Keysight 81150A and 81160A
Pulse Function Arbitrary Noise Generators
Most Versatile Instruments and Their Applications

Application Note

Revision 1.4

KEYSIGHT
TECHNOLOGIES

Unlocking Measurement Insights

Introduction

Physical layer

Automotive	Nanotech	Wearable devices	Medical	Data comm	Aviation/defense	Energy
Collision prevention	Biosensors Semiconductors	Sensor signals	Doppler sonography	IQ modulation WLAN 802.11ac Gigabit Ethernet SATA	Radar Satellite	Safety testing
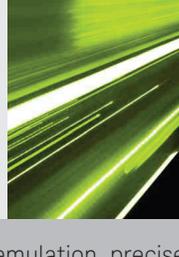
Device emulation, precise clock source, noise immunity testing, simulation of customer design, DC brushless motors, sonar testing, modulator testing, component testing, mixed signal devices, trigger...

The Keysight Technologies, Inc. 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
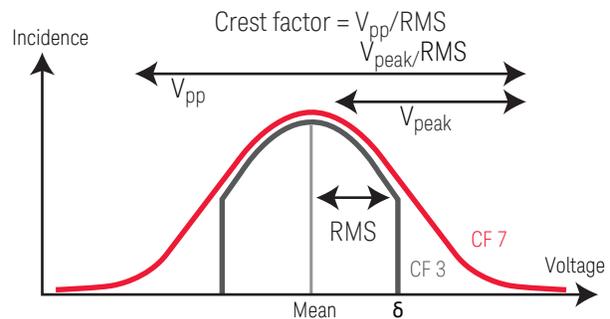
Gaussian curve of crest factor 3 and 7

BER and the different crest factors
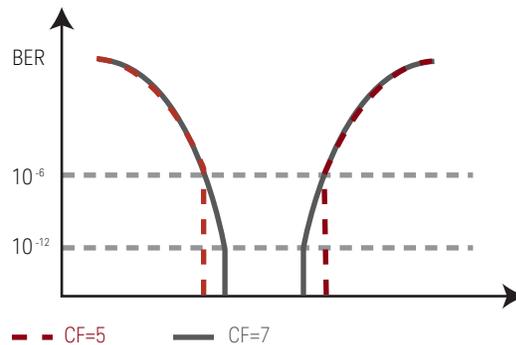
Bath tub with different crest factors

Automotive – Testing Collision Avoidance Radar Systems

The Challenge

Driverless cars may already have lost the taste of science fiction. The safety question remains a critical one. A multitude of collision preventing and mitigating sensors, above all radar sensors, are already in place in existing conventional cars in park and lane change assistant systems, blind spot detection and pedestrian protection elements. But without an interacting driver the reliability requirements are by far higher.

The Solution

The security systems of driverless and conventional cars need to be tested thoroughly before going to market. The tests need to cover a vast range of scenarios to guarantee security. For that purpose realistic radar sensor signals in multi-target situations need to be simulated.

The Contribution of 81150A/ 81160A

The two-channel 81150A and 81160A Pulse Function Arbitrary Noise Generators offer an incomparable versatility in waveform creation to cover ideal and real-world scenarios. Commonly used ultra-short pulses in the nm-range can be created up to 120 MHz and 330 MHz respectively with variable rise and fall times and also in burst mode. Both channels can be used for coupled (for example with a fixed delay) or independent signals. Gaussian noise with adjustable crest factor can be added to any signal. The function generator also provides FM and FSK modulation.

Other Useful Instruments and Software

– 33503A BenchLink Waveform Builder Pro Software for additional quick waveform creation and Fourier analysis capabilities
– Keysight 2000, 3000 and 4000 X-Series InfiniiVision oscilloscopes

Radar pulses

Distortion/noise/...

Power-train control system

81150A/ 81160A Pulse Generator

Nanotech – Characterization of New Devices and Materials

The Challenge

Nanotechnology has gained 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 voltages and repeatable measurements. The ultra-fine structures can be easily damaged and therefore the amount of energy during measurements needs to be controlled.

The Solution

To avoid heat generation, short test pulses and bursts are needed.

