Application Note
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Replacement for Crystals - PXOs

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with significant contributions from
especially John Gebuhr, WB0CMC,
also Dave Pelaez, AH2AR and Tom O'Hara, W6ORG

"Where can I buy crystals ?" This is a lament heard often from hams owning older ham gear. Crystals were a very necessary item in many ham transmitters and receivers. The major supplier for many years, since 1951, was International Crystal Manufacturing (ICM) in Oklahoma City, OK. ICM went out of business in 2017. They were the last manufacturer in the US that made crystals to order in quantities as little as a single piece, and most recently, at a cost $35 each.

Don, N0YE, has just made an inquiry to the Microwave Reflector inquiring about sources for crystals. This search has now found a few crystal manufacturers that will make custom crystals in small quantities. In the USA, it is Bomar (www.bomarcrystal.com) Bowmar however requires a minimum order of $100. In the U.K., it is QuartSLab (www.quartslab.com). They offer more reasonable prices of about λ35 for a single crystal. In the Czech Republic, it is Krystaly (http://old.krystaly.cz/index.htm). It has been reported that Krystaly's crystals sell for $22. It is also reported that QuartSLab & Krystaly take credit cards and will ship to the USA. There may also be others ?

For the amateur TV market, the major supplier for many years has been Tom O'Hara, W6ORG, of PC Electronics (www.hamtv.com), Arcadia, CA. All of Tom's AM-TV transmitters, prior to 2004, were crystal controlled. In 2017, when ICM announced their closing, Tom and I were discussing options. With Tom's big installed base of thousands of his TV transmitters, he needed somewhere to refer hams to get crystals for them. I mentioned Programmable Crystal Oscillators (PXO) as an option. At the time, we agreed

that I would investigate their possibility for use in Tom's TV transmitters. I purchased some Epson PXOs for experimenting, but found they did not work well in PCE transmitters. They had spurs in their spectrum which caused horizontal tearing of the TV picture. Thus, we lost interest and dropped the project.

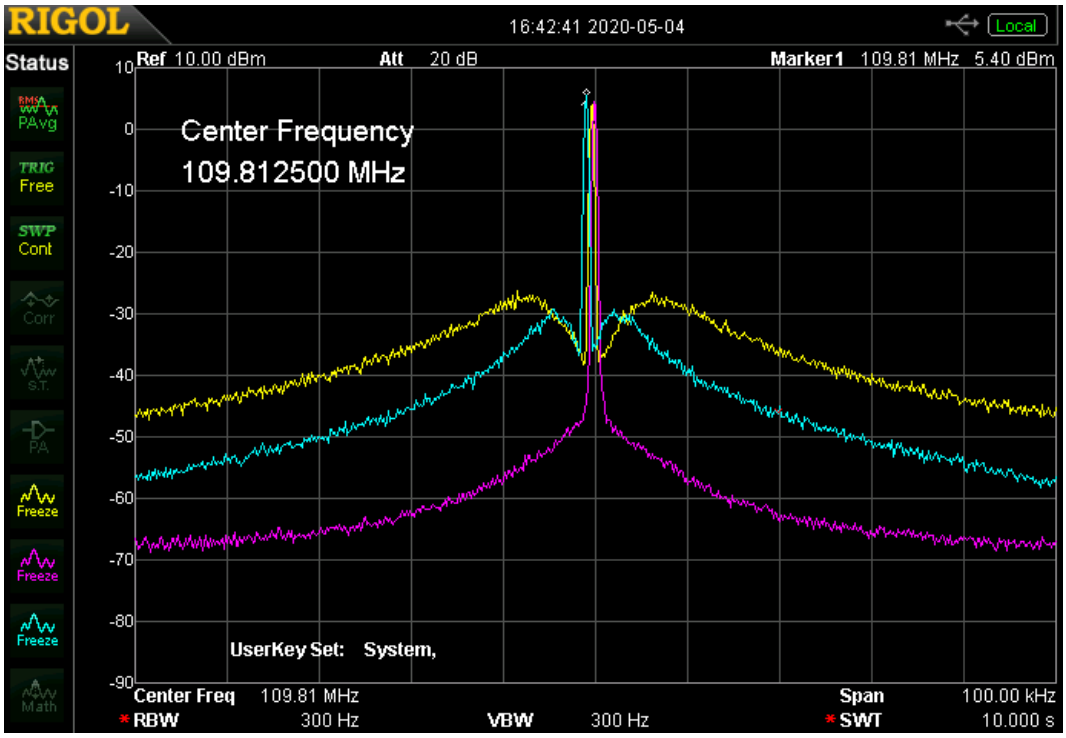
Most recently, in the BATVC newsletter (issues #33 & 38), we had two articles from hams about using PXOs in PCE transmitters. The hams were Dave Pelaez, AH2AR, Dayton, Ohio and John Gebuhr, WB0CMC, Omaha, Nebraska. This revived Tom, W6ORG's interest in pursuing using PXOs as replacement crystals in his TV transmitters. So, as a result, Tom, Dave, John and I have been having four way, e-mail conversations on the topic.

