Doug Demaw, W1FB

A Simple 455-kHz BFO for Your Receiver

Some shortwave receivers lack a BFO (beat frequency oscillator). Without a BFO we cannot copy CW or SSB signals, which sound like mush without it. Some imported portable short-wave radios are designed for only AM and FM signals. Also, older radios that use tubes may not have BFOs.

It is a simple and inexpensive procedure to construct a BFO for the lower intermediate frequencies (IFs) of many receivers. This month's column explains how it is done and provides circuit information for a two stage BFO circuit that can be connected to the detector in a receiver that uses a 455-kHz IF.

Beating the High Cost of Crystals

BFOs are designed to provide reception for the upper and lower sidebands of an SSB signal. SSB is used by most radio amateurs for phone communications. But, some commercial broadcasters also use SSB. There are many commercial and amateur CW signals to monitor. A BFO is essential for that mode, also.

Normally, two quartz crystals are switched in an oscillator to provide upper (USB) and lower (LSB) sideband reception. CW may be copied by selecting either the USB or LSB modes. Typically, the crystal frequencies are approximately 1.3 kHz above and below the center frequency of the IF. Thus, if the IF in a receiver happens to be 455 kHz, crystals for 456.3 and 453.7 kHz are used in the BFO. From an engineering point of view, the BFO should be set for a frequency on the IF response curve that is 20 dB down from the peak response (center frequency) of the IF system or IF filter. Since we are not interested in this aspect of BFOs, we will move on to the practical aspects of our discussion.

Crystals other than surplus computer types are extremely expensive. A quality 455-kHz crystal can cost $20 or more if it is supplied by a commercial manufacturer. Although a crystal provides excellent stability (minimal frequency change with temperature variations), we can build a coil and capacitor BFO that is stable enough for general use by hams and SWLs. A 50-cent RF choke, or a one dollar 455-kHz IF transformer will replace the two crystals under discussion. Figure 1 illustrates how a crystal-controlled BFO might be wired. The figure 2 circuit utilizes a coil and some capacitors to replace the crystals.

A Practical BFO

Please refer to figure 2. L1 is the primary winding of an imported 455-kHz transistor radio IF transformer.[1] The secondary winding is not used, nor is the tap on the primary winding. Use the two outer pins on the side that has three pins. Resonance is provided by the effective capacitance presented by C1, C2 C3, C4, C5, and D1.

Tuning is accomplished by means of D1 and R1. With the circuit values indicated in figure 1 there is a frequency change of 4 kHz (453 to 457 kHz) when R1 is adjusted through its range.

D1 is a voltage-variable-capacitance diode (VVC).[2] These devices are also known as tuning diodes or varactors. As the positive voltage applied to the D1 cathode is varied by adjustment of R1, the internal capacitance of D1 changes to shift the BFO frequency. R1 permits USB, LSB, and CW reception. The BFO creates an audible tone (beat note) during CW reception. For SSB it supplies the missing carrier for the transmitted signal. The carrier is included in an AM signal, and thus no BFO is required.

Q1 functions as a Colpitts oscillator. Capacitors C4 and C5 form a feedback divider that allows some of the output signal (emitter) to be fed back to the transistor input (base). This causes Q1 to oscillate at the chosen frequency. L1 and the related capacitors determine the resonant frequency.

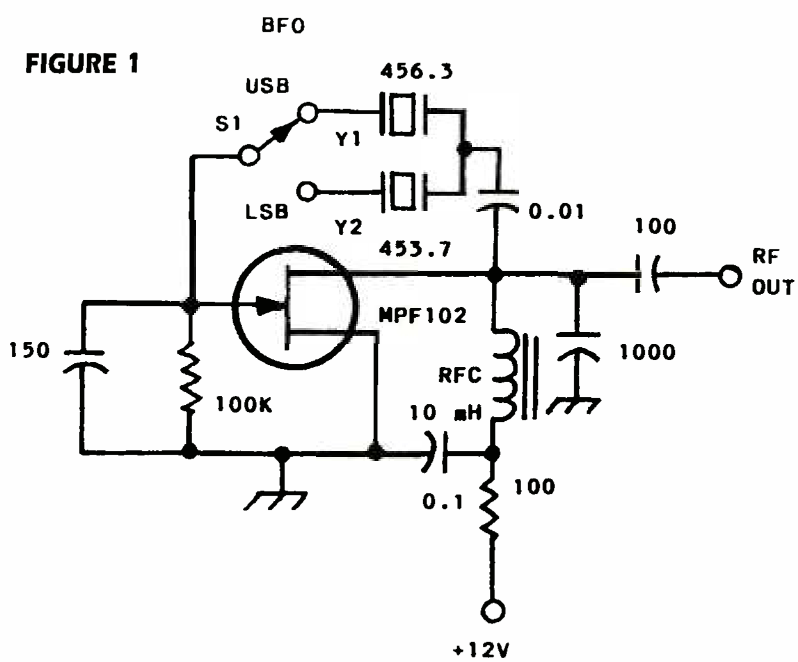
Frequency stability (minimal drift) is vital for CW and SSB reception. If the BFO drifts it becomes necessary to continuously readjust R1 to keep the received signal sounding right. Therefore, the types of capacitors used for C1 through C6 must be temperature-stable. For use at 455 kHz we may expect good performance from polystyrene, NP0 ceramic, or silver-mica capacitors.

