

Innovation for the next generation



## ML4039EN

4-Channel | 56 GBd PAM & NRZ |  
400G BERT with ISI, JTOL & Crosstalk  
Noise injection |

4 x 56 GBd NRZ/PAM-4 BERT | SSPRQ, PRBS13Q &  
PRBS31Q | 7-Tap PPG Linear Equalizers | Signal SNR,  
Histogram and Dynamic FFE | Programmable ISI  
Emulator to 9 dB | Line Shallow Loopback | FEC

### Summary

With the accelerated growth of hyperscale datacenters, the performance demands on Ethernet network infrastructure is increasing exponentially, and customer expectations for high-speed data throughput is at an all-time high. As a result, Bit Error Rate Testers (BERT) have become a cornerstone for physical layer testing, from qualifying bit transmission for fiber optic and copper-wire digital data transmission lines to testing signal integrity.

A BERT generates a sequence of bits through a communication channel and the received bits are then compared against the transmitted bits. A Bit Error Ratio (BER) evaluates the full end-to-end performance of a connectivity system and assures communication reliability.

The ML4039EN is a 4-channel, 56 GBd PAM & NRZ, 400G BERT with a unique crosstalk noise injection capability. In addition, it can be used in combination with ML407-PAM for jitter tolerance testing and has a programmable ISI emulator. Real hardware FEC testing is also possible with the versatile ML4039EN.

# ML4039EN

## 4 x 56 GBd BERT

### Introduction

The ML4039EN is a full feature 400G BERT that can be configured as a four-channel PAM4 56 GBaud or four-channel NRZ 28/56 Gbps lanes. Also, half rates of 23 to 29 GBd are supported.

The transmitters Support all standard test patterns mandated by IEEE and OIF such as PRBS13Q, SSPRQ, PRBS31Q, etc.

It is also possible to program the TX to output a user-defined pattern up to 32 kb long.

The ML4039EN is specifically designed to add crosstalk noise with configurable frequency up to 29.6 Gbps for NRZ and up to 29.6 GBaud for PAM. Additionally, the user can select to programmatically add an ISI channel equivalent to a frequency-dependent attenuator with 1 to 9 dB loss at Nyquist.

When used in conjunction with the ML407PAM clock synthesizer, it can modulate its output pattern with SJ of over 5UI and up to 4 MHz.

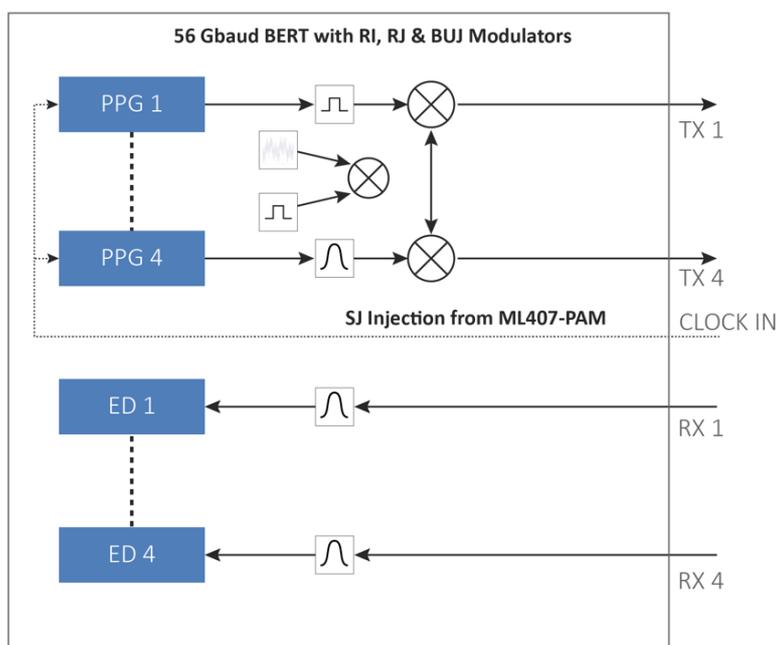


Figure 1: ML4039EN Block Diagram

### Key Features

#### Transmit

- Data Rates: 23 – 29 & 46 – 58 GBd
- Ability to tune the bit rate in steps of 100 kbps and find the RX PLL locking margin.
- Independent control of inner eye levels
- Up to 0.8 Vppd output swing
- Supports Gray coding and polarity inversion

