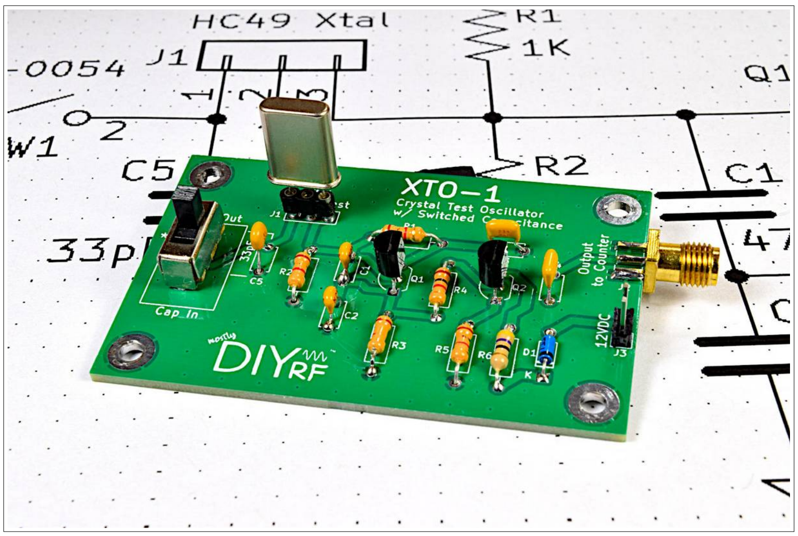
XTO-1

Crystal Test Oscillator



User's Guide

The intrepidity of the amateur-radio homebrewer knows few bounds. Once the province only of major manufacturers, the making of a crystal bandpass filter for single-sideband generation and reception can be done by a dedicated Ham. The flood of inexpensive “xtals” produced for computers and other digital gadgets makes homebrewed SSB filters quite practical. In addition to a little advanced knowledge–and a good calculator–a few pieces of (also homebrewed) test gear are needed.

So enter, then, the XTO-1. It’ based on the classic xtal test oscillator devised by G3UUR to find the resonant frequency and other important parameters of a batch of crystals. It is used in conjunction with a good frequency counter (with a resolution to 1Hz). With the help of computer software (several pieces of which are free), you’d then use this data to design a filter of a given 3dB bandwidth, shape factor, pass-band ripple, and other important characteristics. For more on the G3UUR method, watch M0NTV’s video, “Crystal Filters for the Fearful.”

The XTO-1 is also useful to determine the series resonance of individual crystals to sort them into narrow batches (with a frequency spread of less than 50Hz) for use in filter designs that do not rely on the motional parameters calculated using the G3UUR method. These alternative designs, such as the quasi-equiripple (QER) variant of the Cohn-type filter, can be built using the resonant frequency (for close matching of xtals) and experimentation with different values of shunt capacitors.

