Beat frequency oscillator for shortwave receivers

Build it & resolve SSB & Morse code signals

Want to receive Morse code and SSB signals, but can't afford to outlay the cash for one of those classy communications receivers? You can alleviate the problem by building this simple beat frequency oscillator, or BFO. Fitted to a portable AM shortwave receiver, it may enable you to resolve both SSB and Morse, with a modicum of operating skill.

by IAN POGSON

There are quite a number of shortwave receivers on the market capable of resolving both Morse code and SSB signals, in addition to AM transmissions. While such receivers may represent good value for money, when their various features are considered, the fact remains that not everybody can afford to outlay several hundred dollars cash to acquire one.

So, for many enthusiasts, the reality is a modest multiband receiver capable of resolving AM transmissions only, and usually costing less than $100. Of course, these receivers are no match for the expensive communications receivers - far from it. But they can still log a good many shortwave stations and offer the listener a great deal of enjoyment.

That's where this simple project comes in. It's a device called a beat frequency oscillator, or BFO for short. Added to your AM shortwave receiver, it will enable you to resolve SSB and Morse code stations as well. All you need is $15 worth of parts and a little operating skill.

But enough of the sales talk! What exactly is a BFO and does it work? Let's find out.

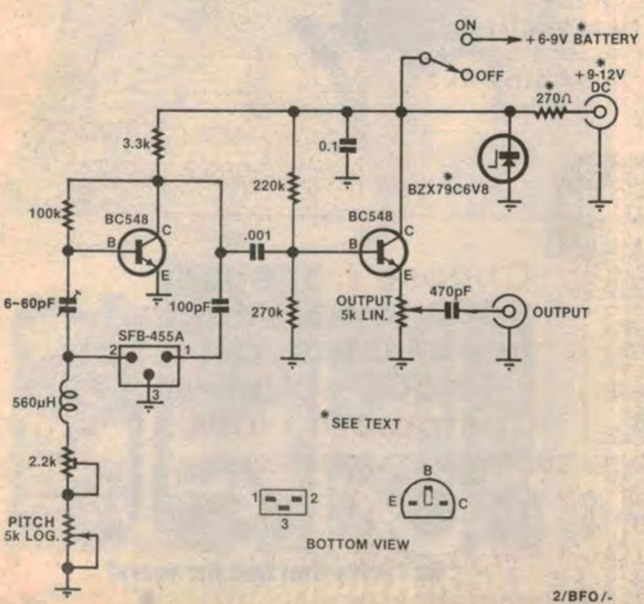
Basically, a BFO is an oscillator with a stable output frequency that can be adjusted over a very small range. The BFO signal is generated at the intermediate frequency (IF) of the receiver and is injected into the system at some convenient point in the IF chain up to or at the detector. The design presented here has a nominal output frequency of 455kHz, and can only be used with receivers with a 455kHz IF.

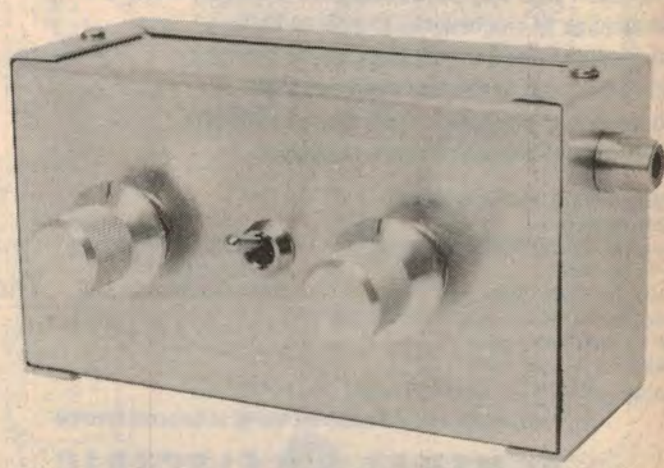
Fortunately, the majority of receivers come into this category.