Available patterns are:

- PRBS 7/9/11/13/15/16/23/31/58 and their inverses
- PRBS13Q, PRBS31Q
- SSPRQ
- Square wave
- Error injection
- 3-tap LUT-based Pre- and Post-emphasis
- 7-tap linear TX FFE
- Programmable ISI Emulation

#### Receive

- SNR monitoring over time.
  - PAM histogram monitor.
  - PAM slicer threshold adaptive.
  - Error-detection on following patterns:
    - PRBS 7/9/11/15/16/23/31
    - PRBS13Q and PRBS31Q
  - LOS indicators.
  - LabView sample and Python wrapper available.
- Same product available in ATE format for Verigy 93K and Teradyne.

#### General

- API libraries with documentation.
- Line Shallow Loopback:
  - Support PRBS traffic
  - Support FEC encoded traffic

- FEC:
  - Support generation of idle pattern with RS544/RS528 encoding types
  - Support FEC decoding on RX and FEC statistics measurement
- Addition of crosstalk (currently it is added in the Introduction text only):
  - Configurable frequency in the range of 9-14.2 Gbps and 22-29.6 Gbps for NRZ and 22-29.6 GBaud for PAM

## Target Applications

- Production testing of transceivers
- Functional and SI testing
- JTOL for 26 and 53 GBd receivers.

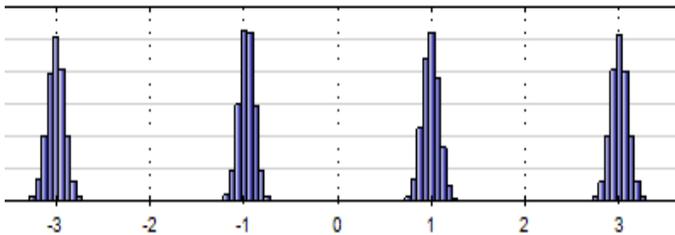


Figure 2: PAM eye histogram

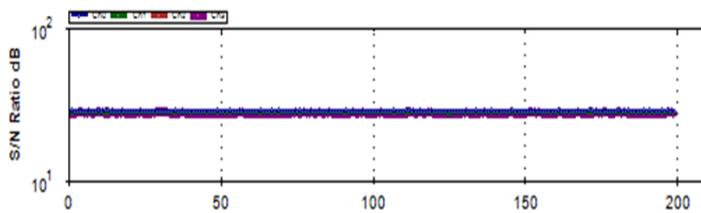


Figure 3: SNR capture overtime

## ISI Channel Emulation

The ML4039EN can programmatically emulate the effect of frequency-dependent attenuators with 1 dB up to 10 dB loss at the Nyquist frequency and a frequency roll-off similar to a PCB trace. When it comes to compliance testing on transceivers, more specifically for the stressed input test, this is highly practical. Effects of the different settings are shown below. Both in eye diagram mode, as well as in pattern view.

