Electric lab-assistant

Engineering Applications using Matlab

TNG016

ED3:

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Abstract

For engineers, scholars and researchers, Matlab is one of the common tools for calculation and simulation. This report investigates the possibility of using Matlab to connect lab equipment for electronics with a personal computer, and thus streamlining lab work and documentation. The result is a software that clearly shows the possibilities are real, and that with minor further development could be used for actual lab work.

Contents

1 Introduction

The personal computer is at the center of attention for a large portion of our daily lives. In electronics education and research it is used to write code, design and simulate circuits, take measurments and to write about the the results. This project focuses on the borderlands between the latter two; connecting lab equipment and results presentation.

1.1 Background

Doing lab work often includes tedious, repetitive and time-consuming tasks. Some times good solutions are lacking, for example when a large series of values need to be measured at different signal frequencies, or when students are encouraged to take photographs of the oscilloscope screen for presenting in lab reports.

1.2 Purpose

The goal of this project was to investigate weather Matlab could be used to create a common interface to speed up and streamline electronic lab tasks and documentation.

1.3 Method

Matlabs tools for graphical user interfaces were used in conjuction with the GPIB-bus to create software for controling both input and output of an experiment, aswell as exporting the results in various ways.

2 Lab-Assistant

The user interface of Lab-Assistant (Appendix A) is designed to be intuitive and user-friendly. When launched the user is met by three empty columns, each with a popup-menu at the top. The columns are called *input*, *output* and *export*, each with a set of 3-4 different options. Using different combinations of these options, a variety of tasks can be performed.

2.1 Inputs

Lab Assistant supports two types of devices for input; function generators and voltage generators. The function generator can also be used to generate a frequency sweep.

Function Generator

Uses function generator to output a signal. The *waveform* popup-menu sets the signal type to sine, square, triangle or sawtooth. If no waveform is selected the current waveform of the function generator is used. *Frequency*, *amplitude* and *offset* controlls the parameters of the output. In order to establish a connection to the function generator its GPIB-address must be put into the *GPIB-address* field. All options are shown in Figure 1.

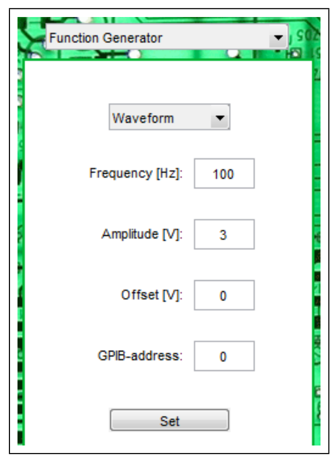


Figure 1: Function Generator settings.

Frequency Sweep

The function generator can also be used to generate a Bode plot of a connected system. When *frequency sweep* is selected as input, output is automatically set to *bode graph* and no other outputs can be chosen. Available settings for the sweep are *start frequency*, *end frequency*, *step length*, *amplitude* and are shown in Figure 2. GPIB-address must allso be filled in as described above.

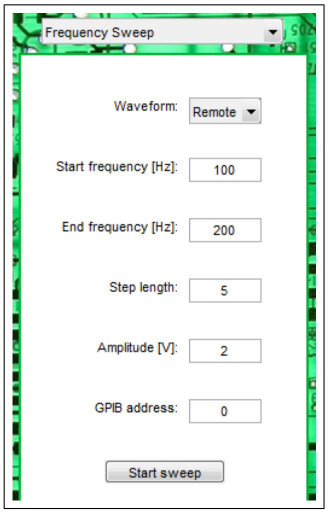


Figure 2: Frequency sweep settings.

Voltage Generator

The other device supported is the voltage generator. Apart from *GPIB-Address* of the voltage generator, the available settings are *voltage* and *current limit*. Output can be toggled with the *output on/off* push-button. These options are shown in Figure 3.

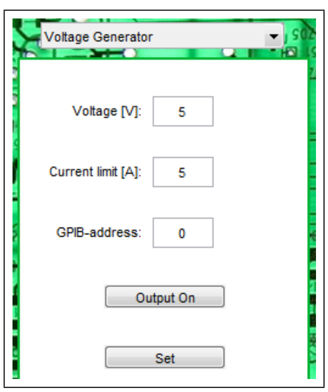


Figure 3: Voltage Generator settings.