As we've already indicated, the main purpose of fitting a BFO is to enable you to make sense of Morse code and SSB signals. Morse code, for example, is still used by many radio amateurs and in some commercial applications. Without a BFO, the received Morse signal will be heard as a series of "thumps", or it may not be audible at all. To resolve Morse signals, it is necessary to "beat" the received signal against a locally generated signal (the BFO signal), suitably offset in frequency so that the difference between the two is heard as an audio tone or "beat" note.

The function of a BFO is rather different for SSB reception. In contrast to a normal AM signal, an SSB signal has one of its sidebands and the carrier suppressed at the transmitter, leaving only one sideband. There are many advantages to SSB transmission, but it does require special facilities in the receiver. In particular, a signal equivalent to the missing carrier must be re-inserted at the receiver, and this is the purpose of the BFO.

Without a BFO, SSB signals are quite unintelligible and are often aptly described as "duck talk". Those expensive com-





We housed the prototype in a small aluminium case. Controls from left to right are: pitch, on/off and output level.

Left: the complete circuit diagram for the BFO. It consists of Pierce oscillator feeding an emitter-follower stage.

munications receivers we referred to earlier incorporate a BFO as standard. The BFO is automatically switched in whenever the operator selects the appropriate receiving mode.

THE CIRCUIT

Let's now have a look at the circuit diagram. It's really very simple, and uses just two transistors, a ceramic filter, and a handful of other parts.

Basically, the circuit is similar to the familiar Pierce crystal oscillator, but with a ceramic filter used instead of a quartz crystal. The main advantage of a ceramic filter in this application is that it can be shifted in frequency by a significant amount, whereas a crystal cannot. Other advantages of a ceramic filter type BFO include low cost and adequate frequency stability.

To be used as a BFO, the circuit needs to be variable over a limited range. The 60pF trimmer capacitor connected in series with the ceramic filter provides the lower frequency limit, while the upper limit is set by the 560uH choke and the 2.2k preset pot. Tuning between the two limits is accomplished by the 5k (log) pot which becomes the pitch control.

We have used an emitter-follower stage to provide isolation between the oscillator and the output – a provision which reduces frequency variation due to loading. A 5k output level control varies the signal injection into the receiver.

The 270 ohm resistor and the zener diode are required only if the circuit is to be powered from a plugpack supply. Alternatively, the unit may be powered from a 9V battery, as was the prototype.

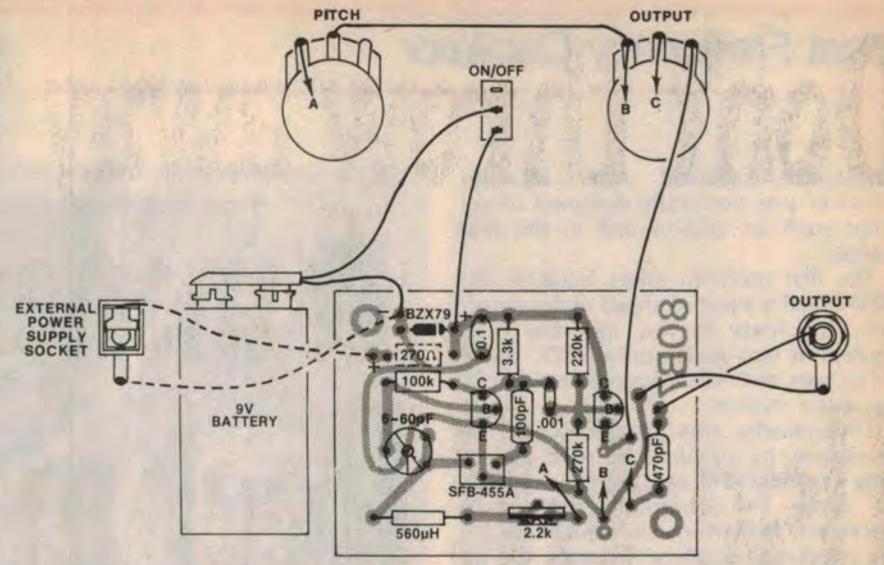
CONSTRUCTION

Construction of the BFO is straightforward, with most components mounted on a small PC board measuring 68 x 50 mm and coded 80B7. All components, with the exception of the ceramic filter, should be readily available from components stores. The ceramic filter used in the prototype came from Radio Despatch Service (869 George St, Sydney 2000).

