Communication Systems based on Software Defined Radio (SDR)

Dr. Ing. Alejandro José Uriz

GNU Radio Companion basics usage

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GNU Radio is free and open software that consists of tools for digital signal processing that allow the implementation of communication systems.

The project website is: https://www.gnuradio.org/

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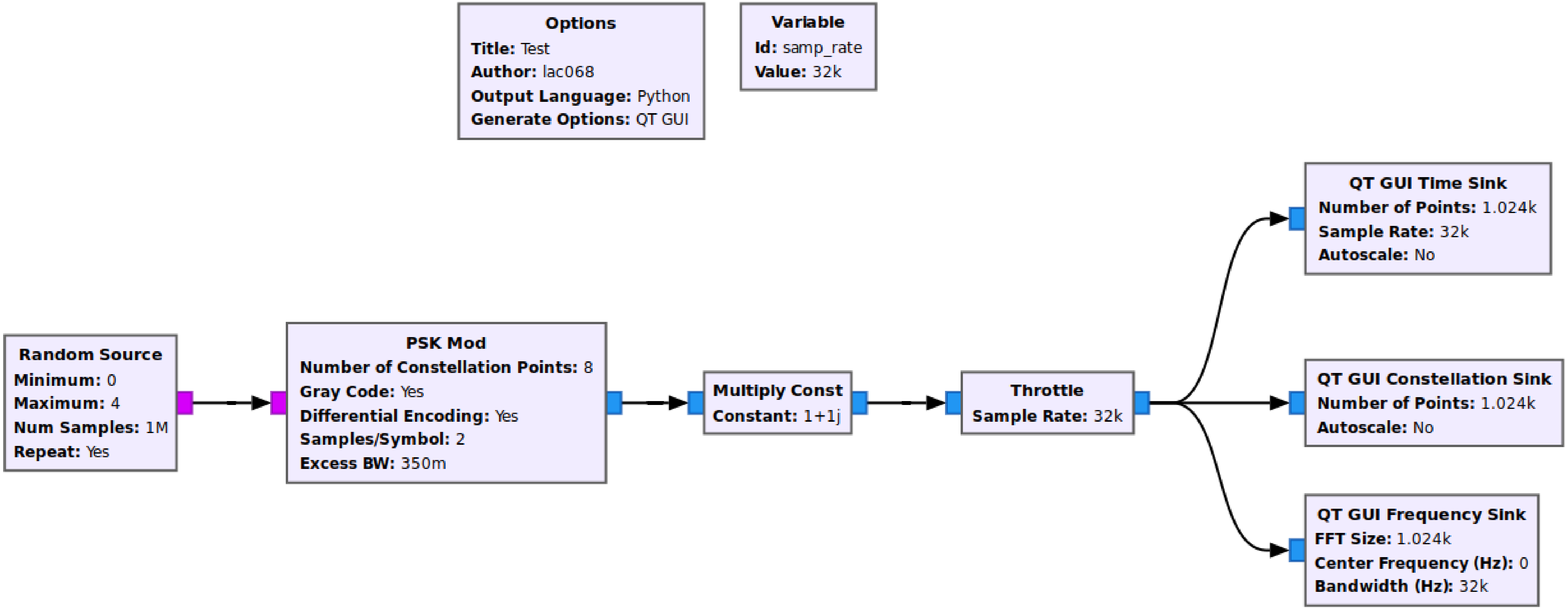
This platform is widely used for simulation and implementation of communication systems. But it also has the ability to integrate software-defined radios and therefore implement communication systems.

The previously described advantages make it widely used for research, teaching, industry and also by radio amateurs.



Options
Title: Test
Author: lac068
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

Random Source
Minimum: 0
Maximum: 4
Num Samples: 1M
Repeat: Yes

PSK Mod
Number of Constellation Points: 8
Gray Code: Yes
Differential Encoding: Yes
Samples/Symbol: 2
Excess BW: 350m

Multiply Const
Constant: 1+1j

Throttle
Sample Rate: 32k

QT GUI Time Sink
Number of Points: 1.024k
Sample Rate: 32k
Autoscale: No

QT GUI Constellation Sink
Number of Points: 1.024k
Autoscale: No

QT GUI Frequency Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k

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Waveform Generators

- Constant Source
- Noise Source
- Signal Source (e.g. Sine, Square, Saw Tooth)

Modulators

- AM Demod
- Continuous Phase Modulation
- WBFM Receive / NBFM Receive
- PSK Mod / Demod
- GFSK Mod / Demod
- GMSK Mod / Demod
- QAM Mod / Demod

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Instrumentation (i.e., GUIs)

- Constellation Sink
- Frequency Sink
- Histogram Sink
- Number Sink
- Time Sink
- Waterfall Sink

Channel Models

- Channel Model
- Fading Model
- Dynamic Channel Model
- Frequency Selective Fading Model

Filters

- Band Pass / Reject Filter / Low / High Pass Filter
- IIR Filter
- Generic Filterbank
- Hilbert
- Decimating FIR Filter
- Root Raised Cosine Filter
- FFT Filter

Fourier Analysis

- FFT / Log Power FFT
- Goertzel (Resamplers) / Fractional Resampler / Polyphase Arbitrary Resampler / Rational Resampler (Synchronizers)
- Clock Recovery MM / Correlate and Sync
- Costas Loop
- FLL Band-Edge / PLL Freq Det / PN Correlator / Polyphase Clock Sync

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The modularity of the GNU Radio blocks allow the implementation of communication systems in a very agile way.

Also, because it is open source, there is a wide variety of codes and libraries generated by the community available.

Blocks and libraries can be created and edited in C++ and/or Python.

