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Implementing an Automated Antenna Measurement System

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Category
R&D/Lab Automation

Products Used
LabView 6.1

The Challenge
Automating the data collection process for the characterization of a microwave feed horn for use in a reflectarray antenna.

The Solution
Using LabView 6.1 to control an X-Y positioning system and perform microwave frequency measurements using an Automatic Network Analyzer (ANA).

Abstract
We developed an automated measurement system using a PC running a LabView application, a Velmex BiSlide X-Y positioner, and a HP8510C network analyzer. The system provides high positioning accuracy and requires no user supervision. After the user inputs the necessary parameters into the LabView application, LabView controls the motor positioning and performs the data acquisition. Current parameters and measured data are shown on the PC display in two 3-d graphs and updated after every data point is collected. The final output is a formatted data file for later processing.

Introduction
The National Aeronautics and Space Administration at Glenn Research Center has been developing a Ka-Band reflectarray antenna for low earth orbiting communications satellites and other remote sensing and industrial applications. A reflectarray phased array antenna has been designed so that the radiating surface has no RF feedthroughs, but instead consists of a plane of small patch antennas, each with its own phase shifter. The 28 cm diameter circular aperture is illuminated from a dual-mode microwave feed horn mounted perpendicularly to the center of the surface.
The phase shifters of the entire surface may be adjusted to electronically steer the main beam of the antenna to a specific direction.

The Ka-Band reflectarray design requires 616 modules, each consisting of a patch antenna and a phase shifter. These modules are mounted in a rectangular grid pattern arranged to approximate a circular outline. A rendering of the setup is shown in Figure 1.

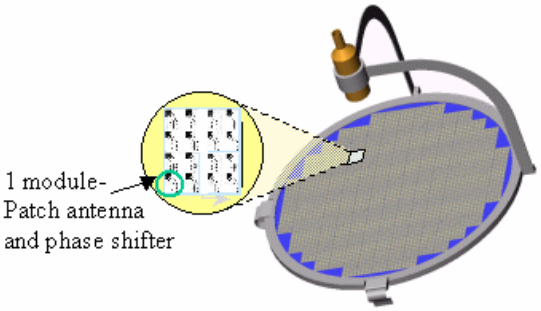

Figure 1.—Reflectarray Patch and Phase Shifter Layout.

The computer program used to control the phase shifters assumes an incoming planar wave front. However, the feed horn produces a spherical phase front. Precise characterization of the horn's phase front is necessary for compensation and to ensure a cophasal reradiated beam. To do this, the relative phase of the signal at each of the 616 patch antenna locations must be measured and incorporated into the control program.

Originally a manually adjustable X-Y positioning system was constructed to measure the principal E- and H- plan patterns of the horn. Asymmetries in these measurements pointed to either real asymmetries in the horn pattern or inaccuracies in the measurement setup. A more accurate positioning system was needed.

Implementation

LabView 6.1 provided an easy solution to this automation task. Its interoperability with GPIB made it an obvious choice for interfacing with the network analyzer. It also contained built-in functionality for RS-232 serial communications. This feature was important because a Velmex VP9000 X-Y positioning system was to be operated via serial communications with the PC.

A LabView application was written to control the experimental setup shown in Figure 2 and Figure 3. When the program is started, the motor stage jog controls are enabled. The user aligns the center of the patch to the laser point using the jog controls. Once this is done, the microwave coax-to-waveguide transition is attached to the feed horn and the laser is turned off. The program is then flipped into measurement mode. This sets the current motor positions to 0 and initializes the network analyzer with the specified parameters.

