

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

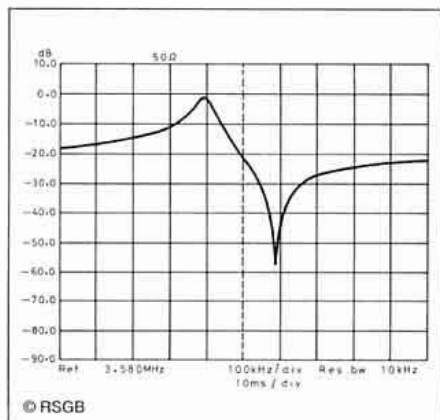


Fig 1: Frequency response of 3.58MHz ceramic resonator.

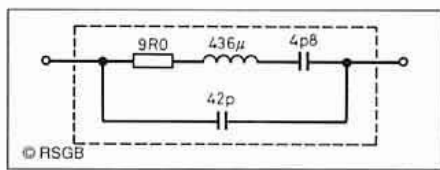


Fig 2: Equivalent circuit of 3.58MHz ceramic resonator close to resonance.

with the 3.58MHz resonator. Although precise measurements were not made, the Q factor was not significantly affected by this amount of pulling.

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 $\pm 0.5\%$, 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

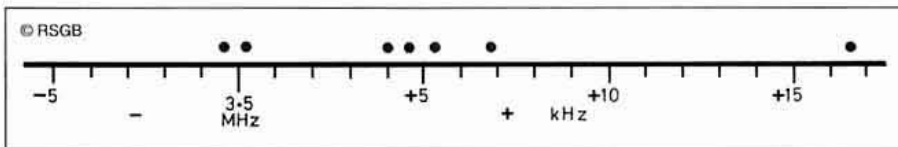


Fig 3: Scatter in frequency of seven 3.58MHz resonators.

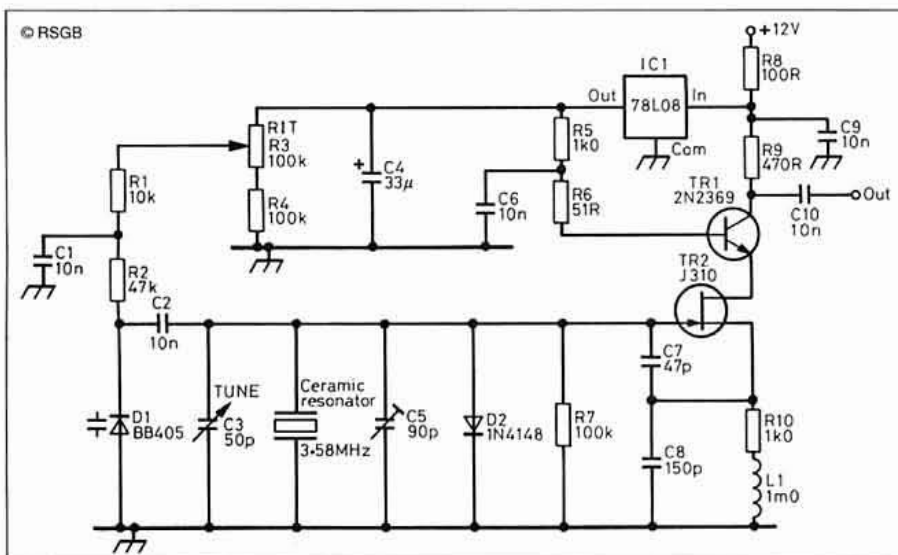


Fig 4: Circuit diagram of ceramic resonator VFO.

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.

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.

