

Converting the Heathkit SB-620 for 3395kHz IF Receivers

By Stephen H. Lafferty, Rev.5



The Heathkit SB-620 “Scanalyzer” is an IF spectrum analyzer. It graphs the amplitude of signals in a range of frequencies around the one that your receiver is looking at. It can show spans of 500kHz, 50kHz and 10kHz, so you can see all of the signals around you at a glance. Problem is, it has to be setup for the particular IF frequency of your receiver. In the original kit, Heath kindly included the various coils and other parts which you would need for a wide range of IF frequencies. You could only install one though and of course, the coils for the others are rare.

I have a classic Heathkit SB-301 receiver which has an IF of 3395kHz. This is also the IF of many other Heath receivers, including: SB-100, SB-101, SB-110, SB-102, SB-104, SB-300, SB-301, SB-303, HW-100, HW-101 and HW-104. The SB-620 I had was setup for 455kHz, though.

Here is how I converted it to work with my receiver. The photo above shows it operating with actual 80m signals. Please refer to the complete schematic of the modified unit at the end of this article. The changes to be made are summarized in the table below.

Part Reference	455kHz	3395kHz	Comment
Transistor Booster amp	(none)	installed	Optional home brew, see below.
L2 IF Coil	40-590	52-101	Now home brew.
L3 Osc Coil	40-775	40-776	Now home brew.
1-post Terminal Strip	(none)	installed	Used at L3.
RFC1	300uH	(none)	
R1	820K	22M	
R2	100K	5.6M	
C3	260pF	470pF	
C4	75pF	5-65pF var	Originally 56pF for 3395kHz

R26 becomes R28	15K	10K	
R27, 29	(none)	3.3K	
C14	510pF	(none)	
C16	470pF	(none)	
C15 becomes C18	0.02uF	0.02uF	Just changes name.
C17	(none)	0.02uF	
C19,22	(none)	120pF	
C21	(none)	1800pF	Can use 1500+330pF
C19A, C22A	(none)	5-65pF var	Added as modification.

The following parts which connect to the coils were replaced rather than salvaged:

<u>Part Reference</u>	<u>455kHz/3395kHz</u>
R7	47K
R8	22K
R9	10K
C2	100pF
C5	120pF
C23	0.02uF

Test Equipment

I recommend that you have the following test equipment to debug and adjust the modified unit:

- RF Generator
- Frequency counter
- Volt-ohmmeter
- Oscilloscope

Why the Booster Amp?

My good friend Dave, who has to have a logical explanation for everything, demanded this section. :) The transistor booster amp is optional. I needed it. Maybe my SB-620 was weak. Maybe your receiver supplies more IF signal than my SB-301. You could try it without the amp and add it if necessary (as I did). Still, it remains somewhat of a mystery as to why Heath didn't provide more gain. There might be many answers to that question.

I found that, with just the gain of the RF amp stage ahead of the mixer, the IF tap on the SB-301 produces only about -90dBm for a weak signal. With about 20dB of loss due to the 10pF tap, this seems reasonable. Before adding the amp, my SB-620 could display a pip at -80dBm. Heath specs about -87dBm. Admittedly, a couple tubes in the SB-620 look rather weak on an Eico 667 tester. On the other hand, some people don't consider tube testers to be very accurate at gauging the quality of a tube. I must also confess that my antenna is just an inverted-L, 20-feet high and 60-feet long, without any tuning network. So your situation might be somewhat better than mine.

I did go through the unit pretty well and couldn't find any smoking gun as far as gain is concerned. Could have tried to scratch for a couple dB here and there. Bear in mind though, that on the 40dB log scale displayed, differences of 6dB or so don't look like very much. I like to be able to see the noise floor on a spectrum analyzer. It makes a good reference point. Even in the impressive scope photos in the Heath manual, you don't see the noise floor. It was clear that the only way to get there would be with an extra amplifier. It does show the noise on 80m now, at least in my neighborhood.

Heath might have been satisfied with less gain than I would want. They had to keep the cost reasonable and with its big transformer, CRT and HV power supply, the parts cost was probably getting worrisome. In 1969 they sold it for just \$119. Being just an optional accessory, it couldn't command a high price, like the \$260 SB-301. So I hope this explains to some extent, why I feel

the amplifier is needed and why Heath might not have felt that way. The PIP Gain control has stayed at max, by the way.

