

Using Raspberry Pi to Control Your Oscilloscope

APPLICATION NOTE



Introduction

Raspberry Pi is a single-board small computer originally used as a tool to teach computer science to students. It has since grown in popularity due its compact size, low cost, modularity and open design. Each revision has added more capability to the original Raspberry Pi, and the computer is now widely used in applications beyond education.

Because of its limited computing power, the Raspberry Pi will not replace the regular PC in many areas. However, with its compact size, flexible I/O interfaces, low cost and built-in support for Python, it is an ideal platform to automate a lab test bench or a manufacturing test rack to control the instruments, capture waveform data and measurement results, and act as a hub to manage data from the instruments or remote access of the instruments.

This application note shows how to quickly set up a Raspberry Pi to automate a Tektronix 2 Series MSO Mixed Signal Oscilloscope and configure the instrument to control it remotely. You can also watch how to configure the setup in [this video](#).

Setting up a Raspberry Pi

The setup for a Raspberry Pi as the controller PC for the lab bench is simple.

Basic requirement and setup:

- Raspberry Pi 4 with Raspberry Pi OS (formerly Raspbian)
- Python 3.7 or above
- PyUSB 1.2.1
- PyVISA 1.11.3
- PyVISA-py 0.5.2

The communication support between the oscilloscope and the Raspberry Pi is based on pyVISA.

Before starting the setup, make sure that the Raspberry Pi's software components are up to date. If they are not current, connect the Raspberry Pi to the network for the software updates.



Figure 1: A quick setup for the Tektronix 2 Series MSO Mixed Signal Oscilloscope and a Raspberry Pi.

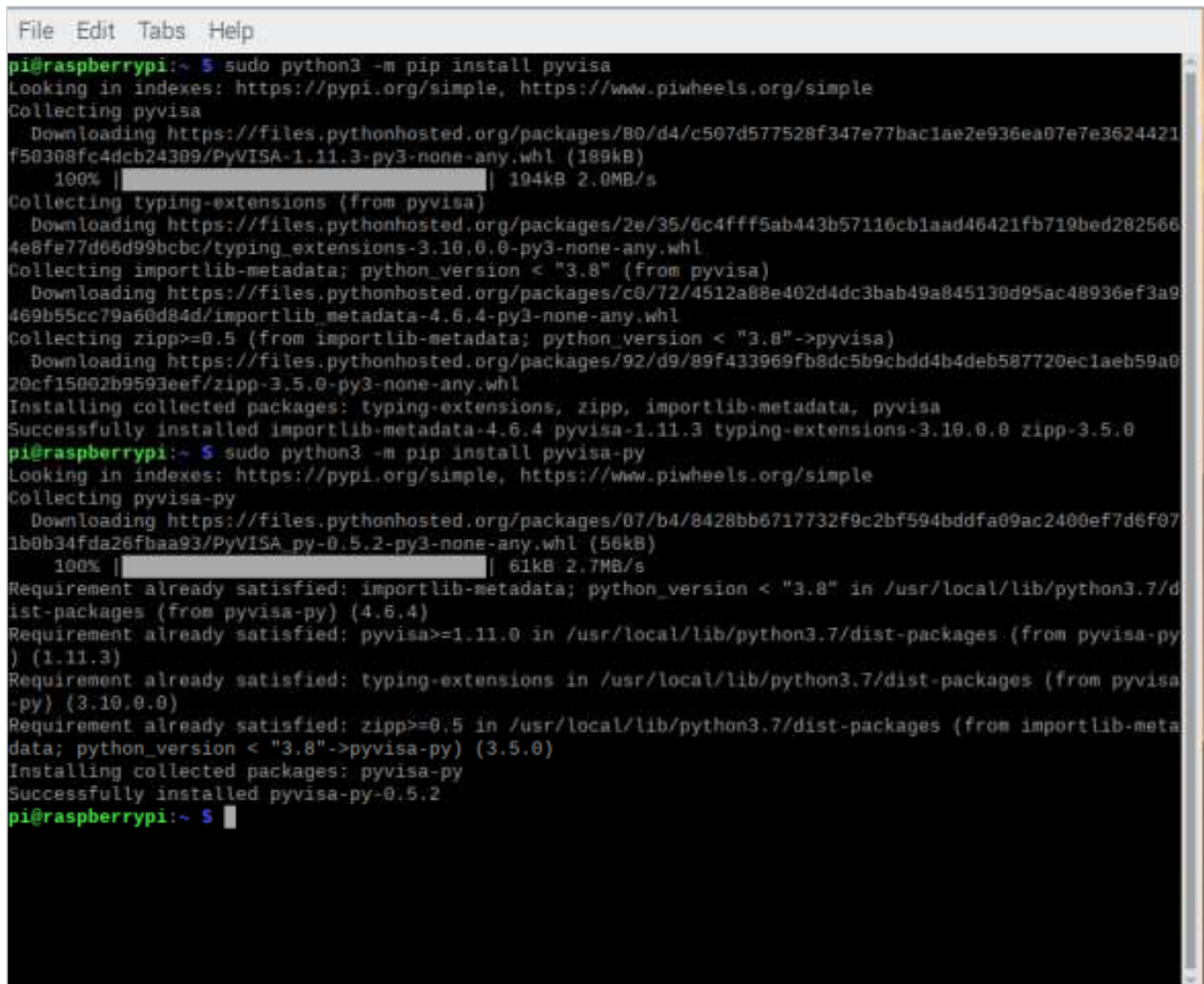
From the command prompt, enter

```
sudo apt update && sudo apt upgrade -y
```

