

4 State QRP Group

Crystal Spotter Kit

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Assembly and Operation Manual

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Circuit Description

The Crystal Spotter uses a Pierce oscillator circuit to produce a signal at the series resonant frequency of a quartz crystal. Take a look at the schematic on **page 7**.

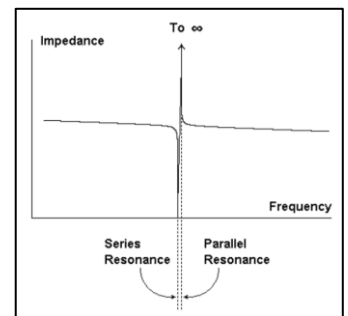
Voltage divider R1 and R2 establish a DC bias voltage at the base of Q1, while emitter resistor R3 introduces some negative feedback at DC to stabilize the bias against variations in transistor characteristics.

Capacitor C1 bypasses the emitter resistor so that negative feedback is eliminated at high frequencies. Oscillation is produced by the positive feedback from the collector to base of Q1 through the quartz crystal. NP0 capacitors C2, C4 and resistor R5 provide a constant load on the oscillator.

RF choke L1 isolates the collector of Q1 from the DC power source, while C3 and C6 bypass that power source at high frequency, establishing the RF ground. R4 works with C3 as an RC low pass filter to reduce high frequency noise.

Power is applied to the circuit by grounding the negative side of the battery through normally open pushbutton SW1. The circuit draws only about 11 mA, and since it is only energized for the brief intervals when SW1 is pressed, battery life should be approximately the shelf life of the battery.

As shown in the diagram, quartz crystals have two resonances – series mode and parallel mode. The series resonance is always slightly lower in frequency by a few tens or hundreds of Hz. Though all crystals will work in either mode, the frequency marked by the manufacturer may be either of the two resonances, depending on what kind of circuit the crystal is designed for. For crystals made for parallel resonance operation, it is customary for the manufacturer to specify a load capacitance, usually a few pF, for which the crystal will operate at its marked frequency. No load capacitance specification is needed for series resonance operation.



For the above reasons, don't be concerned if the frequency you determine using the spotter differs from the frequency stamped on the crystal. Circuit type, resonance mode, and temperature all play a role. But you should find the signal from the spotter within a couple of kHz of the marked frequency – usually near or below the marked value.

In particular, the oscillator circuit used in the *Bayou Jumper* transceiver generally will oscillate several hundred Hz below the frequency marked, especially if the crystal is marked for its parallel resonance.

Assembly Instructions

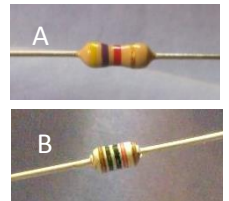
Except for the switch (SW1) all other components are installed on the top side of the printed circuit board, in what is call the “Pittsburg Style” construction, named for the Pittsburg KS home of the inventor of that technique: Joe Porter, WØMQY.

The components are all conventional through-hole, leaded parts, but they are attached to the circuit board as if they were surface mount. The wire leads are to be bent, formed, and trimmed into little “gull-winged” shapes that are then soldered to the circular pads on the circuit board. It helps to lightly tin each pad with solder before attaching a component lead. You may also wish to tin the large pads where the crystal will be connected.

Refer to the photos, schematic, and top and bottom PC board images and install the following components on the TOP side of the circuit board. The part IDs and the component values are marked on the silkscreened legend.

Resistors:

- R1 4.7 K, ¼ W resistor, *yellow-violet-red*
- R2 47 K, ¼ W resistor, *yellow-violet-orange*
- R3 220 Ω, ¼ W resistor, *red-red-brown*
- R4 100 Ω, 1/8 W resistor, *brown-black-brown*
- R5 1 K, ¼ W resistor, *brown-black-red*



