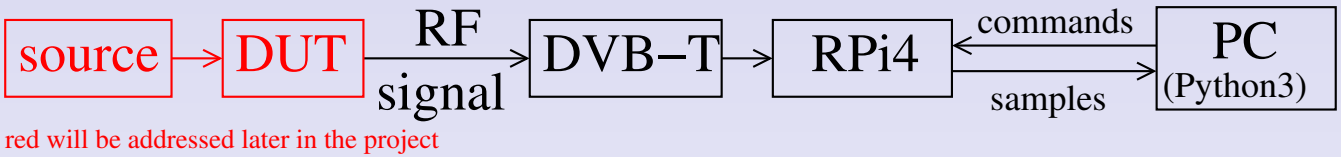
Outline

General context: we wish to design an instrument in which the data are collected by the Raspberry Pi 4, under control of the PC, to be transferred to the PC for processing and display.



GNU Radio on Raspberry Pi 4

1. making sure GNU Radio is properly installed: accessing GNU Radio blocks and playing a sound
2. first demonstration with RTL-SDR dongle: FM receiver
3. from RPi4 to PC used as sound card: Zero-MQ publish/subscribe
4. from PC to RPi4: TCP/IP server running as a Python thread

Objective: a FM radio receiver running on the RPi4, streaming sound from the RPi4 to the PC, whose carrier frequency is controlled from the PC

GNU Radio 3.8 on the PC

Many stable distributions are still providing GNU Radio 3.7 as package (obsolete since Jul. 2019). We will launch `gnuradio-companion` on **the PC**:

1. check the packaged version of GNU Radio: `apt-cache policy gnuradio`
2. if the version is 3.8, install the packaged version
3. if the version is 3.7, use PyBOMBS (Python Build Overlay Managed Bundle System) as described at `https://github.com/gnuradio/pybombs`
   1. `sudo apt-get install python3-pip`
   2. `sudo pip3 install pybombs`
   3. `pybombs auto-config`
   4. `pybombs recipes add-defaults`
   5. `pybombs prefix init ~/prefix-3.8 -R gnuradio-default` assuming the installation directory is in `$HOME/prefix-3.8`
   6. `source ~/prefix-3.8/setup_env.sh` (will have to be repeated in each terminal launching GNU Radio Companion)
   7. `gnuradio-companion`
4. if GNU Radio Companion has started: install osmosdr, either from the binary package `apt` if GNU Radio 3.8 is packaged, or with PyBOMBS (`pybombs install gr-osmosdr`) if this installation system was used
5. close GNU Radio Companion and launch again (or refresh package list) to access Osmocom Source: the links between blocks must be curves and not lines at right angles.

GNU Radio on Raspberry Pi4

1. Check that GNU Radio is properly installed: on the RPi4,

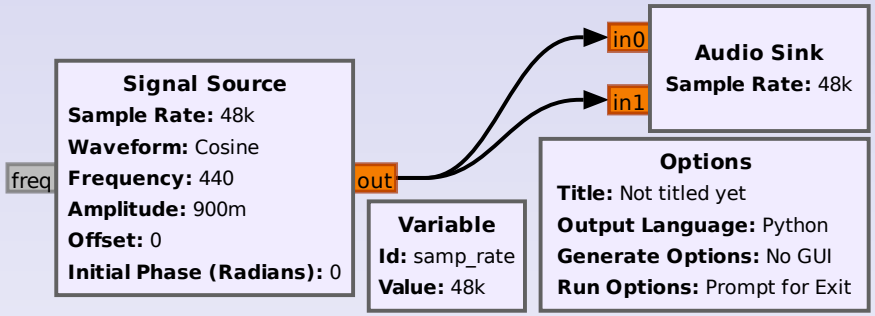
   ```
   # python3
   import gnuradio
   ```

   must return with a prompt and no warning/error
2. basics of GNU Radio flowcharts: one source, digital processing blocks, and sinks with consistent datarate along the processing path (**samp_rate**/decimation factors)
3. no graphical output in the Raspberry Pi4: launch `gnuradio-companion` on the PC and select **Options** → **Generate Options** → **No GUI**
4. the **Id** defines the name of the output Python script
5. **Run** → **Generate** to convert the flowgraph in a Python script (see console for output file & path)
6. copy (**scp** [1] the Python script from the PC to the Raspberry Pi4
7. on the Raspberry Pi4, execute with **python3 my_script.py**