The update may take a few minutes or more, depending on when the system was last updated.

A few Python 3.x modules will be needed for setup. To install all the required modules, from the command prompt, enter the following commands for the update:

- `sudo python3 -m pip install pyvisa`
- `sudo python3 -m pip install pyvisa-py`
- `sudo python3 -m pip install PyUSB`



```
File Edit Tabs Help
pi@raspberrypi:~ $ sudo python3 -m pip install pyvisa
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting pyvisa
  Downloading https://files.pythonhosted.org/packages/80/d4/c507d577528f347e77bac1ae2e936ea07e7e3624421f50308fc4dcb24309/PyVISA-1.11.3-py3-none-any.whl (189kB)
    100% |#####| 104kB 2.0MB/s
Collecting typing-extensions (from pyvisa)
  Downloading https://files.pythonhosted.org/packages/2e/35/6c4fff5ab443b57116cb1aad46421fb719bed2825664e8fe77d66d99bcbcb/typing_extensions-3.10.0-py3-none-any.whl
Collecting importlib-metadata; python_version < "3.8" (from pyvisa)
  Downloading https://files.pythonhosted.org/packages/c0/72/4512a88e402d4dc3bab49a845130d95ac48936ef3a9469b55cc79a60d84d/importlib_metadata-4.6.4-py3-none-any.whl
Collecting zipp>=0.5 (from importlib-metadata; python_version < "3.8"->pyvisa)
  Downloading https://files.pythonhosted.org/packages/92/d9/89f433969fb8dc5b9cbdd4b4deb587720ec1aeb59a020cf15002b9593eef/zipp-3.5.0-py3-none-any.whl
Installing collected packages: typing-extensions, zipp, importlib-metadata, pyvisa
Successfully installed importlib-metadata-4.6.4 pyvisa-1.11.3 typing-extensions-3.10.0 zipp-3.5.0
pi@raspberrypi:~ $ sudo python3 -m pip install pyvisa-py
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting pyvisa-py
  Downloading https://files.pythonhosted.org/packages/07/b4/8428bb6717732f9c2bf594bddfa09ac2400ef7d6f071b0b34fda26fbaa93/PyVISA_py-0.5.2-py3-none-any.whl (56kB)
    100% |#####| 61kB 2.7MB/s
Requirement already satisfied: importlib-metadata; python_version < "3.8" in /usr/local/lib/python3.7/dist-packages (from pyvisa-py) (4.6.4)
Requirement already satisfied: pyvisa>=1.11.0 in /usr/local/lib/python3.7/dist-packages (from pyvisa-py) (1.11.3)
Requirement already satisfied: typing-extensions in /usr/local/lib/python3.7/dist-packages (from pyvisa-py) (3.10.0)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from importlib-metadata; python_version < "3.8"->pyvisa-py) (3.5.0)
Installing collected packages: pyvisa-py
Successfully installed pyvisa-py-0.5.2
pi@raspberrypi:~ $
```

Figure 2: Required Python 3 modules for instrument control.

In some cases, a Raspberry Pi will only allow the root user to access the USB devices. To ensure that all users have access, modify the rule in the Raspberry Pi.