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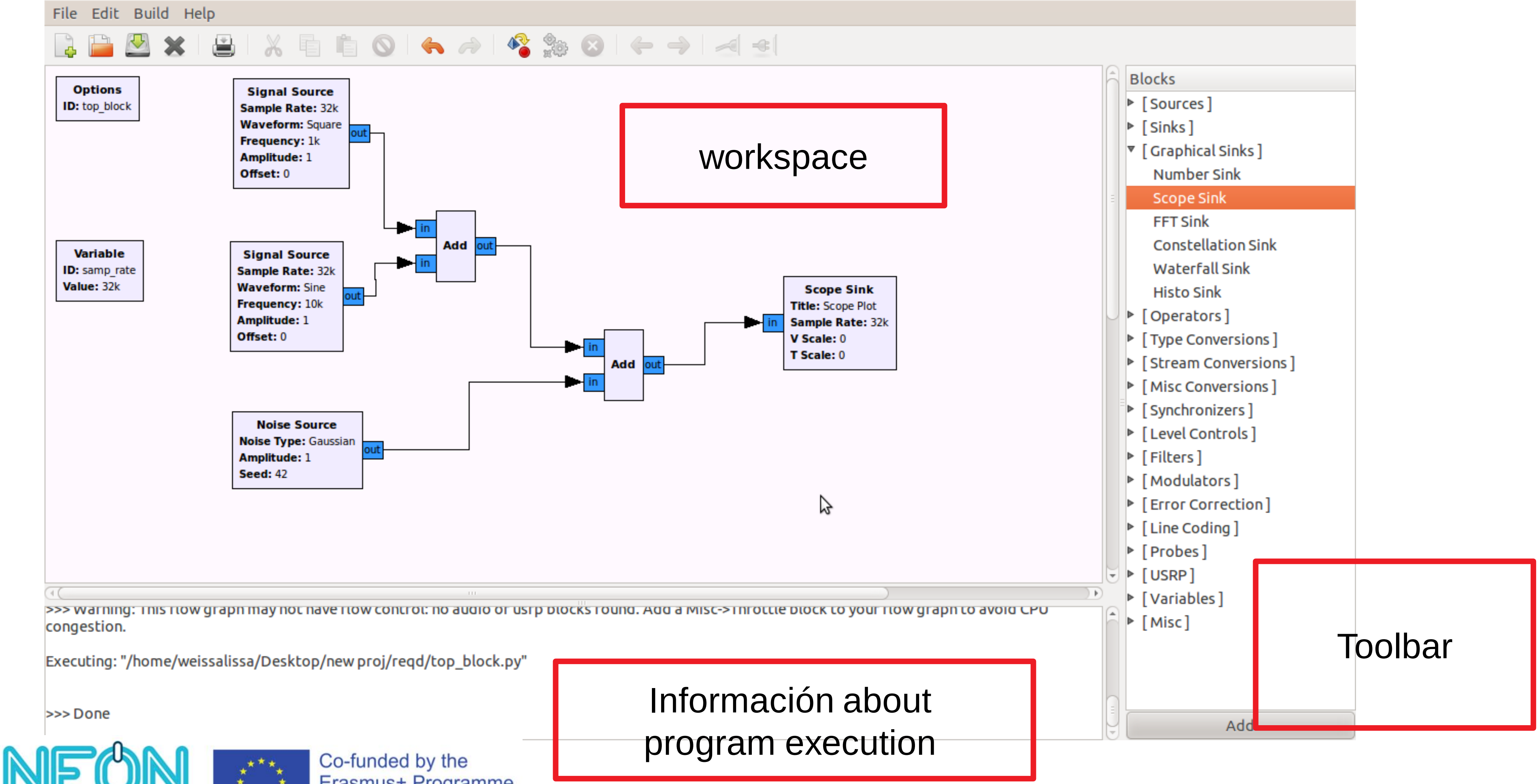

Options
ID: top_block

Variable
ID: samp_rate
Value: 32k

Signal Source
Sample Rate: 32k
Waveform: Square
Frequency: 1k
Amplitude: 1
Offset: 0

Signal Source
Sample Rate: 32k
Waveform: Sine
Frequency: 10k
Amplitude: 1
Offset: 0

Noise Source
Noise Type: Gaussian
Amplitude: 1
Seed: 42

Scope Sink
Title: Scope Plot
Sample Rate: 32k
V Scale: 0
T Scale: 0

```
>>> Warning: This flow graph may not have flow control: no audio or usrp blocks found. Add a Misc->Throttle block to your flow graph to avoid CPU
congestion.

Executing: "/home/weissalissa/Desktop/new proj/reqd/top_block.py"


>>> Done
```

workspace

Toolbar

Información about program execution

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In this way, there are blocks suitable for implementing classic communications systems such as AM, FM, PSK, FSK and QAM, to more complex ones such as OFDM.

There are also libraries for specific applications and protocols. Some examples are listed below:

- Digital television.
- Satellite communications.
- Cellphones.
- ADS-B.
- AIS.

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Variable Types

GNU Radio blocks are suitable for different types of variables, depending on their nature. The types of variables available in the environment are:

- Complex (8 bytes).
- Float (4 byte floating point).
- Int (4 byte integer).
- Short (2 byte integer).
- Byte (1 byte of data).

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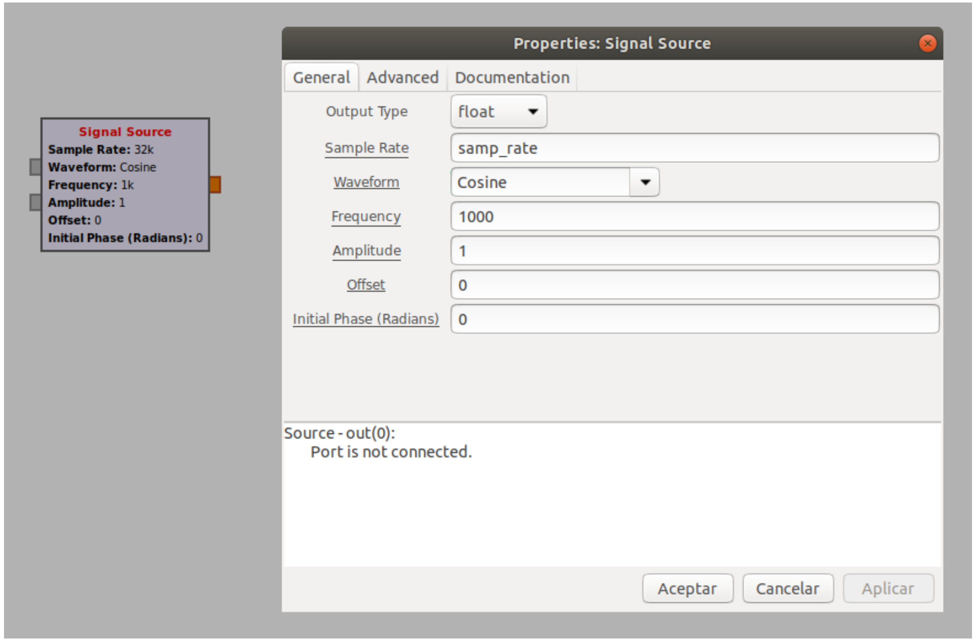


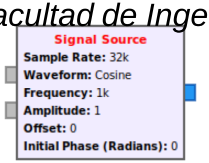
Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Properties: Signal Source

General | Advanced | Documentation

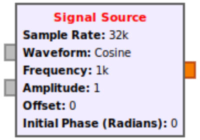
Output Type	float
Sample Rate	samp_rate
Waveform	Cosine
Frequency	1000
Amplitude	1
Offset	0
Initial Phase (Radians)	0

```
Source - out(0):
    Port is not connected.
```



