Heathkit of the Month #79:
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Heathkit

AMATEUR RADIO - SWL

Heathkit VF-1
External VFO (Variable Frequency Oscillator).

Introduction:

In 1951 the FCC totally revamped the license classes for radio amateurs. Prior to 1951 three classes existed, **A, B,** and **C**. In 1951 the FCC changed the licensing structure into six classes: **Novice Class** (a new introductory class), **Technician Class** (a new class for VHF and UHF advancement), **Conditional Class** (for people unable to be tested in front of an FCC examiner - formerly class C), **General Class** (formerly class B), **Advanced Class** (formerly class A - but no new advanced class licenses were granted after December 31, 1952 until the introduction of incentive licensing in 1968), and the **Amateur Extra Class** (the new top-level class.)

The Novice Class was severely limited in HF operating privileges. Power was limited to 75 watts, and initially operation was limited to CW on a 50 kc band segment on 80 meters and on the full 11 meter band. The transmitter frequency control had to be by crystal. "Rock-bound" was a term used for being crystal-controlled, and most novices owned at most a few crystals for each band they operated. The novice class license was limited to a one-year term and was **not** renewable. You either moved to General, or Technician, or took up a new hobby. Changes took place over the next 20 years to the novice bands, then in 1972 the FCC allowed novices to use VFOs that were FCC Type A accepted.

Figure 1: Heathkit VF-1 VFO

Novices in the 1950s and 60s spent their year operating HF to get their code speed up to the required thirteen words-per-minute, and studying the theory if they wanted to keep their HF privileges. Most stayed away from 2-meters where they had phone privileges, afraid they might squander the year.

Operating "rockbound" resulted in some interesting operating techniques. Since the odds of two hams having the same crystal frequency was low, and it was an advantage to have a crystal at a less common frequency, one had to tune around the novice band after calling CQ. Also, the replying station had to send a long reply so the other station had time to tune to his frequency. Thus, the first thing a graduating novice did when he upgraded to General or Conditional Class was to become "un-rock-bound" by adding a VFO.

During the fifties and sixties Heathkit sold a lot of transmitters for use by novices including the AT-1, DX-20, DX-35, DX-40, DX-60

series and the HX-11. All of these were designed to use crystals and could also use, or be modified to use, an external VFO.

The VF-1 Variable Frequency Oscillator:
In 1952 Heathkit released it's first VFO, the VF-1. It sold for $19.50 throughout its production. Table I shows the specifications. The VF-1 was originally designed to work with the AT-1 transmitter and uses it to get power and key-line via a three conductor shielded cable that plugs into an octal socket on the rear of the AT-1. A separate coax cable, with a two-prong connector that plugs into the crystal socket, supplies the VFO signal to the AT-1.

The early VF-1 manual discusses only operation with the AT-1 transmitter, though the use of the VF-1 is covered in the DX-20, DX-35, DX-40 and DX-60 manuals.

The DX-20 and HX-11 require the use of a separate power supply to run the VF-1 and the placing of a jumper across the transmitter's oscillator cathode RF choke. The VFO signal is then plugged into the crystal socket as on the AT-1. It is necessary to be sure the grounded side of the coax cable is connected to the grounded side of the crystal socket, which is the left side.

The DX-35 and DX-40 can provide power to the VF-1 through their accessory socket. The two prong plug on the VFO signal coax cable must be replaced with an RCA-type phono plug. These two transmitters are wired with a switch to select between one of three crystals and VFO operation; this switch also shorts out the RF choke when in the VFO position.

The DX-60, DX-60A and DX-60B also have an accessory socket that can supply power to the VF-1, and an RCA jack for the VFO signal. Since the older radios use cathode keying and the DX-60 line uses grid-block keying, a simple modification to the VF-1 must also be made.

