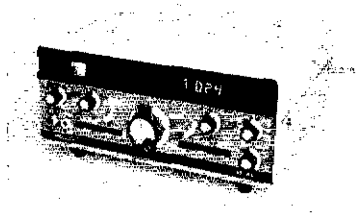
The Heath SB-104 SSB Transceiver



THE HEATH SB-104 features an all solid-state design with digital readout. In other respects, the new rig is quite similar to contemporary transceivers in the Heath line. For instance, the basic transceiver mixing scheme and band coverage are the same as the popular HW-100 series and the preceding models of the SB series.

The Digital Readout

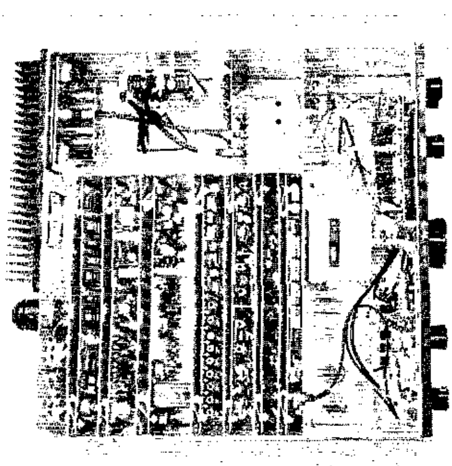
Perhaps the most notable operating feature of the SB-104 is the digital readout. One merely dials up a frequency with the VFO knob until the desired frequency is displayed on the Beckman planar gas-discharge tubes. The arrangement is not only easy to use but the need for a linear master oscillator (LMO) is eliminated as well. The latter presents a problem with analog readouts and requires factory adjustment if highest accuracy is to be maintained. With digital readout, VFO linearity is relatively unimportant. This permits the VFO in the SB-104 to be constructed by the builder.

Designing a digital readout for a transmitter would be a rather simple task. Outputs from the VFO, HFO, and carrier oscillator could be combined in a mixing scheme to provide an output of the operating frequency. An ordinary counter would be sufficient as a frequency readout. Unfortunately, such a system would most likely prove unsuitable for receiving pruposes. A signal at the operating frequency strong enough to drive the counter would require adequate isolation between the signal source and the receiver front end. Considering the small signal levels at the receiver input, such isolation would be very hard to achieve. On the other hand, merely counting the VFO frequency and adding in some correction factor for the other oscillators would result in relatively inferior frequency accuracy.

The digital display in the SB-104 utilizes a modification of the latter method but without compromising frequency accuracy to any noticeable extent. Since the same carrier oscillator is used on all bands, its output is not counted, but the correct frequency is preprogrammed into the counter circuitry. Since there is a different carrier frequency for lsb, usb, and cw, the corresponding frequency must be selected (by means of the mode switch on the front panel).

Output from the VFO and HFO is fed into a mixer and the difference signal between the two frequencies is then conducted to the counter. A "false zero" of 10,000 is selected for this scheme and the count starts from 10,000 minus the required carrier frequency (6603.6 for usb operation, for instance). After the VFO and HFO difference frequency is counted, the last five digits of the count correspond to the last five digits of the operating frequency. The first digit is either 1 or 2 (or is left blank in the case of 3.5- or 7-MHz operation). This first digit is selected by means of the band switch.

The advantages of this system are that no signal at the operating frequency is required and errors caused by any slight deviation in HFO crystal frequency are eliminated. Once calibrated, accuracy of the SB-104 display will be the same for all bands. The only errors that could occur would be changes in the carrier oscillators or counter standard oscillator. However, spot checks with the SB-104 on CHU over a period of months indicated that if any such changes did occur, they were too small to be detected.



Top view of the SB-104 receiver.

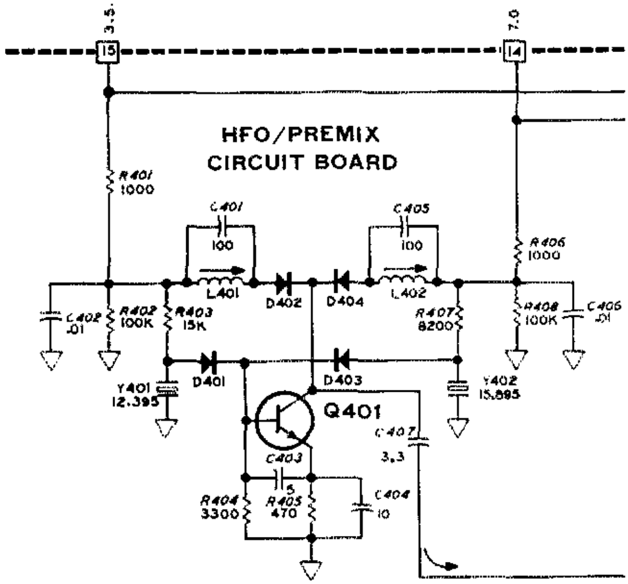


Fig. 1 — Diode-switching arrangement in the HFO/premixer board.

