AN INEXPENSIVE VFO
FOR THE YAESU FT-102

The basis of this circuit is a solid-state Franklin oscillator

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How would you like an external VFO for your Yaesu FT-102 that doesn't require any modifications or cost a small fortune? Mine uses the transceiver's digital readout, works on either or both transmit and receive, and drifts so little you'll need a frequency standard to measure it. Interested? Read on.

How it all started

In 1982 I bought a Yaesu FT-102 as a Christmas present (for myself). I got the AM/FM board and some crystal filters for CW and SSB, but I couldn't go the extra $500 or more for an external VFO. Not only was there not a "plain vanilla" VFO available, but the $500 one had memories, scanning functions, and a veritable calliope of bells and whistles. Besides, I couldn't see any real need for split frequency at that time.

Everything went beautifully until the 10-meter band started to open up this past year. I suddenly discovered that the 10-meter FM band required 100-kHz splits, and I didn't have that capability. I remembered an ad for the FV-102DM external VFO, which stated that the correct operating frequency was always displayed on the FT-102 digital readout. If I could do that I wouldn't need a fancy dial on the external VFO.

Fortunately, I had purchased a technical supplement for my FT-102 when they were available, although at the time I thought the price (about $25) was atrocious. Since then I've installed all the relevant mods, repaired the receiver preamp switch, and replaced a defective meter.

Digging into my supplements, I discovered the connections for the external VFO plug, and learned that I could indeed use the internal digital readout to display the frequency of an external VFO. This plug is an eight-pin DIN plug, type B (P1 in the schematic). There are two types of eight-pin DIN plugs. Naturally, according to Murphy's Law, I got the wrong one first. The correct plug is the nonsymmetrical one. (See **Figure 1**). Notice also that the pin numbering is not what one would consider normal — not me anyhow.

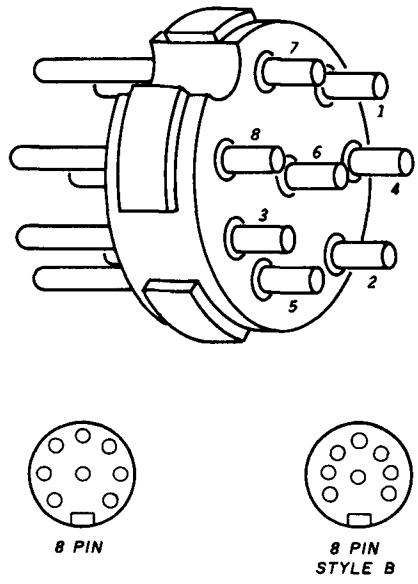
Developing the ideal VFO

Armed with all this technical information on how to connect the external VFO plug, I started looking for a suitable circuit. My ideal was preferably without coil taps, and certainly without parallel capacitors — too big to be air spaced, which could ruin the tuned circuit Q. I wasn't having much luck, until I came across the circuit for the Franklin oscillator in the *RSGB Handbook*. This is reproduced in **Figure 2A**.

The Franklin oscillator has no large capacitors paralleling the tuned circuit, and no taps on the coil. Only a pair of small coupling capacitors connects the coil to the oscillator circuit. It's an astable oscillator (multivibrator to us oldtimers). The tuned circuit is in parallel with one of the crossed feedback lines, where it offers a high impedance across the line at the resonant frequency, and a low impedance at all other frequencies.

This looked interesting so I built an FET circuit on a protoboard, scaling the drain resistors to work with an 8-volt supply. The circuit is shown in **Figure 2B**. Note the similarity to the original tube circuit. I had to increase the coupling capacitors to 10 pF to ensure reliable oscillation at that voltage. This oscillator delivered 1.3 volts p-p at about 1000-ohms impedance. This was too high for the FT-102, which requires 200 mV p-p at 50 ohms. I followed it with a Darlington emitter follower to lower the impedance and a lowpass filter simi-

FIGURE 1



Eight-pin DIN plug showing pin numbering. Type B is the correct plug.

