RFID TESTING IN ANECHOIC CHAMBERS: DESIGN OF A CHAMBER FOR ISO TR 18047-6 TESTING OF UHF RFID

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ABSTRACT

The present paper introduces the audience to testing procedures for RFIDs. An general introduction of the technology and the current status is followed by a description of the equipment and facility necessary to perform testing. The presentation looks mainly at the 910MHz band. The presentation concentrates on the design of an anechoic chamber to perform the test per the ISO TR 18047-6 standard which is based on the EPC Globlal (an industry association) procedures.

Keywords: Absorbers, RFID, Standarized testing, chamber design

1.0 Introduction

Before we start we need some definitions and to understand what RFID is. RFID is the reading of physical tags on single products, cases, pallets, or re-usable containers that emit radio signals to be picked up by reader devices. The goal among several companies is a complete RFID "network". This "network" or complete RFID picture combines the technology of tags and readers with access to standardized databases globally ensuring real time access to up to date information about products at any point in the supply chain. While this may slightly reduce our cost at the grocer's it has not too much interest for the RF engineer except that this is a promising system and that companies of many backgrounds will invest into this technology as a way to improve their stock management and traffic problems.
For RF engineers (and that includes EMC ones) RFID is reduce to a system where an interrogator sends an inquiry coded within a radiated signal. A tag will pick up this radiation and respond by radiating back some information. The information encoded on the radiation from the tag identifies the product (see Figure 1).

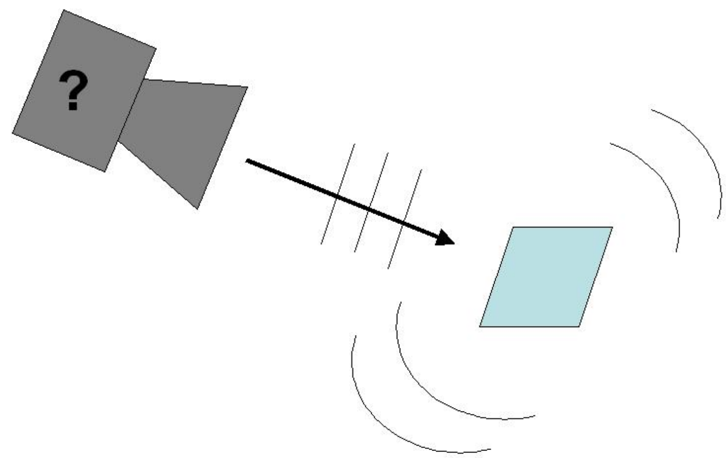

Figure 1 - An RFID system, interrogator/reader and the tag.

The history of RFID starts in the late 1930s. As we many new technologies it is surprising to learn that they have been around for several decades. The Chain Home Network was a radar network operating in the 20 to 46MHz range at 350 to 750kW with 4 to 45 microsecond pulses. By 1938 a lot of Airmen were worried that the radar could not identify friendly aircraft and that they could be shut down by their own anti-air artillery. The solution was IFF (Identification Friend or Foe). The IFF device will reradiate a much powerful pulse that it received on the same frequency so that its "blip" on the radar screen will be stronger and identify it as a friendly aircraft [1]. After the war research on RFID continues with advances in IFF systems. In the 1960s the first RFID companies appear (Sensormatic and Checkpoint). These companies introduce the first commercial application of RFID with their Electronic Article Surveillance (theft prevention device) systems.
The 1970s see the adoption of toll collecting RFID systems by the New York and New Jersey Port Authorities. RFID enters the mainstream during the next decade. Personal access, animal tagging and transportation systems are adopted and enter the market during the 80s. In the 1990s sees the emergence of standards that direct the communication protocols for different applications of RFID. There is also a wide use

of RFID for animal tagging and toll collection. So, why suddenly in the new millennium we see the explosion of the RFID business? The most important reason is large retailers like Wal-Mart in the USA and Metro in Europe start demanding from their vendors that they supply merchandise tagged so that it will ease their management of stocks. In some cases Government departments, like the United States Department of Defense, ask for their suppliers to provide RFID in their merchandise by a given date.

