Update of IEEE Std 1720-2012 Recommended Practice for Near-Field Antenna Measurements

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***Abstract*— The IEEE Standards Association Standards Board (IEEE-SASB) approved the IEEE Std 1720™ "Recommended Practice for Near-Field Antenna Measurements" in 2012 [1]. More than forty dedicated people from industry, academia and other institutions contributed to the creation of this new document. The main motivation for a new standard dedicated to near-field measurements was to complement the existing IEEE Std 149-1979™ "Test Procedures for Antennas" [2].**

According to the IEEE-SA policies, the existing standard IEEE Std 1720-2012™ is approaching expiration in 2022. A working group of the APS Standard Committee has been formed to review the current document. Most of the current standard is still relevant and useful for individuals designing and evaluating near-field antenna measurement facilities and other people involved in antenna measurements. However, the standard needs update and renewal in areas in which new developments and technologies have matured. This paper gives an overview of the current standards and discusses the suggested potential changes.

I. Introduction

Near-field techniques matured and became usefull systems for antenna measurements about four decades ago. Today, there are several hundreds of near-field antenna test facilities installed around the world. Such test facilities are deployed for three main geometries: planar, cylindrical and spherical as shown in Figure 1.

The planar near-field scanning method, in which the probe is scanned on a planar surface in front of the Antenna Under Test (AUT) is ideally suited for measuring moderately to highly directive antennas. The cylindrical near-field scanning method is ideally suited for measuring fan-beam type antennas. Spherical near-field scanning is a versatile measurement method that can be applied to all measurement scenarios. However, it is considered to be ideal for low to moderate directive antenna.

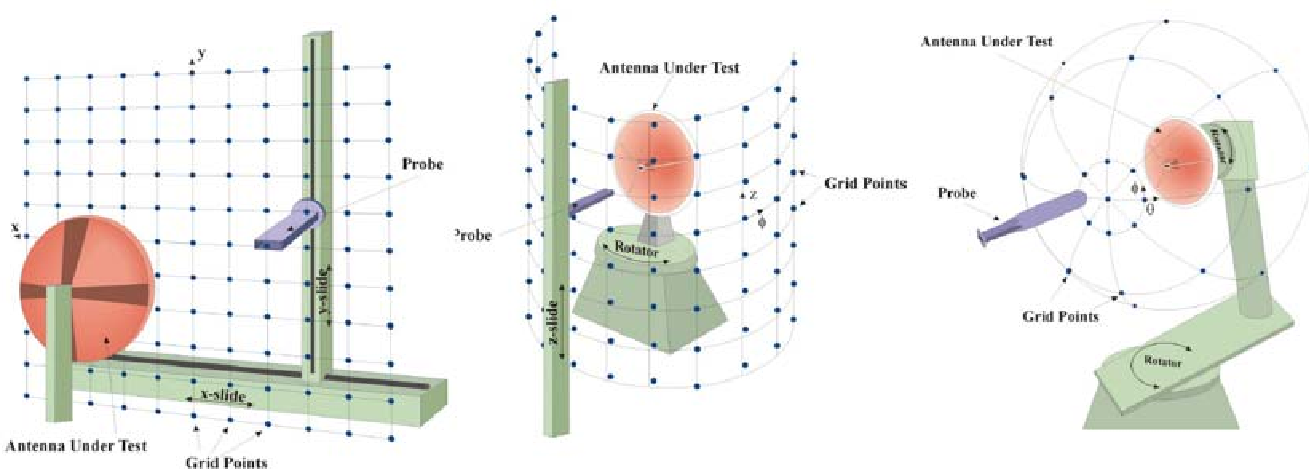

Figure 1. Illustration of the main three near-field scanning geometries: Planar, Cylindrical and Spherical.

