BUILD THIS Hobby Spectrum Analyzer

At less than $100 to build, this spectrum analyzer is a must for every hobbyist!

BOB KOPSKI

Over the last two months we have discussed the theory behind the $100 *Hobby Spectrum Analyzer* and built and tested its various boards and subassemblies Now it's time to put everything together and finish up the project

Functional Interconnection and Test. Connect all four functional modules together on the bench top for a final check This is not the *cleanest* RF arrangement, but it is workable for initial inter-module checkout

Hook up the bench supply and current meter to the DC/DC converter and regulators battery lead Turn on the HSA power switch but not the comb generator switch, and slowly run up the variable supply from zero, watching the current drain behavior as you advance to 12-volts DC. Look for a current draw of 26-31 mA. Turn on the comb generator; the current draw should increase 5-8 mA. Turn the comb generator off.

Connect the log amplifier output temporarily to the oscilloscope input, and the trigger output to the oscilloscope's trigger input. Set the vertical coupling to AC, and the range to 0 1 volts/division. Set the sweep to 1-mS per division Set the IF ATTN to normal, and the INPUT SWITCH to mid-position (50 ohms). You should see a noisy baseline trace having about 0.1 volt peak-to-peak of noise Be sure the oscilloscope is triggered for a stable display. Turn on the comb generator. You can expect a mess of vertical lines to appear on the oscilloscope If so, you're now ready to do final assembly and alignment

Cabinet Assembly. All modules and related parts easily fit in the specified cabinet; nevertheless, care is required in marking, drilling, and installing everything

Start by flattening the dimples in the cabinet bottom where the feet screws were intended to go. The rubber feet can be glued on later. Hold a Universal prototyping board on the cabinet floor and mark four hole locations for the stack bolts The rear board edge should be located 0.5-inch inside the rear panel, and as far to the right side of the cabinet as possible Drill the holes. The stack screws are #6 machine screws. It is easier to slip the Universal prototyping boards over the #6 screws if the holes in the boards are drilled out to 5⁄32-inch diameter.

Next, drill the holes for the four phono jacks on the rear panel located on a line 1⅜-inch up from the cabinet floor to clear the stacked boards inside Jack-to-jack spacing and electrical assignment are not critical. Glue or double stick tape a ¼- inch thick, ¾-inch wide, 2½-inch wood or foam spacer block on the rear cabinet wall right behind the battery box location Attach a strip of self-adhesive-backed Velcro tape to the battery box bottom and the cabinet inside floor, and trial mount the battery box.

The front panel is the most difficult mechanical task With the RF circuit

PARTS SUPPLIERS

DC Electronics
PO Box 3203
Scottsdale, AZ 85257-3293
Tel: 800-467-7736

Digi-Key Corp.
701 Brooks Ave So
Thief River Falls, MN 56701-0677
Tel: 800-344-4539

Electronix Express
365 Blair Road
Avenel, NJ 07001
Tel: 800-972-2225

Hosfelt Electronics Inc.
2700 Sunset Blvd.
Steubenville, OH 43952-1158
Tel: 800-524-6464

Ocean State Electronics
PO Box 1458
6 Industrial Drive
Westerly, RI 02891
Tel: 401-596-3080

