**System Testing Station:**

Description:

This product will be able to monitor communication protocols and provide a visual display. In addition, this system will have the ability to decode common communication protocols. In addition, this product with offer the basic functionality of a waveform generator and oscilloscope. As this system will be centered around a raspberry pi, the functionality of these features will be limited in comparison to modern equipment but the price comparison is substantially in favor of this system. All of this functionality will be available from desktop icons on the raspberry pi.

Equipment:

1. Raspberry Pi (Preferably a Pi 3)
2. 24MHz 8 Channel USB Logic Analyzer (Ex. <https://www.amazon.com/gp/product/B06Y2TTFR1/ref=oh_aui_detailpage_o00_s00?ie=UTF8&psc=1>)
3. DAQC2 Pi-Plate (<http://pi-plates.com/daqc2r1/>)
4. Common UI devices (keyboard, mouse, monitor)
5. Logic Probes (Ex. <https://www.amazon.com/gp/product/B00NHG8Q5U/ref=oh_aui_detailpage_o00_s00?ie=UTF8&psc=1>)
6. Male to Male Jumper Wires

System Setup:

1. Raspberry Pi Setup:
   1. Make sure your Raspberry Pi is running Debian Jessie (or the most recent version)
      1. If it is not download the image from here (<https://www.raspberrypi.org/downloads/raspbian/>)
      2. You will need to etch this image to an SD card. This tool makes this process extremely simple (<https://etcher.io/>)
      3. Once the Image has been loaded insert the SD card.
      4. Update the OS
         1. sudo apt-get update
         2. sudo apt-get upgrade (if any packages are noted as left out run sudo apt-get dist-upgrade)
   2. Make sure python2.7 and python3 have been installed.
      1. Run python in the terminal and note the version
      2. Then run python3 in the terminal and note the version
   3. Enable SPI Communication:
      1. Go to the start menu
      2. Click Preferences
      3. Click Raspberry Pi Configuration
      4. Navigate to the Interfaces Tab
      5. Enable SPI and click OK
2. Install Supporting Software:
   1. To install the SW and examples for the Pi-Plate follow the directions below:
      1. Open a Linux Terminal
      2. Navigate to your home directory
      3. sudo pip install Pi-Plates
      4. sudo pip3 install Pi-Plates
      5. sudo apt-get install python3-pyqt4
      6. sudo wget https:/piplates.com/downloads/DAQC2apps.tar.gz
      7. tar -xzvf DAWC2apps.tar.gz
      8. rm DAQC2apps.tar.gz
      9. To confirm proper installation:
         1. Run: sudo python3
         2. import piplates.DAQC2plate as DAQC2
         3. print(DAQC2.getID(0))
         4. #A valid response is “Pi-Plate DAQC2plate”
   2. To install and setup the Logic Analyzer software remain in the home dir and enter:
      1. sudo apt-get sigrok
      2. Connect your USB logic analyzer to the Raspberry Pi.
      3. Open a Linux Terminal and enter pulseview
      4. Click File
      5. Click Connect to Device
      6. Select a drive and click Scan for Devices. Continue this process till you discover your device. Then click OK

Signal Module Use:

1. Function Generator:
   1. Before running the software, you must connect jumper wires to the correct pins on the pi-plate. The function generator makes use of pins AOUT0 and AOUT1 as channel 1 and two respectively. Two GND terminals can be found on this same row of headers which can be used during signal generation. For more help consult the pi-plate manual @ (<http://pi-plates.com/daqc2-users-guide/>)
   2. To start this module, you can navigate to the pi-plate applications folder or click on the desktop icon.
   3. From here on out refer to either the user manual mentioned above or the directions included in the applications folder.
2. Oscilloscope:
   1. As with the function generator, before using the o-scope you should attached the needed jumper wires. The o-scope makes use of AIN0 and AIN4 as channel 1 and channel 2 respectively. Terminal 9 of this row will be used as the o-scope’s reference GND. The user manual can be consulted for further direction (<http://pi-plates.com/daqc2-users-guide/>)
   2. Once the correct wires have been attached you can start the oscilloscope from the applications folder or by using the desktop icon.
   3. The SW’s functionality is very similar to that of most standard o-scopes. For in-depth operation instructions navigate to the oscilloscopes operation instruction manual contained within the applications folder.
3. Logic Analyzer:
   1. Before running the logic analyzer, make sure you have attached the logic probes to the USB device and have the USB device plugged into the Raspberry Pi.
   2. To run the logic analyzer, you can open a Linux terminal and enter pulseview
   3. Once the GUI has opened select your device with the drop-down menu next to the red dart.
   4. Once your device has been selected you can enable/disable the probes you want be clicking on the red dart.
   5. If you would like the SW to interpret the communication protocol you are monitoring you can add a decoder by navigating to the menu bar, clicking Decoders, selecting Add, then choosing which protocol to decode.
   6. If a decoder is selected a new “probe” will appear on the screen. You must click on its title and set it up to use the correct pins.
   7. NOTE: Decoders can be stacked if their functionality builds off each other. This is done by clicking on the currently active decoder and selecting Stack Decoder.
   8. To run a scan select you sample rate and the number of samples to be taken.
   9. NOTE: Make sure you stay within the sampling rate limitations of your logic analyzer.
   10. NOTE: Because of the limitations of the Raspberry Pi, it would be wise to keep your samples at 500M or less or you risk crashing the software.

System Limitations:

1. Function Generator:
   1. Square wave rounding even at low frequencies but high and low levels are still discernable.
   2. Highest attainable frequency for any waveform is 10kHz.
   3. Max Voltage is approximately 4 volts.
   4. 12 bit resolution
2. Oscilloscope:
   1. Input range: +/- 10V
   2. Input Bandwidth: 100kHz
   3. Sampling rate (1 channel): 1M samples/sec
   4. Sampling rate (2 channel): 500,000 samples/sec
   5. 12 bit resolution
3. Logic Analyzer:
   1. 8 channels
   2. 24MHz sampling Frequency
   3. 500M sample limit on Raspberry Pi (during testing)

Future Work:

If the project is deemed worthy of further development the following options should be considered to make the system user friendly and portable.

1. A case or board designed to hold all components in place. This will eliminate the sliding of the Raspberry Pi as probe connections are made.
2. PCBs: Given the resources a PCB could be designed to hold BNC female connectors such that standard oscilloscope probes and function generator clips could be connected to the system. This PCB would be directly connected to the Pi-Plate, thus reducing error in wire connections on the Pi-Plates terminals. In addition, this PCB layout could include a row of header pins for easy connection of any set of logic probes. As with the o-scope and function generator, the logic analyzer would be directly connected to the PCB making wiring issues less prevalent.
3. If a Higher Current is Desired: If the system is desired to produce greater currents and external power supply could be connected to the system and by extension the Pi-Plate. The regulation of this power supply could be done in the wall transformer itself (if the desired V and I is known during purchase) or a section can be added to the PCB mentioned above to handle this issue.
4. System Dedicated Monitor: To keep the system isolated a dedicated display could be added to the system and connected “permanently” to the Raspberry Pi.
5. System Dedicated User Input: To keep the system isolated a dedicated keyboard and mouse could be attached to the system. Preferably a Bluetooth combination of the two.