[1] on the PC: `scp my_script.py root@pi4_IP_address:/root`

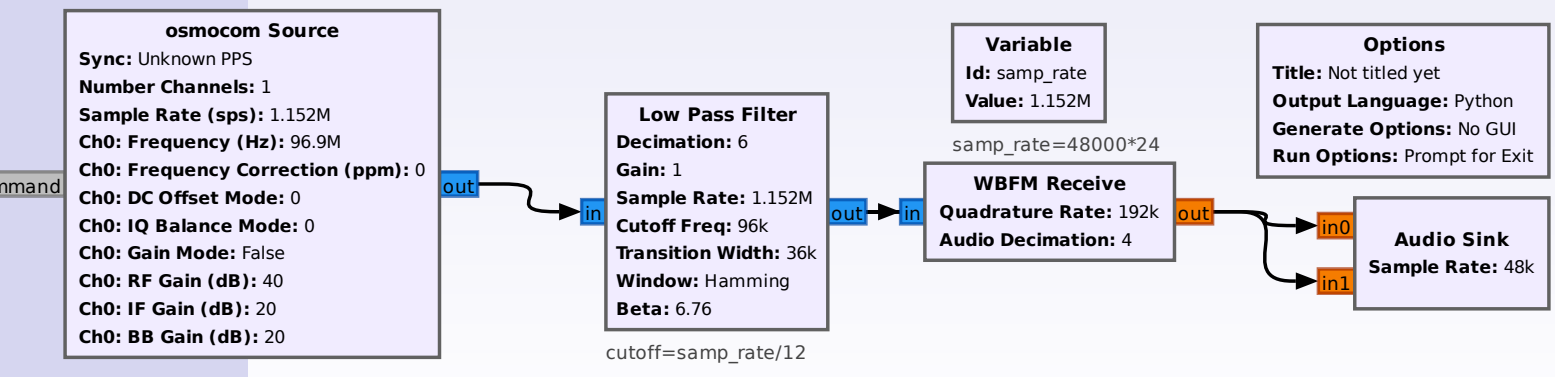
GNU Radio on Raspberry Pi4

1. the trivial flowchart generated on the PC with GNU Radio Companion (3.8 – check the curved connections)
   - 2 audio outputs (GNU Radio inputs) for stereo
   - 48 kS/s sampling rate
   - sine wave signal source
   - run on the RPi4 with **python3 pgm.py**



   ⇒ must output a tone on the audio jack

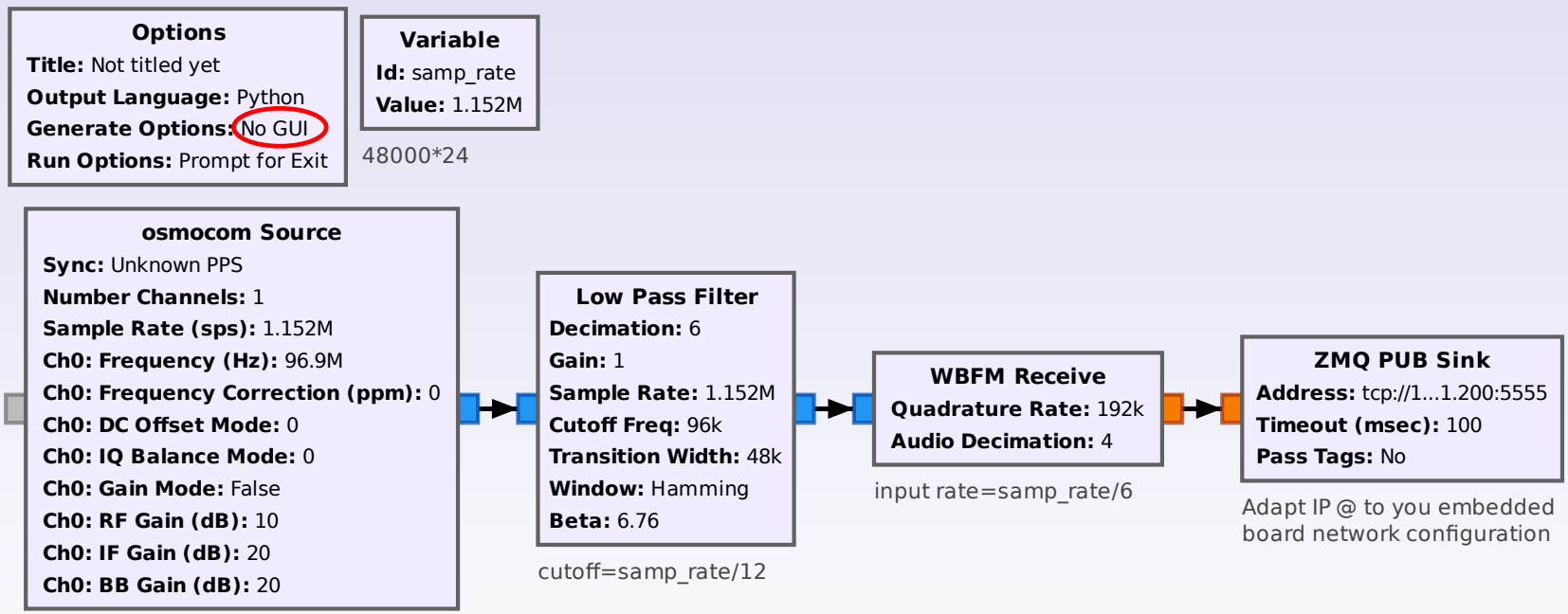
2. FM radio receiver to check proper operation of DVB-T dongle



