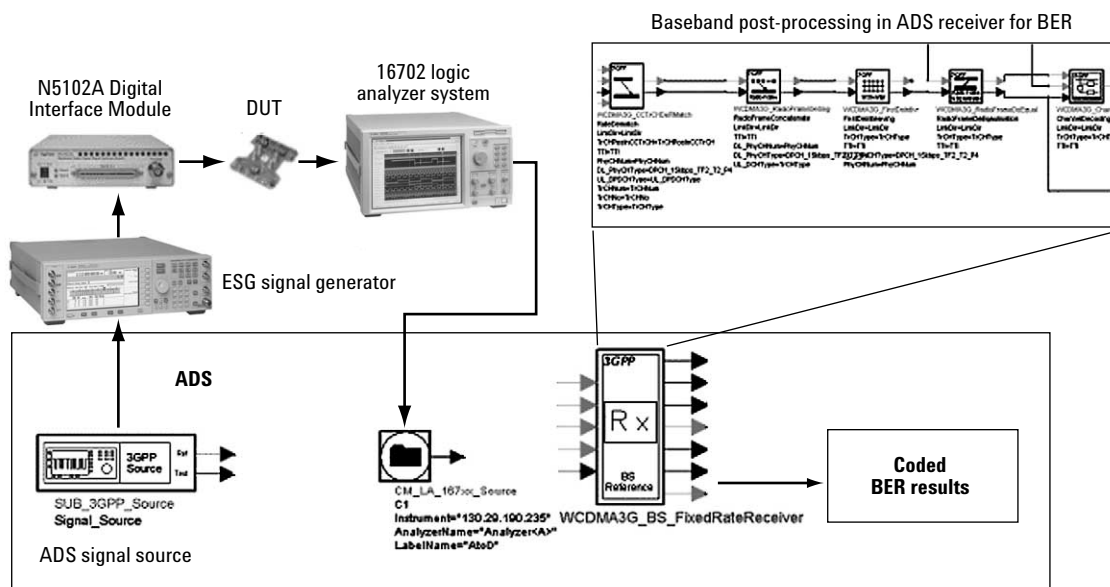


# Performing Digital-IF/RF-Digital Bit Error Rate Measurements

## Connected Solutions Application Bulletin 1476-4



### Introduction

Verifying Bit Error Rate (BER) performance can present a real challenge to RF engineers. RF engineers designing RF receivers may not have access to the baseband functionality required to perform coded BER measurements, which can present a barrier to verifying coded BER - a key receiver design specification with today's digital communications signal formats.

Some systems also have Digital-to-Analog (D/A) converter(s) at the transmitter input and Analog-to-Digital (A/D) converter(s) at the RF receiver output, which add additional complexity in evaluating RF performance metrics such as EVM along the RF transmitter and receiver chain.

Lastly, because BER is an end-to-end metric, it may be desirable to perform digital-IF/RF-digital BER verification by generating a digital stimulus for the D/A converters on the transmitter and capturing the digital output of the receiver after the signal has been digitized with A/D converters. This would allow the entire transmit-receive path to be verified from digital bits in to digital bits out, including the IF/RF and RF/IF upconverters and downconverters.

This Connected Solutions application bulletin describes how to use Agilent instruments and Advanced Design System (ADS) EDA software to verify RF performance measures such as BER and EVM for end-to-end digital-IF/RF-digital systems—from bits in to bits out.



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## Concept

A conceptual flow diagram is shown on the cover of this application bulletin. The ADS simulation signal is downloaded to the ESG vector signal generator's arbitrary waveform memory. Baseband Studio is then used to route the arbitrary waveform generator signal to a Baseband Studio digital signal interface module to turn the simulated signal into a digital test signal, which can then be used to stimulate a D/A converter(s). The digital test signal is input into the DUT, which could be an entire transmitter/receiver chain with a Digital-to-Analog (D/A) converter(s) at its input and Analog-to-Digital (A/D) converter(s) at its output. The digital output of the DUT is then captured in the Logic Analyzer's memory and then read back into ADS using the new ADS Logic Analyzer simulation signal source. After it is read into ADS, the signal can be post-processed with a simulation baseband receiver (for example, WLAN or WCDMA) to compute the coded BER or Packet Error Rate (PER).

