# DSP Speaker

Build this noise reducing system to enhance your station's audio

Adaptive filters using Digital Signal Processing can be very effective in improving the voice quality of amateur radio communications. DSP analyzes the signal and differentiates the noise from the speech. Unwanted noise and interference is then attenuated to leave only the speech. The signal is constantly monitored and the DSP automatically adapts to any changes in the signal conditions.

BHI Ltd[1] has a line of DSP products aimed at the amateur radio community. A popular radio modification is to add the NEDSP1061-KBD module inside the radio[2]. It adds a microprocessor and LED to the basic module with a pushbutton that steps through four levels of noise reduction. To take advantage of noise reduction on multiple radios this project uses the basic NEDSP1061-PCB module and offers eight levels of noise reduction. Audio from the radio is fed to a level attenuator, clipping indicator, DSP module, and a power amplifier that drives a speaker and headphones.

**Circuit Description**

Toggle switch S3 powers the unit and turns on the yellow PWR LED. Speaker and headphone levels are controlled by VOLUME potentiometer R17. The DSP LEVEL is selected by rotary switch S1. Toggle switches S2 and S4 switch the DSP in and out and turn the speaker on and off, respectively. The rear panel contains INPUT jack J1, PHONES jack J2, and 12VDC power jack J3. Board mounted jumper JP1 allows the use of stereo headphones by connecting the output to both channels. Ferrite beads are used on all signals entering and exiting the circuit.

*M1, NEDSP1061-PCB*

This tiny noise reduction module measures 1.45" x 1.06" and has 10 input/output pins. It has an internal voltage regulator allowing it to operate over a 5-15 VDC range. The eight available DSP levels correspond to 9-35 dB of white noise reduction (hiss), and 4-65 dB of tone reduction (heterodynes). Pins 1-3 have internal pull-up resistors to 3.3VDC and determine the DSP level according to Table 1.

| NEDSP1061-PCB DSP Level Setting | | | | | | |
|---|---|---|---|---|---|---|
| **DSP Level** | **Tone Reduction** | **White Noise Reduction** | **Pin 3-N2 (VDC)** | **Pin 2-N1 (VDC)** | **Pin 1-N0 (VDC)** | **BCD** |
| 1 | 4 dB | 9 dB | 0 | 0 | 0 | 0 |
| 2 | 5 dB | 11 dB | 0 | 0 | 3.3 | 1 |
| 3 | 6 dB | 13 dB | 0 | 3.3 | 0 | 2 |
| 4 | 8 dB | 15 dB | 0 | 3.3 | 3.3 | 3 |
| 5 | 16 dB | 17 dB | 3.3 | 0 | 0 | 4 |
| 6 | 21 dB | 20 dB | 3.3 | 0 | 3.3 | 5 |
| 7 | 25 dB | 24 dB | 3.3 | 3.3 | 0 | 6 |
| 8 | 65 dB | 35 dB | 3.3 | 3.3 | 3.3 | 7 |

***Table 1***

The N0, N1, and N2 voltage levels correspond to BCD numbers 0-7 and would preferably be set with an eight position BCD complement switch. However, panel mounted BCD switches are not readily available, so the DSP level is set with a SP8T rotary switch and diodes D1-D12. Resistors R6 and R7 form a -10 dB attenuation pad to reduce speaker level to line level.

The noise cancellation can be turned off by grounding pin eight. However, this method results in a loss of high frequencies, so toggle switch S4 switches between the input and the module output.

*U1, TL062 Dual Op Amp*

The M1 module requires input levels greater than 50 mV RMS, with a nominal level of 300 mV RMS. The maximum input level is not specified but appears to be around 350 mV RMS. The module includes a surface mounted LED to indicate clipping levels but the LED is very small and not amenable to panel mounting. Therefore, a simple CLIP indictor has been added. U1 forms a window comparator to detect the positive and negative peaks of the audio input. The op amp outputs are mixed by diodes D13 and D14, smoothed by C6, R5 and R14, and feed the LED driver Q1 with a positive pulse. C10 adds a small output delay in order to allow detection of very short peaks[3].

*U2, Audio Amplifier, TDA7240AV*

When supplied with 12VDC, this amplifier will deliver approximately 8 watts RMS into an 8Ω load at 0.5% THD. This is more than enough power to cleanly drive most speakers. U2 has one input and a differential output, so neither side of the bridged speaker output is grounded. The headphone output utilizes one side of the amplifier output referenced to ground. Do not omit coupling capacitor C8 as the amplifier will not work without it.

*SP1, Speaker, HiVi B3N*

This full range shielded speaker has a frequency response of 80-8,000Hz and a fairly smooth response curve. The speaker was selected to cover the voice frequency spectrum without adding too much bass. Although the speaker sensitivity level (SPL) is low at 81

dB the U2 amplifier has enough reserve power to overcome this deficiency. A speaker grill is recommended for those who are concerned about the unprotected speaker cone getting damaged. Commercially available grills are either too large for the enclosure or have mounting holes that interfere with the speaker frame. A substitute speaker grill can be fashioned from a fan guard which is mounted on ¼-inch standoffs in front of the speaker.

**Construction**

The prototype was built using perf-board construction and point to point wiring. Keep inputs away from outputs and be sure to ground the enclosure. For non-metallic enclosures, shielded cable is recommended on all audio lines. To prevent unwanted rattles, put a small dab of silicon sealant on the ferrite beads.

10-pin and 5-pin headers are soldered to the M1 module which is then plugged into board mounted sockets. The 5-pin header/socket helps to mechanically secure the module to the board and has no pin connections. For ease of assembly, components mounted off of the board are connected via male headers and female header plugs. The LED rear mounting nut can be threaded over the 2-pin header connector. First, knock the edges off of the connector with a small file and then cut threads by screwing the nut over the connector.