So how this technology will affect the other tracking system? The other tracking system is of course, bar codes. Bar code is another way of RF, or better yet Electromagnetic identification device (EMID) since light is part of the EM spectrum. While this is not the place to predict the future of technologies it is very probable that RFID and Barcodes will co-exist for several decades and it may be possible that bar codes will never disappear 100%. On figure 2 a comparison of the pors and cons of both technologies are presented. Right now the only main benefit of bar codes is the low cost of the tags compared to the chip and antenna marriage found in RFID tags.

			RFID Benefit
Line of sight	**required**	**Not required**	**No need to orientate scanned items**
Number of items to be scanned	one	multiple	Faster inventory scan
Data storage	Limited codes	Up to several kB data	Real time data in any location
Automation & accuracy	Manual read errors prone to mis-scanning	Fully automated and highly accurate	Error free inventory count

Figure 2. Pros and Cons of RFID and Barcode

2. Classification of Tags

Human beings like to classify things for their study. Whether it is plants, animals, minerals or RFID systems human beings will group them by their most clear characteristics. Based on that, we can classify RFID systems by their frequency of operation or by the type of tag. While the industry has already their internal classification based on the above factors as well as the protocol of communications I am going to present here a simpler classification that should serve as an introduction to the reader. By frequency we can separate the tags in some groups depending of at which band of the spectrum they operate:

Low Frequency (125/134KHz) – Most commonly used for access control, animal tracking and asset tracking. Magnetic coils usual antenna used

High -Frequency (13.56 MHz) – Used where medium data rate and read ranges up to about 1.5 meters are acceptable. This frequency also has the advantage of not being as susceptible to interference from the presence of water or metals.

Ultra High-Frequency (850 MHz to 950 MHz) – offer the longest read ranges of up to approximately 3 meters and high reading speeds.

This last group, the UHF is the one that we are going to concentrate in the present paper when we talk about the testing methods.

By looking at the type of tags we can divide the systems into active and passive. Active RFID Tags are battery powered. They broadcast a signal to the reader and can transmit over the greatest distances (100+ meters). Typically they can cost $10 - $40 or more and are used to track high value goods like vehicles and large containers of goods. Shipboard containers are a good example of an active RFID tag application.

Passive RFID Tags do not contain a battery. Instead, they draw their power from the radio wave transmitted by the reader. The reader transmits a low power radio signal through its antenna to the tag, which in turn receives it through its own antenna to power the integrated circuit (chip). The tag will briefly converse with the reader for verification and the exchange of data. As a result, passive tags can transmit information over shorter distances (typically 3 meters or less) than active tags. They have a smaller memory capacity and are considerably lower in cost (less than $1) making them ideal for tracking lower cost items.

3. Standards

Standards rule how we make our measurements and which levels should our equipment emit or withstand in a given environment. There are several Standarization bodies and for RFIDs these can be international, government and industrial. Government Standard are going to standardize the maximum power and the frequencies of operation. International standard may put forward technical reports for recommended practices to measure the systems and for the protocols. The goal of course is that regardless of the manufacturer of the tag and of the interrogator all interrogator/reader systems will be able to talk to any of the tag systems. Nobody is more interested on this than the RFID industry itself. Hence as it happened with the cell phone industry in the 1990s with the creation of the CTIA (cellular telecommunications industry association) the RFID industry has created its own industry association for the development of standards. So, we can say that Frequencies, power levels and operating cycles are regulated by government groups such as the FCC (in the USA) or the European Telecommunications Standards Institute (ETSI).

Protocols for communication between tags and readers are proposed by a number bodies and equipment manufacturers. The two most prominent organisations for setting standards are the International Standards Organisation (ISO) and EPCglobal. EPCglobal is a member-driven organisation comprised of leading firms and industries focused on creating global standards is developing a standards-based network to support RFID globally. This is to ensure that data created in one place can be read and interpreted anywhere in the global supply chain. EPC Global is part of GS1 which also manages the UCC-EAN system responsible for standardising barcodes, so they are well placed to develop, manage, promote and deploy the EPC standard.

The reader of this paper however will be more interested in performance testing specifically of the air interface communications of the system. On the next section of the paper, we will be reviewing the standard for UHF RFID tag air interface testing.

