Instrumentation for Base Station and Earth Station Antenna Testing

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Introduction

Modern base station antenna stresses antenna measurement instrumentation because of their narrower beamwidths and multi-sector characteristics. More complete testing must be performed preferably without appreciably increasing measurement time. MI Technologies has met this challenge by using increased automation and by designing its instrumentation specifically for antenna measurements. Earth station antennas require good polarization, gain, sidelobe, and multiband performance. The choice of an antenna test range to test an antenna is dependent on many factors, such as the directivity of the antenna under test (AUT), frequency range and desired test parameters. Care must be taken in the design of an antenna range to ensure that the performance parameters are measured with sufficient accuracy [1-5]. Often the mechanical features of the antenna (size, weight and volume) can have as much influence on the selection of an antenna range as do the electrical performance factors.

Antenna Range Types

A few of the more commonly used antenna test ranges are shown in the **Figure 1** and are discussed below. Testing indoors (**Figures 1a , 1b, 1e, 1f, 1g**) offers many advantages to conventional outdoor ranges (**Figures 1c and 1d**) including improved security, avoiding unwanted surveillance, and improved productivity due to less time lost because of weather and other environmentally related factors. The advantages of testing indoors are driving the trend toward more advanced test ranges such as the compact range and near-field ranges.

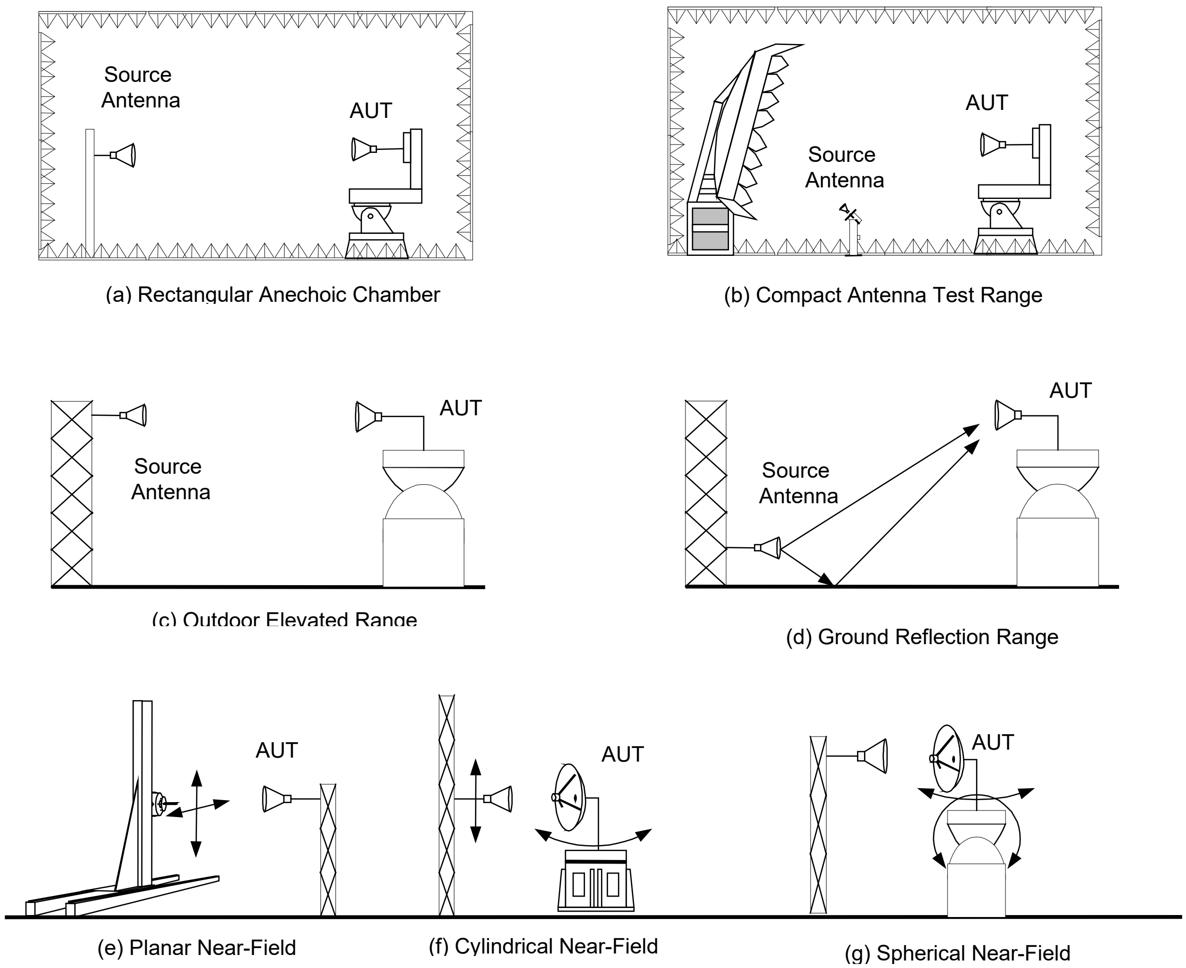


Figure 1. Common Antenna Range Types.

Far-Field Ranges

In an outdoor far-field range configuration (**Figures 1c and 1d**), the AUT is installed on the test positioner located on a tower, roof or platform outside the instrumentation control room. The receiver front end (Local Oscillator) is usually located at the base of the test positioner, with the mixer connected directly to the AUT port. This configuration requires only a single RF path through the positioner, greatly simplifying system design. For multi-ported antennas, simultaneous measurements can be made on all ports through the use of multiplexers installed in front of the mixer.

