# new life for the Collins 51J receiver vfo

The local oscillator in this excellent receiver can be restored to like-new operation with these modifications

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**The Collins 51J series receiver (military type R-388/URR) is a valuable adjunct to any amateur station. Several articles have described modifications to make this superb receiver better suited to single sideband reception.[1,2,3]**

Available through surplus sales or MARS issue, the 51J receiver offers low-drift frequency readout capability from 500 kHz to 30.5 MHz. Indeed, a mint condition 51J with its 100 kHz crystal calibrator makes a good frequency meter for the home laboratory or amateur station in addition to providing excellent high-frequency and broadcast-band reception.

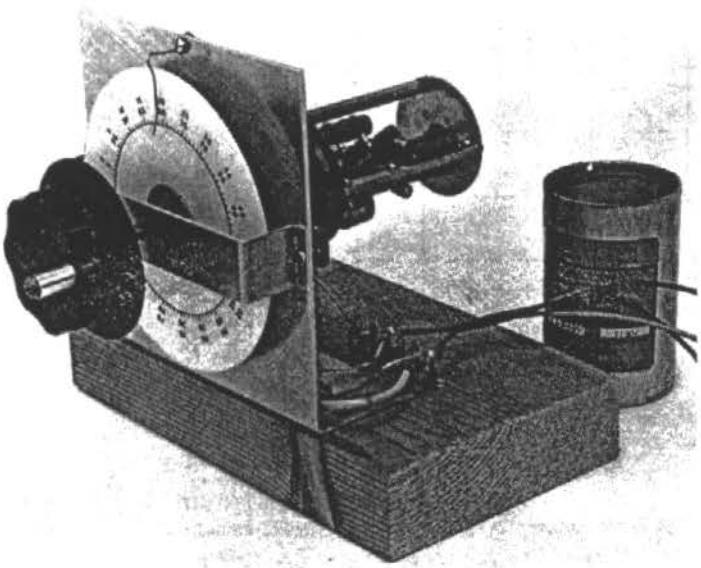
I've noticed that secondhand 51J receivers seem to be valued in proportion to the accuracy of tuning-dial calibration which, in turn, is a direct function of tuning linearity of the variable frequency oscillator (vfo)—the heart of the receiver. The better the vfo tracking characteristics, the greater the worth of the receiver. The difference in cost between a receiver having a good and a poor tracking characteristic is several hundred dollars.

## vfo calibration shift

My 51J receiver was purchased secondhand in 1956. At that time, I made an accurate frequency check of the vfo and filed

the results. Over the years, I noticed a gradual, slow shift in calibration linearity. Finally, in early 1968, I found that correction was beyond the capability of the dial zero adjust (or fiduciary setting, as it's sometimes called).

A check with other owners of older 51J's indicated that their receivers had the same slow drift to a certain extent. Interestingly enough, in all cases, the calibration shift was in the same direction and of the same magnitude. That is, the vfo tuning range



**Jig for Collins vfo adjustment. Oscillator cover is removed to expose adjustment coil, L-002. Shield must be replaced for calibration, as it shifts resonant-circuit frequency.**

gradually contracted. Instead of tuning 1000 kHz with ten revolutions of the tuning dial, the tuning range was reduced to about 990 kHz with ten revolutions. This made each end of the dial in error by 5 kHz when calibration was established at the center of the tuning range. For example, when calibration was "on the nose" at 15 MHz, at 14.5 MHz the dial would read 14.505 MHz; and at 15.5 MHz, it would read 15.495 MHz.

The 51J instruction manual is full of exhortations about not tampering with the sealed vfo, otherwise frequency calibration will be degraded. True, there's an auxiliary adjustment on the front of the vfo that can be used to restore tracking. However, in most older 51J's, the adjustment will have been "used up," and no further adjustment is possible.

## modifications

This being the case, I felt my receiver's calibration was so far off that no further damage could be done to the sealed vfo unit if it was carefully opened and examined. Accordingly, the vfo was removed from the 51J (not without some trepidation), opened, modified, resealed, and replaced in the receiver. Results were so gratifying that I prepared this article to describe the modification, with the hope that it will benefit other owners of this fine receiver.