4. ISO/IEC TR 18047 an international Standard for Measuring RFID

In the previous section, the reader learned that there are some international and industry standards that are setting methods for the measurement of RFID systems over the air performance. In this section we concentrate on the international standard method for measuring over the air performance of RFID tags and interrogators or readers. The Standard [2] or to be more specific, the technical report of recommended practice is divided on many parts depending on the frequency of the system being tested. Additionally part one is a list of definitions. Part 2 deals with 135kHz, part 3 deals with 13.56MHz, part 4 with 2.45GHz, part 6 with UHF and part 7 deals with 433MHz. In this paper we will concentrate on part 6 of the standard. This part of ISO/IEC TR 18047 defines test methods for determining the conformance of radio frequency identification devices (tags and interrogators) for item management with the specifications given in ISO/IEC 18000-6, which deals with the protocols of communications. but does not apply to the testing of conformity with regulatory or similar requirements, that is with EMC requirements. The test methods require only that the mandatory functions, and any optional functions which are implemented, be verified. This may, in appropriate circumstances, be supplemented by further, application specific functionality criteria that are not available in the general case.

In the present paper we will concentrate on the test facility requirements. The standard calls for the temperature to be 23 C plus or minus 3 degrees and a non-condensing humidity of 40%. The noise floor in the test area (measured with an spectrum analyzer with 10MHz span and 1minute acquisition) must be 20dB below the value of the tag backscatter at minimum power with the tag at 10 wavelengths. The tolerance for all quantities is plus or minus 5%, unless otherwise specified.

Based on the above requirements it is clear that an anechoic chamber is required for testing RFID systems at the UHF frequencies. The 20dB below the backscattered level required by the standard is the key to designing the chamber required for the test. Part of the requirement is met by the shielding of the chamber. At these frequencies most chambers have better than 80dB isolation. However, a shielded room by itself cannot be used for the type of testing required. The chamber needs to be lined with absorber, and the absorber has to be such that the reflected energy from the walls has to be 20dB lower than the tag backscatter at minimum power. The standard covers from 860 to 960 MHz so a typical rectangular footprint chamber is sufficient to get the required –20dB Quiet Zone (QZ) Level. The Standard specifies the test distance to be at most 10 wavelengths. At 866MHz the lowest test frequency, the wavelength is 34.6cm so the maximum test distance is 3.46m or 11.4ft. Giving 2ft diameter for each of the devices inside the chamber and assuming 12 inch pyramids we can assume 20ft long chamber. The Standard itself recommends carbon-doped polyurethane to be used. Based on the information provided by the standard we can suggest the use of a 20 by 12 by 12 ft. for the specular regions of the chamber, namely the side walls, ceiling and floor we can use 18 inch absorber to get the required 20dB attenuation. Figure 3 shows the recommended chamber solution.

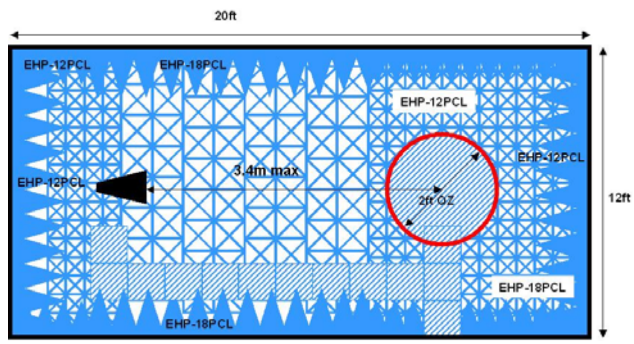

Figure 3. The recommended chamber solution for RFID system testing.

There are two parts to the RFID system, the interrogator and the tag. The ISO standard has sections to describe the test each of the parts of the system.

a) Interrogator test

For the interrogator over the air performance we want to test the modulation of the outgoing signal. The interrogator is placed in the chamber and it will radiate with the antenna that is part of the interrogator system. The signal is to be received by a non-reactive dipole tuned at the frequency of operation of the system. These dipoles can be typical precision dipoles with a quarter wavelength balun like the one shown in figure 4. These dipoles have 50ohms of input impedance and a VSWR of less than 1.2:1 as required by the standard.

