Revision Progress 2024: IEEE Std 1720

Lars Jacob Foged, *Fellow, AMTA,*
MVG, Microwave Vision Italy,
Pomezia, Italy
lars.foged@mvg-world.com

Jeff Fordham, *Fellow AMTA*
President, AMTA
Jeff.Fordham@IEEE.org

Justin Dobbins, *Fellow AMTA,*
Raytheon Technologies,
Tucson, AZ, USA,
justin.dobbins@rtx.com

Vince Rodriguez *Fellow AMTA*
NSI-MI Technologies, Suwanee, GA, USA
vince.rodriguez@ametek.com,

Vikass Monebhurrun, *Senior Member, AMTA*.
Chair IEEE APS/SC
CentraleSupélec, GeePs, Paris, France,
vikass.monebhurrun@centralesupelec.fr

***Abstract*—The IEEE Std 1720™, "Recommended Practice for Near-Field Antenna Measurements," serves as a dedicated guideline for conducting near-field (NF) antenna measurements [1]. It serves as a valuable companion to IEEE Std 149-2021™, "IEEE Recommended Practice for Antenna Measurements," which outlines general procedures for antenna measurements [2]. IEEE Std 1720-2012 was approved in 2012 as a completely new standard by the IEEE Standards Association Standards Board (SASB). It holds significant importance for users engaged in NF antenna measurements and contributes to the design and evaluation of NF antenna measurement facilities.**

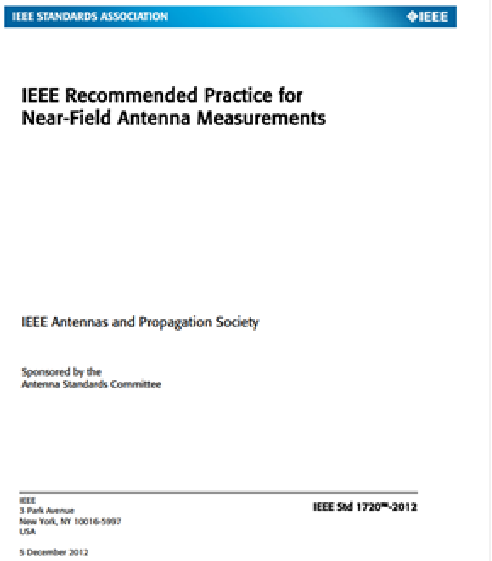
A revision of the existing standard is nearing completion and is expected to be completed in 2025. The objective of this paper is to provide insights into the ongoing activities and to explore the proposed changes. It aims to continue the discussion on the modifications to the standard and their implications for modern NF antenna measurements.

I. INTRODUCTION

Near-field measurements are widely recognized as a highly accurate and versatile technique for testing antennas. These measurements techniques emerged and soon became one of the the preferred approach for testing a broad range of antennas. Today, there are hundreds of near-field antenna test facilities installed across the globe, attesting to the method's proven effectiveness and significance.

The IEEE Std 1720™ shown in Figure 1, was initially approved in 2012 as a completely new standard by the IEEE Standards Association Standards Board (SASB). Advancements in technology and emerging developments over the past decade have made a revision necessary to ensure the document is current. In 2019, the IEEE-SASB approved project authorization request (PAR), P1720, which aims to undertake a revision of the current standard. To accomplish this task, a dedicated Working Group (WG) has been formed under the Antennas and Propagation Society Standards Committee (APS/SC). Currently comprising around fifty committed volunteer members from industry, academia, and government, the WG is representative of the near-field measurement community, with both users and experts in the field.

The WG has been actively engaging in regular virtual meetings, with occasional face-to-face gatherings when possible. The primary focus of the WG has been on revising the existing material and identifying pertinent new NF measurement topics to be included in the updated standard. To facilitate smooth collaboration, the IEEE-SASB has provided a dedicated workspace with an accessible database for all WG members. This comprehensive platform houses up-to-date documents and a complete history of developments [3]. Additionally, the workspace enables group decision-making through online discussions and electronic voting on various topics. The efficiency of this approach has significantly contributed to the progress of the WG's efforts.



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IEEE Recommended Practice for
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IEEE Antennas and Propagation Society

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3 Park Avenue
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USA

5 December 2012

IEEE Std 1720™-2012

Figure 1. IEEE Std 1720$^{\mathrm{TM}}$-2012 Recommended Practice for Near-Field Antenna Measurements [1].

