Heathkit of the Month:
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AMATEUR RADIO - SWL
Heathkit HW-12 / HW-22 / HW-32
"*Single-Bander*" SSB Transceivers - PART I

Fig. 1 - HW-22 40-meter Transceiver

Author's Note:
I have received many requests to cover the Heathkit *Single-Bander* SSB Transceivers, many more than any other kit. Unfortunately, little was available on the net in the way of manuals and schematics for these six kits. I looked into purchasing the manuals, but the cost was approaching $200 and these articles are written and distributed without charge as a hobby. Thus, the idea was kept on the back burner, and anytime some information was found, it was squirreled away for later use. One difficulty was that, in the first few partial manuals obtained, no crystal frequency information was given, only their part numbers.

Recently, I felt I had gathered enough information to begin the article. At first, the plan was to cover all six units, while focusing on the HW-22. After working on the article awhile, it quickly became evident it would be very long - much too long for our monthly newsletter. The decision was made to split the article into two, covering the HW-12, HW-22 and HW-32 in the first article and the later HW-12A, HW-22A and HW-32A in a second, shorter article, where only the changes from the earlier models would be covered.

As I continued to write, it was evident the article would still be too long. So the plan now is to cover the HW-12, HW-22 and HW-32 in a multipart series of articles. This might take two or even three parts. Here's part I:

[1] Notes appear at the end of the article.

Introduction:
In late 1963, while I was away at my first year of college, Heathkit introduced three single-band, SSB only, HF ham transceivers. They were the HW-12, the HW-22 and the HW-32 which operate on the SSB portion of the 75, 40 and 20 meter bands, respectively. They each operate in a single mode, LSB for 75 and 40 meters and USB for 20 meters, at 200 watts PEP input. They are powered by an external power supply, such as the HP-23, and can be used in the home or mobile. Over their life they sold for $119.95 each, and they immediately became big sellers. Orders quickly exceeded Heathkit's production rates, creating a backlog. Heathkit had a hit on their hands, and I was off the air! Besides appropriate power supplies, Heathkit sold three accessories that work with the HW "*Single-Bander*" series, a push-to-talk microphone - the GH-12 ($6.95); a mobile speaker - the HS-24 ($7.00); and a plug-in 100 kc[1] crystal calibrator - the HRA-10-1 ($8.95).

The original *"Single Bander"*s remained in production for three years, until 1966, when they were replaced by the HW-12A / HW-22A / HW32A, which were updated and refined versions of the originals. In this series, the focus will be on the earlier transceivers, with the later ones possibly being covered in a future article.

The Heathkit "*Single-Bander*":
We will focus on the HW-22 - 40-meter Single-Bander (Figure 1), but will discuss differences between the HW-22 and the HW-12 and HW-32 as they are encountered. The specifications for the radios are exceptional for the selling price (See

Table I). Due to the size of the schematic, it is not included in this article. However snippets of the schematic will be used as needed. A copy of the full HW-22 schematic, found on the web, is posted on the club website at:

http://www.w6ze.org/Heathkit/Sch/hw22.pdf.

Heathkit recommended the HP-23[2] fixed or HP-13[3] mobile power supplies for the *"Single-Bander"* transceivers; these power supplies may be used without modification; just be sure the octal power plug to the HW-12 / 22 / 32 is wired correctly. These radios may also be used with the earlier HP-20 (AC) and HP-10 (DC) power supplies after a simple modification to the radio (and also to the HP-10, if used). Instructions for these modifications are given in the *"Single-Bander"* manuals.

General	
Frequency Coverage (Mode) -	
HW-12	3.8 - 4.0 mc. (LSB)
HW-22	7.2 - 7.3 mc. (LSB)
HW-32	14.2 - 14.35 mc. (USB)
Stability:	200 cps / hr.
# of Tubes (Total Sections):	14 (20)
Cabinet Size:	6-1/4" H x12-1/4" W x 10" D
Assembled Weight:	12 lbs.
Shipping Weight:	15 lbs.
Power Requirements -	
High Voltage:	800 VDC @ 250 mA peak
B+ Voltage:	250 VDC @ 100 mA
Bias Voltage	–130 VDC @ 5 mA
Filament Voltage:	12 VAC/DC 3.75 A
Transmit	
Power Input:	200 Watts PEP
Finals:	2 x 6GE5
RF Output Z (Loading):	50Ω (Fixed)
Transmit IF:	2,305.0 kc
Carrier Suppression:	45 dB
Unwanted Sideband Suppression:	45 dB
Mic Input:	Hi-Z
Receive	
Sensitivity:	1μV for 15 dB (S + N)/N
Receive IF:	2,305.0 kc
Selectivity:	2.7 kc @ 6dB. 6 kc @ 50 dB
Image Rejection (HW-32):	100 dB (60 dB)
IF Rejection (HW-32):	50 dB (65 dB)
Audio Output:	1 Watt @ 8Ω