Making the Coils

The two coils needed are L3, a tapped oscillator coil and L2, a 1:1 IF transformer of sorts. A quick search convinced me that the original parts are rare. Using information gleaned from the web and from kind members of eHam.net, I constructed new ones. For L3 you can start with:

- <http://www.surplussales.com/inductors/Ind-SlugTu/Ind-SlugTu-1.html>
part number: (IVF) SMB-72905. \$5.60 each.
- The inductance is about right but it needs a tap added *as shown in the picture below*. Note that it does NOT have the low-side range claimed. Might have been a typo. (Have informed Surplus Sales.) I found that it goes down to about 20uH. That is the reason that C4 was changed to a trimmer.
- The terminal on the right was added using #12 wire and 5-minute epoxy. If you wrap it all the way around as I did, be sure to cut the circle with a rotary tool or such after it hardens to avoid a shorted-turn effect.

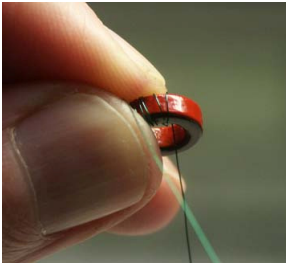


- To connect the tap: (Refer to figure above.)
 - Disconnect the outer end of the coil wire from its terminal and unwind 10-turns. By “outer end,” I mean the end which is on the outside of the windings, so you can unwind some turns.
 - Route the wire to the new lug and wrap a couple turns around it so you can solder.
 - Route the rest of the wire back to the coil and wind 6-turns in the direction it originally had, on top of the existing turns.
 - Wrap the end around the disconnected old lug and cut off the remaining wire.
 - Solder the old lug and the new lug. 750C iron temperature and extra rosin flux will help get through the insulation.
 - Secure any loose wire with adhesive or clear fingernail polish. I used heatshrink around the coil wire for protection.

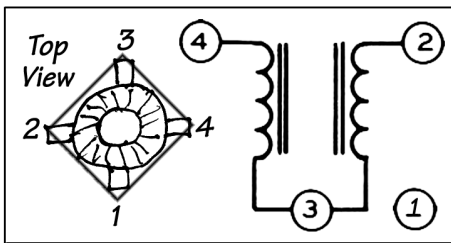
To make the L2 transformer, you can construct it *as shown below*:



- Order the two toroids needed from the same website mentioned above. Part number (ICH) MM-T37-2 Iron Powder Toroid, Red, \$0.45 each.
- I used a 10-32x2" nylon screw as a form with seven nuts: One holds the top toroid, two hold the other toroid, two hold the terminal board and two secure the assembly to the chassis.
- Wind 62-turns of #34 magnet wire around each of two toroids. As you can see *in the photo below*, it's a bit of a dexterity test but you get better at it quickly and it goes a lot faster than you might imagine at first. Try to keep tension on the turns as you wind. Avoid crossing over previous turns. At the end, don't worry if they rearrange themselves rather haphazardly around the core. Just try to keep tension on it. Twist the two leads on each finished coil a couple of times to secure the windings.



- Position the toroid coils on the nylon screw and adjust their separation to exactly 5/8". Measure that between the closest edges of the toroid cores.
- Make a terminal board from a square of perf board cut on 0.6" rows. Drill a 7/32" hole in the center for the screw.
- I use press-fit wire wrap stakes for terminals, cutting them off underneath at about 1/8."
- Polarity of the primary and secondary does not seem to matter but you will want to keep the Heath terminal pattern (including the unused #1 lug) for ease of installation, *as shown below*.



- Mount the terminal board as shown in the photo. Bring the leads from the toroids down the column in wide spirals, to keep them snugly against the post. Wrap a couple of tight turns around the bottom of the terminals under the board and solder.
- Two more nuts at the end of the screw are used to mount L2 to the chassis.
- Sources:

<http://www1.msdirect.com/cgi/nnsrhm>

10-32x2" nylon screws #67347161 \$10.35 per 100.

10-32 nylon nut #67352005 \$8.16 per 100.

