Agilent 81150A and 81160A Pulse Function Arbitrary Noise Generators

Accurate Pulse, Function Arbitrary and Noise Generation in a Single Box

Application Note, Version 1.3

- Noise and Jitter Tolerance Testing
- Noise Source for SATA
- Gigabit Ethernet
- Radar Communication Systems
- Nanotechnology
- Reactor Stability Testing
- IQ Modulation

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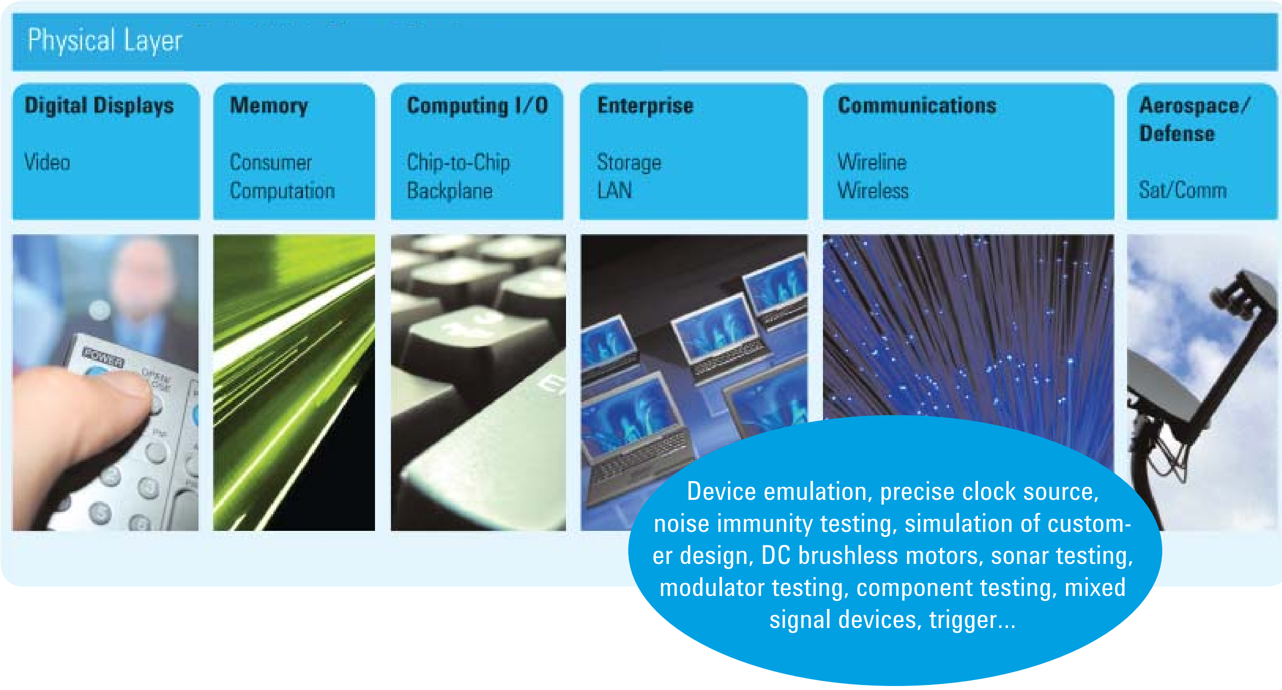

Introduction

The Agilent 81150A and 81160A pulse function arbitrary noise generators focus on engineers in manufacturing, R&D and education across the industry.

The new class of instrument combines four instruments in one:

- The high precision **pulse generator** is enhanced with a versatile signal generator, offering distortion capabilities to stress your device to its limit.
- The **function arbitrary generator** provides versatile waveforms and modulation capabilities to adapt the signal to devices requirements.
- The optional **pattern generator** allows analog, digital and mixed signal device tests with ideal and real-world pattern.
- The **noise generator** combines two required extremes: random noise and repeatable noise with very long repetition rates for simple problem identification.

The versatile and precise instruments are a must have for every lab as many different devices under test can be stimulated.

In addition, the 81150A and 81160A let you inject noise for testing serial bus standards.

Both of them provide accurate and accelerated insight into your device through ideal and real-world signals. Just generate the signal you need—because just enough is not enough.

Noise and Jitter Tolerance Testing

Jitter and noise cause misalignment of edges and levels, resulting in data errors. Noise is by its nature unpredictable because it can have many different causes, from signal interference caused by sudden voltage changes, to distortions introduced during transmission.

It is important to be able to simulate noise-based malfunctions, for example to identify the additive noise produced by receiving systems—it is cheaper to lower the noise figure than to increase the transmitter power. The 81150A and 81160A let you control the quality of the noise and test different cases according to various specifications.