Sealed speaker enclosures should be airtight to prevent unwanted air leaks. Small gaps can cause air noises and unload the speaker. For this reason, the front and rear panel controls and jacks are threaded and sealed with a nut. There is still some air leakage but it is not objectionable in this frequency limited application. The enclosure features a front panel gasket which reduces air leakage and prevents rattles. The enclosure walls are lined with ½" adhesive-backed acoustic foam to absorb internal standing waves and prevent reflections to the speaker cone. Keep the foam away from the heat sink to prevent it from melting. Before mounting the speaker, install the supplied adhesive backed gasket material around the speaker cutout and install the speaker from the outside of the enclosure using 6-32 x ½-inch screws.

If the front and rear panel components are mounted on the perf-board according to the drawing, then the drilling template can be used to mark the holes. Print the full-size drilling template and then measure the panel and mark horizontal and vertical centerlines. Align the template with the panel centerlines and fasten it to the panel using a glue stick or rubber cement. Next, center-punch and drill all holes. The 2-7/8" diameter speaker cutout was made with a metal hole saw. Alternatively, small holes can be drilled around the circumference of the hole to remove the bulk of the material and then filed smooth.

Labeling can be added using dry transfer letters or a labeling machine. I used white dry transfer lettering (Woodland Scenics Railroad Gothic DT507) from the railroad section of my local hobby shop. A method for applying dry transfer letters is to print the lettering template full size on clear film. Secure the panel to a table top and then center and tape the clear film over the panel. Place the dry transfer sheet under the clear film, line up the appropriate letter, and then burnish. Follow up with a couple of coats of clear matt lacquer to protect the lettering. Be sure to test the lacquer on a test piece to ensure compatibility.

**Setup**
Connect 12VDC from the radio power supply to a 2.5mm x 5.5mm plug (center positive) to power the unit. The DSP Speaker can draw over one amp at high volumes so make sure the power supply is adequate. Connect the speaker/headphone output from the radio to the INPUT jack using a shielded cable with a 3.5mm mono phone plug on one end and a suitable plug on the radio end. The Yaesu FT-817/857 radios have a slide switch that switches the audio output to speaker or headphone levels but there is little difference observed between the two settings.

The M1 module has onboard input and output trimpots for setting sensitivity levels. Set these input and output trimpots to midpoint. The trimpots don't have stops so there will be a dead band area where the sound disappears. Referring to Figure 1, the trimpot settings are indicated by a small circle in front of the screwdriver slot and are shown at midpoint. The DSP level is set by rotary switch S1 so remove the shorting blocks on headers JP1, JP2, and JP3.

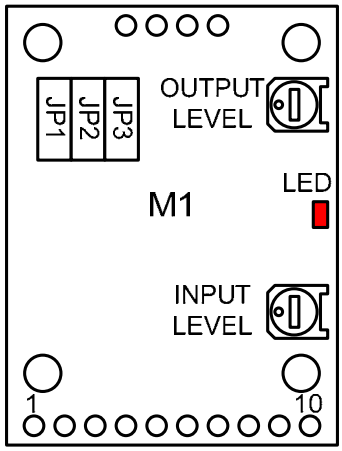


***Figure 1***

The CLIP detector is adjusted with the DSP Speaker connected to the radio. Tune in to a strong station and adjust the radio volume until you see the M1 overload LED light on the peaks. Adjust trimpot R16 until the CLIP LED turns on, mimicking the M1 LED.

**Operation**
Operation couldn't be simpler. At first, set your radio receiver for full bandwidth and disable any built-in noise reduction. Start with low DSP levels and increase the level as band conditions warrant. At the higher DSP levels the audio is somewhat "watery" sounding but still readable. The DSP is compatible with all modes of operation but is most remarkable on SSB. Heterodynes, static, hiss, buzzing, and other noises can be attenuated to a remarkable degree. The included audio files were made with a DSP setting of 5.

Like all DSP processors, there is a time delay associated with the reduction of noise. The time required to analyze the signal and respond appears to be less than a second for the BHI DSP unit and is the same for all levels of DSP.

Yaesu FT-817/857 radios will begin to light the CLIP LED with the volume control at the 12 o'clock position. For other radios, increase the radio volume until the CLIP LED lights and then back off slightly. The DSP Speaker volume is set to the 9 or 10 o'clock position for normal listening. I find that the extra audio power comes in handy when I am away from the radio, manually turning a beam while listening for peak reception. I am looking forward to the next VHF contest to put the DSP Speaker to good use. Six meter band noise at our contest location gets old after only a few hours of operation.

**Conclusion**

The DSP Speaker is a versatile tool that will clean up received audio and significantly improve intelligibility. The aluminum enclosure has a small footprint (6-3/4"H x 4-3/4"W x 4"D) and can be used with any radio with a speaker or headphone output. A highly effective noise reduction module teamed up with a hefty power amplifier and quality speaker form an impressive audio system for your radio. The end result is less listener fatigue, so clean up the noise pollution and get more enjoyment out of your radio!

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**Attachments**

- Schematic
- Bill of Materials
- Assembly Drawings & Templates
- Pictures
- Audio Files

**Notes**

1. BHI Ltd, PO Box 318, Burgess Hill, West Sussex, RH15 9NR, UK, http://www.bhi-ltd.com/
2. *BHI DSP Noise Reduction Module for Yaesu FT-817,* Chris Lorek, G4HCL, http://www.wimo.de/download/bhi_rdcom_nedsp1061_review-dec03.pdf
3. *Audio Clipping Indicator*, http://www.redcircuits.com/Page132.htm