

Physics Can Solve Your RFID Puzzle

Some say that getting RFID reader and tags to communicate is a dark art, but here's how you can apply science to make your systems work.

Sept. 13, 2004—Many end users face difficulties with their RFID programs right from the beginning. They blame poor performance on immature equipment and believe the physics of RF are the biggest barrier to an effective RFID solution. There is no doubt that the challenges of liquids, metals, refraction, collision and environmental interference cause frequent RFID deployment headaches. But there is science behind each of these challenges. Far from being a barrier, the physics of RFID are the key to designing and implementing an optimal solution.

People unfamiliar with RF physics often refer to RFID deployments as a black art. Nothing could be further from the truth. As the name implies, Radio Frequency Identification is radio based. The entire front end of an RFID system is a wireless data communication network. The reader is simply a high power radio transmitter and a high sensitivity radio receiver. The tag can be viewed in a similar manner, except it has a low power radio transmitter (backscatter) and a low sensitivity receiver.

When you view RFID as a radio communication network, the physics of RF become the obvious source to understanding challenges and determining the optimal RFID system configuration. The principles and methods for characterizing the radio communications channel—and the electronics and antennas for RFID—are all well understood based on decades of RF research and use. When I worked at Motorola in the 1970s and 1980s, we applied these principles to designing RF devices. You can successfully apply them to your RFID deployment today and save time, money and headaches.

So how can physics help you? It can tell you where you are likely to face challenges, why they exist and how to overcome them. To fully characterize an RFID application design, you first must break it down into its components.

1. The environment—RFID systems don't live in a vacuum

You will not be deploying your RFID system in a clean environment. You cannot see it, but your air is dirty. There are electromagnetic waves, radio frequency signals and other noise in your environment that can and will interfere with your RFID system. You need to identify these sources of interference with a spectrum analyzer over a full operational business cycle, which typically is a minimum of 24 to 48 hours (Full Faraday Cycle Analysis). This information will tell you what frequencies will cause the most trouble operating your RFID system in your facility and, similarly, if your new RFID system will interfere with your other wireless communication systems.

You also need to perform a more detailed RF path loss contour (PLC) analysis at the planned locations of your RFID reader deployment. The PLC data defines how RF waves are distorted or degraded at the location of intended use. This information is critical to properly defining deployment variables, such as antenna direction and location, power setting and field strength. RF path loss contouring defines the blueprint for

tuning an optimal interrogation zone and allows you to “see” the RF field.

2. The materials—beyond trial and error SKU testing

Just as the electromagnetic waves from the reader are affected by the environment, the material that tags are placed on will alter their “signature,” or radiation pattern, for both transmit and receive. For example, many people are aware that liquids tend to absorb UHF waves and metal will cause reflections. What most people don’t know is that you can measure the tag signature distortion and backscatter loss along a range of frequencies.

This frequency response characterization (FRC) enables you to scientifically identify optimal tags, placements and remediation strategies. On easy-to-tag materials, this analysis may simply tell you where not to place the tags or which tags are unacceptable. For hard-to-tag materials, it often defines your limited options for tags and placements. Moreover, the data can shed further light on the reader and antenna configurations that will optimize your chance of consistent read success. We saw this in a recent client engagement where the first project team could not achieve better than an 80 percent read rate through a trial and error tag selection approach. By measuring the FRC and tag signatures, we were able to provide a solution for consistent 100 percent read rates.

3. The RFID network architecture—specifications for deployment

Once you understand the environmental variables, the product material variables and the business process and objectives, you can then begin to design an optimal RFID network architecture. The RFID network architecture includes topological specifications such as location and setup, equipment specifications such as reader and tag selection, reader configuration settings such as power and interrogation rates, and connectivity specifications governing how readers will communicate and interoperate.

Most end users today fire up the reader at the factory configuration settings, set up the antennas facing each other and see what happens when tags pass by. If the performance is insufficient, they change one or two settings and try again. You can see that by measuring how radio waves propagate at certain locations with certain products, you can start with a topology, equipment and configuration that will succeed from the outset.

If you have a harsh environment or product materials tough on RF wave propagation, understanding the nature of destructive interference is even more critical. In an RF friendly environment, you have a chance of getting lucky and achieving a sufficient if not optimal configuration. This is not at all likely in RF unfriendly settings. The measurements and calculations provided by RF physics can help you solve the most challenging RFID puzzles. It can suggest a focus in specific frequencies, locations and applications, and use of specific tags and readers to meet demanding requirements.

The question is: Do you want to guess at your RF configuration or do you want to know the answer? Physics can provide the information you require to deploy a successful RFID system the first time. Trial and error approaches will only be as good as the trials and won’t shed any light on what you didn’t try. Physics can lead you to the optimal solution, no matter what your environment.

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