



Understanding Filters

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What am I going to learn?

- ✓ Understand why we need filters
- ✓ What are filters?
- ✓ What are the types of filters?
- ✓ How are these filters used in context of amateur radio?
- ✓ How are filters designed?
- ✓ How do I use these filters in MY radio?



Intelligibility

- In speech communication, intelligibility is a measure of how comprehensible speech is, in given conditions.
- Intelligibility is affected by the **level** and **quality** of the speech signal, the **type** and **level** of **background noise**, any **compression** or **reverberation**, and for speech over communication devices, the properties of the communication system. (ie over the air)
- Proper **filtering** can greatly improve intelligibility.



What exactly is a filter?

- A porous material through which a liquid or gas is passed in order to separate the fluid from suspended particulate matter.
 - Example: Your coffee filter or water filter
- A device containing such a material, especially one used to extract impurities from air or water.
 - The air filter in your car
- Any of various electric, electronic, acoustic, or optical devices used to reject signals, vibrations, or radiations of certain frequencies while allowing others to pass.
 - Audio, powerline, and IF/RF filters in radio equipment

“Ham Radio World” Filters

- **Audio Filters**

- Filter out audio noises like impulse noise and crackle
- Usually used to limit audio bandwidth

- **IF Filters**

- Change the response of the IF stage of the radio to help filter out signals that may be adjacent to the desired signal.

- **RF Filters**

- Limits your RF reception and transmission to a particular range of frequencies usually in a defined band

Audio Filtering and Equalization



Cleans up and boosts certain audio frequencies for greater articulation.

Limits audio to 6KHz for better understandability

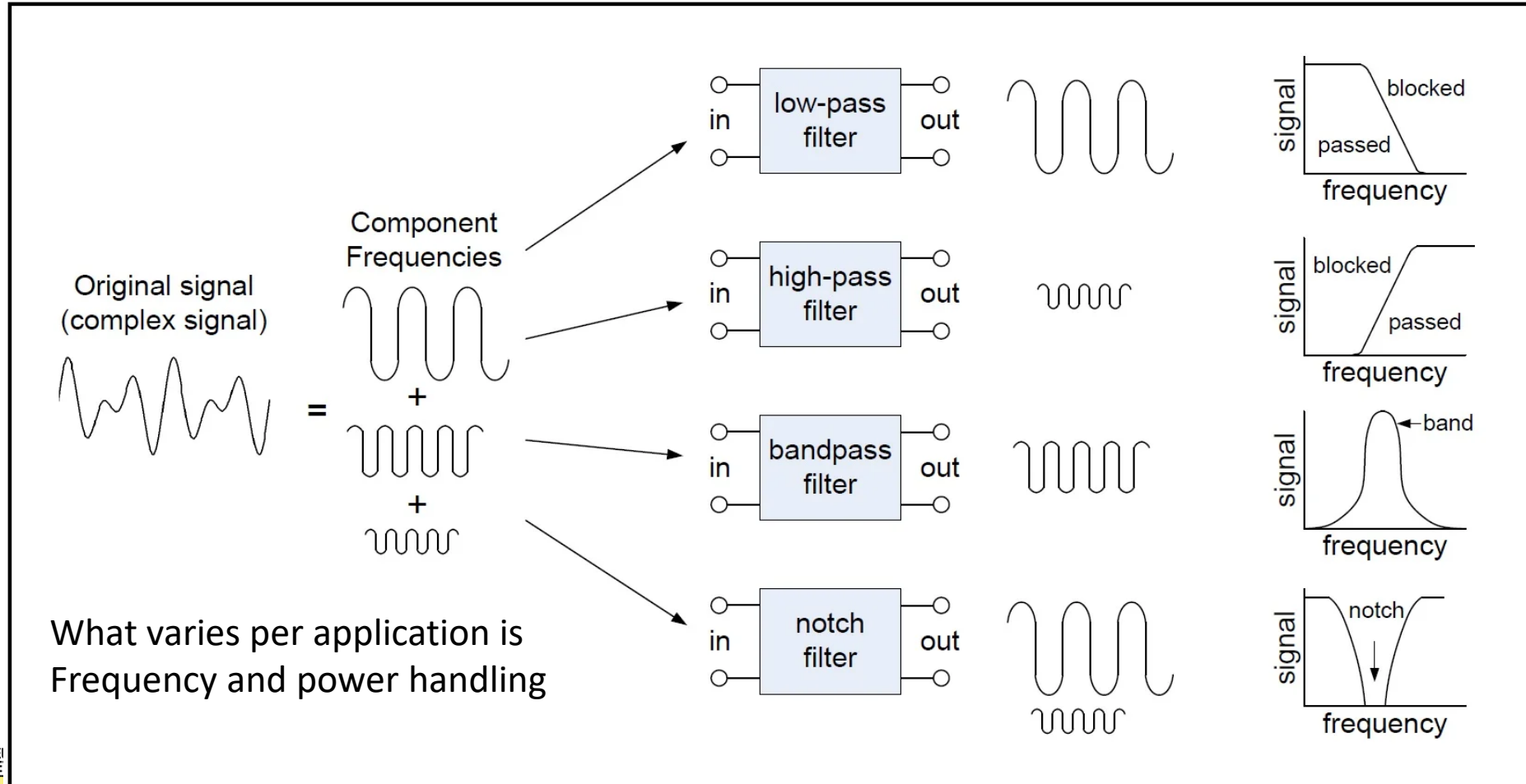
See QST April 2019 review

Product of Heil Sound, Amateur Radio Division
About \$270.00

Resource: <https://heilhamradio.com/dsp-settings/>

Filter Classifications

Does what?



