D9011PAMA / D9020PAMA

PAM-N analysis software for Infiniium oscilloscopes

Introduction

The switch from NRZ to PAM creates many new design and measurement challenges. D9011PAMA/D9020PAMA gives you analysis capabilities for today's PAM systems, with the ability to grow as higher levels of PAM are introduced.

KEYSIGHT

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Product Overview

PAM (Pulse Amplitude Modulation) signals use more levels than the "high" and "low" levels of NRZ (non-return-to-zero) to achieve greater throughput with the same Baud rate. For example, PAM-4 uses 4 levels where each level represents 2 bits of data (00, 01, 10, and 11). Because the signal-to-noise ratio (SNR) of PAM signals is lower, they are more susceptible to noise.

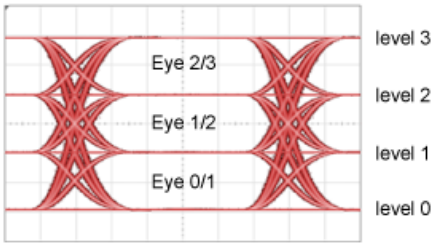
Time Locations	PAM Waveform Levels and Eyes
Level 3: Center time of Eye 2/3.	
Level 2: Average time of Eye 2/3's center time and Eye 1/2's center time.	
Level 1: Average time of Eye 1/2's center time and Eye 0/1's center time.	
Level 0: Center time of Eye 0/1.	

Figure 1. The PAM-4 uses 4 levels to represent 2 bits of data

To perform PAM level and rise/fall time measurements, the oscilloscope needs to determine the PAM levels and the thresholds that separate them. The oscilloscope needs to recover the clock from the PAM signal to display a real-time eye, make eye measurements, and perform jitter/noise measurements. Non-explicit clock recovery methods require PAM signals with open eyes.

Because some PAM designs operate on links with BER of ~1E-5, equalization may be used to widen eye openings. Feed-Forward Equalization (FFE) of PAM signals requires open eyes to begin with. This is different from FFE of NRZ (non-return-to-zero) signals, where open eyes are not required to begin with. Decision Feedback Equalization (DFE) of PAM signals or NRZ signals requires open eyes to begin with.

The Keysight D90xxPAMA PAM-N analysis software extends the ease-of-use advantages of the Infiniium oscilloscopes to the analysis of PAM-3, PAM-4, PAM-6, and PAM-8 signals.

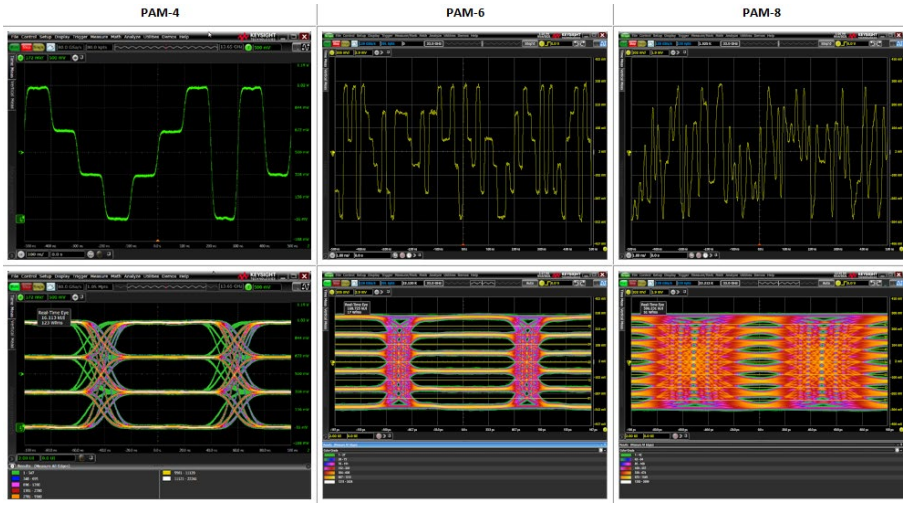


Figure 2. Infiniium PAM-4/6/8 analysis

PAM-N Measurement Setup

The Signal Type Setup dialog box is where you launch the PAM measurements setup wizard or manually enter your PAM measurements settings. In Signal Type Setup, you can specify the type of PAM signal being measured and the nominal symbol rate. Moreover, in the new 11.x software(available for UXR and MXR-Series oscilloscopes) you can launch the SNDR Setup dialog box where you can set up SNDR measurements like Sigma-n, Sigma-e, Pmax, and SNDR. If PAM-4 is selected as the signal type, you can enable PAM-4 12 Edge Jitter measurements. For the SSPRQ100 Setup box, A UXR-Series oscilloscope can be used to deskew SSPRQ100 patterns from a Keysight A400GE test system(part of 400GBase FEC-aware receiver test solution).