VF-1 SPECIFICATIONS
(from Heathkit VF-1 Manual)

Output Frequencies:	**1750 - 2000, 7000 - 7425. 6740 - 6808 kilocycles**
Calibrated Bands:	**160-80-40-20-15-11-10 M**
RF Output:	**Approximately 10 volts**
Tube Complement:	**6AU6 Oscillator 0A2 Voltage Regulator**
Power Requirements:	**6.3 V AC at 0.45A 250 - 350 V DC at 15-20 mA**
Cabinet Size:	**7" H x 6-1/2" W x 7" D**
Net Weight:	**4 lbs.**

Table I - VF-1 Specifications

The VF-1 VFO operates over the full amateur bands of 160 meters through 10 meters

VF-1 FREQUENCIES

Freq. Range 1:

Band (M)	Band (Kcs)	VFO Freq. (Kcs)	×
160	1750 - 2000	1750 - 2000	1
80	3500 - 4000	1750 - 2000	2
40	7000 - 7300	1750 - 1825	4

Freq. Range 2:

Band (M)	Band (Kcs)	VFO Freq. (Kcs)	×
40	7000 - 7300	7000 - 7300	1
20	14000 - 14350	7000 - 7175	2
15	21000 - 21450	7000 - 7150	3
10	28000 - 29700	7000 - 7425	4

Freq. Range 3[1]:

Band (M)	Band (Kcs)	VFO Freq. (Kcs)	×
11	26960 - 27230	6740 - 6807.5	4

Notes:
1. Prior to its use for CB, 11 meters was an amateur band.
2. × is the multiplication factor that occurs in the transmitter.

Table II - VF-1 Band Operation

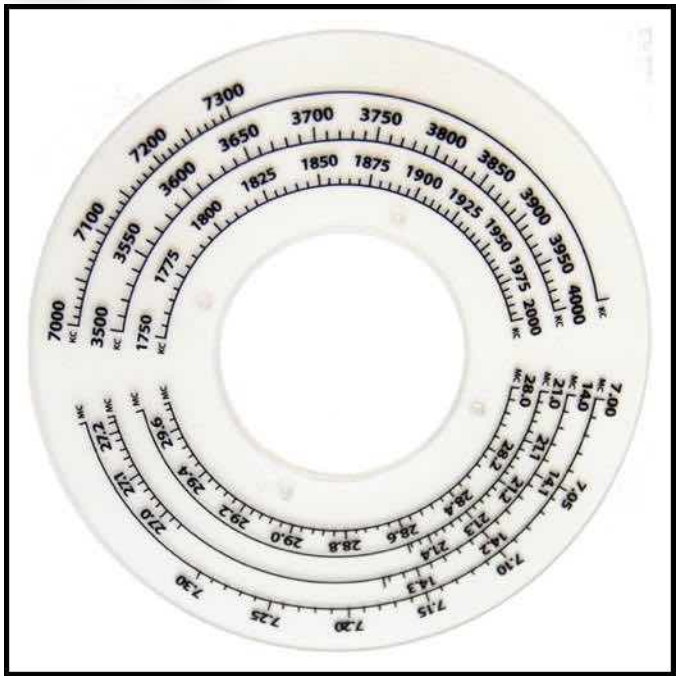

Figure 2: Heathkit VF-1 VFO Dial
Upper scales are range 1 and
lower scales are ranges 2 and 3.

(see Table II). This includes what is now the 11-meter CB band which was a ham band until September 11th, 1958. The VF-1 has just three controls on the front panel and a lighted window with a circular dial with scales to indicate frequency (See Figure 2). A large tuning knob is connected to the dial via a vernier friction drive. The dial is split into two segments, one that covers band range 1 (160, 80 and 40 meters), and one that covers both band range 2 (40, 20, 15 and 10 meters) and band range 3 (11 meters). The tuning capacitor has two sections, 35 µµf maximum for range 1 and 11 µµf maximum for ranges 2 and 3. The control on the left is a three-position rotary switch that selects the range: (**160**, **80 40** - range 1), (**40**, **20**, **15**, **10** - range 2) and (**11** - range 3). The switch on the right is a three-position function rotary switch that selects **OFF**, **STANDBY** and **ON**.