Gaussian white noise is a good approximation of many real-world situations and creates mathematically traceable models, with statistically independent values.

The crest factor is an indicator of signal quality. The higher the crest factor is, the more noise is used. The 81150A and 81160A provide four selectable crest factors using Vp/RMS or Vpp/RMS. The Vp/RMS definition is used by both instruments.

RX jitter tolerance tests conducted by a noise source with a low crest factor might let you pass the test even if the device is momentarily substandard.

The crest factor of seven corresponds to a BER 10^{-23} which is required by the serial bus standards. The noise provided by the instruments is triggerable, and the signal repetition rate is 20 days for the 81160A and 26 days for the 81150A. This guarantees randomness and repeatability. The 81150A and 81160A let you define any arbitrary distribution, which is ideal if you need your noise with a non-Gaussian distribution. Both instruments provide deterministic white noise either with Gaussian or arbitrary distribution.

Different crest factors

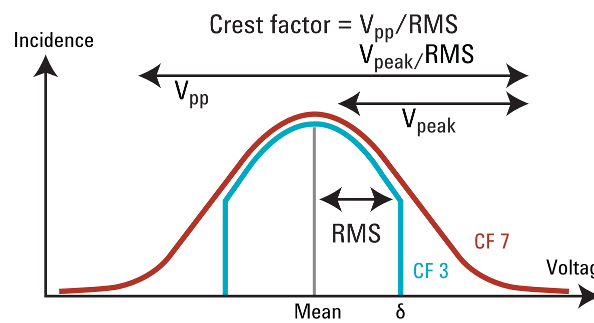

Figure 1. Gaussian curve of crest factor 3 and 7

BER and the different crest factors

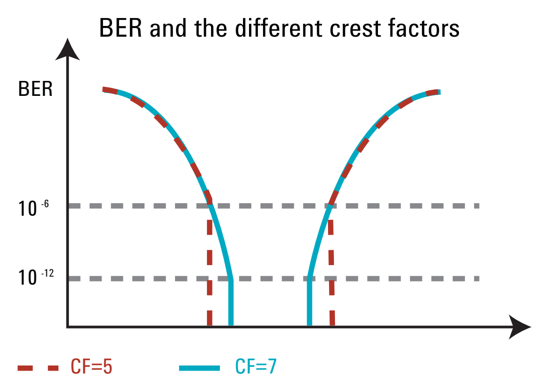

Figure 2. Bath tub with different crest factors

Noise Source for SATA

Serial ATA (SATA) is the next generation personal computer storage interface. SATA I operates at 1.5 Gb/s, SATA II at 3 Gb/s and SATA III at 6 Gb/s.

In order to perform receiver jitter tolerance testing on SATA transceivers, several pieces of equipment are needed.

So far, an Agilent 33250A was needed for the sinusoidal jitter and a noise source for the random/deterministic jitter. The jitter is injected to the delay control in line of a pattern generator, which generates the signal with the appropriate frequency.

The 81150A and 81160A can generate both jitter types in one instrument, thus providing a cost-effective solution as two instruments with a power divider are no longer required.

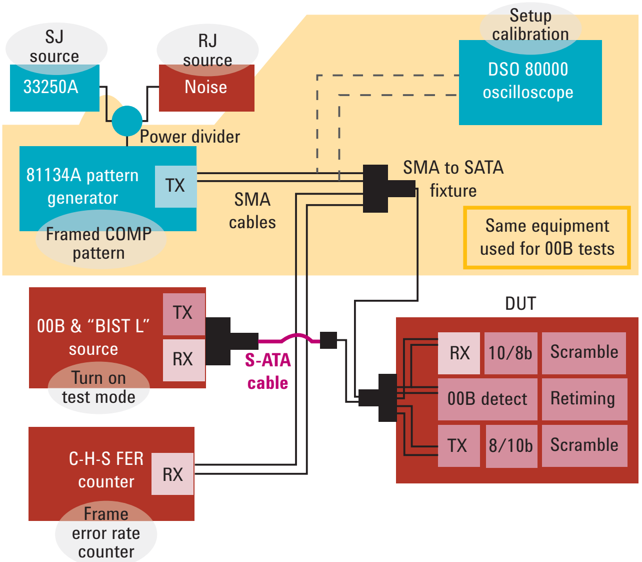

Figure 3. SATA receiver test set up

Random jitter

The Agilent 81150A and 81160A pulse function arbitrary noise generators provide deterministic Gaussian white noise, with a signal repetition of 20 days for the 81160A and 26 days for the 81150A. You can decide on any arbitrary distribution and trigger the noise to start when you need it.

