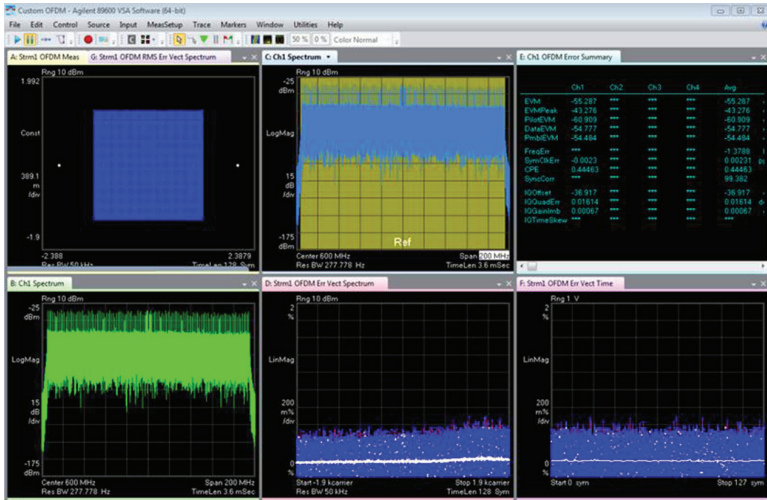# Keysight Technologies
Quickly Validate Designs
for DOCSIS 3.1 Compliance

Application Brief

Accelerate research and development and design verification test of DOCSIS 3.1 designs with a cost-effective, standards-based measurement solution, that provides high speed, wide bandwidth, deep memory and flexibility.

KEYSIGHT
TECHNOLOGIES

Abstract

The latest version, DOCSIS 3.1, of the Data Over Cable Service Interface Specification (DOCSIS) standard, has now been officially released. Designing DOCSIS 3.1-based transmitters, receivers and components, and verifying their performance against the new standard requires stringent testing - a process made more complex by the standard's adoption of new technologies and the need for backward compatibility with previous DOCSIS versions.

This document describes the Keysight Technologies, Inc. portfolio of DOCSIS 3.1 test solutions – hardware and software to generate and analyze signals up to 192 MHz bandwidth, as shown in Figure 1. These solutions can be used to test transmitters, receivers and components against the new requirements set forth in the DOCSIS 3.1 specification.
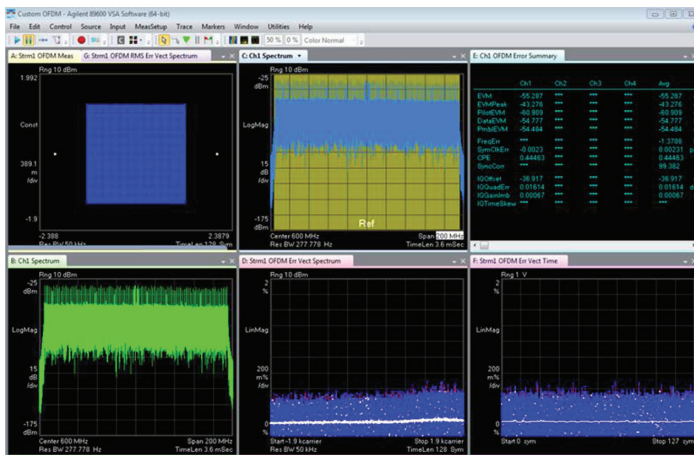

Figure 1. Analysis of statistically correct 4096 QAM DOCSIS 3.1 signal using 89600 VSA software, demonstrating MER > 55 dB.

Introduction

Over the years, the DOCSIS standard evolved to meet the needs of cable operators and their subscribers. Emerging applications like HDTV video streaming around the home and in-room gaming, is driving demand for multi-gigabit data rates. The need for increased bandwidth led to the latest standard revision - DOCSIS 3.1.

DOCSIS 3.1 provides a way for cable operators to increase capacity and speed, with up to 50 percent more data throughput over the same spectrum than DOCSIS 3.0, and the ability to deliver 2.5 Gbps in the upstream and 10 Gbps in the downstream on an existing hybrid fiber-coaxial (HFC) network. Its efficient spectrum use enables a significant decrease in the cost per bit for data delivery. This provides cable operators a competitive advantage over satellite and wireless providers in the hotly contested battle for today's bandwidth-hungry broadband data subscribers.

Key issues faced by R&D engineers

DOCSIS 3.1 achieves its increased speed and capacity through its use of orthogonal frequency-division multiplexing (OFDM) and low-density parity-check (LDPC) forward error correction (FEC) technology. The standard mandates the use of up to 4096 QAM modulation with a 24 to 192 MHz channel bandwidth in the downstream, and up to 4096 QAM modulation with up to a 96 MHz bandwidth in the upstream. It also supports pure IP payload data and can co-exist with legacy channels on the existing HFC infrastructure.

While these technologies enable needed capacity and speed improvements, they also pose a number of new challenges in design and test; namely the generation and analysis of wider bandwidth signals for DOCSIS 3.1's 192 MHz channel. Many generators simply do not have a high enough sampling rate to support the typical minimum 2x oversampling ratio needed for signal generation. Without this support, images can occur in the signal due to aliasing. Additionally, finding a test solution that can handle the complexity of OFDM and LDPC FEC, and supports legacy DOCSIS technologies, while also being cost- effective, fast, and flexible enough to accommodate future standard revisions can also be problematic.

