

Add Tracking Sidetone to Your ICOM IC-765 Transceiver

With a stock IC-765, adjusting CW receiving pitch leaves the radio's sidetone oscillator pitch unchanged. This circuit generates a sidetone that tracks the '765's receiving pitch to within 1 or 2 Hz!

By Michael A. Mraz, N6MZ

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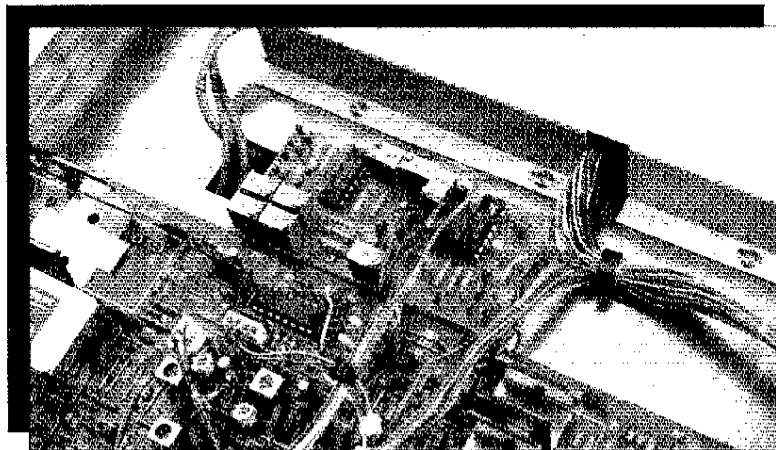
One of the ICOM IC-765's few weaknesses is that its sidetone oscillator doesn't track its **CW PITCH** control.¹ This means that you can change the frequency of the '765's received CW note, but because the sidetone is fixed at 700 Hz, you have no reference against which you can zero-beat incoming signals if you set **CW PITCH** to anything other than 700 Hz.

Variable CW pitch is an extremely useful feature. But if you can't zero-beat by comparing the incoming CW signal to the sidetone, you'll probably never change the CW pitch. This is really unfortunate: I find a 700-Hz pitch to be very fatiguing after several hours of listening—especially during CW contesting.

Because I find the IC-765 to be an excellent CW transceiver in almost every other respect (especially its receiver's wide dynamic range and superb cascaded 250-Hz CW filters), I decided to design and install a tracking sidetone oscillator in my radio. Here's the circuit I came up with, and the rationale behind it.²

How the IC-765 Controls Received-CW Pitch

The IC-765's **CW PITCH** control varies the beat-frequency oscillator (BFO) frequency by "pulling" the radio's BFO crystal with a variable-capacitance diode. ICOM uses a nonlinear potentiometer (R317c) for the **CW PITCH** control. This partially compensates for the variable-capacitance diode's nonlinear voltage/capacitance characteristic. It also means that the BFO frequency is a nonlinear function of the voltage available on the **CW PITCH** potentiometer wiper line (labeled **PIT** in the '765 schematic). Fig 1 shows this nonlinear relationship.



Settling on a Tracking-Sidetone Solution

I had more than one design idea for the tracking sidetone. One idea was to mix the BFO output with a 9-MHz signal from a crystal oscillator—the same method used in the '765 to monitor its transmitted signal in the SSB and RTTY modes. The anticipated advantage to this circuit was that it would track the radio's BFO tuning perfectly. Unfortunately, however, the IC-765's BFO does not oscillate during CW transmit! An audio oscillator generates the '765's **MONITOR** signal on CW.

I decided that the most practical tracking sidetone circuit would be a function-

generator IC controlled by the existing, nonlinearly variable **PIT** voltage. The only challenge was converting the **PIT** voltage's nonlinear variation into a linear variation suitable for driving the function generator's frequency-sweep input. Because I wanted the sidetone to track the BFO to within a few hertz, the **PIT** linearizing circuit would have to be quite accurate.

The Tracking Circuit

To linearize the **PIT** voltage, I used diodes and resistors to imitate a nonlinear dc amplifier. The diode/resistor networks change the gain of the circuit in six steps, as a function of the input (**PIT**) voltage. After calibration, the circuit is quite accurate and easily tracks the demodulated CW note to within 1 or 2 Hz.

