



GNU Radio Tutorials: Half-Way Update



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January 13, 2022

Schedule



Update covering:

- Monday, January 3 to Thursday, January 13
- 11 New Tutorials with 160 new images



Guiding Principles



Principles from Marc L.:

1. Focus on GNU Radio, not RF/DSP
2. Get new users up to speed ASAP
3. Make use of existing content
4. Support a broad audience



New Tutorials

<https://wiki.gnuradio.org/index.php/NewTutorialReview>

Beginning Tutorials [\[edit\]](#)

Please start here if you are new to GNU Radio. These tutorials show flowgraphs.

Introducing GNU Radio [\[edit\]](#)

These introductory tutorials are intended for new users and walk you

1. What is GNU Radio?
2. Installing GNU Radio
3. Creating Your First Flowgraph

Flowgraph Fundamentals [\[edit\]](#)

These tutorials describe flowgraph fundamentals such as variables

1. Variables in Flowgraphs
2. Runtime Updating Variables
3. Signal Data Types
4. Converting Data Types
5. Streams and Vectors
6. Creating Your First Block
7. Hier Blocks and Parameters

DSP Blocks [\[edit\]](#)

The following tutorials will describe how to build flowgraphs with ba

1. Low Pass Filter Example
2. Designing Filter Taps
3. Sample Rate Change

Tutorial flow:

- Start easy, slowly add complexity
- Build tools, then apply tools to DSP
- Building knowledge of GR over time



Tutorial Formula



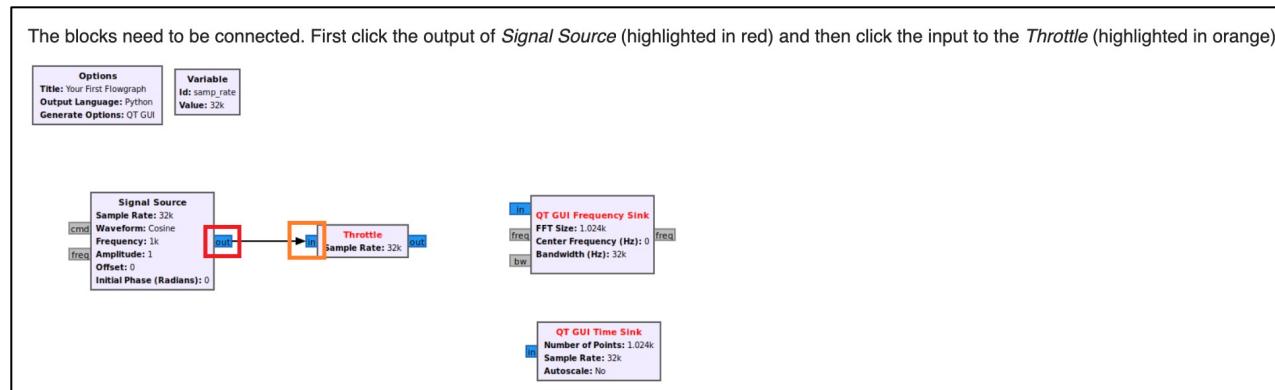
- Step-by-step instructions, easily replicated
- Emphasis on images over text
- Minimal DSP knowledge required
- Tutorials build on one another
- Users build own flowgraph (no download for .grc or .py)
 - Avoids GRC & GNU Radio versioning problems
 - Forces user to learn the tool and build “muscle memory”



New Tutorial: Your First Flowgraph (1)

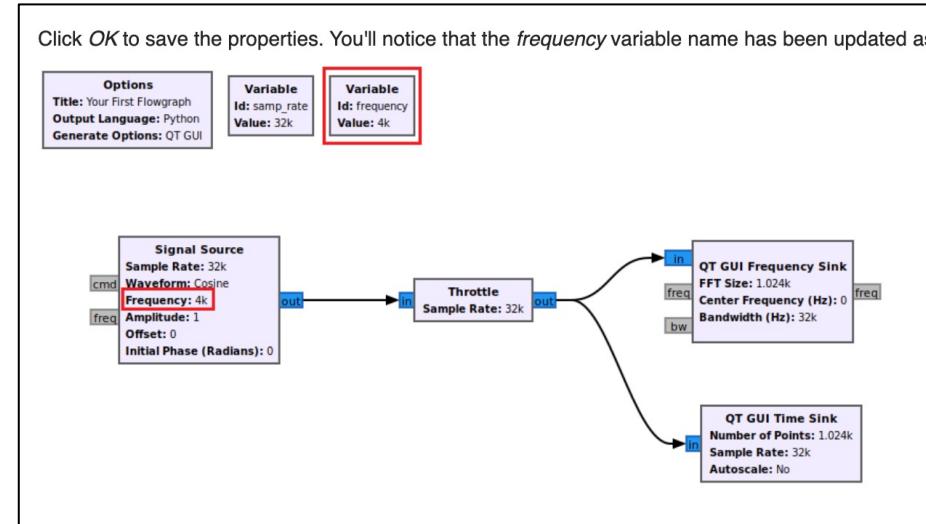
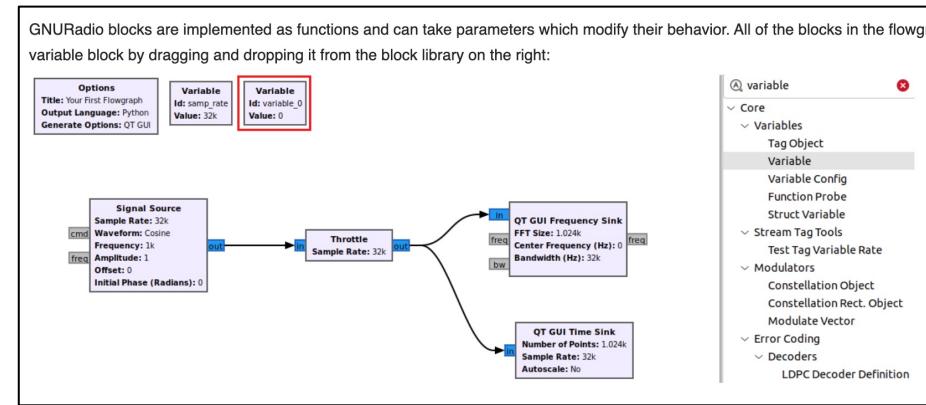
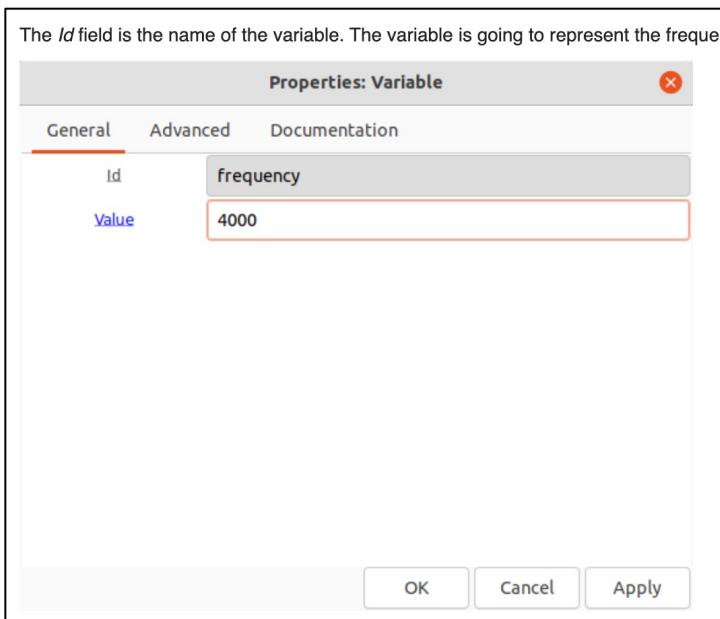
- https://wiki.gnuradio.org/index.php/Your_First_Flowgraph
- Starting GRC
- Searching for blocks
- Editing properties
- Connecting Blocks
- Running the Flowgraph