Other Features

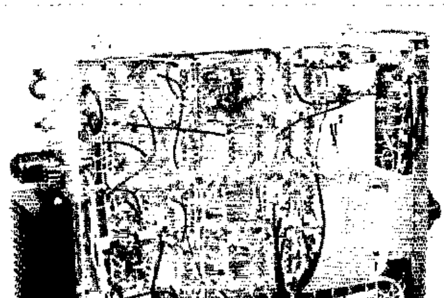
Other features include a modular type of construction, extensive use of diode switching, and a broadband solid-state PA. An extender board supplied with the kit permits in-circuit testing of a subassembly with the circuit board out of its shielded enclosure. This feature simplifies alignment and testing of the transceiver considerably.

Bandpass filters, in conjunction with diode switching, eliminate the need for a complicated band-switching arrangement. However, a separate band switch is necessary for the bandpass filter following the PA because of the power level involved. Voltages routed through another wafer of the band switch are conducted to the various subassemblies in order to complete the remaining band-switching functions. Two examples of how this is accomplished are shown in Figs. 1 and 2. Forward bias is applied to the diodes in the circuits to be activated while the diodes in the unused sections are reverse biased.

The schematic diagram of the PA is shown in Fig. 3. One of the difficulties with solid-state rf power amplifiers is that the devices become harder to fabricate as the power level is increased. Frequency considerations dictate that the internal elements of the transistor be as small as possible. However, gettong rid of excess heat becomes more difficult as the size is decreased. An alternative solution is to design a circuit that uses a larger number of low-power devices rather than a few high-power ones. The heat dissipation is then spread out through a number of units rather than being concentrated in only a few transistors.

The latter approach is evident in the PA for the SB-104. Two push-pull amplifiers are used instead of a single one. At the input of the amplifier, drive power is split equally by the hybrid combiner consisting of L951 and conducted to the push-pull amplifiers. The push-pull configuration has the advantage that even-order harmonics are suppressed, which makes filtering requirements less severe. The output of the two amplifiers is then recombined in the hybrid combiner consisting of L958 where it is then conducted to the ALC/OUTPUT circuit board.

Bias for the amplifier is obtained from the 13.8-V supply through R14 and across D1. D1 is mounted on the same heat sink as the four PA transistors and acts as a compensating network for temperature rises caused by dissipation. The diode conducts more heavily as the temperature increases and lowers the bias current applied to base of the transistors.



Bottom view of the transceiver. Most of the wiring is simplified by the cable and wiring harnesses shown in the photograph. The heat sink appearing at the lower left is for the PA transistors.

Construction

The chassis of the SB-104 serves as a main frame for the transceiver. There are a number of shielded compartments for the various subassemblies which are mounted on plug-in printed-circuit boards. A wiring harness and a cable harness interconnect the shielded compartments together along with the front-panel switches and the rear-panel connectors. The system results in a very neat package with all wiring connections easily accessible. Labels are provided for the circuit-board terminal strips. This helps in identifying test points and reduces the possibility of making a wiring error.

In spite of its complexity, the SB-104 proved to be a rather simple kit to build. Components for each circuit board are packaged separately which makes assembling an SB-104 seem as though a number of small kits were being put together instead of one gigantic one. There is even a map to show the locations of the parts compartments in the packing case. There are no tricky areas in the kit construction and any ham with some building experience should have little difficulty in assembling an SB-104. However, the kit is *not* recommended for a first assembly attempt. One should have mastered the technique of soldering (including IC sockets) and be able to put connectors on cables properly.

Before starting assembly, this writer spent a few evenings perusing the manuals for the SB-104. There are two of them. One covers the construction of the unit and the second one contains theory of operation, schematic diagrams, and test procedures. Photographs of a finished chassis are also included which proved helpful determining cable runs and other facets of construction. Proceeding at a leisurely pace, it took approximately 80 hours to complete assembly. This included frequent double checks on proper placement of components and correct wiring connections. A number of mistakes were found this way and it is embarrassing to note . . . one got through to the testing stage where it was uncovered by the test procedures! The problem was not with the manuals or the kit itself, but was the result of the writer's faltering ability to concentrate for long periods of time. SB-104s have been put together by others in less time and with no mistakes.

