3D ANTENNA MEASUREMENT SYSTEM - LOW GAIN ANTENNA MEASUREMENTS AND CTIA OTA TESTING

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ABSTRACT

We are in the era of wireless communications and devices. The antennas that enable these technologies are electrically small and can be challenging to test and analyze. Yet, the industry is becoming more standardized, and so too are the tests and certifications being adopted to validate these antennas. These antennas must undergo "antenna measurements" to characterize such information as far-field patterns and gain. Additionally, hand-held devices, such as cell phones, must satisfy requirements of the Over-the-Air (OTA) performance tests as specified by the Cellular Telecommunication and Internet Association (CTIA). These tests require a measurement system that can accurately collect data on a spherical surface enclosing the AUT. This system also has to provide the appropriate data analysis capabilities and has to be constructed from dielectric materials to minimize reflections.

Keywords: CTIA; Low-gain Antennas, Omni-directional antennas; OTA, TIS, TRP, Wireless

1. Introduction

This paper describes a 3D measurement system that addresses the challenges in testing antennas and devices engineered for wireless communications. It is an ideal system for measuring medium and low gain antennas and is well suited for wireless antenna testing. It has successfully demonstrated testing and characterization of far-field angular spectra, CTIA OTA performance data, and Effective Isotropic Radiated Power (EIRP).

Those familiar with antenna measurements know the challenges in measuring omni-directional antennas. The antennas are small and difficult to mount in a manner that reduces blockage. A sphere (or nearly a sphere) of energy about the antenna must be collected to have enough sampling to test and analyze the far-field radiation pattern. If these are not handled well, then significant errors will incur.

In addition to the challenges listed above, new OTA testing has been developed for hand-held wireless devices. The OTA testing characterizes the performance of the integrated handset (not just the antenna) to verify the radiation pattern and sensitivity of the device in a real-world setting.

2. CTIA OTA Performance Tests

The OTA testing is not well-known within the antenna measurement community, but it readily is becoming adopted. The need exists to test wireless products (cell phones, PDAs, laptops, RFID) as an integrated product. Manufacturers need to verify the product design and performance. Similarly, customers want to know what will work and which products perform better than others. The CTIA created a specification for wireless hand-held devices that would provide an industry standard to address these issues. Part of this specification defines the test criteria for OTA performance.

The CTIA certification program for products consists of three parts: 1) testing conformance to industry standards; 2) testing radiated performance (or Over-the-Air performance); and 3) FCC Acceptance testing.

The first two parts of the CTIA certification testing must be accomplished in a CTIA Authorized Test Laboratory (CATL), and the third part must be accomplished in an FCC Authorized Test Laboratory.

The Over-the-Air (OTA) performance testing consists of two basic tests: 1) Total Radiated Power (TRP) and 2) Total Isotropic Sensitivity (TIS). The TRP measurement is basically EIRP integrated over the total sphere. TIS refers to receiver sensitivity, in dBm, integrated over the sphere. TIS measures the minimum power required to achieve a specified Bit Error-Rate (BER) or Frame Erasure Rate (FER).

To execute the TRP test, radiated power samples are collected along a sphere every 15 degrees. These power samples are then integrated over the whole sphere to determine the total EIRP. To perform the TIS test, measurements are taken at 30 degree intervals. During this measurement, the power is varied at each interval to determine the threshold at which the DUT can maintain the specified BER (or FER). This establishes the power level at which a signal can still be received without compromising data quality.

As with typical low-gain antenna measurements, positioning equipment and a chamber are required. In addition, a Base Station Simulator (BSS) is needed to communicate with and control the device under test. Popular base station simulators for these types of measurements include the Anritsu MT8820A, Agilent 8960, or the R&S CMU200

The CTIA OTA measurements apply only to cell phone products. However, other tests and standards are being developed to address other wireless devices. These include EVDO (the wireless internet for Verizon & Sprint); Bluetooth, GPS; Edge; and GPRS. Testing standards are very important throughout the production cycle.