The test positioner axes are controlled and read out by the positioner control and readout units located in the control room. The positioner controller interfaces to a power amplifier unit located near the test positioner. This configuration keeps the high power drive signals near the positioner and away from sensitive measurement instruments while providing remote control of positioner functions from the equipment console.

The source antenna is normally located at the opposite end of the range on a tower or other supporting structure. The signal source is installed near the source antenna to minimize signal loss. For some applications a multiplexer can be used between the signal source and a dual polarized source antenna allowing simultaneous co- and cross-polarization measurements to be performed.

The most common indoor far-field antenna test range configuration is the rectangular anechoic chamber shown in **Figure 1a** which is typically designed to operate at frequencies above 1-2 GHz. The range length is designed to meet the $2D^2/\lambda$ phase taper requirement for the antenna under test. The walls, floor and ceiling are covered with microwave absorber to minimize reflection into the test zone.

Anechoic Chambers are instrumented essentially the same way as outdoor ranges with range lengths the primary difference. The receiver front end is typically positioned near the test positioner with the mixer connected directly to the AUT port. The source is located near the source antenna. The control room is generally centrally located and connected to both ends of the range via cables or digital links.

Compact Antenna Test Ranges

A compact range is an excellent alternative to a traditional far-field range. Any testing that can be accomplished on a far-field range can be accomplished on a compact antenna test range. The principle of operation of a compact range is based on the basic concepts of geometrical optics. Diverging spherical waves from a source antenna located at the focal point of a paraboloidal surface are collimated into a plane wave. This plane wave is incident on the AUT. The resultant plane wave has a very flat phase front and small amplitude taper over the test zone. A typical compact range measurement system is shown in **Figure 2**.