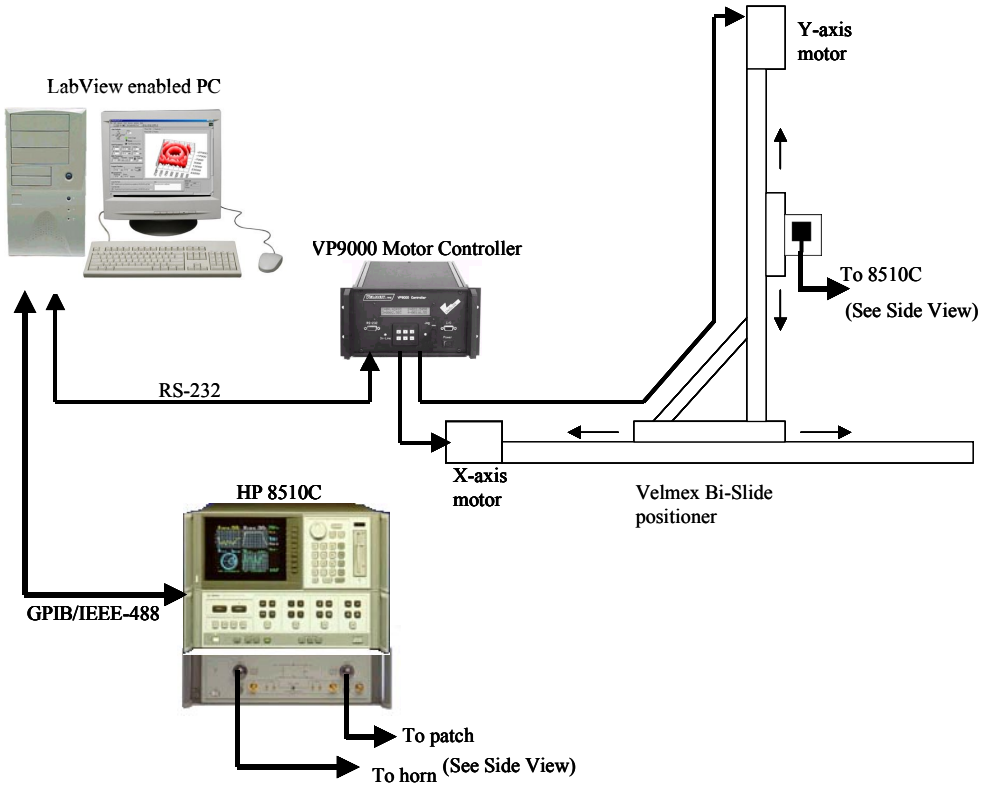

Figure 2.—Schematic representation of the Antenna Measurement System

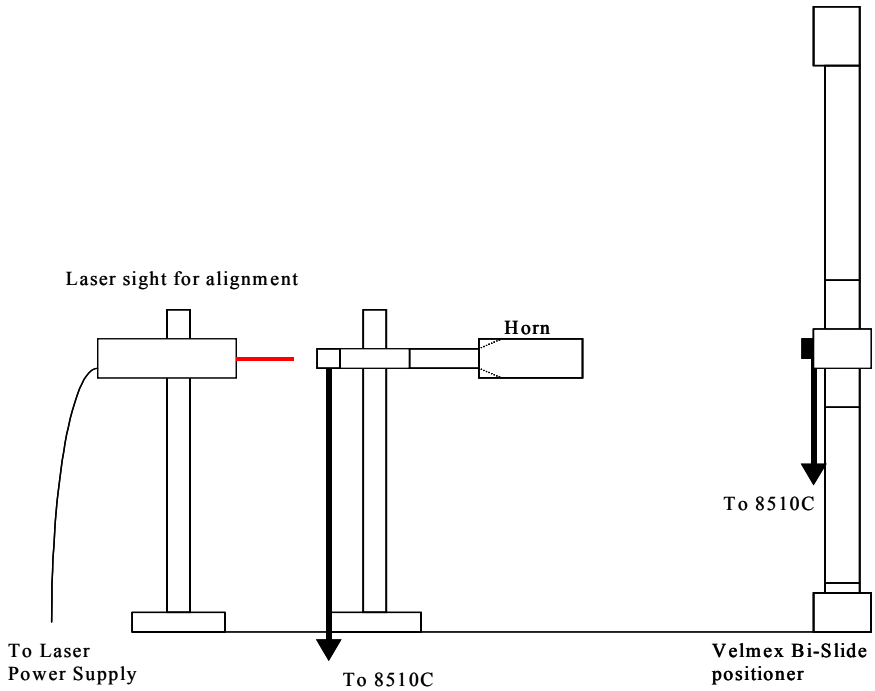

Figure 3.—Side view of the experimental setup showing location of horn and laser alignment

The LabView application then begins the positioning/measurement loop. Absolute coordinates are sent to the motor controller from the computer over the RS-232 interface. The motor controller positions the patch at the desired location. LabView then instructs the network analyzer using GPIB to measure the desired data. The collected data is plotted in a 3-dimensional graph and updated after each point is read. Two graphs show relative phase of S_{21} plotted against X and Y position and relative magnitude of S_{21} plotted against X and Y position. This process is repeated for each of the 616 positions on the reflectarray surface. Once the program has completed the measurements, two data files are created in a user-specified location. One file contains the raw data ready to be loaded into Excel or Mathcad for further processing. The other contains a complete listing of the on-screen parameters used to perform the measurement. A text box allows the user to enter any descriptive information about the measurement for later reference. A screen shot of a completed measurement run can be seen in Figure 4. One would expect the Phase Shift plot to be a paraboloid, and indeed it is. However, breaks are introduced as the values shift from –180 degrees to 180 degrees. The numbers on the two position axes use the motor controller scale, and the z-axis is in degrees.