3. The Production Cycle

Testing, of various types, is needed during the entire production cycle. Figure 1 shows a conceptual view of the production cycle for cell phones. At each level there is a need to test and validate antennas and overall product performance. Ultimately, the subscriber wants assurances that the cell phone product he or she is buying will have and will maintain a good connection.

Consider a manufacturer such as BenQ in Taiwan. BenQ is a considered by many as a technology leader in mobile phones. Using a hypothetical scenario, assume BenQ receives an order from a phone supplier such as Motorola. The request is for a new mobile phone that uses GSM, CDMA, and TDMA formats. Also, this product must incorporate an MP3 player, a PDA, a camera, GPS, and RFID into the device. Lastly, in our world of technology, tighter specifications are given.

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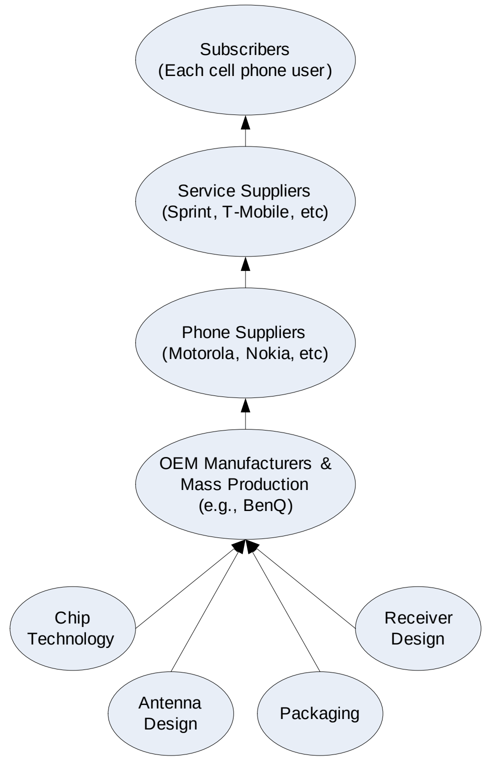

Figure 1 – Production Cycle

BenQ will want to design and validate a new antenna design for the phone. These antennas must be designed to co-exist with other technologies, such as GPS and RFID. During the design phase these antennas need to undergo antenna pattern measurements. After the antenna design is completed, the impacts of the packaging need to be tested. Thus, BenQ will want to see test results of the radiation patterns using a prototype of the integrated package. These types of tests will be done in an antenna measurement range.

The next step of testing will be to test the phone as an integrated product to see how the package and interaction of the other antennas and components perform. At this point, CTIA OTA performance testing is required. This will verify how the phone radiates and interacts with the other antennas, components, and modes.

To fulfill the order, BenQ must meet the challenges of designing and testing electrically small antennas and validate the overall performance of these antennas as they are packaged into a final product. At any step along the way, problems may exist which will necessitate design modifications and further testing. A measurement system that is capable of testing at each step is needed to facilitate the entire process. Such a system will save time and expense, and will decrease the time to market for orders.

4. The Ideal System

The ideal system for testing in the wireless market has the following capabilities:

- Accurately collects data on a spherical surface enclosing the antenna
- Collects and processes data in near-field and far-field modes
- Tests radiated performance of stand-alone or integrated antennas
- Performs CTIA OTA performance measurements

This system is a hybrid system that can accomplish all of the tests with a single configuration. It should allow the OEM manufacturers, the service providers, and the antenna manufacturers alike to characterize the wireless device for its unique sets of challenges and issues. To meet these challenges, NSI has developed the NSI-700S-90 3D Measurement System that is demonstrated in Figure 2.

Figure 2 - NSI-700S-90

Near-field Antenna Measurements

Electrically small antennas have short far-field distances (that is, 2D**2/lambda is short). Still, there are many advantages to performing near-field measurements on these devices. One advantage is that the complete sphere of data about an antenna or device can be measured with a high degree of fidelity and measurement speed in the near-field mode.