<http://www.oemwire.com/smagwireq.htm>

34 Awg Copper Magnet Wire 1/4 lb \$8.79.

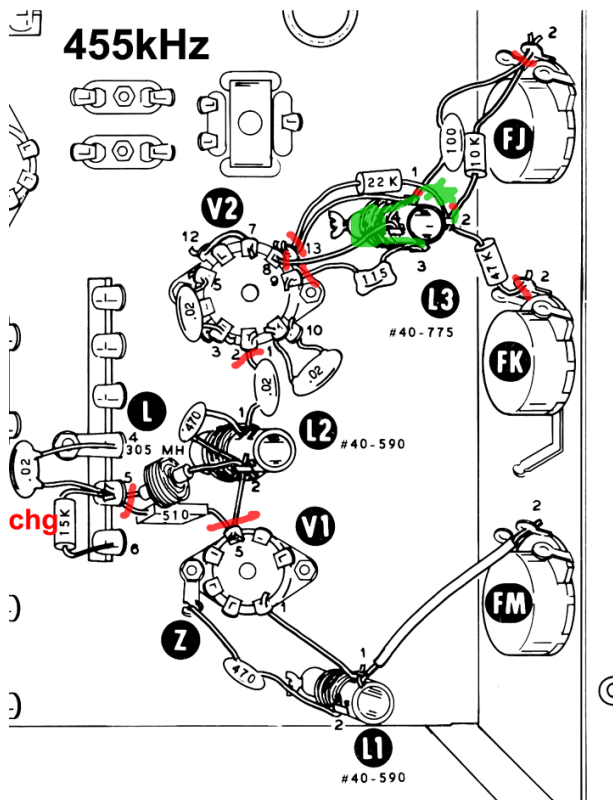
<http://www.mouser.com/>

574-T68/C Wire Wrap Post \$10.71 per 100.

Removing the Old Parts

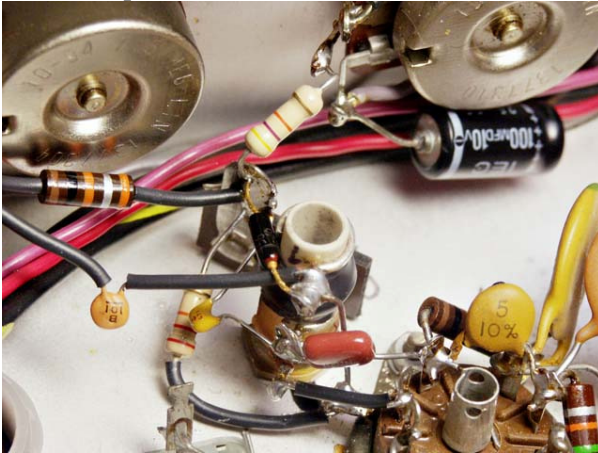
My SB-620 was setup for 455kHz. If yours is something different, the details of this section may not apply. Rather than attempt to salvage resistors and some caps which are attached to the coils, I removed them with the coils and provided replacements, where appropriate. I would urge you to remove the original coils carefully so that they might be used in another SB-620 whose owner needs the old frequency.

The figure below shows the main cuts used to remove the old parts. One part that you DO need to salvage is the varactor diode which is mounted on L3. The Web suggests that the diode might be an MV1638. It is shown roughly sketched in green since Heath didn't show it. A missing cap is also roughly shown in green. Use a heatsink such as a hemostat while you remove the diode. I know stainless steel isn't the best heatsink but its tight grip and small jaws work well in a crowded situation like this. Minimize the heat stress.

