RADPAT:
A NEW PORTABLE DIGITAL
RADIATION PATTERN RECORDING SYSTEM

E. P. Augustin, D. S. Dunn, J. F. Posada, A. Sullivan

Technical Systems Associates, Inc.
1900 Central Florida Parkway
Orlando, FL 32837-9290
Phone (407) 857-3235, Fax (407) 857-2377
E-mail: tsaorlando@aol.com

ABSTRACT

This paper describes a novel Radiating Antenna Digital Pattern Analysis Test system (RADPAT). The RADPAT system consists of a portable computer and a compact electronic module (EM) that interfaces to the antenna under test . The EM has standardized inputs and outputs that make it easy to adapt to any antenna or antenna system. In addition to functioning as a standard radiation pattern recorder, the RADPAT system can record conically scanning (CONSCAN), single channel monopulse, or sequential lobing patterns with only one sweep per axis . Since the radiation pattern is recorded digitally, it can automatically extract actual system data such as the error slope, crosstalk, 3 or 10 dB beamwidths, sidelobe levels, boresight shift, etc.. The briefcase size RADPAT system is portable, weighing only 18 lbs (8 kg). This can be a significant advantage for either verification of system parameters or for troubleshooting a component or system problem . Thus, the RADPAT system combined with a standard pattern receiver or a telemetry receiver can provide instantaneous, on-site evaluation of the radiation characteristics of an installed antenna system.

KEY WORDS

Antenna, Patterns, Recording, Tracking, Testing

INTRODUCTION

This paper introduces a new automatic radiation pattern recording system, called RADPAT, which is lightweight, compact and portable . This system can record the radiation pattern of any antenna and has several features tailored to the needs of tracking antennas and systems. RADPAT has the ability to record multiple scanned radiation patterns simultaneously and display them in real time . The RADPAT system is packaged in a durable, transportable briefcase and is comprised of a notebook computer and an electronic module (EM) . The EM has standard inputs and outputs allowing connections to an existing tracking system . Any antenna, including all types of tracking antennas, can be connected to the RADPAT system . For example, to record the radiation patterns from a CONSCAN tracking system as shown in figure 1, the RADPAT EM requires a synchro, resolver, or encoder input, a scanner reference pulse, and an input signal proportional to the RF energy . The tracking system can bbe in an operational mode with the scanner rotating, typically between 1 and 30 Hz . The input signal is either a bolometer type signal in volts or a signal in dB/volts depending on the receiver. The bolometer signal in volts is typically a 1 KHz amplitude modulated signal from a standard pattern receiver . The signal in dB/volts is proportional to the RF power in dB and can be an analog DC voltage, RS232, or GPIB. The scanner reference pulse synchronizes the scanning radiation lobe with the sampled RF data and enables the system to digitally record the radiation of the antenna. The RADPAT computer, which can be customer furnished equipment (CFE), communicates via software and a RS485 serial port to the EM . The software gives the