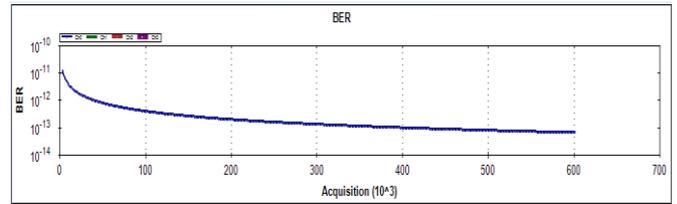


Figure 4: BER curves for one channel with 1 error

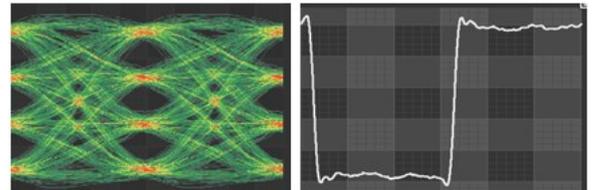


Figure 5: 1 dB ISI Channel

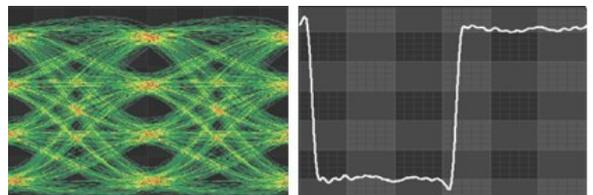


Figure 6: 2 dB ISI Channel

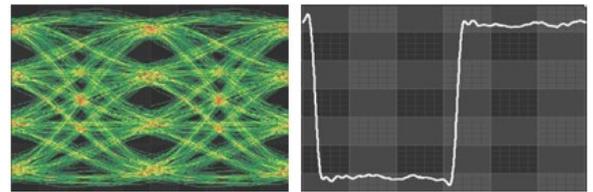


Figure 7: 3 dB ISI Channel

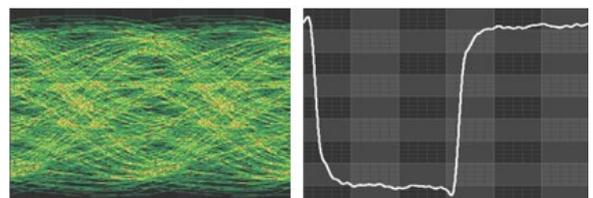


Figure 8: 4 dB ISI Channel

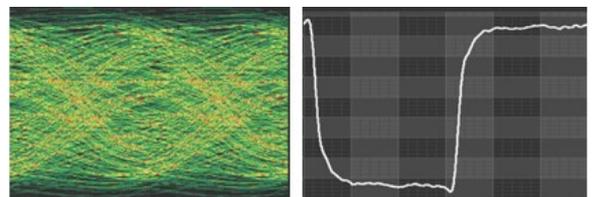


Figure 9: 5 dB ISI Channel

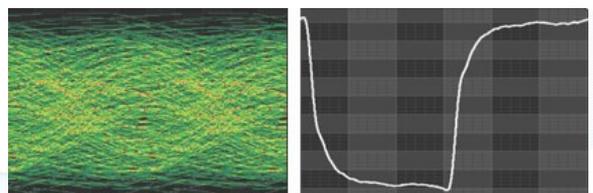


Figure 10: 8 dB ISI Channel

## Jitter Tolerance Testing

The following measurement captures on 26/53 GBd PAM4 show the effects of crosstalk and jitter injection on a clean pattern.