Fig 2 shows the circuit's schematic. U1A-C, R1-R14 and D1-D20 linearize the voltage from the **CW PITCH** potentiometer. U1A and U1B are unity-gain buffer amplifiers. U1C and R8-R14 set U1C's dc offset and gain at the lowest **PIT** voltage (**CW PITCH** control fully clockwise). At the lowest **PIT** voltage, none of the diodes conduct, and the R1-R2 voltage divider determines circuit gain. As you turn the **CW PITCH** control counterclockwise past about 2 o'clock, the increasing **PIT** voltage causes D1 and D2 to conduct, which causes potentiometer R3 to parallel R2, thus decreasing the gain

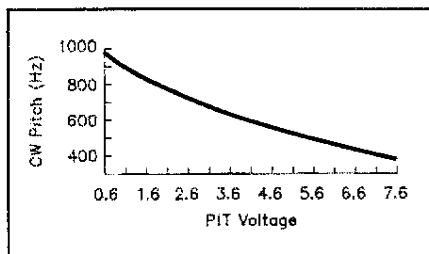


Fig 1—The IC-765's CW receiving pitch is a nonlinear function of the voltage on its **CW PITCH** control wiper line (**PIT**).

¹Notes appear on page 42.

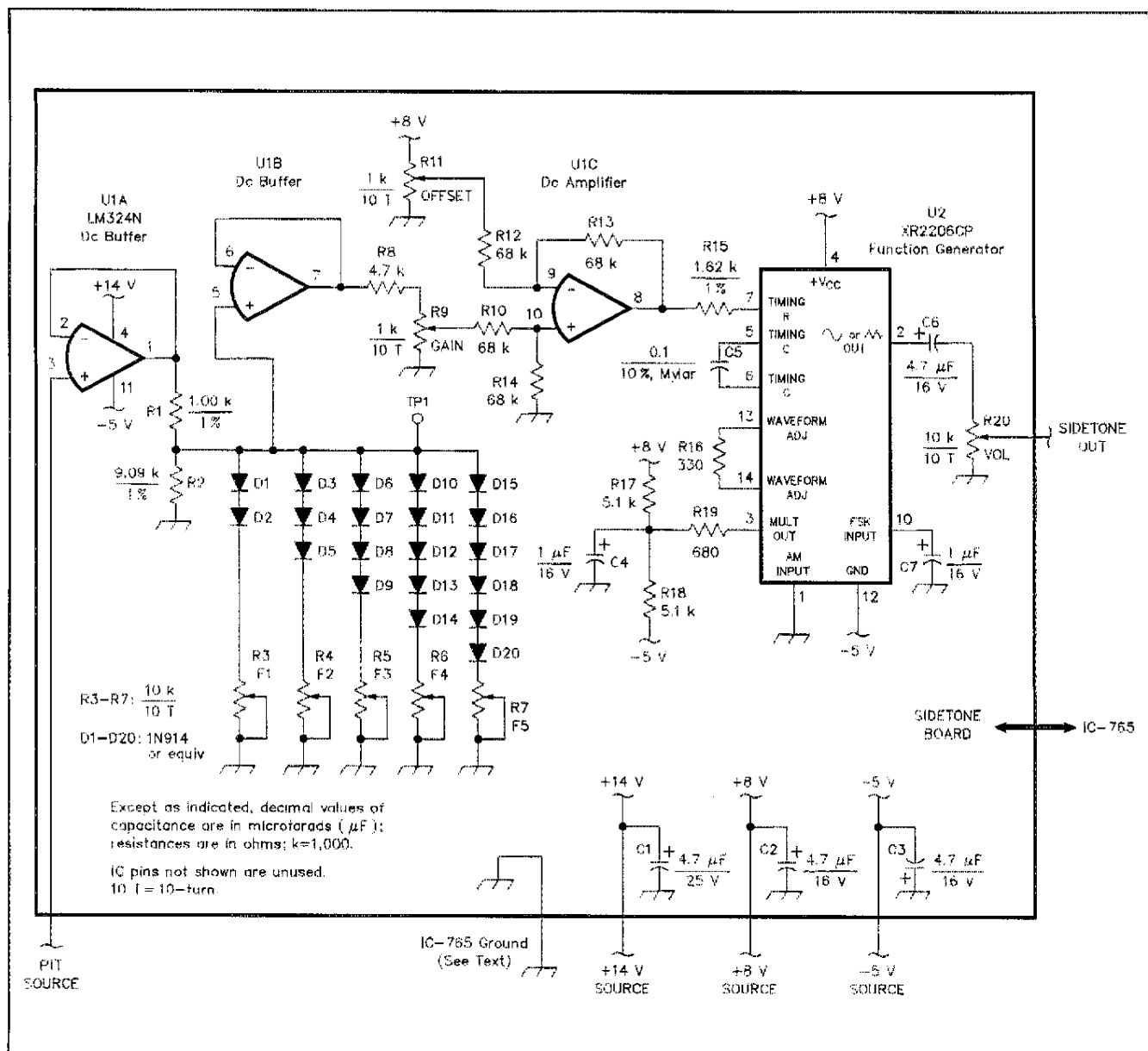


Fig 2—The tracking sidetone circuit uses the IC-765's PIT voltage to drive an Exar XR2206CP function generator (U2) via three sections of an LM324N quad op amp (dc buffers U1A and U1B, and dc amplifier U1C). Diode strings additively switch in compensation potentiometers R3-R7 as the PIT voltage increases, linearizing the voltage applied to U2 in five steps. Aside from the 1%-tolerance units, which are metal-film, all of the circuit's resistors are 5%-tolerance, carbon-film types. Except for C5, which is a 10%-tolerance Mylar type for better temperature stability, the circuit's nonelectrolytic fixed capacitors are general-purpose ceramic. The electrolytic (polarized) capacitors are tantalum. A complete parts kit, including a circuit board, is available for this circuit; see Note 3.