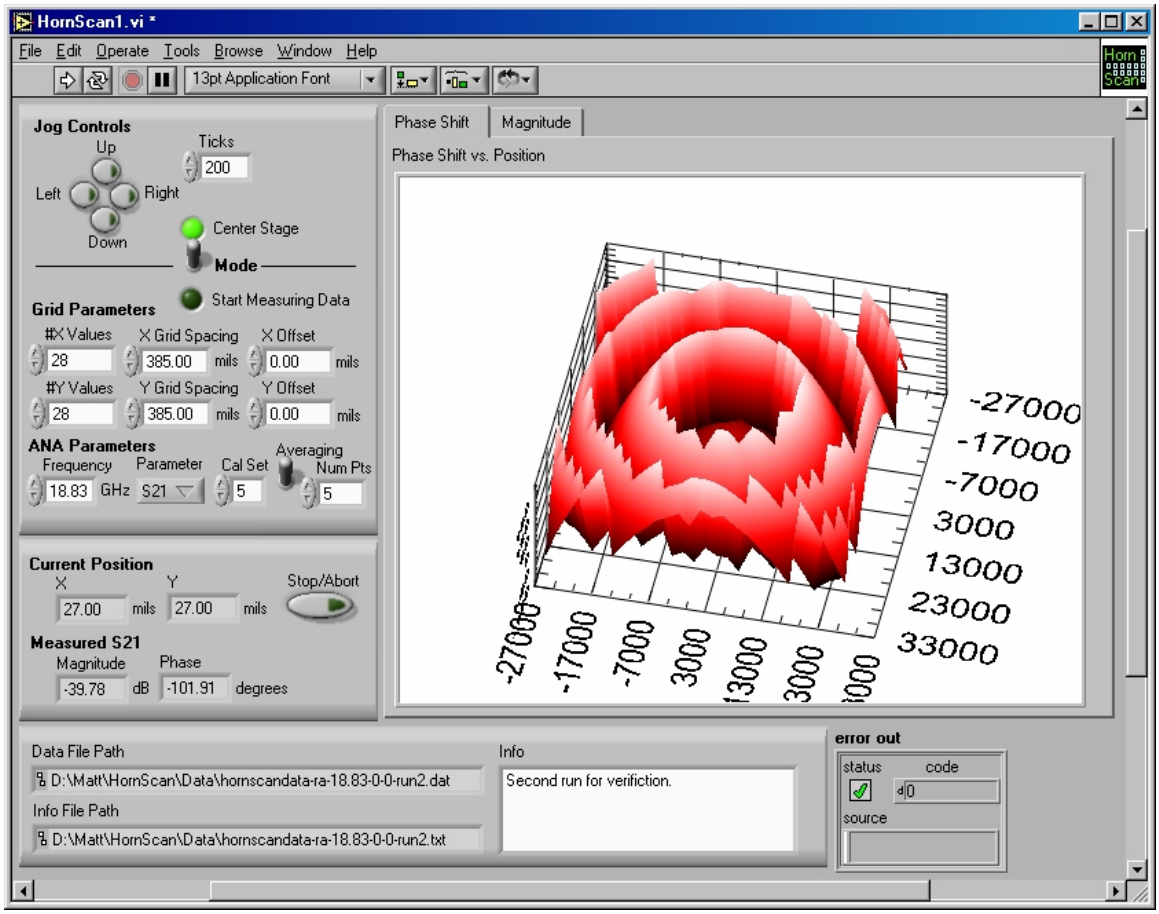

Figure 4.—Screen shot of the LabView application once it has finished a measurement

System Benefits

Comparison	Manual System	Automated LabView System
Positioning Accuracy	Poor accuracy due to manual tightening of bolts and wobble in setup	Extremely accurate to within .0005”
Time Needed	Only the cardinal X and Y axis positions could be measured in 90 minutes. This is only 54 of 616 points.	All 616 points measured in 90 minutes. Setup time is 10 minutes.
Phase/Magnitude Accuracy	Data collected was mentally averaged from points displayed on screen.	LabView performs averaging calculations.
Further Processing	Data recorded in notebook must be entered into the computer for processing.	Data files automatically generated by LabView.

Conclusion

LabView provided a highly effective and efficient solution for our horn characterization. Versatility, ease of programming, and ease of operation made it the perfect product for the foundational component in the antenna measurement automation system. Superior savings in time and effort in the data collection process have made efficient phase front characterization of the dual-mode horn realizable.

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