

# An Inexpensive, Software-Defined IF Modulator

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# Chapter 1

## Bug List

**File [alsa\\_test.cpp](#)**

Clicking noise from sinusoidal discontinuity

**File [Filter.hpp](#)**

Discontinuities created at the beginning of each pass

**File [lsb\\_filter\\_test.cpp](#)**

Clicking occurs at start of each filter pass

**File [Modulator.hpp](#)**

Both FM modulations don't work

Clicking on the filtered SSB

**File [modulator\\_test.cpp](#)**

Filtered SSB clicking

**File [usb\\_filter\\_test.cpp](#)**

Clicking occurs at start of each filter pass



## Chapter 2

# Namespace Index

### 2.1 Namespace List

Here is a list of all namespaces with brief descriptions:

<a href="#">radio</a> . . . . .	11
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## Chapter 3

# Hierarchical Index

### 3.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

radio::Filter . . . . .	19
radio::Gain . . . . .	21
radio::Modulator . . . . .	22
radio::Sinusoid . . . . .	25
radio::PITone . . . . .	23





## Chapter 4

# Class Index

### 4.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<a href="#">radio::Filter</a>	19
<a href="#">radio::Gain</a>	21
<a href="#">radio::Modulator</a>	22
<a href="#">radio::PITone</a>	23
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## Chapter 5

# File Index

### 5.1 File List

Here is a list of all files with brief descriptions:

<a href="#">makefile</a>	Contains recipes to compile the main program and the tests programs as well as making documentation and counting total lines of code in src/ . . . . .	32
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<a href="#">src/alsa_test.cpp</a>	Contains program to tests sinusoidal tone generation . . . . .	33
<a href="#">src/auxiliary.hpp</a>	Contains helper-functions for <a href="#">main()</a> . . . . .	35
<a href="#">src/baseband_filter_test.cpp</a>	Contains a program to demonstrate the the baseband/AF filter . . . . .	37
<a href="#">src/definitions.hpp</a>	Contains declarations of system-independant (universal size) integers and float types, shortened type names for some commonly used types, and enumerations . . . . .	39
<a href="#">src/fft_test.cpp</a>	Tests FFT, IFFT, and Hilbert implementations . . . . .	42
<a href="#">src/fft_test2.cpp</a>	Tests FFT, IFFT, and Hilbert implementations in <a href="#">zdomain.hpp</a> . . . . .	47
<a href="#">src/Filter.hpp</a>	Defines the Filter class . . . . .	49
<a href="#">src/fvectors.hpp</a>	Defines the transfer function coefficients used in the instances of the Filter class in this program. The coefficients are listed by greatest order to least . . . . .	51
<a href="#">src/Gain.hpp</a>	Contains the Gain class . . . . .	53
<a href="#">src/iq_test.cpp</a>	Generates test IQ signal . . . . .	55
<a href="#">src/lsb_filter_test.cpp</a>	Contains a program to demonstrate the the LSB/AF filter . . . . .	56

src/main.cpp	Contains the "brains" of the entire project . . . . .	59
src/mic_test.cpp	Tests getting mic input via ALSA. May not even compile at the moment . . . . .	61
src/Modulator.hpp	Contains the classes for the various types of modulation supported by the program . . . . .	64
src/modulator_test.cpp	Contains a test program to test the Modulator class . . . . .	66
src/multi_sinusoid_test.cpp	Contains a program to demonstrate the ability of the Sinusoid class and the sound card to generate sinusoids accross the spectrum . . . . .	69
src/piped_test.cpp	Contains the original program used to test the piping-in idea . . . . .	71
src/pl_tone_test.cpp	Contains a test program to test the PITone class . . . . .	72
src/PITone.hpp	Contains the PITone class . . . . .	74
src/Sinusoid.hpp	Contains the Sinusoid class . . . . .	76
src/sinusoid_test.cpp	Contains a test program to test the Sinusoid class . . . . .	78
src/usb_filter_test.cpp	Contains a program to demonstrate the the USB filter . . . . .	80
src/zdomain.hpp	Contains the functions to manipulate sequential data in the frequency (z) domain . . . . .	83

## Chapter 6

# Namespace Documentation

### 6.1 radio Namespace Reference

#### Classes

- class [Filter](#)
- class [Gain](#)
- class [Modulator](#)
- class [PITone](#)
- class [Sinusoid](#)

#### Enumerations

- enum [Age](#) { [OLD](#), [NEW](#) }
- enum [Fractional](#) { [NUM](#), [DEN](#) }
- enum [Argument](#) { [FREQ](#) = 1, [MODE](#), [PL\\_TONE](#) }
- enum [ModulationType](#) {  
    [ModulationType::DSB\\_LC](#), [ModulationType::DSB\\_SC](#), [ModulationType::USB\\_FILTERED](#), [ModulationType::USB\\_HILBERT](#),  
    [ModulationType::LSB\\_FILTERED](#), [ModulationType::LSB\\_HILBERT](#), [ModulationType::FM\\_NARROW](#),  
    [ModulationType::FM\\_WIDE](#) }

#### Functions

- void [ShowHelp](#) ()
- void [to\\_sint32](#) (float32 \*data, uint32 size)
- [ModulationType to\\_type](#) (std::string str)
- void [aconj](#) (cfloat32 \*data, uint32 size)
- void [fft](#) (cfloat32 \*data, uint32 size)
- void [hilbert](#) (float32 \*data, float32 \*dest, uint32 size)
- void [ifft](#) (cfloat32 \*data, uint32 size)
- void [makeIQ](#) (float32 \*data, float32 \*dest, uint32 size)

#### Variables

- fparams [F\\_BASEBAND](#)
- fparams [F\\_LOWERSIDEBAND](#)
- fparams [F\\_UPPERSIDEBAND](#)
- const uint32 [FREQ\\_INTERMEDIATE](#) = 20000
- const uint32 [SAMPLING\\_RATE](#) = 48000

### 6.1.1 Detailed Description

This namespace contains all the classes, functions, and enumerations used in the application.

### 6.1.2 Enumeration Type Documentation

#### 6.1.2.1 enum radio::Age

Describes the age of a filter (from last Pass() or in this Pass()). Not currently used.

Enumerator

***OLD***

***NEW***

Definition at line 60 of file [definitions.hpp](#).

#### 6.1.2.2 enum radio::Argument

Describes the arguments in argv. Never actually used.

Enumerator

***FREQ***

***MODE***

***PL\_TONE***

Definition at line 70 of file [definitions.hpp](#).

#### 6.1.2.3 enum radio::Fractional

Describes the numerator and denominator of a z-domain transfer function

Enumerator

***NUM***

***DEN***

Definition at line 65 of file [definitions.hpp](#).

#### 6.1.2.4 enum radio::ModulationType [strong]

Describes a form of modulation.

Enumerator

***DSB\_LC***

***DSB\_SC***

***USB\_FILTERED***

***USB\_HILBERT***

***LSB\_FILTERED***

***LSB\_HILBERT***

***FM\_NARROW***

***FM\_WIDE***

Definition at line 75 of file [definitions.hpp](#).

### 6.1.3 Function Documentation

#### 6.1.3.1 void radio::aconj ( cfloat32 \* data, uint32 size )

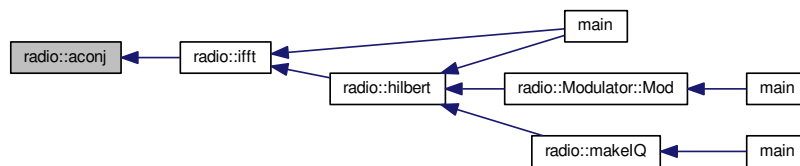
Replaces the values in an array of complex float32's with their respective conjugates.

Parameters

<i>data</i>	the array whose values should be replaced with their respective conjugates
<i>size</i>	the number of elements in the data array

Definition at line 84 of file [zdomain.hpp](#).

Here is the caller graph for this function:



#### 6.1.3.2 void radio::fft ( cfloat32 \* data, uint32 size )

Replaces the values of an array of cfloat32's with the array's DFT using a decimation-in-frequency algorithm.

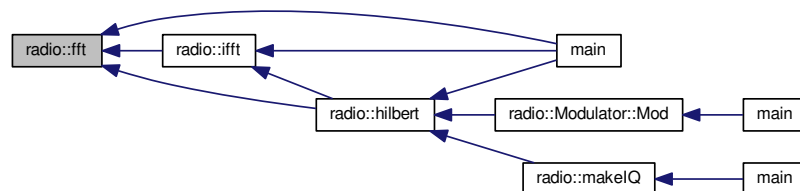
This code is based on code from [http://rosettacode.org/wiki/Fast\\_Fourier\\_transform#C.2B.2B](http://rosettacode.org/wiki/Fast_Fourier_transform#C.2B.2B).

Parameters

<i>data</i>	the array whose values should be replaced with its DFT
<i>size</i>	the number of elements in the data array

Definition at line 90 of file [zdomain.hpp](#).

Here is the caller graph for this function:



#### 6.1.3.3 void radio::hilbert ( float32 \* data, float32 \* dest, uint32 size )

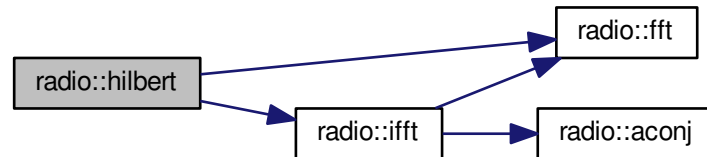
Performs the hilbert transform of an array of float32's.

## Parameters

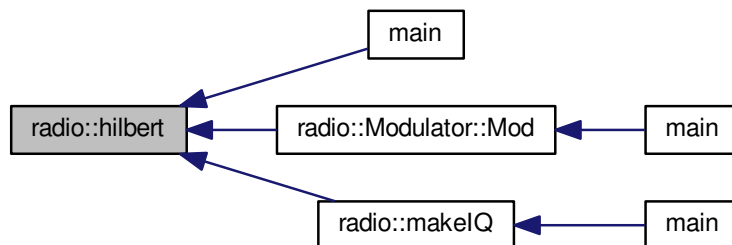
<i>data</i>	the source array of the REAL numbers of which to take the Hilbert transform
<i>dest</i>	the destination array of REAL numbers for the results of the Hilbert transform
<i>size</i>	the number of elements in the data and dest arrays

Definition at line 138 of file [zdomain.hpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 6.1.3.4 void radio::ifft ( cfloat32 \* data, uint32 size )

Replaces the values of an array of `cfloat32`'s with the array's inverse DFT.

This code is based on code from [http://rosettacode.org/wiki/Fast\\_Fourier\\_transform#C.2B.2B](http://rosettacode.org/wiki/Fast_Fourier_transform#C.2B.2B).

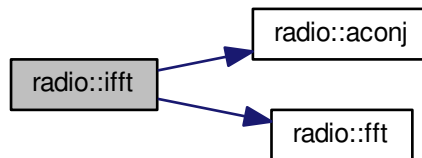
## Parameters

<i>data</i>	the array whose values should be replaced with its inverse DFT
<i>size</i>	the number of elements in the data array

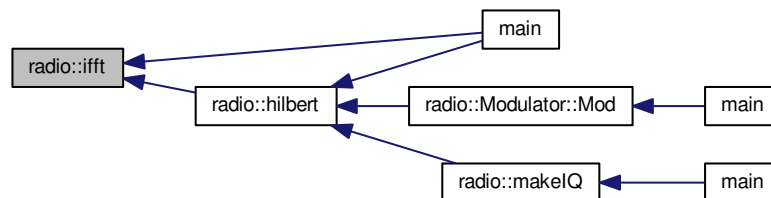
Definition at line 161 of file [zdomain.hpp](#).



Here is the call graph for this function:



Here is the caller graph for this function:



#### 6.1.3.5 void radio::makeIQ ( float32 \* data, float32 \* dest, uint32 size )

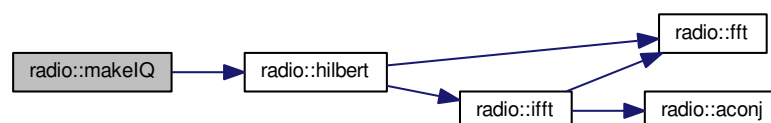
Produces an interleaved array with an element from an original array of data first and then an element from the original data's Hilbert transform second. This function is intended to generate a two-channel output (I/Q output) for mixing applications.

##### Parameters

<i>data</i>	the original data (left channel)
<i>dest</i>	the interleaved data (left channel original data, right channel transformed data) twice the size of the original data array
<i>size</i>	the number of elements in the data array (NOT in the destination array)

Definition at line 171 of file [zdomain.hpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

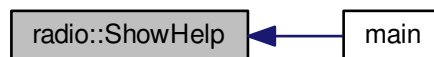


#### 6.1.3.6 void radio::ShowHelp ( )

Displays the help information and exits the program.

Definition at line 22 of file [auxiliary.hpp](#).

Here is the caller graph for this function:



#### 6.1.3.7 void radio::to\_sint32 ( float32 \* data, uint32 size )

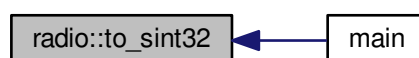
Replaces float32 samples with sint32 equivalents. Rounds conversion to nearest integer.

##### Parameters

<i>data</i>	the array containing the float32 samples that are directly replaced by their respective sint32 representations
<i>size</i>	the number of elements in the data array

Definition at line 62 of file [auxiliary.hpp](#).

Here is the caller graph for this function:



### 6.1.3.8 ModulationType radio::to\_type ( std::string str )

Converts a string representation of the supported modulation types (see [ShowHelp\(\)](#) documentation) to the enum class ModulationType value.

This function is not as elegant as it could be. Ideally, I would have used a `std::map<string, ModulationType>` rather than a long series of if-else's.

#### Parameters

<i>str</i>	type of modulation in typed form
------------	----------------------------------

#### Returns

enum value of the type of modulation

Definition at line 80 of file [auxiliary.hpp](#).

Here is the caller graph for this function:



## 6.1.4 Variable Documentation

### 6.1.4.1 fparams radio::F\_BASEBAND

#### Initial value:

```

= { std::vector<float64> {
    0.0008977019461,
    -0.002215694636,
    0.001372192986,
    0.001372192986,
    -0.002215694636,
    0.0008977019461
}, std::vector<float64> {
    1,
    -4.678616047,
    8.822912216,
    -8.379911423,
    4.007629871,
    -0.7719064355
} }

```

Baseband filter coefficients. Generated with MATLAB 2015A.

Definition at line 20 of file [fvectors.hpp](#).

### 6.1.4.2 fparams radio::F\_LOWERSIDEBAND

#### Initial value:

```

= { std::vector<float64> {
    0.2758039069174,
    2.763578787693,
    12.83915022756,

```

```

        36.47584850651,
        70.37084637368,
        96.76893503179,
        96.76893503179,
        70.37084637368,
        36.47584850651,
        12.83915022756,
        2.763578787693,
        0.2758039069174
    }, std::vector<float64> {
        1,
        7.605497780083,
        27.34180552438,
        60.83375457605,
        92.60908886875,
        100.8363857,
        79.74796574736,
        45.4982252145,
        18.13566776308,
        4.690036472717,
        0.6617552879305,
        0.0281427334611
    } }

```

Lower-sideband filter coefficients. Generated with MATLAB 2015A.

Definition at line 39 of file [fvectors.hpp](#).

#### 6.1.4.3 fparams radio::F\_UPPERSIDEBAND

**Initial value:**

```

= { std::vector<float64> {
    0.001690387681463,
    0.01145271586989,
    0.03591799189724,
    0.06576926098562,
    0.07119343282702,
    0.03156377419766,
    -0.03156377419766,
    -0.07119343282702,
    -0.06576926098562,
    -0.03591799189724,
    -0.01145271586989,
    -0.001690387681463
}, std::vector<float64> {
    1,
    9.465175013624,
    41.62402815905,
    112.0971027069,
    205.2097686473,
    267.9378582311,
    254.486805213,
    175.7772755115,
    86.51619894548,
    28.89988093561,
    5.89781461091,
    0.5572910543053
} }

```

Upper-sideband filter coefficients. Generated with MATLAB 2015A.

Definition at line 70 of file [fvectors.hpp](#).

#### 6.1.4.4 const uint32 radio::FREQ\_INTERMEDIATE = 20000

The default intermediate carrier frequency

Definition at line 27 of file [Modulator.hpp](#).

#### 6.1.4.5 const uint32 radio::SAMPLING\_RATE = 48000

The default sampling rate (frequency)

Definition at line 32 of file [Modulator.hpp](#).