A wizard walks you quickly through the steps required to set up measurements for a PAM encoded signal, select methods for clock recovery, and then the measurements you wish to have performed on your PAM signal. Our PAM software is also able to accurately set the individual threshold levels of your PAM signal and render each individual eye. The number of mask regions currently supported by Infiniium software is sufficient for up to PAM-8 signals, so mask testing works the same as with NRZ (non-return-to-zero) signals.

Figure 3. Infiniium PAM signal type setup

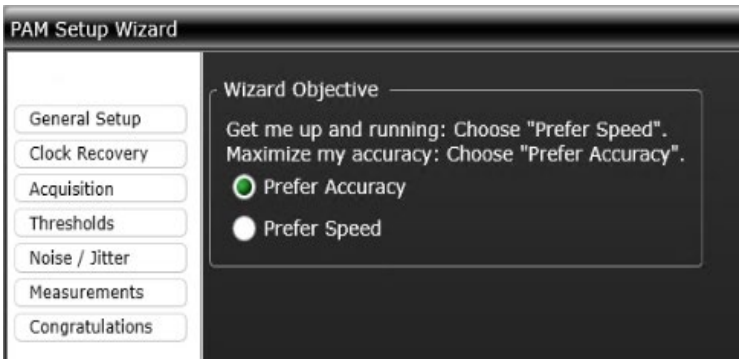


Figure 4. Infiniium PAM setup wizard

Noise or Data TIE (Jitter) Measurements

In D90xxPAMA PAM-N analysis software, you can do noise measurements for each level and jitter measurements for each threshold. You can specify the pattern length and measurement location within the bit where 0% is the beginning of the symbol, 50% is the middle of the symbols, and 100% is the end of the symbol. PAM threshold can be selected for which you want jitter measurements. You can also set the bit error rate (BER) value that is used in conjunction with BER Bathtub curve to calculate the total jitter(TJ) peak-to-peak value displayed in the RJ/DJ tab.

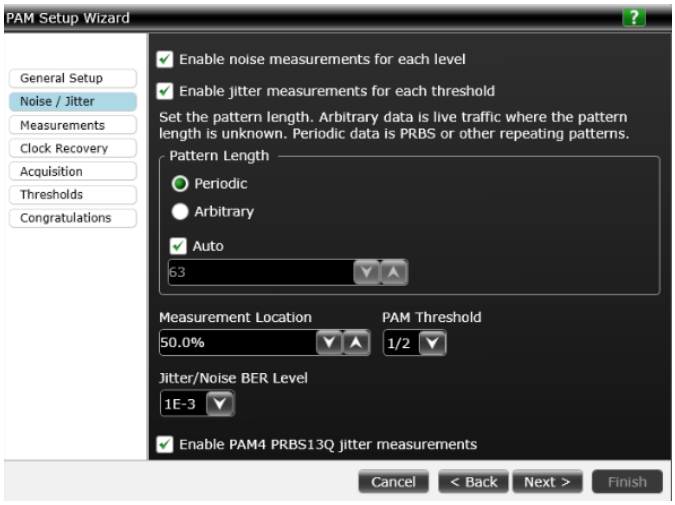


Figure 5. Noise/Jitter setup in PAM Wizard

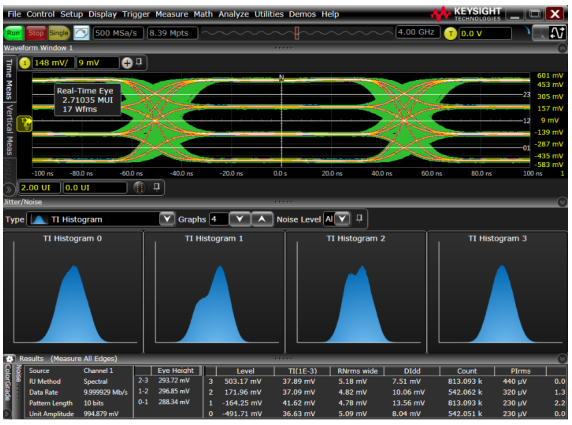


Figure 6. PAM-4 Noise Measurements

Figure 7. PAM-4 Jitter (Data TIE) Measurements

PAM Eye, Level and Rise/Fall Time Measurements

The PAM measurements can be enabled in the setup wizard (for PAM-3/4/6/8). You can track particular measurements with markers and use measurement call-outs to identify the measured edges.