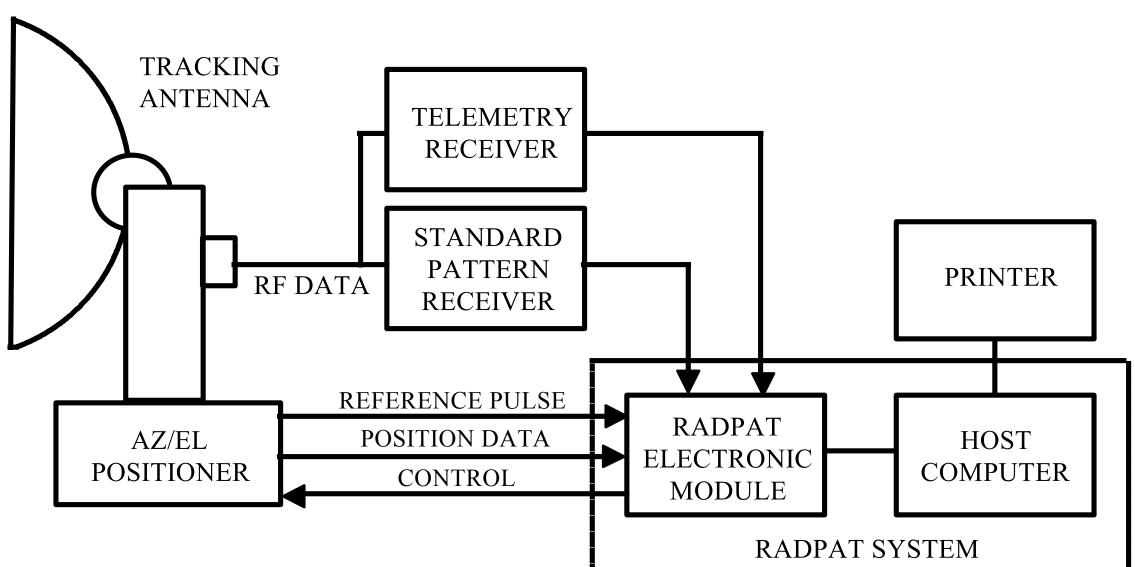

Fig. 1. Block diagram of the RADPAT connected to a tracking antenna.

user full control over various aspects of the data collection from the antenna under test. The stored data is in text files and can be used with a variety of applications such as spreadsheets or virtually any platform . The RADPAT system, when used with a boresight antenna, can quickly and efficiently measure all system parameters and enables the user to troubleshoot a tracking problem .

RADPAT HARDWARE

The RADPAT EM is the interface between the antenna and the host computer . It provides the inputs and outputs to and from the antenna system and communicates to the computer software via a RS485 serial communication . The user can setup various aspects of the system to execute the data collection process . The EM hardware can be broken down into three main sections: A. Analog Amplifier, B. Two-axis Angle Interface C. Micro-Processor Board.

A. Analog Amplifier

If the signal output from a standard pattern receiver is in volts, (i.e. from a bolometer) it is connected to an analog amplifier by a standard BNC connector . The output of the pattern receiver using a bolometer is usually a 1 KHz amplitude modulated signal which is filtered, demodulated and then processed . High quality bandpass filters are used to reduce the noise energy and to maintain the dynamic range of the system . High-pass filters are also used to reduce the noise and to AC couple the output . A protection circuit is built into the bolometer interface to prevent bolometer circuit damage when making connections to the unit while the power is on . The output of the analog amplifier is input to an analog to digital circuit .

If the signal output from a standard pattern receiver is in dB/volts, the analog amplifier is bypassed and is connected directly to an analog to digital circuit.

B. Two-axis Angle Interface

The standard RADPAT EM contains two angle channels for azimuth and elevation position information. The EM can interface to encoders, resolvers and synchros of various voltages (2 Vrms, 8 Vrms, 11.8 Vrms, 115 Vrms, etc.) and frequencies (50 Hz, 60 Hz, 400 Hz, 1 KHz, etc.) . The RADPAT standard interface is 115 volt, 60 Hz synchros, however, any type of positional transducer can be accommodated. The two-axis angle interface is enclosed on two PC-104 interface cards which are accessed by the embedded controller.

C. Micro-Processor Board

The processor board is designed around Dallas Semiconductors high performance 8-bit microprocessor DS80C320 . The board has 64K bytes of EPROM and RAM, a PC-104 interface connector, a low noise 12-bit analog to digital converter, I/O ports, and a high speed configurable RS-232 or RS-485 serial port . The microprocessor runs an application and exchanges data with the computer over the serial port . It also performs all necessary processing on the signal from the analog amplifier and maintains the synchronization with the position data . The RAM is used as a buffer when the system is required to gather data in real time such as when recording data while CONSCANning. The PC-104 interface is based on the popular ISA interface standard and is used as a communications channel between the microprocessor and various peripherals. The analog to digital converter resolves the demodulated signal from the analog amplifier and converts it to a digital number for further processing by the microprocessor and the host computer.