Definitions to know

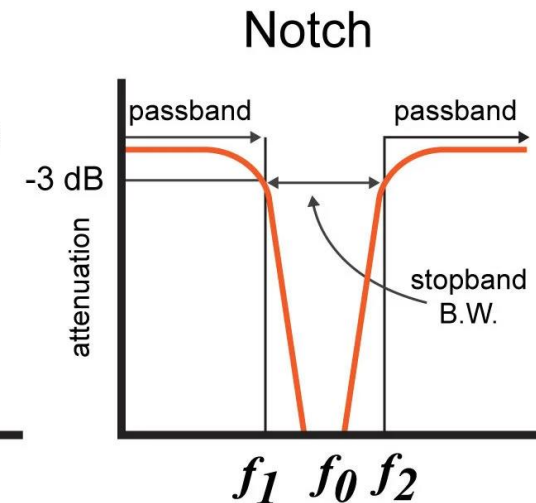
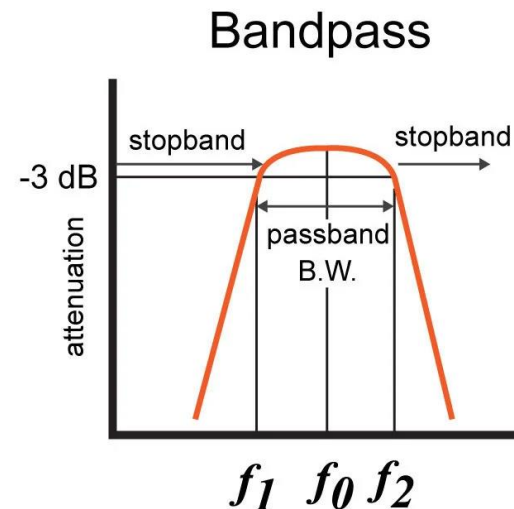
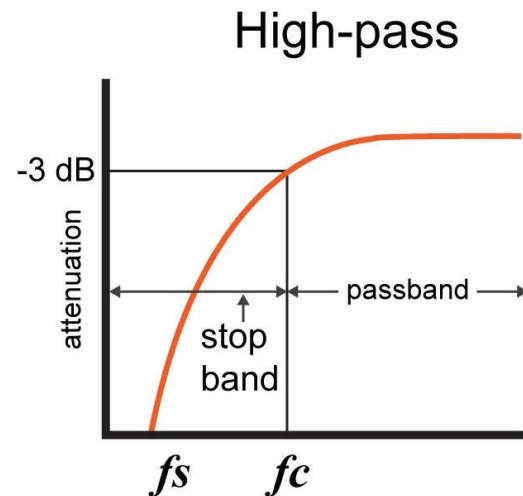
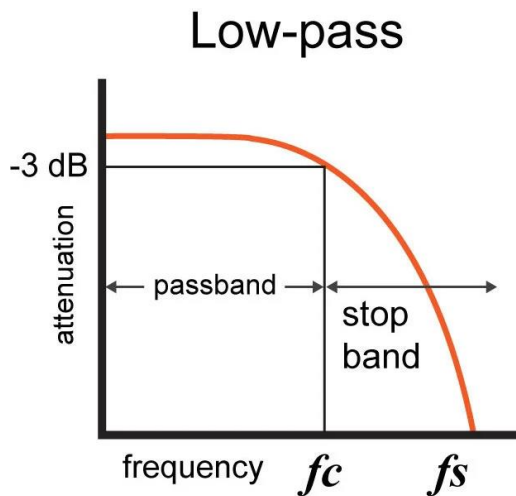
Passband = The band of signals passed greater than -3dB of attenuation

Stopband = Band of signals that are greater than -3dB of attenuation

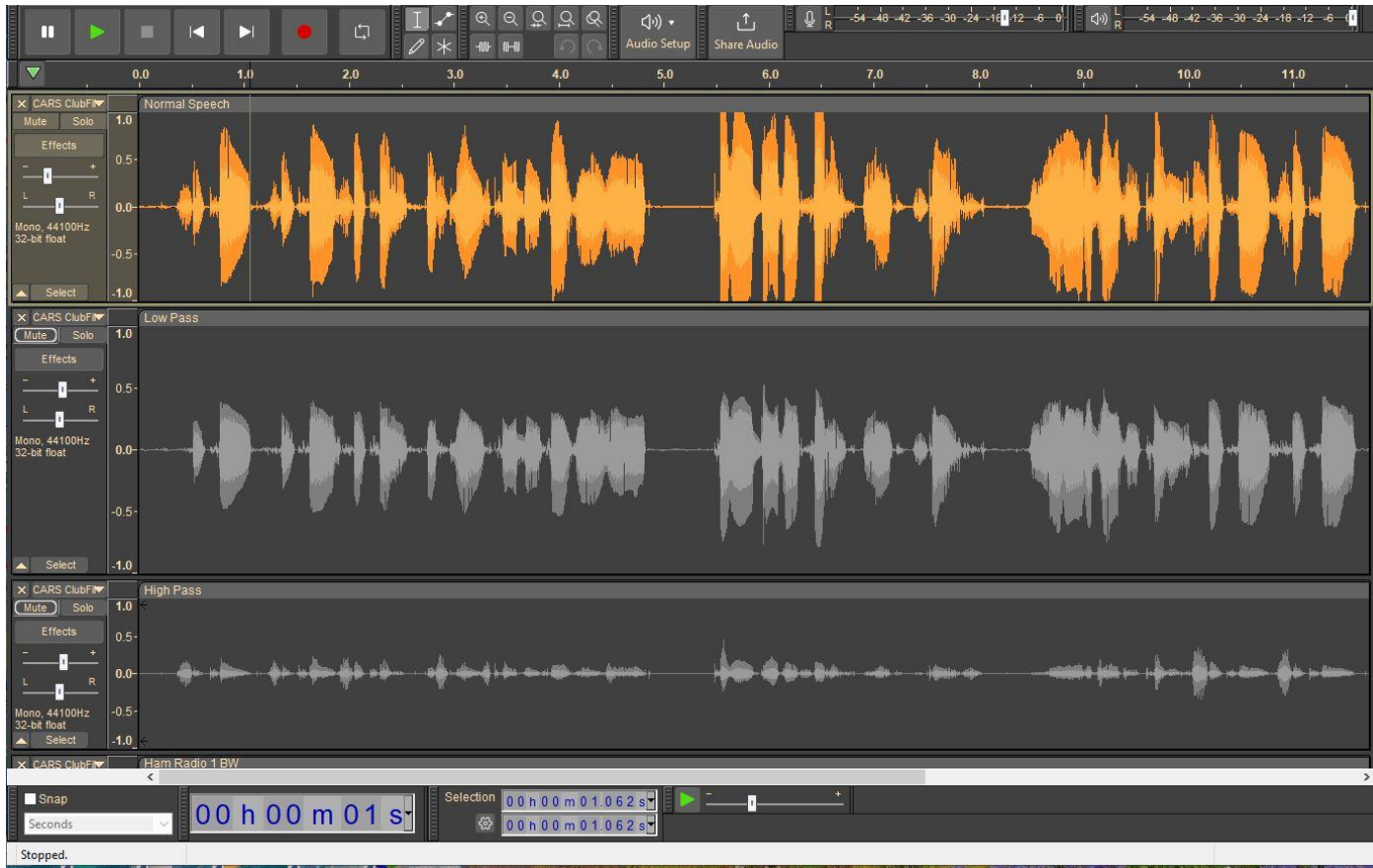
f_0 = fundamental frequency – ie the center point of a band

f_c = corner frequency – where the signal is -3dB down

f_s = stop frequency – where the signal is > -65dB down or more



Audio Filter Demo



No Filters (100-18000 Hz)

Low Pass filter (cutoff at 300Hz)

High Pass filter (cutoff at 1000 Hz)

Standard Ham Radio BW (300-3300 Hz)

Contesting Ham Radio BW* (900-2700Hz)

