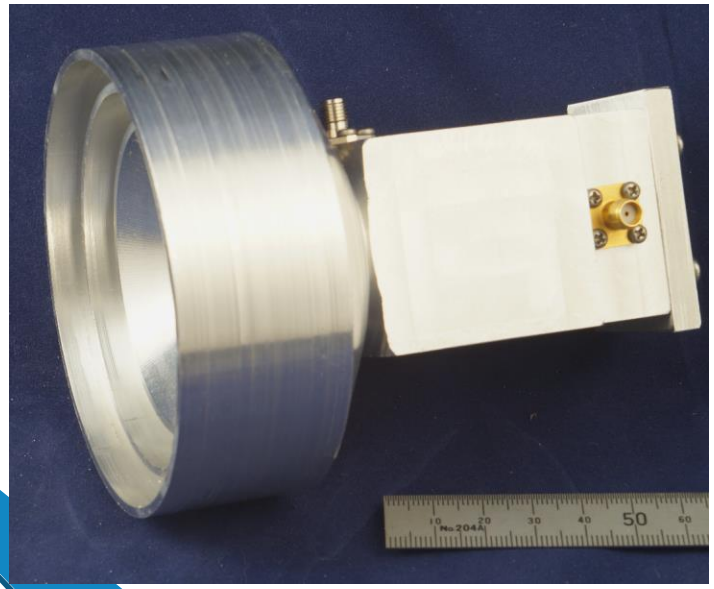
Phase 4 Ground! SDR and GNU Radio!

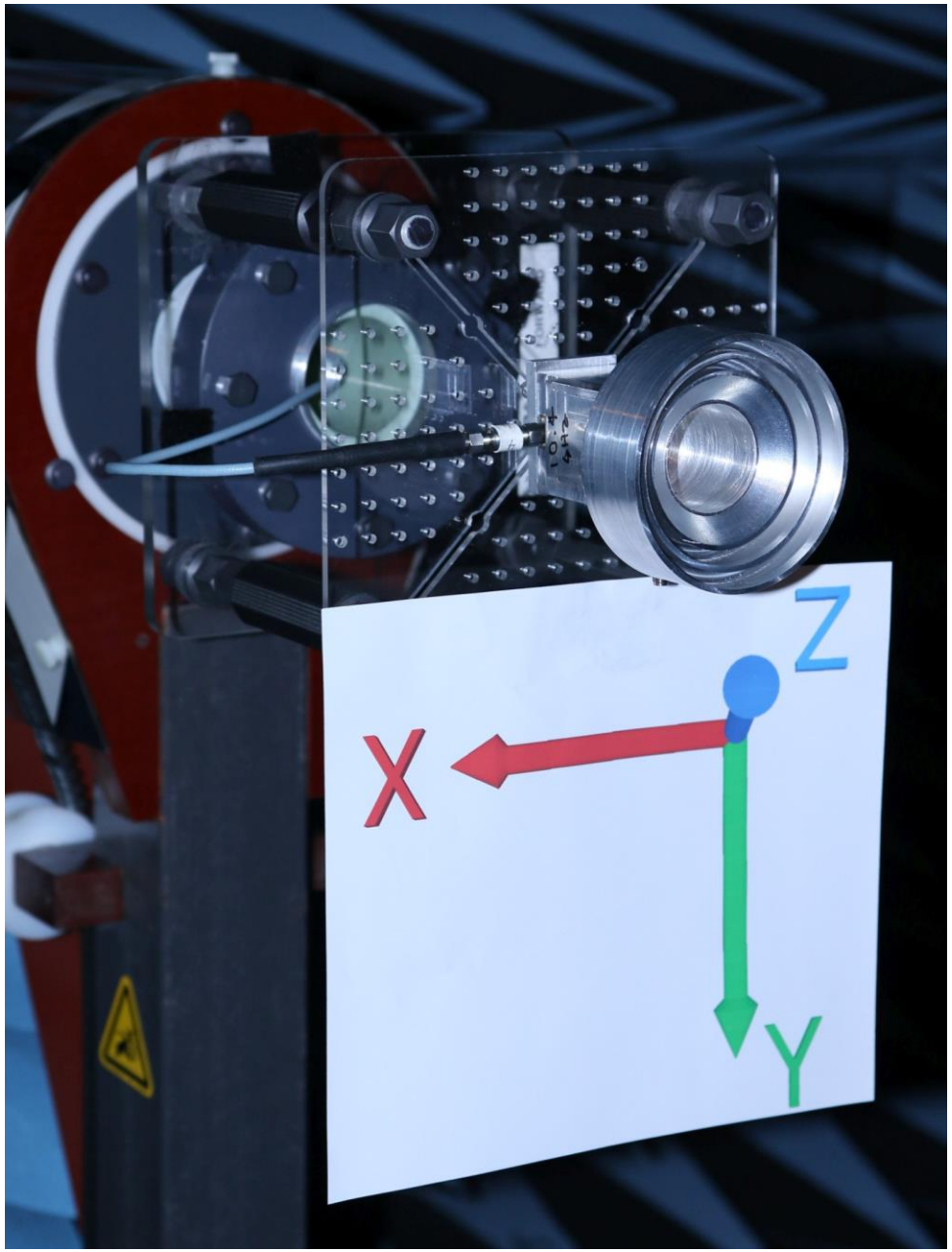
JAMSAT 2019

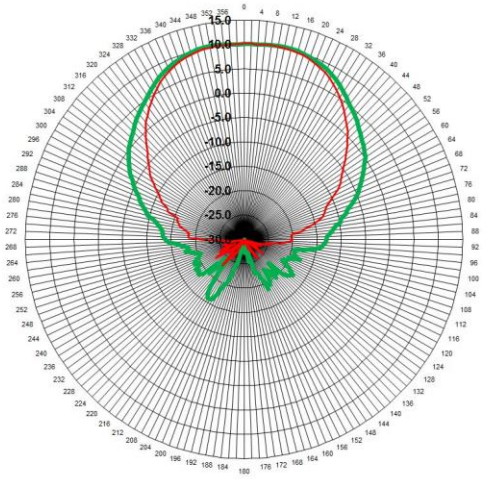
Definitions

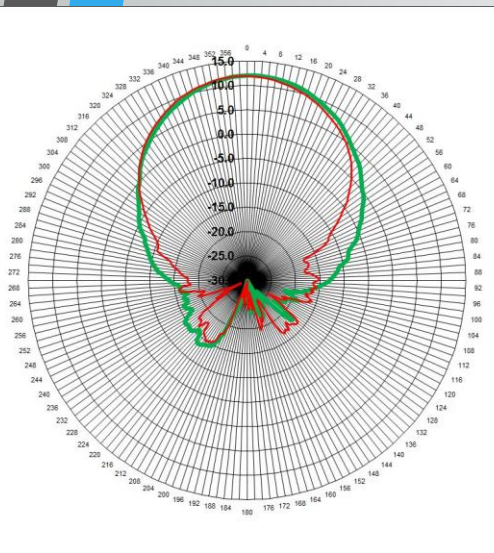
Phase 4 Ground

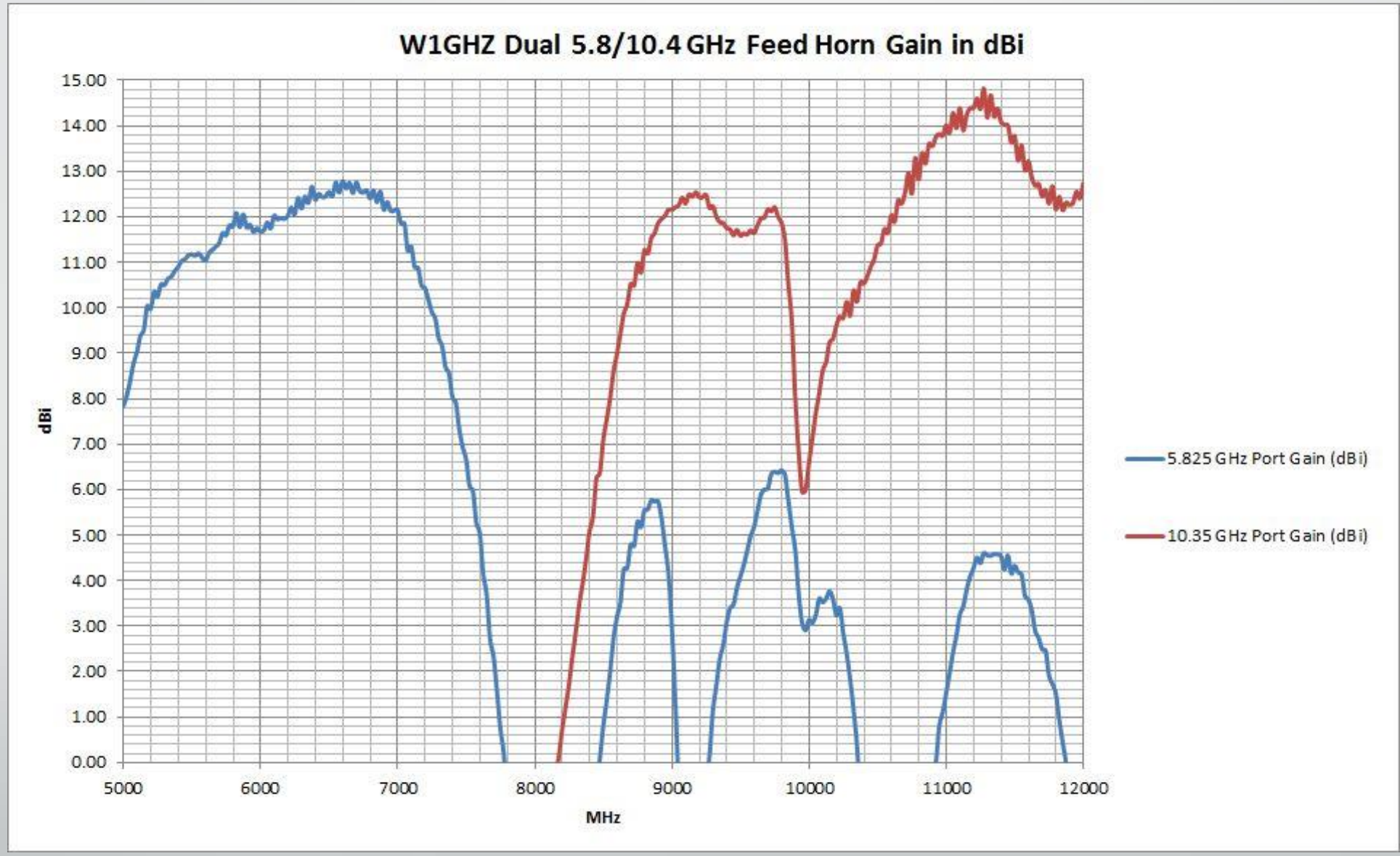
- **Open source** amateur radio project.
- Multi-user broadband digital microwave system for space (**GEO, HEO**) and **terrestrial** deployment.
- 5GHz channelized uplink. Many users! Up to 10Mhz.
- 10GHz **DVB-S2/X** single downlink. Up to 10Mhz.
- https://phase4ground.github.io/index.html
- Multiplexed signals allow any digital data including voice, text, and image. **GSE** is used, not **MPEG**.

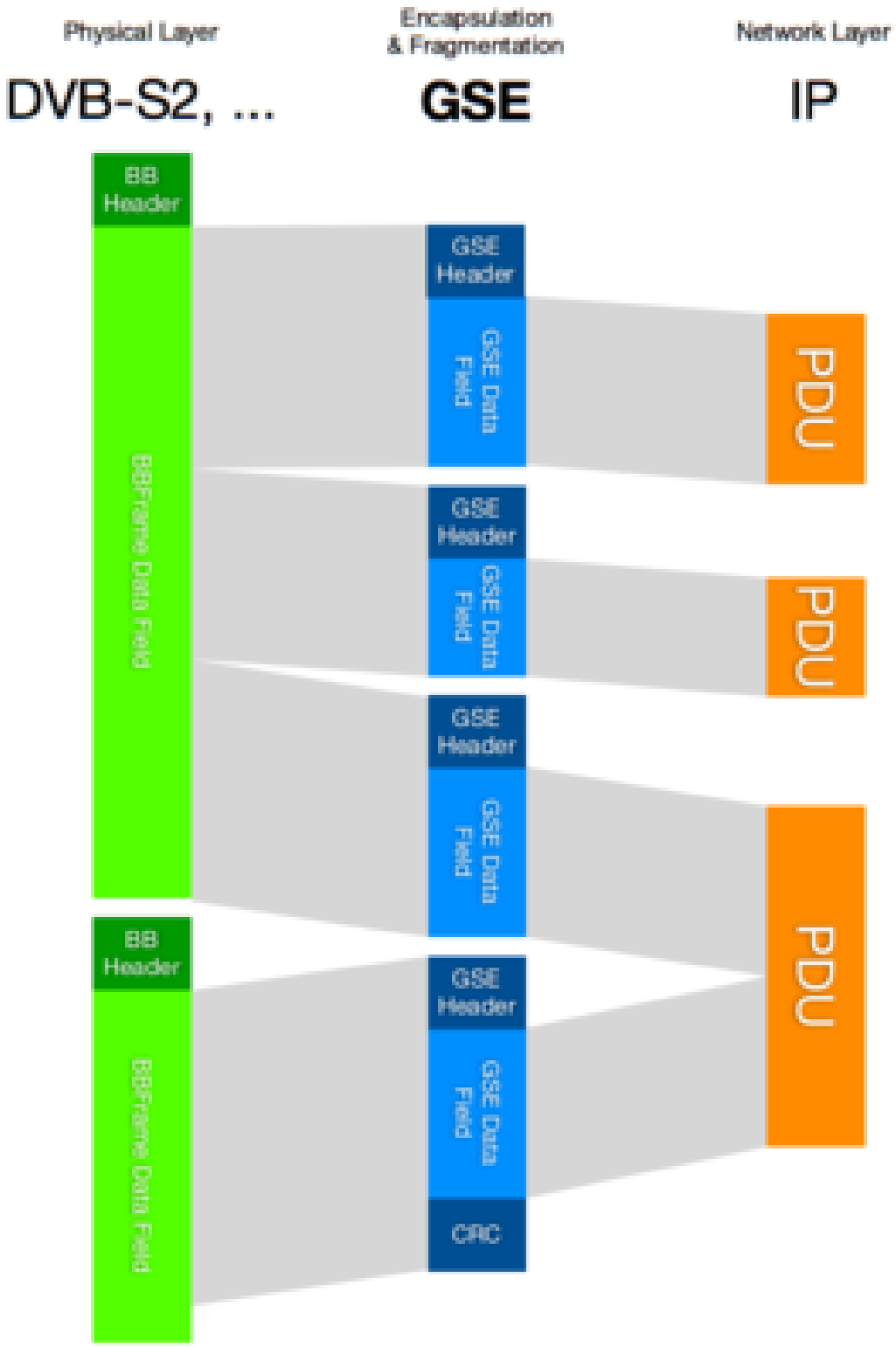


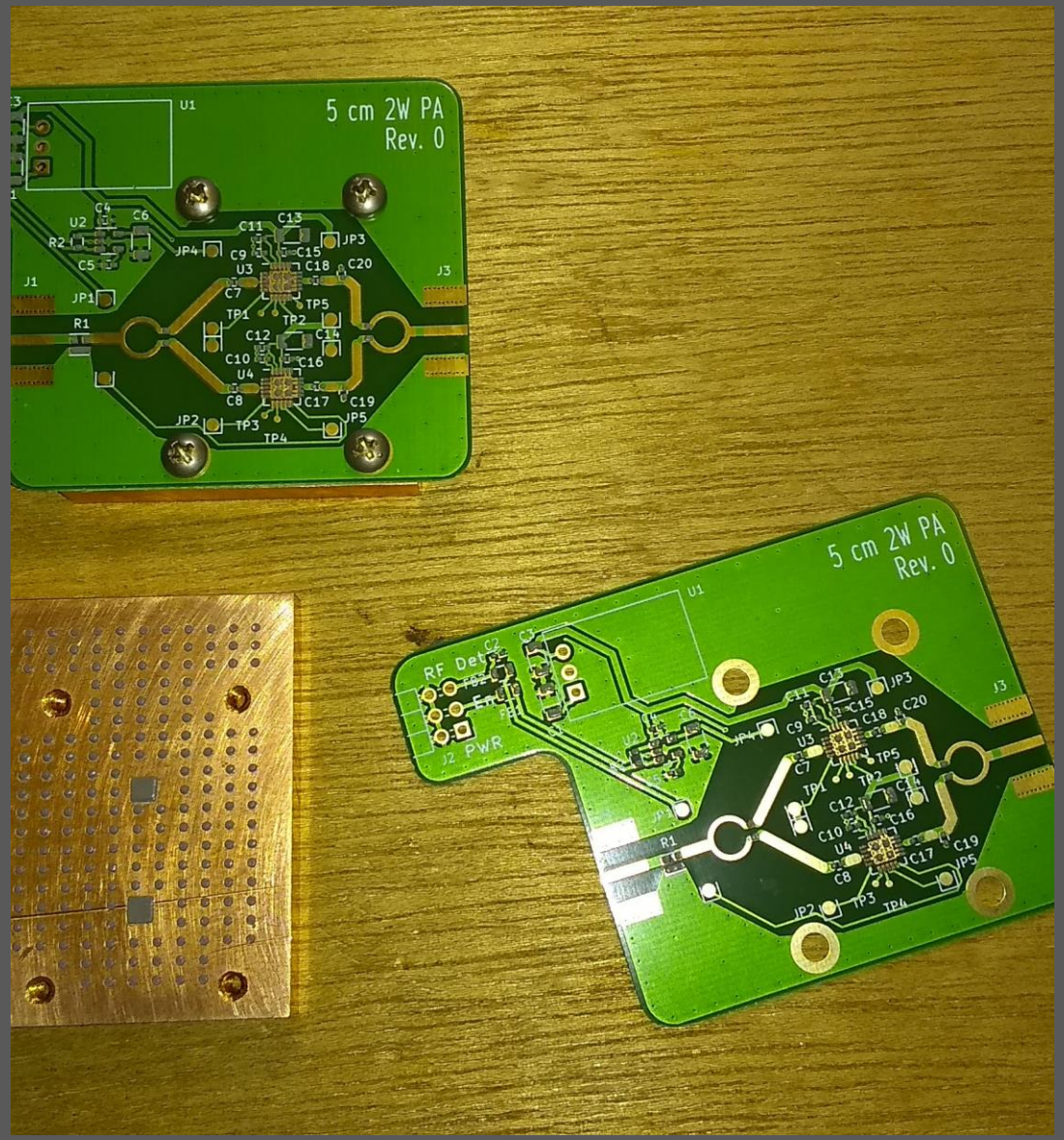

Z
X
Y

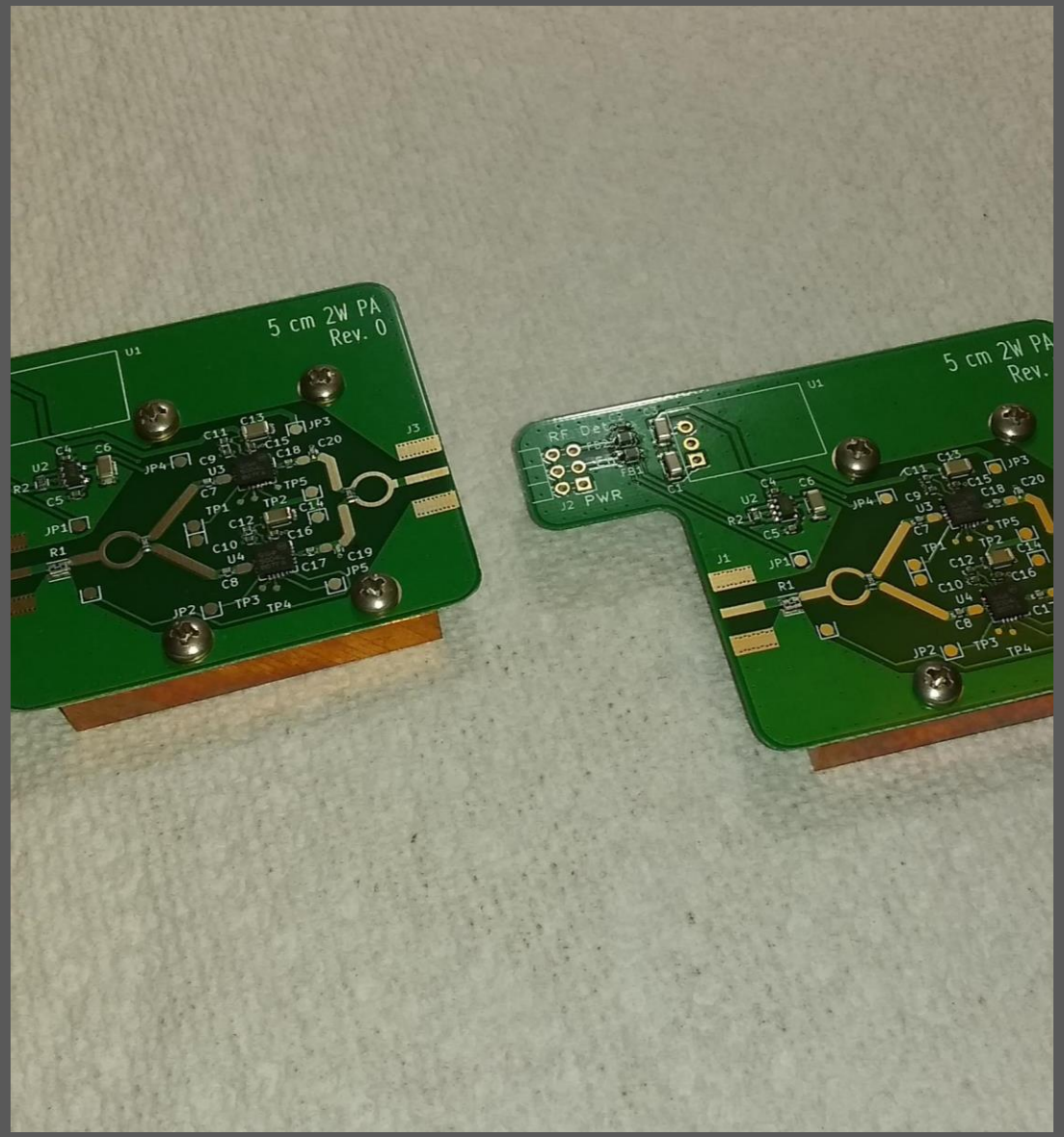





W1GHZ Dual 5.8/10.4 GHz Feed Horn Gain in dBi
dBi
15.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
5000
6000
7000
8000
9000
10000
11000
12000
MHz
5.825 GHz Port Gain (dBi)
10.35 GHz Port Gain (dBi)


Physical Layer
DVB-S2, ...
Encapsulation & Fragmentation
GSE
Network Layer
IP
BB Header
BBFrame Data Field
BB Header
BBFrame Data Field
GSE Header
GSE Data Field
GSE Header
GSE Data Field
GSE Header
GSE Data Field
GSE Header
GSE Data Field
CRC
PDU
PDU
PDU


5 cm 2W PA
Rev. 0
U1
U2
U3
U4
J1
J2 PWR
J3
JP1
JP2
JP3
JP4
JP5
R1
R2
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
TP1
TP2
TP3
TP4
TP5
RF Det


5 cm 2W PA
Rev. 0
U1
J1
J2 PWR
J3
JP1
JP2
JP3
JP4
JP5
R1
R2
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
TP1
TP2
TP3
TP4
TP5
RF Det

GNU Radio

- **Free and open source** digital signal processing framework for software-defined radio.
- http://gnuradio.org
- Inputs, outputs, filters, functions, displays, and more.
- Used by hobbyists, researchers, companies, governments, schools, and hams.

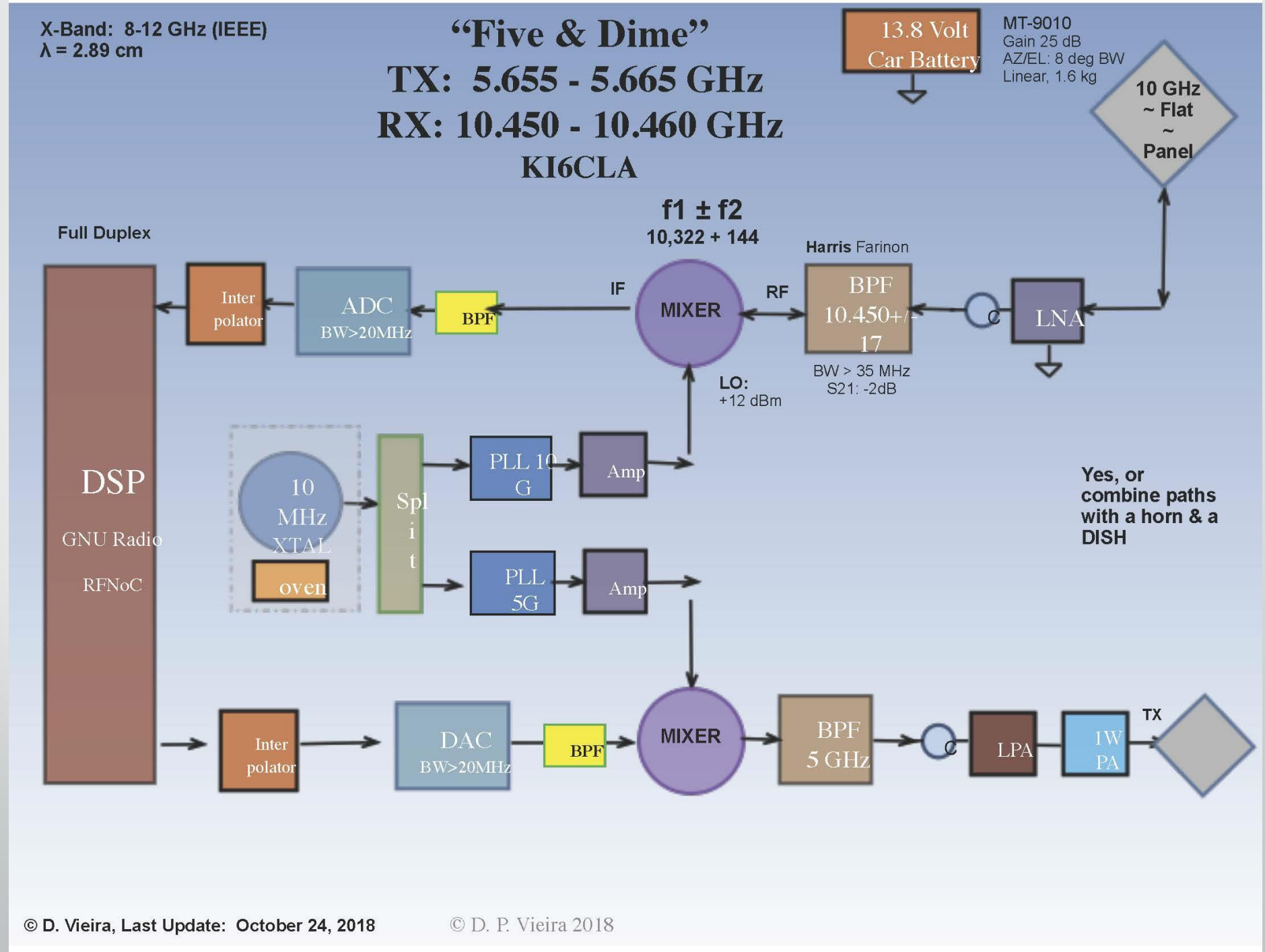
GNU Radio Conference

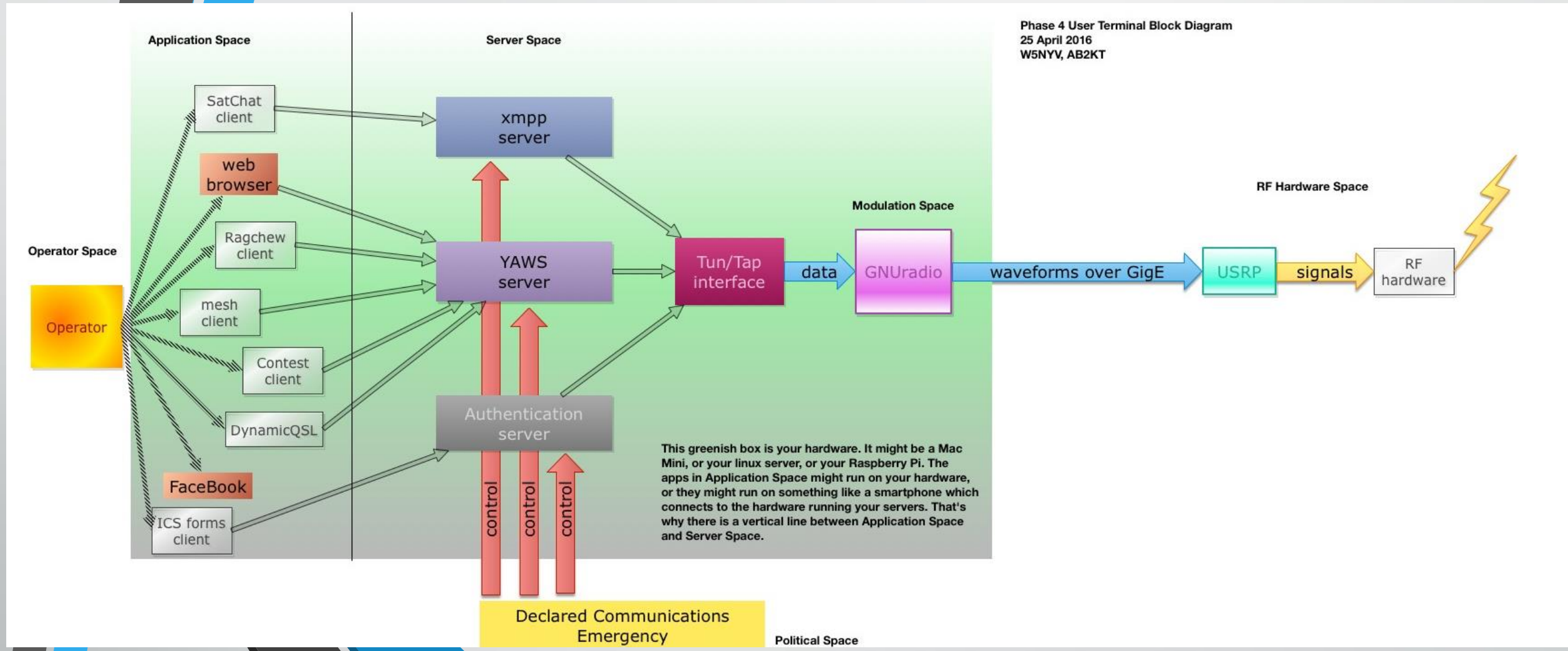
- Huntsville, Alabama, USA 16-20 September 2019
- 2019 has a Space and Amateur Radio Theme!
- Please consider submitting a paper for the proceedings or a poster for the poster session.
- If you can attend, please consider submitting a presentation!
- I am the co-chair for 2019 and will help you participate.

Software Defined Radio

- SDR = some number of radio functions are controlled by **software**.
- Flexibility at the cost of complexity and power consumption.
- Signals digitized as soon as possible and DSP functions done in a GPP or an FPGA or a GPU.

- Phase 4 Ground uses SDRs and GNU Radio for research and development.
- GNU Radio is the home of our reference designs, so that others can build our radio system.
- GNU Radio is both **tool** and **archive.**





User Terminal Block Diagram

How do we build something in GNU Radio?

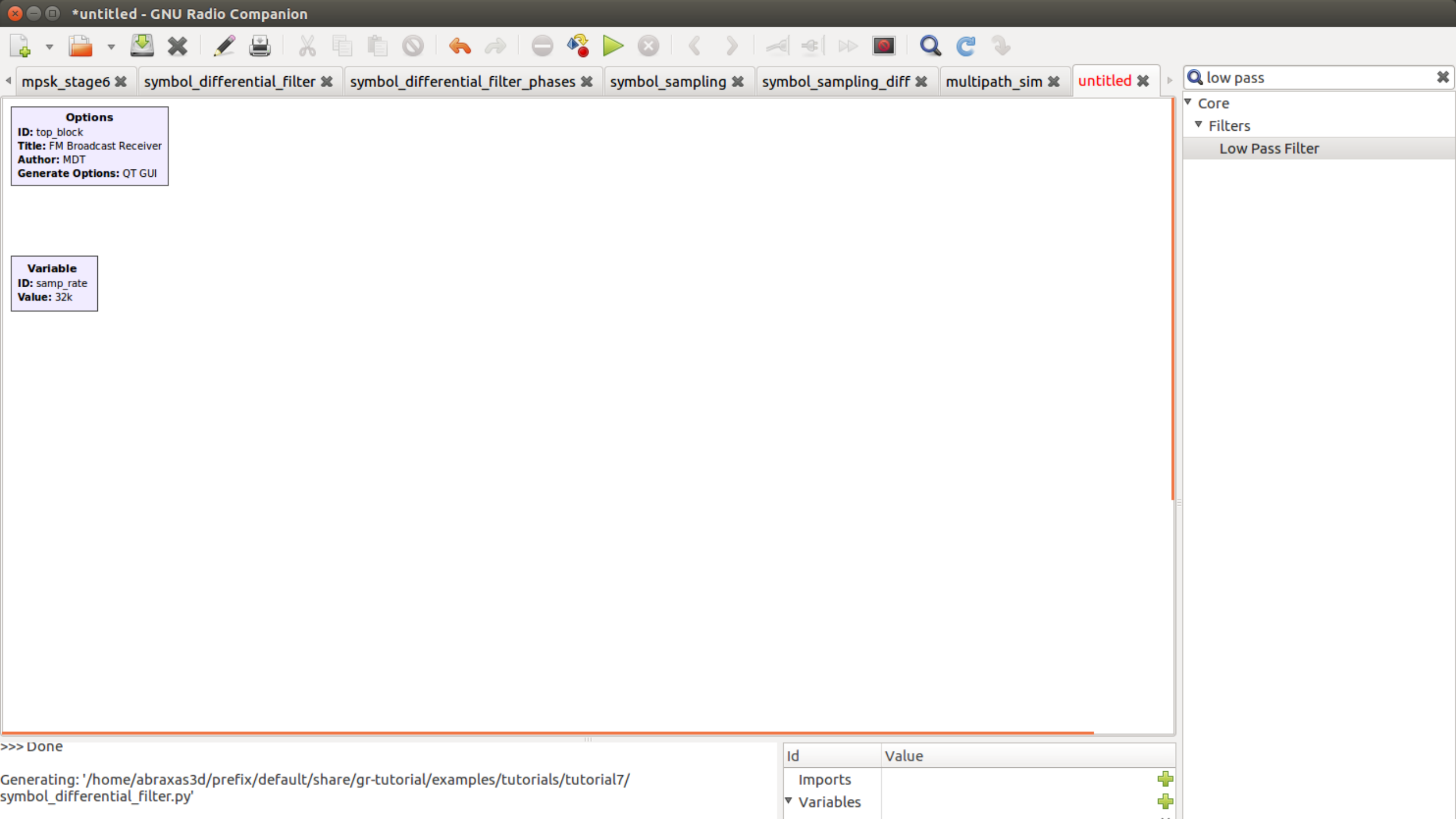
Why is this so great?

Let's build a radio with an RTL-SDR!