The Contribution of 81150A/ 81160A

The 81150A and the 81160A provide ultra-short pulses of 4.1 ns and 1.5 ns respectively. The variable independent rise and fall times can be as short as 2.5 ns/ 1.0 ns. Small duty ratio allows the device under test to cool down and short pulse width avoids leakage through gate oxide.

The 81150A and 81160A are the right choice for this kind of measurements because they guarantee accurate and repeatable measurements. The combination of pulse in addition to function, noise and arbitrary waveform generation permits all kinds of special stress tests.

Other Useful Instruments

– Keysight 2000, 3000 and 4000 X-Series InfiniiVision oscilloscopes

Short pulses - clean or distorted

81150A/ 81160A Pulse Generator
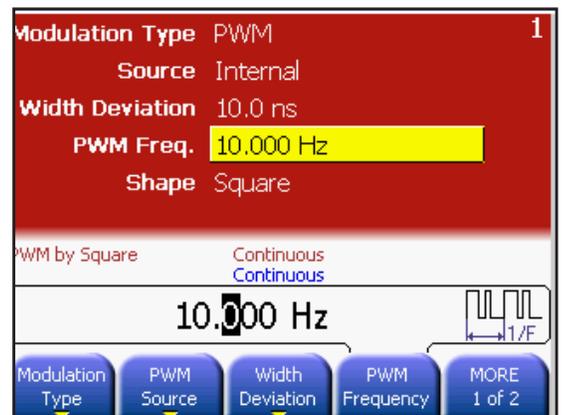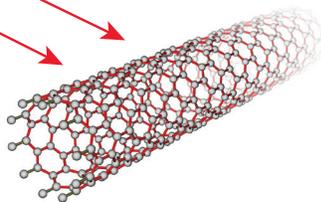
Setting up a pulse width modulation

Nanotech – Biosensors

The Challenge

Carbon nanotubes (CNT) have proven their high potential in realization of inexpensive low-size bio sensors such as humidity, pH, flow, strain and gas sensors. The sensors' dimensions allow the integration in bioelectrical chips. At the same time, the fabrication is challenging as it is difficult to bring up such thin structures of only a few molecules between two electrodes as the sensing element.

The Solution

In a deionized water dispersion , the CNTs are able to move freely. When brought into a non-uniform electric field between the electrodes, the electric force rotates and aligns the particles along the electric field from one electrode to the other.

The Contribution of 81150A

The 81150A is used as function generator and serves here as an AC source to generate the electric field. The sine signal usually has a frequency of several MHz and a peak voltage of 10 V.

Other Useful Instruments and Software

– M70754B Mixed Signal Oscilloscope, 500 MHz, 4 GSa/s sample rate
– For monitoring the voltage changes during dielectrophoresis in realtime

M70754B Mixed Signal Oscilloscope

81150A/ 81160A Pulse Generator

Sine function

CNT dispersion
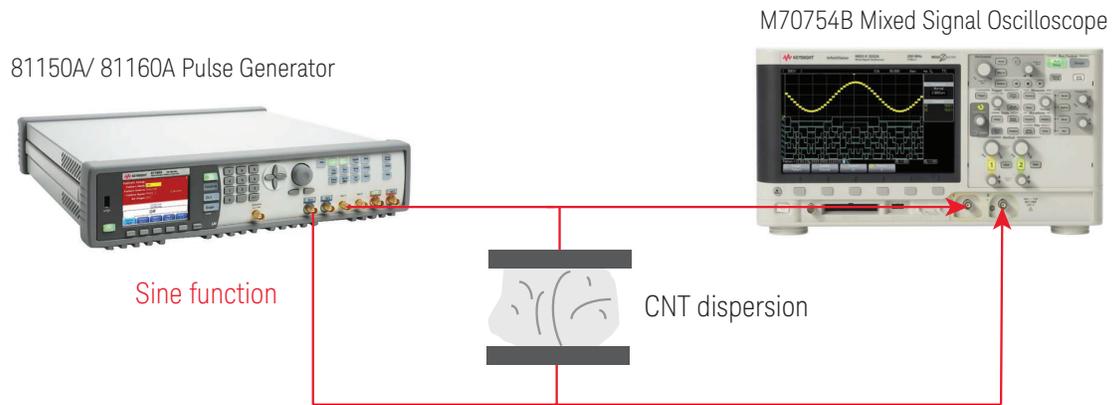
Wearable Devices – Simulate Distorted Sensor Signals