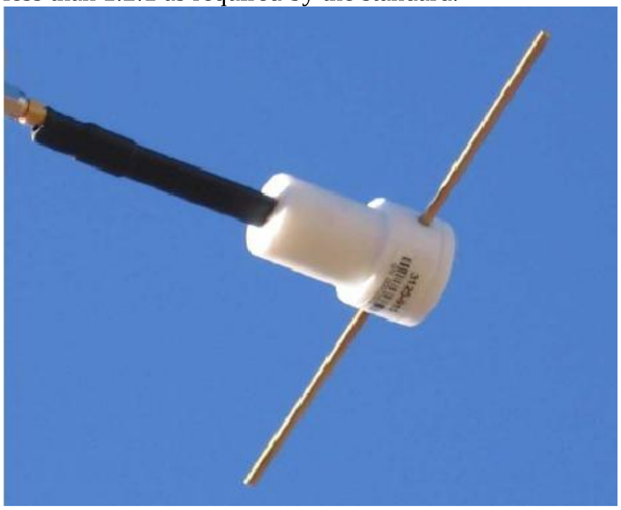

Figure 4. A precision half-wave dipole with a quarter wavelength balun

The antenna of the interrogator and the dipole are co-polarized and placed at both three wavelengths and ten wavelengths. The modulation is tested at both these distances. Figure 5 shows a sketch of the chamber with the dipole and the interrogator showing how the test is to be conducted.

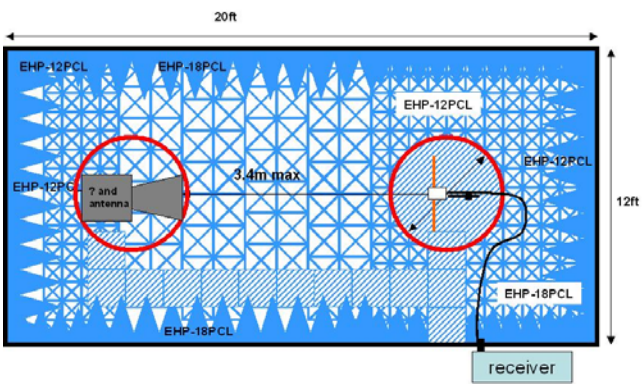

Figure 5. Interrogator modulation test.

The other part of the interrogator test is the demodulation and turn around time. Once the tag receives a signal from the interrogator with the proper modulations as tested in the first part, the tag must prepare itself to receive instruction. Once it receives the instructions it has a specified period of time to respond back. The interrogator must then be prepared to receive the data from the tag within a small fraction of time. For this test a simulation tag is used. This is basically the same non-reactive dipole as the shown in figure 4, but connected to a circuit. Figure 6 shows a sketch of the chamber with the interrogator and the tag emulator with the dipole.

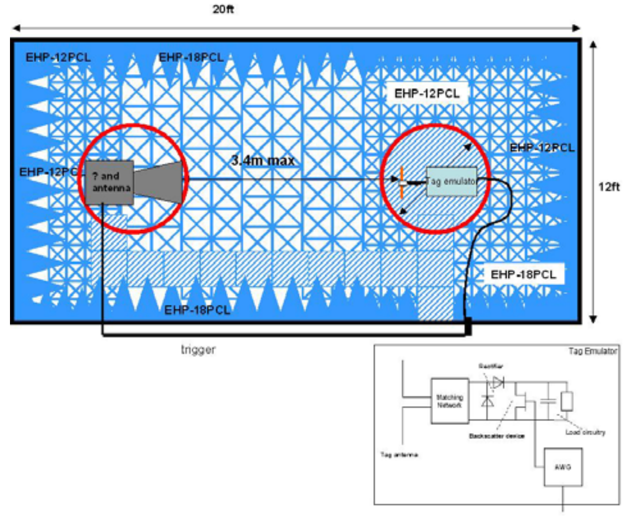

Figure 6. The second part of the interrogator test. Turn around and demodulation of tag signal.

b) Tag Testing.

The tag test involves the following parts. The tag must demodulate signals from the interrogator. Receive data from the interrogator and after a specified turn around time it must then return a set of data to the interrogator. Part of the test is to verify that the tag provides the proper modulation and backscatter to be successfully detected by readers or interrogators. The test uses an interrogator simulator and an antenna. A secondary antenna is connected to a receiver to check the power level and the modulations of the signal emitted by the tag. The test is conducted on the far field of the antennas and the angle between the two antennas has to be less than 15 degrees as show in figure 7.