# Chapter 7

## Class Documentation

### 7.1 radio::Filter Class Reference

```
#include <Filter.hpp>
```

#### Public Member Functions

- [Filter](#) ([float32](#) \**data*, [uint32](#) *size*, [fparams](#) &*diffEq*)
- void [Pass](#) ()

#### Protected Attributes

- [uint8](#) *eqLength*
- [uint32](#) *size*
- [float32](#) \* *data*
- [fparams](#) *diffEq*

#### 7.1.1 Detailed Description

This class implements a z-domain filter on a specified array of float32's (a.k.a. singles, floats). It requires the transfer function coefficients be already calculated (i.e., it does not generate the coefficients based on desired filter characteristics). MATLAB and its Signal Processing Toolbox can be used to generate the coefficients.

While this class is designed to implement a single-section filter, several instances of the class can be created and run over the data array in sequence to effectively implement a multi-section filter.

Definition at line 28 of file [Filter.hpp](#).

#### 7.1.2 Constructor & Destructor Documentation

##### 7.1.2.1 radio::Filter::Filter ( [float32](#) \* *data*, [uint32](#) *size*, [fparams](#) & *diffEq* )

Initializes [Filter](#) based on a difference equation.

Parameters

---

<i>data</i>	array to be filtered. The filtered data will be placed here.
<i>size</i>	number of elements in the data array
<i>diffEq</i>	a vector containing two vectors of float32's (a.k.a. singles, floats), that contains the numerator and denominator coefficients, respectively, of the z-domain transfer function of the filter in descending order ( $z^0$ , $z^{-1}$ , $z^{-2}$ , etc.).

Definition at line 80 of file [Filter.hpp](#).

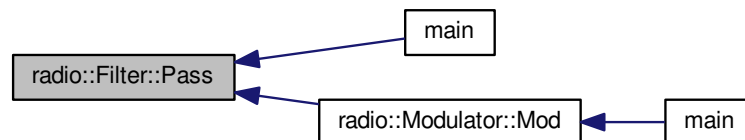
### 7.1.3 Member Function Documentation

#### 7.1.3.1 void `radio::Filter::Pass ( )`

Passes the data array through the digital filter but does not account for previous  $x[n]$  and  $y[n]$  values from the previous call to [Pass\(\)](#).

Definition at line 87 of file [Filter.hpp](#).

Here is the caller graph for this function:



### 7.1.4 Member Data Documentation

#### 7.1.4.1 `float32*` `radio::Filter::data` [protected]

A pointer to the start of the data array to be filtered when [Pass\(\)](#) is called.

Definition at line 69 of file [Filter.hpp](#).

#### 7.1.4.2 `fparams` `radio::Filter::diffEq` [protected]

A vector containing two vectors of float32's (a.k.a. singles, floats), containing the numerator and denominator coefficients, respectively, of the z-domain transfer function of the filter in descending order ( $z^0$ ,  $z^{-1}$ ,  $z^{-2}$ , etc.).

Definition at line 77 of file [Filter.hpp](#).

#### 7.1.4.3 `uint8` `radio::Filter::eqLength` [protected]

The number of terms in the numerator (or denominator) of the transfer function (i.e., function order + 1).

Definition at line 58 of file [Filter.hpp](#).

#### 7.1.4.4 `uint32` `radio::Filter::size` [protected]

The number of elements in the data array.

Definition at line 63 of file [Filter.hpp](#).

The documentation for this class was generated from the following file:

- [src/Filter.hpp](#)

## 7.2 radio::Gain Class Reference

```
#include <Gain.hpp>
```

### Public Member Functions

- [Gain](#) ([float32](#) \*data, [uint32](#) size, [float32](#) gaindB)
- void [Apply](#) ()

### 7.2.1 Detailed Description

Increases the power of a (baseband) signal.

Definition at line 18 of file [Gain.hpp](#).

### 7.2.2 Constructor & Destructor Documentation

#### 7.2.2.1 radio::Gain::Gain ( [float32](#) \* data, [uint32](#) size, [float32](#) gaindB )

Initializes a [Gain](#) object and converts gain from decibels to a standard value.

Parameters

<i>data</i>	the signal to which the gain is applied
<i>size</i>	the number of elements in the data array
<i>gaindB</i>	the desired gain in decibels (of power)

Definition at line 61 of file [Gain.hpp](#).

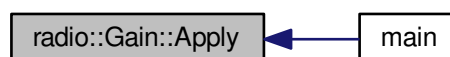
### 7.2.3 Member Function Documentation

#### 7.2.3.1 void radio::Gain::Apply ( )

Applies the gain to the signal contained in the data array.

Definition at line 67 of file [Gain.hpp](#).

Here is the caller graph for this function:



The documentation for this class was generated from the following file:

- [src/Gain.hpp](#)

## 7.3 radio::Modulator Class Reference

```
#include <Modulator.hpp>
```

### Public Member Functions

- [Modulator](#) (float32 data[], uint32 size, [ModulationType](#) type, float32 freqInter=[FREQ\\_INTERMEDIATE](#), uint32 rate=[SAMPLING\\_RATE](#))
- [~Modulator](#) ()
- void [Mod](#) ()

#### 7.3.1 Detailed Description

This class implements various types of modulation.

Definition at line 37 of file [Modulator.hpp](#).

#### 7.3.2 Constructor & Destructor Documentation

**7.3.2.1** [radio::Modulator::Modulator](#) ( float32 data[], uint32 size, [ModulationType](#) type, float32 freqInter = [FREQ\\_INTERMEDIATE](#), uint32 rate = [SAMPLING\\_RATE](#) )

Creates a [Modulator](#) with the specified parameters.

Parameters

<i>freqInter</i>	the frequency of the IF carrier sinusoid
<i>rate</i>	the sampling rate of the baseband and IF signals
<i>data</i>	the array holding initially the baseband signal
<i>size</i>	the number of elements in the data array
<i>type</i>	form of modulation to use

Definition at line 100 of file [Modulator.hpp](#).

**7.3.2.2** [radio::Modulator::~~Modulator](#) ( )

Frees the memory needed for the Hilbert transform.

Definition at line 114 of file [Modulator.hpp](#).

#### 7.3.3 Member Function Documentation

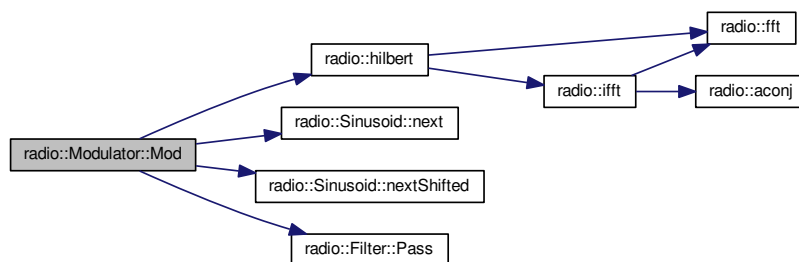
**7.3.3.1** void [radio::Modulator::Mod](#) ( )

Modulates the audio currently in the data array.

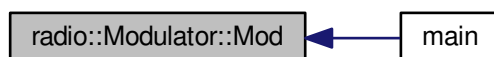
Definition at line 118 of file [Modulator.hpp](#).



Here is the call graph for this function:



Here is the caller graph for this function:



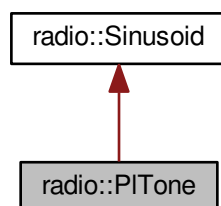
The documentation for this class was generated from the following file:

- [src/Modulator.hpp](#)

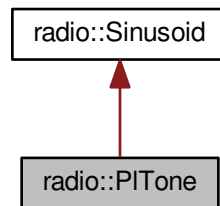
## 7.4 radio::PITone Class Reference

```
#include <PlTone.hpp>
```

Inheritance diagram for `radio::PITone`:



Collaboration diagram for radio::PITone:



## Public Member Functions

- `PITone` ([float32](#) amplitude, [float32](#) \*data, [uint32](#) size, [float32](#) frequency, [uint32](#) samplingRate=48000)
- void `Add` ()

### 7.4.1 Detailed Description

This class creates a PL tone (CTCSS tone) at a specified frequency in a baseband signal.

Definition at line 18 of file [PITone.hpp](#).

### 7.4.2 Constructor & Destructor Documentation

**7.4.2.1** `radio::PITone::PITone ( float32 amplitude, float32 * data, uint32 size, float32 frequency, uint32 samplingRate = 48000 )`

Creates a [PITone](#) object.

Parameters

<i>amplitude</i>	the amplitude (0-1) of the subcarrier. Assumes baseband signal has a peak-to-peak range of -1 to 1.
<i>data</i>	an array containing a portion of the discrete baseband signal
<i>size</i>	the number of elements in the data array
<i>frequency</i>	the frequency of the CTCSS tone in the baseband (not in the IF or RF signals)
<i>samplingRate</i>	the sampling frequency of the baseband signal

Definition at line 63 of file [PITone.hpp](#).

### 7.4.3 Member Function Documentation

**7.4.3.1** `void radio::PITone::Add ( )`

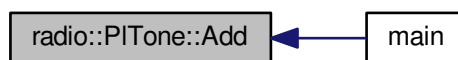
Adds the PL tone to the baseband signal.

Definition at line 75 of file [PITone.hpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



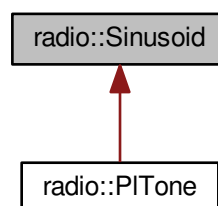
The documentation for this class was generated from the following file:

- [src/PITone.hpp](#)

## 7.5 radio::Sinusoid Class Reference

```
#include <Sinusoid.hpp>
```

Inheritance diagram for `radio::Sinusoid`:



### Public Member Functions

- [Sinusoid](#) ([float32 frequency](#), [uint32 samplingRate=48000](#))
- [~Sinusoid](#) ()
- [float32 next](#) ()
- [float32 nextShifted](#) ()

## Protected Attributes

- `float32 frequency`
- `uint32 sinIndex = 0`
- `uint32 sinIndexShifted = 0`
- `uint32 samplingRate`
- `float32 * sinusoid`
- `float32 * sinusoidShift90`

### 7.5.1 Detailed Description

This class creates an easy-to-call pair of sinusoids,  $\pi/2$  radians out of phase with each other, that will preserve its phase throughout its lifespan. Essentially, it is a ring buffer.

Definition at line 21 of file [Sinusoid.hpp](#).

### 7.5.2 Constructor & Destructor Documentation

#### 7.5.2.1 `radio::Sinusoid::Sinusoid ( float32 frequency, uint32 samplingRate = 48000 )`

Creates two ring-buffer sinusoids.

Definition at line 78 of file [Sinusoid.hpp](#).

#### 7.5.2.2 `radio::Sinusoid::~Sinusoid ( )`

Frees arrays malloc'ed in the constructor.

Definition at line 93 of file [Sinusoid.hpp](#).

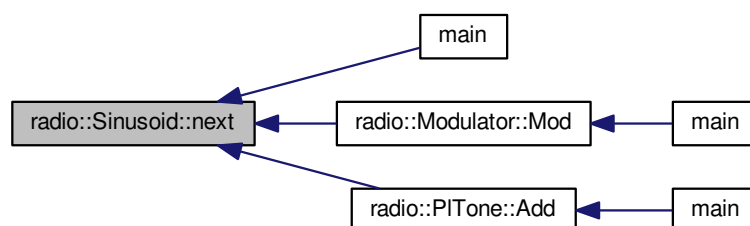
### 7.5.3 Member Function Documentation

#### 7.5.3.1 `float32 radio::Sinusoid::next ( )`

Provides the next value of the sinusoid in a manner consistent with a ring buffer.

Definition at line 98 of file [Sinusoid.hpp](#).

Here is the caller graph for this function:



### 7.5.3.2 float32 radio::Sinusoid::nextShifted ( )

Provides the next value of the shifted sinusoid in a manner consistent with a ring buffer.

Definition at line 103 of file [Sinusoid.hpp](#).

Here is the caller graph for this function:



## 7.5.4 Member Data Documentation

### 7.5.4.1 float32 radio::Sinusoid::frequency [protected]

The frequency of the sinusoid.

Definition at line 49 of file [Sinusoid.hpp](#).

### 7.5.4.2 uint32 radio::Sinusoid::samplingRate [protected]

The sampling rate.

Definition at line 64 of file [Sinusoid.hpp](#).

### 7.5.4.3 uint32 radio::Sinusoid::sinIndex = 0 [protected]

The current index of the sinusoid's unshifted array.

Definition at line 54 of file [Sinusoid.hpp](#).

### 7.5.4.4 uint32 radio::Sinusoid::sinIndexShifted = 0 [protected]

The current index of the shifted sinusoid's array.

Definition at line 59 of file [Sinusoid.hpp](#).

### 7.5.4.5 float32\* radio::Sinusoid::sinusoid [protected]

Initialized as an array of the sinusoid values.

Definition at line 69 of file [Sinusoid.hpp](#).

### 7.5.4.6 float32\* radio::Sinusoid::sinusoidShift90 [protected]

Initialized as an array of the sinusoid values shifted 90 degrees.

Definition at line 75 of file [Sinusoid.hpp](#).

The documentation for this class was generated from the following file:

- [src/Sinusoid.hpp](#)



## Chapter 8

# File Documentation

### 8.1 bin/bbftest File Reference

#### 8.1.1 Detailed Description

##### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [bbftest](#).

### 8.2 bbftest

```
00001 basebandfiltertest | aplay -c 2 -r 48000 -t raw -f S32_LE
```

### 8.3 bin/lbftest File Reference

#### 8.3.1 Detailed Description

##### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [lbftest](#).

### 8.4 lbftest

```
00001 lowersidebandftest | aplay -c 2 -r 48000 -t raw -f S32_LE
```

### 8.5 bin/modtest File Reference

#### 8.5.1 Detailed Description

##### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [modtest](#).

## 8.6 modtest

```
00001 OPTIONS="-c 2 -r 48000 -t raw -f S32_LE -q"  
00002 modulatortest $1 $2 $3 | aplay $OPTIONS -D plughw:0,0
```

## 8.7 bin/msintest File Reference

### 8.7.1 Detailed Description

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [msintest](#).

## 8.8 msintest

```
00001 multisinusoidtest | aplay -c 2 -r 48000 -t raw -f S32_LE
```

## 8.9 bin/pltest File Reference

### 8.9.1 Detailed Description

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [pltest](#).

## 8.10 pltest

```
00001 OPTIONS="-c 2 -r 48000 -t raw -f S32_LE"  
00002 pltonetest $1 | aplay $OPTIONS
```

## 8.11 bin/radio File Reference

### 8.11.1 Detailed Description

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [radio](#).

## 8.12 radio

```
00001 OPTIONS="-r 48000 -t raw -q"  
00002 arecord $OPTIONS -c 1 -D plughw:1,0 -f FLOAT_LE | sdr $1 $2 $3 | \  
00003 aplay $OPTIONS -c 2 -f S32_LE -D plughw:0,0
```



## 8.13 bin/sintest File Reference

### 8.13.1 Detailed Description

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [sintest](#).

## 8.14 sintest

```
00001 OPTIONS="-c 2 -r 48000 -t raw -f S32_LE"
00002 sinusoidtest $1 | aplay $OPTIONS
```

## 8.15 bin/usbftest File Reference

### 8.15.1 Detailed Description

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [usbftest](#).

## 8.16 usbftest

```
00001 uppersidebandftest | aplay -c 2 -r 48000 -t raw -f S32_LE
```

## 8.17 etc/doxygen.config File Reference

Contains doxygen configuration.

### 8.17.1 Detailed Description

Contains doxygen configuration.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [doxygen.config](#).

## 8.18 doxygen.config

```
00001 PROJECT_NAME = "An Inexpensive, Software-Defined IF Modulator"
00002
00003 INPUT = makefile src/ etc/doxygen.config bin/bbftest bin/modtest bin/msintest bin/lsbftest bin/pltest
         bin/radio bin/sintest bin/usbftest
00004 OUTPUT_DIRECTORY = doc/
00005
00006 GENERATE_HTML = YES
00007 GENERATE_RTF = YES
```

```

00008 GENERATE_LATEX = YES
00009 GENERATE_MAN = YES
00010 GENERATE_XML = NO
00011 GENERATE_DOCBOOK = NO
00012
00013 USE_PDF_LATEX = YES
00014 USE_PDF_HYPERLINKS = YES
00015
00016 RECURSIVE = YES
00017 SOURCE_BROWSER = YES
00018 SOURCE_TOOLTIPS = YES
00019 EXTRACT_ALL = YES
00020 DISABLE_INDEX = NO
00021 GENERATE_TREEVIEW = YES
00022 SEARCHENGINE = YES
00023 SERVER_BASED_SEARCH = NO
00024
00025 LATEX_SOURCE_CODE = YES
00026 STRIP_CODE_COMMENTS = YES
00027 INLINE_SOURCES = NO
00028
00029 HAVE_DOT = YES
00030 CALL_GRAPH = YES
00031 CALLER_GRAPH = YES

```

## 8.19 makefile File Reference

Contains recipes to compile the main program and the tests programs as well as making documentation and counting total lines of code in `src/`.