The serial port allows high speed communication between the microprocessor and the host computer. Standard serial port connectors are used (DB-9 for IBM compatible and Mini-8 for the Macintosh) . An optional SCSI or GPIB (IEEE-488) interface card is available and installs directly onto the processor board . The SCSI interface card implements data communications with the host computer using a high speed 8-bit parallel port. The SCSI port is normally found on the back of all Macintosh computers (external disk I/O port) and allows faster data transfers . The GPIB interface card is also an 8-bit parallel port.

RADPAT SOFTWARE

The RADPAT software is a versatile, easy to use program written by people familiar with the nuances of radiation pattern recording . Because of this fact, several useful and functional features have been included as standard features in the software . A graphical user interface (GUI) application is used to control the RADPAT system and to customize it to the user's needs . The GUI application consists of pull down menus and a data plot area. Figure 2 is a picture of the RADPAT GUI utilizing a Macintosh computer. The software program utilizes convenient pull down menus . A few of the pull down menu features are listed below.

FILE

- New: Clear the plot buffer and screen for a fresh start.
- Open: Append a file to the plot buffer and display it.
- Save: Save the data in the buffer to the filename of the last file open.
- Save As: Save the data in the buffer under a new filename.
- Print: Print the screen contents to a printer.
- Options: Set the defaults for the header or change print offsets.
- Header: View and edit the current header settings.
- Quit: Exit the RADPAT program.

VIEW

Window: Change the view window in angle and amplitude.
Polar/Linear: Toggle the display between rectangular and polar plots.
dB vs Azimuth/Elevation: Toggle the horizontal axis.
Normalized: View the plot with the peak at 0 dB.
Refresh: Clear the screen and replot the buffer contents.

PEDESTAL

Set Azimuth 0: Zero the azimuth resolver at it's current position.
Set Elevation 0: Zero the elevation resolver at it's current position.
Set Travel Limits: Set the software travel limits of pedesta l.
Commands: Command the pedestal to an angle at a specified rate.

ANALYSIS

Sidelobes: Calculate and display the highest sidelobe.
Beamwidth: Calculate and display the 3 dB beamwidth.
Reset Meter Peak: Reset the peak signal displays.