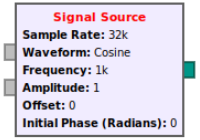
Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Blue: Complex type



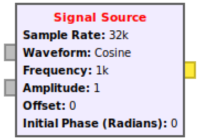
Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Orange: Float type



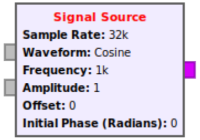
Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Green: Int type



Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Yellow: Short type



Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Magenta: Byte type

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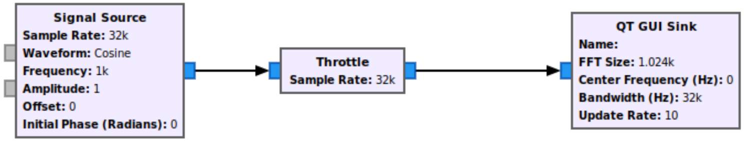
Connection between blocks

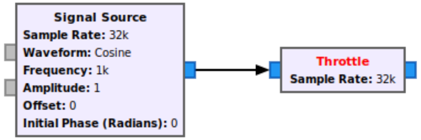


Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

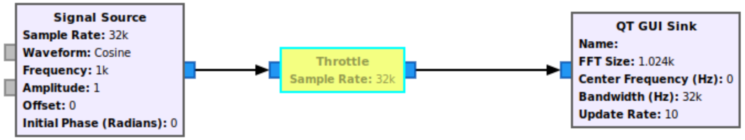
Black font in block title: Correct



Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

Red font in block title: Error



Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

Block shaded in yellow: By-passed block .

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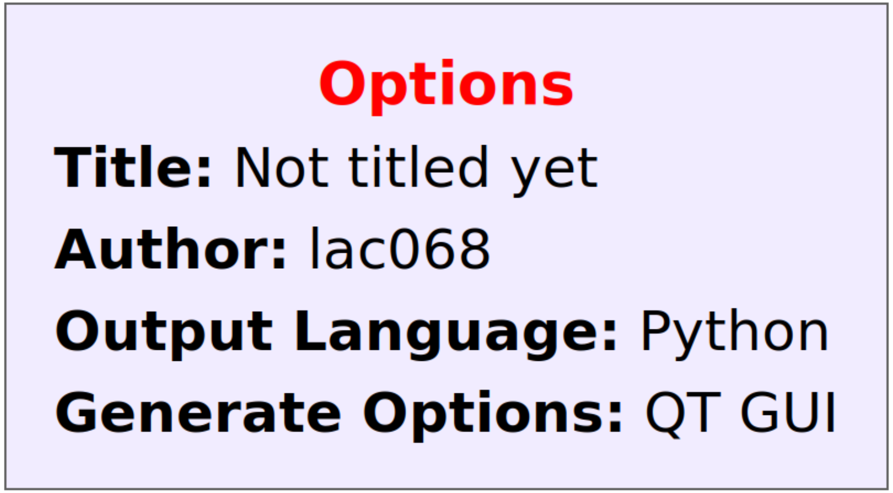
Steps to create a project

When a new project is created, two blocks must be configured: the “Options” and the one for a variable called “samp_rate” (sample rate).



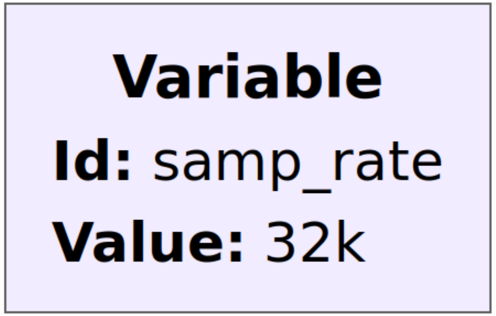
Options

Title: Not titled yet

Author: lac068

Output Language: Python

Generate Options: QT GUI



Variable

Id: samp_rate

Value: 32k

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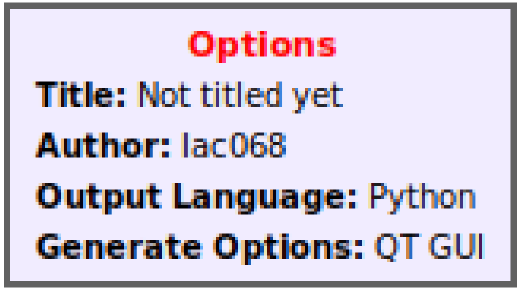
“Options” block