From the command prompt, enter

- `sudo su`
- `echo 'SUBSYSTEM=="usb", MODE="0666", GROUP="usbusers"' >> /etc/udev/rules.d/99-com.rules`
- `exit`

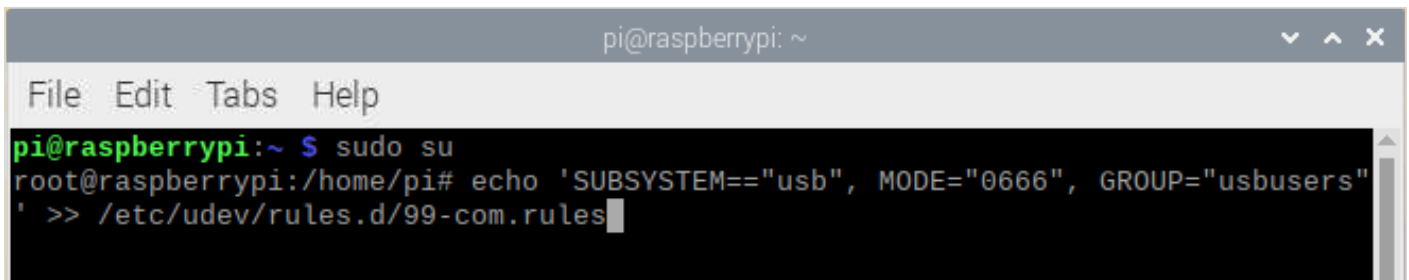
A terminal window titled 'pi@raspberrypi: ~' with a menu bar (File, Edit, Tabs, Help). The terminal shows the command 'sudo su' being executed, followed by a root prompt 'root@raspberrypi:/home/pi#'. The root user then enters the command 'echo 'SUBSYSTEM=="usb", MODE="0666", GROUP="usbusers"' >> /etc/udev/rules.d/99-com.rules'.

Figure 3: Modify the rule to allow all users to access the USB devices.

To commit the changes, restart the Raspberry Pi. From the command prompt, enter

- `sudo reboot`

Setting up the connection with a Tektronix 2 Series MSO Mixed Signal Oscilloscope

Most entry-level oscilloscopes come with the USB device port for connectivity. To connect a Raspberry Pi with a 2 Series MSO

- Connect the USB device port on the right side of the instrument to the Raspberry Pi.
- Check if the Raspberry Pi is able to detect the 2 Series MSO. From the command prompt, enter
 - `lsusb`

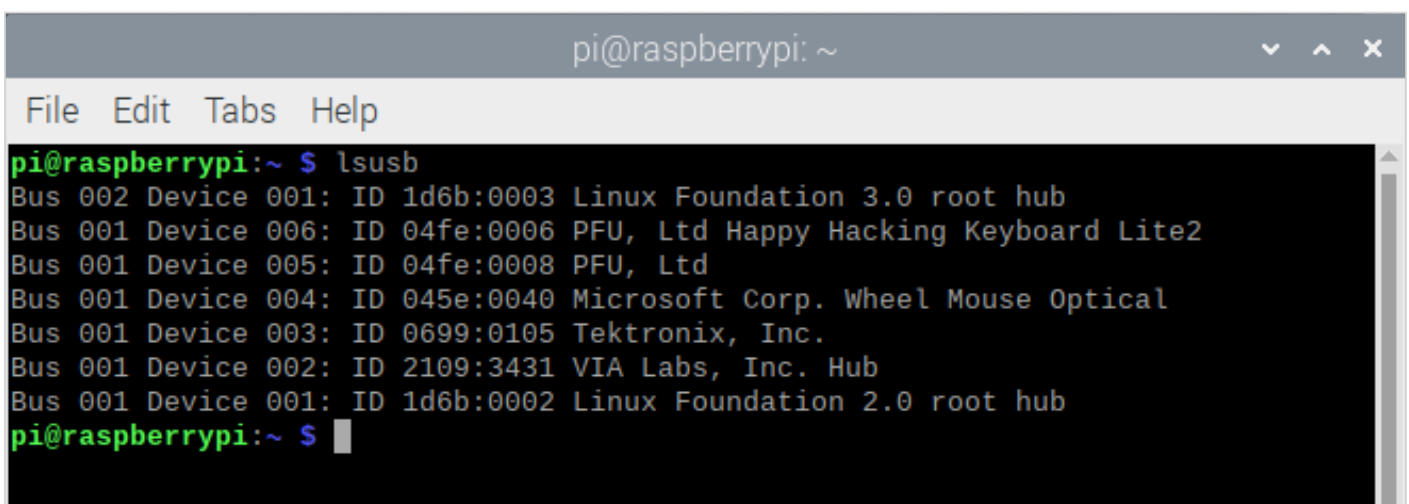
A terminal window titled 'pi@raspberrypi: ~' with a menu bar (File, Edit, Tabs, Help). The terminal shows the command 'lsusb' being executed. The output lists several USB devices, including 'Linux Foundation 3.0 root hub', 'PFU, Ltd Happy Hacking Keyboard Lite2', 'PFU, Ltd', 'Microsoft Corp. Wheel Mouse Optical', 'Tektronix, Inc.', 'VIA Labs, Inc. Hub', and 'Linux Foundation 2.0 root hub'.

