

IEEE TC-10: Update 2006

Thomas E. Linnenbrink¹, William B. Boyer², Nicholas G. Paulter, Jr.³, Steven J. Tilden⁴

¹Chair, Waveform Generation, Measurement, and Analysis Committee (TC-10)

Hittite Microwave Corporation, Colorado Springs, CO, USA

Email: linnenbrink@hittite.com

²Chair, Subcommittee on Digital Waveform Recorders

Sandia National Laboratory (SNL) (retired), Albuquerque, NM, USA

Email: billboyer@netscape.com

³Chair, Subcommittee on Pulse Techniques (SCOPT)

National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA

Email: nicholas.paulter@nist.gov

⁴Chair, Subcommittee on Analog-to-Digital Converters (ADCs)

Chair, Subcommittee on Digital-to-Analog Converters, (DACs)

Texas Instruments, Inc. (TI), Tucson, AZ, USA

Email: tilden_steve@ti.com

Abstract – *There is a need throughout the world for uniform test methods for devices used to generate, measure, and analyze waveforms. Technical Committee 10 (TC-10), the Waveform Generation, Measurement, and Analysis Committee of the Instrumentation and Measurement (I&M) Society, is tasked to develop standards to address these needs. To date, standards have been developed for digitizing waveform recorders, analog-to-digital converters, and transitions, pulses, and related waveforms. A standard for digital-to-analog converters is in progress.*

Keywords – *IEEE Std 181, IEEE Std 1057, IEEE Std 1241, IEEE Std 1658 (Draft), Digitizing Waveform Recorder, Pulse, ADC, DAC, Measurement*

I. INTRODUCTION

There is a need throughout the world for uniform test methods for devices used to generate, measure, and analyze waveforms; uniformly-defined terms that describe these devices, and their operation and performance characteristics; and uniform methods of computing the values of the parameters describing these performance characteristics. Users need to be able to unambiguously specify the device performance required for particular applications. Manufacturers need to be able to unambiguously state the performance of their devices (e.g., instruments, components, etc.). Metrology facilities need to perform calibrations with well-defined methods to produce reliable, unambiguous data expressed in clear terms. Measurement instruments need to acquire data with well-defined methods and present it clearly. Technical Committee 10 (TC-10), the Waveform Generation, Measurement, and Analysis Committee of the

Instrumentation and Measurement (I&M) Society, is tasked to develop standards to address these needs. TC-10 comprises an international group of electronics engineers, mathematicians, and physicists with representatives from national metrology laboratories, national science laboratories, ADC manufacturers, the test instrumentation industry, academia, and users.

The initial project for TC-10 was to develop the IEEE Standard for Digitizing Waveform Recorders, IEEE Std 1057-1994 [1]. Work on this standard unofficially began with the “Seminar on Waveform Recorder Measurement Needs and Techniques for Evaluation/Calibration,” hosted by the National Institute of Standards and Technology [NIST] (then the National Bureau of Standards) in 1981. Dissatisfied with the state of measurement standards and test techniques for waveform recorders, a group of concerned users, manufacturers, and researchers who attended the seminar formed a committee to crystallize waveform recorder specifications and achieve consensus on them. This effort gathered additional members and became affiliated with the IEEE Instrumentation and Measurement Society in 1983. The initial work was completed in 1988, and a Trial-Use Standard [2] was issued in July of 1989. Since that time, the standard has been substantially revised, resulting in the current standard, which now has full-use status.

During the course of developing IEEE Std 1057, TC-10 noted that much of the standard applied to analog-to-digital converters (ADCs). However, it was aware that there are additional terms and test methods that are unique to ADC characterization. Consequently, when IEEE Std 1057 was completed, TC-10 focused its attention on a standard

specifically for ADCs. The Subcommittee on ADCs was formed to develop the IEEE Standard for Terminology and Test Methods for Analog-to-Digital Converters. This standard was completed and released in December 2000 as IEEE Std 1241-2000 [3].

Several standards have previously been written that address the testing of analog-to-digital converters either directly or indirectly. These include:

- IEEE Std 1057-1994, which describes the testing of waveform recorders. This standard has been used as a guide for many of the techniques described in this standard.
- IEEE Std 746-1984 [4], which addresses the testing of analog-to-digital and digital-to-analog converters used for PCM television video signal processing.
- JESD99-1 [5], which deals with the terms and definitions used to describe analog-to-digital and digital-to-analog converters. This standard does not include test methods.
- IEC 60748-4, Interface Integrated Circuits, Semiconductor Devices- Integrated Circuits, which provides [6] criteria for Analogue-Digital Converters (ADC).