of the circuit. As the voltage increases further, additional diode/potentiometer branches conduct, further decreasing the circuit gain. In this way, the circuit converts the nonlinear PIT voltage into a linear voltage that can be used to drive the function generator's frequency sweep input.

The function generator is an Exar XR2206CP. This 16-pin IC contains a voltage-controlled oscillator, sine-wave shaper and associated bias circuits. The XR2206CP's output frequency is a linear function of the current drawn from pin 7, which is a function of the linearized PIT voltage at U1C pin 8. The '2206's sine-wave output has fairly low distortion, which re-

sults in a soft sidetone that is pleasant to listen to.

Construction

The tracking sidetone's circuitry operates at dc and audio frequencies, so you can use whatever construction technique seems appropriate. (I used haywire construction on a piece of perf board.) Complete kits of parts are also available.³ However you build your version, make it no larger than about $2\frac{1}{2} \times 5$ inches to ensure an easy fit into your IC-765.

Installation

Installing the board involves tapping into

the 765's +14-V, +8-V, and -5-V power supplies, connecting the sidetone input to the PIT voltage, removing a resistor on the '765's Main circuit board, and connecting the sidetone output to one of the pads from which the resistor was removed.

You must also decide how to mount the sidetone circuit board. I chose to use two aluminum brackets. These attach the sidetone board to the IC-765 chassis using two of the screws that fasten the '765's Main circuit board to the chassis.

Unplug your IC-765 from ac power and place the transceiver, upside down, on a soft towel. Remove the lower cover from the transceiver. Turn the transceiver on its left

