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NVM Express® Technical Proposal for New Feature

Technical Proposal ID	TP 4119 Rx Phy Eye Opening Measurement (EOM)
Change Date	2022-09-07
Builds on Specification	NVM Express NVMe over PCIe Transport Specification 1.0b NVM Express Base Specification 2.0b NVM Express Management Interface Specification 1.2b
References Specification	

Technical Proposal Author(s)

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Gerry Houlder, Jim Hatfield	Seagate
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Curtis Ballard	HPE

This proposal intends to:

For the NVM Express Base Specification 2.0b

This proposal defines methods to:

- a) Start the measurement process in a transport-agnostic, and implementation-agnostic manner; and
- b) Report the measurement result in a transport-agnostic, and implementation-agnostic manner.

For the NVM Express NVMe over PCIe Transport Specification 1.0b

This proposal defines methods to:

- a) Pass selection parameters to start the measurement process in a transport-specific, but implementation-agnostic manner; and
- b) Return measurement results in an PCIe-specific, but implementation-agnostic manner.

For the NVM Express Management Interface Specification 1.2b

This proposal adds a new log to the list of supported logs.

Revision History

Revision Date	Change Description
2021.08.12	Initial phase 2 revision
2021.08.19	Comments from 2021.08.19 meeting
2021.08.26	Comments from 2021.08.26 meeting
2021.11.05	Resynched to NVMe 2.0a, PCIe transport 1.0a Got rid of 'primary/secondary' controller verbiage Expanded header and added time estimates for good/better/best Added generation number
2021.11.19	Responded to comments from Mike Allison, Austin Bolen, and the Technical WG meeting of Nov. 18, 2021 <ul style="list-style-type: none"> - Removed the 'Port' field - Replaced Action='establish context' with 'start measurement' - Replaced Action='release context' with 'abort measurement and clear log' - Added to the header: in process indicator, header length, specified for all fields what value is returned if no measurement has been done
2022.01.11	Changed copyright date from 2021 to 2022
2022.01.31	<ol style="list-style-type: none"> 1. Addressed editorial comments from Mike Allison 2. addressed what to do if any lanes failed to be measured 3. addressed what to do if the measurement process is interrupted by I/O 4. updated base references to 'b' revisions 5. marked headings for the search window.
2022.02.03	<ol style="list-style-type: none"> 1. Accepted all changes and removed resolved comments 2. EOM header: inserted a current link speed field, a reserved field, and shifted fields that followed to larger offsets 3. the EOM Lane Descriptor: added Status field (success/fail)
2022.02.09	<ol style="list-style-type: none"> 1. Resolved many editorial and technical comments from Austin Bolen (making it very clean for Phase 3) 2. Added Figures 198, NewZ
2022.02.10	<ol style="list-style-type: none"> 1. changed 'in process' to 'in progress' 2. Revised the text about 'quiescing' in 3.new.B.x 3. Swapped the columns in figure NewZ 4. Named the PCIe register containing the Current Link Speed
2022.03.02	<ol style="list-style-type: none"> 1. Addressed editorial (phase 3 type) comments from Mike Allison 2. Addressed technical comments from Mike Allison adding clarification to multiple fields in the log page. 3. Synched to 'b' versions of the affected specs 4. Addressed the scope as all physical controllers associated with the same PCIe port.
2022.03.10	<ol style="list-style-type: none"> 1. Removed most of the changes to the base spec, per new style guidelines for command specific logs (Mike Allison) 2. Changed the wording about 'physical controller' to say 'controller... that supports this log' 3. Numerous editorial corrections suggested by Austin Bolen 4. Corrected math errors in the offset column of Figure www, including removing the need for the VSOFF field. 5. Removed the Version field in the EOM Lane descriptor. Having one version for the log is sufficient.
2022.03.24	<ol style="list-style-type: none"> 1. Entered phase 3 2. Renamed Header Length (HLEN) -> Header Size (HSIZE) Log Version -> Log Revision 3. Changed the polarity of the Measurement Successful bit 4. Removed the Measurement In Process bit in the EOM descriptor, and changed the dependencies of fields there to use the EOMIP field instead. 5. Reworded the VSLEN field description to not say 'supported', but instead to just say it is the number of bytes. 6. Adjusted the scope of the log page in 3.new.B.x, per a suggestion from Austin Bolen. 7. Resolved all previous comments.
2022.03.25	<ol style="list-style-type: none"> 1. Resolved editorial comments from Austin Bolen
2022.07.25	<ol style="list-style-type: none"> 1. Integrated
2022.08.10	<ol style="list-style-type: none"> 1. Resolved editorial comments from Mike Allison, Jim Hatfield, and Austin Bolen.
2022.08.26	<ol style="list-style-type: none"> 1. Modified Base spec Figure 202