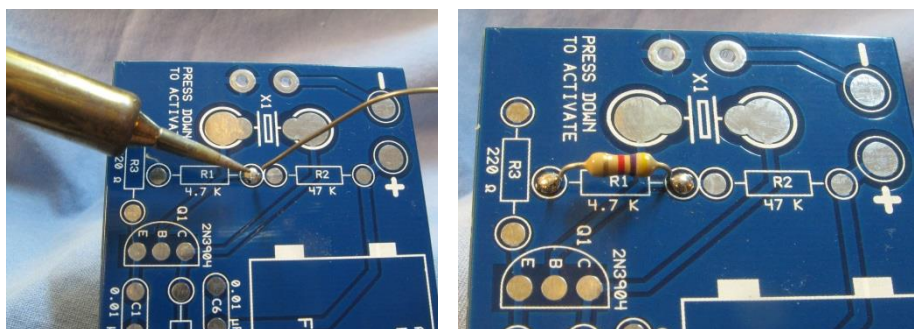
A: 1/4 W resistor
B: 1/8 W resistor

If you have a lead bending jig, use it to form the resistor leads for 0.4” spacing. Then form the “gull wing” shape, as shown in the photo sequence below:



It helps to lightly tin the PC board pads with solder before soldering the component in place.

Hold the part in position with tweezers or long nosed pliers. Solder one lead, check the positioning before soldering the other lead.



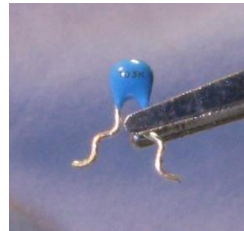
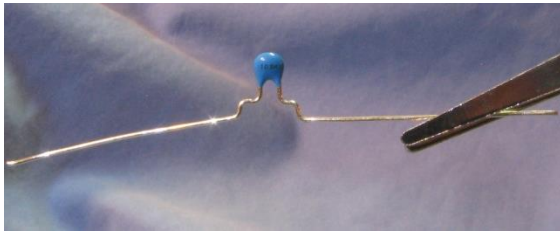
Left - Tinning the pads, Right - Resistor after installation

Capacitors:

C1, C3, and C6 0.01 μF X7R ceramic capacitor, blue body, marked 103

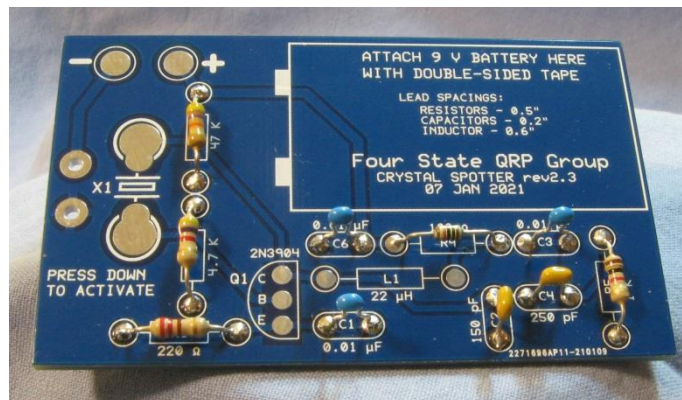


Form the capacitor leads into the “gull wing” shape, tin the pads, and solder in place as in the sequence below:



Now prepare and install these last two capacitors in the same manner. They may look like either of the two photos below. Be sure to carefully inspect the value markings, with a magnifier if necessary. When you have installed them, your board should look like the photo.

- C2 150 pF NP0 ceramic capacitor, tan body, marked 151
or, may alternatively be supplied as 120 pF, tan body, marked 121
- C4 250 pF NP0 ceramic capacitor, tan body, marked 251
or, may alternatively be supplied as 220 pF, tan body, marked 221



Inductor:

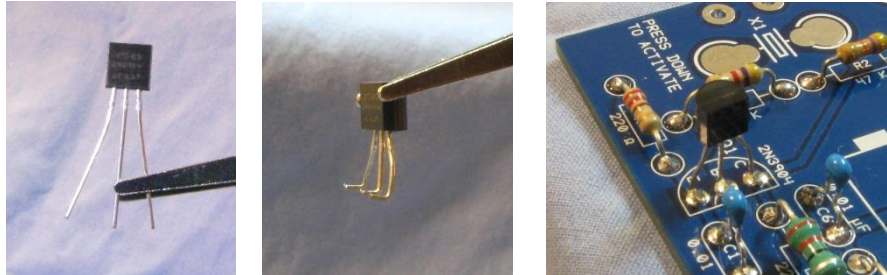
L1 22 μH molded inductor, marked *red-red-black-gold*. It looks like a resistor, but has a green body. Form the leads like the resistors, but use your lead bender at 0.6 in. Install it in the same manner as the resistors.