The small panel on the rear contains two grommets allowing the power cable (left side from rear) and VFO signal cable (right side) to exit. Between the two grommets is a 1/4" phone jack for the key.

The VF-1 continued in production until 1961 when it was replaced by the HG-10. The HG-10 is a completely new circuit with styling to match the DX-60 series. The built-in VFO of the DX-100 AM/CW transmitter (HOM #8) follows the design of the VF-1.

VF-1 Construction:

Heathkit, in their ads and in their manual, touted the mechanical design of the VF-1 and how it adds to frequency stability - a most important aspect for a VFO. They dedicated a full page to the VF-1 in the 1956 main catalog. The chassis is copper-plated with shielding designed for thermal considerations, and structural rigidity in mind. The two tank coils are wound on heavy ceramic coil forms and Q-Max doped for stability. The case is aluminum and vent holes on the rear, top and bottom align with the trimmers and coils so the VFO may be calibrated in situ. Initial rough calibration is done with the case off. Figure 3 is an inside view of a VF-1.

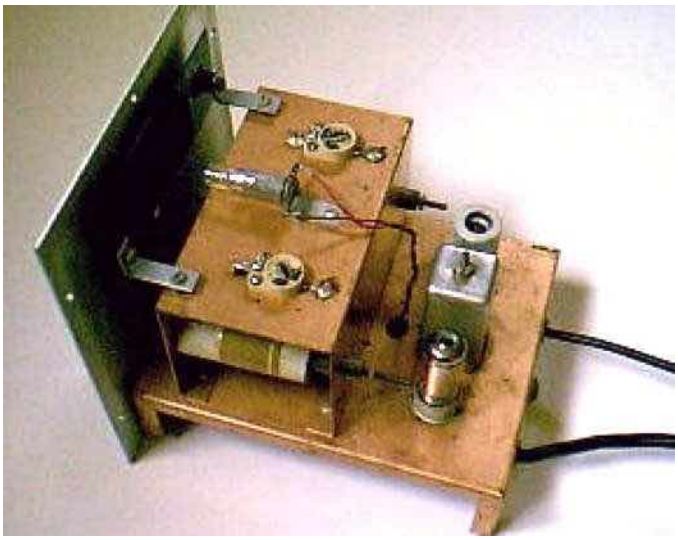

Figure 3: Heathkit VF-1 VFO Internal View

Heathkit VF-1 VFO Circuit:

The VF-1 uses two tubes, a 6AU6 oscillator tube, and an 0A2 voltage regulator tube that

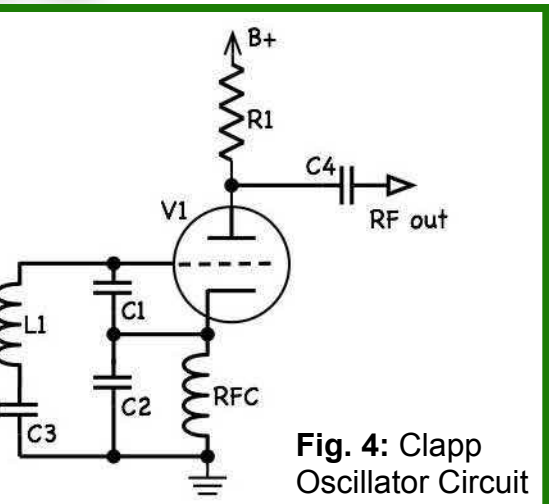

Fig. 4: Clapp Oscillator Circuit

controls the screen voltage. The circuit is a Clapp oscillator. The basic circuit of a Clapp oscillator is shown in Figure 4. It is the standard Colpitts oscillator with an added capacitor C_3 in series with the inductance. This capacitance is normally much smaller than C_1 and C_2 and can be a variable capacitor. In a VFO circuit C_3 is generally multiple capacitors in parallel. In the VF-1 C_3 is composed of the main tuning variable capacitor, a trimmer capacitor for calibration and two fixed capacitors, one with a negative temperature coefficient to reduce drift due to temperature. The equation for determining the frequency of oscillation is:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L_1}\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)}$$