The Challenge

One of today's most rapidly evolving markets covers the immense field of wearable devices, from smart watches and glasses over fitness or medical devices integrated into clothes to textiles with alerting and GPS functions. They all have in common that they embed in a minimum of space a multitude of sensors, for example light sensors, temperature sensors, pressure sensors, microphones, CMOS image sensors (CIS) for face, fingerprint and gesture recognition, GPS sensors and movement sensors which utilize accelerometers. The functionality of the devices is risked by a multitude of distortions. The sensed signals may be subject to motion artifacts and other disturbing influences.

The Solution

In the design phase, the robustness of wearable devices need to be thoroughly tested with simulated ideal and distorted signals. Depending on sensor and scenario, the needed test signals can vary tremendously.

The Contribution of 81150A/ 81160A

With the two-channel 81150A/ 81160A Pulse Function Arbitrary Noise Generators you can do high-precision and repeatable simulations of any kind of clean signals overlaid with a distortion. This way you can generate motion artifacts in the Hz-range and acoustic signals corrupted by ambience acoustic noise or the absorbing effects of cloths covering the microphone, distortions of up to tenths of kHz. The noise generator also allows modulation of white Gaussian noise with adjustable crest factor. This way, CMOS image sensor signals – often subject to Gaussian noise due to high temperatures or a non-sufficient illumination – can be simulated. Furthermore, overshoot and other voltage level effects, that you face during wake-up from sleep mode, can be created.

Other Useful Instruments and Software

– Oscilloscope, e.g. MSO9404A, 4 GHz, 20 GSa/s

81150A/ 81160A Pulse Generator

Signal

Distortion

DUT

Wearable device

Oscilloscope

Medical – Doppler Sonography

The Challenge

In research and in the clinical routine, medicine often faces the challenge to quantify with non-invasive methods processes inside the body. Often, the used techniques have the disadvantage that the resulting images only indirectly represent the region of interest and therefore impede quantitative analysis.

The Solution

With a known ultrasound signal, processes like metabolism, blood flow, eardrum motion, muscle contractions etc. can be monitored noninvasively by benefiting of the Doppler Effect. When the ultrasound is reflected at the object in motion, the reflected signal will be shifted in frequency. The size of the frequency shift provides information on the velocity of the reflector.

The Contribution of 81150A/ 81160A

The 81150A/ 81160A can be used as a function generator emitting a continuous sinusoidal signal in the kHz range (depending on the investigated process) which is transmitted into an ultrasonic transducer. The generator's high frequency resolution of 1 µHz guarantees the most accurate results.

Other Useful Instruments

– DSOX2002A Oscilloscope, 70 MHz, 2 GSa/s and 1 GSa/s
– For analysis of the reflected and amplified ultrasound signal