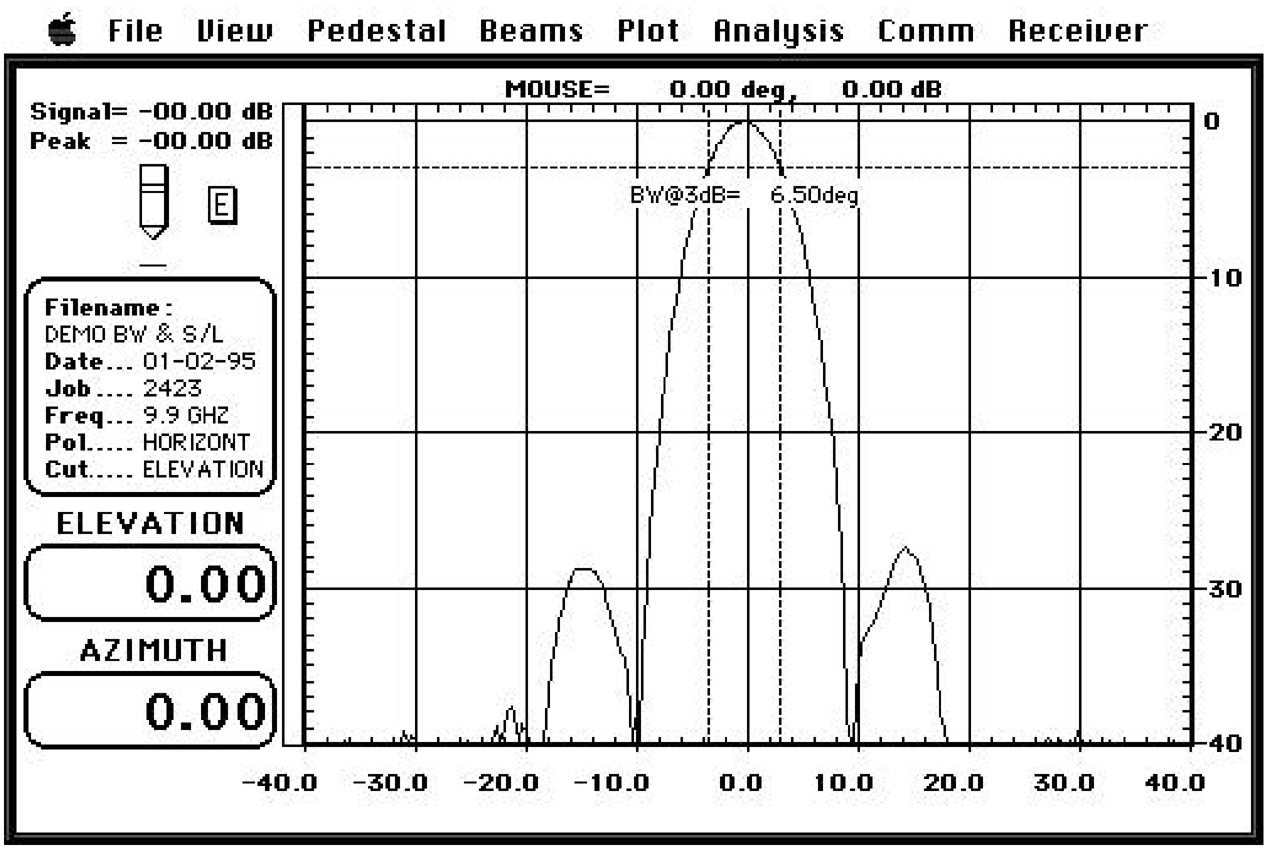

Fig. 2. RADPAT graphical user interface display on a Macintosh computer.

Another useful feature is that while the mouse is within the active data plotting area, its coordinates showing angle and relative amplitude are constantly displayed on the computer screen. Thus, if the radiation pattern is normalized to 0 dB, you can move the mouse to any sidelobe and read its relative amplitude and angle . Clicking the mouse at a given location will instantly print the amplitude and angle on the radiation pattern. The notebook computer can also act as a controller for the positioner . Note the PEDESTAL pull down menu features listed above . The software contains several other features that are too numerous to list . The convenience of using a computer to record radiation patterns is obvious . The fact that the data is recorded digitally enables it to be analyzed, imported, exported, and stored rapidly and in a variety of different formats. This reduces test time and increases productivity.

Figure 3 shows a typical radiation pattern output of a tracking antenna . These composite patterns were recorded with a single azimuth sweep. The RADPAT system is also capable of generating contour plots from a set of radiation pattern files after they have been recorded at several different elevation angles . The result of combining all the plots produces a color contour plot with different colors representing the relative power of the radiation pattern as it is plotted versus the azimuth and elevation angle. The color contour plot gives a clear representation of the three dimensional

