Using Spectrogram To Measure The Filter Response of a High Frequency Receiver

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Introduction

Spectrogram is a program that uses a PC sound card to make spectral measurements in the audio range. With an RF noise generator as a source, you can measure the filter frequency response of an HF SSB or CW communications receiver with a dynamic range of over 70 dB. This note is written toward measuring the filter frequency response of an Elecraft K2 receiver, but it can be applied to any HF communications receiver.

Getting Started

You will need to download a copy of Spectrogram. These instructions were written for version 5.1.6, but the latest download on the web, version 6, should also work fine. Spectrogram can be downloaded from http://www.monumental.com/rshorne/gram.html. Install Spectrogram on your computer and check that you can feed audio into it through your the sound card. This may require configuration of the audio mixer in Windows.

A RF noise source is needed to provide strong broadband noise to the input of the receiver. Noise from the preamp or antenna noise is not strong enough to make measurements over the full dynamic range of the filters. A Noise Bridge works as a source, or the ARRL Handbook for 2001 contains construction details for a noise source and a Noise Bridge.

Finally, you will need a cable to connect from the headphone output of the receiver to the input of the sound card. You may need to use an attenuator between them, especially if you are using the microphone input rather than the line input on the sound card. You can follow the step-by-step instructions to determine if the attenuator is needed. Radio Shack sells a 40 dB audio attenuator (#274-300), or you can construct an attenuator yourself from a pair of resistors.

Step By Step Instructions

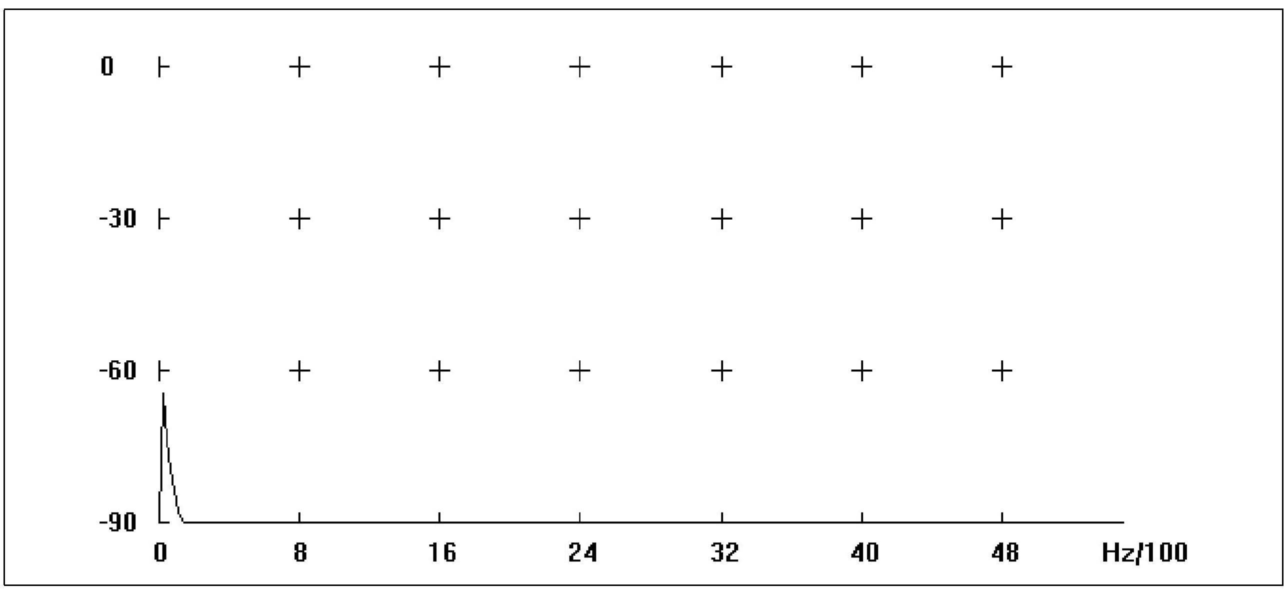
1. Launch Spectrogram

When the display comes up, select **File/F3 – Scan Input**. This will bring up the **Scan Input** dialog box in which you need to select the following options. Most recent computers can use the Preferred Selection; if Spectrogram runs really slow, the Alternative Selection should run faster. Do not vary these settings unless you thoroughly understand Spectrogram and what effect the changes will have. These settings will provide a frequency resolution of 20 Hz, which is more than sufficient to resolve any filters used for CW or SSB reception. All of the following instructions assume that Spectrogram is configured as given in the table below.

