IMPLEMENTATION OF A 22' X 22' PLANAR NEAR-FIELD SYSTEM FOR SATELLITE ANTENNA MEASUREMENTS

Antenna Measurement Techniques Association Conference
October 4-8, 1993

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ABSTRACT

Design and implementation of a large horizontal planar near-field system delivered to Space Systems / Loral for satellite antenna testing will be discussed. The 22' by 22' scan plane is 25' above the ground and employs real-time optical compensation for the X,Y, and Z corrections to the probe position. The system provides high-speed multiplexed near-field measurements using NSI's software and the HP-8530A microwave receiver. System throughput is enhanced through the use of a powerful and flexible test sequencer software module.

Keywords: Near-field, satellite testing,

1. INTRODUCTION

Satellite antenna test verification can be done using a variety of methods including near-field, far-field, compact range, or analysis with measured feed data. Outdoor far-field testing is undesirable due to factors such as weather, gravity effects, handling and transportation issues, and real estate investment requirements. Large aperture sizes demand large and expensive compact range systems. A planar near-field range becomes quite attractive by comparison to other methods. Following is a partial list of advantages of the planar near-field technique:

- Minimal real-estate requirements
- Lower cost than compact range
- No motion of test antenna or satellite
- More symmetrical gravity effects on antennas
- Co-located with spacecraft assembly area
- High accuracy and high test throughput
- Complete characterization of antenna

For these reasons, Space Systems Loral selected Nearfield Systems Inc. to implement a large precision planar near-field system for tests on their satellite antennas. NSI's scanner design includes a high accuracy optical system for tracking and correcting the probe position errors. The RF subsystem includes a high speed Hewlett Packard 8530A microwave receiver used in the dual-source external mixer configuration, and several custom built dual-port probes calibrated by NIST.

2. DESIGN REQUIREMENTS

Figure 1 summarizes the design requirements for the system. Key among these was to provide high throughput for the development and production tests required on the project. The frequency coverage was from 2.5 to 15 GHz over 5 specific bands. Multiplexing requirements were to measure up to 80 switch and frequency configurations on the fly while scanning at speeds up to 17 inches per second. The data is typically taken for 10 frequencies, 4 antenna beam ports, and 2 polarizations during a given data acquisition scan. The gain accuracy and cross polarization requirements dictated the need for low cross polarization probes and NIST calibration.

3. HARDWARE DESCRIPTION

SCANNER - The scanner consists of two X-axis rails spanned by a Y-axis bridge. The X motion is accomplished using motor drives at both rails, synchronized by the computer software and running at speeds up to 10 inches per second. The Y axis motion is accomplished using a high speed belt drive system providing probe scan speeds up to 17 inches per second. The scanner is mounted on top of a steel support frame, putting the system approximately 25 feet in the air to allow clearance for the antennas and the complete satellite if required. The scanner orientation with respect to the test antenna is shown in figures 2 and 3.

The system is also provided with 10" of Z-axis travel for changing the probe to antenna spacing, and a rotator for use with single polarization probes. The spacecraft antenna is mounted on a cart with nearly 5' of vertical motion to position the antenna at the correct height with respect to the scanner.

OPTICAL STRUCTURE MONITOR - Because the system is located in a seismically active area in California, a basic design objective was to allow for and compensate for some movement of the structure due to ground settling and small earthquake effects. An optical structure monitoring system was designed and implemented to track probe X and Y linear positions, and probe X,Y, and Z errors. The system uses HP laser interferometers for the linear position feedback, and a custom designed NSI optical subsystem for measuring the probe position errors. The probe Z position error is derived using a spinning plane laser tracked by a sensor at the probe. A major advantage of this optical structure monitor concept is that it reduces the design requirements on the scanner and can yield a much more cost effective design than traditional mechanical design methods.

RF PROBES - Four dual-polarization probes were implemented to cover the bands of interest. Because the test antennas were large and the far-field coverage requirements were quite narrow, high gain probes were desirable(1). The Ku-band probe was dual-linear, and the lower frequency probes were dual-CP. Comsat was selected to design and fabricate the probes, and NIST gain and pattern calibrations were performed on each probe. Figure 4 shows one of the probe assemblies.