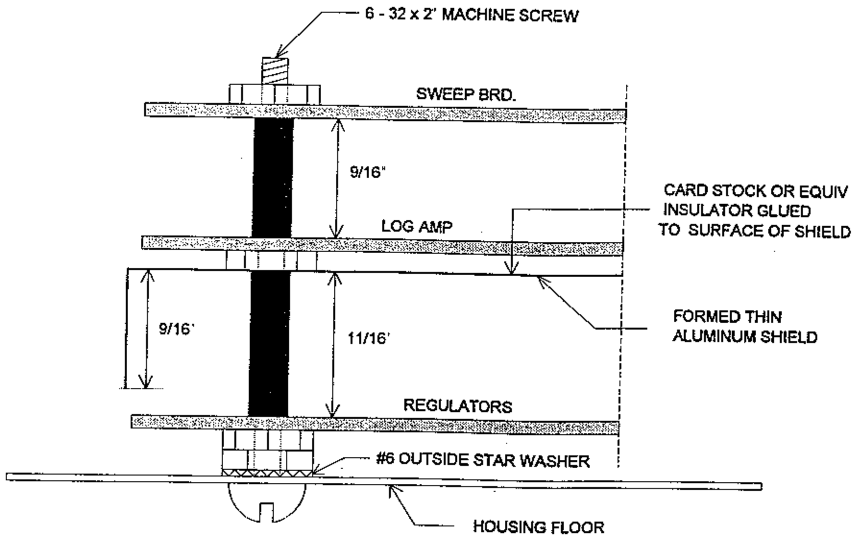
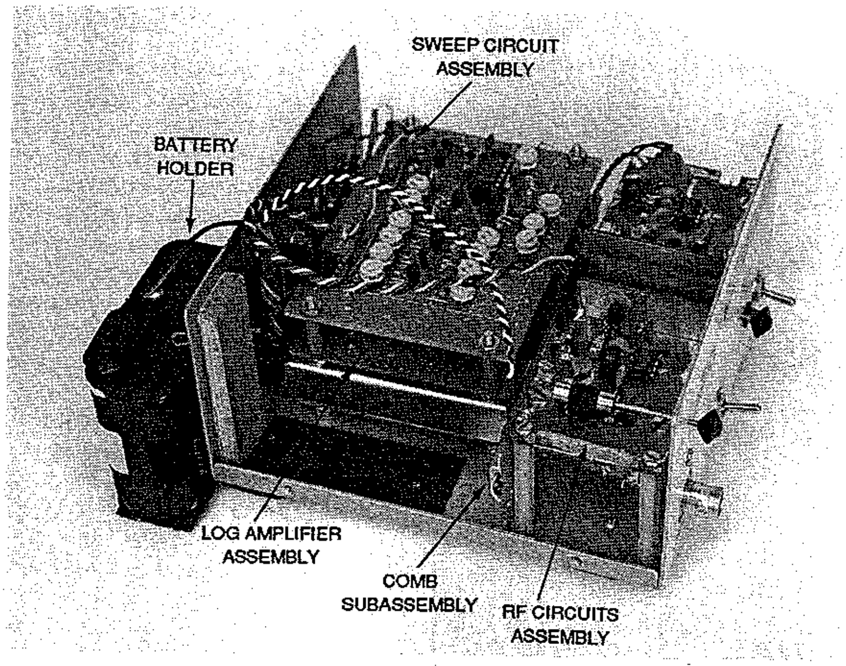


FIG. 12—MODULE STACK ASSEMBLY details are illustrated here (not to scale). Aluminum shields between the log amplifier module and DC/DC converter and regulators module provides RF shielding from stray radiation generated in the DC/DC converter circuitry



FRONT PANEL OF THE HSA mounts four switches and a BNC connector for the input signal. The rear panel (not shown) has four RCA phono jacks that provide three output signals and a battery test point

module in hand, mark off the various hole centers in the front panel. There are two critical hole locations: the 5/64-inch holes for the switch push rods (discussed in a moment) Make sure the alignment is correct before you drill. Use a 5/8-inch chassis punch to make the clearance opening for the BNC connector. Finally, the panel screw just above the BNC connector is a 4-40-1/4-inch screw. It screws into a tapped hole in the BNC mounting plate to draw the latter snug against the rear surface of the cabinet front panel

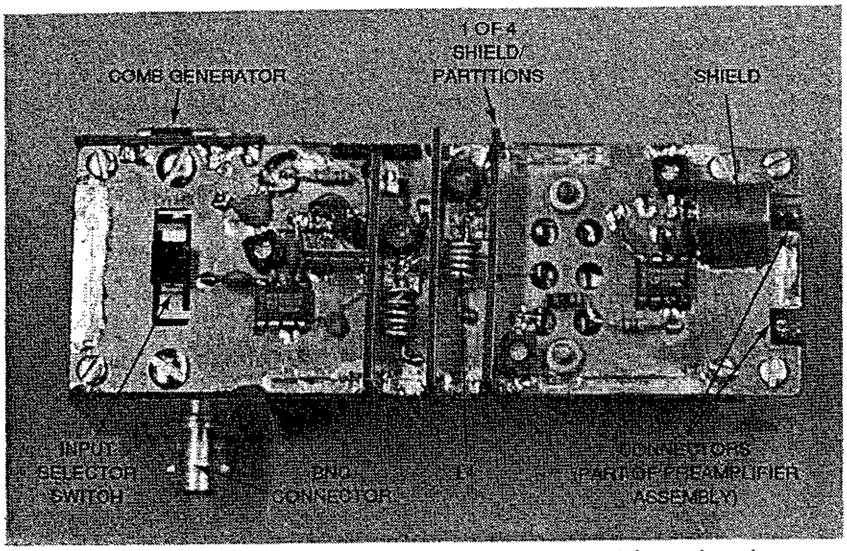
Locate and drill the four mounting holes in the cabinet floor for the RF circuit module spacers ("legs"). The mounting holes for the toggle switches and POWER LED2 are not critical Make push rods for the switches using 1/16-inch brass rod, a decorative bead glued on for a knob, and model-plane wheel collars to capture the sliding switch knobs themselves. Install all the electronics/interconnections in the cabinet as in the drawings and photos Temporarily omit the topmost stack nuts (Fig. 12), so that the sweep board can be lifted to access the log amplifier.

