Heathkit of the Month:
by Bob Eckweiler, AF6C

Heathkit HX-20 and HR-20 Mobile HF Twins

Introduction:

Last month we looked at the Heathkit Cheyenne and Comanche mobile twins. They were manufactured from 1959 into 1962, and while the receiver was adequate at receiving SSB with its product detector, the transmitter was strictly CW and AM, using rather inefficient screen-grid modulation. In the early sixties AM was on its way out and SSB was becoming much more popular and less expensive. SSB requires more stable circuitry, especially in the mobile environment. Therefore Heathkit, in 1962, replaced the MT-1 Cheyenne transmitter with the HX-20 (price not found), and the MR-1 Comanche receiver with the HR-20 ($134.50). By that time Heathkit had either stopped using, or ran out of, popular Indian tribe names. Let's look at these two updated radios. You might want to reread last month's issue because some aspects of the equipment, especially the HR-20, are very similar.

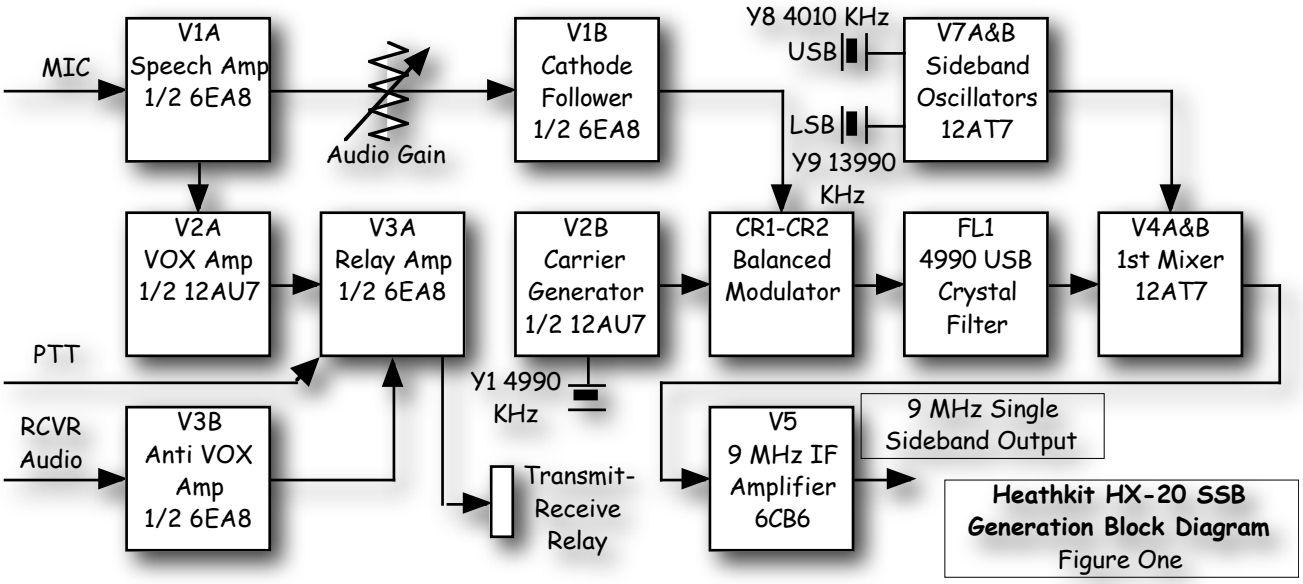
Both the HX-20 and the HR-20 are the same size and look almost identical to their predecessors. They use the same part number cabinets and the front panel layouts are similar. Gone are the tribe names on the front panel, but the most obvious difference is on the HX-20 transmitter; the VFO slide rule dial is flat and has just two scales marked 0 - 500 and 500 - 1000. The dial is no longer etched on a cylinder that rotates with the band switch. The companion HR-20 receiver, though, still has the rotating slide rule dial. Also the newer radios use light text on a dark background instead of the older dark text on a light background on the meter scale and slide-rule dials. Let's take a closer look at these updated radios and compare them with their predecessors.

The Heath HX-20 Mobile Transmitter:

I was unable to obtain much information on the web concerning this transmitter except for catalog specifications, a hard to read copy of the schematic and some poor resolution pictures of the radio. Using the schematic, I was able to piece together the block diagrams of figure 1 & 2. Thus the following information is my unconfirmed interpretation of how the HX-20 works.