81150A/ 81160A Pulse Generator

Sine signal

Ultrasonic transducer

Preamplifier

DSOX2002A Oscilloscope
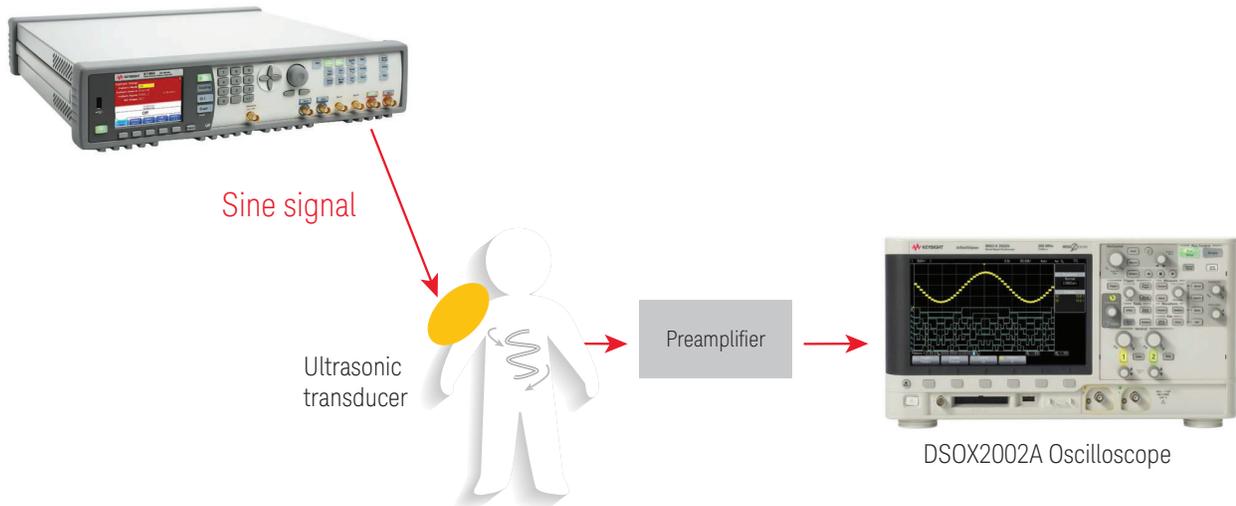
Data Comm- Wideband IQ Modulation Test in RF and Microwave (1)

The Challenge

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 Solution

This is a classical application for an arbitrary waveform generator.

The Contribution of 81160A

In a much lower price class than the typical arbitrary waveform generator, the 81160A can also do the job. It 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. This makes it easy to set up and vary the parameters you need to stress your DUT comprehensively.

Testing IQ modulators

For this purpose, you may need to measure quadrature or DC offset errors, or phase or gain imbalances to be able to measure the error vector magnitude (EVM). 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 arbitrary generator. You can introduce further stress by adding a noise component, using the noise generator.

Oscilloscope
Keysight Infiniium Oscilloscope with VSA, or similar

Keysight 81160A
Pulse Function Arbitrary Noise Generator

DUT

RF or microwave source as local oscillator (optional)
Keysight N5183A MXG Microwave Analog Signal Generator (up to 40 GHz), or similar
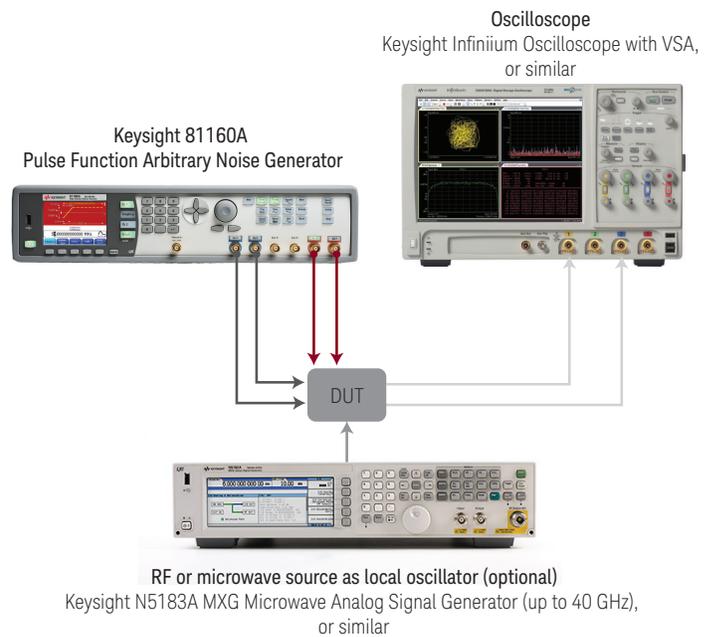
IQ modulator test setup

Data Comm- Wideband IQ Modulation Test in RF and Microwave (2)

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.