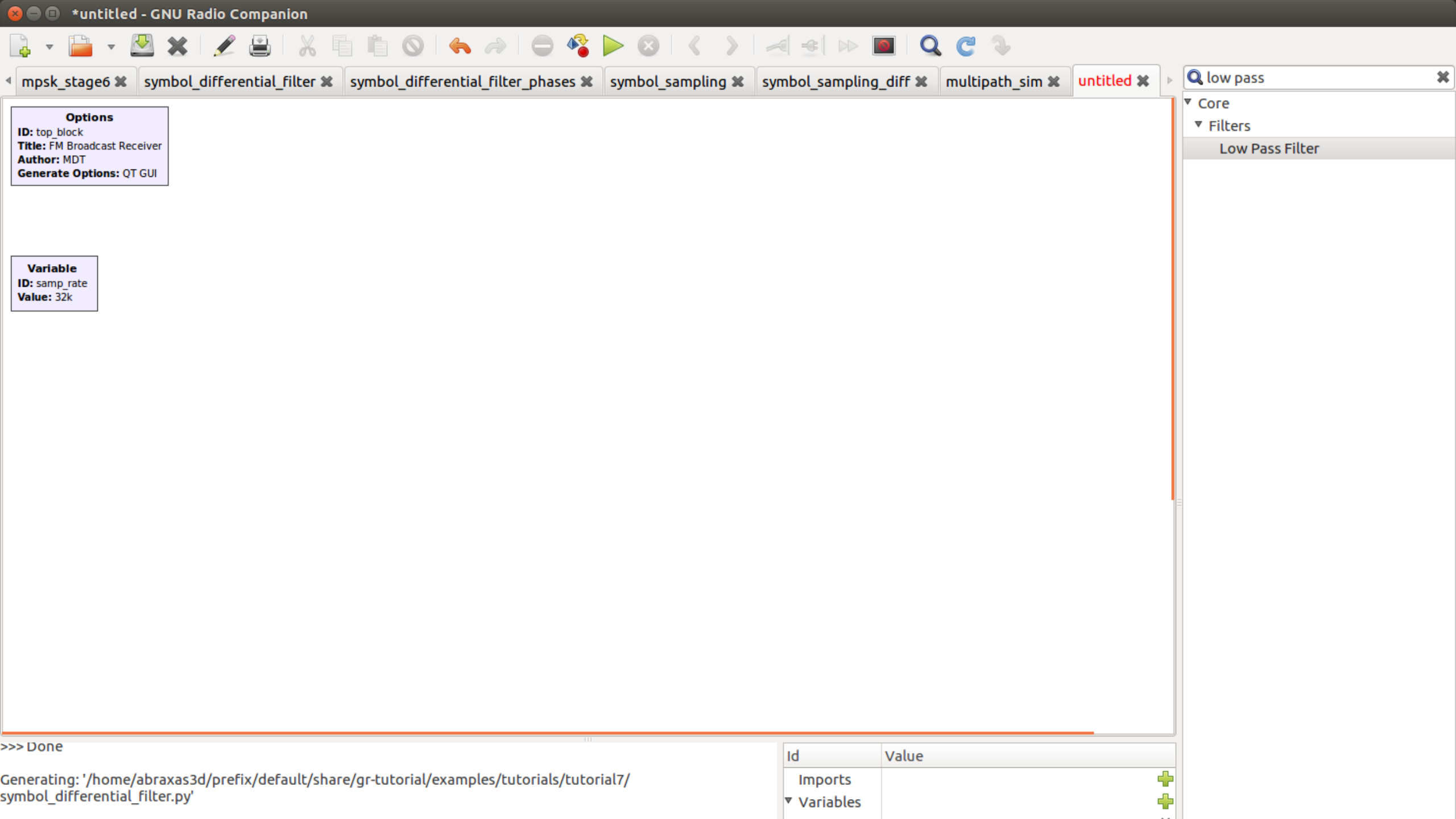
- RTL-SDR is a very inexpensive receive-only software-defined radio.
- 24MHz to about 2GHz coverage with a 2.4MHz bandwidth.
- $25-$40! USB dongle.
- SMA connectors and bias tees available.
- Lots of software available! **Works with GNU Radio.**

1. Install GNU Radio*
2. file – new

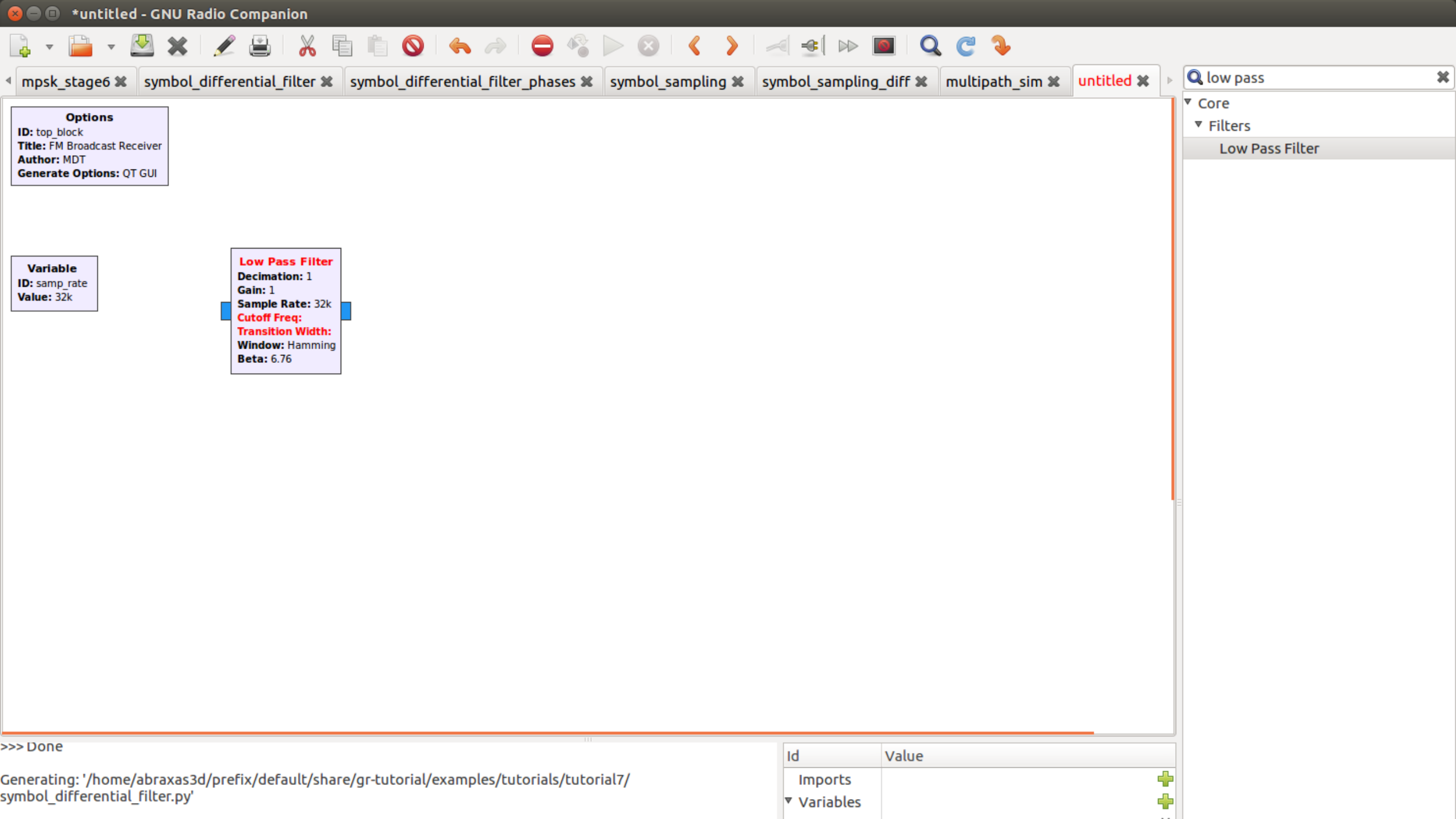
What do we see?

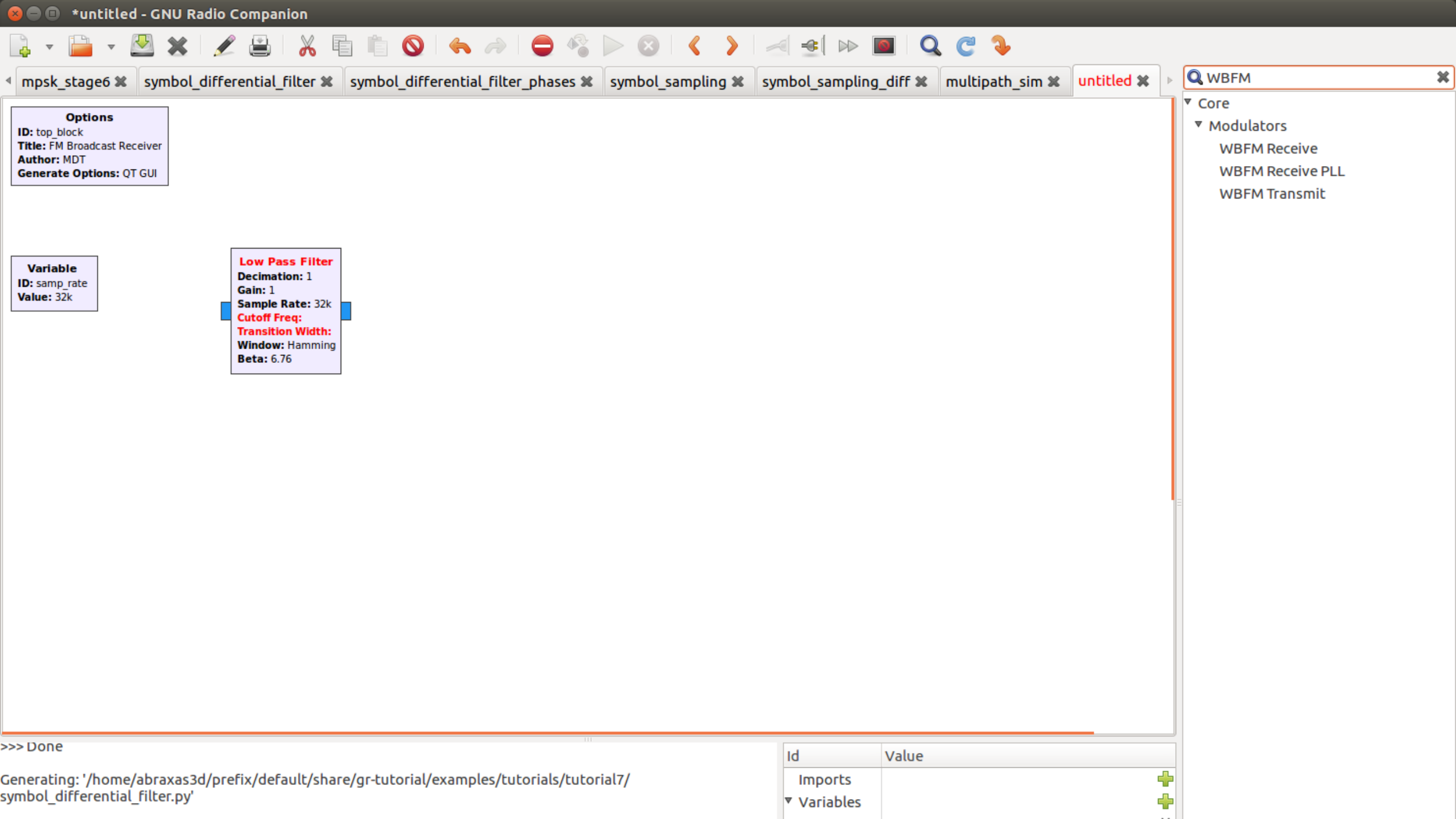

*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
low pass
Core
Filters
Low Pass Filter
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/
symbol_differential_filter.py'
Id
Value
Imports
Variables

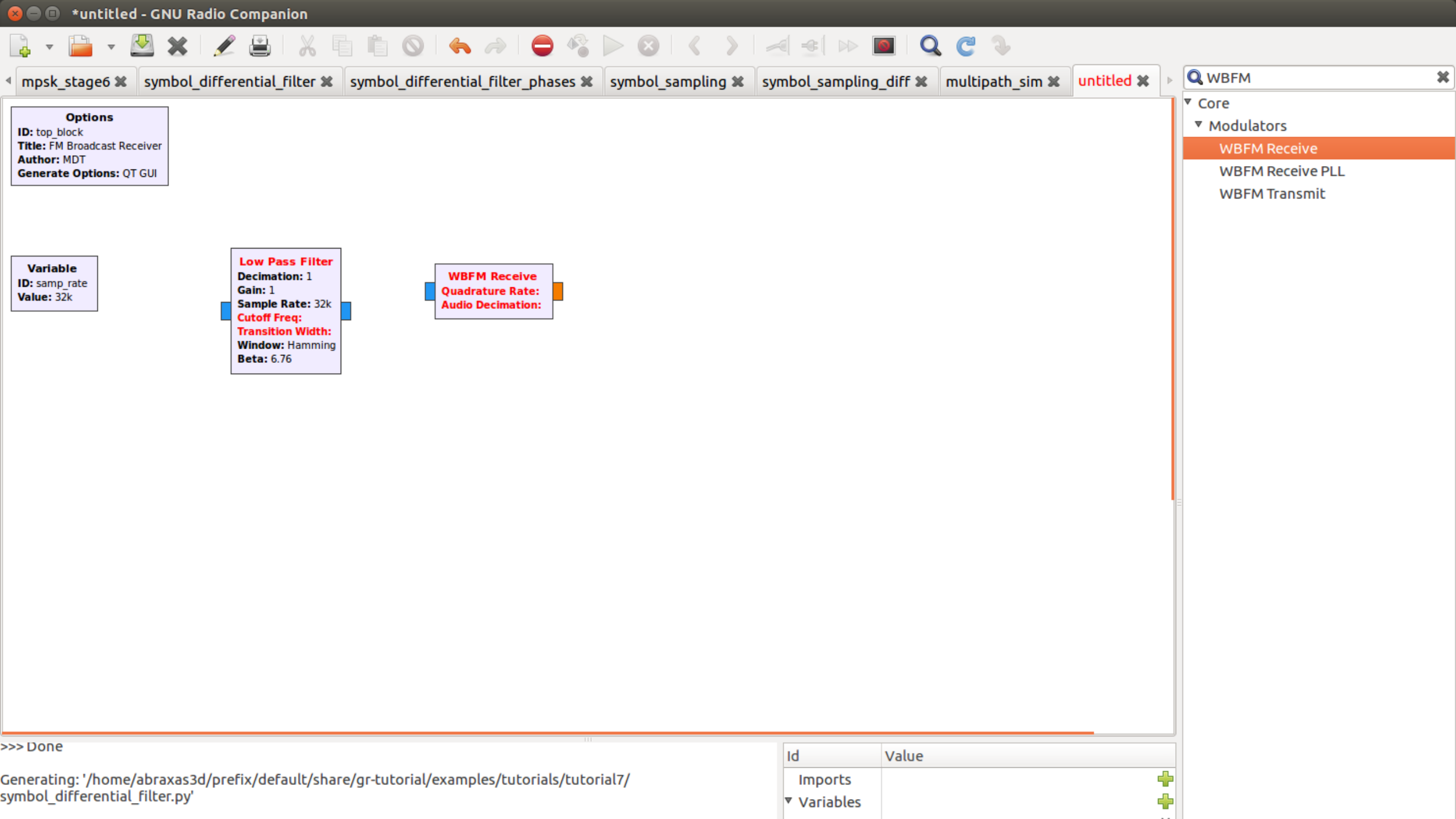
What do we have?
Two required blocks, a canvas, a console, menu functions across the top, a block search bar, and block search results.

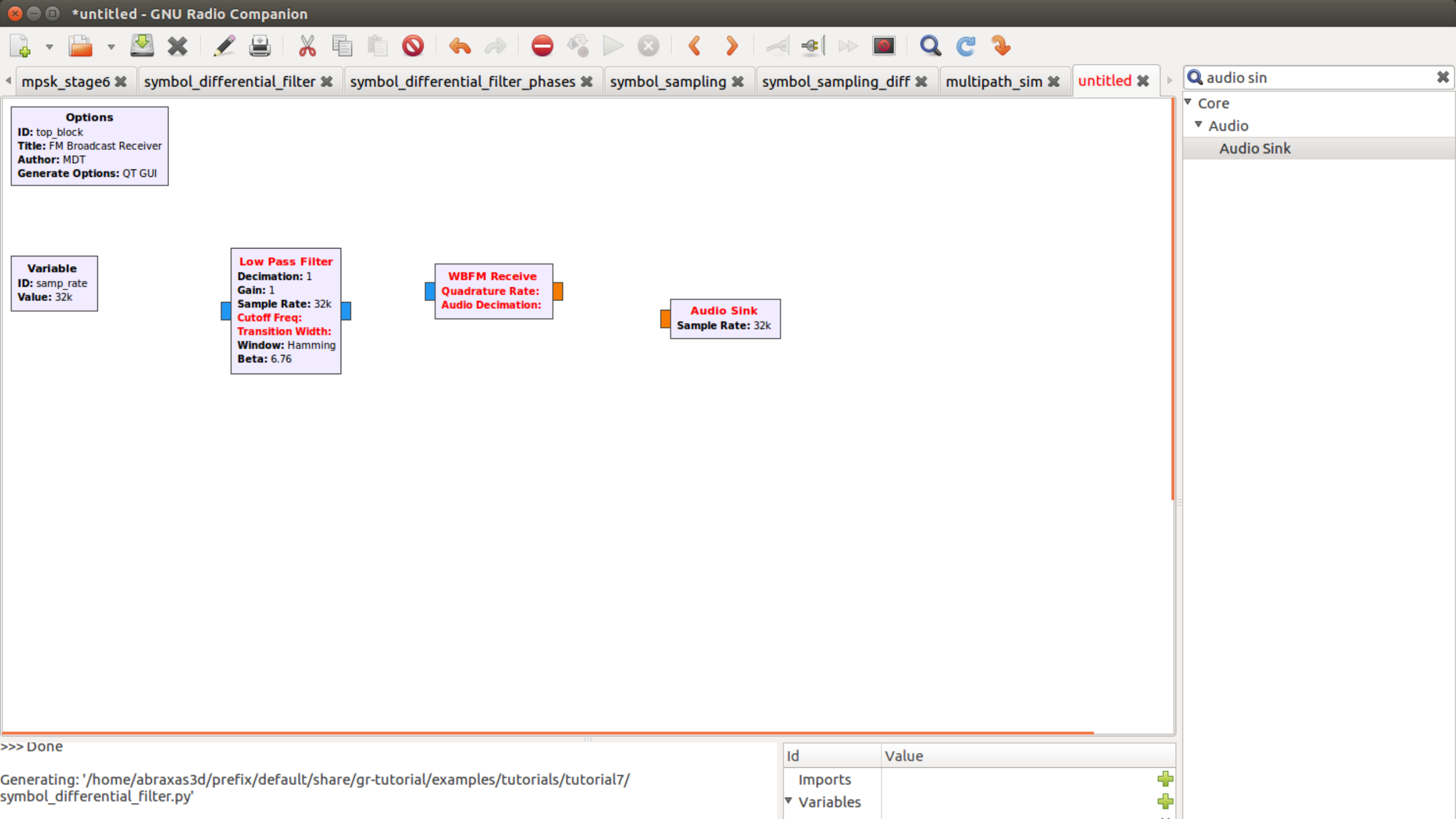

*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
low pass
Core
Filters
Low Pass Filter
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/
symbol_differential_filter.py'
Id
Value
Imports
Variables

Let's make an FM broadcast receiver. We need a signal source, a low pass filter, a wideband FM demodulator, and audio output.


*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 32k
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
low pass
Core
Filters
Low Pass Filter
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_differential_filter.py'
Id
Value
Imports
Variables


*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 32k
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
WBFM
Core
Modulators
WBFM Receive
WBFM Receive PLL
WBFM Transmit
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_differential_filter.py'
Id
Value
Imports
Variables


*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 32k
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate:
Audio Decimation:
WBFM
Core
Modulators
WBFM Receive
WBFM Receive PLL
WBFM Transmit
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_differential_filter.py'
Id
Value
Imports
Variables

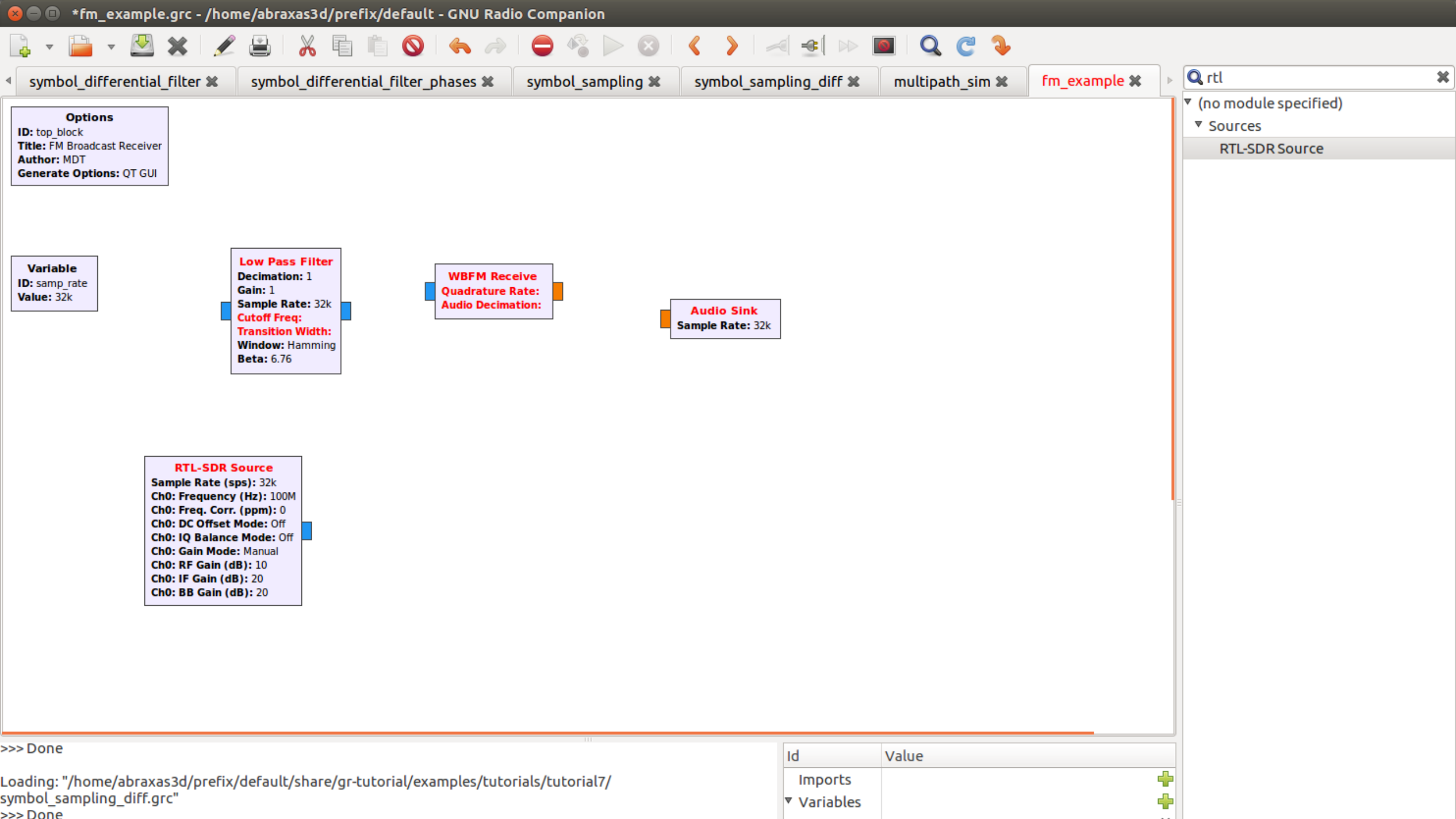

*untitled - GNU Radio Companion
mpsk_stage6
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
untitled
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 32k
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate:
Audio Decimation:
Audio Sink
Sample Rate: 32k
audio sin
Core
Audio
Audio Sink
>>> Done
Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_differential_filter.py'
Id
Value
Imports
Variables

Now we have our basic blocks!

What about our signal source?

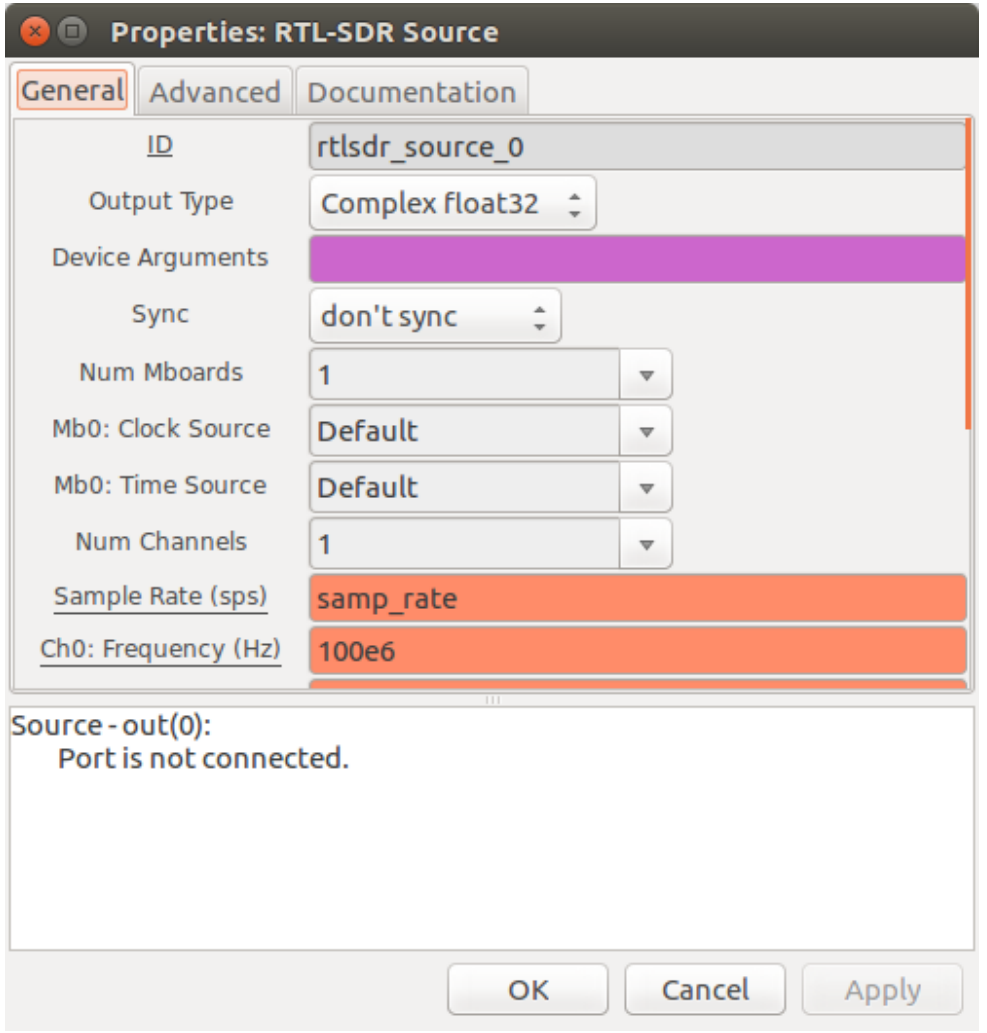
Source blocks!

There are a variety of SDR source blocks in GNU Radio.

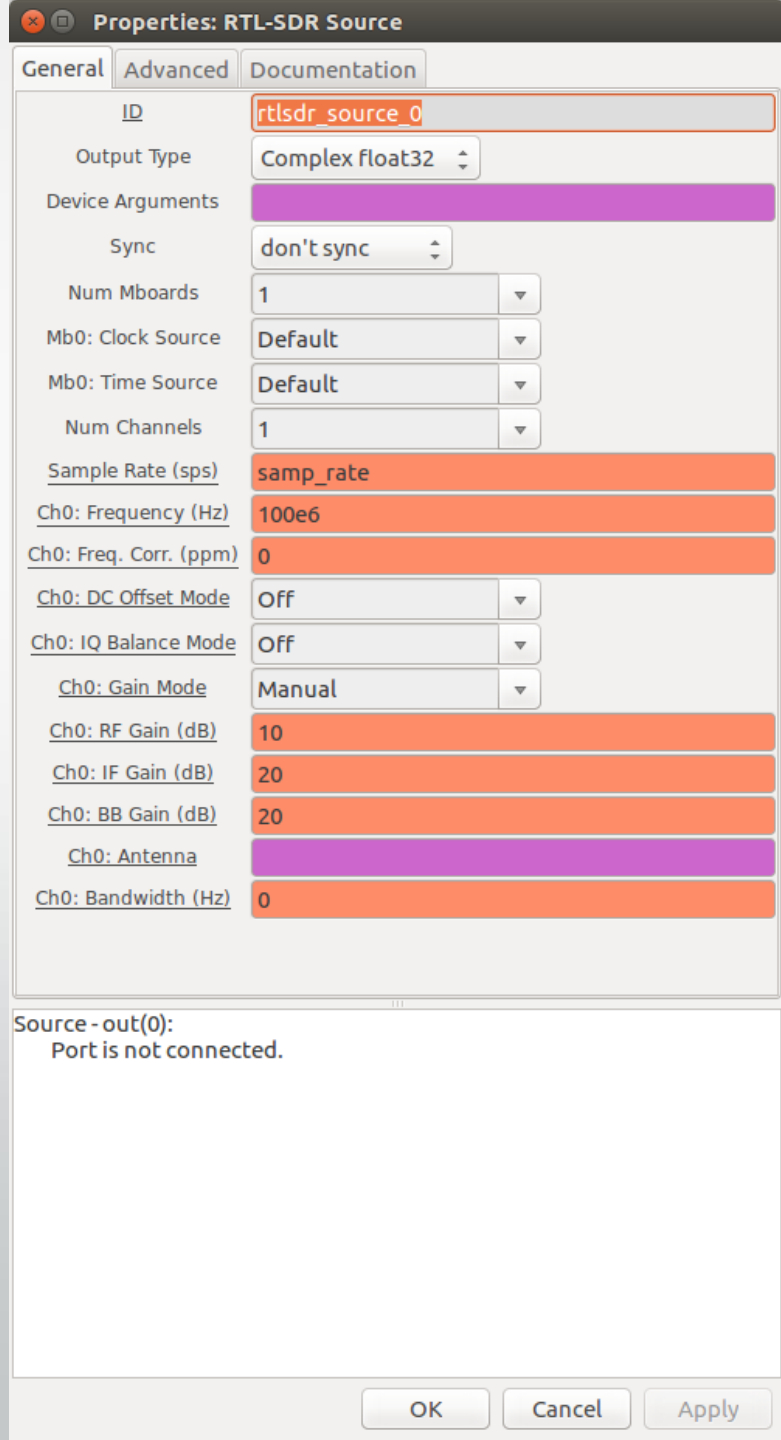

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 32k
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 32k
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate:
Audio Decimation:
Audio Sink
Sample Rate: 32k
RTL-SDR Source
Sample Rate (sps): 32k
Ch0: Frequency (Hz): 100M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
rtl
(no module specified)
Sources
RTL-SDR Source
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Id
Value
Imports
Variables

Click Click!

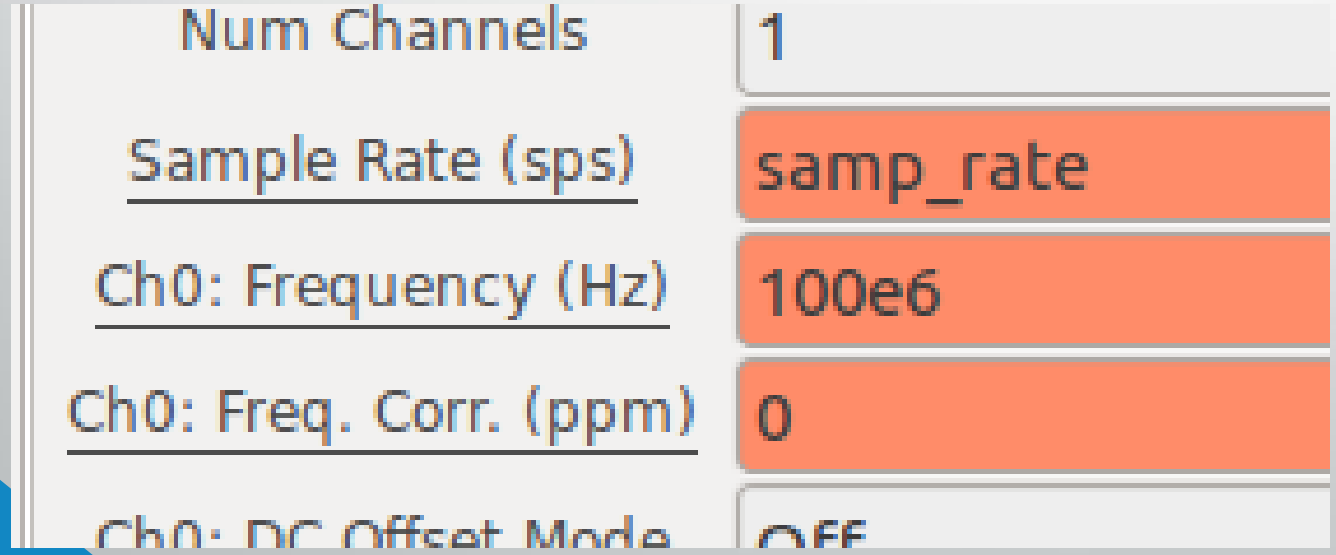
Click on a block to open a pop up for configuration and setttings.

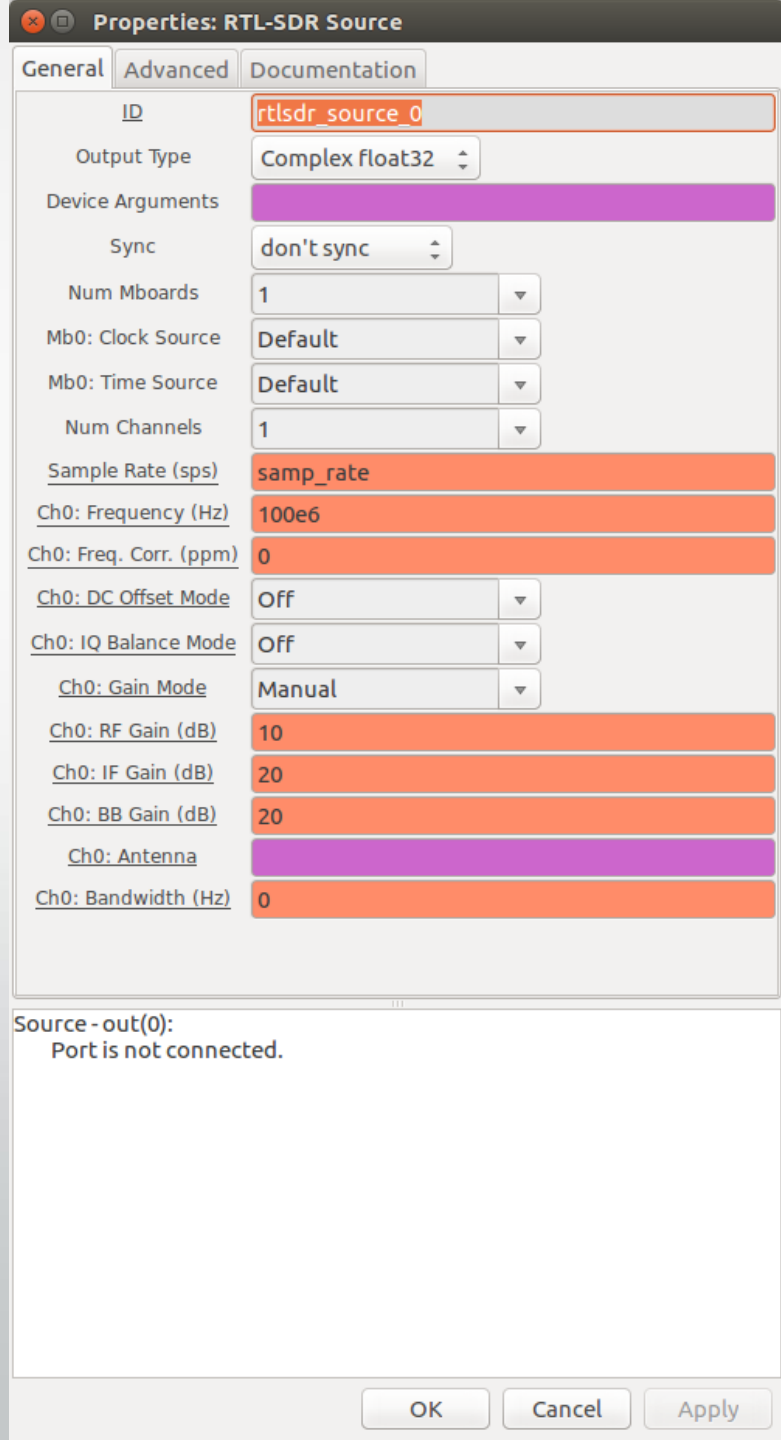


Set up your RTL-SDR Source Block from this pop-up.