During the Antenna Measurements Techniques Association symposium in 2023, a comprehensive report of progress on special topics was presented [4]. A review of this paper can provide detail on the contents of the special topics section. In this paper, we provide an update of progress and highlight a few of the newer additions to the standard.

I. CONTENT OF THE REVISED IEEE STD 1720™

As the document revision is considered “minor”, the outline of the new document closely follows the original standard [1]. The main NF scanning geometries, planar, cylindrical, and spherical are covered in detail. This original material is being updated, reviewed, or rewritten depending on the level of review performed. The changes are intended to renew, update, and reflect widely accepted changes in technology and post-processing techniques. The draft outline is shown below:

1. Overview
2. Normative reference
3. Background
4. Measurement systems
5. Planar near-field scanning measurements
6. Cylindrical near-field scanning measurements
7. Spherical near-field scanning
8. Non regular scanning techniques
9. Probes
10. Determination of antenna gain
11. Uncertainty analysis
12. Special topics

II. CHANGES TO THE MAIN CLAUSES

The IEEE standard time convention for time-harmonic electromagnetic fields is of the form exp(+jωt), where j is the imaginary unit, ω the angular frequency, and t is time. Using this convention, the corresponding propagation phase factor is exp(-jkr), where k is the wave number and r is the propagation distance. This notation is sometimes referred to as the *engineering* time notation. This differs from the *physics* notation wherein the “+” and “-” signs are interchanged in the above expressions. Throughout the standard, both time conventions are used without much distinction.

As the choice of convention does not matter if consistency is maintained, the group decided to preserve the mix of *engineering* and *physics* time conventions in the standard as foundational references exist using both conventions. Any new material based on commonly accepted practices will be in the engineering time convention. It is important that the convention used in the text is clear to the user of the standard.

In Clause 3, “Background”, the *physics* time convention is used predominantly. The rest of the document mainly use the *engineering* convention. Mixed time conventions are commonly encountered in antenna measurements. It is particularly important that the system hardware/software implementations have the same convention to avoid erroneous results during near-field to far-field (NFFF) transformation.

Clause 4 of the standard is dedicated to the discussion of measurement systems used in near-field scanning. These systems require a combination of essential components, including a radio-frequency (RF) transmit and receive system, computerized scanning capabilities, data acquisition tools, and analysis software. The practical implementation of mechanical and electrical systems in these measurement setups can vary based on specific requirements, suitability, and the relative importance of different factors. The initial focus is on the acquisition of data on specific geometries, such as planes, cylinders, or spheres. This provides practitioners with valuable insights into the selection of appropriate scanning systems that align with their specific measurement needs. An important new addition to Clause 4 is a comprehensive discussion on modern anechoic chamber design, along with corresponding recommendations. This inclusion addresses the significance of optimizing the chamber environment for accurate and reliable near-field scanning measurements (see Figure 2).

In IEEE STD 1720-2012 [1] there was only a short paragraph on the RF absorber placement. Clause 5.3.1.8 of IEEE STD 1720-2012 [1] dealt with the absorber placement, however, there were no specific recommendations for coverage except for planar near field (PNF) scanning. Indeed, Clause 5 dealt with PNF scanning measurements. Hence, the only recommendation in 5.3.1.8 of the previous version of the standard was to treat the range surface in front of the antenna such that the main beam was maximally absorbed [1].

Much like it was done on the IEEE STD 149-2021 [2], in the new version of 1720, the work presented in [5] is used to provide recommendations for the size and positioning of the RF absorber, not only for the PNF case, but for the spherical and cylindrical scanning cases as well.

The recommendations presented aim to reduce the range multi-path two levels that are at least -40 dB lower than the direct path between probe and AUT. In addition to these recommendations, the standards point to references in the bibliography where optimizations of the absorber layout can be performed as it was shown in [5]. Figure 2 shows the possibility of using numerical methods to evaluate the illumination of the range walls to optimize the RF absorber coverage.

