improved receiver performance

for the Heathkit SB-104A

Modifications for better sensitivity, selectivity, and overload capability

The Heath SB-104A is a good transceiver. It can be made even better by incorporating the simple modifications described in this article. The modifications, if made according to the directions given, will provide significant improvements in:

1. Receiver sensitivity, especially on the 10- and 15-meter bands;
2. Receiver selectivity in the SSB mode;
3. Receiver strong-signal-handling capability.

These modifications, as well as a few others, have been developed over a two-year period with great care and attention to detail. Before snipping any wires, I strongly recommend that you fully understand what is being accomplished by each and every circuit change. In addition, the modified circuits should be studied and compared with the original Heath circuits.

receiver sensitivity improvements

In my opinion, the SB-104A suffers from inadequate sensitivity, especially on 10 and 15 meters. The six bandpass filters for the 80- through 10-meter Amateur bands, located on circuit board **G**, are diode switched. That is, when the radio is on a particular band, diodes on circuit-board **G** associated with the bandpass filter in use are forward-biased to provide a low-loss rf path for that band. The diodes do have some loss, however. These losses can be reduced by replacing diodes D701 through D704 (Heathkit parts designations); D707 through D710; D713, D714; and D717, D718 with Motorola MPN3401 PIN diodes,* which are intended for rf-switching use. (See **fig. 1**.)

To make the mods, first remove the original diodes, using a Solderwick.™ Install the new PIN devices in place of the original diodes. Pay attention to the polarity of the MPN3401s. These devices are in a square epoxy package; the end with the ridge, or high spot, is the cathode. The leads on the MPN3401 are very short, so they must be mounted on the foil side of the board.

mixer improvements

The next step is to replace the receiver mixers. The original first and second mixers on board **G** can be improved by substituting minicircuit Labs SBL-1 broadband mixers.†

These new mixers provide better isolation between ports and have less conversion loss than the original mixers. They also have good strong-signal-handling capabilities. They are commonly used in high-performance uhf receiving systems.

To make the mixer modification, first remove the Heath first mixer, consisting of T701 and T702 and diodes D719, D721, D722, and D723. Also remove capacitors C741 and C742. Apply some epoxy to the top of one of the SBL-1 mixers and cement it to the component side of the board, as indicated in **fig. 1**. The pins on the mixer should now be facing upward. Wire the mixer as shown using two 0.01-μF capaci-

*Available from Circuit Specialists, Box 3047, Scottsdale, Arizona 85257.

†Available from Advanced Receiver Research, Box 1242, Burlington, Connecticut 06013.

By **Richard Tashner, N2EO**, 163-34 21 Road, Whitestone, New York 11357

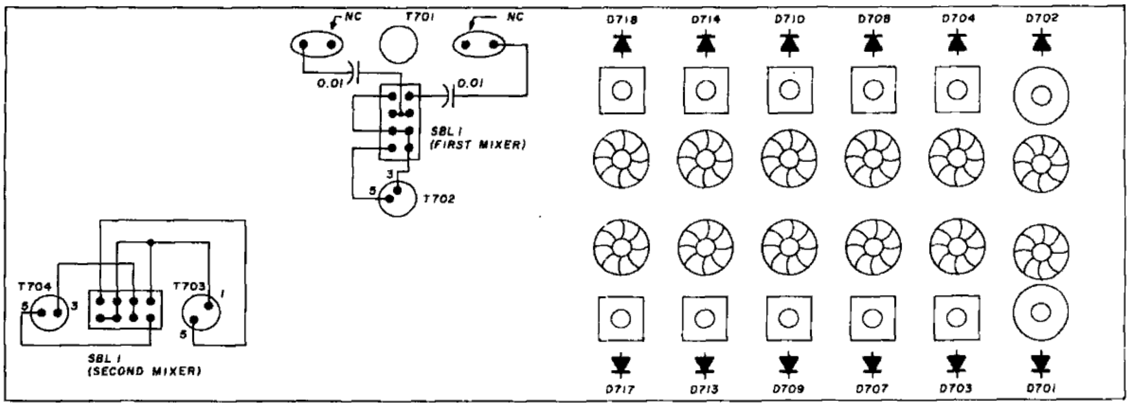


fig. 1. Circuit board *G* in the Heath SB-104A showing, at right, the locations of the original bandpass-filter switching diodes, which are replaced with MPN3401 PIN diodes to reduce loss through the circuit. The original first and second mixers on board *G* (center and left) are replaced with SBL-1 broadband mixers to reduce conversion loss and improve strong-signal-handling capability. Original Heath parts designators are shown.

tors. The capacitors connect from the mixer module to one of each of the indicated holes in the PC board.

