A LOW COST SPHERICAL NEAR-FIELD SYSTEM

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ABSTRACT

The Spherical Near-Field measurement technique has been in existence for a number of years. The cost associated with this type of measurement system has often been assumed to be substantial. Herein is presented the system configuration for a low cost Spherical Near-field System whose design goals include the capability for production line testing while retaining simplicity in approach. NSI has been contracted to provide a Spherical Near-field antenna measurement system. This paper focuses upon the design considerations undertaken during the prototype development of that system.

Keywords: Spherical Near-Field Test Facility, Near-field Measurements, Rotation Stages, Probes, Alignment

1. INTRODUCTION

Near-field measurements have long been performed by many companies and individuals. The near-field measurement technique allows the facility to be totally enclosed and quite compact. This provides the user with a facility that can be closed off for testing of classified items.

Three types of near-field scanning are generally recognized as the defining parameters for the system and are largely determined by the type of AUT (Antenna Under Test) to be measured. They are:

Planar - for highly directive aperture antennas

Cylindrical - for less directional, fan beam type antennas

Spherical - for very broad beam antennas

Note that directive antennas can also be measured with both cylindrical and spherical scanners and that fan beam type antennas can also be measured with a spherical system.

The near-field test range under consideration is to be used in the production line testing of various flight articles for a major aerospace company rather than developmental testing. Therefore, the software features are highly tailored for each type of test article.

2. RANGE DESCRIPTION

The production line near-field range in this discussion will be housed inside an indoor anechoic chamber approximately 14 feet wide by 20 feet deep by 12 feet high. The AUT positioner is a Phi over AZ positioner with motorized translation capability to place the AUT phase center over the center of rotation. Two probes are mounted on separate towers and are described in

*Now with Hughes Space and Communication, Los Angeles, CA (310) 416-6037 more detail later. On the opposite end of the chamber is another tower with a polarization rotator that holds a source antenna to provide far-field measurements. The polarization rotator is used for axial ratio measurements. The equipment rack is located adjacent to the chamber. Control cables to the positioners, AUT and probes are routed underneath the floor and walkway absorber.

Figure 1 provides a block diagram of this test facility showing the interconnections between the motion control stages, the computer and the receiver. Figure 2 provides a layout of the chamber interior. Note that the range will be instrumented for both far-field and near-field measurements. At the near-field end of the chamber, two probes are mounted on separate towers.

Figures 3 and 4 provide photos of the prototype system and equipment rack.

3. DATA ACQUISITION SUBSYSTEM

The data acquisition system is a 5 axis stepper motor driven system. The controlled axes are AUT Azimuth, AUT Phi, Far-field Source Antenna Polarization, AUT translation and Probe translation. Each axis is controlled by the PC (Personal Computer) through an NSI Antenna Range Controller interface. This interface provides the current pulses to the stepper motors as well as returning the limit switch telemetry to the PC controller.

Table 3.1 Positioner Specifications

Parameter	Specification
Range Height	6 ft.
Azimuth Stage Rotation Speed (nominal)	20 deg/sec
Azimuth Stage Resolution	0.018°
Maximum Azimuth Load (centered)	300 lbs
AUT Translation Stage Travel	24 inches
AUT Translation Stage Resolution	0.01"
Far-field Source Polarization Rotation Stage Speed (maximum)	30 rpm
Far-field Source Polarization Rotation Stage Resolution	0.10°
Primary Probe Translator Travel	4 inches
Secondary Probe Translator Travel (manual control)	4 inches
Phi Stage Head Rotation Speed	20 deg/sec
Phi Rotation Stage Resolution	0.01°

Phi Stage Maximum Load	

Table 3.1 Positioner Specifications

Table 3.1 contains various parameters of the range with emphasis on the specifications of the various motion stages.

4. RF SUBSYSTEM

The RF subsystem is comprised of the circular waveguide probes, cabling, rotary joints and receiver. The receiver used in this system is the HP 8530A Microwave Receiver utilizing an HP 8511 test set and 83620 synthesizer. The receiver is housed in its own test equipment rack that also includes the NSI Antenna Range Controller. The receiver is triggered by the PC which is also controlling the movement of the various motorized stages. Data is collected bi-directionally on the fly.

Semi-rigid phase stable cable is used to connect the receiver to the various rotary stages or to items that do not require constant motion (e.g., probes or the fixed end of a rotary joint). Flexible low loss, phase stable cables are used to connect the test articles wherever movement is required. Low phase wow rotary joints are also utilized to minimize the effects of cable flex wherever possible. They are used in the AUT rotation stage and Far-field Source Antenna polarization rotator.

