The Internet of Things (Part 4)

Cell Modem Certification

In the third part of this article series, Bob detailed how to connect simple devices wirelessly to the Internet. This month he looks at the requirements for, the cost of, and some of the problems with cell modem certification for embedded systems.

By Bob Japenga (US)

Almost every month, I get a call from some budding new entrepreneur with a great idea for an Internet of Things (IoT) product. Before we get too far along in the conversation, I ask the question: "What is your budget for cell modem certification?" More often than not, the answer is: "What is that and how much does it cost?" This month I would like to address these two questions as well as address the major issues we have had in cell certification. As always, this is a big topic that we cover in thin slices.

WHAT ARE THE REQUIREMENTS?

All cell modems are required to be certified by cell carriers prior to sale to customers like you and me. However, just because the cell modem is certified for a particular carrier, you are still required to certify the device that incorporates this modem. This makes sense for a lot of the certification requirements. For example, just because the cell modem has an acceptable receiver sensitivity and good robust transmit power, it doesn't mean that your design has met these requirements. This necessitates that you separately test your device to the carrier's requirements. The only exception to this is when the cell modem is self-contained and not an integral part of your design. For purposes of brevity, I will only cover the requirements for North America. Nor will I go over definitions defined in previous articles in this series.

AT&T

If your IoT device is going to use AT&T (3G or 4G), you will be required to pass PTCRB and AT&T certification testing. PTCRB (an obsolete acronym that used to stand for PCS Type Certification Review Board) is an independent certification agency used by some North American cell carriers, including AT&T. Testing to the PTCRB standard is done by a third-party independent test lab. You, the designer, are responsible to contract with one of these independent test labs. Cetecom (www.cetecom.com) and 7Layers (http://7layers.com) are two such labs that we have worked with.

After you have passed the PTCRB tests, you need to obtain AT&T approval. Once scheduled, PTCRB testing will take three to four weeks. AT&T approval takes another one to two weeks. The lab costs depend on the

particular test lab, but it will cost between $20,000 to $40,000 for GSM modems and $60,000 to $70,000 for LTE modems.

VERIZON

The process of certification for Verizon 3G (CDMA) and 4G (LTE) is done directly through Verizon. This testing can be done through an independent lab or through Verizon. Verizon recommends that you pre-certify your product through its Innovation Center. There you can work with Verizon test engineers and technicians to make sure your design is ready for prime time before you go to certification. Verizon provides this service to qualified companies.

Once you have pre-certified, then you can contract with an outside independent certification lab (e.g., Cetecom, 7Layers, and Intertek). The cost for a CDMA certification will be $15,000 to $20,000 while the LTE certification can cost as much as $70,000. Once scheduled, the pre-certification timeframe is about two to three weeks with another three to four weeks for certification once it is scheduled.

AERIS

If you are deploying a GSM modem on the Aeris network in North America, you will require PTCRB certification as well as Aeris certification. The cost and schedule are the same as I described earlier. If you are deploying a CDMA solution, you only require Aeris certification (which has the least stringent requirements of all the carriers, is free and takes less than a week). Aeris also allows you to self-certify for small volumes of installations.

TECHNICAL REQUIREMENTS

Let's summarize the technical requirements for certification and our experience with these.

Total Isotropic Sensitivity (TIS): All carriers for all radio access technologies require a minimum receiver sensitivity. Basically, this test determines how weak a signal from the cell tower your device can respond to. This is one of the situations where certification is your friend—not your enemy. You don't want to deploy your great new idea and have a lot of "Can you hear me now?" problems.

There are three primary ways that we have improved our TIS. First you must make your device whisper quiet in terms of radiated emissions in and around the receiver frequencies. If you thought meeting FCC Class B EMC requirements were tough, your requirements for making your device whisper quiet to meet the TIS requirements are much more stringent. I'll talk more about this when I discuss EMC requirements.