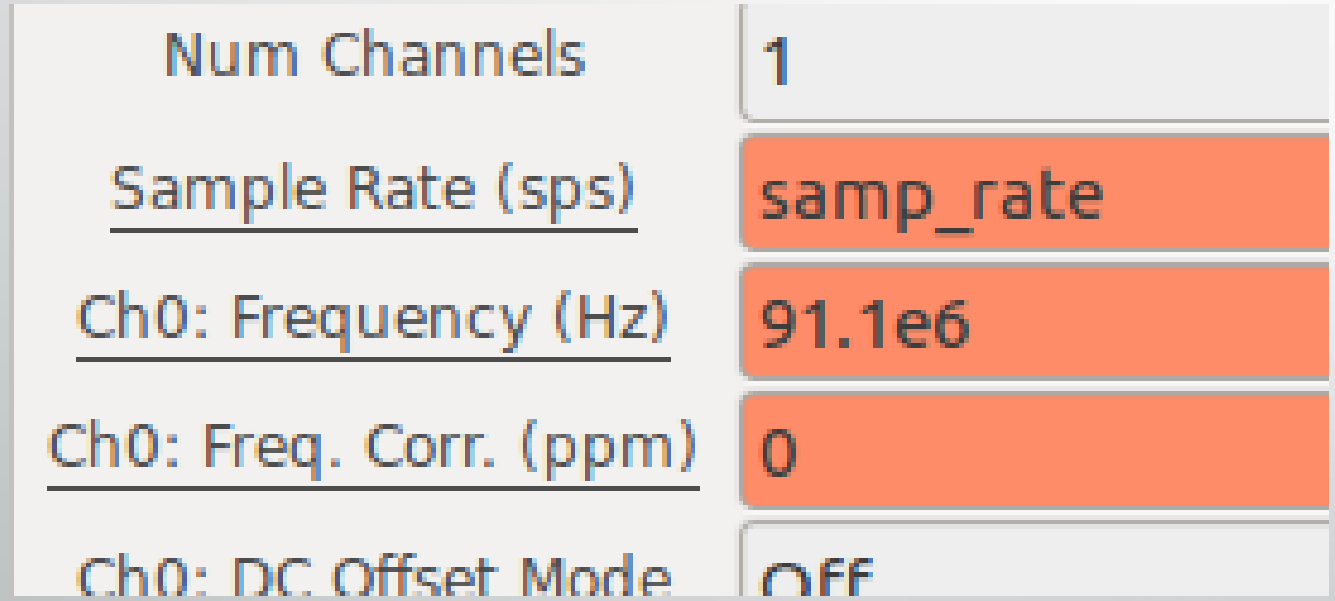


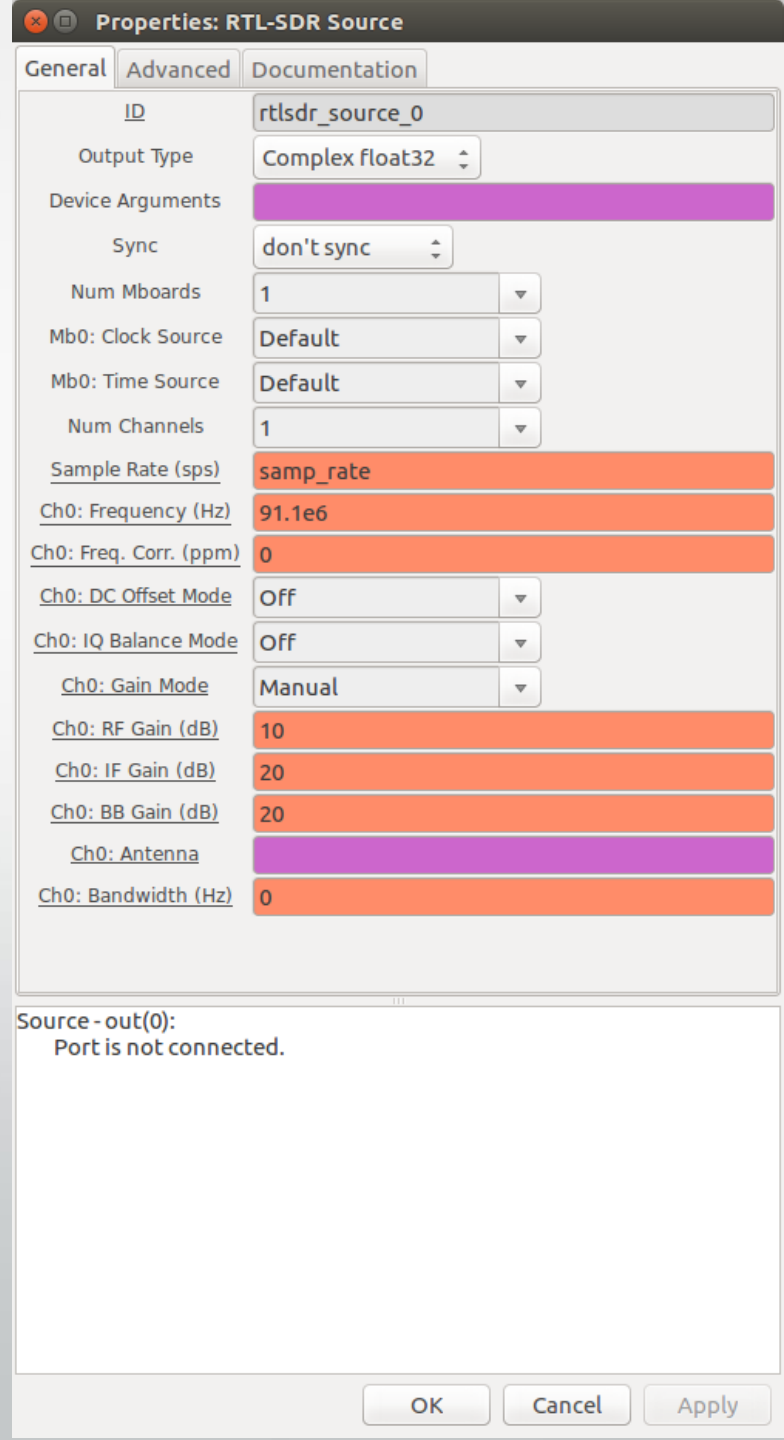
Set up your RTL-SDR Source Block from this pop-up.





Change the center Frequency.

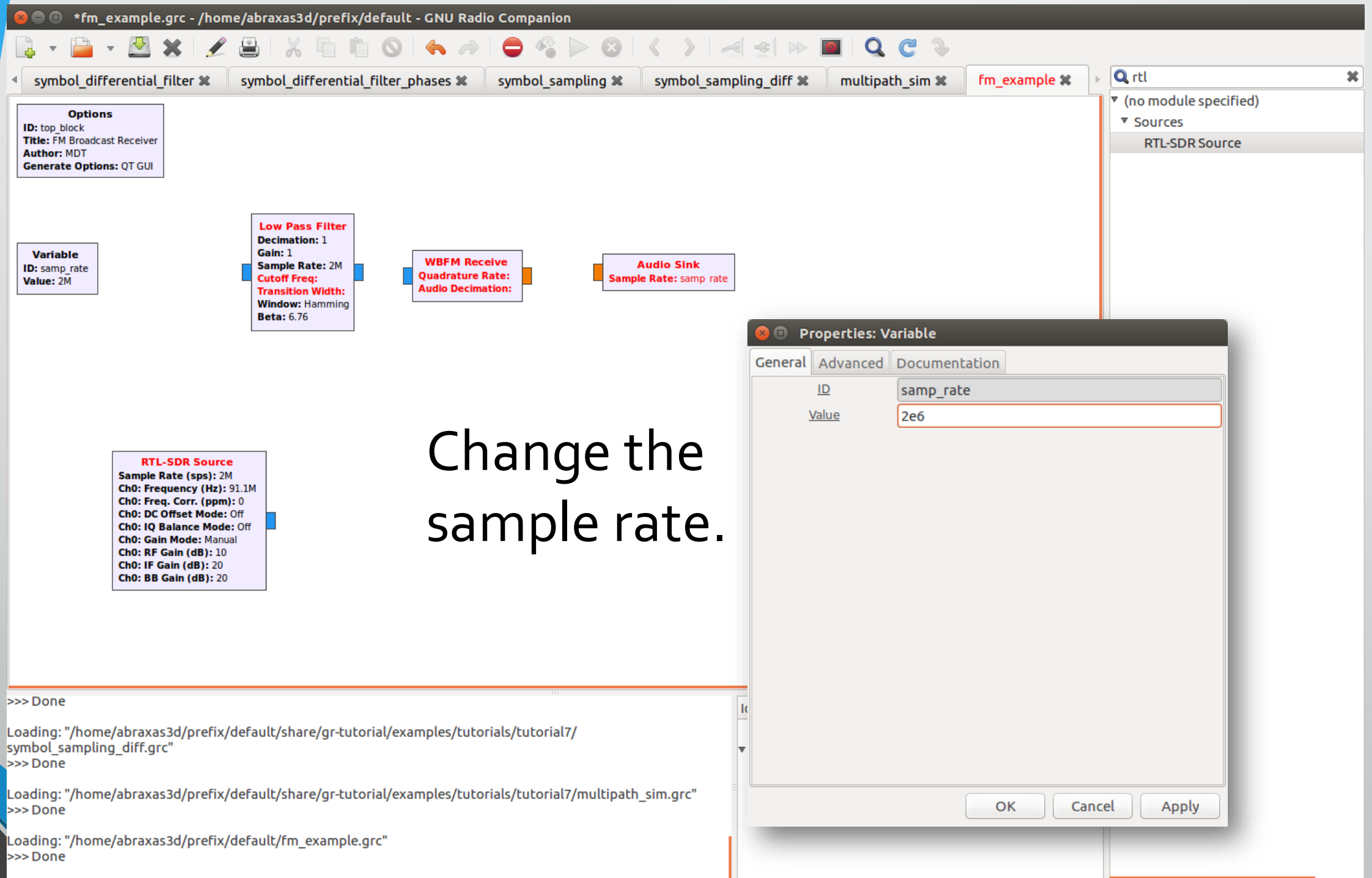




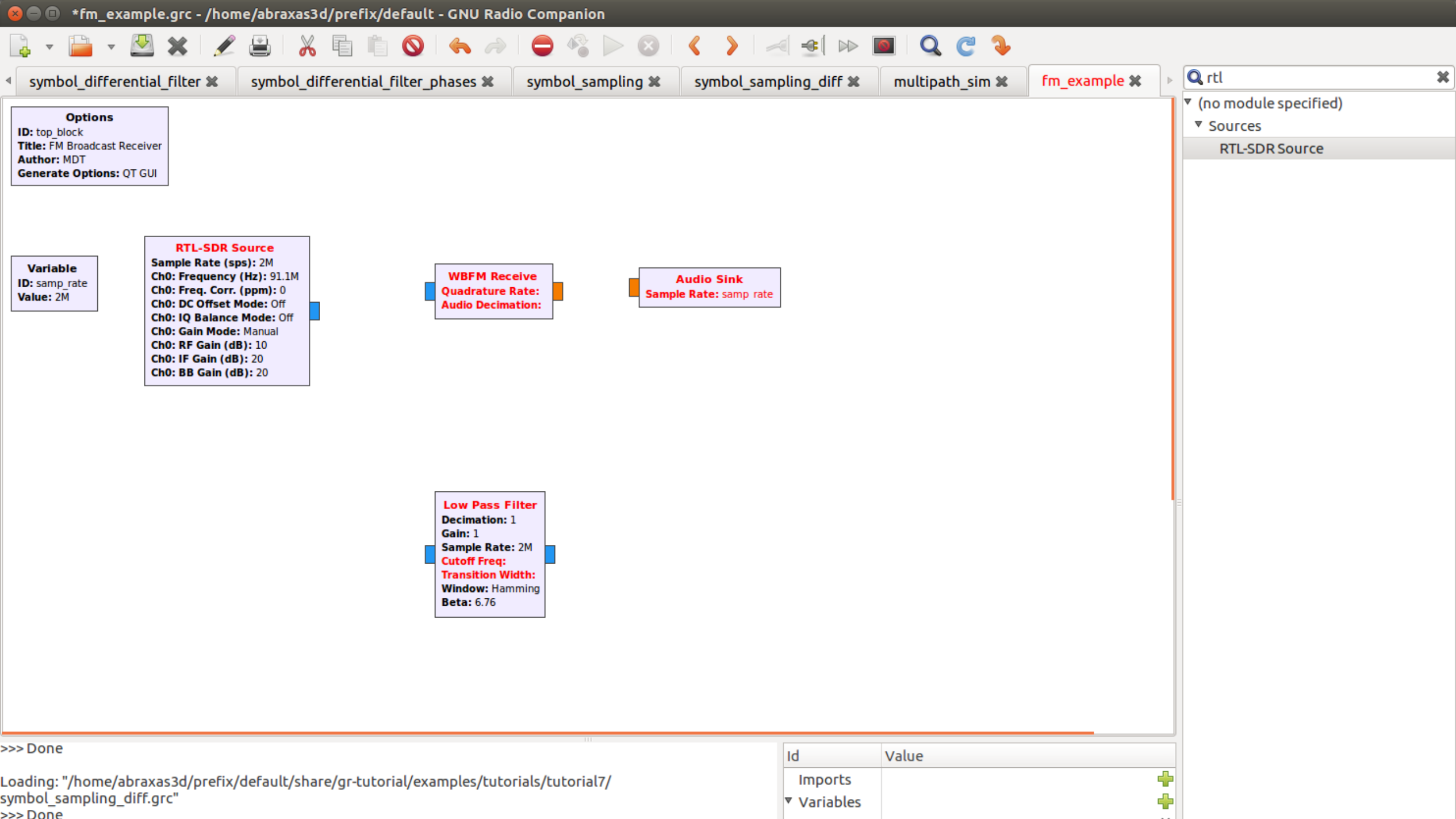
Sample Rate Block

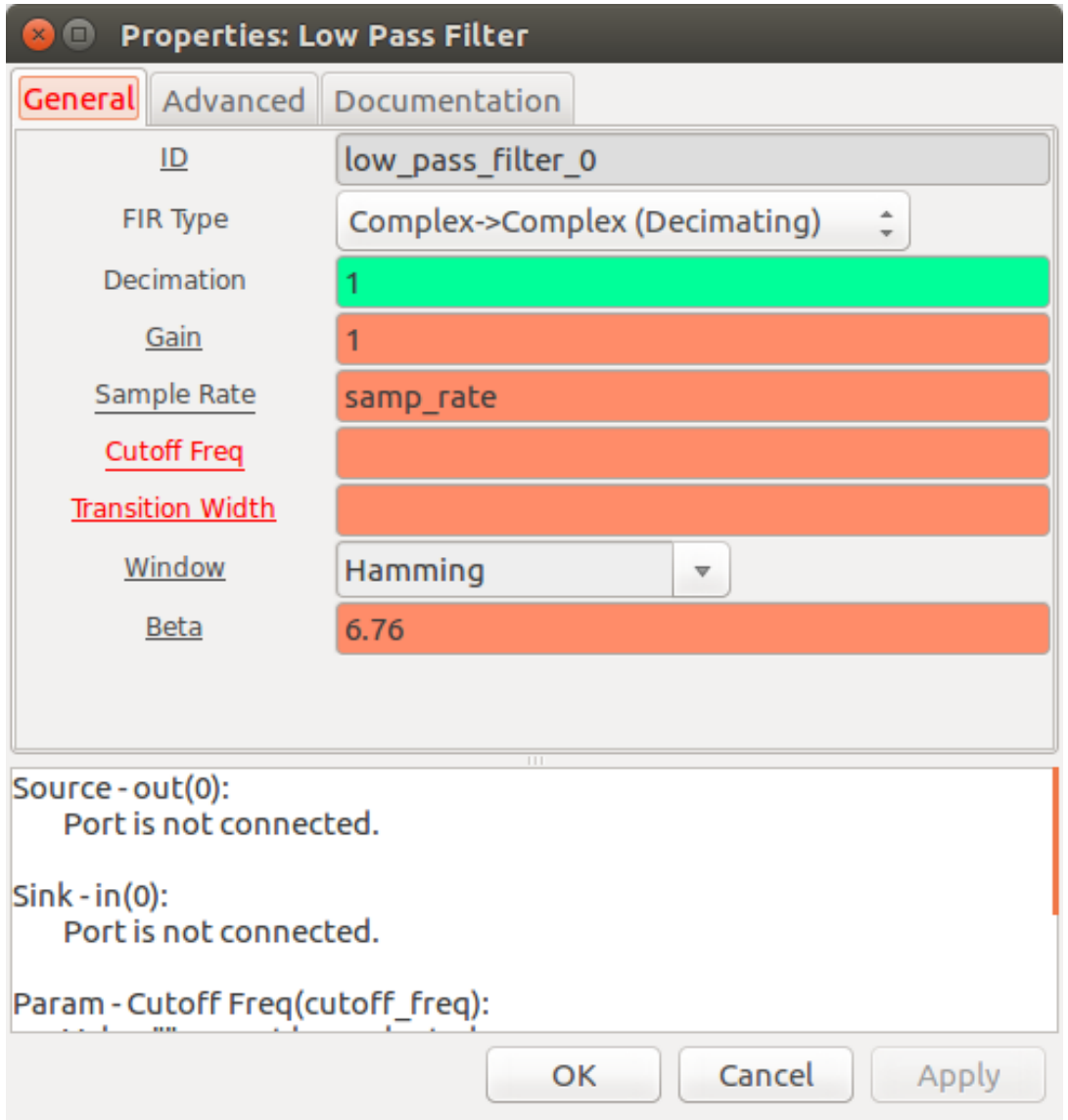
What is sample rate in GNU Radio?

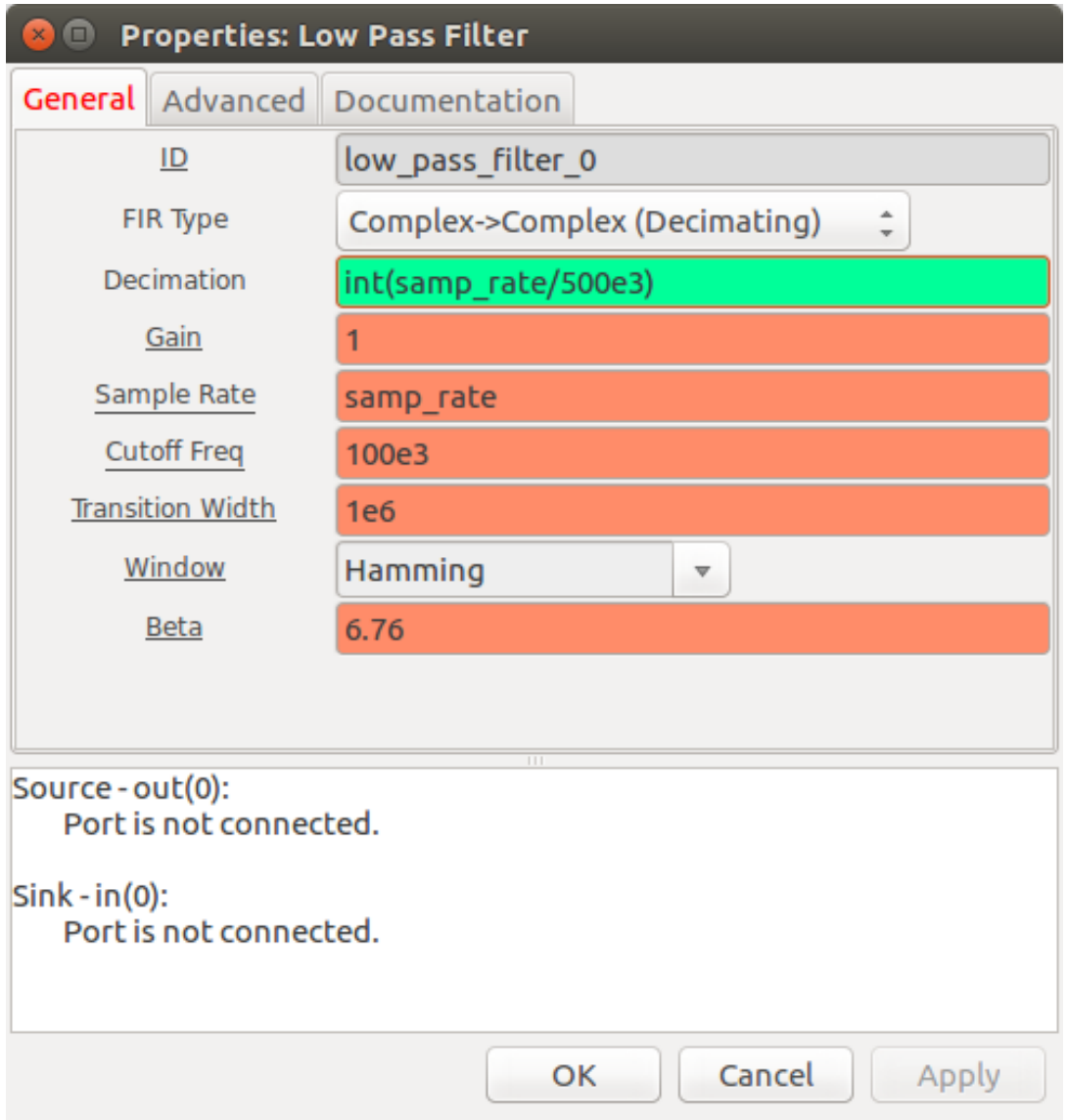
1. Hardware devices sample a signal with some number of **samples per second**.
2. How many samples are required is in relation to the **amount of information** in the signal. 2xBW!


*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
rtl
(no module specified)
Sources
RTL-SDR Source
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 2M
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate:
Audio Decimation:
Audio Sink
Sample Rate: samp_rate
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Change the sample rate.
Properties: Variable
General
Advanced
Documentation
ID
samp_rate
Value
2e6
OK
Cancel
Apply
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/fm_example.grc"
>>> Done

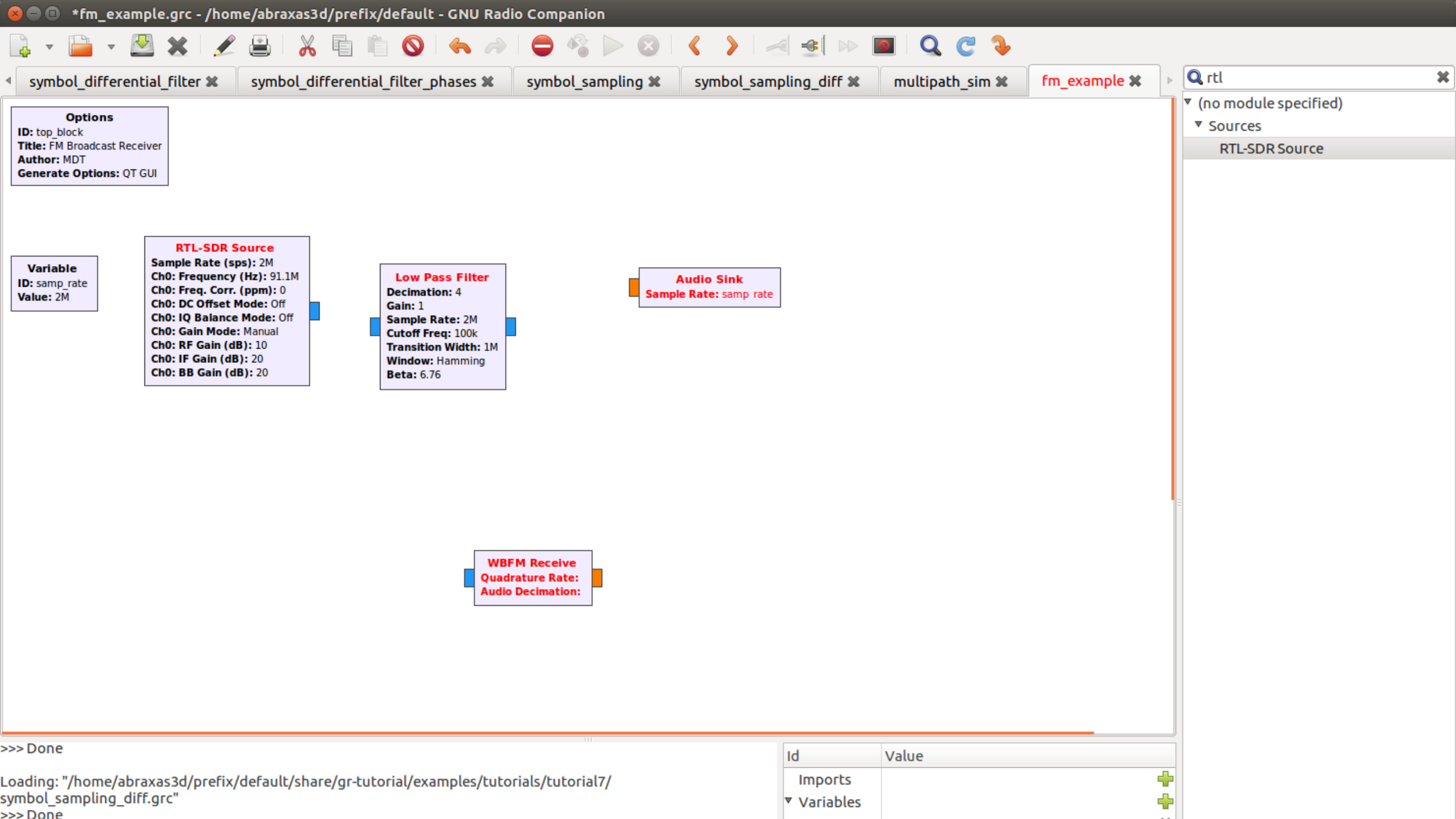
Configure our low pass filter! Use the sample rate variable, set cutoff and transition frequencies.

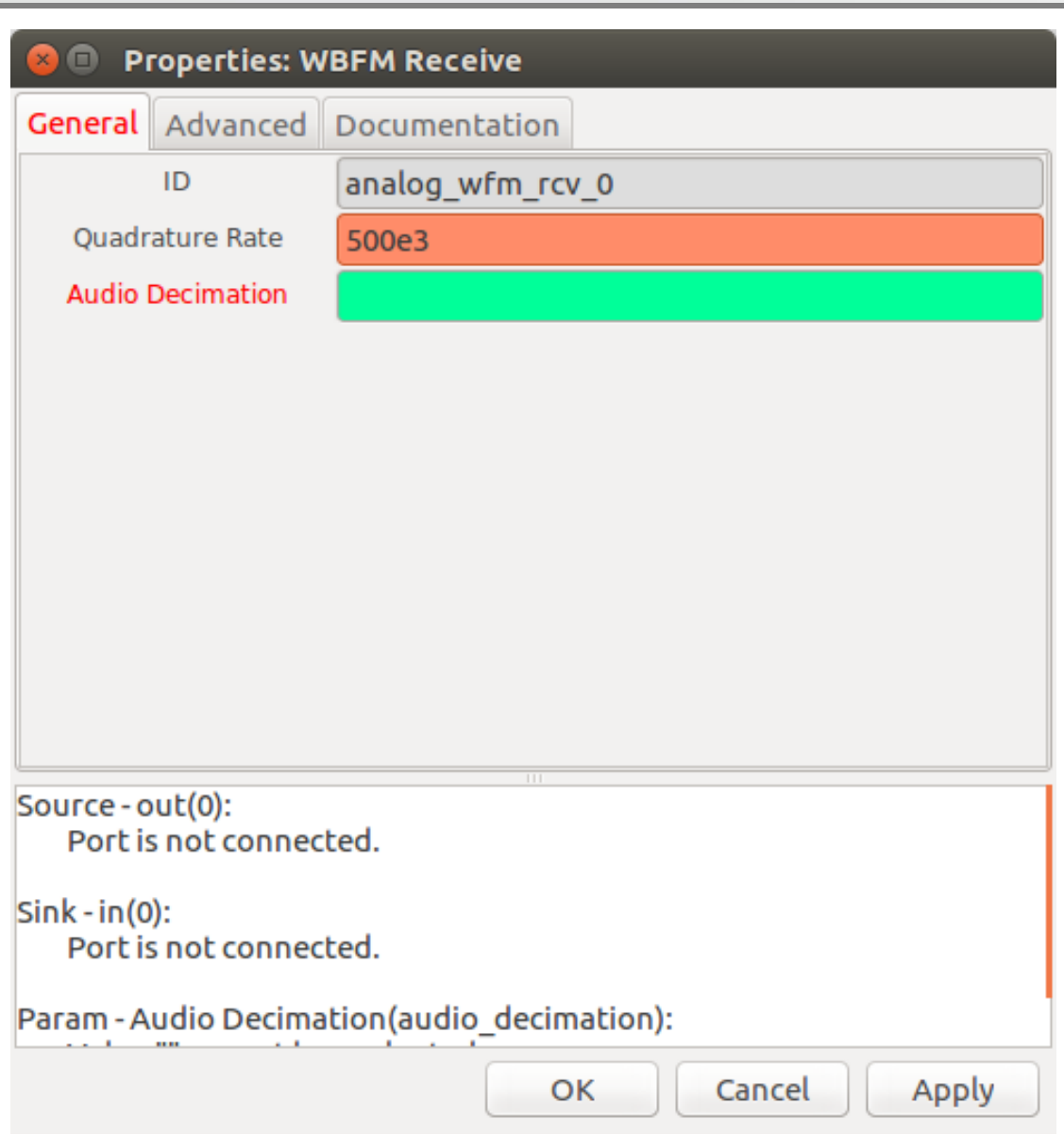

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
WBFM Receive
Quadrature Rate:
Audio Decimation:
Audio Sink
Sample Rate: samp_rate
Low Pass Filter
Decimation: 1
Gain: 1
Sample Rate: 2M
Cutoff Freq:
Transition Width:
Window: Hamming
Beta: 6.76
rtl
(no module specified)
Sources
RTL-SDR Source
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Id
Value
Imports
Variables

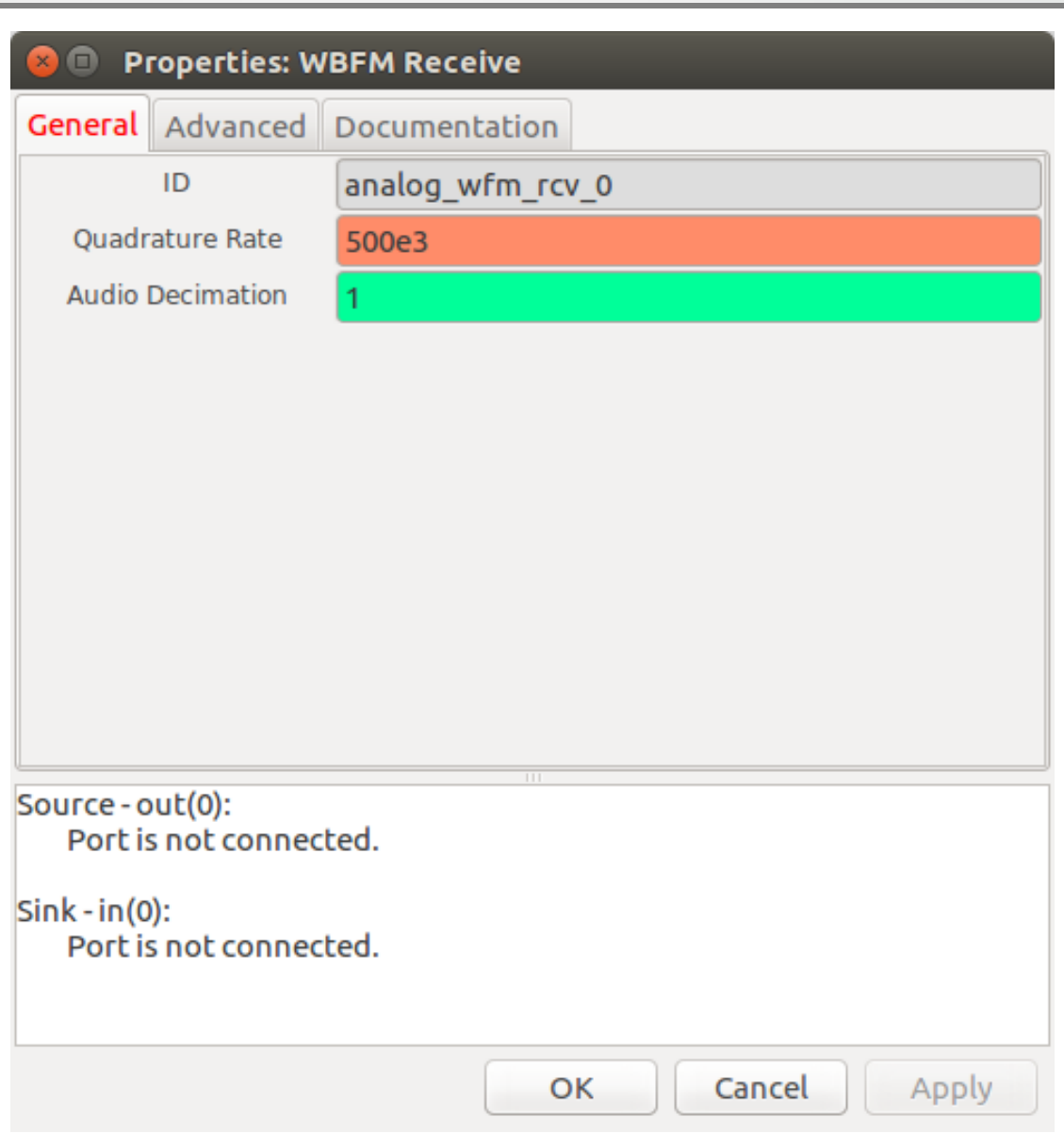

Properties: Low Pass Filter
General
Advanced
Documentation
ID
low_pass_filter_0
FIR Type
Complex->Complex (Decimating)
Decimation
1
Gain
1
Sample Rate
samp_rate
Cutoff Freq
Transition Width
Window
Hamming
Beta
6.76
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
Param - Cutoff Freq(cutoff_freq):
OK
Cancel
Apply


Properties: Low Pass Filter
General
Advanced
Documentation
ID
low_pass_filter_0
FIR Type
Complex->Complex (Decimating)
Decimation
int(samp_rate/500e3)
Gain
1
Sample Rate
samp_rate
Cutoff Freq
100e3
Transition Width
1e6
Window
Hamming
Beta
6.76
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply

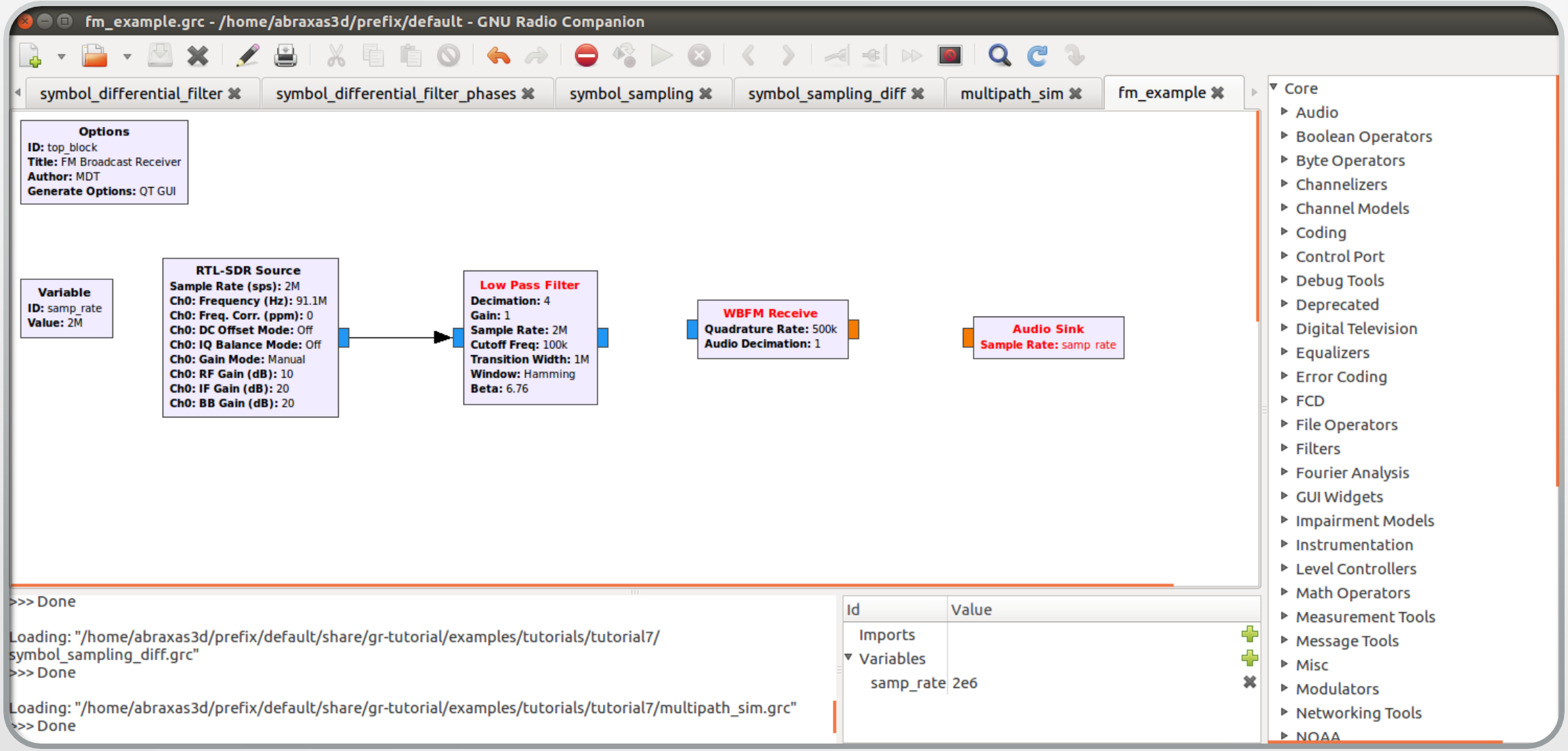
Configure our wideband FM demodulator!
Quadrature rate, audio decimation.