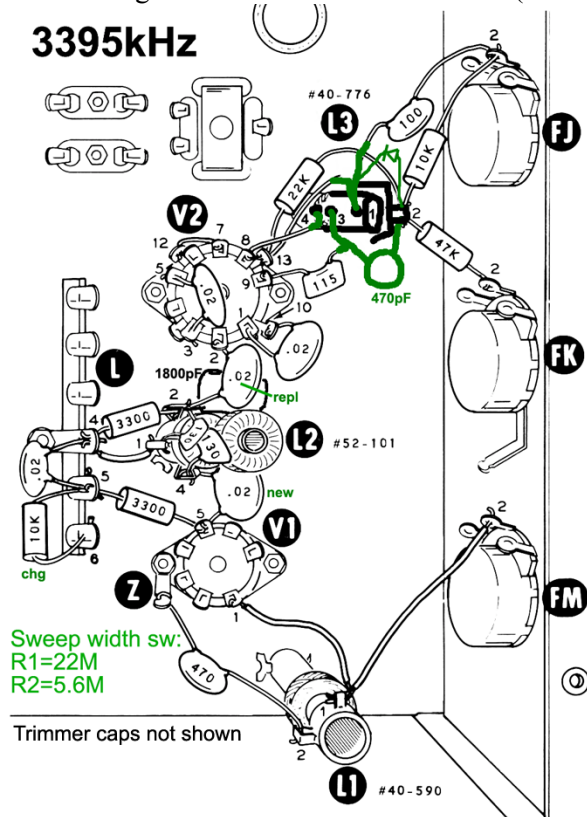


Installing the New Parts

- Mount oscillator coil L3 with the included nut and a 1-post terminal strip nearest the front panel. Since the existing hole is larger than the threaded shaft, I drilled-out a suitable fiber washer to make a ring to fill the gap. *The next photo* shows L3 before the variable cap C4 was added.



- Mount transformer L2 with the two nylon nuts. Use a fiber washer as with L3. Orient pin-1 towards the nearby terminal strip.
- Install the new resistors and capacitors for L3 *as shown in the following diagram*. The numbers on the L3 terminals match those of the original schematic. Lug-2 is represented by the terminal strip lug. Notice that the trimmer caps are not shown, as they go in last. Don't forget 1800pF C21 (like I did :) which is partially hidden. Its hidden lead goes to Lug-3 on L2 which is also hidden. (It's on the side of L2 nearest the pots.)



- Solder the trimmer cap to lugs 1 and 3 of L3 as shown in the photo of the booster amp, second photo down.

Below you can see L2 with the trimmer caps. Mount the trimmers across lugs 1-2 and 1-4 of L2. Sharp eyes will notice that the forgotten C21 is missing. This picture was also taken before the booster amp was added. With the booster amp, C23 (above the left trimmer) will go to the amp instead of V2-2.

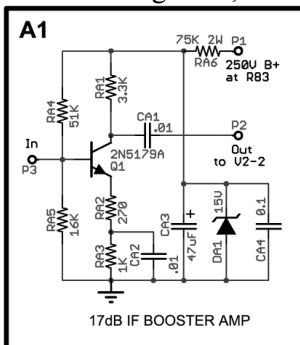


Adding the Transistor Booster Amp

The photo below shows the IF Booster Amp. It provides about 17dB of gain which I found was needed to use the scanalyzer effectively with my SB-301 receiver.



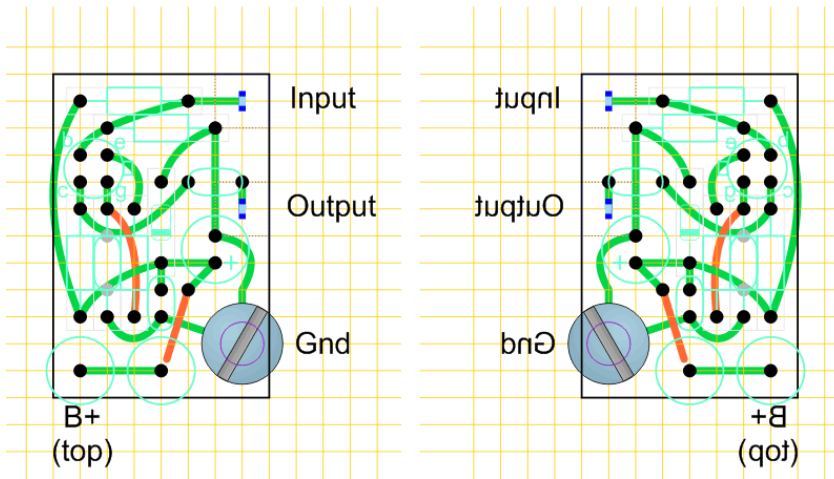
- The schematic of the booster amp *is shown below*. It connects in the main circuit as triangle A1, between C23 and V2-2.



