



## P1765

Type of Project: Revision to IEEE Standard 1765-2022 Project Request Type: Initiation / Revision PAR Request Date: 13 Dec 2022 PAR Approval Date: 15 Feb 2023 PAR Expiration Date: 31 Dec 2027 PAR Status: Active Root Project: 1765-2022

### 1.1 Project Number: P1765

1.2 Type of Document: Recommended Practice

1.3 Life Cycle: Full Use

**2.1 Project Title:** Recommended Practice for Estimating the Uncertainty in Error Vector Magnitude of Measured Digitally Modulated Signals for Wireless Communications: Conducted and Over-the-Air Hardware Verification

**Change to Title:** <u>IEEE</u> Recommended Practice for Estimating the Uncertainty in Error Vector Magnitude of Measured Digitally Modulated Signals for Wireless Communications <u>: Conducted and Over-the-Air</u> <u>Hardware Verification</u>

#### **3.1 Working Group:** Modulated Signal Measurement Uncertainty(MTT/SC/MSMU\_WG) **3.1.1 Contact Information for Working Group Chair:**

Name: Paritosh Manurkar

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3.1.2 Contact Information for Working Group Vice Chair: None

**3.2 Society and Committee:** IEEE Microwave Theory and Techniques Society/Standards Committee(MTT/SC)

- 3.2.1 Contact Information for Standards Committee Chair: Name: Ronald Ginley Email Address: rginley@ieee.org
- 3.2.2 Contact Information for Standards Committee Vice Chair: None
- **3.2.3 Contact Information for Standards Representative:**
- None
- **3.3 Co-Stds Committee(s):**

3.3.1 IEEE Instrumentation and Measurement Society/TC4 - High Frequency Measurement (IM/HFM) Contact Information for Standards Committee Chair: Name: Yeou Song Lee Email Address: brian.lee@ieee.org Change to Co-Stds Committee(s): IEEE Instrumentation and Measurement Society/TC4 - High Frequency Measurement(IM/HFM)

### 4.1 Type of Ballot: Individual

**4.2 Expected Date of submission of draft to the IEEE SA for Initial Standards Committee Ballot:** Nov 2024

4.3 Projected Completion Date for Submittal to RevCom: Nov 2025

# **5.1** Approximate number of people expected to be actively involved in the development of this project: 25

**5.2 Scope of proposed standard:** This document provides recommended practices for the determination of uncertainty in the estimation of error vector magnitude (EVM) of a measured digitally modulated wireless communication signal using both conducted and over-the-air (OTA) methods for receiver hardware verification. **Change to scope of proposed standard:** This <u>standard document</u> provides recommended practices for the determination of uncertainty in the estimation of error vector magnitude (EVM) of a measured digitally modulated wireless communication signal <u>. Such practices include several methods for validating a user's measurement of a specific reference waveform by comparison to a reference measurement. The methods differ based on the level of rigor desired by the user and the accessibility to timing and waveform recording capabilities of the available hardware. Methods for evaluating measurement uncertainty in EVM are also presented. Some of the methods described <u>using here both</u> focus on measurements <u>conducted</u> and</u>

-uncertainties related to the use of laboratory <u>over</u> - based measurement equipment such as vector receivers, real-time and equivalent-time sampling oscilloscopes and other types of waveform recorders that have access to the measured waveform. This allows time - alignment and gain <u>air</u> normalization of measured waveforms priorto the calculation of EVM. Other <u>(OTA)</u> methods focus on specialized for receivers that report symbols directly. As part of the assessment of the measurement <u>receiver</u> hardware and associated uncertainty analyses, this practice includes a mathematically rigorous method for the determination of EVM <u>verification</u>.

### 5.3 Is the completion of this standard contingent upon the completion of another standard? No

**5.4 Purpose:** The purpose of this recommended practice is to provide best practices to assess the impact of non-ideal user receiver hardware on the uncertainty in EVM measurements by comparing user measurements of digitally modulated signals to those made with a calibrated reference receiver having a complete uncertainty analysis. This enables common design criteria and practices for conducted and OTA systems design, test, and measurement. Keeping this purpose in mind, we have made all the developed codes [2] available on IEEE Open-Source website [3] for broader dissemination.

**Change to Purpose:** The purpose of this recommended practice is to provide a standardized best approach practices to assess the impact of the non-ideal user receiver hardware performance on a measurement-based estimate the of uncertainty the in EVM-of measurements a by distorted comparing signal. user This measurements is of done digitally by modulated comparing signals a to user's those measurement made to with a calibrated reference measurement receiver of having a specific complete uncertainty waveform analysis. The This reference enables measurement common is design intended criteria to and provide practices a for well-characterized conducted estimate and of OTA the systems EVM design, to which the user's measurement test, and associated uncertainty are compared measurement. In addition to Keeping the this IEEE purpose 1765 baseline approach in to mind, estimating we EVM, have various made example all approaches the to developed validating codes receiver [2] measurements available of on EVM IEEE are Open-Source provided website in [3] this for recommended broader practice dissemination.

**5.5 Need for the Project:** Many wireless telecommunication organizations and standards bodies require the calculation of EVM to evaluate the quality of wireless systems when they are excited by digitally modulated signals. The determination of EVM always includes some uncertainty which should be well characterized in order to correctly evaluate the quality of the measured signal. The recommended practices described here provide guidance in the evaluation of the impact of receiver hardware non-idealities on the uncertainty in the determination of the EVM of a measured digitally modulated communication signal. The methods allow users to compare their EVM measurements to those made on a calibrated reference instrument that has an uncertainty analysis.

**Change to Need for the Project:** Many wireless telecommunication organizations and standards bodies require the calculation of various system-level distortion metrics <u>EVM</u> to evaluate the quality of wireless <u>circuits and</u> systems when they are excited by digitally modulated signals. Such distortion metrics include error vector magnitude (EVM). The determination of these metrics <u>EVM</u> always includes some uncertainty which should be well characterized in order to correctly evaluate the quality of the measured signal. The recommended practices described here provide guidance in the evaluation of the impact of receiver hardware non-idealities on the <u>uncertainty</u> in the determination of the EVM of a measured digitally modulated communication signal. The methods allow users to compare their EVM measurements to those made on a calibrated reference instrument that has an uncertainty analysis.

**5.6 Stakeholders for the Standard:** Stakeholders include wireless telecommunication organizations and standards bodies who perform conducted and OTA measurements of digitally modulated signals, as well as instrument manufacturers.

**Change to Stakeholders for the Standard:** Stakeholders include wireless telecommunication organizations and standards bodies who perform <u>conducted and OTA</u> measurements of digitally modulated signals, as well as instrument manufacturers.

### 6.1 Intellectual Property

**6.1.1 Is the Standards Committee aware of any copyright permissions needed for this project?** No

**6.1.2 Is the Standards Committee aware of possible registration activity related to this project?** No

7.1 Are there other standards or projects with a similar scope? No

### 7.2 Is it the intent to develop this document jointly with another organization? No

**8.1 Additional Explanatory Notes:** [1] Recommended Practice for Estimating the Uncertainty in Error Vector Magnitude of Measured Digitally Modulated Signals for Wireless Communications, IEEE 1765, 2022. [2] Additional algorithms' codes will be made available at a later date on the IEEE open-source website (see below).

[3] IEEE P1765 Recommended Practice for EVM Measurement and Uncertainty Evaluation, https:// opensource.ieee.org/1765/crg/1765