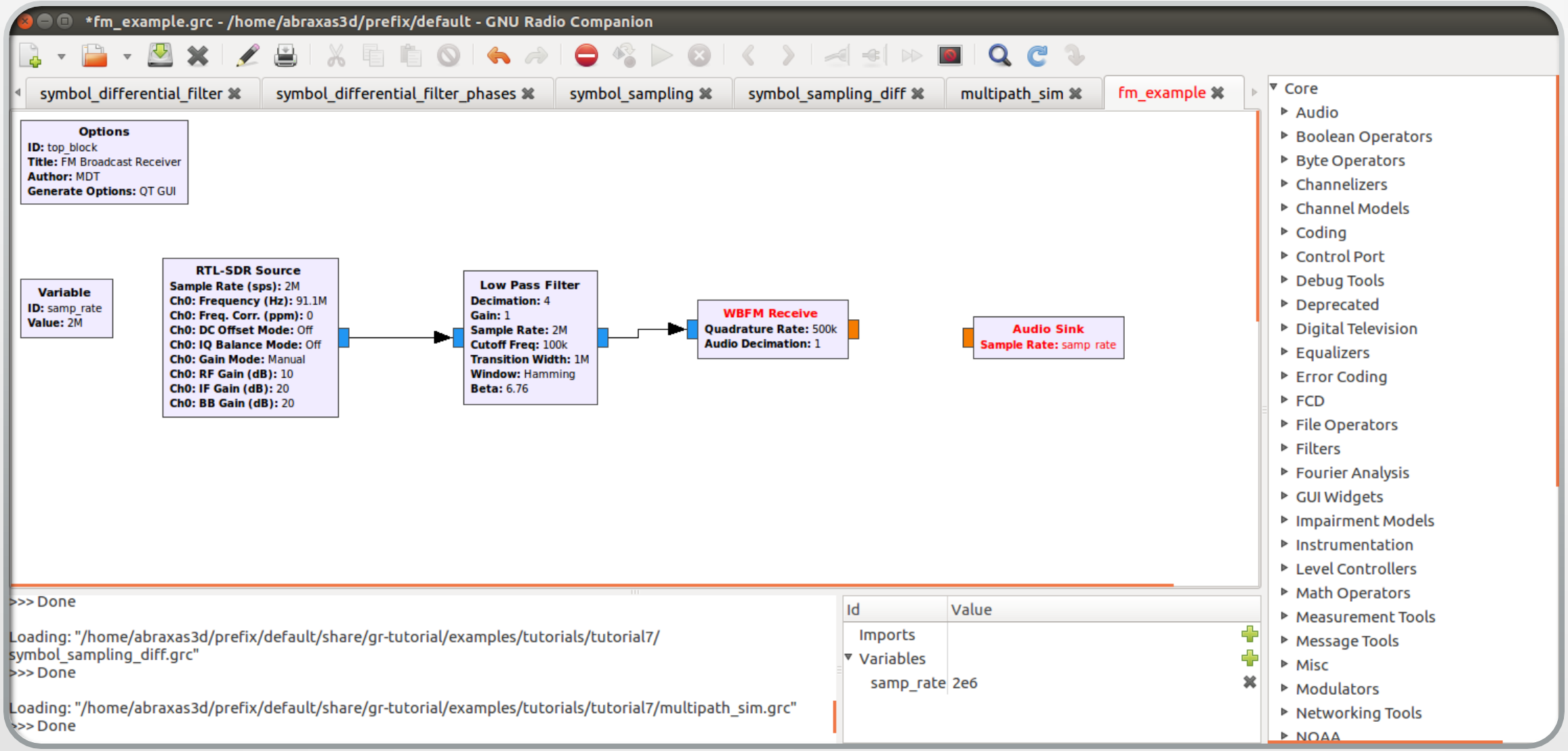

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
Audio Sink
Sample Rate: samp_rate
WBFM Receive
Quadrature Rate:
Audio Decimation:
rtl
(no module specified)
Sources
RTL-SDR Source
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Id
Value
Imports
Variables

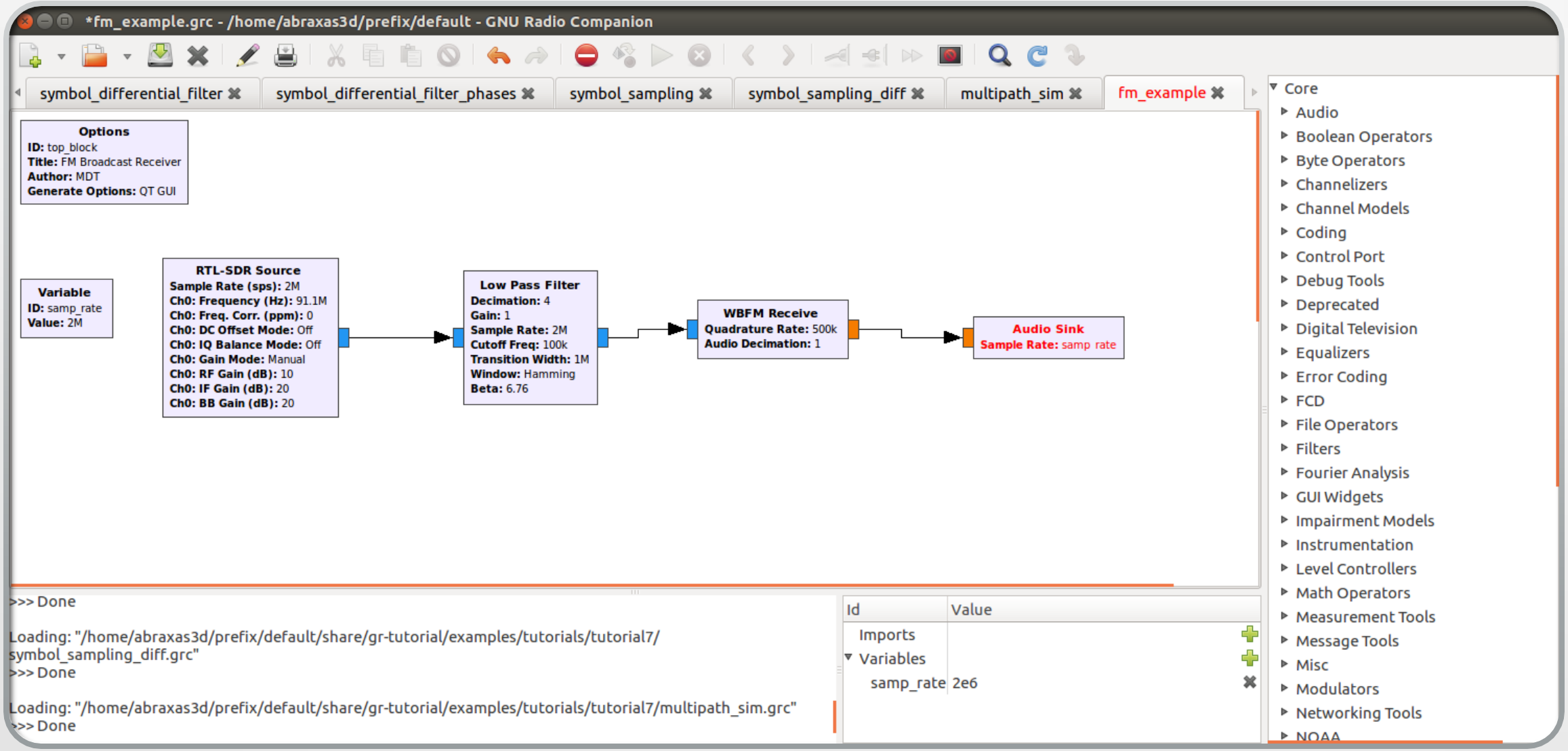

Properties: WBFM Receive
General
Advanced
Documentation
ID
analog_wfm_rcv_0
Quadrature Rate
500e3
Audio Decimation
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
Param - Audio Decimation(audio_decimation):
OK
Cancel
Apply


Properties: WBFM Receive
General
Advanced
Documentation
ID
analog_wfm_rcv_0
Quadrature Rate
500e3
Audio Decimation
1
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply

We have configured the blocks.
How do we connect them?


fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: samp_rate
Core
Audio
Boolean Operators
Byte Operators
Channelizers
Channel Models
Coding
Control Port
Debug Tools
Deprecated
Digital Television
Equalizers
Error Coding
FCD
File Operators
Filters
Fourier Analysis
GUI Widgets
Impairment Models
Instrumentation
Level Controllers
Math Operators
Measurement Tools
Message Tools
Misc
Modulators
Networking Tools
NOAA
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done
Id
Value
Imports
Variables
samp_rate
2e6


*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: samp_rate
Core
Audio
Boolean Operators
Byte Operators
Channelizers
Channel Models
Coding
Control Port
Debug Tools
Deprecated
Digital Television
Equalizers
Error Coding
FCD
File Operators
Filters
Fourier Analysis
GUI Widgets
Impairment Models
Instrumentation
Level Controllers
Math Operators
Measurement Tools
Message Tools
Misc
Modulators
Networking Tools
NOAA
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done
Id
Value
Imports
Variables
samp_rate
2e6

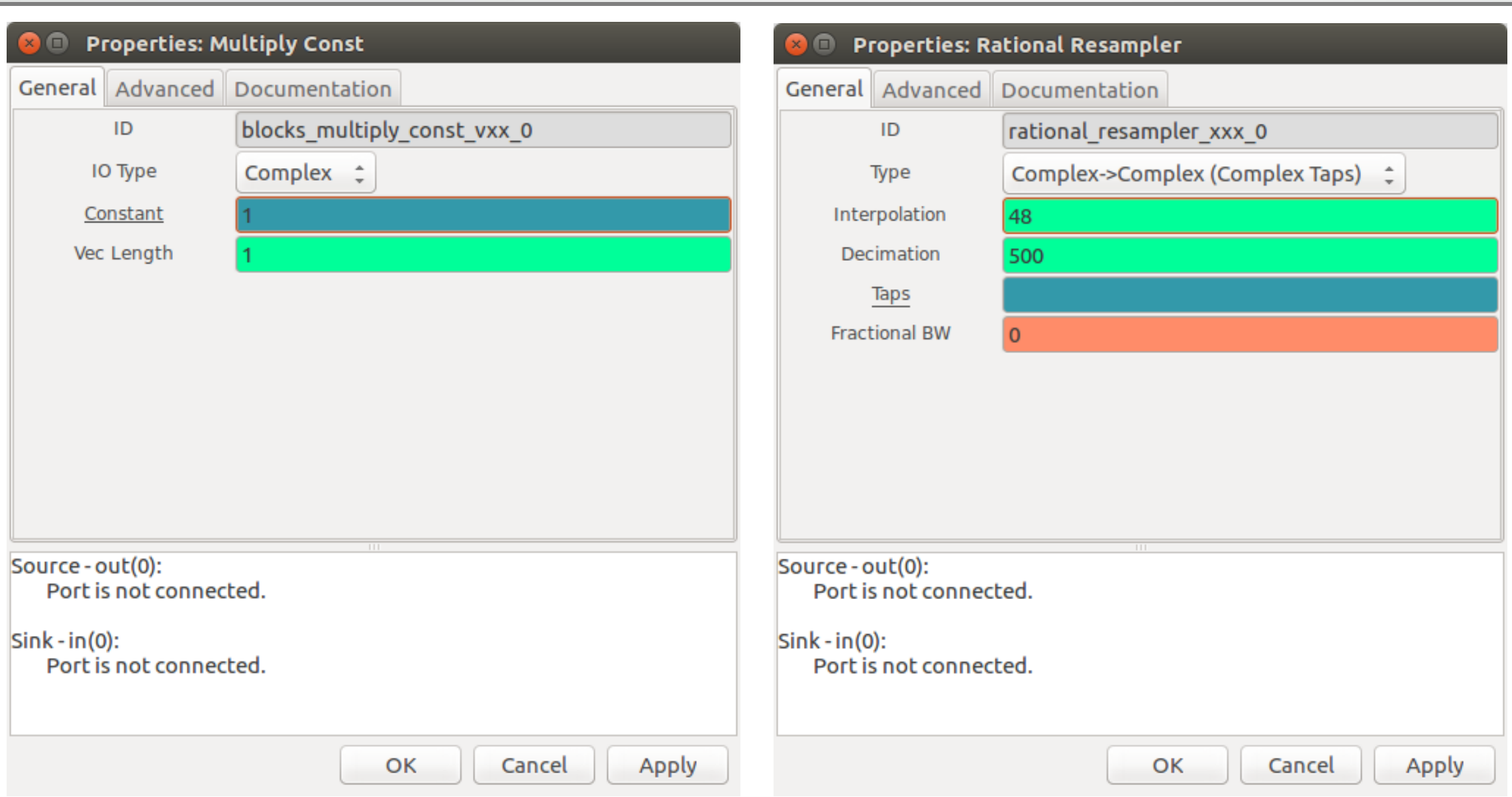

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: samp_rate
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done
Id
Value
Imports
Variables
samp_rate
2e6
Core
Audio
Boolean Operators
Byte Operators
Channelizers
Channel Models
Coding
Control Port
Debug Tools
Deprecated
Digital Television
Equalizers
Error Coding
FCD
File Operators
Filters
Fourier Analysis
GUI Widgets
Impairment Models
Instrumentation
Level Controllers
Math Operators
Measurement Tools
Message Tools
Misc
Modulators
Networking Tools
NOAA

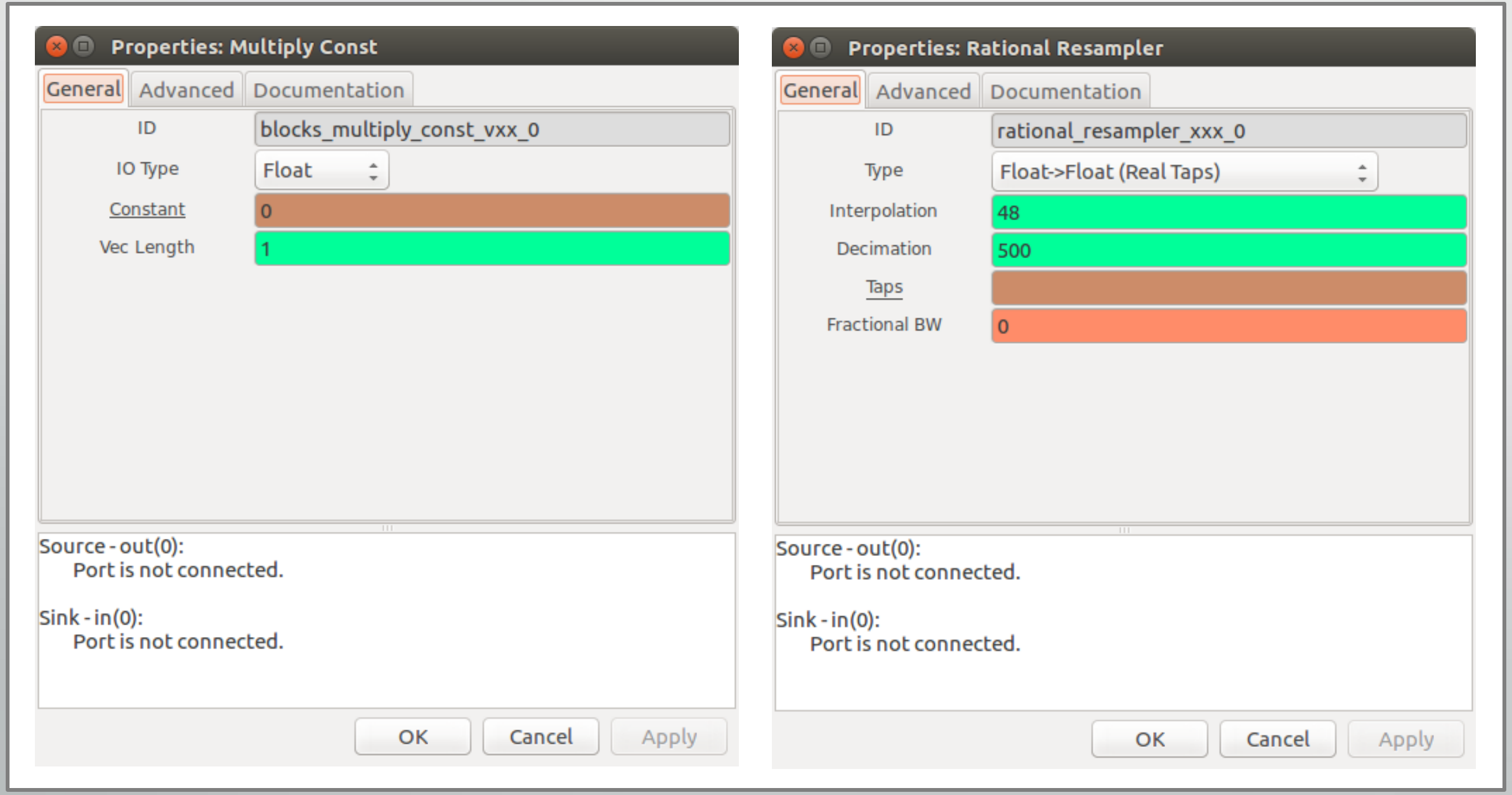
Uh oh!

Why is the audio block red?

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 91.1M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: samp_rate
Rational Resampler
Interpolation: 1
Decimation: 1
Taps:
Fractional BW: 0
Multiply Const
Constant: 0
multiply
Core
Math Operators
Multiply by Tag Value
Multiply Conjugate
Multiply Const
Fast Multiply Const
Multiply by Matrix
Multiply
Message Tools
Tagged Stream Multiply Length
(no module specified)
Tutorial
Multiply Py
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/symbol_sampling_diff.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done
Loading: "/home/abraxas3d/prefix/default/fm_example.grc"
Id
Value
Imports
Variables
samp_rate
2e6

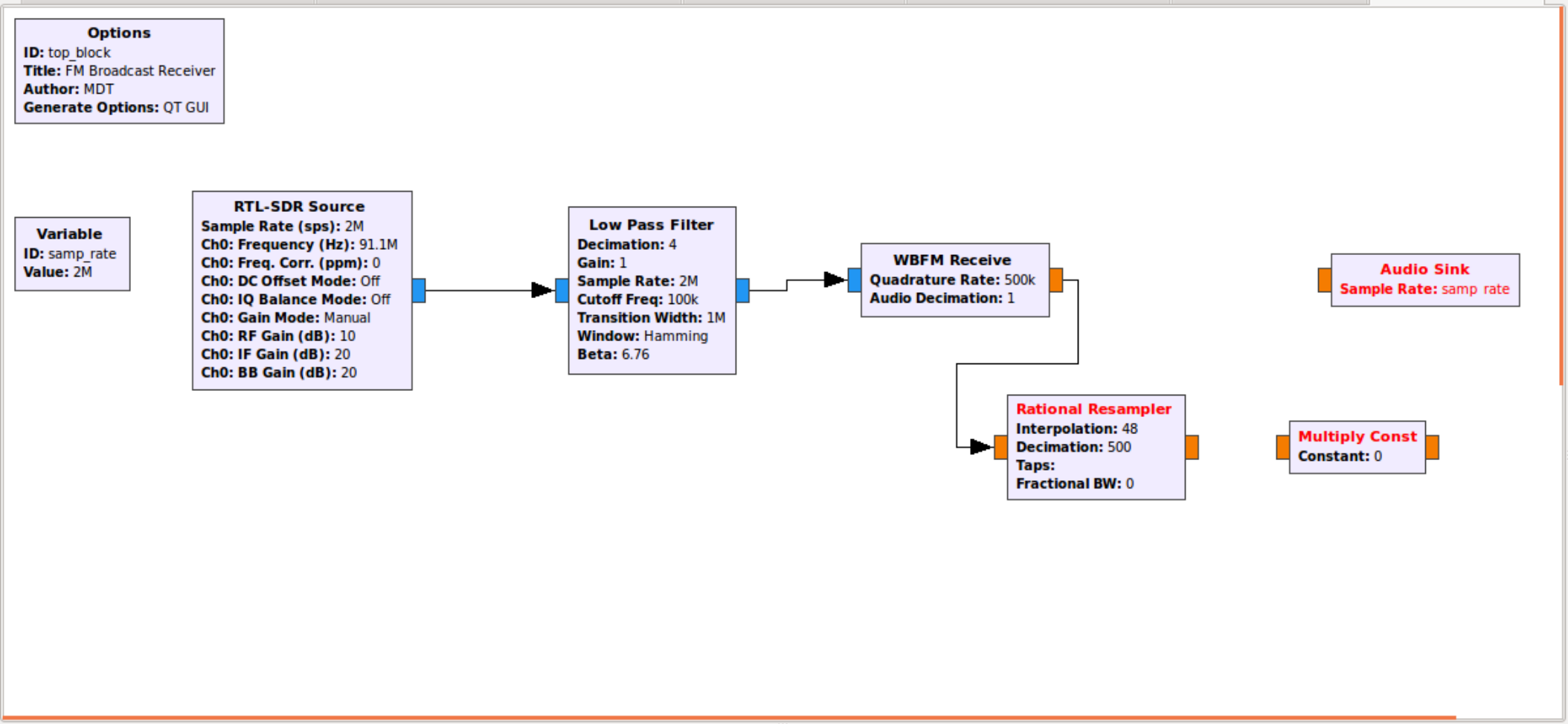
Uh oh!
Why is the rational resampler red?


Properties: Multiply Const
General
Advanced
Documentation
ID
blocks_multiply_const_vxx_0
IO Type
Complex
Constant
1
Vec Length
1
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply
Properties: Rational Resampler
General
Advanced
Documentation
ID
rational_resampler_xxx_0
Type
Complex->Complex (Complex Taps)
Interpolation
48
Decimation
500
Taps
Fractional BW
0
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply


Properties: Multiply Const
General
Advanced
Documentation
ID
blocks_multiply_const_vxx_0
IO Type
Float
Constant
0
Vec Length
1
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply
Properties: Rational Resampler
General
Advanced
Documentation
ID
rational_resampler_xxx_0
Type
Float->Float (Real Taps)
Interpolation
48
Decimation
500
Taps
Fractional BW
0
Source - out(0):
Port is not connected.
Sink - in(0):
Port is not connected.
OK
Cancel
Apply

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example




```
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/
symbol_sampling_diff.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/fm_example.grc"
```

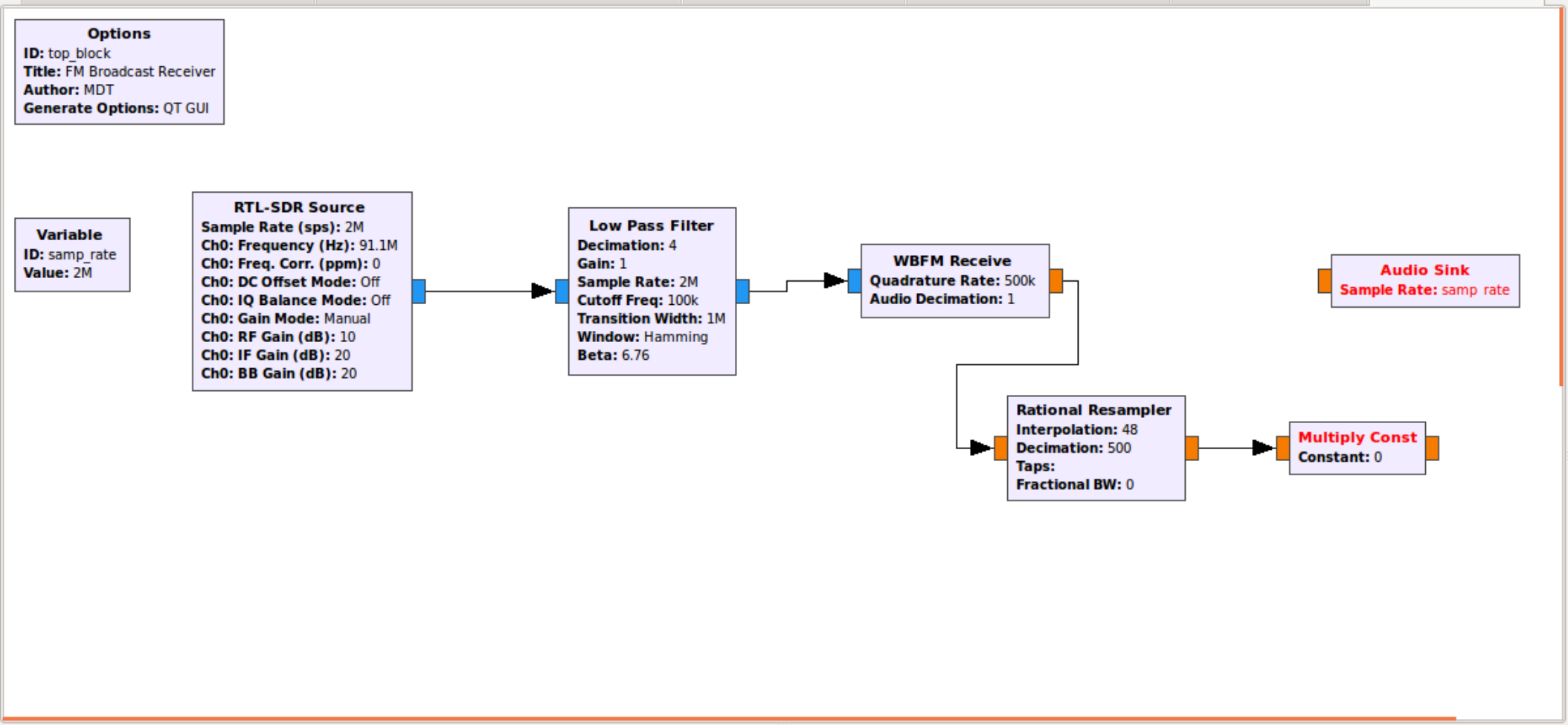
Id	Value
Imports	
Variables	
samp_rate	2e6

multiply

- Core
  - Math Operators
    - Multiply by Tag Value
    - Multiply Conjugate
    - Multiply Const
    - Fast Multiply Const
    - Multiply by Matrix
    - Multiply
  - Message Tools
    - Tagged Stream Multiply Length
- (no module specified)
  - Tutorial
    - Multiply Py

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example




```
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/
symbol_sampling_diff.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/fm_example.grc"
```

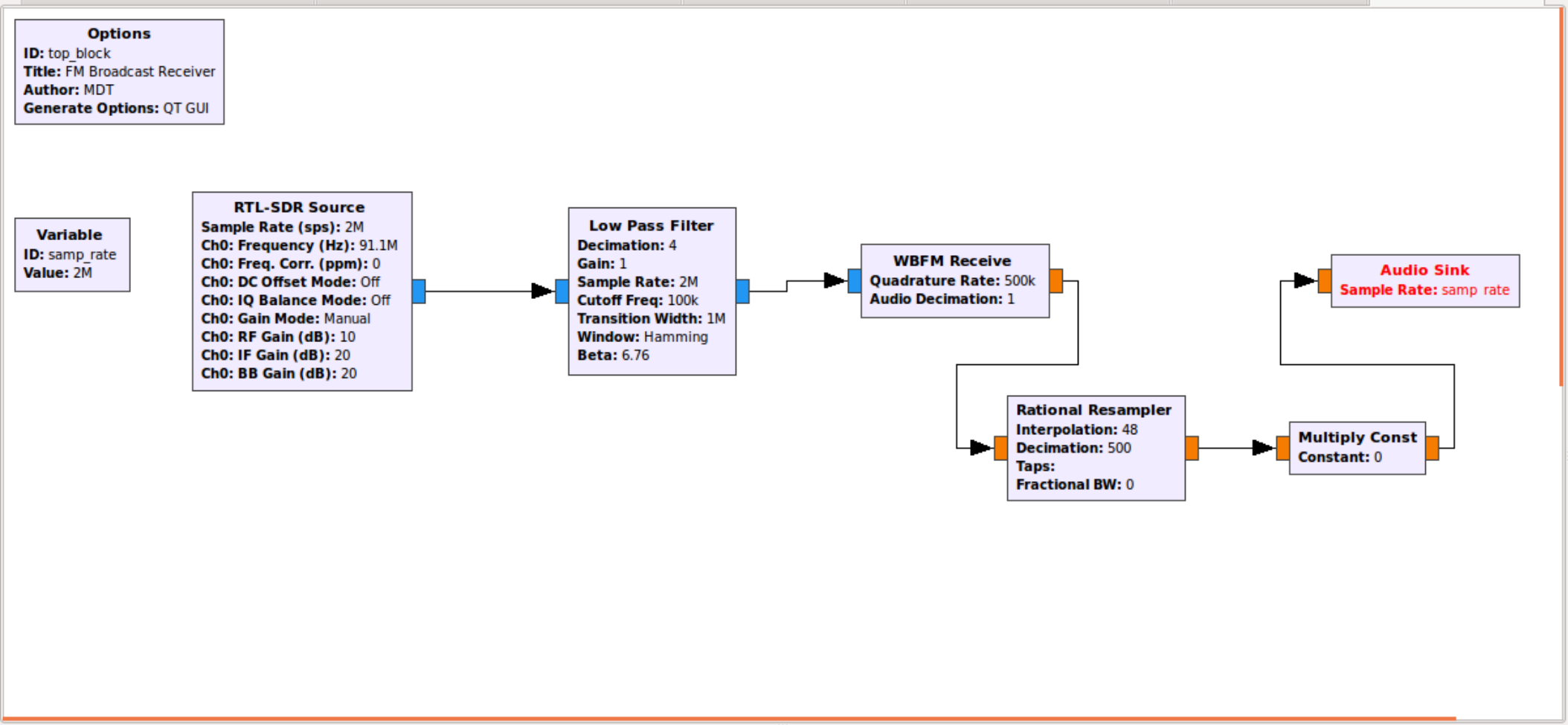
Id	Value
Imports	
Variables	
samp_rate	2e6

multiply

- Core
  - Math Operators
    - Multiply by Tag Value
    - Multiply Conjugate
    - Multiply Const
    - Fast Multiply Const
    - Multiply by Matrix
    - Multiply
  - Message Tools
    - Tagged Stream Multiply Length
- (no module specified)
- Tutorial
  - Multiply Py

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example




```
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/
symbol_sampling_diff.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.grc"
>>> Done

Loading: "/home/abraxas3d/prefix/default/fm_example.grc"
```