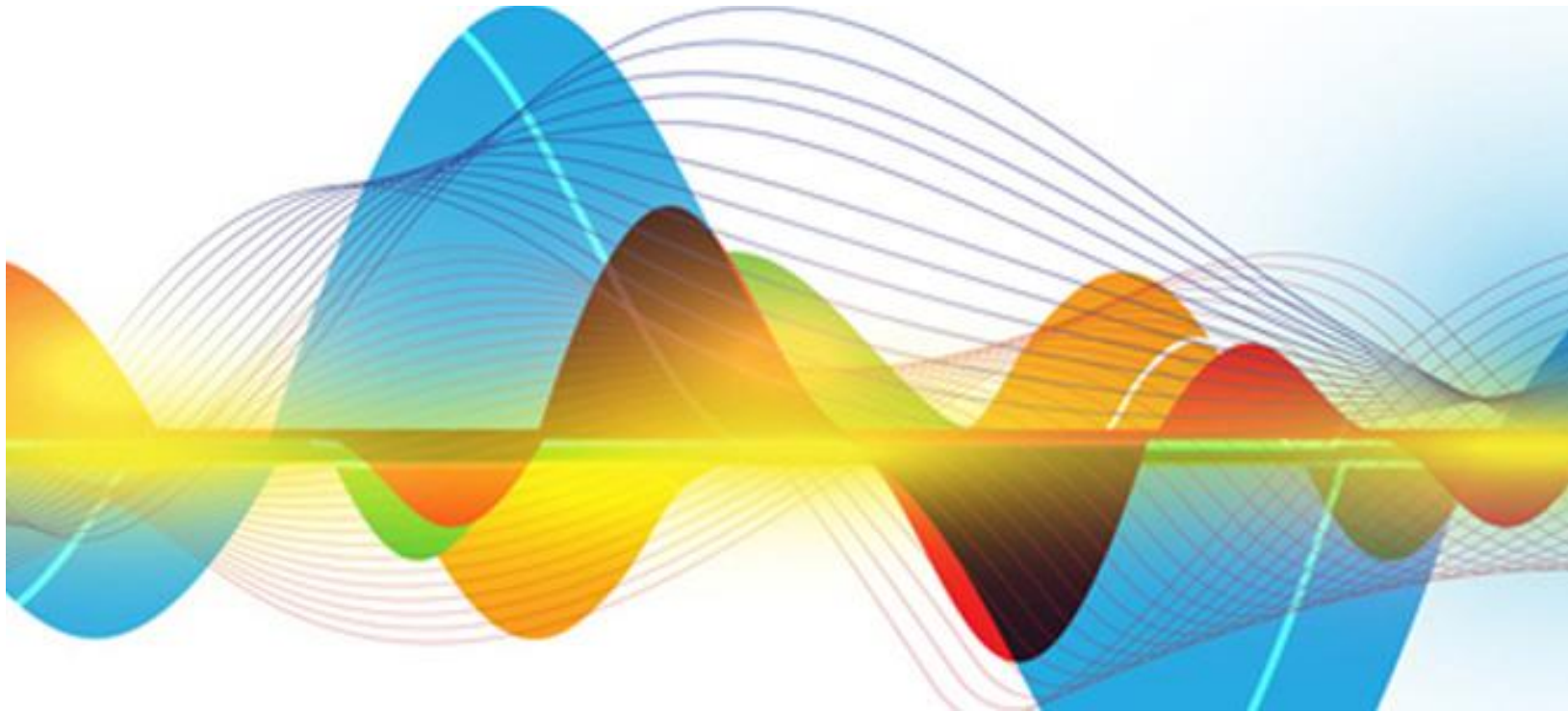
*Bob Heil (K9EID) EQ recommendation

Using Audacity - <https://www.audacityteam.org/>



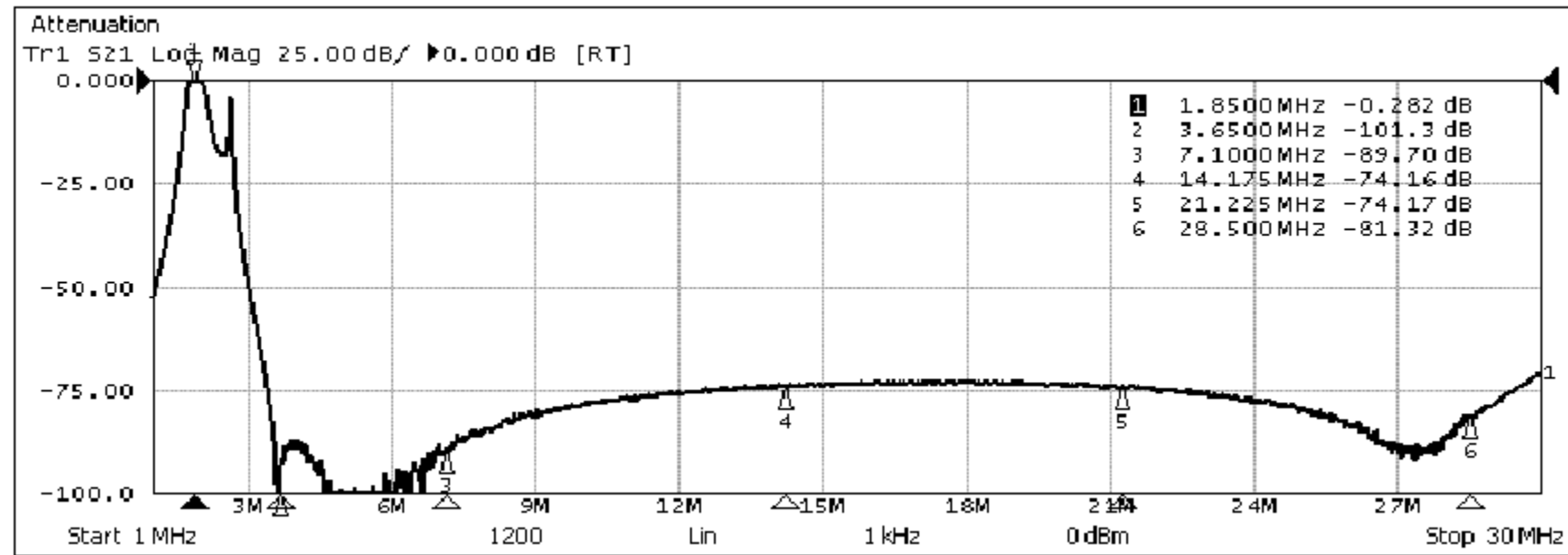
RF Filtering

Can I limit my RF with a Filter? Why filter RF?