2022.08.27	1. Added notes in Figure ttt for the “Maximum Top Bottom” and “Maximum Left Right” EOM Header fields to say “The value reported is the maximum value from the center point to the outside of the eye diagram. This is not a measured value.”
2022.08.29	1. Added changes to Base spec figures 24, 29, and 33 2. Added Gerry Houlder as a co-author from Seagate 3. Figure 202: changed reference from specifically the PCIe transport, to ‘the appropriate transport specification’
2022.09.07	1. Integrated changes from 2022.08.26, 2022.08.27, and 2022.08.29
2022.09.07	Corrected figure numbering and references.

Description for NVM Express Base Specification 2.0b Changes Document

Feature Enhancement

- Added log page 19h to the Get Log Page command allowing a host to request that a controller perform a receiver eye measurement process in a transport-agnostic, and implementation-agnostic manner; and provide a way for the host to read the measurement results in a transport-agnostic, and implementation-agnostic manner.

Description for NVM Express NVMe over PCIe Transport Specification 1.0b Changes Document

Feature Enhancement

- Added log page 19h with PCIe transport-specific content, allowing a host to pass selection parameters to start the measurement process in a transport-specific, but implementation-agnostic manner, and to return measurement results in an PCIe-specific, but implementation-agnostic manner.

Description for NVM Express Management Interface Specification 1.2b Changes Document

Feature Enhancement

- Added log page 19h to the list of supported logs.

Markup Conventions:

- Black: Unchanged (however, hot links are removed)
- ~~Red Strikethrough~~: Deleted
- Blue: New
- Blue Highlighted: TBD values, anchors, and links to be inserted in new text.
- <Green Bracketed>: Notes to editor

...

<Modify portions of NVM Express Base Specification 2.0a as shown below>

<add a log to the list of logs supported for I/O controllers>

3.1.2.1.2 Log Page Support

Figure 24 defines log pages that are mandatory, optional, and prohibited for an I/O controller. I/O Command Set specific log page support requirements are described within individual I/O Command Set specifications.

Figure 24: I/O Controller – Log Page Support

Log Page Name	Log Page Support Requirements ¹
...	
Physical Interface Receiver Eye Opening Measurement	O ⁴
...	
Notes: 1. O/M/P definition: O = Optional, M = Mandatory, P = Prohibited 2. Mandatory for controllers that support Fixed Capacity Management (refer to section 8.3.2). 3. Optional for NVM Express revision 1.4 and earlier. 4. If this log page is not described for a specific physical interface (refer to the applicable NVM Express transport specification), then this log page is prohibited for that transport.	

<add a log to the list of logs supported for Administrative controllers>

3.1.2.2.2 Log Page Support

Figure 29 defines log pages that are mandatory, optional, and prohibited for an Administrative controller.

Figure 29: Administrative Controller – Log Page Support

Log Page Name	Command Support Requirements ¹
...	
Physical Interface Receiver Eye Opening Measurement	O ⁵
...	
Notes: 1. O/M/P definition: O = Optional, M = Mandatory, P = Prohibited 2. Optional if Set Features command is not supported (refer to Figure 28). 3. Optional if NVMe-MI Send command and NVMe-MI Receive command is not supported (refer to Figure 28). 4. Optional for NVM Express revision 1.4 and earlier. 5. If this log page is not described for a specific physical interface (refer to the applicable NVM Express transport specification), then this log page is prohibited for that transport.	

<add a log to the list of logs supported for Discovery controllers>

3.1.2.3.3 Log Page Support

The Discovery controller shall support the Discovery Log Page. The log pages that a Discovery controller may support are shown in Figure 33.

Figure 33: Discovery Controller – Log Page Support

Log Page Name	Command Support Requirements ¹
...	
Physical Interface Receiver Eye Opening Measurement	P
...	
Notes 1. O/M/P definition: O = Optional, M = Mandatory, P = Prohibited 2. Optional if Set Features command is not supported (refer to Figure 32). 3. Optional if NVMe-MI Send command and NVMe-MI Receive command is not supported (refer to refer to Figure 32). 4. Optional for versions 1.1 and earlier of the NVMe over Fabrics specification.	

