40 kHz Piezo Ceramic Transducers

By MidnightScience Staff

So what's a PZT? It's a passive device that produces a voltage when perturbed by a pressure wave and vice versa. Generally PZTs are optimized to work as a transmitter (TX) or receiver (RX) or sold in matched pairs. Some are designed to do both and are applied to systems such as echo-location.

For starters, the equivalent circuit of a 40 kHz PZT is like that of the quartz crystal. It consists of a series circuit composed of resistance, inductance, and capacitance – an RLC circuit – with a package capacitance added in parallel. A quartz crystal stretches/compresses when a voltage is applied across it; the PTZ produces a pressure wave when a voltage is applied. Typical values for the parameters of each at given frequencies are noted in Table 1. In both cases, the devices exhibit series and parallel resonance. Like the quartz crystal, these frequencies are close together, for the PZT typically within 1 kHz apart. At series resonance, *f*r, the PZT's impedance is low and resistive; at parallel resonance, *f*a, – also called anti-resonance – impedance is high and resistive. Yes, you've guessed it; the rules of thumb for design with quartz crystals apply, in general, to PZTs. That means detuning, matching, and maximum power transfer techniques should be applicable to these devices as well, but of course in the 20 – 160 kHz range for most applications.

Table 1: Typical Quartz and PZT Resonators

Transducer Type	Frequency Series Resonance	R	L	C	Cp	Q
A quartz crystal	1 MHz	260	2.9 H	0.0085 pf	3.4 pf	> 10k
A transmit PZT	40 kHz	300	0.170 H	95 pf	2.4 nf	<10

As you may recall, quartz crystals can be "pulled" a bit, made to operate just off resonance. The same applies to PZTs. Designers typically add inductance in series with a transmit PZT or in parallel with a receiving PZT in order to force it – detune it – to operate over a broader frequency range. Figure 1 illustrates a simple transmit circuit, wherein the transmit PZT is detuned to operate with a nearly flat output in pressure from 35 to 45 kHz. This is

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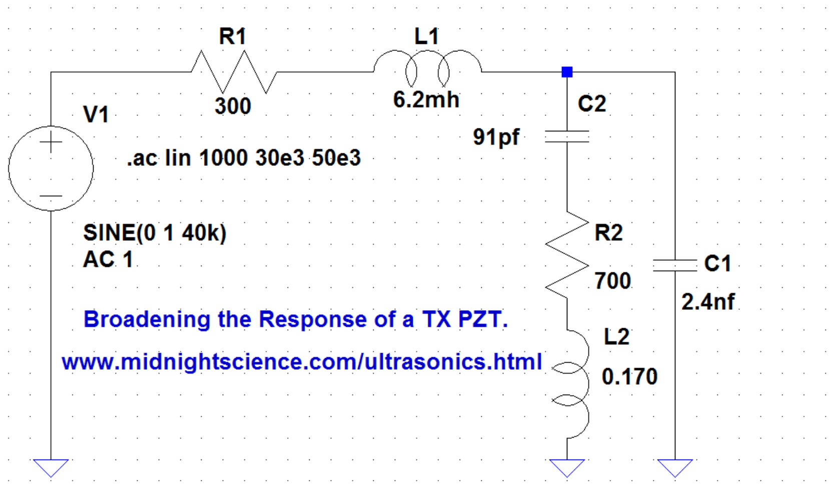
reminiscent of a double-tuned circuit. Since the Q of these circuits are generally low and the PZT parameters vary even within produced lots, an op-amp synthetic inductor can be substituted to adjust tuning. Without adding a fixed inductor or the added circuitry, output pressure will be down - about -20 dB – at the band edges. Clearly, circuits without compensation are used in single-frequency applications. For more detail, see our article "Measuring & Calculating Piezo Transducer Parameters."

Figure 1: A Detuned PZT Transmitter Circuit



In closing, viewing the voltage at the intersection of L1 and C2 with a scope – or in running a spice simulation - will display a notch at the series resonant frequency. Certainly that voltage does not display a flat response. The flat response we are looking for is the pressure transmitted by the PZT; hence, one must look at the current through the resistance, R2, in the series branch. A portion of this dissipation represents the emitted pressure wave. It does indeed provide a flat response when L1 and R1 are tuned.

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