Table I: HW-12 / 22 /32 Specifications

HW-22 Controls and Connectors:

Except for the frequency dial, the front panel of all three units are identical. On it are nine controls and a meter, arranged in two rows. The top row (L to R) consists of the **FINAL TUNE** capacitor, the large VFO tuning knob with arched tuning window and frequency dial - featuring a seven to one vernier drive - and a meter that operates as an S-meter on receive and a relative output meter on transmit. Below the meter is a slide switch marked **BIAS SET** to the left and **OPERATE TUNE** to the right. The switch is normally in the right position, and is moved to the left to set the bias on the final tubes. In the left position the meter reads the cathode current of the finals. The proper bias setting is marked as a small white triangle above the S-3 mark on the meter scale.

The second row (L to R) consists of a four-position rotary **FUNCTION** switch (**OFF**, **PTT**, **VOX**, **TUNE**), a screwdriver adjustable **S-METER ADJ.** pot, an **RF GAIN** pot, an **AF GAIN** pot, a screwdriver adjustable **VOX DELAY** pot, and a **VOX** sensitivity pot.

Along the rear apron of the HW-22 (L to R, viewed from the rear) are: a two-pin Amphenol **MIC** connector, three screwdriver adjustable pots (**MIC GAIN**, **TUNE LEVEL**, **FINAL BIAS**), four RCA phono connectors (**SPKR 8Ω**, **EXT. RELAY**, **ANT.**, **RCVR**), and a male octal **POWER** connector).The EXT. RELAY connection switches to ground on transmit and is open on receive; it is used to key an amplifier or external antenna relay. RCVR is a separate antenna lead that goes directly to the receiver input, and is useful with an amplifier that requires an external antenna relay.

Each model has a different frequency dial behind the arched window. The HW-12 dial tunes up in frequency from 3.8 to 4.0 mc as the tuning knob is turned clockwise. However, the HW-22 and HW-32 actually tune down in frequency as their tuning knob is turned clockwise. The HW-22 tunes 7.3 to 7.2 mc, and the HW-32 tunes 14.35 to 14.2 mc. The frequency dial also shows the model number, which is not printed anywhere else on the front panel.

Heathkit *"Single-Bander"* Construction:
For each kit, most of the components mount on a single circuit board that holds about 90% of the components, including tubes. Parts not located on the circuit board are controls and other items on the front and rear panels, as well as the audio output transformer, T/R relay and the VFO frequency components that need mechanical stability. Figure 2 shows the top view of an HW-22 removed from its cabinet.

All fourteen tubes, including the final amplifier tubes and the octal socket for the optional 100 kc crystal calibrator accessory, mount on the circuit board. The board itself mounts over a large cutout in the chassis, and takes up most of the top chassis space. A prefabricated and color-coded wiring harness makes almost a full circuit around the edges of the chassis, making connections between the components off the circuit board, as well as connections to the circuit board itself, easier and less prone to wiring errors.

The "*Single-Bander*" transceivers were designed keeping mobile operation in mind. The cabinet includes a gimbal mount that allows mounting the radio under the dash or on the transmission hump in a typical automobile of the sixties. The manual contains a lot of information on using the "*Single-Bander*" mobile, including discussions on reducing engine noise and choosing and mounting an appropriate antenna.

Heathkit states that the kit can be assembled in just 15 hours, due mainly to the large circuit board construction. Comments in the reviews agree that the 15-hour claim is easily achieved by a builder with average kit-building competence. Figure 3 is from the March 1965 Heathkit catalog supplement (800/53) offering the "Single-Bander: SSB Transceivers and two of their accessories.

Figure 2: Top view of the HW-22 out of its cabinet. Final tubes are to the left behind vertically mounted pi-network coil. In the back left is the octal socket for the optional crystal calibrator.

