Treetop Circuits
Owner's Manual for SB-51 SSB adapter

Version 5

The SB-51 SSB adapter *(Fig. 1)* from Treetop Circuits is designed specifically as an accessory for the Collins R-388 and 51J series receivers. It provides enhanced performance in SSB and CW modes. Performance in AM mode is largely unchanged. A 12-volt DC supply for the receiver's muting relay is incorporated as an added convenience.

To maintain consistency with the receiver documentation, and in deference to the distinguished history of these receivers, we use 1950's terminology -- for example "megacycles", not "MHz" -- in this document.

The SB-51 comes as a PC board, ready to install and operate. It plugs into the radio in place of the detector/AVC tube V110 *(Fig. 2)*, and most connections are made through the tube socket. In addition, two (optionally three) wires are connected from the SB-51 to the radio and two components are removed. With the SB-51 installed, all controls operate as before, but performance in SSB and CW modes is markedly improved. Please note that the noise limiter will distort the audio if turned on in SSB (cw) mode. This occurs because the limiter was designed to work with AM signals only.

To achieve this improved performance, the SB-51 replaces the diode detector with a high-level product detector, and provides a fast-attack slow-return AVC circuit. These circuits are automatically switched in when the receiver's BFO is turned on. With the BFO turned off, AM detector and AVC circuits which closely mimic the original circuits are switched in.

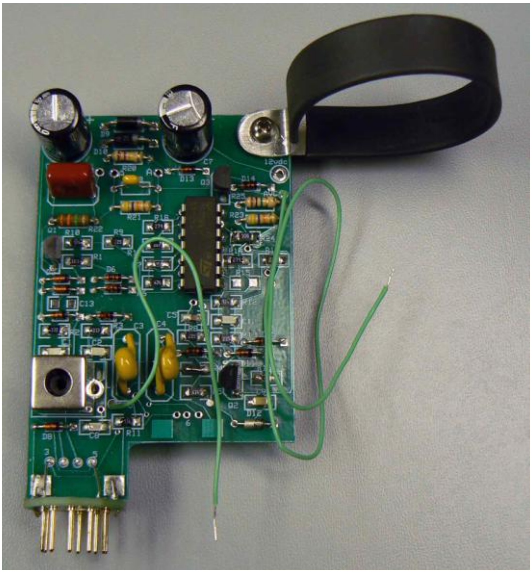

Fig. 1 –The SB-51 as supplied.

Fig. 2 – As installed in the receiver. The white wire (optional, to be supplied by owner) supplies 12 volts to the muting relay. You can also leave it out, or route it below the chassis and solder to the terminal inside the receiver.

Degree of Difficulty

Installation will present no problem for an experienced technician or hobbyist. However, it does require some skill, and should not be undertaken as a "first project". If you are uncertain about this, the best bet is to read the instructions thoroughly and make sure you are comfortable with all the steps.

Treetop Circuits can provide clarification on specific points, so please do not hesitate to e-mail. But please also bear in mind that there is no substitute for basic electronic skills and good workmanship.

And as always, remember that voltages approaching 300 volts are present in this receiver.

Modifications by Owner

Some owners will want to experiment with the circuit. To facilitate this, through-hole resistors and capacitors are used in parts of the AVC circuit, and extra holes are provided near C10 and C11. Please read the section on warranty before modifying the circuit.

Before Proceeding

We recommend that you check our web page http://treetopcircuits.com/docs for the latest version of this manual. Do not hesitate to e-mail us at radio@treetopcircuits.com if you need assistance.

Like all semiconductor circuits, the SB-51 can be damaged by electrostatic discharge. Appropriate practices should be used when handling it.

Preparing the Radio

The radio should be in good operating condition and properly aligned. If this is not the case, it is recommended that a performance check and alignment be performed before proceeding.

Complete documentation for the R-388A/51J-4 can be downloaded from the Collins Collectors Association website at www.collinsradio.org at no charge; this organization is authorized by Collins to disseminate Collins documentation. Membership is not required in order to access the website, the reflector, or other services. However, Collins enthusiasts are encouraged to join.

The BFO alignment instructions in parts 5.3.5 (g) and 5.3.6 of the Collins document ensure that the BFO is centered at 500 kilocycles. This is adequate for CW because it generally does not matter whether the BFO is above or below the IF passband. With an SSB signal, best performance requires that the BFO be placed on the correct side of the passband, and ideally just outside it. Correct settings can be found by trial and error, but these will vary in a complex manner from band to band.