### 8.19.1 Detailed Description

Contains recipes to compile the main program and the tests programs as well as making documentation and counting total lines of code in `src/`.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [makefile](#).

## 8.20 makefile

```

00001 GCC = g++ -g -std=gnu++14
00002
00003 alsa-test:
00004     $(GCC) src/alsa_test.cpp -o bin/alsatest -O0 -lasound
00005
00006 baseband-filter-test:
00007     $(GCC) src/baseband_filter_test.cpp -o bin/basebandfiltertest
00008
00009 count:
00010     grep -r "src/" -e "Samuel Andrew Wisner" -l | xargs wc -l
00011
00012 docs:
00013     rm -r doc/
00014     doxygen etc/doxygen.config
00015     cd doc/latex; make pdf;
00016     git reset
00017     git add doc/.
00018     git --no-pager log > etc/log.txt
00019     git add etc/log.txt
00020     git commit -m "Updated documentation."
00021     git push
00022
00023 fft-test:
00024     $(GCC) src/fft_test.cpp -o bin/fft-test
00025
00026 fft-test2:
00027     $(GCC) src/fft_test2.cpp -o bin/fft-test2
00028
00029 iq-test:

```

```

00030      $(GCC) src/iq_test.cpp -o bin/iqtest
00031
00032 multi-sinusoid-test:
00033      $(GCC) src/multi_sinusoid_test.cpp -o bin/multisinusoidtest
00034
00035 modulator-test:
00036      $(GCC) src/modulator_test.cpp -o bin/modulatortest
00037
00038 lsb-filter-test:
00039      $(GCC) src/lsb_filter_test.cpp -o bin/lowersidebandftest
00040
00041 pl-tone-test:
00042      $(GCC) src/pl_tone_test.cpp -o bin/pltonetest
00043
00044 radio:
00045      $(GCC) src/main.cpp -o bin/sdr
00046
00047 sinusoid-test:
00048      $(GCC) src/sinusoid_test.cpp -o bin/sinusoidtest
00049
00050 usb-filter-test:
00051      $(GCC) src/usb_filter_test.cpp -o bin/uppersidebandftest
00052
00053

```

## 8.21 src/alsa\_test.cpp File Reference

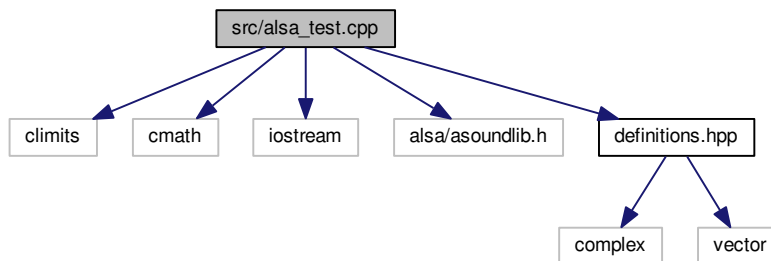
Contains program to tests sinusoidal tone generation.

```

#include <climits>
#include <cmath>
#include <iostream>
#include <alsa/asoundlib.h>
#include "definitions.hpp"

```

Include dependency graph for alsa\_test.cpp:



### Functions

- `int main ()`

#### 8.21.1 Detailed Description

Contains program to tests sinusoidal tone generation.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Clicking noise from sinusoidal discontinuity

Definition in file [alsa\\_test.cpp](#).

## 8.21.2 Function Documentation

### 8.21.2.1 int main ( )

This program tests sinusoidal speaker output through the ALSA API. Not sure if it currently works. When it did at least compile and run, it produced a sinusoid with an approximately twice-per-second clicking noise.

Definition at line 22 of file [alsa\\_test.cpp](#).

## 8.22 alsa\_test.cpp

```

00001
00008 #include <climits>
00009 #include <cmath>
00010 #include <iostream>
00011 #include <alsa/asoundlib.h>
00012
00013 #include "definitions.hpp"
00014
00015 using namespace std;
00016
00022 int main() {
00023     int ret;
00024
00025     snd_pcm_t* pcm_handle; // device handle
00026     snd_pcm_stream_t stream = SND_PCM_STREAM_PLAYBACK;
00027     snd_pcm_hw_params_t* hwparams; // hardware information
00028     char* pcm_name = strdup("plughw:1,0"); // on-board audio jack
00029     int rate = 48000;
00030
00031     const uint16 freq = 440;
00032     long unsigned int bufferSize = 4096*4; // anything >8192 causes seg fault
00033     const uint32 len = bufferSize*100;
00034     const float32 arg = 2 * 3.141592 * freq / rate;
00035     sint16 vals[len];
00036
00037     long unsigned int count = 0;
00038
00039     for(uint32 i = 0; i < len; i = i + 2) {
00040         vals[i] = (sint16)(SHRT_MAX * cos(arg * i/2) + 0.5);
00041         vals[i+1] = vals[i];
00042     }
00043
00044     ret = snd_pcm_open(&pcm_handle, pcm_name, stream, 0);
00045     cout << "Opening: " << snd_strerror(ret) << endl;
00046
00047     ret = snd_pcm_hw_params_any(pcm_handle, hwparams);
00048     cout << "Initializing hwparams structure: " << snd_strerror(ret) << endl;
00049
00050     ret = snd_pcm_hw_params_set_access(pcm_handle, hwparams,
00051         SND_PCM_ACCESS_RW_INTERLEAVED);
00052     cout << "Setting access: " << snd_strerror(ret) << endl;
00053
00054     ret = snd_pcm_hw_params_set_format(pcm_handle, hwparams,
00055         SND_PCM_FORMAT_S16_LE);
00056     cout << "Setting format: " << snd_strerror(ret) << endl;
00057
00058     ret = snd_pcm_hw_params_set_rate(pcm_handle, hwparams,
00059         rate, (int)0);
00060     cout << "Setting rate: " << snd_strerror(ret) << endl;
00061
00062     ret = snd_pcm_hw_params_set_channels(pcm_handle, hwparams, 2);
00063     cout << "Setting channels: " << snd_strerror(ret) << endl;
00064
00065     ret = snd_pcm_hw_params_set_periods(pcm_handle, hwparams, 2, 0);
00066     cout << "Setting periods: " << snd_strerror(ret) << endl;
00067
00068     ret = snd_pcm_hw_params_set_buffer_size_near(pcm_handle, hwparams,
00069         &bufferSize);
00070     cout << "Setting buffer size: " << snd_strerror(ret) << endl;
00071
00072     ret = snd_pcm_hw_params(pcm_handle, hwparams);
00073     cout << "Applying parameters: " << snd_strerror(ret) << endl;
00074
00075     // ret = snd_pcm_hw_params_get_period_size(hwparams, &count, 0);
00076     cout << "Actual period size: " << count << endl;

```

```

00077     cout << "Returned: " << snd_strerror(ret) << endl;
00078
00079
00080
00081     cout << endl << endl;
00082
00083     const void* ptr[100];
00084
00085     for(int i = 0; i < 100; i++) {
00086         ptr[i] = (const void*)&vals + bufferSize*i;
00087     }
00088
00089     int err;
00090
00091     for(int i = 0; i < 100; i++) {
00092         do {
00093             ret = snd_pcm_writei(pcm_handle,
00094                 ptr[i], count);
00095
00096             if(ret < 0) {
00097                 err = snd_pcm_prepare(pcm_handle);
00098                 cout << "Preparing: " << snd_strerror(err)
00099                     << endl;
00100             }
00101         } while(ret < 0);
00102     }
00103     cout << "Writing data: " << ret << endl;
00104 }
00105 }
00106 }

```

## 8.23 src/auxiliary.hpp File Reference

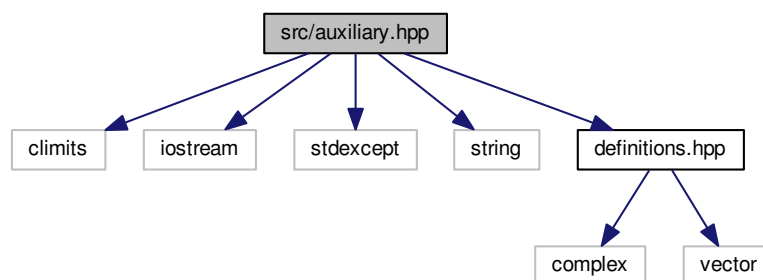
Contains helper-functions for `main()`.

```

#include <climits>
#include <iostream>
#include <stdexcept>
#include <string>
#include "definitions.hpp"

```

Include dependency graph for auxiliary.hpp:



This graph shows which files directly or indirectly include this file:



## Namespaces

- [radio](#)

## Functions

- void [radio::ShowHelp](#) ()
- void [radio::to\\_sint32](#) (float32 \*data, uint32 size)
- ModulationType [radio::to\\_type](#) (std::string str)

### 8.23.1 Detailed Description

Contains helper-functions for [main\(\)](#).

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [auxiliary.hpp](#).

## 8.24 auxiliary.hpp

```

00001
00007 #ifndef auxiliary_H
00008 #define auxiliary_H
00009
00010 #include <climits>
00011 #include <iostream>
00012 #include <stdexcept>
00013 #include <string>
00014
00015 #include "definitions.hpp"
00016
00017 namespace radio {
00018
00022     void ShowHelp() {
00023         std::cerr << std::endl << "Usage: radio [MODE] [MIC GAIN] "
00024             "[PL TONE]" << std::endl << std::endl
00025             << "MODE: one of the following types "
00026             "of modulation" << std::endl << std::endl;
00027
00028         std::cerr << "dsblc\t\tDouble sideband, large carrier" << std::endl
00029             << "am\t\tAlias for dsblc" << std::endl
00030             << "dsbsc\t\tDouble sideband, suppressed carrier" << std::endl
00031             << "lsbhil\t\tLower sideband created via Hilbert transform"
00032             << std::endl
00033             << "lsbfilt\t\tLower sideband created via digital low-pass filter"
00034             << std::endl
00035             << "usbhil\t\tUpper sideband created via Hilbert transform"
00036             << std::endl
00037             << "usbfilt\t\tUpper sideband created via digital high-pass filter"
00038             << std::endl
00039             // << "nfm\t\tFrequency modulation, 2.5 kHz bandwidth"
00040             << std::endl;
00041             // << "wfm\t\tFrequency modulation, 5 kHz bandwidth" << std::endl
00042             // << "fm\t\talias for wfm" << std::endl << std::endl;
00043
00044         std::cerr << "MIC GAIN: Microphone power gain expressed in decibels"
00045             << std::endl << std::endl;
00046
00047         std::cerr << "PL TONE: Optional specification for CTCSS tone from "
00048             "60-260 Hz" << std::endl << std::endl;
00049
00050         std::exit(ERROR);
00051     }
00052
00062     void to_sint32(float32* data, uint32 size) {
00063         for(uint32 i = 0; i < size; i++) {
00064             ((sint32*)data)[i] = (sint32)(data[i] * INT_MAX + 0.5);
00065         }
00066     }
00067

```

```

00080     ModulationType to_type(std::string str) {
00081         ModulationType type;
00082
00083         if(str == "dsblc" || str == "am") {
00084             type = ModulationType::DSB_LC;
00085         } else if(str == "dsbsc") {
00086             type = ModulationType::DSB_SC;
00087         } else if(str == "lsbhil") {
00088             type = ModulationType::LSB_HILBERT;
00089         } else if(str == "lsbfilt") {
00090             type = ModulationType::LSB_FILTERED;
00091         } else if(str == "usbhil") {
00092             type = ModulationType::USB_HILBERT;
00093         } else if(str == "usbfilt") {
00094             type = ModulationType::USB_FILTERED;
00095         } else if(str == "wfm" || str == "fm") {
00096             type = ModulationType::FM_NARROW;
00097         } else if(str == "nfm") {
00098             type = ModulationType::FM_WIDE;
00099         } else {
00100             throw std::logic_error("The given modulation type is invalid!");
00101         }
00102
00103         return type;
00104     }
00105 }
00106
00107 #endif

```

## 8.25 src/baseband\_filter\_test.cpp File Reference

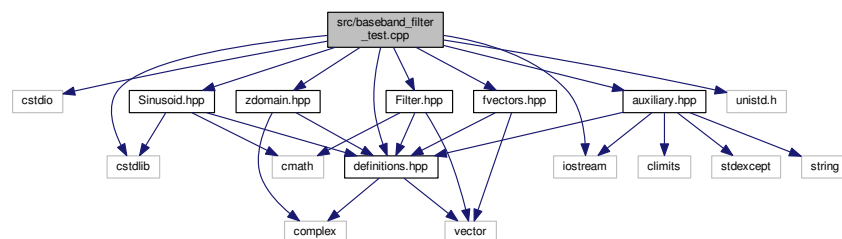
Contains a program to demonstrate the the baseband/AF filter.

```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <unistd.h>
#include "auxiliary.hpp"
#include "definitions.hpp"
#include "Filter.hpp"
#include "fvectors.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"

```

Include dependency graph for baseband\_filter\_test.cpp:



## Functions

- int `main` (int argc, char \*argv[])

### 8.25.1 Detailed Description

Contains a program to demonstrate the the baseband/AF filter.

**Author**

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

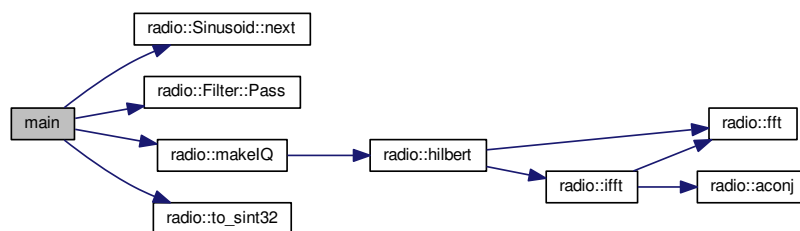
Definition in file [baseband\\_filter\\_test.cpp](#).

**8.25.2 Function Documentation****8.25.2.1 int main ( int argc, char \* argv[] )**

Program to test the Filter class and the baseband filter coefficients.

Definition at line 25 of file [baseband\\_filter\\_test.cpp](#).

Here is the call graph for this function:

**8.26 baseband\_filter\_test.cpp**

```

00001
00007 #include <cstdio>
00008 #include <cstdlib>
00009 #include <iostream>
00010 #include <unistd.h>
00011
00012 #include "auxiliary.hpp"
00013 #include "definitions.hpp"
00014 #include "Filter.hpp"
00015 #include "fvectors.hpp"
00016 #include "Sinusoid.hpp"
00017 #include "zdomain.hpp"
00018
00019 using namespace std;
00020 using namespace radio;
00021
00025 int main(int argc, char* argv[]) {
00026
00027     // Constants
00028     const uint16 BUFFER_SIZE = 48000;
00029
00030     // Declare primitive Variables
00031     uint8 i = 0;
00032     uint8 size = 0;
00033     uint16 delta = 250;
00034     float32 dataBuffer[BUFFER_SIZE];
00035     float32 iqBuffer[2 * BUFFER_SIZE];
00036
00037     // create 1 sec of audio
00038     for(uint16 f = delta; f <= 3000; f += delta, i++) {
00039         Sinusoid sinusoid(f);
00040
00041         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00042             dataBuffer[i] += sinusoid.next();
00043         }
00044     }
00045     size = i;
00046
00047

```



```
00048 // adjust dataBuffer so values are between -1 and 1
00049 for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00050     dataBuffer[i] /= size;
00051 }
00052
00053 Filter filter(dataBuffer, BUFFER_SIZE, F_BASEBAND);
00054 filter.Pass();
00055 makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00056 to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00057
00058 while(true) {
00059     write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00060 }
00061 }
```

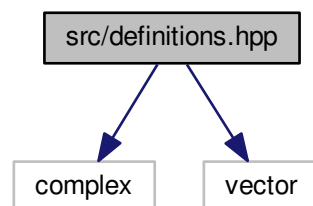
## 8.27 src/definitions.hpp File Reference

Contains declarations of system-independant (universal size) integers and float types, shortened type names for some commonly used types, and enumerations.