2.2 Outputs

Lab-Assistant supports two types of devices for output; oscilloscopes and multimeters. The oscilloscope function can display the measured signal. The multimeter can produce a bodeplot from a frequency sweep or display measured values. Two methods of gathering output data are available

Oscilloscope

The oscilloscope has two functions, *picture* and *measurement* shown in Figure 4. The picture option practicaly takes a copy of the oscilloscope screen and shows it in the panel. The measurement option is used for getting the graph and plot with Matlab without all extra information the oscilloscope shows. The plot is then displayed in the panel. After entering the *GPIB address* for the oscilloscope, the *Start* button will execute the option chosen. (Figure 4)

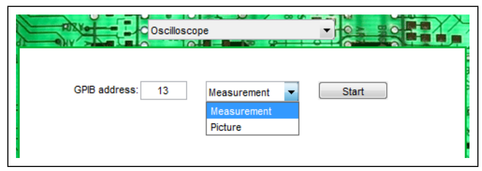


Figure 4: Oscilloscope output settings.

Multimeter

The multimeter function is just a multimeter, that displays the value in the panel as shown in Figure 5. When the *Start* button is hit the multimeter begins uppdating the value in the panel. When the *Stop* button is hit the multimeter stops updating and instead plot all previous values in a stem plot. (Figure 5)

Figure 5: Multimeter output settings.

Bode Graph

When the frequency sweep is chosen in the input panel it automaticaly chose the bode graph in the output pane and shown in Figure 6. The Bode Graph only works with the frequency sweep as the start button is placed in the input panel. The plot is shown in the output panel.

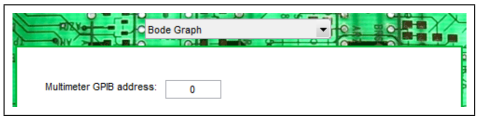


Figure 6: Bode plot output settings.

2.3 Exports

The program has four different choices for exporting the obtained data; copy to clipboard, save as image, create LaTeX report and create Microsoft Word report.

Clipboard

Copies the figure to clipboard. Textboxes enable the user to modify title and axis labels before copying. (Figure 1)

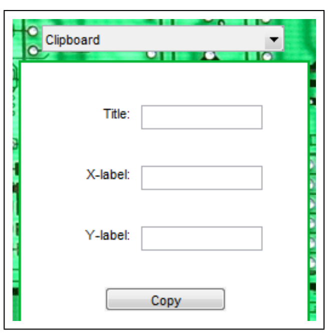


Figure 7: Copy to clipboard export settings.

Image

Saves the image to disk. Textboxes enable the user to modify title and axis labels before copying. (Figure 8)

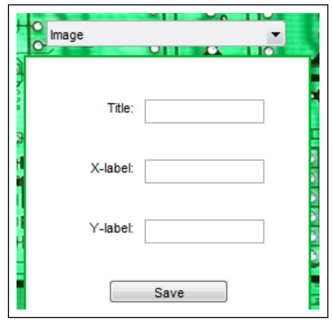


Figure 8: Image export settings.

LaTeX

Generates LaTeX report (Appendix B) containing the figure. *Image name* textbox enables user to choose file name and format for the figure, which will be saved at the same location as the tex-file. *Caption*, *label* and *width* properties are transferred to corresponding LaTeX commands, while tite and labels are applied directly to the figure before exporting. (Figure 1)

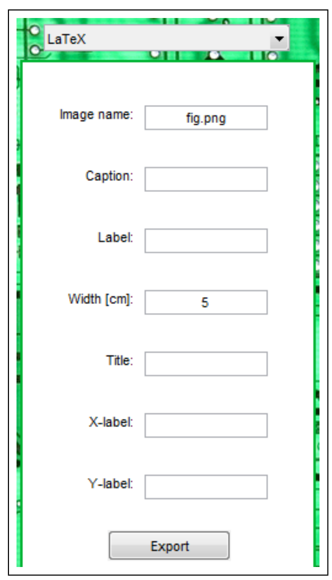


Figure 9: LaTeX export settings.

Word

Generates Microsoft Word report containing the figure. *Title*, *x-label* and *y-label* overrides the settings of the figure and the caption is inserted on a centred line below. (Figure 10)

Figure 10: Word export settings.

Workspace

The measurment data can be saved to a .mat-file. This export option has no settings other than save-location.

3 Lab demonstration

To demonstrate the functionality of the program an easy lab-assignment was performed. A RC-circuit was connected like figure 11, the circuit is a low-pass filter with the cutoff frequency at $f = 1.5\ kHz$.

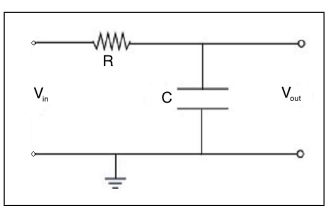


Figure 11: RC-circuit

Start with connecting the oscilloscope, multimeter, function- and voltage generator to the computer using the GIPB-port. Check that every device has a different GPIB-address to be sure that all will work.

