

D9110PAMA / D9120PAMA

PAM-N Analysis Software for Infiniium Oscilloscopes

Introduction

The switch from NRZ to PAM creates many new design and measurement challenges.

D9110PAMA/D9120PAMA gives you analysis capabilities for today's PAM systems, with the ability to grow as higher levels of PAM are introduced.



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.

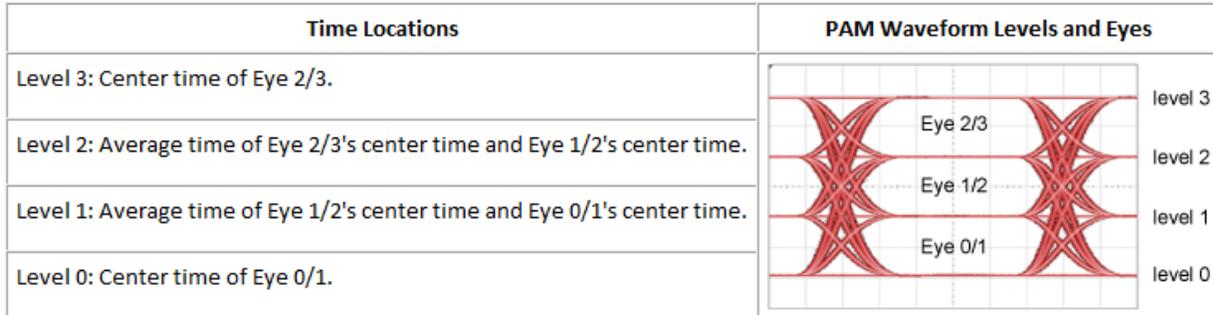


Figure 1. The PAM-4 uses 4 levels to represent 2 bits of data

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

Because some PAM designs operate on links with BER of $\sim 1E-5$, 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 D9120/D9110PAMA 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.

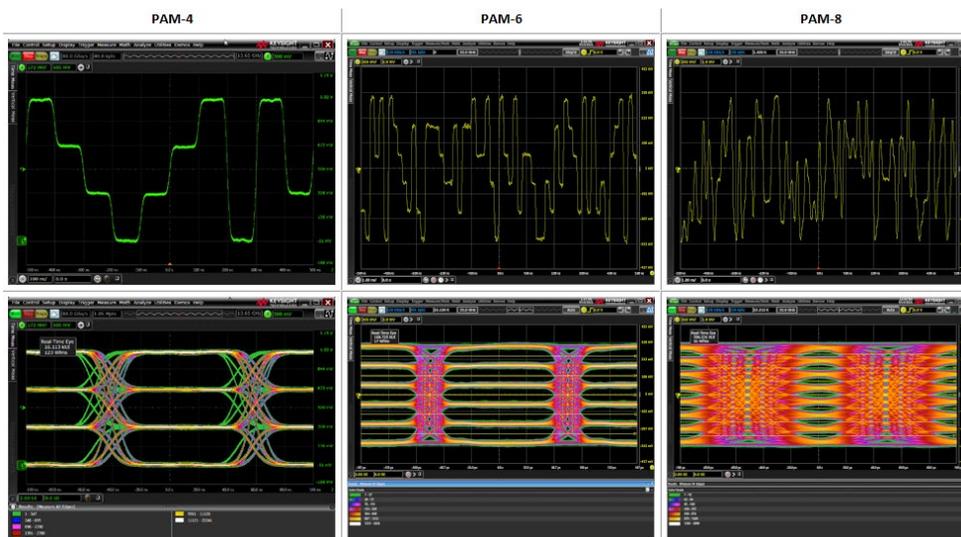


Figure 2. Infiniium PAM-4/6/8 analysis

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 setup measurements for a PAM encoded signal, to 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.

