Minispot 455kHz signal generator

Basic Electronics

Here is a handy little device for broadcast and shortwave receiver alignment. It is the Minispot. It generates a fixed 455kHz RF signal modulated at 500Hz.

by JOHN CLARKE

A problem which many enthusiasts encounter is that, having completed building a broadcast or shortwave receiver, they have no equipment to provide accurate IF alignment.

Very poor performance can result from lack of, or inaccurate alignment, but, on the other hand, the experimenter who makes only a few projects may hesitate to invest a lot of money, or time, in acquiring a full size service oscillator or signal generator.

Alignment of IF systems is aimed at satisfying two requirements: (a) ensuring that all tuned circuits in the IF systems are tuned to the same frequency and (b) that the frequency to which they are tuned is the correct one.

Failure to satisfy requirement (a) will result in degraded sensitivity and selectivity. Failure to satisfy (b) can result in spurious heterodynes or whistles in certain localities, as well as failure of the tuning system to track accurately with the dial calibrations, particularly in the centre of the dial.

The simplest approach to receiver alignment is "by ear." Using broadcast signals at appropriate positions on the band, the various tuned circuits are adjusted to produce maximum output from the loudspeaker.

While this approach has the advantage of simplicity and will undoubtedly result in some improvement, it leaves a lot to be desired.

It cannot ensure that the IF system's tuned circuits are tuned to a specific frequency, only that they are all tuned to approximately the same frequency. This is only approximate, because we are depending on the ear to tell us when the maximum signal level has been reached.

The ear is notoriously insensitive to small changes in signal level (less than 3dB) so that each adjustment could conceivably be in error by, say, 2dB. If there are six adjustments to make there is room for a possible total error of 12dB – a very significant amount. While the error will usually be less than this in practice, it may still be significant.

The more usual approach calls for the use of an oscillator (or signal generator) and an output meter. The generator should be capable of generating RF signals, suitably modulated, at the IF used by the receiver, at frequencies at each end of the broadcast band, and in similar positions on the short-wave band or bands, where these are featured.

In use, the generator is connected so as to feed signals into the appropriate part of the receiver, while the output meter is connected to the output circuit feeding the loudspeaker.

The generator is modulated with a steady tone – rather than music or speech as from a broadcast station – and this is registered as a fixed level on the output meter. As various adjustments are optimised (peaked), the meter will swing up the scale to maximum reading, giving a far more accurate indication than can the ear.

While most multimeters can serve as an output meter, it is the generator which most experimenters find hard to provide. Indeed, a generator to satisfy all the requirements we have just enumerated would be a relatively costly instrument.

However, if we accept the compromise that the IF system is the one most needing adjustment by this method, and that the other adjustments can be made "by ear" without serious error, then a very much simpler and cheaper device will serve our purpose.

More precisely, we can settle for a simple, low cost, single frequency oscillator, preset to the popular 455kHz IF, and intended to do no more than provide alignment facilities for the IF channel.

Rather than implementing the oscillator with an LC circuit, a very good alternative is to use a ceramic filter element. This provides a cheap and reliable alternative 455kHz oscillator when used in the feedback loop of a high frequency amplifier. The stability of this arrangement is close to that of a crystal based oscillator but without the additional associated cost.

Considering the comparative cost and the inherent stability, we feel sure that the alignment generator described here would be a worthwhile device to have. It will fill the need for an inexpensive but reliable source of modulated 455kHz signal suitable for IF alignment of broadcast and shortwave receivers.

The PC board should be housed in a metal case to prevent stray radiation.

We estimate that the current cost of components for this project including battery and suitable case is

$9.00

This includes sales tax.

The circuit is also quite easy to modulate. The modulating tone is generated by a free-running bistable multivibrator operating in the vicinity of 500Hz.

It modulates the RF oscillator by varying the supply voltage fed from the junction of the two resistors forming the collector load of one of the multivibrator transistors. The two resistors function as a voltage divider to control the depth of modulation.

