WA3TFS Audio Notch Filter and Clipper

Improve the performance of vintage or recent receivers with this circuit.

Jim Forkin, WA3TFS

Not all receivers and transceivers come equipped with narrow IF filters for CW operation, so you must rely on the wider SSB — or even AM — filter, and selectivity suffers. Quite often, under busy conditions during CW operation there are other signals within the filter passband of your receiver. With a notch filter, you can suppress an interfering CW signal, or null heterodynes from signal carriers, or from off-frequency AM stations. Additionally, you can limit atmospheric and lightning noise pulses with a clipper circuit, making a difficult contact possible. With a notch filter, you can greatly attenuate a narrow slice of audio frequencies and by doing so, hear the signal you wish to copy more clearly. Also on signals with high bass levels, you can move the notch to attenuate the low frequency, leaving the easier to copy higher frequencies during weak signal conditions.

This article describes an easy-to-build device that provides you with an adjustable frequency audio notch filter along with an adjustable noise clipper. The device includes an audio amplifier to drive a speaker. While this device cannot equal the capabilities of high-quality IF filtering and high performance noise reduction circuits, it is inexpensive and attaches easily without any internal modifications to the receiver or transceiver. This device can allow pleasant operation while using vintage or inexpensive older equipment under adverse conditions.

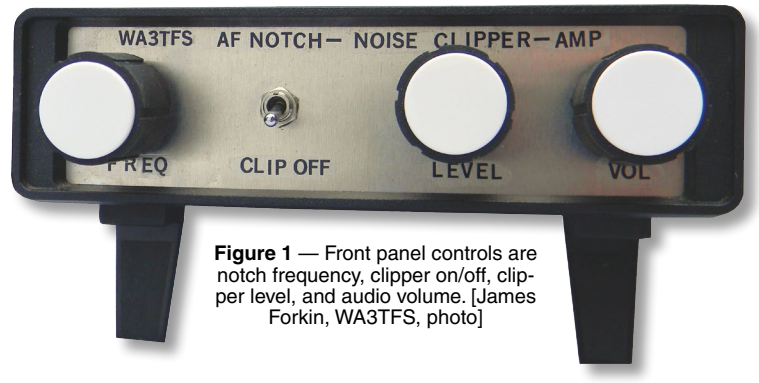

Figure 1 — Front panel controls are notch frequency, clipper on/off, clipper level, and audio volume. [James Forkin, WA3TFS, photo]

The Design

You can duplicate this device on a printed circuit board or build it using point-to-point wiring if you take proper care with layout and grounding. The choice of component manufacturers is not critical, but don't change the values of the components or the device's performance may be less than expected. The device consists of three distinct sections: an audio notch filter, a clipper circuit, and an audio amplifier.

Audio notch filter

A single transistor amplifier having two adjustable RC resonant filters makes up the audio notch filter. One filter is series tuned and the other is parallel tuned. Audio passing through each of the two filters is out of phase at the notch frequency, and when combined, the signals cancel, resulting in a null. Signals outside the notch frequency pass unattenuated since the phases don't cancel. The notch filter attenuates signals by approximately –45 dB. You tune the notch using a ganged potentiometer notch FREQ control (Figure 1) that adjusts both filters. In effect, this circuit places a hole in the audio spectrum at a frequency you select using the notch FREQ control. If the notching function is not required, you can tune the control to place the notch outside of the audio reception spectrum.

Audio Clipper

The CLIP OFF switch engages an audio clipper circuit. Diodes D1 and D2 clip the positive and negative audio peaks at a level set by the LEVEL potentiometer. An audio clipper can't eliminate all the noise present on the signal, but by clipping the noise peaks, you can reduce noise power so the signal-to-noise ratio improves. Disengaging the CLIP OFF switch allows audio to pass through without clipping when noise is not a problem.

An audio clipper can't eliminate all the noise present on the signal, but by clipping the noise peaks, you can reduce noise power so the signal-to-noise ratio improves.

Audio Amplifier

I designed the audio amplifier section to drive a speaker or earphones. Its maximum gain is 50, or 200 if you short out R12 (Figure 2). This flexibility lets you use this device as the complete audio section of a home-built receiver. Integrated circuit IC2 can provide up to 1 W of audio output. Adjust the audio level with the VOL control. Typically, you adjust the audio output of the receiver to a low level and the VOL control on this amplifier sets the audio level at the speaker. Adjust both volume controls for best results. Use the notch filter and clipper individually or together. You will quickly get a feel for the best settings.