Solution overview

Keysight's solution for DOCSIS 3.1 test, shown in Figure 2, features the M9703A AXIe high-speed digitizer, its PCIe version, the U5303A, and the M8190A arbitrary waveform generator (AWG). Keysight's 89600 VSA software (with OFDM demodulation option BHF) and SystemVue electronic system level (ESL) design software, generates fully coded DOCSIS 3.1 waveform files that can be generated using the M8190A AWG.
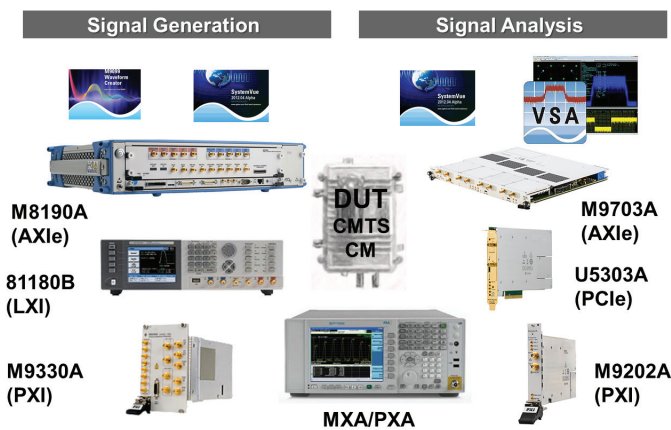

Figure 2. Keysight DOCSIS 3.1 test portfolio.

Signal Generation (192 MHz bandwidth)

- Customer available DOCSIS 3.1 upstream and downstream statistically correct waveform files
- Waveform Creator software tool to generate and modify statistically correct DOCSIS 3.1 waveform files
- SystemVue software tool to generate and modify fully coded DOCSIS 3.1 waveform files
- Selection of arbitrary waveform generators (AWGs) to generate 192-MHz bandwidth DOCSIS 3.1 signals

Signal Analysis (192 MHz bandwidth)

- 89600 VSA software supporting multiple hardware platforms offering greater than 192-MHz bandwidth demod analysis capability
- Digitizers configured as 4-and 1-channel are able to capture DOCSIS 3.1 192-MHz bandwidth signals
- Spectrum analyzers able to support DOCSIS spectral measurements
- SystemVue's DOCSIS library can be used to demodulate and decode DOCSIS 3.1 downlink signals

The M9703A is an 8-channel, 12-bit wideband digital receiver/digitizer. Its channel interleaving capability enables a 4-channel configuration to capture DC to 1.4 GHz signals for DOCSIS 3.1 waveform acquisition at up to 3.2 GS/s. This configuration provides exceptional measurement accuracy.

The U5303A, option D31, is a single slot, 12-bit, PCIe 2-channel digitizer. Its channel interleaving capability enables a 1-channel configuration to capture DC to 1.4 GHz signals for DOCSIS 3.1 waveform acquisition at up to 3.2 GS/s. This configuration enables the U5303A-D31 to deliver the performance necessary to meet the new DOSCIS 3.1 test requirements at a low cost.

The M8190A, a 12 GS/s, 2-channel AWG, features 2-GS memory per channel, 5-GHz analog bandwidth and up to 90 dBc SFDR.

Such deep memory, wide bandwidth and excellent SFDR, coupled with its inherent flexibility, enable the M8190A to realistically stress DOCSIS 3.1 signals and perform transmision network test over the HFC network.

Solution details

Transmitter Test

Testing a DOCSIS 3.1 transmitter requires both a Keysight high-speed digitizer and 89600 VSA software with option BHF. Together, the two can demod and analyze statistically correct wideband signals (up to 192 MHz) with a -50 dB MER or better.

A test setup for DOCSIS 3.1 transmitter testing is shown in Figure 3. The M9703A or U5303A-D31 digitizer effectively captures the wide bandwidth signals, while the 89600 software demodulates and analyzes them. With the custom OFDM demodulation capability, engineers can even define their own custom OFDM signal parameters. For spectral tests, Keysight's MXA or PXA signal analyzer is required.

A portable test solution that complements the use of the MXA is shown in Figure 4.

Receiver Test

A setup for performing a DOCSIS 3.1 receiver test is shown in Figure 5. Testing the receiver requires both the wideband M8190A AWG and SystemVue software. DOCSIS 3.1 waveforms are created using Waveform Creator or SystemVue, depending on the level of complexity required, and downloaded to the M8190A, which generates the signals required for test. Together, the M8190A and Waveform Creator or SystemVue software can be used to realistically stress DOCSIS 3.1 signals during receiver test and simulate signals over the whole HFC bandwidth, up to 1.2 GHz, for transmission network test.

Component Test

During component test, the M8190A AWG and M9703A/U5303A-D31 digitizers are both employed, along with the 89600 VSA with Option BHF and Waveform Creator or SystemVue software to offer a fully coded stimulus and response test system.