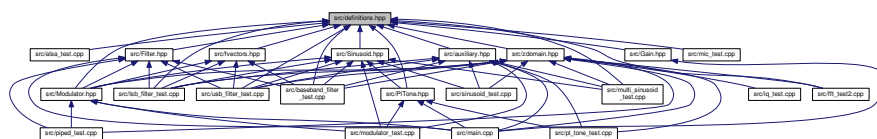
```
#include <complex>
```

```
#include <vector>
```

Include dependency graph for definitions.hpp:



This graph shows which files directly or indirectly include this file:



## Namespaces

- radio

## Macros

- #define ENUM signed char
- #define ERROR -1

## Typedefs

- typedef unsigned char [byte](#)
- typedef unsigned char [uint8](#)
- typedef signed char [sint8](#)
- typedef unsigned short [uint16](#)
- typedef signed short [sint16](#)
- typedef unsigned int [uint32](#)
- typedef signed int [sint32](#)
- typedef unsigned long long [uint64](#)
- typedef signed long long [sint64](#)
- typedef float [float32](#)
- typedef double [float64](#)
- typedef std::complex< [float32](#) > [cfloat32](#)
- typedef std::vector  
     < std::vector< [float64](#) > > [fparams](#)

## Enumerations

- enum [radio::Age](#) { [radio::OLD](#), [radio::NEW](#) }
- enum [radio::Fractional](#) { [radio::NUM](#), [radio::DEN](#) }
- enum [radio::Argument](#) { [radio::FREQ](#) = 1, [radio::MODE](#), [radio::PL\\_TONE](#) }
- enum [radio::ModulationType](#) {  
[radio::ModulationType::DSB\\_LC](#), [radio::ModulationType::DSB\\_SC](#), [radio::ModulationType::USB\\_FILTERED](#),  
[radio::ModulationType::USB\\_HILBERT](#),  
[radio::ModulationType::LSB\\_FILTERED](#), [radio::ModulationType::LSB\\_HILBERT](#), [radio::ModulationType::FM\\_NARROW](#), [radio::ModulationType::FM\\_WIDE](#) }

### 8.27.1 Detailed Description

Contains declarations of system-independant (universal size) integers and float types, shortened type names for some commonly used types, and enumerations.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [definitions.hpp](#).

### 8.27.2 Macro Definition Documentation

#### 8.27.2.1 #define ENUM signed char

The type used for the enumerations.

Definition at line 18 of file [definitions.hpp](#).

#### 8.27.2.2 #define ERROR -1

A generic error constant.

Definition at line 23 of file [definitions.hpp](#).

### 8.27.3 Typedef Documentation

#### 8.27.3.1 typedef unsigned char byte

Definition at line 25 of file [definitions.hpp](#).

#### 8.27.3.2 typedef std::complex<float32> cfloat32

Complex float32's.

Definition at line 44 of file [definitions.hpp](#).

#### 8.27.3.3 typedef float float32

Definition at line 38 of file [definitions.hpp](#).

#### 8.27.3.4 typedef double float64

Definition at line 39 of file [definitions.hpp](#).

#### 8.27.3.5 typedef std::vector<std::vector<float64> > fparams

Defines a type for the filter coefficients.

Definition at line 49 of file [definitions.hpp](#).

#### 8.27.3.6 typedef signed short sint16

Definition at line 30 of file [definitions.hpp](#).

#### 8.27.3.7 typedef signed int sint32

Definition at line 33 of file [definitions.hpp](#).

#### 8.27.3.8 typedef signed long long sint64

Definition at line 36 of file [definitions.hpp](#).

#### 8.27.3.9 typedef signed char sint8

Definition at line 27 of file [definitions.hpp](#).

#### 8.27.3.10 typedef unsigned short uint16

Definition at line 29 of file [definitions.hpp](#).

#### 8.27.3.11 typedef unsigned int uint32

Definition at line 32 of file [definitions.hpp](#).

### 8.27.3.12 typedef unsigned long long uint64

Definition at line 35 of file [definitions.hpp](#).

### 8.27.3.13 typedef unsigned char uint8

Definition at line 26 of file [definitions.hpp](#).

## 8.28 definitions.hpp

```

00001
00009 #ifndef definitions_H
00010 #define definitions_H
00011
00012 #include <complex>
00013 #include <vector>
00014
00018 #define ENUM signed char
00019
00023 #define ERROR -1
00024
00025 typedef unsigned char byte;
00026 typedef unsigned char uint8;
00027 typedef signed char sint8;
00028
00029 typedef unsigned short uint16;
00030 typedef signed short sint16;
00031
00032 typedef unsigned int uint32;
00033 typedef signed int sint32;
00034
00035 typedef unsigned long long uint64;
00036 typedef signed long long sint64;
00037
00038 typedef float float32;
00039 typedef double float64;
00040
00044 typedef std::complex<float32> cfloat32;
00045
00049 typedef std::vector<std::vector<float64>> fparams;
00050
00055 namespace radio {
00060     enum Age { OLD, NEW };
00061
00065     enum Fractional { NUM, DEN };
00066
00070     enum Argument { FREQ = 1, MODE, PL_TONE };
00071
00075     enum class ModulationType {
00076         DSB_LC, DSB_SC,
00077         USB_FILTERED,
00078         USB_HILBERT,
00079         LSB_FILTERED,
00080         LSB_HILBERT,
00081         FM_NARROW,
00082         FM_WIDE
00083     };
00084 }
00085
00086 #endif
00087
00088 // Doxygen descriptions for non-code files
00089

```

## 8.29 src/fft\_test.cpp File Reference

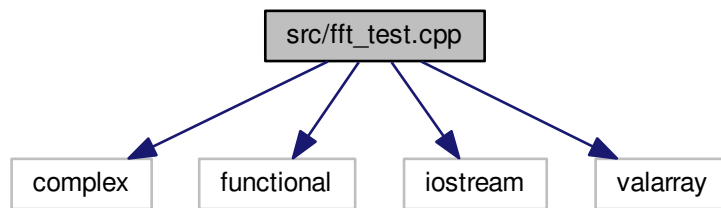
Tests FFT, IFFT, and Hilbert implementations.

```

#include <complex>
#include <functional>
#include <iostream>
#include <valarray>

```

Include dependency graph for fft\_test.cpp:



## Typedefs

- typedef std::valarray  
< std::complex< double > > [CArray](#)

## Functions

- void [fft](#) ([CArray](#) &x)
- void [ifft](#) ([CArray](#) &x)
- std::complex< double > [hilbert](#) (std::complex< double > n)
- int [main](#) ()

## Variables

- const double [PI](#) = 3.141592653589793238460

### 8.29.1 Detailed Description

Tests FFT, IFFT, and Hilbert implementations.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [fft\\_test.cpp](#).

### 8.29.2 Typedef Documentation

#### 8.29.2.1 typedef std::valarray<std::complex<double> > [CArray](#)

Definition at line 14 of file [fft\\_test.cpp](#).

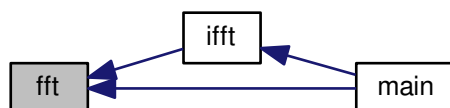
### 8.29.3 Function Documentation

#### 8.29.3.1 void [fft](#) ( [CArray](#) & x )

This code was taken from [http://rosettacode.org/wiki/Fast\\_Fourier\\_transform#C.2B.2B](http://rosettacode.org/wiki/Fast_Fourier_transform#C.2B.2B).

Definition at line 23 of file [fft\\_test.cpp](#).

Here is the caller graph for this function:



#### 8.29.3.2 `std::complex<double> hilbert ( std::complex< double > n )`

Definition at line 87 of file [fft\\_test.cpp](#).

Here is the caller graph for this function:



#### 8.29.3.3 `void ifft ( CArray & x )`

Definition at line 72 of file [fft\\_test.cpp](#).

Here is the call graph for this function:



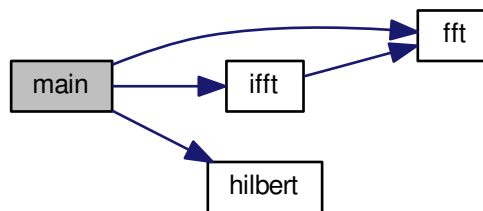
Here is the caller graph for this function:



#### 8.29.3.4 int main ( )

Definition at line 91 of file [fft\\_test.cpp](#).

Here is the call graph for this function:



### 8.29.4 Variable Documentation

#### 8.29.4.1 const double PI = 3.141592653589793238460

Definition at line 12 of file [fft\\_test.cpp](#).

## 8.30 fft\_test.cpp

```

00001
00007 #include <complex>
00008 #include <functional>
00009 #include <iostream>
00010 #include <valarray>
00011
00012 const double PI = 3.141592653589793238460;
00013
00014 typedef std::valarray<std::complex<double>> CArray;
00015
00021 // Cooley-Tukey FFT (in-place, breadth-first, decimation-in-frequency)
00022 // Better optimized but less intuitive
00023 void fft(CArray &x)
00024 {
00025     // DFT
00026     unsigned int N = x.size(), k = N, n;
00027     double thetaT = 3.14159265358979323846264338328L / N;
00028     std::complex<double> phiT(cos(thetaT), sin(thetaT)), T;
00029     while (k > 1)
  
```

```

00030     {
00031         n = k;
00032         k >>= 1;
00033         phiT = phiT * phiT;
00034         T = 1.0L;
00035         for (unsigned int l = 0; l < k; l++)
00036         {
00037             for (unsigned int a = 1; a < N; a += n)
00038             {
00039                 unsigned int b = a + k;
00040                 std::complex<double> t = x[a] - x[b];
00041                 x[a] += x[b];
00042                 x[b] = t * T;
00043             }
00044             T *= phiT;
00045         }
00046     }
00047     // Decimate
00048     unsigned int m = (unsigned int)log2(N);
00049     for (unsigned int a = 0; a < N; a++)
00050     {
00051         unsigned int b = a;
00052         // Reverse bits
00053         b = ((b & 0xaaaaaaaa) >> 1) | ((b & 0x55555555) << 1);
00054         b = ((b & 0xcccccccc) >> 2) | ((b & 0x33333333) << 2);
00055         b = ((b & 0xf0f0f0f0) >> 4) | ((b & 0x0f0f0f0f) << 4);
00056         b = ((b & 0xff00ff00) >> 8) | ((b & 0x00ff00ff) << 8);
00057         b = ((b >> 16) | (b << 16)) >> (32 - m);
00058         if (b > a)
00059         {
00060             std::complex<double> t = x[a];
00061             x[a] = x[b];
00062             x[b] = t;
00063         }
00064     }
00065     //std::complex<double> f = 1.0 / sqrt(N);
00066     //for (unsigned int i = 0; i < N; i++)
00067     //    x[i] *= f;
00068 }
00069 // inverse fft (in-place)
00070 void ifft(CArray& x)
00071 {
00072     // conjugate the complex numbers
00073     x = x.apply(std::conj);
00074     // forward fft
00075     fft(x);
00076     // conjugate the complex numbers again
00077     x = x.apply(std::conj);
00078     // scale the numbers
00079     x /= x.size();
00080 }
00081 std::complex<double> hilbert(std::complex<double> n) {
00082     return std::complex<double>(-2 * n.imag(), 0);
00083 }
00084 int main()
00085 {
00086     const std::complex<double> test[] = { 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 };
00087     CArray data(test, 16);
00088     // forward fft
00089     fft(data);
00090     std::cout << "fft" << std::endl;
00091     for (int i = 0; i < 16; ++i)
00092     {
00093         // std::cout << data[i] << std::endl;
00094     }
00095     for(int i = 8; i < 16; i++) {
00096         data[i] = 0;
00097     }
00098     // inverse fft
00099     ifft(data);
00100     std::cout << std::endl << "ifft" << std::endl;
00101     for (int i = 0; i < 16; ++i)
00102     {
00103         // std::cout << data[i] << std::endl;
00104     }
00105 }
00106
00107
00108
00109
00110
00111
00112
00113
00114
00115
00116
00117

```



```

00118     data = data.apply(hilbert);
00119
00120     std::cout << std::endl;
00121
00122     for(int i = 0; i < 16; i++) {
00123         std::cout << data[i].real() << std::endl;
00124     }
00125
00126     return 0;
00127 }

```

## 8.31 src/fft\_test2.cpp File Reference

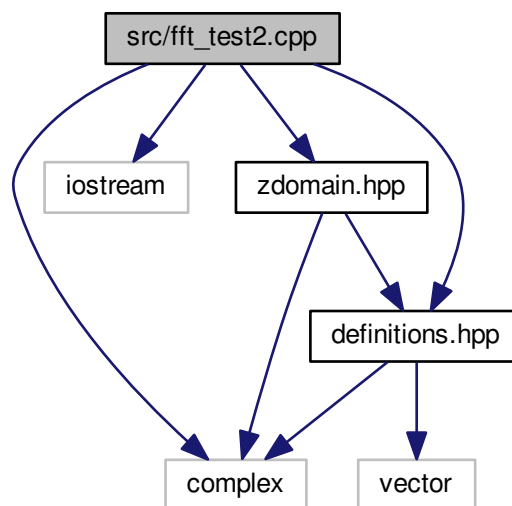
Tests FFT, IFFT, and Hilbert implementations in [zdomain.hpp](#).

```

#include <complex>
#include <iostream>
#include "definitions.hpp"
#include "zdomain.hpp"

```

Include dependency graph for `fft_test2.cpp`:



### Functions

- `int main ()`

#### 8.31.1 Detailed Description

Tests FFT, IFFT, and Hilbert implementations in [zdomain.hpp](#).

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [fft\\_test2.cpp](#).

## 8.31.2 Function Documentation

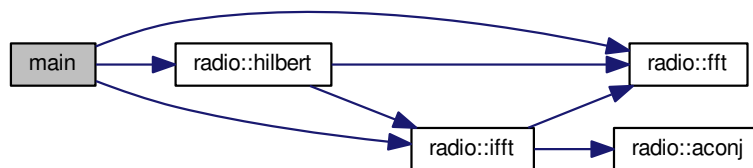
### 8.31.2.1 int main ( )

This program tests the `fft()`, `ifft()`, and `hilbert()` functions in the `zdomain.hpp` file.

This code is based on code from [http://rosettacode.org/wiki/Fast\\_Fourier\\_transform#C.↔2B.2B](http://rosettacode.org/wiki/Fast_Fourier_transform#C.↔2B.2B).

Definition at line 22 of file `fft_test2.cpp`.

Here is the call graph for this function:



## 8.32 fft\_test2.cpp

```

00001
00007 #include <complex>
00008 #include <iostream>
00009
00010 #include "definitions.hpp"
00011 #include "zdomain.hpp"
00012
00013 using namespace radio;
00014
00022 int main()
00023 {
00024     std::complex<float32> test[] = { 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 };
00025     float32 ftest[16];
00026     float32 dest[16];
00027
00028     for(int i = 0; i < 16; i++) {
00029         ftest[i] = test[i].real();
00030     }
00031
00032     // forward fft
00033     fft(test, 16);
00034
00035     std::cout << "fft" << std::endl;
00036
00037     for (int i = 0; i < 16; ++i)
00038     {
00039         // std::cout << test[i] << std::endl;
00040     }
00041
00042     // inverse fft
00043     ifft(test, 16);
00044     std::cout << std::endl << "ifft" << std::endl;
00045
00046     for (int i = 0; i < 16; ++i)
00047     {
00048         std::cout << test[i] << std::endl;
00049     }
00050
00051     hilbert(ftest, dest, 16);
00052     std::cout << std::endl << "hilbert" << std::endl;
00053
00054     for(int i = 0; i < 16; i++) {
00055         std::cout << dest[i] << std::endl;
00056     }
00057
00058     return 0;

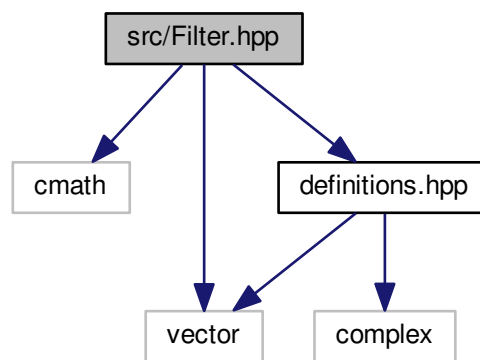
```

```
00059 }
```

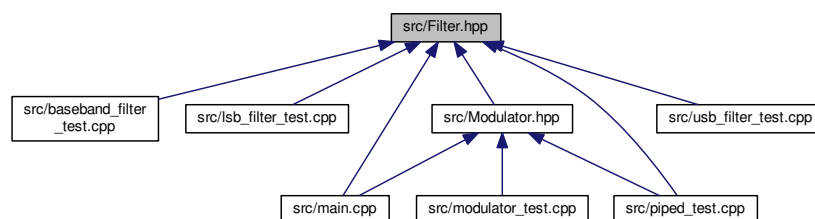
## 8.33 src/Filter.hpp File Reference

Defines the Filter class.

```
#include <cmath>
#include <vector>
#include "definitions.hpp"
Include dependency graph for Filter.hpp:
```



This graph shows which files directly or indirectly include this file:



### Classes

- class `radio::Filter`

### Namespaces

- `radio`

### 8.33.1 Detailed Description

Defines the Filter class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Discontinuities created at the beginning of each pass

Definition in file [Filter.hpp](#).

