RADCOM TECHNICAL FEATURE

Using Ceramic Resonators in Oscillators

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FORTUNATELY, IT IS possible to build quite simple transmitters and receivers with very respectable performance on the air. These all require a stable oscillator, traditionally based on a resonator using either the piezoelectric effect of a quartz crystal, or a combination of inductors and capacitors.

In recent times, low cost piezoelectric ceramic resonators have become available, around which good variable frequency oscillators (VFOs) can be built. This article describes work done in this area, the intention being to stimulate further experiments.

CERAMIC RESONATOR CHARACTERISTICS

FIG 1 SHOWS A SPECTRUM analyser/tracking generator frequency response measurement of a 3.58MHz ceramic resonator, which bears a strong resemblance to that of a quartz crystal. Notice that 3.58MHz, at the centre of the plot, lies between the series and parallel resonance. From such a plot, it is possible to extract the parameters given in **Fig 2**. The peak in response is due to the resonance of the series inductor and capacitor, the higher frequency notch being the parallel resonance.

Compared with a typical quartz crystal, the series resistance is similar, and series capacitance higher by a factor of up to 100. Series inductance and unloaded Q are lower by a similar factor, and parallel capacitance is higher by a factor of about 10.

What makes the ceramic resonator promising for a VFO covering the relatively narrow range of an amateur band, is that its Q factor is several times larger than for a high quality inductor-capacitor (LC) tuned circuit, while its series equivalent inductance is much smaller than for a quartz crystal, which suggests that a much larger pulling range is possible.

In addition, ceramic resonators are physically small, and are readily available at low cost. Although the available frequencies are limited, they include 3.58MHz, conveniently in the 80 metre band (see Appendix).

PULLING THE FREQUENCY

THIS CAN BE ACHIEVED quite readily either by adding series capacitance to shift the series resonance higher in frequency, or parallel capacitance to shift the parallel resonance lower. A sample measurement using a 13-80pF variable capacitance gave an 80KHz tuning range, both for the series resonance when placed in series, and the parallel resonance when placed in parallel with the 3.58MHz resonator. Although precise measurements were not made, the Q factor was not significantly affected by this amount of pulling.

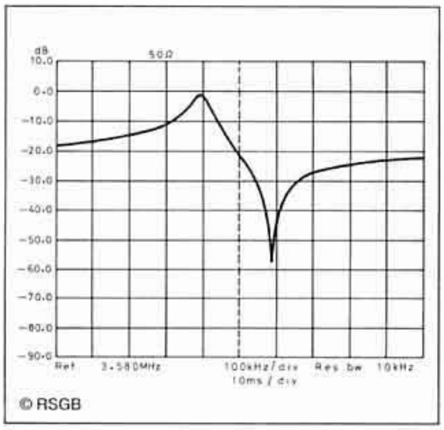

Fig 1: Frequency response of 3.58MHz ceramic resonator.

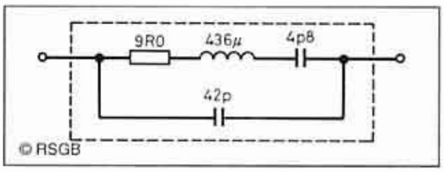

Fig 2: Equivalent circuit of 3.58MHz ceramic resonator close to resonance.

EFFECT OF TEMPERATURE

A CRUDE TEST USING a hair dryer to raise the resonator temperature from room temperature (23°C or so) to over 50°C produced the following observations:

- The shift with temperature appeared far from linear. Lowering the temperature with freezer spray shifted the frequency in the same direction as raising the temperature, suggesting a turning point to room temperature, where temperature sensitivity would be relatively low.
- For the sample tested, the parallel resonance shift of around 3kHz over the 23 to 50°C range was less than half that of the series.

Although much further work could be done, it is obvious that rapid temperature changes must be avoided if a low drift rate VFO is to be achieved.

FREQUENCY ACCURACY

FIG 3 SHOWS THE SCATTER in frequency of seven resonators placed in an oscillator circuit. The range is about 0.2%. The specification allows ±0.5%, and so some trimming must be included in the oscillator design.

A PRACTICAL OSCILLATOR CIRCUIT

THE CIRCUIT OF A CERAMIC resonator VFO is given in **Fig 4**. The oscillator operates in the high impedance, parallel resonant mode because the series resonance occurs a little below the 80 metre band, and pulling it up would have wasted tuning range. A 50pF air-spaced variable capacitor is the main tuning element, with a 90pF trimmer used to set the frequency. The oscillator transistor is a J310 junction gate FET, and a common base transistor buffers the output.

A voltage regulator feeds both the receiver incremental tuning (RIT) control and the base of the buffer transistor, which in turn regulates the oscillator drain voltage. This arrangement results in very low sensitivity to supply voltage changes. The oscillator was constructed on a small printed circuit board as the photograph shows.

