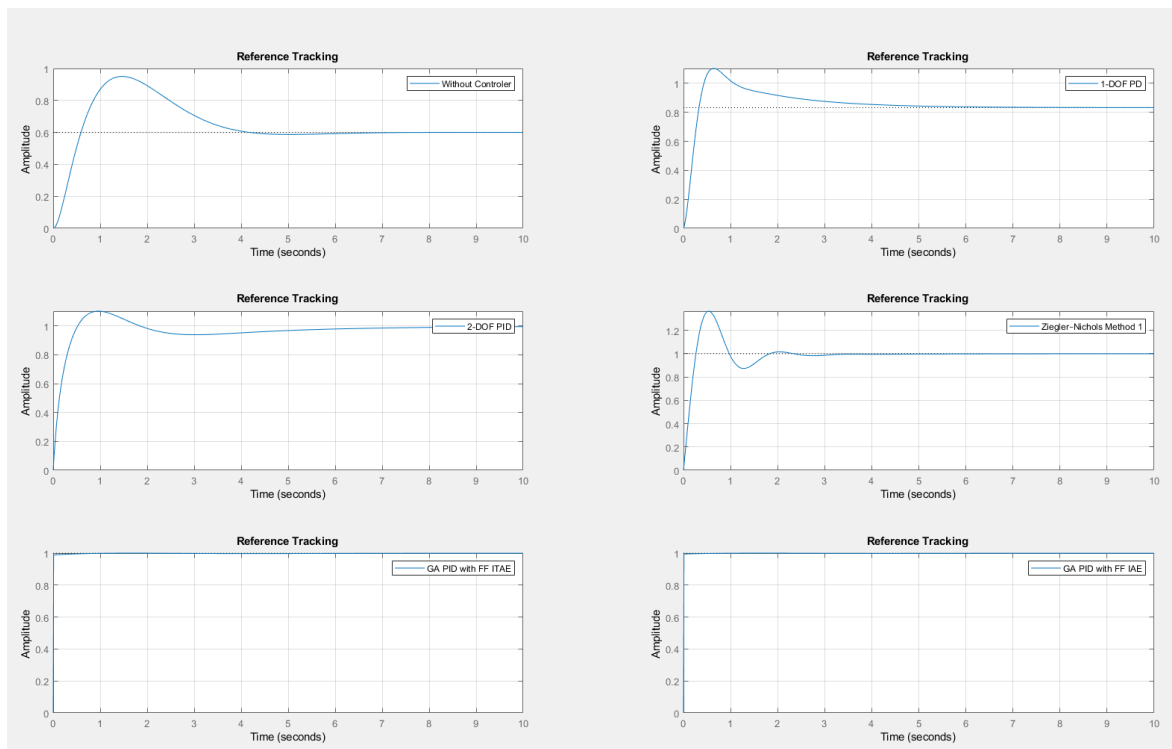
if e ~= 1
    disp('System is stable!');
end
```

Command Window

New to MATLAB? See resources for [Getting Started](#).

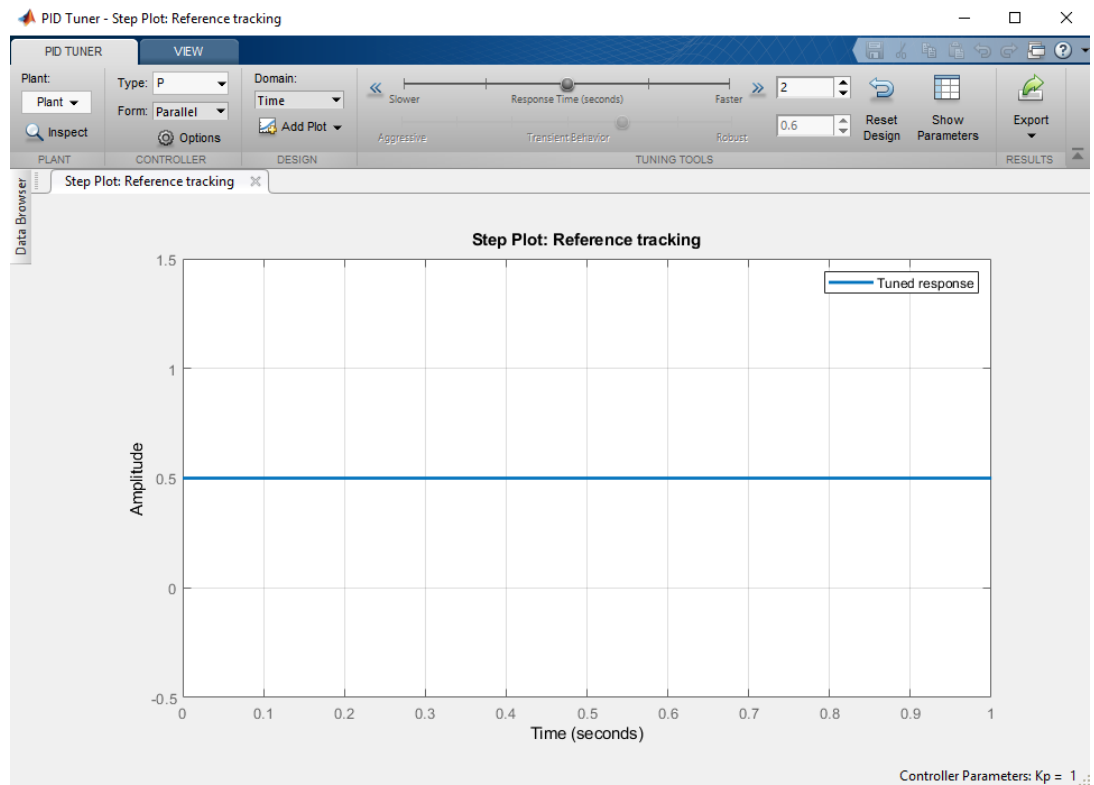
System is stable!