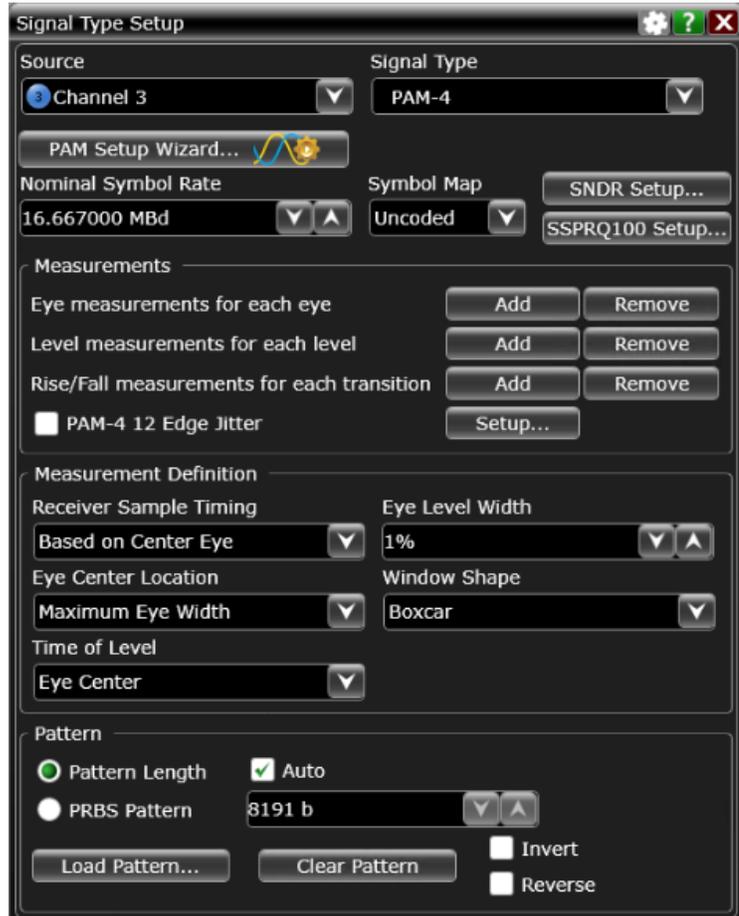


Figure 3. Infiniium PAM signal type setup

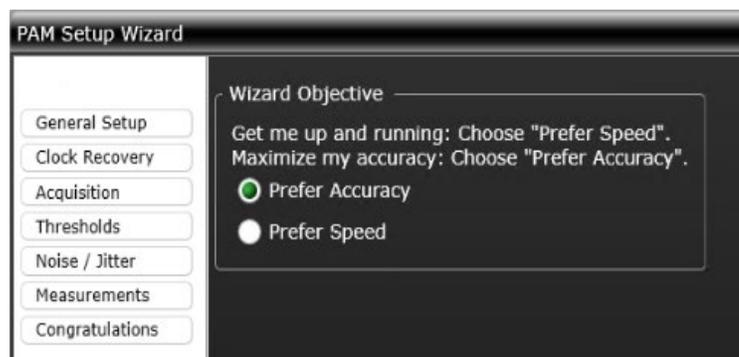


Figure 4. Infiniium PAM setup wizard

Noise or Data TIE(Jitter) Measurements

In D91x0PAMA 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% in 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.

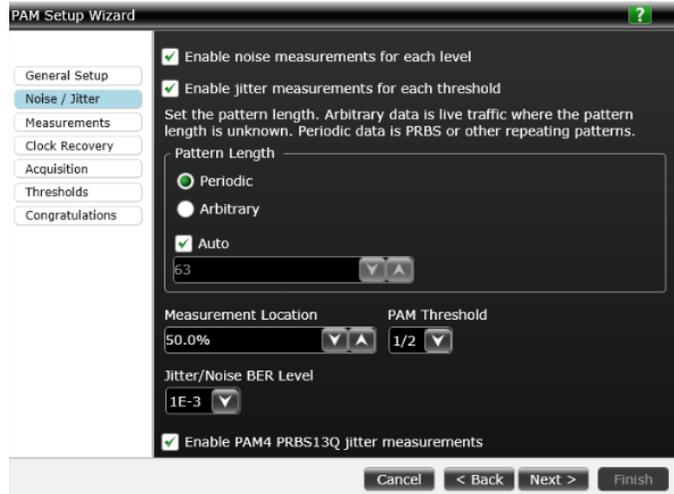


Figure 5. Noise/Jitter setup in PAM Wizard



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 that include 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.