You can select the required crest factor of seven—using Vp/RMS. This crest factor corresponds to a BER 10^{-12}.

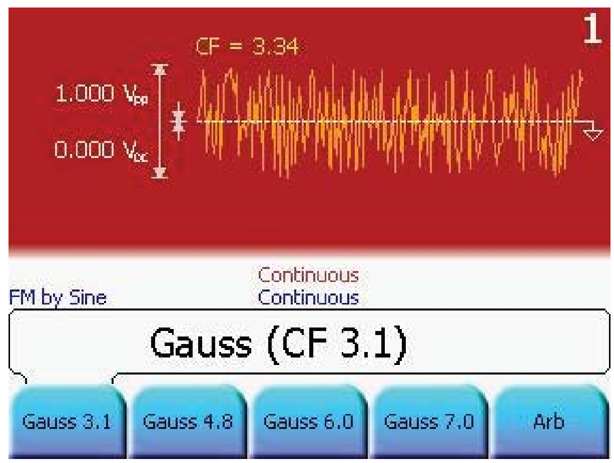

Figure 4. Noise probability function screen

Sinusoidal jitter

For the sinusoidal jitter select a sine wave and set the required frequency. Calibrate the jitter by adjusting the amplitude and observing the jitter on the jitter measurement device.

The 81150A and 81160A are integrated in the Agilent test automation software platform, N5990A Option 103. The software provides compliance and interoperability testing and fully controls the test setup including sinusoidal and random noise.

Stressing Gigabit Ethernet Receivers

1000Base-T Ethernet is a proven and economic technology and used in many devices. 5-level pulse amplitude modulated (PAM-5) signals are transmitted over unshielded, balanced, twisted-pair copper cable at data rates of 1 Gb/s.

Its great advantage—that it can reuse existing 10/100Base-T infrastructures—is also its greatest potential weakness.

Inadequate cabling can introduce distortions and threaten signal integrity. It is crucial to be able to quantify phenomena like noise, delays and distortions to characterize receivers. At theses speeds, the traditional ways of examining these, (e.g. using a 1000Base-T transmitter as a source and a cable plant to degrade the signal) are not suitable because they are expensive, time-consuming and may even be unreliable.

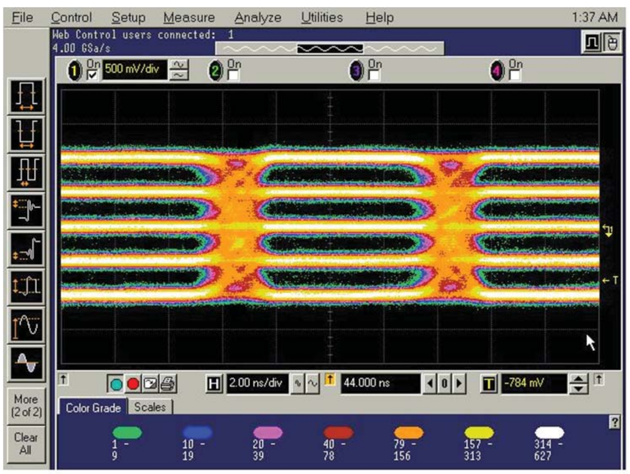

Figure 5. PAM-5 signal with 0.1 VPP noise

The 81160A is an affordable way of characterizing Gigabit Ethernet receivers quickly and reliably because it offers:

A unique combination of pulse pattern generator and versatile arbitrary waveform generator at the needed speed to generate PAM-5 signals for 1000Base-T. Full control over the probing signal, to alter the parameters and explore borderline conditions, or troubleshoot areas where a device fails to meet the specifications. An integrated noise generator with different crest factors, which generates random and repeatable noise. Glitch-free change of timing parameters, such as e.g. delay and frequency, for efficient testing without reboots and resynchronizations.

The signal is set up as an arbitrary waveform. This can be either done on the instrument, using the Agilent BenchLink Waveform Builder Pro software, or with a Matlab script. Stress can be easily achieved by adapting the rise time from 5.12 s to 4.61 ns.