John and I in particular have been evaluating several PXO models and comparing results. We evaluated several models from Epson and found them to be unsatisfactory for various reasons. The Epson models evaluated were the models: SG-8003, SG-8002 and the SG-8101. ***Finally John found a "winner" from the company Silicon Labs. It was their model 510CBA***. Figs. 1 & 2 show the measurements of the phase noise of the various PXOs and for comparison an HC-50/U, 5th overtone crystal. They were all measured in the same oscillator circuit shown in Fig. 3. This oscillator circuit is similar to those found in the PC Electronics AM-TV transmitters. **The 510CBA's phase noise is almost a perfect replica of that measured from the crystal**. The only difference noted is very tiny spurs at ± 425 kHz that are -80 dBc.

The issues with the Epson PXOs were related to unsatisfactory phase noise and spurs. When they were used as a crystal replacement in Tom's 70cm, ATV transmitter, they created various undesirable artifacts in the resultant TV picture. The SG-8003 caused horizontal tearing. The SG-8101 caused background white noise, thus a P3 picture. The least objectionable was the SG-8002, but it still introduced some residual noise in the TV image, resulting in a P4 picture. The TV picture using the 510CBA was P5 and identical to using a crystal in the oscillator.

The result is our conclusion that the Silicon Labs 510CBA, PXO can work as a suitable replacement crystal in PC Electronics, AM-TV transmitters.

Thus, KH6HTV VIDEO has agreed to help Tom by building and selling these to ATV hams for their PCE transmitters at a price of $20 each, including postage.



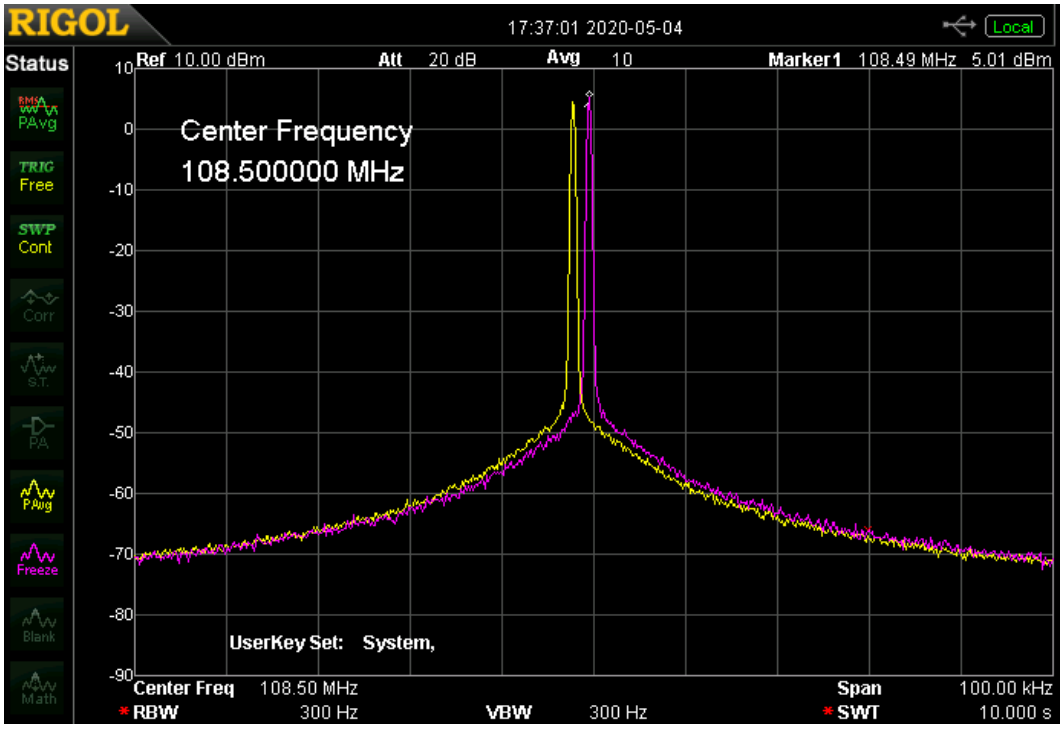


Fig. 1 Close in, ± 50 kHz, Phase noise of various oscillators:
10dB/div, 10kHz/div, 300 Hz bandwidth.
top photo: yellow = SG-8003, magenta = SG-8101, cyan = SG-8002 PXOs
bottom photo: yellow = HC-50/U crystal, magenta = 510CBA PXO