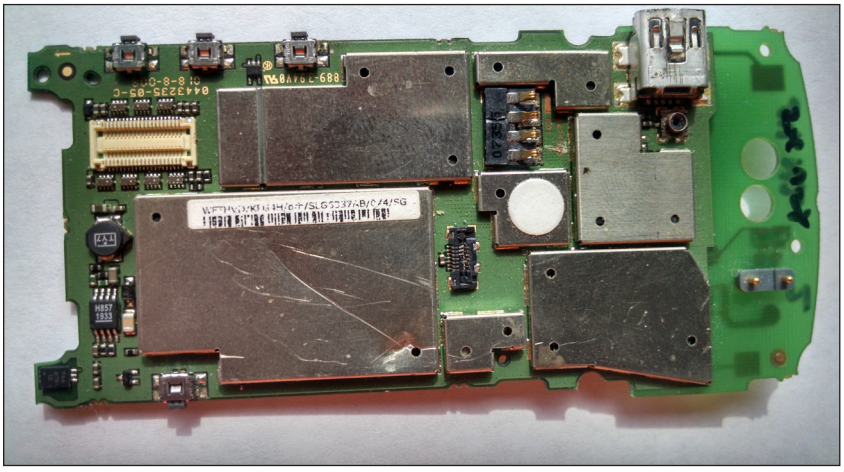

PHOTO 1
Old cell phone

Next is your choice of antenna. We have been unsuccessful meeting TIS requirements without using antennas significantly larger than used in our cell phones. We have often wondered how all of our cell phones met the TIS requirements with their very small antennas. I will leave it to your research and your imagination as to how cell phones are passing the cell carriers TIS requirements with such small antennas. In the words of Deep Throat, "Follow the money!"

Finally, your antenna should be placed as far away from any metal as possible and should have a nonmetallic path to the outside world. One product we had was mounted in a large metal base mounted to an outside wall that shadowed the entire hemisphere behind the product. PTCRB testing of this product required it to meet the TIS requirements completely and evenly around the sphere. We could not get the test lab to relax this 360° requirement. Instead we removed the product from its real world enclosure and performed the testing in a nonrealistic environment. This seemed ludicrous to us since we wanted to test it in the real world enclosure. This resulted in uncertainty on our part once the product passed certification. We were not certain how it would work in the real world when it had this metal box shadowing the back hemisphere. Thankfully, we have deployed more than 50,000 of these with no TIS problems.

Total Radiated Power (TRP): As with TIS, certification testing is your friend concerning TRP. The carriers have similar stringent requirements for TRP. Here your design must carefully place and tune your antenna to obtain the maximum TRP. A little bit of movement of the antenna can make a significant improvement or degradation of your radiated performance.

Another critical requirement for your design is that your power supplies must be

ABOUT THE AUTHOR

Bob Japenga has been designing embedded systems since 1973. In 1988, along with his best friend, he started Micro-Tools, which specializes in creating a variety of real-time embedded systems. With a combined embedded systems experience base of more than 200 years, they love to tackle impossible problems together. Bob has been awarded 11 patents in many areas of embedded systems and motion control. You can reach him at rjapenga@microtoolsinc.com.

capable of instantaneously delivering 1 to 2 A of power when a transmission takes place. Cell modems have one of the more demanding power supply requirements that we have worked with.

One design flaw we saw in one design was having the ground plane under the u.fl connector going to the external antenna. This ground plane was absorbing a significant amount of both outgoing (TRP) and incoming radiation (TIS). Your antenna connector must not be near either the ground or power plane.

Electromagnetic Compatibility/Electromagnetic Interference (EMC/EMI): We did a preliminary EMC scan on our first IoT cell modem design and were very happy that we met FCC Class B requirements for radiated spurious emissions (EMI) with flying colors. What we didn't know was that PTCRB had its own idle mode radiated spurious emissions requirements which were far more stringent than FCC Class B. Initially, we were not even close to meeting these PTCRB requirements. We hired an RF expert to help us. His first suggestion was for us to rip apart an old cell phone and tell him what we saw. When we did this, we saw that the entire circuit board was covered with EMI shield cans (see **Photo 1**). "That's what you need to do with your design." So, after designing the circuit with all of the EMI suppression techniques and good layout practices that we knew, we still needed to populate the board with five shield cans.

