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Product Review

QRP Labs QCX-mini CW Transceiver Kit

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You can fit this single-band CW transceiver in your shirt pocket, but it can do much of what a full-size home-station radio can do. The QCX-mini is the latest in a series of QRP transceivers from QRP Labs. The radio delivers about 5 W RF output with a 13.8 V power supply, and it will operate from 7 to 14 V. On receive, it draws a battery-friendly 85 mA, helpful for portable operation. An optional case, shown in the title photograph, is available.

The QCX-mini includes two VFOs with adjustable tuning rate, receiver incremental tuning (RIT), and 16 frequency memories. There's a CW memory keyer with practice and straight key modes, along with a CW decoder. CW offset and sidetone are adjustable. The display can show an S-meter, battery voltage, and the current time. The QCX-mini can also be set up to transmit WSPR (Weak Signal Propagation Reporter) beacons. To see the extent of this small radio's capabilities, check out the detailed documentation on the QRP Labs website.

We reviewed the original QCX transceiver in the August 2019 issue of *QST*. The most notable change from the original transceiver is the QCX-mini's smaller size. The QCX-mini in its optional case measures approximately 3.7 × 2.5 ×1 inches excluding protrusions, and it weighs 7 ounces.

Overview

The QCX-mini is available as a kit or assembled and tested. It can be built for 80, 60, 40, 30, 20, or 17 meters, and the features are the same for all versions. The front panel has a 16 × 2 (16 character by 2 line) LCD, two knobs, and two pushbuttons. Look for the *Cheat Sheet* page in the assembly or operation manual for details on using these controls.

The left knob (**VOL**) is the receiver volume control. The markings on the front panel help with using the two pushbuttons. Above the left-hand pushbutton is a single dot with the word **KEYER**. Push the button once and you can select the keyer speed by rotating the **TUNE** control. Other keyer choices are available in a menu. Below this **KEYER** label is the **RIT** label with two dots. Push the button twice, and you can select receiver incremental tuning (RIT) settings. Finally, the bottom **MENU** label has a dash next to it. Give the button a long press to open up the nine-section menu described in the *Cheat Sheet*.

One press of the other pushbutton selects the VFO mode (VFO A, VFO B, or split-frequency operation). Two presses, and you can save or recall a VFO memory. A long push transfers information from one VFO to the other.

The right-hand **TUNE** knob is a rotary encoder with a pushbutton switch. It is used primarily for frequency tuning, settings, and menu selections. A single press of the **TUNE** button changes the tuning rate (1 kHz, 500 Hz, 100 Hz, or 10 Hz). A double or long press is used to select and send a stored CW message from memory. With these three controls, many common operating choices may be made without going into the detailed menus.

Bottom Line

The QCX-mini from QRP Labs is a popular, tiny 5 W CW transceiver kit that can be built for 80, 60, 40, 30, 20, or 17 meters. Construction requires mounting through-hole components, and the instruction manual is excellent.

Circuit Highlights

The construction manual has a full schematic and an extensive explanation of the circuit operation. The QCX-mini design is similar to the original QCX. It's based on a preprogrammed ATmega328 microcontroller, along with an Si5351A phase locked loop. The Si5351A is controlled by a 27 MHz crystal, and its outputs are used in various ways.

On transmit, the microcontroller generates a signal, which is then shaped for the CW waveform and sent through a driver to a set of three transistors operating in class E. Finally this output is routed through a seven-element low-pass filter. The final three amplifier transistors and the driver are mounted close to each other on the circuit board. A flat washer presses all four transistors against the PC board ground plane, which serves as the heatsink.

On receive, the input signals are routed through the low-pass filter to a quadrature sampling detector, also called a Tayloe detector. Following the detector, two operational amplifiers subtract the phased outputs (I and Q), and then they are combined to form a single output. Next in the chain is a 200 Hz CW filter, followed by the audio amplifier. Enough audio power is available to drive a set of headphones, but not quite enough for a speaker.

Building and Alignment

The QCX-mini assembly manual runs about 120 pages and is available as a PDF on the QRP Labs website. In addition to step-by-step construction details, the manual includes sections on alignment, initial setup, circuit design, and troubleshooting. The manual is exceptionally complete and includes many high-quality illustrations throughout.

Figure 1 — The main circuit board carries most of the components for the receiver and transmitter sections. The microcontroller (white label) is at the upper left. T1 is the larger toroid near the center, and the socket that connects to the display board is in the upper left. The driver and final amplifier transistors are at the upper right, under the washer.