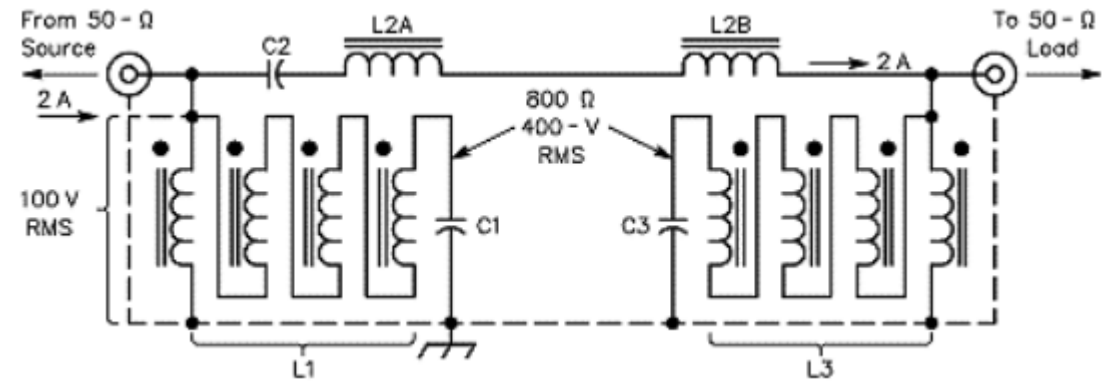
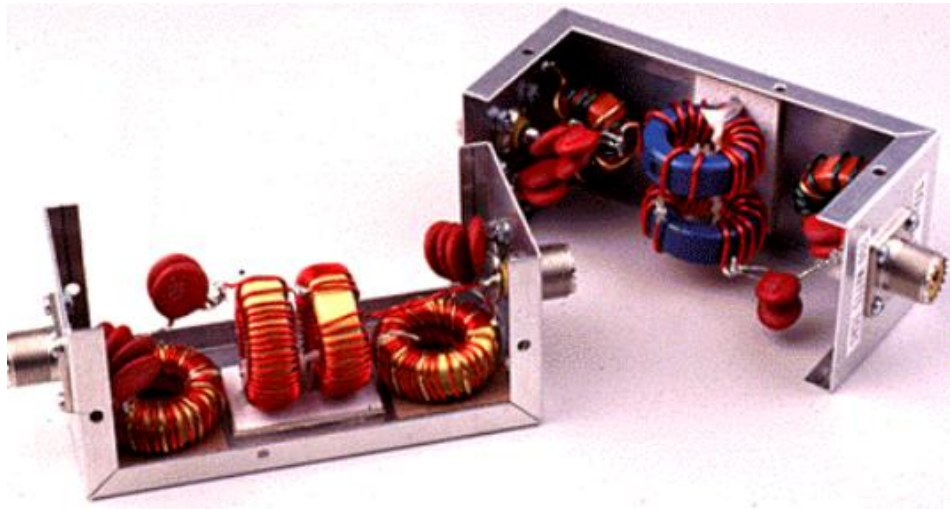


RF Bandpass Filter

We used products like this on Field Day Works for transmit and receive
Restricts RF to a specific band

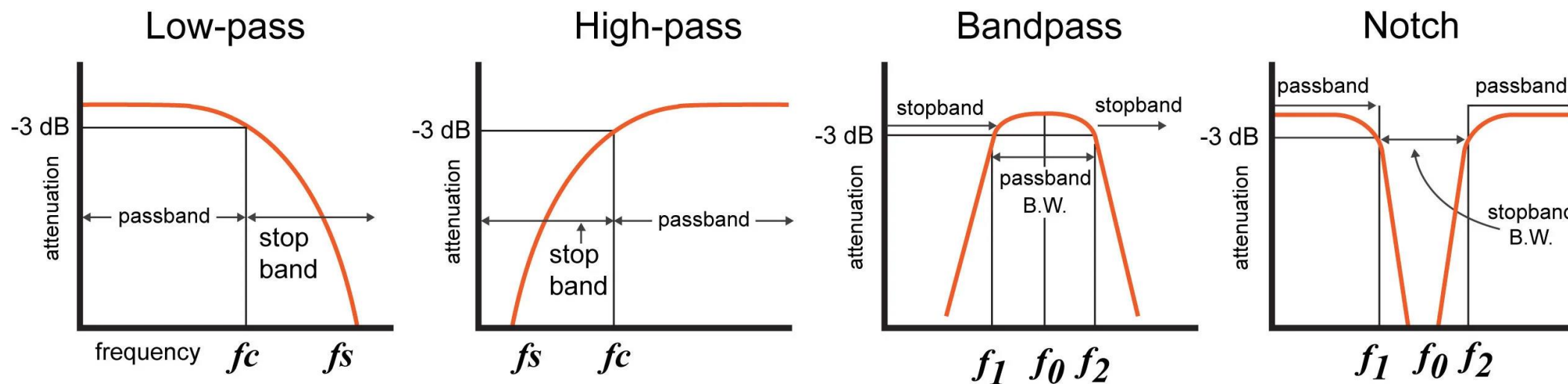


What is inside of these filters?



Consists of series and parallel inductors and capacitors to form a bandpass filter

How do you design these filters?



- ✓ Know what you want to filter
- ✓ Determine what type of filter you need
- ✓ Consider if it will need to handle transmit power, or only be for receive

Designing Filters

markimicrowave.com | Oct 19, 2023

Insertion Loss and Return Loss

Phase and Group Delay

S-Parameters

Export

Frequency (Hz)

markimicrowave.com | Oct 19, 2023

<https://markimicrowave.com/technical-resources/tools/lc-filter-design-tool/>

Window Size: **Large** Small

Powered By: **Nuhertz**

Coilcraft

Low Pass Filter Designer

The Best in Filter Design Software

www.nuhertz.com

www.coilcraft.com

General Requirements	Value (edit)	Low Pass Requirements	Value (edit)	Minimum Capacitors
Pass Band Return Loss	20 dB	Pass Band Frequency	16 MHz	Minimum Inductors
Stop Band Attenuation	40 dB	Number of Poles:	3 5 7	
Impedance	50 Ohms			

Calculate

ABOUT THIS PROGRAM
Coilcraft Filter Designer may be used free of charge. The sole purpose is to assist the user in selecting Coilcraft parts. No warranties are made regarding the accuracy of the program or the

Inductor Parts List: 08HTR47, 08CS561

Request Full Nuhertz Trial

Free samples

Print Copy

Select Coilcraft Inductor Family Group: 0201, 0302, 0402, 0603, 0805, 1008

How to read inductor part numbers

5th Order Low Pass Elliptic

Pass Band Frequency = 18.00 MHz
Pass Band Return Loss = 20 dB
Stop Band Ratio = 1.505
Stop Band Frequency = 24.09 MHz
Stop Band Attenuation = 40 dB

Coilcraft Filter Designer
Nuhertz Technologies, LLC

Thu Oct 19 19:42 2023

Lumped Filter S Parameters

Frequency (Hz)

Thu Oct 19 19:42 2023

<https://www.coilcraft.com/en-us/other/coilcraft-lc-filter-designer-software/>



Filter Calculator



Low Pass/High Pass Filter Calculator

A passive filter (also known as a lumped element filter) is used to attenuate a signal above or below a determined frequency. This passive filter calculator has you – Resistance/Inductance, or LC – Inductance/Capacitive) and enter your values to calculate the cutoff/-3dB frequency. Depending on the configuration of the component. The low-pass filter will pass a signal with minimal distortion up to the cutoff frequency, at which point it will block the input signal. The high-pass filter will block the ones above.