5.16 Get Log Page command

...

<add a new log page to the list of log pages in figure 202>

Figure 202: Get Log Page – Log Page Identifiers

Log Identifier	Scope	Log Page Name	Reference Section
...			
19h	Refer to the appropriate NVM Express transport specification		
...			
KEY: Namespace = The log page contains information about a specific namespace. Endurance Group = The log page contains information about a specific Endurance Group. Controller = The log page contains information about the controller that is processing the command. Domain = The log page contains information about the Domain. NVM subsystem = The log page contains information about the NVM subsystem. Vendor Specific = The log page contains information that is vendor specific.			
NOTES: 1. For namespace identifiers of 0h or FFFFFFFFh. 2. For namespace identifiers other than 0h or FFFFFFFFh. 3. Bit 0 is cleared to '0' in the DSTO field in the Identify Controller data structure (refer to Figure 275). 4. Bit 0 is set to '1' in the DSTO field in the Identify Controller data structure.			

...

<Modify portions of NVM Express NVMe over PCIe Transport Specification 1.0b as shown below>

<add a transport-specific log page, and a new Admin commands section>

3.new Admin Commands

3.new.B Get Log Page command

3.new.B.x Physical Interface Receiver Eye Opening Measurement (Log Identifier 19h)

The Physical Interface (Phy) Receiver (Rx) Eye Opening Measurement (EOM) log page contains information about the Phy receiver eye opening measurement for the Phy associated with this controller. The EOM is a general indication of how well the controller receiver is seeing or receiving the signal. The EOM is a set of data indicating the dimensions of the measured eye pattern or eye diagram.

This log page shall not be supported for secondary controllers.

The scope of the log page is a PCIe port. If this log page is supported, then all non-secondary controllers (i.e., non-SR-IOV controllers and SR-IOV primary controllers) associated with the same PCIe port shall report the same log page information.

If a lane measurement cannot be made (e.g., transport errors), then the measurement for that lane shall indicate that an error occurred (refer to **Figure www**).

Note: Reading this log page while other commands are being processed by the controller may affect the results obtained. The host should quiesce other activity on the port while the measurement is being taken (e.g., not sending I/O commands and setting KATO to a value significantly longer than the estimated time).

The Action field in the Log Specific Parameter field (refer to **Figure NEWa**) specifies whether:

- a) the controller returns the current contents of the log page;
- b) the controller starts the measurement process and returns log page data; or
- c) the controller aborts any EOM measurement in progress and initializes the log page header.

The controller shall initialize the Physical Interface Receiver Eye Opening Measurement log page data if the controller processes:

- a) a Get Log Page command requesting Physical Interface Receiver Eye Opening Measurement log page with the Action field (refer to **Figure NEWa**) set to:
 - a. 01b (i.e., Start Measurement and Read Log Page Data); or
 - b. 10b (i.e., Abort Measurement and Clear Log);

or

- b) a Controller Level Reset.

Figure NewZ specifies the size of the log page.

Figure NewZ - Size of Physical Interface Receiver Eye Opening Measurement Log Page

Value of EOMIP	Size of Log Page (bytes)
0h	HSIZE
1h	HSIZE
2h	HSIZE + (DS * ND)
Note: The EOMIP field, the HSIZE field, the DS field, and the ND field are defined in Figure ttt .	

Figure NEWa - Command Dword 10 - Log Specific Parameter Field

Bits	Description				
14:12	Reserved				
11:10	<p>Action: This field specifies the action that the controller shall take during processing this Get Log Page command.</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Definition</th> </tr> </thead> <tbody> <tr> <td>00b</td> <td>Read Log Data: Return Physical Interface Receiver Eye Opening Measurement log page data starting at the address indicated by the LPOU field and the LPOL field in the Get Log Page command.</td> </tr> </tbody> </table>	Value	Definition	00b	Read Log Data: Return Physical Interface Receiver Eye Opening Measurement log page data starting at the address indicated by the LPOU field and the LPOL field in the Get Log Page command.
Value	Definition				
00b	Read Log Data: Return Physical Interface Receiver Eye Opening Measurement log page data starting at the address indicated by the LPOU field and the LPOL field in the Get Log Page command.				

