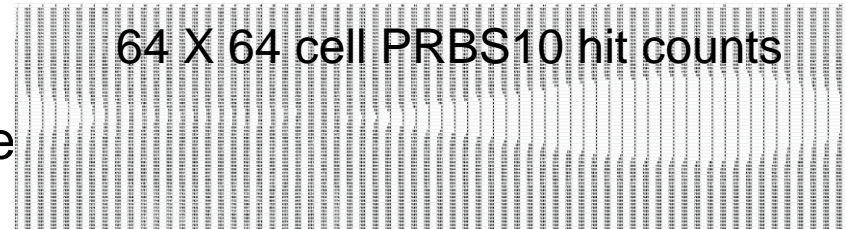
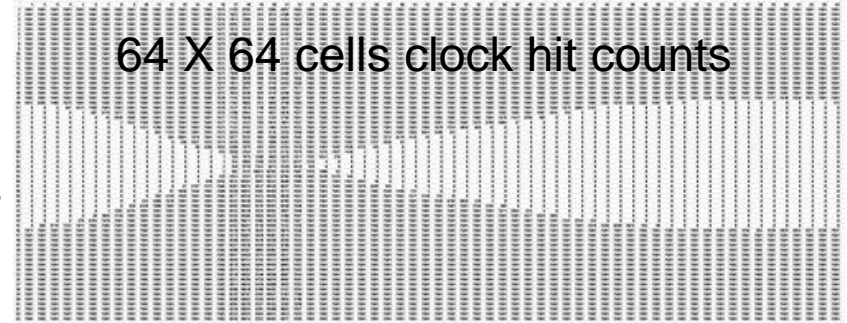


# How Does Eye Opening Monitor Work?

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**High Speed Signal Conditioning Products**  
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# Eye Opening Monitor (EOM) description

- The LMH12XX on-chip Eye Opening Monitor (EOM) is used to analyze and diagnose the post-equalized waveform which is sampled in the phase and voltage domain across one unit interval
- The phase and voltage range is divided into 64 steps each. This results in an eye capture of  $64 \times 64$  cells, with each cell specifying voltage and phase which indicates the number of hits relative to the main reference incoming eye diagram
- The number of hits registered at each point should be taken in context with the total number of bits observed at that voltage and phase offset to determine the corresponding probability for that point.



# Eye-opening numerical representation: HEO / VEO

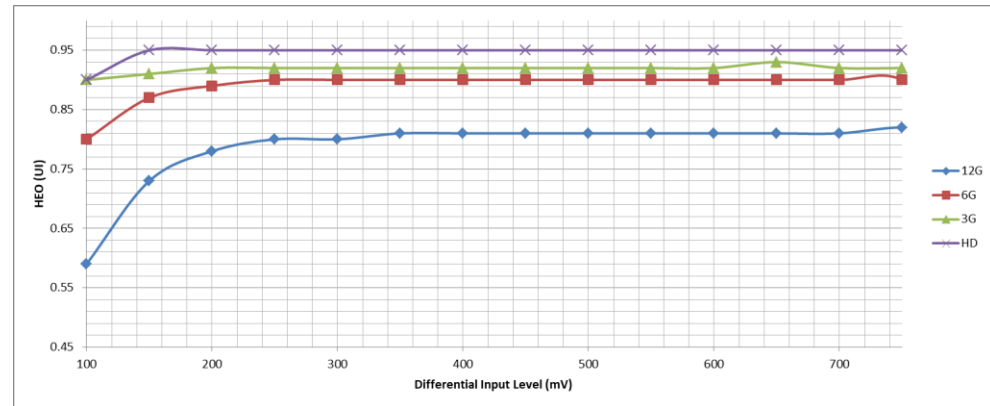
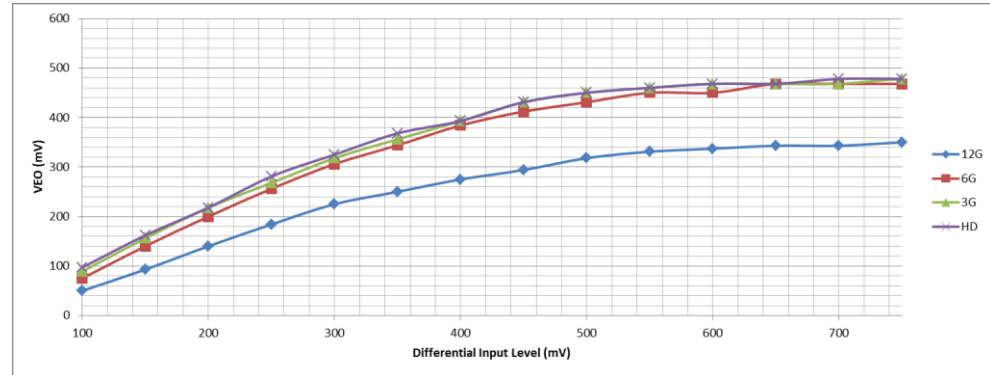
- **Horizontal Eye Opening (HEO):**
  - The value reported by LMH12xx should be converted to a decimal and then divided by 64.  
For example, If HEO is 0 x 20 or 32 decimal, therefore, we have  $32/64 = 0.5$  UI eye opening
- **Vertical Eye Opening (VEO):**
  - The value should be multiplied by 3.125 mV  
For example, if VEO is 0 x 40 or 64 d; therefore,  $64 \text{ d} * 3.125 = 200 \text{ mV VEO}$