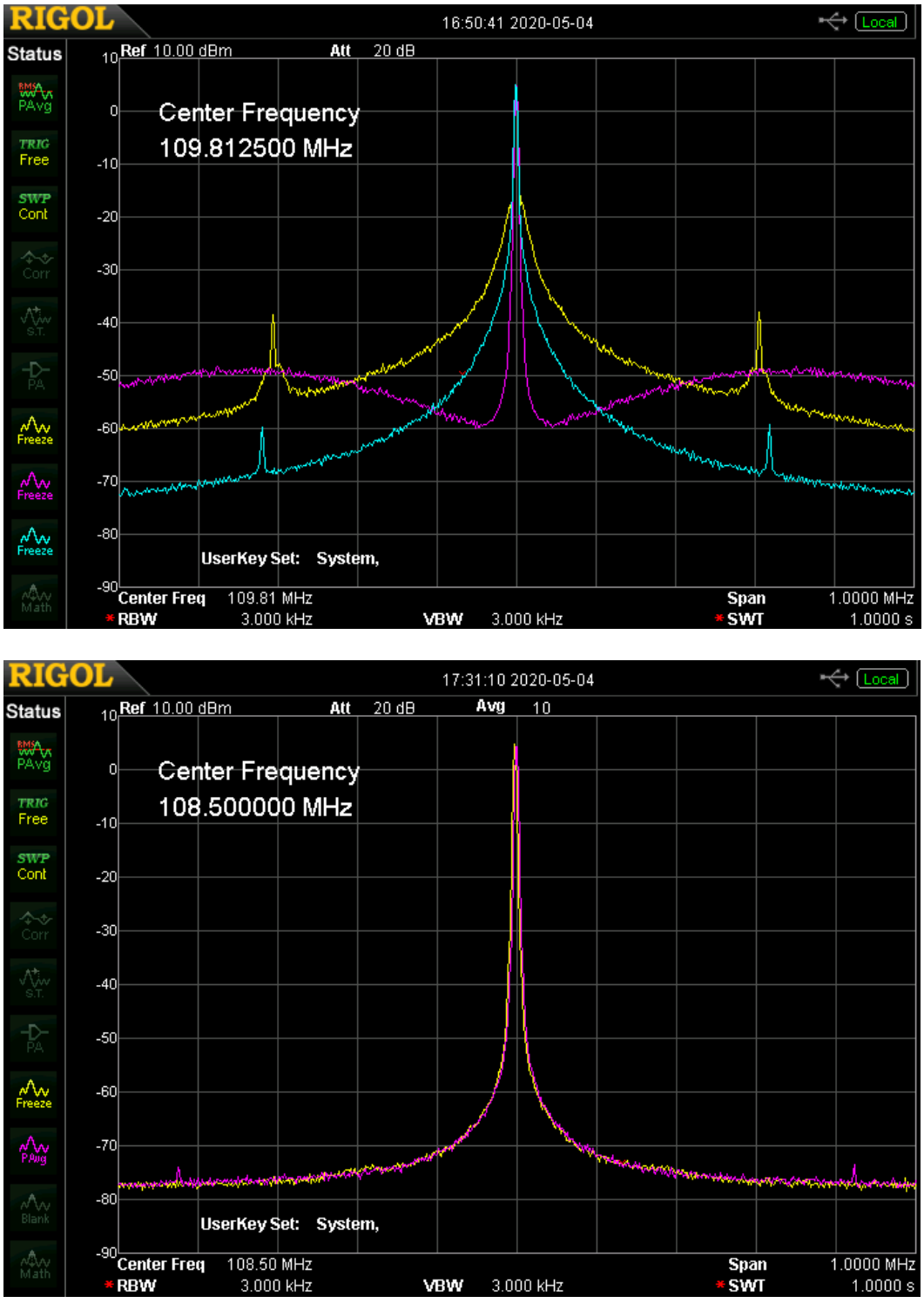


Fig. 2 Wide-band, ± 500 kHz, Phase noise of various oscillators:
10dB/div, 100kHz/div, 3 kHz Bandwidth
top photo: yellow = SG-8003, magenta = SG-8101, cyan = SG-8002 PXOs
bottom photo: yellow = HC-50/U crystal, magenta = 510CBA PXO

