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USING A MODIFIED HEWLETT PACKARD 8410 NETWORK ANALYZER AS AN AUTOMATED FAR-FIELD ANTENNA RANGE RECEIVER

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SUMMARY

A Hewlett Packard 8410 Network Analyzer was modified to be used as an automated far-field antenna range receiver. By using external mixers, analog to digital signal conversion, and an external computer/controller, the HP8410 is capable of measuring signals as low as -110 dBm. The modified receiver is an integral part of an automated far-field range which features computer controlled test antenna positioning, system measurement parameters, and data acquisition, as well as customized measurement file management. The system described was assembled and made operational taking advantage of off-the-shelf hardware available at minimal cost.

INTRODUCTION

As part of its mission to develop and evaluate advanced antenna feed designs, the RF and Antenna Technology Branch of NASA Lewis Research Center's Space Electronics Division required an automated far-field antenna test range. The principle piece of instrumentation in any microwave measurement system is the microwave receiver. For antenna measurements, the receiver must have the capability to measure both the relative (and sometimes absolute) phase and amplitude between a reference and test signal.

Microwave receivers having these capabilities have been developed for the measurement of microwave device and circuit characterization. These receivers are the main component in microwave network analyzers. The Hewlett Packard 8410 Network Analyzer is implemented using such a receiver. When configured for S-parameter measurements of microwave devices and circuits, the system cannot readily be used as an antenna measurement receiver. However, by reconfiguring the receiver, the HP8410 can be converted into a sensitive antenna measurement receiver at minimal cost.

THE HP8410 NETWORK ANALYZER SYSTEM

Shown in figure 1 is the original configuration of the HP8410 microwave receiver as a network analyzer. The key components of the system are an RF source, a low frequency synthesizer, a harmonic generator, and the receiver (ref. 1). The system is phaselocked by using a highly stable LO (local oscillator) signal and a phase comparator to generate an error signal which is used to FM modulate the RF source for a constant intermediate frequency (IF) signal into the receiver. The RF signal is split to provide a reference signal to the receiver and a test signal to stimulate the device under test (DUT). Both RF signals are applied to a harmonic generator which serves two functions; together with the synthesizer, the harmonic generator is used to generate the stable LO source, and it also contains mixers to downconvert the reference and test channel signals to the IF frequency (20.278 MHz). The IF signals entering the receiver are downconverted a second time to 278.78 kHz and then compared to determine the phase and amplitude difference between them.

MODIFIED HP8410 MICROWAVE RECEIVER SYSTEM

The modified HP8410 microwave receiver system is shown in figure 2. In order to function properly, the receiver must receive both a reference and a test IF signal at 20.278 MHz. The modified system develops these signals directly using external mixers and an independent LO source, rather than the harmonic generator and a multiplied, low frequency synthesizer. The external mixers used have considerably less conversion loss as compared to the mixers in the harmonic generator. Two sets of mixers are used to provide frequency measurement capability up to 40 GHz. One set of mixers enables fundamental mixing up to 18 GHz, and a second set of mixers enable even harmonic mixing up to 40 GHz. Above 26.5 GHz, a frequency doubler/amplifier is used to generate the required RF signal.

MODIFIED HP8410 MICROWAVE RECEIVER CHARACTERISTICS

The system described above exhibits remarkable sensitivity. The manufacturer specifies the dynamic range at approximately 65 dB. However, this is only the dynamic range of the receiver's display module. By adjusting the reference level input, it is possible to measure test channel signals as low as -110 dBm. These results were measured by correlating the signal displayed on the HP8410 with a signal displayed on a spectrum analyzer whose resolution bandwidth was set to mimic that of the HP8410 receiver. According to the manufacturer, the maximum IF signal level that can be applied is nominally 0 dBm, which puts the dynamic range at 110 dB. The increased performance is largely due to two factors, the relative adjustment of the reference signal just discussed, and the lower conversion loss achievable with external mixers. If even higher quality measurements are required, the phase comparator can be eliminated and a second microwave synthesizer used for the RF source. In this configuration, the modified HP8410 system imitates that of an HP8510 system.

The modified HP8410 receiver is also easily interfaced with an external computer/controller. The HP8410 provides analog outputs of the signals displayed on its CRT. These phase and amplitude signals can be converted to digital signals by using either analog to digital converters, or by using a digital voltmeter of the appropriate range. The phaselock status of the system can be monitored in a similar fashion. By monitoring these signals, this measurement system is capable of rendering fixed frequency amplitude and phase measurements, as well as stepped frequency scan measurements.