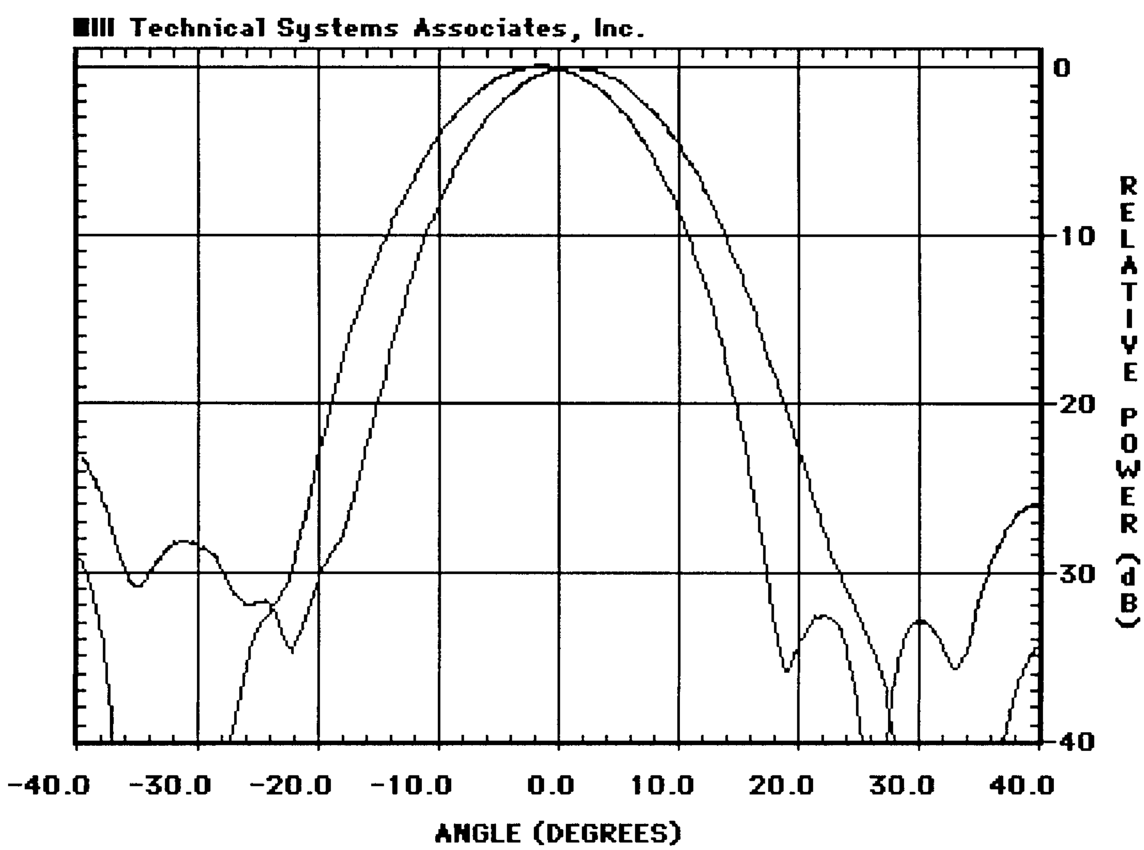

Fig. 3. Recorded composite patterns of a monopulse tracking antenna.

radiation pattern of the antenna under test . Figure 4 shows a sample of a black and white contour plot of a slot array antenna . Color contour plots are considerably more definitive. Three dimensional mesh-like topographical plots of the radiation pattern are also available.