Figure 8. PAM-4 eye, level and rise/fall time measurements.

Clock recovery

You can choose different software-based clock methods, including a first- and second-order phase-locked loop or constant frequency clock recovery. In addition, if you have a reference clock available, you can route that clock signal to an unused scope channel that you configure as an explicit reference clock for your PAM-4 signal. Transition-qualified clock recovery delivers flexible transition-specific reference levels for patterns with low uniform density.

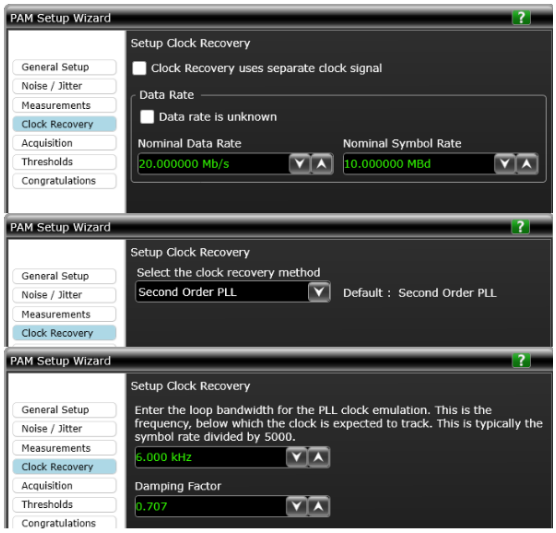


Figure 7. Setup clock recovery

PAM-4 12 Edge Jitter Measurements

PAM-4 J3u, J4u, J6u, Jrms, and even-odd jitter (EOJ) measurements can be made on PRBS13Q, PRBS9Q, PCIe Gen6 (52 symbols), and other data patterns. These measurements are based on the IEEE 802.3bs and other standards for Output Jitter measurements. During these measurements, an RJ/PJ histogram is measured for each of the 12 specific waveform transitions that are called out in the standard as well as for the combined effect of all edge transitions. On PAM-4 signals that are derived from two NRZ signals, these measurements let you observe the effect of different uncorrelated jitter on each stream based on the transitioning bits. For Jrms/Jnu report count, the IEEE 802.3bs standard (and other standards) can specify these measurements be made up to 1,000,000 times. However, you can use this field to change the count that is actually used.

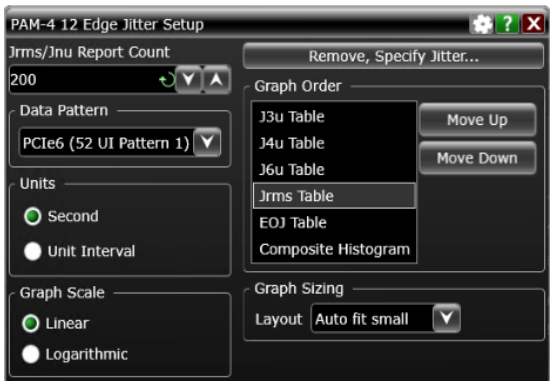


Figure 8. PAM-4 12 Edge Jitter setup

PAM-4 SNDR (Signal to Noise and Distortion Ratio) Measurements

Assuming ISI jitter and noise are 100% compensable by equalizers and are of no consequence to system performance, you can project a system's performance (when equalizers are used) by determining the ratio between the signal from linear fit pulse response and distortion-plus-noise. This ratio is called Signal to Noise and Distortion Ratio (SNDR). Some technology standard documents publish SNDR specifications. The SNDR measurement is arrived at by performing linear fit pulse response and linear fit error (matrix) math functions on the input waveform and then by making calculations based on the results.