SYSTEM AUTOMATION

This section describes both the hardware and software integration, and automation of the modified HP8410 receiver with the antenna positioning and data acquisition subsystems. The key elements of the system automation are the system controller and the positioning hardware. The system controller controls the overall operation of a test run, as well as the processing of the measured data. The positioning hardware, on the other hand, mainly controls the motion of the antenna under test and displays data during a test run.

System Controller

The heart of the system controller is an HP308 personal computer. This PC comes equipped with two processors and several I/O interfaces. One processor operates in the DOS 3.3 environment, the other, in the Hewlett Packard (HP) BASIC 5.0 environment. The two processors communicate through a port connecting them. The versatility of this machine has been fully exploited in the system controlling. Test parameters are specified in the DOS under the control of a software program, and data is taken while in the HP BASIC environment under the control of another software program.

SYSTEM SOFTWARE CHARACTERISTICS AND MANAGEMENT

DOS Environment

The first program discussed is the far-field antenna measurement program (FAMP). The program operates in the DOS environment and is menu driven. This program has four menu options: create control file, edit control file, view data, and run test.

Create Control File

The first option is used to create control files for swept frequency and pattern measurements. The control files are used to specify test conditions during a run. For the swept frequency measurement, the radiated power level and the frequency scan are given. For a pattern measurement, the radiated power level and angular scan are given. For either test, the parameters are saved in files to be edited or executed at a later time.

Edit Control File

The second option is used to modify the control files created in option one. The control files can be renamed, deleted, or printed from within this option. Also, the contents of the file can be edited and saved under the same filename or a different filename. This facilitates changing test conditions when multiple tests are made.

View Data

The third option is used to view data stored in files from previously executed tests. A variety of display options is available. Some examples are: amplitude versus scan angle, phase versus scan angle, amplitude versus scan frequency, and phase versus scan frequency. Each of these displays can be plotted to an HP7475A pen plotter in this option. Examples of these plots are shown in figures 3 to 6 respectively.

Run Test

The last option is used to run a test. This option stores a specified filename in a buffer to be read by the second software program. In this option control transfers from DOS to the HP BASIC operating system.

HP BASIC Environment

The second program, called Analyzer, operates in the HP BASIC environment. It executes all the parameters in the file specified in the buffer. The Analyzer program reads the content of the control file via the communications port. It then uses this information to program both microwave hardware and electronic hardware used in the system.

SYSTEM HARDWARE CHARACTERISTICS

Microwave Hardware

The microwave hardware is programmed through the IEEE-488 interface of the computer. The microwave hardware consists of an HP8350A sweep oscillator/ signal generator and an HP8672A synthesizer configured as the LO. The signal generator is programmed for either stepped continuous wave or continuous wave operations depending on whether a swept frequency or a pattern measurement has been specified. The signal generator is also programmed to the power level specified in the control file. The LO is programmed to the calculated frequency which maintains phaselock with the signal generator.

Automation Hardware

The automation hardware consists of the positioning hardware and the HP59313A analog-to-digital (a/d) converter. The positioning hardware is programmed through the general purpose input/output (gpio) interface of the computer. The test antenna is positioned to boresight during a swept frequency measurement and swept over an angular scan during pattern measurement. The a/d converter is programmed through the IEEE-488 interface. The analog outputs for the relative amplitude and phase of the HP8410 receiver are connected to the inputs of two channels of the a/d converter. The a/d converter is programmed to read both channels at each frequency step, and angular position for swept frequency and pattern measurements, respectively. The PC stores the data in files and displays the data on the screen. In addition, the data is also plotted to an HP7475A pen plotter.

Positioning Hardware

The other key element of the automation process is the positioning hardware. The positioning hardware is used to move the test antenna to any specified position or positions. The positioning hardware includes a three axes motor driver unit, a Scientific Atlanta (SA) 5300 Series pedestal, a SA 1800 Series dual synchro display, and a synchro display select unit.

The motion of the test antenna is controlled by the pedestal and three axes motor driver. The test antenna is mounted to the SA pedestal. The three axes motor driver unit controls the azimuth and elevation motors of the pedestal. This unit was designed and fabricated in-house. The unit can control both DC servo and stepper motors. The axes are selected electronically by the PC. In addition to controlling the motors of the pedestal, this unit also has front panel displays of the amplitude and phase measured by the HP8410 during a test.