RF EQUIPMENT - The RF subsystem is designed around a Hewlett Packard 8530A receiver. The Hewlett Packard equipment was selected because of its high performance and excellent reliability. The multiple frequency switching requirements and cable lengths dictated selection of the dual-source, external mixer system configuration for the HP-8530. The H50 mixer option was chosen which allows operation of the system up to 50 GHz without the need to purchase additional source or receiving equipment. Figure 5 is a block diagram of the RF equipment implemented on the range.

COMPUTER EQUIPMENT - The system runs from a single Compaq 486/50 computer, with a second identical computer provided for additional data processing capability. The systems each have 36 Mbytes of RAM and a 500 Mbyte hard disk drive with tape backup. Computer interface cards include the IEEE-488 interface to the RF equipment, and a Digital Signal Processor (DSP) for interfacing with the optical subsystem.

4. SOFTWARE DESCRIPTION

The software uses NSI's PC-based menu-driven software package. Additional modules were implemented for the optical structure monitoring system, and the time synchronization requirements for the multiple frequency measurements.

The optical module reads the various sensors and derives the probe X,Y and Z position errors. These errors are then used to provide either corrections during data processing, or to actually correct the probe position real-time while scanning. For instance, small movements of the X and Z axes while scanning the Y axis can be used to keep the probe moving in a straight line.

The synchronization module required the PC to take direct control of the HP-8360 sources. Both units are fed with a frequency list at the beginning of each forward or reverse scan. The sources can then be triggered from the PC while scanning with a TTL trigger line. Since the list of one unit is offset from the other by 20 MHz, the HP-8530A receiver remains phase locked and in its fast data mode during the entire measurement sequence. The PC simply triggers the receiver at the appropriate times and reads the data from its buffer. The frequency lists are scanned in reverse order on the reverse pass to insure the near-field points at a given frequency are spatially aligned with the forward pass.

The NSI software also has a built-in expert system and an automated test sequencer. The expert system aids the operator in designing the near-field test and insuring the test parameters selected will yield acceptable results. The automated test sequencer allows complex test scenarios to be set up by an experienced range technician, and run by novice operators with a minimum of keystrokes. These enhancements help increase the productivity of the system, and are described in further detail in another paper[2].

5. SUMMARY

A state-of-the-art near-field test range has been implemented by NSI at Space Systems / Loral for large satellite antenna testing. The system uses a novel real-time optical monitoring system which allows system accuracy to be maintained even with scanner settling and degradation due to seismic motion. The software incorporates a fast, flexible beam multiplexer to achieve high test throughput. An expert system and automated test sequencer are used to help the operator design and implement the required tests.

REFERENCES

1. Near-field Antenna Measurements, by Dan Slater, Artech House, Norwood, MA, 1991.

2. An Automated Test Sequencer for High Volume Near-Field Measurements, by Greg Hindman, Dan Slater, Antenna Measurement Techniques Association (AMTA) symposium, October, 1993.

Parameter	Requirement	Design Constraint
Scan Area	22' x 22'	Scanner to fit in existing Loral chamber
Test configuration	Antenna pointing up w.r.t. gravity	Scanner elevated 25 ft above floor.
Frequency range	General requirement 2.5-40 GHz Optimized for 5 bands 2.5-15 GHz	Wide frequency range - used HP H-50 external mixers
Multiplexed data while continuously scanning	2-polariz. by 4-Beams by 10-Freqs	Fast, accurate source and receiver triggering - NSI DSP synchronizer
Gain measurement accuracy	0.25 dB	Probe gain calibrated at NIST
Cross-polarization accuracy	0.75 dB at -27 dB	Low cross-pol probe - Comsat laboratories
Pointing accuracy	0.02?	Accurate Z-plane