Commence construction by wiring the PC board according to the circuit and component overlay diagrams. Make sure that the transistors and the ceramic filter are correctly oriented, and don't forget to add the 270 ohm resistor and the 6.8V zener diode if you intend powering the unit from a plugpack supply.

This done, the various external items can be mounted on the aluminium case and the wiring completed. The PC board is then fixed to the bottom of the case using machine nuts and screws, with additional nuts used as standoff spacers between the board and the case.

The 9V battery (if used) is mounted at one end of the case, and can be held in position using double-sided adhesive tape. Current drain is just 3mA at 9V and 2mA at 6V, which should result in long battery life.



Follow this diagram in conjunction with the circuit when wiring up the BFO. The wiring shown dotted is required only if an external power supply is used.

PARTS LIST

- *1 aluminium box 102mm × 54mm × 42mm*
- *4 rubber feet for box*
- *1 RCA socket, single hole mounting*
- *1 3.5mm jack socket (see text)*
- *1 5k linear potentiometer*
- *1 5k log potentiometer*
- *1 2.2k mini vertical trimpot*
- *2 knobs*
- *1 SPDT miniature toggle switch*
- *1 9V battery, No 216*
- *1 PC board, 68mm × 50mm, code 80B7*
- *1 Murata ceramic filter SFB-455A*
- *1 560uH RF choke*
- *1 6-60pF Philips trimmer*
- *2 BC548 transistors*
- *1 BZX79C6V8 zener diode (see text)*

RESISTORS (½ watt, 5%)
1 × 270k, 1 × 220k, 1 × 100k, 1 × 3.3k, 1 × 270 ohm (see text).

CAPACITORS
- *1 0.1uF metallised polyester*
- *1 .001uF metallised polyester*
- *1 470pF polystyrene or ceramic*
- *1 100pF polystyrene*

NOTE: Ratings are those used on the prototype. Components with higher ratings may generally be used providing they are physically compatible.

The final job of assembly is the setting-up procedure. If you have access to a frequency meter, we suggest that you use it to set the upper and lower frequency limits to 457kHz and 453kHz respectively. The procedure is as follows:

- connect the meter to the BFO output, switch-on, and set the 2.2k trimpot and pitch control to maximum resistance;
- adjust the 60pF trimmer capacitor to give 453kHz;
- reset the pitch control to minimum resistance and adjust the 2.2k trimpot to give 457kHz;
- repeat the above procedure as many times as necessary to get the correct readings at the two extremes of the pitch control.

For those without access to a frequency meter, the setting up procedure is carried out using the all-wave receiver itself. The idea is to mix the BFO output with the receiver IF and adjust the BFO to obtain a steady tone. This tone will be heard along with the normal program.

First, tune the receiver to a local broadcast station and inject a suitable signal from the BFO into the receiver IF. Now, with the 2.2k trimpot and the pitch control set to maximum, adjust the trimmer until a high-pitched tone is heard. Finally, reset the pitch control to minimum resistance and adjust the trimpot until a similar tone is heard.

Note that as the pitch control is rotated from one extremity to the other, the tone should lower in frequency until, at about the centre of rotation, no audible tone will be heard; ie, BFO frequency = IF (intermediate frequency). The tone frequency should then increase as the other extremity is approached.