Figure 4: "Tektronix, Inc." is listed as one of the vendors of the attached USB devices.

The "Tektronix, Inc." device refers to the oscilloscope. If the Raspberry Pi does not detect the Tektronix device, repeat the steps above with a different USB port or cable.

To validate that the Raspberry Pi can communicate with the oscilloscope, launch [Python 3.0](#). From the command prompt, enter

- `python3`

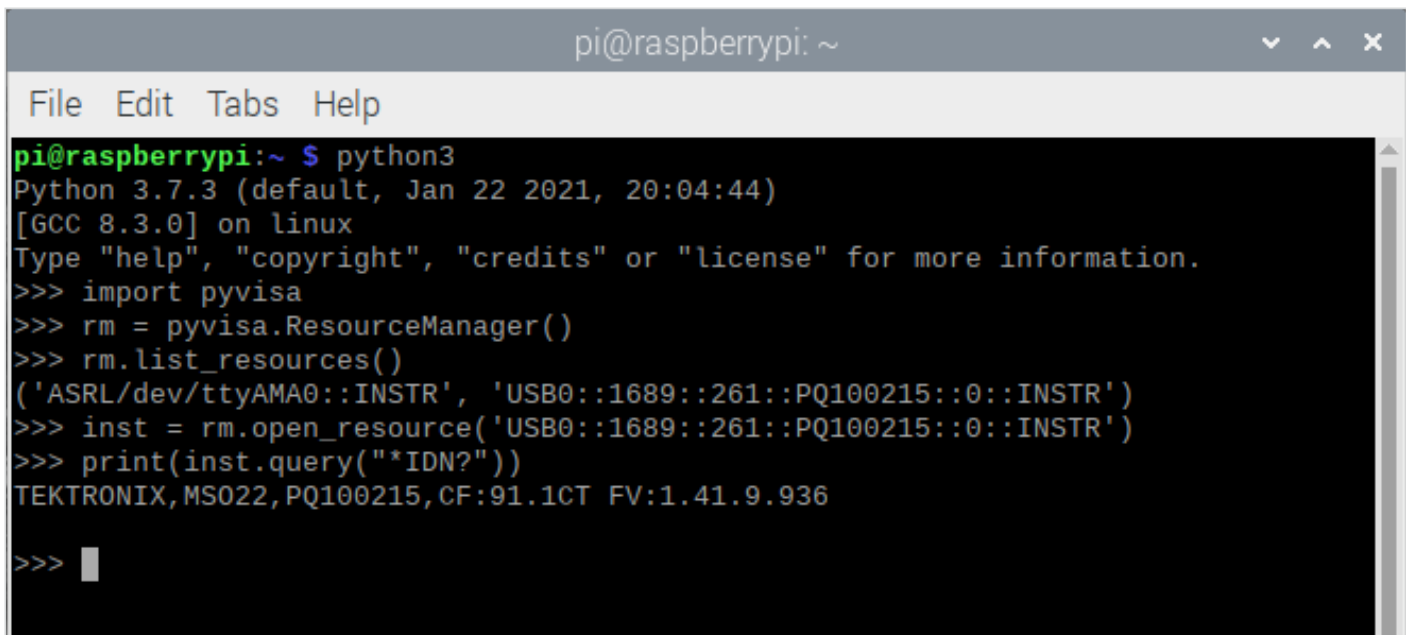
Then enter the following to check the oscilloscope's VISA descriptor:

- `>>> import pyvisa`
- `>>> rm = pyvisa.ResourceManager()`
- `>>> rm.list_resources()`
- `('ASRL/dev/ttyAMA0::INSTR', 'USB0::1689::261::PQ100125::0::INSTR')`
- `>>> inst = rm.open_resource('USB0::1689::261::PQ100125::0::INSTR')`
- `>>> print(inst.query("*IDN?"))`

The return from the `rm.list_resources()` will display the VISA descriptor. After it lists the correct VISA descriptor, enter

- `inst = rm.open_resource(<VISA descriptor>)` to connect the Raspberry Pi to the oscilloscope.