The HX-20 is almost totally redesigned and shares little in common with the MT-1 Cheyenne. It uses a single VFO that operates from 5.5 MHz down to 5.0 MHz. All the remaining oscillators are crystal controlled resulting in outstanding stability. Since no frequency multiplication is used, oscillator drift is not multiplied on the upper bands, resulting in better frequency control on the upper bands. The HX-20 uses the same rugged construction as the MT-1.

The transmitter uses thirteen tubes, including two voltage regulator (VR) tubes; six of the tubes are dual section. Sideband generation is done with a balanced modulator and a crystal filter. The radio runs 90 watts PEP using a 6146 final tube. CW mode uses grid-block keying. The transmitter covers 80 thru 15 meters and the first 1.5 MHz of 10 meters (28 - 29.5) in seven 500 KHz bands. Like the MT-1 the HX-20 requires a separate power supply. Heath made the HP-10 mobile and the HP-20 AC power supplies to run these radios. Let's take a closer look at the HX-20:



Audio and Switching Circuits:

The audio from the microphone is amplified by V1A and is fed through an audio gain control to V1B, a cathode follower. The cathode follower provides the low impedance required to drive a balanced modulator. The audio is also fed into a VOX amplifier which drives the relay amplifier V3A and activates a seven-pole transmit-receive relay when audio is present and VOX is selected. If push-to-talk (PTT) is being used, the PTT line directly switches the relay amplifier. To prevent receiver audio from activating the relay, it is amplified in the anti-VOX amplifier and nulls out any receiver audio picked up by the microphone.

Sideband Generation:

V2B is a crystal oscillator operating at 4990 KHz. It generates an RF carrier that is fed into the balanced modulator that consists of two diodes and bridge balancing circuitry. The audio from the cathode follower is also fed into the balanced modulator. The balanced modulator modulates the carrier, producing upper and lower sideband signals, but also balances out the carrier itself. This double sideband signal with its carrier suppressed is sent through a crystal filter that removes the lower sideband and further reduces any remaining carrier signal. The result is an upper sideband signal at 4990 KHz.

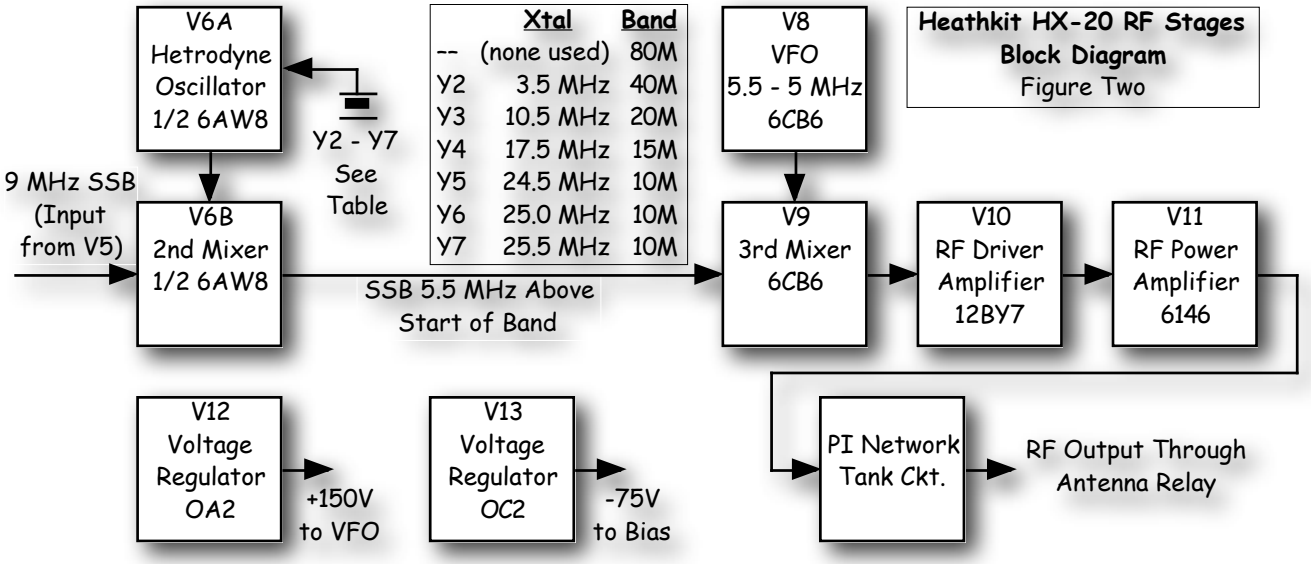
V7 is a dual triode tube that makes up the sideband oscillator. Each section is a separate crystal oscillator. Only one section operates at a time depending on whether USB or LSB is selected. The USB oscillator runs at 4010 KHz and the LSB oscillator runs at 13090 KHz. The 4990 KHz SSB signal is mixed with one of these two oscillator signals in V4, the first mixer. The output is a 9.0 MHz SSB signal on the desired sideband. When in the USB position, the 4990 KHz USB signal is added to 4010 KHz resulting in a 9 MHz USB signal. But when in the LSB position, the 4990 KHz USB signal is subtracted from 13990 KHz resulting in a 9 MHz LSB signal. The sideband inversion is due to the subtraction of the sideband signal from a higher frequency oscillator signal.