Performance and General Comments

The SB-104 either passed or exceeded its

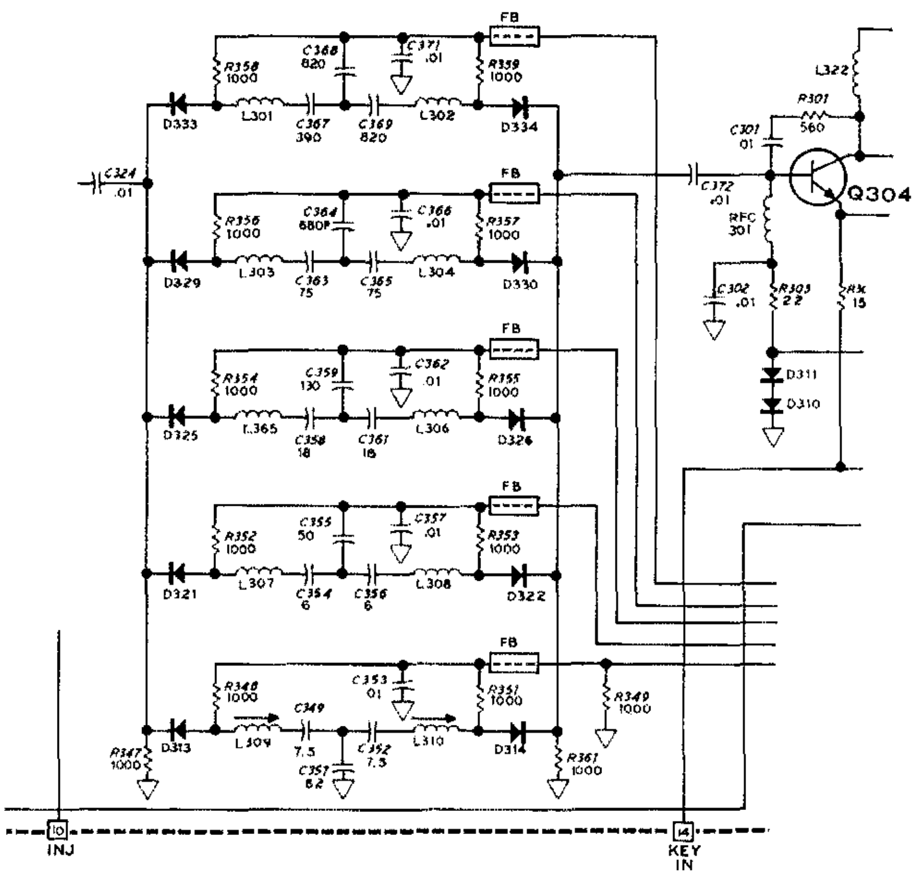
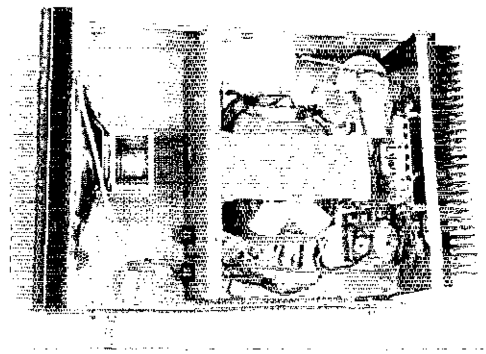


Fig. 2 — Partial schematic diagram of the transmitter i-f circuit board.

Top view of the HP-1144 power supply mounted inside the SB-604 station speaker.



published specifications within the accuracy of available measuring equipment in the ARRL lab. The odd-order IMD suppression is quite impressive as can be seen in the spectrum-analyzer display of Fig. 4. This transceiver is one of the better ones in regard to good linearity. On-the-air reports of audio quality confirmed this and other SB-104s that the writer has heard sounded good.

A wide-dispersion spectral display of the SB-104 is shown in Fig. 5. A *relative* measurement of harmonics and other spurious responses over the frequency range from 0 to 100 MHz can be determined from the photograph. (Accuracy of measurement is degraded somewhat by the frequency response of the coupling network used.) The level of second-harmonic energy is lower than that from other rigs tested but third-harmonic energy seemed somewhat higher. However, the third- and fourth-harmonics shown were eliminated easily with even simple filter networks.