ASSEMBLY

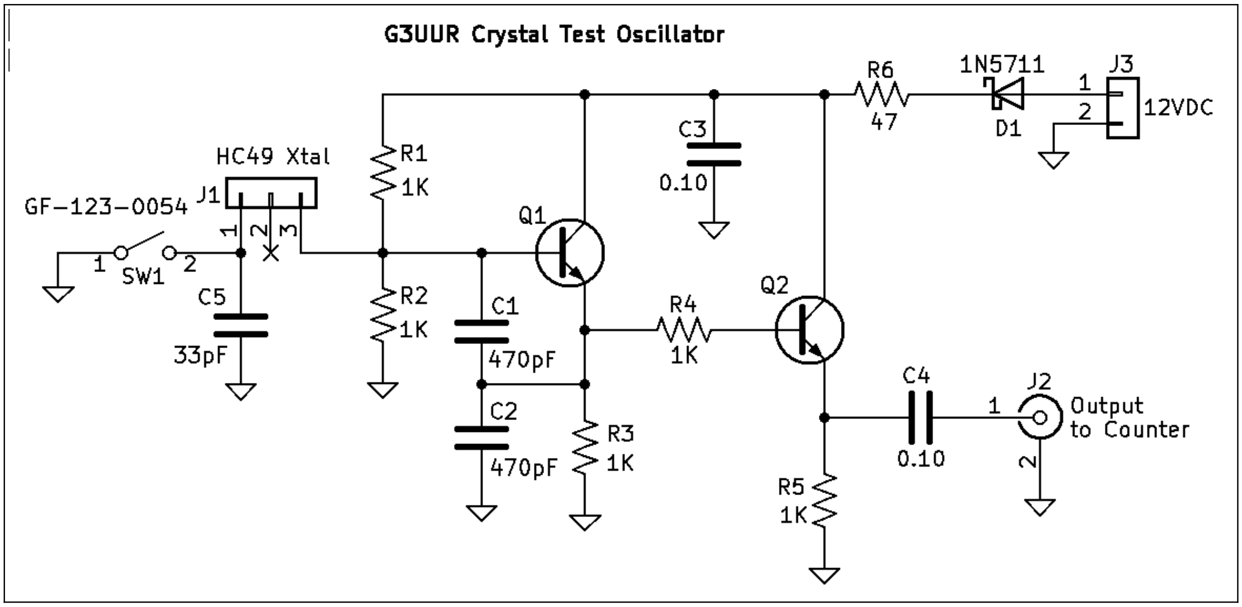
Use the schematic diagram along with the silk-screen legend printed on the PCB to place components. Note in particular the following points.

- If it hasn't already been done, clip off one of the outer pins (not the center pin) of the SPDT slide switch. It will be used as a SPST.
- The capacitors are non-polarized and may be installed in any orientation..
- You can use either the included SMA connector for the output, or solder thin coax (such as RG-174) or stiff solid wire for use with probe clips.

USING the XTO-1

The literature on the G3UUR method of measuring and calculating important crystal parameters is extensive. Here are some important (and readily-accessible) examples.

- Dave Gordon-Smith, G3UUR, "Notes on Measuring Quartz Crystal Motion Parameters," QRP Quarterly Fall 2010.
- Wes Hayward, W7ZOI, "An Oscillator Scheme for Quartz Crystal Characterization," http://w7zoi.net/filters/G3uuralator.pdf. 2007.
- Hayward, Rick Campbell, KK7B, and Bob Larkin, W7PUA, "Crystal Filters," Section 3.4, *Experimental Methods in RF Design*. 2003. https://www.scribd.com/document/336323413/Experimental-Methods-in-RF-Design
- Jack Smith, K8ZOA, "Crystal Motional Parameters: A Comparison of Measurement Approaches," https://www.mikrocontroller.net/attachment/473317/Crystal_Motional_Parameters.pdf. 2006.
- Horst Steder, DJ6EV and Jack Hardcastle, G3JIR, "Crystal Ladder Filters for All," *QEX*, Nov/Dec 2009, https://www.arrl.org/files/file/QEX_Next_Issue/Nov-Dec_2009/QEX_Nov- Dec_09_Feature.pdf.



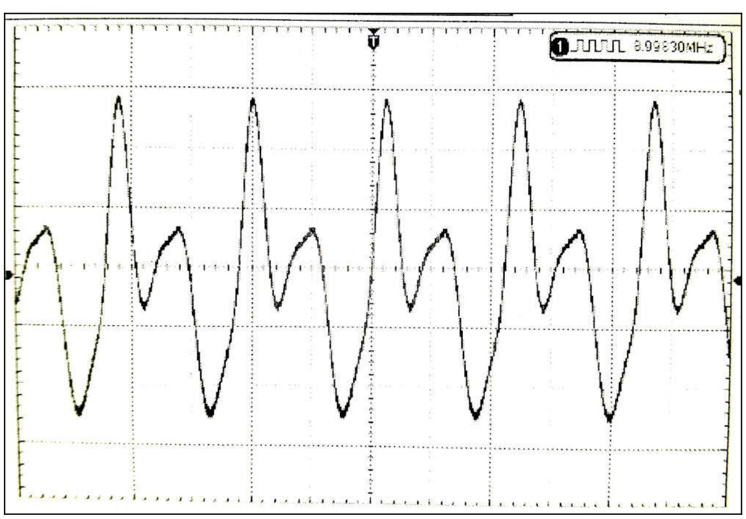
For a scalable PDF of the schematic, go to: mostlydiyrf.com/xto1/