**HEO / VEO parameters are a good indication of incoming signal eye quality**

# LMH1297 VEO vs. actual differential input level

- Key take away:
  - VEO is more linear at lower input voltage swing
  - VEO is a figure of merits
  - HEO/VEO is higher for lower rates
  - Jitter tolerance is 0.6 to 0.55UI:
    - Error Free operation: HEO>0.45

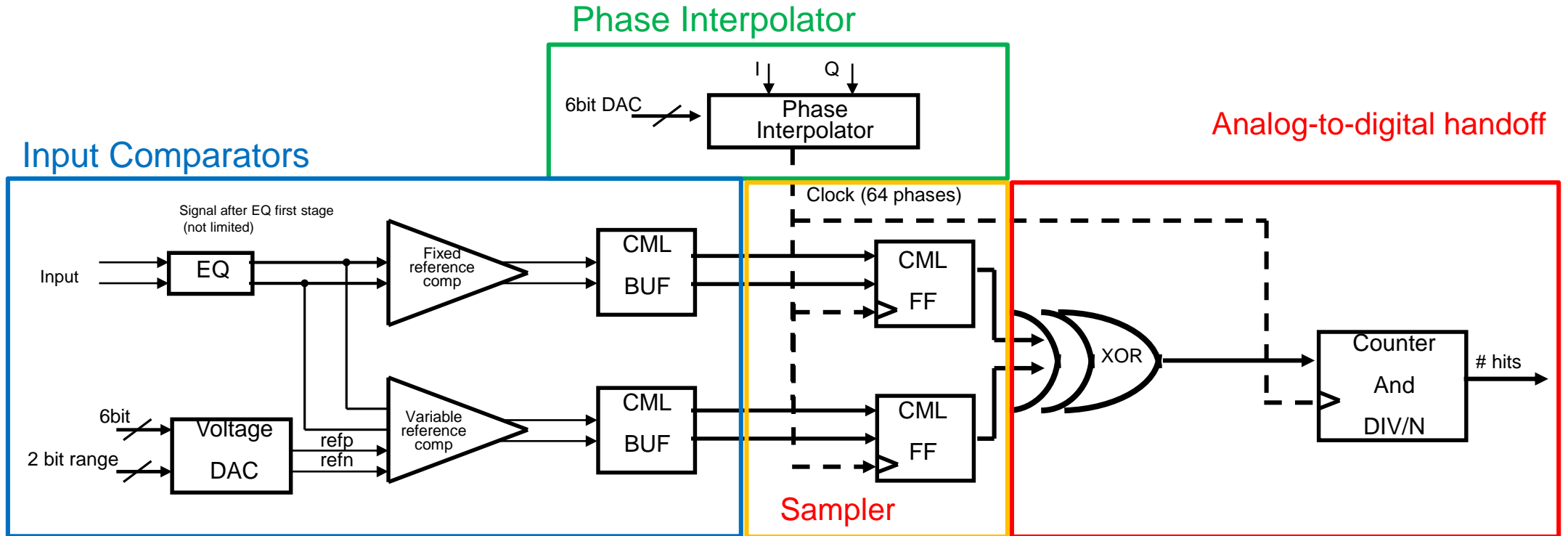


BERT -> LMH1297EVM IN0 Manual CTLE = 0x00

**Error free operation when VEO > 150 mV AND HEO > 0.45 UI**

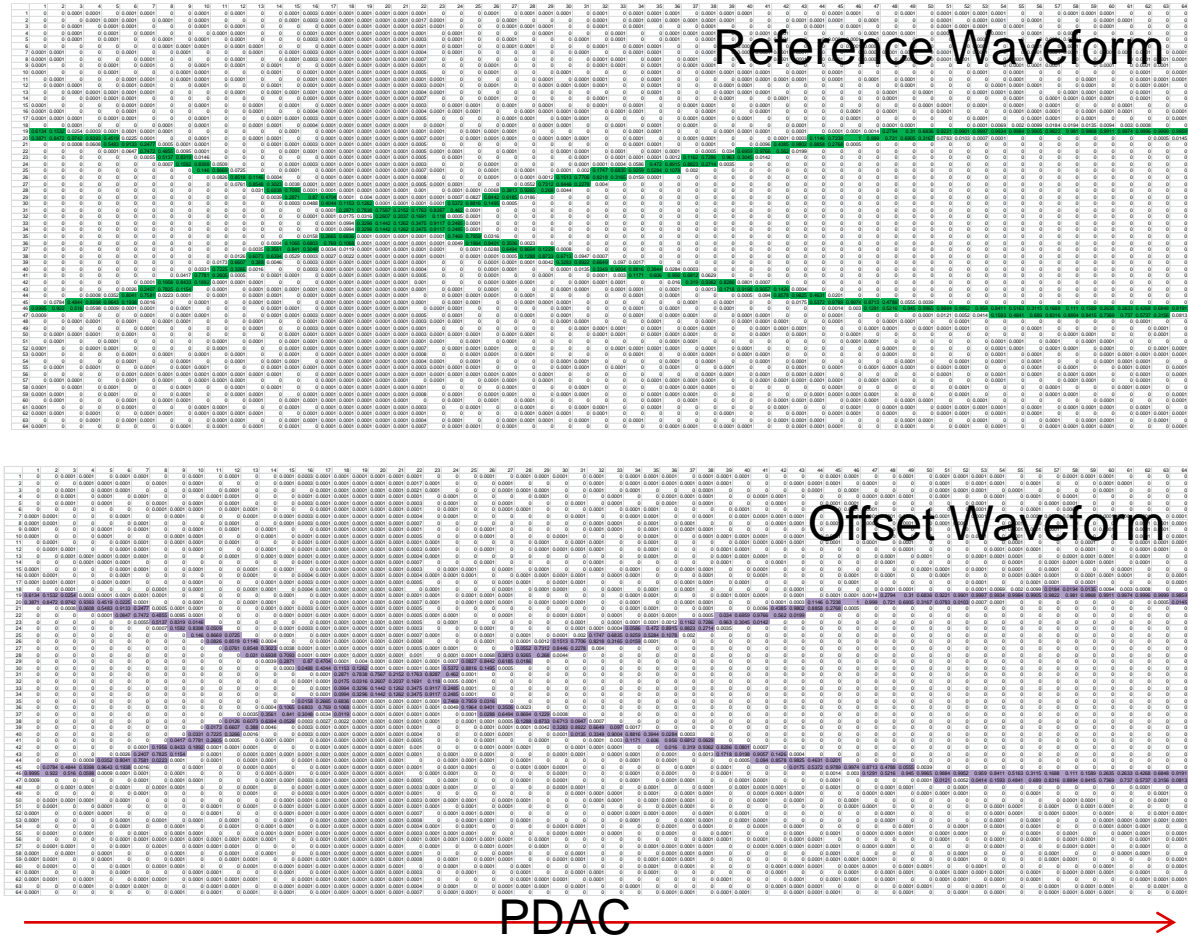
