Experiments with a VXO using a 3.58MHz Ceramic Resonator

After trying many different circuits to build a satisfactory VXO (variable crystal oscillator) using the very common 3.579545MHz American Colour Burst crystals I was never able to achieve a stable frequency shift of more than about 1kHz – inadequate for using the VXO as the "BFO" in a direct conversion receiver to use on the early morning 80m QRP CW net where the transmitting frequencies of the various stations participating can vary in the range of 3.581 to 3.575MHz! As a result I was forced to go for the VFO approach with all its inherent issues of long term and thermal stability etc – a story for another time perhaps.

While browsing through my archives of many photocopies of “circuits which may come in useful someday”, I came across an article by G4COL [1] which piqued my interest – maybe I could use a ceramic resonator VXO, which seems to offer a much wider frequency pulling range than a standard crystal, in place of my current 80m VFO and obtain the improved stability suggested in the article.

Firstly, a comparison of the equivalent circuits of a quartz crystal (Figure 1) and a ceramic resonator (Figure 2) will prove helpful in understanding the fundamental differences between these two component types.

**Figure 1 : Equivalent Circuit of a conventional quartz crystal**

![Figure 1: Equivalent Circuit of a conventional quartz crystal](image)

R1 – Equivalent series resistance  
L – Dynamic or motional inductance  
C1 – Dynamic or motional capacitance  
C2 – Parallel or static capacitance

**Figure 2 : Equivalent circuit of a 3.58Mz ceramic resonator**

![Figure 2: Equivalent circuit of a ceramic resonator](image)
Quoting loosely from G4COL’s article:

Compared with a typical quartz crystal, the series resistance of a ceramic resonator is similar, and the series capacitance higher by a factor of up to 100. The Series inductance and unloaded Q are lower by a similar factor. The parallel capacitance of the resonator is higher than that of the quartz crystal by a factor about 100.

What makes the ceramic resonator promising for use in a wide range VXO, in place of a conventional VFO, is that its Q factor is several times higher than that of a high quality inductor-capacitor tuned circuit, while its series equivalent inductance is much smaller than that of a quartz crystal, which suggests a wider pulling range.

In addition, ceramic resonators are small (a bit smaller than one’s thumbnail), are readily available at low cost and fortuitously are available (3.58Mz) for the 80m amateur band.

Given all the promising attributes, I built an experimental VXO (see Figure 3) and investigated the performance of the five 3.58MHz resonators lurking in my “jewel box”.

**Figure 3 : Experimental ceramic resonator VXO circuit**

Some interesting results were obtained (see Table 1):

- The tuneable frequency range obtained with all the resonators tested were all in excess of 104kHz

- With the capacitor in series with the resonator bypassed, there was a wide spread in the basic operating frequency of the various devices, despite them all being marked with a frequency of 3.58MHz!
Table 1: Results Measured

<table>
<thead>
<tr>
<th>Device</th>
<th>Cap bypassed</th>
<th>Cap at Max C</th>
<th>Cap at Min C</th>
<th>Freq. Range</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3460kHz</td>
<td>3493kHz</td>
<td>3599kHz</td>
<td>106kHz</td>
</tr>
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<td>3493kHz</td>
<td>3597kHz</td>
<td>104kHz</td>
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<td>107kHz</td>
</tr>
<tr>
<td>4</td>
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<td>3499kHz</td>
<td>3605kΩ</td>
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</tr>
<tr>
<td>5</td>
<td>3524kHz</td>
<td>3548kHz</td>
<td>3654kHz</td>
<td>106kHz</td>
</tr>
</tbody>
</table>

I have been very impressed with the results obtained. This VXO design will definitely be finding its way into a future 80m QRP transceiver. What a pity that suitable ceramic resonators do not seem to be available for the 40m band!

Reference

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