To confirm the communication, enter an `*IDN?` query. If the return string lists the correct model number and serial number, then the Raspberry Pi is able to communicate with the oscilloscope. (See **Figure 5** below.)



```
pi@raspberrypi: ~  
File Edit Tabs Help  
pi@raspberrypi:~ $ python3  
Python 3.7.3 (default, Jan 22 2021, 20:04:44)  
[GCC 8.3.0] on linux  
Type "help", "copyright", "credits" or "license" for more information.  
>>> import pyvisa  
>>> rm = pyvisa.ResourceManager()  
>>> rm.list_resources()  
( 'ASRL/dev/ttyAMA0::INSTR', 'USB0::1689::261::PQ100215::0::INSTR' )  
>>> inst = rm.open_resource('USB0::1689::261::PQ100215::0::INSTR')  
>>> print(inst.query("*IDN?"))  
TEKTRONIX,MS022,PQ100215,CF:91.1CT FV:1.41.9.936  
>>> █
```

Figure 5: Validate the communication using `*IDN?` query command.

In addition to the 2 Series MSO, other entry-level oscilloscopes such as the Tektronix TBS2000B and TBS1000C Digital Storage Oscilloscopes are also compatible with the Raspberry Pi setup.

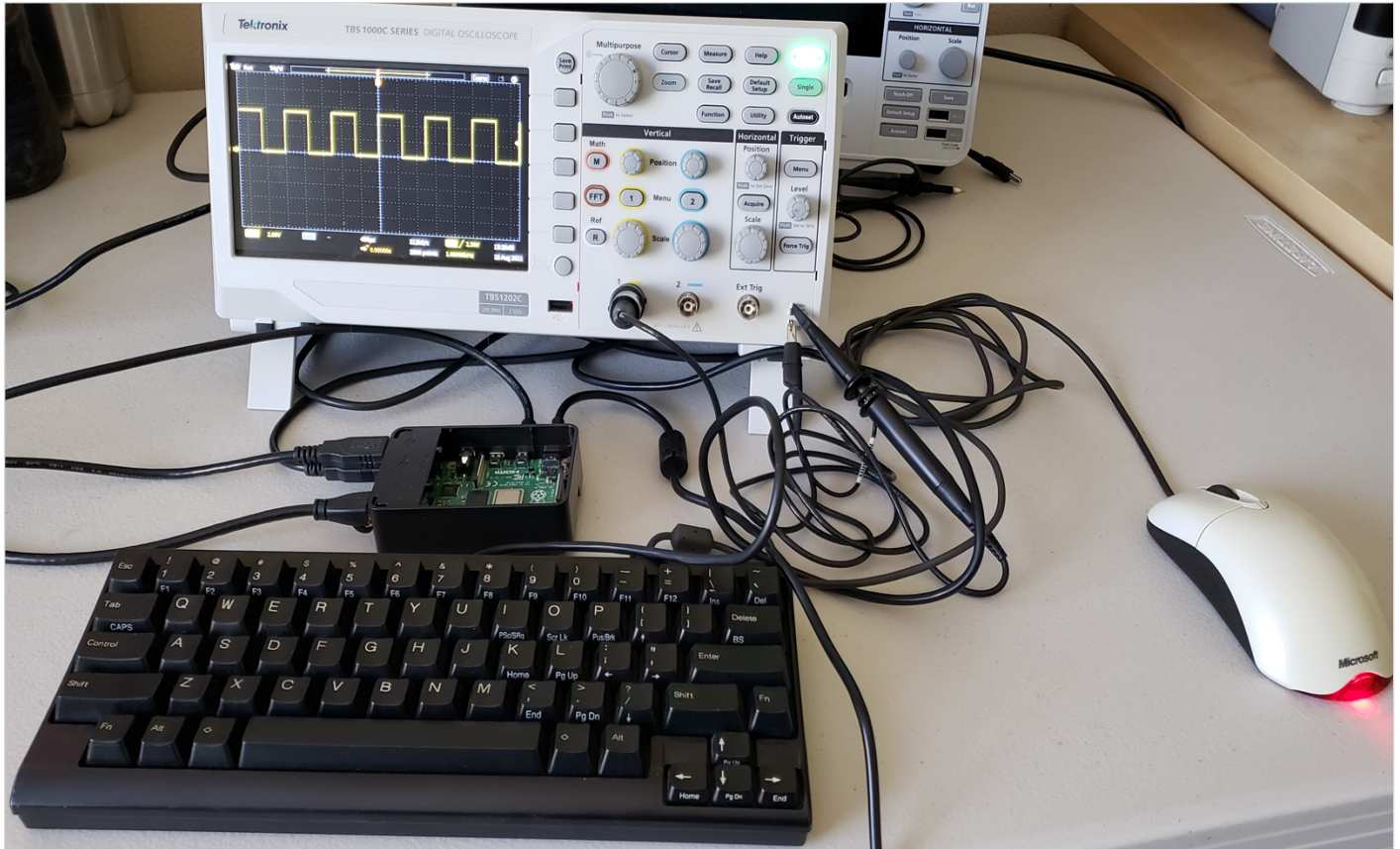


Figure 6: Connecting to the Tektronix TBS1000C Digital Storage Oscilloscope.