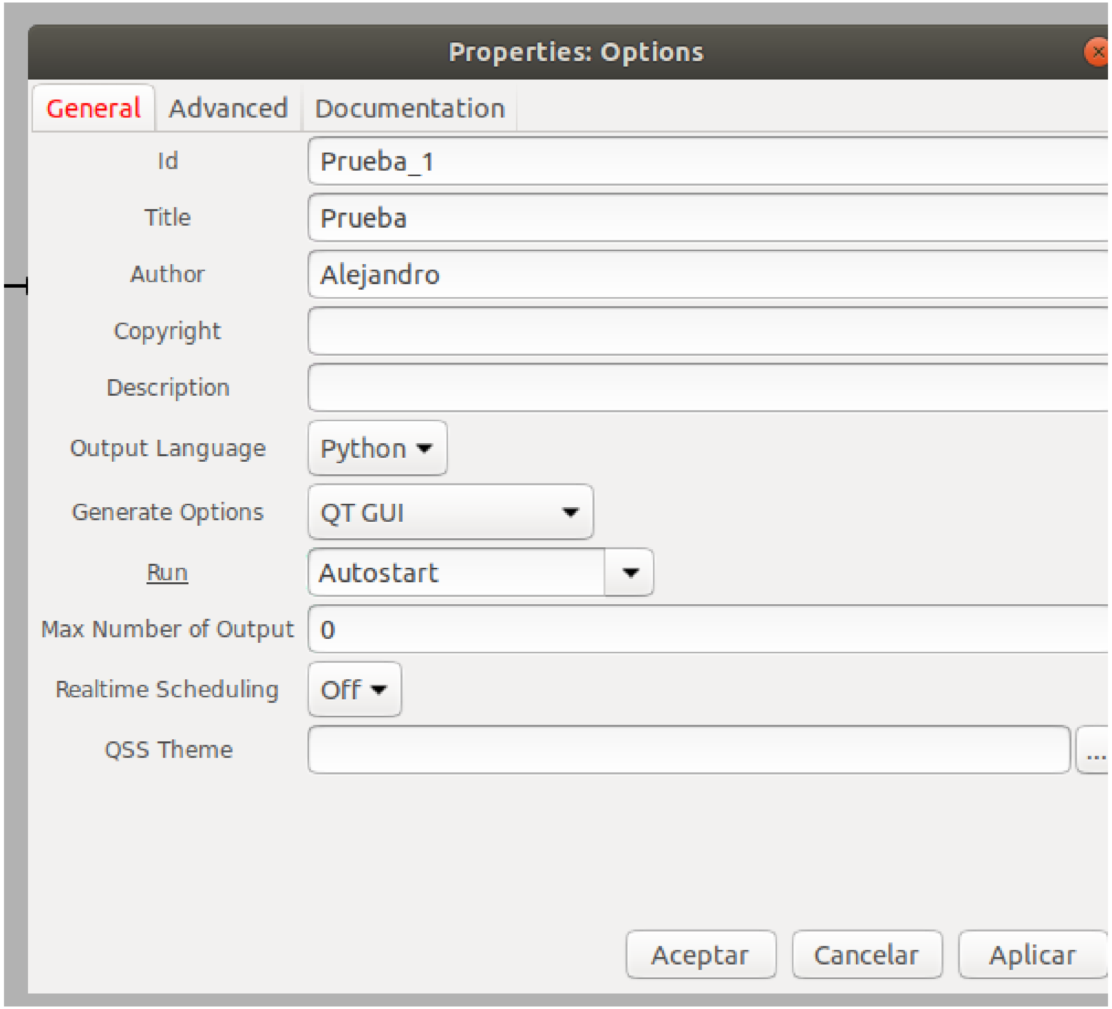
Options

Title: Not titled yet

Author: lac068

Output Language: Python

Generate Options: QT GUI



Properties: Options

Id: Prueba_1

Title: Prueba

Author: Alejandro

Copyright:

Description:

Output Language: Python

Generate Options: QT GUI

Run: Autostart

Max Number of Output: 0

Realtime Scheduling: Off

QSS Theme:

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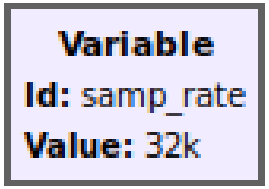
The Options block contains initial configuration options. The following parameters can be set:

- **ID:** Unique name assigned to each block
- **Title:** Title of the project
- **Author:** Author of the project
- **Description:** Description of the project
- **Canvas Size:** Size of the work area
- **Generate Options:** Graphic mode output format.
- **Run:** Form of beginning of the execution of the project
- **Max Number of Output:** Maximum number of outputs
- **Realtime Scheduling:** Activate/deactivate scheduling in real