Generally speaking, this writer was pleased with the performance of the SB-104. Receiver agc action is quite effective and both cw and ssb signals sound good without the annoying "pumping" found in some agc systems. Because it employs broadband amplifiers and bandpass tuning, band switching is simple. There are no tune-up procedures required. Since the specified sensitivity is somewhat lower than that of some other transceivers, there was some concern as to how the SB-104 would perform under typical band conditions. A slight difference could be noted on 15 and 10 meters with weak signals. Greater sensitivity might be advisable especially if only inferior antenna systems are available. On the other hand, the 1-μV sensitivity was more than adequate on the lower bands.

The review unit is from an early production run and some improvements have been incorporated into the SB-104 in later ones. For instance, a number of correction sheets had to be supplied with the manuals, but later editions were revised to include the corrections. There have been some changes to improve keying waveform and VFO stability. Some PA transistors in the early units proved defective and the ones in the review unit had to be replaced after a period of time because

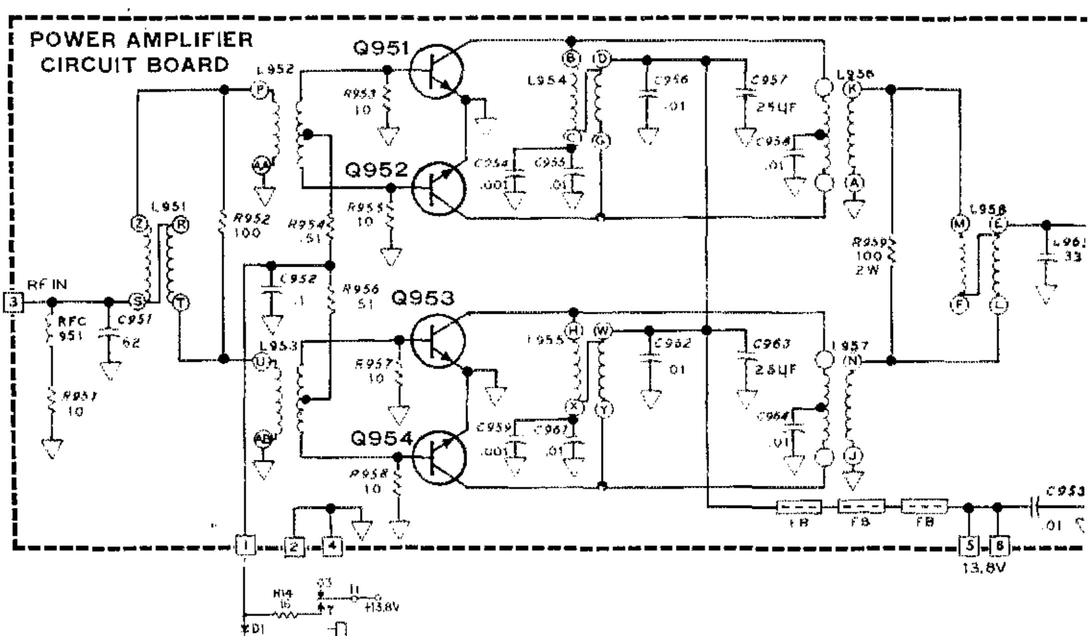


Fig. 3 – Schematic diagram of curcuit board "H," the power amplifier. DI is mounted on the heat sink for the finals but external to the board itself. As the temperature rises, DI conducts and reduces the bias on the transistors thus preventing thermal runaway.

