A NEW METHOD OF RECALIBRATION OF RECEIVERS, BFO'S, ETC.

Bennett Basore, W5ZTN

Many short wave and amateur receivers and VFO's are stored in attics and sheds over the country, having been replaced by modern digital synthesized receivers and tranceivers. But the older gear is still of interest to those who restore old equipment as well as those who are just getting started in amateur radio and aren't prepared to fork out the price of a digital rig. A common problem with the older equipment is that, as a result of aging, tube substitution, or mis- adjustment, they are no longer accurately calibrated. Because standard recalibration techniques involve tedious and often confusing (even divergent) repetitions of adjustment, the needed recalibration is often left undone, or worse, attempted to the point of giving up as the techniques seem to lead nowhere.

The availability of counters and hand calculators makes possible the use of a calibration technique that the author devised and believes to be original. This method shortens the calibration process by several steps, sometimes even an order of magnitude. In particular, the slowly converging process of adjusting inductor and capacitor trimmers at the top and bottom frequencies of the dial can be reduced to as few as three adjustments! (The method is not intended for use with receivers with a padding capacitor for adjusting the low end of the dial.)

RECEIVER ALIGNMENT

With even a cheap RF generator connected to a frequency counter to provide calibration signals, one can begin. The following steps are in the context of variable-capacitor tuning, but are applicable to variable-inductor tuning by simply interchanging references to capacitors and inductors. Before attempting alignment of the oscillator and RF stages of the receiver, be certain that the IF stages are properly aligned on the original IF, modified only if the crystal filter (if any) has drifted off a few hundred hertz. Next, make sure that the dial is properly fixed to the variable capacitor shaft. Usually there is a mark that corresponds to the fully meshed position. It is also necessary that the capacitor plates be relatively free of dust or grime so that the capacitance is close to what it was originally for each setting of the dial.

First, set the receiver dial to the lowest frequency of interest on the band being aligned. Set the calibration signal to this frequency. For example, on the broadcast band, set the dial and the signal generator (as measured on the counter) to 550 khz. This frequency is designated fa. Trim the inductor for the oscillator stage to pick up the calibration signal as accurately as possible. Next, tune the receiver dial to the desired high-end frequency, which is designated fb. In our example, this might be 1550 khz. Now adjust the signal generator until it comes in "on the nose". Read the counter, recording the frequency at least out to the nearest Khz. This frequency is designated f1, and generally will not be equal to the desired frequency, fb. If it is, stop now; the receiver is in calibration on this band!

The three frequencies now provide enough information to reset the inductor and capacitor trimmers to the values needed for accurate calibration. Using the formula below, compute f2.

$$(f_2 \pm IF) = (f_1 \pm IF)\sqrt{\frac{(f_b \pm IF)^2 - (f_a \pm IF)^2}{(f_1 \pm IF)^2 - (f_a \pm IF)^2}}$$

Use the (+ IF) as shown if the local oscillator frequency is above the received signal, but subtract it (- IF) if it is below.

Suppose f1 in our example turned out to be 1562 khz. Then inserting the three frequencies into the formula, each having been increased by the 455 khz IF, we get f2 = 1546 khz.

Set the signal generator to f2 as read on the counter, again to the nearest khz or closer. Without adjusting the receiver dial, trim the capacitor trimmer to bring in f2 as accurately as possible. Next, adjust the trimmer capacitors on the RF and ANT stages for maximum signal to be sure they do not affect the tuning of the calibration signal. (Chances are they will to some extent.) Readjust the OSC trimmer if necessary. As the last step, set the signal generator and the receiver dial to the low frequency, fa, and readjust the inductor to tune in this calibration signal. This step should complete the calibration of the dial, and only adjustment of RF and ANT stage inductors should be needed to finish alignment on this band. Check the dial at several frequencies to see. If mid-range frequencies are off but the end frequencies are exact, it means that either the tuning capacitor is not properly aligned with the dial, or that the capacitor has actually changed its capacity-versus-position curve since the dial was originally calibrated. Some older tuning capacitors have bendable outer plate segments that could be adjusted somewhat. (This mid-range problem could also result from poor quality control at the time of manufacture.)