The 9.0 MHz signal is amplified in V5, a double-tuned IF amplifier that removes any unwanted frequencies created in the mixing process.

Frequency Conversion:

The 9.0 MHz sideband signal must be converted to the frequency of operation before it can be amplified powerfully and sent to the antenna. This is done in two stages. The second mixer, V6B adds the 9 MHz signal to the oscillator signal coming out of V6A, the heterodyne oscillator. This oscillator operates on 3.5 MHz

for 40 meters, 10.5 MHz for 20 meters, 17.5 MHz for 15 meters and on 24.5, 25.0 or 25.5 MHz for the three 10 meter segments. On 80 meters the oscillator is off, and the 9.0 MHz signal passes directly through the second mixer. The output of the second mixer is a sideband signal that is on a frequency 5.5 MHz above the low end of the desired ham band.



The VFO, V8, is the only non-crystal controlled oscillator in the circuit. It is designed for stability and low frequency drift. The oscillator is wired so that it runs at 5.5 MHz at the low end of the dial, dropping linearly to 5.0 MHz at the high end of the dial. The dial itself has two scales: 0 - 500 KHz and 500 to 1000 KHz. The first scale is for 40, 20, 15 and the two 10 meter segments starting at 28 and 29 MHz. The second scale is for operation on 80 meters and on the 10 meter segment starting at 28.5 MHz.

The VFO signal is mixed with the output of the second mixer in the third mixer, V9. The difference between the two signals is the desired operating frequency. Since the SSB signal is higher than the VFO signal, no inversion of sidebands takes place.

RF Driver and Amplifier:

The driver stage uses a 12BY7 pentode, V10, to amplify the desired output from the third mixer. To prevent unwanted signals from passing, the driver grid and plate are tuned as part of the band switching, and a ganged four-section capacitor, adjustable on the front panel as Drive Tuning, peaks the driver. On CW the drive level can also be adjusted.

The RF amplifier is driven from the tuned output of the RF driver stage. This is one of the few Heathkit final amplifiers that uses a 6146 tube and doesn't use a PI network between the driver and final stage. The HX-20 has automatic level control (ALC) and if the amplifier is driven too hard, causing the final tube to draw grid current, a voltage is fed back to the grid of the IF amplifier, V5, lowering the overall gain and helping keep the final amplifier operating in its linear region.

From this point the Heathkit HX-20 final amplifier gets a little unusual. First, the PI network used in the output stage has fixed loading capacitors that switch in for each of the different bands. The loading control, so common on HF tube radios including the MT-1, just isn't there. Second, the meter that monitors the final grid and plate current, and often other functions, on most tube amplifiers only has just one function on the HX-20 - relative output. The meter sensitivity is adjustable by a front panel control.

CW Keying:
The HX-20 has an elaborate biasing circuit requiring a negative 150 volts at low current from the external power supply. The bias is regulated in the transmitter to -75 volts using V13, an OC2 gaseous VR tube. In CW the bias to the third mixer and driver stages are keyed.

Front Panel:
The front panel layout shares some commonality with the Cheyenne MT-1 and also some differences. The **Band** switch, **Audio Gain**, **Final** and **Driver** tuning controls are the same, except 10 meters is now spread out over three positions on the band switch. The lever meter switch now is an **Operate - Standby** switch, the spotting switch has been replaced with a potentiometer for setting the meter relative power sensitivity; the Function switch is now the **Mode** switch. Also the MT-1's Loading control has been replaced with a **Driver Level** potentiometer for setting the CW drive level.