TABLE 1

Function of the pins of the FT-102 rear panel connector marked EXT VFO and RCVR — A.

This connector is an eight-pin DIN type B female connector. It is called J7 on the schematic diagram of the complete FT-102 transceiver, and is in the upper left corner of the diagram. Attached to pin 1 of J7 is an unlabeled DPDT switch. It operates when a connector is inserted into J7. It removes the 8-volt DC bias from the internal VFO signal, turning off the diode-switching circuit which normally accepts the internal VFO signal. If you plug a blank DIN connector into J7, the digital display blanks out. The 8-volt input to the internal VFO is connected to pin 1 of J7 when a connector is inserted.

J7 pin functions

1. Internal VFO enable input. Eight volts must be applied to pin 1 to enable the internal VFO when a plug is inserted.
2. Twelve volts output from the transceiver. The maximum available current is 300 mA.
3. Output, 500 kHz. Adds 500 kHz to digital display when required. An example is the 28.5 to 29-MHz band (not used).
4. TX 12 volts. Twelve volts is supplied to this pin by the transceiver in the transmit mode.
5. CW 8 volts. Eight volts is supplied to this pin by the transceiver in CW mode (not used).
6. External VFO input. Requires 200-mV p-p at 50 ohms impedance.
7. Chassis ground.
8. Sample of VFO input selected (not used).

lar to the one Yaesu uses for the internal oscillator. The overall output is about 220 mV p-p at 50 ohms.

Power and control circuitry

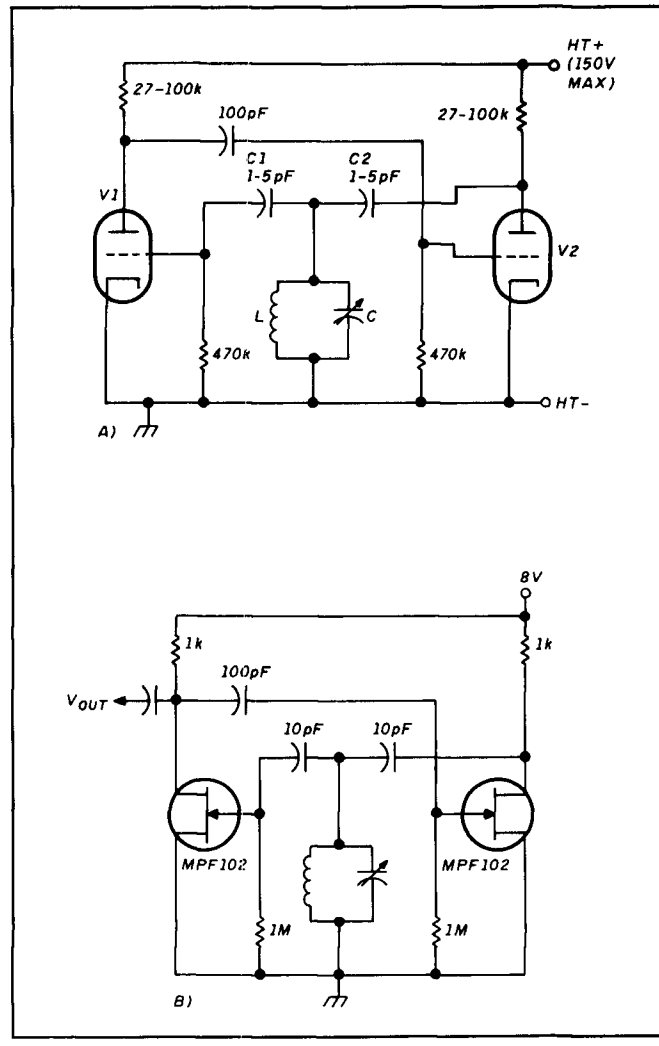
The VFO is powered from the FT-102. A 12-volt source is available on pin 2 of the external VFO connector (see Table 1). The VFO measured current is 55 mA, well within the available 300-mA maximum. A 7808 voltage regulator reduces the 12 volts supplied to the 8 volts desired. This is a bit of "overkill;" the 7808 will handle better than 1 A, so it doesn't need a heat sink. You can replace the 7808 with an LM317 adjustable regulator. The LM317 may be easier to find, and requires only two external resistors to program it. This circuit is shown at the bottom of the schematic in **Figure 3**.