<u>XTO-1 Parts List</u>

C1,C2	470pF NPO ceramic	Q1,Q2	2N3904 NPN TO-92
C3,C4	0.10μF ceramic	R1-R5	1KΩ 1/4W
C5	33pF NPO ceramic	R6	47Ω 1/4W
D1	1N5711 Schottky diode	SW1	SPDT slide (modified)
J2	SMA Jack		

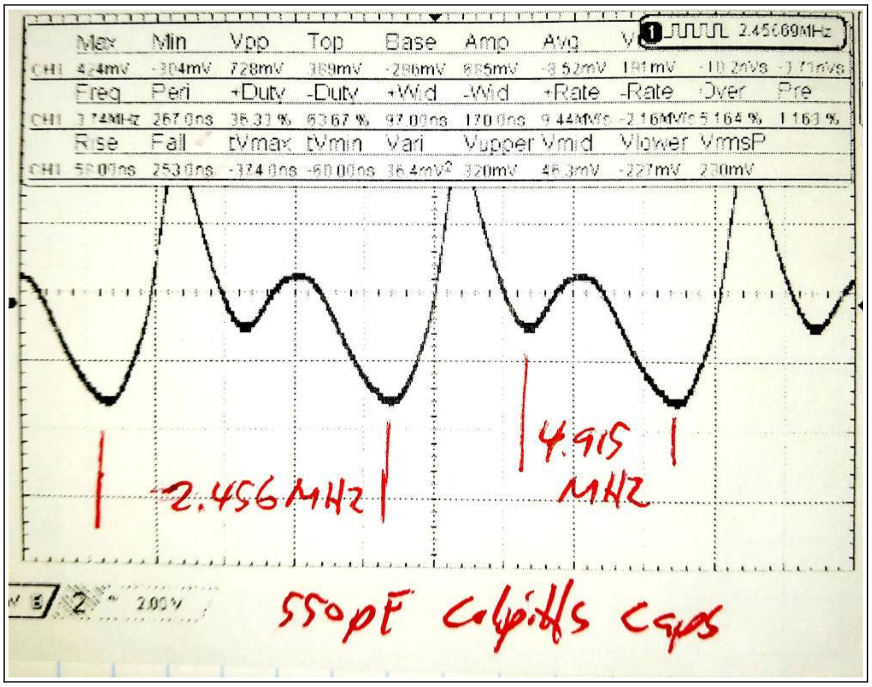
XTO-1 Application Notes

Recent batches of crystals from various manufacturers have shown a tendency in the XTO-1 to be sensitive to the Vcc voltage used to supply the device. With **<u>550pF</u>** "Colpitts" capacitors (C1 and C2) and Vcc at 12V, for instance, a 11.052MHz HC49u (the tall package) will oscillate and produce an output of 1.03Vpp. It will stop oscillating, though, at 4.7Vcc. A 9MHz HC49us (the short package) requires 5.5Vcc but above 8.5Vcc it will break into a complex oscillation:



At 8.5Vcc the XTO-1 output is 528mVpp.

4.915MHz crystals, manufactured either by ECS or CTS, can't tolerate higher than 3.9Vcc without become unstable and exhibit a multi-frequency output of both 4.915MHz and half that (2.456MHz):



I changed the Colpitts capacitors to **<u>440pF</u>** and there was no change in the results for 4.915MHz crystals except the tolerated Vcc was below 3.9V. The 9MHz and 11.052MHz crystals worked fine. The 11.052MHz crystals could take up to 10.2Vcc before becoming unstable.