Filter Type

Low Pass Filter

High Pass Filter

Filter Configuration

- RC - Resistor Capacitor
- RL - Resistor Inductor
- LC - Inductor Capacitor

RC FILTER FORMULAS

$$f_c = \frac{1}{2\pi RC}$$

$$C = \frac{1}{2\pi R f_c}$$

$$R = \frac{1}{2\pi C f_c}$$

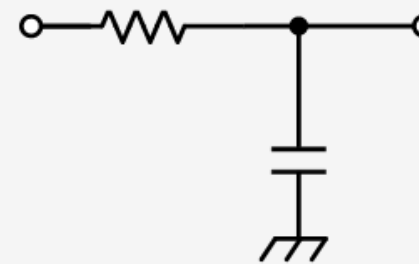
Resistance

 Ω

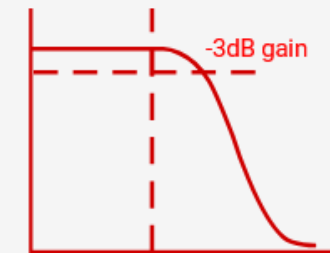
Capacitance

 μF

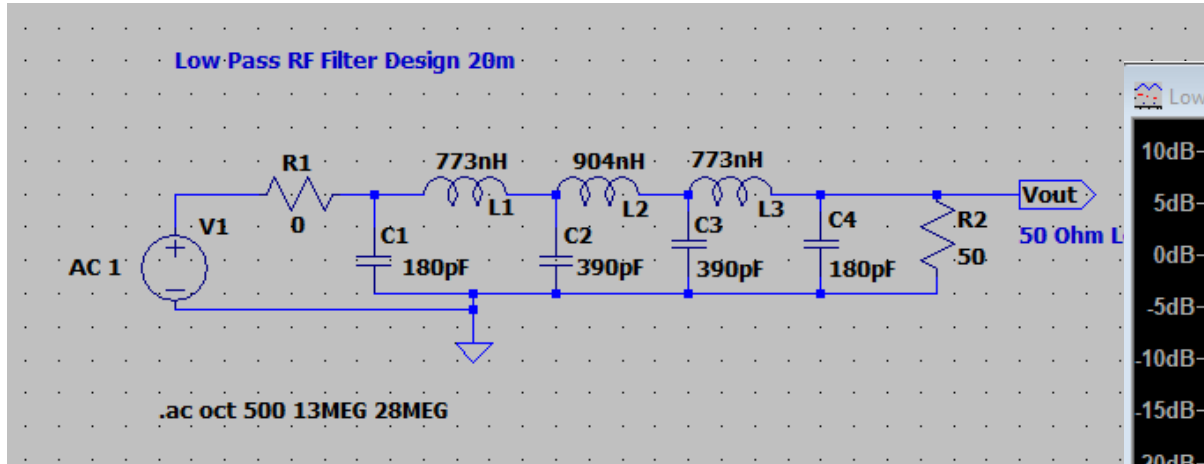
-3dB Cutoff Frequency

 Hz

Bode plot image is a generalized example of response curve, actual results will vary with component selection



Simulating Filters

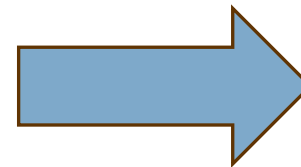


- See how they perform
- Choose values for the components



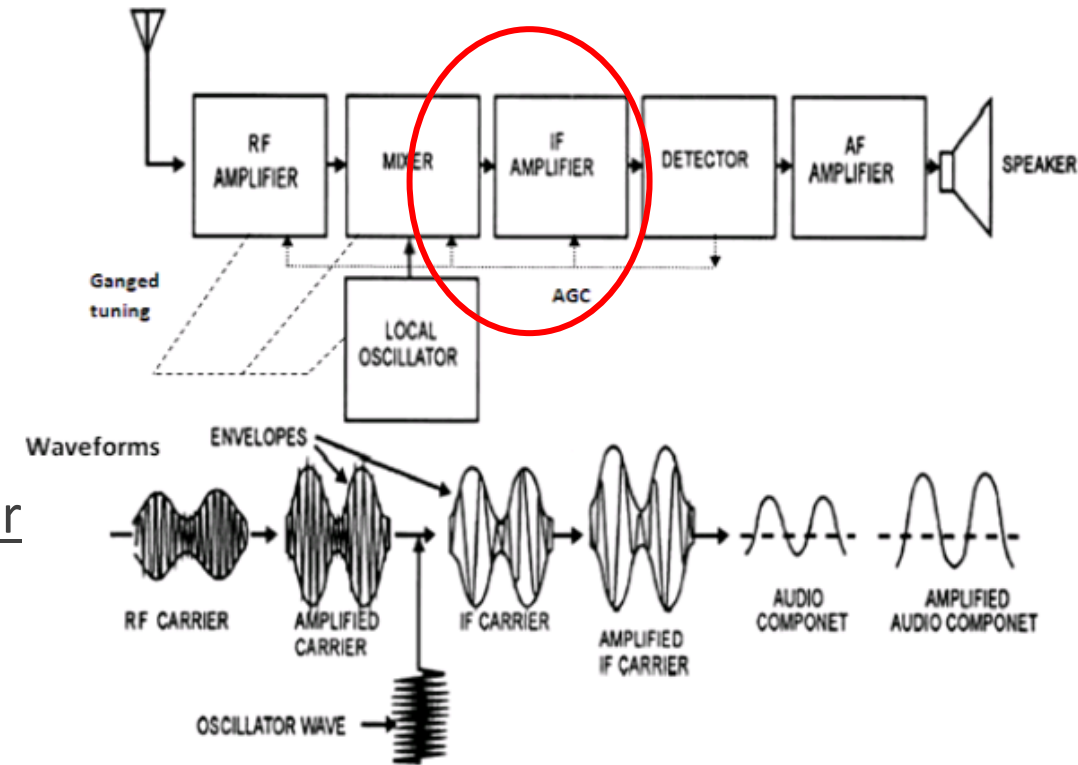
What filtering is in the radio?

- Most radios in the past 10 years have audio (EQ) filtering for audio
- 3rd Party products available for improving audio
- Most radios have a form of **IF filtering** that can be set by the operator to reduce interference from adjacent stations



IF (Intermediate Frequency) Bandpass Filtering

- IF stage
 - used to shift from the received carrier frequency to one that can be filtered to a specific bandwidth of frequencies.
- All radios use some type of IF filtering method
 - Older radios may allow limited shifting of this
 - Newer radios provide more control.
- Without this filtering you would hear a much larger part of the band, all at the same time. This BANDPASS filter limit it to a small range.
 - SSB mode it is 2.3KHz wide
 - In CW mode it narrowed to about 500Hz



