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QST Issue: Feb 2003
Title: Optimizing the Heathkit HW-101, SB101-102 Transceivers
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TECHNICAL CORRESPONDENCE

OPTIMIZING THE HEATHKIT HW-101, SB100-102 TRANSCEIVERS

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◊ The Heathkit HW/SB transceivers were popular in the late 1960s through 1970s and are fairly plentiful on the used market even today. These modifications will increase the audio quality of both receive and transmit, improve operation on CW, enhance strong-signal handling of the rigs and make them usable with low-impedance headphones. These changes require no new holes or mechanical changes at all; the rig can be easily restored to original condition at anytime. The text deals with the HW-101, but the changes are applicable to the above mentioned SB-series as well.

Conversion to Low-Impedance Headphones

These rigs are designed for high-impedance headphones, but if low-impedance phones are used the outboard speaker will not mute completely. To convert for low-impedance phones, make these wiring (refer to WebFig 1,[1] pictorials 8-4 and 8-5 of the HW-101 manual):

1. Move the black wire from terminal strip BA lug 2 to lug 3 (ground).
2. Remove the green wire and the 100-Ω resistor from jack AB (speaker).
3. Connect the green wire to terminal strip BA lug 2.
4. Connect the 100-Ω resistor removed in Step 2 to lugs 2 and 3 of terminal strip BA.
5. Remove the jumper wire from lugs 1 and 2 of headphone jack L.
6. Run a new wire along the wiring harness from speaker jack AB lug 1 to the headphone jack lug 2.

The external speaker should now mute completely with low-impedance phones.

Improved CW Operation

In the CW mode the rig's relays are energized by the CW sidetone driving the VOX relay amplifier. The sidetone drive to the VOX amplifier is a bit weak for fast relay action, and at speeds approaching 20 wpm the first-dot RF may be clipped due to the slow response time. Correcting this is a very simple modification—simply replace the 470-kΩ resistor R328 on the audio board with a 1-kΩ resistor (see WebFig 2). This increases the drive to the VOX amplifier so the relays pull in quicker. Now the rig will key reliably at 20 WPM. The first dot tends to be shortened at 25 WPM but the rig is usable.

Another annoying problem with these rigs is the CW sidetone. Although the sidetone amplifier is in deep cutoff, there is enough coupling through the tube for the sidetone to be heard even when the key is up. Fortunately, this is also fairly easy to correct:

1. Connect a 0.001 µF disk capacitor (*do not* use a higher value) from relay RL1 pin 1, to ground (see WebFig 1).
2. Connect an 8-inch piece of wire to pin 1 of RL1 and run this wire through the same opening in the shield as the wiring harness.
3. On the audio board, replace 1-MΩ resistor R326 with a 2.2-MΩ resistor (see WebFig 2).
4. At the circuit-board junction of R326 and C311, connect one side of a 0.005 µF, 500 V disk capacitor; connect the other side to the wire from RL1 pin 1.

During receive, the sidetone will now be bypassed to ground by the normally closed contact on RL1. During transmit, RL1 opens and the sidetone works normally.

Transmit Improvements

The transmitter audio quality can be improved by changing the value of coupling capacitor C11 on the modulator board from 0.001 µF to 0.01 µF (see WebFig 4). This increases the low-frequency response and gives the transmit audio a little more "body."

If 10 kΩ resistor R202 is present between the IF (L101 pin 4) and band-pass circuit boards (V5 pin 2), replace it with a piece of insulated hook-up wire (see WebFig 3). This increases drive to the first transmit mixer. (This change is already incorporated in later model HW-101s.)

Receive Improvements

The receiver's strong-signal-handling capability and audio quality can be vastly improved by the following changes.