Signal to Noise and Distortion Ratio (SNDR) is defined by the equation:

$$SNDR(in\ dB) = 10 \times log_{10}(\frac{P_{max}^2}{(\sigma_e^2 + \sigma_n^2)})$$

The PAM-4 SNDR measurements include Siga-n, Sigma-e, Pmax, and SNDR. You can also view the math waveforms created during the measurement process: the SNDR Input waveform (with the averaging and pts-per-UI linear fit parameters applied), the linear fit Pulse Corrected waveform, the Error waveform, e(k), and the Linear Fit Pulse Response, p(k).

Figure 9. PAM-4 SNDR setup

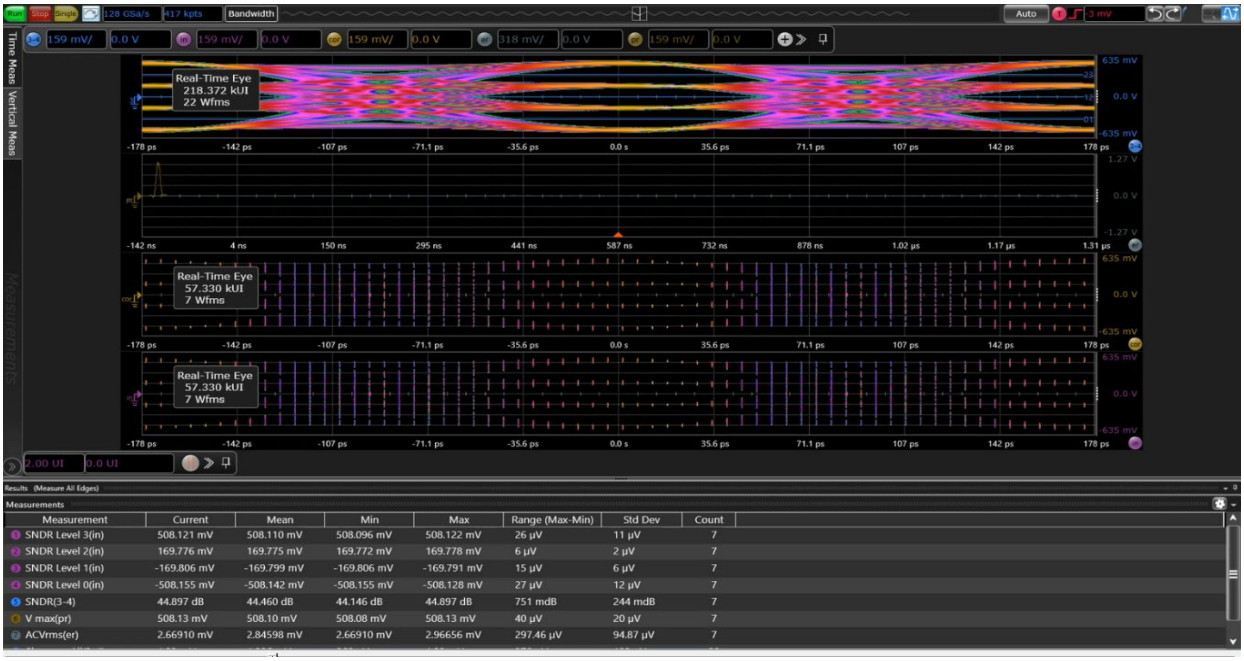


Figure 10. PAM-4 SNDR measurements result

Error Detection

Figure 11. In the Add Measurement dialog box, filter the measurements by selecting PAM in the left-most list; then select the desired BER or SER measurement.

Because PAM signals can use forward error correction (FEC) with possible bit errors on the order of 1e5 or 1e6 bits, it becomes practical for an oscilloscope to measure BER (Bit Error Ratio) and SER (Symbol Error Ratio). The BER (Bit Error Ratio) and SER (Symbol Error Ratio) measurements for PAM signals require clock recovery and at least two error-free copies of an identical repeating bit pattern in acquisition memory. Typically, a PRBS test pattern is used. For the BER and SER measurements, you can make cumulative measurements (over many acquisitions) to measure a statistical BER level or you can make measurements per (for each) acquisition to help identify and locate burst errors. You can enable Limit Test on BER or SER measurements and stop acquisitions when a limit is reached. For the BER (Per Acq) measurement, you can count a certain number of failures or a certain number of failures within a range of bits (burst errors). When Limit Test on measurement is enabled, you can navigate to locations in the signal where the limit test failures occurred.

