Heathkit of the Month #103:
by Bob Eckweiler, AF6C

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 [1]. 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

Figure 1: The GR-98 Air-Band AM VHF Monitor

The GR-88 FM VHF Monitor Receiver and The GR-98 AM Air-band Monitor Receiver:

There are many similarities between these two models that may be discussed in unison. Their specifications are shown in **Table I**. The receivers feature a handle that may be used for carrying and as a foot to hold the receiver at an angle while in use. Either the built-in collapsable whip antenna, or an external antenna (RCA jack) may be used.

Both use a pre-built and pre-aligned modular tuner, simplifying construction and alignment. The tuners each have 3 transistors, two 2SC784 (RF amplifier, and mixer) and an SE5006 local oscillator. The tuner has a three section variable capacitor, tuning the input and output of the RF amplifier as well as setting the oscillator frequency. From the part numbers of the tuner transistors, the tuners were probably manufactured for Heathkit in Japan.

Each radio has a provision for a single crystal controlled channel. When using the crystal channel the main tuning knob should be set near the channel frequency to peak the RF gain at that frequency. Both use the same crystal specifications (**See Table II**).

Specifications

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

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 ¾" W x 7 ½" H x 3 ½" D.
Net Weight:	3 lbs, less batteries

Table I

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

$$\text{GR-88:} \quad X_f = \frac{(R_f - 10.7)}{3}$$

$$\text{GR-98:} \quad X_f = \frac{(R_f + 10.7)}{3}$$

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 **VAR.**iable 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-

Crystal Information

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

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[3] 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.

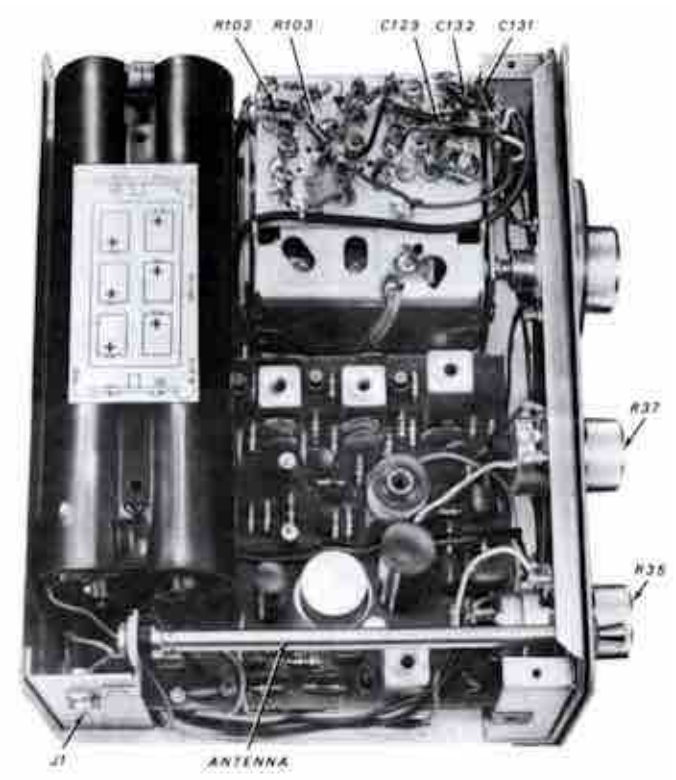

Figure 2: Inside the GR-88 FM VHF Monitor. Note the pre-built and aligned tuner at the top right. the single circuit board in the bottom half and battery pack to the left. The optional AC power supply mounts under the batteries at the upper left.

Semiconductor Complement and Function

Stage	GR-88	GR-89	Part #
RF Amplifier (Tuner)	Q101	Q101	2SC784
Mixer (Tuner)	Q102	Q102	2SC784
Local Oscillator (Tuner)	Q103	Q103	SE5006
1st IF Amplifier	Q1	Q1	2N2369*
2nd IF Amplifier	Q2	Q2	2N2369*
3rd IF Amplifier	Q3	Q3	2N2369*
4th IF Amplifier	Q4	Q4	2N2369*
IF Limiter	Q5		2N2369*
IF AGC Amplifier		Q5	MPF105
1st Audio/Squelch Amp.	Q6		2N3393
Squelch Amplifier	Q7	Q6	2N3393
Squelch Gate	Q8	Q7	X29A829
1st Audio Preamplifier		Q8	MPF105
2st Audio Preamplifier	Q9	Q9	2N3393
Audio Driver	Q10	Q10	X29A829
½ Audio Output Amp.	Q11	Q11	2N2430
½ Audio Output Amp.	Q12	Q12	2N2431
Crystal Oscillator	Q13	Q13	40481*
AGC Gate	Q14		2N3393**
Ratio Detector:	D1		1N191
AM Detector:		D1	S160
Ratio Detector:	D2		1N191
Squelch Rectifier:		D2	1N191
Squelch Rectifier:	D3		1N4646
Squelch Rectifier:		D3	1N191
Squelch Rectifier:	D4		1N4646
Squelch Switch		D4	1N4149
AGC voltage drop		D5**	1N4149

