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

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***Abstract*—The IEEE Std 1720™ "Recommended Practice for Near-Field Antenna Measurements" is specifically dedicated to near-field (NF) antenna measurements [1]. It therefore complements the IEEE Std 149-2021™ "IEEE Recommended Practice for Antenna Measurements" which describes general antenna measurement procedures [2]. IEEE Std 1720™ was originally approved in 2012 as a completely new standard by the IEEE Standards Association Standards Board (SASB). It is highly relevant for users performing NF antenna measurements but also the design and evaluation of the antenna measurement facilities. After ten successful years, the standard expires in 2022 and will no longer be an active standard under the IEEE SASB. A "minor revision" of the current standard is ongoing. This paper gives an update on the running activities and discusses the suggested changes to the standard.**

I. INTRODUCTION

Near-field (NF) measurements is considered as a very accurate and versatile antenna testing technique. It became widely used as a preferred measurement technology in antenna measurement systems about four decades ago. Today, hundreds of near-field antenna test facilities are installed worldwide.

IEEE Std 1720™ (see Figure 1) was originally approved in 2012 as a completely new standard by the IEEE Standards Association Standards Board (SASB). A revision is required to update the document with new developments and technologies that have matured since the first edition. The scope of the project authorization request (PAR), P1720 that was approved by IEEE-SASB in 2019 is to undertake a "minor revision" of the current standard. A Working Group (WG) of the Antennas and Propagation Society Standards Committee (APS/SC) has been formed for this task. The WG, which currently consists of about fifty dedicated volunteer members from industry, academia, and government, is highly representative of the field with users and experts of the near-field measurement community.

Since 2019, the WG has met regularly in virtual meetings and face-to-face, when possible, to revise the existing material and discuss relevant new NF measurement topics that should be included in the revised standard. Recent progress in the WG is discussed in [3], [4], [5].

The IEEE-SASB has provided a dedicated workspace with an accessible database, for all WG members, with up-to-date documents and the full history of the developments [6]. The same platform is also used to arrive rapidly at group decisions through online discussions and electronic voting on various topics.

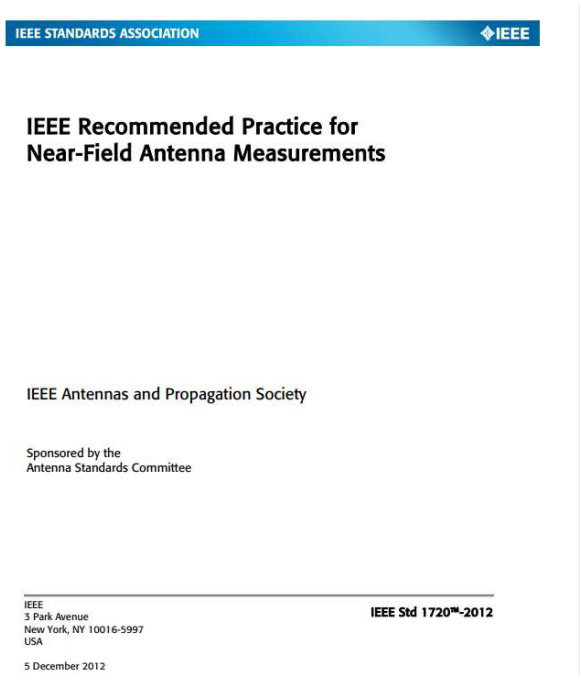

Figure 1. IEEE Std 1720™-2012 Reccomended Pratice for Near-Field Antenna Measurements [1].

II. 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 review performed. The changes are intended to renew, update, and reflect widely accepted changes in technology and post-processing techniques. The outline is in continuous evolution as the revision is progressing as described below:

1. Overview
2. Normative reference
3. Background (Updated)
4. Measurement systems (Updated)
5. Planar near-field scanning measurements (Reviewed)
6. Cylindrical near-field scanning measurements (Reviewed)
7. Spherical near-field scanning (Reviewed)
8. Probes (Updated)
9. Uncertainty analysis (Rewritten)
10. Special topics
11. Summary

In Clause 10, dedicated to "special topics", various subjects of relevance to near-field measurements and techniques are listed. New techniques, widely accepted in near-field measurement post-processing have been included as annotated in the new sub-clause list shown here:

10.1 Antenna system testing (End-to-end, OTA, New)
10.2 (left blank for now)
10.3 Pulsed-mode measurement techniques (to Clause 4)
10.4 (left blank for now)
10.5 Back projections & diagnostics (New & Updated)
10.6 Probe-position correction (Reviewed)
10.7 Truncation mitigation (Rewritten)
10.8 Time gating in near-field antenna measurements (Rewritten)
10.9 (Single Frequency) Spatial Filtering Scattering Suppression Techniques (New)
10.10 Thermal testing (New)
10.11 (left blank for now)
10.12 Non-regular scanning techniques (New)
10.13 Equivalent currents (Moved to 10.5)
10.14 Phase retrieval methods (Rewritten)
10.15 Facility comparison campaigns (New)

III. Changes to the main clauses

The IEEE standard time convention for time-harmonic electromagnetic fields is of the form $\exp(+j\omega t)$, where j is the imaginary unit, ω the angular frequency, and t is time [7]. 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. 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.