- You can make the amp on a piece of perf-board cut to 0.8" x 1.2". Drill a 7/64 hole for the 4-40 mounting screw, 0.1" from the side with the terminals and 0.2" from the side with RA6.
- The layout of the board *is shown below*. Wires on the bottom are in green and top side leads are in orange. Notice that CA2 is piggy-backed on RA3. I used a 1W 33K and a 1W 39K in series to make the 75K 2W resistor.

Top View

Bottom View

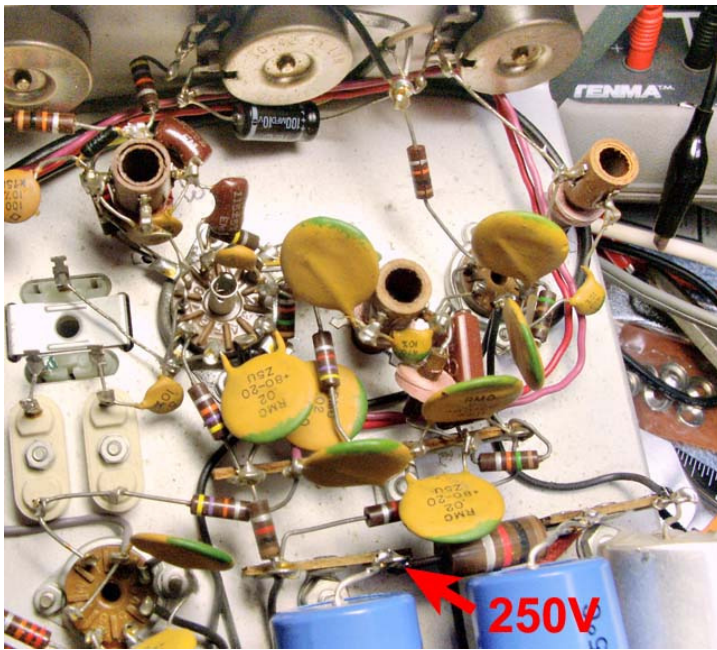


- The 2N5179 RF transistor has a fourth lead tied to the case. I labeled it "g".
- If you decide not to use this layout, try to keep leads and parts which are connected to the base, away from those at the collector. Use good RF layout practice.
- The parts list for the booster amp is below.

Part Reference Description

Q1	2N5179A
DA1	Zener diode 15V at 1mA
CA1, CA2	0.01uF ceramic cap
CA4	0.1uF ceramic cap
CA3	47uF cap 25V or more
RA1	3.3K
RA2	270R
RA3	1K
RA4	51K
RA5	16K
RA6	75K 2W or (33K 1W plus 39K 1W)

- Include a lug connected to the board ground on top at the location of the screw.
- To mount the board in the Scanalyzer, remove the screw and nut nearest the front panel which fastens the tube socket for V2. Replace it with a 4-40x1/4" screw and 9/16" standoff, hex size 3/16" and threaded for 4-40 screws.
- Mount the board, as shown above, to the standoff with another 4-40x1/4" screw.
- Change C23 to connect from lug-2 of L2 to the input lug of the amp board (instead of V2-2).
- Connect a wire from the output lug of the amp board to V2-2.
- Find the +250V terminal marked *in the photo below* (taken before modifications). Run a red wire from there to the top of RA6. Use heat shrink to cover all of the exposed wire at resistor. Very important for safety. Seeing the transistor, one might not expect HV at that board.



Adjusting the Scanalyzer

Now that you've done the hard part, it's time to have some fun! The first thing we need to do is to adjust the local oscillator. It should be at 3.745MHz. Use a scope probe on your frequency counter and clip to V2-2 to read the frequency. Carefully set the PIP Center control for the exact center of its rotation. Set L3 for the lowest frequency (highest inductance). Then adjust trimmer C4 for 3.745MHz.

Next, we will peak the bandpass filter at L2 for 3395MHz. Set an RF generator to that frequency and connect it to the IF input on the rear panel. The switch there should be in the up position for "Ham scan". To find the signal, set PIP Gain to max, PIP Center to center position, Variable Sweep width to max, Variable Sweep Rate to center, Amplitude Scale to Log and Sweep Width to Variable. Zero-in on it by reducing Variable Sweep Width while adjusting PIP Center if necessary to keep it visible.