The screenshot shows the GNURadio Companion (GRC) interface. On the left, there is a sidebar with various block categories like Core, Audio, etc. In the center, there is a main workspace with a terminal window showing '\$ gnuradio-companion &'. Below the terminal is a table with columns 'Block path', 'Imports', 'Value', and 'Variables'. A variable 'samp_rate' is listed with a value of 32000. On the right, there is a detailed view of the 'Properties: Options' dialog box. The 'General' tab is selected, showing fields for 'Id' (set to 'sineWaveFlowgraph'), 'Title' (set to 'Your First Flowgraph'), 'Output Language' (set to 'Python'), 'Generate Options' (set to 'QT GUI'), and 'Run' (set to 'Autostart'). Buttons for 'OK', 'Cancel', and 'Apply' are at the bottom.



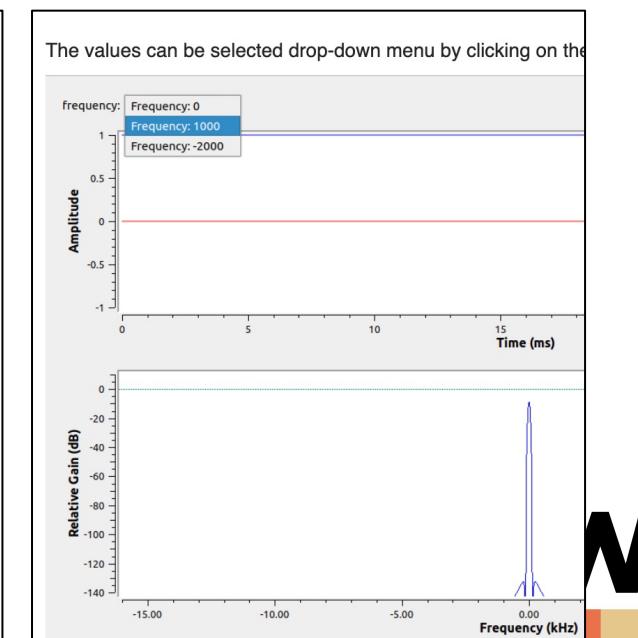
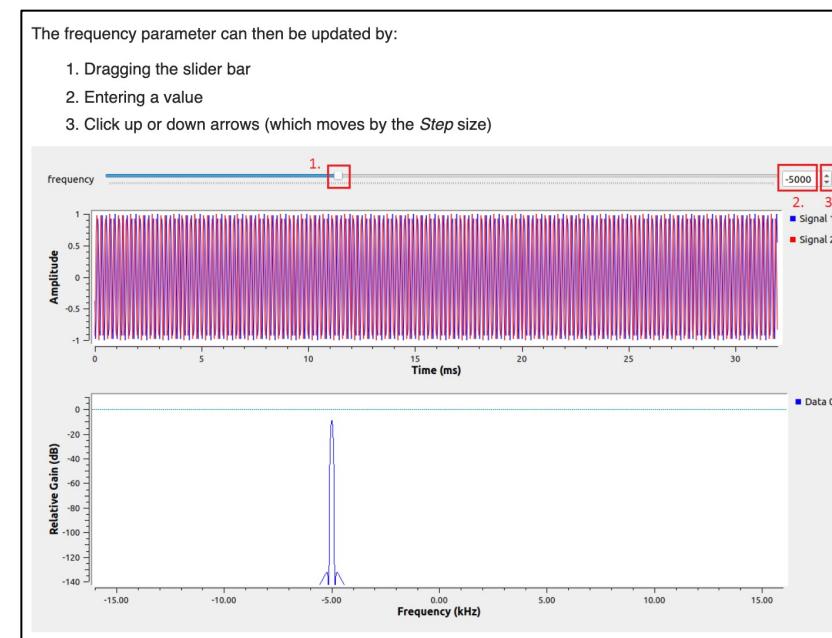
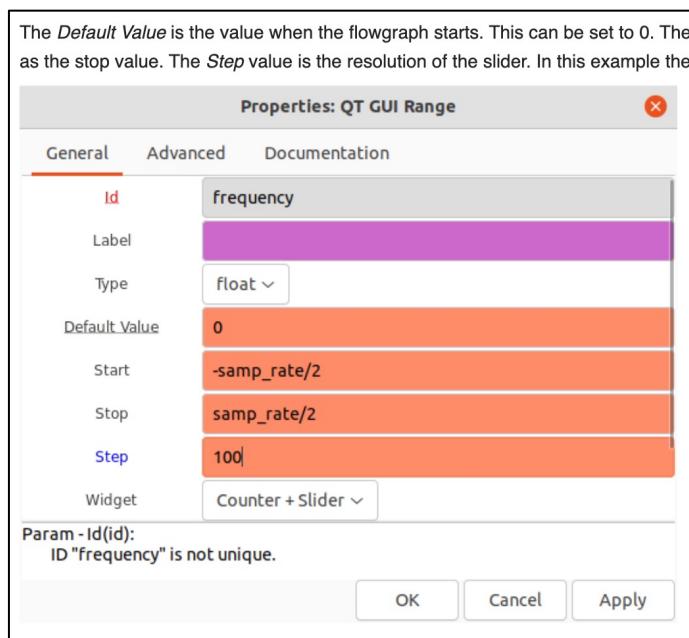
New Tutorial: Variables in Flowgraphs (2)

- https://wiki.gnuradio.org/index.php/Variables_in_Flowgraphs
- Adding new variable
- Modifying variable name
- Modifying variable value
- Adding variable to block



