Parse and Bode Tool Manual

Abstract

These instructions are provided to allow users to maximize the value of having a tool to create bode plots at their fingertips. While there are special purpose instruments available to accomplish similar tasks, most workplaces do not have proper resources to support the demand. This can lead to inefficiency or unnecessary shortcuts. This tool streamlines the process of capturing bode plots and/or impedance plots with minimal resources.

Notices

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1 Introduction

Bode Plots are a crucial tool for determining the stability of control loops. Traditionally, capturing a Bode Plot was a labor-intensive process, requiring analog instruments with data captured by a technician and analyzed and graphed by an engineer. Completing one chart could occupy the better part of a day. Given the demanding nature of this task, organizations often had to develop in-house experts to handle stability issues. These legacy methods have been replaced by special purpose instruments designed to streamline these tasks, allowing an individual to accomplish this in a few minutes with devices such as a Bode Analyzer. Despite these advancements, challenges remain that these instruments can be bulky, or at least take up bench space, and consist of multiple components. Moreover, there are usually too few of these specialized instruments available to meet the demand within an organization.

This tool addresses these limitations by offering a streamlined process that utilizes nearly any commonly available digital storage oscilloscope to quickly and efficiently produce Bode plots. This not only saves time but also makes this critical function more accessible to a broader range of users within the organization. Users are still encouraged to verify their final results with the special purpose instrument to gain experience and better understand the limitations and advantages of each approach.

2 Overview of the Bode Plot for Control Systems.

A typical control problem will include a ‘plant’, a ‘load’, a ‘sensor’, and a ‘compensator’. For the control systems engineer, plant, load, and sensor are usually given, their job would be to design the compensator. From that point of view, the plant and load can be lumped into one element while the sensor and controller are lumped into a second element.

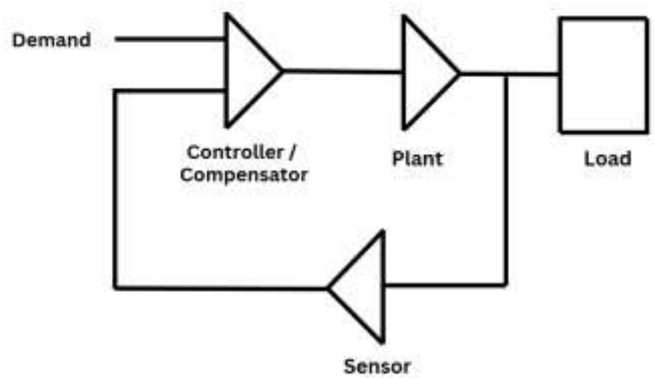

Figure 2-1: Typical Control System

2.1 Open Loop Response

Opening the control loop is a useful method to measure the various gain parameters. The loop can be opened almost anywhere from a theoretical standpoint. From a practical standpoint, the most convenient and available point will be the input to the sensor. The sensor input impedance will typically be well over 1 kΩ. Interrupting this connection with a 50 ohm impedance will have a negligible effect. Once this is done, a signal can be injected through an isolation transformer and measurements can commence.

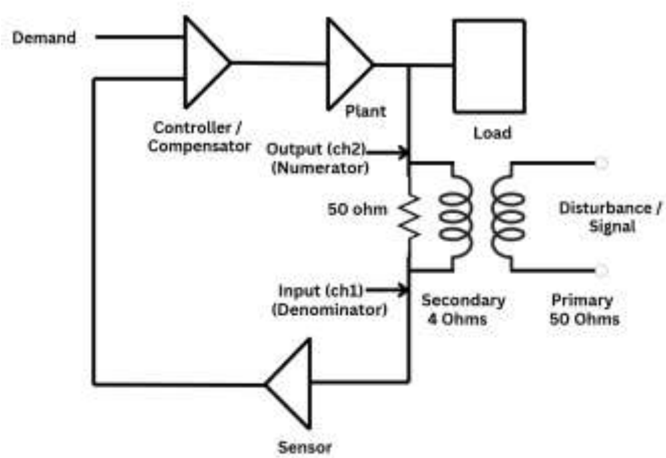

Figure 2-2: Schematic for Open Loop Response

2.2 Plant Gain

Another important measurement is the Plant Gain. This is accomplished by moving the input measurement point to the input of the plant. All other connections remain the same.

