A NOVEL SPHERICAL SCANNER SYSTEM FOR WIRELESS TELEMATICS MEASUREMENTS

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ABSTRACT

Modern vehicle telematics subsystems often employ wireless interfaces. The design and evaluation of these subsystems involves measurement of antenna characteristics or Over-The-Air (OTA) performance of the subsystem as installed in a vehicle. Several subsystems servicing multiple user applications may be installed in a single vehicle, with antenna structures located anywhere on or within the vehicle. In general, the radiation characteristics of each subsystem must be measured over a partial spherical surface surrounding the vehicle and of sufficient radius to be outside the reactive near-field of the Device Under Test (DUT). This paper describes a distributed axis spherical scanning system designed for vehicle applications. The elevation axis which supports the probe antenna has a measurement radius of 25 ft (7.62m). The elevation positioner is supported on a hydraulic vertical lift axis to permit the adjustment of the measurement coordinate origin to be in the same horizontal plane as the DUT phase center. The measurement instrumentation system supports VNA based antenna pattern measurements or active OTA testing of telematics subsystems. The system is suitable for outdoor or indoor measurement facilities. An outdoor installation is described.

Keywords: Antenna Range, Spherical Scanning, OTA Testing, Telematics, Antenna Measurement Instrumentation, Antenna Measurement Positioners.

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1. Introduction

Modern vehicle telematics subsystems often employ wireless interfaces. The design and evaluation of these subsystems involves measurement of antenna characteristics or Over-The-Air (OTA) performance of the subsystem as installed in a vehicle. Several subsystems servicing multiple user applications may be installed in a single vehicle, with antenna structures located anywhere on or within the vehicle. In general, the radiation characteristics of each subsystem must be measured over a partial spherical surface surrounding the vehicle and of sufficient radius to be outside the reactive near-field of the Device Under Test (DUT).

This paper describes a system designed to measure the radiation characteristics of antennas mounted on (and in) modern passenger vehicles. Typically these antennas were embedded in the windshields of vehicles and used to communicate with satellite radio systems.

2. The Spherical Scanner Subsystem

Vehicle mounted antenna systems are intended to cover the upper hemisphere surrounding the vehicle or a defined sector of that hemisphere. Spherical scanning systems are generally employed to measure the radiation pattern of the DUT. Scanner systems intended for vehicle measurements must address two specific challenges:

- The scan radius is generally large (6-12 meters). Drive systems must be robust and scanner structures must be very rigid to achieve satisfactory positioning accuracy.

- The phase center of the DUT can vary from near ground level to several meters above grade. The origin of the scanner coordinate system should be adjustable in height.

A scanner system satisfying the above objectives was designed and installed for Carlex Glass in Vonore, TN. The scanner uses a theta-over-phi distributed axis system. A 4.6 meter diameter turntable is installed in a pit to support the test vehicle and provide phi-axis motion. The turntable is enclosed by a 7.5 meter diameter fiberglass radome for environmental protection and visual security. In situations where the radome interferes with measurements, it can be easily removed using a forklift. The turntable was designed to support testing of vehicles up to 5 meters long and 2 meters high. Figure 1 shows the scanner site with the radome installed over the phi turntable (looking from the control room location).

Figure 1. Carlex Glass Vehicle Antenna Test Site

A gantry-style positioner with a 7.6 meter scan radius is used to provide theta-axis motion. The gantry truss is fabricated from structural fiberglass members to minimize reflections from the gantry structure. The gantry is counterbalanced and driven by a double reduction precision worm gear drive to prevent hazardous motion in the event of drive system power loss.

The theta positioner is mounted on a hydraulically activated vertical lift stage. The lift provides 2 meters of vertical motion. Figure 2 shows the positioner / lift system during factory testing.

The theta positioner and lift were installed in a pit adjacent to the phi turntable to allow the theta-axis to be continuously adjusted from below grade to 1.6 meters above grade. The installed theta positioner system is shown in Figure 3.