Two probes are used to cover separate frequency bands. The two probes are mounted on separate towers. This is done to eliminate the need to change probes when testing units over the 2nd frequency band and thus the need to reverify probe alignment. The software allows the scan to be centered about either probe. The probes with circularly symmetric radiation patterns are of circular waveguide construction with orthomode transducers which provide dual linear orthogonal signals. A high speed computer controlled PIN diode switch is used to select between channels. The probes were fabricated and calibrated by Hughes. The switch allows the measurement of both orthogonal polarizations in one scan. Isolators are used on the input to the probes. An 8PST computer controlled PIN diode switch is also included to switch between various AUT beam ports.

5. COMPUTER/PROCESSING SUBSYSTEM

The Spherical Near-field controller and processing computer is a MAG 486/DX2 66MHz tower PC. It is equipped with a 1.44 MB 3.5" floppy drive and dual Bernoulli disk drives which are removable. Each removable drive has a 150 MB capacity. The PC contains 32 MB of RAM and includes a 15" SVGA monitor. The interface to the receiver and Antenna Range controller is through GPIB and Digital I/O cards respectively. An HP Laserjet 4 printer provides hard copy output. The Bernoulli drives satisfy the customer's security requirements by providing removable media. The tradeoff is in the slower response of the computer.

6. ALIGNMENT

The alignment of the Spherical Near-Field motion stages will be accomplished during installation with optical tooling. A theodolite or sight level can be used to establish the alignments of the various rotation stages. The first device that is aligned is the Azimuth/Translation stage so that the Azimuth axis of rotation is aligned to gravity. The sighting scope is then aligned to this axis at the correct height (6') and is used to position both of the near-field probes and the far-field source antenna. The primary spherical near-field probe is aligned along the same line of sight as the far-field source antenna. The secondary probe's angular offset in azimuth can be accurately measured with either the theodolite or the computer after installation of the azimuth stage. Finally, the phi rotation stage is aligned to the far-field source antenna axis of rotation.

7. EQUIPMENT INTERFACES

The interfaces that were required included:

1) PC to Antenna Range Controller

2) Antenna Range Controller to Motion Stages

3) PC to HP 8530A Receiver

These are described in the following paragraphs.

PC/Antenna Range Controller Interface

The ARC (Antenna Range Controller) box converts the pulses from the PC into current pulses to drive the stepper motors of the various rotation and translation stages. The limit switch telemetry is also fed back through the ARC box to the computer. The trigger for the HP 8530A Receiver is fed through the ARC box. The PC utilizes a Digital I/O card to interface to the ARC box.

ARC Box/Motion Stages Interface

The ARC box is connected to each motorized stage via a single motor cable to each motion stage that also carries the limit switch telemetry. This makes for simple installation and maintenance.

PC/HP 8530A Receiver Interface

The PC communicates to the HP 8530A Receiver via a standard National Instruments GPIB card. It is connected directly to the HP 8530A. The event trigger is generated by the PC and is buffered through the ARC box to the receiver.

8. SOFTWARE

This system uses much of the standard NSI Near-field Antenna Measurement Software Package. However, it has been adapted to incorporate spherical near-field processing. The software incorporates the NIST algorithm and transform to generate the far-field patterns.

Since the system is to be used as a production line test station, much simplification was required in order to custom tailor the testing activity for specific parameters. The normal menu driven user interface, which provides a highly interactive environment and rapid response, needed to be greatly simplified so that only a narrow range of its capabilities were exploited. The most efficient method of accomplishing this task was to make the NSI near-field software executable from a customer written executive program. The NSI software also outputs the far-field data in a format that the customer-generated pass/fail analysis software can accept. This pass/fail analysis software is currently used on a customer operated far-field range.

Should the test article fail to meet its specs or the need for troubleshooting arise, the NSI software is accessible to the test engineer via a special code for direct interaction.

The software performs bidirectional scanning and multiple parameter scan set up. The software can supports an 8-port PIN diode switch used to measure multiple beams. For a detailed description of these features refer to reference 1.

Far-field processing is performed via NIST FFT algorithms. While most of the features of the NSI software will not be exploited during production line testing, the data can be presented in a variety of formats including gray scale imaging, contour plots, 3D plots, E & H plane patterns, and ASCII files. Holographic processing is another powerful feature that will be available to the test engineer during troubleshooting. It will allow one to examine the radiated field at any arbitrary point in Z. However, in this controlled test environment, the output of the testing will be very limited and simplified to an unclassified form.

9. ABSORBER AND CHAMBER CONSTRUCTION

Rantec Corporation was contracted by the customer to provide the chamber absorber layout and installation. The construction utilized walls typically used for in-plant offices to maximize strength while minimizing cost. The pyramidal absorber and walkway absorber were selected to provide a -50 dB quiet zone at the AUT location.