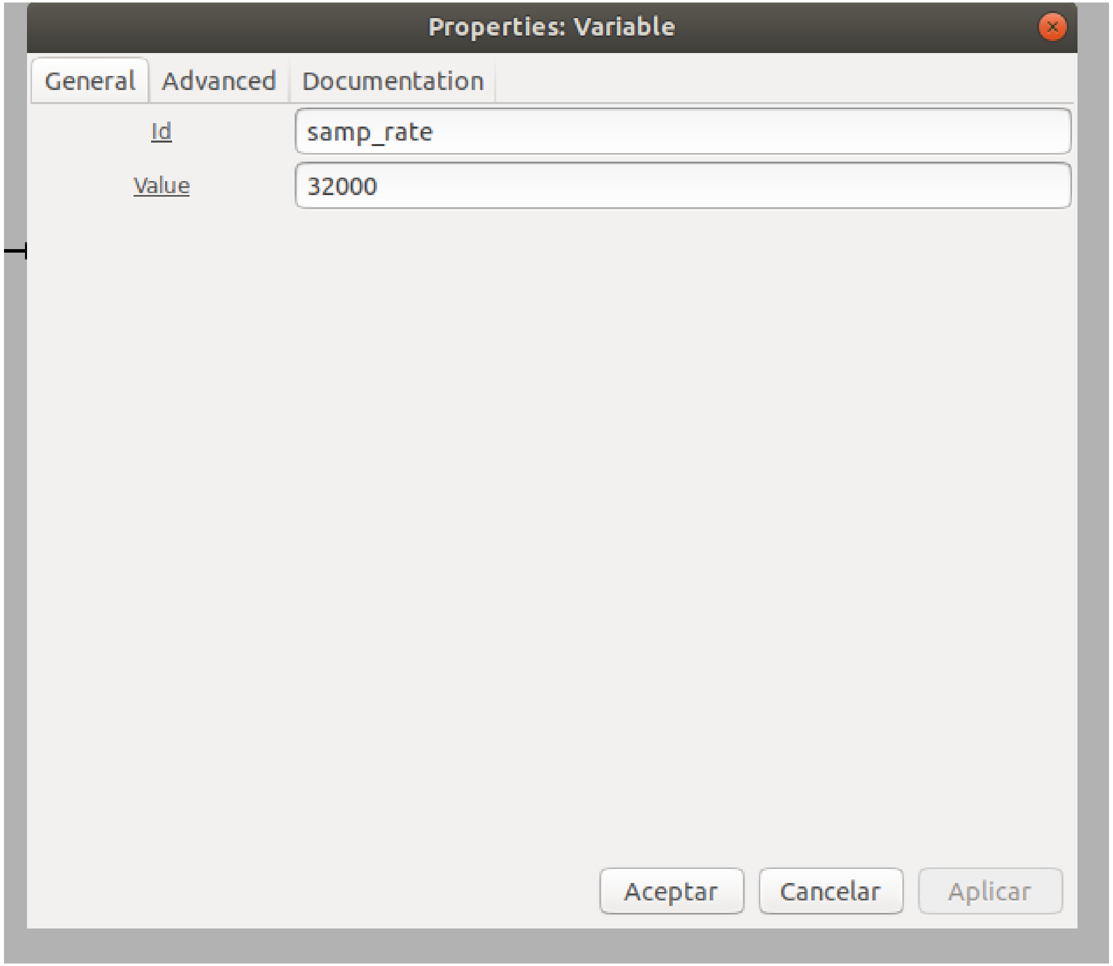
“Variable” block



Variable

Id: samp_rate

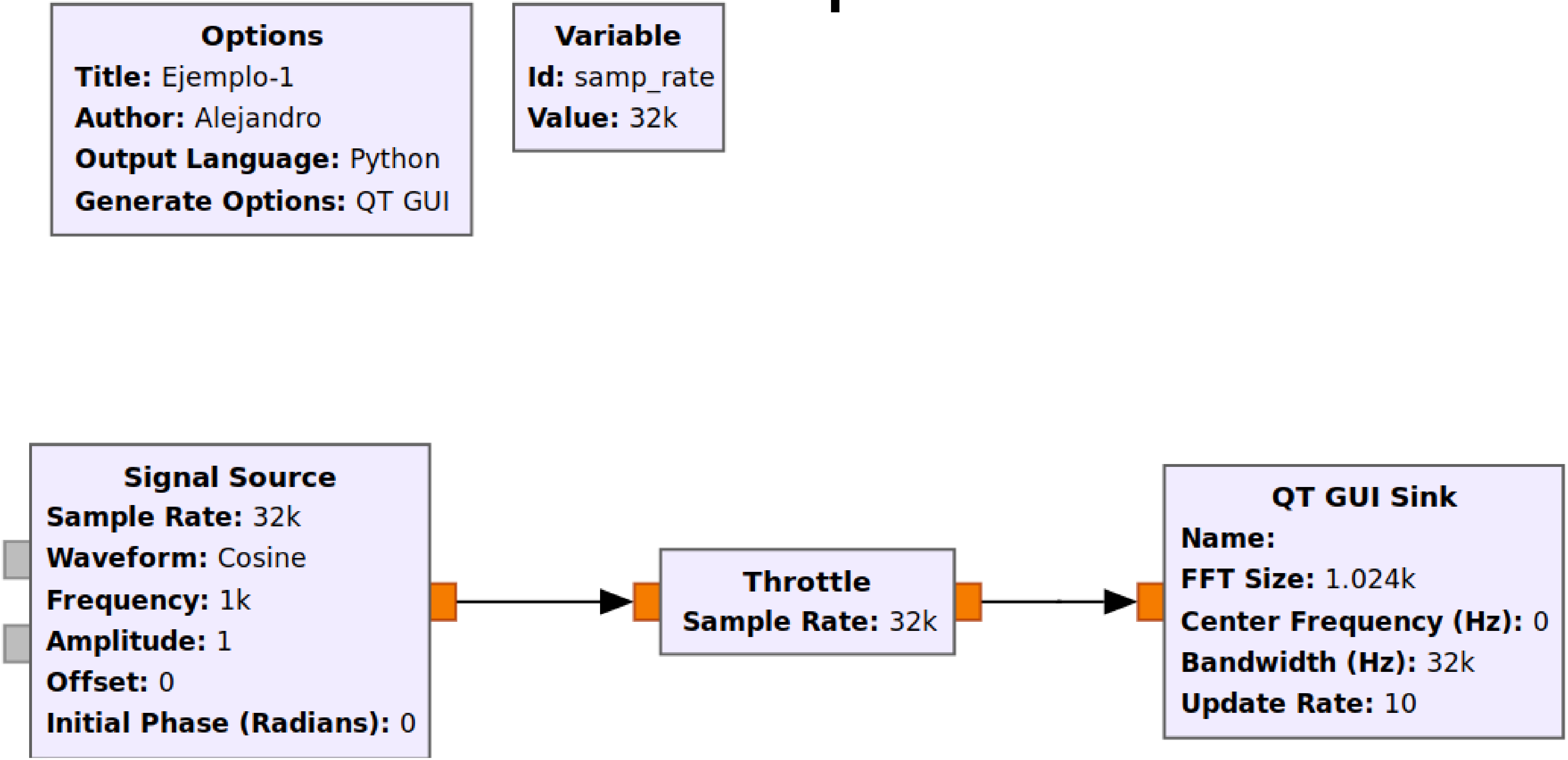
Value: 32k



Id: samp_rate

Value: 32000

Example



Options
Title: Ejemplo-1
Author: Alejandro
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

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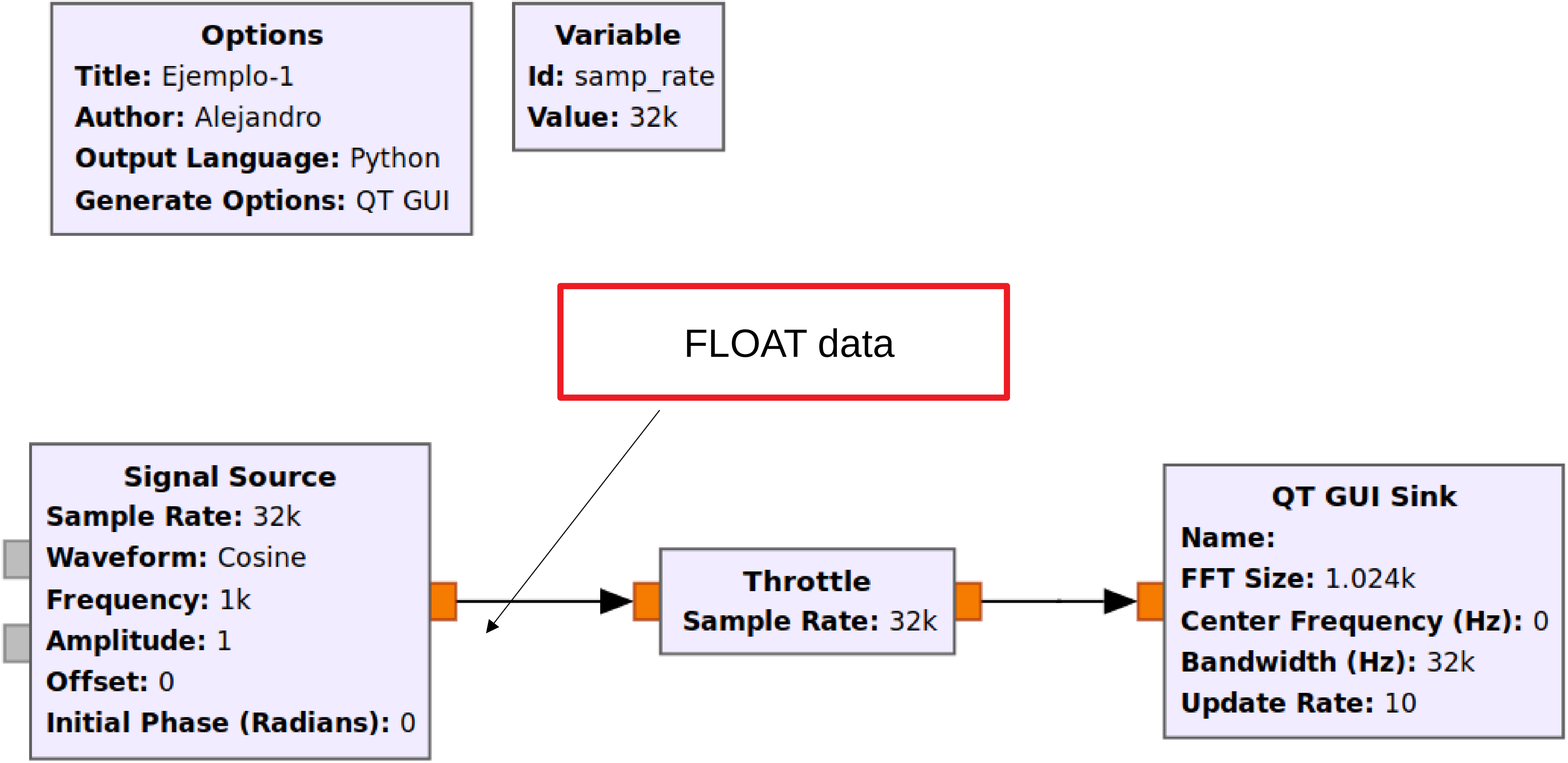
Example