The "*Single-Bander"* Frequency Scheme:
It is always interesting to study the scheme of how the transmitted and received frequencies are created or recovered; this is especially true in a SSB transceiver since filtering of the desired sideband must occur to generate and receive the signal. The "Single-Bander" transceivers only cover one band, simplifying things. These radios also do not incorporate RIT, which allows the operator to adjust the received signal without changing the transmit frequency. The three models all have an IF of 2,305 kc and use a crystal lattice bandpass filter that is shared on transmit and receive. This filter is not a sealed unit like in the SB series, but consists of two pairs of matched crystals, and their associated components, assembled on the circuit board. The filter has a center frequency of 2,305.0 kc with a 6 dB bandwidth between 2,303.7 and 2,306.4 kc, and a 50 dB bandwidth between 2,302.0 and 2,308.0 kcs. (See Figures 4A & 4B)

Figure 3: Heathkit ad for the HW-12, HW-22 and HW-23 in the March 1965 Catalog supplement.

Each model's VFO operates on a different range of frequencies, but all are within 1,400 to 1,800 kc. Using such a low frequency aids in designing a stable VFO; a temperature compensating capacitor further increases the stability. Each VFO's fully clockwise and counterclockwise frequencies are shown in Table II. The transmit frequencies shown are the frequency where the carrier would be if it were not suppressed.

The stage following the VFO varies between models. For the 75-meter HW-12, the stage acts as a buffer, isolating the load from the VFO; however, on the HW-22 and HW-32 this stage is a heterodyne crystal oscillator and mixer. The oscillator runs at 11,190.0 and 18,275.0 kc respectively. The mixer output is the difference between the heterodyne oscillator and VFO, as shown in Table II. Since this is a difference mixer the VFO tuning direction is reversed.

On Transmit (See block diagram - Fig 5):
Each "Single-Bander" carrier oscillator uses either a 2,303.3 kc crystal for USB generation or a 2,306.7 kc crystal for LSB generation. This signal is mixed with the transmit audio in a balanced modulator, producing a double sideband signal. This DSB signal is passed through the crystal lattice bandpass filter, and one of the two sidebands is removed. Since the carrier frequency is also outside the 6 dB filter bandpass, any residual carrier from the balanced modulator is also further attenuated. The HW-12 and HW-32 both use a 2,306.7 kc crystal and create an LSB signal, and the HW-22 uses a 2,303.3 kc crystal and creates a USB signal. It would appear the HW-22 and HW-32 sideband are both incorrect, but they will be inverted in a later stage. Figures 4A and 4B show the filter response in black, the already suppressed carrier in red, the low audio (400 cps) in orange and

RADIO		VFO CCW	VFO CW
HW-12	VFO Freq:	1,493.3	1,693.3
	Buffer Out:	1,493.3	1,693.3
	Carrier (LSB):	2,306.7	2,306.7
	Mixer (sum):	3,800.0	4,000.0
	Final Sideband:	LSB	
HW-22	VFO Freq:	1,586.7	1,686.7
	Het. Xtal Osc:	11,190.0	11,190.0
	Het. Mixer Out:	9,603.3	9,503.3
	Carrier (USB):	2,303.3	2,303.3
	Mixer (Diff.):	7,300.0	7,200.0
	Final Sideband:	LSB	
HW-32	VFO Freq:	1,618.3	1,768.3
	Het. Xtal Osc:	18,275.0	18,275.0
	Het. Mixer Out:	16,656.7	16,506.7
	Carrier (LSB):	2,306.7	2,306.7
	Mixer (Diff.):	14,350.0	14,200.0
	Final Sideband:	USB	
	All frequencies are in kilocycles per second		

Table II: Transmitter Frequencies

the high audio (3,100 cps) in green for the desired sideband.

After filtering, the 2,305.0 SSB signal is converted to the desired transmit frequency. In the

