De-Embedding Errors In Protocol-Aware EVM Test Using Vector Signal Analysis

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Abstract

Protocol-aware EVM tests allow for data correction within the measurement that can alter error behavior and complicate debugging. Vector signal analysis provides a means to isolate these phenomena efficiently, using data provided in the measurement. The interest is in how to implement this data analysis into a production test environment with minimal impact on test time.

1. Introduction

As mixed-signal devices become more complex and integrated, traditional characterization and specification measurements become impractical as test plans become complicated, test times become longer, and there is a growing disconnect between these low-level specifications and gauging the devices overall operational performance. System-level tests such as Error Vector Magnitude (EVM) address these issues by providing a means of encompassing the digital, mixed-signal, and RF performance of a device into a single test metric. Also advantageous is the test setup, where the device is driven in a native I/O environment that replicates in-situ operation. This can be extended by so called "protocol-aware" frameworks in the test equipment to include error correction, equalization, and compensation to emulate wireless standard device interaction. This approach provides a better link between a performance metric and the device's operational compliance.

2. Discussion

The first issue addressed was how to uncouple the device performance from the tester's error correction/compensation for determining root cause impairments in a device. While EVM provides a pass/fail metric of the overall performance of a device, it is labor intensive to extract and identify the types of underlying impairments. Because the test setups and devices under test are fairly complex, the need for contextual device data and failure analysis is needed to supplement the characterization process. Vector signal analysis, a subset of the EVM measurement, provides effective high-level information that aids in identifying and discerning error phenomena from the recovered modulated data. By utilizing this information it is possible to effectively extricate impairments created by the device, from artificial errors created by the test setup or test equipment before or within the correction/compensation techniques. As a test case, a Bluetooth EVM measurement with and without channel correction was studied using the measurement specifications provided in [1]. The EVM performance and modulation analysis were compared with test signals containing transient errors, common in stimulus-response testing, caused by the test equipment. The vector analysis provides insight into error propagation in the measurement, and demonstrates the effects it can have on the resulting EVM measurement. Proposed is an implementation of a rudimentary "expert system" that can utilize and discern this high-level device information to automate the discovery of errors in the DUT and setup and determine subsequent device tests based on the measured impairments extracted from the vector signal data. This provides a mechanism to adapt testing around the measured system performance of the DUT, focusing measurements around problematic device performance, reducing the number of necessary tests and total test times.

The second point of interest focused on implementing this analysis in production test while maintaining reasonable production test times. Because EVM is a computational intensive measurement and very sensitive to setup error, the ability to identify erroneous results in a production setting is crucial for preventing misclassification of tested parts and improving the robustness of the measurement in an automated test environment. Demonstrated is an ATE solution that utilizes an FPGA-based DSP co-processor described in [2]. This approach provides the advantages of real-time EVM processing, flexible device and test reconfigurability, and parallel processing capacity to reduce test time and increase throughput. By utilizing vector signal data available in the EVM measurement on the FPGA, no additional data is required, and the analysis process can be run in parallel with the EVM measurement with no test time degradations.

3. References

[1] *"Enhanced Data Rate Modulation Accuracy,"* Bluetooth Specification Version 2.1+EDR, Vol. 2 Appendix C 7.1 of Radio Specifications, pg. 49-52, 2007.

[2] D. Morris, M. Roos, R. Doporto, "Error Vector Magnitude(EVM) Testing: Improving Throughput and Flexibility Using FPGA Augmentation", IEEE Wireless Test Workshop, 2010.