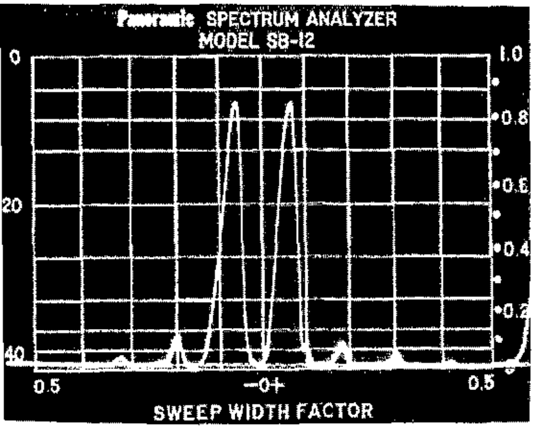


Fig. 4 — Spectrum-analyzer display of the output of the SB-104 transceiver with a two-tone 100-PEP output. The horizontal axis of the display represents frequency, and the vertical axis amplitude. Each "pip" represents a single-frequency component of the rf output. The display is adjusted so the amplitude of each component may be read from the scale at left, directly in decibels below the peak-envelope power (PEP) output, as rated by the manufacturer. Each reticle division represents 5 dB. Responses other than the two individual tones near the center are distortion products; third-order products 35 dB down may be seen here. Individual tones of the two-tone signal are down by 6 dB from the PEP output. This is because the tones are displayed as two discrete frequencies. At the instant when voltages of the individual tones are in phase, they add to produce a peak in the envelope wave-form pattern which is twice the voltage amplitude of a single tone alone. The power at the peaks of the envelope (PEP) is therefore four times that of a single tone, a 4:1 power ratio being equivalent to 6 dB.

of low power output. No difficulty has been encountered in the latter regard since the replacement and full power output has been maintained. The only other difficulty with components was a bad MOSFET in the receiver front end. While such occurrences are unfortunate, they are to be expected with a system containing over 2800 components. Introduction of similar equipment during the writer's former industrial experience would indicate Heath has done a good job in getting most of the bugs out of their gear before it was presented to the market.

Mechanically, the SB-104 seems to be a well designed unit. Stability of the VFO is good and all important control functions are readily accessible from the front panel. The cabinet and front panel are attractively styled, and a rather interesting design permits chassis removal in a matter of seconds. The cabinet consists of two shells for the top and bottom covers and the combination is held together by means of two strips along the side. The latter grip the shells after being compressed by four screws fastened to the chassis.

One of the more common criticisms of the SB-104 is that it doesn't have an option for receiver incremental tuning (RIT). However, this writer didn't find the lack of RIT to be an inconvenience. On the other hand, coverage of the 160-meter band would be very desirable. Because of the solid-state PA, there are some limitations on maximum transmitting time for the various modes of operation. Maximum *continuous* transmit time for ssb is one hour and only the more loquacious might have difficulty staying within these bounds. For ssb, the duty cycle is two units of transmitting time to one unit of receiving time. This restriction would be satisfied under normal conditions of operating and the SB-104 could be treated in the same manner as any other ssb rig. On cw, the restrictions are somewhat more severe with a one-for-one duty cycle and a limitation of 15 minutes for continuous transmitting.

In closing, it might be pointed out that Heath is not a company that lets the grass grow under their feet. It is interesting to speculate what the SB-105 will be like! — *W1YNC*

The Heath SB-104 SSB Transceiver

Dimensions (HWD) and Weight: 7-1/4 × 14-1/2 × 16 inches, 20 pounds.*
Power requirements: 13.8 volts, 2 A receive and 21 A for 100-W output.*
Power output: 100 watts minimum, 3.5 to 21 MHz and 90 watts minimum on 28 MHz.*
Receiver sensitivity: Better than 1 μV for 10-dB signal plus noise to noise ratio on all bands.*
Receiver internally generated spurious signals: Below 2-μV equivalent antenna input except at 3.65, 3.74, 14.24, and 21.2 MHz.*
Price Class: $670.

HP-1141 Power Supply

Dimensions (HWD) and Weight: 7-1/4 × 10 × 15 inches, 27 pounds.*
Power consumption: 75 watts receive and 700 watts for maximum transceiver output (key down) of 100 watts.*
Price class: $90.
Manufacturer: Heath Company, Benton Harbor, MI 49022.

*Measured in the ARRL lab.

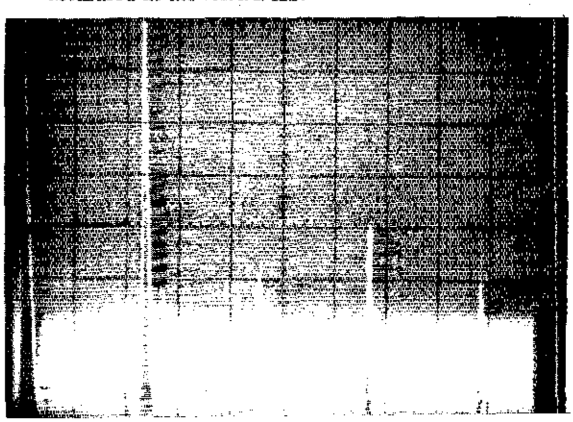


Fig. 5 — Wide-dispersion spectral display of the SB-104 on 21 MHz with 100-watts output.