Example script

Following is a Python example script for querying waveform data and plot. This example script can also be downloaded and copied from the attached file named `example_script.txt`

```
import time # std module
import pyvisa as visa # http://github.com/hgrecco/pyvisa - pyvisa for connectivity
import matplotlib.pyplot as plt # http://matplotlib.org/ - for plotting
import numpy as np # http://www.numpy.org

# VISA descriptor to identify the test and measurement device
# Please update the VISA descriptor from the query result from pyvisa
visa_address = 'USB0::1689::261::Q300209::0::INSTR'

rm = visa.ResourceManager()
scope = rm.open_resource(visa_address)
scope.timeout = 10000 # ms
scope.encoding = 'latin_1'
scope.read_termination = '\n'
scope.write_termination = None
scope.write('*cls') # clear ESR
scope.write('header OFF')
```



```

# acquisition
scope.write('acquire:state OFF') # stop
scope.write('acquire:stopafter SEQUENCE;state ON') # single
r = scope.query('*opc?')

# curve configuration
scope.write('data:encdg SRIBINARY') # signed integer
scope.write('data:source CH1')
scope.write('data:start 1')
acq_record = int(scope.query('horizontal:recordlength?'))
scope.write('data:stop {}'.format(acq_record))
scope.write('wfmmoutpre:byt_n 1') # 1 byte per sample

# data query
bin_wave = scope.query_binary_values('curve?', datatype='b', container=np.array, chunk_size =
1024*2)

# retrieve scaling factors
wfm_record = int(scope.query('wfmmoutpre:nr_pt?'))
pre_trig_record = int(scope.query('wfmmoutpre:pt_off?'))
t_scale = float(scope.query('wfmmoutpre:xincr?'))
t_sub = float(scope.query('wfmmoutpre:xzero?')) # sub-sample trigger correction
v_scale = float(scope.query('wfmmoutpre:ymult?')) # volts / level
v_off = float(scope.query('wfmmoutpre:yzero?')) # reference voltage
v_pos = float(scope.query('wfmmoutpre:yoff?')) # reference position (level)

# disconnect
scope.close()
rm.close()

# create scaled vectors
# horizontal (time)
total_time = t_scale * wfm_record
t_start = (-pre_trig_record * t_scale) + t_sub
t_stop = t_start + total_time
scaled_time = np.linspace(t_start, t_stop, num=wfm_record, endpoint=False)
# vertical (voltage)
unscaled_wave = np.array(bin_wave, dtype='double') # data type conversion
scaled_wave = (unscaled_wave - v_pos) * v_scale + v_off

# plotting
plt.plot(scaled_time, scaled_wave)
plt.title('channel 1') # plot label
plt.xlabel('time (seconds)') # x label
plt.ylabel('voltage (volts)') # y label
print("look for plot window...")

```

```
plt.show()
```

Setting up the TightVNC (optional)

This is optional for the user who prefers to set up VNC on the Raspberry Pi to remote into it.

To update to the latest version, from the command prompt, enter

- `sudo apt update && sudo apt upgrade -y`

Then to install the VNC Server, from the command prompt, enter

- `sudo apt install tightvncserver`

For the initial setup for the VNC server, from the command prompt, enter

- `vncserver`

Because this is the initial setup, the command prompt will ask for a password. Enter a password composed of eight characters. The password will automatically be shortened to eight characters.

Reenter the password for verification.

When asked if it is a viewer-only password, select No.

On the other PC, install the TightVNC client at tightvnc.com.

Once installed, start the TightVNC Viewer. In the connection window, enter the Raspberry Pi's IP address and the default port number (5901).

