# Advanced Control of Continuous Time Systems

Talk to a Teacher Project
http://spoken-tutorial.org
National Mission on Education through ICT
http://sakshat.ac.in

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# Objectives

**At the end of this tutorial, you will learn how to:**

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- **Do a Bode plot**

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- Study `numer` and `denom` functions

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- **Study `numer` and `denom` functions**
- **Plot poles and zeros of the system**

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# System Requirements

- **OS: Ubuntu Linux 12.04**

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- **Scilab 5.3.3**

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# Prerequisite

- Basic knowledge

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- Basic knowledge
  - Scilab
  - Control systems
- Please refer to the relevant tutorials available on http://spoken-tutorial.org

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# Second Order Linear System

**In this tutorial,**

- Define second-order linear system

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# Second Order Linear System

**In this tutorial,**

- **Define second-order linear system**
- **Define complex domain variable 's'**

# syslin command

- **Use the Scilab function** `'syslin'` **to define the continuous time system**

$$G(s) = \frac{2}{s^2 + 2s + 9}$$

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# syslin command

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# syslin command

- **Use the Scilab function** `'syslin'` **to define the continuous time system**

$$G(s) = \frac{2}{s^2 + 2s + 9}$$

- **Use** `csim` **with** `'step'` **option to obtain step response**
- **Plot the step response**

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# Sine Input

**Sine function(s)**

- can easily be given

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- **can easily be given**
- **as inputs**

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# Sine Input

**Sine function(s)**

- **can easily be given**
- **as inputs**
- **to continuous time system**

# Response Plot

- Plots both the **input** and the **output** on the same graph

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- Plots both the input and the output on the same graph
- Output is a sine wave

# Response Plot

- Plots both the input and the output on the same graph
- Output is a sine wave
- Phase lag between the input and the output

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# Response Plot

**As expected,**

- **Amplitude is different for the input and the output**

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# Response Plot

As expected,

- Amplitude is different for the input and the output
- Typical underdamped example

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# Bode Plot

- **Let us plot bode plot of**

$$\frac{2}{s^2 + 2s + 9}$$

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$$\frac{2}{s^2 + 2s + 9}$$

- **Command `‘freq’` : frequency response**

# Bode Plot

- **Let us plot bode plot of**

$$\frac{2}{s^2 + 2s + 9}$$

- **Command '`freq`' : frequency response**
- **Do <u>not</u> use `freq` as a variable!!**

# Overdamped System

- **Define another system: overdamped case**

$$--> p = s^2 + 9*s + 9$$

# Overdamped System

- **Define another system: overdamped case**

$$--> p = s^2 + 9 * s + 9$$

- **Please plot step response for this system**

**Also try:**

- $$G(s) = \frac{2}{s^2 + 6s + 9}$$
  **(critically damped)**
- $$G(s) = \frac{2}{s^2 + 9}$$
  **(undamped)**

# Exercise II

- $$G(s) = \frac{2}{s^2 - 6s + 9}$$
  **(unstable)**
- **Check response to sinusoidal inputs for all cases**
- **Plot bode plot too**

# More about Transfer Function

- The variable ’sys’ is of type ’rational’

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- The variable 'sys' is of type 'rational'
- Its numerator and denominator can be extracted by various ways

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# More about Transfer Function

- `sys(2)`, `numer(sys)` **or** `numer(g)` **gives the numerator**

# More about Transfer Function

- `sys(2)`, `numer(sys)` **or** `numer(g)` **gives the numerator**
- **Denominator can be found by** `sys(3)` **or by** `denom(sys)`

# Poles/Zeros

- **The poles and zeros of** `sys` **can be plotted using the plzr function**

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-

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# Poles/Zeros

- The poles and zeros of `sys` can be plotted using the **plzr** function
- $$--> \texttt{plzr(sys)}$$
- (Shows $\times$ and $\circ$ on the complex plane for poles and zeros)

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# Summary

In this tutorial, we have learnt to:

- Define a system by its transfer function
- Plot step/sinusoidal responses
- Extract poles/zeros of a transfer function

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# About the Spoken Tutorial Project

- **Watch the video available at http://spoken-tutorial.org/What_is_a_Spoken_Tutorial**
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**The Spoken Tutorial Project Team**

- **Conducts workshops using spoken tutorials**
- **Gives certificates to those who pass an online test**
- **For more details, please write to contact@spoken-tutorial.org**

# Acknowledgements


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- It is supported by the National Mission on Education through ICT, MHRD, Government of India
- More information on this Mission is available at http://spoken-tutorial.org /NMEICT-Intro


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