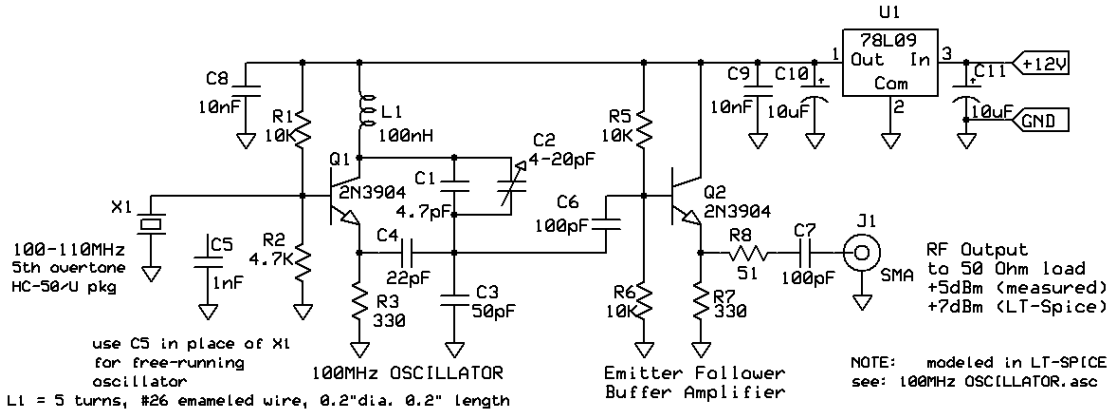


Fig. 3 100 MHz, Overtone Crystal Oscillator --- Test oscillator for crystals and PXOs

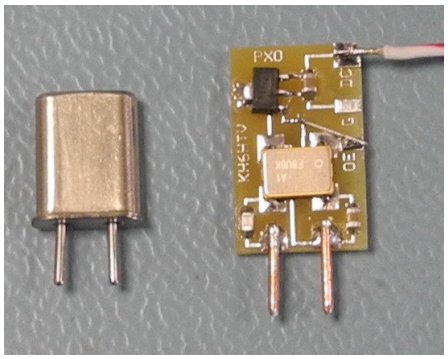


Fig. 4 an HC-50/U crystal and it's PXO replacement

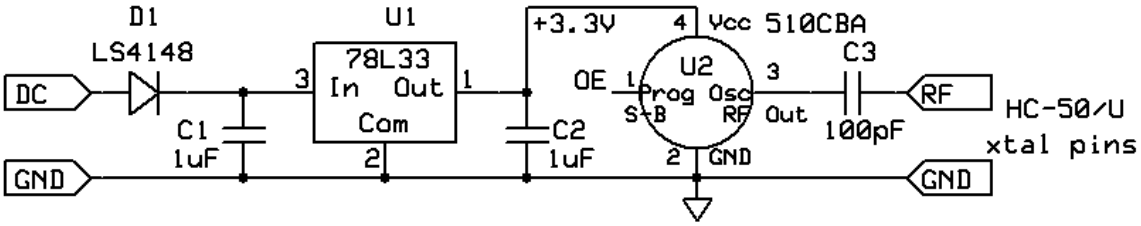


Fig. 5 KH6HTV Video PXO schematic

Fig. 4 Shows a typical crystal and the new KH6HTV Video PXO replacement using the Silicon Logic 510, PXO. Fig. 5 is the schematic diagram. The SL 510, PXO, U2, is a CMOS circuit requiring +3.3Vdc. U1 is the 3.3V voltage regulator. This PXO is intended to be directly plugged into an existing crystal socket in a crystal oscillator circuit. The PXO pc board is provided with 0.04" dia. pins to match those of an HC-50/U crystal package. All connections on the board are labeled. Care must however be exercised as one pin is a DC ground pin and it must be plugged into the appropriate pin in the oscillator circuit. Another requirement is that DC power must be supplied to the PXO. A solder pad is provided on the top right hand corner. Fig. 4 shows a DC power wire attached to this pad. DC voltages from +8 to +15Vdc may be applied. There is another solder tab labeled as OE, for Output Enable. This is a logic input to U2. Normally it is not used and is left open. U2 has an internal, pull-up resistor on OE.