Figure 5 is an annotated schematic of the VF-1. The components of the original schematic are marked only with values. The C_1 and C_2 of the VF-1 circuit are both 510 µµf. On range 1 (1750 to 2000 kc) L_1 is the 114.5 µh tunable coil and C_3 is made up of the 35 µµf tuning capacitor, the 4.5 - 25 µµf trimmer capacitor and a 47 µµf and 10 µµf fixed capacitor. The 10 µµf has a negative (N750) temperature coefficient to compensate for temperature changes. When on range 2 (7000 - 7325 kc) a different set of coil and capacitors is switched in for L_1 (9.3 µh) and C_3. On range 3 (6740 - 6808 kc) the range 2 components continue to be used with an additional trimmer capacitor switched in to lower the frequency to cover the 11 meter band.

The output circuit is electron coupled. The screen grid is regulated at a hard 150 volts by the 0A2 regulator tube and acts as the plate. The actual plate is only coupled to the oscillator by the electron stream. The suppressor grid is hard grounded and acts to further isolate the oscillator from the plate load. The plate voltage is applied through two tuned coils with a 'Q' high enough to provide good output voltage while still having the bandwidth to be effective over the VFO range. On range 1 both coils are in the circuit. On ranges 2 and 3 the larger value is switched out. Output is taken directly from the plate through a 100 µµf blocking capacitor.

Plate and screen grid voltage is derived from either an external power supply or from the host transmitter. When the function switch is in the OFF position filament voltage is removed from the 6AU6 tube and the pilot lamp that illuminates the dial window. When in STANDBY filament and pilot lamp voltage is applied, but the cathode is disconnected from ground and no oscillations occur. However, there are two ways the cathode can become grounded when in the STANDBY mode; if a key is plugged into the rear jack of the VF-1 and the key is closed, or if the key-line, which connects to the transmitter via the power cable, is grounded at the transmitter.

When operating CW the VFO can either be kept running during transmissions or keyed along with the transmitter. The AT-1, the DX-20 and HX-11 normally operate in the former mode with the VFO switch at the ON position while transmitting, and the DX-35 and DX-40

