

Automated MATLAB Matrix Switcher and Accompanying Hardware

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April 25, 2020

1 Design Overview

1.1 Design Features

The purpose of the matrix switching device is to serve as an automated multiplexer that can switch between multiple sources that each contain four wired connections. The associated software allows the user to specify the time delays between switching events and the address number of the switching device. The program is written in MATLAB and uses the MATLAB Instrument Control Toolbox to send SCPI commands to a switching device through a GPIB cable. The program is also designed to account for code execution time. This prevents delay associated with code execution from interfering with switching times.

1.2 Design Resources

The source code contains one main MATLAB script and two MATLAB functions:

- `matrix_switcher.m`
- `set_relay.m`
- `switching_loop.m`

The `matrix_switcher.m` file serves as the top-level MATLAB file. Running this file will begin and the execution of the program. The only two user-defined parameters are found in this file: `address` and `wait_time`.

The source code can be found at:

https://github.com/sheppard1/matrix_switcher

1.3 Block Diagram

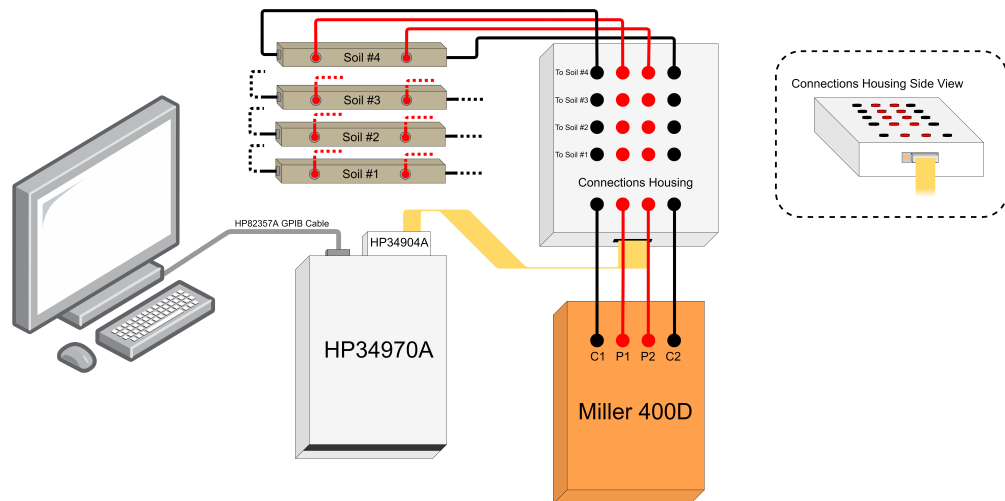


Figure 1: Block Diagram of the Full System

1.4 Devices

- HP34970A Switching Device
- HP34904A Relay Card
- HP82357A GPIB Cable
- Miller 400D Resistivity Meter
- Miller 400D Soil Tubes
- Custom-Made Connection Housing
- Software: MATLAB with Instrument Control Toolbox
- Software: Keysight IO Libraries Suite

Note: The 34970A, 34904A and 82357A devices of any branding can be used (HP, Agilent, Keysight). For the purposes of this documentation, they will be referred to by the HP name.

2 Getting Started/How to use the device

First, ensure that both MATLAB and the Keysight IO Libraries Suite are installed on the PC that will be controlling the matrix switcher. When installing MATLAB, be sure to include the Instrument Control Toolbox. If the PC already has an installation of MATLAB without the Instrument Control Toolbox, simply rerun the MATLAB installer and choose the Instrument Control Toolbox from the list of available toolboxes. This will install the toolbox in the current installation of MATLAB.

Following this, connect the GPIB cable to both the HP34970A and the PC and launch the Keysight Connection Expert (this was installed as part of the Keysight IO Libraries Suite). Be sure that the HP34970A is plugged in and powered on. When this connection is made, the HP34970A should be listed on the left pane of the Connection Expert window under “My Instruments.” If it is not listed, you may need to click the refresh button near the top left of the window. Click on the icon of the HP34970A in this pane. You will see some information in the form of “GPIB0::XX::INSTR” where “XX” is the address number. Take note of this value. If you have not already done so, connect the rest of the hardware as outlined in the diagram in Fig. 1.

Next, open MATLAB and navigate to the directory containing the three MATLAB files previously listed. Open the `matrix_switcher.m` file and go to the line where the address number is defined (this should be one of the first lines of code). Ensure that the address number defined in the code matches the previously noted value. If not, change the number in the code. (As an alternative, you could see and change the address on the HP34970A itself using the following button combination: Shift > Sto/Rcl > Sto/Rcl. Pressing Sto/Rcl again exits back to the home screen). Following this, set the `wait_time` variable in the code to the desired value. This value corresponds to the number of seconds that each soil tube is active. For example, if the value is set to 15, then the matrix switcher will change tubes every 15 seconds. At this point, the program is ready to run.

When running the program, the matrix switcher will switch the soil tubes on in the order listed in Fig. 1 (Soil #1, Soil #2, Soil #3, Soil #4). Only one soil tube will be electrically connected at a time. Once Soil #4 finished, the process will loop back to Soil #1 and start over. During the process, the MATLAB code will create a log file called `soil_log.txt` in the same directory as the switching code. If a log file already exists, the new data will be appended to the existing file. The log file records the time and soil box number every time a switching event happens. This can be referenced to ensure that measurements recorded by the Miller 400D are properly matched with their respective soil samples. An example of a log file's contents is shown in the *Appendix* where the `wait_time` is set to 1. The program can be stopped by entering “ctrl c” in the MATLAB command line.

Note: The software is designed such that code execution time is accounted for. This is accomplished by recording the time at which the process is started and determining switching times in reference to that absolute start time.

3 Back-End Details

The HP34904A relay card turns the various switching tubes on and off using relays. Each relay has two wires passing through it. The card has 32 relays. This application of the relay card uses eight of the relays: two relays per soil box. The relays and their corresponding soil boxes are given below.

Soil Box	Relays Used
1	211 and 222
2	213 and 224
3	215 and 226
4	217 and 228

4 Appendix

4.1 Sample soil.log.txt File Contents

```
Began Switching at 2020-02-13 03:01:48
2020-02-13 03:01:48 Reading Soil Box #1
2020-02-13 03:01:49 Reading Soil Box #2
2020-02-13 03:01:50 Reading Soil Box #3
2020-02-13 03:01:51 Reading Soil Box #4
2020-02-13 03:01:52 Reading Soil Box #1
2020-02-13 03:01:53 Reading Soil Box #2
2020-02-13 03:01:54 Reading Soil Box #3
2020-02-13 03:01:55 Reading Soil Box #4
2020-02-13 03:01:56 Reading Soil Box #1
2020-02-13 03:01:57 Reading Soil Box #2
2020-02-13 03:01:58 Reading Soil Box #3
Program Terminated at 2020-02-13 03:01:59
Elapsed Time: 10.328 seconds
```