Change Amplitude Scale to Lin and adjust PIP Gain and your generator level to get a good showing of amplitude. Adjust trimmers C19A and C22A for max indication. This completes the adjustments for the new circuitry. I recommend that you align the IF, input trap and log tracking.

Installing an IF Tap in the Receiver

You will need to install a tap on the IF of the receiver to be able to use it with the SB-620. Heath has good instructions for this in the manual. Generally, they advise connecting about a 10pF cap to the plate or collector of the mixer stage which is driven by the receiver's variable oscillator. This is routed by a length of shielded cable to a connector. The SB-301 has spare phono connectors for this type of thing. I noticed that the tap drops the level about 20dB. That's the price paid for not loading the mixer heavily. Unfortunately, it also increases the need for the booster amp.

Operating Tips

I won't try to duplicate Heath's excellent operating instructions but here are a few things that are handy to know.

- If possible, you will want to be able to disable the receiver's AGC. Otherwise the whole spectrum moves up and down when you are receiving an SSB signal. If you can't disable it, use slow AGC mode if it is available.

- You may find that some signals, particularly CW, seem to disappear as the receiver is tuned to them. In the SB-301, the crystal IF filter which follows the mixer loads the plate heavily in its passband. That causes the level that is tapped there to drop a great deal. Fortunately, the notch that it creates seems to be very narrow, so it isn't really a problem for viewing voice signals. You just need to know that it's there so you can take it into account.
- During operation, you will want to know where your receiver passband is on the screen. Yet, it can be surprisingly hard to get the SB-620 centered on the receiver if you don't know the tricks. PIP Center must be precisely set to target the receive frequency in the 10kHz and 50kHz modes. A sure way to set that is to put the receiver in 100kHz cal mode. Tune accurately to one of the harmonics.

Next, set the SB-620 to variable sweep, minimum Var Sweep Rate. Center the Var Sweep Width, PIP Center and Horiz Pos controls. Find the tallest cal signal and adjust PIP Center to bring it to center screen. Reduce Var Sweep Width to minimum and adjust PIP Center to bring it back to center.

Switch to 50kHz sweep width. Re-center with PIP Center. You will notice that PIP Center is pretty touchy now. Switch to 10kHz sweep width. Re-center with PIP Center. It will be *really* touchy. You may have to hunt for the signal a little. Notice that the PIP moves in the direction that you turn PIP Center.

Now switch back to variable sweep mode. The position of the PIP is the true receiver frequency. Adjust Horiz Pos to put it in the center. The SB-620 is now aligned to the receiver's passband. This may sound a bit complicated but getting the PIP Center and Horiz Pos controls accurately set make it much easier the next time. Just remember that your goal is to get the PIP targeted in the narrowest (10kHz) sweep range. You have to work your way down in range to find it.

