A PORTABLE 4.5m x 2.0m NEAR-FIELD SCANNER

Antenna Measurement Techniques Association Conference
November 13-17, 1995

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ABSTRACT

Portable scanners used for near-field antenna measurements are usually incapable of providing a large scan area with a high degree of probe position accuracy. This paper discusses a 4.5m x 2.0m portable scanner developed by NSI with a probe position accuracy on the order of 2 mils (0.050 mm) rms. An NSI patented optical measurement system measures the X, Y, and Z position, and provides real-time position correction capability. This lightweight, portable scanner combined with optical correction provides enhanced accuracy while reducing overall antenna measurement system costs and improving test chamber flexibility.

Keywords: Portable, Near-field, Antenna, Optical, Accuracy

1. INTRODUCTION

The portable scanner has a 4.5m x 2.0m vertical scan plane, supported by a lightweight base with retractable wheels, and employs real-time optical compensation for X,Y, and Z correction to the probe position. A patented laser optical tracking system in a small highly integrated package was developed to provide precise probe alignment in spite of the inaccuracies associated with the lightweight mechanical structure. The scanner, as shown in Figure 1, is fully computer controlled and designed to acquire and process near-field antenna measurements using NSI's software and the HP 8530A microwave receiver. System flexibility is enhanced through the use of a GPIB slave operating mode which allows the scanner to function as a robotic controller.

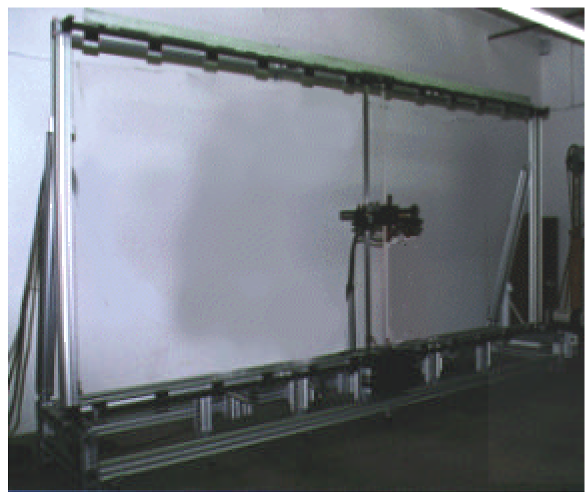

Figure 1 4.5m x 2.0m Portable Scanner

2. OPTICAL SUBSYSTEM DESCRIPTION

The overall optical subsystem, shown in Figure 2, includes a linear XY Laser, patented NSI-OP-5906A optics package, Z-plane spinning Laser, Z-plane sensor, and a twist compensation Z-retro tracker. The NSI-OP-5906A uses the linear XY laser to measure X-axis and Y-axis distance to within .001 mm. The NSI-OP-5906A also measures the following four error components:

- Y-error along the X-axis

- Z-error along the X-axis
- X-error along the Y-axis
- Z-error along the Y-axis

A spinning Z-plane laser is used to define the XY scan plane. The NSI Z-plane sensor is used to measure the Z-error as the probe platform is moved about the XY scan area. The Z-error at each prescribed location is stored in an error map and used by the position correction software to move the probe, in real-time, to create an essentially perfect scan plane. Similarly, the Y-error and X-error information is also used by the position correction software to move the scanner to the corrected position.

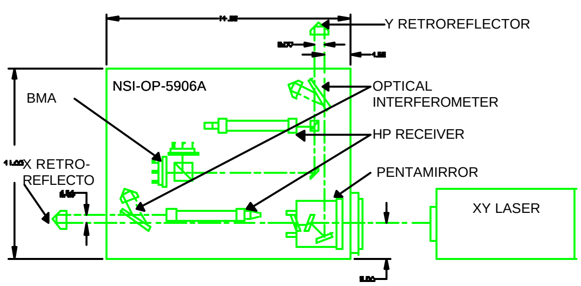

Figure 2 Scanner Optics Block Diagram

3. NSI OPTICAL MEASUREMENT SYSTEM

The NSI-OP-5906A Optical Measurement System (OMS) as shown in Figure 3 represents a 25% reduction in size and a corresponding reduction in weight from the previous design[1]. Other features include improved alignment capability and improved packaging. All XY optics except for the laser head and X & Y retroreflector assemblies are included inside the OMS. The OMS is sealed inside a rugged case with filtered windows to minimize environmental effects and stray light contamination. The OMS is factory aligned and calibrated so there are no adjustments or controls required. On the portable scanner, the OMS is mounted to the X-carriage on a gimbaled mounting assembly so that the entire optics assembly can be aligned about the axis of the laser beam for ease of vertical alignment.