USING THE BFO

As can be expected, there are a few problems in adding a BFO to an AM shortwave receiver. After all, the receiver was not really designed to accept such an add-on unit in the first place.

The first problem arises because the BFO signal is injected ahead of the detector, and finds its way into the AGC system. It thus generates an AGC signal of its own, thereby reducing the sensitivity of the receiver.

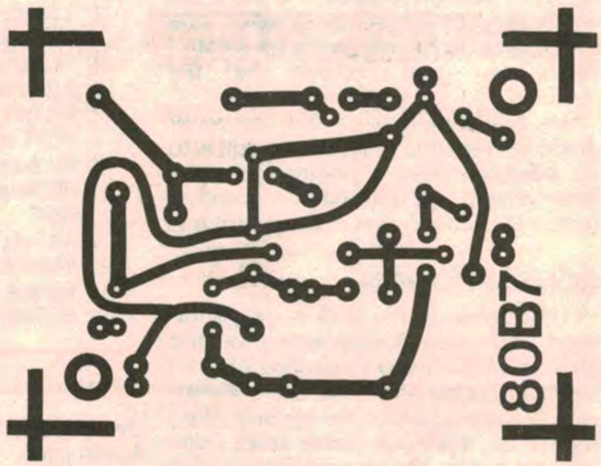
Theoretically, this problem could be overcome by disabling the AGC and fitting a manual RF/IF gain control, much as is done in communications style receivers. However, we would hesitate to encourage readers to attack the innards of their commercial receiver.

But don't worry too much about this. Even with the set in its original form, it should be possible to get acceptable results.

Getting the BFO to "inject" the right amount of signal into the receiver's IF is quite important. Too much BFO signal swamps or even blocks out incoming signals, while too little BFO signal will not do the job either.

Note that although the RCA output socket provides for an earth lead, this should not be required. A length of insulated hookup wire connected to the centre pin of the plug should be quite sufficient, the actual length of the wire depending upon your experiments.

Above: view inside the prototype. Note that this unit is powered from its own 9V battery and has not been wired to accept an external plugpack supply.



Right: actual size reproduction of the PC artwork.

We estimate that the current cost of parts for this project is approximately

$15

This includes sales tax and the battery but does not include the optional plugpack power supply.

The simplest method involves connecting the lead from the BFO directly to the antenna terminal of the receiver. Alternatively, you could try wrapping the insulated lead from the BFO around the base of the telescopic antenna, or even winding a complete loop of wire around the receiver itself. In the latter case, the position of the loop should be adjusted for optimum results.

The best results are usually obtained by gaining access to the inside of the receiver. Without making electrical contact between the receiver and the lead from the BFO, try pushing the lead into the "works" near one of the IF transformers. Suitably adjusted, this method should give sufficient injection by radiation into the IF stages.

As already implied, the amount of injection can be controlled somewhat by varying the position of the output lead with respect to the relevant components of the receiver. We suggest that you arrange for sufficient injection for the strongest signals with the output level control at maximum. Then, for weaker signals, the output level can be easily reduced.

It should not be necessary to make a direct electrical connection to the detector circuit.

It should also be possible to use this unit to resolve SSB signals on many AM CB transceivers. On one unit we tested, all that was necessary was to tape the lead from the BFO to the copper side of the transceiver board, adjacent to the IF stage. SSB signals could then be resolved by careful adjustment of the output level and pitch controls.

Our observations indicate that the BFO signal should make the "S" meter read just over half scale for a satisfactory level of signal injection. Note also that the "delta tune" control, where fitted, can often be used to advantage in resolving SSB signals in conjunction with the BFO.

Finally, some readers may find that a ±2kHz BFO range is inadequate for resolving all SSB signals. If so, the range can be increased by suitable adjustment of the trimmer and the 2.2k trimpot. Depending on the receiver, it may also be necesary to increase or decrease the nominal output frequency. This can be done by respectively increasing or decreasing the value of the inductor.