It should be noted that Collins approval of this radical surgery has not been obtained, and I doubt if such a modification, as described here, would meet with other than raised eyebrows. However, many 51J receivers have outlived their warranty. So if yours is one of these and suffers from the ailment described, the modification will restore receiver dial calibration to that comparable with a new set.

While modifying the vfo, several capacitors that have a notoriously short life can be replaced, thus enhancing the receiver's long-term reliability.

## the variable frequency oscillator

This modification involves the Collins 70E-15 oscillator used in the 51J receivers. The unit tunes 2 to 3 MHz, with a generous overlap at each end of the range. Shaft rotation requires ten turns to cover the 1000-kHz range. Output voltage into an open load varies between 3.5 and 6 volts, at an operating potential of 150. Oscillator tube V-001 (see **fig. 1**) receives in-phase feedback voltage from amplifier tube V-002's screen circuit through capacitor C-008. The oscillator tank consists of trimmer inductor L-002, permeability-tuned inductor L-001, and tank capacitor C-001 in parallel with temperature compensating capacitors. The oscillator is tuned by moving the powdered iron core within inductor L-001. The core, or slug, traverses a lead

screw rotated by the receiver tuning dial. Tuning ranges and other data for the Collins vfo's are listed in **table 1.**

The over-all oscillator tuning range is established by adjustment of trimmer inductor L-002, which may be manipulated through an adjustment hole in the front

points have shrunk, and neither trimmer coil L-002 nor the zero adjust compensation device on the tuning dial will bring the end points within the correct range. When new, the vfo may be adjusted over a range of about 40 kHz, centered about the 1000-kHz tuning range (**fig. 2**). As the unit ages, the

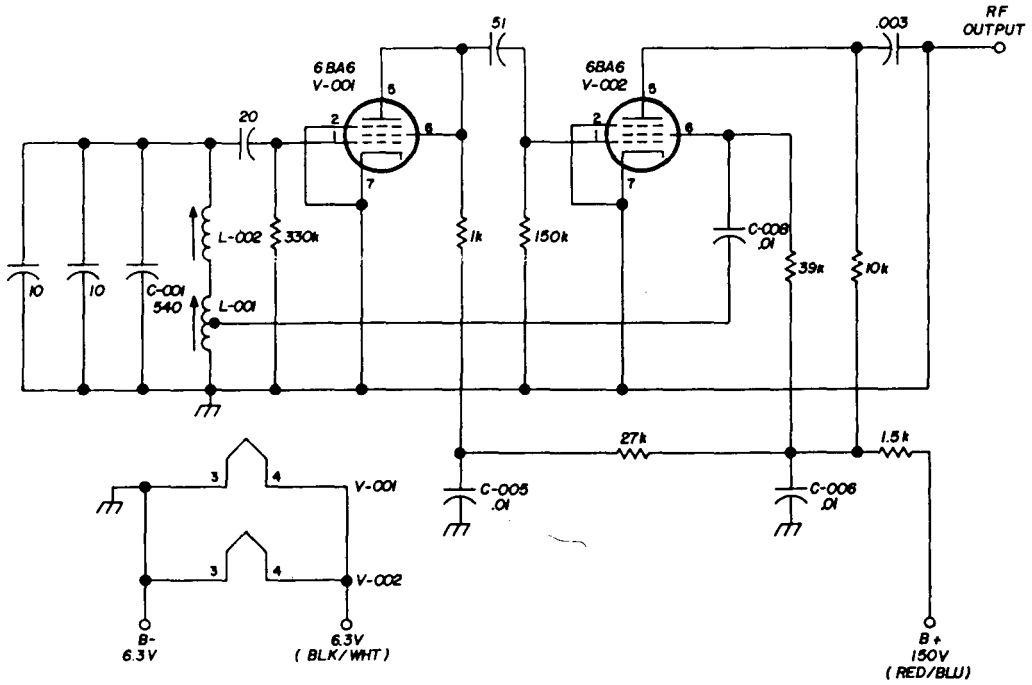



**fig. 1. Collins 70E-15 vfo schematic. As tuning slug in L-001 ages, oscillator tuning range decreases until trimmer L-002 provides no more correction; L-002 is reworked to restore correct tuning range.**

plate of the oscillator. With the aid of a special adjustment tool, L-002 may be tuned without removing the oscillator from the receiver. Vfo alignment by adjustment of coil L-002 is covered in the Collins instruction and maintenance manual (section 5.3.15).