Final Alignment. Temporarily connect the unused preamplifier output test point to the oscilloscope vertical, and connect the trigger output to the oscilloscope trigger input. Power up Connect a lead to a source of 145-MHz signal and allow the lead to *radiate* near the double-tuned 145-MHz filter. Tune the second local oscillator trimmer capacitor C27 and the filter capacitor trimmers C13 and C17 iteratively (again and again) for both a visible audio frequency heterodyne and maximum signal as well Remove the 145-MHz signal

Position the start of the baseline sweep precisely at the left most graticule line on the oscilloscope. Turn on the comb generator. Readjust the sweep circuit board adjustments (in the same sequence as before) to progressively locate the spectral lines on subsequent graticule divisions The sweep offset (R7) and sweep gain (R10) board-mounted controls are used to set the lines from zero to mid-screen (50-MHz) beginning with the 10-MHz component on the first graticule line The remaining adjustments cover the last 50 MHz Unlike the earlier rough tuneup, you can now use the segment gain adjustments (R17, R19, R21, and R23) for fine-fitting the entire sweep shape Work with all the screw adjustments; you can't hurt anything, and you'll observe that sweep alignment goes easily.

If you find that you can't quite hit the highest and/or one or two of the lowest frequencies, note that the HSA will likely not tune below 1-2 MHz As for the high-end difficulties, try adjusting RF circuit module capacitor C6 in conjunction with re-spacing the loops in inductor L2 The trick is to have a suitable ratio of L and C and enough motion in C (via varactor D1) to cover the band

Fine tune the HSA using one of the comb generator's spectral lines The 30-MHz line is good, or an external source can be used Connect the unused preamplifier output to the oscilloscope vertical input and the trigger output to the oscilloscope trigger input. Power up Center up the



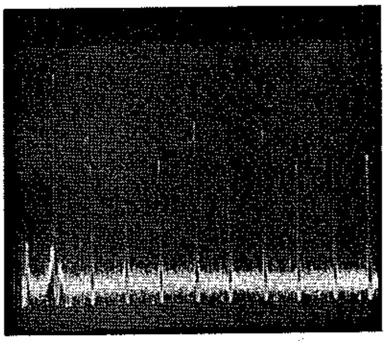
THE RF CIRCUITS MODULE has two subassemblies—preamplifier and comb generator. Note the partition/shield area in the center that isolates the two sections of 145-MHz bandpass filter. Inductor L4 has a tap on the first turn (bottom in photo) that is difficult to see in this view.

desired spectral line on the oscilloscope display, and then use the scope magnifier if it has one. You should see a symmetrical heterodyne bubble including a "suck out" at zero beat. Fine tune the IF trimmer capacitors C13 and C17 iteratively for a smooth sharp passband peak with the heterodyne dead center.

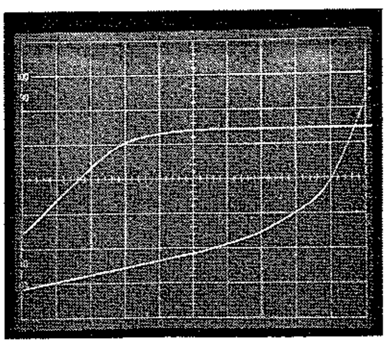
Switch in the IF attenuator and increase signal or oscilloscope gain as necessary to re-display the bubble. It will likely be detuned. Adjust attenuator-compensation capacitor C18 to reshape the display. Note that the bubble should have 1/10 the amplitude of the original signal (it is 20 dB down).

The adjustment of the V+ level is somewhat subjective and somewhat quantitative. Lower voltages reduce the overall HSA gain; the highest values increase it significantly. However, along with higher gains comes more noise, jitter and trash near the baseline. The baseline may also take on an undulating or curvy appearance. Another indication is an unaccounted baseline spike located at about 72 MHz. Setting V+ to a compromise level eliminates all the above unpleasantness and provides for very good operation as well. The prototype's V+ setting is about 5.7 volts.

The spectral line at the 10-MHz position can be used to help adjust HSA amplitude performance. Locate the top of that line on an upper oscilloscope's graticule line at three



A VIEW OF THE HSA comb generator oscilloscope display after the alignment procedure is completed.



