TECHNICAL PAPER

Surface Mount Ceramic Resonators

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Abstract:
Ceramic resonators provide an attractive alternative to quartz crystals for oscillation frequency stabilization in many applications. Their low cost, mechanical ruggedness and small size often outweigh the reduced precision to which frequencies can be controlled, when compared to quartz devices. Ceramic resonators are now available in surface mountable packages suitable for automated production processes.

SURFACE MOUNT CERAMIC RESONATORS

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Ceramic resonators provide an attractive alternative to quartz crystals for oscillation frequency stabilization in many applications. Their low cost, mechanical ruggedness and small size often outweigh the reduced precision to which frequencies can be controlled, when compared to quartz devices. Ceramic resonators are now available in surface mountable packages suitable for automated production processes.

The equivalent electrical circuit of a resonator is shown in Figure 1 and typical values for the equivalent circuit elements of a 455kHz and 4MHz resonator are shown in Table I.

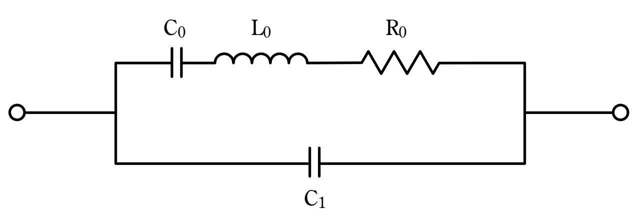

Figure 1. Resonator equivalent circuit

The resonant and anti-resonant frequencies are related to the equivalent circuit parameters by the following expressions, where Fr is the resonant frequency and Fa is the anti-resonant frequency as shown in Figure 2.

$$F_r = \frac{1}{2\pi (L_0C_0)^{1/2}}$$

$$F_a = \frac{1}{2\pi (L_0C_0C_1/(C_0+C_1))^{1/2}}$$

P/N	Freq.	R_0	L_0	C_0	C_1	Qm
		Ω	µH	pF	pF	
KBR-455Y	455kHz	8.8	4700	28	315	1380
PBRC-4.00A[1]	4.0MHz	4.8	310	5.6	44	1500

[1]same as PBRC-4.00B (with built-in capacitor)

TABLE I. Typical equivalent circuit parameters 455kHz and 4.0MHz ceramic resonators

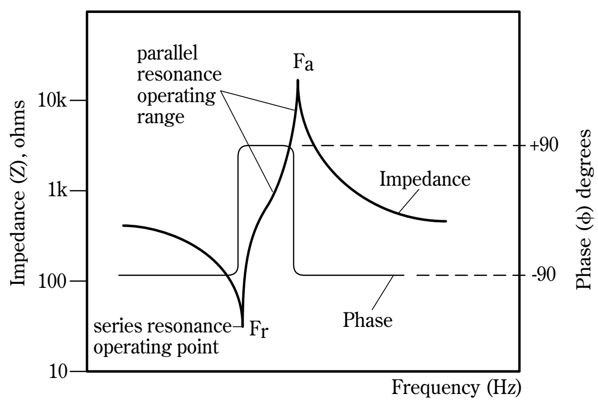

Figure 2. Impedance and Phase response of ceramic resonators

Ceramic resonators are generally operated in the parallel resonance mode. This allows the use of an inverting amplifier or logic inverter which provides 180° of phase shift. The combination of the resonator, in the inductive portion of its response curve, and the load capacitors provide the balance of the 360° of phase shift around the oscillator loop needed to maintain oscillation. In addition the gain of the amplifying device must be sufficient to maintain a loop gain greater than or equal to unity to sustain oscillation.

The oscillation frequency specified for a particular resonator is the frequency at which the device will operate when used with a specific integrated circuit and with appropriate load capacitors. The reference IC used by AVX/Kyocera is a MC14069 (Hex inverter). If the resonator is used with another type of IC or with load capacitors different to those used in the reference circuit then the oscillation frequency may differ slightly from the nominal value. In many cases the frequency can be “trimmed” back to the desired frequency by adjusting the load capacitor values or otherwise modifying the oscillation circuit.

Advice on resonator circuit design with many commonly used ICs can be obtained from the reference document, “Application circuits of ceramic resonators”, available from AVX/Kyocera. For special applications it is possible to obtain resonators which have been matched to a particular IC to improve the frequency tolerance and operating performance.

Figure 3 shows a typical oscillator circuit using a ceramic resonator. The inverter and buffer could be discrete logic elements or the “on chip” oscillator circuit of a microcontroller. The user has the option for many frequencies of using a resonator which has the load capacitors built into a single three terminal package. This permits a reduction in component count and associated board space usage.