The situation arises because these receivers use different conversion schemes on different bands, so the signal in the second IF is sometimes inverted and sometimes not. Also, by convention, the lower sideband is almost always used below 10 MHz and the upper sideband above 10 MHz.

To help resolve this situation, stickers are provided with the unit. These are applied to the skirt of the BFO PITCH knob *(Fig. 3, 5, and 6)*. You can use either the ham band sticker (yellow highlights) or the general coverage sticker (blue highlights), or both. The extra stickers provided are spares -- do not use two stickers of the same type together.

Fig. 3 – The BFO PITCH knob with stickers.

You can safely ignore the band designations on the stickers at this point. A detailed explanation is given in the section on Operation.

The easiest way to proceed is to remove the knob using the appropriate Bristol spline key. Cut out the sticker(s), as shown and apply to the knob skirt. You may need to give them a final trimming with a sharp knife. Orientation on the knob does not matter from a functional point of view, but you may prefer to align the yellow or blue radial line with the white line on the skirt for best appearance.

Alternatively, rather than remove the knob, you can leave it in place and apply the sticker(s) at the end of the procedure.

If you have access to a frequency counter with a high-impedance probe, you can skip steps 3 to 6 and instead measure the BFO frequency at pin 5 of V114. Remember to use a blocking capacitor. Tune the BFO PITCH control for the highest frequency, which should be around 503 kilocycles, and fasten the knob in the position shown in *Fig. 3*. The BFO range should be roughly 497-503 kilocycles.

1. Set the receiver controls as follows:
   CRYSTAL FILTER SELECTIVITY – *0*
   CRYSTAL FILTER PHASING – *CENTERED*
   BFO – *ON*
   Mechanical Filter (R-388A and 51J-4 only) – *6 KC*
   OFF–STANDBY-ON – *ON*
   RF GAIN – *10*
   CALIBRATE – *ON*
   AVC – *OFF*
   LIMITER – *OUT*
   AUDIO GAIN – ADJUST AS REQUIRED
   BAND CHANGE –3.5–4.5 MEGACYCLES
2. If you removed the knob, put it back on and temporarily tighten one setscrew. Orientation doesn't matter at this stage. Disconnect the antenna and tune across the band. You should hear a tone from the calibrator near each 100 kilocycle point.
3. Tune to approximately 3820 kilocycles, then tune down slowly until you hear a high-pitched tone. To confirm that this is the calibrator signal, turn the CALIBRATE control off. The tone should disappear. Turn the CALIBRATE control back on.
4. Tune as needed until the tone is fairly high. Adjust the BFO PITCH to increase the pitch slightly. Adjust the main tuning slightly to keep the pitch in the audible range. Continue to adjust these controls alternately, in small increments, until the BFO PITCH control will not increase the pitch any further.
5. To check, tune up to 3820 kilocycles again and tune down until you hear the high-pitched tone. Move the BFO PITCH control back and forth slightly to make sure that you have the highest possible pitch.
6. Now, being careful not to rotate the shaft, loosen the setscrew so the knob rotates freely. Rotate the knob to the position shown in *Fig. 3* and tighten both setscrews. Alternatively, if you did not remove the knob, apply the sticker(s) in the position shown in *Fig. 3*.

Installation

Unplug the receiver from the power source. Do not trust the switch.

Refer to *Fig. 4* for the following steps.

Be particularly careful not to contact the insulation on the wires with the soldering iron. It melts and burns more easily than modern insulation.

Remove or disconnect C206 (the small capacitor from V114 pin 5 to V110 pins 6 and 7).

Remove or disconnect C204. (100 pF capacitor from pins 6 and 7 to pin 3 of V110).

Remove V110 and its shield. In most radios, the shield base can remain in place, but remove it if there is insufficient clearance. Mount the clamp as in *Fig. 1*. The lockwasher goes under the nut. Remove the hold-down from the large capacitor and slide the clamp down over it as you seat the SB-51 in the socket. Tighten the clamp and replace the hold-down.

Route the green wires through the chassis as shown. Connect the shorter one (BFO) to V114, pin 5 and the longer one (AVC) to the terminal strip at the junction of C213 and R139.