4. Controller design (use 2-3 methods of design, comparison of methods)

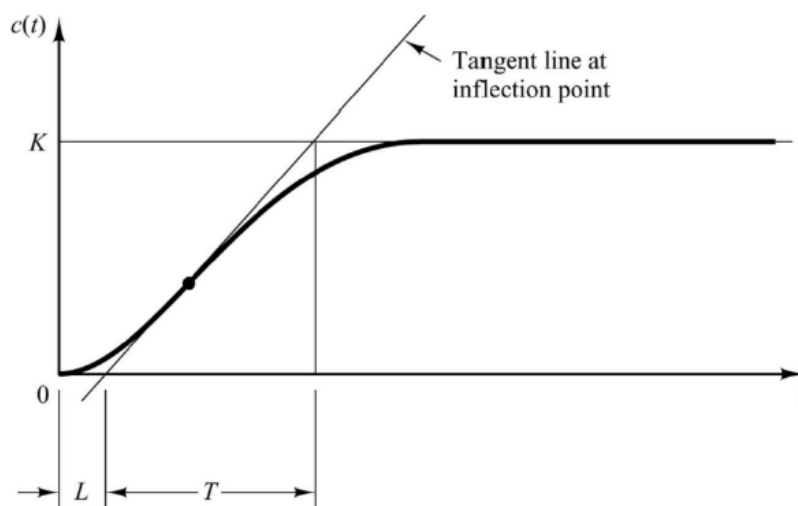


a. PID Tuner – PD Controller, 2-DOF PID

>> pidTuner % matlab toolbox



b. Ziegler-Nichols Method 1



c. Genetic algorithm (ITAE, IAE fitness function)

Optimization Tool

File Help

Problem Setup and Results

Solver: **ga - Genetic Algorithm**

Problem

Fitness function: **@(x)iae_ga(x)**

Number of variables: **3**

Constraints:

Linear inequalities: A: b:

Linear equalities: Aeq: beq:

Bounds: Lower: Upper:

Nonlinear constraint function:

Integer variable indices:

Run solver and view results

☐ Use random states from previous run

Start **Pause** **Stop**

Current iteration: **51** **Clear Results**

than options.FunctionTolerance.

Optimization running.
Objective function value: 0.038740329401620574
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.

Optimization running.
Objective function value: 0.010010739930411149
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.

Final point:

1	2	3
100	99.998	100

Options

Stopping criteria

Generations: ☒ Use default: 100*numberOfVariables
☐ Specify:

Time limit: ☒ Use default: Inf
☐ Specify:

Fitness limit: ☒ Use default: -Inf
☐ Specify:

Stall generations: ☒ Use default: 50
☐ Specify:

Stall time limit: ☒ Use default: Inf
☐ Specify:

Stall test: **average change**

Function tolerance: ☒ Use default: 1e-6
☐ Specify:

Constraint tolerance: ☒ Use default: 1e-3
☐ Specify:

Plot functions

Plot interval: **1**

☐ Best fitness ☐ Best individual ☐ Distance
☐ Expectation ☐ Genealogy ☐ Range
☐ Score diversity ☐ Scores ☐ Selection
☐ Stopping ☐ Max constraint
☐ Custom function:

Output function

☐ Custom function:

Display to command window

Level of display: **off**

User function evaluation

Quick Reference

Genetic Algorithm Solver

This tool corresponds to the ga function.

Click to expand the section below corresponding to your task.

Problem Setup and Results

- Problem
- Constraints
- Run solver and view results

Options

Specify options for the Genetic Algorithm solver.

- Population
- Fitness scaling
- Selection
- Reproduction
- Mutation
- Crossover
- Migration
- Constraint parameters
- Hybrid function
- Stopping criteria
- Plot Functions
- Output function
- Display to command window
- User function evaluation

More Information

- User Guide
- Function equivalent