Other Useful Instruments and Software

– N6171A Matlab Software for programming multilevel signals
– N5183A MXG Microwave Analog Signal Generator
  (up to 40 GHz), or similar, as RF or microwave source as local oscillator (optional)
– Infiniium 9000 Series Oscilloscope with 89600 VSA Software
– E8267D PSG Vector Signal Generator
– N8212A Vector Upconverter or similar

Keysight 81160A Pulse Function Arbitrary Noise Generator

IQ Modulator
Keysight E8267D PSG Vector Signal Generator, Keysight N8212A Performance Vector Upconverter, or similar

DUT
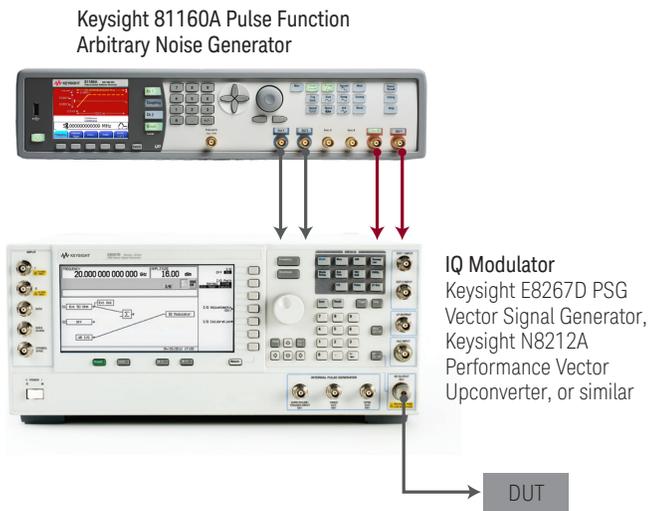
IQ receiver test setup
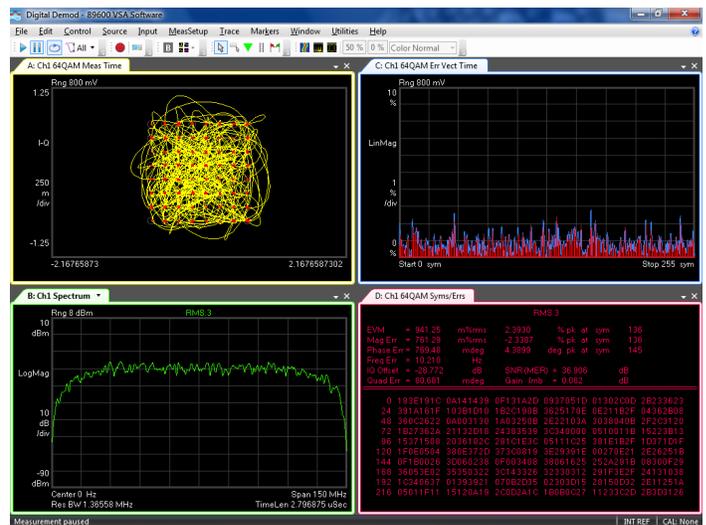
64-QAM modulated signal, 110 Msym/s

Data Comm – Power Amplifier Test for WLAN 802.11ac

The Challenge

The WLAN 802.11ac standard with its 256 QAM modulated signals comes with tighter requirements for the used power amplifiers, also regarding their contribution to the overall error vector magnitude of the signal which must not exceed 1.5%. For 802.11n it was still 3%. At the same time, the power amplifiers' power consumption needs to be reduced. This is usually achieved by only powering the amplifier when a data package arrives and disabling it for the rest of the time. Here we face a classic trade-off because for power saving reasons the delay between switch-on and the signal should be minimized but if it is too little, the so-called dynamic EVM in this process is rising due to thermal effects in the transition phase.

The Solution

In the amplifier's design phase, its EVM contribution needs to be analyzed in dependence of the enabling signal.

The Contribution of 81150A/ 81160A

The 81150A/ 81160A pulse generator functionality can be used to simulate an enabling signal which can be varied in voltage level, pulse width, rise and fall time. The repeatable high-precision pulses allow a most accurate characterization of the power amplifier.