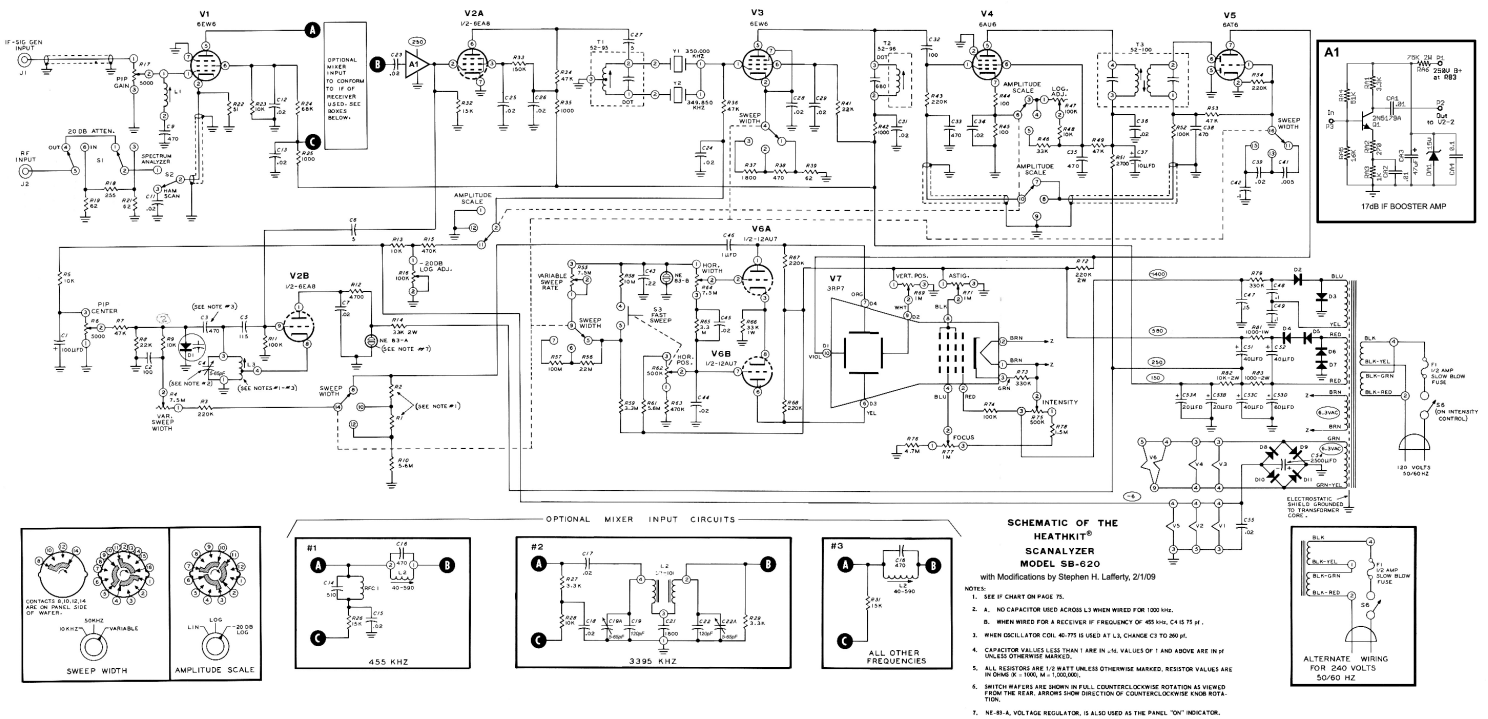
General Info about the SB-620

- It might seem obvious but it should be stated that the SB-620 horizontal scale increases in frequency from left to right. You might be surprised to find though, that as you tune your receiver up the band, IF signals seem to move up in frequency, instead of down. The reason, in the case of the SB-301, is that the receiver uses a high-side LO. That causes the spectrum at IF to be reversed.
- The local oscillator in the SB-620 is a high-side LO. With the Scanalyzer IF at 350kHz and the receiver IF at 3395kHz, the nominal Scanalyzer LO is at 3745kHz.
- 3dB IF bandwidth of the SB-620 is fixed by its crystal filter at roughly 200Hz. They specify a usable resolution of 1kHz.

The Var Sweep Width control affects the 10kHz and 50kHz modes, as well as the variable mode. As called for in the Heath alignment procedure, you should find out what setting of Var Sweep Width is needed to get actual 10, 50 and 500kHz sweeps. In my case, they all happened to be at the second mark of the control.

Schematic

The schematic below incorporates all of the modifications described in this article. That includes adding trimmers to the 3395kHz option circuit, replacing C4 in the oscillator with a trimmer and adding the booster amp, A1.



Acknowledgments

Thanks to Data Professionals, for permission to use the schematic and illustrations from the SB-620 documentation.

I would like to thank Allen Ward, KA5N for his very helpful advice regarding the coils.

I also thank Kees Talen, K5BCQ for his excellent Web page on the SB-620, which made this project possible: <http://www.qsl.net/k5bcq/620/620.html>

Thanks to David Gillespie, for reading the manuscript and making several good suggestions for improvements.

And of course, many thanks to the Heathkit company for this and all the wonder, teaching and joy that they have given us over the years.

Contact Info

I will try to help if you have any questions about this article. Comments and feedback about your experiences with the modification are most welcome. You can reach me at: steve@tronola.com

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