An EMC troubleshooting kit - part 4 (radiated immunity)

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This is a continuation of a description of my EMC troubleshooting kit. In this next installment, I’ll describe a few of the tools I use to test radiated RF immunity of a prototype product. In my experience, radiated immunity issues have now become the third-most prevalent issue besides radiated emissions and ESD. Bear in mind, full immunity testing is a lot tougher to perform on the bench, so the actual compliance test levels and frequency range may not be accommodated. To really ensure accurate radiated immunity levels, the product under test will have to be taken to a test lab.

While you can’t beat a test lab for radiated immunity pre-compliance testing, there are a number of simple RF generators that will work well to at least give you a general feel for whether your circuitry is immune. One handy gadget I’ve used for a coarse look at immunity is a hand held Family Radio Service (FRS) transceiver. These may be purchased in most electronics stores for $20 to $30 for a pair. While their transmitted frequency is limited to 462 to 467 MHz at 0.5 watts power, it is still useful for inducing product failures when held very close to the circuitry or I/O cables. Note that many “FRS” radios also transmit on the General Mobile Radio Service (GMRS) frequencies (also 462 to 467 MHz, but 5 watts power). These frequencies require an FCC license and should not be used for immunity testing, due to possible interference to established GMRS communications.
Figure 1 - Here, I’m shown testing a bare digital board for radiated immunity. I’m monitoring one of the outputs while transmitting on the FRS radio. The circuit appears to working just fine.

In my experience, radiated immunity issues have now become the third-most prevalent issue besides radiated emissions and ESD. In the last few months I’ve used the FRS radio to troubleshoot a couple products: a small medical blood glucose monitor and a large industrial controller.
Figure 2 - FRS radio inducing circuit upset in a handheld medical device. Because the product under test was so small, we had to refine the technique by utilizing an RF generator and small H-field loop probe.

**Medical Device** - The glucose level monitor had RF immunity issues in several frequency bands, but was worse around 800 to 950 MHz. This is not good, as this is also where several mobile phone bands are located. When I arrived, we immediately tried to duplicate the failure mode with the FRS radio and were able to do so easily. Unfortunately, as indicated above, sometimes you’ll find that transmitting close to a physically small product will not allow you to pinpoint the section of circuitry that is susceptible to the RF energy. In this case, I’ve found that connecting a small H-field or E-field probe to a variable frequency RF generator capable of achieving at least +10 dBm (+20 dBm is better) power output allows you to “zero in” on specific circuitry or I/O cables. The client was more than willing at this point to locate and purchase a used RF generator (about $1000) and I connected the smallest Beehive H-field loop probe to the output. We adjusted the generator for maximum output (+11 dBm, in this case) and tuned it for one of the peak failure frequencies. In short order, we were able to pinpoint the specific flex-cable that was giving the problem. At that point, the design engineer took it from there and I suspect a combination of filtering and bypassing took care of the issue.
Industrial Controller - The industrial controller was also an interesting job. Unfortunately, the client didn’t wish images or specifics released, so I’ll do my best to describe in general terms the troubleshooting process. When I arrived at the client’s facility, I was shown immunity data that seemed to peak in the 200 to 300 MHz range, but also had multiple issues from 80 to 1000 MHz. The controller was an elaborate mixture of subassemblies and interconnecting cables. When I tried transmitting with the FRS radio, I could cause upset to one of the measured readings on the display from over six feet away! This was going to be easy, I thought.

Well, it wasn’t cut and dried, as there appeared to be multiple sensitive areas. One of the best troubleshooting tools is your pair of eyes. I noticed right away that of the multiple shielded cables in this system, none of the shields were apparently bonded to the metal enclosures - they were simply pushed through grommets, penetrating the shielded enclosure where they were terminated in a large terminal block. There was also an instrument amplifier mounted in this same shielded enclosure that was likely being affected by RF currents induced along these cables during the immunity test.

As a temporary fix, we removed the preamp and mounted it in its own shielded box, bonding the input and output shielded cables to the new box. This helped immensely, but there were still issues
when holding the FRS radio really close to the preamp input cable cable, in particular. It turned out the other end of thos cable was connected to a strain gauge buried deep within the machine. When we finally extricated the strain gauge, we discovered (you guessed it!) the other end of the shield was floating. When it was bonded temporarily, the system seemed completely immune to the FRS radio - a very good sign. Running the radio along all the remaining wiring looked good. As a precaution, I then connected my old HP 8640A RF signal generator up to one of the larger Beehive H-field probes, set it for maximum output power and tuned it to several of the other frequency bands that had proved sensitive. While we never were able to test to the required RF levels, we were pretty sure that with this particular configuration, things were looking good.

In summary, using an FRS radio or a variable RF signal generator will allow you to simulate the radiated immunity test to some degree. Once the susceptible part of the circuitry or cabling is identified, you can then go in and implement potential fixes, retesting as you go. This will save you time and money as opposed to performing troubleshooting at the test facility.

The last installment in this series will summarize all the components, tools, instruments and accessories in my personal EMC troubleshooting kit, along with recommendations on assembling your kit in phases, so as to help remain within department (or personal) budgets. Stay tuned!

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