Transistor:

Q1 2N3904 NPN bipolar transistor, marked 2N3904

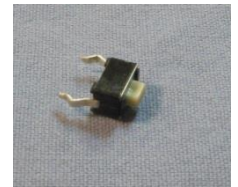
Form the usual “gull wings” and match the shape of the case with the silkscreened outline on the PC board. Solder one lead, re-check the positioning, then solder the remaining leads.



Final Assembly:

Now install from the **BOTTOM** of the circuit board, soldering on the top side, the pushbutton tactile switch:

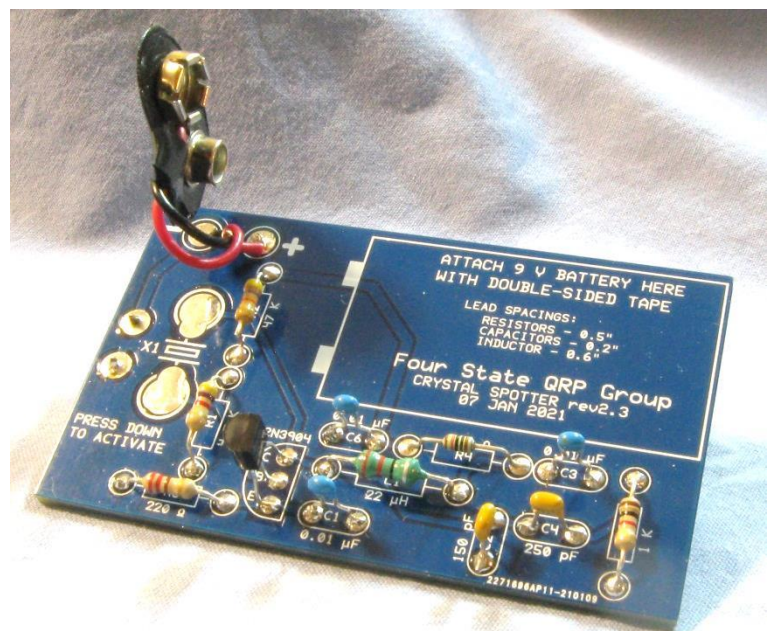
SW1, SPST, normally open, momentary pushbutton



Trim the excess lead length from the 9V battery clip, then strip and tin the wire ends. Solder the RED wire to the + battery pad, and the BLACK wire to the - pad.

Use a square of double-sided mounting tape to attach a 9V battery to the PC board. Add the felt bumpers on the bottom at the two indicated locations. Finally, snap the battery clip onto the battery.

You're done! Your completed PC board should look like this:



Operation

Use a piece of double-sided mounting tape to secure the 9 volt battery to the PC board. Be sure to check the battery orientation so that the leads from the battery clip are oriented conveniently.

To operate the Spotter, touch the pins or wire leads of your crystal to the large pads on the left side of the PC board. Press down gently until you hear the “click” that indicates SW1 is closed. This will power up the oscillator and generate the signal.



On your nearby receiver (set for SSB or CW reception), tune slowly starting a few kHz above the marked crystal frequency, tuning downward until you hear the steady tone.

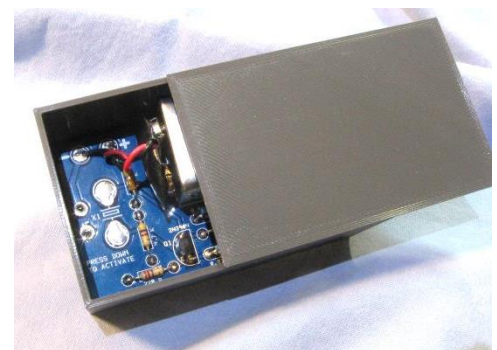
It is also possible to connect a frequency counter or an oscilloscope (with high impedance input) across R5 and measure the frequency directly.

As you can tell from the chart in the **Appendix**, a crystal used in a Bayou Jumper tends to oscillate a few hundred Hz lower in frequency than when it is used with the Crystal Spotter. Armed with this foreknowledge, tune your Bayou Jumper to zero beat the Crystal Spotter signal, then move the dial slightly counter-clockwise to the low side of zero beat. When you hear a tone a little higher in pitch than the usual rig sidetone, you should be just about spot on the crystal when it’s plugged into the Bayou Jumper.