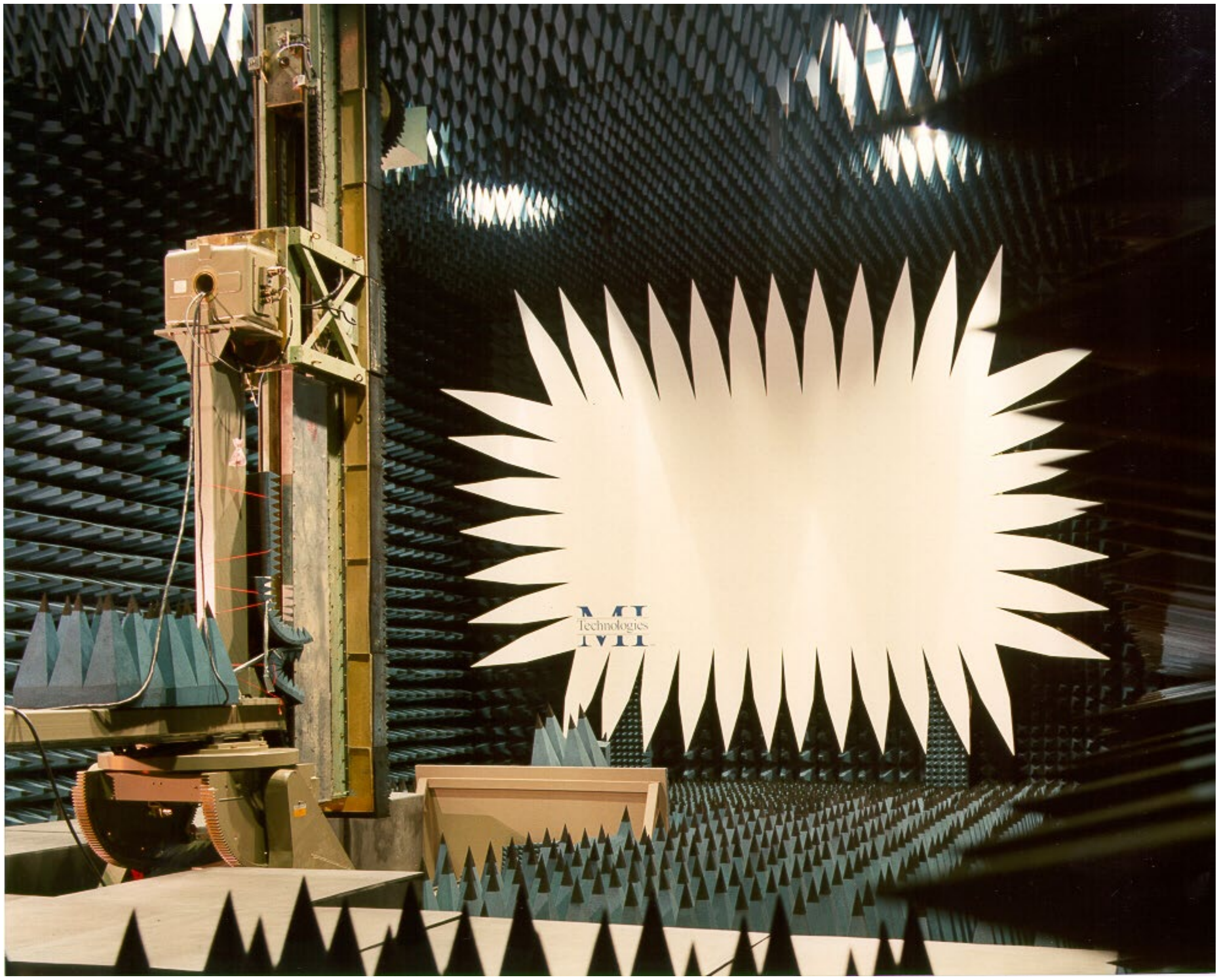


Figure 2. A Compact Range Reflector in an Anechoic Chamber.

Near-Field Antenna Test Ranges

Near-field ranges are used where large antennas are to be tested indoors in a relatively small space. This type of range uses a small RF probe antenna that is moved over a surface surrounding the AUT. Typically separation between the probe and the AUT is on the order of 4 to 10 wavelengths. During the measurement, near-field phase and amplitude information is collected over a discrete matrix of points. This data is then transformed to the far-field using Fourier techniques. The resulting far-field data can then be displayed in the same formats as conventional far-field antenna measurements. The large numbers of measurements required, and the need to transform the measured data, require the use of a computer system both for data acquisition and for data reduction and display

Planar Near-Field Measurements: For this measurement technique, a X-Y scanner is used to move a probe very accurately over a plane located in front of the AUT's aperture. **Figure 3** shows the near-field probe of a planar scanner located on the vertical carriage which in turn moves on the horizontal carriage which is at the bottom of the scanner. Data taken on the planar measurement surface determines the AUT pattern in the forward direction.

Figure 3. A Typical Planar Near-Field Scanner.

Cylindrical Near-Field Method: In this method the probe is typically scanned in one linear dimension using a single axis linear positioner, and the AUT is stepped in angle on a rotary axis oriented parallel to the linear axis. The resulting scan describes a cylindrical surface around the AUT. Cylindrical near-field scanning can provide complete angular coverage of the AUT's pattern in azimuth and over a range of elevation angles. This technique is well suited to base station antenna measurements.

Spherical Near-Field Method: Spherical near-field scanning normally involves installing the AUT on a spherical scanning positioner. The probe antenna is normally fixed in space, and the AUT is scanned in one angular axis and stepped in an orthogonal angular axis. The resulting data is collected over a spherical envelope surrounding the AUT. Full or nearly full coverage of the AUT's radiating field can be evaluated with this type of near-field system.