1. During alignment, check to see if T-102 (WebFig 3) peaks at two points—one for transmit and a slightly different setting for receive. If so, peak the transformer for maximum transmit drive rather than maximum receive gain. The receiver has an abundance of gain, but the transmitter could use a little extra. This lowers the receiver gain but *does not* affect receiver sensitivity.
2. Change screen dropping resistor R113 in the second IF amplifier (V4) from 1 kΩ to 10 kΩ (see WebFig 3). This reduces the stage gain a bit and improves gain distribution.
3. The receiver improvement is to increase the BFO (carrier oscillator) drive to the product detector. This should be about five times the voltage level of the IF signal to minimize distortion, but on these rigs, the IF signal can equal the BFO level under strong-signal conditions, resulting in a very raspy, distorted audio quality. The major problem is that during receive, the BFO signal is coupled to the product detector cathode through C17, a 12-pF silver-mica capacitor and a piece of coax. The capacitance of the coax cable exceeds the value of C17, and the combination of the two acts as a voltage divider, greatly reducing BFO drive to product-detector V13C. To correct this increase the BFO coupling and decrease, the IF drive to V13C.

To increase BFO coupling, replace C17 on the modulator board with a 100-pF silver mica, and replace the 33-kΩ resistors R6 and R7 on the modulator board with 27-kΩ resistors (see WebFig 4). To reduce the IF drive, change resistor R123 on the IF board from 470 Ω to 75 Ω (see WebFig 3).

4. Additional high-frequency roll off removes the raspy nature of the receive audio. This is accomplished by changing the value of capacitor C119 on the IF board from 500 pF to 0.001 µF (see WebFig 3). The low-end response of the audio amplifier increases slightly if you replace coupling capacitor C306 on the audio board with a 0.01-µF disc capacitor (see WebFig 2).
5. Any voltage-regulator hash generated by V18 can be reduced by connecting a 0.001-µF, 500-V disk capacitor from V18 pin 1 to the ground foil on the audio board.
6. Some birdies heard in the tuning range of the receiver are weakened

[1]Because of space constraints, the figures cannot be presented within Technical Correspondence. The description here is sufficiently detailed for readers to perform the modifications. Readers who want the graphics can download a graphics package from the ARRLWeb at **www.arrl.org/files/qst-binaries/**. Look for 03TC02.ZIP.

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considerably by bypassing the filament string to ground with a 0.01 µF capacitor connected from the filament common point on the bandpass circuit board to ground. This is the point where the four brown wires connect, about an inch below pin 1 of V19 (WebFig 5).

IF Filter Passband Improvements

I believe the crystals for the carrier oscillator are of fairly wide tolerance, so the injected LSB/USB/CW carrier may be improperly positioned on the slope of the IF filter. This can affect both receive and transmit audio responses greatly. Telltale signs of this are audio responses that vary between USB and LSB, and reduced CW power output when using the CW filter.

It is relatively easy to tell if the USB/LSB carrier insertion points aren't placed equidistant from the center of the IF filter passband. After a 1/2-hour warm-up, disconnect any antenna and peak the preselector for maximum receiver gain. Next turn up the volume control to a slightly higher than normal level and listen closely to the hiss coming from the speaker. Switch to the opposite sideband. The pitch of the receiver background noise should be the same, if the USB and LSB carriers are equidistant from the filter center frequency.

If the carrier oscillator frequency is too far from the filter passband, the receive and transmit signals lack "lows," but the opposite sideband rejection is high. If the carrier oscillator frequency is too close to the filter center frequency, the receive and transmit signals will have excessive "lows" and the opposite sideband rejection and carrier suppression will suffer. Balance is the key.

On my particular HW-101, the measured carrier-oscillator frequencies were 3393.8 kHz (LSB), 3395.9 kHz (USB) and 3395.17 kHz (CW). This resulted in a "tinny" sounding audio response in LSB compared to USB, and a very "bassy" USB. The CW power output while using the SSB filter was 110 W, but since the CW carrier oscillator injection was so far from the CW filter center-frequency of 3395.4 kHz, the CW power output was 50 W while using the CW filter!

Heath's intended frequencies for the carrier oscillator were 3393.6 kHz (LSB), 3396.6 kHz (USB) and 3395.4 kHz (CW). With the specified filter center-frequency of 3395.0 kHz, the USB and LSB carrier positions would be 1.6 kHz each side of the filter center-frequency. Unfortunately, the filter center-frequency may not be exactly 3395.0 kHz. In order to determine the filter center-frequency one must balance the audio response between both sidebands, measure the USB and LSB carrier frequencies, add them and divide by two. The result will be the IF filter center frequency of your rig.