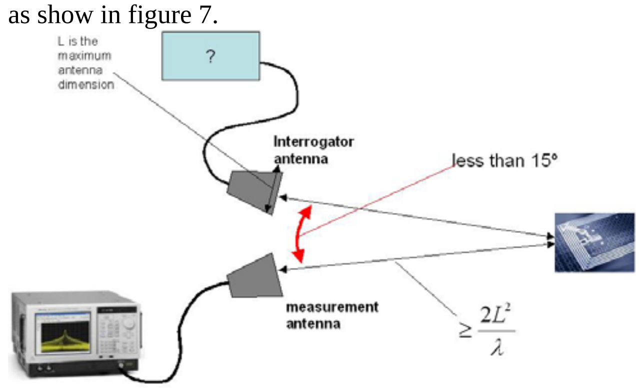

Figure 7. Tag testing.

It is important that the antennas used on this test have a half power beamwidth of less that 30 degrees. This translates roughly into about 8dBi gain. Additionally the crosstalk between the two antennas has to be less than 45dB. As in all the previous tests the antennas have to be co-polarized with the antennas on the tag. I suggest in those cases to use a dual polarized antenna and combine the power from the two inputs with a power combiner. The antenna in figure 8 has adequate half power beamwidth and gain and it is dual polarized making it ideal for this test. In figure 8 we also see an absorber septum that can be place between the antennas to reduce the crosstalk between them for the test.

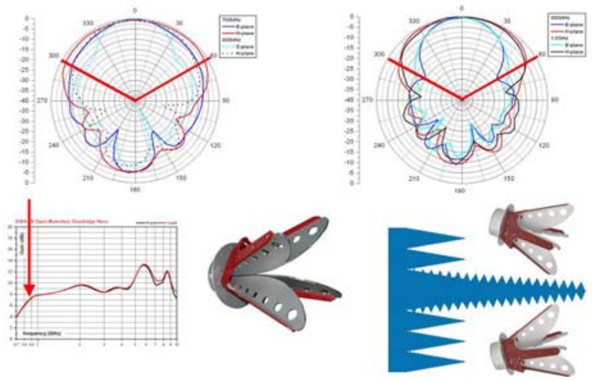

Figure 8. A dual linear polarized antenna that closely meets the requirements of the test.

Figure 9 shows a sketch of the tag test in the same chamber as the previous test. The chamber treatment has not changed, the only changes are to the antennas and devices being tested. While this chamber was designed for the UHF test per the ISO standard, the tags operating at higher frequencies can also be tested.

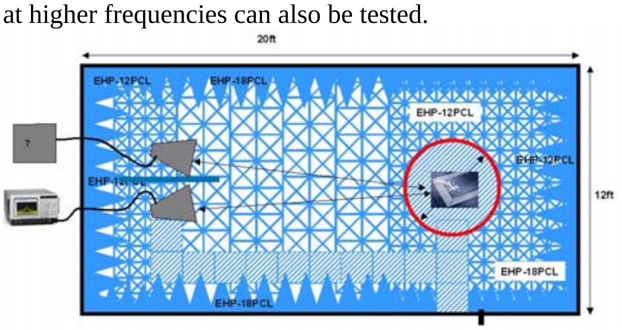

Figure 9. Tag test set up in chamber

5. Conclusion

This paper was intended to give you, the reader, a brief introduction into RFIDs and RFID testing. Because of my particular background I have concentrated on the chamber design required for these tests to be performed at the 860-960MHz band. Also, I have tried to shed a little light onto the test procedure when related to antennas and the set up inside the anechoic chamber. Most of all I hope that you have learned something in reading this paper and that I increase your curiosity about a growing technology that may require the skill of the EMC engineer when testing the true over the air performance of these devices per a give standard.

6. REFERENCES

[1] Deighton, L. *Fighter: the true story of the the battle of Britain* Triad Grafton Books: London 1987

[2] ISO/IEC TR 18047 "Information technology Radio frequency identification device conformance test methods—Part 6: Test methods for air interface communications at 860 MHz to 960 MHz".

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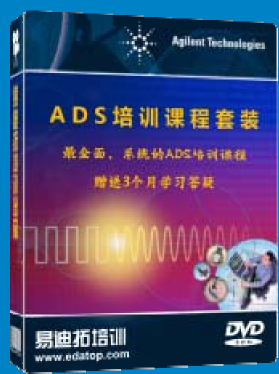

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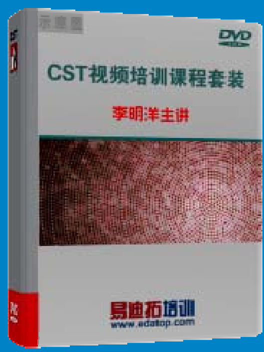

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