X and Y-position information is derived using standard HP doppler receivers and NSI interferometers. The output of the receivers are converted to quadrature signals for X and Y distance and sent to the computer for processing.

The Beam Monitor Assembly (BMA) measures four components of scanner error: Yerr, Zyerr, Xerr, and Zxerr. These errors are used during initial scanner alignment and during periodic calibration of the scan plane.

All optics data is sent to the computer via the NSI-OP-5905 DSP interface unit located in the receiving system console.

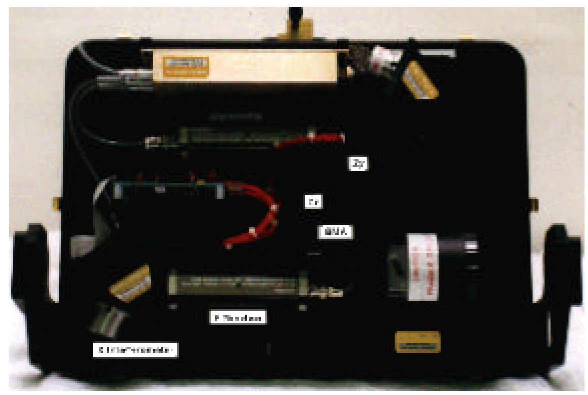

Figure 3 NSI-OP-5906A Optics Package

4. Z-PLANE MEASUREMENTS

The Z-plane laser measurement system consists of a rotating Z-plane laser installed at the base of the scanner and a Z-plane sensor mounted on the probe antenna platform at a 45 degree angle. The Z-plane sensor is connected by cable to the DSP interface unit which supplies power and receives the processed photodetector information.

The NSI-OP-5908 Z-plane laser provides the rotating laser beam. The laser plane generator consists of a stabilized horizontal laser beam with a spinning pentamirror which turns the beam precisely 90 degrees to produce a highly accurate vertical plane. Once set up and leveled manually, autoleveling of the laser is accomplished by an internal biaxial tilt meter and dual-axis servo loop. After rough leveling to within ±4 degrees, the laser has automatic re-leveling, and its electronic compensation shuts off the laser beam when knocked out of level or plumb, then turns it on again only after the laser has been automatically releveled or replumbed.

The NSI-OP-5904 Z-plane sensor, shown in Figure 5, is mounted on the probe antenna platform at a 45 degree angle for illumination by the rotating Z-plane laser beam. It detects and processes probe Z-plane error and provides that information to the computer for analysis. It has a measurement range of ±0.1 inch with 0.001 inch rms accuracy. Power-on and beam detection LEDs provide visual status indication.

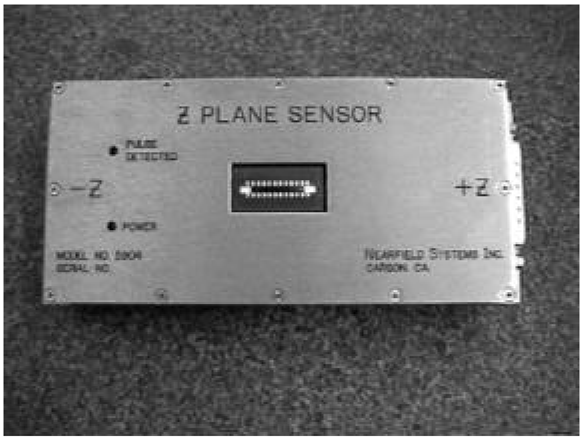

Figure 4 NSI Z-Plane Sensor

Figure 5 shows an example of a three dimensional uncorrected Z-plane map of the scanner using data collected by the Z-plane subsystem. The uncorrected planarity shown is 0.450 mm rms. With the Z-axis structure monitor enabled, scanner planarity was improved to 0.050 mm rms.