Figure 1-- System Design Requirements

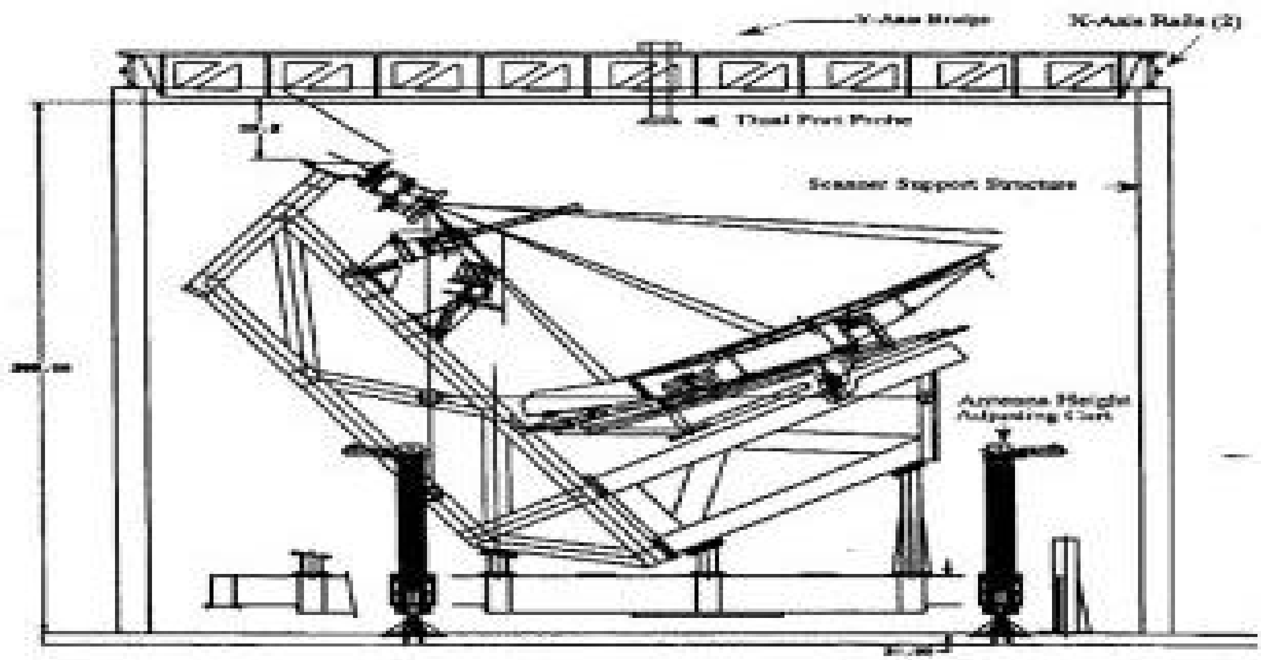

Figure 2 NSI Scanner Y-Axis Bridge Above SS/L Antenna