Rear Panel:
The rear panel of the HX-20 contains a lot more than the earlier Cheyenne. Also, less expensive connectors are used, a questionable change for equipment designed for the mobile environment. Left to right, the rear panel contains a **RCVR** power jack to provide receiver power; a **POWER** plug that mates with the power supply; **CUT OFF BIAS** jack for using a linear amplifier, **SIDE BAND BALANCE** adjustment potentiometer; **FUSE**; **RCVR ANT**; **RF OUT**; **KEY** 1/4" phone jack and **EXT RELAY**.

The power connectors are the octal tube socket variety (one male and one female), instead of the rugged Jones plugs used on the MT-1 and MR-1. Also, gone are the SO-239 UHF connectors for the RCVR and RF OUT; they are replaced by RCA jacks.

The Heath HR-20 Mobile Receiver:
Unlike the new HX-20 transmitter, the HR-20 receiver is very similar to the MR-1 Comanche it replaces, with a few circuit improvements. The only change in the vacuum tube lineup is that the multi-section 6T8 (triple diode - triode) and 6AQ5 (pentode) audio power amplifier of the MR1 were replaced with a 6BJ7 (triple diode) and a 6EB8 (triode - pentode). However functionally the circuit is similar.

One big change is in the product detector. Instead of a tunable 3000 KHz BFO oscillator, the HR-20 product detector uses a switchable crystal oscillator that operates on 2998.5 KHz for USB and 3001.5 for LSB. this makes tuning SSB signals easier.

A second change is in the AVC circuit. The MT-1 AVC switch had two positions, OFF - ON. The HR-20 allows two different time constants for the AVC. the switch is now OFF - SLOW - FAST.

A third change is in the filament circuitry. When running on 12 volts, as when operating mobile in a modern US car of the time that uses a 12 volt negative ground electrical system, the filament voltage can vary with engine speed. While this has little effect on most of the circuitry, it can cause changes in a critical frequency determining circuit such as the VFO. Thus Heath decided to regulate the VFO filament voltage on the HR-20. This capability is only available when running on 12 volts. The

regulator uses a CDT-1337 (2N301 equiv.) PNP TO-3 transistor to provide the regulation.

Front Panel:
The HR-20 front panel layout is identical with the MT-1 with two exceptions: The BFO tuning control of the MR-1 was replaced with a two position **SIDEBAND SELECT** switch that chooses either the **USB** or **LSB** BFO crystal. Also, the **AVC** switch now has three positions: **OFF**, **FAST**, and **SLOW** instead of just off or on.

Rear Panel:
Mounted on the rear panel of the HR-20 are an **ANT** RCA jack; male octal **POWER** plug; ear **PHONES** 1/4" phone jack; **SPKR** RCA jack and **FUSE**.

Comments on the HX-20 and HR-20:
The HX-20 and HR-20 require an external power supply. Both require 6.3 or 12.6 volts (AC or DC) for the filaments and 300 volts DC. The transmitter also requires 600 volts and -120 volts. Originally Heath developed the UT-1 AC Power Supply and the MP-1 Mobile DC Power Supply for the MT-1 and MR-1. Later Heath replaced these units with the HP-20 AC Power Supply and HP-10 Mobile DC Power Supply. These are similar but also provide the negative bias voltage required for the later HX-20. The HP-10 is also more ruggedly designed than its MP-1 predecessor and runs more efficiently. The early radios will run off either supply, while the newer units require the later power supply.

While Heathkit was selling the HX-20 and HR-20, many manufacturers were going to single boxed transceivers that incorporate the transmitter and receiver in one unit. Heathkit, responding to the market, replaced the HX-20 - HR-20 twins with the SB-100 transceiver in 1965. Heath had earlier (1963) come out with the 200 watt PEP, SSB only, HW-12, HW-22 and HW-32 “Single-bander” HF mobile transceivers for the 80, 40, and 20 meter bands respectively.

HAVE YOU EVER WONDERED…?
… why it is common practice to use lower sideband on 80 and 40 meters and upper sideband on 20, 15 and 10 meters?

Most early SSB exciters generated a fixed frequency upper sideband signal at or around 9 MHz. When heterodyned down to 3.5 or 7 MHz the sideband was inverted to lower sideband. However when heterodyned up to 14, 21 or 28 MHz the sideband was not inverted. Early rigs worked this way and had no switch to change to the other sideband.

This protocol remains in effect and is still the general rule today!

73, from AF6C

Remember if you come across any old Heathkit Manuals or Catalogs that you do not need, please pass them along to me.
Thanks - AF6C

This article originally appeared in the December 2008 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.