Spectrogram Settings	**Preferred Selection**	**Alternative Selection**
Sample Rate (Hz)	44k	22k
Resolution	16 bit	16 bit
Type	Mono	Mono
Display Type	Line	Line
Scale (dB)	90	90
Palette	CB or BW	CB or BW
Time Scale (msec)	100	100
Cursor Offset (Hz)	0	0
Freq Scale	Linear	Linear
FFT Size (Points)	2048	1024
Freq Resolution (Hz)	21.5	21.5
Band (Hz)	0 to 5512	0 to 5512
Spectrum Average	128	128
Pitch Detector	Off	Off
Recording Enable	Off	Off

2. Check Soundcard

In the **Scan Input** dialog box, click **OK**. Adjust the slider on the right side of the Spectrogram display to its maximum (top most) setting. The display should show a frequency range from 0 Hz to above 4800 Hz and an amplitude range of –90 to 0 dB. There should be a small blip in the display near 0 Hz, but the rest of the display should show a flat line at –90 dB. The display below is in the BW Palette and the black crosses may be turned on and off with **Toggle Grid**.



If there is noise above the –90 dB line (except the blip at 0 Hz), there is a problem with the sound card and the noise will limit the dynamic range that can be obtained in these measurements.

3. Connect Cable

With the power to the receiver turned off, connect the cable between the headphone output and the sound card input. There should still be no noise on the display. If noise is present, it is probably due to a defective cable or a ground loop in the audio connection. You will need to determine the cause of the noise and eliminate it if possible. You may also try to use an audio attenuator to reduce the noise.

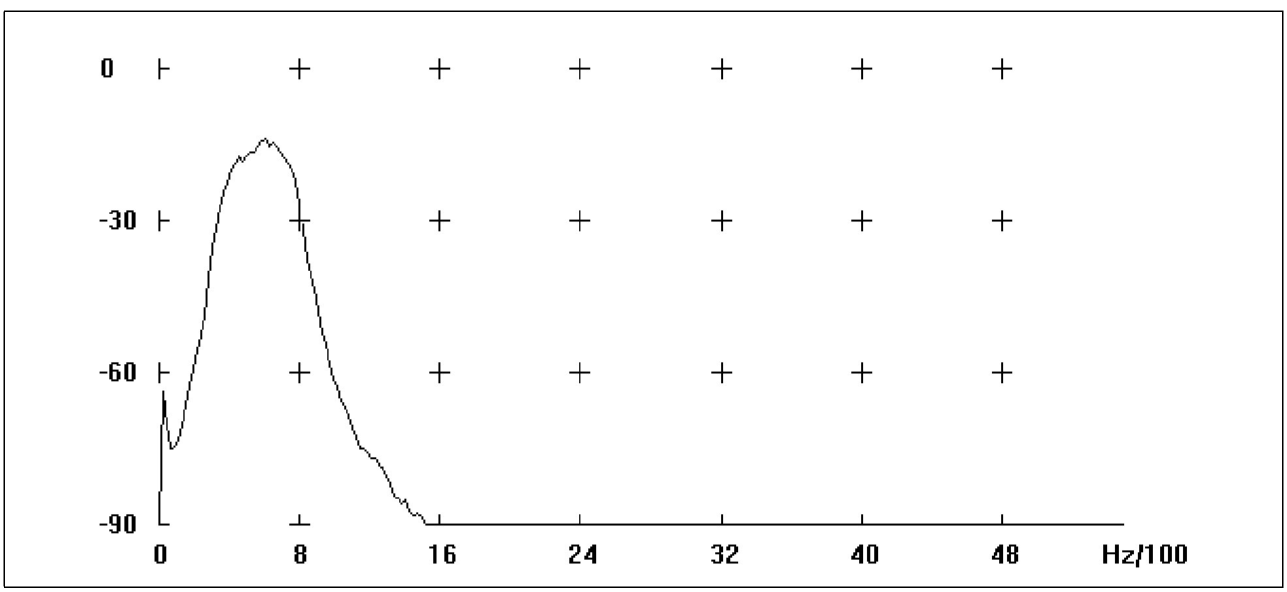
4. Power On Receiver

Turn on the power to the receiver. The audio and RF gain controls should be set to their minimum level and the AGC should be turned off (Hold PRE/ATT and AGC buttons on K2). Disconnect any antenna to the radio. Set the frequency to 80 meters and the mode to CW or SSB. The Spectrogram display should still show no noise other than the 0 Hz blip. If there is noise present, you will need to use an audio attenuator between the headphone output and the sound card input to eliminate this noise.