When the receiver is new, this adjustment permits expansion and contraction of the vfo tuning range from a minimum of about 980 kHz to a maximum of about 1020 kHz. Proper adjustment of L-002's slug permits the tuning range end points to be moved sufficiently to ensure good calibration at the ends and center.

Alas, as the 51J receiver ages, it seems that the powdered-iron core of the main tuning slug ages also. At some future time, it will be found that the tuning range end

total range of L-002 remains about the same, but the entire range shifts in frequency as shown, until it doesn't include the desired correction range.

Luckily the slow shift of the vfo tuning range seems to decrease with time. Eventually stability is achieved, but at just about the time the user finds he has run out of vfo compensation because of the combined aging of the main tuning slug and the relatively restricted adjustment range of coil L-002.

An astute student of Murphy's Law could have predicted this impasse; thus the question is raised: what can be done to reestablish the correct tuning range of trimmer coil L-002 so that an older 51J may be brought into calibration and allowance provided for future corrections, if needed?

## vfo removal

In order to work on the vfo, it's necessary to remove it from the receiver and mount it in a temporary calibration jig, as shown in the photograph. To begin this task, remove the vfo tubes and the following panel dials: selectivity, phasing, main tuning, band change, antenna trim and bfo pitch. Next, remove the front panel by removing 11 securing screws, and unhook the two dial lamps over the dial drum. Tilt the panel forward. Now, remove the plastic "kilocycles" dial from the vfo shaft, after first setting the vfo shaft at about the center of the tuning range.

Remove the three screws and lock washers holding the vfo to the chassis panel. Unsolder the two power leads (black/white is filament; red/blue is B-plus to pin 5 of the voltage-regulator tube). Unsolder the coaxial output cable from pin 1 of the 6BE6 mixer tube. The vfo is now free of the receiver.

The easiest way to remove the vfo is to lift it upwards through the top of the receiver, as the under-chassis area is blocked by other components. To do this, remove the bottom tapped panel spacer from the front of the vfo, the spacer otherwise will hit the shaft coupler and prevent the vfo from being tipped forward for removal.

As you remove the vfo, take care to catch and carefully retain the central portion of the flexible shaft coupler, which usually falls out at this point. Note that the upper-right screw holding the vfo, as viewed from the front, is accessible from the front of the receiver through a hole in the tuning gear by turning the "kilocycle" shaft to align the hole over the screw.

Once the vfo is out of the receiver, mount it in the jig. Attach a flexible coupler to the vfo tuning shaft. When you remove the original coupling from the vfo shaft, note its location on the shaft **before** you remove it. This will allow it to be returned to the same position after completion of work. Normally, the coupling plate is flush, or nearly so, with the end of the shaft.

The plastic "kilocycles" dial and an extension shaft permit the vfo to be tuned during tests, and a makeshift pointer is mounted to the aluminum plate so dial calibration may be noted. Place the receiver aside, and cover the main drum dial with a cloth to protect its printed surface.