10. SUMMARY

A low cost Spherical Near-Field Measurement System has been presented. Much of its lower cost results from its simplified approach. That is, the utilization of simple motion control stages that are less expensive yet highly accurate and simplified software performance requirements (output).

REFERENCES

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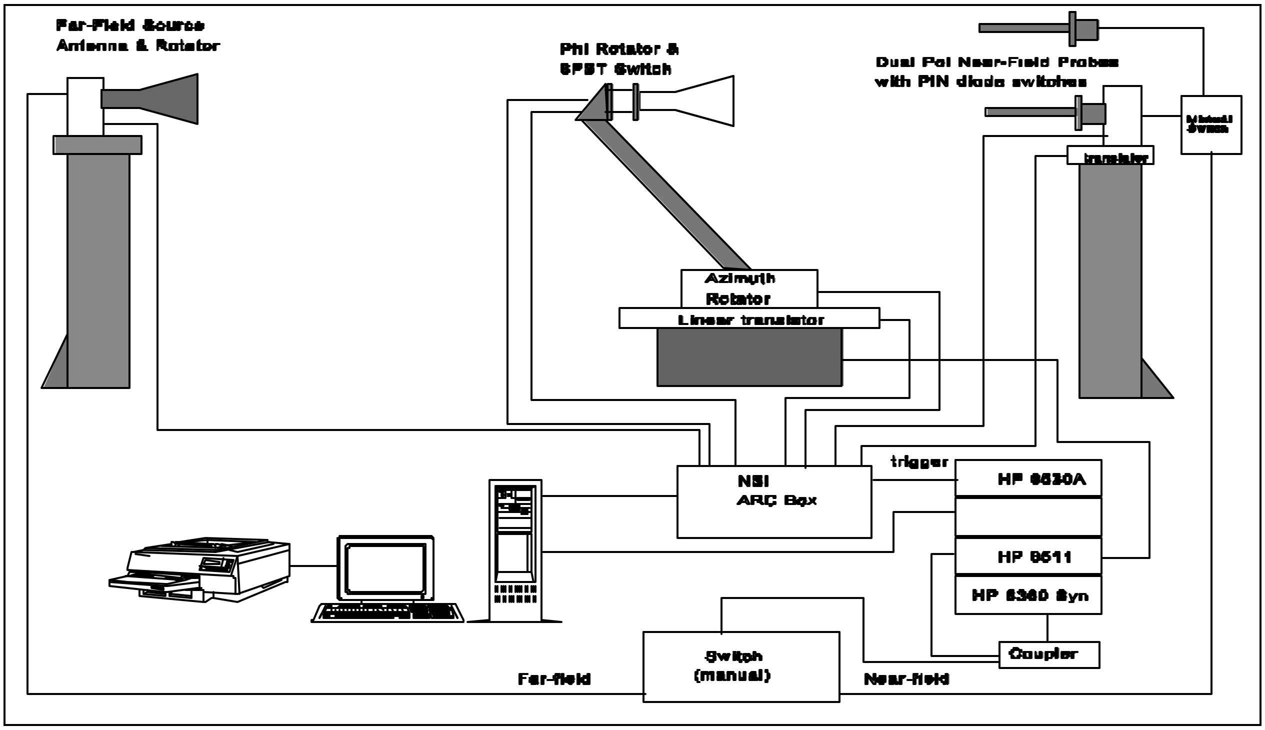