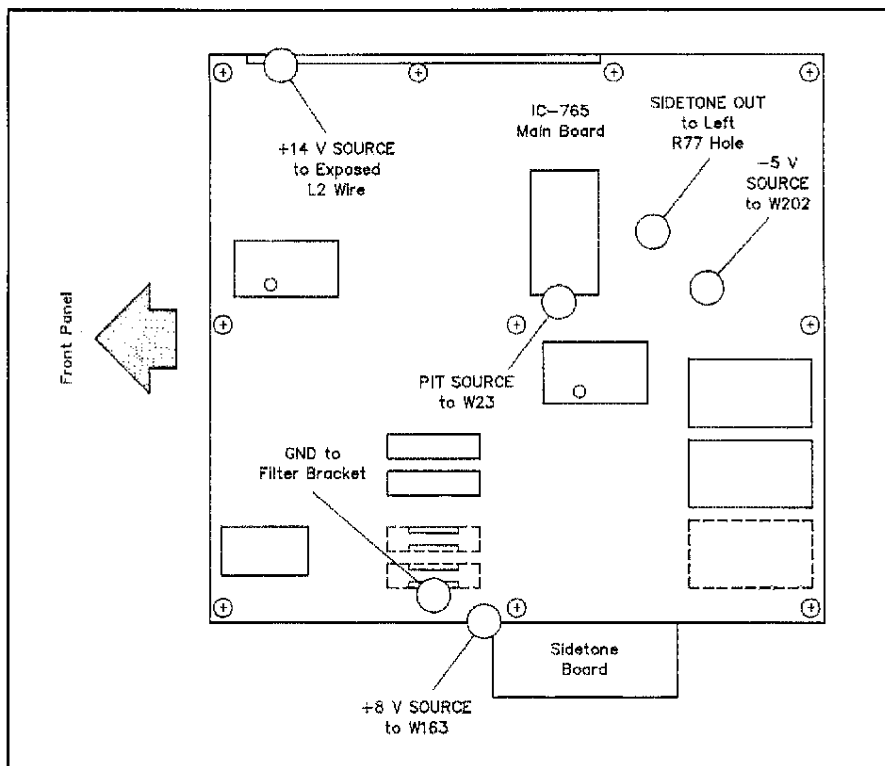


Fig 3—Overview of IC-765 Main board connection points for the tracking-sidetone module's +14 V SOURCE, +8 V SOURCE, -5 V SOURCE, SIDETONE OUT and PIT SOURCE wires.

side, so that the front panel is to your left as you look at the Main circuit board.

Locate L2, a wire-and-ferrite-bead inductor near the top-left corner of the Main circuit board; see Fig 3. L2 may be hidden by the large wiring harness. Carefully solder one end of a 12-inch length of #24 or #26 hookup wire to the exposed lead of L2. Label this wire **+14 V SOURCE**. Be careful not to melt the insulation on the wires in the wiring harness when you solder the wire to L2. **BE EXTREMELY CAREFUL** not to short the +14-V trace to any other component, or to the regulator heat sink which is immediately above L2.

Remove the 10 screws that attach the Main circuit board to the chassis. Using Fig 3 (and your service manual, if necessary), locate R77, and then carefully unsolder the resistor and remove it from the board. Solder a 12-inch length of hookup wire to the pad of R77 that is closer to the '765's front panel; see Fig 4. Label this wire **SIDETONE OUT**. Replace the Main circuit board; if you'll mount the sidetone board using brackets, do not replace the two screws that will attach the sidetone board to the chassis.

Locate jumper wire W163 on the Main board, using Fig 3 for reference. Solder another 12-inch length of hookup wire to W163. Label this wire **+8 V SOURCE**.

Locate jumper wire W202 on the Main board, using Fig 3 for reference. Solder another 12-inch length of hookup wire to W202. Label this wire **-5 V SOURCE**.

Locate jumper wire W23 on the Main board. Solder another 12-inch length of hookup wire to W23. Label this wire **PIT SOURCE**.

Place the sidetone board in its final location. Carefully cut each of the five new wires (+14 V SOURCE, +8 V SOURCE, -5 V SOURCE, SIDETONE OUT and PIT SOURCE) to appropriate lengths and strip and tin the ends. Solder the wires to the sidetone board and then double-check to ensure that they are connected to the correct pads.

Mount the sidetone board to the IC-765 chassis. If you home-brew your board and your mounting method completes its ground connection, fine; otherwise, you'll need to connect the sidetone board's ground to the IC-765's ground. (The outer surface of the nearest 9-MHz-filter bracket will suffice.) The LTA kit version requires a separate ground wire. The title photo shows the LTA sidetone board in place. Check all the connections and the wire dressing one more time, before you apply power to the '765.

Calibration

Attach the positive lead of a digital voltmeter (DVM) to TP1; the DVM's ground lead, to any chassis ground point. If you don't have a DVM, you can probably calibrate the sidetone based on the position of the **CW PITCH** control. Apply power to the radio and let it warm up for 10 to 15 minutes. Open the top hatch cover and turn the **MARKER** switch on. Put the '765 in CW mode and tune the radio to receive WWV

strongly at one of its exact frequencies (15.00000 MHz, etc). Rotate the top-hatch **CALIBRATOR** control to zero beat the IC-765's marker with WWV.