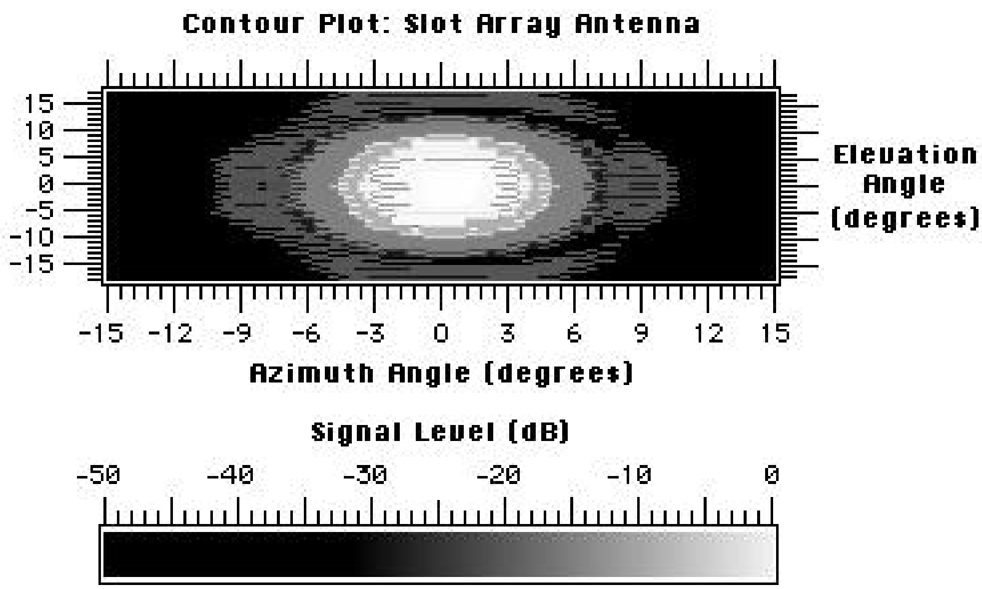

Fig. 4. Contour plot of a low sidelobe slot array antenna.

MODES OF OPERATION

The RADPAT system has three modes of operation: normal, track and radome . All three modes are selectable by the user.

In normal mode, the unit functions as a normal radiation pattern recorder . No reference pulses or external timing signals are required . The RADPAT EM requires a signal input proportional to the RF energy from a receiver and an angle input from the positioner. This is all the data necessary to record the radiation pattern of any type of antenna.

In track mode the system can plot CONSCAN, single channel monopulse, sequential lobing, or up to five separate radiation patterns in a single sweep per axis . To operate in track mode, the RADPAT EM requires a reference pulse to synchronize the sampling of the RF energy . The software allows the user to define the reference pulse with regard to his specific system . For a CONSCAN antenna the reference pulse is input to the EM and synchronizes the sampled RF data with the angular position . This enables CONSCAN composite patterns to be plotted with one sweep per axis . To record the composite patterns of a monopulse antenna, the reference pulse is synchronized to the switches in the scan converter. With an optional switch, monopulse sum and difference patterns can be plotted simultaneously. Thus, depending on the location of the detector and hardware configuration either composite or sum and difference patterns can be plotted with one sweep per axis. A sequential lobing antenna has the reference pulse synchronized to the switches of each off axis feed and again plots the composite patterns with a single sweep per axis. The system can also accept a start/read pulse train to record up to five patterns in a single sweep per axis.

The unique feature of the track mode is that all the desired radiation patterns and corresponding parameters for a specified axis can be recorded with a single sweep in that respective axis. To record the composite patterns for a CONSCAN system, typically two azimuth sweeps are required and the patterns are overlaid on the same chart paper. One lobe is recorded with the scanner in one position and the other lobe is recorded after the scanner has been rotated 180 degrees. With the RADPAT system, both patterns can be recorded simultaneously in one sweep and displayed in real time.

Radome is the third mode of operation. This portion of the program analyzes the effects of a radome on the performance of an antenna. Specifically, the radome mode enables the user to measure the boresight shift due to the radome. Ideally a radome has no effect on the radiation from an antenna. In practice, however, even a properly designed radome usually has a small effect on the radiation properties of the antenna. These changes may be caused by an amplitude or a phase variation or a combination of the two.

One important effect that a radome often has on a tracking antenna is boresight shift of the tracking axis. If the antenna boresight axis is different due to the radome, this difference is measurable and must be known for high accuracy tracking. Since it is common to have only a small boresight shift the measurements are made in milliradians. Figure 5 shows a Macintosh computer displaying the recorded plots of an azimuth and elevation boresight shift of a radome under test. Both the azimuth and elevation boresight shift are measured and displayed simultaneously. If a color printer is available the plots are recorded in different colors. The radome mode can be used in conjunction with the track mode and is the easiest way to measure the boresight shift of a tracking antenna and eliminates the need for a complicated "null seeker" type system.

CONCLUSION

RADPAT features the necessary hardware and software that enables recording up to five antenna radiation patterns of a tracking antenna in a single sweep per axis. The RADPAT system has the following advantages over existing pattern recorders:

- Record multiple scanned radiation patterns in a single sweep per axis and display them in real time.
- In addition to the tracking antenna and radome features, the RADPAT system can be used as a standard antenna pattern recorder.
- Reduced test time compared to conventional techniques increases productivity.
- The host computer can be CFE and used for other applications.
- Highly portable, weighing only 18 lbs and packaged in a durable briefcase.
- Troubleshoot or verify of tracking antenna system parameters on an installed operational system.