The FT-102 has another 12-volt output available on transmit only. This powers an SPDT relay which switches the 8-volt supply to provide both a receive-only and a transmit-only voltage. These switch the VFO diode circuits in the FT-102 and are selected with the front panel EXTERNAL/INTERNAL toggle switches. I could have done this with CMOS logic, but I had the relay on hand. The complete circuit of the VFO is shown in **Figure 3**.

Mechanical construction

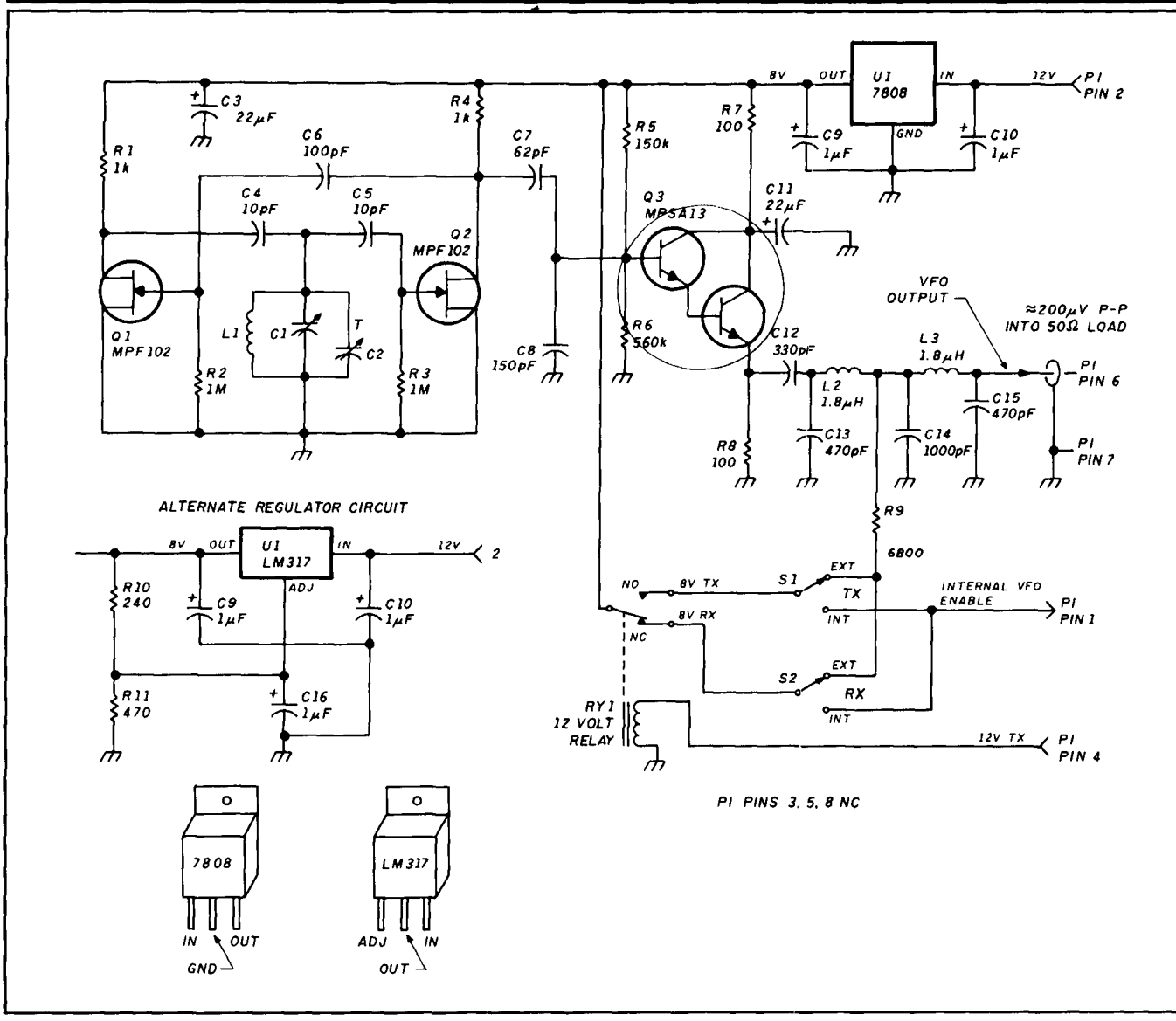
- **Tuned circuits.** Now that I'd designed the VFO, I had to build it. I measured a military surplus coil on a 1-3/8 inch