The QCX-mini is a sandwich of two printed circuit boards. The main board, shown in Figure 1, comes with many SMD (surface-mounted device) components already installed. The builder only has to add standard through-hole parts. The parts you must insert yourself have almost one page devoted to each component. Occasionally, the instructions for inserting a component run over to a second page, so it's a good idea to check the next page for additional information. The board is tightly packed, so take your time building it.

Large, clear, color photos and drawings make the construction task easier. The text notes that additional heat from your soldering iron may be needed occasionally because connections are made to the hidden ground plane. When it appeared more heat was needed, I left the soldering iron on the joint a bit longer.

Five toroids have to be wound. T1, the input transformer, is critical and a bit challenging (the manual calls it "the only really tricky piece of assembly"). The input signal is routed to five turns on T1, wound on a T50-2 toroid about the size of a dime. A multi-turn winding on the same core is resonant with a variable capacitor for the band selected. Two other five-turn windings have to be phased correctly and as identical as possible. During alignment, three variable resistors compensate for slight differences between these windings. The manual includes detailed instructions and several illustrations to help you build T1.

The manual recommends burning the insulation off the enameled wire used to wind the toroids. I followed this procedure, but during testing, the ARRL Lab discovered that in some cases, enough insulation was left to make poor soldered connections. It's probably best to scrape off the insulation first.

When the assembly of each board is completed, the two boards plug together as a sandwich with the display board on top (see Figure 2). I had a minor issue

Figure 2 — The display/control PC board completes the sandwich, with the main board on the bottom.

assembling the unit in its optional enclosure, but after re-reading the instructions, I realized that the case would go on only one way. The complete alignment procedure is brief and can be accomplished quickly. If for some reason you are not happy with the result, you can run through the alignment procedure again.

The QCX-mini has built-in troubleshooting capability, and the manual includes approximately 40 pages of circuit and troubleshooting information. As with most QRP transceivers and kits, there's an active online group with other builders willing to help (see **groups.io/g/QRPLabs**).

A nice added benefit of the QCX series transceivers is built-in test equipment. Although the test equipment is designed primarily to allow alignment and troubleshooting of the QCX-mini, the manual shows PC board connections for making external measurements. The test equipment set consists of a digital voltmeter (0 – 20 V dc), an RF power meter (0 – 5 W), a frequency counter (0 – 8 MHz), and a signal generator (3.5 kHz – 200 MHz).

Using the QCX-mini

The left side of the radio has a 2.1-millimeter coaxial dc power jack (cable and connector not supplied). There's a 3.5-millimeter phone jack for a keyer paddle, and another for stereo headphones. The right side panel has a BNC connector for the antenna feed line, 3.5-millimeter phone jacks for PTT output (for controlling an external amplifier or other device), and a computer-aided transceiver (CAT). I didn't use the CAT feature, but the manual gives instructions for making a cable to interface the transceiver with a PC serial port or USB-to-serial converter. The QCX-mini is compatible with the Kenwood TS-480S command set found in most logging software.

Table 1
QRP Labs QCX-mini, firmware version 1.07

Manufacturer's Specifications	Measured in the ARRL Lab
Frequency coverage: 40-meter amateur band.	Receive and transmit: As specified.*
Power requirements: 7 V dc minimum to 14 V dc maximum.	At 13.8 V dc: Receive, 85 mA (backlight on); 66 mA (backlight off). Transmit, 682 mA.
Modes of operation: CW. In beacon mode, CW, FSK CW, and WSPR.	As specified.
Receiver	**Receiver Dynamic Testing**
Sensitivity: Not specified.	Noise floor (MDS): –130 dBm at 7 MHz.
Noise figure: Not specified.	7 MHz, 21 dB.
Blocking gain compression dynamic range: Not specified.	Blocking gain compression dynamic range: 20 kHz offset, 126 dB; 5/2 kHz offset, 116/110 dB.
Reciprocal mixing dynamic range: Not specified.	Not measured. Low-noise 7 MHz oscillator not available.