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

PCB SERVICES FOR RADCOM PROJECTS

PCBs

THESE PCBs ARE NOT AVAILABLE FROM RSGB HQ, BUT DIRECT FROM BADGER BOARDS

Description	RadCom	Part no	Price
RSGB Morseman		MMPCB	£10.00
Morseman EPROM		MMEPROM	£5.00
GW4HWR 12V 1A PSU	(May/June 91)	99137	£3.25
ICOM IC725/735 Controller	(Oct 92)	ICREMPCB	£10.00
IC725/735 Ctrlr EPROM		EPROMICOM	£5.00
Wobbulator	(Nov 92)	WOBB	£4.95
Wobbulator ready built		RBWOBB	POA
Simple Spectrum Analyser	(Nov 89)	1189SSA	£16.00
Oscilloscope Probe Tester	(Nov 91)	OSCPRO	£4.50
G3TSO 5-band Transceiver	(Sep 88)	TSO07	£28.00
G3TXQ 3-band Transceiver	(Feb/Mar 89)	TXQ07	£23.50
G3TSO Miniature 80m Tcwr	(Jun/Jul/Aug 91)	G3TSOMIN	£8.00
G4WIM 50/70MHz Transceiver	(May - Aug 1990)	WIM10	£52.00
2m noise eliminator	(Apr 92)	2MTRRF	£9.00
Ultimate keyer	(early 80s)	ULTKEY	£6.00
White Rose Receiver	(Feb 90)	WRMAIN	£4.25
White Rose Plug-in converters	(each)	WRCONV	£2.00
White Rose Case		WRCASE	£15.75
G3PCJ 160m Transceiver	(Jan/Feb 93)	TOP160	£7.50
Direction Finder	(TT Apr 91)	VHFDF	£3.75
AF Oscillator	(Sep 90)	AFOSC	£4.95
Synthesiser	(Jul/Aug 92)	SYNCPCB	POA

Add £1.50 to all prices for postage and packing

Available from:
Badger Boards
87 Blackberry Lane, Four Oaks,
Sutton Coldfield, B74 4JF. Tel: 021 353-9326

KIT SERVICES FOR RADCOM PROJECTS

KITS

JAB's aim is to have kits available off the shelf. Sometimes, especially following publication, demand is unknown so you are advised to check availability or allow 28 days for delivery. Kit contents vary, the contents are given, eg 1+2 means that PCB parts and PCBs are supplied. Price shown is the price you pay except that if the order value is under £15.00, please add £1.00 towards P&P.

Contents Codes:
1 = PCB Mounted Parts Only
2 = PCB Only
3 = Case Mounted Parts
4 = Ready Punched Case
5 = Case Un-Punched

Exclusions Codes:
A = Air Spaced Variable
B = Crystals
C = Display
Notes:
SF = State Frequency or Band
POA = Price on Application

Author	Date	Kit	Contents	Price	Notes
G3TSO	1088	Multiband Tx/Rx		POA	
G4PMK	1189	Spectrum Analyser	1+3	£55.65	
G3TDZ	0290	White Rose Radio		POA	
G4WIM	0590	Dual Bander 50+70MHz		POA	
G3BIK	0990	AF Oscillator	1+2+3+5	£25.00	
G3TSO	0491	Digital Freq Display	1-C		
G3TSO	0691	80m SSB Tx/Rx	1-A	£77.00	
G3BIK	0192	HF Absorb W/meter		POA	
G4SGF	0492	A Novice ATU	1+2+3+5	POA	
G4ENA	0592	QRP+QSK Tx/Rx	1+2+3+4	£45.05	SF
G3ZYY	0992	4m/6m IRS		POA	
G7IXK	1192	Wobbulator	1+2+3+4	£21.50	
G3VML	0493	2m SSB/CW Transceiver		POA	
G3ROO	0493	6m Converter	1+2	£11.85	SF
G4ENA	0593	Direction Finding Kits 160m-			
		DF Receiver	1+2+3	£32.50	
		DF Transmitter	1+2+3	£25.30	
G3TDZ	0793	Phasing Transceiver:-			
		Receiver	1	£27.00	
		Exciter	1	£24.10	
		Converter	1-B	£11.40	SF
		Power Amp	1	£18.60	SF

Available from:

J.A.B. Electronic Components, The Industrial Estate, 1180 Aldridge Road, Great Barr, Birmingham B44 8PE. Tel: 021-366-6928