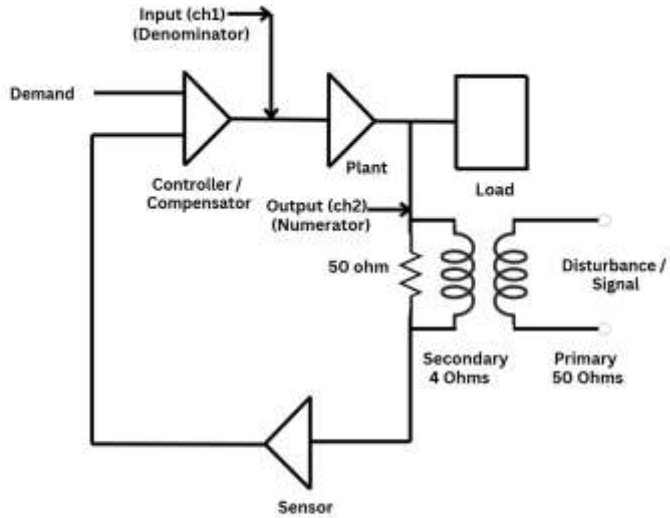

Figure 2-3: Schematic for Plant Gain

3 Hardware and Settings

The tools required are a Digital oscilloscope, a function generator, and an inexpensive audio transformer to inject the signal. Many Digital oscilloscopes have built-in function generators. It is best to have this type of scope as standard lab equipment because it will save bench space, and having a generator readily available will streamline many tasks. The audio transformer should have a 50 ohm primary and a 4 ohm secondary. The transformer should be rated for about 1W. These ratings only need to be approximate.

It is important for the transformer to be a step-down as indicated above (50 ohm primary to 4 ohm secondary).

Setup the hardware as indicated in Figure 2-2 or Figure 2-3.

Connect a third channel (channel 3 or channel 4) to the primary of the injection transformer. Set this input channel as the trigger for the scope.

Set the function generator to 100, 1000, or 10,000 Hz depending on what frequency range you would like to span. The application's default setting configures the maximum frequency to be 100 times the injected signal, though users can adjust this as needed.

Set the wave shape to square and the amplitude (from the generator) to 0.5V p-p. This should result in a 0.1V p-p waveform on the secondary. It is expected that the waveform will be distorted. The signal amplitude can be increased or decreased based on the application. It is best to have the largest signal possible, however the injected signal must remain much smaller than the normal voltage seen by the sensor in order to maintain integrity of the system.

Set the time base to capture 2 or more complete cycles of the waveform. For example for a 100Hz excitation, the time base should be set to 2 mS / Division. The scope will capture a total of 20 mS or 2 cycles of 100 Hz. The horizontal delay should be set to about 10% so that some pre-trigger is visible, and the number of data points should be set to 10,000.

Make sure the trigger channel is providing a stable reading.

It will likely be necessary to set the acquisition mode to averaging. It is best to use the relatively high averaging value, usually 500 to 1000. This will improve the signal to noise ratio.

Save the waveform data and bring the waveform as a csv file (comma separated variables) over to a computer.

4 Using the Interface

The interface is first asking the user to choose a file to upload. This will be the file saved in the previous section. If there is no file available, click on the ‘Sample File’ to download a typical file to operate the interface. Once Downloaded, that file can be selected with the ‘Choose File’ button. Once the file is selected, the interface will automatically graph the data. The application will ignore any header information in the files created by the scope.

Figure 4-1: Sample Data Plotted by Application

In this case, we can see the data is plotted from -0.2 mS to 1.8 mS, a total span of 2 mS capturing 2 cycles. So we know the injected signal was 1 kHz. Alternatively, when saving the scope file, the user should give the file an intelligent name with information to ease this part of the process.