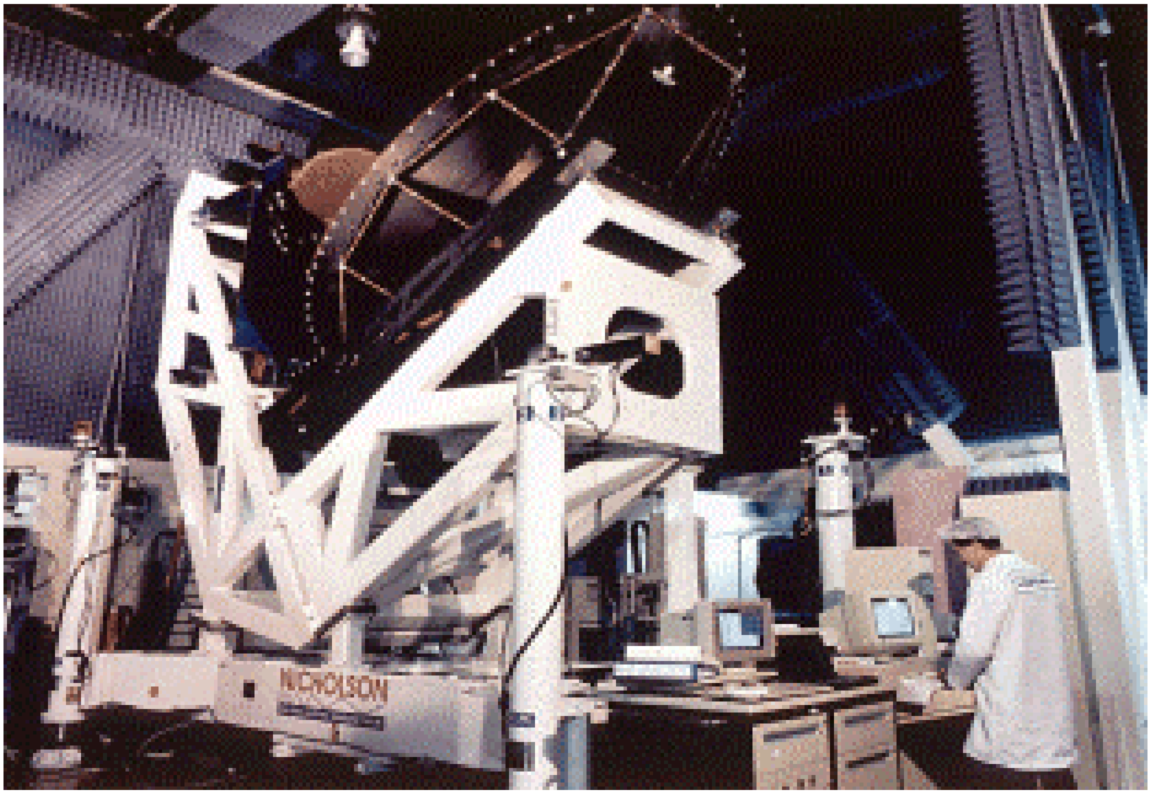

Figure 3 - NSI Scanner Testing SS/L Antenna

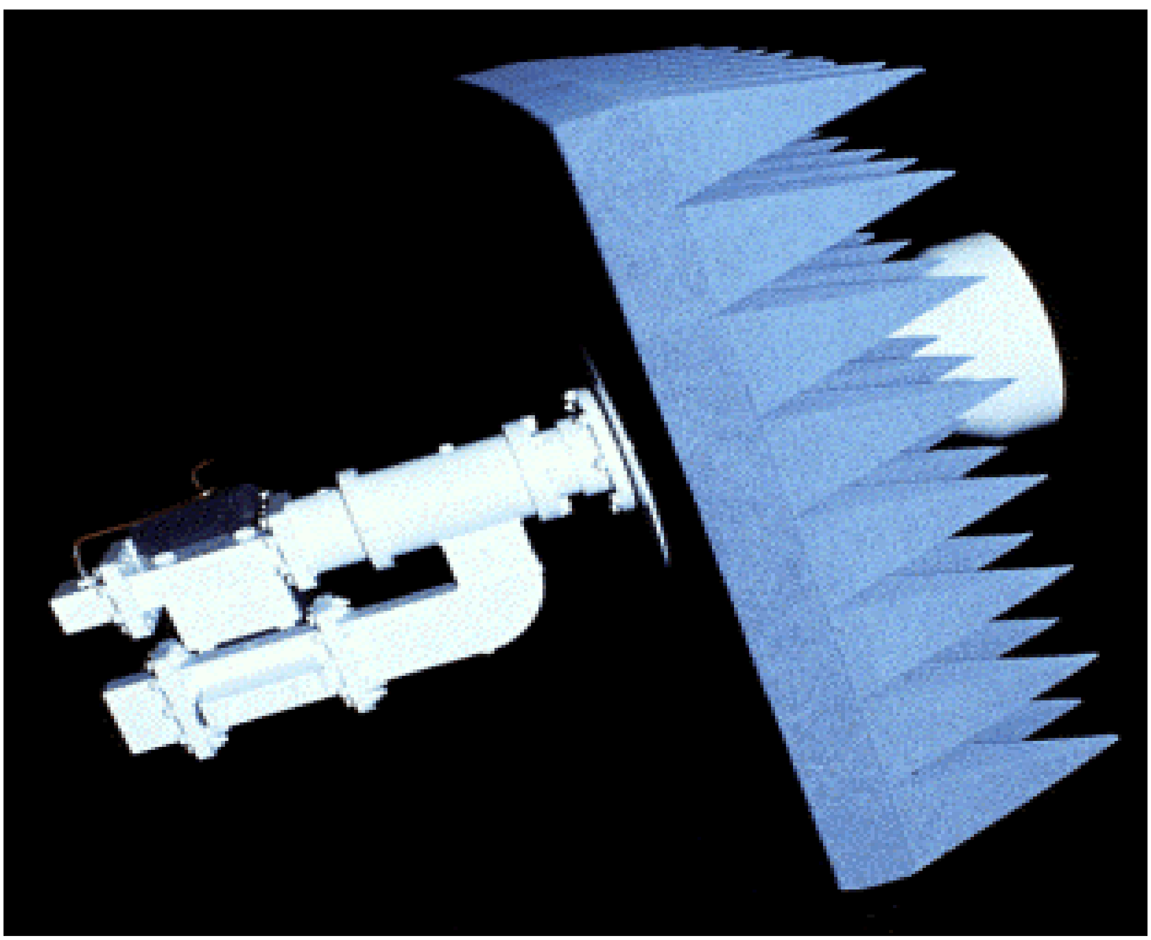