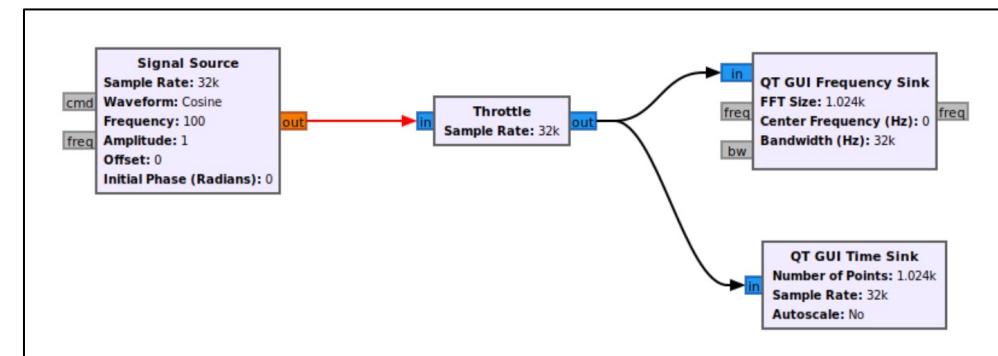
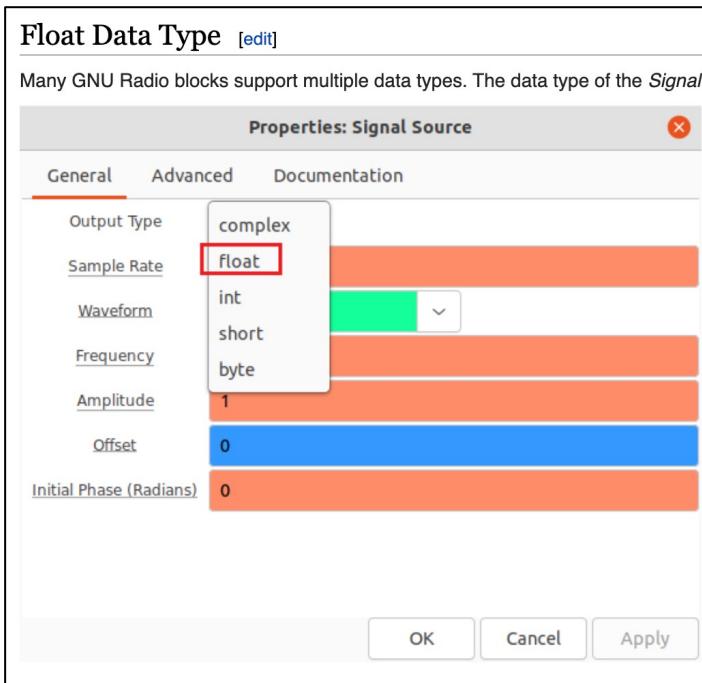
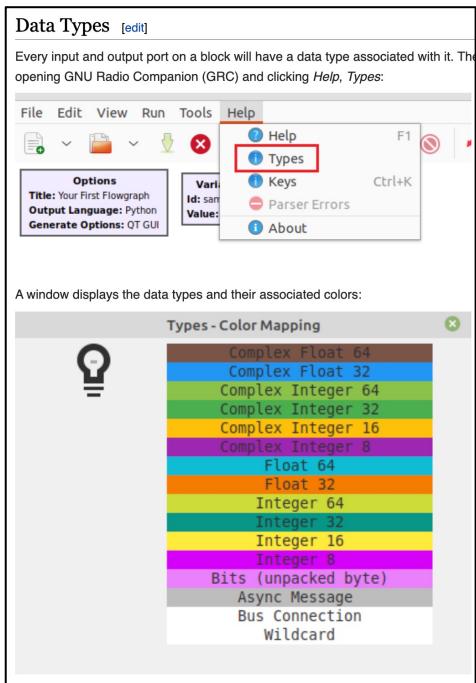
New Tutorial: Runtime Updating Variables (3)

- <https://wiki.gnuradio.org/index.php/Runtime Updating Variables>
- QT GUI Range bar as variable
- Setting range properties
- Variables update in real time
- QT GUI Chooser



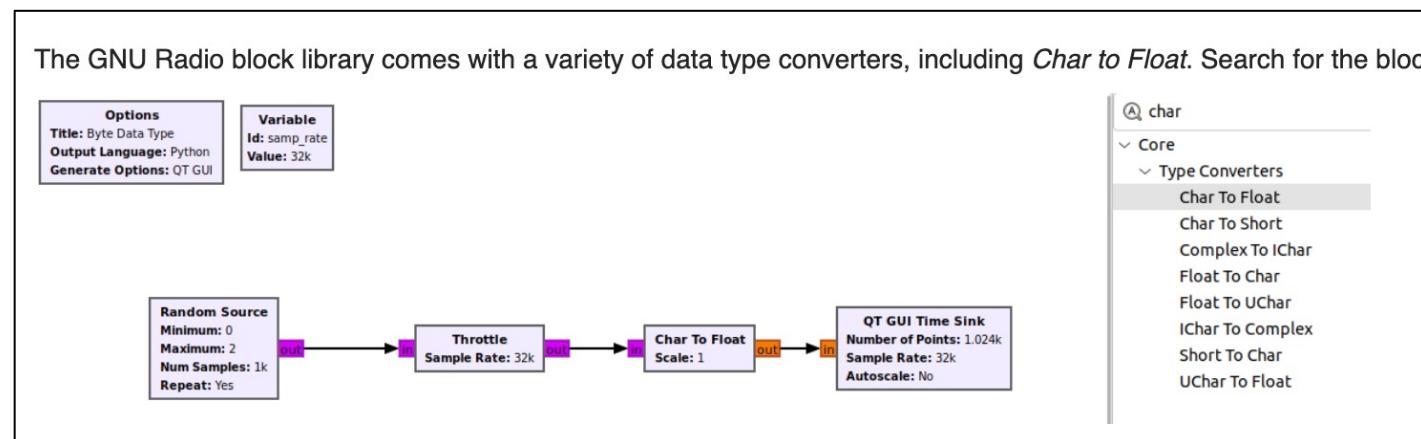
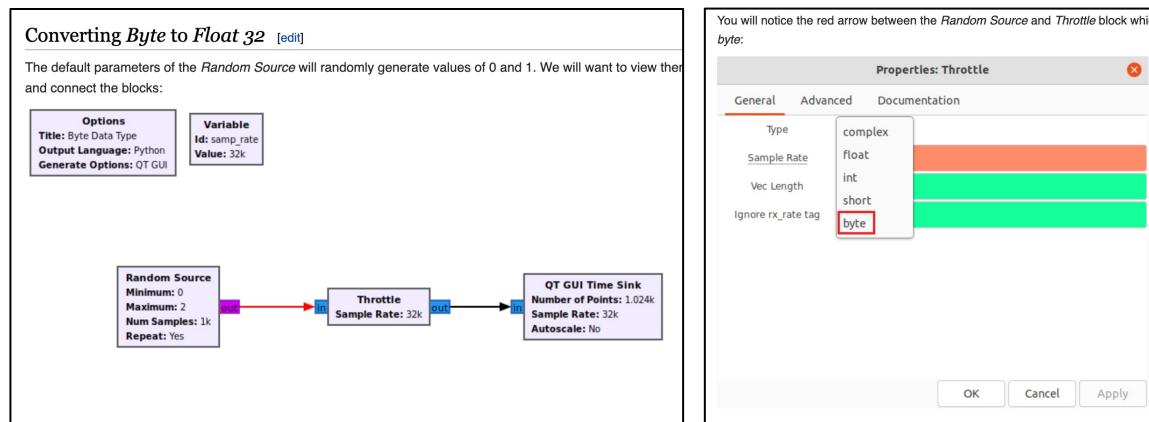
New Tutorial: Signal Data Types (4)

