TALES FROM THE CUBE

BY PAUL L SCHIMEL • FAIRCHILD SEMICONDUCTOR

You're gonna do *what* with an LCR bridge?

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A long time ago, when I still thought I was smart, I had just finished a transformer design and handed it off to the in-house magnetics shop. There, I learned about a technique that left me a little baffled. My drawing specified magnetizing inductance, leakage inductance, turns, phasing, pinouts, bobbin, wire, insulation systems, bake times, and the core. My expectation was that the folks in production would use a trusty old oscilloscope and a function generator to verify phase—just like I would! I was the smart one, after all.

When I checked in to see how the build was coming along, I discovered that the magnetics shop had no oscilloscope or function generator. When I asked the folks there how they measured phase, they told me that they used an LCR bridge, and the response was sharp enough to warrant my standing around for a while to see how they did it. The woman at the inspection station was mumbling something to the effect of "Looks like we gotta train the eng-HUH-neers again!" while she was jumpering pins on the bobbin.

The first test was magnetizing inductance at the primary. OK, I got that. The second test was shorting secondaries with the same primary connections. Yup, that's leakage inductance; I was still in the game. She performed similar operations for the secondary winding, most likely to check for the turns ratio looking at the ratios $\sqrt{(L_{MAG\ PRI}/L_{MAG\ SEC})}$. All right, I was still keeping up. The third test connected the secondary in series with the primary. She looked at the measurement and switched the phase on the secondary for another reading. It was a pass-fail test, no data logged. This test and its results left me puzzled. The front end of my brain was in total compression. Yet, I did have some fundamental knowledge, and I thought I knew something about flux and MMF (magnetomotive force), as I was the guy that designed the darn structure. She ran one last test to measure the dc resistance of each winding, which was reassuring in that it made sense to me. A given mean-length turn of a given wire over given turns should have consistent dc resistance. (Maybe I should have specified that fact in the drawing.) I thanked the quality-assurance woman and went back to my "eng-HUH-neering" office to ponder.

If inductance is proportional to turns squared and I have solenoidal windings around a common low reluctance path, a winding of five turns may measure an inductance of 200 μH, and another winding of 10 turns might measure an inductance of 800 μH. OK, that idea makes sense. What, then, of combinations and phase? Well, if I connect the same two windings together in series, there may be two outcomes. One outcome places the windings in phase and should yield a total of 10 plus five turns, or 1800 μH. The other outcome places the windings out of phase and yields a total of 10 minus five turns, or 200 μH. Therein lies the solution: It is possible to arbitrarily connect the windings and determine phase by flipping the polarities of one of the windings in the connection and observing the inductances associated with each phase arrangement. (Note that for this experiment to work, the windings must share the same low-reluctance flux paths.) Given this knowledge, it would also then be possible to take an arbitrary structure and determine the turns simply by unwinding a few turns and measuring the inductance before and after, or by sneaking in a few turns, again measuring the inductance before and after and noting the phase. EDN

Paul Schimel has seven years of experience as an field-applications engineer and more than six years of experience designing power supplies for consumer and industrial applications. Like Paul, you can share your Tales from the Cube and receive $200. Contact Maury Wright at mgwright@edn.com.