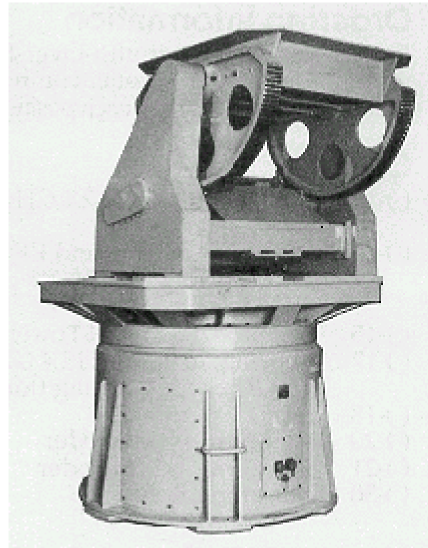
Antenna Range Instrumentation

Regardless of the type of antenna range to be implemented, the complement of instruments to operate the range is very similar. Differences occur due to the location of the various instruments with respect to the source and AUTs, types of measurements to be performed, and the degree of automation desired. A description of the basic instrumentation subsystems and typical applications of different types of antenna ranges is presented next.

The instrumentation for measuring antenna patterns consists of four subsystems, which can be controlled from a central location. These subsystems are:

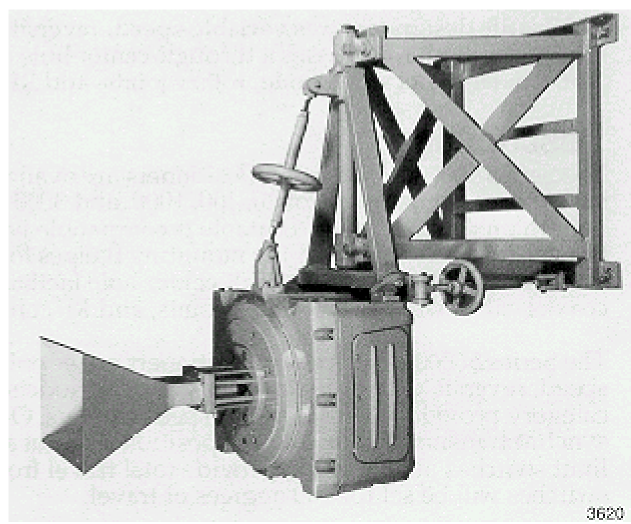
1. Positioning and Control
2. Receiving
3. Signal Source
4. Acquisition and Processing

The AUT is installed on a **positioner** and is usually tested in the receive mode. A positioner control unit located in the control room controls the motion of the positioner (rotation of the AUT). The positioner is equipped with synchro transmitters or high accuracy encoders to provide angle data for the position indicator and the recording/processing subsystem. A variety of positioners are available, as shown in **Figure 4,** to allow single or multi-axis positioning of antennas.



Az Positioner

El-over-Az Positioner



Model Tower

Polarization Positioner

Figure 4. Some of the Positioner Types Used in Antenna Measurements.

A **microwave receiver** is employed on the antenna range to accept the very low-level signals from the AUT and to downconvert these signals to lower frequencies for processing. Microwave receivers offer many advantages including improved dynamic range, better accuracy, and rejection of unwanted signals that may be present in the area. Also, phase/amplitude receivers provide the ability to measure phase characteristics of the received signal which are required for near-field measurements.

A **signal source** provides the RF signal to source antenna. The signal source can be permanently fixed on the ground or floor, or located on a tower near the source antenna, depending on the frequency of operation and mechanical considerations. The signal source is usually designed for automated remote operation by a computer located in the control room.

Often, a **computer subsystem** is added to the instrumentation in the control room to automate acquisition and processing of antenna data. This computer subsystem employs a standard bus interface, like the IEEE-488, to setup and monitor the individual instruments. High-speed data busses are utilized to maximize data throughput and productivity. The MI-3000 Data Acquisition and Analysis Workstation uses an IEEE-488 General Purpose Interface Bus (GPIB) to control Microwave Receivers, Microwave Frequency Synthesizers, Position Controllers, and other instruments during the process of conducting measurements. Instrument control drivers are available for a large number of receivers, frequency synthesizers, position controllers and position indicators. To support the high-speed acquisition capability designed into MI Technologies receivers and synthesizers, the MI-3000 (see **Figure 5**) also interfaces with an optional Data Acquisition Coprocessor (DAC) that uses a Digital Signal Processor (DSP) to handle the fast triggering and data collection over parallel digital interfaces. The DAC can also be adapted to provide users with general digital I/O control of external devices such as beam-steering computers.

Figure 5. MI-3000 Data Acquisition and Analysis Workstation.

References

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