AUTOMATED EIRP MEASUREMENTS ON A NEAR-FIELD RANGE

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ABSTRACT

Accurate EIRP measurements are possible to make on a near-field range but require great care and attention to detail. NSI has recently implemented a near-field test range for the Globalstar satellite program which makes automated EIRP and gain measurements. Automation for this program is extremely important since the production cycle requires testing many antenna systems per month, each of which has two antennas with 16 separate beams per antenna. Among the various range measurements, EIRP is the key parameter of the Transmit antenna's performance. This paper reviews the measurement theory of EIRP measurements and presents some of the results of this automated activity.

1. INTRODUCTION

NSI recently completed installation on a near-field measurement system to measure Globalstar satellite antennas and payloads[1]. The Globalstar antenna system has two active multi-beam antennas: one receive and one transmit. Each has 16 beams. The goal was to be able to measure and process all 16 beams of an antenna automatically with a single key stroke. The most important parameter for the transmit antenna is Effective Isotropic Radiated Power (EIRP). EIRP includes the performance of the complete antenna system, including amplifiers.

In this paper we present some general theory on EIRP measurements and identify some simple ways of improving measurements speed. In addition, test results and accuracies are presented.

2. EIRP MEASUREMENTS

EIRP is defined[2] as the directional gain of a transmitting antenna multiplied by the power into the antenna:

$$P_{in\ dBm} + G_{dBi}(\theta) = EIRP_{dBm}$$

Ignoring mismatch losses, EIRP measurements can be made by first measuring the gain of the antenna and then measuring the power into it. In planar near-field measurements this can be done by the following procedure:

1. Bypass the probe and AUT cables (16 connections required) and measure the signal amplitude for each beam.
2. Re-connect cables and measure the near field.
3. Select a specific beam and compute its pattern.
4. Measure the power into each antenna beam.
5. Plot the EIRP pattern
6. Repeat for each beam.

The result is a contour or linear-plot in dBm for each measured beam similar to that shown in Figure 1.

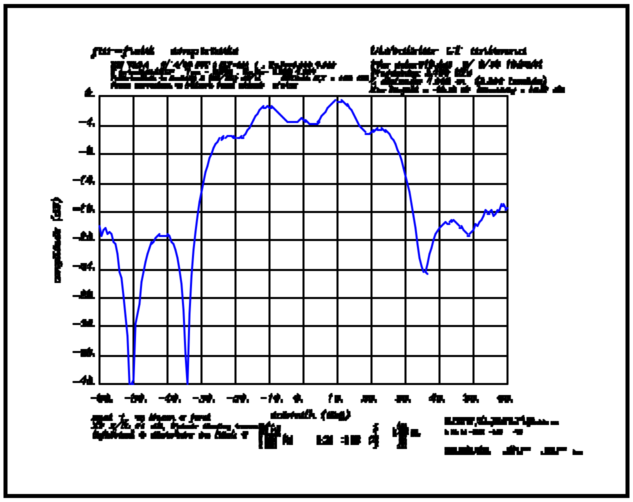

Figure 1-Linear Plot Showing EIRP Pattern

An alternative method[3] for measuring EIRP (Direct-EIRP) to the general one is simpler and requires fewer measurements. In this method it is not necessary to measure gain to compute the EIRP. Instead we measure radiated power out of the antenna directly. Since we are in the near field, the power measured at any one point is not sufficient to determine EIRP, however a complete scan and an antenna measurement system calibrated in dBm will suffice. Measuring EIRP directly is useful for two reasons: 1.) Often the antenna port where the gain would be measured is not available such as in satellite measurements and 2.) Individual cable losses for multi-beam antennas need not be calibrated since the input power is often not important for EIRP.

In a typical receiver such as the HP8530 there is a reference channel and a test channel. The two are compared and the result is that the test channel is so many dB below (-) or above (+) the reference channel level. This value is displayed on the receiver. As long as the measurements are linear, the receiver does not care and does not know what power level it is actually operating at.