ARRL Lab Two-Tone IMD Testing

Band	*Spacing*	*Measured IMD Level*	*Measured Input Level*	*IMD DR*
7 MHz	20 kHz	–130 dBm	–31 dBm	99 dB
		–97 dBm	–18 dBm	
		–50 dBm	0 dBm	
7 MHz	5 kHz	–130 dBm	–46 dBm	84 dB
		–97 dBm	–29 dBm	
7 MHz	2 kHz	–130 dBm	–52 dBm	78 dB
		–97 dBm	–38 dBm	

Second-order intercept point: Not specified.	14 MHz, +53 dBm.
IF/audio response: Not specified.	Range at –6 dB points: 605 – 854 Hz (249 Hz).
Receive processing delay time: Not specified.	4 ms.
Transmitter	**Transmitter Dynamic Testing**
Power output: Up to 5 W, depending on supply voltage.	0.4 W at 7 V dc; 2.3 W at 10 V dc; 3.5 W at 12 V dc; 4.9 W at 14 V dc.
Spurious-signal and harmonic suppression: >50 dB.	49 dB. (See Figure A.) Complies with FCC emission standards.
CW keyer speed range: Not specified.	1 to 99 WPM, iambic A and B.
CW keying characteristics: Not specified.	See Figures B and C.
Transmit-receive turnaround time: Not specified.	S-9 signal, 23 ms (full-break-in); 570 ms (semi-break-in).
Transmit phase noise: Not specified.	See Figure D.

Size (height, width, depth): 2.5 × 3.7 × 1 inches, excluding protrusions. Weight, 7 ounces.

Second-order intercept point was determined using S-5 reference.

*The QCX-mini can be built for 80, 60, 40, 30, 20, or 17 meters. The 40-meter version was tested. Transmitter is capable of transmitting outside of the 40-meter band.

When I first turned on the radio, it was ready to get on the air with CW. All I had to do was select CW speed and reduce the sidetone volume, because I was testing with an external audio amplifier and speaker connected to the headphone output.

In addition to the assembly manual, the QRP Labs website offers a 52-page downloadable QCX operating manual. The radio has a lot of features, and it's well worth the time to read through this document. I found the *Cheat Sheet* near the end to be a helpful summary of the

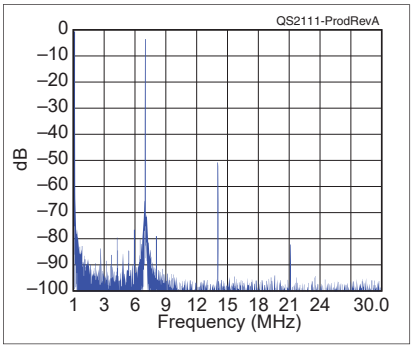


Figure A — Spectral display of the QCX-mini transmitter output. Power output is 5 W on the 7 MHz band. This plot shows the output spectrum from 0 to 30 MHz. The second harmonic is down 49 dB from the carrier, and the third harmonic is down 80 dB. The vertical scale is 10 dB per division.

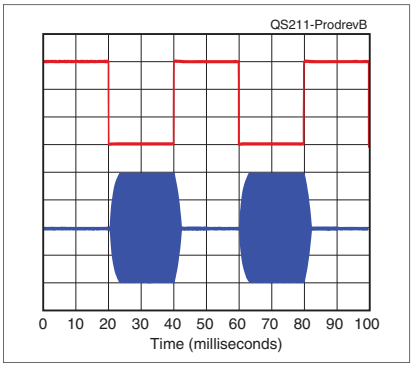


Figure B — CW keying waveform for the QCX-mini showing the first two dits in full-break-in (QSK) mode using external keying. Equivalent keying speed is 60 WPM. The upper trace is the actual key closure; the lower trace is the RF envelope. Horizontal divisions are 10 ms. The transceiver was being operated at 5 W output on the 7 MHz band. Rise time is 2.1 ms and fall time is 1.8 ms. First dit: on delay, 1.1 ms; off delay, 1.7 ms. Second dit: on delay, 0.8 ms; off delay, 1.6 ms.

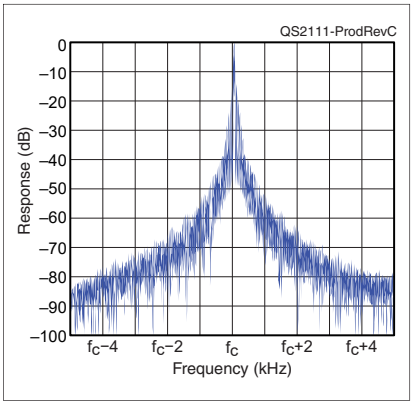


Figure C — Spectral display of the QCX-mini transmitter during keying sideband testing. Equivalent keying speed is 60 WPM using external keying. Spectrum analyzer resolution bandwidth is 10 Hz, and the sweep time is 30 seconds. The transmitter was being operated at 5 W PEP output on the 7 MHz band, and this plot shows the transmitter output ±5 kHz from the carrier. The reference level is 0 dBc, and the vertical scale is in dB.