RESULTS

TABLE 1 GIVES SOME DRIFT figures for the oscillator. Although these cannot be guaranteed to be reproduced consistently, they were obtained without any special effort, and are very acceptable. The resonator is not noticeably sensitive to vibration.

The oscillator is the signal source for a three-band direct conversion transceiver, the 40 and 20 metre bands being obtained by frequency multiplication. Coverage on 80 metres is a little over 20kHz with the values given, the RIT range being 1.5kHz at the high capacitance, and 3kHz at the low capacitance end of the main tuning capacitor. The resonator is not noticeably microphonic.

CONCLUSIONS AND SUGGESTIONS

CERAMIC RESONATORS offer the constructor a cheap and convenient way of making compact VFOs with the stability of a good LC oscillator and much greater tuning range than that of a crystal oscillator.

The limited set of available frequencies is not as much of a disadvantage as might be thought. Most of the amateur bands have a lower boundary at a multiple of 1MHz, which can be exploited in a number of ways. For instance, I built a multi-band transmitter using an oscillator phase-locked to a multiple of a

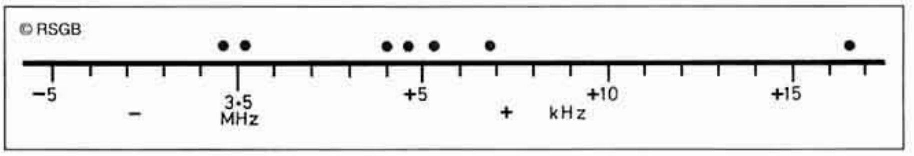

Fig 3: Scatter in frequency of seven 3.58MHz resonators.

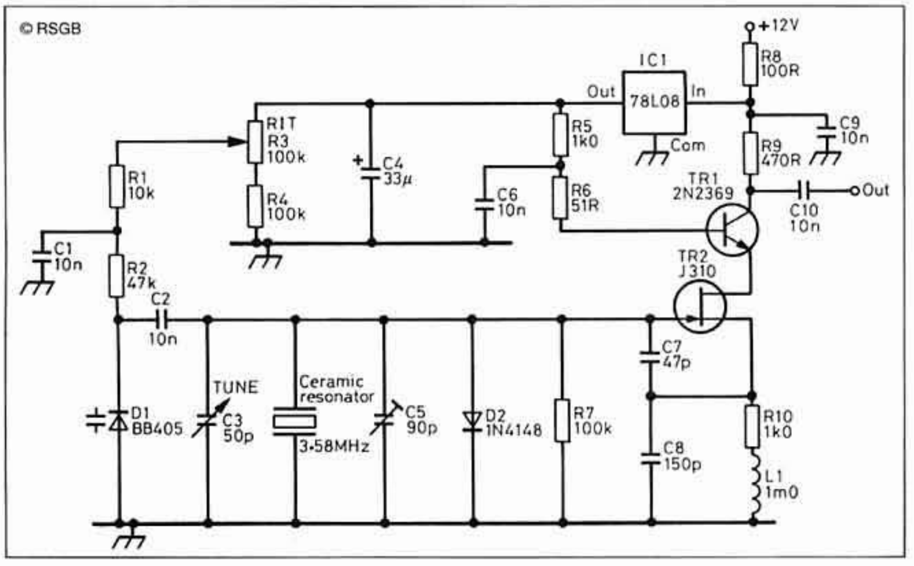

Fig 4: Circuit diagram of ceramic resonator VFO.

Elapsed time	Frequency (MHz)	Drift (Hz) from datum
0	3.550321	0
1 min	3.550306	−15
9 min	3.550302	−19
28 min	3.550314	−7
3hr 27 min	3.550350	+29
3hr 58 min	3.550338	+17

Table 1: Drift figures for ceramic resonator oscillator.

1MHz ceramic resonator VFO, covering 7, 14, 18, 21 and 28MHz with a tuning range of over 150kHz on 28MHz.

Fertile areas for experimentation might be temperature compensation or stabilisation, miniaturisation, direct keying and frequency modulation. There is clearly scope for some fun with these devices.

APPENDIX

WHERE TO OBTAIN CERAMIC RESONATORS

The following frequencies are available for less than a pound each from Electromail (RS Components): tel 0536 204555, or Maplin, tel: 0702 554161 with stock codes as shown:

Frequency (MHz)	Electromail Code	Maplin Code
0.5	658-514	DJ28F
1	656-158	CP91Y
2	656-164	DJ30H
3.58	656-170	DJ31J
4	656-186	DJ32K
4.19	656-192	DJ33L
4.91	656-209	DJ34M
6	656-215	DJ35Q
7.37	656-221	DJ36P
8	656-237	DJ37S
10	656-243	DJ38R
11	656-259	DJ39N
12	656-265	DJ40T