IEEE Std 1241-2000 for analog-to-digital converters is intended to focus specifically on terms and definitions as well as test methods for ADCs for a wide range of applications.

The Subcommittee on Pulse Techniques (SCOPT) was formed to revise and combine two out-of-date IEEE standards dealing with pulses. Starting in 1996, the SCOPT wrote a revision to the now-withdrawn standards, IEEE Std 181-1977, Standard on Pulse Measurement and Analysis by Objective Techniques [7] and IEEE Std 194-1977, Standard Pulse Terms and Definitions [8]. These standards dealt with terms and definitions for describing and computing waveform parameters and for describing the waveform measurement process. The IEEE Std 181-1977 superseded the IEEE Std-181-1955 [9], Methods of Measurement of Pulse Quantities. The IEEE Std 194-1977 superseded IEEE Std 194-1951, Standards on Pulses: Definition of Terms - Part 1, 1951 [10]. Close collaboration with the International Electrotechnical Commission (IEC) resulted in IEC Publication 469-1, 1974, Pulse Techniques and Apparatus, Part 1: Pulse Terms and Definitions [11], which is substantially the same as IEEE Std 194-1977. Further collaboration with the IEC resulted in IEC Publication 469-2, 1974, Pulse Techniques and Apparatus, Part 2: Pulse Measurement and Analysis, General Considerations [12], which is substantially the same as IEEE 181-1977.

Development of a set of agreed-upon terms and definitions presented the greatest difficulty because of the pervasive misuse, misrepresentation, and misunderstanding of terms. Legacy issues for instrumentation manufacturers and terms of common use also had to be addressed. In the end, however, the importance of unambiguously and accurately defined terms prevailed. Consequently, many terms were deleted and

many others added. Most definitions were modified. This work finally ended in September 2002 followed by the publication of IEEE Std 181-2003, IEEE Standard on Transitions, Pulses, and Related Waveforms [13]. The Std 181-2003 combines information from both of the withdrawn IEEE standards and supersedes both of them.

As work progressed on the ADC standard, TC-10 realized that a substantial portion of the concepts behind the ADC standard would also apply to digital-to-analog converters (DACs). In fact, many of ADC subcommittee members were also professionally involved with DACs as well as ADCs. As the ADC standard development approached completion, TC-10 searched for existing DAC standards. Finding no DAC standard that provided the broad, general treatment (specifically including dynamic performance) that TC-10 envisaged, it set out to develop a DAC standard. The Standard for Terminology and Test Methods for Digital-to-Analog Converters, P1658, has been in development since March 2004.

II. RESULTS

The efforts of TC-10 have resulted in three published IEEE standards.

A. IEEE Std 1057-1994, “Standard for Digitizing Waveform Recorders”

The purpose of this standard is to provide common terminology and test methods for describing the performance of waveform recorders. It is meant for users and manufacturers of these devices. The main body presents main performance features, sources of error, and test methods. The tests are meant to be used by manufacturers to locate and correct sources of error in the hardware. The information in this standard can also be applied by users to correct some of the errors by software processing after the signal has been recorded. Another planned use for this standard is to aid users in writing specifications for purchasing new waveform recorders.

Instruments covered by this standard are electronic digitizing waveform recorders, waveform analyzers, and digitizing oscilloscopes with digital outputs. This standard is directed toward, but not restricted to, general-purpose waveform recorders and analyzers. Special applications may require additional manufacturer information and verification tests.

B. IEEE Std 1241-2000, “Standard for Terminology and Test Methods for Analog-to-Digital Converters”

This standard identifies analog-to-digital converter (ADC) error sources and provides test methods with which to perform the required error measurements. The information in this standard is useful both to manufacturers and to users of ADCs in that it provides a basis for evaluating and comparing

existing devices, as well as providing a template for writing specifications for the procurement of new ones. In some applications, the information provided by the tests described in this standard can be used to correct ADC errors, such as, gain and offset errors. This standard also presents terminology and definitions to aid the user in defining and testing ADCs.