FIGURE 2



Original diagram of the Franklin oscillator reproduced from the RSGB Handbook (A). The same circuit modified for FETs is shown in B.

FIGURE 3



Schematic diagram for the FT-102 external VFO.

ceramic form; it had 6.8 μH inductance. I used an FM-tuning capacitor that had been in the junkbox for a couple of years. It had three sections which, when connected in parallel, produced 30-pF capacitance change. This enabled a frequency shift that exceeds the required 5.0 to 5.5-MHz VFO frequency range slightly. A 150-pF air-spaced, screwdriver-adjusted trimmer capacitor completes the tuned circuit.

- **Circuit board assembly.** Keeping as much room as possible around the coil, I mounted the tuning and trimmer capacitors in one end of the cabinet and assembled the electronic parts on top of them. I don't usually build pc boards for my projects as they are one-of-a-kind things. I used a universal circuit board and assembled this circuit at the right side of the cabinet. You don't need to take any special precautions. Just be sure to make the assembly as mechanically stable as possible.
- **Reduction gear and tuning capacitor.** One aluminum bracket holds the 3:1 reduction gear for the dial; another ties from this to the back of the case as a support for the tuning capacitor. I bent both brackets to fit the cabinet by hand and assembled them with nuts, bolts, and lockwashers. My leads are as short and direct as possible. All ground leads in the oscillator circuit are connected to a common ground at the frame of the tuning capacitor. I used an insulated coupling between the tuning capacitor and the dial to avoid hand capacitance effects. The coil is raised to the center of the clear space with spacers, in keeping with the idea of having everything clear of the coil by a distance at least that of the coil diameter. This is necessary to obtain a high-Q tuned circuit.
- **Dial readout.** If you look at **Photo A**, you'll notice that the dial reads backwards. This is because the VFO frequency is subtracted from other frequencies in the FT-102. If you have a double shaft tuning capacitor, arrange it to have maximum capacitance at the clockwise end of the dial. This will make it read forward. The dial consists of a paper scale behind a plastic plate. The

PARTS LIST

Capacitors

C1	Tuning capacitor, should be air spaced, approximately 50 pF maximum (see text)
C2	Trimmer capacitor, air spaced, 150 pF maximum
C3,C11	22-μF tantalum, 10 volts
C4,C5	10-pF silver mica
C6	100-pF mica preferred, ceramic otherwise
C7	62-pF mica or ceramic (see text)
C8	150-pF mica or ceramic (see text)
C9,C10,C16	1-μF tantalum, 10 volts, Radio Shack 272-1434
C12	330-pF mica or ceramic
C13,C15	470-pF mica or ceramic
C14	100-pF mica or ceramic

Inductors

L1	6.8 μH, 16 turns of no. 16 tinned copper wire on 1-3/8 inch diameter ceramic form, coil length 1-⅛ inches
L2,L3	1.8 μH, 13 turns of no. 24 enameled wire on FT 50-61 core.