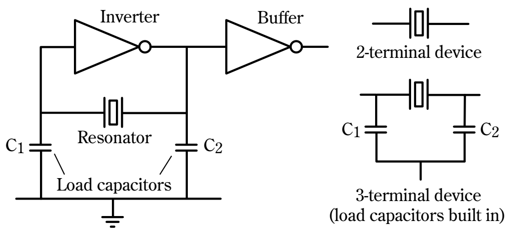

Figure 3. Typical resonator oscillator circuit and functional circuits of 2 and 3 terminal (built in load capacitors) resonators

It should be noted that ceramic resonator frequency tolerance is quoted by the manufacturer at a temperature of 25°C, when used with the reference IC as mentioned previously. In addition to the frequency tolerance a temperature stability is also quoted, usually over a temperature range of -20 to +80°C. A typical value for the tolerance at 25°C is ±0.5% although for applications such as telephone DTMF tone generation it is possible to produce resonators matched to a particular IC which have a frequency tolerance of ±0.3%. The temperature stability of resonators is typically within ±0.3% over the range -20 to +80°C. Figure 4 shows temperature stability characteristics for three types of resonators, a 480kHz device and two 4.19MHz resonators, one with and one without built in load capacitors.

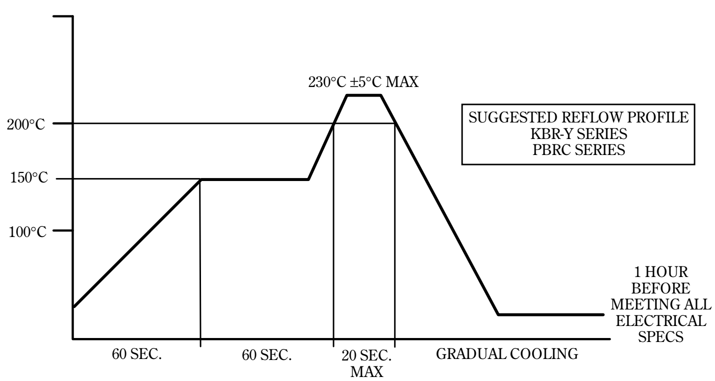

Figure 5. Recommended IR reflow profile — Surface mount resonators

Surface Mount Process Considerations

The three types of resonators being discussed here were all specifically designed to be surface mounted and are capable of withstanding infra red, convection and vapor phase reflow soldering processes and subsequent circuit board cleaning. It is however recommended that exposure to the high temperatures involved during soldering be limited to a single time to prevent possible permanent damage to the resonators. The recommended temperature profile for Infra red reflow soldering of the resonators is shown in Figure 5.