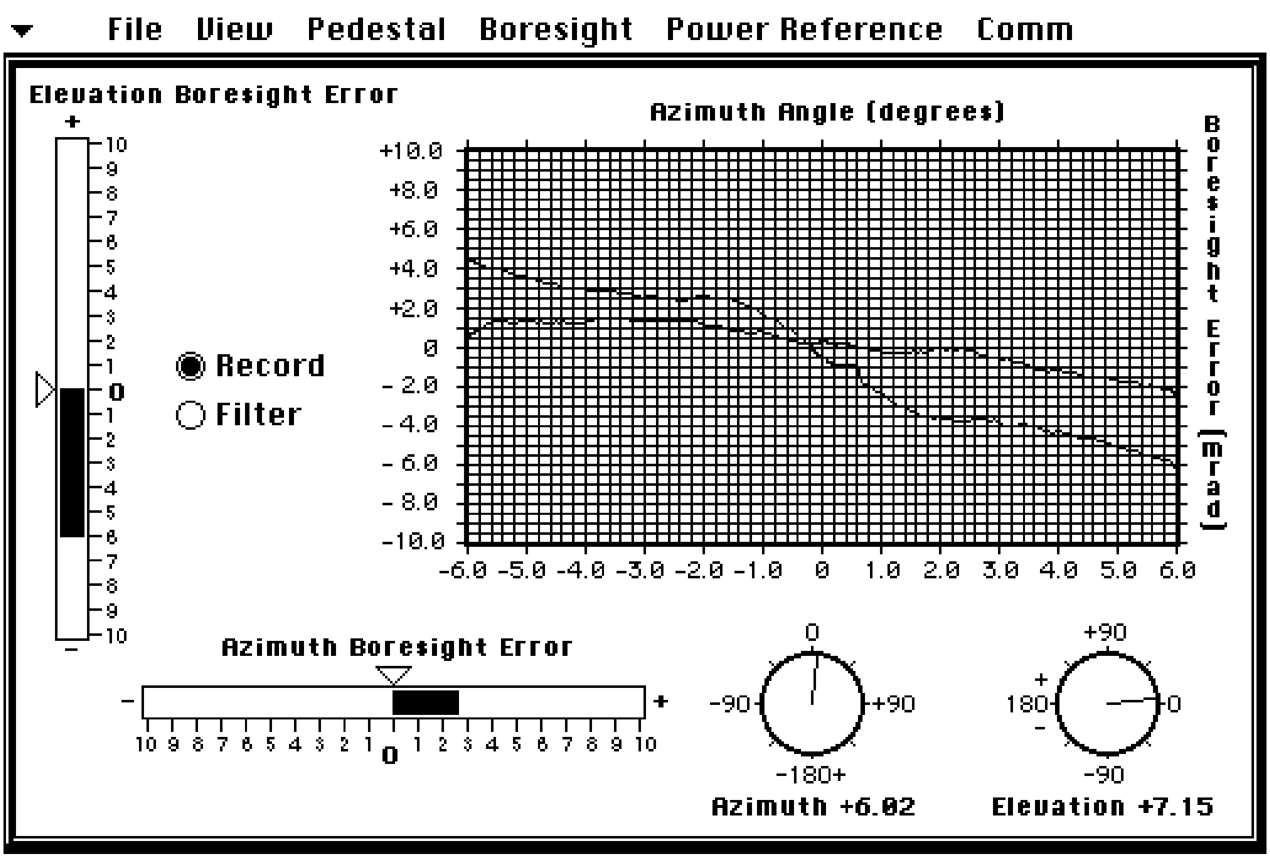

Fig. 5. Boresight shift recorder application screen in RADOME mode.