3.1 Assignment 1

The first assignment is about looking at the difference between the in- and out-signal. Set the function generator frequency to 1 kHz and the amplitude to 3 V. Also add the GIPB-address of the function generator and the oscilloscope. Click *Set* at the bottom of the function generator panel and select *oscilloscope picture* in the popup-menu at the out panel. Next, add the GPIB-address to the oscilloscope and click start to get a picture from the oscilloscope. Figure 12 shows a picture from the oscilloscope with the settings mentioned above.

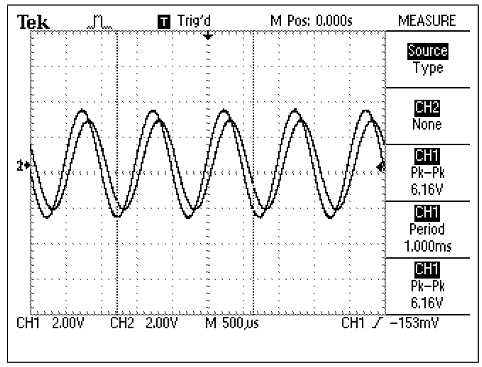


Figure 12: Oscilloscope picture.

Now use the export function to put the figure in a report by selecting the *LaTeX* alternate in export popup-menu. It will be possible to change the title and figure labels by typing the wanted label name in the *X-Label* and *Y-Label* text boxes. The figure title is changed by typing in the *Title* text box. The LaTeX figure caption and reference label can be set by typing in the *Label* and *Caption* text boxes. Finally, type a figure name and click *export* and chose a location for the files to be saved.

3.2 Assignment 2

Connect the multimeter to measure the voltage over the resistor. Change the output panel to multimeter, select the *Voltage [AC]* in the measuring popup-menu, add the GPIB-address for the multimeter and press start button. The multimeter will be displayed in the black text box in the output panel. By clicking the *Stop*-button multimeter will stop and the data can be saved to a .mat file or present in a stem-graph by exporting the figure. The generated stem-graph is presented in Figure 13.

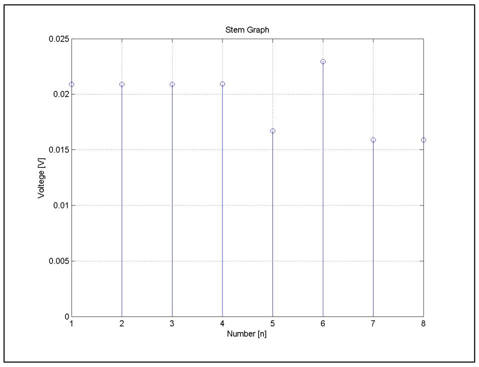


Figure 13: Stem graph from multimeter measurment

3.3 Assignment 3

Move the multimeter probes to measure the output voltage and change to *frequency sweep* in the input popup-menu and set the start- and end frequency to 0 Hz and 3000 Hz and the step length to 100 Hz use *Sine* as waveform with an amplitude 3 V and click *Start sweep*. This will take some time.

The generated bode graph figure 14 can be exported to a Word-document in the same way as the LaTeX export, the generated frequency and voltage can also be saved for other use in Matlabs workspace.

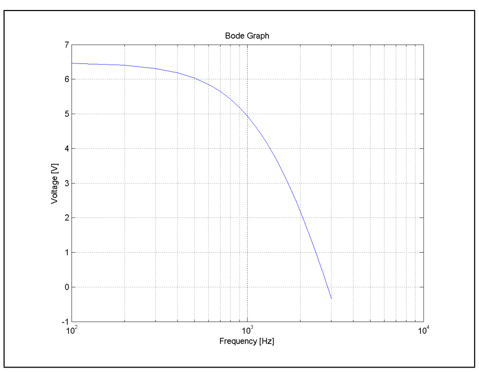


Figure 14: Bode graph

4 Conclusion

The Lab-Assistant is easy to use, but it would be possible to make it even more user friendly by making more intelligent dialogues for connecting the GPIB-devices, enabling models from other vendors etcetera. Overall, more of the device functionalities can be brought into the software, focus during the project has been diversity rather than depth on this part.