Both the theta and phi positioners use stepper-motor drive systems and provide 0.1 deg positioning accuracy. The range of motion for the theta-axis is -5 deg to +95 deg. The entire theta positioning system is lowered below grade for storage.

Final alignment of the theta- and phi-axes was accomplished using a laser position sensor system. Axis intersection was within 2 mm. Axis orthogonality was within 0.1 deg. The completed installation with the theta-axis in motion is shown in Figure 4.

Figure 2. Theta Positioner and Lift Stage

Figure 3. Theta Postioner Installed in Pit

Figure 4. Completed Vehicle Scanner System

3. The Instrumentation Subsystem

The Instrumentation Subsystem installed at the Carlex Glass site utilizes a Vector Network Analyzer (VNA) to perform passive radiation pattern measurements for antennas installed in a vehicle. Additional instrumentation can be added to the system to perform OTA measurements if required. Figure 5 is a simplified block diagram of the instrumentation system.

The Instrumentation Subsystem is controlled and operated through the Measurement Control Computer, which controls both the motion of the two spherical scanner axes and the measurement instrumentation. The motion indexer for this system is installed in a PCI slot in the Measurement Computer and it provides step and direction signals to the Motion Control Unit, which houses the Stepper Motor driver for each axis. The Motion Control Unit and motion indexer also monitor e-stop switches and travel limit switches on each axis.

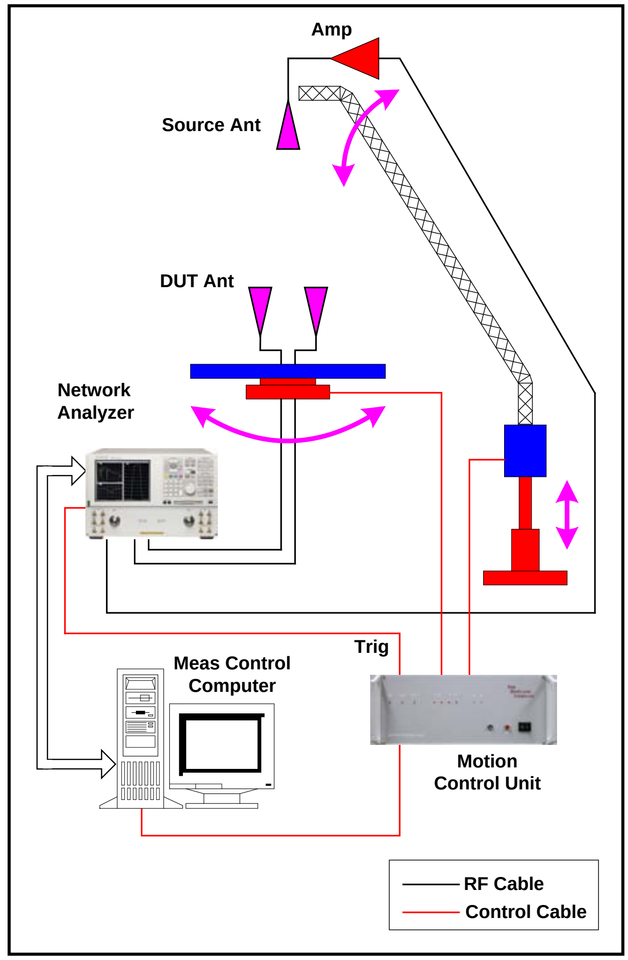

Figure 5 Simplified Block Diagram of the Instrumentation Subsystem

The Motion Control Software can be configured to generate a trigger signal to the external trigger input of the VNA to initialize a measurement sweep at specified positions of the scanner axes. Alternatively, the Measurement Control Computer can use the GPIB interface to control the VNA, trigger the measurement at the desired locations, collect the results from each sweep, and plot the measurement results over the complete hemisphere measurement.

4. Measurement Software

The Howland Company provides a modular measurement software solution that can be used to configure a test, control the scanner motion axes, control the VNA to perform a measurement at each of the desired scanner positions, collect the measurement results from the VNA, and graph the measurement results versus scanner position.