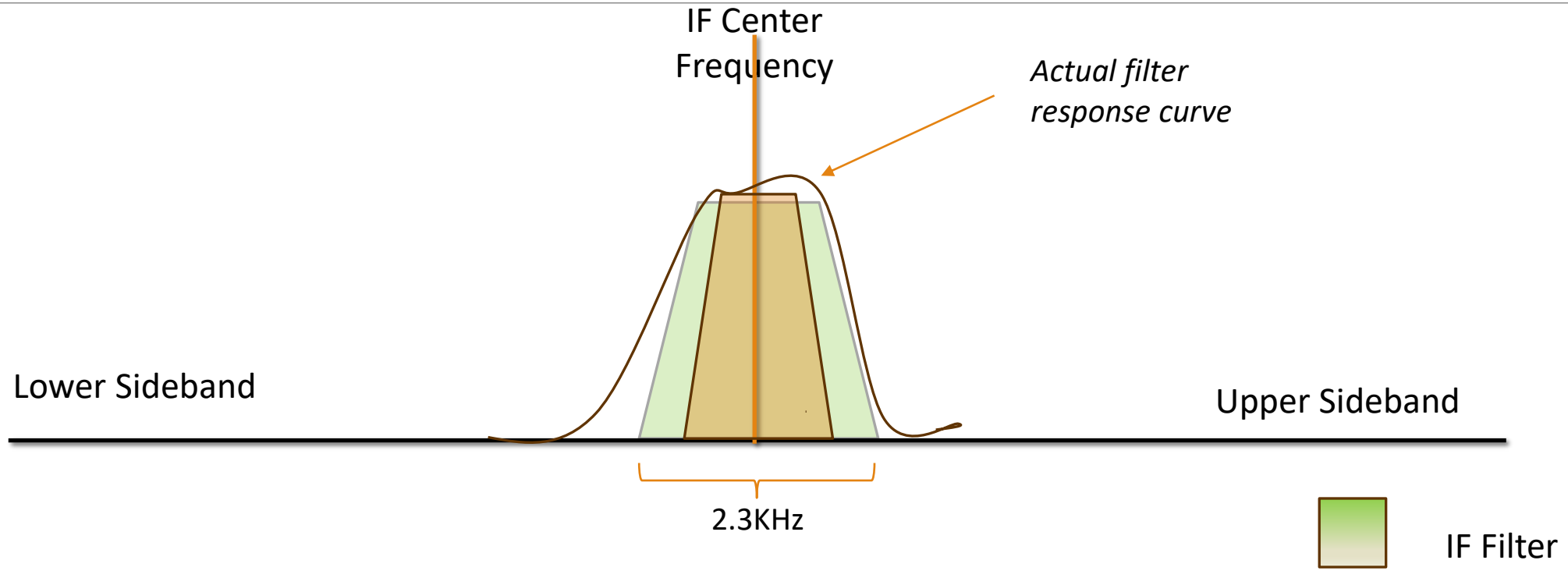


Vintage Rigs often have just IF Shifting

IF Shift Knob

Kenwood TS-440S Transceiver

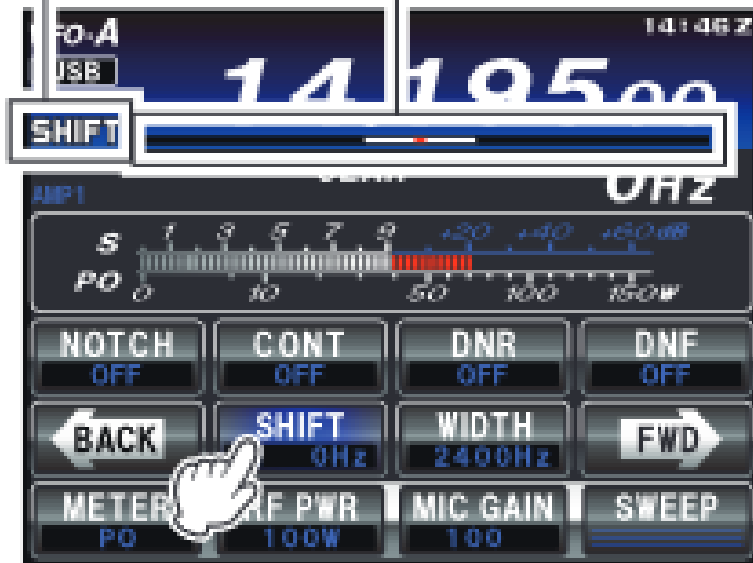
IF Passband Filtering



Yaesu 991A Transceiver

SHIFT indicator

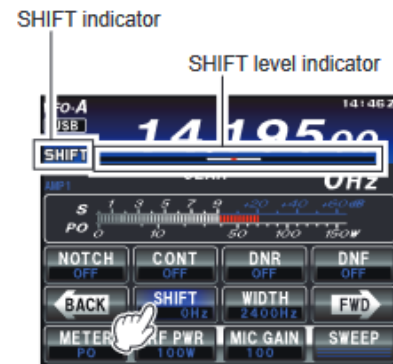
SHIFT level indicator



IF SHIFT OPERATION (SSB/CW/RTTY/DATA MODES)

IF SHIFT permits moving the DSP filter passband higher or lower, without changing the pitch of the incoming signal, and thus reduces or eliminates interference. Because the tuned carrier frequency is not varied, there is no need to re-tune the operating frequency to eliminate the interference. The total passband tuning range for the IF SHIFT system is ± 1.2 kHz.

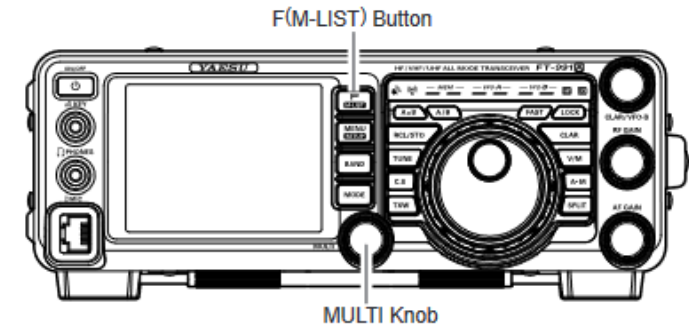
1. Press the **F(M-LIST)** button to display the function menu list. Touch [SHIFT] to reduce the interference. The **MULTI** knob functions as the SHIFT adjustment knob.



2. Rotate the **MULTI** knob to the left or right to reduce interfering signals.

ADVICE:

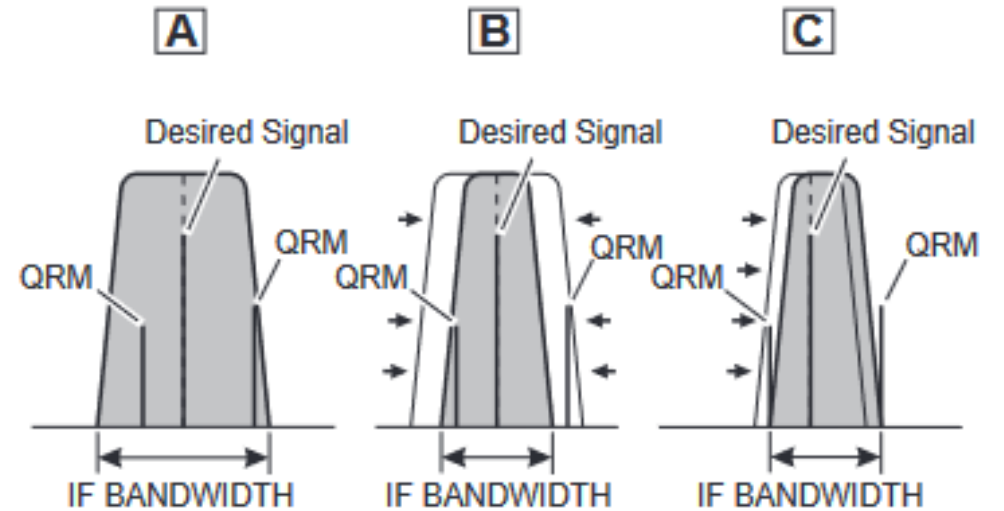
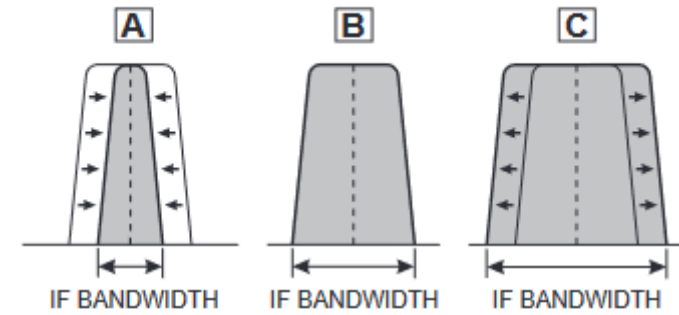
- Rotate the **MULTI** knob to display the shift offset of the IF filter ($-1,200$ Hz to $+1,200$ Hz) below the [SHIFT] indicator.
- The level indicator shows the shift offset direction for your reference.