D2 is a 9.1-volt Zener diode. It regulates the Q1 and D1 operating voltage to aid frequency stability: Voltage changes cause the BFO frequency to shift.

Q2 is used as a buffer and amplifier. It helps to isolate Q1 from load changes that may occur in the receiver. Such impedance changes can "pull" an oscillator and cause frequency shifts. Q2 also boosts the output from Q1 to a level that is suitable for injecting a low-impedance AM type of diode detector.

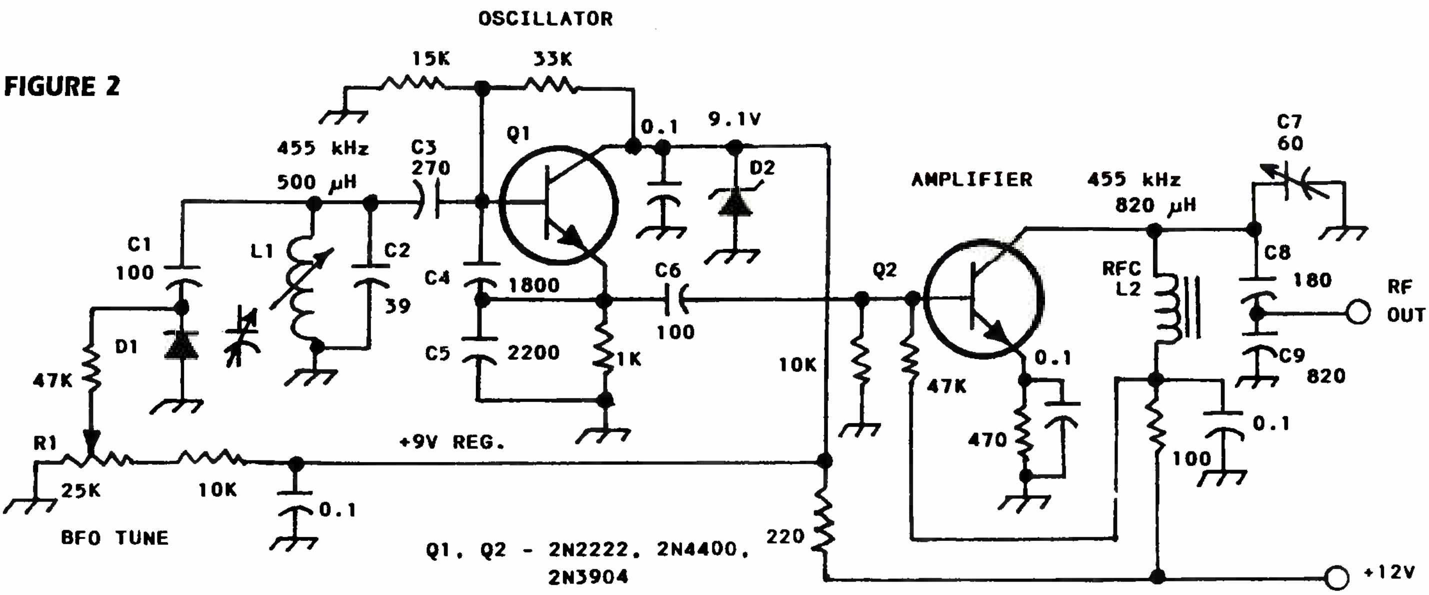
A low cost 820 microhenry RF choke is employed at L2 to provide a suitable inductance for the amplifier tuned circuit. C8 and C9 form a capacitive di-

FIGURE 1



Example of a crystal-controlled BFO for CW, USB, and LSB reception. Y1 and Y2 determine the BFO frequency. S1 selects the desired sideband mode.