Options
Title: Ejemplo-1
Author: Alejandro
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

FLOAT data

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

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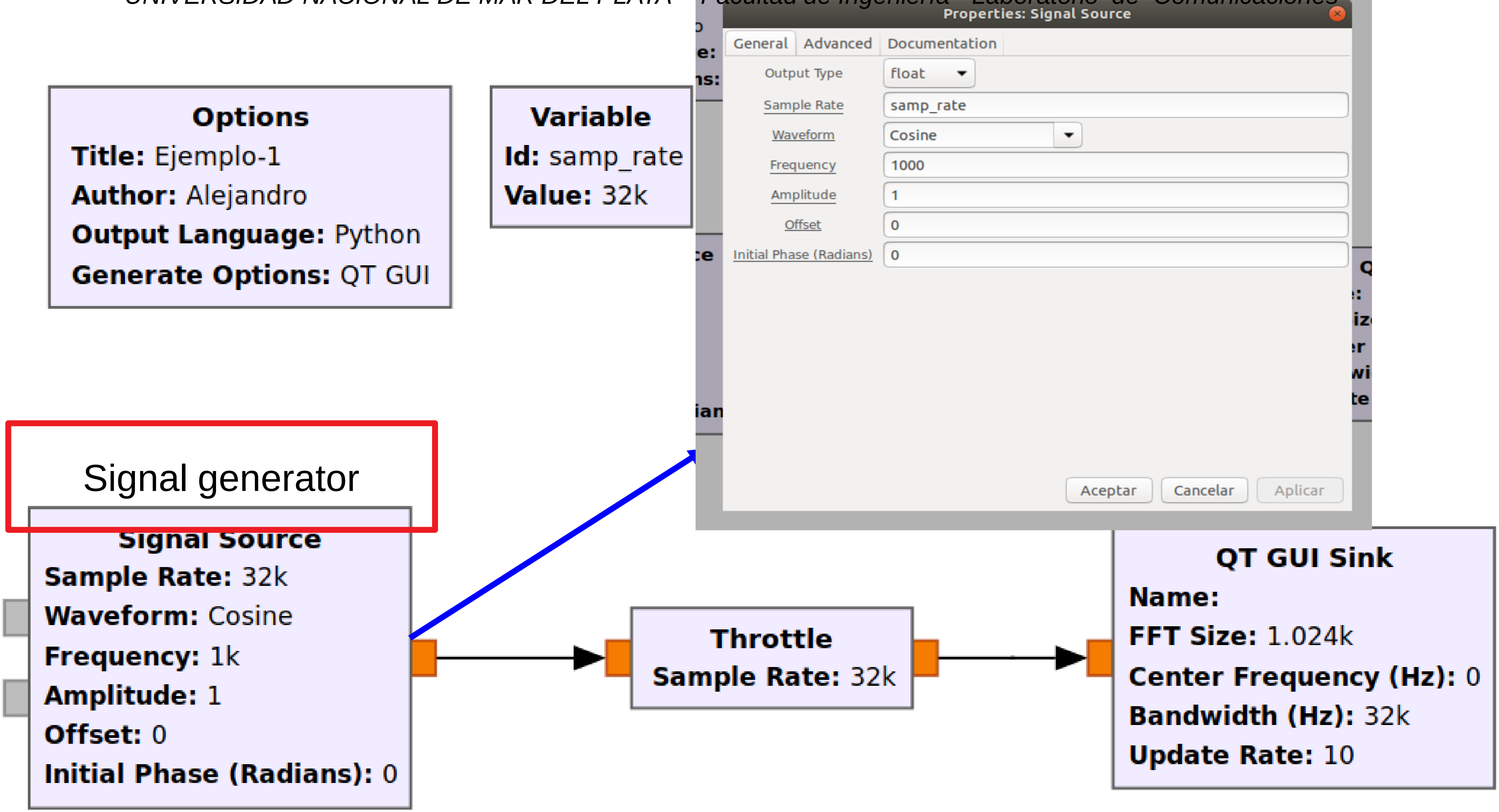

Options
Title: Ejemplo-1
Author: Alejandro
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

Signal generator

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

Properties: Signal Source

Output Type: float
Sample Rate: samp_rate
Waveform: Cosine
Frequency: 1000
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