Yaesu 991A Transceiver

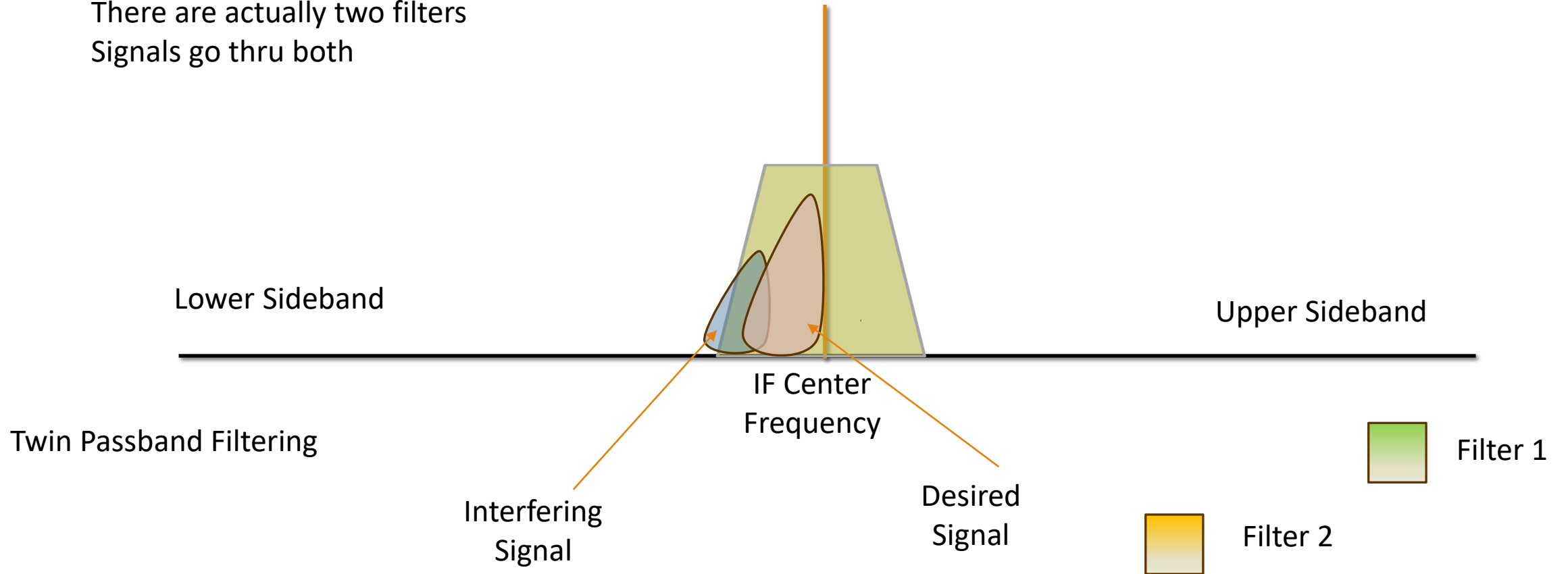
WIDTH indicator

WIDTH level indicator

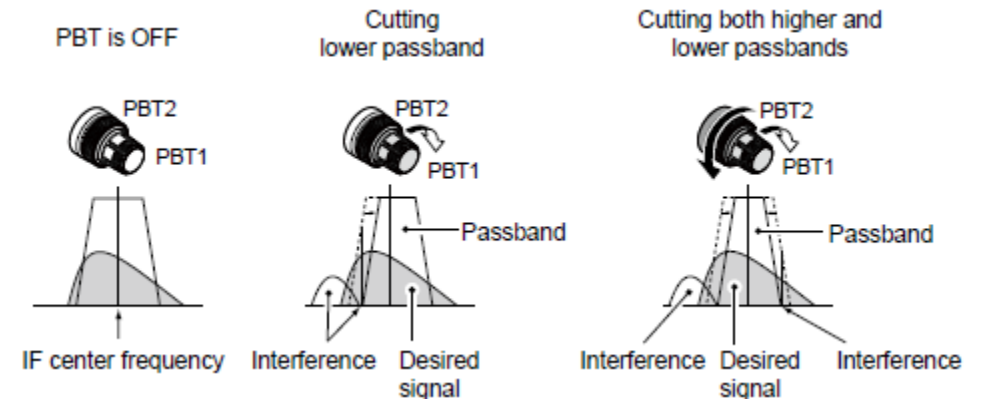


ICOM – PBT Twin Pass Band Tuning

There are actually two filters
Signals go thru both

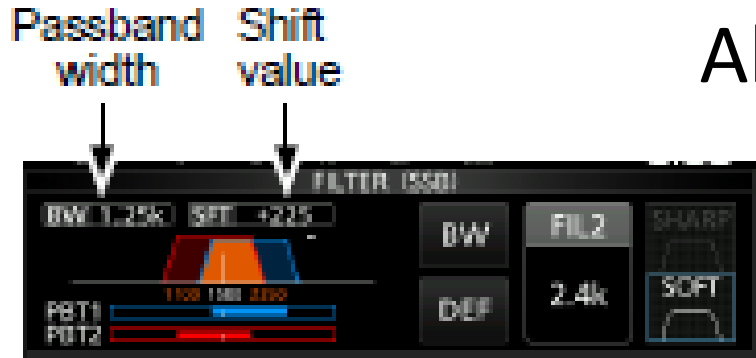


ICOM 7300 has Twin Filter Controls



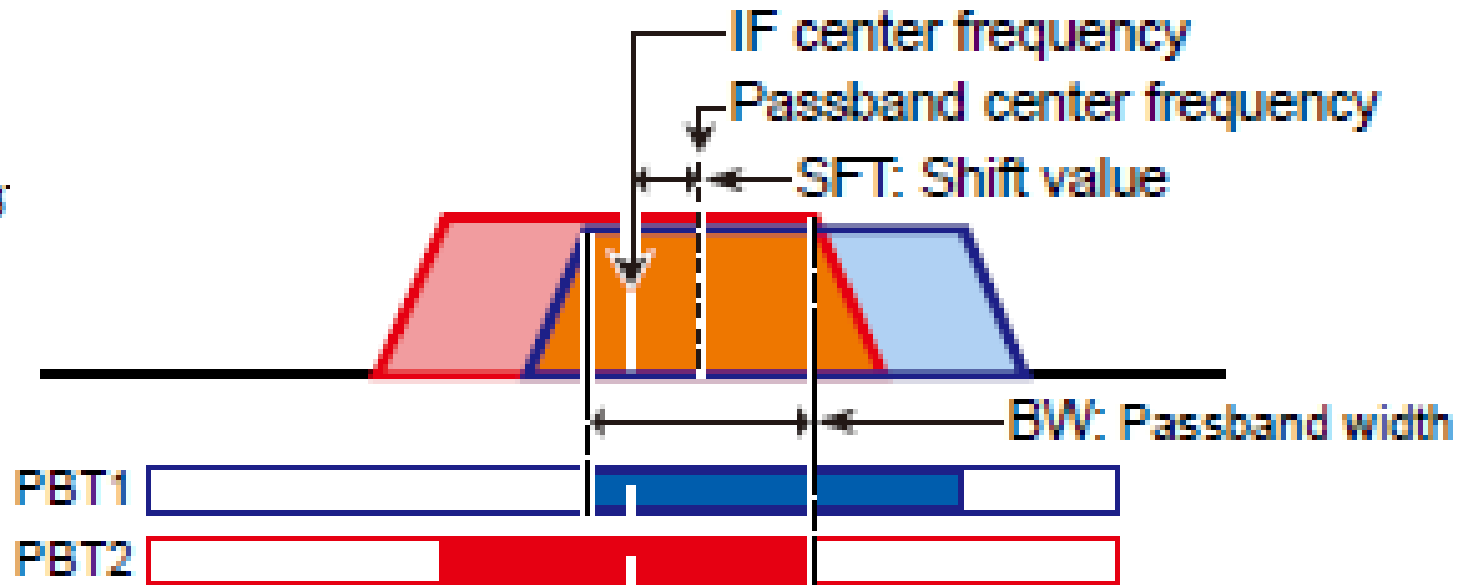
ICOM 7300 and 705

All IF tuning is done in software

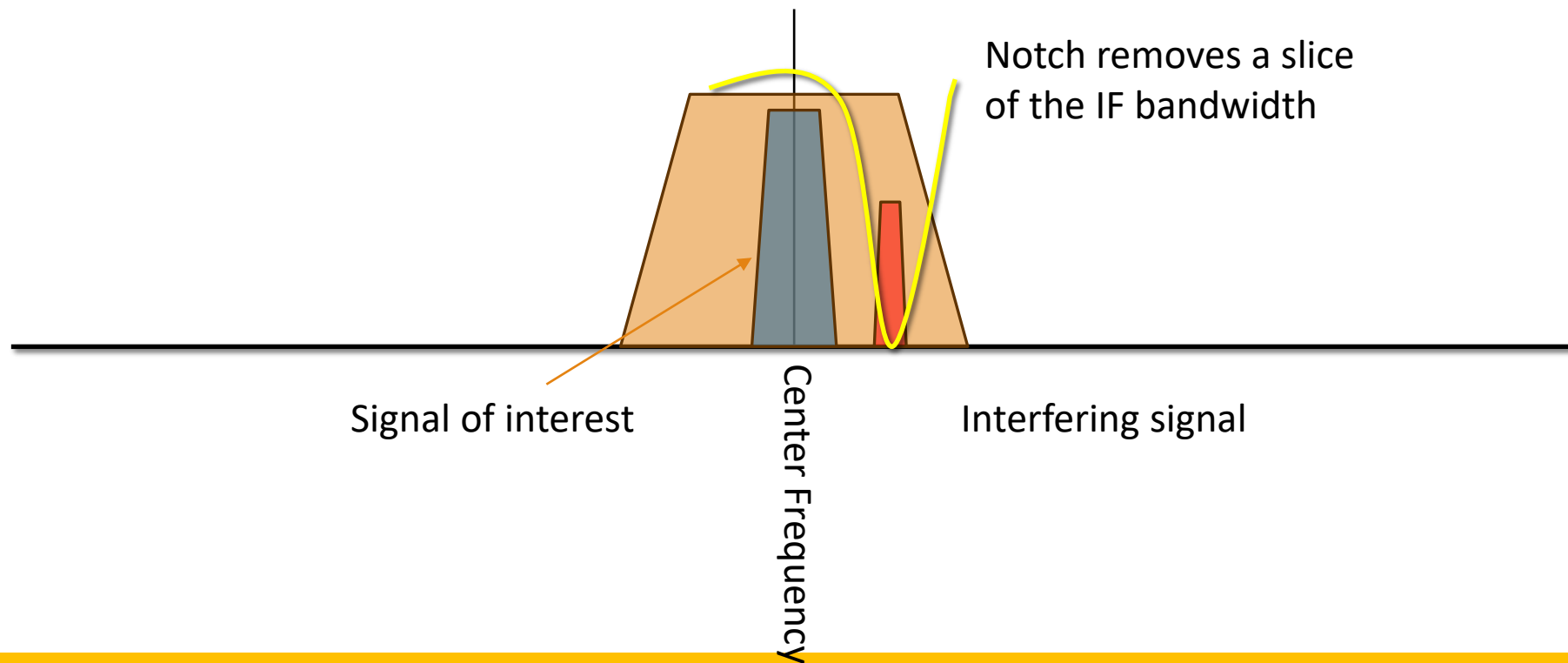


FILTER (SSB) screen (while operating Twin PB)

Touch and hold on **Filter** on the touch screen to keep it persistent on the screen



What is a notch filter?



ICOM 7300 Manual Notch Filter



Comparisons of Passband Methods

IF TUNING

- ✓ Can be effective with QRM
- ✓ Shifts the IF, but bandwidth is constant
- ✓ May allow presets for IF BW
- ✓ May work in the majority of cases

DUAL PASSBAND TUNING

- ✓ Can be very effective with QRM
- ✓ Shifts two IF filters, and determines the bandwidth dynamically
- ✓ Filters move independently, or can still be used like the conventional IF shifting
- ✓ Gives you total filter control
- ✓ Many new rigs have this feature

High End Radios - Elecraft K4



Sophisticated SDR filtering for passbands

All filtering in software

Signal knob on the front panel

Twin filters for control of bandwidth dynamically

I don't know a lot about it, but demos show very impressive receiver performance.

Cost \$5,900 , so it should be good!

Summary

- ✓ We Learned –
- ✓ What is a filter and why do we need one?
- ✓ What are the common types of electronic filters?
- ✓ What are the characteristics of a filter?
- ✓ How do audio, IF, and RF filters differ and how are they the same?
- ✓ How are filters used on ICOM and Yaesu radios?



Live Demo of filters for HF

ICOM 705 Filters (same as available on the 7300)

Will show Passband Tuning (PBT)

Notch Filtering (auto & manual)

Noise Reduction (NR)

- Noise Blanking (pulse noise)
- Noise Reducer (random noise)



First play audio of W1A special event station with varying filter adjustments



CHEROKEE AMATEUR RADIO SOCIETY

Questions and Comments
Thank You!