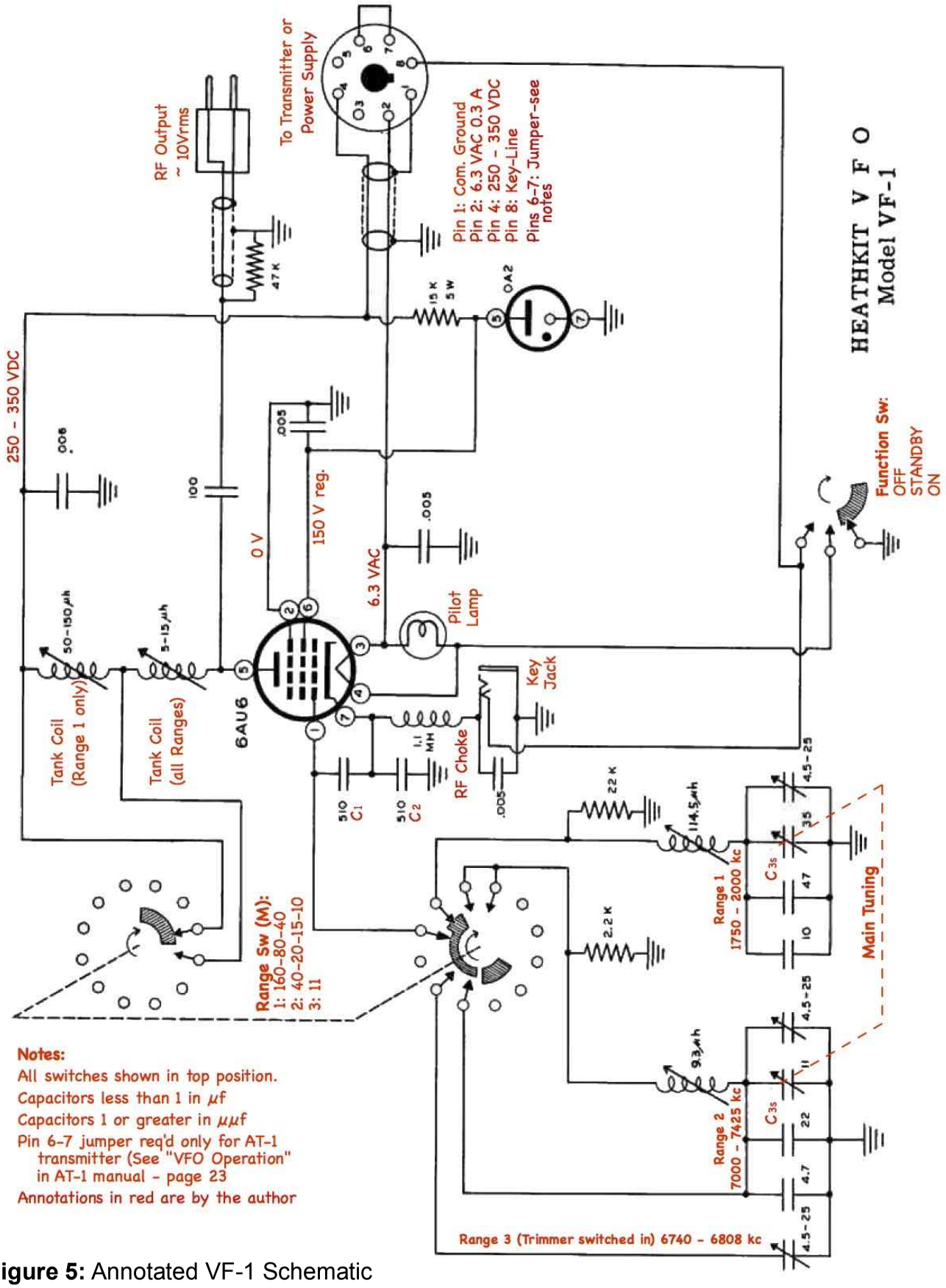

Figure 5: Annotated VF-1 Schematic

operate in the latter mode with the VFO switch at the STANDBY position with the VFO being controlled by the transmitter.

Summary:

The VF-1 VFO can still be found on the air. Some older hams so enjoyed their novice year that they have set up a second station, often closely resembling their original novice station. The two most frequent upgrades they include with that second station are a better receiver of about the same time period, and a VFO. The VF-1 remains a sought after product in todays vintage amateur radio world.

In the spring of 1960 I passed my General Class license. While awaiting the license to arrive I assembled a VF-1 VFO to go with my DX-40 and put my collection of four novice band crystals (two for 40 and two for 15 meters) into a drawer. The VF-1 worked well and did its job. I don't ever remember having trouble with stability, or frequency drift, but I'm sure by today's standards it would be large. The freedom to move around in frequency and call stations on their own frequency made operating a lot easier. Many of the friends I made as a novice had also upgraded and we held short nets a few times a week; one was even on AM phone. Not long after I upgraded, the DX-40 and VF-1 were sold and a new Heathkit TX-1 Apache was assembled and put on the air.

Coming up:

When I started this article I had planned to include the HG-10 and HG-10B VFO's also. In order to keep to a reasonable article size I later decided to feature them in a future separate article. There is little difference between the original and the 'B' model (no 'A' model was produced) so both can be covered easily.

73, from AF6C

This article originally appeared in the October 2017 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