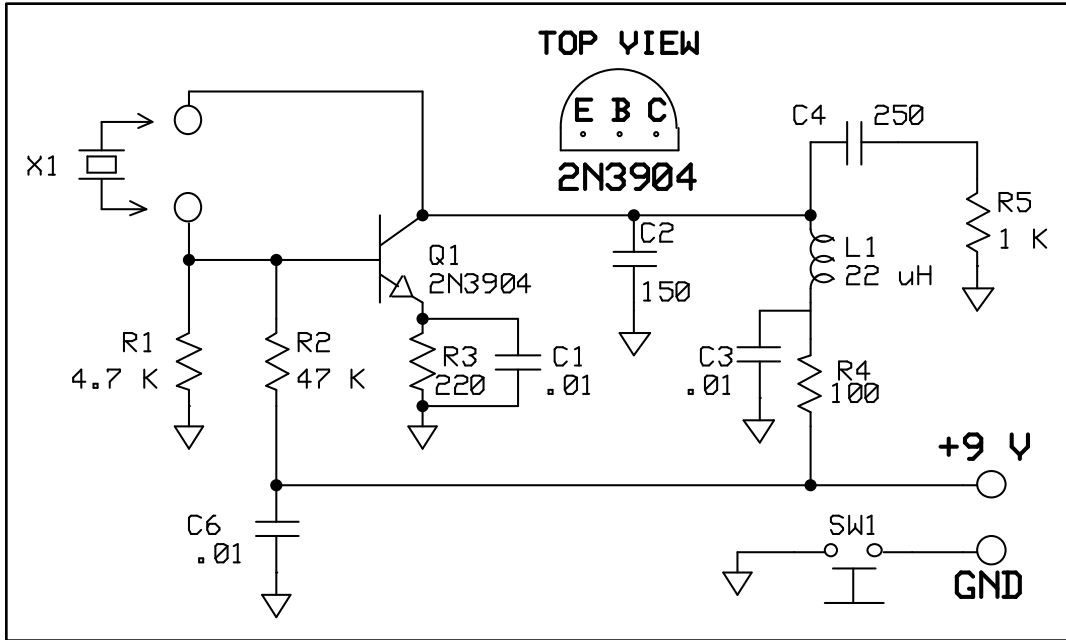
Enclosures

The prototype Crystal Spotter was designed to fit into a small wood box from Hobby Lobby (SKU 288743S), but that item appears to be no longer available. Other small wood or plastic boxes that fit can no doubt be located, but no enclosure is really needed. In particular, a metal enclosure is NOT recommended, as that would shield the desired signal.