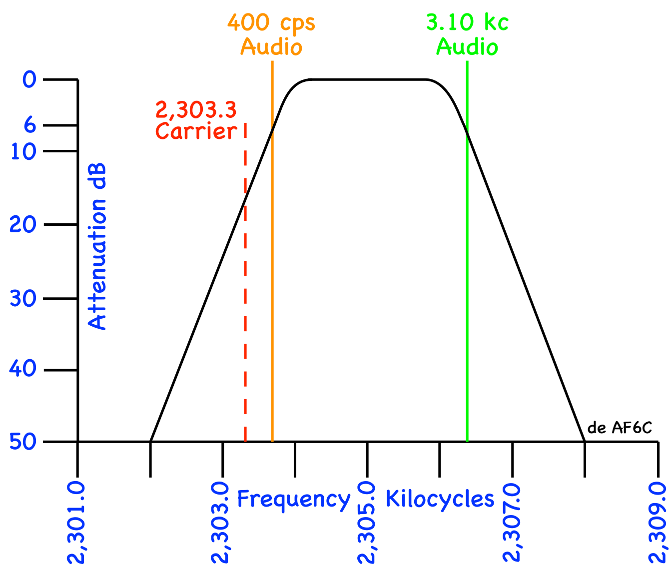

Fig. 4A: Upper sideband creation in the crystal filter. The lower sideband is to the left outside the filter's response.

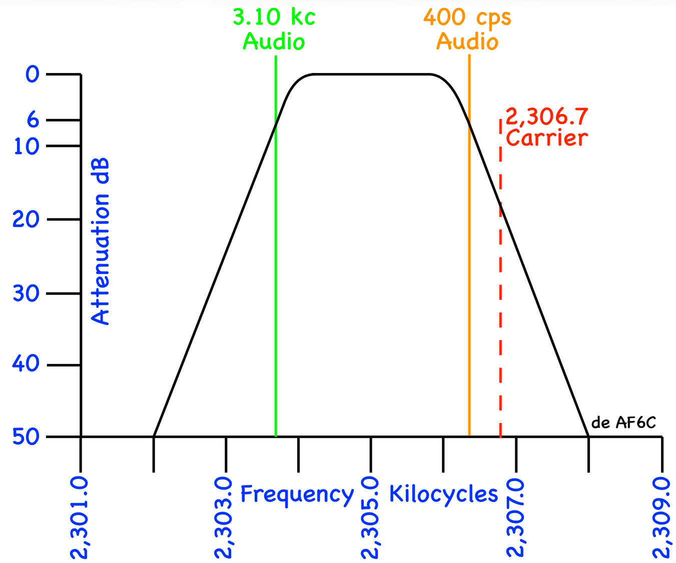

Fig. 4B: Lower sideband creation in the crystal filter. The upper sideband is to the right, outside the filter's response.

HW-12 it is added to the the buffered VFO frequency in the transmitter mixer stage, producing an LSB output between 3.8 and 4.0 mc. In the HW-22 and HW-32 the SSB signal is subtracted from the heterodyne mixer output in the transmitter mixer stage; the sideband is inverted during this mixing process. This results is an LSB output between 7.3 and 7.2 for the HW-22,

Radio		VFO CCW	VFO CW
HW-12	Rcvd Freq (LSB):	3,800.0	4,000.0
	VFO Buffer Out:	1,493.3	1,693.3
	Rcvr Mixer Out (LSB):	2,306.7	2,306.7
	Carrier (LSB)	2,306.7	2,306.7
HW-22	Rcvd Freq (LSB):	7,300.0	7,200.0
	Het. Mixer Out:	9,603.3	9,503.3
	Rcvr Mixer Out: (USB):	2,303.3	2,303.3
	Carrier (USB)	2,303.3	2,303.3
HW-32	Rcvd Freq (USB):	14,350.0	14,200.0
	Het. Mixer Out:	16,656.7	16,506.7
	Rcvr Mixer Out: (LSB):	2,306.7	2,306.7
	Carrier (LSB):	2,306.7	2,306.7

Table III: Receiver Frequencies

and a USB output between 14.35 and 14.20 for the HW-32.

A good way to examine what is going on more closely is to track two tones as they are transmitted and later received. We'll use the HW-22 for this example with its VFO set for 7,250 kc. A good choice of tones are 400 cps and 3.1 kc as they represent the 6 dB points in the filter. These tones are fed into the microphone input, are amplified and mixed with the carrier in the balance modulator. The four outputs of the balanced modulator are the 2,303.3 kc carrier oscillator plus and minus teach of the tones or: 2,300.2, 2,302.9, 2,303.7 and 2,306.8 kc. The 2,303.3 carrier has been balanced out does not appear in the output. These four tones are fed into the crystal filter and only two remain - 2,303.7 and 2,306.4 kc. (see figure 4A).

Meanwhile, if we are transmitting with the VFO set to 7,250.0 kc, the VFO is tuned to actually produce a frequency of 1,636.7 kc. which is mixed with the 11,190.0 kc crystal heterodyne oscillator producing outputs of 9,553.3 and 12,826.7 kc as well as the two original frequencies. L5 is tuned so it passes only the 9,553.3 kc difference signal. This is true during receive also.