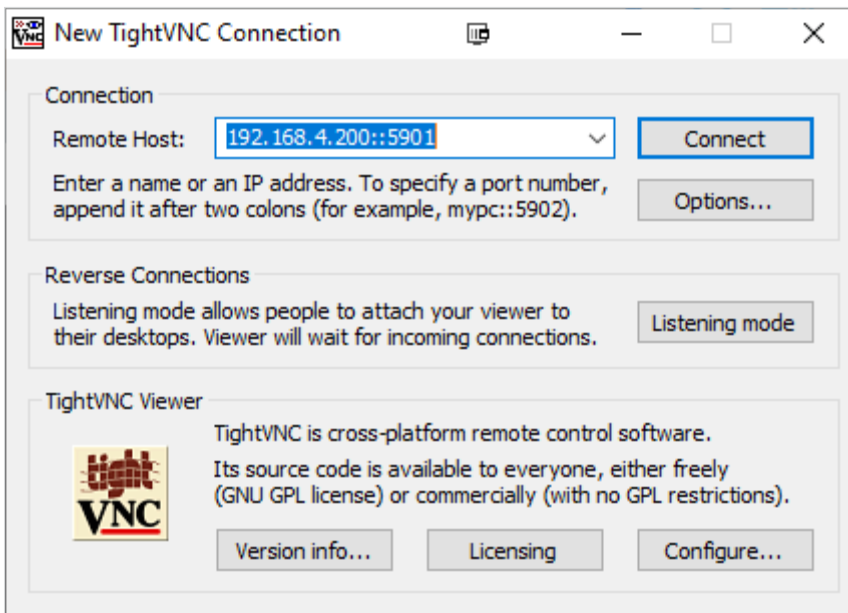
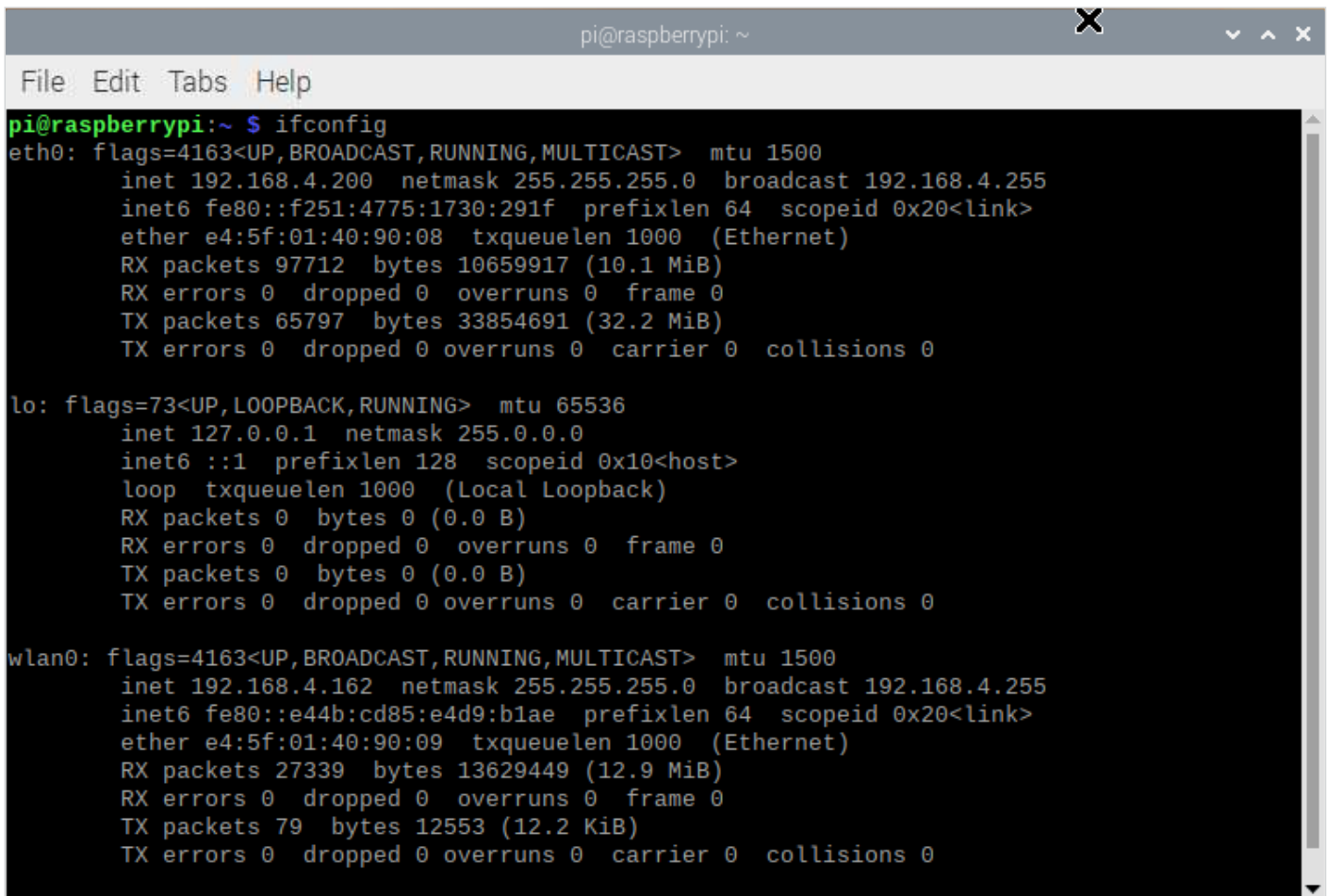


Figure 7: TightVNC viewer connection window.