Other Useful Instruments and Software

– N5182B MXG X-Series RF Vector Signal Generator, 9 kHz to 6 GHz for data signal generation
– N9020A X-Series Signal Analyzer, 10 Hz to 26.5 GHz for dynamic EVM analysis

81150A/ 81160A Pulse Generator

Power amplifier enabling signal

Sync

Trigger In

DUT

MXG X-Series RF Vector Signal Generator

Power amplifier

X-Series Signal Analyzer
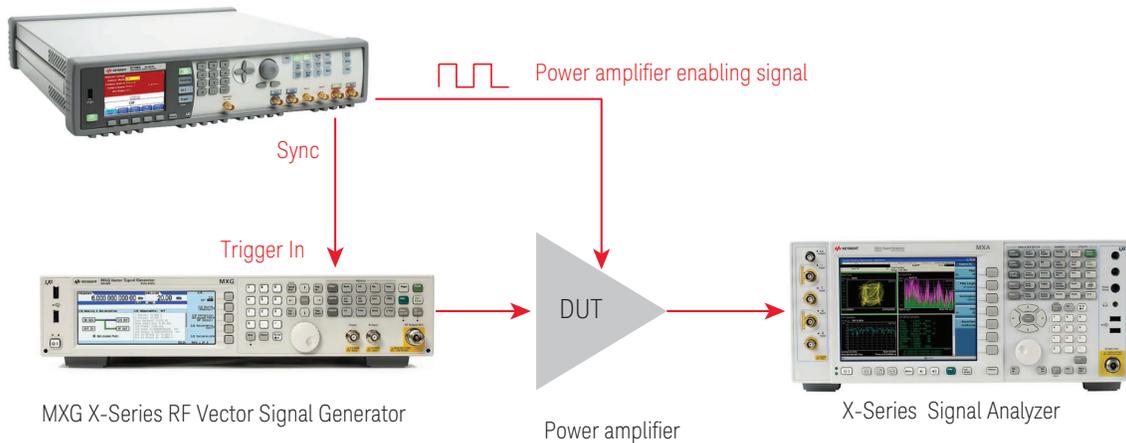
Data Comm – Stressing Gigabit Ethernet Receivers

The Challenge

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.

The Solution

For characterizing Gigabit Ethernet receivers, a synthetic signal is needed to simulate borderline conditions, or troubleshoot areas where a device fails to meet the specifications.

The Contribution of 81160A

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 an integrated noise generator with different crest factors, which generates random and repeatable noise. Glitch-free change of timing parameters, such as delay and frequency, for efficient testing without reboots and resynchronizations.

The signal is set up as an arbitrary waveform. Stress can be easily achieved by adapting the rise time from 5.12 s to 4.61 ns.

Other Useful Instruments and Software

– 33503A BenchLink Waveform Builder Pro Software for additional quick waveform creation
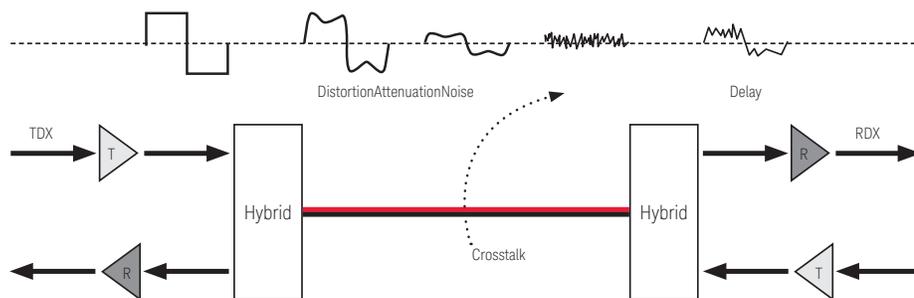
Attenuation, distortion, noise and delays can be added to the signal to emulate real-world conditions
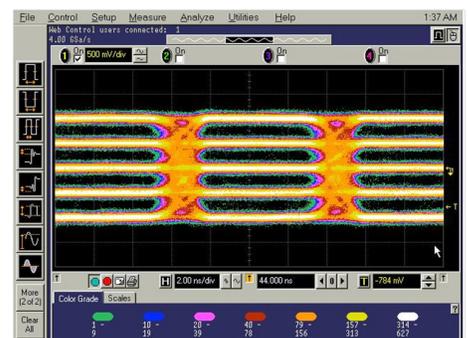
PAM-5 signal with 0.1 VPP noise

Data Comm – SATA Receiver Jitter Tolerance Test

The Challenge

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, a Keysight 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 Solution

A cost-effective solution to speed up testing could be a signal generated by a single instrument.