4.1 Parsing the Data

Parsing the data is required to enable the analysis to continue to the frequency domain. The technique used in this application requires the data set to contain a number of samples that is the power of 2. The application allows the user to set this value freely in case the application is being used for other purposes. In this case we know the scope was set to capture 10,000 samples, otherwise it may be required to determine the number of samples by inspecting the data. It is not important to be exact. Knowing that 2 cycles are covering 10,000 samples, the sample size must be reduced to less than 5000 samples. 4096 is the next power of 2 less than 5000. That value will be used, enter it into the box labeled ‘Number of Samples’. The default value for Start time is 0. That is present on the graph, so that will be left alone. The stop time for 1 cylcle is 1 mS as was previously ascertained. So set the stop time to 0.001. Pushing the parse button will line up the data as prescribed and output the parsed data to an output file. The file is created to allow the user to independently process the data. A new graph is plotted using the parsed data and the ‘Analyze’ button on the frequency domain side should have turned to Green.

Note that the start time did not need to be at 0. The most important part is that the difference between the start time and stop time is equal to exactly 1 cycle of the disturbance.

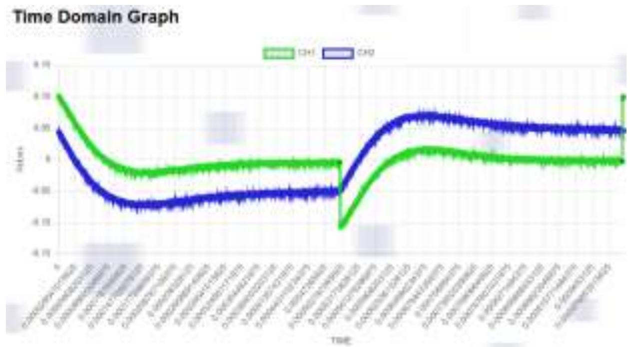

Figure 4-2: Parsed Data Plotted by Application

4.2 Analyze Function

Pushing the ‘Analyze’ button allows the frequency domain analysis to proceed. Once completed, a Frequency domain chart will appear.

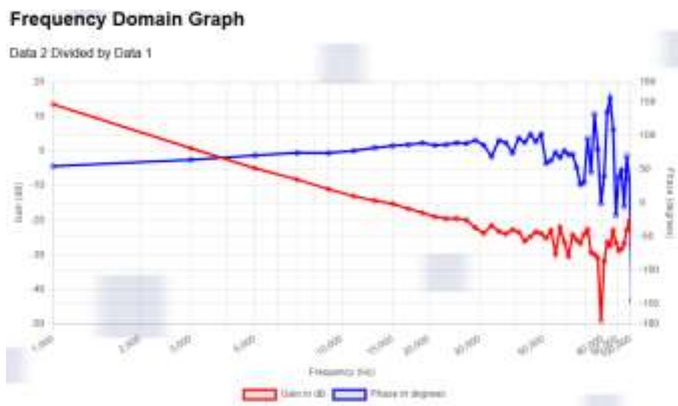

Figure 4-3: Frequency Domain Data Plotted by Application

The chart spans from the excitation frequency to a default setting of 100 times that frequency. The user can change this frequency. A title, Sub title, Y1 axis label and Y1 data label can be changed.

Figure 4-4: Annotated Graph Plotted by Application

4.3 Save and Recall Functions

Update Chart

This button takes the Max frequency variable and the annotation text boxes and places them onto the chart.

Save / Recall Chart Settings

It is recognized that optimizing a control loop can take several iterations. To streamline this process, the application gives the ability to save and recall settings so that the tedious task of repeating or remembering what settings were used is eliminated. The data is saved to a default file name. The user is free to change that file name once it has been saved on the local computer. When the recall button is pressed, the user will be asked to select a file.

Save Chart

This button will create and download an image of the Frequency Domain Graph. The format will be png. The file will have a default name which can be changed once the file is downloaded on the host computer.

Save / Load Chart Data

The chart Data can be saved so that it can be manipulated at a later date. The file will be downloaded to a default filename. The user can rename this file once it is downloaded. The 'Load Chart Data' button allows the user to select a file of any name. The settings and annotations are preserved in the data file and will be restored when the file is loaded. There is no need to save a separate file with the settings.