As can be seen, the Minispot circuit is quite simple and consists of three low cost transistors, seven resistors, six capacitors and the ceramic filter. Two of these transistors are used in the multivibrator and the other in the 455kHz oscillator. The two capacitors in series with the ceramic filter set the frequency to close to 455kHz. AC coupling is provided for the RF output by way of a 27pF capacitor.

PARTS LIST

1 PC board coded 80if12, 67 × 39mm
1 metal case to suit
1 9V, 216 battery
1 clip connector to suit battery
1 RCA panel socket
1 RCA plug
1 Murata type SFB455A ceramic filter

SEMICONDUCTORS
3 BC548 NPN transistors

RESISTORS (¼W 10%)
1 × 100k, 2 × 47k, 1 × 3.3k, 1 × 1.5k, 1 × 1k, 1 × 470 ohms

CAPACITORS
1 0.22uF metallised polyester
2 .047uF metallised polyester
2 68pF NPO ceramic disc
1 27pF ceramic disc

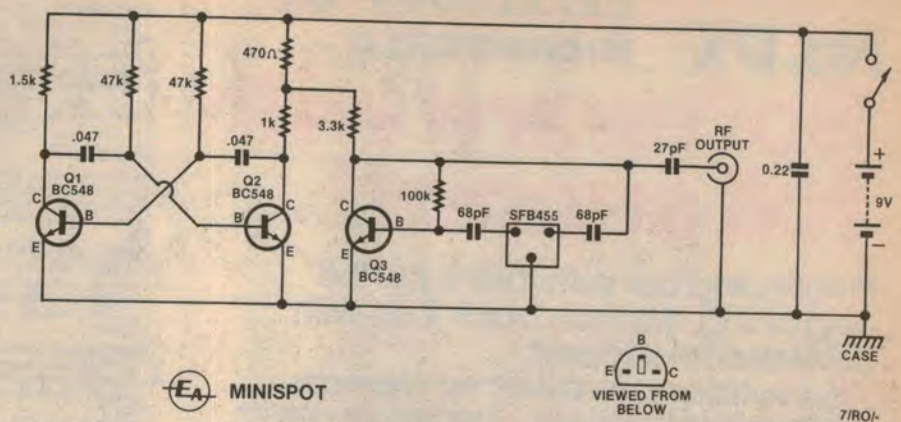
NOTE: Ratings are those used on the prototype. Components with higher ratings may be used providing they are physically compatible.

Construction of the Minispot is relatively simple and could be finished within an hour or so. Start by mounting the components on the printed circuit board coded 80if12 and measuring 67 × 39mm. No particular order is necessary in placing the components.

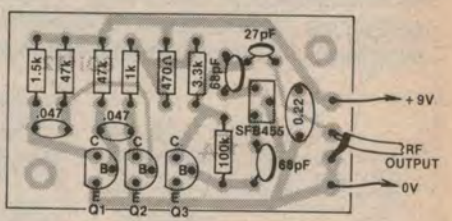
No problems should be encountered in housing the device. A metal housing must be used, however, to prevent direct radiation from the multivibrator coupling into the audio stages of a receiver.

Any small metal box can be used, such as a general purpose aluminium box measuring 100 × 30 × 54mm (W × H × D) or larger or a box can be fashioned from some scrap aluminium or tin plate.

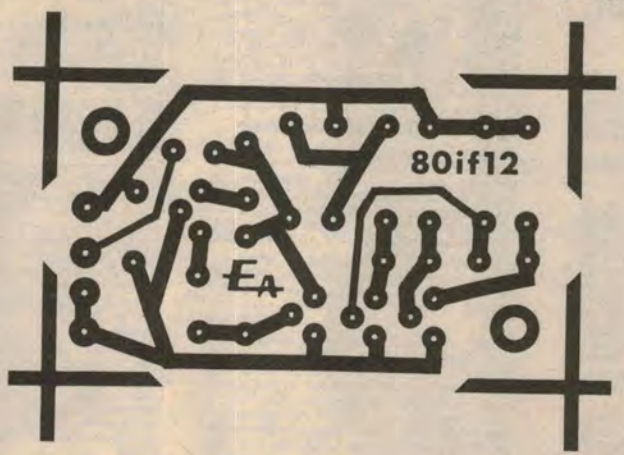
Build the Minispot



ABOVE: A multivibrator (Q1 and Q2), an RF amplifier (Q3) and a ceramic filter make up this simple circuit. It generates a 455kHz RF signal modulated at 500Hz.



