DC MOTOR EXPERIMENT

User's Guide

1   Installation Instructions

1.1   Disclaimer

Be aware that the Institute of Control Systems is not responsible if you or someone else who uses this experimental setup receives injuries while conducting the experiments. Furthermore, the Institute of Control Systems will not make up for any damage inflicted by this experimental setup to your computer. Use the DC motor experiment at your own risk.

1.2   Installation on your Personal Computer

The DC motor experiment requires a working MATLAB installation (version 2019a or higher). The motor's controller is based on the Arduino Due board and requires the Arduino drivers to operate. **Please perform any installation from an administrator account.**

Installing MATLAB

To install MATLAB click <u>here</u> and proceed as follows:

1) Register for the *Student Option TAH License* for MATLAB,

2) An email with a download link that works from inside the TUHH VPN will be sent to you,

3) Download and unpack the files (e.g. to a folder called 'Matlab').

4) Run the setup of MATLAB.

The MATLAB installation will automatically match your operating system with regards to 32-Bit or 64-Bit.

Note: This experimental setup has been tested only for Windows PCs using Windows 7, Windows 8 and Windows 10.

Installing the Arduino Due Drivers

Newer versions of Windows recognize and install the Arduino Due drivers automatically. Connect the motor to the computer using the USB cable and wait until Windows completes the installation. In case Windows fails to automatically install the drivers, please follow the instructions <u>here</u>.

To make sure the drivers were installed properly, go to the Windows control panel and look for the Arduino Due under 'Devices and Printers' (while the motor is connected to the computer). A proper installation will show as in Figure 1.
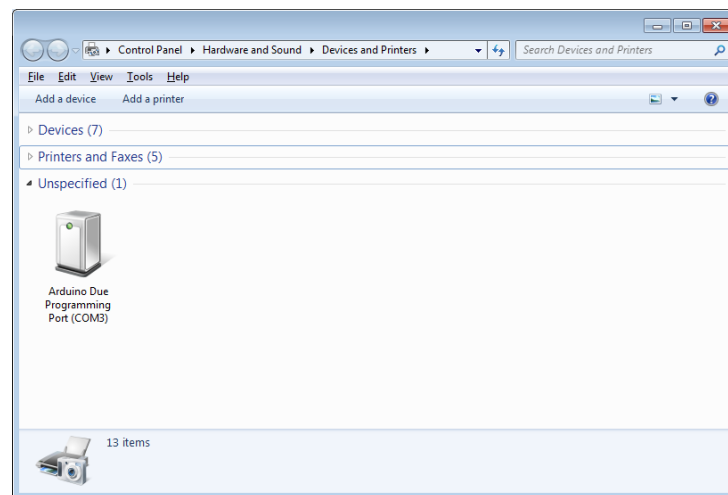

Figure 1: Windows control panel showing a proper Arduino Due installation. In this case with COM port number 3. Also the Device Manager provides this information.

1.3 Installation in the Computer Pools

The DC motor experiment can also be conducted in the university's computer pools (only Windows pools). The software is already pre-installed. In case MATLAB is not already configured in your account (check by searching for MATLAB in the start menu), configure it using the following steps:

- Open the shortcut '*My Applications*' on the desktop.

- Add the item '*Matlab*'.

You can now connect the DC motor to the USB port of the computer, start MATLAB and run the experiments.

2 SIMULINK Experiments

SIMULINK is a commercial tool for modeling, simulating and analyzing dynamic systems. It is widely used in control theory and digital signal processing.

The DC motor suitcase experiment makes extensive use of the features of SIMULINK frequently encountered in fundamental control theory. Therefore a short introduction to SIMULINK and how it can be used to conduct experiments on the DC motor will be given here.

- Start MATLAB.

- Change the current directory to the folder into which you copied the MATLAB/SIMULINK files from GitLab.

- Make a right-click on the copied folder an choose the option 'Add to Path → Selected Folders and Subfolders'

- Double-click on the folder to open it.

You should see the following files and folders inside the 'Current Directory' window:

- **'Chapter 1'** to **'Chapter 5'** are folders which contain Matlab and Simulink files you need for the different execises.

- **'MotorLib.slx'** is a SIMULINK file containing the motor block. The motor block can be dragged into new SIMULINK models to communicate with the motor.

- **'test_openloop.mdl'** is a SIMULINK file for testing the connection with the motor.

- **'Motor'** is a directory containing files needed for communication with the motor. Running experiments does not require direct interaction with these files.