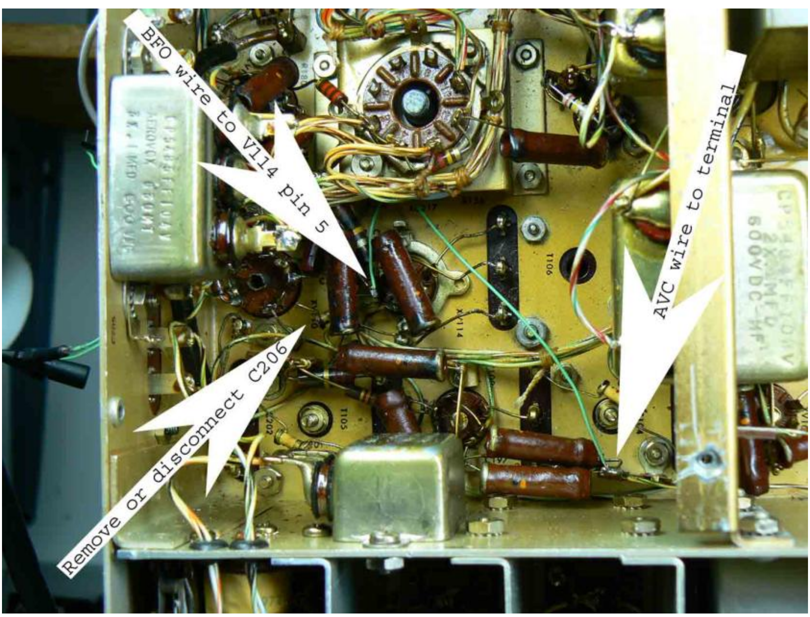

Fig. 4 –C204 has been removed and C206 disconnected. The green wires from the SB-51 have been routed through the chassis beside the large filter capacitor (in the octal socket).

If you want to use the 12-volt supply to operate the muting relay K101, connect a wire from the 12vdc point on the SB-51 to terminal 3 on the "REMOTE" terminal strip E101 on the rear of the chassis (*Fig. 2*). This wire can be routed below the chassis and soldered to the terminal, or brought through one of the slots in the side of the receiver and fastened under the screw on the terminal strip. With this in place, a ground applied to terminal 2 (typically from an associated transmitter) will mute the receiver. **Please note that this relay does not replace the antenna relay in the transmitter.**

Operation

Now you can connect an antenna and try it out.

Control functions are unchanged. AM operation is completely unaffected. On SSB, the receiver will be much easier to operate. In most situations, you can leave the RF gain turned up and the AVC on. It will no longer be necessary to "ride" the RF gain control.

The band designations on the BFO pitch knob are mostly self-explanatory, but the following notes may be helpful.

The sticker with yellow highlights is marked for the ham bands. Setting the knob according to the sticker automatically selects LSB for bands below 10 megacycles, and USB above 10 megacycles. Since portions of the 10 meter band fall in three different bands in this receiver, things get a bit more complicated. The portion from 28 to 28.5 megacycles is designated 10A, the portion from 28.5 to 29.5 megacycles is 10B, and the portion from 29.5 to 29.6 megacycles is 10C.

If you never need to listen to SSB outside the ham bands, you can skip the next two paragraphs, and ignore the "blue" settings. But they'll come in handy if there's an interesting SSB signal around (for example) 13 megacycles.

To provide for general coverage, we take advantage of the fact that there are actually two positions of the BFO PITCH control which will produce a given frequency. The sticker with the blue highlights uses these "extra" positions. The section marked "3, <10 EVEN, >10 ODD" is used for Band 3 (2.5 to 3.5 MHz) and for bands 2, 4, 6, 8, and the lower half of Band 10. This automatically gives LSB operation. Above 10 MHz, USB is normally used, so the same setting would be used for odd Bands 11, 13, ...29.

The other section of this sticker applies to bands 1, 2, 3, 5, 7, 9, the upper portion of Band 10, and Bands 12, 14, ...30.

You'll need to establish the best BFO PITCH settings for your particular receiver. To get started, turn the SELECTIVITY control to 0 and set the mechanical filter switch (if present) to 6 kc. Turn the AVC and BFO on. Choose a band where there will be lots of SSB signals, and set the BFO PITCH control to the position shown in Fig. 3, or the diametrically opposite position, depending on the band you're using. For instance, on 20 meters, you'd use the opposite position. With a bit of careful tuning, you should be able to receive SSB stations. You'll find the tuning a bit more critical than with many receivers; this is because the tuning rate is 100 kilocycles per revolution, as opposed (for instance) to 25 in the Collins S-line radios.