Construction

The printed circuit board design is available on the *QST* in Depth web page or from the author.[1, 2] All components are soldered onto the circuit board as shown in the schematic (Figure 2) and parts layout drawing (Figure 3). All parts mount on the top side of the board, and the board can be mounted on four standoffs using the four holes at the corners of the board. All controls are attached to the enclosure that you have selected to house the unit. The layout drawing shows all the necessary connections between controls and the circuit board.

Use only the length of wire necessary, but allow a little slack in your connections. If necessary, you might need to add ferrite beads or bypass capacitors to external connections when in proximity to high

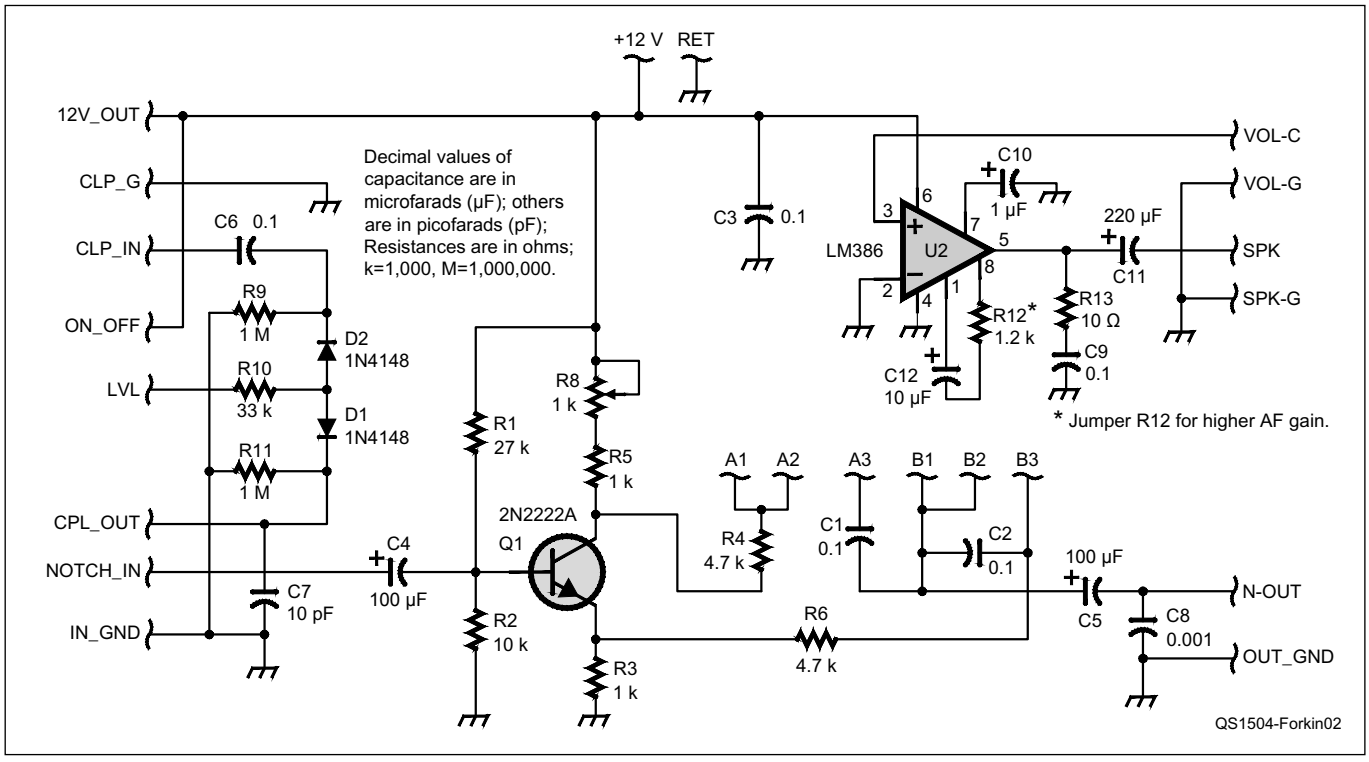

Figure 2 — Schematic diagram of the notch filter/clipper board. (Stackpole, Yageo, Vishay BC, Panasonic components from **digikey.com**; Kemet parts from **mouser.com**).