The Contribution of 81150A/ 81160A

The 81150A and 81160A can generate both jitter types in one instrument.

They 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 of 10-12. 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 Keysight test auto-mation software platform, N5990A Option 103. The software pro-vides compliance and interoperability testing and fully controls the test setup including sinusoidal and random noise.

Other Useful Instruments and Software

– N5990A-103 Automated Compliance and Device Characterization Tests for SATA 1.0, 2.0 and 3.0 RSG
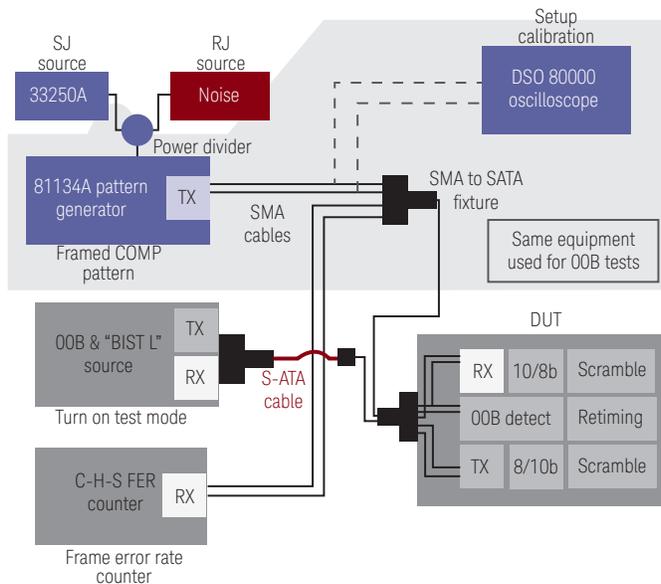
SATA receiver test set up
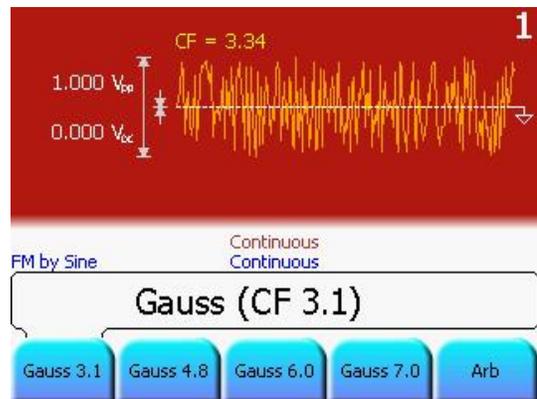
Noise probability function screen

Aviation and Defense – Radar Communication Systems

The Challenge

In radar communication systems in the military and the aviation industry, the highest level of reliability is a must. The same applies to the precision requirements for determining the distance of a moving object, for example an airborne plane. For distance measurements, 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.

The Solution

Thorough testing of the radar system has to be performed before putting it into service. For this purpose, the radar signals need to be simulated.

The Contribution of 81150A/ 81160A

The 81150A and 81160A offer the flexibility to simulate any scenario. Varying the delay from the external trigger to the start of the output radar signal can simulate various distances from the control tower. The generators provide triggered pulse streams internally or via an external signal, bursts of pulse streams with small duty cycles guaranteeing at the same time highest possible frequency accuracy.

Besides the precise signal with accurate rise and fall times of 2.5 ns, a distortion can be added to the signal using the channel add functionality with the second channel. This can be Gaussian noise with different crest factors or any other modulation.