The position of the test antenna is read by the PC through the SA digital synchro display and the synchro select unit. The digital synchro display simultaneously monitors the azimuth and elevation synchro of the pedestal. The synchro select unit electronically selects the display corresponding to the axis being controlled by the PC. This unit was also designed and fabricated in-house.

CONCLUSIONS

The development of an automated far-field antenna range measurement system featuring a modified HP8410 microwave receiver has been presented. With the addition of a few external components, the HP8410 network analyzer has been modified to function as a highly sensitive, general purpose microwave receiver, suitable for pattern and frequency swept antenna measurements. The system automation described in this paper combines techniques demonstrated in other automated systems (refs. 2 and 3) and techniques unique to this system. Menu driven software programs have been used in other automated systems and data processing in the HP BASIC environment has also been used. However, incorporating both techniques in one system and using control files to coordinate the operation of both techniques has not been demonstrated previously. Also, each of the two units of the positioning hardware has been fabricated and assembled in-house at minimal cost. A similar cost savings has been realized by the in-house development of the automation software.

REFERENCES

1. Beauchamp, B.: A Low Cost, Unified Approach to Antenna Data Processing. AMTA Proceedings, Antenna Measurement Techniques Association, Atlanta, GA, Sept. 1988.

2. Shively, D.G.; and Stutzman, W.L.: A Low Cost, PC Based Far-Field Antenna Range. AMTA Proceedings, Antenna Measurement Techniques Association, Atlanta, GA, Sept. 1988.

3. Operating and Service Manual for the HP8410B Network Analyzer, Hewlett Packard Company, June 1979.

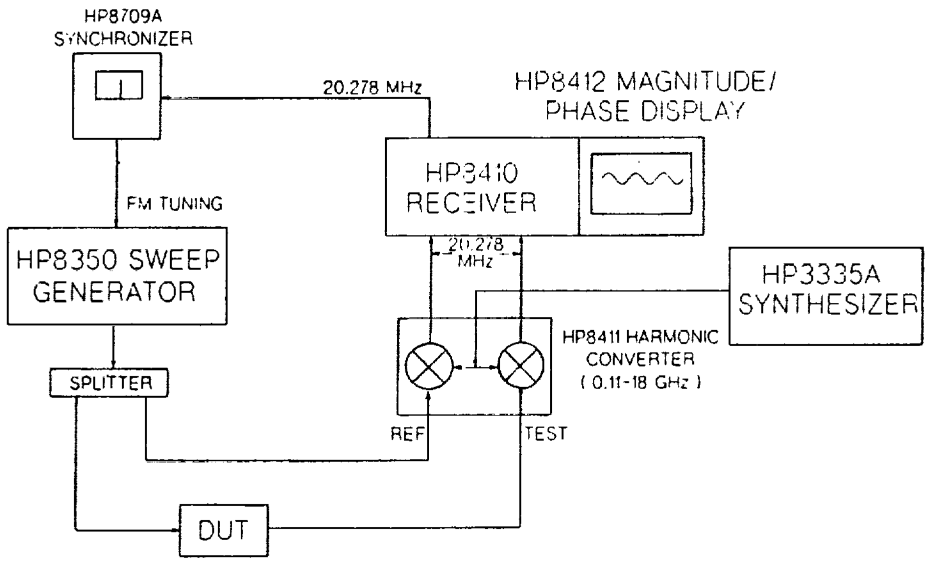

Figure 1.—Unmodified HP8410 configuration.