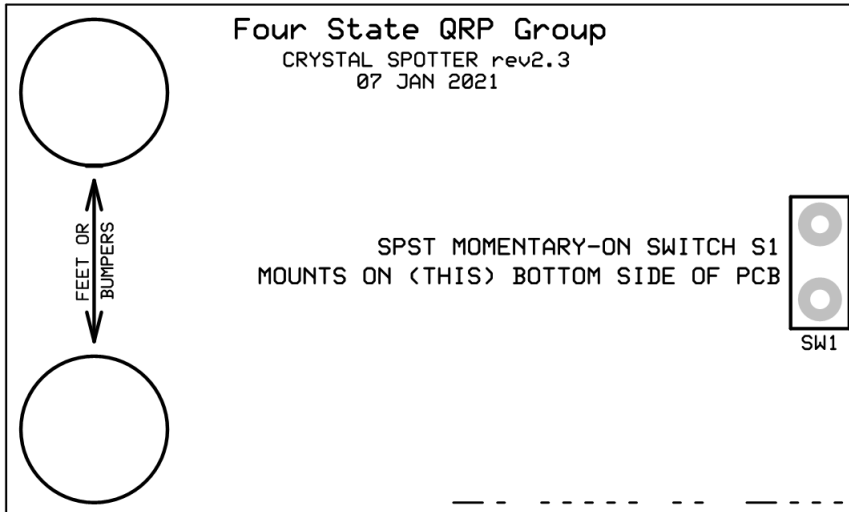
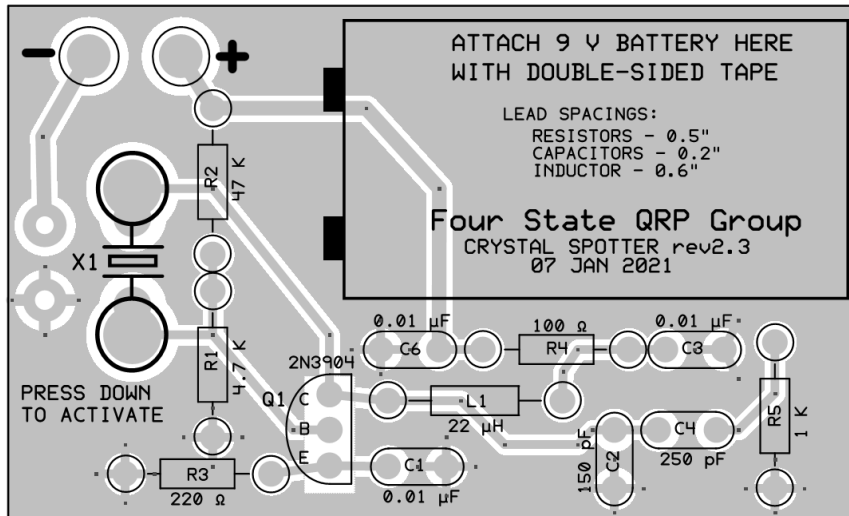
For those with access to 3D printing, an STL file for an appropriate enclosure will be posted on the Four State QRP Group’s Crystal Spotter Kit web page.



Schematic and Circuit Board Views



Actual PC board dimensions: 2.950" x 1.775"



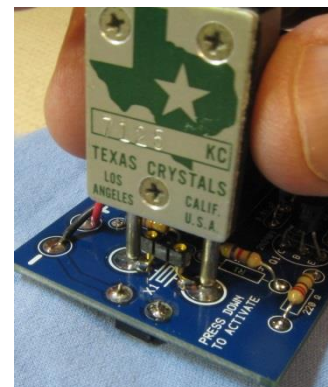
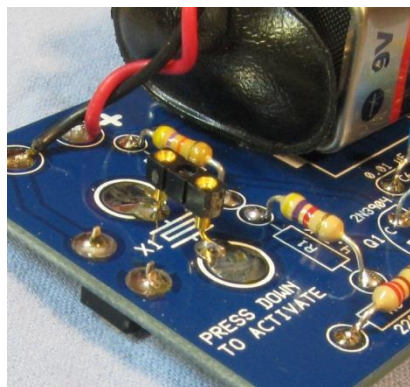
APPENDIX

Variations in measured frequencies for different crystals in different circuits
As measured with BK Model 1820 frequency counter

Crystal Type	Marked Frequency	Frequency in 4SQRP Spotter	Frequency in 4SQRP Bayou Jumper	Frequency in prototype Bayou Jumper
Vintage FT-243	7050	7050.30	7049.43	7050.09
HC-49 (tall)	7050	7050.47	7049.49	7050.27
HC-49 (short)	7680	7680.55	7679.06	7679.83

Ideas for Modifications

Two pins of a 3-pin strip of machined socket pins can be soldered to the crystal test pads. This will allow wire lead crystals to be conveniently tested, while not interfering with the ability to quick-test FT-243 sized crystals.



Voltage Chart for Troubleshooting

Connect voltmeter (-) lead to battery (-) with a fresh 9 V alkaline battery installed

* Battery (+) terminal	9.2 V	<i>Slight voltage drop under load</i>
* Upper pad of R2	9.2 V	
* Q1 collector	7.4 V	
* Q1 base	2.1 V	<i>RF present here</i>
* Q1 emitter	3.9 V	
# Battery (+) terminal	9.6 V	<i>Only very light load on battery</i>
# Q1 collector	9.5 V	
# Q1 base	0.85 V	
# Q1 emitter	0.21 V	

* Measurements taken with a crystal connected and SW1 activated

Measurements taken with NO crystal connected and SW1 activated

The unusual voltage measurement at Q1-base (lower voltage than the emitter) WITH a crystal is because of the presence of RF