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. A paragraph will be added to clarify both conventions and explain what such differences could bring to measurement results.

Other important changes are found in Clause 4 "Measurement systems" where a discussion on modern anechoic chamber design and recommendations has been added. The treatment of sources of measurement uncertainty and different correction schemes will be moved from Clause 4 to complete Clause 9 on "Uncertainty analysis". Clause 9 will be modified to follow the practice of the generally accepted ISO "GUM" [8]. Finally, higher order probe compensation schemes will be added to Clause 7 on "Spherical near-field scanning".

IV. Changes to Special Topics clause

Most of the proposed changes are found in the "Special topics" Clause 10. These changes have come about from many discussions and suggestions, and agreed within the WG.

A new topic, 10.1 "Antenna system testing" is dedicated to recommendations on antenna testing as a system. Such techniques are commonly used in military/space measurement applications and telecommunication. The treatment includes new topics and an elaboration of existing topics and material from the std 1720-2012. This includes techniques for end-to-end testing and Over-The-Air (OTA) testing. With the increasing importance of NF testing methods of personal communication equipment such as 4G/5G and internet-of-things (IoT) devices, the measurement of power/sensitivity parameters of devices that do not allow direct measurements of the integrated antenna are now routinely performed. Some of these techniques have previously been reported mainly in telecommunication literature. The discussion of these topics in the revised Std 1720 reports on commonly accepted techniques in the community. This new material is presented using standard IEEE conventions and relative to accepted methods, methodology, and language in the community to give the reader guidance and introduction to commonly used techniques.

Sub-clause 10.5, "Back projections & diagnostics" comprises an introduction to field expansion using equivalent

current/sources as non-orthogonal expansion functions. This approach is frequently used in NFFF transformation for measurements on non-canonical scanning surfaces including the non-regular scanning grids, that is treated separately in 10.12. It is also used as a spatial filtering technique by virtue of the spatial quality of the current as discussed further in 10.9.

Sub-clause 10.6 “Probe-position correction” is closely linked to 10.12 "Non-regular scanning techniques” as many of the same techniques that are used to correct for intentionally non regular grids can be used for correcting non-intentional but known probe position errors during processing.

The discussions in sub-clause 10.7 “Truncation mitigation” and 10.8 “Time gating in near-field antenna measurements” will be completely rewritten to reflect commonly accepted but recent changes in the techniques and to guide potential users.

The topic in sub-clause 10.9 “(Single Frequency) Spatial Filtering Scattering Suppression Techniques” was treated marginally in the 2012 standard. Frequency domain scattering suppression techniques have been used for years in antenna measurements. A variety of different methods have been harnessed that utilize a range of techniques, however the techniques discussed in this sub-clause differ from those discussed in the standard as they operate within the frequency domain, requiring only a single frequency measurement, and do not necessitate any special dedicated hardware. The most adopted approach is to decompose the fields onto a set of modes in which those modes that are primarily associated with the test antenna are, within the mode domain, mostly separated from those modes that are primarily associated with the scattered signal thereby enabling the unwanted spurious signals to be largely extracted from the antenna pattern.

The 10.10 sub-clause on “Thermal testing” includes recommendations on the use of climate chambers for radiated testing of devices over temperature, also used in military/space applications. With the increasing complexity of antenna systems, their varied fields of applications and the need for high reliability, it is often required to ensure that antenna or device performance is not deteriorated or dependent on its surrounding environment. Although this environment changes depending on the application, temperature is often a common denominator in environment characteristics that may modify the performance of the antenna and/or device. Thermal testing allows characterizing critical antenna performance parameters in a representative environment, ensuring that the antenna performs as intended in the various conditions it will face during its operation. Typical applications include antennas systems operating in areas with extreme temperature conditions, antennas that require handling high levels of RF power, and antennas for space applications. The sub-clause gives guidance on thermal testing set-up, system components, and criticalities and data processing.

Sub-clause 10.12 “Non regular scanning techniques” includes non-redundant sampling representations that can be applied in classical scan geometries such as planar, cylindrical, and spherical, aiming at reducing the measurement time. 10.12 also include a discussion on sampling over non-canonical surfaces, a practice that has become more common with the recent availability of airborne drones.

Sub-clause 10.14 “Phase retrieval methods” deals with the challenge of unavailable phase information in the near-field measurement. All near-field techniques require precise knowledge of amplitude and phase data at some specified distance and frequency on a prescribed surface in order to perform the NFFF transformation. In cases where phase is not available or difficult to obtain accurately, phase retrieval methods prove to be an important tool.. A phase retrieval technique classification would lead to three categories: four magnitudes techniques, indirect holography techniques, and multiple scan techniques by means of iterative and optimization schemes. Even combinations or variations of such techniques can be found in the literature. The sub-clause is completely rewritten and updated to reflect recent changes.

Sub-clause 10.15 “Facility comparison campaigns” is a completely new topic. In recent years, many facilities have been involved in measurement comparison campaigns as these activities play an important role for the documentation and validation of laboratory proficiency and competence, helping to improve the antenna measurement procedures/protocols in facilities and standards. The paragraph recommends on the organisation and/or participation in such campaigns.

V. Conclusion

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

Acknowledgement

The authors would like to recognise the keen work of the P1720 WG [6] for the continued dedication to the review and development of the standard.

References

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