BY JIM CHRISTENSEN • KRIS DESIGN SERVICES

Dumping the noise

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I recently completed designing an ultrasonic receiver that accepted signals in the 100- to 200-kHz band, downconverted the signal to an audio band, digitized it, and sent it to a remote computer. The computer provided an audio output and could display an FFT (fast-Fourier-transform) spectral analysis on the received signal. The receiver was closely integrated with a microcontroller that handled the serial communications and sent the local oscillator plus gain commands to the receiver.

I closely modeled this receiver after a successful through-hole design that included various ICs, some inductors, and the usual resistors and ceramic capacitors. The new receiver used surface-mount components on a small PCB (printed-circuit board) that plugged into a female header on the microcontroller board. I was well-aware that microcontroller circuits could generate a lot of electrical noise, but the position of other elements constrained the location of the receiver. On firing up the receiver for the first time, I observed considerable noise, which, although not unexpected, was nevertheless disappointing. To facilitate test and evaluation, I built a small test board that had the female header; a ribbon cable connected the test board to the microcontroller board. And, by moving the receiver around the microcontroller circuits, I found that the noise-entry point was through the inductors. I changed the inductors to the shielded variety, but the approach yielded no improvement. Although the inductors were part of a required passive-filter circuit, the inescapable conclusion was that they had to go. In the final design, an active filter replaced this passive filter.

But another problem now popped up: When the receiver was on the ribbon cable, I occasionally knocked the board against the hard table surface, which produced an audible click in the sound output when the board hit the table. This event blew me away. The components on my receiver board were totally solid-state, and such a thing should never happen. I immediately suspected a cold solder joint and sent the board back to the assembly area, where workers inspected it and reheated the suspicious joints—but to no avail. I then pulled out the previous through-hole receiver and banged away with some vigor against the table, but that design was as quiet as a mouse.

Now, I commenced thinking about how the construction of the various components might result in microphonics, and this idea brought up a dim memory that ceramic capacitors were made from barium-titanate. I knew that barium-titanate is a piezoelectric material, which kicked my suspicions up a notch. A Web search with piezoelectric and ceramic capacitors together in the search phrase generated several articles on the effect (www.atceramics.com).

So, there it was: The problem definitely arose from the ceramic capacitors. The through-hole board was not microphonic because the capacitor leads absorbed the shock. But a PCB with surface-mount components is a relatively rigid structure able to pass a shock wave directly to the interior of the piezoelectric capacitor, thereby inducing a small electric signal. For the final iteration, I replaced all ceramic capacitors with film ones, removed all components from the bottom of the board, and installed an unbroken, edge-to-edge ground plane. I removed the inductors and covered the front-end circuits with a machined aluminum enclosure electrically connected to the ground plane. Now, I had a receiver that operated magnificently. EDN

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