Figure NEWa - Command Dword 10 - Log Specific Parameter Field

Bits	Description										
01b	<p>Start Measurement and Read Log Data: The controller shall:</p> <ol style="list-style-type: none"> begin to perform the eye opening measurements on all lanes of the PCIe port associated with the specified Target Controller (refer to Figure NewB); and return the new Physical Interface Receiver Eye Opening Measurement log page data starting at the offset indicated by the LPOU field and the LPOL field in the Get Log Page command. <p>If an EOM measurement is in progress, then the previous measurement shall be terminated and a new measurement shall be started.</p>										
10b	<p>Abort Measurement and Clear Log: The controller shall abort any EOM measurement in progress and shall initialize the log header to indicate that no measurement is reported. It is not an error if the controller does not have an EOM measurement in progress.</p>										
11b	Reserved										
09:08	<p>Measurement Quality: If the Action field is set to 01b, then this field specifies the relative quality of the measurement and the relative degree of effort to that the host requests to spend on performing the measurements. The measurement qualities are relative and vendor specific, but: Good quality <= Better quality <= Best quality</p> <p>If the Action field is not set to 01b, then this field shall be ignored by the controller.</p> <p>Note: Higher quality measurements may require more time to complete the measurement than lower quality measurements.</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Definition</th> </tr> </thead> <tbody> <tr> <td>00b</td> <td>Good quality</td> </tr> <tr> <td>01b</td> <td>Better quality</td> </tr> <tr> <td>10b</td> <td>Best quality</td> </tr> <tr> <td>11b</td> <td>Reserved</td> </tr> </tbody> </table>	Value	Definition	00b	Good quality	01b	Better quality	10b	Best quality	11b	Reserved
Value	Definition										
00b	Good quality										
01b	Better quality										
10b	Best quality										
11b	Reserved										

Figure NEWb - Command Dword 11 - Log Specific Identifier Field

Bits	Description
15:00	<p>Target Controller: Specifies the Controller ID of the controller associated with the PCIe port to be measured.</p>

The log page returned is described in Figure yyy. The EOM Lane Descriptors described in Figure yyy shall be sorted in order of:

- increasing lane number; and
- then increasing eye number.

Figure yyy: Physical Interface Receiver Eye Opening Measurement Log Page

Bytes	Description
63:00	EOM header (refer to Figure tt)
DS+63:64	EOM Lane Descriptor 0 (refer to Figure www)
...	...
(DS * ND) + 63:(DS * (ND-1)) + 64	EOM Lane Descriptor ND-1
<p>Note: DS is the value of the Descriptor Size field in Figure tt. ND is the value of the Number of Descriptors field in Figure tt.</p>	

Figure ttt describes the EOM header data.