C1, C2, C6 — 0.1 µF Capacitor, ceramic Kemet CK05BX104KTR
C3 — 0.01 µF Capacitor, ceramic, Vishay B,C K103K10X7RF5UH5
C4, C5 — 100 µF Capacitor, Elect. 50 V, Panasonic ECA-1HM101
C7 — 10 pF Capacitor, ceramic, TDK Corp. FK28C0G1H100D
C8 — 0.001 µF Capacitor, ceramic, Kemet CK05BX102KTR
C9 — 0.05 µF Capacitor
C10 — 1 µF Capacitor, ceramic 50 V, Vishay BC K105K20X7RF5UH5
C11 — 220 µF Capacitor, Elect. 50 V, Panasonic EEU-EB1H221
C12 — 10 µF Capacitor, Elect. 50 V, Panasonic EEU-EB1H100S.
D1, D2 — 1N4148 Switching diode
IC2 — Amplifier, LM386-4, TI M386N-4/NOPB
Q1 — 2N2222 NPN Transistor, On Semi, PN2222AG
R1 — 27 kΩ Resistor, ¼ W, 5%, Stackpole CF14JT27K0
R2 — 10 kΩ Resistor, ¼ W, 1%, Yageo MFR-25FBF52-10K
R3, R5 — 1 kΩ Resistor, ¼ W, 5%, Stackpole CF14JT1K00
R4, R6 — 4.7 kΩ Resistor, ¼ W, 5%, Stackpole CF14JT4K70
R8 — 1 kΩ Trimmer potentiometer, CTS Components 201XR102B
R9, R11 — 1 MΩ Resistor, ¼ W, 5%, Stackpole CF14JT1M00
R10 — 33 kΩ Resistor, ¼ W, 5%, Stackpole CF14JT33K0
R12 — 1.2 kΩ Resistor, ¼ W, 5%, Yageo CFR-25JR-52-1K2
R13 — 10 Ω Resistor, ¼ W, 5%, Stackpole CF14JT10R0

RF fields, although I have not found this necessary at my station location running up to 1000 W RF power. You can use any convenient power supply for the unit that supplies 12 V dc at about 1 A.

Adjustments

After you complete construction, you must make a preliminary adjustment to the notch filter section. An oscilloscope or an ac voltmeter is best for the task, but if neither is available, just use your ears. Turn off the clipper (CLIP OFF switch is ON). Next, connect the speaker and apply 12 V dc. Attach the oscilloscope test lead to the top (non-grounded side) of the VOL control. Alternatively, set your voltmeter to ac and attach it to this same point. Attach the ground test lead to the ground side of the VOL potentiometer.

Apply a sine wave audio signal of approximately 1 kHz and 1 V peak to the input (CLP_IN in Figure 3). The frequency or amplitude is not critical. If you have no way of introducing this signal, find a heterodyne on the radio and use it for the adjustment.

Adjust the VOL control to a comfortable level. You should hear the signal in the speaker. Slowly tune the notch control until the level of the input sine wave signal diminishes. Tuning back and forth, find the point where the signal is attenuated the most. This point is very narrow. Now, adjust trimmer R8 on the circuit board for greatest attenuation. Repeat the above steps for the best results. R8 needs no further adjustment.

With the notch FREQ adjust control turned to either end of travel, engage the clipping function using the CLIP OFF switch. With an oscilloscope or ac meter, you can see the signal being clipped on positive and negative peaks as you adjust the clipping LEVEL control. Turn OFF the clipper, and the full sine wave will appear. This completes the adjustments.

Using the Audio Frequency Notch/Clipper

This device connects between your receiver audio output and a speaker. Connect the receiver audio output to the CLP_IN connection on the board. Connect the SPK and SPK_G connection to the speaker or headphones. Apply 12 V dc to the power connection.