Data Retry: If you were a carrier, you would not want to have devices tie up band width with incessant retries. So each carrier has its own unique retry requirements. Some of this retry logic is handled by your cell modem (retries connecting to the cell tower). But in addition, your application software must meet the retry requirements of each carrier. Generally, we are designing systems that use less than 1 MB of data every month so we don't want too many retries at the application level either.

Data Throughput: Remembering that carriers are trying to get as much data through as quickly as possible, each carrier has data throughput requirements for some radio access technologies. This requirement is strictly a function of your cell modem chip. Since your chip is already certified for the particular carrier, it has already passed these tests. Unfortunately, some carriers require you to retest many of these requirements that have absolutely no bearing on your design unless you have modified the cell modem chip (which you can do). It is understandable that the carriers need to protect their network from rouge devices but I feel very strongly that they need to simplify this area of certification. So chip makers, carriers, and PTCRB board, if you are listening, isn't there a better way to detect if we have modified the chip's operation? For example, if there was a flag in the chip that indicated that the radio parameters have been altered in such a way that the carrier/PTCRB certification has been compromised, certification could be made much simpler.

A lot of these tests are very complicated and are being performed to moving standards. We were certifying one product that was failing tests that had nothing to do with our design—only with the cell modem chip. What it boiled down to was this: The chip was tested and passed Version A certification requirements. More stringent requirements were created later (Version B) which our modem failed. Since we were only required to pass Version A requirements, we should have been able to re-run the tests to Version A. The problem was that the certification lab did not have test equipment that ran Version A tests! Hopefully you see the problem. I strongly think this must change as it wastes a lot of time and money in the certification process. We have wasted several months trying to get this device ready for sale.

HARMONICS

In 2010, I was at a football game with my grandsons and 103,000 other people. One of my grandsons was not able to make the game, so I wanted to send him a text at kickoff. Even though I had maximum signal strength, I could not make the call. When I looked around the stadium, it was clear that many wanted to text or call at the same time. Cell phones must work in close proximity to other cell phones. Most M2M devices do not have that requirement. PTCRB certification requires that your device not be transmitting on any frequencies other than the frequency you are licensed to transmit on so as to avoid interfering with nearby cell phones. The first device we took through PTCRB testing failed these tests at a couple of points. What we discovered was that every diode in your

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RESOURCES

OET FCC, "Understanding the FCC Regulations for Computers and Other Digital Devices," OET Bulletin No. 62, 1996, https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet62/oet62rev.pdf for a summary of FCC requirements.

PTCRB, "Who Does Testing?," www.ptcrb.com.

Verizon Innovation Center, www.innovation.verizon.com.

design acts as a re-radiator of the radio signal you are transmitting. And it radiates at one of the harmonics of the transmit frequency. This must be squelched or you will fail your Harmonic Radiated Spurious Emissions (RSE) tests.

WAIVERS

Even after doing another spin of the board with small capacitors around every diode, we were still failing Harmonic RSE at a couple of frequencies by a few decibels. The product was already several months late. Should we do another spin of the board after we find the diode we missed? At this point, I pushed through a waiver. This was a formal request to the PTCRB board for an exception to the requirements. Our unit was stationary. Our unit did not operate in the presence of other cell phones. Come on, we are talking about only 2 db! Thankfully and quickly, the waiver got approved. We had our first cell modem-based IoT device ready to ship. So the moral of the story is: Work with the certifying agency. Some requirements that apply to cell phones do not apply to M2M products. Sometimes the certification process is our friend but a lot of time it is just a pain in the neck.

CERTIFY FIRST

You have a good IoT idea that will make this world a better place. But before you bring it to fruition, you will need to pass the necessary certification tests imposed on you by the cell network carriers. This article gives you a thin slice as to what's involved and what it will cost.