Next remove the Heath second mixer by removing T703, T704, D724, D725, D726, D727, and epoxy the new SBL-1 second mixer to the board. Wire as indicated. No additional capacitors are needed on the second mixer, as they already exist on the PC board.

Finally locate transistor Q702. This transistor is a 2N5109, which is an epitaxial planar low-noise device. It is used as a post amplifier between the first and second mixers.

Remove R721, the 1-kilohm collector resistor and replace it with a 1-mH choke. Next remove R722, the 560-ohm emitter resistor, and replace it with a 100-ohm resistor. Finally replace C745 emitter bypass capacitor with a 0.01-μF disc capacitor.

The above modification serves two purposes. First, it increases collector current to about 100 mA, which greatly reduces the chances for the stage to clip on strong signals. (The 2N5109 is rated for an IC of 400 mA.) It also increases the stage gain, which is needed to overcome the losses of the second crystal filter.

At this point, reinstall board **G**. Turn on the SB-104A, and check out the receiver to make sure it's receiving on all bands.

Next pull out the board, install the extender board in the SB-104A along with board **G**, and retune the filters and second mixer trimmers according to the Heath operation manual. If a scope and sweep generator are available, the board may be sweep-aligned.

taming the noise blanker

The next step is to rewire the noise blanker as shown in **fig. 2**. This modification will allow the blanker to be totally removed from the signal path when turned off. I found that the blanker caused cross modulation, even when turned off, by virtue of its being in the signal path at all times as originally wired. The noise-blanker switch is a dpdt and no problems should be encountered in wiring it as indicated in **fig. 2**. Use shielded cable (RG-174/U).

improving SSB selectivity

To improve skirt selectivity on SSB, remove the original crystal filter from circuit board **E** and install a Fox Tango Corporation 33H2.1 filter* in its place. Mount the original SSB filter to the chassis just to the left of the VFO, directly in front of the noise blanker. I suggest that you measure the filter dimensions carefully; make a template, and tape it to the chassis before drilling the four mounting holes. Drill up from the bottom of the chassis.

The new filter is wired as shown in **fig. 2**, using two 15.5-μH coils and two 150-pF mica capacitors, which provide the proper impedance match for the filter.

further improvements

More modifications were made to the SB-104A to achieve the following goals:

---

*Available from Fox Tango Corporation, Box 15944, West Palm Beach, Florida 33406.

Notes:

1. Heath filter is remounted directly to chassis in front of noise blanker. Matching network is held in place by terminal strips bolted to filter mounting studs.

2. All shielded cable is RG174/U miniature coax.

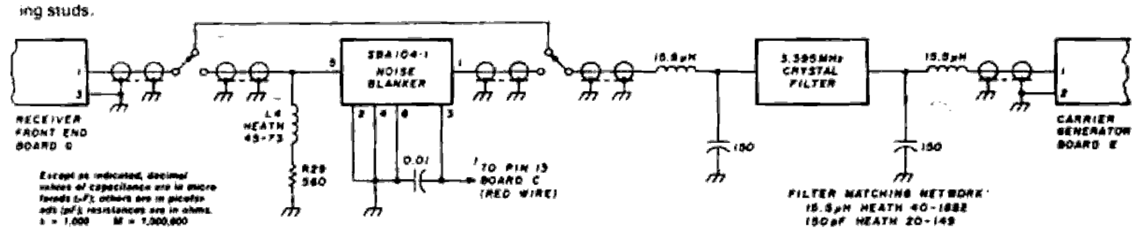


fig. 2. Block diagram showing cascaded filter system. A Fox Tango Corporation 33H2.1 filter is substituted for the original Heath crystal filter, which is relocated on the chassis as described in the text. Wiring changes to the noise blanker are also shown, completely removing it from the signal path when turned off.

1. To further improve strong-signal-handling capability
2. To improve the active audio filter
3. To reduce receiver hiss
4. To provide a slower AGC release time

Make the following changes to board F. Refer to fig. 3, which is a partial schematic of board F. (Parts designators are as shown in the Heath schematic.*) Proceed as follows:

1. **R513**. Remove the 2400-ohm resistor and replace it with a 1-meg resistor.

2. **R502**. Remove the 820-ohm resistor and replace it with a 1500-ohm resistor.

*As mentioned at the beginning of this article, it is important that you understand just what is being done when these modifications are made. *Before* attempting to make any changes, study the Heath schematics for the SB-104A and familiarize yourself with the original design so that you thoroughly understand how the changes are made, why they are made, what components are involved, and how to proceed without damaging the radio. The importance of this advice cannot be overly stressed.