Rotate the **CW PITCH** control fully clockwise. Tune the '765 to 14.00000 MHz in CW mode. You should hear the radio's marker as a strong (S9+) CW note in the speaker or headphones. Press the **LOCK** button to lock the tuning at this frequency. Push the **VOX** button (to turn **VOX** off) so that you will not transmit a CW signal, and then lock the key. You should hear the 14-MHz CW note and the sidetone beating against each other. If you don't hear the sidetone, adjust the sidetone board's **VOL** trimmer until you hear the beat note. Adjust the sidetone board's **OFFSET** trimmer until the sidetone and received 14-MHz signal are exactly zero-beat with each other.

The voltage at TP1 should be about 0.5 to 0.6. Rotate the IC-765's **CW PITCH** control until the voltage at TP1 is 0.9 (approximately 3 o'clock), and then adjust the **GAIN** trimmer to zero-beat the sidetone and received 14-MHz signal. Repeat this step until the sidetone tracks the 14-MHz signal perfectly between the two positions of the **CW PITCH** control.

Rotate the **CW PITCH** control counter-clockwise until the voltage at TP1 is 1.2 (approximately 2 o'clock). Adjust trimmer **F1** for zero beat.

Rotate the **CW PITCH** control counter-clockwise until the voltage at TP1 is 1.7 (approximately 12 o'clock, the detent position). Adjust trimmer **F2** for zero beat.

Rotate the **CW PITCH** control counter-clockwise until the voltage at TP1 is 2.6 (approximately 9 o'clock). Adjust trimmer **F3** for zero beat.

Rotate the **CW PITCH** control counter-clockwise until the voltage at TP1 is 3.1 (approximately 8 o'clock). Adjust trimmer **F4** for zero beat.

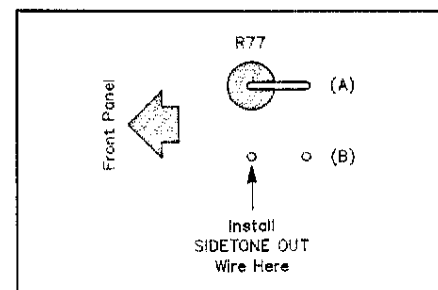


Fig 4—Connecting the sidetone's **SIDETONE OUT** wire requires the removal of the Main board's R77, a 270-kΩ resistor installed vertically. Finding R77 on the component side of the board is easy; finding and desoldering the corresponding pads on the underside of the Main board is more difficult. (The Main board graphic in the IC-765 service manual can help you find them.) As this top view shows, the circuit's **SIDETONE OUT** wire connects to the R77 pad that's closer to the IC-765 front panel.

Rotate the **CW PITCH** control fully counterclockwise. The voltage at TP1 should be approximately 3.4. Adjust trimmer **F5** for zero beat.

Slowly rotate the **CW PITCH** control from stop to stop, listening to the beat note. The sidetone should track the 14-MHz CW note very closely, within 1 or 2 Hz. If it doesn't track, repeat the calibration procedure. You can tweak the sidetone for more accurate tracking using the trimmers that correspond to the TP1 voltage breakpoints in the preceding paragraphs. After several months, I found that I used the 400- to 500-Hz range (approximately the 9 o'clock position) most often, so I tweaked **F3**, **F4**, and **F5** for perfect tracking in this range.

Turn the **MARKER** switch off, and then replace the top hatch cover. Adjust the **VOL** trimmer for the desired sidetone listening level. (You can use the '765's **MONITOR VOLUME** control to adjust the sidetone level when you're using the radio.) Remove power from the IC-765 and replace the bottom cover. This completes the modification.

Summary

Although this modification is not trivial to do, it's well worth the trouble. I have used the tracking sidetone modification for almost a year, including hundreds of DX contacts and three serious CW contest efforts. The circuit is rock-solid and does not drift with temperature as the '765 warms up. When I rotate the **CW PITCH** control back to the 700-Hz position and make a contact, I can't believe I waited over a year to design this circuit!

I have also installed the PBT modification as described in Hints and Kinks,⁴ a mod that I consider absolutely indispensable for the '765. The combination of the IC-765's excellent receiver, the two optional 250-Hz CW filters, and these two modifications, makes it an unbeatable CW transceiver.

Notes

¹M. Wilson, "ICOM IC-765 160- to 10-Meter Transceiver," Product Review, *QST*, Dec 1990, pp 52-55.