Please note the following hints before running an experiment:

- You will always have to use the DC motor block. Communication with the motor is otherwise not possible.

- You will have to enter all parameters in the mask:

    - By double-clicking on the block called 'Motor' a window should appear where you can change certain parameters concerning the DC motor (see Figure 2).
    - The COM port number given to the motor can be found in the Windows control panel under 'Devices and Printers' – see Figure 1. Note that the COM port number might change when disconnecting and reconnecting the motor to the computer.
    - The sampling time should be 10 ms for almost all experiments and should only be changed if noted differently. Although it is possible to choose a smaller sampling time, doing so will most likely cause a simulation time slower than the real time!

- The motor block has one input (voltage) and two outputs. The first output is the electric current. The second output can be the (angular) velocity or the angle. Please set the second output according to the task at hand.

- When using the motor's angle output, please turn the motor (by hand) twice in each direction directly after connecting it to the computer. Failing to do so might result in inaccurate results.

- For every new SIMULINK model you will have to change the simulation parameters: Go to 'Simulation' and then to 'Configuration Parameters' and change 'Type:' to 'Fixed-Step' and 'Solver:' to 'discrete(no continuous states)'. The sampling time does not change during an experiment and only discrete data are acquired from the DC motor.

- Do not use the 'Desktop Real-Time' mode but the standard 'Simulation' mode. You can switch between these two modes in the top bar.
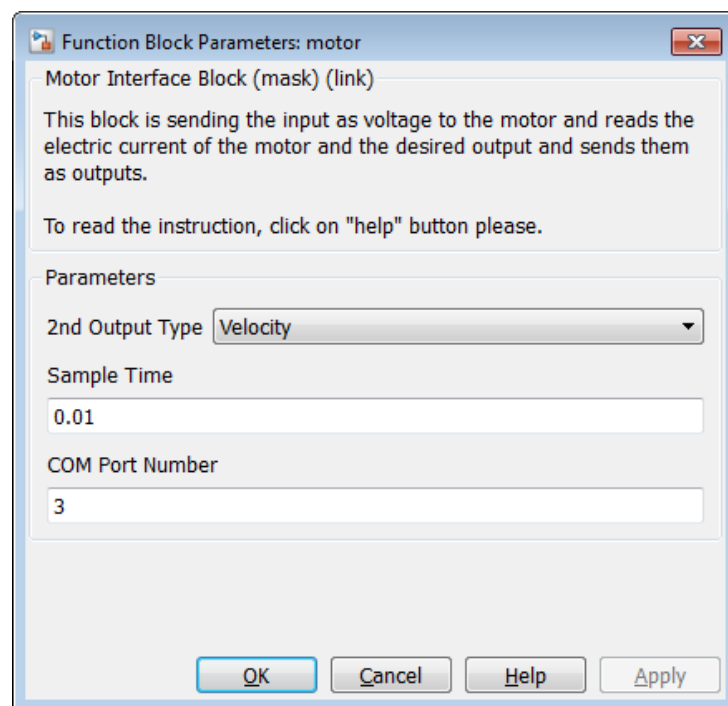

Figure 2: Function Block Parameters of the 'DC Motor'.

2.1   Troubleshooting

Below follows a list of frequently asked questions and solutions. If you are having problems with the DC motor, please contact us. Provide a concise and accurate explanation of the problem you are encountering and, if possible, send us the SIMULINK model you were using.

1) **Q.:** Sometimes my experiments do not run until the specified final time. After that MAT-LAB/SIMULINK is not responding to any mouse button.

   A.: Disconnect and reconnect the USB cable from the motor. On some systems there seems to be a communication problem via USB. Try to rerun the experiment and set the experiment time to a final time which is sufficiently long, but not longer.

2) **Q.:** MATLAB tells me it cannot find a certain variable, when I try to run one of your template SIMULINK models.

A.: Almost all templates already include some kind of parameterized controller, say e.g. a P controller. The controller's gain K_P is entered as a variable in the gain block and needs to be specified in MATLAB's workspace. Just go to the command window and type `Kp = 0.5`. You have now tuned your P controller to have a proportional gain $K_P = 0.5$. If you are trying to run a more complex template, you will have to specify several controller parameters.

3) **Q.:** MATLAB tells me it cannot find a certain file used in the SIMULINK model.

   A.: Make sure, that the current working directory of MATLAB is properly set to the directory containing all the relevant motor files listed above.