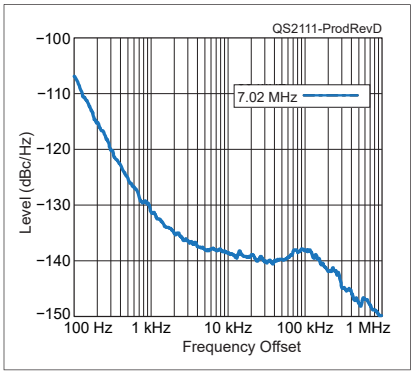
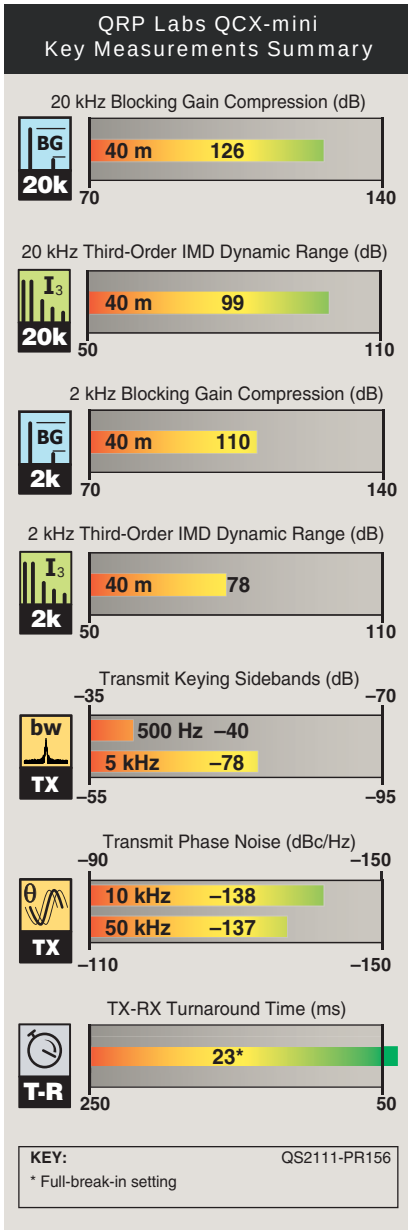


Figure D — Spectral display of the QCX-mini transmitter output during phase-noise testing. Power output is 5 W on the 7 MHz band. The carrier, off the left edge of the plot, is not shown. This plot shows phase noise 100 Hz to 1 MHz from the carrier. The reference level is –100 dBc/Hz, and the vertical scale is 10 dB per division.



menu items and controls. Once you have selected your default settings, you can save most of them from the configuration menu.

On the Air

As with any 5 W transceiver, your on-air results will depend somewhat on your antenna and band conditions. I was able to make contacts on 40-meter CW, mostly in the evening, without telling anyone that I was using just 5 W. My antenna is a fairly low 80-meter dipole fed with 10 feet of coax and then through a balun to ladder line to the dipole. A small tuner provides the needed match.

The 200 Hz CW filter seemed to work well, and with the speaker volume turned up, I did not hear noticeable ringing. The QCX-mini can operate in QSK (full break-in) or semi-break-in via a menu choice. The solid-state transmit-receive switching is silent.

Setting up the WSPR beacon was somewhat tedious, but it worked fine once I finished the configuration. If you plan to do a lot of WSPR operation, check out the optional QRP Labs QLG2 GPS module for time and frequency discipline and automatic setting of the Maidenhead grid locator.

In Summary

The QCX-mini QRP CW transceiver works well and offers many useful features. It makes extensive use of menus, so keep a copy of the *Cheat Sheet* from the manual handy. Kit construction is not too hard, although building the T1 input transformer can be challenging.

Manufacturer: QRP Labs, Mugla, Turkey; **www.qrp-labs.com**. Price: QCX-mini kit (specify band), $55. Built and tested, $100. Aluminum enclosure, $20. QLG2-SE GPS module, $20. TCXO module, $8.25. Shipping to the US is around $12 via FedEx and typically takes about a week.