Slowly turn up the audio level until you can barely see noise at the –90 dB level. This sets the maximum audio level without sampling the internal radio noise in Spectrogram.

5. Connect The Noise Source

Turn on the receiver preamp. Connect the noise source to the radio input and turn it on. This maximizes the noise injected into the radio and will yield the best dynamic range. Set the receiver to the filter bandwidth that you want to measure. Gradually turn up the RF gain until the maximum reading in Spectrogram is approximately –20 dB. For the K2 in the 700 Hz filter bandwidth, the plot will look similar to the one below.

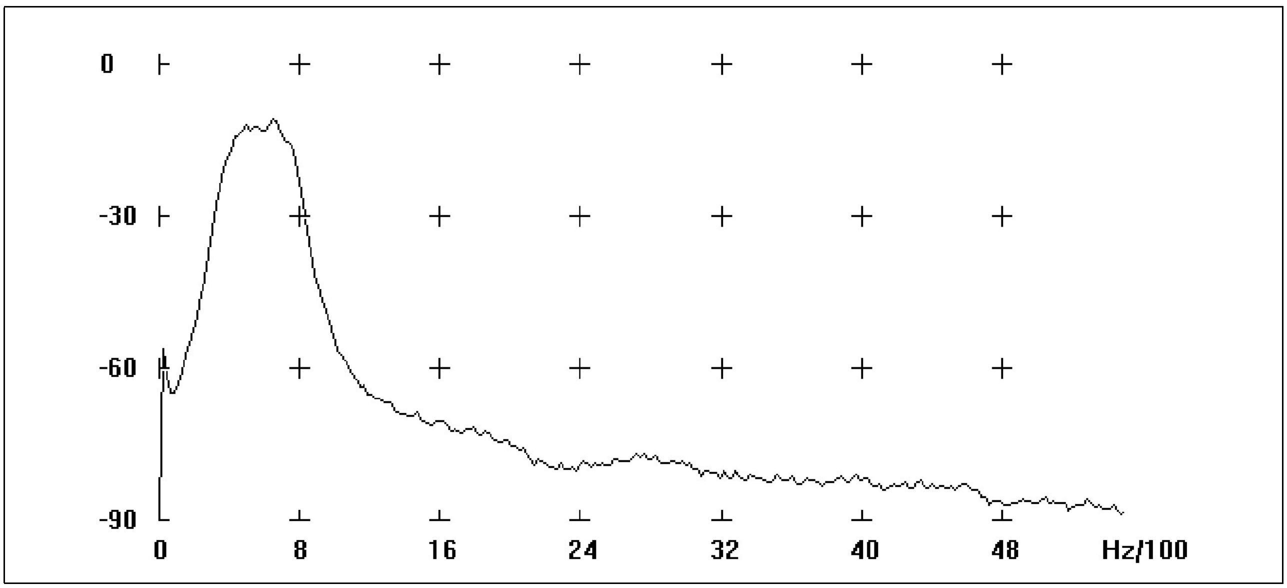


6. Adjust The Displayed Level

The following step is very important to avoid clipping in the sound card and the resulting intermodulation distortion. Gradually increase the RF gain until the noise starts to rapidly increase at the higher frequencies. Reduce the RF gain from this point by at least 3 dB; a larger reduction won't hurt, but a smaller one could lead to measurement errors in the spectral intensity.

This step sets the input level into the sound card so that we are avoiding any clipping and the resulting distortion; this distortion can be a significant source of errors when measuring the filter response. For filters with a bandwidth of less than 1 kHz, a setting of –15 dB is safe, and for bandwidths equal or greater than 1 kHz a setting of –20 dB is safe. The previous Spectrogram display was taken with a maximum displayed level of -15 dB and a filter bandwidth of 700 Hz.

If your audio level is set too high, the picture below shows what the distortion will look like. Compare this to the previous Spectrogram display. The level at the higher frequencies is very sensitive to changes in the audio input level.



7. Make The Measurement

You are now ready to measure the filter response. It takes at least 15 seconds to read all 128 measurements for the average, and it may take even longer if you have a slower computer. When you are satisfied that you have obtained a good image, click **Stop** on the Spectrogram display. The image may be saved as a display of the Spectrogram window using the **File/Save Image** command or it may be saved as a set of data in text format that can be read into Excel or other graphing programs using the **File/Log Data** command.

Conclusion

Spectrogram can make wide dynamic range measurements of the filter response of HF receivers. It does require some care in its use to obtain accurate measurements, and to utilize the full dynamic range provided by the program. I'd like to thank Tom Hammond, N0SS, for taking the time to review this material and making a number of helpful comments.