For the Carlex Glass facility, Howland WTL Module 10 software was installed. This Module provides test motion configuration and it provides a VNA external trigger input. Figure 6 show the control panel for the WTL Module 10 software.

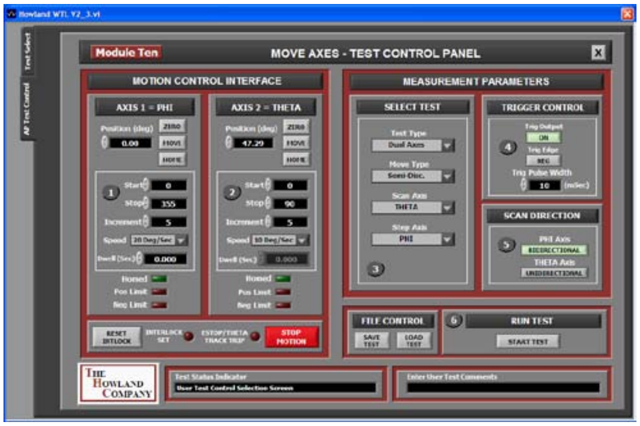

Figure 6. Howland WTL Module 10 Test Control Panel

The WTL Module 10 software can be configured to run its motion using either a single axis or both axes. Tests can run either in the Discrete mode or the Semi-Discrete mode. In the Discrete mode, the scan moves one or both axes to the desired measurement potion, stops the axes, and then triggers a measurement on the VNA. In the Semi-Discrete mode the scanner steps one of the axes to its desired position, stops it, then starts a scan on the second axis. In this mode, it provides triggers to the VNA at each of the angle increments desired without stopping the scan axis. Once the scan is completed the step axis is moved to its next position, stopped, the scan axis is again put in motion and a new set of triggers are sent to the VNA.

The WTL software has the capability to perform either unidirectional scans where each scan is performed in the same direction, or bi-directional scanning where the scan direction is alternated for each scan. Bi-directional scanning saves time by eliminating the retrace of the scan axis after each test as is required for unidirectional scanning.

The Howland WTL modular software package can be configured to run a suite of different tests. These test capabilities include Fast Multi-Frequency Antenna Pattern Measurements measuring both the magnitude and the phase of the received signal, OTA Total Radiated Power Measurements (TRP), and OTA Total Isotropic Sensitivity Measurements (TIS). For these tests the software takes full control over the necessary RF instrumentation to perform the test, collects the test results, and provides graphic results of the measurements.

5. The Completed System

The completed system is shown in Figure 4. It has been in service for more than a year. It is used to measure the radiation characteristics of satellite radio antenna systems embedded in the glass of automobiles.

The facility where the spherical scanner was installed was originally used to make far-field antenna patterns on AM/FM radio antennas. This capability has been preserved and in this mode the scanner is parked below grade.

For future requirements the spherical scanner system can be upgraded to accommodate higher frequencies and active measurements. Applications such as WiMax, WiFi, GPS, Bluetooth and cellular can all be accommodated with upgrades to the basic system. Additionally, the accuracy and stability of the spherical scanner would support the use of spherical near-field processing in cases where the range length of the spherical scanner was not adequate. The spherical scanner is also compatible with commercially available OTA software packages such as the Rohde & Schwarz AMS32.

6. Summary

A spherical scan measurement system designed for telematics applications has been described. Novel features of this system include the use of structural fiberglass in the design of the gantry and an elevator to set the height of the theta axis. The system is operational and is used to measure the radiation characteristics of antennas embedded in the windshields of automobiles.

7. REFERENCES

[1] A.R. Howland et al, "Novel Spherical Near-Field Antenna Measurement Techniques Advance State-of-the –Art", AMTA, October 2001.

[2] Svigelj, J. et al, "Correction of Antenna Phase Center Offsets in Outdoor Range Measurements", 2003 IEEE Antennas and Propagation Society International Symposium, Volume 3, Page(s): 808 – 811

8. ACKNOWLEDGEMENTS

The authors wish to thank Hisashi (Henry) Takanoya and Ross Freeman of Carlex Glass for their support and patience during the execution of this project.