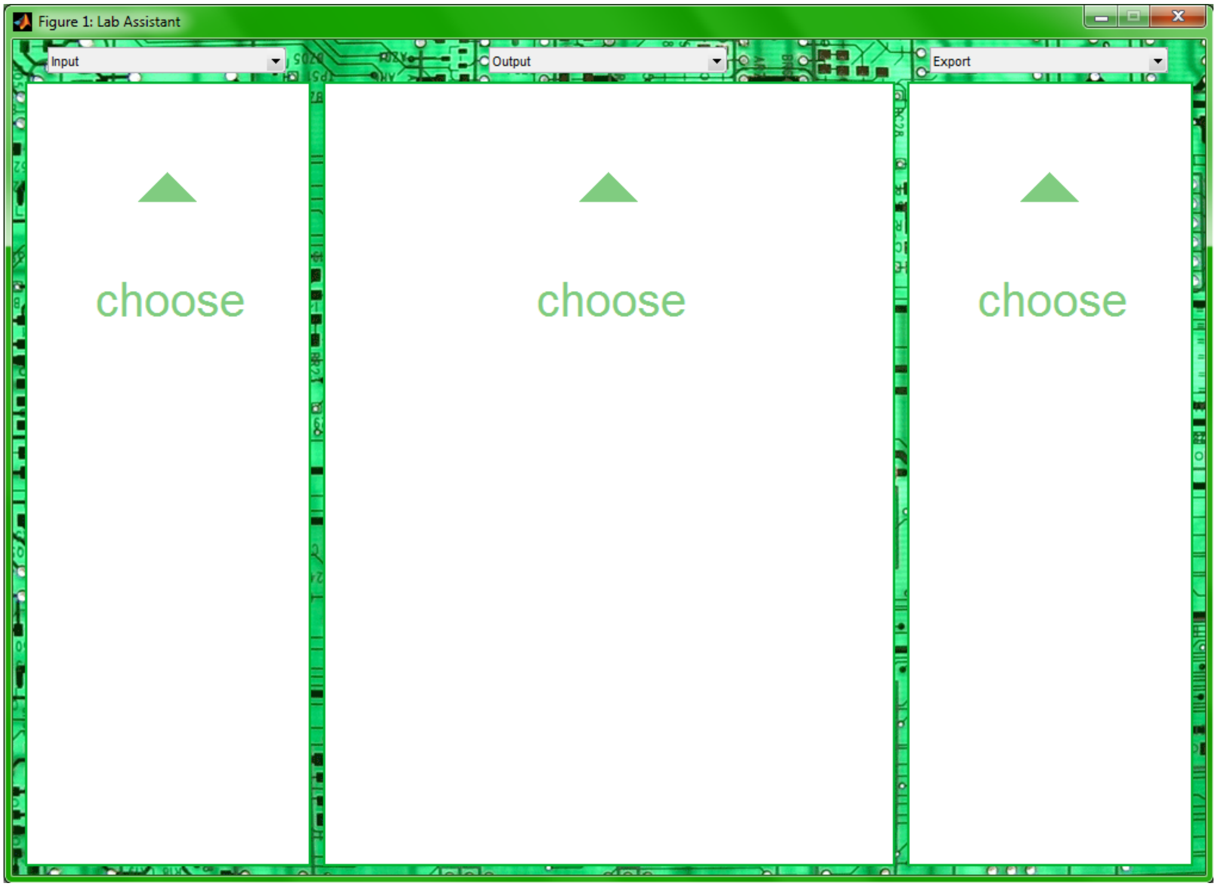
The program can always be improved with more functions and calculations. For example Matlab offers a lot of ways to modify colors, line types and other features of the obtained figure. Another way to go is adding different types of input methods beside GPIB, like serial or USB.

Another future application is to implement the oscilloscope function TRIGger together with voltage generator. This would make it easy to generate a step-signal and to obtain a step-response of the system, by importing the graph from the oscilloscope to Matlab. The Matlab toolbox Transfer Function can be used to identify the system and the different parameters for example the capacitance and the resistance. The transfer function can also be exported to Simulink to make more simulations of the measured system but also to simulate the real system and compare it wtih the measurements.

An interesting issue is the matter of special cases such as the Bode plot generator, where one choice of the input reduces the number of available outputs to just one. How should this be solved in the user interface? Should the function generator pane have multiple modes, or should each mode have a different name in the input selection menu? The latter was chosen to highlight the dilemma and show a way to solve it; when the user chooses to perform a frequency sweep, Bode plot becomes the only output option available (for the sake of this argument, of course functionality could be developed for other output modes as well).

It is indeed possible, as proven by the Lab-Assistant software, to make lab work more efficient by utilizing the power of Matlab to create a general user interface for commonly used equipment. Connecting control over multiple instruments with direct export of the results can definitely be done effectively on a PC.

A User Interface



B Sample LaTeX output

```
\documentclass{article}
\begin{document}
\begin{figure}
\centering
\includegraphics[width=5cm]{fig_name.png}
\caption{Figure caption.}
\label{figure label}
\end{figure}
\end{document}
```