Streaming from RPi4 to PC

- An instrument collects the data and sends them to a PC for processing
- the PC might not process all data but only segments
- UDP-like Zero-MQ stream: Publish-Subscribe mechanism (supported by Python, GNU/Octave, C, C++ ...)
- demonstration: stream the FM demodulated sound to the PC used as sound card.

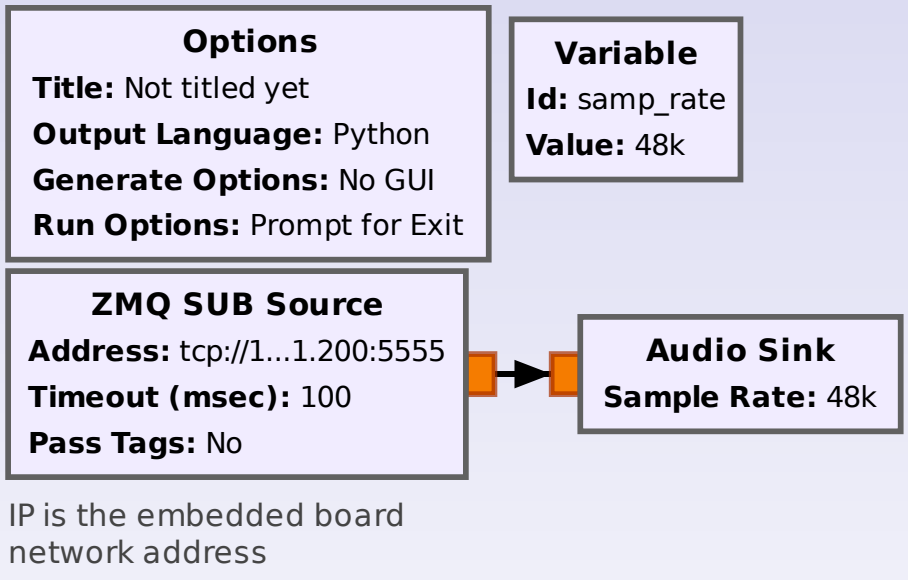
On the Raspberry Pi4, fetch samples, demodulate and send



Publish Sink: the address **tcp://192.168.x.y:5555** is the *Raspberry Pi4* Ethernet address (listening to incoming connection requests).
The port is a random value >1024, here 5555.