By comparing the absolute power at a particular signal level to that measured by the receiver, we can calibrate the receiver in dBm. To do this we simply measure the absolute power received in the test channel for a given receiver reading. In this method it is only necessary to calibrate one beam since the absolute power-to-receiver reading will not change for different beams as long as the system is linear. This reduces the pre-calibration time.

The process for performing the Direct-EIRP measurement is as follows:

1. Find the highest power level in the near-field for any beam and verify that the receiver is operating linearly.
2. Use a power meter to measure the power out of the probe at location X,Y in the near field when the AUT is transmitting.
3. Use the receiver to measure the signal out of the probe at the same X,Y location and enter the difference into a table
4. Measure the near field of the multi-beam antenna.
5. Select a specific beam and compute its pattern.
6. Plot the EIRP pattern
7. Repeat for each beam.

The result is the same plot as Figure 1. The difference is that only one reference measurement is required instead of 16 (one for each beam). In addition, if a power meter is placed near the output of the probe the system will lend itself well to automated measurements. (See Figure 4)

3. NEAR-FIELD MEASUREMENT SYSTEM

Figure 2 and Figure 3 show the planar near-field measurement system at Alcatel Espace in Toulouse France. The system has an X-Y range of 6.6 x 6.6 meters and was designed to operate at L- and S-bands which are the Globalstar frequencies. The range can also operate up to 18 GHz with the appropriate change to mixers and probes.

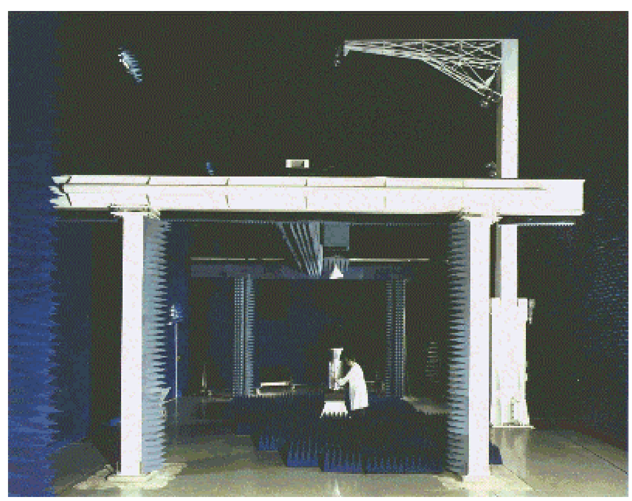

Figure 2 Alcatel Near-field Measurement Facility

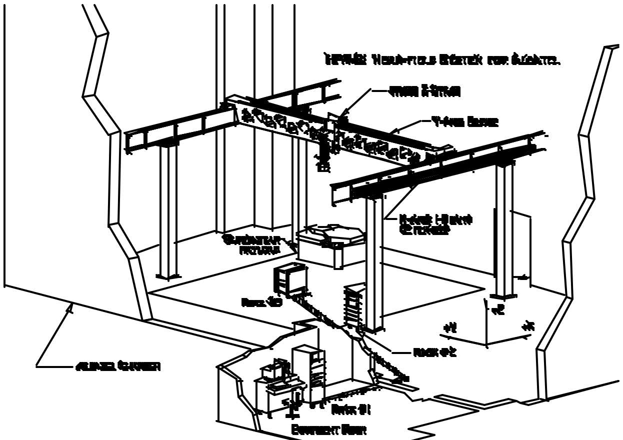

Figure 3-Alcatel Near-field Measurement Facility

Figure 4 shows a simplified block diagram of the probe network and power meter. The power meter is connected to a power splitter near the output of the probe so that the power-to-signal calibration can be easily made. During the power calibration step of the Direct-EIRP measurements, the power and signal paths are automatically measured without physically changing any cables. This saves time, and makes repetitive measurements easier.

Special care and consideration must be given to mismatch effects in order to make accurate EIRP measurements. A special RF calibration procedure was implemented to guarantee the accuracy of the EIRP measurements. An accuracy of ±0.18 dB was achieved for EIRP measurements of on-axis beams. Table 1 shows the NIST 18-term error budget generated for the Globalstar Beam-1 EIRP measurement.