- https://wiki.gnuradio.org/index.php/Signal_Data_Types
- Describes complex, float
- Changing block data types
- Error connecting incorrect types



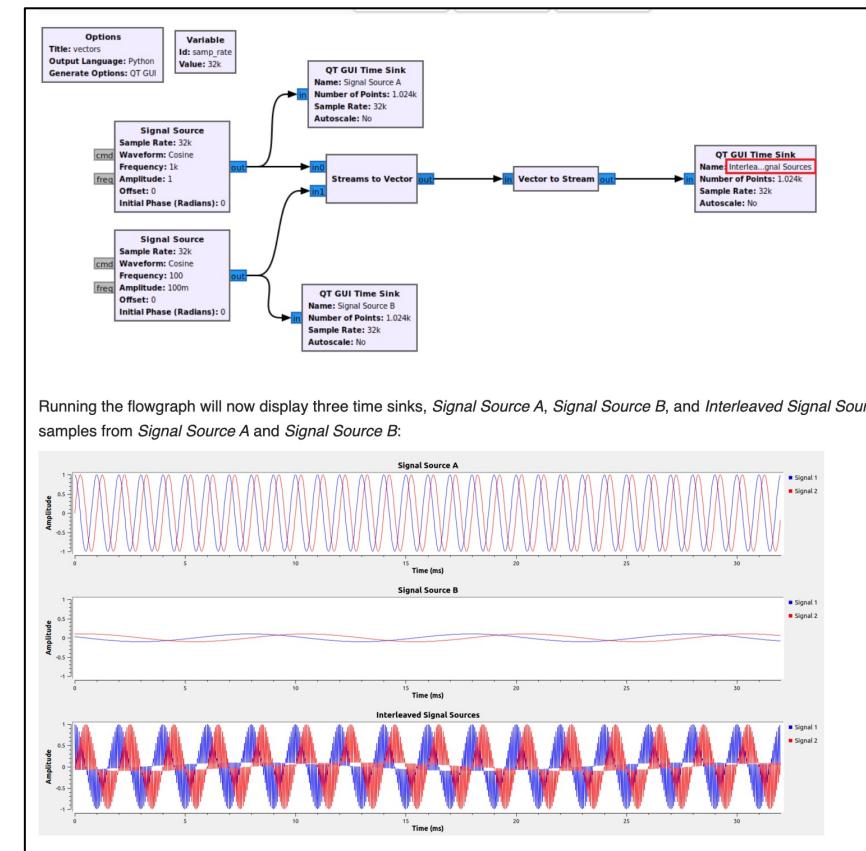
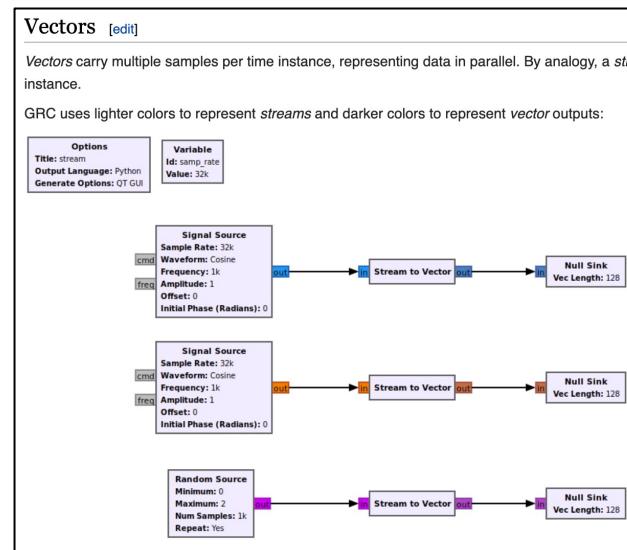
New Tutorial: Converting Data Types (5)

- https://wiki.gnuradio.org/index.php/Converting_Data_Types
- Char/Byte Data Type
- Char to Float



New Tutorial: Streams and Vectors (6)

- https://wiki.gnuradio.org/index.php/Streams_and_Vectors
- Stream as serial data, vector as parallel data
- Darker colors in GRC
- Streams to vector
- Plotting interleaved data
- Vector to streams
- Plotting deinterleaved data