VFO ADJUSTMENT

The technique works equally well with VFO's. Connecting the counter to the VFO output provides accurate frequency data, so that no signal generator is necessary. The addition or subtraction of the intermediate frequency is also unnecessary, and the formula becomes:

$$f_2 = f_1 \sqrt{\frac{f_b^2 - f_a^2}{f_1^2 - f_a^2}}$$

This technique can be justified theoretically, and is exact for ideal inductors and capacitors. It is also quite accurate where some distributed capacitance is present in the inductor and its wiring, and some inductance in the capacitor wiring, as long as these minor contributors do not change as the capacitor changes position.

JUSTIFICATION

Resonant frequency is inversely proportional to the product of the inductance and the capacitance. Thus a variable capacitor "tunes" the frequencies that correspond to the changing capacity, which is the sum of the trimmer capacity and the variable capacity. Adjustment at any point on the dial to make the received frequency equal to the dial frequency merely makes the error in the adjusted parameter (L or C) equal, percentagewise, to the error in the other. Because the percentage error in the capacity is larger at the high end than at the low end of the dial, adjusting the inductor at the low end after adjusting the capacitor at the high end will begin a series of adjustments which eventually converge to the desired end state. Knowing this, experienced technicians will overadjust at the high end in hopes of converging more rapidly to the correct values.

Figure one illustrates a situation where, after step one, the inductor error is positive and the compensating capacity error is negative. Thus, at the high-frequency end of the dial, the capacity error is greater, percentagewise, than the inductor error, and the LC product is smaller than needed, leading to a higher tuned frequency than indicated on the dial.

Also shown in the figure is the computed frequency. f2, that would be tuned in if the capacity error were zero, but the inductor error remained positive. Note that it is below the desired frequency fb, thus in the direction of an overadjustment at the high end. It is precisely the needed overadjustment to remove all the error in capacity. Next, at any frequency on the dial, the inductance error can be tuned out. But by doing so at the low end of the band, the residual capacity error that may have remained after adjusting the capacity trimmer will be a minimum percentage error, and yield a commensurate error in the inductor setting.

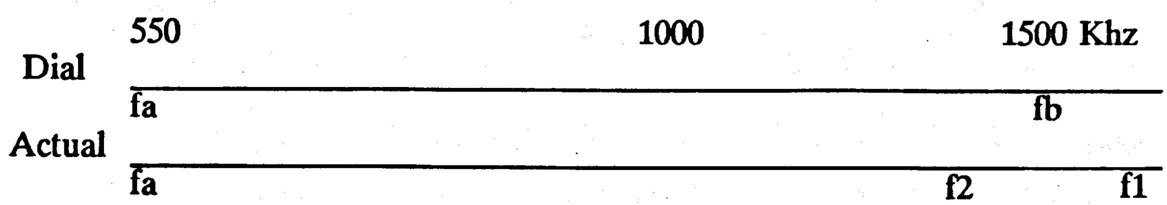

Figure 1

In step one, the LC product is adjusted to correspond to the desired value for fa. Thus, assuming that L, Cmax and Cmin are the precise values needed for exact calibration, and that dL and dC are the errors, dL and dC offset each other after completing step one, and

$$(L + dL)(C_{max} + dC) = LC_{max} = k/f_a^2$$

Then, at step two, by tuning to the dial frequency fb, and reading the actual frequency f1, we obtain the frequency that corresponds to the product.

$$(L + dL)(C_{min} + dC) = k/f_1^2$$

while

$$LC_{min} = k/f_b^2$$

Manipulating these three equations for the product (L + dL)Cmin, which is defined as k/f2**2, we can use that frequency to zero out dC without changing the dial, and finally, returning to fa, zero out dL!

When the local oscillator is being adjusted, each of the dial freqencies is increased (or decreased if the LO is below the dial frequency) by the IF frequency. Thus the formula follows.