Calibration Exercise Report

Your Name

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1 Introduction

Inverse problems constitute a fundamental aspect of signal processing and scientific inquiry, dealing with the challenge of inferring unknown causes or parameters from observed effects or measurements. In various fields, including engineering, physics, and medicine, these problems arise when attempting to recover critical information about a system or process from available data.

The Characteristics of Inverse Problems: Ill-behaved and also Ambiguity and Non-Uniqueness, which necessities the need of regularization techniques to solve of perturbations and uniqueness of solution.

In the context of the calibration exercise, inverse problems find relevance in the process of determining unknown parameters or properties of a model or system. Calibration involves adjusting or determining model parameters to minimize the discrepancy between model predictions and observed data, effectively framing it as an inverse problem.

Harmonic Oscillator model

In the calibration exercise, the objective revolves around refining the parameters of a harmonic oscillator model to achieve a better fit with measured data. This process involves solving an inverse problem by iteratively adjusting parameters to minimize the difference between model predictions and actual measurements. Here, mean squared error is used as objective function. The techniques such as optimization algorithms and cost function evaluation are employed to find optimal parameter values, reflecting the essence of solving an inverse problem.

In summary, the exercise of calibration exemplifies the practical application of solving an inverse problem within signal processing, *aiming to refine model parameters to accurately represent observed data and enhance the model's predictive capabilities.*

2 Model Overview

In our model, we consider the following differential equation:

$$\rho u'' + cu' + ku = 0$$

where:

- $u(t)$ represents the dependent variable, often denoting displacement, voltage, or any quantity that varies with time t.
- $u''(t)$ signifies the second derivative of u with respect to time, indicating the acceleration or rate of change of the rate of change of u with respect to time.
- ρ denotes a coefficient or parameter, typically representing mass density or a similar physical property.
- c stands for another coefficient, often associated with damping or resistance in the system.
- k represents stiffness or restoring force in the system, associated with the force that tends to restore the system towards its equilibrium position when displaced.
- t represents time, the independent variable in the equation.

This type of equations generally defines the movement of a body with the time, in real scenarios, we consider the effect of friction in the form of damping, further it maybe a constant or forced value. This differential equation characterizes systems exhibiting harmonic behavior, combining the effects of inertia, damping, and restoring forces influencing the system's motion or behavior over time.

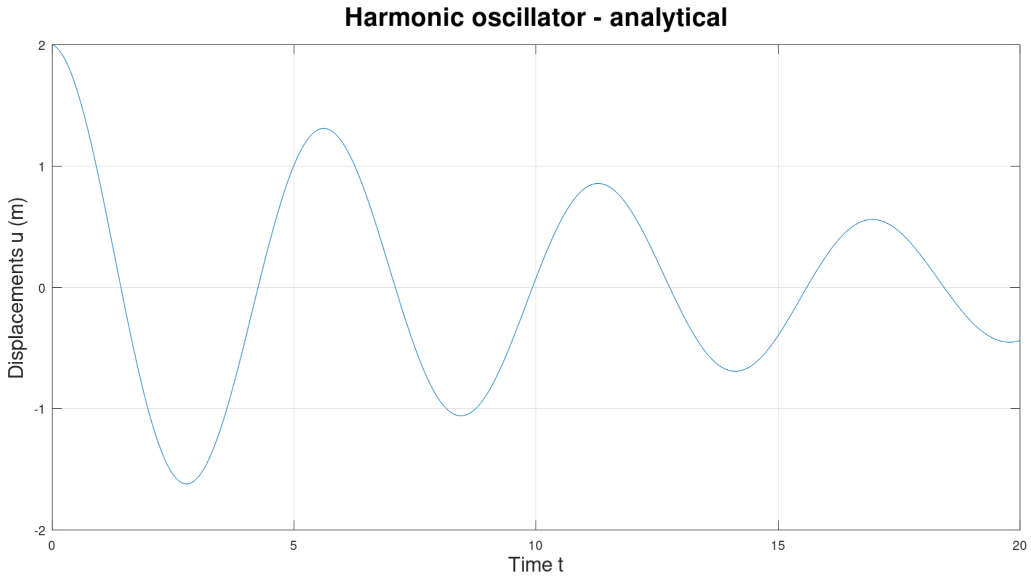

Figure 1: Schematic Diagram of a Harmonic Oscillator with (k,c, rho) as (5, 0.6, 4)

3 Parameter Variation

4 Plotting Configuration

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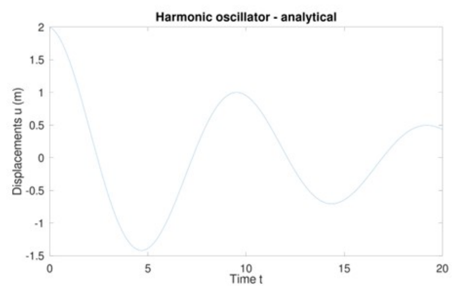

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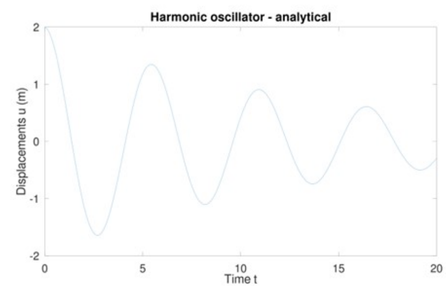

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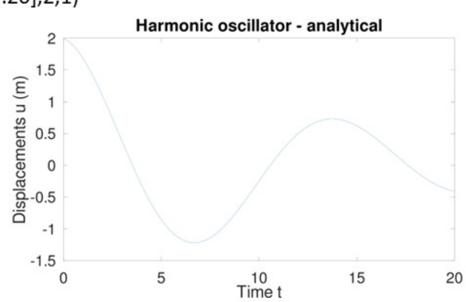

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Figure 2: Schematic Diagram of a Harmonic Oscillator with (k,c, rho) as (5, 0.6, 4)