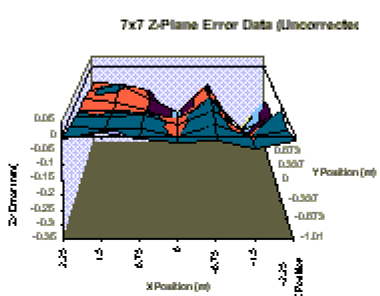

Figure 5 Scanner Planarity Measured by the Z-Laser Subsystem (Uncorrected)

5. TWIST COMPENSATION

Many lightweight scanners are vulnerable to twisting of the horizontal rail as the carriage moves along its intended line of travel. Those which carry a heavy payload or an extended probe are particularly susceptible to this condition as well as other types of scanner deformation. These twists can create tracking errors which may be beyond the ability of the standard laser receiver to operate. NSI has developed a technique, using real time software tracking and a small motorized retro adjuster, to eliminate the errors and keep the laser system aligned. Figure 6 shows measurements of the Zx error as a function of Y for 7 different X positions. In this case, the error was caused by a combination of bowing in the upper X rail and twist in the lower X rail. Figure 7 shows the results with the NSI optics system enabled.

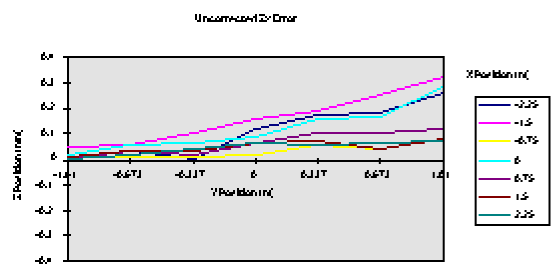

Figure 6 Scanner Zx Error Before Correction

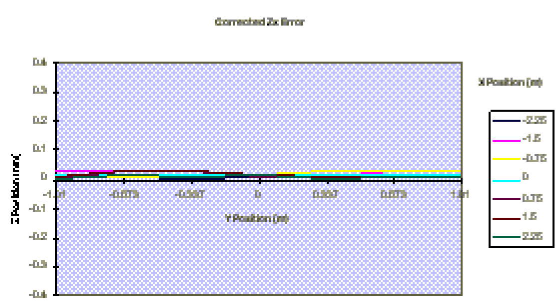

Figure 7 Scanner Zx Error After Correction

7. SOFTWARE

The NSI data acquisition software includes the following functions:

- Sensor signal processing
- Deformation table and adaptive filter
- Scanner error correction on-the-fly
- Real time sensor displays
- Automatic data recording for calibration
- Tracking of Y-axis retrotracker in Z direction.

The deformation table is used because the optical sensor measurements are subject to atmospheric noise, and require averaging over time to enhance the signal-to-noise ratio. The table size is selectable and is dependent on the straightness of the scanner. Low frequency warpage due to manufacturing tolerances or rail bowing can be handled typically with small grid sizes.

The real time sensor displays, and ability to plot the sensor data versus X or Y motion are invaluable tools for scanner rail alignment and as an aid during the system optical alignment process. The real-time sensor displays may also be plotted versus time for stability and sensitivity testing. During RF data acquisition, the NSI software will scan the Y-axis while performing cross-axis corrections of the probe postion by stepping the X-axis and Z-axis stepper motors, according to the interpolated values derived from the deformation table.

9. SUMMARY

NSI has implemented a number of optical correction systems on large scanners[2][3]. NSI has also delivered many small, portable scanners with very good accuracy over a small (1m x 1m) scan area[4]. This paper has described the application of a small optics package to improve the measurement accuracy of a relatively large (4.5m x 2.0m), lightweight, portable scanner. Novel optical techniques have been used to significantly improve scanner accuracy problems associated with the lightweight structure. A large, lightweight, portable structure is a low cost option for antenna measurement facilities which require flexibility in chamber usage, yet need the high degree of accuracy normally only available with a more stable, permanent structure.

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