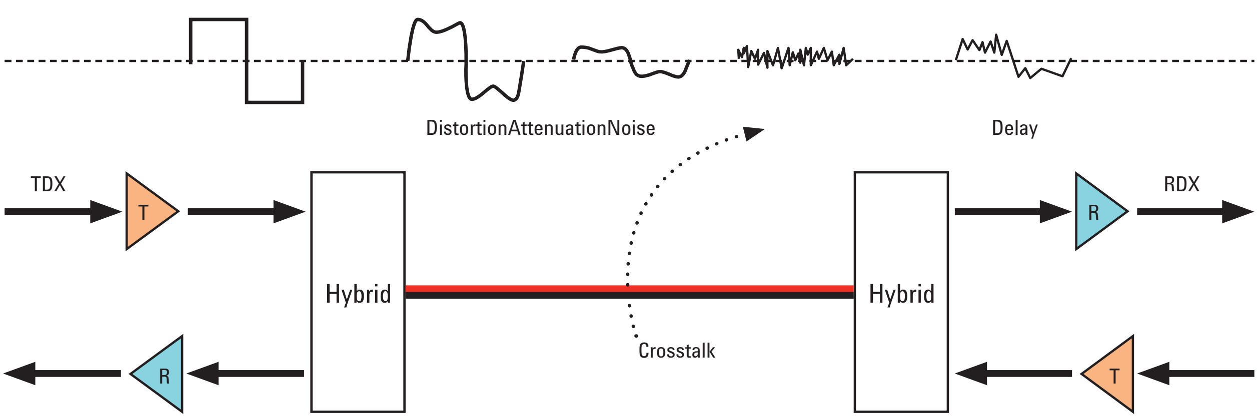

Figure 6. Attenuation, distortion, noise and delays can be added to the signal to emulate real-world conditions

Radar Communication Systems in the Aviation and Military Industries

Figure 7. Radar distance test to airborne planes

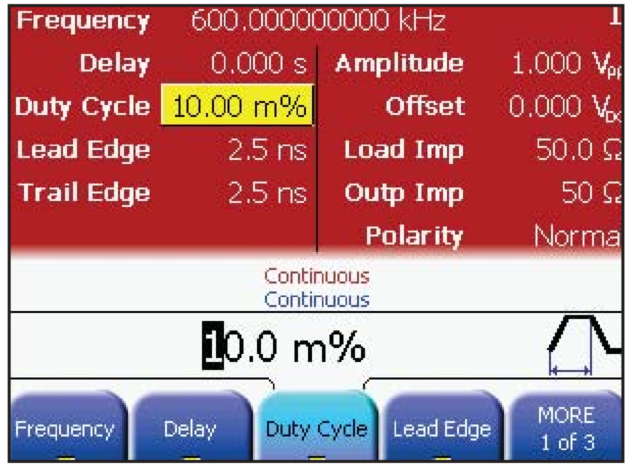

Figure 8. Example settings channel 1

Agilent pulse generators are often used for testing radar communication systems in the military industry and the aviation industry. The application note, "Radar Distance Test to Airborne Planes" (5968-5843E), describes the usage of the 81110A.

To determine the distance of a target object e.g. an airborne plane, a triggered pulse train is sent from the control tower's radar system to an airborne plane. The plane responds with a standard signature which is sent back to the control tower. The tower receives the signal, recognizes the signature, and then analyzes the delay to determine the distance between the tower and the airborne plane.

Important functionality:

- Rise/fall times 2.5 ns
- Triggered pulse stream internally or via an external signal
- Burst of pulse stream
- Small duty cycles
- Highest possible frequency accuracy

The 81150A and 81160A can be used to simulate the radar signal. Varying the delay from the external trigger to the start of the output signal can simulate various distances from the control tower.

Besides the precise signal with accurate rise and fall times of 2.5 ns, a distortion of the signal is interesting.

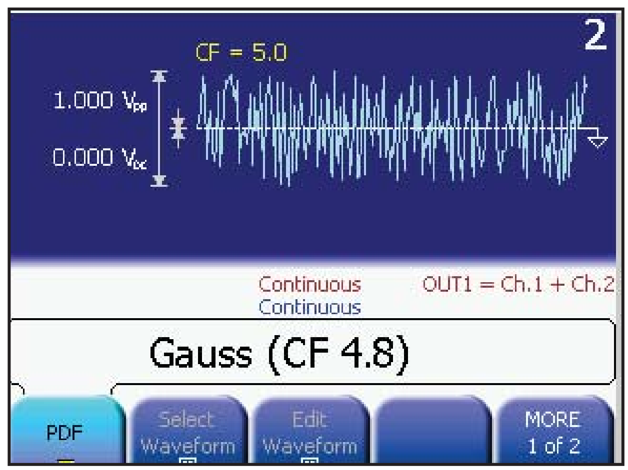

Figure 9. Channel 2 with selected crest factor of 4.8

The crest factor is a sign of signal quality, the higher the crest factor the more complete—real world—noise is available. The channel add functionality can add the signal of channel two to channel one. So any modulation or noise with different crest factors can be added to the precise signal.