THE SWEEP-CIRCUIT OUTPUTS as viewed on an oscilloscope. The lowermost curve is the varactor (sweep) drive waveform—the bottom grid line is 0.0 volts. 5-volts per division. The uppermost waveform is the local-oscillator boost waveform—1-volt/division, top of trace is 4.5 volts. Both curves are displayed on a 1-ms/division time base.

main graticule divisions up from center face. This is the −30-dBm level. The base-line noise should be down around the third main division below center line (almost six divisions below the signal). Set the IF attenuator to −20 dB. The signal should fall two vertical divisions. If it travels less, increase log amplifier output gain (R28); if it travels more, decrease the gain. Continue the adjustment until the attenuator change and the change in display agree. This calibrates the 10-mV/dB log constant.

Adjust log amplifier input gain (R2) so that logging begins above the base-line noise (positive noise peaks should not appear compressed). In all the steps above, be sure the base-line clipper trimmer (R26) is set to *just* trim off negative going spectral lines and *not* infringe on the magnitude of the base-line noise. Trimmer R26 will require resetting during the above procedures.

With that done, the 30-MHz line should be 10 dB lower than the 10 MHz line. The 50-MHz line should be down 5 more dB. The 70-MHz line should be about 3 dB down from that. Finally, the 90-MHz line should be 21 dB below the 10-MHz line. The latter is the line most likely to be off due to the comb-generator-waveform quality limitations. Finally, pay no attention to the even-order spectral lines; if the comb generator waveform were ideal they would not be present at all.

Frequency flatness is best confirmed with a quality signal source/power meter combination. The rough tuneup of the local oscillator boost given earlier should be fairly good, but if you have access to a flat source you can fine tune the boost function. The adjustments R33 and R30 control boost waveform "zero" and ramp rate respectively. The setting of R35 controls the waveform effect on local oscillator power.

Hints. The Hobby Spectrum Analyzer just begins to overload for signals exceeding −30 dBm. This is about 20 mV peak-to-peak on 50-ohm lines. Distortion manifests itself in several ways including baseline "buckling" at the base of such a spectral line, and "splatter" across the display. This situation can often be controlled with the input and/or IF attenuators.

It is sometimes convenient to transformer couple RF energy into the HSA.

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SPECTRUM ANALYZER

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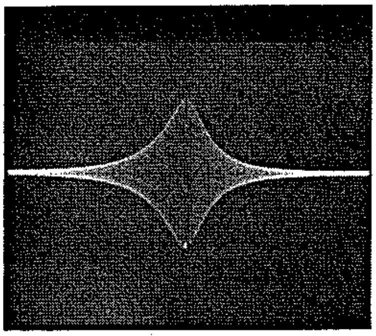
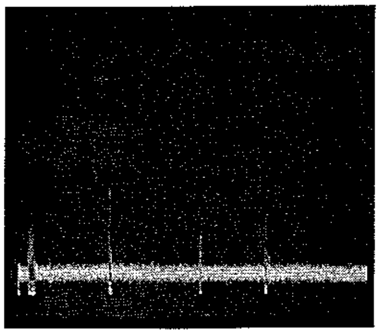


THE OSCILLOSCOPE'S VIEW of the bubble sampled from the preamplifier assembly's test point after the 145-MHz IF filter alignment. The oscilloscope's 10× time-base magnifier is switched on. You should be able to see the zero beat at the center of the bubble.

For example, EMI on cables might be best observed by passing the cable through a toroid ferrite. Wrap a few turns of finer wire as a secondary and



THE OSCILLOSCOPE'S DISPLAY of the HSA output when a short-wire antenna is connected to the BNC connector. The extreme left burst is an unknown signal. Local radio-control signals from left to right are at 27.995 MHz, 53.4 MHz, and 72.280 MHz.

connect to the HSA. This allows examination of what is on a suspect cable but avoids electrostatic pickup.

It is also possible to extend the reach of the HSA with a length of coax cable with a one or two turn sniffer loop on the pickup end. In all cases, be careful when working around power lines or line-powered equipment.

Parts and Supplies Hints. All parts and supplies for the Hobby Spectrum Analyzer came from electronics parts mail-order suppliers listed in the sidebar and from local hardware, model hobby, craft, and RadioShack stores. No single parts source can supply everything needed. A very few parts such as slide switches and beads came only from Digi-Key. The NE602 IC came from Ocean State Electronics and DC Electronics. The MV209 varactor comes from DC Electronics or Hosfelt. Many catalogs list ceramic disc capacitors; however, the RadioShack capacitor assortment #272-806 has all the smaller picafarad values on the RF circuit module. Consider using cut-to-length plastic ball pen handles for spacers. Metal and plastic tubing of many sizes as well as brass, aluminum, tin plate, and copper sheet is available at model hobby shops. Ω