## 8.34 Filter.hpp

```

00001
00008 #ifndef Filter_H
00009 #define Filter_H
00010
00011 #include <cmath>
00012 #include <vector>
00013
00014 #include "definitions.hpp"
00015
00016 namespace radio {
00028     class Filter {
00029     public:
00044         Filter(float32* data, uint32 size,
00045                fparams& diffEq);
00051
00052         void Pass();
00053
00054     protected:
00058         uint8 eqLength;
00059
00063         uint32 size;
00064
00069         float32* data;
00070
00077         fparams diffEq;
00078     };
00079
00080     Filter::Filter(float32* data, uint32 size,
00081                   fparams& diffEq) {
00082         this->data = data;
00083         this->size = size;
00084         this->diffEq = diffEq;
00085         eqLength = this->diffEq[DEN].size();
00086     }
00087
00088     void Filter::Pass() {
00089         float64 temp[size];
00090
00091         // create first values in filtered data
00092         for(int i = 0; i < eqLength; i++) {
00093             temp[i] = 0;
00094
00095             for(int j = 0; j < eqLength; j++) {
00096                 temp[i] += diffEq[NUM][j] * (j > i ? 0 : data[i - j]);
00097             }
00098
00099             for(int j = 1; j < eqLength; j++) {
00100                 temp[i] -= diffEq[DEN][j] * (j > i ? 0 : temp[i - j]);
00101             }
00102
00103         // create the REST of the values in filtered data
00104         for(int i = eqLength; i < size; i++) {
00105             temp[i] = 0;
00106
00107             for(int j = 0; j < eqLength; j++) {
00108                 temp[i] += diffEq[NUM][j] * data[i - j];
00109             }
00110
00111             for(int j = 1; j < eqLength; j++) {
00112                 temp[i] -= diffEq[DEN][j] * temp[i - j];
00113             }
00114         }
00115     }

```

```

00116         // save final values of data and filtered data
00117         for(int i = 0; i < size; i++) {
00118             data[i] = temp[i];
00119         }
00120     }
00121 }
00122
00123 #endif

```

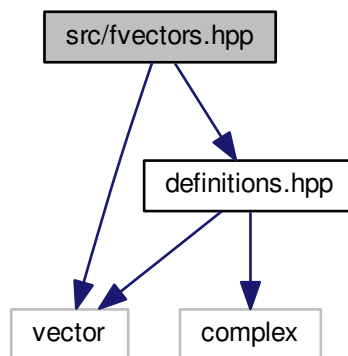
## 8.35 src/fvectors.hpp File Reference

Defines the transfer function coefficients used in the instances of the Filter class in this program. The coefficients are listed by greatest order to least.

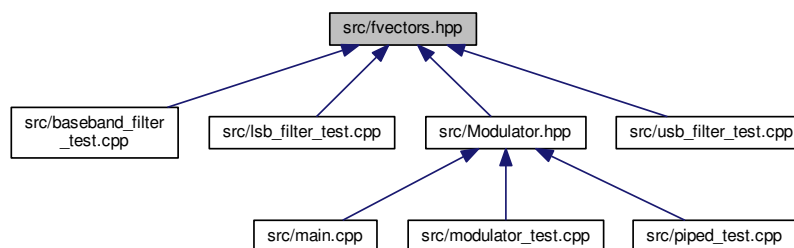
```
#include <vector>
```

```
#include "definitions.hpp"
```

Include dependency graph for fvectors.hpp:



This graph shows which files directly or indirectly include this file:



## Namespaces

- [radio](#)

## Variables

- [fparams radio::F\\_BASEBAND](#)
- [fparams radio::F\\_LOWERSIDEBAND](#)
- [fparams radio::F\\_UPPERSIDEBAND](#)

### 8.35.1 Detailed Description

Defines the transfer function coefficients used in the instances of the Filter class in this program. The coefficients are listed by greatest order to least.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [fvectors.hpp](#).

## 8.36 fvectors.hpp

```

00001
00009 #ifndef fvectors_H
00010 #define fvectors_H
00011
00012 #include <vector>
00013
00014 #include "definitions.hpp"
00015
00016 namespace radio {
00020     fparams F_BASEBAND = { std::vector<float64> {
00021         0.0008977019461,
00022         -0.002215694636,
00023         0.001372192986,
00024         0.001372192986,
00025         -0.002215694636,
00026         0.0008977019461
00027     }, std::vector<float64> {
00028         1,
00029         -4.678616047,
00030         8.822912216,
00031         -8.379911423,
00032         4.007629871,
00033         -0.7719064355
00034     } };
00035
00039     fparams F_LOWERSIDEBAND = { std::vector<float64> {
00040         0.2758039069174,
00041         2.763578787693,
00042         12.83915022756,
00043         36.47584850651,
00044         70.37084637368,
00045         96.76893503179,
00046         96.76893503179,
00047         70.37084637368,
00048         36.47584850651,
00049         12.83915022756,
00050         2.763578787693,
00051         0.2758039069174
00052     }, std::vector<float64> {
00053         1,
00054         7.605497780083,
00055         27.34180552438,
00056         60.83375457605,
00057         92.60908886875,
00058         100.8363857,
00059         79.74796574736,
00060         45.4982252145,
00061         18.13566776308,
00062         4.690036472717,
00063         0.6617552879305,
00064         0.0281427334611
00065     } };
00066
00070     fparams F_UPPERSIDEBAND = { std::vector<float64> {
00071         0.001690387681463,
00072         0.01145271586989,

```

```

00073         0.03591799189724,
00074         0.06576926098562,
00075         0.07119343282702,
00076         0.03156377419766,
00077         -0.03156377419766,
00078         -0.07119343282702,
00079         -0.06576926098562,
00080         -0.03591799189724,
00081         -0.01145271586989,
00082         -0.001690387681463
00083     }, std::vector<float64> {
00084         1,
00085         9.465175013624,
00086         41.62402815905,
00087         112.0971027069,
00088         205.2097686473,
00089         267.9378582311,
00090         254.486805213,
00091         175.7772755115,
00092         86.51619894548,
00093         28.89988093561,
00094         5.89781461091,
00095         0.5572910543053
00096     } };
00097
00098
00099 }
00100
00101 #endif

```

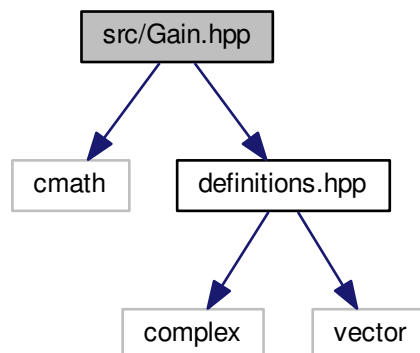
## 8.37 src/Gain.hpp File Reference

Contains the Gain class.

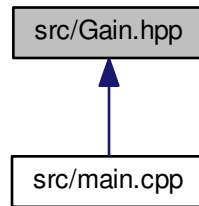
```
#include <cmath>
```

```
#include "definitions.hpp"
```

Include dependency graph for Gain.hpp:



This graph shows which files directly or indirectly include this file:



## Classes

- class [radio::Gain](#)

## Namespaces

- [radio](#)

### 8.37.1 Detailed Description

Contains the Gain class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [Gain.hpp](#).

## 8.38 Gain.hpp

```
00001
00007 #ifndef Gain_H
00008 #define Gain_H
00009
00010 #include <cmath>
00011
00012 #include "definitions.hpp"
00013
00014 namespace radio {
00018     class Gain {
00019     public:
00030         Gain(float32* data, uint32 size, float32 gaindB);
00031
00035         void Apply();
00036
00037     private:
00041         float32* data;
00042
00046         float32 gainCoeff;
00047
00052         bool hasClipped = false;
00053
00057         uint32 size;
00058
00059     };
00060
```



```

00061     Gain::Gain(float32* data, uint32 size, float32 gaindB) {
00062         this->data = data;
00063         this->size = size;
00064         gainCoeff = pow(10, gaindB / 20);
00065     }
00066
00067     void Gain::Apply() {
00068         for(uint32 i = 0; i < size; i++) {
00069             data[i] *= gainCoeff;
00070
00071             if((data[i] > 1 || data[i] < -1) && !hasClipped) {
00072                 hasClipped = true;
00073                 std::cerr << "Baseband clipping has occurred!"
00074                     << std::endl;
00075             }
00076         }
00077     }
00078 }
00079
00080 #endif

```

## 8.39 src/iq\_test.cpp File Reference

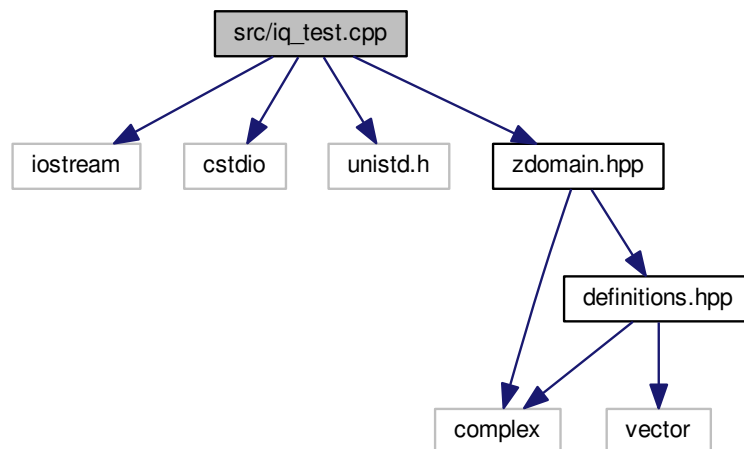
Generates test IQ signal.

```

#include <iostream>
#include <cstdio>
#include <unistd.h>
#include "zdomain.hpp"

```

Include dependency graph for iq\_test.cpp:



### Functions

- int `main` ()

### 8.39.1 Detailed Description

Generates test IQ signal.

**Author**

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

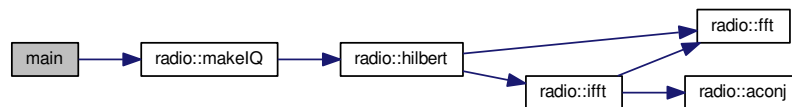
Definition in file [iq\\_test.cpp](#).

**8.39.2 Function Documentation****8.39.2.1 int main ( )**

This small program demonstrates the IQ generation abilities of the [makeIQ\(\)](#) function.

Definition at line 20 of file [iq\\_test.cpp](#).

Here is the call graph for this function:

**8.40 iq\_test.cpp**

```

00001
00007 #include <iostream>
00008 #include <cstdio>
00009 #include <unistd.h>
00010
00011 #include "zdomain.hpp"
00012
00013 using namespace std;
00014 using namespace radio;
00015
00020 int main() {
00021     const uint16 len = 16384;
00022     float32 data[len];
00023     float32 iqData[2*len];
00024
00025     for(int i = 0; i < len; i++) {
00026         data[i] = sin(2*3.141592*170*i/len);
00027     }
00028
00029     while(true) {
00030         read(STDIN_FILENO, &data, len * sizeof(float32));
00031         makeIQ(data, iqData, len);
00032         write(STDOUT_FILENO, &iqData, 2 * len * sizeof(float32));
00033     }
00034 }
  
```

**8.41 src/lb\_filter\_test.cpp File Reference**

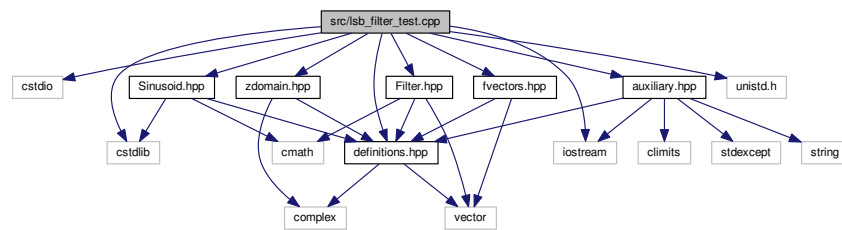
Contains a program to demonstrate the the LSB/AF filter.

```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <unistd.h>
#include "auxiliary.hpp"
#include "definitions.hpp"
#include "Filter.hpp"
#include "fvectors.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"

```

Include dependency graph for lfb\_filter\_test.cpp:



## Functions

- int [main](#) (int argc, char \*argv[])

### 8.41.1 Detailed Description

Contains a program to demonstrate the the LSB/AF filter.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Clicking occurs at start of each filter pass

Definition in file [lfb\\_filter\\_test.cpp](#).

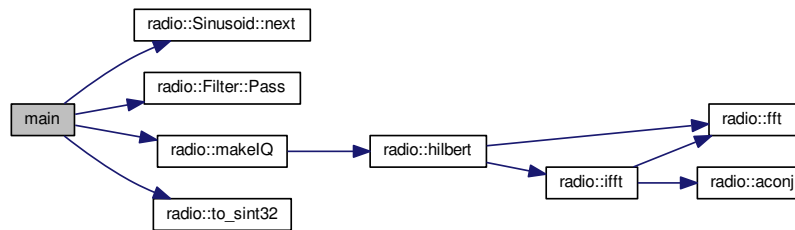
### 8.41.2 Function Documentation

#### 8.41.2.1 int main ( int argc, char \* argv[] )

Program to test the Filter class and the LSB filter coefficients.

Definition at line 26 of file [lfb\\_filter\\_test.cpp](#).

Here is the call graph for this function:



## 8.42 lsb\_filter\_test.cpp

```

00001
00008 #include <cstdio>
00009 #include <cstdlib>
00010 #include <iostream>
00011 #include <unistd.h>
00012
00013 #include "auxiliary.hpp"
00014 #include "definitions.hpp"
00015 #include "Filter.hpp"
00016 #include "fvector.hpp"
00017 #include "Sinusoid.hpp"
00018 #include "zdomain.hpp"
00019
00020 using namespace std;
00021 using namespace radio;
00022
00026 int main(int argc, char* argv[]) {
00027
00028     // Constants
00029     const uint16 BUFFER_SIZE = 48000;
00030
00031     // Declare primitive Variables
00032     uint8 i = 0;
00033     uint8 size = 0;
00034     uint16 delta = 250;
00035     float32 dataBuffer[BUFFER_SIZE];
00036     float32 iqBuffer[2 * BUFFER_SIZE];
00037
00038     // create 1 sec of audio
00039     for(uint16 f = 17000; f <= 23000; f += delta, i++) {
00040         Sinusoid sinusoid(f);
00041
00042         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00043             dataBuffer[i] += sinusoid.next();
00044         }
00045     }
00046
00047     size = i;
00048
00049     // adjust dataBuffer so values are between -1 and 1
00050     for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00051         dataBuffer[i] /= size;
00052     }
00053
00054     Filter filter(dataBuffer, BUFFER_SIZE, F_LOWERSIDEBAND);
00055     filter.Pass();
00056     makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00057     to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00058
00059     while(true) {
00060         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00061     }
00062 }

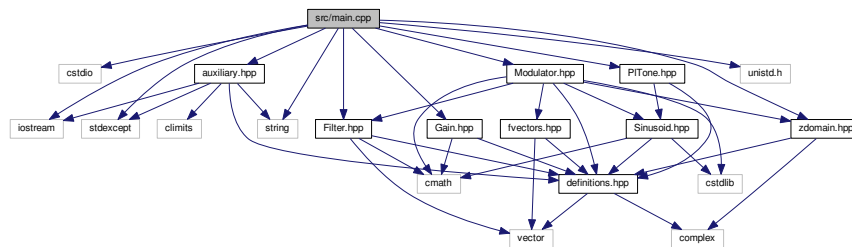
```

## 8.43 src/main.cpp File Reference

Contains the "brains" of the entire project.

```
#include <cstdio>
#include <iostream>
#include <stdexcept>
#include <string>
#include <unistd.h>
#include "auxiliary.hpp"
#include "Filter.hpp"
#include "Gain.hpp"
#include "Modulator.hpp"
#include "PlTone.hpp"
#include "zdomain.hpp"
```

Include dependency graph for main.cpp:



### Functions

- int [main](#) (int argc, char \*argv[])

#### 8.43.1 Detailed Description

Contains the "brains" of the entire project.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [main.cpp](#).