II. Content of IEEE Std 1720™-2012

The IEEE Std, 1720™-2012 IEEE Recommended Practice for Near-Field Antenna Measurements" include the following sections:

1. Overview
2. Normative reference
3. Background and Summary
4. Measurements systems
5. Planar near-field scanning measurements
6. Cylindrical near-field scanning measurements
7. Spherical near-field scanning
8. Probes
9. Uncertainty analysis
10. Special topics
11. Summary

A given near-field measurement system may have its own specific characteristics for the data acquisition e.g., mechanical or electrical scanning system. Nonetheless, whatever scanning system is adopted, all systems are composed of a radio frequency transmit and receive system with some type of automated scanning, data collection and control system (DCCS) and computerized analysis ability. The calibrated probe used for the measurement of the antenna under test (AUT) should minimize the distortion of its far-field characteristics.

The measurements systems section discusses the various scanning subsystem configurations and their implementation and requirements. The basic geometries for planar, cylindrical, and spherical near-field scanning and data point acquisition methods are presented and practical implementations of mechanical and electrical systems are discussed.

Also, the Radio-Frequency (RF) transmit and receive system with computerized scanning, data acquisition, and analysis capability is covered in some detail. Throughout the document the importance of the probe selection depending on the scan geometry to minimize its influence on the determined far-field characteristics of the test antenna or Antenna Under Test (AUT) is pointed out.

The planar near-field scanning method, in which the probe is scanned on a planar surface in front of the AUT is ideally suited for measuring moderately to highly directive antennas. It was the first near-field scanning geometry for which probe corrected theory, performed direction by direction was developed. The section on planar near-field measurements gives a brief summary of planar near-field theory and the FFT based near-to-far-field (NFFF) transformation. The reader is directed to the literature for more detailed discussion. The section also provides a discussion on the practical implementation of planar near-field systems as shown in the example in Figure 2.

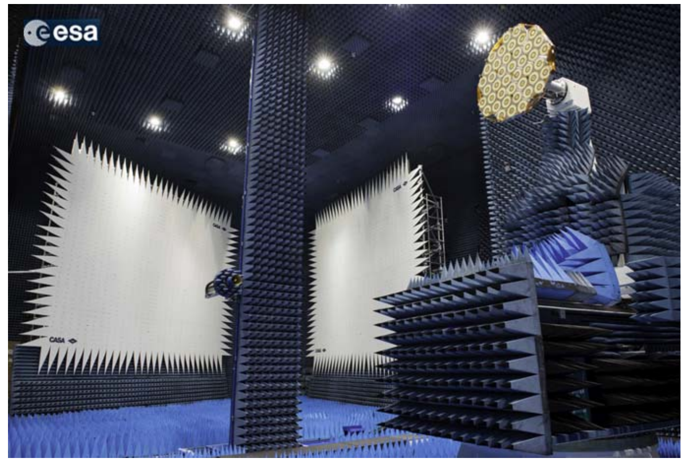

Figure 2. ESA-ESTEC "HERTZ" planar near-field system.

The cylindrical near-field scanning method is ideally suited for measuring fan-beam type antennas at the cost of a moderate increase in the analytical and computational complication. This technique is discussed in a dedicated section.

The section on spherical near-field scanning methods include a description of different spherical scanning geometries and implementations. It also contains a brief introduction to spherical near-field transformation techniques. The benefits of probes with special symmetry properties (referred to as a $\mu = \pm 1$ probe) are also explained. An example of a spherical near-field system is shown in Figure 3.

Figure 3. DTU-ESA Spherical Near-Field Antenna Test Facility. Calibration of "MIROS" radiometer.

To accurately determine the far field of test antenna or AUT from near-field data, it is necessary to correct for the effects of the probe. This requires knowledge of the probe's on-axis gain and polarization, as well as the probe's co-polarization and cross-polarization patterns. How to select, measure and determine probe properties is covered in the section dedicated to probes. This section also has a short introduction to multi-probe systems in which the mechanical scanning using a single probe is substituted with an array of probes or sensors to increase measurement speed as shown in Figure 4.