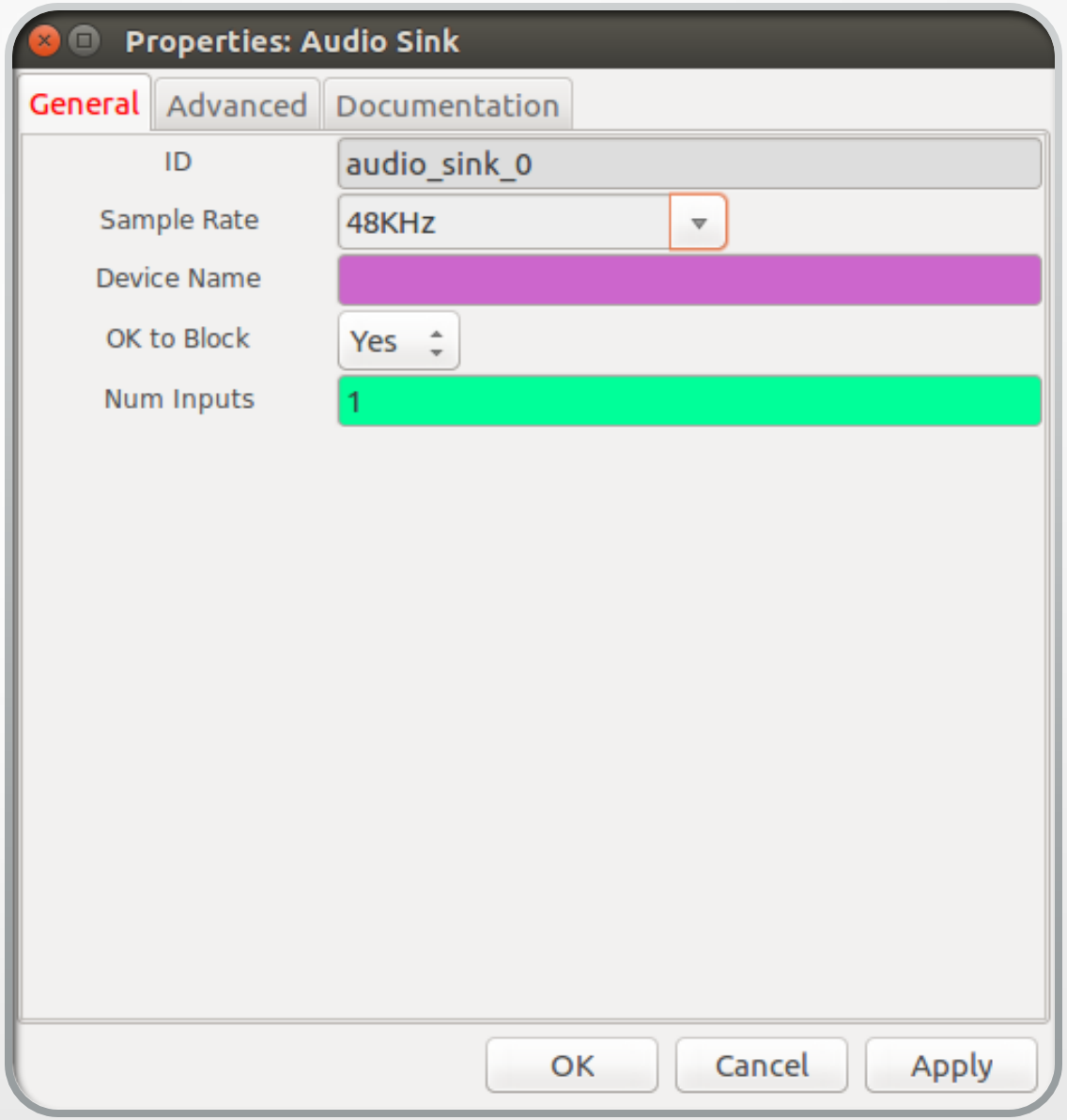
Id	Value
Imports	
Variables	
samp_rate	2e6

multiply

- Core
  - Math Operators
    - Multiply by Tag Value
    - Multiply Conjugate
    - Multiply Const
    - Fast Multiply Const
    - Multiply by Matrix
    - Multiply
  - Message Tools
    - Tagged Stream Multiply Length
- (no module specified)
- Tutorial
  - Multiply Py

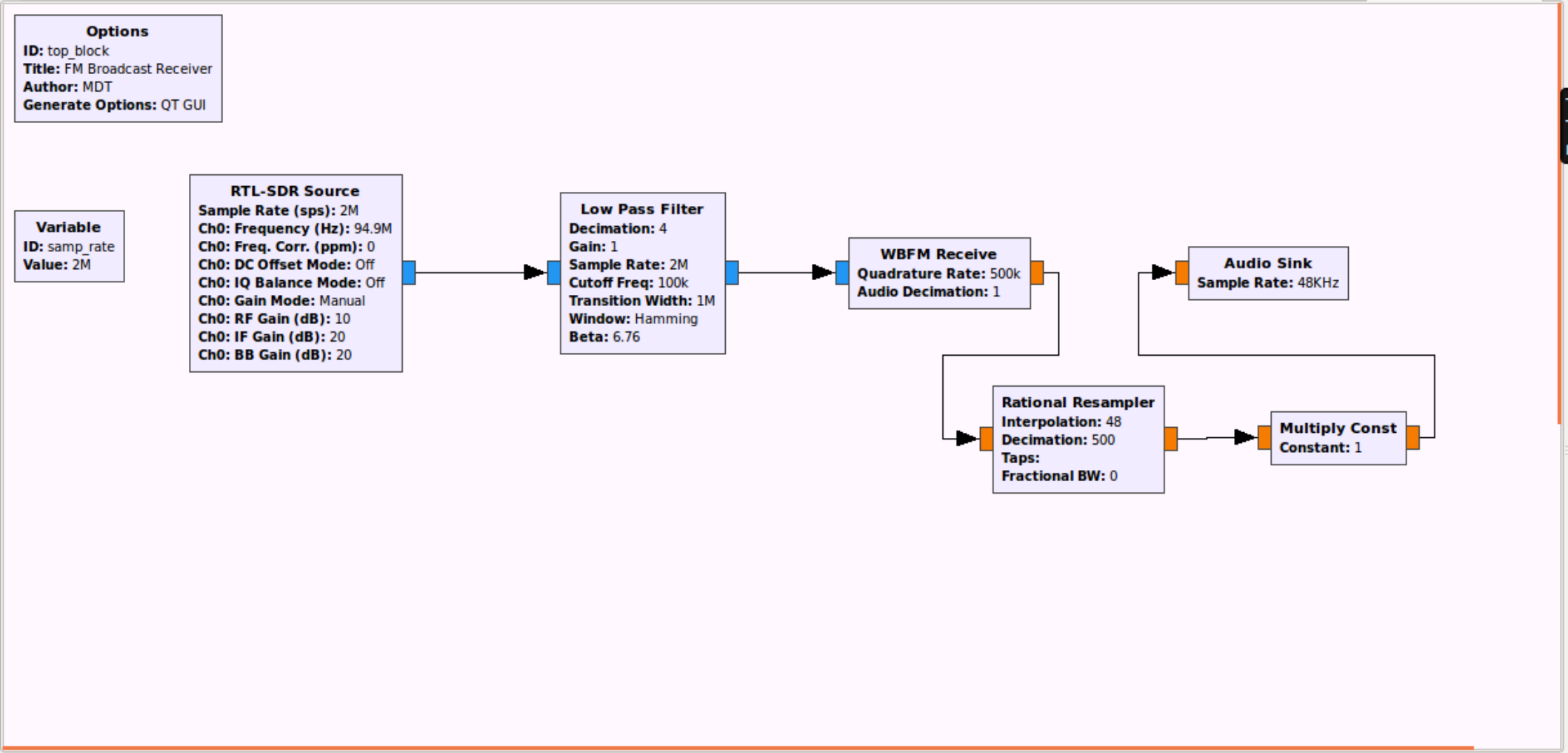
Uh oh!
Why is the audio block STILL red?
Wrong sample rate!

Adjust sample rate!



*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example




```
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
gr::log :INFO: audio source - Audio sink arch: alsa
aUaUaUaUaU
>>> Done
```

var

- [Variables]
  - Tag Object
  - Variable

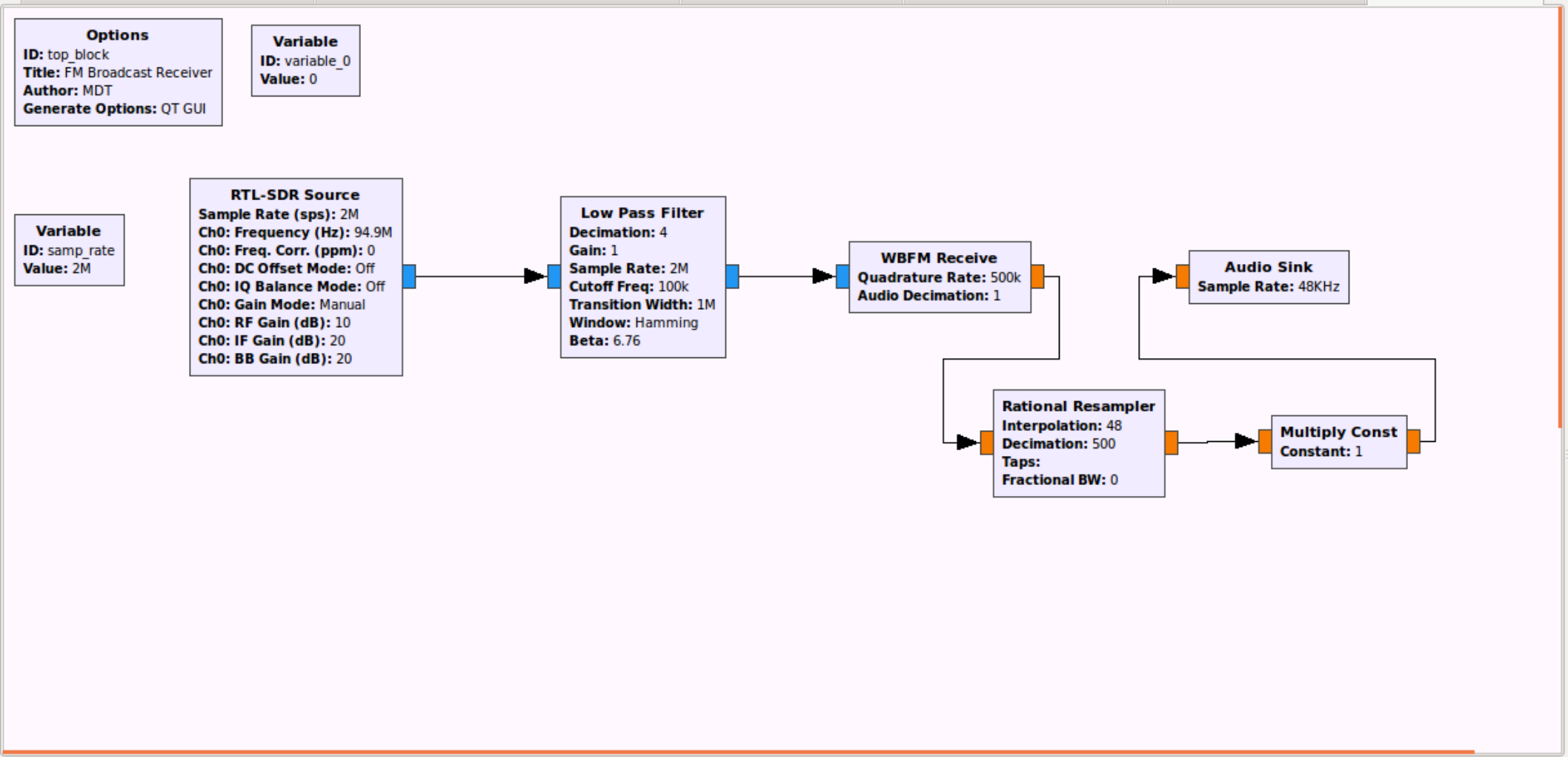
This block maps a value to a unique va
This variable block has no graphical representation.

- [Modulators]
  - Constellation Object
  - Constellation Rect. Object
  - Modulate Vector
- [Error Coding]
  - [Decoders]
    - LDPC Decoder Definition
    - TPC Decoder Definition
    - CC Decoder Definition
    - Dummy Decoder Definition
    - LDPC Bit Flip Decoder Definitio
    - POLAR Decoder SC Definition
    - POLAR Decoder SC List Definiti
    - systematic POLAR Decoder SC D
    - Repetition Decoder Definition
  - [Encoders]
    - LDPC Encoder Definition
    - TPC Encoder Definition
    - CC Encoder Definition
    - CCSDS Encoder Definition
    - Dummy Encoder Definition
    - LDPC Encoder Definition (via Ge
    - LDPC Encoder Definition (via Pa
    - POLAR Encoder Definition
    - systematic POLAR Encoder Defi
    - Repetition Encoder Definition

If a variable works for sample rate, why not use it for frequency and cutoff too? Parameters!

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

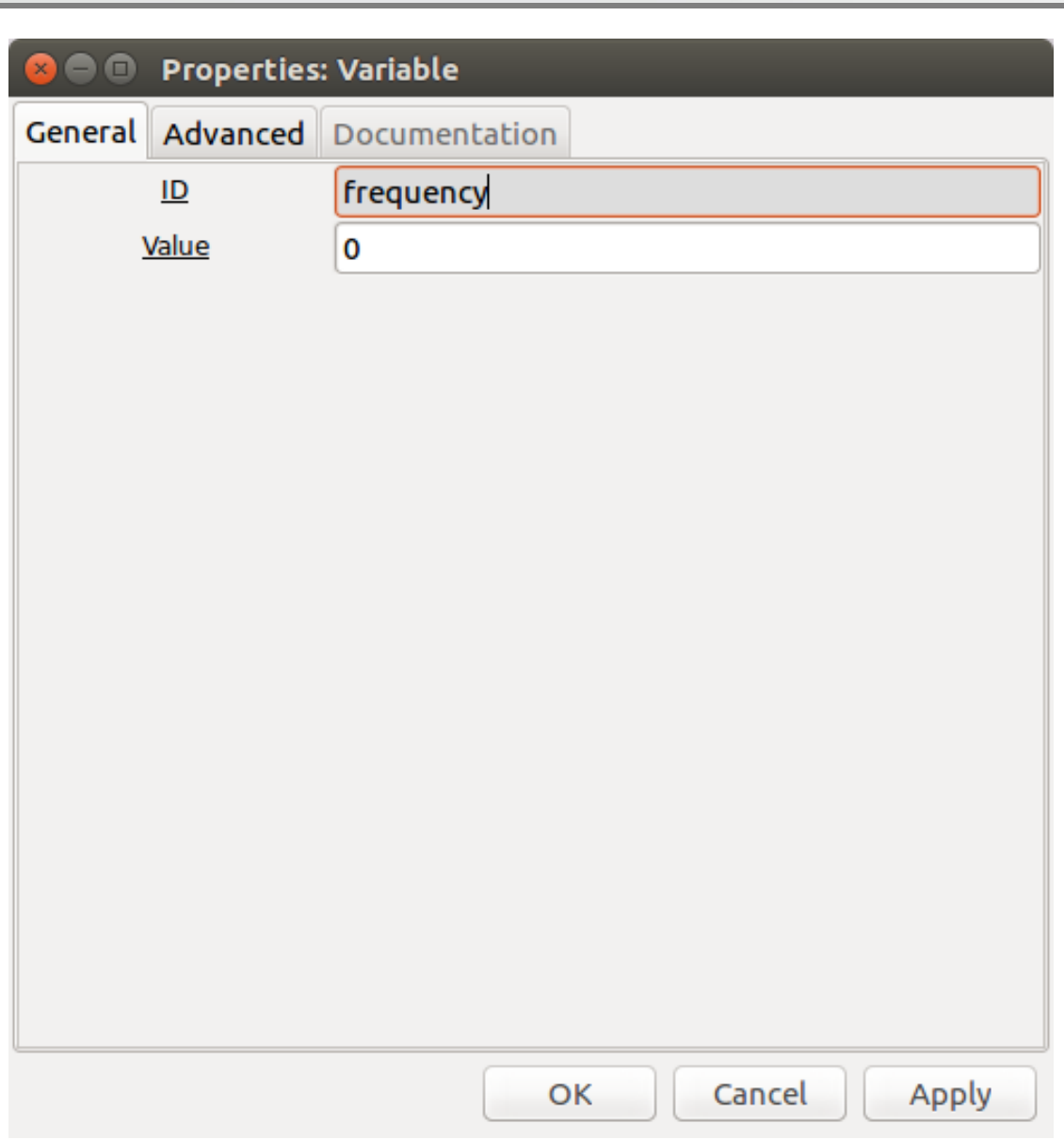
symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example

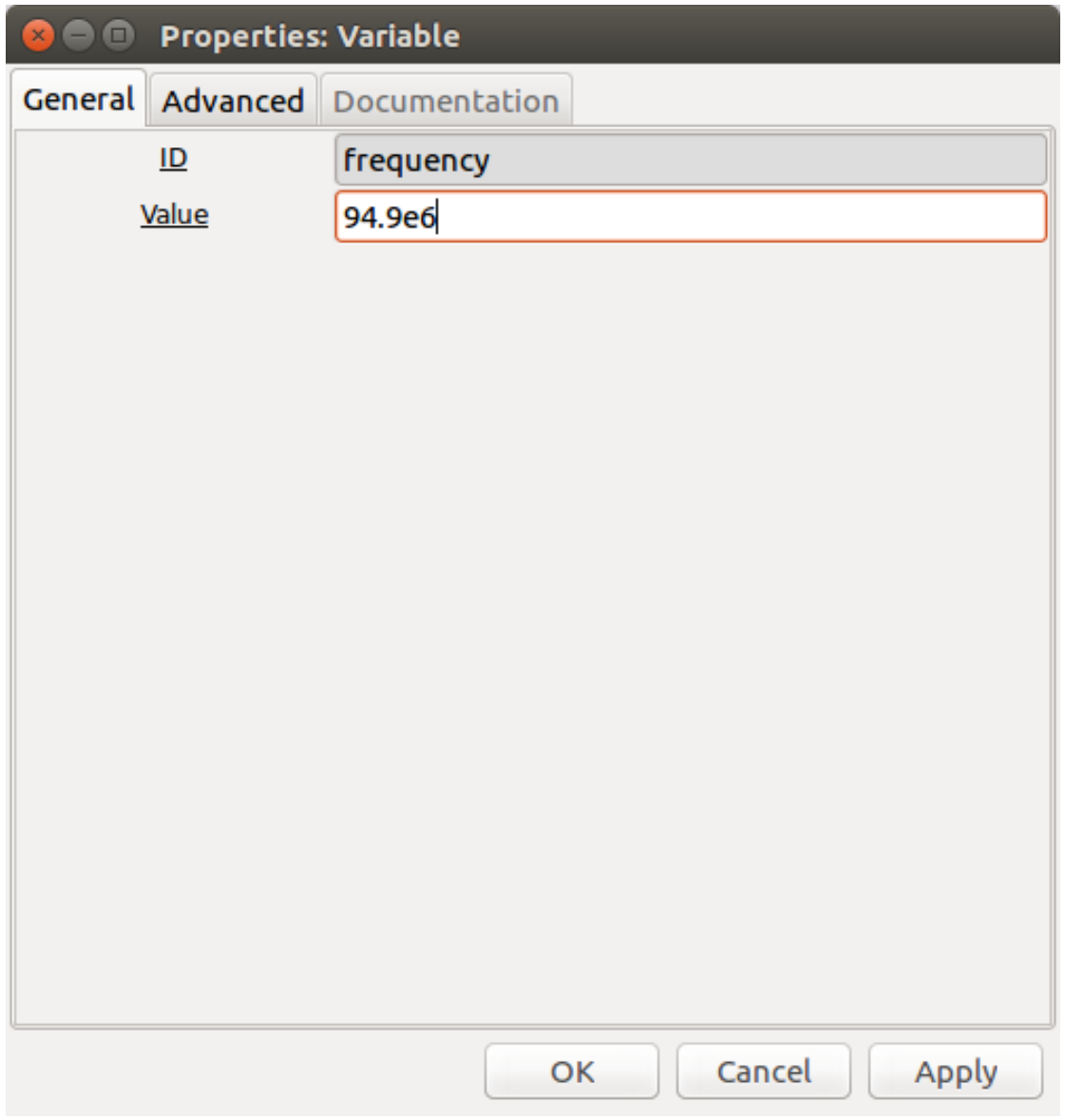


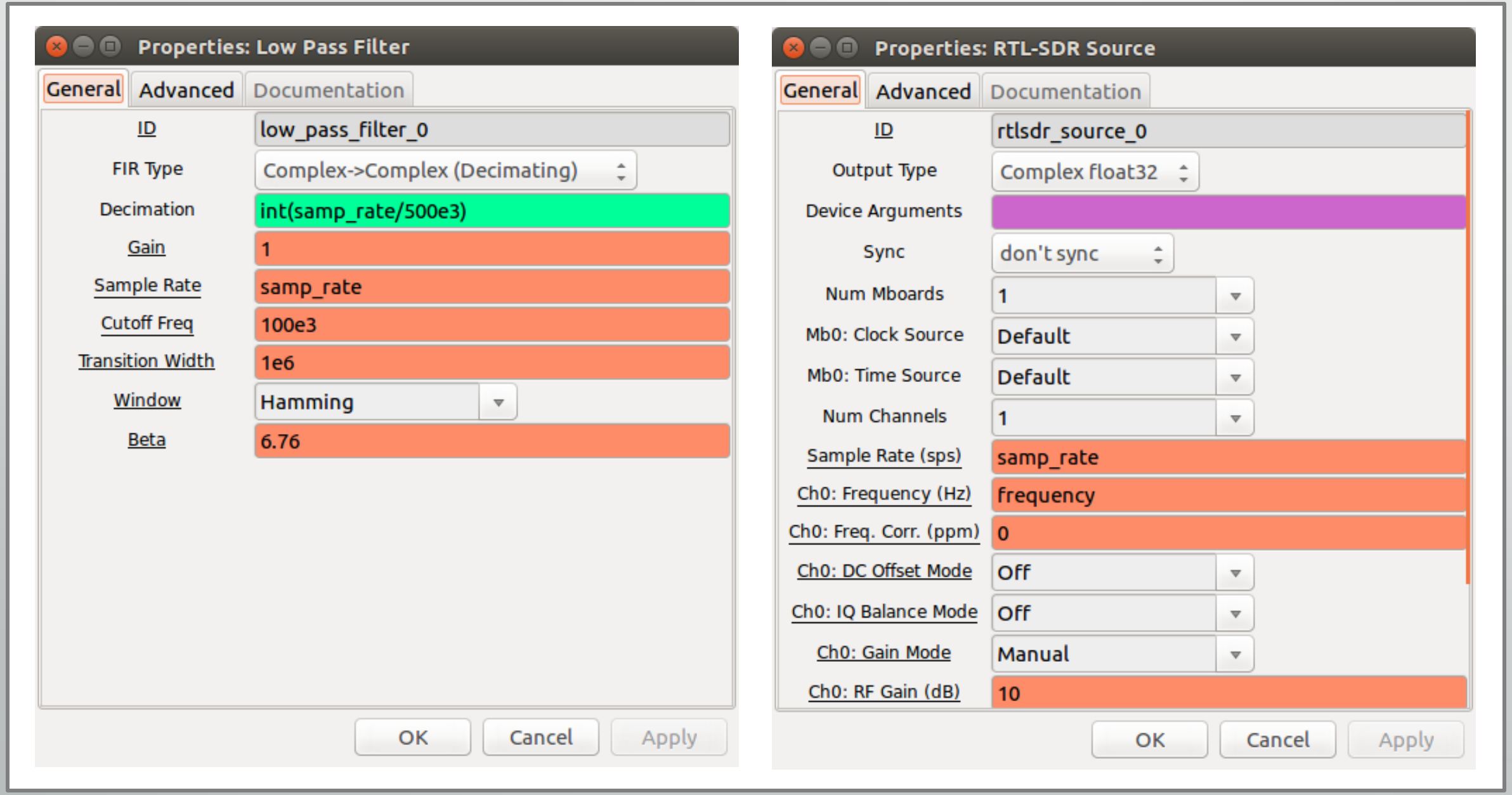

```
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
gr::log :INFO: audio source - Audio sink arch: alsa
aUaUaUaUaU
>>> Done
```

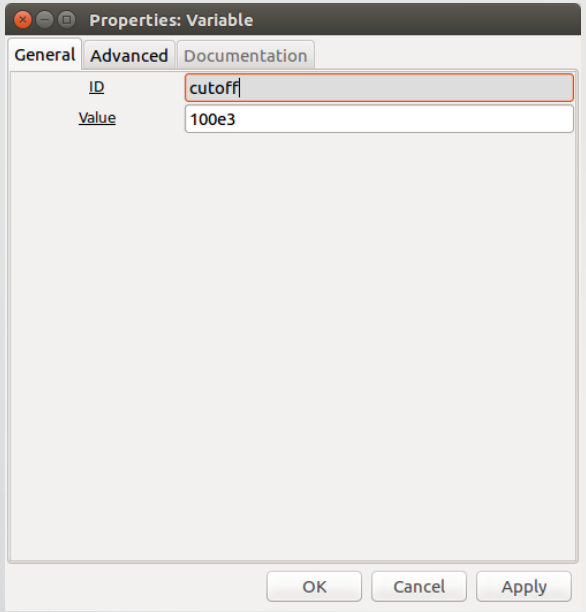
var

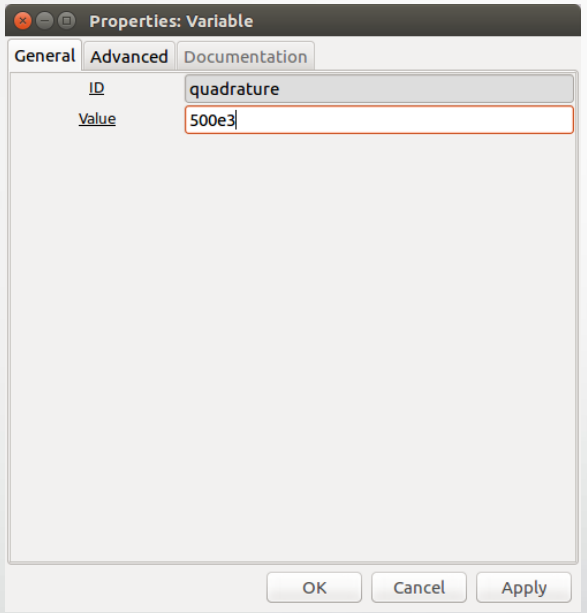
- [Variables]
  - Tag Object
  - Variable
  - Variable Config
  - Function Probe
  - Struct Variable
- [Modulators]
  - Constellation Object
  - Constellation Rect. Object
  - Modulate Vector
- [Error Coding]
  - [Decoders]
    - LDPC Decoder Definition
    - TPC Decoder Definition
    - CC Decoder Definition
    - Dummy Decoder Definition
    - LDPC Bit Flip Decoder Definitio
    - POLAR Decoder SC Definition
    - POLAR Decoder SC List Definiti
    - systematic POLAR Decoder SC D
    - Repetition Decoder Definition
  - [Encoders]
    - LDPC Encoder Definition
    - TPC Encoder Definition
    - CC Encoder Definition
    - CCSDS Encoder Definition
    - Dummy Encoder Definition
    - LDPC Encoder Definition (via Ge
    - LDPC Encoder Definition (via Pa
    - POLAR Encoder Definition
    - systematic POLAR Encoder Defi
    - Repetition Encoder Definition

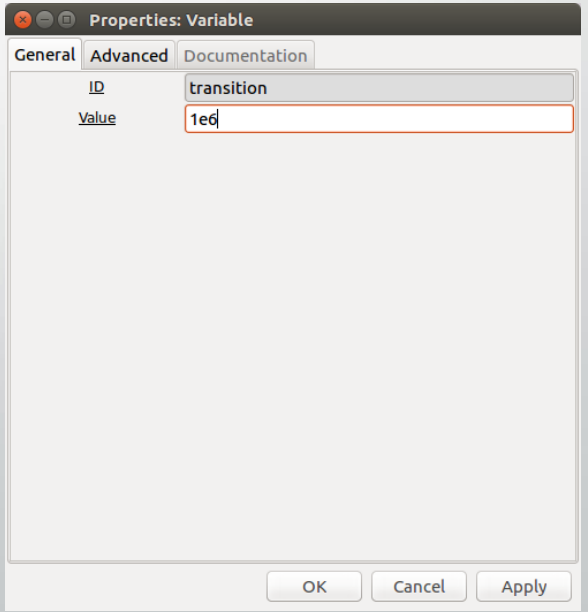

Properties: Variable
General
Advanced
Documentation
ID
frequency
Value
0
OK
Cancel
Apply

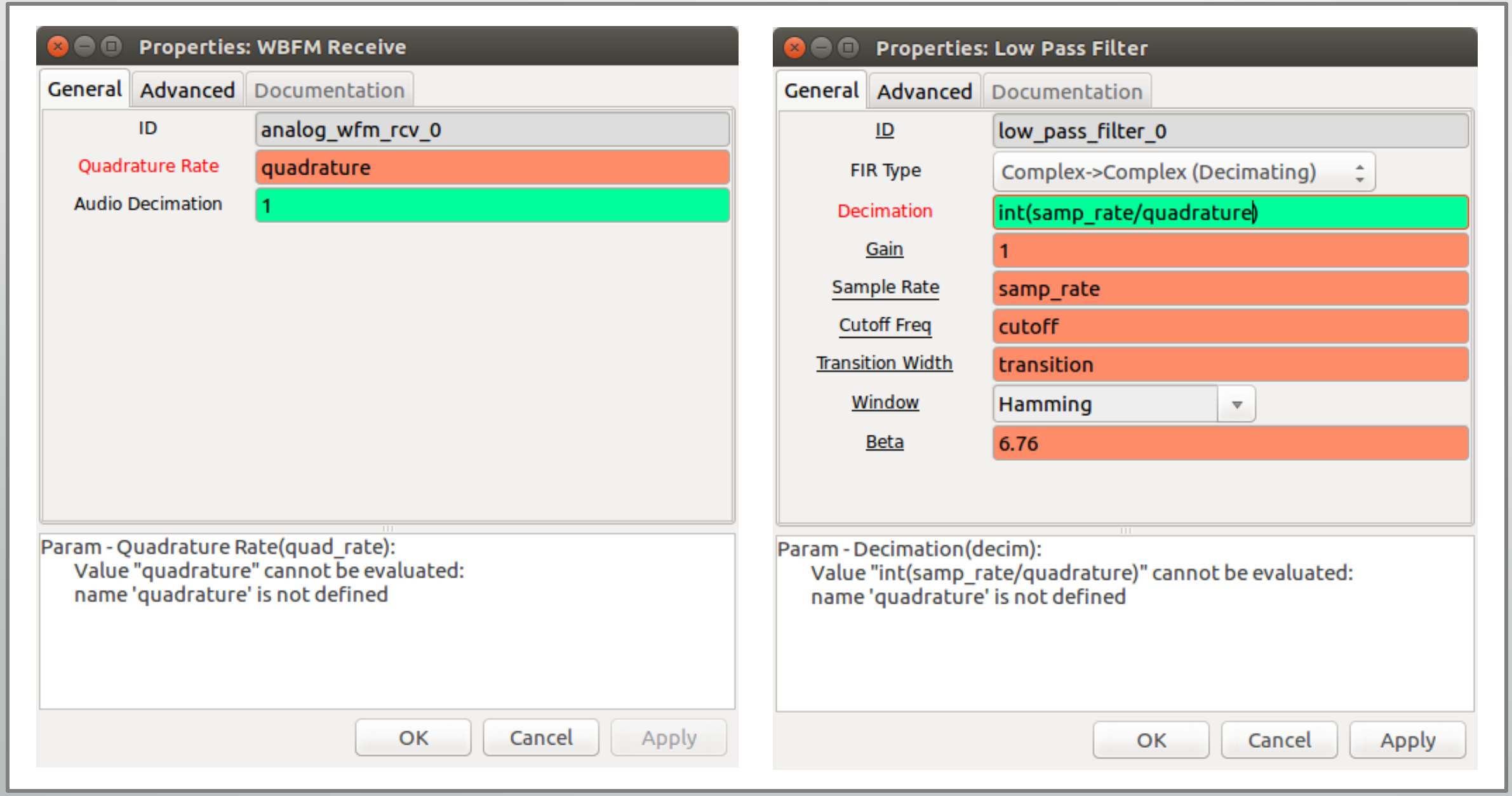

Properties: Variable
General
Advanced
Documentation
ID
frequency
Value
94.9e6
OK
Cancel
Apply


Properties: Low Pass Filter
General
Advanced
Documentation
ID
low_pass_filter_0
FIR Type
Complex->Complex (Decimating)
Decimation
int(samp_rate/500e3)
Gain
1
Sample Rate
samp_rate
Cutoff Freq
100e3
Transition Width
1e6
Window
Hamming
Beta
6.76
OK
Cancel
Apply
Properties: RTL-SDR Source
General
Advanced
Documentation
ID
rtlsdr_source_0
Output Type
Complex float32
Device Arguments
Sync
don't sync
Num Mboards
1
Mb0: Clock Source
Default
Mb0: Time Source
Default
Num Channels
1
Sample Rate (sps)
samp_rate
Ch0: Frequency (Hz)
frequency
Ch0: Freq. Corr. (ppm)
0
Ch0: DC Offset Mode
Off
Ch0: IQ Balance Mode
Off
Ch0: Gain Mode
Manual
Ch0: RF Gain (dB)
10
OK
Cancel
Apply


Properties: Variable
General
Advanced
Documentation
ID
cutoff
Value
100e3
OK
Cancel
Apply

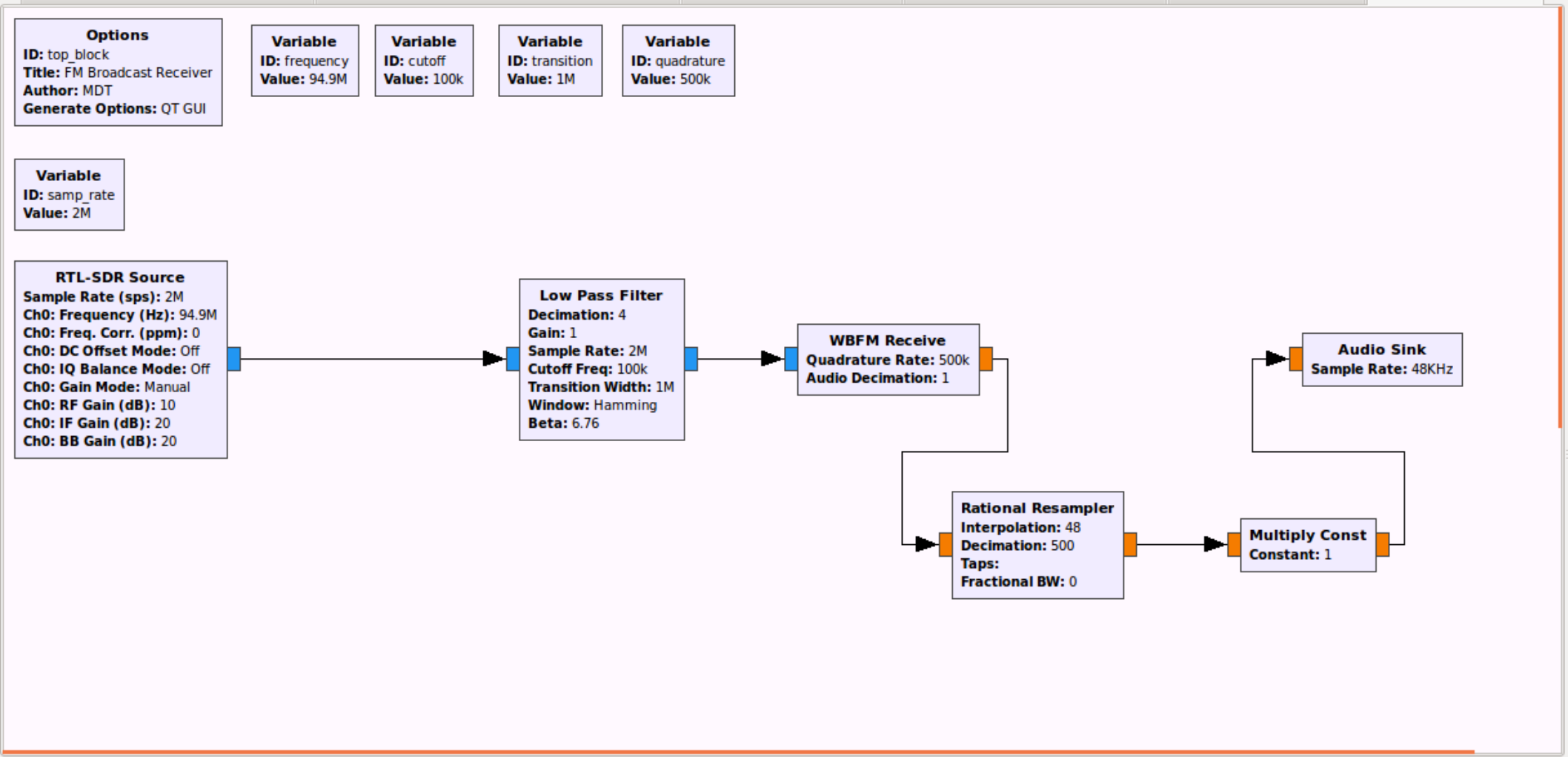

Properties: Variable
General
Advanced
Documentation
ID
quadrature
Value
500e3
OK
Cancel
Apply