With these settings, the BFO PITCH adjustment is not very critical. However, you'll want to be able to use the crystal and/or mechanical filters in crowded band conditions. In general, as you move to narrower bandwidths, you will find that the best setting is closer to the center of the range, as in Fig. 5 or 6.

Fig. 5 – A typical ham-band setting for a narrow-band filter.

Fig. 6 – This setting actually produces the same result as Fig.. 6. You'd use it for Band 13, which is >10 megacycles and odd-numbered.

The required setting is a function of the filter, not the band. So once you've found the best point for, say, 80 meters with a given filter, the same setting will work for the other bands in the same portion of the label.

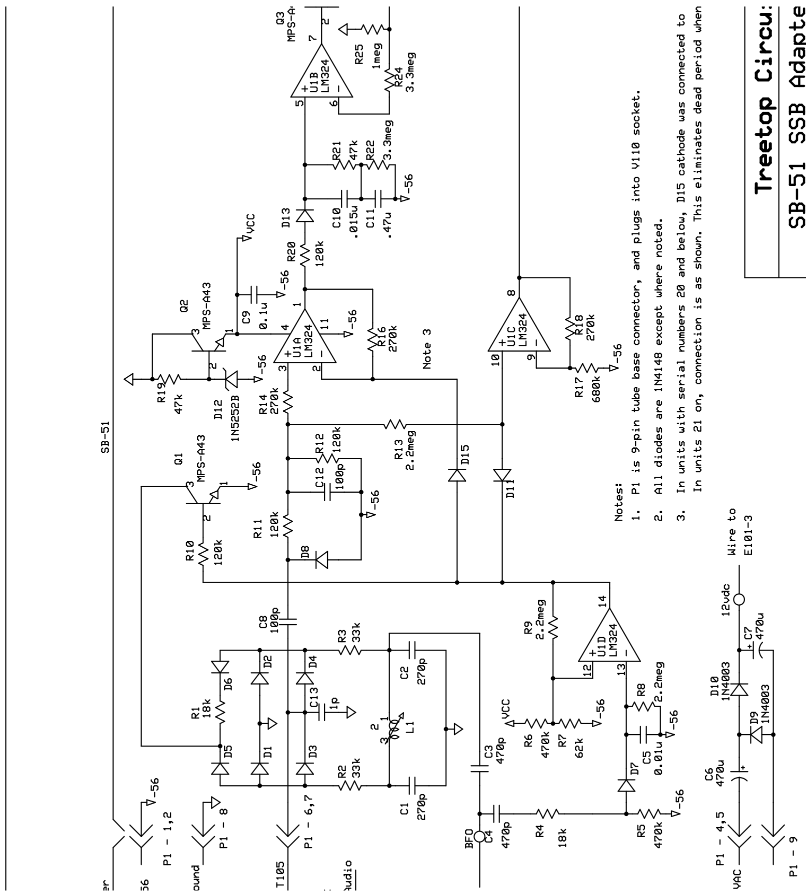

Fig. 7 – SB-51 schematic.

Circuit Description: ***(see Fig. 7*****)**

In the following description, references to components on the SB-51 circuit board are shown in bold (**C1**, etc.), and those in the receiver are in normal text. To assist in following this description, the schematic shows some of the receiver circuitry.

The SB-51 plugs into the V110 socket instead of the tube. Most interconnections are made through the 9-pin connector P1. In addition, direct wire connections are used for BFO and AVC signals and the 12 volt DC supply.

Operating power is derived from the -56 volt line in the receiver, which appears at pins 1 and 2 of P1. Since the AVC amplifier in the receiver uses this line as a reference, it is convenient to reference most of the circuitry in the SB-51 to this line as well. Zener diode **D12** and transistor **Q1** provide a regulated voltage (VCC), which is held at +23 volts relative to the -56 volt supply line. This powers the quad amplifier **U1**.

In the original receiver circuitry, an envelope detector circuit is used for AM, CW, and SSB reception. The AVC circuit is useful only for AM. To receive CW or AM, the BFO is simply switched on. The SB-51, on the other hand, uses a product detector and fast-attack, slow-return AVC system for CW and SSB, so mode switching is required.

Mode switching in the SB-51 occurs automatically when the BFO signal is present. **D7** and associated components rectify the BFO signal; **U1D** acts as a comparator, with the threshold set by **R6** and **R7**.