Resistors (all ¼ watt)

R1,R4	1000
R2,R3	1 meg
R5	150 k
R6	560 k
R7,R8	100
R9	6800
R10	240, R10 and R11 required only if LM317 voltage regulator is used
R11	470

Miscellaneous

Q1,Q2	MPF-102 or 2N3819 N-channel JFET, Radio Shack 276-2035
Q3	MPSA30 Darlington transistor, Radio Shack 276-1631 is an assortment of six Darlingtons
U1	7808 voltage regulator, substitute LM317 (see Figure 4), LM317 is Radio Shack 276-1778
RY1	SPDT contacts, 12-volt coil, Radio Shack 275-241 or 275-213 (DPDT)
S1,S2	SPDT toggle switches, Radio Shack 275-625
P1	Eight-contact DIN plug (type B), Armaco type DD 8281 (should be available from Yaesu as a replacement part for the FV-102DM synthesized VFO), Yaesu USA, 17210 Edwards Road, Cerritos, California 90701.

The cable to the P1 plug requires one shielded and three unshielded leads. I made it about 2 feet long.

The cabinet I used is a Hammond type 1426KB. It measures 4″ high by 6″ wide by 5″ deep. You can order this cabinet from: Hammond Manufacturing Company, 394 Edinburgh Road, Guelph, Ontario, Canada N1H 1ES, or 1690 Walden Avenue, Buffalo, New York 14225

pointer is a no. 16 tinned copper wire attached to the vernier drive mechanism.

- External VFO calibration. Toggle switches S1 and S2 select either internal and/or external VFO for transmit and receive. It's only necessary to provide rudimentary calibration on the external VFO. I placed only the 100-kHz marks on the dial for frequency selection, as the exact frequency is displayed on the FT-102 digital readout. See Photos B and C for internal parts placement.

Parts substitution

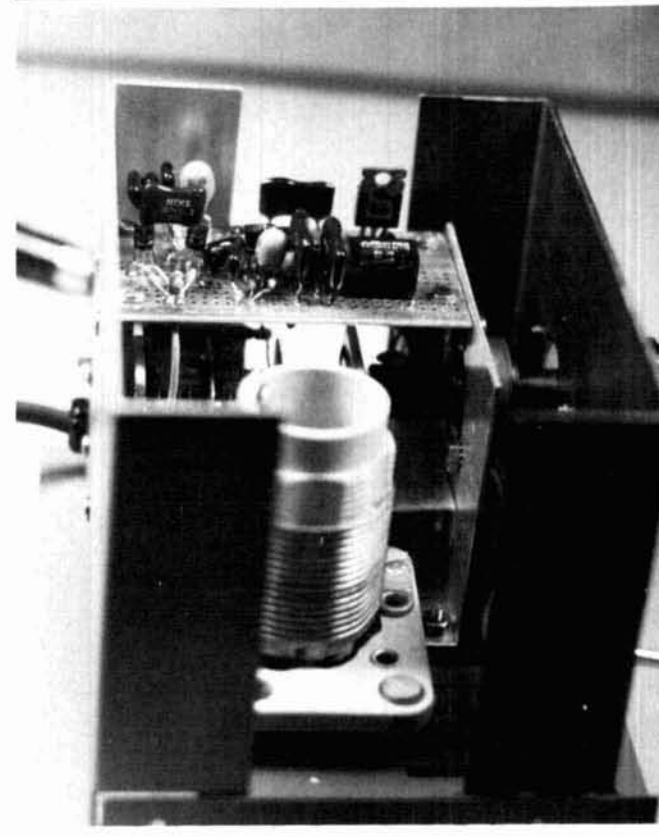
If you're like me, you'll want to change a few things. Very few of the parts are critical. Perhaps the most important are the two 10-pF capacitors that couple the frequency-determining tuned circuit into the oscillator. These should be the best capacitors you can get. I used silver mica, but ceramic disc capacitors would probably do. The tuning capacitor and trimmer are both air-spaced capacitors; nothing less should be used for these. I used tantalum bypass capacitors because they are good high frequency caps. The 1-μF capacitors at the regulator should be mounted as close to the regulator as practical because the regulator contains a high gain amplifier that will oscillate if not well bypassed.