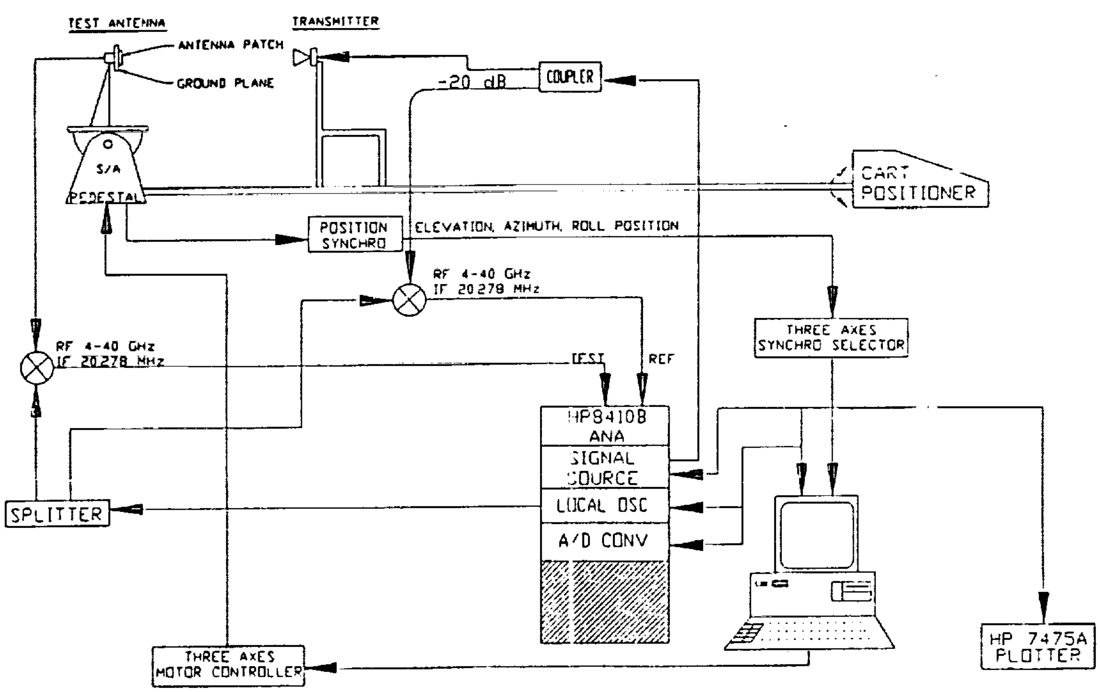

Figure 2.—Automated far field antenna measurement system using modified HP8410.

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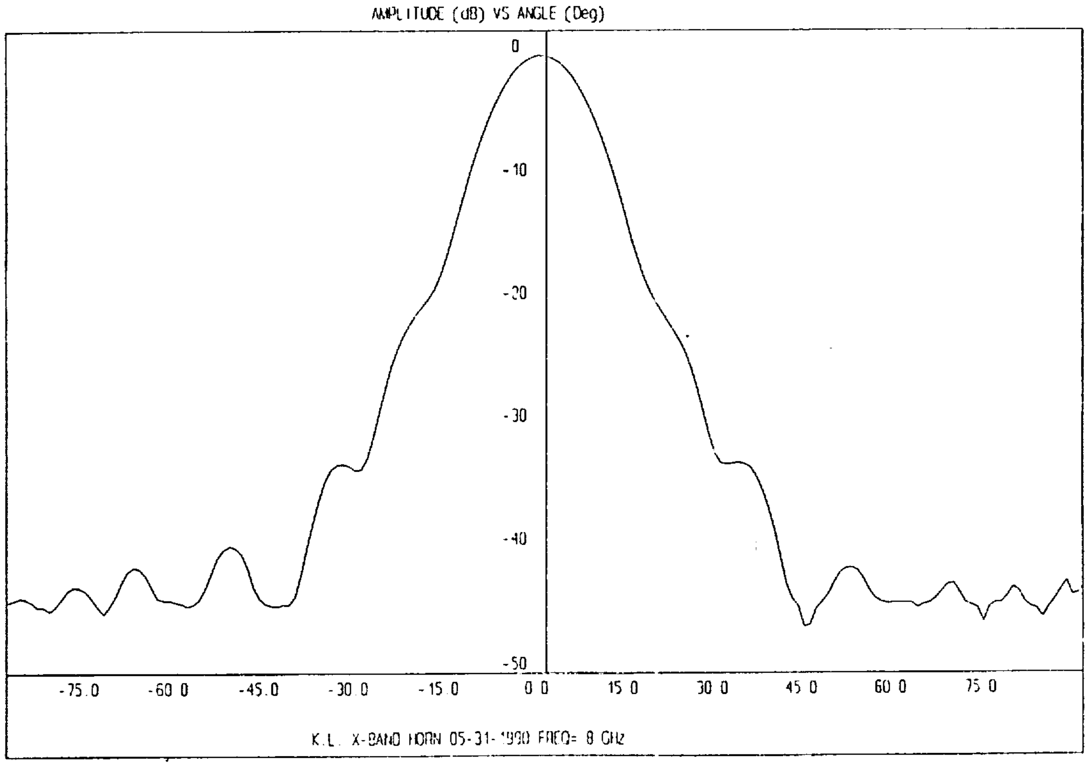

Figure 3.—Amplitude plot of corrugated horn.