# Detailed Block Diagram

- DAC controlled offset for variable comparator (**VDAC**)
- Comparison with fixed comparator (offset = 0) determines voltage level
- Variable and fixed comparators are sampled and compared
- Sweeping phase of sampling point using Phase interpolator (**PDAC**) determines zero crossing
- XOR is sampled and divided down for handoff to digital
- N full-rate “hits” overflow output counter and send digital toggle



# How eye-opening capture works

- 1) Offset waveform PDAC is held constant while VDAC is swept from lowest to highest value
- 2) Next PDAC is increased by one step and again VDAC is swept across its range
- 3) This continues until 64 X 64 (or 4096) cells are recorded.
- 4) Number of hits where two waveforms are overlapped are counted as hits





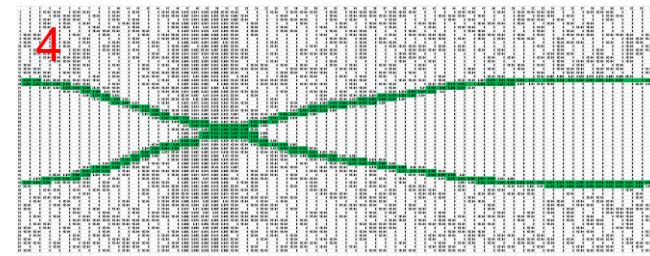
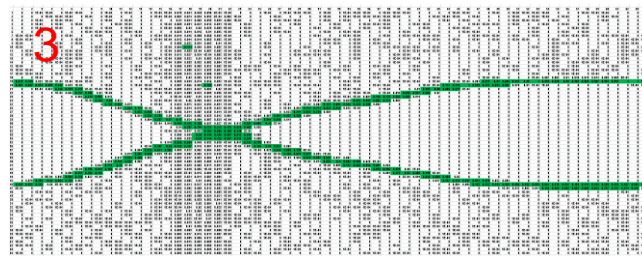
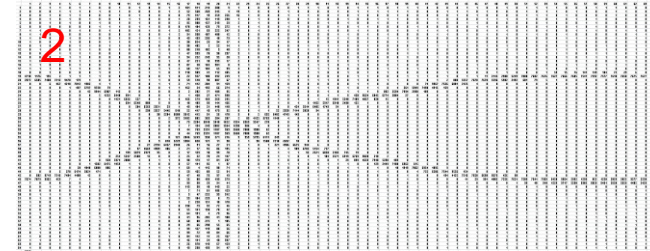
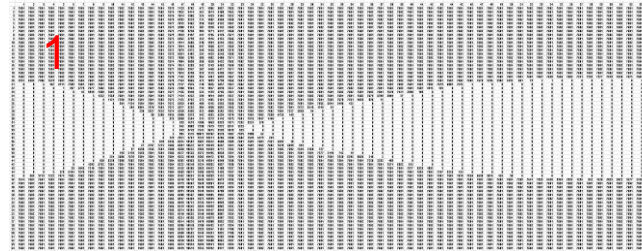
# Clock pattern fast eye data stream format