Figure 1 Near-field System Block Diagram

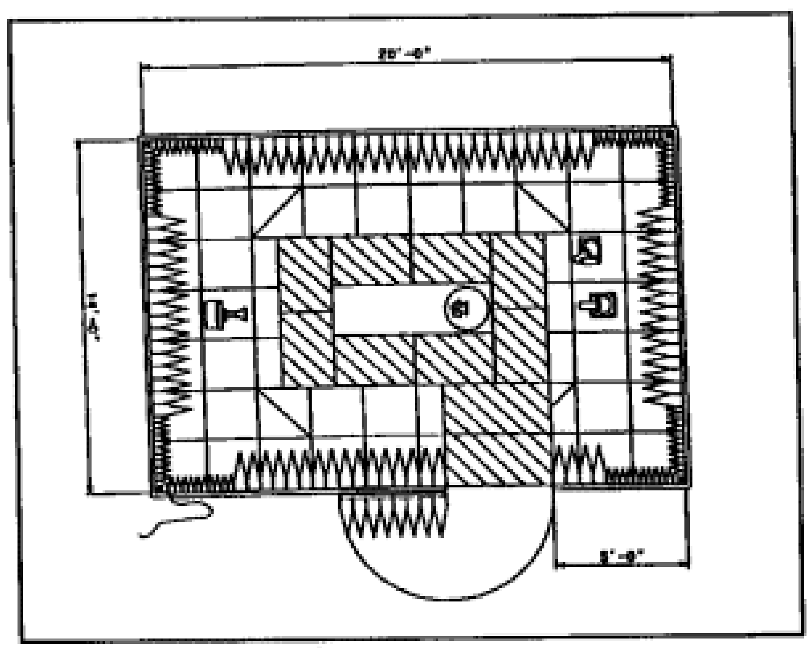

Figure 2 Spherical Near-Field Chamber Layout

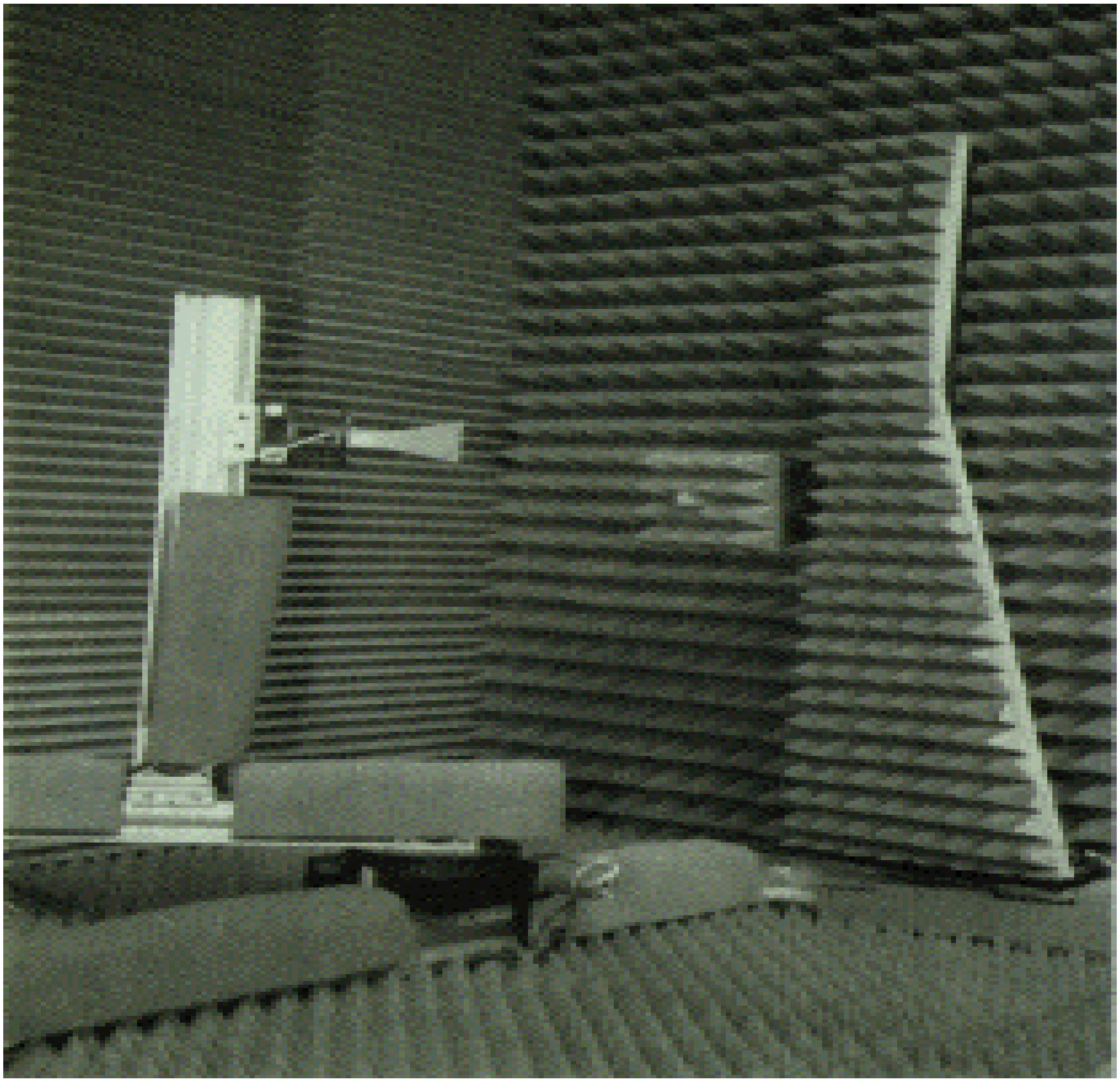

Figure 3NSI Spherical Near-Field Test Facility

Figure 4 NSI Sherical Near-Field Test Equipment