Control the Amount of Energy for Nanotechnology Devices

Nanotechnology starts to gain importance in the semiconductor technologies through denser memory, faster processors and electronic devices that need less power. Engineers need to fully characterize devices and materials, which requires:

- Small voltage
- Accurate and repeatable measurements

The measurement techniques and instruments require minimal noise and other sources of error that might interfere with the signal.

It is very important to control the amount of energy during the measurement, otherwise you damage the device under test.

Short pulses and bursts of pulses are important to avoid heat generation. Small duty ratio allows the device under test to cool down and short pulse width avoids leakage through gate oxide.

The Agilent 81150A provides:

- Pulse width 4.16 ns to (period – 4.16 ns)
- Transition times 2.5 ns to 1000 s (10/90)
- Variable rise and fall time
- Differential output
- Pulse width modulation for real stress test

The Agilent 81160A:

- Pulse width 1.50 ns (period – 1.50 ns)
- Transition times 1.0 ns to 1000 s (10/90)
- Variable rise and fall time
- Differential output
- Pulse width modulation for real stress test

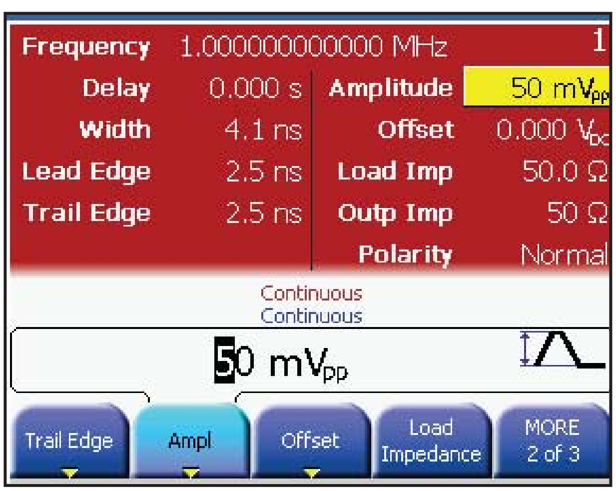

Figure 10. Setting up a pulse

The 81150A and 81160A are pulse generators, an instrument typically used for this kind of measurements. They guarantee accurate and repeatable measurements.

The combination of the pulse and function arbitrary generator allows special stress tests like the pulse width modulation. The modulation of the duty cycle allows for control of the amount of power, which is critical for this type of device.

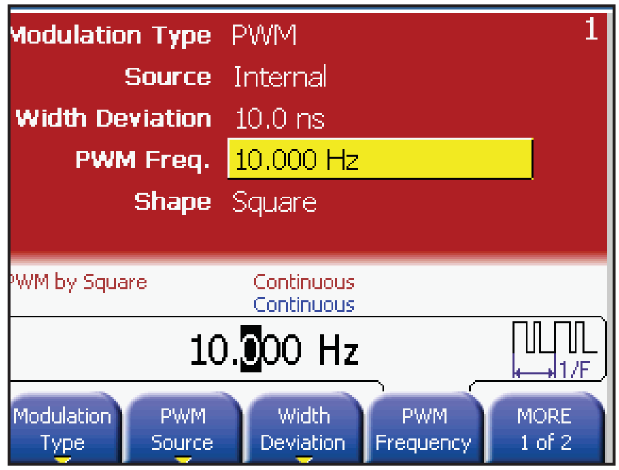

Figure 11. Setting up a pulse width modulation

The 81150A and 81160A include a noise generator as well. Through channel add, noise can be added to the pulse or pulse width modulated signal. By adding different amounts of noise you can stress your device to its limit.

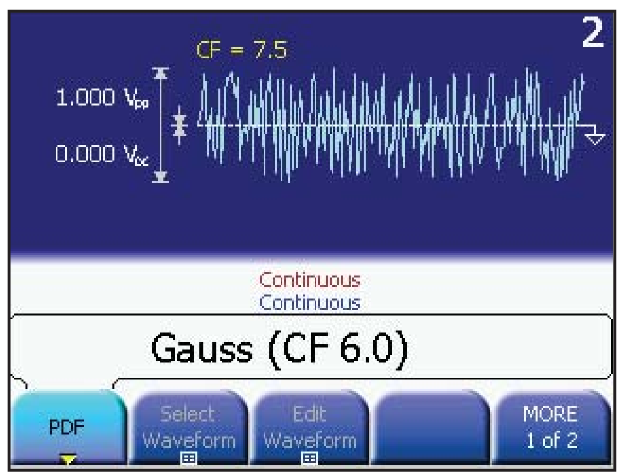

Figure 12. Setting up noise

Signal Emulation for Nuclear Power Stations

Simulation solutions for reactor stability testing are very sensitive. It is extremely important that the monitoring system is well tested and fault events generate an alarm.