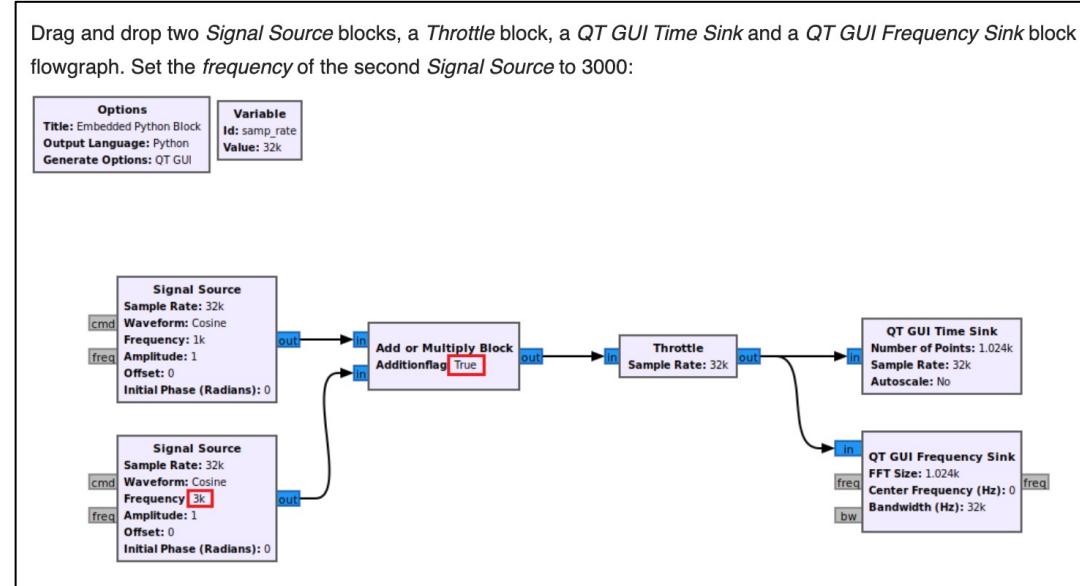
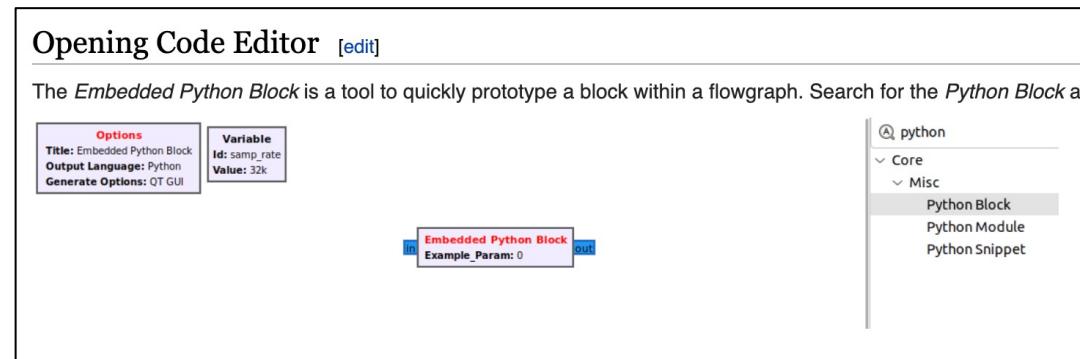
New Tutorial: Creating Your First Block (7)

- https://wiki.gnuradio.org/index.php/Creating_Your_First_Block
- Embedded Python block
- Opening and editing code
- Describes components of Python block
- Changing parameter name
- Adding a second input
- Editing work function

Editing Block Inputs [edit]

The default block has a single input and a single output, however we need two inputs for the block. To add an input, click the "Add Input" button.

```
epy_block_0_xlnx1whm.py /tmp
1 """
2 Embedded Python Blocks:
3
4 Each time this file is saved, GRC will instantiate the first class it finds
5 to get ports and parameters of your block. The arguments to __init__ will
6 be the parameters. All of them are required to have default values!
7 """
8
9 import numpy as np
10 from gnuradio import gr
11
12 class blk(gr.sync_block): # other base classes are basic_block, decim_block, interp_block
13     """Embedded Python Block example - a simple multiply const"""
14
15     def __init__(self, additionFlag=True): # only default arguments here
16         """arguments to this function show up as parameters in GRC"""
17         gr.sync_block.__init__(
18             self,
19             name="Embedded Python Block", # will show up in GRC
20             in_sig=[np.complex64,np.complex64],
21             out_sig=[np.complex64]
22         )
23
24         # if an attribute with the same name as a parameter is found,
25         # a callback is registered (properties work, too).
26         self.additionFlag = additionFlag
27
28     def work(self, input_items, output_items):
29         """example: multiply with constant"""
30         output_items[0][:] = input_items[0] * self.additionFlag
31         return len(output_items[0])
32
```

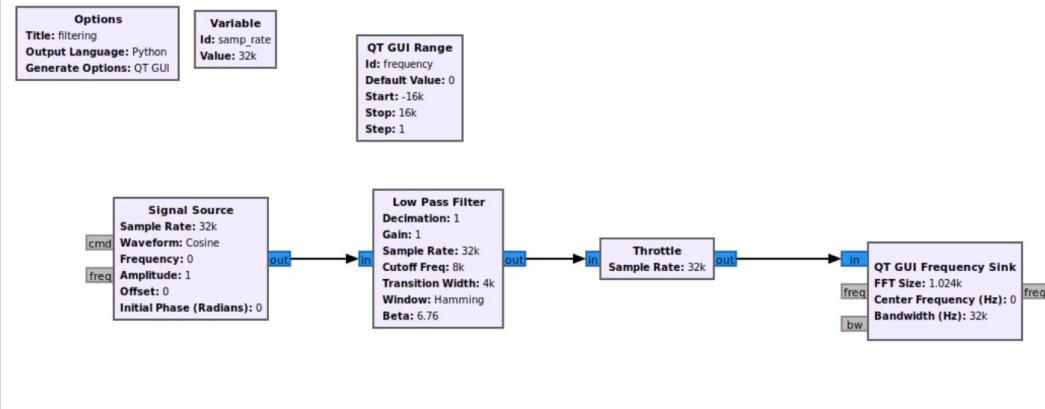


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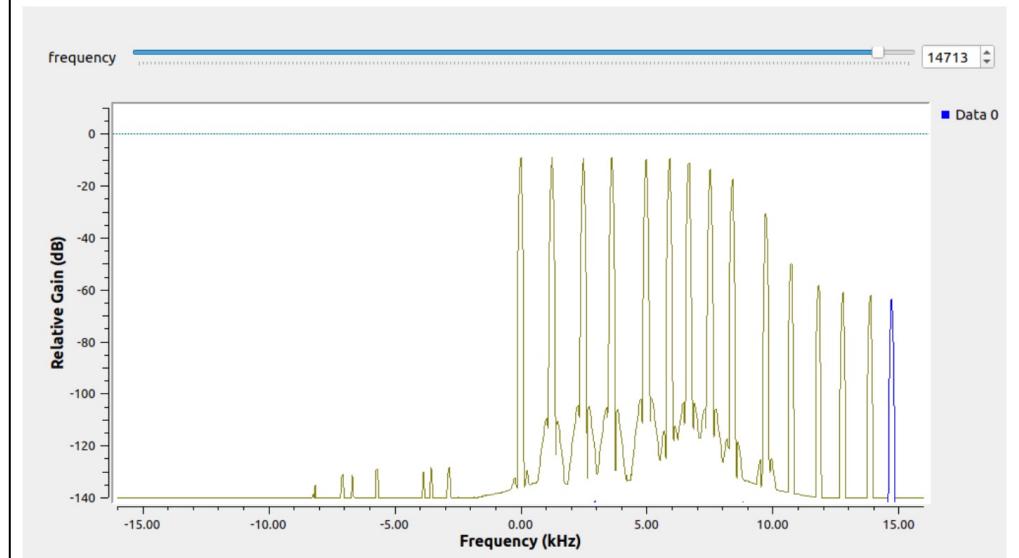
New Tutorial: Low Pass Filter Example (8)

- https://wiki.gnuradio.org/index.php/Low_Pass_Filter_Example
- Using Low Pass Filter block
- Setting parameters
- Max hold-based Frequency Response

