AMATEUR RADIO - SWL

Heathkit GR-88 & GR-98 Portable VHF Monitor Receivers.

Introduction:
In 1969 Heathkit released two solid-state portable monitor receivers. One, the GR-88 covers police, fire, marine and weather bands from 152 to 174 MHz. It can receive narrow and wide-band FM. The other, the GR-98 covers the aircraft NAV and COMM bands, 108 - 118 and 118 - 136 MHz respectively. The GR-98 receives AM. Both units operate portable on six ‘C’ cell batteries, or can run on 120 VAC power using the optional GRA-88-1 AC power supply. This accessory mounts internally to the monitor receiver.

The two radios each sold for $49.95 in the Summer 1969 catalog. The optional AC power supply was initially an additional $7.95, but was raised to $8.50 in 1972. The price for these radios remained at $49.95 through most of their life but did raise to $56.95 in 1975. In fall 1976 catalog they dropped back down to $49.95 as they were evidently being closed out. The GR-98 was last seen in 1976, but the GR-88 remained for sale into 1977. This may have just been because the stock of GR-98s sold out first?

\(^1\) Notes appear on page 5

Here is a link to the index of Heathkit of the Month (HotM) articles:
http://www.w6ze.org/Heathkit/Heathkit_Index.html

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However, the two crystal formulas are different (Note the change in sign):

\[ X_f = \frac{(R_f - 10.7)}{3} \]

\[ X_f = \frac{(R_f + 10.7)}{3} \]

where:
- \( X_f \) is the crystal frequency, and
- \( R_f \) is the desired receive frequency.

Both receivers use an IF frequency of 10.7 MHz. However, the IF and detector circuit are different, as are their AGC circuits; these differences can be attributed to AM vs. FM detection. The two stages of audio pre-amplification, the audio driver and audio output stages are identical with a few minor exceptions.

Both receivers have the same controls. From left to right the front panel contains, in the upper left a pull-out whip antenna, the VOLUME control with power OFF switch at the full CCW position, the SQUELCH control, the main tuning dial, which has a 6:1 vernier action, and the OSC. slide switch that selects either VARiable tuning (down) or XTAL channel (up). An RCA external antenna connector is located on the left side of the case. If the optional AC power supply is installed an AC power cord connector and a BATT - AC slide switch are present on the right side of the case. If the optional supply is not installed the openings for these components are covered with ‘knock out’ plates. The radios are packaged in a leatherette case (See Figure 3).

Both radios use a single conversion superheterodyne circuit \(^2\). This circuit has been discussed before and won’t be covered here. Over the production run changes were made to the radios, a lower cost TO-92 plastic-case 2N5770 transistor replaced the 2N2369 TO-18 metal-case transistors in the IF circuits. The 2N5770 also replaced the TO-17 metal cased RCA 40481 transistor (Q13) in the crystal oscillator circuit. The 2N5770 probably had a positive effect on perfor-

<table>
<thead>
<tr>
<th>Specifications</th>
<th>GR-88</th>
<th>GR-98</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuning Range</td>
<td>152 - 174 MHz</td>
<td>108 - 136 MHz</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>&lt;2.0 µV for</td>
<td>1.5 µV for</td>
</tr>
<tr>
<td></td>
<td>20 dB quieting</td>
<td>10 dB (S+N)/N @ 1 KHz 30% modulation</td>
</tr>
<tr>
<td>IF Selectivity</td>
<td>±40 KHz</td>
<td>40 KHz</td>
</tr>
<tr>
<td>@ 6 dB down</td>
<td>(not given)</td>
<td>100 KHz</td>
</tr>
<tr>
<td>@ 30 dB down</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transistor &amp; Diode Complement</td>
<td>See Table III</td>
<td></td>
</tr>
</tbody>
</table>

Common to both the GR-88 and GR-98

- Antenna Input: 50 - 75 Ω
- IF Frequency: 10.7 MHz
- Image Rejection: 40 dB or greater
- IF Rejection: 80 dB or greater
- Audio Output: 250 mW @ < 10% distortion
- Speaker: 3" round, 24Ω
- Batteries: 1.5V 'C' cells (Six required)
- Dimensions: 8 3/4" W x 7 1/2" H x 3 1/2" D.
- Net Weight: 3 lbs, less batteries

