Transfer Function Analysis of Dynamic Systems
Curriculum Module

Created with R2020b. Compatible with R2020b and later releases.

Description

This curriculum module contains interactive *live scripts* and a *MATLAB app* that teach transfer function analysis of dynamic systems. In the first script, students learn to derive transfer functions from ODEs and compute impulse, step, and forced responses. In subsequent scripts, students perform pole-zero and frequency domain analyses. Throughout the module, students apply transfer functions to analyze the dynamics of physical and electrical systems. In the final lesson, students perform a frequency domain analysis of an LC filter in a buck converter. A review of Laplace transforms is also included for students seeking a refresher. These lessons can be used as part of a lecture, as activities in an instructional setting, or as interactive assignments to be completed outside of class.

Suggested Prework

MATLAB Onramp – a free two-hour introductory tutorial that teaches the essentials of MATLAB.
Introduction to Symbolic Math with MATLAB – a two-hour self-paced introductory course that teaches the basics of symbolic mathematics in MATLAB. Note that this course is only available to users with access to the Online Training Suite.

Details

Part0_ConceptReview.mlx | Part0_ConceptReviewSoln.mlx

Contents: An interactive lesson that reviews Laplace transforms.
Learning Goals:
- Compute Laplace transforms by hand and using symbolic math
- Describe the properties of the Laplace transform
- Apply Laplace transforms to solve initial value problems
- Recall the definition of a linear time-invariant (LTI) operator

Part1_TransferFunctionBasics.mlx | Part1_TransferFunctionBasicsSoln.mlx

Contents: An interactive lesson that teaches how to derive transfer functions and compute time responses analytically and in MATLAB.
Learning Goals:
- Derive transfer functions by hand
- Derive transfer functions using symbolic math
- Numerically evaluate and plot the impulse, step, and forced responses of a system
- Analytically derive the step and forced responses of a system
- Explain the physical significance of time responses

Part2_PoleZeroAnalysis.mlx | Part2_PoleZeroAnalysisSoln.mlx

Contents: A live script lesson that teaches pole-zero analysis.
Learning Goals:
- Describe how the transfer function of a DC motor is derived
- Identify the poles and zeros of a transfer function
- Assess the stability of an LTI system based on the transfer function poles
- Relate the position of poles in the s-plane to the damping and natural frequency of a system
- Explain how poles of a second-order system relate to its dynamics
- Examine how transfer function zeros affect the dynamics of a system

Part3_FrequencyDomainAnalysis.mlx | Part3_FrequencyDomainAnalysisSoln.mlx

Contents: An interactive lesson that teaches frequency domain analysis using transfer functions.
Learning Goals:
- Explain how a Bode plot is generated

© 2020 The MathWorks, Inc.

- Use MATLAB to numerically calculate the frequency response of a transfer function
- Discuss how features of the Bode plot relate to characteristics of physical systems
- Describe how to derive a differential equation model for a buck converter with an LC filter
- Apply the Bode plot to analyze an LC filter in a buck converter

polesApp.mlapp

Contents: A MATLAB app that lets you construct a transfer function by graphically positioning the poles and zeros. You can also compute and plot the impulse and step responses.

Products used in this module: MATLAB, Symbolic Math Toolbox, Control System Toolbox