The flowgraph is now complete and should look like the following:

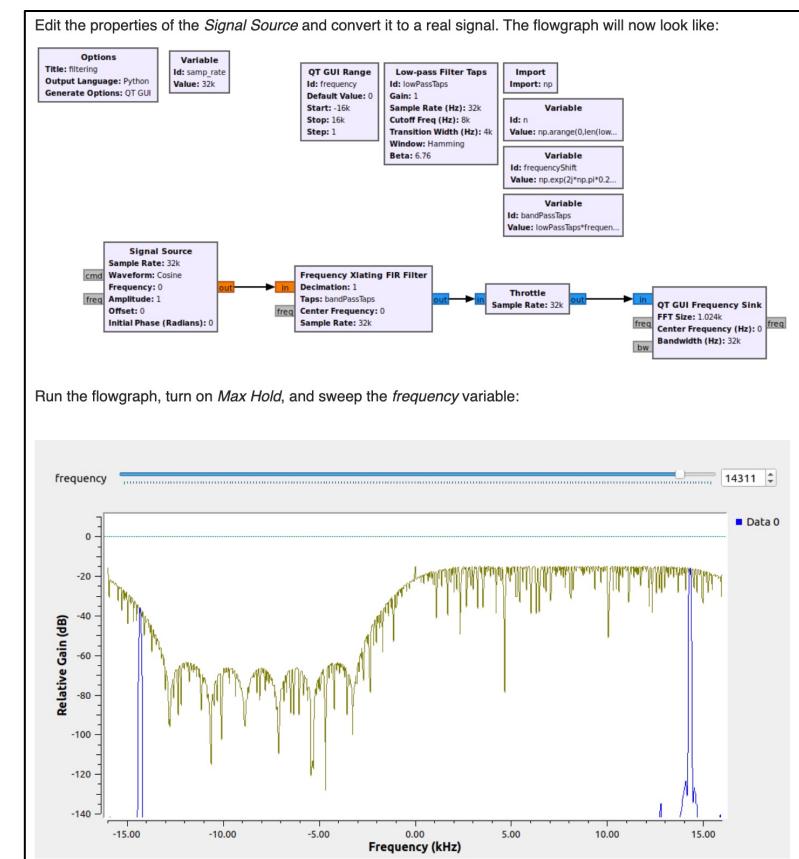
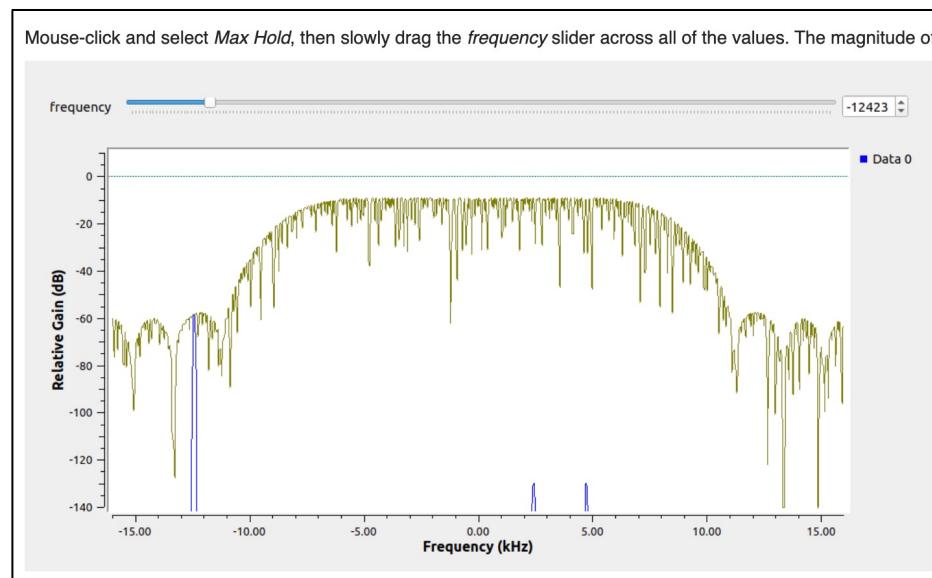
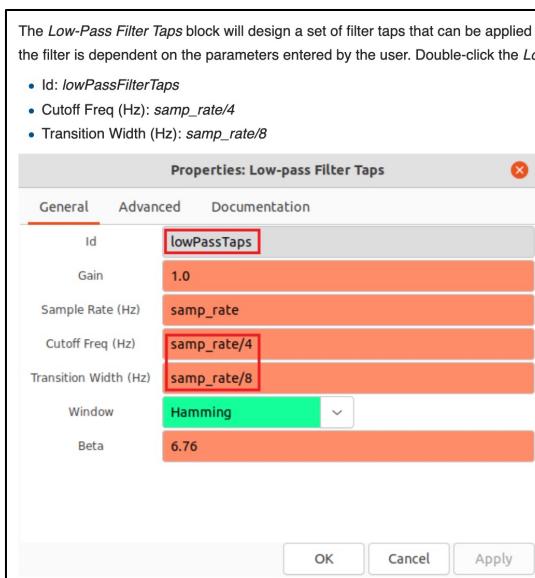


The *Max Hold* option will retain and display the maximum value at each frequency until the the flowgraph is closed. the low pass filter response:



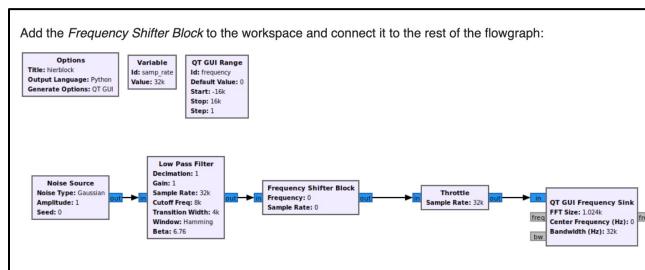
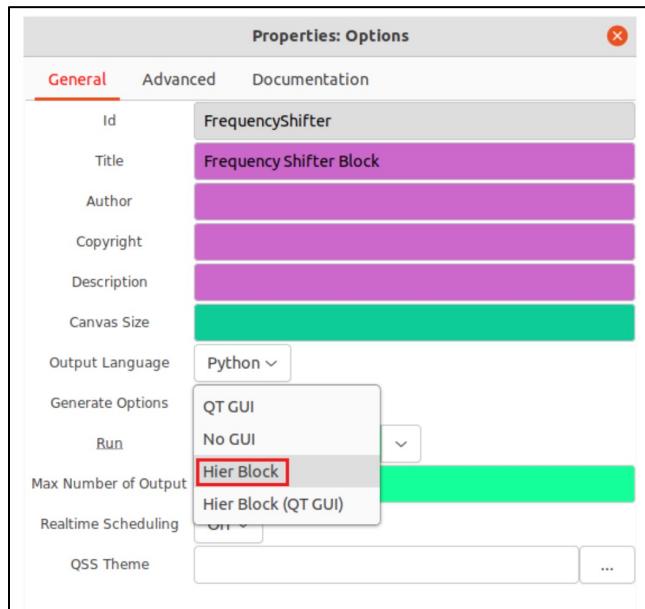
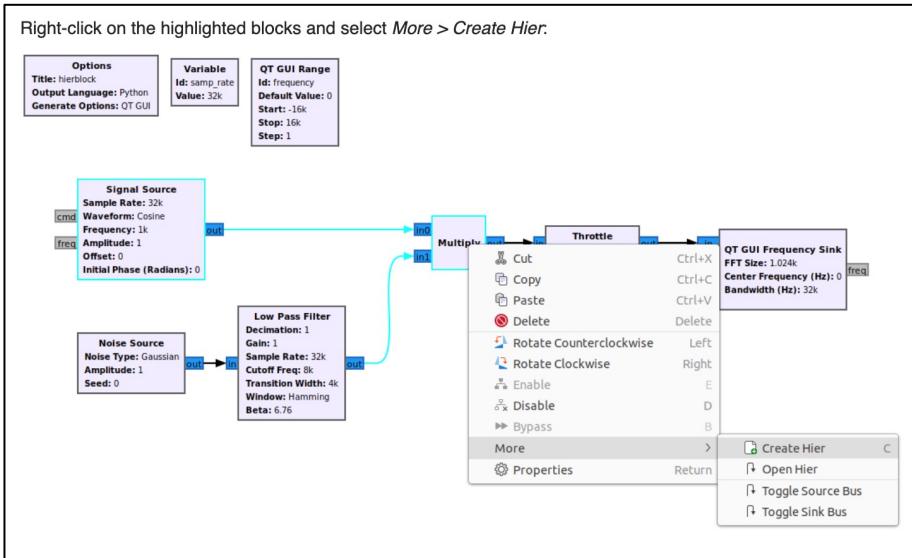
New Tutorial: Designing Filter Taps (9)

- https://wiki.gnuradio.org/index.php/Designing_Filter_Taps
- GR-based design of low pass filter taps
- Manual design of boxcar filter taps
- Convert real LPF to complex BPF weights in variable
- Variables as tuples, NumPy arrays
- Real to complex filter block



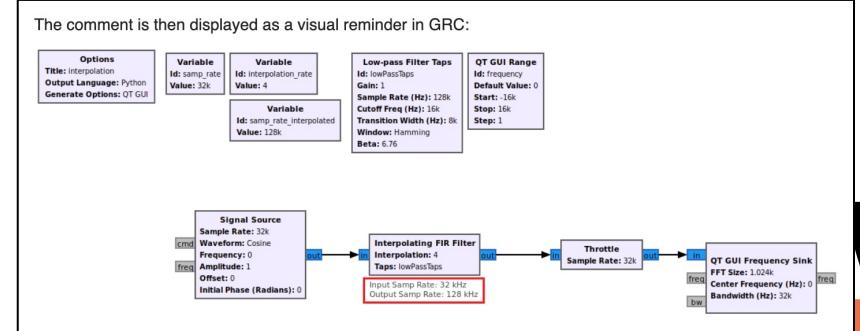
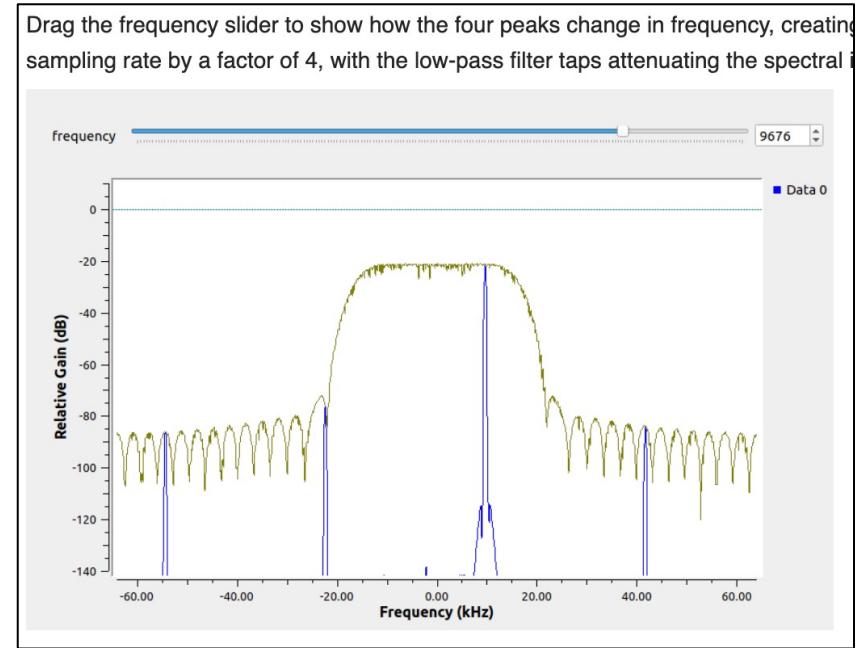
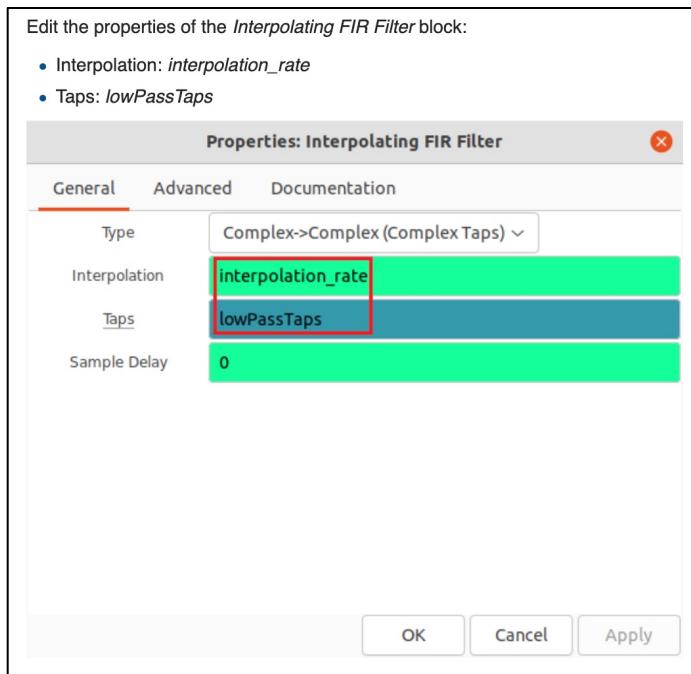
New Tutorial: Hier Blocks and Parameters (10)

- https://wiki.gnuradio.org/index.php/Hier_Blocks_and_Parameters
- Creating a Hier Block
- Using Parameters
- Adding in/out ports
- Using Hier Block
- Deleting Hier Block



New Tutorial: Sample Rate Change (11)

- https://wiki.gnuradio.org/index.php/Sample_Rate_Change
- Interpolation
- Decimation
- Rational Rate
- Irrational Rate: *Complete Next week*



Navigation Menu

- Added tutorial navigation menu
- Menus automatically update across all pages

Introducing GNU Radio [\[edit\]](#)

These introductory tutorials are intended for new users and walk you through the basics of GNU Radio.