C. IEEE Std 181-2003, "Standard on Transitions, Pulses, and Related Waveforms"

The purpose of the standard is to facilitate accurate and precise communication concerning parameters of transition, pulse, and related waveforms and the techniques and procedures for measuring them. Because of the broad applicability of electrical pulse technology in the electronics industries (such as computer, telecommunication, and test instrumentation industries), the development of unambiguous definitions for pulse terms and the presentation of methods and/or algorithms for their calculation is important for communication between manufacturers and consumers within the electronics industry. The availability of standard terms, definitions, and methods for their computation helps improve the quality of products and helps the consumer better compare the performance of different products. Improvements to digital waveform recorders have facilitated the capture, sharing, and processing of waveforms. Frequently these waveform recorders have the ability to process the waveform internally and provide pulse parameters. This standard is needed to ensure that the definitions and methods of computation for pulse parameters are consistent.

III. CONTINUING ACTIVITY

TC-10 is promoting awareness of its activities and soliciting involvement from interested people. To that end, papers have been presented at IMTC and IMEKO conferences over the past several years. It also has a general interest in incorporating IEEE standard terms, definition, and test methods into IEC standards. Specific activities of its TC-10 subcommittees follow.

A. Subcommittee on Digital Waveform Recorders (1057)

IEEE Std. 1057-1994 has been re-instated and is in revision at this time. To the extent applicable, portions of IEEE Std. 1241-2000 are incorporated. In common areas between the standards, terms and methods originally published in IEEE Std 1057 were refined and enhanced in IEEE Std 1241. IEEE Std 1057 is leveraging these advances. In a similar manner, pulse terms, definitions, and test methods developed in IEEE Std 181 will be incorporated. Pulse techniques are especially important since many digital oscilloscopes directly report pulse parameters. Finally, the subcommittee is working to improve definitions and test

methods for critical metrics, such as, Effective Number of Bits (ENOB), total harmonic distortion, noise, locating code transitions. Other improvements include detailed discussion of requirements for and errors in signal sources.

B. Subcommittee on ADC (1241)

The subcommittee is promoting awareness of IEEE Std 1241-2000 through papers at conferences as well as in trade journals. It is seeking to promote usage with a logo that manufacturers can use if they follow IEEE Std. 1241-2000, analogous to the "Intel Inside" logo. While the subcommittee collects responses to IEEE Std. 1241-2000, it supports the development of terms and techniques currently being pursued for 1057. This subcommittee is also participating on the IEC SC47A/WG4 committee developing standard IEC 60748-4-3 on Dynamic criteria for Analogue-Digital Converters (ADC). The subcommittee has just begun to revise IEEE Std 1241-2000. Its first step is to incorporate improvements developed for the current revision of IEEE Std 1057-1994 as appropriate. Feedback from outside the subcommittee is welcomed.

C. Subcommittee on Pulse Techniques (SCOPT) (181)

SCOPT is promoting awareness of IEEE Std 181-2003 through publications and communication at technical meetings. It is seeking assistance in this process and welcomes your suggestions and participation. SCOPT has also been interacting with the IEC for the purpose of having the Std 181-2003 considered as a replacement for the IEC 469-1 and 469-2.

D. Subcommittee on DAC (1658)

Due to their numerous features and wide range of application uses, it is very difficult to define a unique way in which DACs can be specified and tested. For this reason the need is growing for DAC standardization. However, a standard does not exist focusing specifically on terms, definitions and test methods for DACs for a wide range of applications as already done for ADCs (IEEE Std. 1241 [3]). In order to fill this need, TC-10 is working to realize a standard to provide common terminology and test methods for the testing and evaluation of DACs. The information in this standard will be useful both to manufacturers and users of DACs because it will provide a basis for evaluating and comparing existing devices, as well as providing a template for writing specifications for the procurement of new ones. Moreover, in some applications, the information provided by the tests described in this new standard could be used to correct DAC errors.

E. Probe Characterization Effort

The TC-10 has been interacting with manufacturers and users of high-bandwidth circuit probes to develop standard methods for the characterization of the performance of these probes. This activity is still in its infancy. An initial membership list has been formed, and this group is in the process of finalizing the scope, purpose, and goal prior to submitting a Project Authorization Request to the IEEE.

IV. CONCLUSION

IEEE standards are living documents. They must be revised and/or renewed every five years. TC-10 is dedicated to nurturing its three current standards and promoting their acceptance. It is currently developing a new standard for digital-to-analog converters (DACs) and considering a new standard for probes. Your comments and participation are welcomed. See our website (<http://grouper.ieee.org/groups/1057/>) for contact information.

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