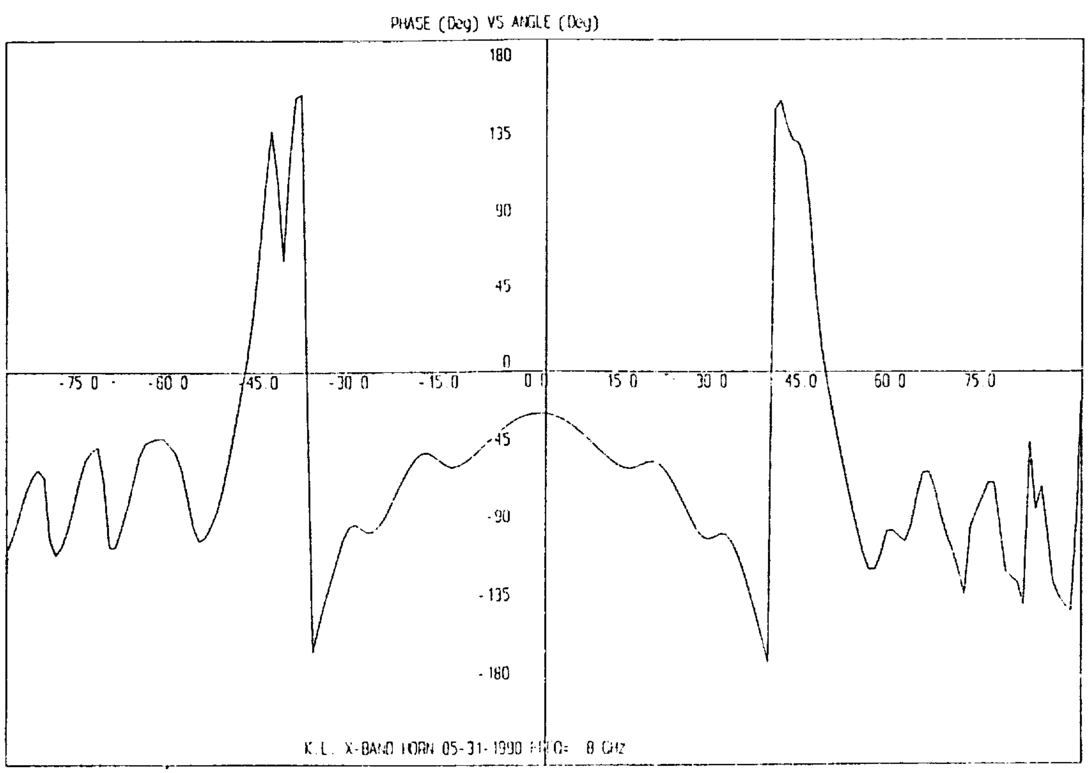

Figure 4.—Phase plot of corrugated horn.