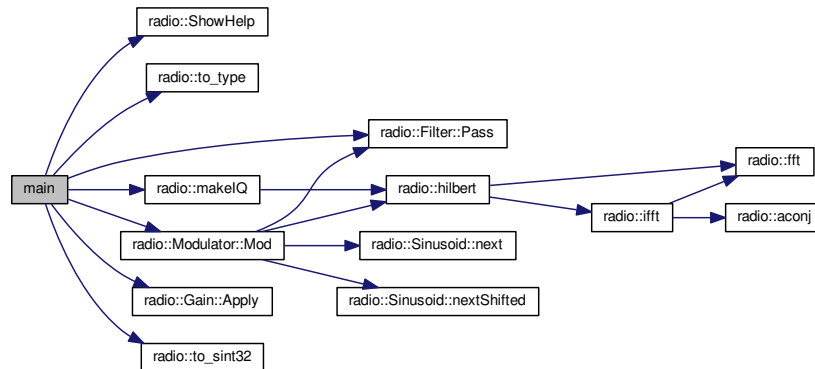
#### 8.43.2 Function Documentation

##### 8.43.2.1 int main ( int argc, char \* argv[] )

Final result of the entire project. Completes all goals and more!

Definition at line 26 of file [main.cpp](#).

Here is the call graph for this function:



## 8.44 main.cpp

```

00001
00007 #include <cstdio>
00008 #include <iostream>
00009 #include <stdexcept>
00010 #include <string>
00011 #include <unistd.h>
00012
00013 #include "auxiliary.hpp"
00014 #include "Filter.hpp"
00015 #include "Gain.hpp"
00016 #include "Modulator.hpp"
00017 #include "PlTone.hpp"
00018 #include "zdomain.hpp"
00019
00020 using namespace std;
00021 using namespace radio;
00022
00026 int main(int argc, char* argv[]) {
00027
00028     // Constants
00029     const uint8 NUM_TYPES = 8;
00030     const uint16 BUFFER_SIZE = 16384;
00031     const uint32 BUFFER_BYTE_COUNT = BUFFER_SIZE * sizeof(sint32);
00032     const uint32 IQ_BUFFER_SIZE = 2 * BUFFER_SIZE;
00033     const uint32 IQ_BUFFER_BYTE_COUNT = BUFFER_BYTE_COUNT * 2;
00034     const uint32 SAMPLING_RATE = 48000;
00035
00036     // Ensure 1 or 2 arguments given
00037     if(argc > 4) {
00038         std::cerr << "Error: too many arguments!" << std::endl;
00039         ShowHelp();
00040         return ERROR;
00041     } else if(argc < 2) {
00042         std::cerr << "Error: too few arguments!" << std::endl;
00043         ShowHelp();
00044         return ERROR;
00045     }
00046
00047     // Declare primitive Variables
00048     float32 micGain = 0;
00049     float32 toneFreq = 0;
00050     float32 dataBuffer[BUFFER_SIZE];
00051     float32 iqBuffer[IQ_BUFFER_SIZE];
00052     ModulationType type;
00053
00054     // validate modulation type
00055     try{
00056         type = to_type(string(argv[1]));
00057     } catch(std::exception ex) {
00058         std::cerr << "The given modulation type is invalid!" << std::endl;
00059         ShowHelp();
00060     }
00061

```

```

00062     // process mic gain
00063     if(argc >= 3) {
00064         try {
00065             micGain = std::stof(argv[2]);
00066         } catch(std::invalid_argument ex) {
00067             std::cerr << "The specified microphone gain is not a number."
00068                 << std::endl;
00069             ShowHelp();
00070         }
00071     }
00072
00073     // validate CTCSS tone
00074     if(argc == 4) {
00075         try {
00076             toneFreq = std::stof(argv[3]);
00077
00078             if(toneFreq < 60 || toneFreq > 260) {
00079                 throw std::out_of_range("");
00080             }
00081         } catch(std::out_of_range ex) {
00082             std::cerr << "The specified CTCSS frequency is outside of the "
00083                 "standard PL tone range." << std::endl;
00084             ShowHelp();
00085         } catch(std::invalid_argument ex) {
00086             std::cerr << "The specified CTCSS frequency is not a number."
00087                 << std::endl;
00088             ShowHelp();
00089         }
00090     }
00091
00092     // Declare objects
00093     Filter baseFilter(dataBuffer, BUFFER_SIZE, F_BASEBAND);
00094     Gain gain(dataBuffer, BUFFER_SIZE, micGain);
00095     PlTone pltone(0.15, dataBuffer, BUFFER_SIZE, toneFreq, SAMPLING_RATE);
00096     Modulator modulator(dataBuffer, BUFFER_SIZE, type, 20000);
00097
00098     // SDR guts of the program
00099     while(true) {
00100         // get next samples
00101         read(STDIN_FILENO, &dataBuffer, BUFFER_BYTE_COUNT);
00102
00103         // process/modulate samples
00104         baseFilter.Pass();
00105         // pltone.Add();
00106         gain.Apply();
00107         modulator.Mod();
00108         makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00109         to_sint32(iqBuffer, IQ_BUFFER_SIZE);
00110
00111         // write samples
00112         write(STDOUT_FILENO, &iqBuffer, IQ_BUFFER_BYTE_COUNT);
00113     }
00114 }

```

## 8.45 src/mic\_test.cpp File Reference

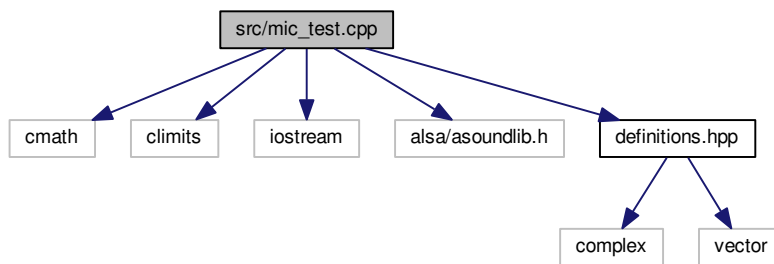
Tests getting mic input via ALSA. May not even compile at the moment.

```

#include <cmath>
#include <climits>
#include <iostream>
#include <alsa/asoundlib.h>
#include "definitions.hpp"

```

Include dependency graph for mic\_test.cpp:



## Functions

- `int main()`

### 8.45.1 Detailed Description

Tests getting mic input via ALSA. May not even compile at the moment.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [mic\\_test.cpp](#).

### 8.45.2 Function Documentation

#### 8.45.2.1 `int main()`

This program tests taking information from the microphone via the ALSA API. Not sure if it works.

Definition at line 21 of file [mic\\_test.cpp](#).

## 8.46 mic\_test.cpp

```

00001
00008 #include <cmath>
00009 #include <climits>
00010 #include <iostream>
00011 #include <alsa/asoundlib.h>
00012
00013 #include "definitions.hpp"
00014
00015 using namespace std;
00016
00021 int main() {
00022     int ret;
00023
00024     snd_pcm_t* pcm_handle; // device handle
00025     // snd_pcm_stream_t stream = SND_PCM_STREAM_PLAYBACK;
00026     snd_pcm_stream_t stream = SND_PCM_STREAM_CAPTURE;
00027     snd_pcm_hw_params_t* hwparams; // hardware information
00028     char* pcm_name = strdup("plughw:1,0"); // on-board audio jack
00029     //char* pcm_name = strdup("plughw:0,0"); // on-board audio jack
00030     int rate = 48000;
00031

```



```

00032     const uint16 freq = 440;
00033     long unsigned int bufferSize = 8192*4;
00034     const uint32 len = bufferSize*100;
00035     const float32 arg = 2 * 3.141592 * freq / rate;
00036     sint16 vals[len];
00037
00038     float test;
00039     float last = 0;
00040     long unsigned int count = 0;
00041     int count2 = 0;
00042
00043     for(int i = 0; i < len; i = i + 2) {
00044         bool lastWas = abs(sin(last)) < 0.01;
00045
00046         last += arg;
00047         if(last > 2 * M_PI) last -= 2 * M_PI;
00048
00049         test = 32000 * sin(last);
00050
00051         if(abs(sin(last)) < 0.01 && lastWas) count++;
00052
00053         vals[i] = (sint16)(test + 0.5);
00054         vals[i+1] = vals[i];
00055     }
00056
00057     cout << "COUNT: " << count << endl;
00058     snd_pcm_hw_params_alloca(&hwparams);
00059
00060     ret = snd_pcm_open(&pcm_handle, pcm_name, stream, 0);
00061     cout << "Opening: " << snd_strerror(ret) << endl;
00062
00063     ret = snd_pcm_hw_params_any(pcm_handle, hwparams);
00064     cout << "Initializing hwparams structure: " << snd_strerror(ret) << endl;
00065
00066     ret = snd_pcm_hw_params_set_access(pcm_handle, hwparams,
00067         SND_PCM_ACCESS_RW_INTERLEAVED);
00068     cout << "Setting access: " << snd_strerror(ret) << endl;
00069
00070     ret = snd_pcm_hw_params_set_format(pcm_handle, hwparams,
00071         SND_PCM_FORMAT_S16_LE);
00072     cout << "Setting format: " << snd_strerror(ret) << endl;
00073
00074     ret = snd_pcm_hw_params_set_rate(pcm_handle, hwparams,
00075         rate, (int)0);
00076     cout << "Setting rate: " << snd_strerror(ret) << endl;
00077
00078     ret = snd_pcm_hw_params_set_channels(pcm_handle, hwparams, 2);
00079     cout << "Setting channels: " << snd_strerror(ret) << endl;
00080
00081     ret = snd_pcm_hw_params_set_periods(pcm_handle, hwparams, 2, 0);
00082     cout << "Setting periods: " << snd_strerror(ret) << endl;
00083
00084     ret = snd_pcm_hw_params_set_buffer_size_near(pcm_handle, hwparams,
00085         &bufferSize);
00086     cout << "Setting buffer size: " << snd_strerror(ret) << endl;
00087
00088     ret = snd_pcm_hw_params(pcm_handle, hwparams);
00089     cout << "Applying parameters: " << snd_strerror(ret) << endl;
00090
00091     /* ret = snd_pcm_hw_params_get_period_size(hwparams, &count, &count2);
00092     cout << "Actual period size: " << count << endl;
00093     cout << "Returned: " << snd_strerror(ret) << endl;*/
00094
00095
00096
00097     cout << endl << endl;
00098
00099
00100     //const void* ptr = (const void*)&vals;
00101     void* ptr = (void*)&vals;
00102     int err;
00103
00104     for(int i = 0; i < 100; i++) {
00105         do {
00106             ret = snd_pcm_readi(pcm_handle,
00107                 ptr, bufferSize);
00108
00109             if(ret < 0) {
00110                 err = snd_pcm_prepare(pcm_handle);
00111                 cout << "Preparing: " << snd_strerror(err)
00112                     << endl;
00113             }
00114         } while(ret < 0);
00115
00116         cout << "Writing data: " << ret << endl;
00117     }
00118 }

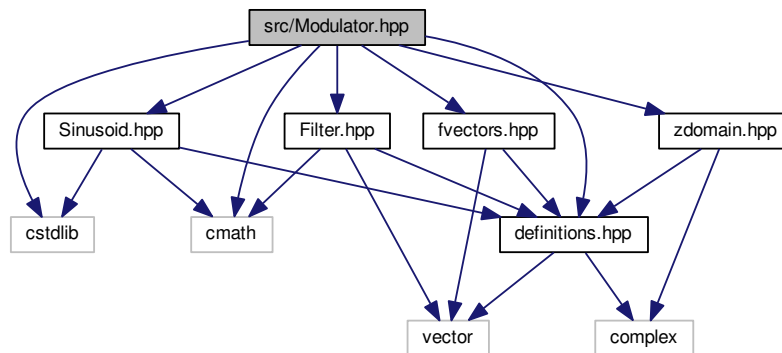
```

## 8.47 src/Modulator.hpp File Reference

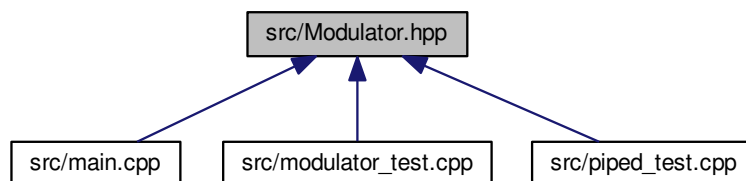
Contains the classes for the various types of modulation supported by the program.

```
#include <cmath>
#include <cstdlib>
#include "definitions.hpp"
#include "Filter.hpp"
#include "fvectors.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"
```

Include dependency graph for Modulator.hpp:



This graph shows which files directly or indirectly include this file:



### Classes

- class [radio::Modulator](#)

### Namespaces

- [radio](#)

## Variables

- const `uint32` `radio::FREQ_INTERMEDIATE` = 20000
- const `uint32` `radio::SAMPLING_RATE` = 48000

### 8.47.1 Detailed Description

Contains the classes for the various types of modulation supported by the program.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Both FM modulations don't work

Clicking on the filtered SSB

Definition in file [Modulator.hpp](#).

## 8.48 Modulator.hpp

```

00001
00010 #ifndef modulation_H
00011 #define modulation_H
00012
00013 #include <cmath>
00014 #include <cstdlib>
00015
00016 #include "definitions.hpp"
00017 #include "Filter.hpp"
00018 #include "fvectors.hpp"
00019 #include "Sinusoid.hpp"
00020 #include "zdomain.hpp"
00021
00022 namespace radio {
00023
00027     const uint32 FREQ_INTERMEDIATE = 20000;
00028
00032     const uint32 SAMPLING_RATE = 48000;
00033
00037     class Modulator {
00038     public:
00052         Modulator(float32 data[], uint32 size,
ModulationType type,
00053                     float32 freqInter = FREQ_INTERMEDIATE,
00054                     uint32 rate = SAMPLING_RATE);
00055
00059         ~Modulator();
00060
00064         void Mod();
00065
00066     private:
00071         float32* data;
00072
00076         float32 freqCarrier;
00077
00078
00082         float32* hilData = nullptr;
00083
00087         float32 rate;
00088
00092         uint32 size;
00093
00097         ModulationType type;
00098     };
00099
00100     Modulator::Modulator(float32 data[], uint32 size,
ModulationType type,
00101                          float32 freqInter, uint32 rate) {
00102         freqCarrier = freqInter;
00103         this->rate = rate;
00104         this->data = data;
00105         this->size = size;
00106         this->type = type;

```

```

00107
00108     if(type == ModulationType::USB_HILBERT
00109         || type == ModulationType::LSB_HILBERT) {
00110         hilData = (float32*)malloc(size*sizeof(float32));
00111     }
00112 }
00113
00114 Modulator::~Modulator() {
00115     if(hilData != nullptr) free(hilData);
00116 }
00117
00118 void Modulator::Mod() {
00119     // these variables should only ever be created once
00120     static float32 fmArg = 2 * M_PI * freqCarrier / (float32)rate;
00121     static float32 fmK = 2 * M_PI / rate;
00122     static float32 fmSum = 0; // cumulative sum used in FM modulation
00123     static Filter lsbFilter(data, size, F_LOWERSIDEBAND);
00124     static Sinusoid sinusoid(freqCarrier, rate); // IF carrier sinusoid
00125     static Filter usbFilter(data, size, F_UPPERSIDEBAND);
00126
00127     // take hilbert transform if necessary
00128     if(type == ModulationType::USB_HILBERT
00129         || type == ModulationType::LSB_HILBERT) {
00130         hilbert(data, hilData, size);
00131     } else if(type == ModulationType::FM_NARROW) {
00132         fmK *= 2.5;
00133     } else if(type == ModulationType::FM_WIDE) {
00134         fmK *= 5;
00135     }
00136
00137     // perform main modulation
00138     for(uint32 i = 0; i < size; i++) {
00139         switch(type) {
00140             case ModulationType::DSB_LC:
00141                 data[i] = ((data[i] + 1) * sinusoid.next()) / 2;
00142                 break;
00143
00144             case ModulationType::DSB_SC:
00145             case ModulationType::USB_FILTERED:
00146             case ModulationType::LSB_FILTERED:
00147                 data[i] = data[i] * sinusoid.next();
00148                 break;
00149
00150             case ModulationType::USB_HILBERT:
00151                 data[i] = data[i] * sinusoid.next()
00152                     - hilData[i] * sinusoid.nextShifted();
00153                 break;
00154
00155             case ModulationType::LSB_HILBERT:
00156                 data[i] = data[i] * sinusoid.next()
00157                     + hilData[i] * sinusoid.nextShifted();
00158                 break;
00159
00160             case ModulationType::FM_NARROW:
00161             case ModulationType::FM_WIDE:
00162                 fmSum += fmK * data[i];
00163                 data[i] = cos(fmArg * i + fmSum);
00164                 break;
00165         }
00166     }
00167
00168     // filter out a sideband if using filtered SSB modulation
00169     if(type == ModulationType::LSB_FILTERED) {
00170         lsbFilter.Pass();
00171     } else if(type == ModulationType::USB_FILTERED) {
00172         usbFilter.Pass();
00173     }
00174 }
00175 }
00176
00177 #endif

```

## 8.49 src/modulator\_test.cpp File Reference

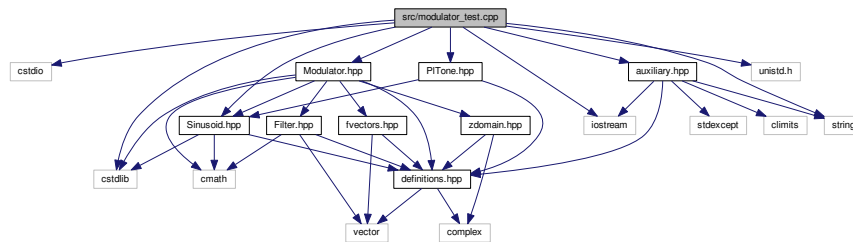
Contains a test program to test the Modulator class.

```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <string>
#include <unistd.h>
#include "auxiliary.hpp"
#include "Modulator.hpp"
#include "Sinusoid.hpp"
#include "PlTone.hpp"

```

Include dependency graph for modulator\_test.cpp:



## Functions

- int [main](#) (int argc, char \*argv[])

### 8.49.1 Detailed Description

Contains a test program to test the Modulator class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Filtered SSB clicking

Definition in file [modulator\\_test.cpp](#).