3. **R514**. Remove the 620-ohm resistor and replace it with a 100-ohm resistor shunted by a 0.01-μF capacitor.

4. **R517**. Remove the 2400-ohm resistor and short the foil with a jumper.

5. **R511**. Remove and discard (or save for your junkbox).

6. **R512**. Remove the 4700-ohm resistor and replace it with a 1-mH choke.

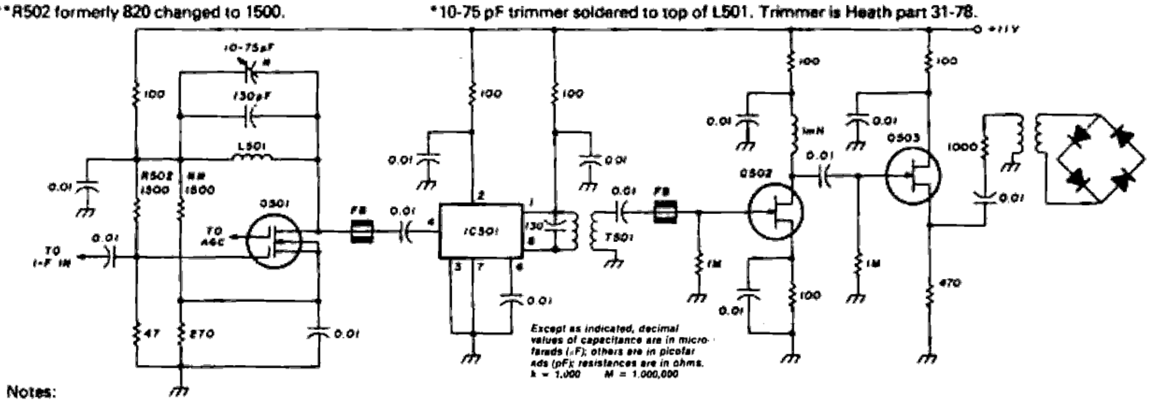
7. **R516**. Remove and discard.

8. **R518**. Remove the 10k resistor and replace it with a 1-meg resistor.

9. **R572**. Remove the 4700-ohm resistor and replace it with a 2200-ohm resistor.

10. **R541**. Remove the 1500-ohm resistor and replace it with a 1000-ohm resistor.

**R502 formerly 820 changed to 1500. *10-75 pF trimmer soldered to top of L501. Trimmer is Heath part 31-78.



Notes:

1. Install Q502, Q503 as follows: *Gate* goes to former base lead. *Drain* goes to former collector lead. *Source* goes to former emitter lead on PC board.

fig. 3. Partial schematic of the SB-104A i-f/audio board *F* showing modifications to improve strong-signal-handling capability.

11. R545. Remove the 820k resistor and replace it with a 2.2-meg resistor.

12. R546. Remove the 5.6-meg resistor and replace it with a 33-meg resistor.

13. C535. Remove the 2.2-μF tantalum capacitor and replace it with a 5-μF, 15-volt electrolytic capacitor.

14. Q502, Q503. Remove and replace with 2N3819 JFETs. See note 1 on **fig. 3**.

On the right-hand upper corner of board **F**, from the component side of the board, locate the foil going to Q517 base and carefully drill a 1/16-inch (1.6-mm) or smaller hole through the base foil and the ground foil. Scrape off the green or blue coating around the holes and install a 0.1-μF Mylar capacitor in the two holes.

Locate coil L501 and remove the associated 100-pF mica capacitor. Replace it with a 130-pF mica capacitor.

Solder a 10-75 pF trimmer (Heathkit 31-78) across the pins of L501. Piggyback this trimmer on top of L501 by soldering the trimmer directly to the top of the pins on L501.

Install board **F** in the extender board in the SB-104A. Either peak the 10-75 pF trimmer for maximum noise, or, if a signal generator is available, put the rig on 80 meters and inject a signal into the antenna jack. Use only enough signal to get an S-5 or so meter reading. Peak the 10-75 pF trimmer for maximum S-5 meter reading. Use care not to saturate the i-f. Use only as high a signal level as is necessary.

Next, remove board **D** and change capacitor C441 (33pF) to 100 pF. This change increases HFO injection and reduces receiver overload. Reinstall board **D**.

Remove transmit audio regulator board **B**, and make the following changes:

1. Change R217 from 4700 to 2200 ohms.

2. Remove Q207 and replace it with a Radio Shack 276-2026 transistor.

The reason for these changes on board **B** is as follows. Q207 is the PTT switching transistor. When Q207 conducts, the relay in the SB-104A closes, and the unit is in the transmit mode. Before I changed the transistor, I'd had two failures of the Q207. For that reason, the Radio Shack device was installed; it's a tab-type transistor and is more capable of supplying the necessary collector current without premature failure.