Other Useful Instruments and Software

– 33503A BenchLink Waveform Builder Pro Software for additional quick waveform creation

Radar distance test to airborne planes
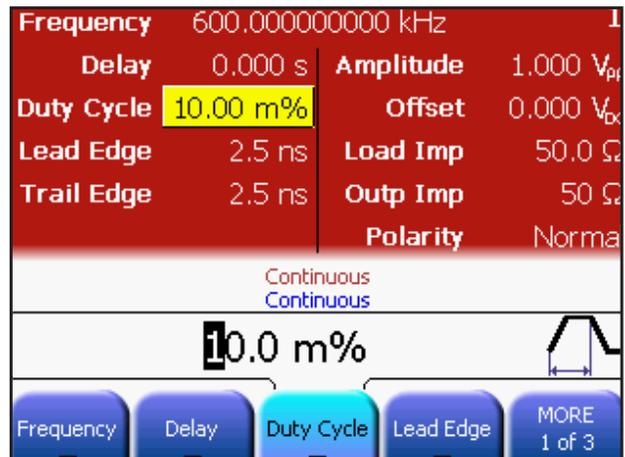
Example settings channel 1

Energy – Reactor Stability Testing

The Challenge

As accidents in nuclear power stations have an enormous impact even at a radius of thousands of miles, the well-functioning of safety systems is of utmost importance. For preventing a reactor meltdown, an alarm needs to be triggered most reliably in case of a fault event – for example when the nuclear fuel rod is pulled out of the cooling pond.

The Solution

The pulling out of the water causes an exponential increase of pulse frequency. The verification of the alarm and monitoring system requires generators to simulate such a signal which shows at the same time constant pulse duration.

The Contribution of 81150A/ 81160A

With the 81150A and the 81160A you can create these test signals with just one instrument where previously, you needed both, a pulse generator and an arbitrary generator. This makes testing more efficient by winning accuracy and repeatability at the same time.

For this application, the two-channel version is mandatory: The first channel creates the pulses, the second channel provides a frequency sweep and triggers the first channel.

The channels can work entirely independently as required with this application but channels can be coupled as well with a defined delay.

Required signal:

|_____|_____|_____|__|__|__| |
T(0)   T(1)   T(2)   T(3)T(4) ...
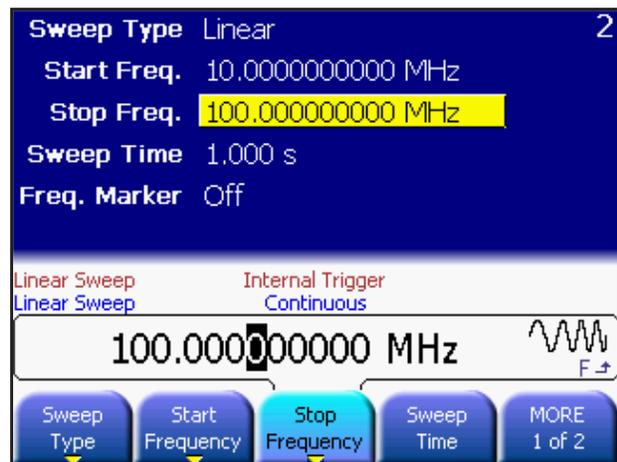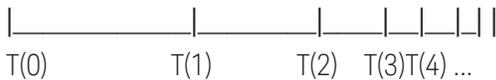
Frequency sweep configuration screen

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	Calibration + uncertainties + guardbanding
#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
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	Calibration + uncertainties + guardbanding
#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
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
Keysight 81150A and 81160A Pulse Function Arbitrary Noise Generators, Data Sheet	5989-6433EN
Keysight 81150A and 81160A Pulse Function Arbitrary Noise Generators, Demo Guide	5989-7718EN
Keysight 81150A Pulse Function Arbitrary Noise Generator, Flyer	5989-7720EN
Keysight 81150A Pulse Function Arbitrary Noise Generator, Quick Fact Sheet	5990 4565EN
Keysight 81160A Pulse Function Arbitrary Noise Generator, Quick Fact Sheet	5990-6984EN
Pulse Pattern Generators, Selection Guide	5991-1757EN
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
Keysight 81160A Pulse Function Arbitrary Noise Generator for Wireless Applications, Application Note	5992-0806EN
Testing Circuit Board Power Distribution Using Real World Distortions, Application Note	5991-1330EN
Stressing 1 GbE Receivers on the Physical Layer, Application Note	5990-9346EN

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