Consider that in near-field measurements, amplitude and phase are typically sampled at half-wavelength increments to satisfy the Nyquist sampling criteria. This data is then transformed to reconstruct the far-field angular spectra at any arbitrary angle. To perform similar 3-dimensional analysis with a traditional far-field measurement system requires far greater sampling and takes much longer to acquire. The picture in Figure 3 is an example of the 3D fidelity that was obtained using spherical near-field acquisition mode on a 700S-90 system. This same degree of fidelity could not be achieved on a different far-field system.

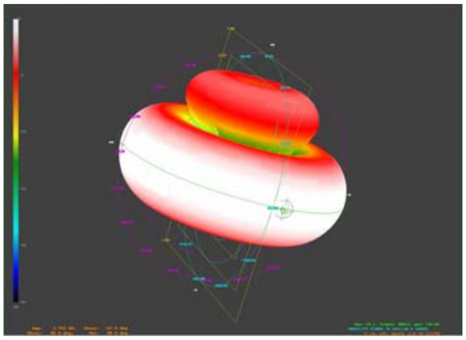

Figure 3 – 700S-90 Near-field Test Data

The data in Figure 3 shows a slightly larger pattern in the right side of the upper "doughnut" than on the left side, which indicated a design and fabrication flaw. This was not as apparent in the data obtained from a different far-field system due to resolution issues.

The figures below are other examples of near-field antenna measurements from the BenQ 700S-90. Figure 4, shows the 3D pattern of an RFID Tag Antenna and Figure 5 shows an RFID Tag Antenna placed on a loaded box. These figures show how, with high-resolution 3D graphics, users can analyze the pattern characteristics of an antenna as it is integrated into a real-world setting.

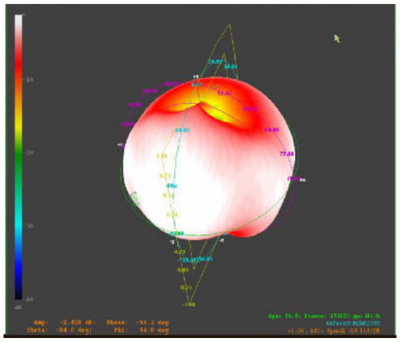

Figure 4 - RFID Tag Antenna

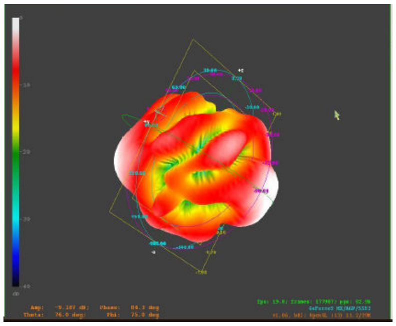

Figure 5 - RFID Tag Antenna on Loaded Box

Another benefit of near-field antenna measurements is that once the amplitude and phase data around a DUT has been obtained, other information can easily be extracted. For example, holographic back-projection can provide very useful information in characterizing an aperture of an antenna, for tuning elements, or for analyzing relative power density at arbitrary distances.

<u>Far-field Antenna Measurements</u>

Sometimes, traditional far-field measurements are the optimal choice for performing a particular antenna measurement. For example, 2-dimensional radiated pattern data (i.e., single, principal-plane cuts) can be taken very quickly using the far-field mode. Additionally, far-field antenna measurements provide real-time data acquisition and are the best choice for applications in which an immediate response to a stimulus must be characterized. In the case of measuring & characterizing handheld devices, the CTIA specification states the OTA testing must be done in the far-field mode. Thus, a system capable of performing far-field measurements is highly desired for testing in the wireless industry.

<u>OTA Performance Measurements</u>

The CTIA OTA performance tests aim to provide independent standards and certification for hand-held devices. The CTIA specification primarily applies to products sold in the US; however, other countries are beginning to adopt the CTIA OTA criteria. For example, many OEM & ODM manufacturers outside of the US, such as BenQ, are requesting systems that give OTA capability, along with the traditional antenna radiation measurements. The CTIA OTA measurements enable better standardization, better consistency between manufacturers and result in better, more informed comparisons.