1. [What is GNU Radio?](#)
2. [Installing GNU Radio](#)
3. [Creating Your First Flowgraph](#)

Flowgraph Fundamentals [\[edit\]](#)

These tutorials describe flowgraph fundamentals such as variables and expressions.

1. [Variables in Flowgraphs](#)
2. [Runtime Updating Variables](#)
3. [Signal Data Types](#)
4. [Converting Data Types](#)
5. [Streams and Vectors](#)
6. [Creating Your First Block](#)
7. [Hier Blocks and Parameters](#)

DSP Blocks [\[edit\]](#)

The following tutorials will describe how to build flowgraphs with basic DSP blocks.

1. [Low Pass Filter Example](#)
2. [Designing Filter Taps](#)
3. [Sample Rate Change](#)

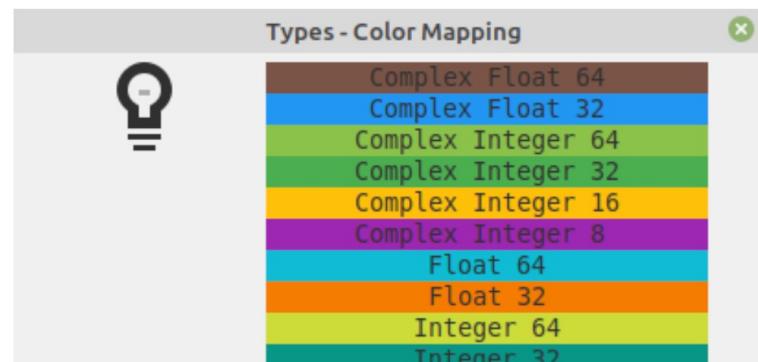
Converting Data Types

This tutorial demonstrates how to convert between data types.

The previous tutorial, [Signal Data Types](#), presents an introduction to the *Complex Float 32* and *Float 32* data types for representing digitized signals. The next tutorial, [Streams and Vectors](#), describes the differences between streams and vectors and how to use them in flowgraphs.

Char/Byte Data Type [\[edit\]](#)

The *Char* or *Byte* data type is another useful data type for representing binary data. The *Byte* data type is represented by the magenta color in GRC:



GNU Radio Tutorials

Introducing GNU Radio

1. [What is GNU Radio?](#)
2. [Installing GNU Radio](#)
3. [Creating Your First Flowgraph](#)

Flowgraph Fundamentals

1. [Variables in Flowgraphs](#)
2. [Runtime Updating Variables](#)
3. [Signal Data Types](#)
4. [Converting Data Types](#)
5. [Streams and Vectors](#)
6. [Creating Your First Block](#)
7. [Hier Blocks and Parameters](#)

DSP Blocks

1. [Low Pass Filter Example](#)
2. [Designing Filter Taps](#)
3. [Sample Rate Change](#)



Navigation Menu

- Navigation menu uses templates

GNU Radio Tutorials

- Introducing GNU Radio
 - 1. What is GNU Radio?
 - 2. Installing GNU Radio
 - 3. Creating Your First Flowgraph
- Flowgraph Fundamentals
 - 1. Variables in Flowgraphs
 - 2. Runtime Updating Variables
 - 3. Signal Data Types
 - 4. **Converting Data Types**
 - 5. Streams and Vectors
 - 6. Creating Your First Block
 - 7. Hier Blocks and Parameters
- DSP Blocks
 - 1. Low Pass Filter Example
 - 2. Designing Filter Taps
 - 3. Sample Rate Change

{{Template:TutorialNavigation}}



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Introducing GNU Radio
{{Template:NavigationIntroducingGNURadio}}


Flowgraph Fundamentals
{{Template:NavigationFlowgraphFundamentals}}


DSP Blocks
{{Template:NavigationDSPBlocks}}


| }
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Navigation Menu

- Nav menu templates are nested

```
{Template:TutorialNavigation}
```



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```

Introducing GNU Radio

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{Template:NavigationIntroducingGNURadio}
```

Flowgraph Fundamentals

```
{Template:NavigationFlowgraphFundamentals}
```

DSP Blocks

```
{Template:NavigationDSPBlocks}
```

```
|}
```

```
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```
{Template:NavigationIntroducingGNURadio}
```



```
# [[What_Is_GNURadio|What is GNU Radio?]]
# [[InstallingGR|Installing GNU Radio]]
# [[Your_First_Flowgraph|Creating Your First Flowgraph]]
```

```
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```



```
# [[Variables_in_Flowgraphs|Variables in Flowgraphs]]
# [[Runtime Updating_Variables|Runtime Updating Variables]]
# [[Signal_Data_Types|Signal Data Types]]
# [[Converting_Data_Types|Converting Data Types]]
# [[Streams_and_Vectors|Streams and Vectors]]
# [[Creating_Your_First_Block|Creating Your First Block]]
# Variables vs Parameters
```

```
{Template:NavigationDSPBlocks}
```



```
# [[Low_Pass_Filter_Example|Low Pass Filter Example]]
# [[Designing_Filter_Taps|Designing Filter Taps]]
# Sample Rate Change
# Building an FM Demodulator
```



Prioritized List for Tutorials



- Week 3:
 - Tutorial: Irrational Rate Resampling
 - Tutorial: Setting tag based on threshold
 - Tutorial: Sending/Receiving messages, adapting block behavior with messages (includes PMT)
 - Tutorial: Profiling blocks with "htop" Shelved for time, would be good for follow on
- Week 4:
 - Tutorial: Build an example FM radio tuner
 - Starting page for solving common errors (renaming "default", etc.)
 - Link against external resources for DSP explanations to fill in knowledge gaps
 - Reserve time, last minute changes, updating wiki home page, etc.
- Please let me know about:
 - Changing priority of this list
 - Adding/subtracting from this list



Remaining Schedule



Work Pause:

- Friday, Jan 14 – Wed, Jan 19
- Allow time for review of tutorials and feedback (per Marc L. request)

Resume work:

- Thurs, Jan 20 – Fri, Jan 28
- Add ~4 more tutorials



Contact

- Thank you!
- You can contact me at matt@wavewalkerdsp.com