1	7681	7681	63	64
2	7681	7681	7681	7681
3	7681	7681	7681	7681
4	7681	7681	7681	7681
5	7681	7681	7681	7681
6	7681	7681	7681	7681
7	7681	7681	7681	7681
8	7682	7682	7681	7682
9	7681	7681	7682	7681
10	7682	7681	7681	7681
11	7681	7681	7681	7681
12	7681	7682	7682	7681
13	7681	7681	7681	7681
14	7681	7681	7681	7681
15	7681	7681	7681	7681
16	7682	7681	7681	7681
17	7681	7682	7681	7682
18	7682	7681	7681	7681
19	7682	7681	7681	7681
20	2972	6505	4	111
21	0	0	0	0
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	0	0	0
31	0	0	0	0
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0
45	0	602	0	45
46	7674	7681	5258	7057
47	7681	7681	7681	7681
48	7681	7681	7681	7681
49	7681	7681	7682	7681
50	7681	7682	7681	7681
51	7681	7681	7681	7681
52	7682	7681	7682	7682
53	7681	7681	7681	7681
54	7681	7681	7681	7681
55	7681	7682	7681	7682
56	7681	7682	7681	7681
57	7681	7681	7681	7681
58	7682	7681	7681	7681
59	7681	7682	7681	7682
60	7681	7681	7681	7681
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63	7681	7682	7681	7682
64	7682	7682	7681	7681

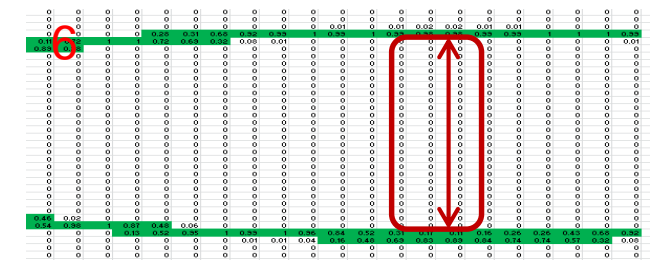
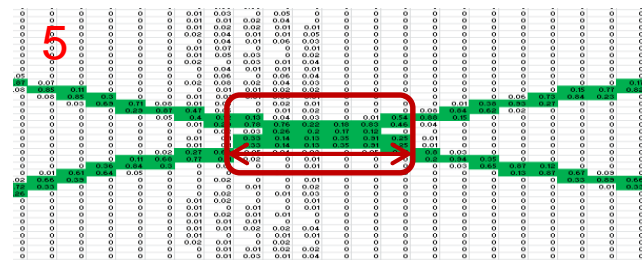
1. 64 X 64 Cells Hit Counts Streamed Raw Data:
  1. 1UI of data
  2. Based on device, it could be from eye crossing to eye crossing or within eye
2. 64 Cells of column on left is streamed out first – top to bottom – followed by second column – top to bottom – until we go through 64 columns
3. Maximum hit count is about 7681. If we don't get maximum hits:
  1. There is no eye crossing
  2. Or range register setting is too low

# 12G 1010.. Clock pattern fast EOM data

1. Raw 64 X 64 EOM raw data
2. Hit count subtracted from next vertical cell
3. Normalized by maximum hit count
4. Cleanup hits due to limited sampling rate
5. HEO Calculation:



1. Jitter = 6 columns =  $6/64 \sim 0.1$
2. HEO =  $1 - 0.1 = 0.9UI$



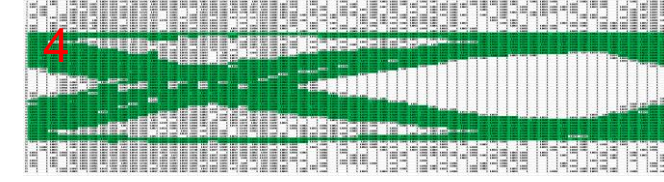
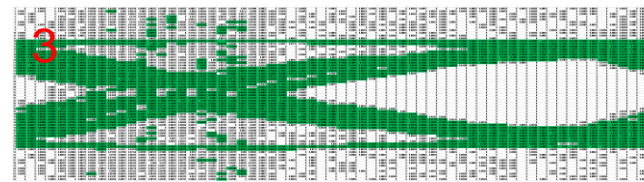
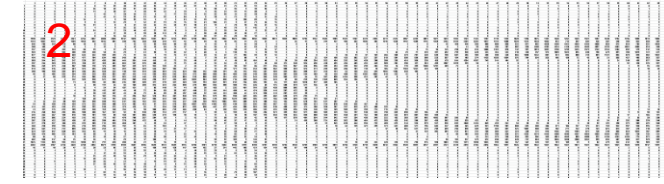
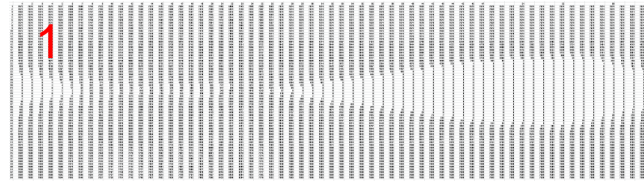
6. VEO Calculation:
  1. VEO = 28 Rows X 12.5mV = 350mV
  1. Vrange reg 0x11 = 12.5mV per step

Setup: BERT -> LMH1228EVM -> 3m B1694A -> LMH1219EVM

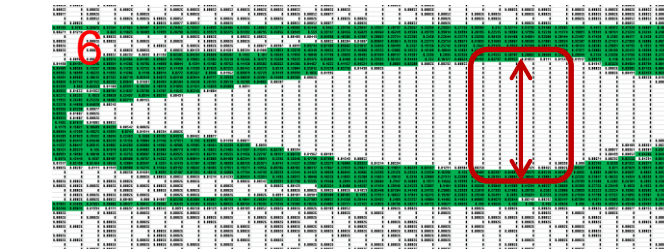
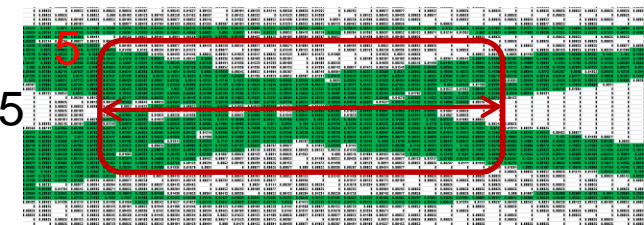


# 12G PRBS10 50m B1694A pattern fast EOM data

1. Raw 64 X 64 EOM raw data
2. Hit count subtracted from next cell
3. Normalized by maximum hit count
4. Processed hits - due to limited sampling rate



5. HEO Calculation:
  1. Jitter = 22 columns =  $22/64 = 0.0.35$
  2. HEO =  $1 - 0.35 = 0.65UI$



6. VEO Calculation:
  1. VEO = 25 Rows X 12.5mV = 312mV
  1. Vrange reg 0x11 = 12.5mV per step

Setup: BERT -> LMH1228EVM -> 50m B1694A -> LMH1219EVM

# Eye Diagram Hit Count Processing

- For visual observation, hit count can be normalized and scaled
- Reg 0x2A content indicates length of time to capture hit counts per cell
  - Hit count duration per cell =  $256 * \text{reg } 1218.0x2A(\text{decimal}) * (32 / \text{data rate})$
  - Example: 11.88Gbps, reg 0x2A = 0x30 = 48 Decimal
    - Hit counts duration per cell =  $256 * 48 * (32 / 11.88E9) = 33\mu\text{S}$
    - Total time to capture  $64 \times 64 = 4096$  cells =  $4096 * 33\mu\text{S} = 135\text{mS}$

# Summary

- On-chip Eye Opening Monitor (EOM) is used to analyze and diagnose the post-equalized waveform and this is used as a guideline for analyzing signal integrity during development or remote diagnostics
- EOM Capture can be used while user data is going through the device
- HEO/VEO can be optioned to cause interrupt when certain a threshold is reached
- Please refer to the programming guide for detailed HEO / VEO and Eye Opening Monitor detailed register settings



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