**Table I**

**Crystal Information**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>See Text for Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holder Type</td>
<td>HC-18/U</td>
</tr>
<tr>
<td>Load Capacitance</td>
<td>32 pF.</td>
</tr>
<tr>
<td>Mode</td>
<td>Parallel mode, 3rd Overtone</td>
</tr>
<tr>
<td>Frequency Tolerance</td>
<td>0.0025% at 25° C (77° F)</td>
</tr>
<tr>
<td>Maximum Drive Level</td>
<td>1.2 mW.</td>
</tr>
<tr>
<td>Effective Resistance</td>
<td>25 ohms.</td>
</tr>
<tr>
<td>Xtal Range GR-88</td>
<td>47.1000 to 54.4333 MHz</td>
</tr>
<tr>
<td>Xtal Range GR-98</td>
<td>39.5666 to 48.9000 MHz</td>
</tr>
</tbody>
</table>

**Note:** Provide these specifications to the crystal manufacturer.

**Caution:** The formula to determine the crystal frequency for a given receive frequency is different between the two radios.

**TABLE II**
mance as the 2N5770 transistor is designed for RF while the 2N2369 is a high-speed switching transistor.

The GR-88:
Being an FM receiver, the GR-88 has a Ratio Detector composed of T4, D1 and D2. This detector circuit was discussed in HoTM #63. The interior of the GR-88 is shown in Figure 2.

The GR-88 has no AGC (automatic gain control) circuit. The gain of the RF Amplifier in the tuner is set by fixed resistors R102 and R103. The IF selectivity is determined by L1, a high ‘Q’ tuned circuit at the input of the IF chain. The IF gain is high and on all but the weakest signals the last IF stage limits the peaks of the IF signal eliminating any AM signals. On the strongest of signals all the IF stages act as limiters. In between strengths, are limited in one or more of the IF stages.

A squelch circuit quiets the receiver audio when there is no signal present, removing the tedium of constant white noise between transmissions. After the audio is recovered it is amplified by Q6 and fed to the volume control and audio circuits. The output of Q6 is also fed to a notch filter composed of C24, C26 and L2. The resulting sampling of noise voltage is sent through the squelch control to the Squelch Amplifier Q7, a voltage doubling detector circuit composed of D3, D4, C29 and C32 and on to Q8, the Squelch Gate. When Q8 is conducting it

![Figure 2: Inside the GR-88 FM VHF Monitor. Note the pre-built and aligned tuner at the top right, the single circuit board in the bottom half and battery pack to the left. The optional AC power supply mounts under the batteries at the upper left.](image)