## Test Setup Overview

This application uses the new Logic Analyzer simulation signal source in ADS 2003C and the Connection Manager, an ADS option that reads data from, downloads data to, and controls selected instruments. An E4438C ESG with the new option 602 and Baseband Studio with digital signal interface module (N5102A) is used to convert the ESG Arb waveform to a digital test signal for digital-to-digital BER measurements. With this new Baseband Studio option, the Arb signal can either be output as an RF signal or as a digital signal using the interface module.

The 16702 Logic Analyzer System with a 167XX state/timing module is used to capture the digital data and ADS wireless design libraries, such as the WCDMA or WLAN design libraries, and is used to post-process the data to compute BER or PER. The 89601 Vector Signal Analyzer (VSA) software with option 105 is useful for performing RF measurements such as EVM on the digital data in ADS.

## Performing RF Measurements on Digital Data

After the measured digital data is captured with the Logic Analyzer and read into ADS, it can be post-processed with simulation measurements such as the 89600 VSA simulation software. An example is shown in Figure 1 on the upper-right, where a measurement is being performed on cascaded DUTs, a 16-bit dual D/A converter board, I/Q modulator, and a 14-bit A/D converter board. The D/A is stimulated using Baseband Studio with the interface module and the digital output of the A/D is captured with the Logic Analyzer. Once the digital output of the cascaded DUTs is captured by the Logic Analyzer, it is demodulated with the 89600 VSA simulation measurement software used in ADS. In this example it is a 3GPP WCDMA signal being demodulated with the 89600 VSA simulation measurement software in ADS.

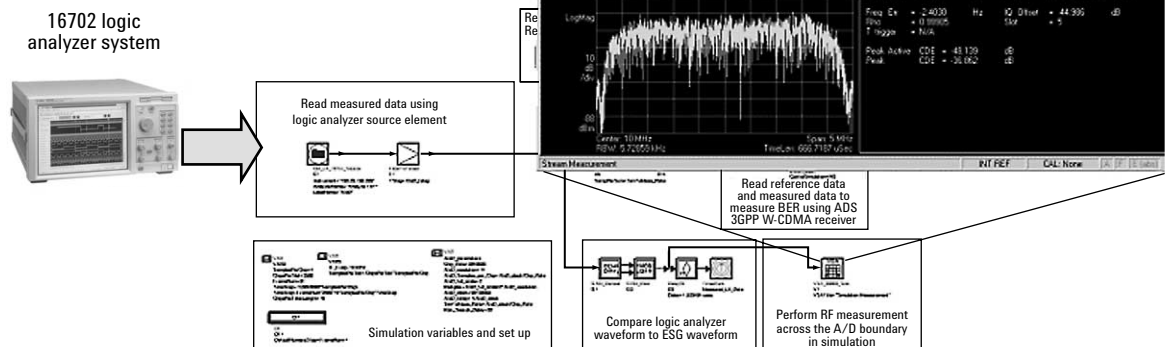


Figure 1. Post processing measured digital data with the 89600 VSA simulation software.

## Verifying BER/PER Performance of RF/Digital Hardware

One of the challenges of verifying coded BER/PER performance of RF hardware is that the baseband functionality required for coded BER/PER may not be available for testing. For example, performing a coded BER measurement for 3GPP W-CDMA requires that the baseband functionality to perform such tasks as de-scrambling, de-spreading, de-interleaving, de-multiplexing, and so on, are required to recover the data bits from the measured signal so that a BER measurement can be performed. This can present a potential barrier if the RF hardware being tested does not include this baseband functionality.

This Connected Solutions application uses the wireless Design Libraries in ADS to perform the post-processing on the measured signal so that coded BER/PER can be measured.

An example of a coded BER measurement for 3GPP WCDMA is shown in Figure 2. The example uses the ADS WCDMA Design Library to post-process the signal from the cascaded 16-bit D/A converter, I/Q modulator, and 14-bit A/D converter. The D/A is stimulated using Baseband Studio with the digital interface module and the digital output of the A/D is captured with the Logic Analyzer.

## Summary

This Connected Solutions application can help designers perform coded BER/PER measurements on the entire end-to-end signal path (digital-IF/RF-digital), from digital bits in to digital bits out. This is useful for RF transmitter/receiver applications where there is a Digital-to-Analog converter(s) at the transmitter's input and an Analog-to-Digital converter(s) at the receiver's output. The new Baseband Studio digital signal interface module with the E4438C ESG provides the digital stimulus, while the new Logic Analyzer simulation signal source in ADS allows the digital signal to be captured and post-processed.