Electrical and optical analysis

D90xxPAMA performs accurate analysis on electrical PAM-n signals using measurements integrated directly into the Infiniium user interface (no external application is required). Communication links using PAM typically operate at a much higher Symbol Error Rate (SER) than traditional NRZ links, so the analysis algorithms have been engineered to provide robust measurements on real-world waveforms including those from severely degraded signals.

Deeper analysis with de-embedding and equalization

The existing library of Infiniium optional software analysis features also supports more advanced analysis of PAM signals, providing even more insight into your designs. Using the Infiniium signal processing interface tools for real-time oscilloscopes, you can (for example), cascade S-parameter models and/or equalizers to model your transmission line, or backplane, and receiver.

The optional D90x0ASIA includes InfiniiSim Serial Data Equalization Software, which adds powerful software equalization capability. You can leverage CTLE, DFE, and FFE/LFE.

The optional D9010DMBA includes InfiniiSim Basic, which can simulate PAM signals at the end of a channel (embed) or remove the effects of a cable or channel (de-embedding). If you need to simulate more than one element to de-embed or embed, consider D90x0ASIA, which includes InfiniiSim advanced.

Supported Features

	Supported specifications and characteristics
Supported oscilloscopes	**Infiniium 6.x software**: 90000 Series, S-Series, V-Series, Z-Series **Infiniium 11.x software**: EXR-Series, MXR-Series, UXR-Series
PAM levels supported	3, 4, 6, 8
Eye measurements	Eye center, eye width, eye height, eye skew, eye level, eye opening probability
Level measurements	Level mean, level RMS, level thickness, level skew
Other measurements	Rise/fall times (for all edges at once with PAM-3/4/6/8) PAM-4 12 Edge Jitter Noise measurements (levels can be specified, graphed) Jitter measurements (levels can be specified, graphed) Jitter (Data TIE) measurements BER (cumulative or per acquisition) SER (cumulative or per acquisition) PBRS13Q (VEC, J3U, J4U, J6U, Jrms, EOJ) PBRS9Q (VEC, J3U, J4U, J6U, Jrms, EOJ) PCIe Gen6 (52 symbols) (VEC, J3U, J4U, J6U, Jrms, EOJ) Clock recovery rate Pattern length SNDR (Sigma-n, Sigma-e, Pmax, SNDR, Level Mean)(available for Infiniium 11.x only)
Equalizers	CTLE, FEE/LFE (requires D90x0ASIA)
De-embedding	Channels, cables, fixtures (requires D9010DMBA or D90x0ASIA)

Ordering Information

Required hardware

Model	Compatibility
D9011PAMA	Infiniium 9000, S-Series, EXR-Series, MXR-Series
D9020PAMA	Infiniium 90000, V-Series, Z-Series, UXR-Series

Flexible software licenses and KeysightCare Software Support Subscriptions

Keysight offers a variety of flexible licensing options to fit your needs and budget. Choose your license term and license type.

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Perpetual – Perpetual licenses can be used indefinitely.

Subscription – Subscription licenses can be used through the term of the license only.

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Node-locked – License can be used on one specified instrument/computer.

Transportable – License can be used on one instrument/computer at a time but may be transferred to another using Keysight Software Manager (internet connection required).

USB Portable – License can be used on one instrument/computer at a time but may be transferred to another using a certified USB dongle (available for additional purchase with Keysight part number SW1000-D10).

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Perpetual licenses are sold with a 12 (default) and up to 60-month software support subscription with a user-selected start and end date. Support subscriptions can be renewed for a fee after that.

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Step 1. Choose your software product (e.g. D9020ASIA)

Step 2. Choose your license term: perpetual or subscription.

Step 3. Choose your license type: node-locked, transportable, USB portable, or floating.

Step 4. Depending on the license term, choose your support subscription duration.

Example

If you selected:	Your quote will look like this:	
D9020ASIA Node-locked Perpetual license	Part number D9020ASIA SW1000-LIC-01 SW1000-SUP-01	Description Advanced Signal Integrity Software (EQ, InfiniiSimAdv, Crosstalk) Node-locked perpetual license Node-locked KeysightCare software support subscription with user-selected start and end dates
D9020ASIA Transportable Subscription 6-month license	Part number D9020ASIA SW1000-SUB-01	Description Advanced Signal Integrity Software (EQ, InfiniiSimAdv, Crosstalk) 6-months, transportable subscription license

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Contact your Keysight representative or authorized partner for more information or to place an order:

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