* **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

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

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 [4] 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-

Special Purpose & Exploration Gear

Hear Police, Fire, Marine & Weather Broadcasts With This Heathkit VHF-FM Monitor Receiver . . . Covers 152 to 174 MHz

GR-88 **$49.95**

• Receives both narrow and wide band FM signals • 152-174 MHz coverage • High sensitivity and selectivity • Six-to-one vernier tuning control plus single channel crystal control • Adjustable squelch control quiets 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 & aligned 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

GR-88 SPECIFICATIONS—**Tuning range:** 152-174 MHz. **Antenna input:** 50-75 ohms. **Sensitivity:** 2.0 uV or less for 20 dB quieting. **IF Frequency:** 10.7 MHz. **IF Selectivity:** ±40 kHz @ 6 dB down. **Image rejection:** 40 dB or greater. **IF Rejection:** 80 dB or greater. **Audio output:** 250 mW at less than 10% distortion. **Speaker:** 3" round, 24 ohms, permanent magnet. **Transistor complement-tuner:** (2) 2SC784 and (1) SE-5006. **Transistor complement-IF & Audio:** (3) 2N2369, (4) 2N3392, (1) X29A829, (1) 2N2430, (1) 2N2431, (1) 40481. **Diode complement:** (2) 1N191 and (2) 1N4446. **Batteries:** Six 1.5 volt "C" cells, not supplied. **Dimensions:** 8¼" W x 7⅝" H x 3⅛" D. **Net weight:** 3 lbs. without batteries.

Monitor The Aircraft Band With This Heathkit GR-98

• 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 tilt-stand/carrying handle combination • Excellent sensitivity and selectivity • Vernier tuning • Adjustable squelch control • Single channel crystal-control feature • Built-in external antenna jack • Accessory AC power supply available • Fast, enjoyable assembly with circuit board construction and factory assembled and aligned tuner

Kit GR-98, 5 lbs. $49.95
Kit GRA-88-1, Accessory AC Power Supply, 1 lb $7.95

GR-98 SPECIFICATIONS—**Tuning range:** 108-136 MHz. **Antenna input:** 50 to 75 ohms. **Sensitivity:** 1.5 uV or less for 10 dB signal-to-noise plus noise ratio @ 1000 Hz 30% modulation. **IF Frequency:** 10.7 MHz. **IF Selectivity:** 40 kHz @ 6 dB down. 100 kHz @ 30 dB down. **Image rejection:** 40 dB or greater. **IF rejection:** 80 dB or greater. **Audio output:** 250 milliwatts or less than 10% distortion. **Speaker:** 3" round, 24 ohm, permanent magnet. **Transistor complement-tuner:** (2) 2SC784 and (1) SE-5006. **Transistor complement-IF & Audio:** (4) 2N2369, (3) 2N3392, (2) X29A829, (1) MPF-105, (1) 2N2430, (1) 2N2431 and (1) 40481. **Diode complement:** (2) 1N191, (1) 1N4446 and (1) S-160. **Batteries:** Six 1.5 volt size "C" cells (not included). **Dimensions:** 8¼" W x 7⅝" H x 3⅛" D. **Net weight:** 3 lbs. without batteries.

GR-98 **$49.95**

Figure 3: Ad from Winter 1970Heathkit 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

73, from AF6C

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:

Crystal Transmitters

Radically new design suitable for Class B modulation or high output C.W. on 14, 7 and 3.5 M.C.

Consists of crystal-oscillator, buffer amplifier, and Class C output amplifier mounted on polished aluminum and hard rubber chassis with plug-in coils and plug-in crystal holder for quick change of frequency. Complete Kits, less tubes, crystal and power supply:

210 Output.....$37.25 203A Output....$47.50
852 Output.....$47.25

The smoothest, neatest little rig you ever saw—and what a Kick she has!

Immediate Delivery *Write for data sheets*

ARTHUR A. COLLINS

Cedar Rapids, Iowa Radio Laboratories, Inc., W9CXX

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
3. Photo taken from Heath GR-88 manual 595-1080-05.
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