When barium sticks are pulling out, pulse quantity increases exponentially. The verification of the alarm and monitoring system requires generators to simulate an exponential increase of pulse frequency whereby the pulse duration has to be consistent.

Required signal:

|____________|________|____|__|__|_||

T(0)   T(1)   T(2)   T(3)T(4) ...

T(n) must vary in exponential law. The pulse duration should be constant. The period between pulses is exponential.

Previously, both a pulse generator and an arbitrary generator were needed for this application, however, the 81150A and 81160A combine an Agilent proven pulse generator and a function arbitrary generator, meaning only one instrument is needed.

The first channel provides the pulses.

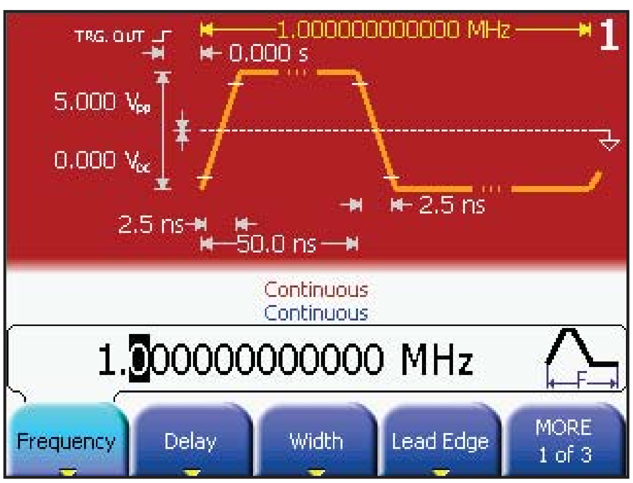

Figure 13. Pulse generator configuration screen

The second channel provides a frequency sweep and triggers the first channel.

Figure 14. Frequency sweep configuration screen

The 81150A and 81160A allow the reduction from two to one instrument which corresponds with higher test efficiency.

For this application the two channel version is needed. The channels can work entirely independently as required with this application, but the channels can be coupled with a defined delay as well.

Testing Wide Bandwidth In-Phase and Quadrature Modulation in RF and Microwave Communications Channels

Whether testing a wide bandwidth modulator, or using an existing modulator to provide test signals for other components in the transmission channel, you need differential, in-phase and quadrature (IQ) baseband signals.

In cases where you need to test beyond the standards and predefined protocols, you need more flexibility to generate or control the amplitude, phase, and frequency of your signals than a vector signal generator can typically provide. The Agilent 81160A Pulse Function Arbitrary Noise Generator has two, differential ports that let you independently control signal levels, frequency (up to 500 MHz in sine mode), offset voltages, and the phase difference between the ports. In arbitrary mode, up to 330 MHz is available separately for the I and Q channels, which means up to 660 MHz IQ modulation bandwidth [1]. This makes it easy to set up and vary the parameters you need to stress your DUT comprehensively.

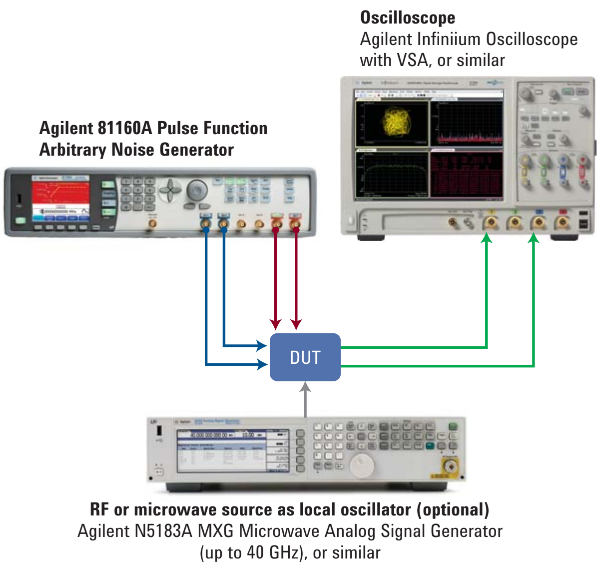

Figure 15. Typical set-up to test an IQ Modulator

Testing IQ modulators

For example, when testing or characterizing an IQ modulator, you may need to measure quadrature or DC offset errors, or phase or gain imbalances, to be able to optimize the Error Vector Magnitude.