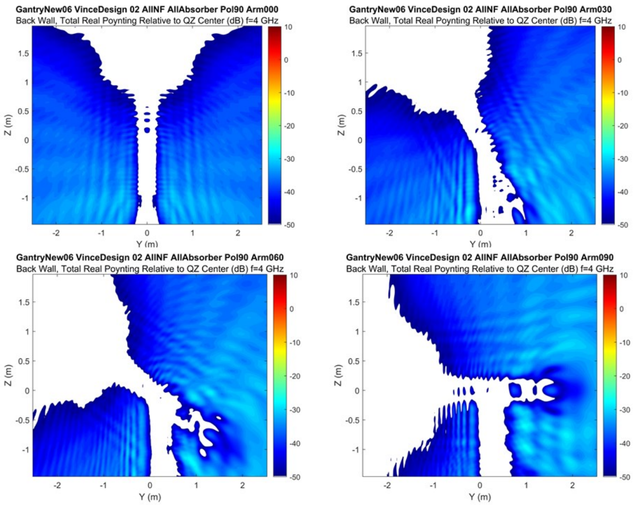

Figure 2. Recommendations for range absorber coverage are now presented in Clause 4. In this figure from the standard, the illumination of the end wall of a SNF range with a movable gantry is shown.

Clause 5 of the standard provides an overview of planar near-field theory along with practical implementation considerations. This method is particularly suitable for measuring antennas with moderate to high directivity. During planar near-field measurements, a probe is scanned over a planar surface located in front of the antenna under test (AUT). To transform the near-field measurements into the far-field domain, a fast Fourier transform is commonly employed. Planar near-field scanning is commonly employed for high directivity antennas due to the truncation of the scan area. The planar near-field scanning method was the first geometry for which probe correction theory was developed. The probe correction process is performed direction by direction, ensuring accurate and reliable results.

Clause 6 of the standard focuses on NFFF transformation techniques using cylindrical scanning. While this approach introduces a moderate increase in analytical and computational complexity compared to planar scanning, it offers the advantage of reconstructing the complete radiation pattern of the antenna, excluding the regions near the positive and negative cylindrical axes. In cylindrical scanning the near-field data is acquired along a cylindrical grid and is thus particularly well-suited for fan-beam type antennas. By accounting for the effects of the probe, it becomes possible to accurately determine the far-field pattern of the AUT. A brief introduction to advanced scanning techniques aimed at reducing the number of measurements points (and thus measurement time) and the associated processing is also included.

Clause 7 of the standard is dedicated to spherical scanning techniques. It starts by providing a fundamental explanation of the theory behind spherical scanning, highlighting the use of probes with special symmetry properties, specifically the $\mu = \pm 1$ probes. The benefits and advantages of employing these probes are thoroughly explained, emphasizing their significance in achieving accurate measurements. The clause has been further enhanced by an expanded discussion on higher-order probe compensation strategies. By incorporating probe compensation techniques of any order, practitioners can effectively minimize the impact of probe characteristics and enhance the accuracy of the measured results for a wider variety of probes. This comprehensive coverage of probe compensation techniques ensures that practitioners have the necessary tools and knowledge to perform precise spherical near-field scanning measurements. The clause also includes a new comprehensive discussion on various techniques for AUT gain determination. Different approaches, applied to spherical near-field measurements, providing practitioners with a comprehensive understanding of the measurement process.

Clause 8, titled "Non-regular scanning techniques," encompasses the implementation of non-redundant sampling representations in different canonical scanning geometries such as planar, cylindrical, and spherical configurations. The primary objective of these techniques is to minimize measurement time. Furthermore, this clause also provides guidance on techniques applicable in the growing trend of sampling over non-canonical surfaces, highlighting the increased use of airborne drones and robotic systems for this purpose.

In Clause 9 of the standard, the selection and calibration of probes for near-field measurement applications are thoroughly discussed. The choice of suitable probes for near-field measurements is crucial as it directly affects the accuracy of the calculated far-field characteristics of the AUT. To ensure precise determination of the far field of an AUT using near-field data, it is essential to account for the probe's influence during the measurement process. This necessitates knowledge of the probe's on-axis gain, polarization characteristics, as well as its co-polarization and cross-polarization patterns. This clause provides detailed instructions on measuring and determining these probe properties, enabling practitioners to accurately characterize the probe's behaviour. The clause offers guidance on selecting an appropriate probe for specific measurement scenarios. Factors such as the scan surface geometry and the desired measurement accuracy are taken into consideration to aid practitioners in making informed decisions regarding probe selection.