FIGURE 2



Schematic diagram of a practical tunable BFO that permits reception of CW, upper sideband, and lower sideband. C1, C2 and C6, are NP0 disc ceramic types. Silver-mica capacitors may be used if ultimate stability is not a concern. C4 and C5 are polystyrene or silver-mica units. C8 and C9 and silver-mica or quality disc ceramic capacitors. C7 is a 60-pF mica, ceramic or plastic trimmer. D1 is a tuning diode that has a nominal 56-pF value (type MV2112, MV1644, or 1N5453A). A 15-pF air-variable capacitor may be substituted for the D1 tuning circuit. D2 is a 9.1-volt, 400-mW or 1-Watt Zener diode. L1 is the primary winding (highest dc resistance) of a 455-kHz IF transformer (Mouser no. 421F203, black core). Remove the tiny fixed-value capacitor in the outer base of the unit. The secondary winding is not used. L2 is a Mouser no. 434-06-821K 820-microhenry RF choke. A transistor radio IF transformer (do not remove base capacitor) may be substituted for C7, C8, C9, and L2. BFO output can then be taken from the transformer secondary winding through a 0.01 µF blocking capacitor. R1 is a 25k-ohm linear-taper carbon control. Fixed-value resistors are 1/4-Watt carbon.

vider that resonates the Q2 output circuit at 455 kHz while providing a low impedance output point from which to extract the BFO signal. Trimmer C7 is adjusted for maximum power output (resonance).

■ Construction Notes

The BFO can be assembled on low-cost perforated board. You may prefer the more professional approach if you are skilled at laying out and etching PC boards. My unit is built on perf board. Almost any type of point-to-point "ugly" wiring is okay if you keep the leads short and direct. This practice aids stability.

The completed circuit should be enclosed in a shield box to prevent stray radiation of the BFO energy. For example, the second harmonic of 455 kHz could appear as an unmodulated carrier at 910 kHz on your receiver. A box can be made inexpensively from sections of single- or double-sided PC board.

R1 should be a quality potentiometer that can sustain frequent adjustment without becoming worn and noisy. I prefer the more costly 2-watt industrial controls of the Allen-Bradley variety.

Connection between the BFO and your receiver should be made with shielded cable. Miniature RG-174 50-ohm coax is suitable. Shielded cable will prevent unwanted radiation of the BFO energy into other parts of the receiver circuit.

■ Adjustment and Operation

A frequency counter is helpful for getting the BFO on 455 kHz. If you do not have access to a counter, tune your receiver to 910 kHz and connect a short length of hook-up wire to the output of the BFO. Place the wire near the antenna lead-in to your receiver. Adjust L1 for maximum S-meter response by tweaking its slug. R1 should be set at mid range for this step. Next, adjust C7 for a maximum S-meter reading. If you have no S meter, make these adjustments by ear. Tune for maximum quieting of the receiver background noise.

If you do not have a 12-volt power supply you may use a 9-volt transistor radio battery to power the BFO. Total current drain is on the order of 10 mA. Eliminate D2 if you use a battery.

BFO output energy should be connected to the anode of the receiver detector diode (side toward the last IF transformer) through a 100-pF capacitor. If your receiver uses a transistor instead of a diode in the detector circuit, route the BFO signal to the base of the transistor. The AM detector always follows the last IF transformer in a radio.

During reception you must adjust R1 to obtain an intelligible signal. First tune in the SSB or CW signal for maximum S-meter (or audible) response. Then adjust R1 for the desired CW-signal pitch, or set it to obtain the most natural sounding SSB voice characteristics.

The frequency stability of the tunable BFO is excellent. My test model drifted approximately 50 Hz during a 1-minute warmup. For the next hour the frequency varied only plus and minus approximately 5 Hz. My tests were conducted at a room temperature of 70 degrees F. My frequency counter was allowed to warm up for one hour before the drift tests were started.

■ Notes

1 — Most of the BFO parts are available from Mouser Electronics, 2401 HWY 287 N., Mansfield, TX 76063-4827. Phone: 1-(800) 346-6873 for catalog or to order.

2 — VVC diodes and other parts for the BFO are available from Hosfelt Electronics, 2700 Sunset Blvd., Steubenville, OH 43952-1158. Phone: 1-(800) 524-6464 for catalog or to order.