- You can first use single tone baseband signals, adjusting the amplitudes, frequencies, voltage and phase offsets independently to stress the modulator.
- Later you can test the response to multilevel signals (programmed, for example, in MatLab) to make the most of the 14-bit vertical resolution of the function arbitrary generator [2].
- You can introduce further stress by introducing a noise component, using the built-in noise generator.

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1. *For test set-ups that do not need the full bandwidth of the 81160A, the 81150A Pulse Function Arbitrary Noise Generator offers the same functionality with 330 MHz bandwidth in sine mode, or 120 MHz in arbitrary mode for up to 240 MHz IQ modulation bandwidth.*
2. *If this is an important part of the test, it may be worth considering the Agilent 81180B or M8190A Arbitrary Waveform Generators.*

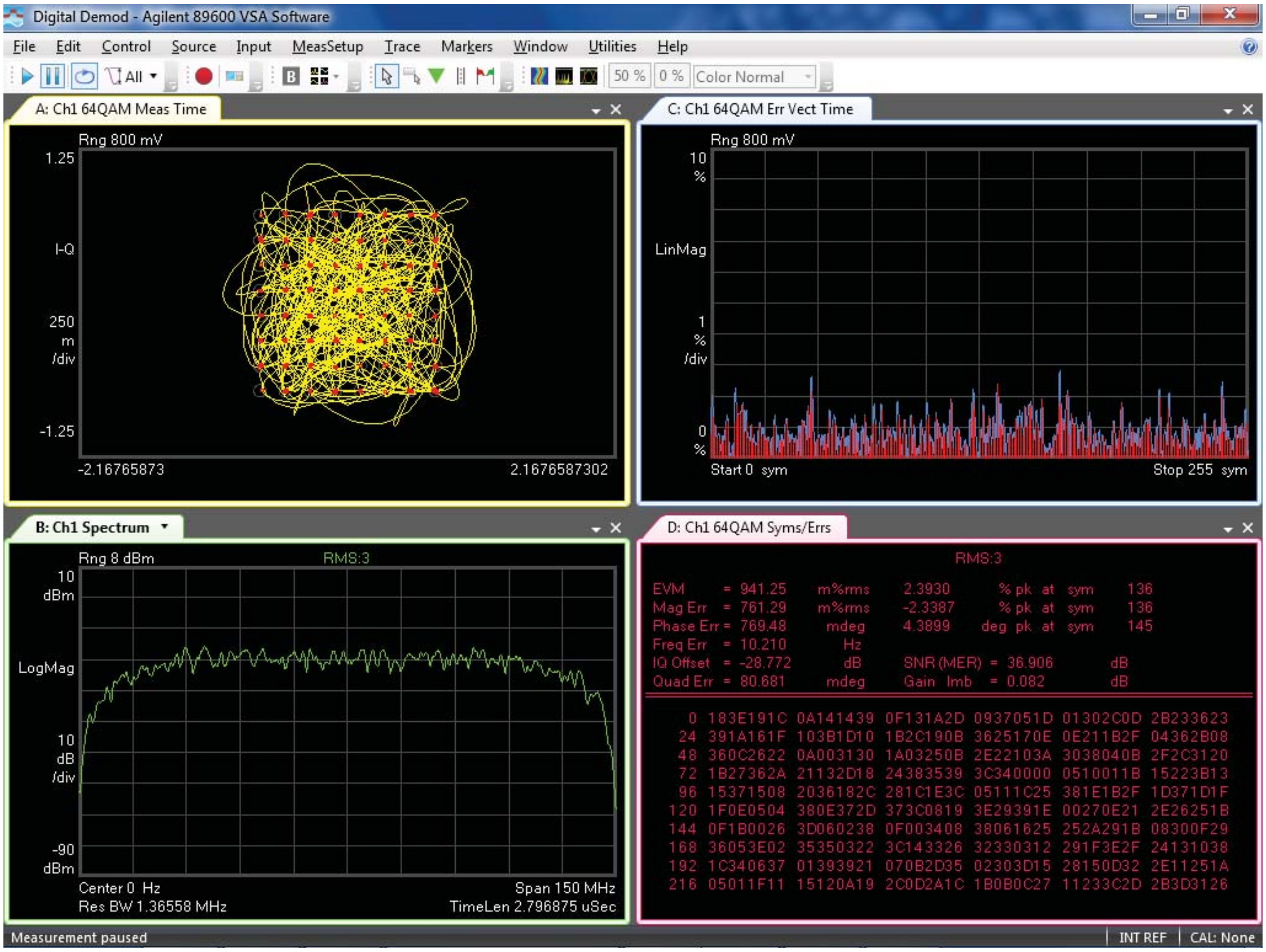

Figure 16. 64-QAM modulated Signal with 110 Msymb/s and EVM of 0.94% rms. Created using an Agilent 81160A Pulse Function Arbitrary Noise Generator. Measured on an Agilent Infiniium 90000 Series Oscilloscope using the 89600 VSA Software