²Don't attempt to install this modification unless you're comfortable with invasive surgery on crowded circuit boards. If your IC-765 is still under warranty, a modification of this magnitude will surely void your warranty. As useful as the tracking sidetone is, be sure to consider the implications of voiding your warranty before proceeding.

³An etched, drilled circuit board and complete kit of parts for the tracking sidetone circuit is available for \$49, plus \$2 shipping to points in the US, from LTA, PO Box 77, New Bedford PA 18140, tel 216-565-9950. LTA intends to have tracking sidetone boards and kits available for sale at this year's Dayton HamVention; for details, and for particulars on export orders, contact LTA.

⁴R. Guski, "Variable-Bandwidth Tuning for the ICOM IC-765 Transceiver," Hints and Kinks, *QST*, Mar 1991, p 37.

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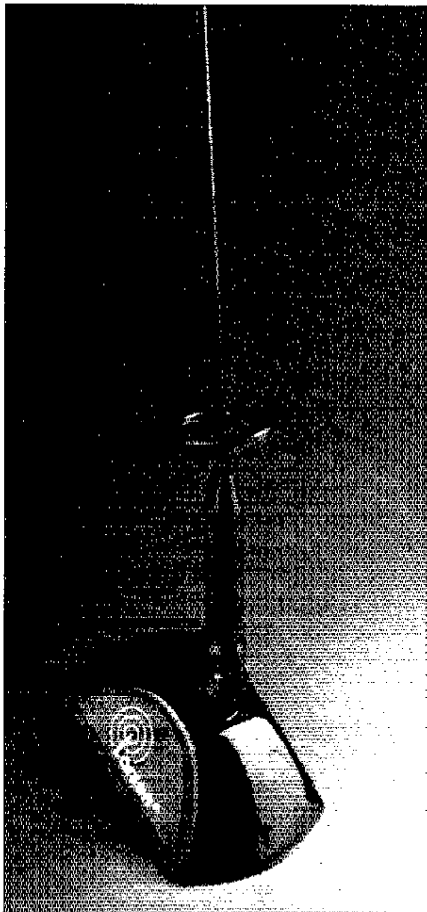
New Products

CORRECTION

◊ The Digi-Field wide-range signal-strength meter was listed on page 46 of March *QST* with a retail price of \$79.95. IC Engineering informed us that the correct price is \$119.95.

ON-GLASS 23-CM ANTENNA

◊ If you enjoy operating mobile on the "higher" UHF bands, you can do so without a mag-mount or permanent whip antenna. The KG-1290 is the first on-glass antenna for amateur use on 1.2 GHz. The manufac-



turer claims a low SWR from 1.235-1.432 GHz for this black 1/2-wave-over-1/4 wave Kulrod. The antenna comes with Belden RG-58/U cable, Amphenol TNC or MPL connectors and 3M adhesive. Retail \$59.95. Larsen Antennas, 3611 NE 112th Ave, PO Box 1799, Vancouver, WA 98682; tel 206-944-7551, fax 206-944-7556.

HF ANTENNAS

◊ If you're looking for a fresh approach to HF beam antenna designs, Force 12 features multiband no-trap antennas and systems, and monobanders designed for high performance, minimal weight, high strength and a neighborhood-friendly appearance. These contest- and DXpedition-proven Yagis

present less tower, tripod and rotator loading, while providing considerable wideband gain and low SWR ratings. Force 12 antennas are constructed with wind-balanced multitapered, riveted elements, requiring no slots, hose clamps or sheet-metal screws. The elements come aligned and riveted to the boom. The unpolished aluminum elements and booms reduce sun glint, which should please the neighbors. Tailgunner technology provides the operator with the ability to immediately reduce the front-to-back ratio for instant listening and/or transmitting in the opposite direction.

Nomad dual-band direct-feed models cover the following frequency bands (boom lengths in feet): 10/12 (12, 16 and 24), 15/17 (16, 20 and 36), 12/17 (16), 10/15 (18), 20/30 (from 20). Nomad dipoles cover 12/17, 12/17/30 and single bands. There are single-band models for 10 meters with 3 or 4 elements on a 12-foot boom, 6 elements on a 24-footer, the Elite 510 with 5 elements on an 18-foot boom for \$259, and the 8-element 308 Magnum for \$489; 15 meters with 3 elements on a 16-foot boom, the 4-element Elite 415 for \$449, and the 357 Magnum with 6 elements on a 36-foot boom for \$695; the Elite 320 with 3 elements on an 18-foot boom for \$379, the Elite 420 with 4 elements on a 30-foot boom for \$549, and the 44 Magnum with 6 elements on a 44-foot boom for \$849; 40 meters with a single linear-loaded dipole and the 3-element Elite 340 for \$795.