After changing the Colpitts caps to **<u>660pF</u>**, the 4.915 crystals were stable and at their fundamental frequency up to 3.9Vcc. Below 3.5V, though, they were unstable. At 3.9Vcc, the XTO-1 outputted 360mVpp. With the 660pF caps, the 9MHz crystals required 7.1Vcc for stability. They became unstable at 13.1Vcc. The 11.059MHz crystals remained stable to at least 16Vcc (not tested above that) but were unstable below 5.5Vcc. At 12Vcc, the XTO-1 produced 616mVpp with 9MHz crystals and 784mVpp with 11.052MHz ones.

<u>The Bottom Line</u> (so far)

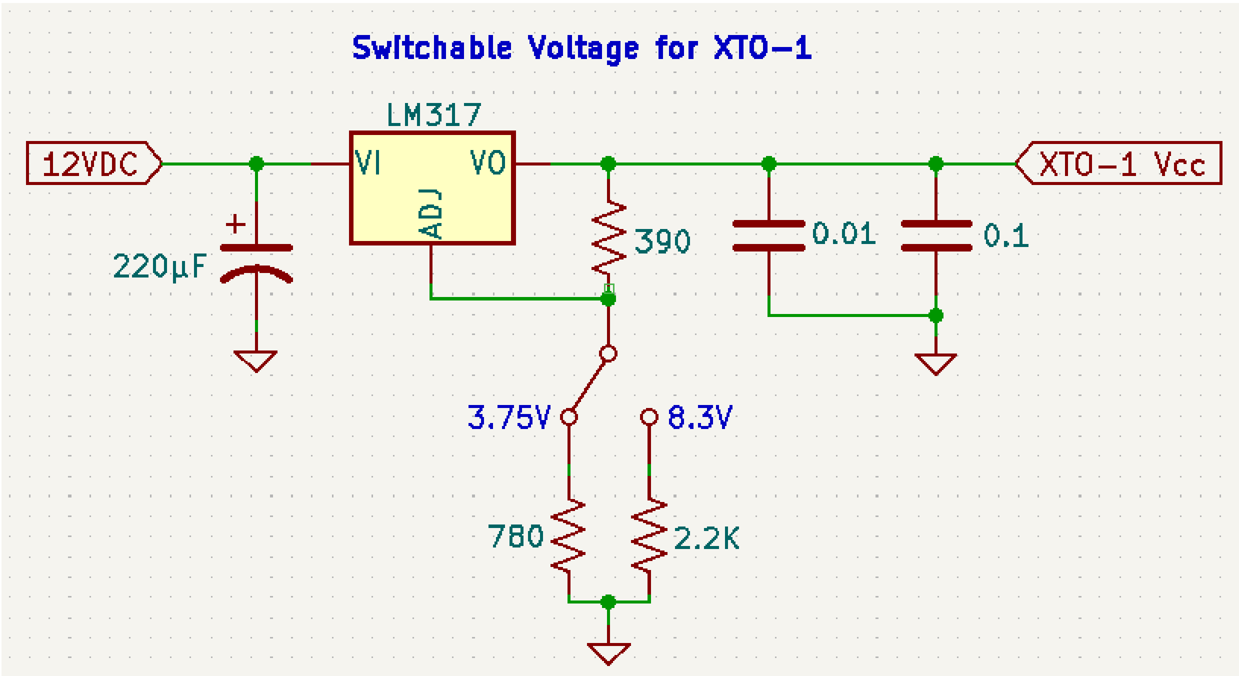
1. Use **<u>660pF</u>** for the Colpitts capacitors.

2. Two Vcc settings are needed: 3.8V (for safety margin) and 7.5V.

3. Numbers 1 and 2 have been tested with 4.915MHz, 9MHz, and 11.059MHz crystals. OFMV (other frequencies may vary).

4. The switchable shunt capacitance (used to calculate motional parameters) seems to have no effect on either Vcc or Colpitts-capacitor conditions.

5. Either a bench power supply set to the appropriate voltage, or a dedicated switched regulator (see below) can be used for Vcc.



6. XTO-1 output should be adequate for any frequency counter, including the inexpensive Sanjian 6- or 8-digit modules.