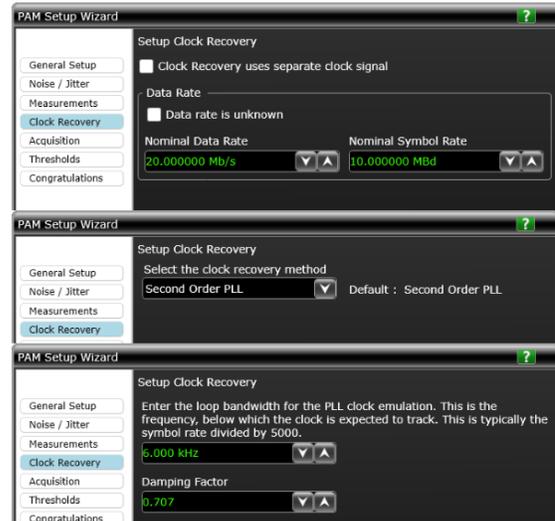


Figure 7. Setup clock recovery

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 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.

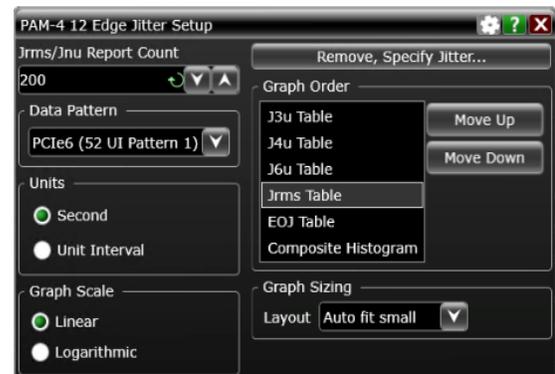


Figure 8. PAM-4 12 Edge Jitter Setup

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

Assuming ISI jitter and noise is 100% compensable by equalizers and is 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:

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

The PAM-4 SNDR measurements include Sigma-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

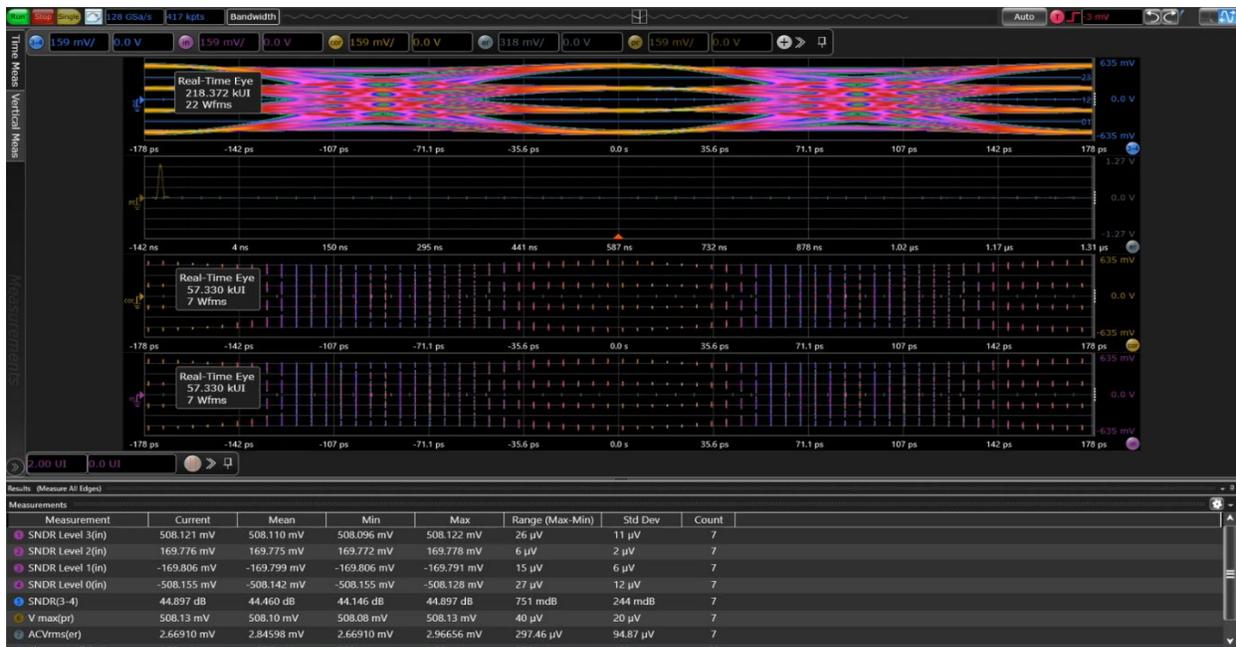


Figure 10. PAM-4 SNDR measurements result

Error Detection

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 requires 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.