RIGHT: This wiring diagram shows the PC board from the component side.



At left is an actual size reproduction of the PC board.

A small on/off switch should be installed within the box and connected in series with the battery lead. The PC board has provision for two mounting screws on opposite corners and it should be raised from the base with bushes to prevent shorting.

An RCA phono panel socket can provide for the RF output on the case and the output connecting lead made from two pieces of hookup wire soldered into an RCA plug. Connect the opposite ends to alligator clips or probe clips.

Finally the battery can be connected to the PC board with leads and a suitable clip and the circuit is ready to be used.

The Minispot can be used to align the IF amplifier section of receivers equipped with 455kHz IFs, with or without a ferrite antenna.

In the solid state receivers, the most common input point is the base of the mixer, or mixer-oscillator stage. The tuning capacitor should be set for minimum capacitance to avoid any undue loading on the generator signal.

At the mixer input, coupling can be made through a twisted pair of insulated wires, the amount of wire and twisting controlling the capacity (and hence the RF level) between them. The RF level can be reduced by simply unwinding the twisted pair.

In any alignment procedure, the presence of an AGC (Automatic Gain Control) system presents a minor problem.

Virtually all sets are fitted with AGC systems, the purpose being to maintain, as nearly as possible, a constant audio output regardless of whether the received signal is weak or strong. This they do very well (though not perfectly) but, fairly obviously, this action is undesirable during alignment, since it tends to mask the effectiveness of each adjustment as it is made.

Fortunately, most AGC systems are deliberately designed to have a threshold level below which they do not operate (delayed AGC). This is to ensure maximum sensitivity to weak signals.

We can take advantage of this during alignment, by deliberately keeping the input from the generator at the lowest possible level, at the same time keeping the gain of the receiver at the highest level. As various adjustments increase the sensitivity of the receiver, the input should be reduced by a like amount.

Almost any multimeter having the usual AC ranges can be used as an output meter. Connection can be readily made across the loudspeaker terminals.

With the Minispot connected to the receiver, adjust each IF transformer core for maximum indication on the output meter, reducing the RF input level as necessary for the reasons outlined previously.

The cores should be adjusted so that their physical positions are at the outside of each coil in the IF transformers, NOT towards the inner area through the coils.

All the foregoing methods of connection have assumed that the user has ready access to any part of the receiver; a situation which would normally apply where a receiver had just been constructed but not yet fitted to its case. However, if we wish to work on a complete receiver, it may not be convenient to remove it from its case.

As already discussed, the output meter can be connected to the loudspeaker terminals, which are generally accessible. However, the input to the mixer stage may not always be so easy to get at, particularly in very small receivers. In this case it is usually possible to feed the signal in through the antenna terminal where fitted, or by coupling to the ferrite rod antenna.

The "Minispot" can be coupled to a ferrite antenna either by laying its output lead across the coil on the rod, or forming an induction loop by connecting the two clips on the output leads together. The lead or loop should be spaced away from the rod so as to control the output as mentioned earlier.

After peaking the IF transformers, turn off the Minispot. Find a broadcast station at the low end of the dial and adjust the oscillator coil core to place the station at its correct dial position. Tune a station at the top end of the dial and adjust the oscillator trimmer to place it at its correct marking. Repeat the procedure until the two ends are correctly placed.

Find a weak station at the top end of the dial and adjust the aerial trimmer for maximum volume from the speaker. Return to the low end of the dial to a weak station and adjust the position of the coil on the ferrite rod, or the aerial coil's core for maximum audio level. Repeat the procedure until no further change is detected.

As a final note, although the frequency of the Minispot will run close to 455kHz, the operating frequency can be set to an "exact" 455kHz with the aid of a frequency meter. By adjusting the values of the 68pF capacitors in series with the ceramic filter frequency changes can be made. In general, though, without adjustment the Minispot will operate to within 1kHz of 455kHz.