A PXI-based setup for DOCSIS 3.1 component testing is suggested in Figure 6. In this case, the baseband signals or waveform sequences are created in Waveform Creator or SystemVue and downloaded to the M9330A PXI AWG, which drives the I/Q inputs to a PXI vector signal generator and provides the stimulus for the component under test. The PXI M9202A digitizer than captures the signals for analysis by the 89600 VSA software. This combination of hardware and software makes it possible to create compact, dynamic and realistic scenarios for component testing.

In the R&D environment, SystemVue's simulation library can create multi-format signals and demodulate received waveforms to recover DOCSIS 3.1 coded bit sequences, supporting BER and other system-level investigations.
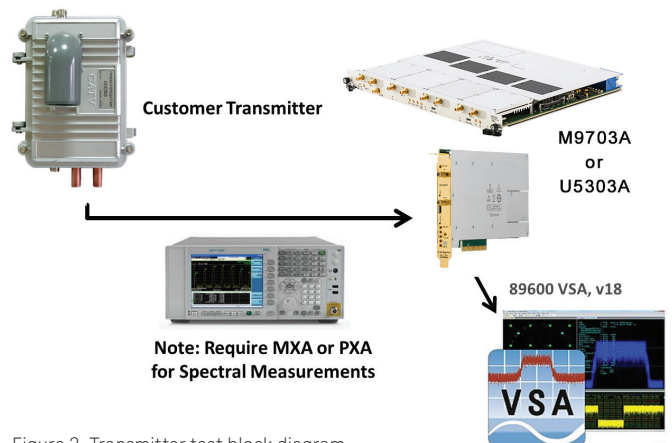

Figure 3. Transmitter test block diagram.

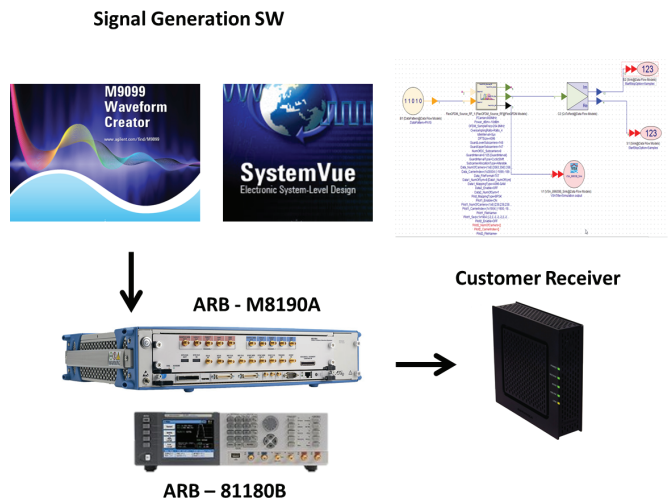Figure 4. Portable 192 MHz bandwidth demod test solution.

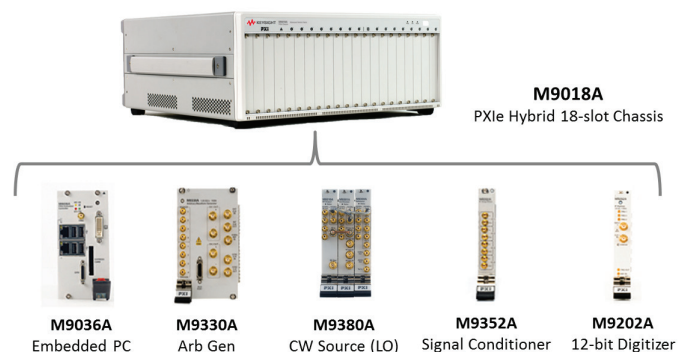Figure 5. Receiver test block diagram.

Figure 6. Component test block diagram.

Ordering information

Model	Description
M8190A	AXIe arbitrary waveform generator
81180B	LXI arbitrary waveform generator
M9099T	Waveform creator
W1461BP/BT	SystemVue sofware
E4729A	SystemVue custom DOCSIS library *Call for quotation*
M9703A	AXIe digitizer
U5303A-D31	PCIe digitizer with DOCSIS application
89601B	89600 VSA software, v18
89601B-BHF	Custom OFDM demod
N5182A	MXG signal generator
N9020A	MXA signal analyzer
N9030A	PXA signal analyzer

Please contact your local field engineer for detailed ordering information.

Want to know more?

M8190A AXIe Arbitrary Waveform Generator data sheet
Literature number 5990-7516EN

81180B LXI Arbitrary Waveform Generator data sheet
Literature number 5991-0364EN

M9099T Waveform Creator Software technical overview
Literature number 5991-3153EN

SystemVue 2013 Software technical overview
Literature number 5990-4731EN

M9703A AXIe High Speed Digitizer data sheet
Literature number 5990-8507EN

U5303A PCIe High Speed Digitizer data sheet
Literature number 5991-1104EN

89600 VSA software technical overview
Literature number 5990-6405EN

PXI and AXIe Modular Solutions – On Demand Catalog
http://wireless.keysight.com/mod/

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