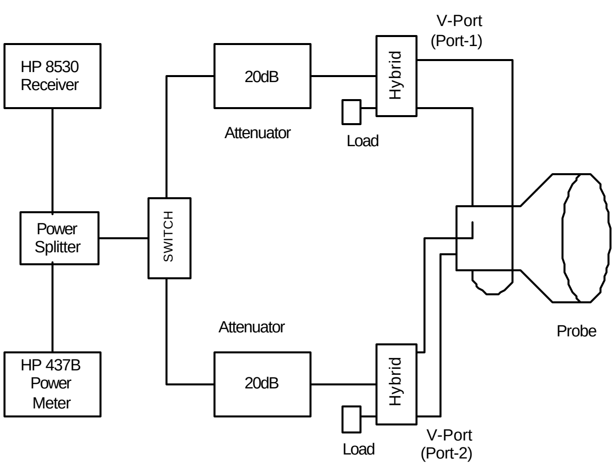

Figure 4 Probe and Power Meter Configuration

		Beam-1 Co-pol		
Term	Item	EIRP (Peak)	-10 dB	-20 dB
1	Probe relative pattern	0.00	0.09	0.09
2	Probe polarization ratio	0.00	0.01	0.04
3	Probe gain	0.09	0.00	0.00
4	Probe alignment	0.05	0.02	0.08
5	Normalization constant	0.10	0.00	0.00
6	Impedance mismatch	0.06	0.00	0.00
7	AUT alignment	0.00	0.00	0.00
8	Data point spacing	0.03	0.09	0.28
9	Measurement truncation	0.01	0.04	0.12
10	XY errors	0.00	0.00	0.01
11	Z errors	0.00	0.00	0.01
12	Probe-AUT reflections	0.06	0.09	0.27
13	Receiver linearity	0.02	0.06	0.19
14	Systematic phase	0.00	0.01	0.02
15	Dynamic range	0.00	0.01	0.02
16	Room scattering	0.04	0.11	0.34
17	Leakage and crosstalk	0.01	0.04	0.11
18	Random errors	0.00	0.00	0.00
	RSS total	0.18	0.21	0.59

Table 1 NIST 18-Term Uncertainty table for EIRP

4. AUTOMATED DATA PROCESSING

The key to Automated EIRP measurements on a multi-beam antenna is reducing pre-calibration, acquisition and processing time required to produce the plots and files. NSI is the leader in high-speed near-field data acquisition. NSI's data acquisition system has the capability of measuring all 16 beams while continuously scanning. In addition, NSI has recently added a simple interface to create automated processing tasks. This approach allows a set of Sequence Files to be written to perform tasks such as: Beam selection, Plot setup, Processing, and generation of hard-copy plots and files.

A Sequence file can include as many commands as required to process all beams. As an example, the Alcatel system required one contour plot and one file generated for each processed beam. All plots and files were output in EIRP. This is easily accomplished with a single NSI Sequence File.

Automation of the acquisition and processing tasks was very effective in reducing test time and operator error. Table 2 shows the comparison of manual power-meter measurement and processing to that of automation.

Parameter	Manual	Automatic
Pre-calibration	60 min	60 min
Power meter measurement	30 min	1 min
Acquisition	55 min	55 min
Total Acquisition, pre-cal and meas.	145 min	116 min
Processing per beam	3 min	1.75 min
Total Processing (16 beams)	48 min	28 min
Total Pre-calibration Acquisition and Processing for 16 beams	193 min	144 min

Table 2 Acquisition and Processing of 16 beams with manual/automatic power meter and processing

5. CONCLUSION

The Direct-EIRP method and the special system NSI implemented for Alcatel Espace was very effective in reducing EIRP measurement and setup time for Globalstar multi-beam active antennas. The Direct-EIRP measurement method also increases reliability by reducing cable manipulations. NSI's Sequence file system for automatic multi-beam processing decreases keystrokes and processing time, and can be set up so that less knowledgeable personnel can acquire and process very complex data presentations and plots.

6. ACKNOWLEDGMENTS

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