Tune in a signal on the receiver. While listening, slowly adjust the notch FREQ control until an interfering signal dimin-

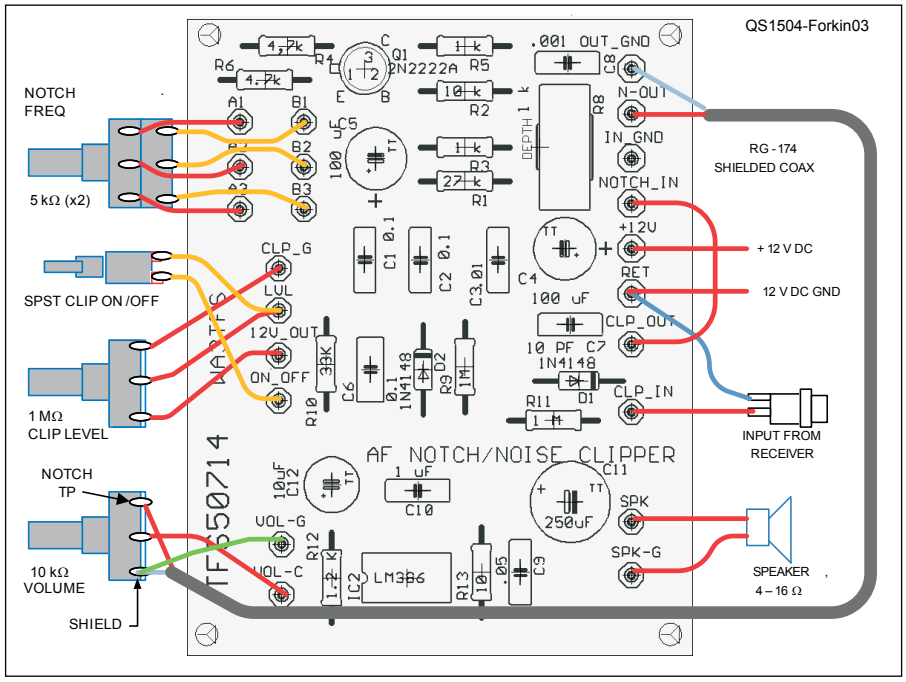

Figure 3 — Connections between controls and the circuit board. (Bournes, CTS, NKK components from **digikey.com**).

Notch frequency — 5 kΩ dual-ganged potentiometer, linear taper, Alpha/Mouser 31VW305-F
Clip On/Off — SPST switch NKK Switches M2011SS1W01/UC
Clipping level — 1 MΩ potentiometer, single, Bournes Inc. PDA241-SRT02-105B0
Volume — 10 kΩ potentiometer, single, CTS Elec. 026TB32R103B1A1

ishes. Depending on the frequency of the interfering signal, you may need to tune the control above or below that signal. If you hear pulse noise on the signal, turn on the noise clipper and adjust the clipper LEVEL control to attenuate the noise peaks.

Vary the adjustments as necessary for best performance. The notch or clipper may be used separately or together. You might need to adjust both the clip LEVEL control and the receiver volume control for best performance. I've found that the clipper is also useful to limit the audio level and save your ears when using earphones to copy that very weak CW signal and the ham next door suddenly tunes near your frequency and calls CQ.

Conclusion

This device may prove very useful on the "top" ham bands such as 160, 80, and 40 meters, where noise and foreign broadcasts are common. Also, reception will be improved on any band plagued with heterodynes from off frequency signal carriers. Shortwave and broadcast radio listeners may find the notch filter especially helpful to separate signals. The completed device can be mounted within its own enclosure, or it can be placed inside a vintage radio that has space to accommodate the unit and the added controls. My board measures less than 3 × 3 inches. If you take the time to duplicate this device, I believe you will find it a useful accessory for your station that will add enjoyment to listening under less than ideal conditions.

Notes

[1]**www.arrl.org/qst-in-depth**

[2]Printed circuit boards, assembled boards, and parts kits are available from the author Jim Forkin, WA3TFS, 3210 Shadyway Dr, Pittsburgh, PA 15227, **wa3tfs@arrl.net**.

An ARRL member since 1972, James Forkin, WA3TFS, was first licensed in 1972 as Novice WH6HOC while in the US Army stationed in Hawaii. He became Advanced class WA3TFS upon returning home to Pittsburgh. Jim retired from electronics design engineering after 45 years working in aerospace, medical, industrial, and electro-mechanical design. He enjoys designing and building receivers and transceivers. Jim operates SSB, CW, AM, and FM and has been active in several Amateur Radio clubs. He has previously published articles in *Ham Radio* magazine. You can reach Jim at **jforkin@verizon.net** or **wa3tfs@arrl.net**.

For updates to this article, see the *QST* Feedback page at www.arrl.org/feedback.