Properties: Variable
General
Advanced
Documentation
ID
transition
Value
1e6
OK
Cancel
Apply


Properties: WBFM Receive
General
Advanced
Documentation
ID
analog_wfm_rcv_0
Quadrature Rate
quadrature
Audio Decimation
1
Param - Quadrature Rate(quad_rate):
Value "quadrature" cannot be evaluated:
name 'quadrature' is not defined
OK
Cancel
Apply
Properties: Low Pass Filter
General
Advanced
Documentation
ID
low_pass_filter_0
FIR Type
Complex->Complex (Decimating)
Decimation
int(samp_rate/quadrature)
Gain
1
Sample Rate
samp_rate
Cutoff Freq
cutoff
Transition Width
transition
Window
Hamming
Beta
6.76
Param - Decimation(decim):
Value "int(samp_rate/quadrature)" cannot be evaluated:
name 'quadrature' is not defined
OK
Cancel
Apply

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example



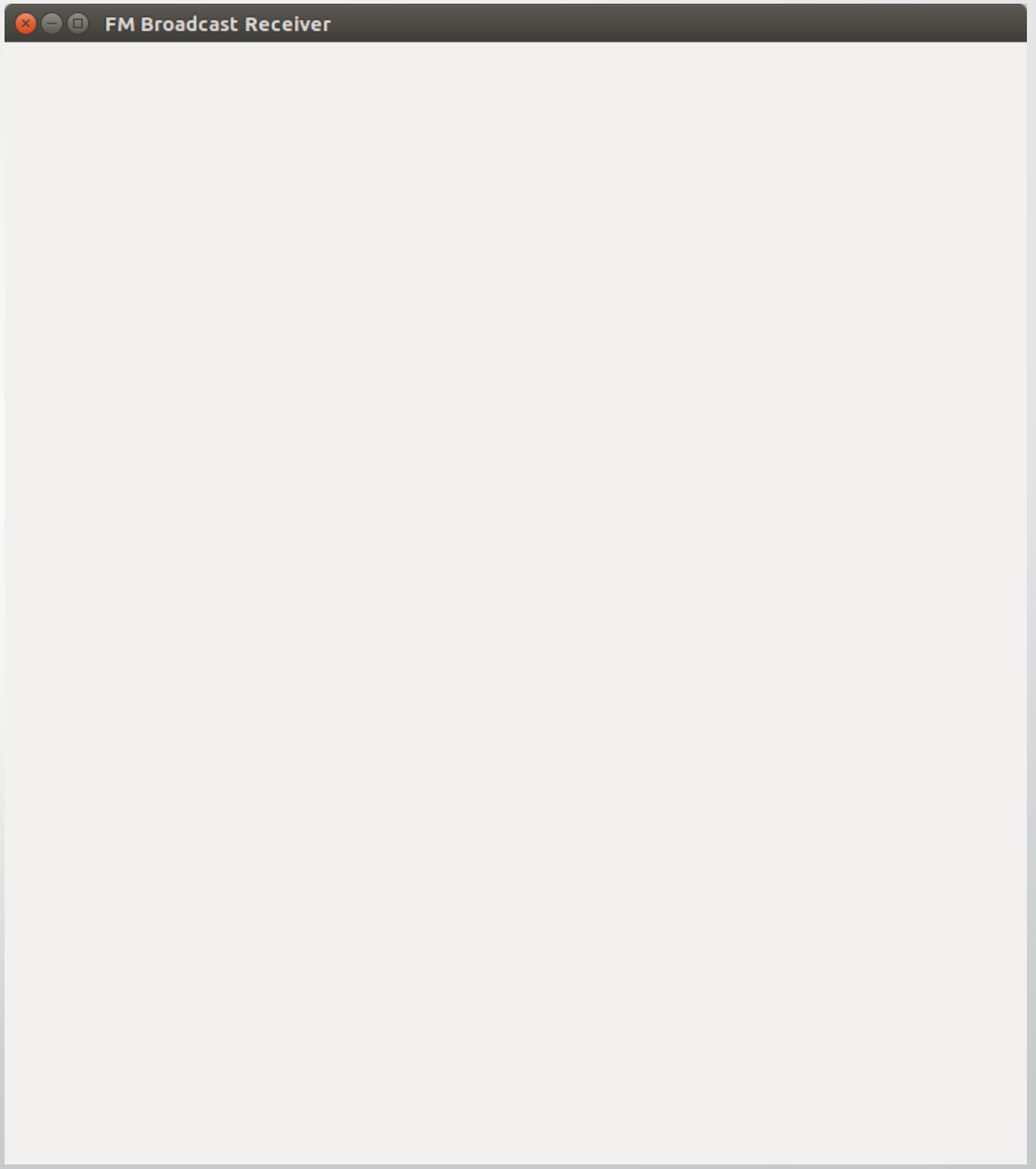

```
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
gr::log :INFO: audio source - Audio sink arch: alsa
aUaUaUaUaUaUaUaU
>>> Done
```

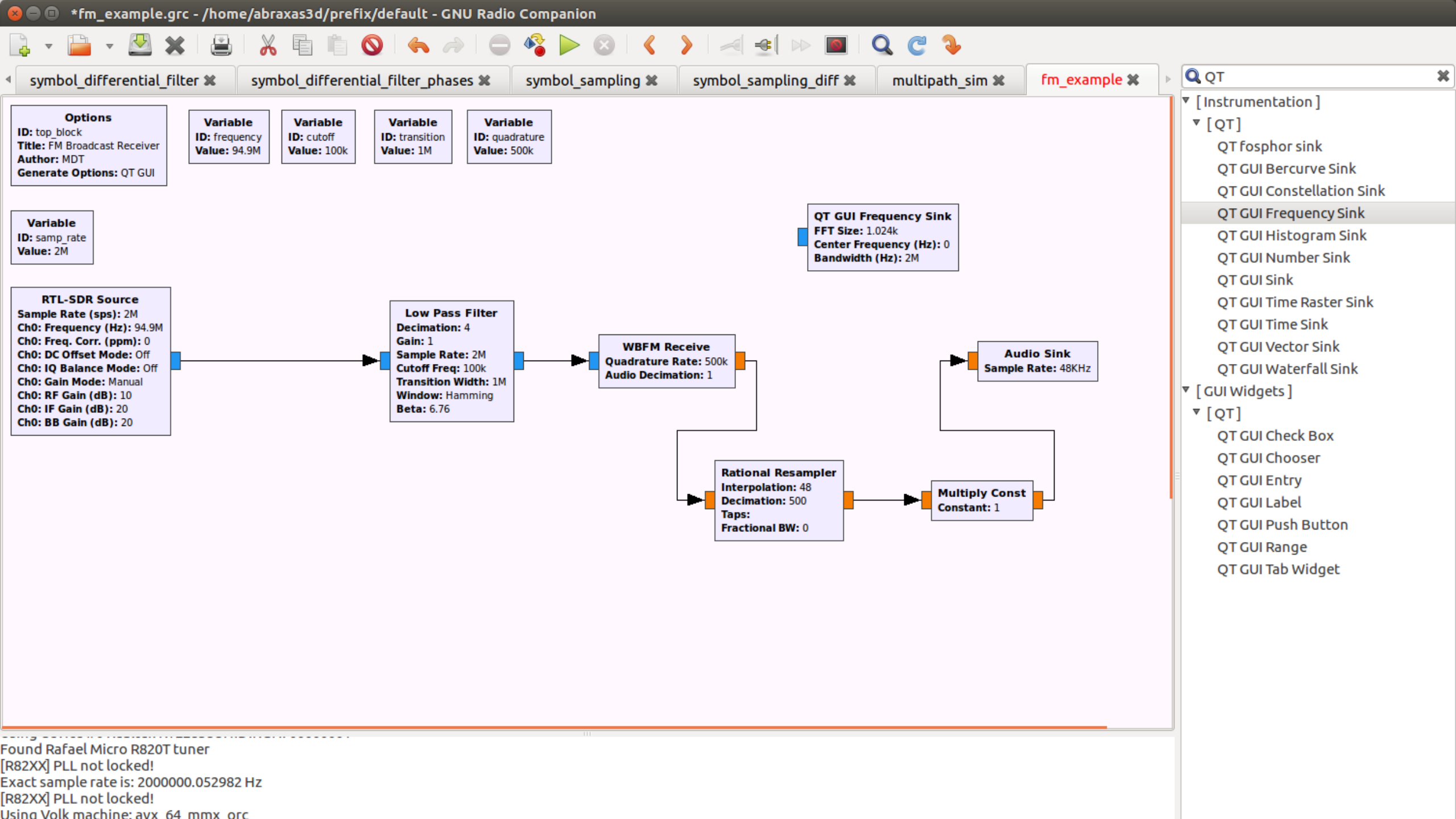
var

- [Variables]
  - Tag Object
  - Variable
  - Variable Config
  - Function Probe
  - Struct Variable
- [Modulators]
  - Constellation Object
  - Constellation Rect. Object
  - Modulate Vector
- [Error Coding]
  - [Decoders]
    - LDPC Decoder Definition
    - TPC Decoder Definition
    - CC Decoder Definition
    - Dummy Decoder Definition
    - LDPC Bit Flip Decoder Definitio
    - POLAR Decoder SC Definition
    - POLAR Decoder SC List Definiti
    - systematic POLAR Decoder SC D
    - Repetition Decoder Definition
  - [Encoders]
    - LDPC Encoder Definition
    - TPC Encoder Definition
    - CC Encoder Definition
    - CCSDS Encoder Definition
    - Dummy Encoder Definition
    - LDPC Encoder Definition (via Ge
    - LDPC Encoder Definition (via Pa
    - POLAR Encoder Definition
    - systematic POLAR Encoder Defi
    - Repetition Encoder Definition

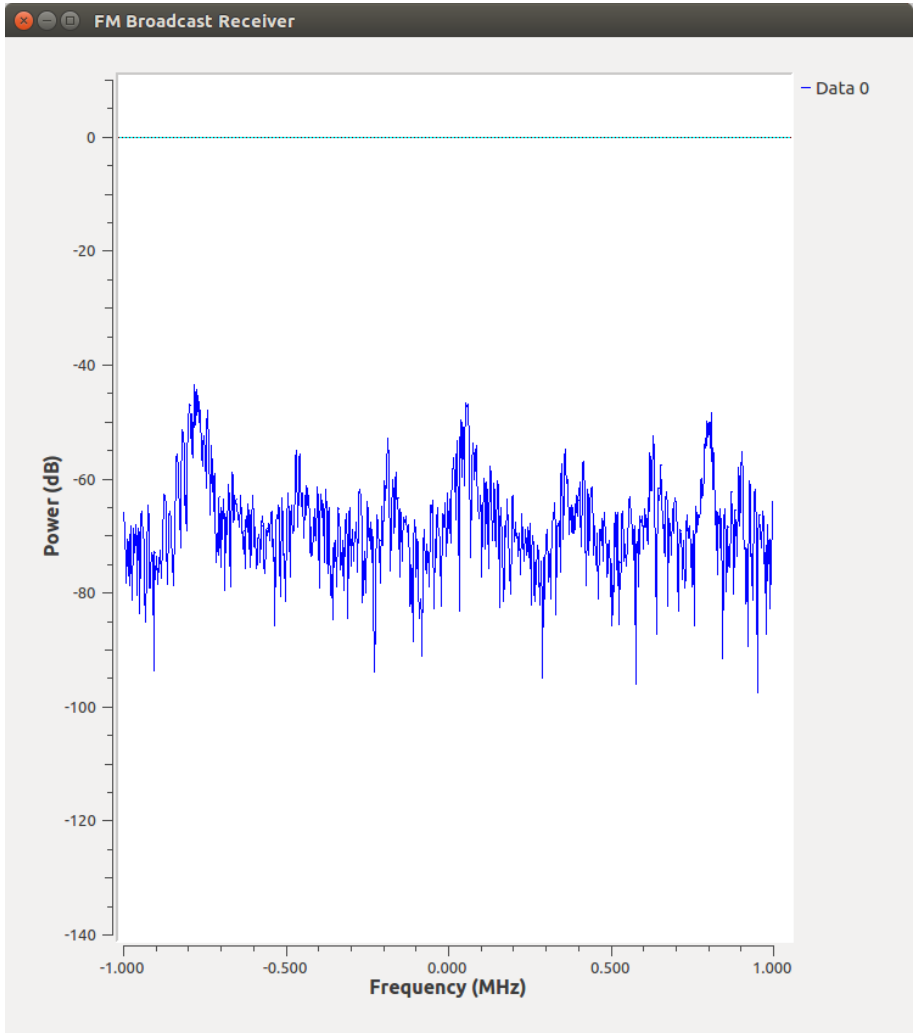
All blocks configured! We changed our hardcoded numbers to variables. We press play. Audio comes out of the speakers! We have a radio! But it is kind of dull to look at. Is there any way to see what is going on?

Yes!

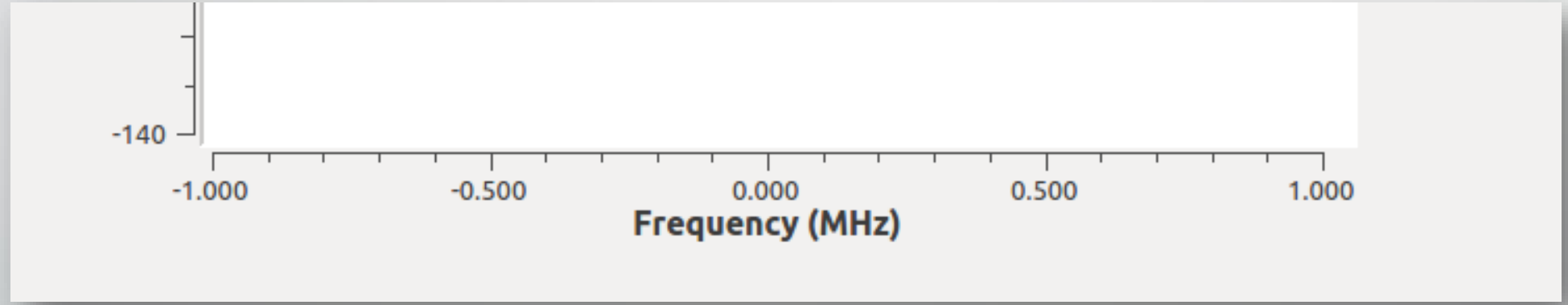


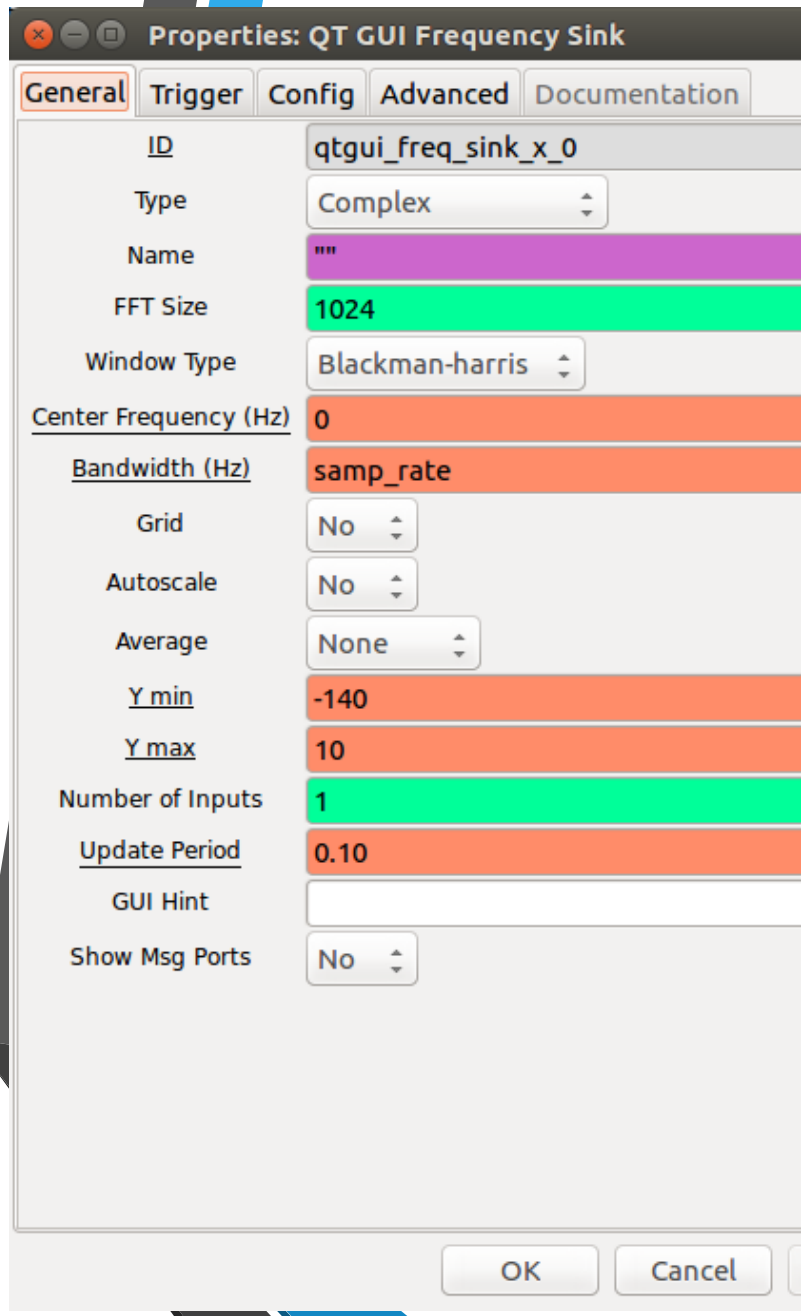

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: frequency
Value: 94.9M
Variable
ID: cutoff
Value: 100k
Variable
ID: transition
Value: 1M
Variable
ID: quadrature
Value: 500k
Variable
ID: samp_rate
Value: 2M
QT GUI Frequency Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 94.9M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: 48KHz
Rational Resampler
Interpolation: 48
Decimation: 500
Taps:
Fractional BW: 0
Multiply Const
Constant: 1
QT
[Instrumentation]
[QT]
QT fosphor sink
QT GUI Bercurve Sink
QT GUI Constellation Sink
QT GUI Frequency Sink
QT GUI Histogram Sink
QT GUI Number Sink
QT GUI Sink
QT GUI Time Raster Sink
QT GUI Time Sink
QT GUI Vector Sink
QT GUI Waterfall Sink
[GUI Widgets]
[QT]
QT GUI Check Box
QT GUI Chooser
QT GUI Entry
QT GUI Label
QT GUI Push Button
QT GUI Range
QT GUI Tab Widget
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc

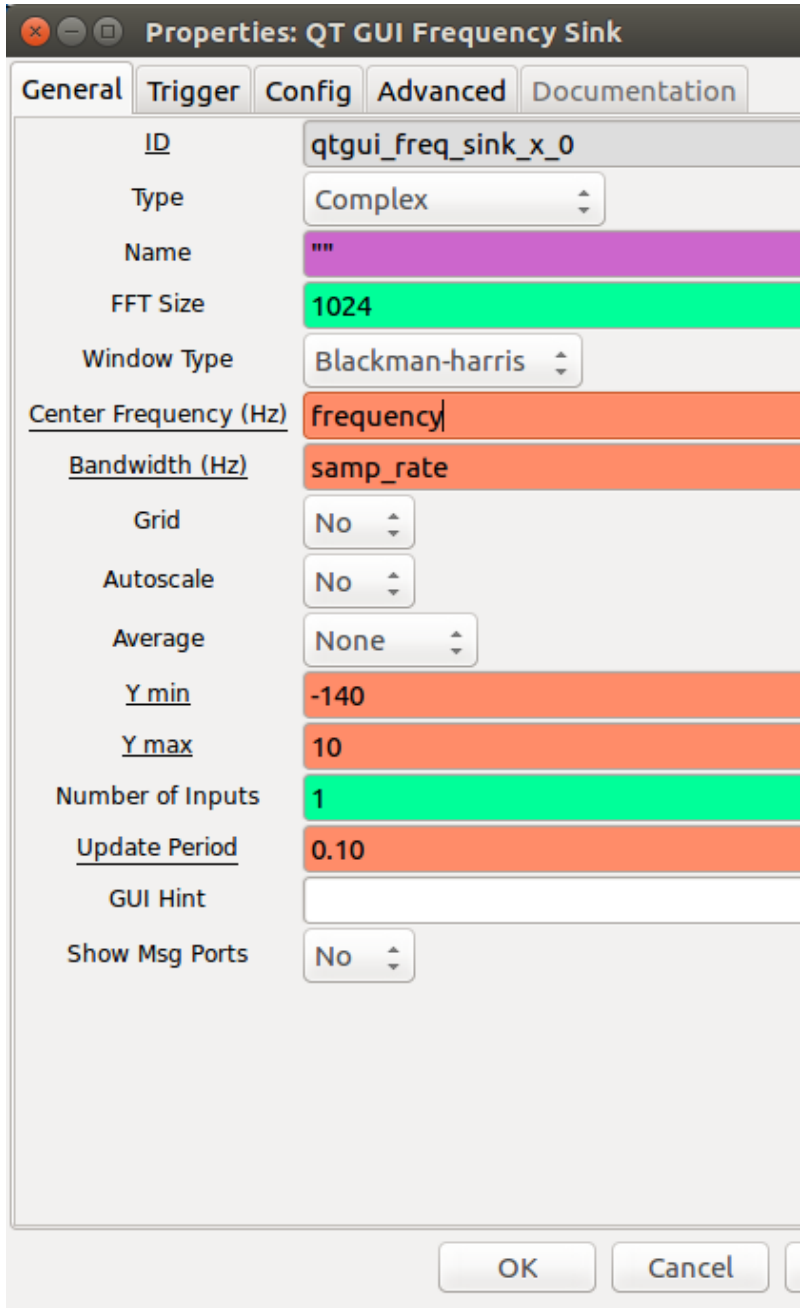
*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: frequency
Value: 94.9M
Variable
ID: cutoff
Value: 100k
Variable
ID: transition
Value: 1M
Variable
ID: quadrature
Value: 500k
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 94.9M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: 48KHz
Rational Resampler
Interpolation: 48
Decimation: 500
Taps:
Fractional BW: 0
Multiply Const
Constant: 1
QT GUI Frequency Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 2M
QT
[Instrumentation]
[QT]
QT fosphor sink
QT GUI Bercurve Sink
QT GUI Constellation Sink
QT GUI Frequency Sink
QT GUI Histogram Sink
QT GUI Number Sink
QT GUI Sink
QT GUI Time Raster Sink
QT GUI Time Sink
QT GUI Vector Sink
QT GUI Waterfall Sink
[GUI Widgets]
[QT]
QT GUI Check Box
QT GUI Chooser
QT GUI Entry
QT GUI Label
QT GUI Push Button
QT GUI Range
QT GUI Tab Widget
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc

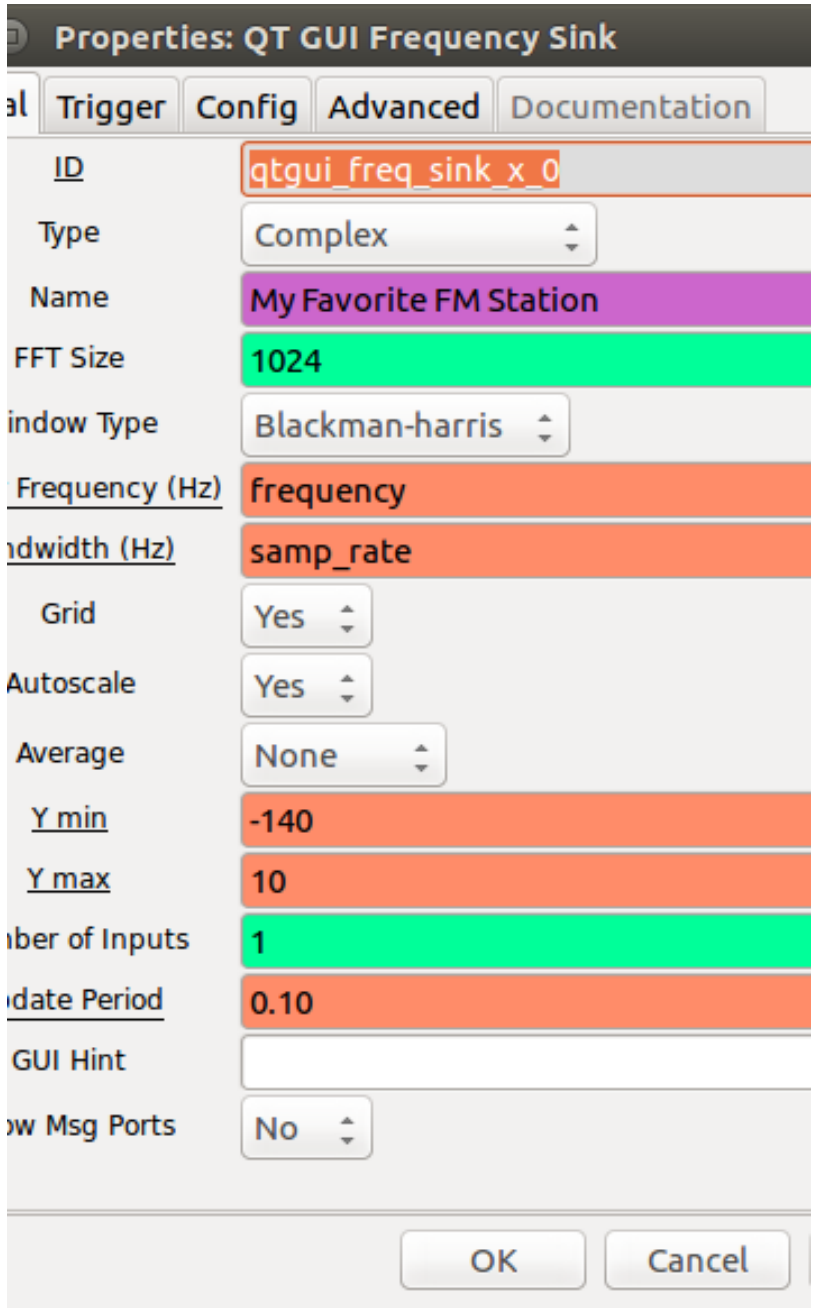

FM Broadcast Receiver
Data 0
0
-20
-40
-60
-80
-100
-120
-140
Power (dB)
-1.000
-0.500
0.000
0.500
1.000
Frequency (MHz)

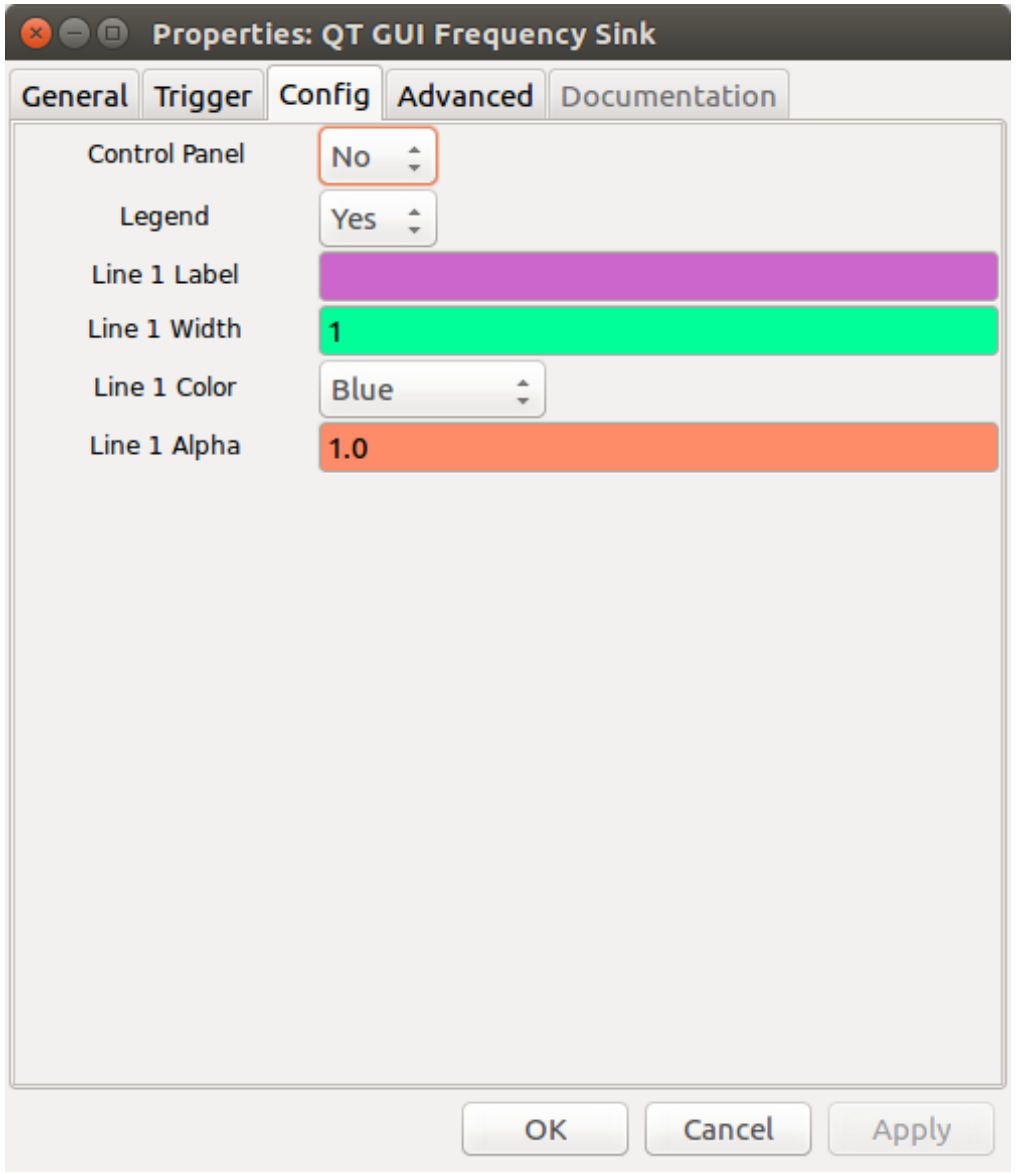
Uh oh. Why is the frequency axis wrong?