For AM reception, the BFO is switched off. The output of **U1D** goes positive. **Q1** saturates, applying nearly -56 volts to the anodes of **D1** and **D3** so they do not conduct. Current flows through **D6** and **D2** to ground. Additional current flows through **D2** to ground via the path **D5**-**R2**-**L1**-**R3**.This keeps its cathode, and the cathode of **D4**, at an essentially constant voltage of about 0.7 volts below ground. **D4** then acts as a pre-biased diode detector, replacing one section of V110 as an AM detector. As in the original circuit, this causes the audio component to appear on C202.

For CW or SSB reception, the rectified BFO signal causes the output of **U1D** to approach the -56 volt line, turning **Q1** off. Diodes **D1-D4** and associated components form a high-level single-balanced mixer. The BFO voltage (about 35 volts RMS, 497 to 503 kilocycles) is applied via **C3** to the resonant circuit consisting of **C1**, **C2**, and **L1**. **C3** blocks the DC component, so the voltage on **C2** swings above and below ground. Due to the resonant circuit, the voltage on **C1** is equal to that on **C2** but in opposite phase. When the voltage on **C2** is negative, the voltage on **C1** is positive, so current flows through **R2**, **R3**, and **D1**-**D4**. This forces the IF signal line to ground. On the alternate half-cycle, diodes **D1**-**D4** are reverse-biased, so they present an open circuit to the IF signal. The path from ground via pins 6 and 7 and T105 to C202 is thus interrupted at the BFO rate, causing the demodulated audio signal to appear on C202.

In either mode, The AVC signal is developed using **D8** and associated components. The resulting roughly-filtered positive DC signal is applied to non-inverting amplifiers **U1A** and **U1C** via **R13** and **R14**.

In AM mode, since the output of **U1D** is near VCC, the inverting input of **U1A** is driven positive via **D15**; this cuts off **Q3**. **D11** is reverse-biased, so the AVC signal is applied via non-inverting amplifier **U1C** to the original time-constant circuit and thence to the grid of the AVC amplifier V111. AM operation is thus essentially the same as the original.

In CW/SSB mode, the input of **U1C** is driven close to -56 volts, thus forcing its output below the threshold of the AVC amplifier in the receiver. The AVC signal is applied via **U1A** to the fast-attack, slow-return network. The main time-constant capacitor is **C11**, with the attack time controlled by **R20** and **R21**, and the return time by **R22**. **R21** and **C10** provide a fast-attack fast-return function which prevents overload on brief noise pulses while avoiding desensitization. **U1B** drives inverting amplifier **Q3**, which drives the main AVC line in the receiver. The AVC amplifier V111 is not used in SSB mode. **R25** provides a small threshold voltage, eliminating the long "tail" on the AVC return.

The +12 volt DC supply for the muting relay is derived from the 6.3 volt AC filament supply by a doubler consisting of **D9**, **D10**, **C6**, and **C7**. The RTN connection goes to ground via pin 9 of **P1**, so the supply is ground-referenced.

Warranty and Return Policy

If you are not satisfied with the product for any reason, you can ship it back to us. Provided that it is shipped within 30 days of your receiving it, and we receive it in good shape, we will credit your PayPal account with the amount you paid us – that is, full purchase price including shipping one way.

If the product fails in normal use within one year from when you received it, return it to us at your expense. We will repair it and ship it back to you at no charge or replace it (our option)."Normal use" means that it is installed in a correctly functioning Collins R-388, R-388A, 51J-3, or 51J-4 receiver, according to the instructions provided and using good workmanship. Also, we will not be responsible for damage caused by receiver malfunction or other events beyond our control, including (but not limited to) power surges and lightning hits.

Non-warranty repairs will be carried out for a flat fee of $20 U.S. plus shipping both ways. We reserve the right to refuse to repair heavily damaged units under this policy.

If you ship the unit, use an anti-static bag like the one it came in, or wrap it in aluminum foil, to protect it from static electricity generated by packing material.

You can modify the unit without automatically voiding the warranty. However, you must tell us in detail what changes were made, the workmanship must be good (in our judgment), and we have the final word on whether your actions caused the failure. We make this provision so that knowledgeable owners can alter the AVC time constants and other properties according to individual preferences.

73,

Bob Thomas   VE3TOU

Owner, Treetop Circuits