In the transmitter mixer, the 9,553.3 kc frequency is mixed with the two signals from the crystal filter, after they are amplified. L2 passes only signals within the 40 meter band. These are the two difference frequencies 9,553.3 – 2,303.7 and 9,553.3 -– 2,306.4, or 7,249.6 and 7,246.9 kc. Note that these two frequencies are 0.4 and 3.1 kc <u>below</u> the tuned frequency showing that they are LSB components of a 7,250.0 transmitted signal. These two frequencies are further amplified and sent to the antenna.

On Receive (See block diagram - Fig 6):
During receive, the incoming RF signal is first amplified and then mixed in the receiver mixer stage with the same heterodyne signal used by the transmitter mixer. As a result, the received signal is converted to the 2,305.0 kc IF frequency, and the sideband is inverted on the HW-22 and HW-32. The IF signal then passes through the crystal filter where only the desired sideband is passed. From here it is amplified and finally mixes with the same carrier oscillator used for transmit. The result is audio in the 400 cps to 3.1 kc range. The resulting frequencies are shown in Table III.

Continuing the exercise of tracking the 0.4 and 3.1 kc tones at the receiving end - if the receiver is tuned to 7,250 kc the two signals at 7,249.6 and 7,246.9 are amplified by the receiver RF amplifier and fed to the receiver mixer where they are mixed with the same 9,553.3 signal as during transmit. The difference frequencies are 2,303.7 and 2,306.4 kc, and the sideband is inverted back to USB. These two signals pass through the filter, while signals outside the bandpass are removed, or heavily attenuated. This includes any interference that might be in the other sideband's frequency range. The two signals are then amplified in the IF amplifiers and mixed in the product detector, with the crystal carrier oscillator oscillating at 2,303.3 kc. Only the audio frequencies are passed on to the audio stages, while RF frequencies are bypassed to ground. The results are 2,303.7 – 2,303.3 and 2306.4 – 2,303.3 kc or 0.4 and 3.1 kc. which are the original tones sent, and are now being heard in the receiver speaker.

Service Bulletins:
Heathkit put out several service bulletins on the HW-12/22/32. to increase stability and other improvements. Filament and other bypassing is improved, especially around the VFO. A small 0.001 capacitor is added between the mic amplifier and ground on the two higher frequency radios to curb RF getting into the audio. Bias voltages are tweaked by a resistor change and finally, on all three units, one of the bias resistors is replaced by a higher wattage resistor.

In another service bulletin, specific to the HW-32, coil cans L5 and T2 are connected together with heavy bare wire to prevent a ground-loop. T3, L2 and L3 are likewise connected. Here is a link to these mods:

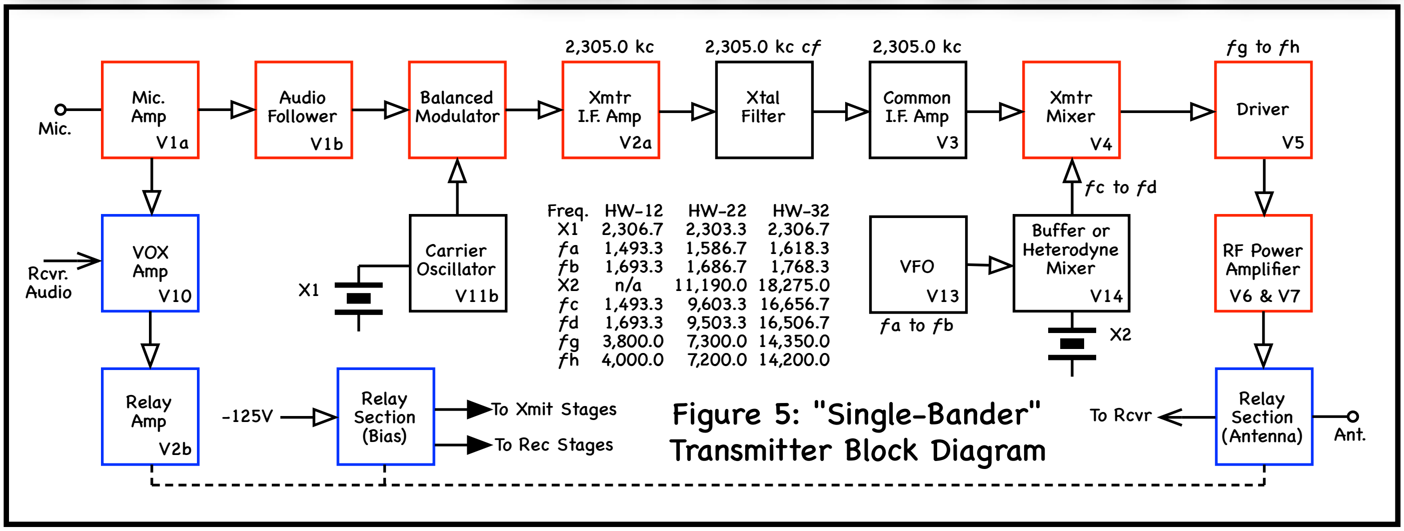

Figure 5: "Single-Bander" Transmitter Block Diagram

http://www.w6ze.org/Heathkit/TN/hw22.pdf.

Comments:

In the July 1964 Heathkit catalog there was a "Special value price" of $310 for the HW-42. This was a package deal for all three transceivers I don't know how long it lasted, but I never saw it offered in any later catalog that I have access to.

In the next article we'll discuss the general tube line-up and delve into the transmitter circuitry, and if space permits, cover the receiver circuitry as well.

73, from AF6C

Notes:

1. When this kit was released kc - kilocycle [per second] was the common term used. KHz - Kilohertz was still to be adopted. I try to use the terms that existed when the kits were introduced.
2. HP-23 Series, see HOM #26 - Mar. 2011
3. HP-13 Series, see HOM #40 - Jun. 2012

HOM (Heathkit of the Month) Articles are available at: http://www.w6ze.org/Heathkit/Heathkit_Index.html

This article originally appeared in the February 2016 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.

Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.

Thanks - AF6C

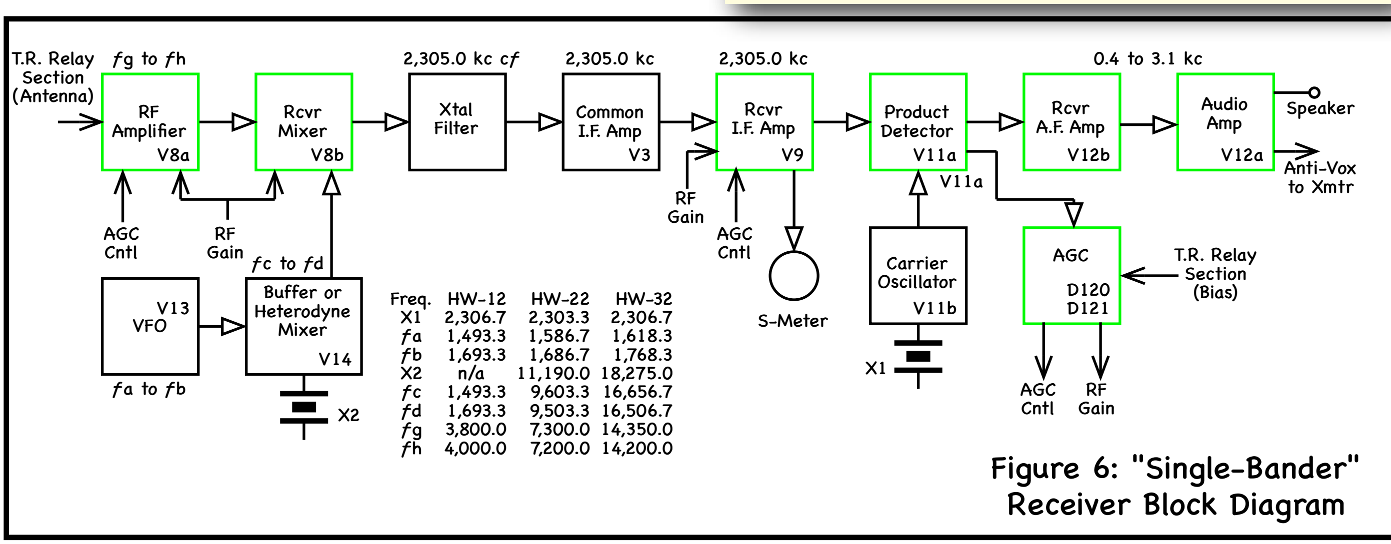

Figure 6: "Single-Bander" Receiver Block Diagram