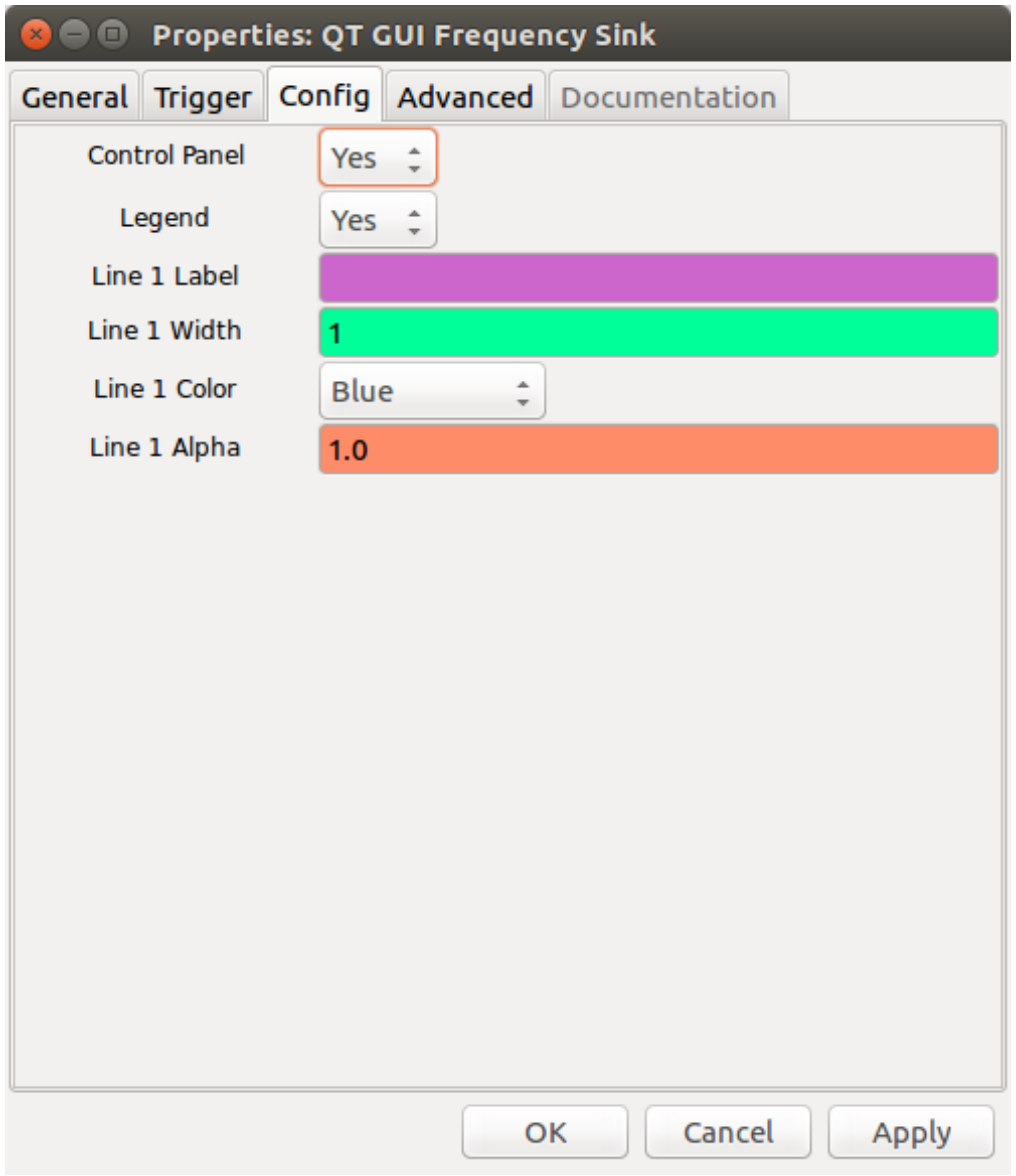


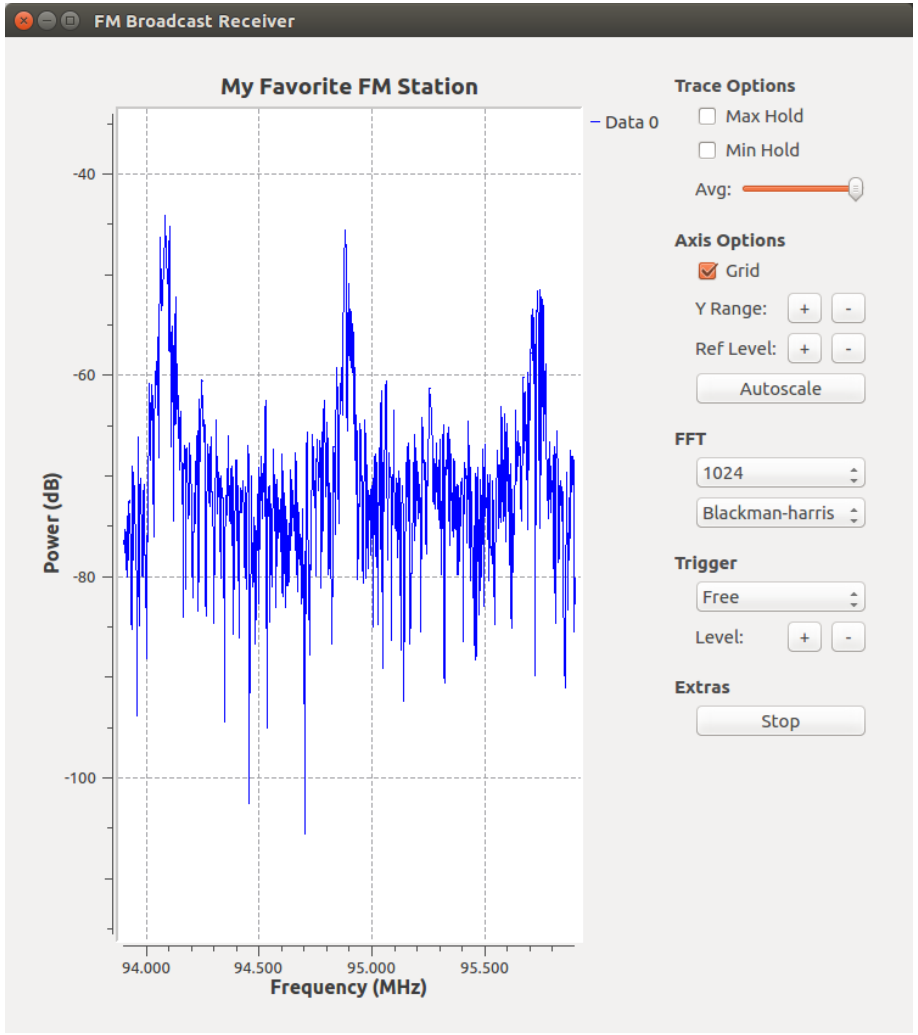

Properties: QT GUI Frequency Sink
General
Trigger
Config
Advanced
Documentation
ID
qtgui_freq_sink_x_0
Type
Complex
Name
""
FFT Size
1024
Window Type
Blackman-harris
Center Frequency (Hz)
0
Bandwidth (Hz)
samp_rate
Grid
No
Autoscale
No
Average
None
Y min
-140
Y max
10
Number of Inputs
1
Update Period
0.10
GUI Hint
Show Msg Ports
No
OK
Cancel

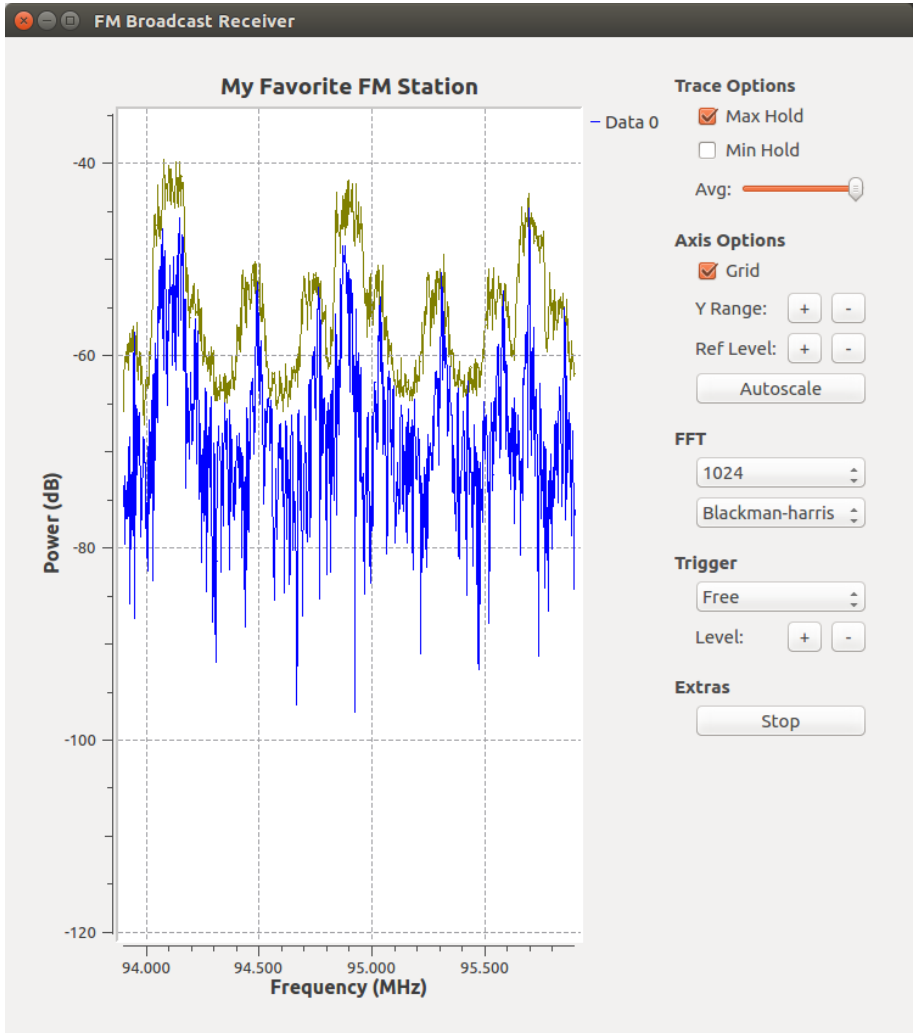

Properties: QT GUI Frequency Sink
General
Trigger
Config
Advanced
Documentation
ID
qtgui_freq_sink_x_0
Type
Complex
Name
""
FFT Size
1024
Window Type
Blackman-harris
Center Frequency (Hz)
frequency
Bandwidth (Hz)
samp_rate
Grid
No
Autoscale
No
Average
None
Y min
-140
Y max
10
Number of Inputs
1
Update Period
0.10
GUI Hint
Show Msg Ports
No
OK
Cancel

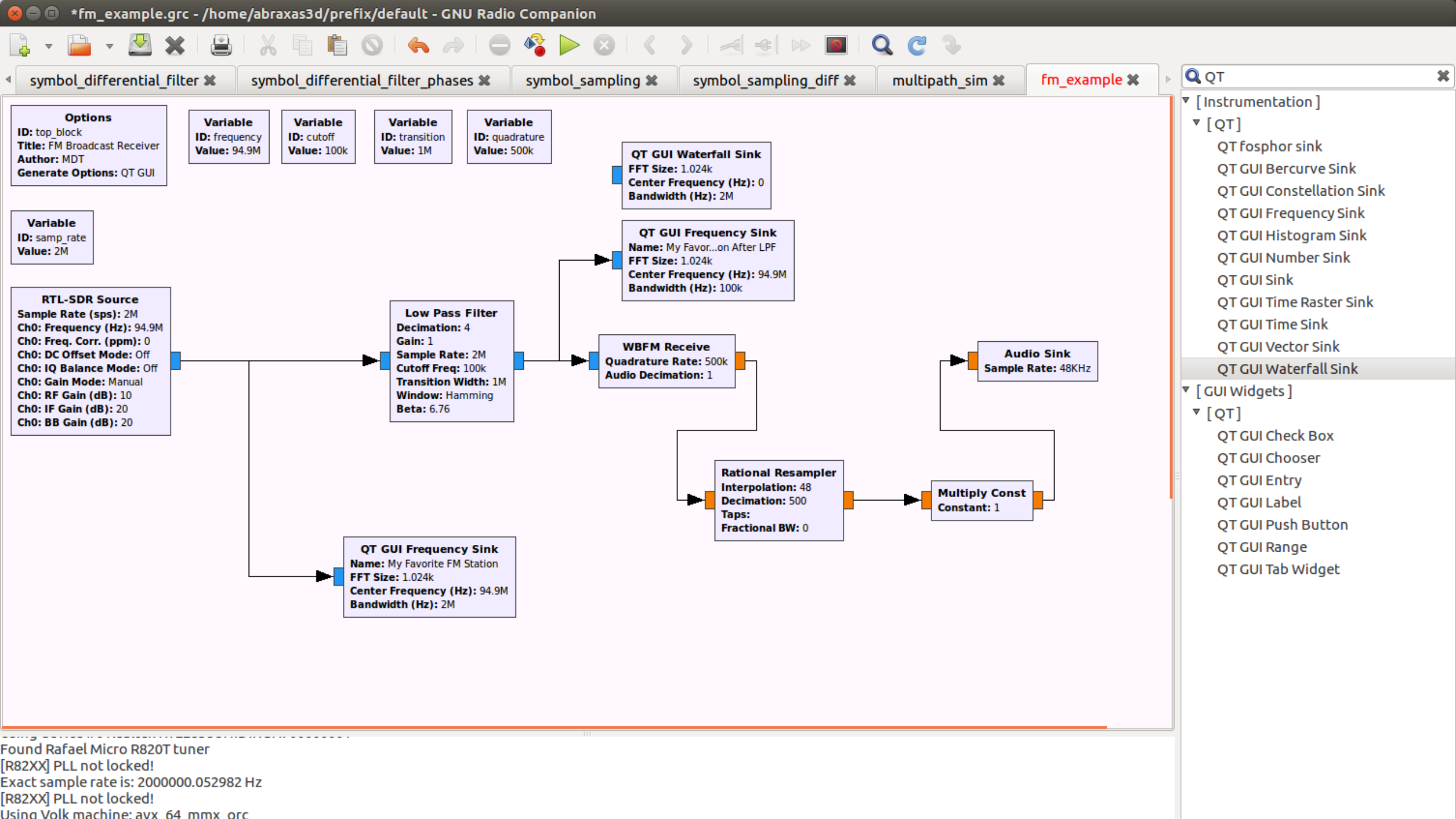

Properties: QT GUI Frequency Sink
Trigger
Config
Advanced
Documentation
ID
qtgui_freq_sink_x_0
Type
Complex
Name
My Favorite FM Station
FFT Size
1024
Frequency (Hz)
frequency
Bandwidth (Hz)
samp_rate
Grid
Yes
Autoscale
Yes
Average
None
Y min
-140
Y max
10
GUI Hint
OK
Cancel

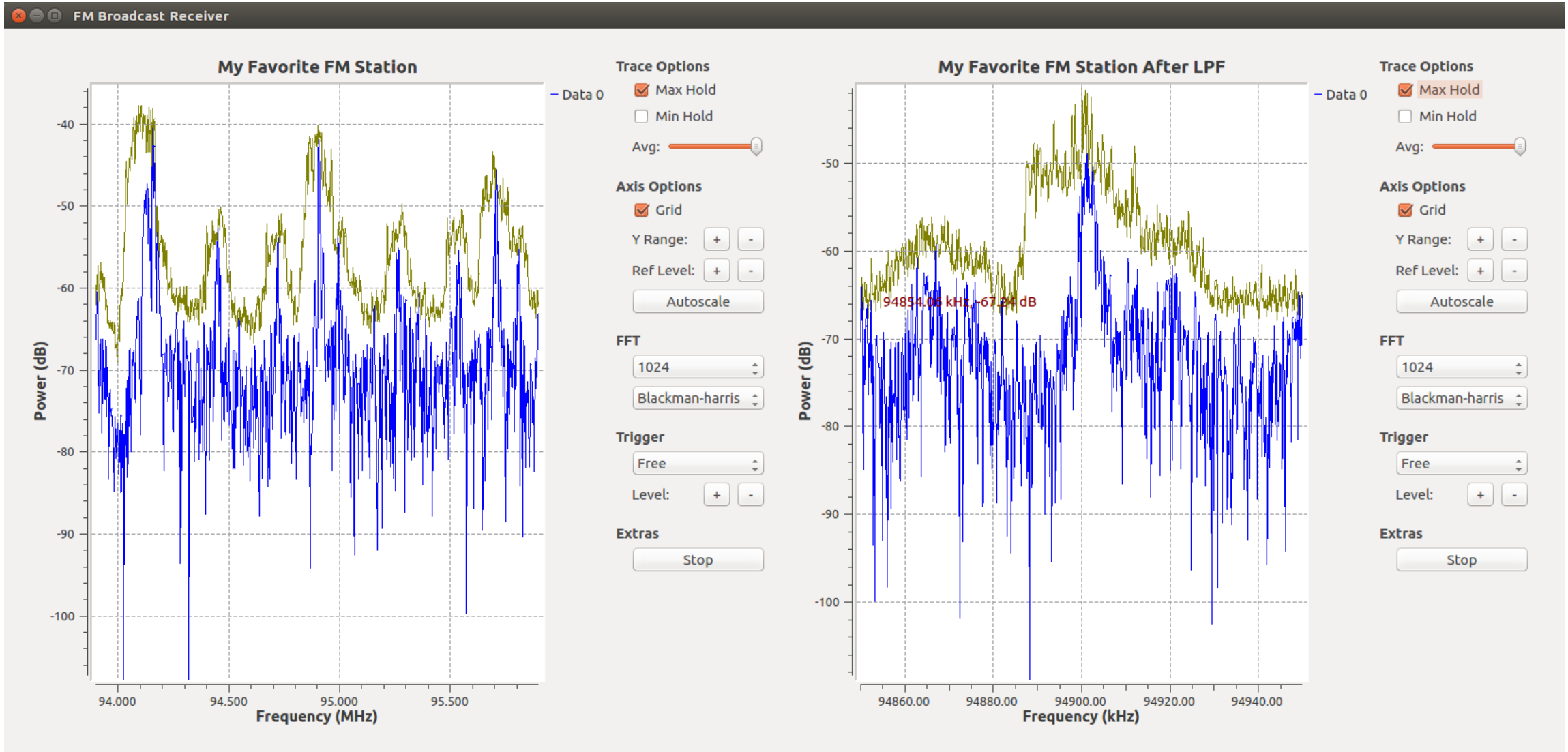

Properties: QT GUI Frequency Sink
General
Trigger
Config
Advanced
Documentation
Control Panel
No
Legend
Yes
Line 1 Label
Line 1 Width
1
Line 1 Color
Blue
Line 1 Alpha
1.0
OK
Cancel
Apply

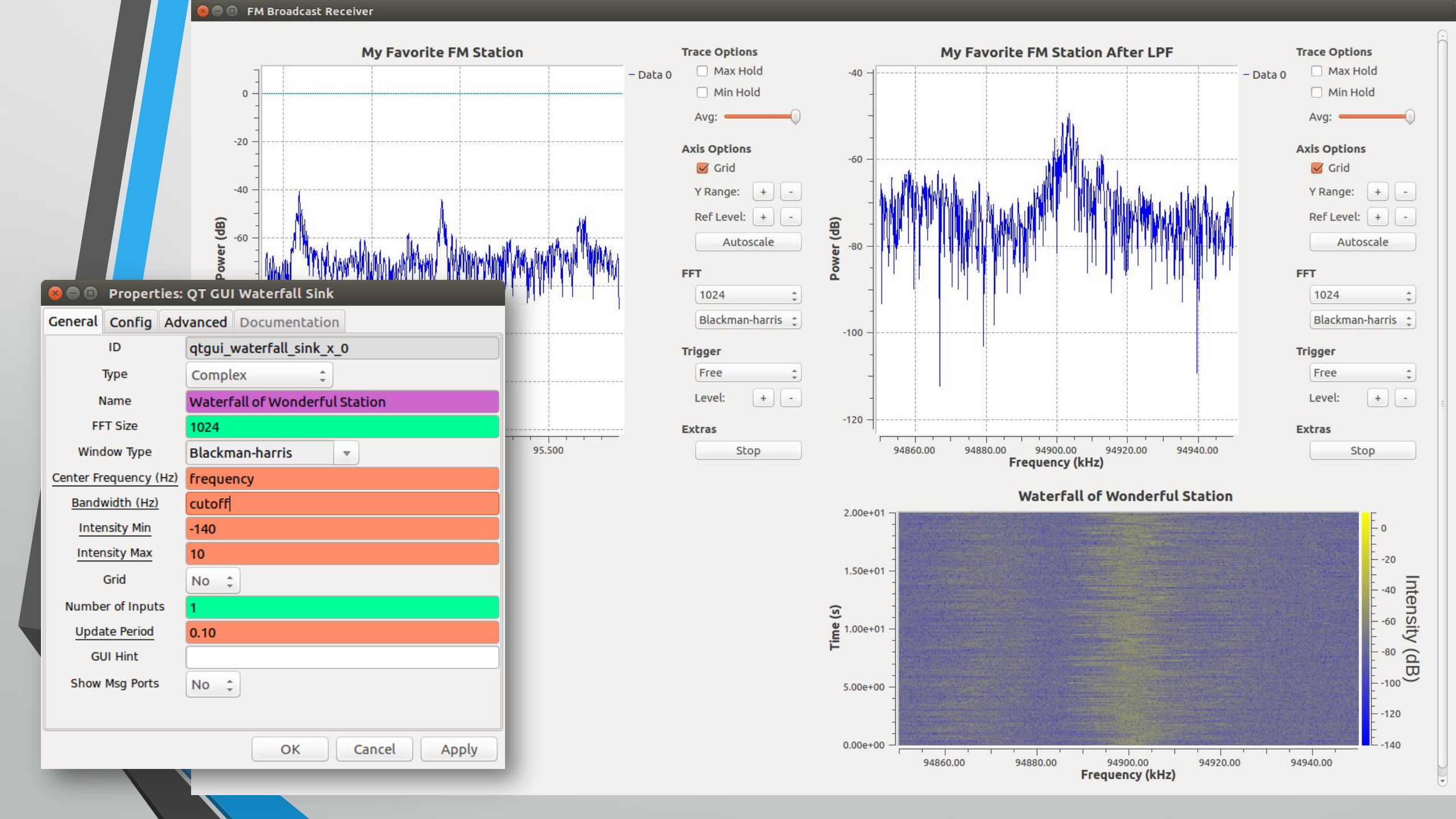

Properties: QT GUI Frequency Sink
General
Trigger
Config
Advanced
Documentation
Control Panel
Yes
Legend
Yes
Line 1 Label
Line 1 Width
1
Line 1 Color
Blue
Line 1 Alpha
1.0
OK
Cancel
Apply


FM Broadcast Receiver
My Favorite FM Station
Data 0
-40
-60
-80
-100
Power (dB)
94.000
94.500
95.000
95.500
Frequency (MHz)
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop


FM Broadcast Receiver
My Favorite FM Station
Data 0
-40
-60
-80
-100
-120
Power (dB)
94.000
94.500
95.000
95.500
Frequency (MHz)
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop

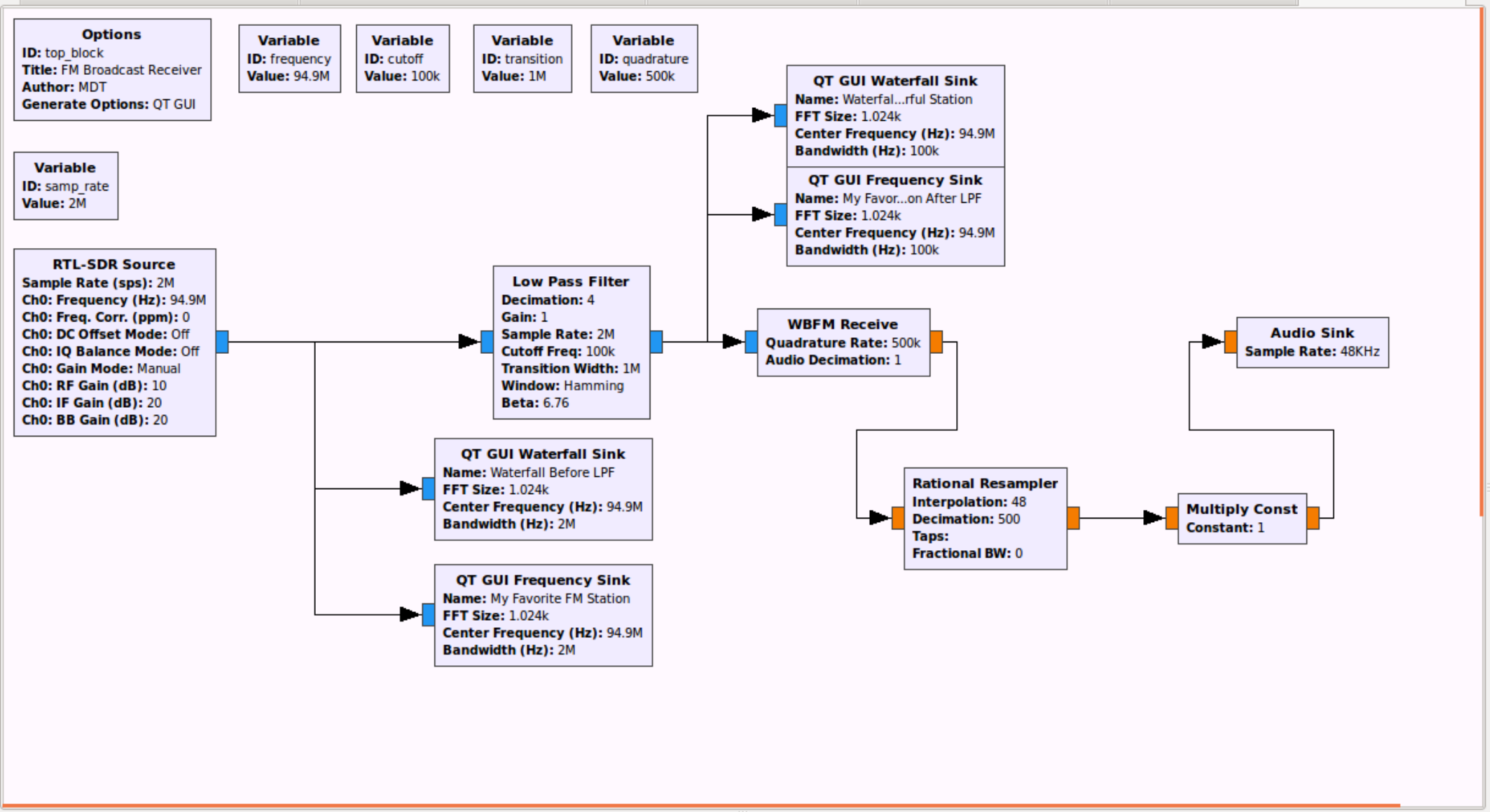

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
symbol_sampling
symbol_sampling_diff
multipath_sim
fm_example
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: frequency
Value: 94.9M
Variable
ID: cutoff
Value: 100k
Variable
ID: transition
Value: 1M
Variable
ID: quadrature
Value: 500k
Variable
ID: samp_rate
Value: 2M
QT GUI Waterfall Sink
FFT Size: 1.024k
Center Frequency (Hz): 0
Bandwidth (Hz): 2M
QT GUI Frequency Sink
Name: My Favor...on After LPF
FFT Size: 1.024k
Center Frequency (Hz): 94.9M
Bandwidth (Hz): 100k
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 94.9M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
WBFM Receive
Quadrature Rate: 500k
Audio Decimation: 1
Audio Sink
Sample Rate: 48KHz
Rational Resampler
Interpolation: 48
Decimation: 500
Taps:
Fractional BW: 0
Multiply Const
Constant: 1
QT GUI Frequency Sink
Name: My Favorite FM Station
FFT Size: 1.024k
Center Frequency (Hz): 94.9M
Bandwidth (Hz): 2M
QT
[Instrumentation]
[QT]
QT fosphor sink
QT GUI Bercurve Sink
QT GUI Constellation Sink
QT GUI Frequency Sink
QT GUI Histogram Sink
QT GUI Number Sink
QT GUI Sink
QT GUI Time Raster Sink
QT GUI Time Sink
QT GUI Vector Sink
QT GUI Waterfall Sink
[GUI Widgets]
[QT]
QT GUI Check Box
QT GUI Chooser
QT GUI Entry
QT GUI Label
QT GUI Push Button
QT GUI Range
QT GUI Tab Widget
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc


FM Broadcast Receiver
My Favorite FM Station
Data 0
Power (dB)
-40
-50
-60
-70
-80
-90
-100
94.000
94.500
95.000
95.500
Frequency (MHz)
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop
My Favorite FM Station After LPF
Data 0
Power (dB)
-50
-60
-70
-80
-90
-100
94860.00
94880.00
94900.00
94920.00
94940.00
Frequency (kHz)
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop


FM Broadcast Receiver
My Favorite FM Station
Data 0
Power (dB)
95.500
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop
My Favorite FM Station After LPF
Data 0
Power (dB)
Frequency (kHz)
94860.00
94880.00
94900.00
94920.00
94940.00
Trace Options
Max Hold
Min Hold
Avg:
Axis Options
Grid
Y Range:
Ref Level:
Autoscale
FFT
1024
Blackman-harris
Trigger
Free
Level:
Extras
Stop
Properties: QT GUI Waterfall Sink
General
Config
Advanced
Documentation
ID
qtgui_waterfall_sink_x_0
Type
Complex
Name
Waterfall of Wonderful Station
FFT Size
1024
Window Type
Blackman-harris
Center Frequency (Hz)
frequency
Bandwidth (Hz)
cutoff
Intensity Min
-140
Intensity Max
10
Grid
No
Number of Inputs
1
Update Period
0.10
GUI Hint
Show Msg Ports
No
OK
Cancel
Apply
Waterfall of Wonderful Station
Time (s)
Frequency (kHz)
Intensity (dB)

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example

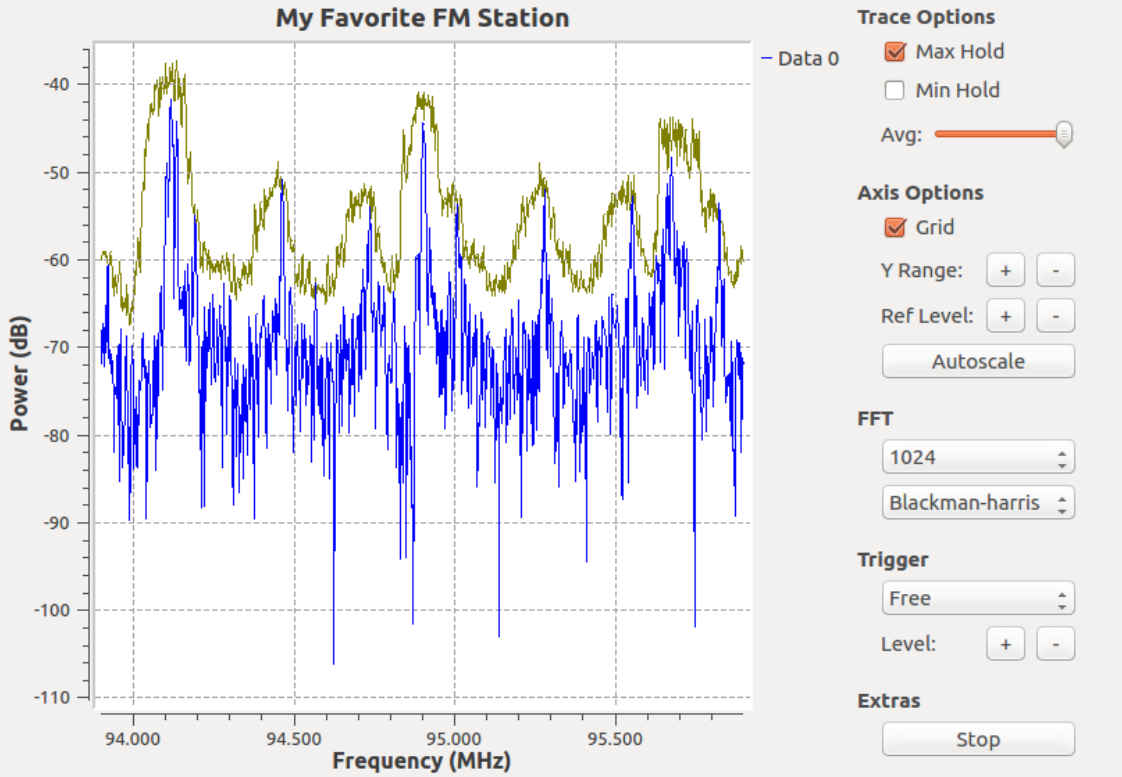



```
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
```

QT

- [Instrumentation]
  - [QT]
    - QT fosphor sink
    - QT GUI Bercurve Sink
    - QT GUI Constellation Sink
    - QT GUI Frequency Sink
    - QT GUI Histogram Sink
    - QT GUI Number Sink
    - QT GUI Sink
    - QT GUI Time Raster Sink
    - QT GUI Time Sink
    - QT GUI Vector Sink
    - QT GUI Waterfall Sink
- [GUI Widgets]
  - [QT]
    - QT GUI Check Box
    - QT GUI Chooser
    - QT GUI Entry
    - QT GUI Label
    - QT GUI Push Button
    - QT GUI Range
    - QT GUI Tab Widget

FM Broadcast Receiver



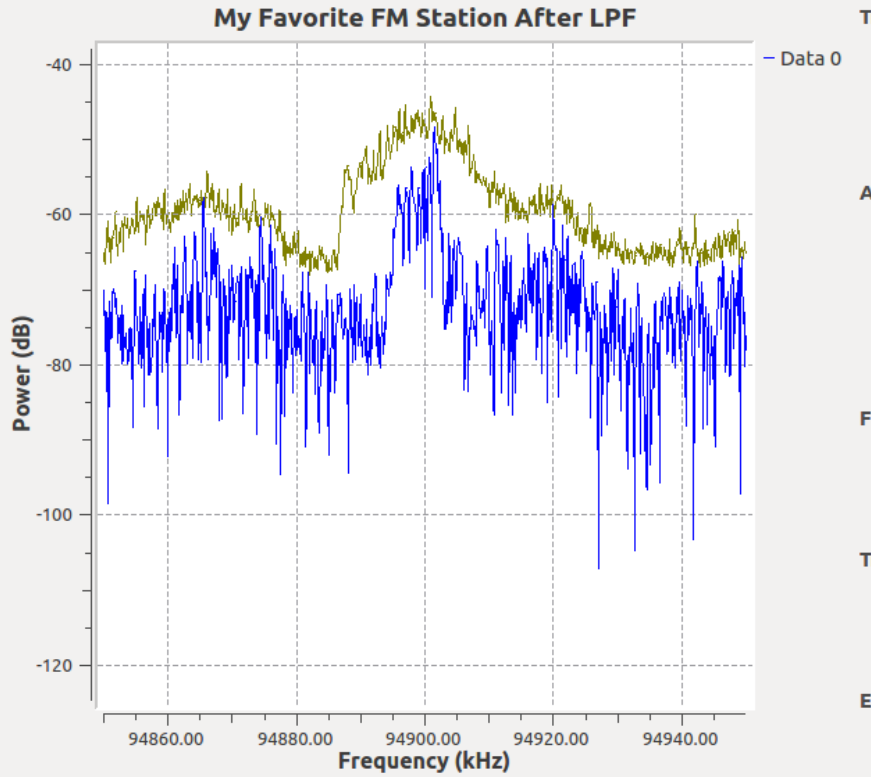
Trace Options
Max Hold
Min Hold
Avg:

Axis Options
Grid
Y Range: + -
Ref Level: + -
Autoscale

FFT
1024
Blackman-harris

Trigger
Free
Level: + -

Extras
Stop



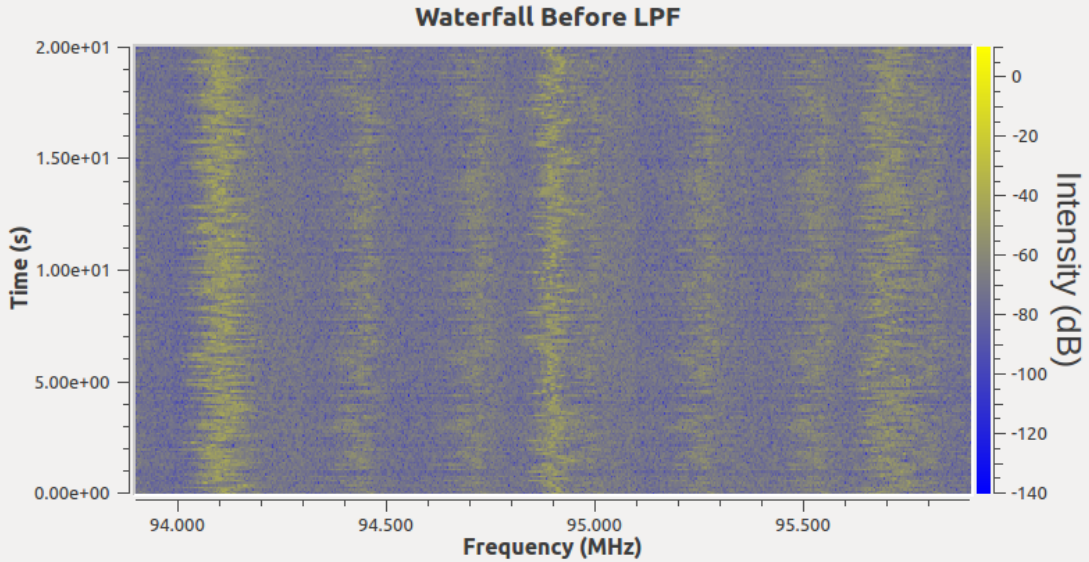
Trace Options
Max Hold
Min Hold
Avg:

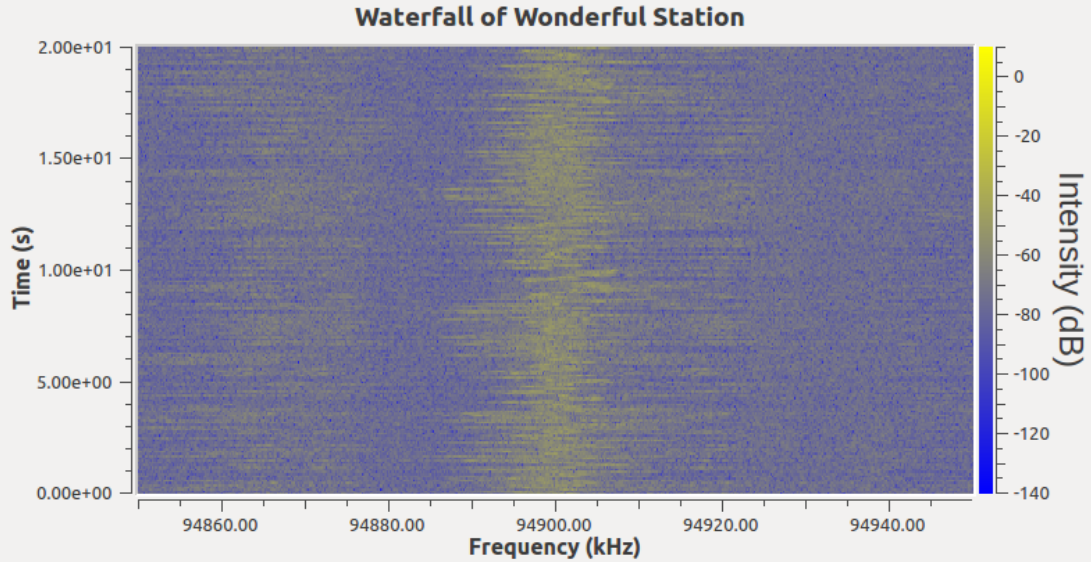
Axis Options
Grid
Y Range: + -
Ref Level: + -
Autoscale