I wound L2 and L3 on ferrite cores salvaged from a Jerrold CATV amplifier. Realizing that these wouldn't be reproducible, I got an FT50-61 core and wound another on it. It required 13 turns of no. 24 enameled wire for 1.8 μH. The universal pc board I used is similar to Radio Shack's 276-158.

PHOTO A

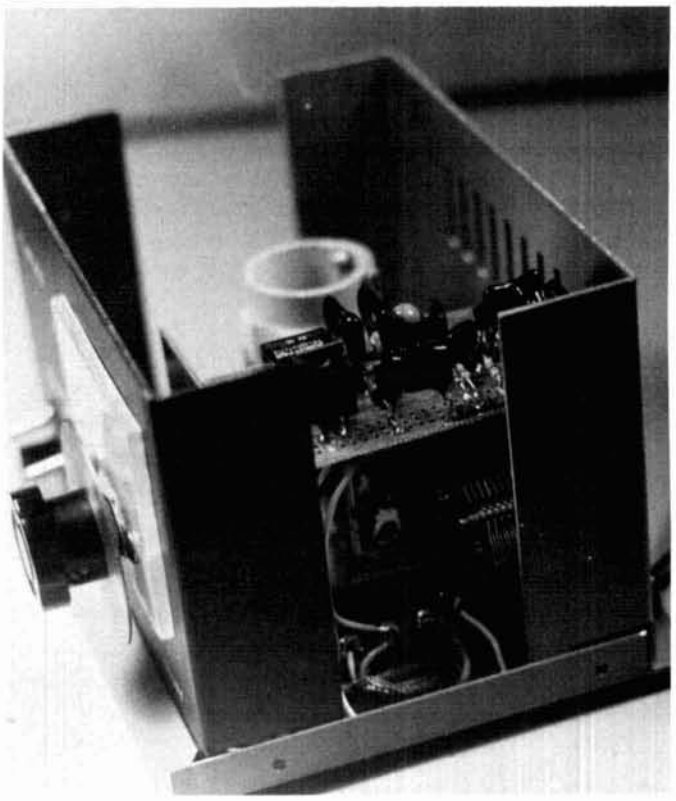
Front view of the VFO with the cover removed showing the DIN plug and the circuit diagram inside the lid.

PHOTO B



Left-side view of the VFO showing component placement.

PHOTO C



Right-side view of the VFO showing trimmer capacitor mounted at rear of cabinet.

Testing and calibration

The two capacitors at the oscillator output (C7 and C8) form a voltage divider to reduce the oscillator output. Make C8 larger if you have too much output, or smaller if there's too little output. Measure the output at pin 6 of the DIN plug, loaded with a 50-ohm resistor, or plugged into the FT-102. It should be approximately 200-mV p-p.

Calibration is simplicity itself. Warm up the FT-102 on the 40-meter band with the external VFO attached for at least five minutes. Switch the RX switch on the VFO to the external position and set the tuning capacitor to maximum capacitance. Adjust the trimmer until the FT-102 digital readout reads slightly lower than 7000 kHz. Tune the VFO to the other end of its dial. The frequency should read slightly more than 7500 kHz. A reading lower than this would indicate that there's not enough variation of capacitance in the tuning capacitor; a much higher frequency would means there's too much variation. Mine tunes from 6955 to 7525 kHz. You could also use a digital frequency counter to read the frequency.

Remember that it's backwards, so a VFO frequency of 5500 kHz corresponds to 7000 kHz, and 5000 kHz corresponds to 7500 kHz. If your counter requires more than the 200 mV at the output, there's more than 1 volt available at the drain of Q2 — although the counter may change the oscillator frequency by a few hertz.

When you've finished your work, but before you button up the cabinet, glue a schematic diagram inside the lid of the case. In five years time, you'll have forgotten all the circuit details and will need the diagram for servicing. hr