If this change is made, you must reduce the value of R217 from 4700 ohms to 2200 ohms. If you don't plan to change Q207, leave R217 alone. When installing the new Q207, bend the leads of the transistor at a right angle and allow the transistor to lie over the top of IC202. This will allow PC board **B** to slip into its compartment in the chassis.

Additional changes to board **B**, which are optional, are as follows. R214, the collector resistor of audio transistor Q201, may be reduced from 33k to 15k. This change will eliminate asymmetrical clipping — which may cause slight audio distortion during transmit in some units — in Q201.

Capacitor C204, the 0.01-μF coupling capacitor on Q201's base, may be increased to a 0.1-μF Mylar. This change will increase the low-frequency response of the transmit audio. This is a personal preference. You may like the transmitter audio better one way than the other, so get some on-the-air checks from a few local stations and try the two different capacitor values.

Finally, one change suggested by Heathkit is as follows. Remove the ALC/filter board and change capacitor C887 on Q802's collector to a 0.68-μF tantalum. If your rig is of late vintage, the 0.68-μF cap may already be installed.

test results after modification

Three other active Amateurs are located within a half mile of me. After modifications were made, I made on-the-air checks with two of these stations. I was able to tune my SB-104A 18-20 kHz away from the other stations' 60 dB over S-9 signals and only slight desensitization was noted. Stations as weak as S-3, 30 kHz away from the 60-dB over S-9 local SSB signals, were solid copy, and only a slight hiss was noted while the local station was transmitting. These tests were made with the noise blanker off.

The Heathkit SB-104A was also tested side-by-side with a top-of-the line Japanese transceiver. Both rigs were connected to a common antenna. The two units ran neck-and-neck as far as sensitivity was concerned. All bands, 80-10 meters, were tested. When the two rigs were tuned to the same station, the SB-104A had much less receiver hiss than the Japanese rig, which made the SB-104A much more pleasant to listen to. The modified AGC action was very pleasant to listen to. No pumping was present in the SB-104A after modification.

A comparative check of selectivity was also made on both units. Tuning the same station on upper sideband on the Japanese rig, and moving off frequency produced a high-pitched "Donald Duck" response that could be heard up to 3.5 kHz away from center frequency. However, on the SB-104A, tuning more than 2.8 kHz away from the center frequency produced a sharp cutoff of the signal, and the same signal that was heard 3.5 kHz away on the Japanese rig was undetectable on the SB-104A. The i-f shift control in the Japanese rig was purposely left in the center position and not used during the checks. Turning the i-f shift knob did not help the Japanese rig; however, the cascaded filters in the SB-104A were definitely doing their job. Before modification, the SB-104A exhibited lockup of the AGC, which would manifest itself with the S-meter hanging up at S-6 across large portions of the band when a strong local signal was on. After modification, this problem totally disappeared, and just a barely perceptible increase in hiss was noted.

some afterthoughts concerning the SB-104A

As mentioned, the tests were made with the SB-104A noise blanker turned off. Turning on the blanker still produces cross modulation. This is because the noise blanker keys on signal as well as noise. Because of the broadband nature of the rig, the blanker is subjected to 500 kHz or more of crowded spectrum when turned on, and it just can't handle that much signal. One answer to this problem is to put a monolithic crystal filter about 6 or 8 kHz wide ahead of the noise blanker. During the modifications, I placed the 2.1-kHz filter ahead of the noise blanker, and the cross modulation totally disappeared. However, the blanker became totally ineffective on noise spikes. Propagation through the filter caused the pulses to be rounded off, rendering the blanker ineffective. For this reason only a modest filter should be placed in front of the blanker so that the pulses will not be rounded off, and the spread range of signals presented to the blanker at any one time will be reduced.

I would greatly appreciate hearing from others who have done work in this area, and I will answer questions upon receipt of a self-addressed stamped envelope.

acknowledgments

I with to thank Vinney Maida, WA2EVS, for his helpful suggestions with this project. Thanks also to Brian Selman for drafting the diagrams. Finally, my thanks to David Fentem, WB4RRC, for his ideas in his "Heath 104 Series Information Sheet," dated August 31, 1979.

bibliography

Shuch, Paul, WA6UAM, "Circuit Packaging for UHF Double-Balanced Mixers," *ham radio*, September, 1977, page 41.

The Radio Amateurs Handbook, Chapter 8, "Receiving Systems," Chapter 9, and "VHF and UHF Receiving Techniques," ARRL, Newington, Connecticut, 1979.

ham radio