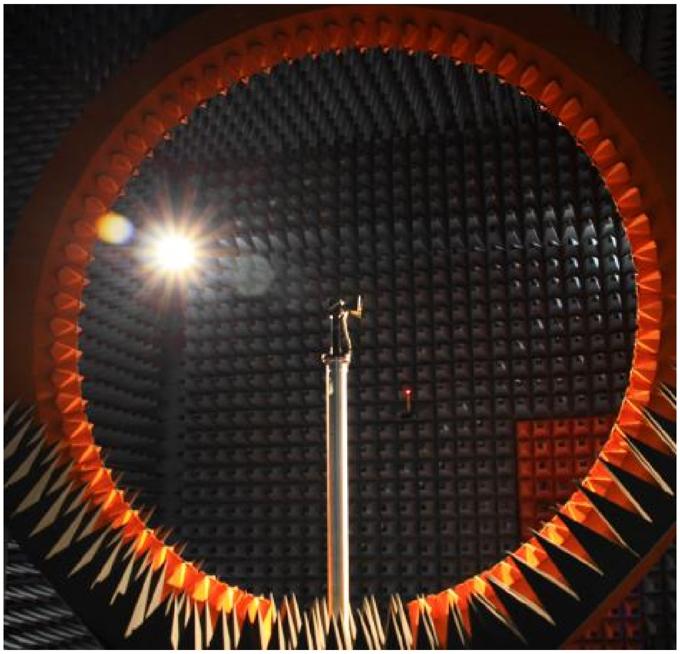

Figure 4. Example of a multi-probe spherical system.

The section dedicated to antenna measurement uncertainty gives a brief introduction to uncertainty analysis of and the NIST 18-term uncertainty model is introduced. The sources of uncertainty are discussed and methods of estimating the magnitude of these are delineated for spherical, planar and cylindrical scan geometries.

In the section on special topics various arguments of relevance to near-field measurement and techniques are listed.

10.1 Effective isotropic radiated power
10.2 Saturating flux density
10.3 Pulsed-mode measurement techniques
10.4 Phase retrieval methods
10.5 Back projections
10.6 Probe-position correction
10.7 Truncation mitigation
10.8 Time gating in near-field antenna measurements

III. Suggested Changes

The current standard is still highly relevant and useful for individuals designing and evaluating near-field antenna measurement facilities and other people involved in antenna measurements. However, it must be reviewed and updated in areas where new technological developments have become adapted as standard procedures by the community. As the work is ongoing the suggested topics to be included in the new standard are likely to evolve in the duration of the review.

A special section dedicated to the design of appropriate chambers including recommendations on absorber layout has been suggested. Similar recommendations are being incorporated in the review of the IEEE Std 149™ [2-3].

The paragraph dedicated to uncertainty analysis must be renewed and updated. In particular, the new text must follow the practice of the generally accepted ISO “GUM” document, Guide to the expression of uncertainty in measurement [4].

Some new techniques now widely applied in near-field measurement post-processing could also merit inclusion or mentioning in the standard. Such techniques include higher order probe compensation [5-6], echo reduction techniques [7] and use of non-orthogonal expansion functions in the Near-Field to Far-Field transformation such as equivalent currents [8].

With the growing importance of near-field testing methods of devices for personal communication such as 4G/5G and internet-of-things (IoT) there is a need to include commonly used techniques and definitions in the testing of devices in the new standard. These include the use of climate chambers for temperature testing also used in military and space applications and measurement of radiated power (TRP) and sensitivity (TRS) of devices.

IV. Conclusion

The current IEEE Std 1720-2012™ “Recommended Practice for Near-Field Antenna Measurements” is expiring in 2022. A working group of the APS Standard Committee has been formed to update and modernize the current standard. This paper gives an overview of the current standards and discus the suggested changes.

References

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[2] IEEE Standard Test Procedures for Antennas, IEEE Std. 149-1979.

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