### Semiconductor Complement and Function

<table>
<thead>
<tr>
<th>Stage</th>
<th>GR-88</th>
<th>GR-89</th>
<th>Part #</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Amplifier (Tuner)</td>
<td>Q101</td>
<td>Q101</td>
<td>2SC784</td>
</tr>
<tr>
<td>Mixer (Tuner)</td>
<td>Q102</td>
<td>Q102</td>
<td>2SC784</td>
</tr>
<tr>
<td>Local Oscillator (Tuner)</td>
<td>Q103</td>
<td>Q103</td>
<td>SE5006</td>
</tr>
<tr>
<td>1st IF Amplifier</td>
<td>Q1</td>
<td>Q1</td>
<td>2N2369*</td>
</tr>
<tr>
<td>2nd IF Amplifier</td>
<td>Q2</td>
<td>Q2</td>
<td>2N2369*</td>
</tr>
<tr>
<td>3rd IF Amplifier</td>
<td>Q3</td>
<td>Q3</td>
<td>2N2369*</td>
</tr>
<tr>
<td>4th IF Amplifier</td>
<td>Q4</td>
<td>Q4</td>
<td>2N2369*</td>
</tr>
<tr>
<td>IF Limiter</td>
<td>Q5</td>
<td>Q5</td>
<td>2N2369*</td>
</tr>
<tr>
<td>IF AGC Amplifier</td>
<td>Q5</td>
<td>Q5</td>
<td>MPF105</td>
</tr>
<tr>
<td>1st Audio/Squelch Amp.</td>
<td>Q6</td>
<td>Q6</td>
<td>2N3393</td>
</tr>
<tr>
<td>Squelch Amplifier</td>
<td>Q7</td>
<td>Q7</td>
<td>2N3393</td>
</tr>
<tr>
<td>Squelch Gate</td>
<td>Q8</td>
<td>Q8</td>
<td>X29A829</td>
</tr>
<tr>
<td>1st Audio Preamplifier</td>
<td>Q9</td>
<td>Q9</td>
<td>2N3393</td>
</tr>
<tr>
<td>Audio Driver</td>
<td>Q10</td>
<td>Q10</td>
<td>X29A829</td>
</tr>
<tr>
<td>½ Audio Output Amp.</td>
<td>Q11</td>
<td>Q11</td>
<td>2N2430</td>
</tr>
<tr>
<td>½ Audio Output Amp.</td>
<td>Q12</td>
<td>Q12</td>
<td>2N2431</td>
</tr>
<tr>
<td>Crystal Oscillator</td>
<td>Q13</td>
<td>Q13</td>
<td>40481*</td>
</tr>
<tr>
<td>AGC Gate</td>
<td>Q14</td>
<td>Q14</td>
<td>2N3393**</td>
</tr>
<tr>
<td>Ratio Detector:</td>
<td>D1</td>
<td>D1</td>
<td>1N191</td>
</tr>
<tr>
<td>AM Detector:</td>
<td>D2</td>
<td>D2</td>
<td>1N191</td>
</tr>
<tr>
<td>Squelch Rectifier:</td>
<td>D3</td>
<td>D3</td>
<td>1N4646</td>
</tr>
<tr>
<td>Squelch Rectifier:</td>
<td>D4</td>
<td>D4</td>
<td>1N4646</td>
</tr>
<tr>
<td>Squelch Switch</td>
<td>D4</td>
<td>D4</td>
<td>1N4149</td>
</tr>
<tr>
<td>AGC voltage drop</td>
<td>D5**</td>
<td>D5**</td>
<td>1N4149</td>
</tr>
</tbody>
</table>

* Replaced by the 2N5770 transistor in later units.

** Diode D5 was added and Q14 changed to a PNP 2N2431 in later units for better AGC action.

### TABLE III
puts a large positive voltage on the emitter of Q9, the Second Audio Preamplifier driving it into cutoff along with the remaining audio stages.

The GR-98:
Since the GR-98 is an AM receiver it uses an AM detector composed of D1 and C17. Audio from the junction of D1 and R25 is fed through C23 to the audio stages. GR-98 has an AGC circuit that underwent significant modifications during the production run. Voltage from the detected audio is divided by resistors R23, R24 and R25.

In the early AGC circuit, voltage at the junction of R23 and R24, which becomes less positive with stronger audio, is fed back to the tuner and through R101 to the base of the tuner’s RF amplifier Q101 reducing its gain. A bit of the IF signal is rectified by D2 and D3, a voltage doubler, and fed to the gate of a FET amplifier Q5. In the early units this FET was called the AGC Amplifier. The output from the FET source is fed to an NPN transistor Q14, the AGC Gate. It is also fed to the squelch circuit. Q14 is in series with R11, the emitter resistor for Q2, the Second IF Amplifier. As the base of Q14 goes more positive, the gain of the second IF stage is reduced. The intended effect is to keep the volume nearly constant for signals of different strengths.

Evidently Heath was not satisfied and during production the circuit was changed. The voltage at the junction of R23 and R24 is still connected to the tuner RF Amplifier, but first the voltage is dropped about 0.6 volts by D5, controlling the RF Amplifier but at an overall higher gain. Q14 was replaced with a PNP transistor (2N2431) and its base connects to the same R23, R24 junction of the voltage divider. The collector is grounded. As the base voltage to Q14 goes less positive, Q14 draws more current. This current is supplied by R2 and R8, the base resistors for the First IF Am-

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**Special Purpose & Exploration Gear**