Clause 10 of the standard is dedicated to the analysis of gain in near-field measurement systems. Accurate gain determination techniques for near-field measurements are a fundamental challenge. The pursuit for precise gain measurements still revolves around selecting the most suitable gain measurement techniques for a given antenna and measurements scenario. Each technique inherently possesses its own limits in terms of accuracy, influenced by factors such as the measurement setup, environmental conditions, and the necessary equipment.

Additionally, the choice of technique can impact the efficiency and throughput of the measurement setup. Striking a balance between the financial investment required to obtain accurate gain measurements and the desired level of precision remains an ongoing challenge. This clause provide guidance on best practices to help choose the best methodology.

Clause 11 of the standard is dedicated to the analysis of uncertainty in near-field antenna measurements. It serves as a resource for practitioners to understand and address the sources of uncertainty that can arise during the measurement process. The clause has been updated and revised to reflect recent changes and follows standardized procedures in line with widely recognized guidelines.

Clause 11 is dedicated to "special topics", where various themes of relevance to near-field antenna measurements and post-processing techniques are described. Among these are several new techniques that are now widely accepted by near-field antenna measurement practitioners. [4]

Subclause 11.1 is dedicated to antenna system testing. This subclause has undergone some significant changes in the recent update. The term *antenna system* describes a device-under-test that consists of one or more passive radiating (or receiving) antennas that are connected to one or more active electronic devices and typically remain connected for the duration of the test. The testing of such systems typically aims at determining the receive and/or transmit power performance parameters of the electronic devices connected to the antenna.

To illustrate what is addressed in this subclause, three example antenna systems are shown in Figure 3.

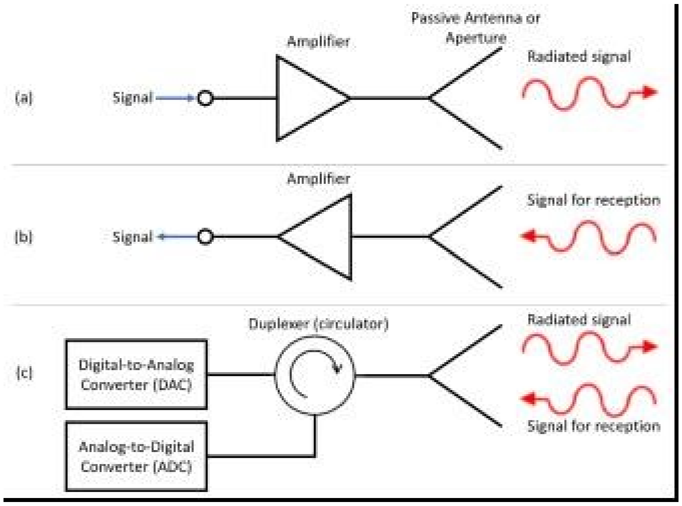

Figure 3. Three antenna systems. (a) A transmitting antenna system. (b) A receiving antenna system. (c) An antenna system capable of transmitting and receiving simultaneously.

In configurations where it is difficult or undesirable to separate the active electronics from the passive antenna aperture(s), it is not possible to measure some component-level quantities of interest (e.g., aperture gain, transmitted power, receiver noise figure) directly, but it is possible to characterize combinations of these parameters that can be used to assess system-level performance.

This subclause of the standard describes methods for the measurement of common antenna system parameters of interest when the measurement probe is in the near field of the DUT. Recommendations on common methods of testing parameters such as equivalent isotropically radiated power (EIRP), saturating flux density (SFD), gain over noise temperature (G/T), effective isotropic sensitivity (EIS), and digital error rates.

III. CONCLUSION AND NEXT STEPS

The IEEE Std 1720-2012™ "Recommended Practice for Near-Field Antenna Measurements" expires in 2022. A working group of the APS/SC has been formed to update the standard. This paper provided an overview of the update and discussed the planned changes.

As of this paper submission, the draft standard is on version P1720/D4. This draft has been reviewed by a small group of knowledgeable practitioners of the art of near-field measurements that have provided valuable comments for incorporation. In order to have time to complete these changes the chairs of the WG have decided to file a one-year extension and go to balloting near the end of the year and complete the standard in early 2025.

ACKNOWLEDGEMENT

The authors would like to recognise the hard work of the entire P1720 WG [3] for their continued dedication to the review of the current standard.

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