For example, if the USB/LSB audio responses are balanced, and the measured carrier frequencies are 3396.31 kHz and 3393.51 kHz, actual filter center frequency is (3396.31 + 3393.51) / 2 = 3394.91 kHz.

I like audio a tad "bassy," so I placed my carrier points closer (1.4 kHz) to the filter center frequency than Heath's recommended 1.6 kHz. The oscillator frequency is lowered by placing a small capacitance across the crystal, and raised by adding capacitance in series with the crystal. To put a capacitor in series with the crystal simply cut one circuit board trace just before the crystal pin as indicated in WebFig 4 and solder the capacitor across the opened trace. A 100-pF series capacitor moves the crystal frequency upward about 100 Hz, but a 100-Hz downward shift requires only about 10 pF across the crystal. In the Heath manual, the positions of Y1 and Y3 were interchanged and have been corrected here.

On my HW-101, I put the capacitors (silver micas) directly on the circuit board foils. I got one sideband to sound the way I liked, and then simply adjusted the other to match it. I needed a 10-pF capacitor across the LSB crystal, 100 pF in series with the USB crystal and 80 pF in series with the CW crystal. Following these changes, the new carrier oscillator frequencies for my rig are 3393.51 kHz (LSB), 3396.31 kHz (USB) and 3395.38 (CW). The audio is perfectly balanced when switching between sidebands, indicating a true IF filter center frequency of 3394.91 kHz. The CW power output while using the CW filter went from 50 W to 110 W. I also soldered a short loop of wire to the center lug of the carrier null pot to serve as a test point to measure the carrier oscillator frequency. Be sure that once you have determined the filter center-frequency, you place the oscillator frequencies no closer than about 1.4 kHz and no further than 1.6 kHz from the filter center-frequency.

To recap, match the responses between USB and LSB by ear. Then verify with a frequency counter that each carrier is between 1.4 kHz and 1.6 kHz from the filter passband center. We can match the pitch between USB and LSB by ear, but we can't tell exactly *where* they are—only that they are at the same point on the filter slope.

When the carrier-oscillator frequencies are changed, the signal level of the oscillator outputs may consequently change and therefore should be adjusted to be equal. Connect a scope or RF probe to the carrier-null pot center-lug test point and switch between sideband modes, checking for equality in level. If need be, adjust R6 or R7 to achieve equality. The level should be at least 1 V RMS or 3 V P-P.

Stabilizing Meter Zero Settings

S-meter zero-setting instability is mainly caused by heat-related resistance changes in R106 (22 kΩ, 1-W) on the IF board. Replace R106 with a 22 kΩ 2-W wire-wound resistor (WebFig 3).

The problem of the meter reading below zero during transmit while in the ALC position is corrected by connecting a 10-MΩ resistor from the meter ZERO-ADJUST pot pin 3, to pin 2 of T-102 on the IF board (hint from N4NRW).

After all the above mentioned changes are made, give the rig a touch-up alignment and enjoy a much improved vintage rig!

MORE ON ANOTHER, CHEAPER AUTOMATICALLY "SAFE" CHARGER

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◊ *The Rechargeable Batteries Application Handbook* by the Technical Marketing Staff of Gates Energy Products has good advice on storing batteries (pp 203-204): "The key to successful storage of sealed-lead batteries is maintaining a minimum level of charge in the cell or battery. As long as the open-circuit voltage remains above this cutoff, the battery does not experience any irreversible changes that affect capacity or life."

Page 8 of **www.batteryweb.com/manuals/techman.pdf** says that "one recharge per year is sufficient to maintain the original capacity of a battery not in use." However, the technical data for the PS-1212 (12 V, 1.2 Ah) found at **www.power-sonic.com** has a note that "due to the self discharge characteristics of this type of battery, it is imperative that they be charged after 6-9 months of storage. Otherwise permanent loss of capacity might occur as a result of sulfation."

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