*Hear Police, Fire, Marine & Weather Broadcasts With This Heathkit  
VHF-FM Monitor Receiver . . . Covers 152 to 174 MHz  
• Receives both narrow and wide band FM signals  
• 150-174 MHz coverage  
• High sensitivity and selectivity  
• SSB-SSB vernier tuning control  
• Multiple channel crystal control  
• Adjustable squelch control  
• Quiet signal background noise  
• All solid-state construction for long, trouble-free life  
• Portable battery operated  
• Convenient carrying handle doubles as a stand  
• Built-in whip antenna  
• Jack for external antenna  
• Accessory AC power supply available  
• Rugged brown leatherette case  
• One circuit board & preassembled & signed tuner save builder time  

The Heathkit GR-88 is easy to build, smooth to operate and easy to take along... anywhere. To make constant monitoring of a particular frequency easier, just plug in a crystal, tune to the approximate frequency, then flip the panel switch to “Xtal” and you’re on frequency. The accessory AC power supply, Kit GRA-88-1, fits inside the GR-88 case. Handle turns 90 degrees from vertical to prop up unit on a table.

Kit GR-88, 5 lbs. $49.95

Kit GRA-88-1, Accessory AC Power Supply, 1 lb. $7.95

Kit GRA-88-2, Accessory AC Power Supply, 1 lb. $7.95

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**Monitor The Aircraft Band With This Heathkit GR-88**

*Tunes the complete Aircraft Band—108 to 136 MHz  
• All solid-state circuitry  
• Completely portable  
• Built-in whip antenna  
• Handsomely styled, rugged brown leatherette case with lift-stand/carrying handle combination  
• Excellent sensitivity and selectivity  
• Vernier tuning  
• Adjustable squelch control  
• Single channel crystalcontrol feature  
• Built-in external antenna jack  

The accessory AC power supply available. Fast, enjoyable assembly with circuit board construction and factory assembled and signed tuner.

Kit GR-88, 5 lbs. $49.95

Kit GRA-88-1, Accessory AC Power Supply, 1 lb. $7.95

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Figure 3: Ad from Winter 1970 Heathkit Catalog showing the GR-88 and GR-98.
plifier (Q1) and the second IF Amplifier (Q2) respectively. This reduces the gain of those stages when more current is drawn by Q14. L2 provides RF isolation between the two controlled stages. Controlling two IF stages give the AGC a lot larger dynamic range.

The GR-98 squelch circuit also went under some minor changes, mostly the addition of a trimpot to set the squelch level and give the front panel control better sensitivity. In the later units the signal from the source of the FET Q5 is fed through the squelch control to the base of Q6, the Squelch Amplifier. Q5 is now called the Amplifier as it no longer plays a part in the AGC circuit. With the SQUELCH control properly adjusted and no signal present Q6 is cutoff, cutting off PNP transistor Q7 causing its emitter voltage to rise and D4 to conduct. This raises the voltage on the emitter of Q9, the Second Audio Preamplifier, causing it to cutoff, muting the audio stages. When a signal is received Q6 conducts turning on Q7 which biases D4 off allowing Q9 to operate normally, passing the audio.

Summary:
GR-88 and GR-98 Receivers may still be found at swap meets and currently there is one of each for sale on eBay. The eBay price is around the $70 mark.

While the GR-98 selectivity was good back in the 70’s, channel spacing has decreased so in more populated areas you may have some co-channel interference on the aircraft bands. the GR-98 was probably quite popular with the aviation crowd. It was light and portable and its sensitivity compares favorably with current day scanners that cover the aircraft band.

The GR-88 probably had a lot more competition with a lot of scanners being sold by both Heathkit and other manufacturers. The continuous tuning, instead of channelized tuning, could be both a drawback and an advantage.

Let me take this time to wish you all a happy holiday season. It has been a tough year in many ways. Don’t despair though, there is light at the end of the tunnel.

Schematics are available at:
http://www.w6ze.org/Heathkit/GR88_98.html

BEFORE HEATHKIT others were introducing kits into amateur radio. Here is an ad from a small startup company. Many are probably familiar with the later non-kit products from this company:

Ad from January 1932 QST Page 77
(Thanks Steve -)

Notes:
1. Much of the police and fire communications have since been moved to UHF and to trunking channels.
2. Schematics are available at:
http://www.w6ze.org/Heathkit/GR88_98.html
4. Aircraft VHF communications use AM. FM has a capture effect that may cause Air Traffic Control to not hear pertinent calls.

This article originally appeared in the December 2020 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.

Thanks - AF6C