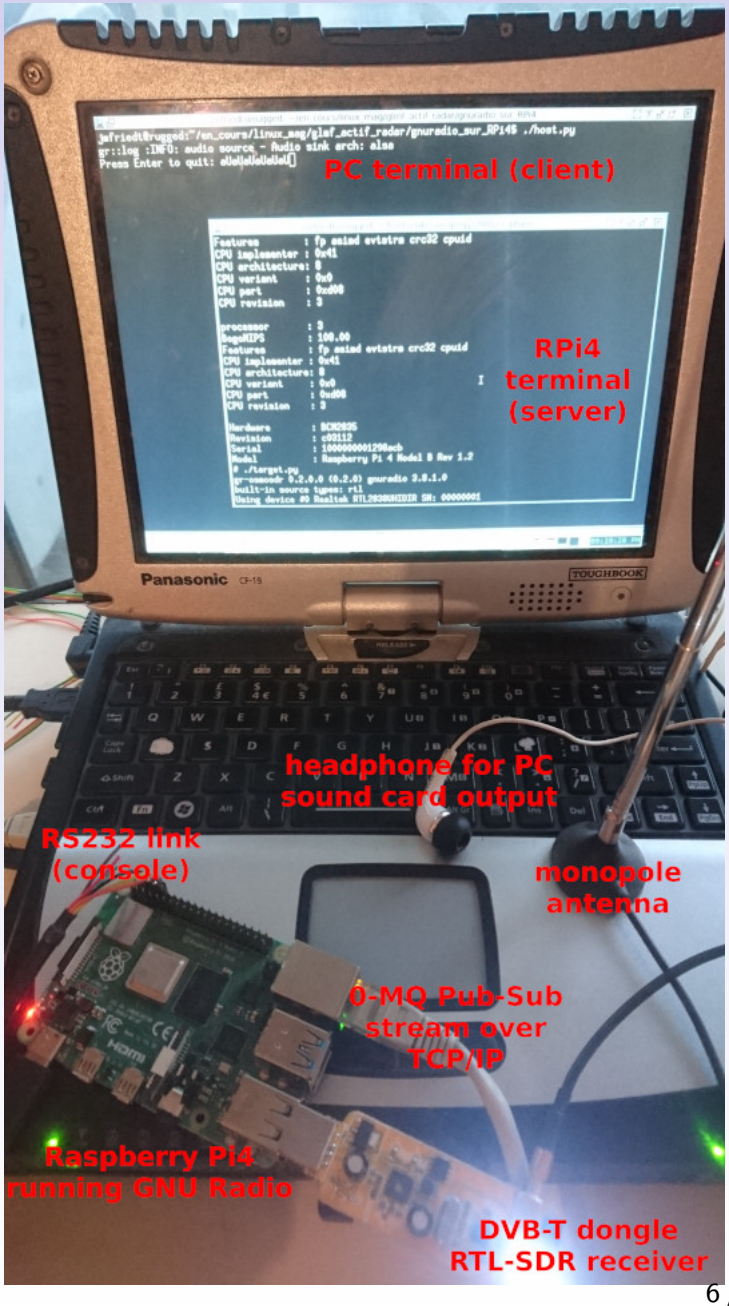
Streaming from RPi4 to PC

On the PC:



IP is the embedded board network address

set the Subscribe Source to the **tcp://192.168.x.y:5555** IP address of the Raspberry Pi4, same port as before.



Commands from PC to RPi4

Multithreaded Python script approach

- GNU Radio Companion is a Python script generator
- GNU Radio Companion 3.8 allows for inserting additional Python commands in its initialization code: **Python Snippets**
- GNU Radio Companion 3.8 allows for adding Python functions: **Python Module**
- Launch a separate thread running a TCP (connected mode) server
- Receive commands from the PC running a TCP client (**telnet**)
- Tune the GNU Radio flowgraph variables by calling the callback function associated with the modified variable

What is a thread ?

- function run in parallel to the main program but sharing the same memory space

```
import threading
import time

def jmf1(argument):
        while True:
                print(argument)
                time.sleep(1)

threading.Thread(target=jmf1,args=(1,)).start()
threading.Thread(target=jmf1,args=(2,)).start()
threading.Thread(target=jmf1,args=(3,)).start()
```

What is a server ?