Figure 4 - Dual-Polarization Probe Assembly

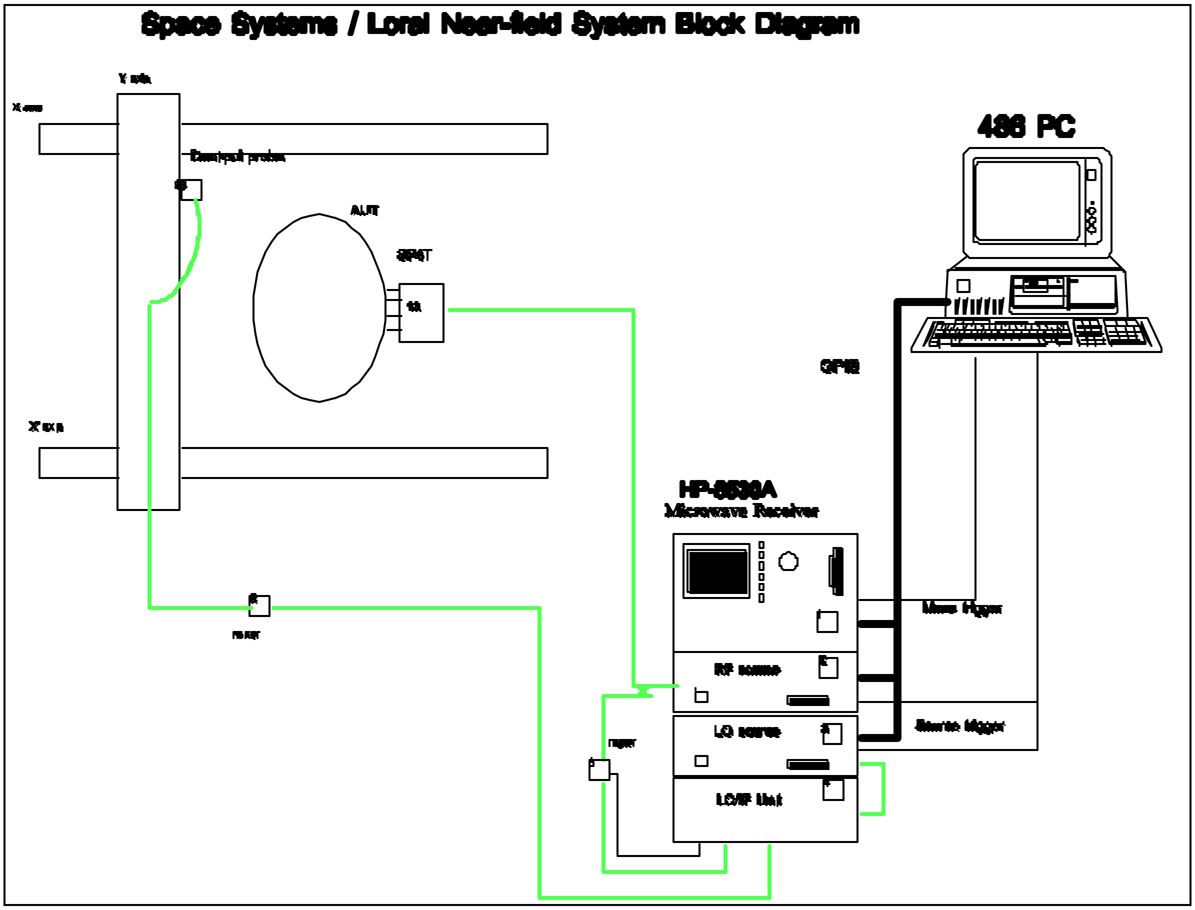

Figure 5 - SS/L RF Sub-system Block Diagram