Force 12 packages two Nomads and an Elite 320 antenna into its Strike Force SF-5B five-band package for \$995. Short-stacking options, custom orders and consultations are welcome. Tom Schiller, N6BT, Force 12, part of BUY USA Inc, 3350 Scott Blvd, Bldg 6102, Santa Clara, CA 95054; tel 800-248-1985 or 408-988-2766, fax 408-988-2767.

INFORMATIVE CATALOG

◊ There's plenty of fun for browsers in the new Reference Catalog from the Radio Works. It's touted as "The Wire Antenna Discovery Book." Not only does it include specifications for all Radio Works baluns, cable, rope, connectors, adapters, wire antennas and accessories, it also features several pages of practical advice, theory and construction tips. It's an unpretentious 127-page 8 1/2- x 11-inch black-and-white illustrated booklet, written in a friendly, folksy style and helps you to understand the applications for many components and designs, particularly parts and kits available from the Radio Works. There's also an extensive list of Radio Works products, although prices aren't included in the Reference Catalog—those are available in the firm's General Catalog. Retail \$5. Jim Thompson Jr, W4THU, The Radio Works, PO Box 6159, Portsmouth, VA 23703; tel 804-484-0140, fax 804-483-1873.

QST

Icom 765 Sidetone Tracking Modification Revisited

By Michael Mraz, N6MZ

Introduction by Floyd Sense, K8AC:

After acquiring a very nice Icom IC-765 at Dayton this year, I set out to find any modifications for the transceiver. One of the most useful I came across was a design by Michael Mraz, N6MZ, in the May 1993 QST article entitled "Add Tracking Sidetone to Your ICOM IC-765 Transceiver".

After a couple of days searching for a source for the PC boards mentioned in the article, I contacted N6MZ to see if perhaps he had a layout for the board. Mike responded immediately, and suggested another way to accomplish this modification, eliminating the need for the circuit board and circuitry described in his article.

I installed the new mod and find that it works just as Mike describes. The variation in volume of the sidetone with the setting of the power control is of no consequence, since the sidetone volume is controlled by the monitor gain control (you must have the monitor ON to hear the sidetone). While I haven't taken the time to measure the sidetone frequency against the received signal pitch, my ear says it's the same or extremely close.

If you don't already have a copy of the IC-765 service manual, you can get one from Icom. But - the manual they are currently selling is NOT a multicolor original, but a black and white copy. However, it's a very good copy, right down to the large fold out pages, and perfectly readable. Finding Q16 and R77 is certainly easier with the manual. If you plan to give this a try without the manual, you can find the two components just behind the shielded BFO enclosure on the main board. The BFO alignment information is found in the IC-765 instruction manual on page 47, and in the IC-765 service manual on Page 6-4.

Here's Mike's description of the newer modification:

I'd recommend doing the tracking sidetone another way. This mod is MUCH simpler and actually uses the 765's monitor mixer to beat the TX carrier oscillator against the RX BFO. The downsides are that the sidetone volume will vary a little, in proportion to the output power setting, and that you won't hear the sidetone when you aren't transmitting (i.e. you can't do CW practice with the "VOX" button off).

This is what I did:

1. Remove Q16 on the Main board. This transistor cuts off the BFO during CW transmit.
2. Remove R77 on the Main board. This resistor couples the CW sidetone oscillator to the audio T/R switching circuit.

Now when you transmit, you should hear the actual tone resulting from the receive BFO beating with the transmit carrier oscillator. The volume of the audio sidetone will vary with the setting of the RF PWR control (more power = louder sidetone). If (*and it's a BIG if*) all the mixer oscillators are aligned perfectly, when you tune the radio to match the sidetone frequency to the frequency of the received signal, you will be exactly zero-beat. My rig is accurate to within 10 Hz or so.

If you plan to work on the 765, you really should buy a copy of the service manual; it has all the two-color drawings that show the component locations on the boards. It also has the calibration procedure and theory of operation.

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