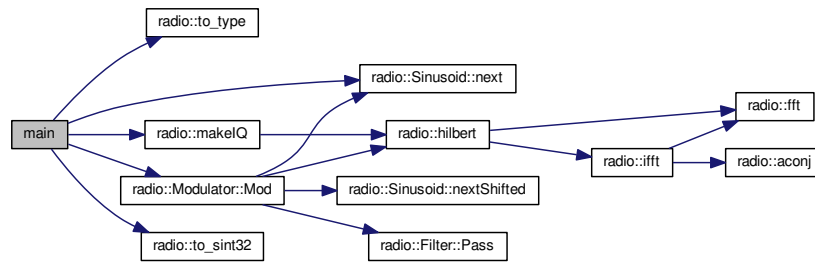
### 8.49.2 Function Documentation

#### 8.49.2.1 int main ( int argc, char \* argv[] )

Program to test the Modulator class.

Definition at line 25 of file [modulator\\_test.cpp](#).

Here is the call graph for this function:



## 8.50 modulator\_test.cpp

```

00001
00008 #include <cstdio>
00009 #include <cstdlib>
00010 #include <iostream>
00011 #include <string>
00012 #include <unistd.h>
00013
00014 #include "auxiliary.hpp"
00015 #include "Modulator.hpp"
00016 #include "Sinusoid.hpp"
00017 #include "PlTone.hpp"
00018
00019 using namespace std;
00020 using namespace radio;
00021
00025 int main(int argc, char* argv[]) {
00026
00027     // Constants
00028     const uint16 BUFFER_SIZE = 16384;
00029
00030     // Declare primitive Variables
00031     float32 dataBuffer[BUFFER_SIZE];
00032     float32 iqBuffer[2 * BUFFER_SIZE];
00033     ModulationType type;
00034     float32 freq = atof(argv[2]);
00035     float32 tone = 0;
00036
00037     if(argc >= 4) tone = atof(argv[3]);
00038
00039     try{
00040         type = to_type(string(argv[1]));
00041     } catch(std::exception ex) {
00042         std::cerr << ex.what() << std::endl << std::endl;
00043         return ERROR;
00044     }
00045
00046     if(freq < 0) {
00047         cerr << "The given tone was invalid." << endl;
00048         return ERROR;
00049     }
00050
00051     // Declare objects
00052     Modulator modulator(dataBuffer, BUFFER_SIZE, type, 20000);
00053     Sinusoid sinusoid(freq);
00054     PlTone(tone > 0 ? 0.15 : 0, dataBuffer, BUFFER_SIZE, tone, 48000);
00055
00056     while(true) {
00057         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00058             dataBuffer[i] = sinusoid.next();
00059         }
00060
00061         modulator.Mod();
00062         makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00063         to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00064         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00065     }
00066 }

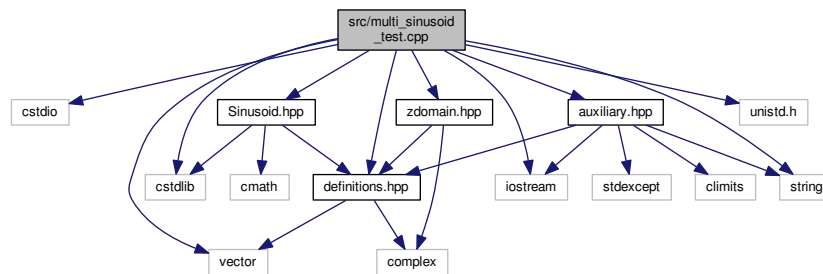
```

## 8.51 src/multi\_sinusoid\_test.cpp File Reference

Contains a program to demonstrate the ability of the Sinusoid class and the sound card to generate sinusoids across the spectrum.

```
#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <string>
#include <unistd.h>
#include <vector>
#include "auxiliary.hpp"
#include "definitions.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"
```

Include dependency graph for multi\_sinusoid\_test.cpp:



### Functions

- `int main (int argc, char *argv[])`

#### 8.51.1 Detailed Description

Contains a program to demonstrate the ability of the Sinusoid class and the sound card to generate sinusoids across the spectrum.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [multi\\_sinusoid\\_test.cpp](#).

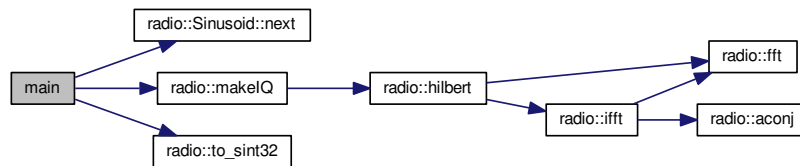
#### 8.51.2 Function Documentation

##### 8.51.2.1 `int main ( int argc, char * argv[] )`

Program to test the Sinusoid class and demonstrate the frequency range of the sound card.

Definition at line 27 of file [multi\\_sinusoid\\_test.cpp](#).

Here is the call graph for this function:



## 8.52 multi\_sinusoid\_test.cpp

```

00001
00008 #include <cstdio>
00009 #include <cstdlib>
00010 #include <iostream>
00011 #include <string>
00012 #include <unistd.h>
00013 #include <vector>
00014
00015 #include "auxiliary.hpp"
00016 #include "definitions.hpp"
00017 #include "Sinusoid.hpp"
00018 #include "zdomain.hpp"
00019
00020 using namespace std;
00021 using namespace radio;
00022
00027 int main(int argc, char* argv[]) {
00028
00029     // Constants
00030     const uint16 BUFFER_SIZE = 48000;
00031
00032     // Declare primitive Variables
00033     uint8 i = 0;
00034     uint8 size = 0;
00035     uint16 delta = 100;
00036     float32 dataBuffer[BUFFER_SIZE];
00037     float32 iqBuffer[2 * BUFFER_SIZE];
00038
00039     for(uint16 f = 100; f < 24000; f += delta, i++) {
00040         Sinusoid sinusoid(f);
00041
00042         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00043             dataBuffer[i] += sinusoid.next();
00044         }
00045
00046         switch(f) {
00047             case 500:
00048                 delta = 1000;
00049                 f = 1000;
00050                 break;
00051
00052             case 2000:
00053                 delta = 2000;
00054                 break;
00055         }
00056     }
00057
00058     size = i;
00059
00060     for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00061         dataBuffer[i] /= size;
00062     }
00063
00064     makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00065     to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00066
00067     while(true) {
00068         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00069     }
00070 }

```

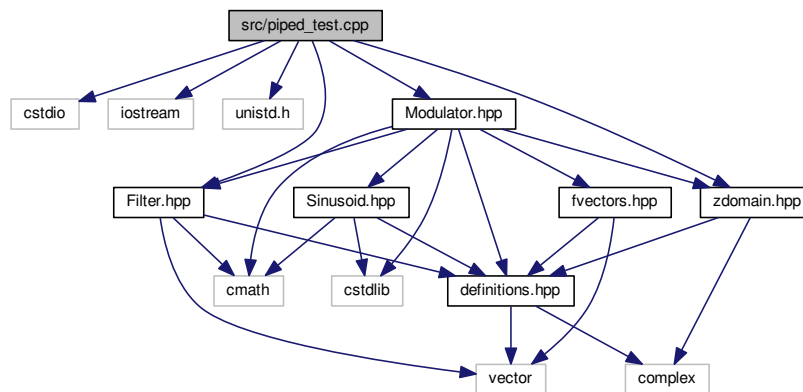


## 8.53 src/piped\_test.cpp File Reference

Contains the original program used to test the piping-in idea.

```
#include <cstdio>
#include <iostream>
#include <unistd.h>
#include "Filter.hpp"
#include "Modulator.hpp"
#include "zdomain.hpp"
```

Include dependency graph for `piped_test.cpp`:



### Functions

- `int main ()`

#### 8.53.1 Detailed Description

Contains the original program used to test the piping-in idea.

##### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [piped\\_test.cpp](#).

#### 8.53.2 Function Documentation

##### 8.53.2.1 `int main ( )`

Program originally used to test whether baseband audio could be piped into the program in real time.

Definition at line 22 of file [piped\\_test.cpp](#).

Here is the call graph for this function:



## 8.54 piped\_test.cpp

```

00001
00007 #include <cstdio>
00008 #include <iostream>
00009 #include <unistd.h>
00010
00011 #include "Filter.hpp"
00012 #include "Modulator.hpp"
00013 #include "zdomain.hpp"
00014
00015 using namespace std;
00016 using namespace lolz;
00017
00022 int main() {
00023     const uint16 len = 16384;
00024     float32 data[len];
00025     float32 iqData[2*len];
00026
00027     while(true) {
00028         read(STDIN_FILENO, &data, len * sizeof(float32));
00029         makeIQ(data, iqData, len);
00030         write(STDOUT_FILENO, &iqData, 2 * len * sizeof(float32));
00031     }
00032
00033 }

```

## 8.55 src/pl\_tone\_test.cpp File Reference

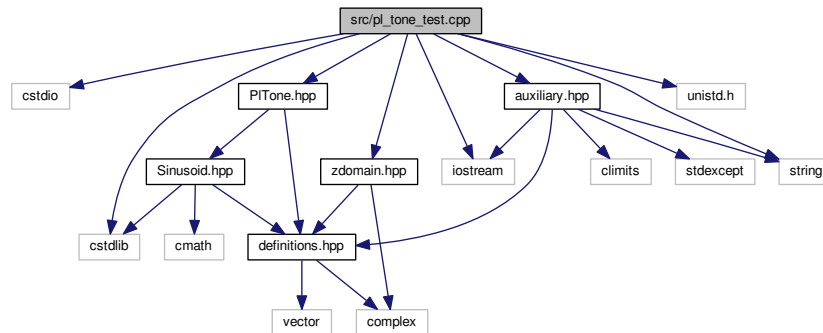
Contains a test program to test the PlTone class.

```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <string>
#include <unistd.h>
#include "auxiliary.hpp"
#include "PlTone.hpp"
#include "zdomain.hpp"

```

Include dependency graph for pl\_tone\_test.cpp:



## Functions

- int [main](#) (int argc, char \*argv[])

### 8.55.1 Detailed Description

Contains a test program to test the PITone class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [pl\\_tone\\_test.cpp](#).

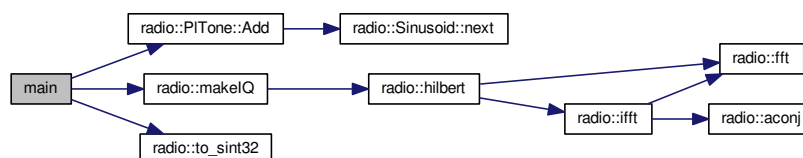
### 8.55.2 Function Documentation

#### 8.55.2.1 int main ( int argc, char \* argv[] )

Program to test the PITone class.

Definition at line 23 of file [pl\\_tone\\_test.cpp](#).

Here is the call graph for this function:



## 8.56 pl\_tone\_test.cpp

00001

```

00007 #include <stdio>
00008 #include <stdlib>
00009 #include <iostream>
00010 #include <string>
00011 #include <unistd.h>
00012
00013 #include "auxiliary.hpp"
00014 #include "PlTone.hpp"
00015 #include "zdomain.hpp"
00016
00017 using namespace std;
00018 using namespace radio;
00019
00023 int main(int argc, char* argv[]) {
00024     // Constants
00025     const uint16 BUFFER_SIZE = 16384;
00026
00027     // Declare primitive Variables
00028     float32 dataBuffer[BUFFER_SIZE];
00029     float32 iqBuffer[2 * BUFFER_SIZE];
00030     float32 freq = atof(argv[1]);
00031
00032     if(freq < 0) {
00033         cerr << "The given tone was invalid." << endl;
00034         return ERROR;
00035     }
00036
00037     PlTone tone(0.15, dataBuffer, BUFFER_SIZE, freq, 48000);
00038
00039     while(true) {
00040         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00041             dataBuffer[i] = 1;
00042         }
00043
00044         tone.Add();
00045         makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00046         to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00047         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00048     }
00049 }

```

## 8.57 src/PlTone.hpp File Reference

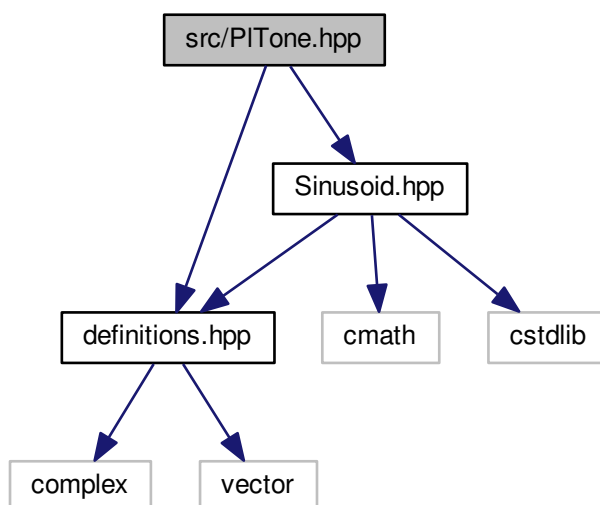
Contains the PlTone class.

```

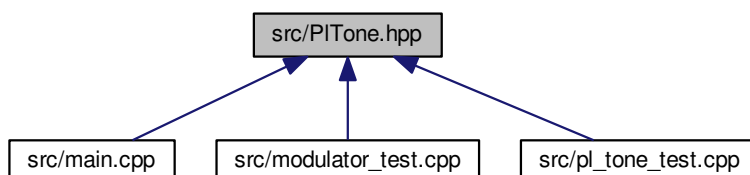
#include "definitions.hpp"
#include "Sinusoid.hpp"

```

Include dependency graph for PITone.hpp:



This graph shows which files directly or indirectly include this file:



## Classes

- class [radio::PITone](#)

## Namespaces

- [radio](#)

### 8.57.1 Detailed Description

Contains the PITone class.

**Author**

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [PlTone.hpp](#).