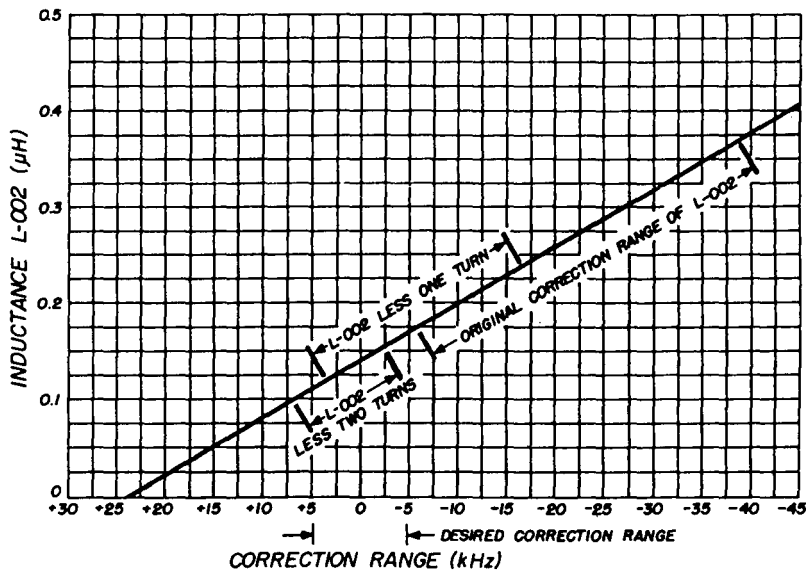



**fig. 2. Plot of trimmer coil L-002 inductance versus correction range. Removing one or two turns reduces over-all correction range, but moves it in proper direction to allow correction as shown.**

## vfo adjustment

Apply filament and plate voltage to the vfo. It should draw about 12 to 15 mA plate current. Make a frequency calibration

chart of the tuning range by checking the 100-kHz points against a well-calibrated receiver tuned to the 2- to 3-MHz range.

Next, remove the vfo shield. The shield will shift the vfo frequency by many kHz when removed. It must be replaced when frequency measurements are made. While the shield is off, however, observe the movement of L-002's slug as you vary it. This will give you a feel as to the amount of expansion or contraction that this adjustment provides. In most cases, you'll find this control won't provide enough expansion for the correction range. A maximum tuning range of about 990 kHz per ten turns of the dial may be found; thus the dial must make about 10-1/8 revolutions for the 1000-kHz range.

Note also that the maximum tuning range is about 12½ turns of the shaft, with the center point about 5½ turns from the 2-MHz end. The most nearly correct tuning range will occur with L-002's slug withdrawn from the coil (minimum inductance).

## replacing capacitors

Before you recalibrate the vfo, it's wise to replace certain capacitors. While they don't affect vfo calibration, they're bound to give trouble sooner or later. These are the two 0.01 μF bypass capacitors, C-005, and C-006, located beneath the tube sockets, and the 0.01 μF feedback capacitor, C-008. (The latter is inside the vfo can at the base of the main tuning coil, L-001.) All are "match stick" capacitors, rated at 200 Vdc. They short out frequently, especially when they age. Since the vfo must be removed to make the coil modifications, it's a good idea to replace these capacitors.

Capacitors C-005 and C-006 may be reached by removing the small U-shaped shield beneath the vfo tube sockets. The shield is soldered in place and can be easily removed. Replace C-005 and C-006 with 0.01μF, 600-volt disc ceramics. Resolder the U-shaped shield, making sure the new capacitors' leads don't short to the metal case or cover.

Feedback capacitor C-008 is located in the vfo at the base of the main oscillator coil, L-001. Replace C-008 with a 0.001μF, 300-volt silver mica capacitor. Secure the new capacitor to the adjacent support terminal with a drop of epoxy cement. The vfo is now ready for final calibration.

## calibrating the vfo

It's necessary to reduce the over-all inductance of the tuned circuit to achieve the proper tuning range. This is most easily done by altering the inductance of trimmer coil L-002. When new, L-002 has an inductance range of about 0.18 - 0.4 μH **(fig. 2).** In order to bring the adjustment range within practical limits, one turn should be carefully removed from L-002's outer end.

Carefully unsolder L-002's terminal connection, and unwind the wire. Scrape the insulation one turn back from the end. Resolder the wire to the terminal at this point. Replace the vfo's cover, and make several frequency checks at different settings of L-002's slug. If the inductance setting of L-002 is correct, the vfo will tune the 1000-kHz range with ten turns of the shaft and with L-002's slug advanced about six turns into the coil. You should be able to expand and compress the over-all tuning range from 995 to 1005 kHz or more by adjusting L-002. If the vfo was very far out of adjustment initially, it may be necessary to remove an additional one-half turn from L-002 (see **fig. 2**).