Testing IQ receivers

The 81160A can also work with an existing modulator or an upconverter to provide controlled signals to stress an IQ receiver by creating conditions with phase mismatch, noise or low signal levels. Again, this uses the function arbitrary generator, noise generator, and the independence of the two channels on the 81160A.

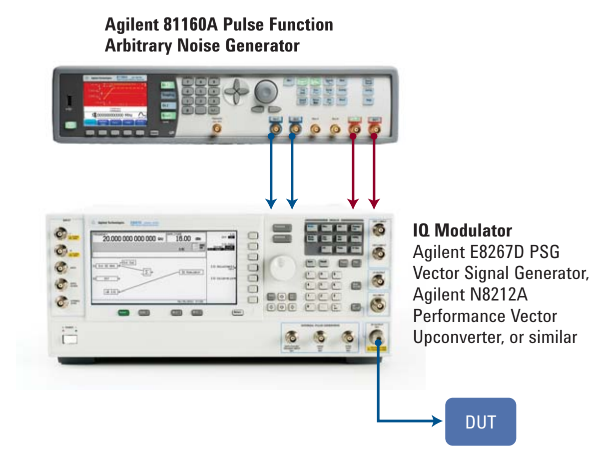

Figure 17. Typical set-up to test an IQ receiver

Configuration Guide for 81150A

Part	Description
#001	1-channel 120 MHz pulse function arbitrary noise generator
#002	2-channel 120 MHz pulse function arbitrary noise generator
#1A7	ISO17025 calibration and certificate
#Z54	Z540.3 calibration and certificate
#PAT	License for 120 Mbit/s pattern generator
Accessories included	
Certificate of calibration	
Local power cord	
USB cable	
Product CD (User Guide, Getting Started Guide, IVI-COM driver, examples for remote access)	
Optional accessories	
#DOC	Printed documentation. Includes printed Getting Started Guide and printed User Guide
#1CP	Rack mount kit
#R1280A	Additional 2-years warranty (3-years total)
Upgrades for 81150A	
81150AU	
#PAT	License for pattern generator
#DOC	Printed documentation
#EHD	Fixture for 100 Mbit ethernet and HDMI 1.4

Configuration Guide for 81160A

Part	Description
#001	1-channel 330 MHz pulse function arbitrary noise generator
#002	2-channel 330 MHz pulse function arbitrary noise generator
#1A7	ISO17025 calibration and certificate
#Z54	Z540.3 calibration and certificate
#330	License for 330 Mbit/s pattern generator
#660	License for 660 Mbit/s pattern generator
Accessories included	
Certificate of calibration	
Local power cord	
USB cable	
Product CD (User Guide, Getting Started Guide, IVI-COM driver, examples for remote access)	
Optional accessories	
#DOC	Printed documentation. Includes printed Getting Started Guide and printed User Guide
#1CP	Rack mount kit
#R1280A	Additional 2-years warranty (3-years total)
Upgrades for 81160A	
81160AU	
#330	License for 330 Mbit/s pattern generator
#660	License for 660 Mbit/s pattern generator
#326	License for upgrade from 330 Mbit/s to 660 Mbit/s pattern generator
#DOC	Printed documentation

Related literature	Publication number
Agilent 81150A and 81160A Pulse Function Arbitrary Noise Generators Data Sheet	5989-6433EN
Agilent 81150A and 81160A Pulse Function Arbitrary Noise Generators Demo Guide	5989-7718EN
Agilent 81150A Pulse Function Arbitrary Noise Generator Flyer	5989-7720EN
Agilent 81150A Pulse Function Arbitrary Noise Generator Quick Fact Sheet	5990 4565EN
Agilent 81160A Pulse Function Arbitrary Noise Generator Quick Fact Sheet	5990-6984EN
Pulse Pattern and Function Arbitrary Generators Brochure	5980-0489E
81150A and 81160A Arbitrary Bit-Shape Pattern Generator Application Note	5990-8822EN
Stressing 1GbE Receivers on the Physical Layer Application Note	5990 9346EN

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