Figure 6 shows data from the OTA measurements of a BenQ phone that was taken on its NSI-700S-90 system. It shows the radiated power pattern for the horizontal polarization from the TRP measurements. Similarly, the sensitivity patterns from the TIS measurements can be plotted and analyzed.

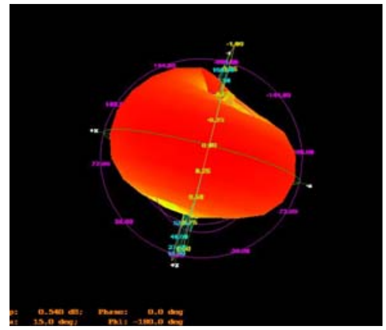

Figure 6 - Radiated Power Pattern for H-pol

5. The NSI-700S-90 System

To provide customers with an optimal, cost effective solution that satisfies typical antenna measurements and the test requirements defined in the CTIA specification, NSI developed the NSI-700S-90 system. The NSI-700S-90 is a combination system that is designed for the wireless market (reference Figure 7). This system uses an overhead dielectric swing-arm for probe motion in the theta axis, and an AUT support stage for motion in the phi axis.

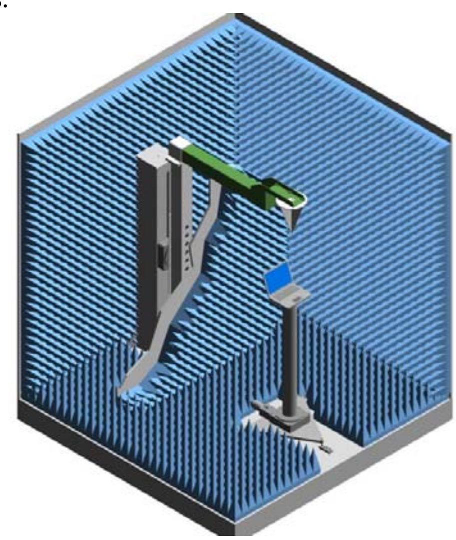

Figure 7 – Cut-Away View of the NSI-700S-90

The system is designed to precisely collect data on a sphere around a device for accurate testing. This ideal 3-dimensional test and measurement system enables far-field, spherical near-field, and CITA OTA testing in one integrated package.

<u>Features</u>

The swing arm and AUT support are constructed of dielectric material to minimize reflections. The AUT support provides “table-top” mounting. This eliminates the need for complicated mounting mechanisms and unwanted orientations for devices such as laptops.

The system comes equipped with a wideband, dual-polarized probe. The polarizations are electronically switched so that both polarizations can be obtained on the fly. The system is designed for testing from 800 MHz to 6 GHz, but it can be easily extended up to 18 GHz.

The 700S-90 is fully adjustable to accommodate lower frequency limits, chamber size restrictions, or various test article sizes.

The system includes the NSI spherical near-field and far-field antenna measurement software and CTIA OTA measurement capability. Additionally, this system includes the NSI automated scripting capability and virtual reality 3D graphics.

7.0 CONCLUSION

As this paper has described, it takes care to test the electrically small antennas engineered for the wireless industry. Moreover, CTIA OTA testing is becoming mandatory for the mobile handsets. This requires a system that can capture a sphere of data around the antenna with a minimum of reflections, blockage, and truncation. The system designed to test antennas and devices in this market should give the capability to execute spherical near-field antenna measurements, far-field antenna measurements, and CTIA OTA performance measurements. For this purpose, NSI designed the NSI-700S-90 measurement system.

The 700S-90 system gives customers the ability to execute each of the three tests described above in one system. Further, it is an optimum system for handling the challenges of accurately collecting – and ultimately, analyzing – energy around low gain antennas and devices.

8.0 REFERENCES

[1] CTIA Certification Test Plan for Mobile Station Over the Air Performance, Method of Measurement for Radiated RF Power and Receiver Performance; Rev 2.1, April 2005

9. ACKNOWLEDGMENTS

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