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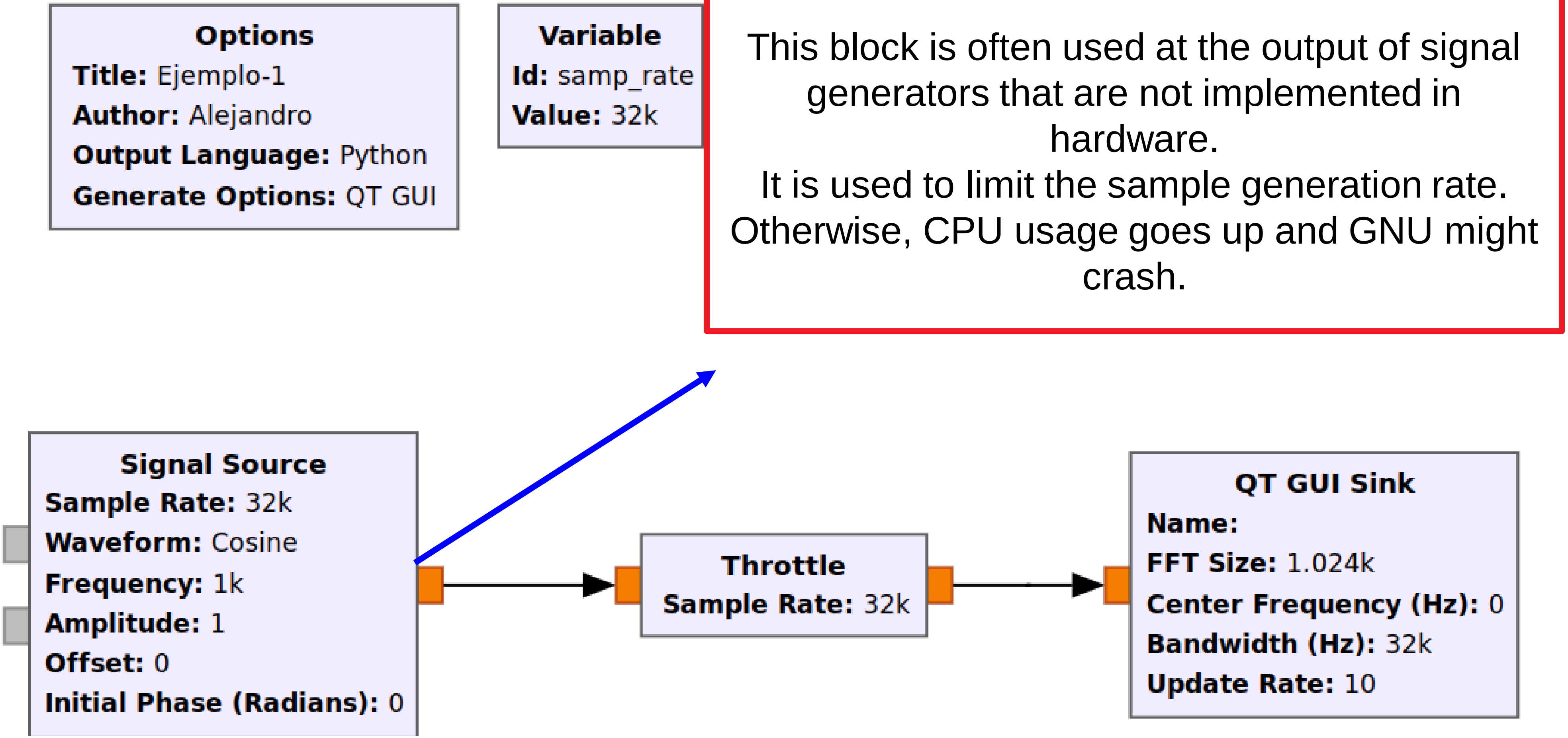

“THROTTLE” block

This block is often used at the output of signal generators that are not implemented in hardware.
It is used to limit the sample generation rate.
Otherwise, CPU usage goes up and GNU might crash.

Options
Title: Ejemplo-1
Author: Alejandro
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

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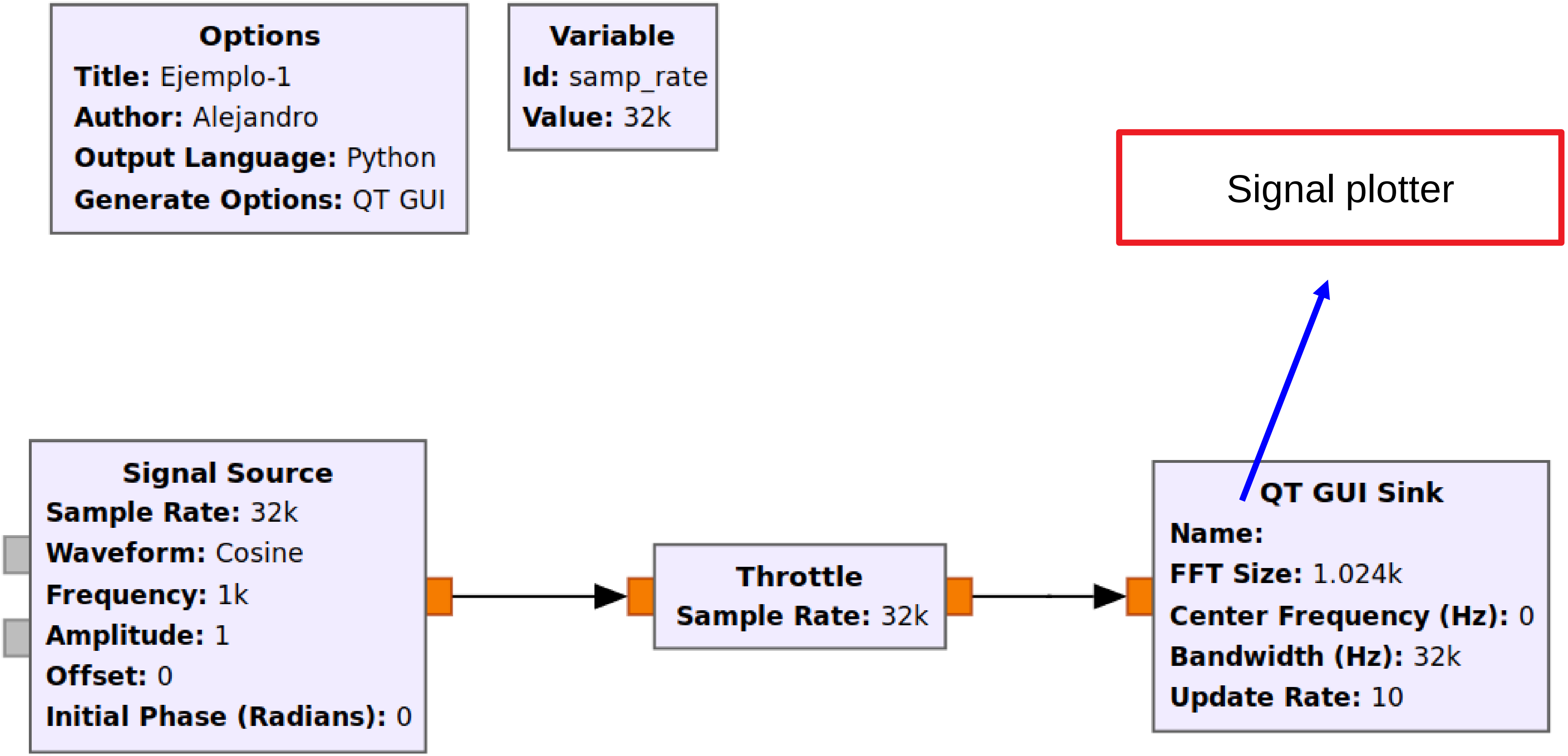

Options
Title: Ejemplo-1
Author: Alejandro
Output Language: Python
Generate Options: QT GUI

Variable
Id: samp_rate
Value: 32k

Signal Source
Sample Rate: 32k
Waveform: Cosine
Frequency: 1k
Amplitude: 1
Offset: 0
Initial Phase (Radians): 0

Throttle
Sample Rate: 32k

QT GUI Sink
Name:
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 32k
Update Rate: 10