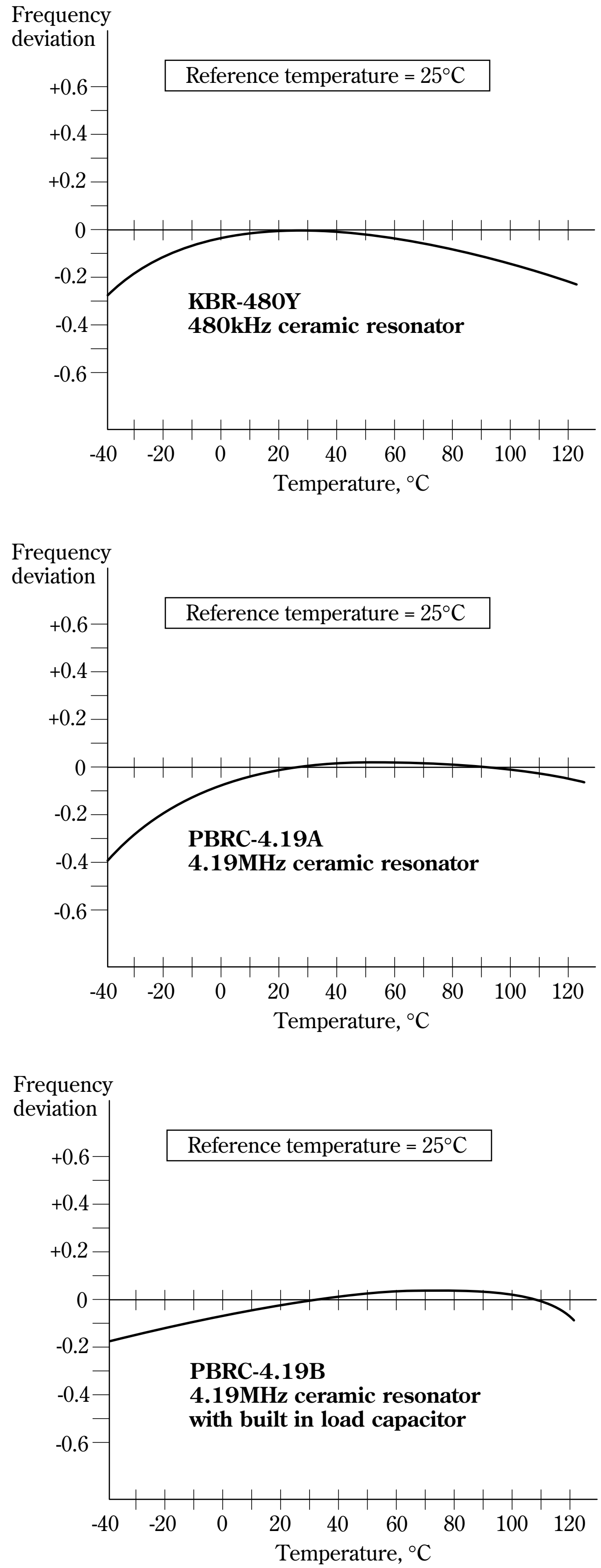

Figure 4. Typical frequency vs. temperature characteristics for three types of surface mountable ceramic resonators.

KBR-Y Series

The KBR-Y is a 2-terminal kHz band surface mountable ceramic resonator. The frequency ranges currently available are: 380-430, 440-525, 600-655, 795-815 and 960-1020 kHz. The gullwing type leads have a spacing of 5mm in frequencies up to 655kHz and 2.5mm in frequencies above this. Recommended solder pad layouts for these two sizes of resonators are shown in Figure 6. It is advisable to attach the plastic case of the resonator to the circuit board using an adhesive which will cure during the reflow cycle to prevent stresses on the solder joints and resonator caused by mechanical shock or vibration.

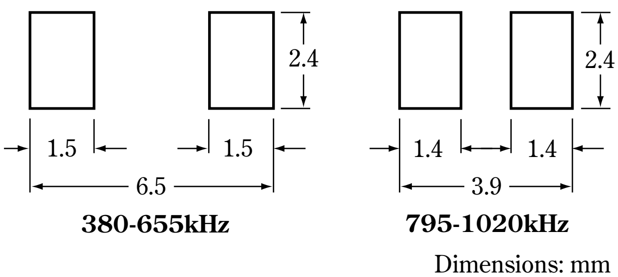

Figure 6. KBR-Y solder land patterns

PBRC-A/B Series

The PBRC-A/B resonators are leadless, ceramic bodies "chip" type devices. They consist of a ceramic substrate with solder terminals onto which a ceramic cover containing the resonator element, is hermetically sealed. The frequency range currently covered by the PBRC-A series is 2.0 to 8.0 MHz and for the PBRC-B series, 2.0 to 20.0 MHz is available. The PBRC-B series has two load capacitors built into the package and has three terminals on the base. It is otherwise identical in size and shape to the PBRC-A series which has no internal load capacitors and thus is only a two-terminal device. Recommended land patterns for both types of resonators are shown in Figure 7.

Good solderability results should be obtained with a solder cream thickness of approximately 0.2mm.

Because these chip type resonators have no compliant leads to absorb stresses induced by circuit board flexing it is suggested that the placement of the resonator on the board be chosen such that stress be minimized. Experiments with a variety of thicknesses of paper/phenol and FR4 circuit boards with 2:1 aspect ratios have shown that alignment of the resonators with the short side of the circuit board allows in excess of twice the board flex before damage occurs to the resonator's solder joints, compared to alignment with the long side of the board.

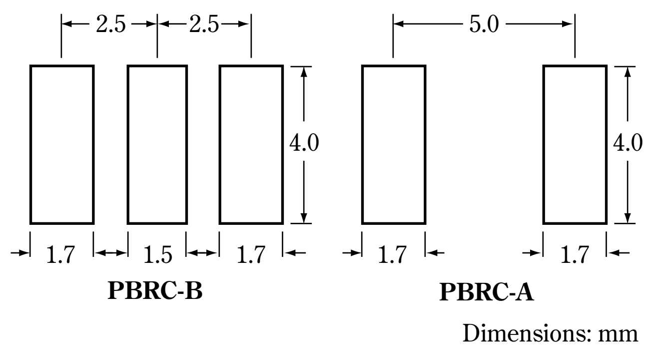

Figure 7. PBRC recommended land patterns

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