To look up the IP address in Raspberry Pi, use the command `ifconfig`.

A terminal window titled 'pi@raspberrypi: ~' with a menu bar (File, Edit, Tabs, Help). The command 'ifconfig' has been executed, displaying configuration details for three network interfaces: eth0 (Ethernet), lo (Local Loopback), and wlan0 (Wireless LAN).

```
pi@raspberrypi:~ $ ifconfig
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 192.168.4.200  netmask 255.255.255.0  broadcast 192.168.4.255
    inet6 fe80::f251:4775:1730:291f  prefixlen 64  scopeid 0x20<link>
    ether e4:5f:01:40:90:08  txqueuelen 1000  (Ethernet)
    RX packets 97712  bytes 10659917 (10.1 MiB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 65797  bytes 33854691 (32.2 MiB)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
    inet 127.0.0.1  netmask 255.0.0.0
    inet6 ::1  prefixlen 128  scopeid 0x10<host>
    loop txqueuelen 1000  (Local Loopback)
    RX packets 0  bytes 0 (0.0 B)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 0  bytes 0 (0.0 B)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
    inet 192.168.4.162  netmask 255.255.255.0  broadcast 192.168.4.255
    inet6 fe80::e44b:cd85:e4d9:b1ae  prefixlen 64  scopeid 0x20<link>
    ether e4:5f:01:40:90:09  txqueuelen 1000  (Ethernet)
    RX packets 27339  bytes 13629449 (12.9 MiB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 79  bytes 12553 (12.2 KiB)
    TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

Figure 8: Look up the IP address using the command `ifconfig`.

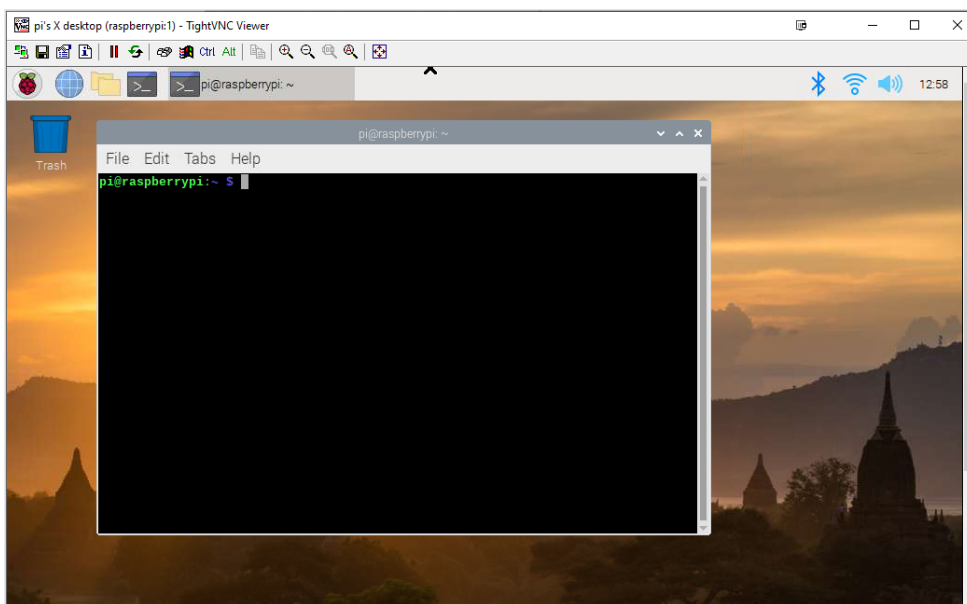


Figure 9: TightVNC viewer on the remote PC.

Contact Information:

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Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium* 00800 2255 4835
Brazil +55 (11) 3530-8901
Canada 1 800 833 9200
Central East Europe / Baltics +41 52 675 3777
Central Europe / Greece +41 52 675 3777
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Finland +41 52 675 3777
France* 00800 2255 4835
Germany* 00800 2255 4835
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India 000 800 650 1835
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People's Republic of China 400 820 5835
Philippines 1 800 1601 0077
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