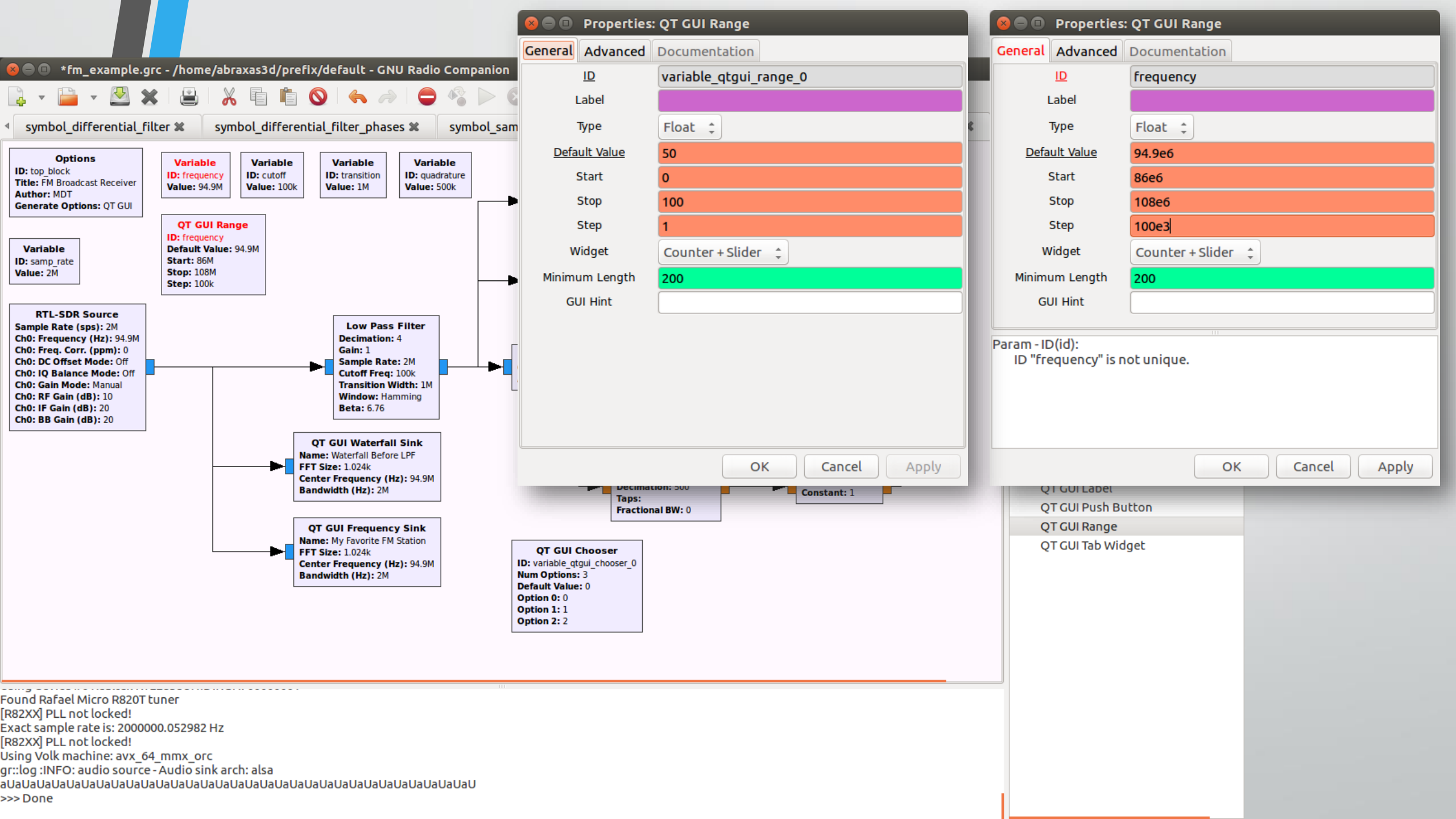
FFT
1024
Blackman-harris

Trigger
Free
Level: + -

Extras
Stop

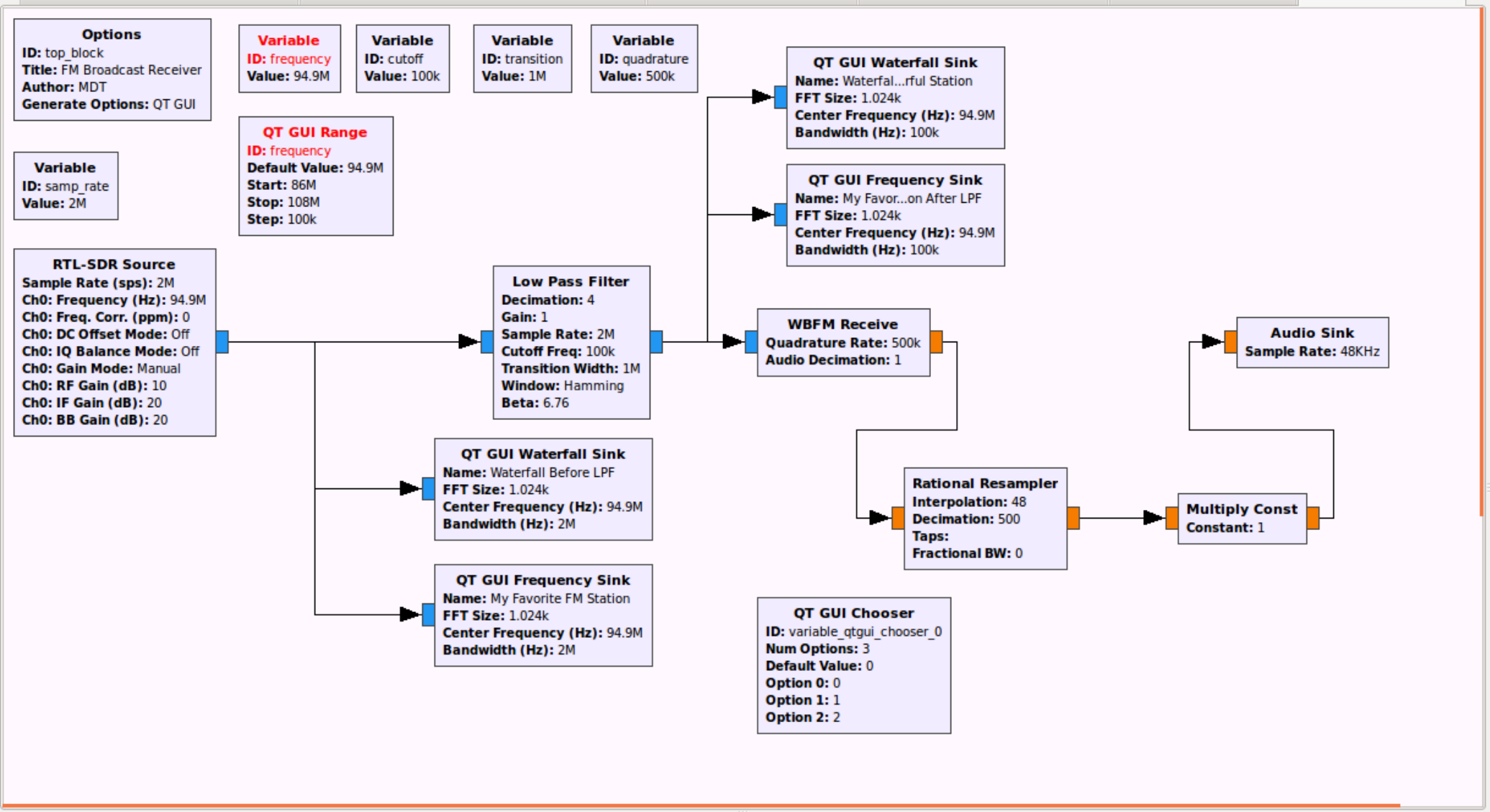





*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion
symbol_differential_filter
symbol_differential_filter_phases
Options
ID: top_block
Title: FM Broadcast Receiver
Author: MDT
Generate Options: QT GUI
Variable
ID: frequency
Value: 94.9M
Variable
ID: cutoff
Value: 100k
Variable
ID: transition
Value: 1M
Variable
ID: quadrature
Value: 500k
QT GUI Range
ID: frequency
Default Value: 94.9M
Start: 86M
Stop: 108M
Step: 100k
Variable
ID: samp_rate
Value: 2M
RTL-SDR Source
Sample Rate (sps): 2M
Ch0: Frequency (Hz): 94.9M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 10
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
Low Pass Filter
Decimation: 4
Gain: 1
Sample Rate: 2M
Cutoff Freq: 100k
Transition Width: 1M
Window: Hamming
Beta: 6.76
QT GUI Waterfall Sink
Name: Waterfall Before LPF
FFT Size: 1.024k
Center Frequency (Hz): 94.9M
Bandwidth (Hz): 2M
QT GUI Frequency Sink
Name: My Favorite FM Station
FFT Size: 1.024k
Center Frequency (Hz): 94.9M
Bandwidth (Hz): 2M
QT GUI Chooser
ID: variable_qtgui_chooser_0
Num Options: 3
Default Value: 0
Option 0: 0
Option 1: 1
Option 2: 2
Taps:
Fractional BW: 0
Constant: 1
Properties: QT GUI Range
General
Advanced
Documentation
ID
variable_qtgui_range_0
Label
Type
Float
Default Value
50
Start
0
Stop
100
Step
1
Widget
Counter + Slider
Minimum Length
200
GUI Hint
OK
Cancel
Apply
Properties: QT GUI Range
General
Advanced
Documentation
ID
frequency
Label
Type
Float
Default Value
94.9e6
Start
86e6
Stop
108e6
Step
100e3
Widget
Counter + Slider
Minimum Length
200
GUI Hint
Param - ID(id):
ID "frequency" is not unique.
OK
Cancel
Apply
QT GUI Label
QT GUI Push Button
QT GUI Range
QT GUI Tab Widget
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
gr::log :INFO: audio source - Audio sink arch: alsa
>>> Done

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example



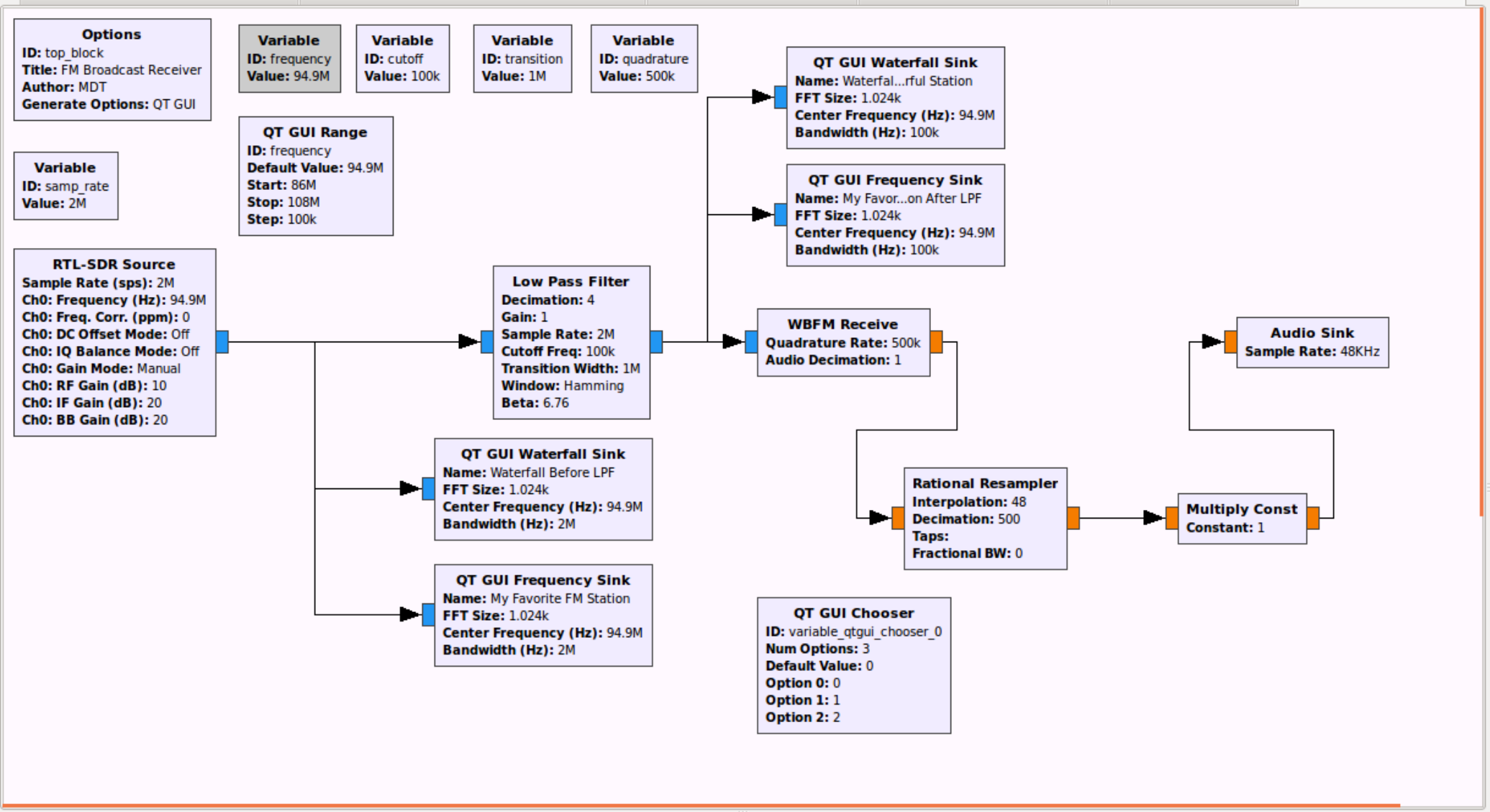

```
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
```

QT

- [Instrumentation]
  - [QT]
    - QT fosphor sink
    - QT GUI Bercurve Sink
    - QT GUI Constellation Sink
    - QT GUI Frequency Sink
    - QT GUI Histogram Sink
    - QT GUI Number Sink
    - QT GUI Sink
    - QT GUI Time Raster Sink
    - QT GUI Time Sink
    - QT GUI Vector Sink
    - QT GUI Waterfall Sink
- [GUI Widgets]
  - [QT]
    - QT GUI Check Box
    - QT GUI Chooser
    - QT GUI Entry
    - QT GUI Label
    - QT GUI Push Button
    - QT GUI Range
    - QT GUI Tab Widget

*fm_example.grc - /home/abraxas3d/prefix/default - GNU Radio Companion

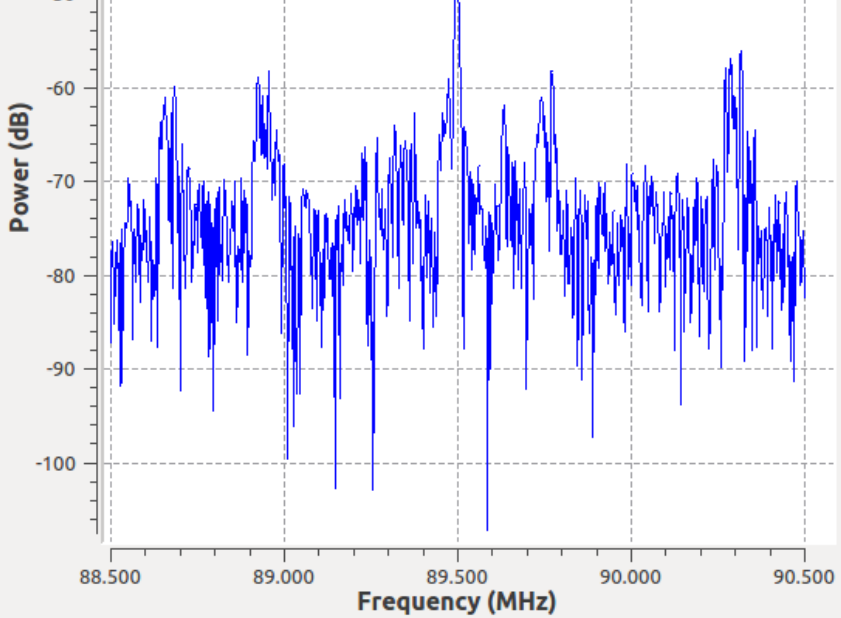
symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim | fm_example




```
Found Rafael Micro R820T tuner
[R82XX] PLL not locked!
Exact sample rate is: 2000000.052982 Hz
[R82XX] PLL not locked!
Using Volk machine: avx_64_mmx_orc
```

QT

- [Instrumentation]
  - [QT]
    - QT fosphor sink
    - QT GUI Bercurve Sink
    - QT GUI Constellation Sink
    - QT GUI Frequency Sink
    - QT GUI Histogram Sink
    - QT GUI Number Sink
    - QT GUI Sink
    - QT GUI Time Raster Sink
    - QT GUI Time Sink
    - QT GUI Vector Sink
    - QT GUI Waterfall Sink
- [GUI Widgets]
  - [QT]
    - QT GUI Check Box
    - QT GUI Chooser
    - QT GUI Entry
    - QT GUI Label
    - QT GUI Push Button
    - QT GUI Range
    - QT GUI Tab Widget



Grid

Y Range: + -

Ref Level: + -

Autoscale

FFT

1024

Blackman-harris

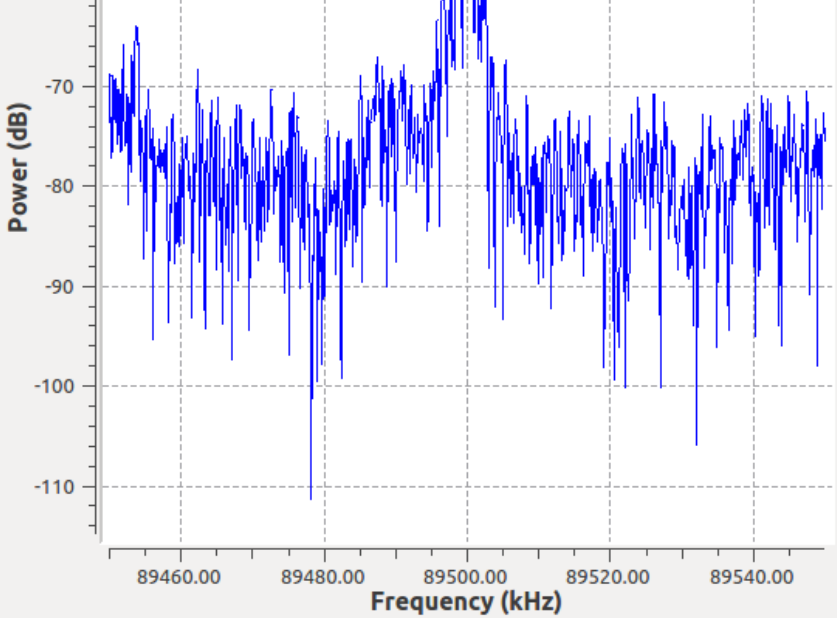
Trigger

Free

Level: + -

Extras

Stop



Grid

Y Range: + -

Ref Level: + -

Autoscale

FFT

1024

Blackman-harris

Trigger

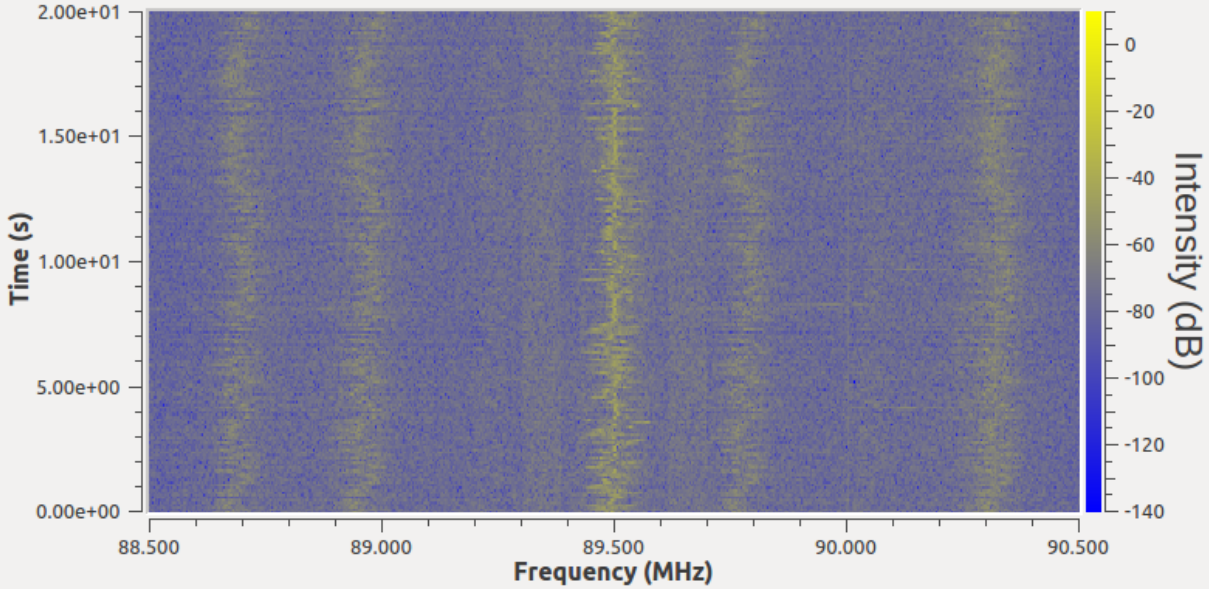
Free

Level: + -

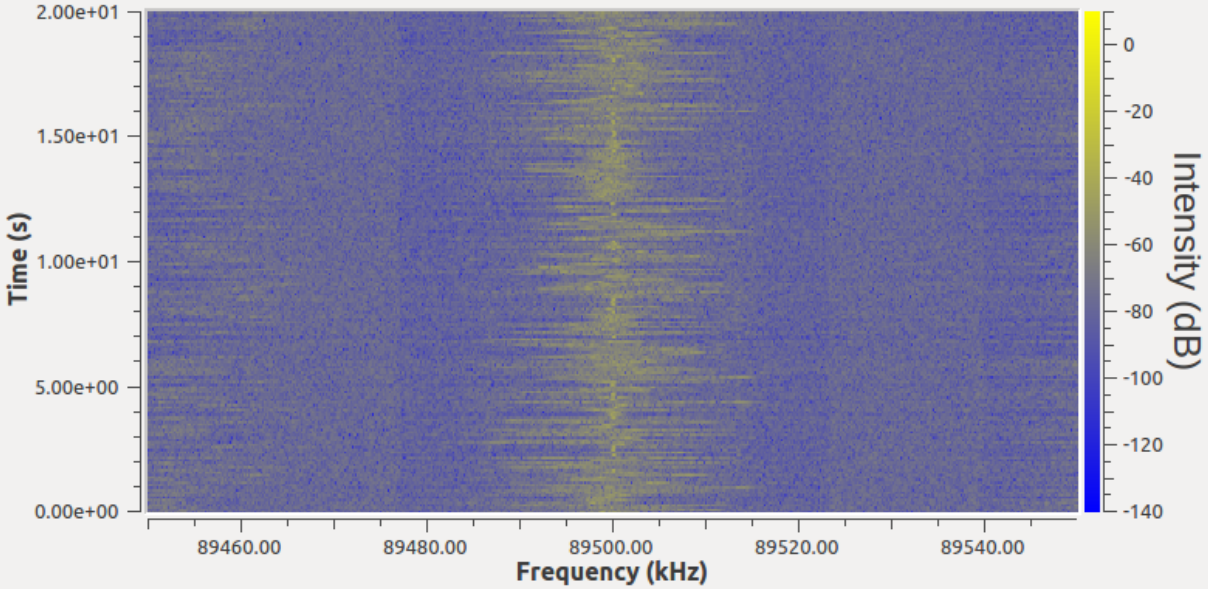
Extras

Stop

Waterfall Before LPF



Waterfall of Wonderful Station



frequency

89500000

Use GNU Radio as Learning Tool

Multipath Simulator

"Why do we need equalizers to deal with multi-path?"

multipath_sim.grc - /home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7 - GNU Radio Companion

mpsk_stage6 | symbol_differential_filter | symbol_differential_filter_phases | symbol_sampling | symbol_sampling_diff | multipath_sim

Options
ID: multipath_sim
Generate Options: QT GUI

Variable
ID: arity
Value: 4

Variable
ID: sps
Value: 4

Variable
ID: samp_rate
Value: 32k

Variable
ID: taps
Value: 19.2705m...m+107.189mj

Import
Import: fftpack

Import
Import: math

Channel Model
Noise Voltage: 0
Frequency Offset: 0
Epsilon: 1
Taps: 19.2705m...5m+107.189mj
Seed: 0

Noise Source
Noise Type: Gaussian
Amplitude: 1
Seed: 0

Throttle
Sample Rate: 32k

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

QT GUI Range
ID: tap1
Default Value: 250m
Start: 0
Stop: 1
Step: 10m

QT GUI Range
ID: tap2
Default Value: 500m
Start: 0
Stop: 1
Step: 10m

QT GUI Range
ID: tap3
Default Value: 600m
Start: 0
Stop: 1
Step: 10m

QT GUI Range
ID: tap4
Default Value: 600m
Start: 0
Stop: 1
Step: 10m

Core
- Audio
- Boolean Operators
- Byte Operators
- Channelizers
- Channel Models
- Coding
- Control Port
- Debug Tools
- Deprecated
- Digital Television
- Equalizers
- Error Coding
- FCD
- File Operators
- Filters
- Fourier Analysis
- GUI Widgets
- Impairment Models
- Instrumentation
- Level Controllers
- Math Operators
- Measurement Tools
- Message Tools

Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.py'

Executing: /usr/bin/python2 -u /home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/multipath_sim.py

>>> Done

Id	Value
Imports	
import_ma	import math
import_sci	from scipy im
Variables	
arity	4

Multipath Sim

QT GUI Plot

Relative Gain (dB)

Frequency (kHz)

Multipath
AWGN

Trace Options
Max Hold
Min Hold
Avg:

Axis Options
Grid
Axis Labels
Y Range:
Ref Level:
Autoscale

FFT
1024
Blackman-harris

Trigger
Free
Level:

Extras
Stop

tap1
tap2
tap3
tap4

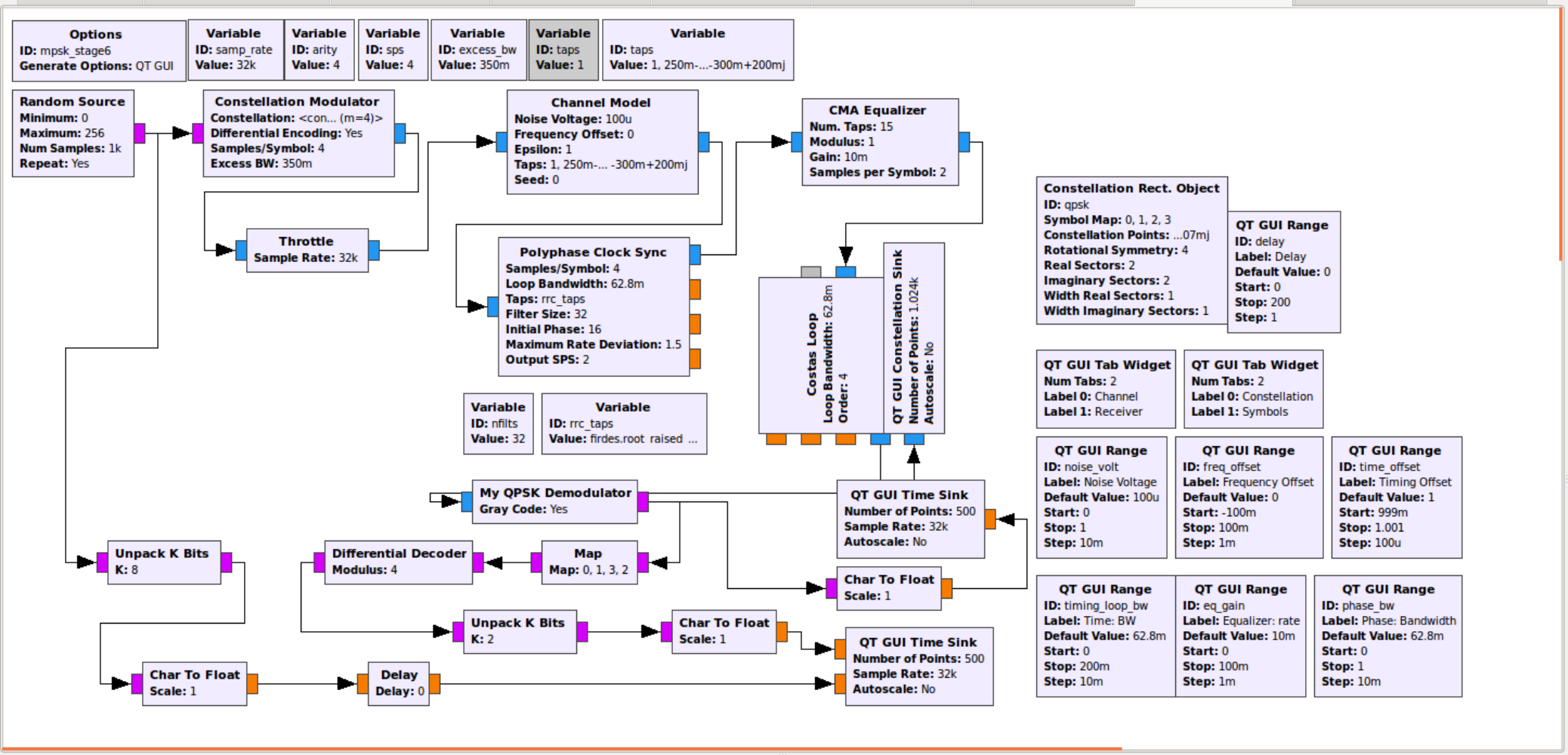
Use GNU Radio as Learning Tool

Phase Shift Keying

"How do I receive a phase shift key signal?"

mpsk_stage6.grc - /home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7 - GNU Radio Companion

FirstTest | mpsk_rrc_rolloff | mpsk_stage1 | mpsk_stage2 | mpsk_stage3 | mpsk_stage4 | mpsk_stage5 | mpsk_stage6 | symbol_differential_filter



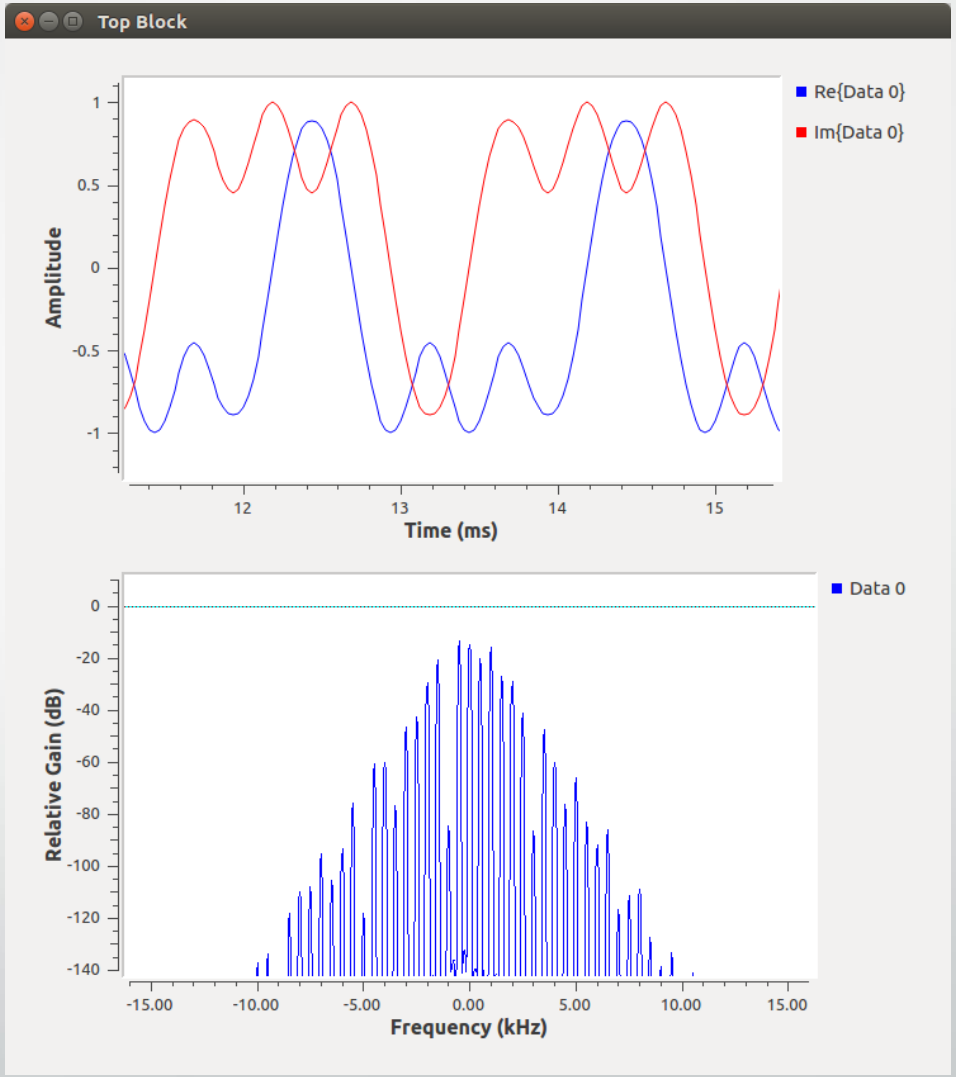

```
Executing: /usr/bin/python2 -u /home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/mpsk_stage2.py

>>> Done

Generating: '/home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/mpsk_stage6.py'

Executing: /usr/bin/python2 -u /home/abraxas3d/prefix/default/share/gr-tutorial/examples/tutorials/tutorial7/mpsk_stage6.py

>>> Done
```

Id	Value
Imports	
Variables	
arity	4
delay	<Open Properties>
eq_gain	<Open Properties>
excess_bw	0.35
freq_offse	<Open Properties>
nfilts	32

- Core
  - Audio
  - Boolean Operators
  - Byte Operators
  - Channelizers
  - Channel Models
  - Coding
  - Control Port
  - Debug Tools
  - Deprecated
  - Digital Television
  - Equalizers
  - Error Coding
  - FCD
  - File Operators
  - Filters
  - Fourier Analysis
  - GUI Widgets
  - Impairment Models
  - Instrumentation
  - Level Controllers
  - Math Operators
  - Measurement Tools
  - Message Tools
  - Misc
  - Modulators
  - Networking Tools
  - NOAA
  - OFDM
  - Packet Operators
  - Pager
  - Peak Detectors
  - Resamplers
  - Stream Operators
  - Stream Tag Tools
  - Symbol Coding
  - Synchronizers
  - Trellis Coding
  - Type Converters
  - UHD
  - Variables

Phase 4 Ground Uplink

We are using GNU Radio to test out uplink modulation, coding, and protocol.



Phase 4 Ground Downlink

We now have the forward error correction for DVB-S2 and DVb-S2X working in GNU Radio. This free and open source Low Density Parity Check decoder uses soft decisions and does all the code rates in the DVB specifications.

NOVEMBER 11, 2018 BY MICHELLE

Open Source Low Density Parity Check Decoder for DVB-S2, DVB-S2X, DVB-T2 Working in GNU Radio

An open source Low Density Parity Check decode from Phase 4 Ground is working for DVB-S2, DVB-S2X, and DVB-T2 in GNU Radio, thanks to the efforts of Ahmet Inan, Ron Economos, and Charles Brain.

GNU Radio is used by hams all over the world for SDR work

What can I do?

- **Localize** GNU Radio Companion for Japanese
- Organize **more articles** about GNU Radio for JAMSAT Newsletter
- **Connect** Japanese hams with GNU Radio community
- **Learn** Japanese ham community concerns
- **Support** Japanese developers contributing to GNU Radio

Your next step? Go work through the GNU Radio Guided Tutorials from the GNU Radio website: https://wiki.gnuradio.org/index.php/Tutorials

Questions?

w5nyv@arrl.net
@abraxas3d