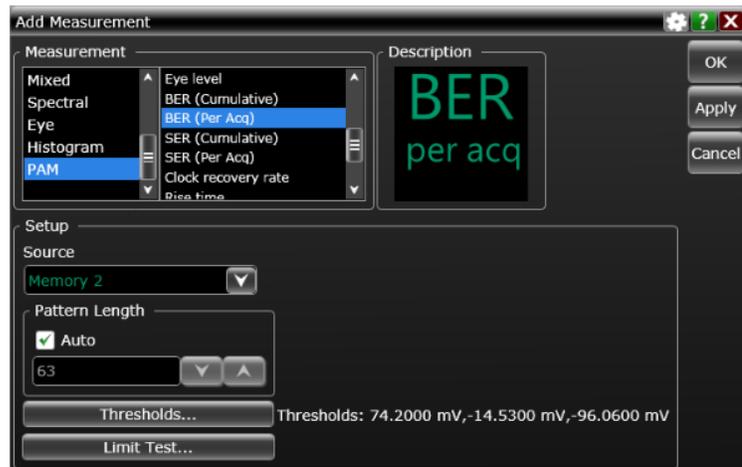


Figure 11. In the Add Measurement dialog box, filter the measurements by selecting PAM in the left-most list; then select the desired BER or SER measurement.

Electrical and optical analysis

D91x0PAMA 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 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 support 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 D91x0ASIA includes InfiniiSim Serial Data Equalization Software, which adds powerful software equalization capability. You can leverage CTLE, DFE, and FFE/LFE.

The optional D9110DMBA 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 D91x0ASIA, which includes InfiniiSim advanced.

Feature supported

	Supported Specifications and Characteristics
Oscilloscopes supported	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 [The following measurements is available in 11.x software only.] SNDR (Sigma-n, Sigma-e, Pmax, SNDR, Level Mean)
Equalizers	CTLE, FEE/LFE (requires D91x0ASIA)
De-embedding	Channels, cables, fixtures (requires D9110DMBA or D91x0ASIA)

Ordering Information

Required hardware

Model	Compatibility
D9110PAMA	Infiniium 9000A, S-Series, EXR-Series Infiniium MXR-Series (Updates and Enhancements are available with a current Core Software subscription)
D9120PAMA	Infiniium 90000, V-Series, Z-Series Infiniium UXR-Series (Updates and Enhancements are available with a current Core Software subscription)

To ensure you continue to receive all the latest software updates and enhancements on your MXR and UXR-Series scopes, you will need to have a current core software subscription. A node-locked perpetual core software license and a minimum 1-year updates and enhancements subscription is included with new MXR and UXR-Series scopes. The subscription can be extended to 3 or 5 years at the time of purchase and can then be renewed later for a fee.

Flexible software licenses

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

License terms

Perpetual – Perpetual licenses can be used indefinitely.

Subscription – Subscription licenses can be used through the term of the license only (6, 12, 24, or 36 months).

License types

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 E8900-D10).

Floating (single site) – Networked instruments/computers can access a license from a server one at a time. Multiple licenses can be purchased for concurrent usage.

Selecting your license

Step 1. Choose your software product (e.g. D9120ASIA)

Step 2. Choose your license term: perpetual or time-based.

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

To ensure you continue to receive all the latest software updates and enhancements on your MXR and UXR-Series scopes, make sure your core software subscription is current.

Example

If you selected:	Your quote will look like this:	
D9120ASIA node-locked perpetual license	Part Number D9120ASIA R-B5P-001-A	Description Advanced Signal Integrity Software (EQ, InfiniiSimAdv, Crosstalk) Node-locked perpetual license
D9120ASIA transportable subscription 6- month license	Part Number D9120ASIA R-B7P-004-F	Description Advanced Signal Integrity Software (EQ, InfiniiSimAdv, Crosstalk) 6-months, transportable subscription license

For More Information

To configure your product and request a quote:

<http://www.keysight.com/find/software>

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

www.keysight.com/find/contactus



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