Signal plotter

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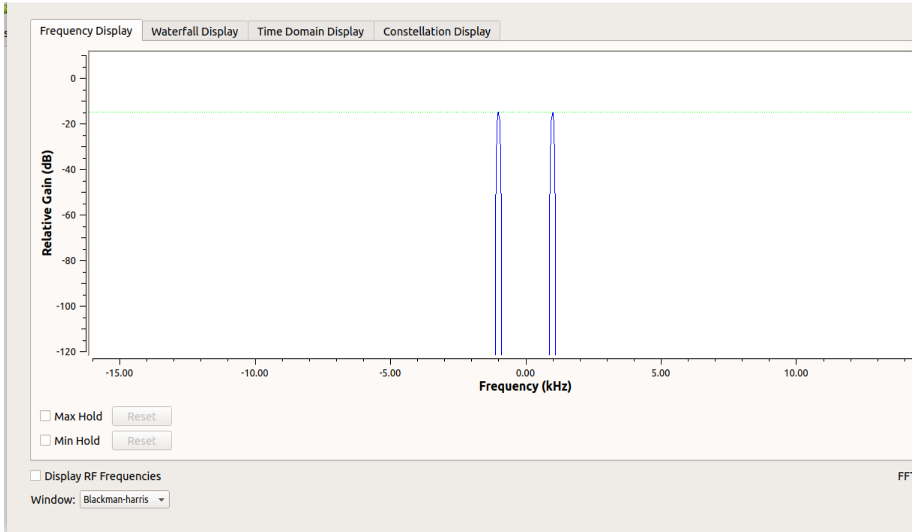
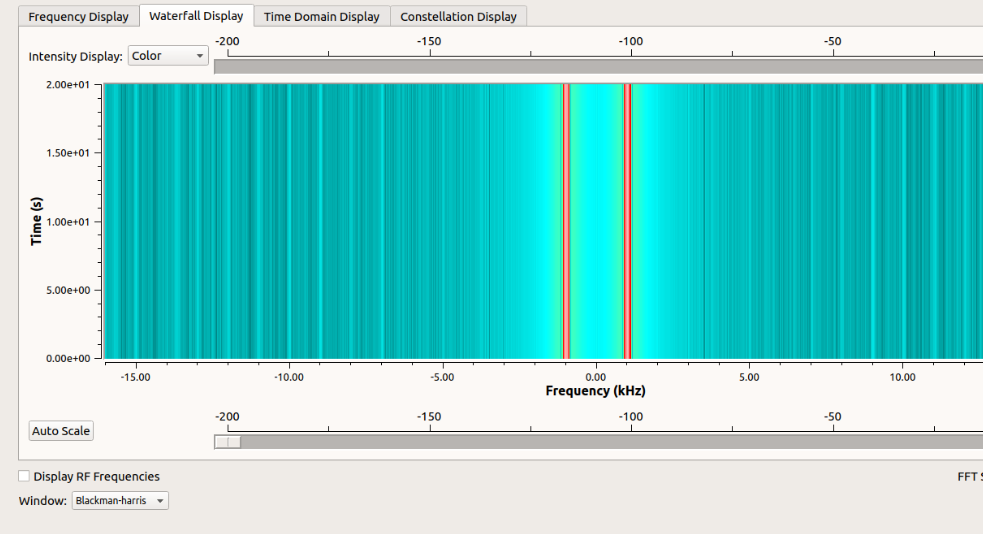


□ Max Hold

□ Min Hold

□ Display RF Frequencies

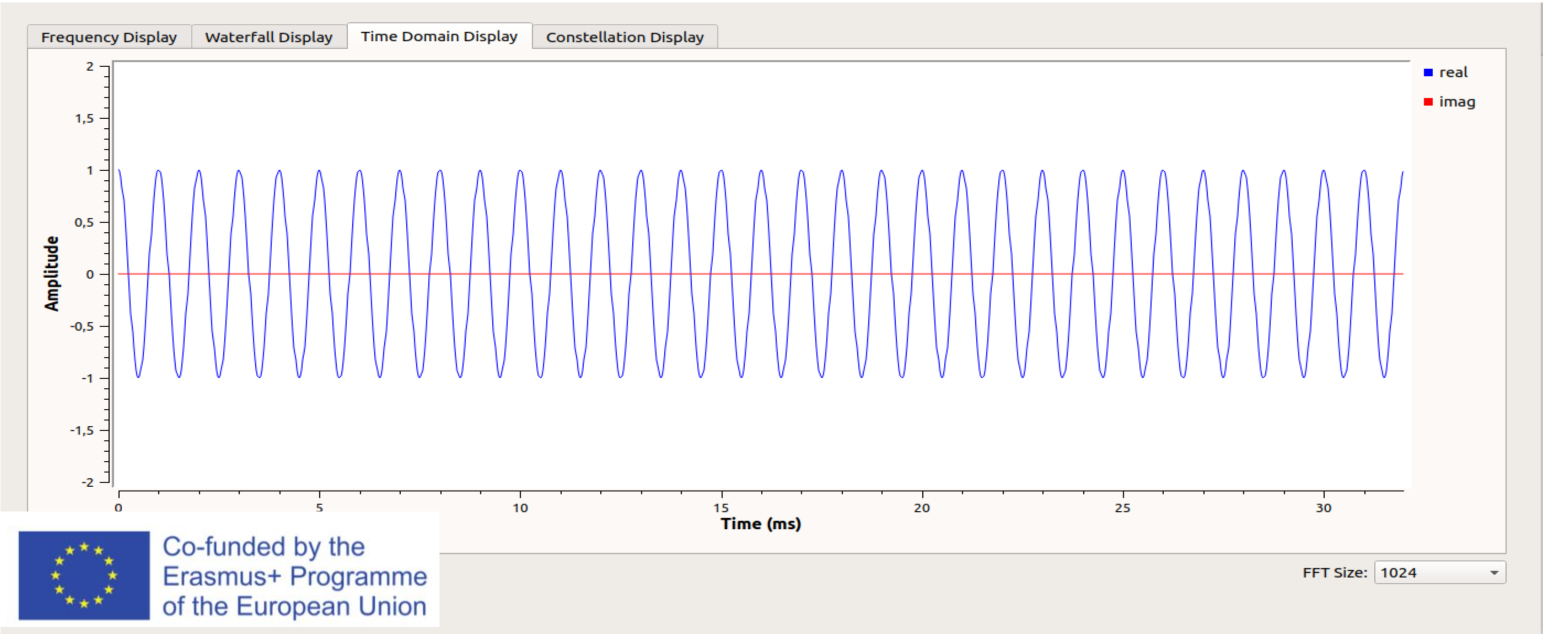
Window: Blackman-harris



Intensity Display: Color

□ Display RF Frequencies

Window: Blackman-harris



FFT Size: 1024

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