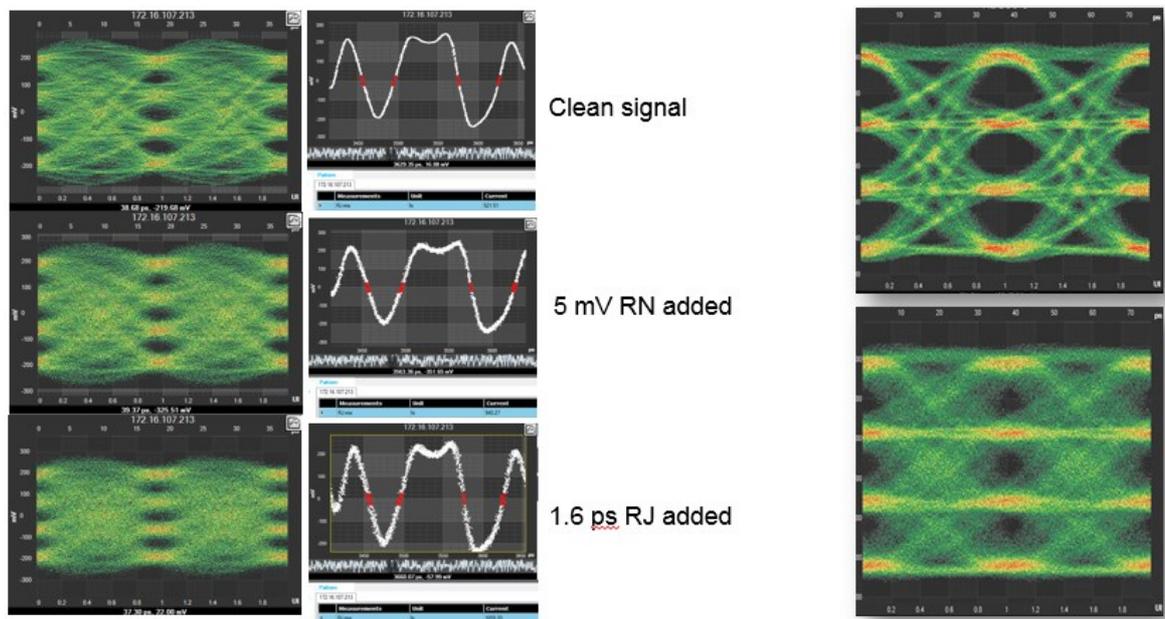


Figure 11: Adding impairments to a 26/53 Gbd signal using the ML407PAM clock synthesizer



Figure 12: JTOL Test Setup



Figure 13: ML407-PAM Clock Jitter Synthesizer

## Electrical Specifications

Parameter	Specifications
Bit Rates	PAM4: 23-29 GBaud and 46-58 GBaud NRZ: 23-29 Gbps and 46-58 Gbps
TX Amplitude Differential	0 - 800 mVpp
Patterns	PRBS 7/9/11/13/15/16/23/31/58 PRBS13Q, 31Q and SSPRQ Square wave & user pattern
TX Amplitude Adjustment	Steps of 2 mV
Pre- / Post-emphasis	6 dB
De-Emphasis Resolution	1000 steps
Equalizing Filter Spacing	1 UI
Random Jitter RMS	230 fs
Rise/ Fall Time (20–80%) <sup>1</sup>	10 ps
Coding	DFE Pre-coding and Gray coding supported
Return Loss up to 10GHz	< -18 dB
Return Loss (16-25GHz)	< -15 dB
Error Detector input range	50 mV– 800 mV diff.
TX/RX connectors	2.4 mm connectors (2.92 mm optional)
Reference clock Output	Rate dividers 8/16/32/128/170
Clock Input max	Up to 2.5 GHz
Clock Input Amplitude	750 mV single-ended
Input Impedance	50 Ω
Temperature range	0-75 °C
Power	110 V, 1.4 A or 220 V, 0.9 A – 50/60 Hz
Power (ATE version only)	12 V, 1.5 A

## Mechanical Dimensions

The ML4039EN is a benchtop instrument that fits in a 19-inch 2U rack. Two ML4039ENs arranged side by side take up one 2U slot in your rack. MultiLane also supplies the needed brackets.



## Ordering Information

Option	Description
<b>ML4039EN</b>	400G BERT (4 CH 56 GBd NRZ/PAM4)
<b>3YW</b>	Total 3-year warranty
<b>CAL</b>	Single calibration
<b>3YWC</b>	Total 3-year warranty with 3 annual calibrations
<b>FEC</b>	Real hardware FEC
<b>29</b>	2.92 mm connectors

## Recommended Accessories

Instruments	Recommended <i>Phase matched cable pairs</i>	Alternative <i>Phase matched cable sets</i>	Comments
<b>ML4039EN standard</b>	8x MLCBPM-2.4-30	2x MLCBPM-2.4-30-8	2.4 mm connector 2x8 channel 30 cm
<b>ML4039EN standard</b>	8x MLCBPM-2.4-60	2x MLCBPM-2.4-60-8	2.4 mm connector 2x8 channel 60 cm
<b>ML4039EN-29</b>	8x MLCBPM-2.92-30	2x MLCBPM-2.92-30-8	2.92 mm connector 2x8 channel 30 cm
<b>ML4039EN-29</b>	8x MLCBPM-2.92-60	2x MLCBPM-2.92-60-8	2.92 mm connector 2x8 channel 60 cm

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