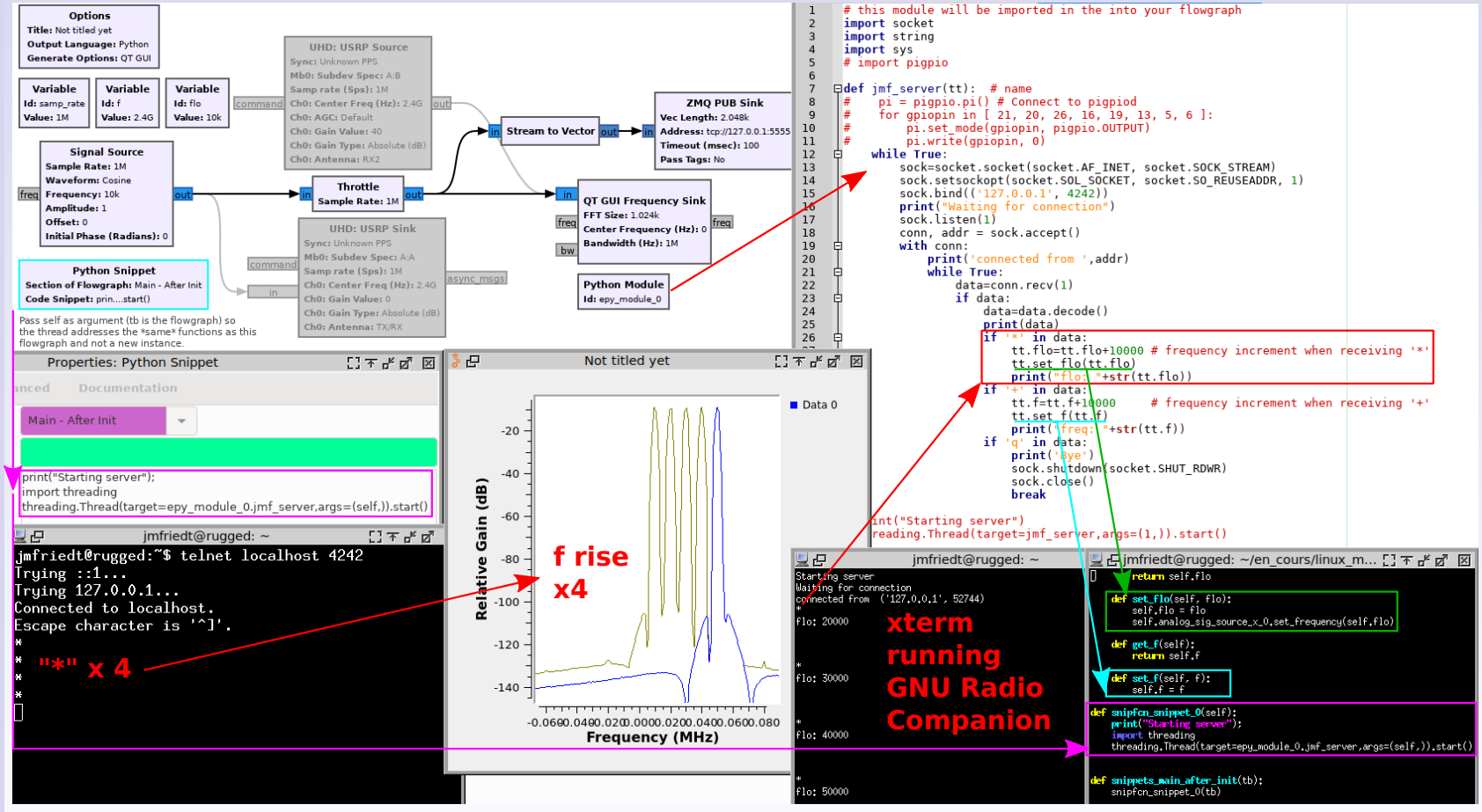
Definition: a *server* waits for a connection, a *client* connects to the server when it needs information

```
import socket
import string
while True:
    sock=socket.socket(socket.AF_INET, socket.SOCK_STREAM)
    sock.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
    sock.bind(('127.0.0.1', 4242))
    print("Waiting for connection")
    sock.listen(1)
    conn, addr = sock.accept()
    with conn:
        print('connected from ',addr)
        while True:
            data=conn.recv(1)
            if data:
                data=data.decode()
                print(data)
                if 'q' in data:
                    sock.shutdown(socket.SHUT_RDWR)
                    sock.close()
                    break
```

- Run `python3 my_server` in one terminal
- Run `telnet localhost 4242` in another terminal
- Enjoy ... quit by sending 'q'

Putting it all together ...

Python Snippet executes the thread including the Python Module running the TCP server controlling the GNU Radio execution by tuning parameters with the associated callback function [2]



[2] J.-M Friedt, W. Feng, *Analyse et réalisation d'un RADAR à synthèse d'ouverture (SAR) par radio logicielle (2/3)*, GNU/Linux Magazine France 242 (Nov. 2020)

Commands from PC to RPi4

- Demonstrate how you modify the previous flowchart, streaming the output of the FM demodulator to the PC, to tune the broadcast station frequency on the Raspberry Pi4 from the PC.
- Provide a graphical user interface allowing to enter the FM radio frequency and transferring the information to the RPi4