ADS Design Libraries help extend the capabilities of the Logic Analyzer by providing the baseband post-processing needed to perform coded BER and PER measurements. In addition, RF measurements such as EVM can be performed on digital signals captured with the Logic Analyzer by using the 89600 VSA simulation software in ADS.

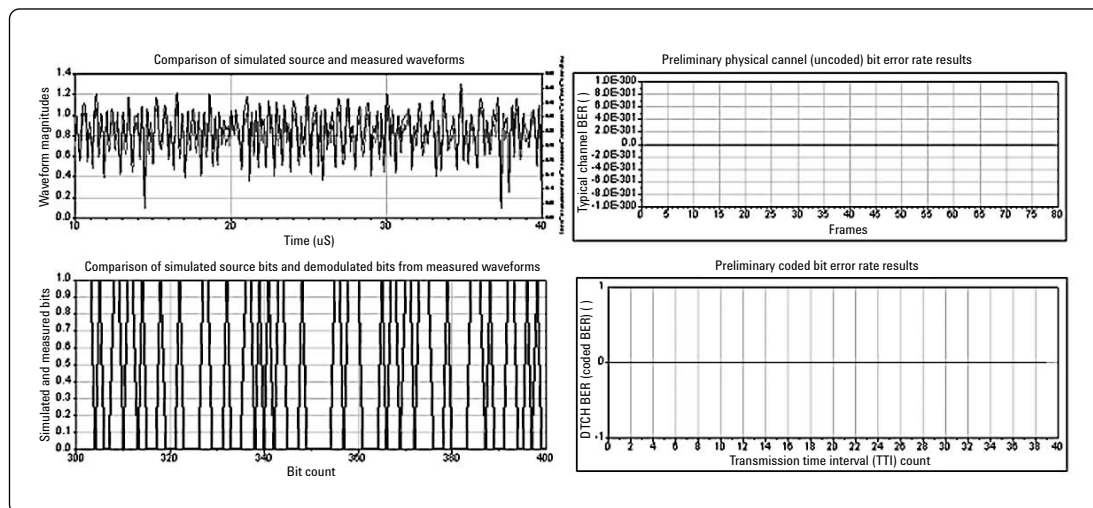


Figure 2. An example coded measurement for 3GPP WCDMA, post-processed using the WCDMA Design Library.

## Required Equipment/Software

**E8900A/AN ADS 2003C**

**E5720A/AN Connection Manger**

**E8850A/AN Comms System Designer**

**E8875A/AN 3GPP W-CDMA Design Library** (optional)

**E8874A/AN WLAN Design Library** (optional)

**E4438C ESG** with opt. 602, opt 003 to enable digital outputs and control the N5102A Digital Signal Interface Module, and Option 004 for digital input capability

**Baseband Studio with Digital Signal Interface Module** (N5102A)

**16702 Logic Analysis System** with 167XX state/timing module

**89601A VSA Software** with opt. 100, AYA, 105, B7N for 3GPP W-CDMA, B7R for WLAN

## Related Application Literature

**RF/IF-to-Digital Connected Solutions Bit Error Rate Using The Advanced Design System**, Application Note Number 147,  
<http://literature.agilent.com/literature/pdf/5989-0024EN.pdf>

**Connected Simulation and Test Solutions Using The Advanced Design System**, Application Note Number 1394,  
<http://literature.agilent.com/litweb/pdf/5988-6044EN.pdf>

For more information about Agilent Technologies' connected solutions, including additional application notes and a configuration guide, visit:

**[www.agilent.com/find/eesof-connectedsolutions](http://www.agilent.com/find/eesof-connectedsolutions)**

For more information about Agilent EEsof EDA, visit:

**[www.agilent.com/find/eesof](http://www.agilent.com/find/eesof)**

For more information about Agilent Baseband Studio, visit:

**[www.agilent.com/find/basebandstudio](http://www.agilent.com/find/basebandstudio)**

For more assistance with your test and measurement needs, visit:

**[www.agilent.com/find/assist](http://www.agilent.com/find/assist)**

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