The chart of **fig. 2** shows that when L-002's inductance is decreased, its adjustment range is accordingly reduced. With one turn removed, the adjustment range is about 18 kHz; with two turns removed, it shrinks to about 8 kHz. Clearly, no more wire than is absolutely necessary should be removed from L-002, as the point of no return approaches rapidly.

Once L-002 has been adjusted to provide the proper tuning range, the vfo is ready to be returned to the receiver. Firmly bolt the vfo's cover into place. Set the vfo to approximately the center of its tuning range (about 2.5 MHz). Set the "megacycle" dial to an integral megahertz (15 MHz, for example).

**table 1. Tuning ranges, operating voltages, and number of tuning dial revolutions to cover tuning ranges of the Collins receiver vfo's.**

| Type | Use | Tuning Range (MHz) | Filament Voltage | B+ | Turns* |
|---|---|---|---|---|---|
| 70E-1 | ARC-2 | 1.0-1.5 | 12.6 | 250 | 10 |
| 70E-2 | ARR-15 | 2.0-3.0 | 12.6 | 250 | 10 |
| 70E-3 | ARR-15 | 0.450-0.550 | 12.6 | 250 | 5 |
| 70E-7A | 75A-1 | 2.0-3.0 | 6.3 | 250 | 10 |
| 70E-8 | 310B 32V | 1.6-2.0 | 6.3 | 180-250 | 16 |
| 70E-10 | 708-A | 0.600-0.800 | 6.3 | 250 | 10 |
| 70E-11 | 708-A | 1.0-1.5 | 6.3 | 250 | 10 |
| 70E-12 | 75A-2 75A-3 | 1.955-2.955 | 6.3 | 150 | 10 |
| 70E-14 | KW-1 | 1.6-2.5 | 6.3 | 210 | 16 |
| 70E-15 | 51-J | 2.0-3.0 | 6.3 | 150 | 10 |
| 70E-23 | KWS-1 | 2.75-3.75 | 6.3 | 210 | 10 |
| 70E-24 | 75A-4 | 1.955-2.955 | 6.3 | 150 | 10 |
| 70H-1 | R-389 | 0.469-0.980 | 6.3 | 180 | 51 |
| 70H-2 | R-390 | 2.455-3.455 | 6.3 | 180 | 10 |
| 70H-12 | R-390A | 2.455-3.455 | 6.3 | 180 | 10 |
| 70K-1 | KWM-1 | 3.455-3.545 | 6.3 | 200 | 1 |
| 70K-2 | KWM-2 | 2.5-2.7 | 6.3 | 130 | 2 |
| 70K-2 | 32S-1 | 2.5-2.7 | 6.3 | 130 | 2 |
| 70K-2 | 75S-1 | 2.5-2.7 | 6.3 | 130 | 2 |

*Number of shaft turns to cover vfo tuning range.

The first step is to replace the center portion of the vfo's shaft coupler on the mating coupler section of the receiver. It may be held in place by friction, plus a little heavy grease. Lower the vfo into position with a twisting motion, and when in place with coupling mated, temporarily lock it into position with two retaining screws through the front panel. Replace the bottom spacer (previously removed), and secure the third panel bolt. Rotate the vfo shaft to make sure the coupling doesn't bind. Then return it to an even "megacycle" position on the main dial.

The final job is to align the vfo shaft and the "megacycle" and "kilocycle" dials for correct readout. Tune in a signal of known frequency from a generator or WWV. Various shaft couplings should be slipped until calibration is correct, using the receiver bfo for zero-beat. The process is markedly speeded if the dial setting and various shaft settings are not touched once the original positions are logged before removing the vfo. However, even if the shaft positions are inadvertently lost, no great harm is done. They may be re-established as long as an accurately known frequency is used for final calibration.

A number of Collins receivers, modified as described here, have dial calibrations accurate to within one kHz at any point on the dial. The zero-set adjustment need not be used unless a very accurate frequency readout is desired.

## references


1. P. H. Lee, "Further Improvements for the Collins 51-J," CQ, April, 1968, p. 68.
2. W. M. Scherer, "More On Updated Improvements for the 51-J Receiver," CQ, December, 1968, p. 64.
3. P. H. Lee, "A Single Tube Product Detector," CQ, April, 1961, p. 50.