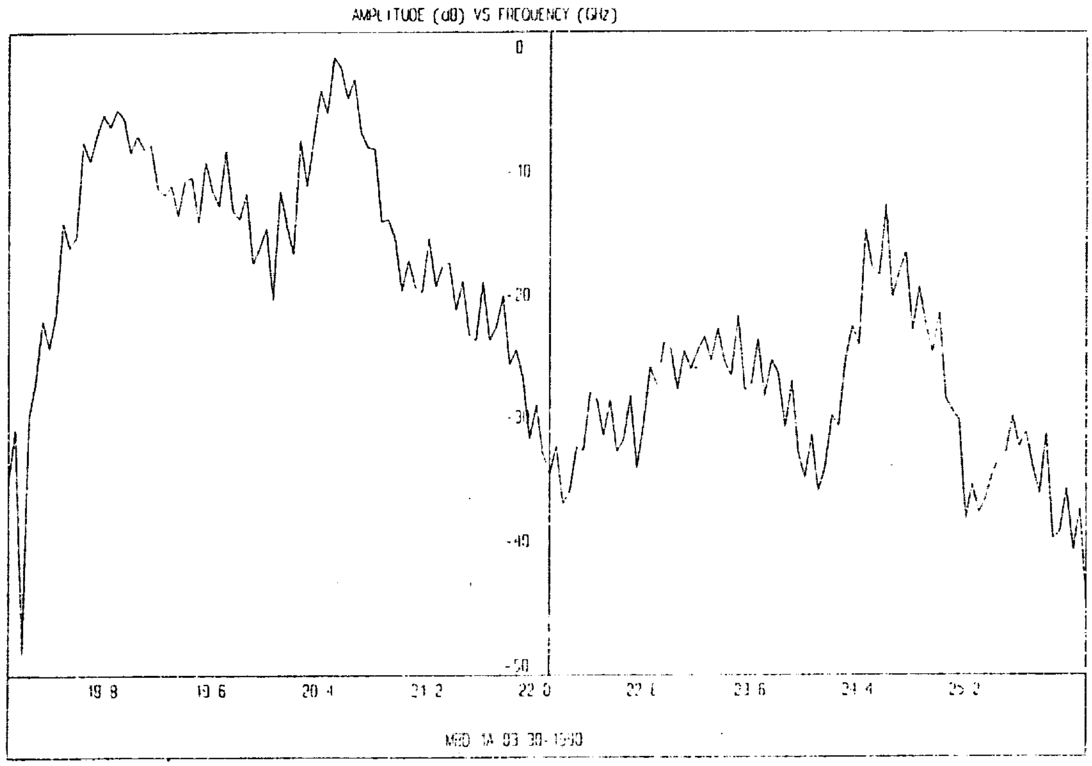

Figure 5.—Frequency swept amplitude plot of corrugated horn.

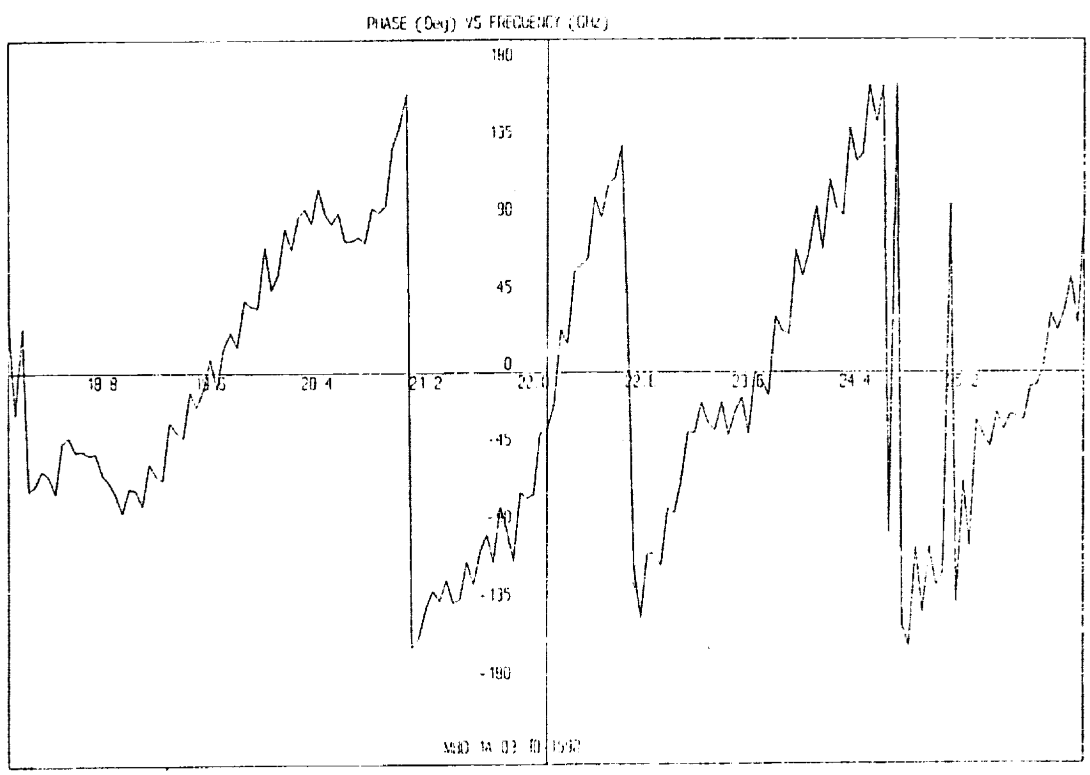

Figure 6.—Frequency swept phase plot of corrugated horn.

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