## 8.58 PlTone.hpp

```

00001
00007 #ifndef PlTone_H
00008 #define PlTone_H
00009
00010 #include "definitions.hpp"
00011 #include "Sinusoid.hpp"
00012
00013 namespace radio {
00018     class PlTone : Sinusoid {
00019     public:
00037         PlTone(float32 amplitude, float32* data, uint32 size,
00038               float32 frequency, uint32 samplingRate = 48000);
00039
00043         void Add();
00044
00045     private:
00050         float32 amplitude;
00051
00055         float32* data;
00056
00060         uint32 size;
00061     };
00062
00063     PlTone::PlTone(float32 amplitude, float32* data,
00064                   uint32 size, float32 frequency, uint32 samplingRate)
00065       : Sinusoid(frequency, samplingRate) {
00066         this->data = data;
00067         this->amplitude = amplitude;
00068         this->size = size;
00069
00070         for(uint32 i = 0; i < samplingRate; i++) {
00071             sinusoid[i] *= amplitude;
00072         }
00073     }
00074
00075     void PlTone::Add() {
00076         for(uint32 i = 0; i < size; i++) {
00077             data[i] += amplitude * next();
00078             data[i] /= (1 + amplitude); // ensures value <= 1
00079         }
00080     }
00081 }
00082
00083 #endif

```

## 8.59 src/Sinusoid.hpp File Reference

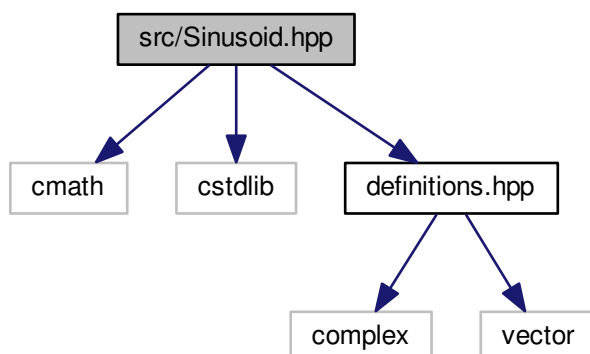
Contains the Sinusoid class.

```

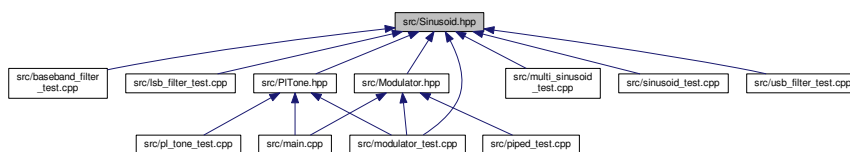
#include <cmath>
#include <cstdlib>
#include "definitions.hpp"

```

Include dependency graph for Sinusoid.hpp:



This graph shows which files directly or indirectly include this file:



## Classes

- class [radio::Sinusoid](#)

## Namespaces

- [radio](#)

### 8.59.1 Detailed Description

Contains the Sinusoid class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [Sinusoid.hpp](#).

## 8.60 Sinusoid.hpp

```

00001
00007 #ifndef Sinusoid_H

```

```

00008 #define Sinusoid_H
00009
00010 #include <cmath>
00011 #include <cstdlib>
00012
00013 #include "definitions.hpp"
00014
00015 namespace radio {
00021     class Sinusoid {
00022     public:
00026         Sinusoid(float32 frequency, uint32
samplingRate = 48000);
00027
00031         ~Sinusoid();
00032
00037         float32 next();
00038
00043         float32 nextShifted();
00044
00045     protected:
00049         float32 frequency;
00050
00054         uint32 sinIndex = 0;
00055
00059         uint32 sinIndexShifted = 0;
00060
00064         uint32 samplingRate;
00065
00069         float32* sinusoid;
00070
00075         float32* sinusoidShift90;
00076     };
00077
00078     Sinusoid::Sinusoid(float32 frequency, uint32 samplingRate) {
00079         this->frequency = frequency;
00080         this->samplingRate = samplingRate;
00081         sinusoid = (float32*)std::malloc(samplingRate * sizeof(
float32));
00082         sinusoidShift90 = (float32*)std::malloc(samplingRate * sizeof(
float32));
00083
00084         float32 arg = 2 * M_PI * frequency / samplingRate;
00085
00086         for(uint32 i = 0; i < samplingRate; i++) {
00087             // cosine argument evaluates as float due to M_PI and frequency
00088             sinusoid[i] = cos(arg * i);
00089             sinusoidShift90[i] = sin(arg * i);
00090         }
00091     }
00092
00093     Sinusoid::~Sinusoid() {
00094         free(sinusoid);
00095         free(sinusoidShift90);
00096     }
00097
00098     float32 Sinusoid::next() {
00099         if(sinIndex >= samplingRate) sinIndex = 0;
00100         return sinusoid[sinIndex++];
00101     }
00102
00103     float32 Sinusoid::nextShifted() {
00104         if(sinIndexShifted >= samplingRate)
sinIndexShifted = 0;
00105         return sinusoidShift90[sinIndexShifted++];
00106     }
00107 }
00108
00109 #endif

```

## 8.61 src/sinusoid\_test.cpp File Reference

Contains a test program to test the Sinusoid class.

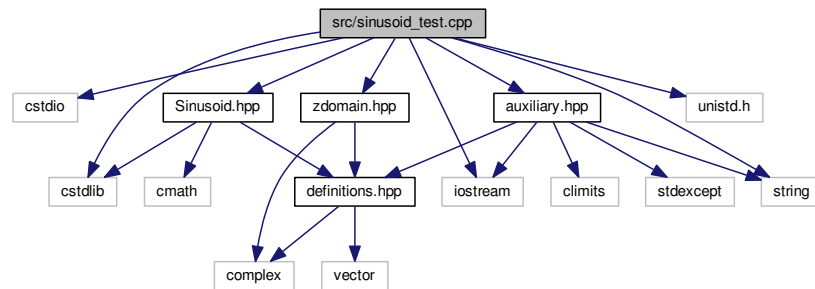


```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <string>
#include <unistd.h>
#include "auxiliary.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"

```

Include dependency graph for sinusoid\_test.cpp:



## Functions

- `int main (int argc, char *argv[])`

### 8.61.1 Detailed Description

Contains a test program to test the Sinusoid class.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [sinusoid\\_test.cpp](#).

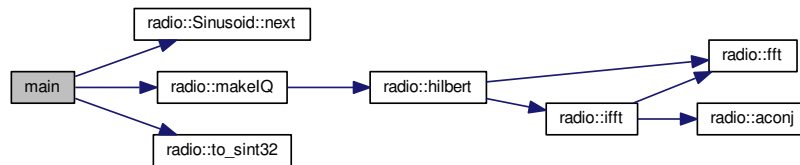
### 8.61.2 Function Documentation

#### 8.61.2.1 `int main ( int argc, char * argv[] )`

Program to test the Sinusoid class.

Definition at line 23 of file [sinusoid\\_test.cpp](#).

Here is the call graph for this function:



## 8.62 sinusoid\_test.cpp

```

00001
00007 #include <cstdio>
00008 #include <cstdlib>
00009 #include <iostream>
00010 #include <string>
00011 #include <unistd.h>
00012
00013 #include "auxiliary.hpp"
00014 #include "Sinusoid.hpp"
00015 #include "zdomain.hpp"
00016
00017 using namespace std;
00018 using namespace radio;
00019
00023 int main(int argc, char* argv[]) {
00024
00025     // Constants
00026     const uint16 BUFFER_SIZE = 16384;
00027
00028     // Declare primitive Variables
00029     float32 dataBuffer[BUFFER_SIZE];
00030     float32 iqBuffer[2 * BUFFER_SIZE];
00031     float32 freq = atof(argv[1]);
00032
00033     if(freq < 0) {
00034         cerr << "The given tone was invalid." << endl;
00035         return ERROR;
00036     }
00037
00038     Sinusoid sinusoid(freq, 48000);
00039
00040     while(true) {
00041         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00042             dataBuffer[i] = sinusoid.next();
00043         }
00044
00045         makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00046         to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00047         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00048     }
00049 }

```

## 8.63 src/usb\_filter\_test.cpp File Reference

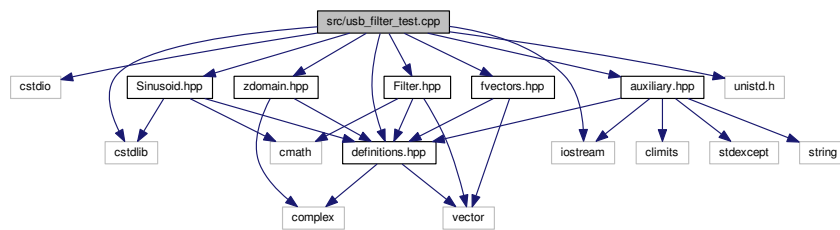
Contains a program to demonstrate the the USB filter.

```

#include <cstdio>
#include <cstdlib>
#include <iostream>
#include <unistd.h>
#include "auxiliary.hpp"
#include "definitions.hpp"
#include "Filter.hpp"
#include "fvectors.hpp"
#include "Sinusoid.hpp"
#include "zdomain.hpp"

```

Include dependency graph for usb\_filter\_test.cpp:



## Functions

- int [main](#) (int argc, char \*argv[])

### 8.63.1 Detailed Description

Contains a program to demonstrate the the USB filter.

#### Author

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

**Bug** Clicking occurs at start of each filter pass

Definition in file [usb\\_filter\\_test.cpp](#).

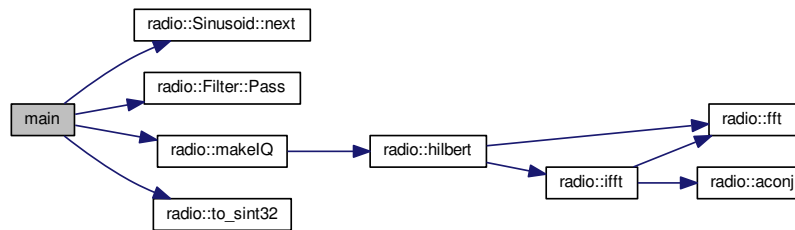
### 8.63.2 Function Documentation

#### 8.63.2.1 int main ( int argc, char \* argv[] )

Program to test the Filter class and the USB filter coefficients.

Definition at line 26 of file [usb\\_filter\\_test.cpp](#).

Here is the call graph for this function:



## 8.64 usb\_filter\_test.cpp

```

00001
00008 #include <cstdio>
00009 #include <cstdlib>
00010 #include <iostream>
00011 #include <unistd.h>
00012
00013 #include "auxiliary.hpp"
00014 #include "definitions.hpp"
00015 #include "Filter.hpp"
00016 #include "fvector.hpp"
00017 #include "Sinusoid.hpp"
00018 #include "zdomain.hpp"
00019
00020 using namespace std;
00021 using namespace radio;
00022
00026 int main(int argc, char* argv[]) {
00027
00028     // Constants
00029     const uint16 BUFFER_SIZE = 48000;
00030
00031     // Declare primitive Variables
00032     uint8 i = 0;
00033     uint8 size = 0;
00034     uint16 delta = 250;
00035     float32 dataBuffer[BUFFER_SIZE];
00036     float32 iqBuffer[2 * BUFFER_SIZE];
00037
00038     // create 1 sec of audio
00039     for(uint16 f = 17000; f <= 23000; f += delta, i++) {
00040         Sinusoid sinusoid(f);
00041
00042         for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00043             dataBuffer[i] += sinusoid.next();
00044         }
00045     }
00046
00047     size = i;
00048
00049     // adjust dataBuffer so values are between -1 and 1
00050     for(uint16 i = 0; i < BUFFER_SIZE; i++) {
00051         dataBuffer[i] /= size;
00052     }
00053
00054     Filter filter(dataBuffer, BUFFER_SIZE, F_UPPERSIDE);
00055     filter.Pass();
00056     makeIQ(dataBuffer, iqBuffer, BUFFER_SIZE);
00057     to_sint32(iqBuffer, 2 * BUFFER_SIZE);
00058
00059     while(true) {
00060         write(STDOUT_FILENO, &iqBuffer, 2 * BUFFER_SIZE * sizeof(sint32));
00061     }
00062 }

```

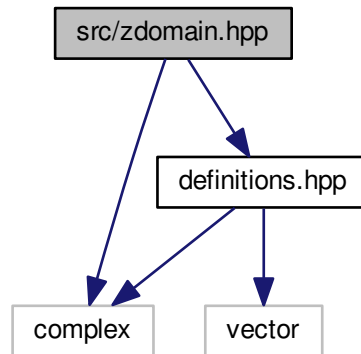
## 8.65 src/zdomain.hpp File Reference

Contains the functions to manipulate sequential data in the frequency (z) domain.

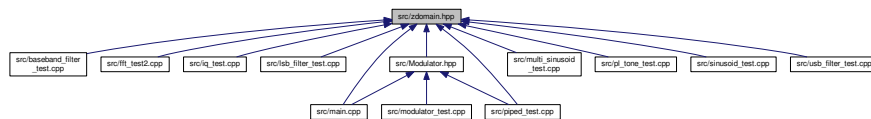
```
#include <complex>
```

```
#include "definitions.hpp"
```

Include dependency graph for zdomain.hpp:



This graph shows which files directly or indirectly include this file:



### Namespaces

- [radio](#)

### Functions

- void [radio::aconj](#) ([cfloat32](#) \*data, [uint32](#) size)
- void [radio::fft](#) ([cfloat32](#) \*data, [uint32](#) size)
- void [radio::hilbert](#) ([float32](#) \*data, [float32](#) \*dest, [uint32](#) size)
- void [radio::ifft](#) ([cfloat32](#) \*data, [uint32](#) size)
- void [radio::makeIQ](#) ([float32](#) \*data, [float32](#) \*dest, [uint32](#) size)

#### 8.65.1 Detailed Description

Contains the functions to manipulate sequential data in the frequency (z) domain.

**Author**

Samuel Andrew Wisner, [awisner94@gmail.com](mailto:awisner94@gmail.com)

Definition in file [zdomain.hpp](#).

**8.66 zdomain.hpp**

```

00001
00008 #ifndef zdomain_H
00009 #define zdomain_H
00010
00011 #include <complex>
00012
00013 #include "definitions.hpp"
00014
00015 namespace radio {
00016
00026     void aconj(cfloat32* data, uint32 size);
00027
00039     void fft(cfloat32* data, uint32 size);
00040
00052     void hilbert(float32* data, float32* dest, uint32 size);
00053
00066     void ifft(cfloat32* data, uint32 size);
00067
00082     void makeIQ(float32* data, float32* dest, uint32 size);
00083
00084     void aconj(cfloat32* data, uint32 size) {
00085         for(int i = 0; i < size; i++) {
00086             data[i] = std::conj(data[i]);
00087         }
00088     }
00089
00090     void fft(cfloat32* data, uint32 size) {
00091         // DFT
00092         uint32 k = size;
00093         uint32 n;
00094         float32 thetaT = M_PI / size;
00095         cfloat32 phiT(cos(thetaT), sin(thetaT));
00096         cfloat32 T;
00097
00098         while(k > 1) {
00099             n = k;
00100             k >>= 1;
00101             phiT = phiT * phiT;
00102             T = 1.0L;
00103
00104             for(uint32 l = 0; l < k; l++) {
00105                 for(uint32 a = l; a < size; a += n) {
00106                     uint32 b = a + k;
00107                     cfloat32 t = data[a] - data[b];
00108                     data[a] += data[b];
00109                     data[b] = t * T;
00110                 }
00111
00112                 T *= phiT;
00113             }
00114         }
00115
00116         // Decimate
00117         uint32 m = (uint32)log2(size);
00118
00119         for(uint32 a = 0; a < size; a++) {
00120             uint32 b = a;
00121
00122             // Reverse bits
00123             b = ((b & 0xaaaaaaaa) >> 1) | ((b & 0x55555555) << 1);
00124             b = ((b & 0xcccccccc) >> 2) | ((b & 0x33333333) << 2);
00125             b = ((b & 0xf0f0f0f0) >> 4) | ((b & 0x0f0f0f0f) << 4);
00126             b = ((b & 0xff00ff00) >> 8) | ((b & 0x00ff00ff) << 8);
00127             b = ((b >> 16) | (b << 16)) >> (32 - m);
00128
00129             if (b > a)
00130             {
00131                 cfloat32 t = data[a];
00132                 data[a] = data[b];
00133                 data[b] = t;
00134             }
00135         }
00136     }
00137

```

```

00138     void hilbert(float32* data, float32* dest, uint32 size) {
00139         cfloat32* temp = (cfloat32*)std::malloc(sizeof(cfloat32) * size);
00140
00141         for(int i = 0; i < size; i++) {
00142             temp[i] = data[i];
00143         }
00144
00145         fft(temp, size);
00146
00147         for(int i = size/2; i < size; i++) {
00148             temp[i] = 0;
00149         }
00150
00151         ifft(temp, size);
00152
00153         for(int i = 0; i < size; i++) {
00154             // parentheses around temp prevent free() error
00155             dest[i] = -2 * (temp[i].imag());
00156         }
00157
00158         free(temp);
00159     }
00160
00161     void ifft(cfloat32* data, uint32 size) {
00162         aconj(data, size);
00163         fft(data, size);
00164         aconj(data, size);
00165
00166         for(int i = 0; i < size; i++) {
00167             data[i] /= size;
00168         }
00169     }
00170
00171     void makeIQ(float32* data, float32* dest, uint32 size) {
00172         float32 quadData[size];
00173         hilbert(data, quadData, size);
00174
00175         for(int i = 0; i < 2 * size; i += 2) {
00176             dest[i] = quadData[i/2];
00177             dest[i+1] = data[i/2];
00178         }
00179     }
00180 }
00181
00182 #endif

```

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