Figure ttt: EOM Header

Bytes	Description										
0	Log Identifier: This field shall be set to 19h.										
1	<p>EOM In Progress (EOMIP): This field indicates whether a measurement is in progress.</p> <table border="1"> <thead> <tr> <th>Value</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>0h</td> <td>No measurement has been started since this log page was initialized.</td> </tr> <tr> <td>1h</td> <td>A measurement is in progress.</td> </tr> <tr> <td>2h</td> <td>A measurement has completed since this log page was initialized.</td> </tr> <tr> <td>3h to FFh</td> <td>Reserved</td> </tr> </tbody> </table>	Value	Description	0h	No measurement has been started since this log page was initialized.	1h	A measurement is in progress.	2h	A measurement has completed since this log page was initialized.	3h to FFh	Reserved
Value	Description										
0h	No measurement has been started since this log page was initialized.										
1h	A measurement is in progress.										
2h	A measurement has completed since this log page was initialized.										
3h to FFh	Reserved										
3:2	Header Size (HSIZE): This field indicates the number of bytes in the EOM Header data structure and shall be set to 64.										
7:4	Result Size: This field indicates the number of bytes in this log page. Refer to Figure NewZ.										
8	EOM Data Generation Number: This field is incremented each time the Physical Interface Receiver Eye Opening Measurement log page is read with the Action field (refer to Figure NEWa) set to Start Measurement and Read Log Data (i.e., 01b). If the value of this field is set to FFh, then the field shall be cleared to 0h when incremented (i.e., rolls over to 0h).										
9	Log Revision: This field indicates the version of this log page. This field shall be set to 01h.										
10	<p>Optional Data Present: This field indicates which optional fields are present in the log page.</p> <table border="1"> <thead> <tr> <th>Bits</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>7:2</td> <td>Reserved</td> </tr> <tr> <td>1</td> <td>If set to '1', then the Vendor Specific field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Vendor Specific field is not present.</td> </tr> <tr> <td>0</td> <td>If set to '1', then the Printable Eye field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Printable Eye field is not present.</td> </tr> </tbody> </table>	Bits	Description	7:2	Reserved	1	If set to '1', then the Vendor Specific field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Vendor Specific field is not present.	0	If set to '1', then the Printable Eye field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Printable Eye field is not present.		
Bits	Description										
7:2	Reserved										
1	If set to '1', then the Vendor Specific field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Vendor Specific field is not present.										
0	If set to '1', then the Printable Eye field in the EOM Lane Descriptor data structure is present. If cleared to '0', then the Printable Eye field is not present.										
11	Lanes: This field indicates the number of lanes configured for this port.										
12	Eyes Per Lane: This field indicates the number of EOM Lane Descriptor data structures to be returned per lane.										
13	<p>Log Specific Parameter Field Copy: This field contains additional log specific information.</p> <table border="1"> <thead> <tr> <th>Bits</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>Reserved</td> </tr> <tr> <td>6:0</td> <td>This field contains the value of the Log Specific Parameter field in CDW10 (refer to Figure NewA) for the Get Log Page command that started the measurement (i.e., the Action field was set to 10b). If no measurement has been started since the log page was initialized, then this field shall be cleared to 0h.</td> </tr> </tbody> </table>	Bits	Description	7	Reserved	6:0	This field contains the value of the Log Specific Parameter field in CDW10 (refer to Figure NewA) for the Get Log Page command that started the measurement (i.e., the Action field was set to 10b). If no measurement has been started since the log page was initialized, then this field shall be cleared to 0h.				
Bits	Description										
7	Reserved										
6:0	This field contains the value of the Log Specific Parameter field in CDW10 (refer to Figure NewA) for the Get Log Page command that started the measurement (i.e., the Action field was set to 10b). If no measurement has been started since the log page was initialized, then this field shall be cleared to 0h.										
14	<p>Link Information: This field contains information about the PCIe link.</p> <table border="1"> <thead> <tr> <th>Bits</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>7:4</td> <td>Reserved</td> </tr> <tr> <td>3:0</td> <td>These bits contain the value of the Current Link Speed field in the PMLS register (refer to Figure 55) at the time the measurement was started.</td> </tr> </tbody> </table>	Bits	Description	7:4	Reserved	3:0	These bits contain the value of the Current Link Speed field in the PMLS register (refer to Figure 55) at the time the measurement was started.				
Bits	Description										
7:4	Reserved										
3:0	These bits contain the value of the Current Link Speed field in the PMLS register (refer to Figure 55) at the time the measurement was started.										
17:15	Reserved										
19:18	Log Specific Identifier Copy: This field contains the value of the Log Specific Identifier field in CDW11 for the Get Log Page command that started the measurement (i.e., the Action field was set to 10b). If no measurement has been started since the log page was initialized, then this field shall be 0h.										
23:20	Descriptor Size (DS): This field indicates the number of bytes in each EOM Lane Descriptor (refer to Figure www).										

Figure ttt: EOM Header

Bytes	Description
25:24	Number of Descriptors (ND): This field indicates the number of EOM Lane Descriptors returned (refer to Figure www). There are no EOM Lane Descriptors returned for lanes that are not implemented or are not active. If no EOM measurement has been taken (i.e., the EOMIP field is cleared to 0h), this field shall be cleared to 0h.
27:26	Maximum Top Bottom (MAXTB): This field indicates the maximum value for the Top and Bottom fields in the EOM Lane Descriptor. If no EOM measurement has been taken (i.e., the EOMIP field is cleared to 0h), this field shall be cleared to 0h. The value reported is the maximum value from the center point to the outside of the eye diagram. This is not a measured value.
29:28	Maximum Left Right (MAXLR): This field indicates the maximum value for the Left and Right fields in the EOM Lane Descriptor. If no EOM measurement has been taken (i.e., the EOMIP field is cleared to 0h), this field shall be cleared to 0h. The value reported is the maximum value from the center point to the outside of the eye diagram. This is not a measured value.
31:30	Estimated Time for Good Quality (ETGOOD): This field indicates the estimated time in seconds to complete the measurement if the Measurement Quality field (refer to Figure NewA) specifies Good quality (i.e., 00b). A value of 0h indicates less than one second.
33:32	Estimated Time for Better Quality (ETBETTER): This field indicates the estimated time in seconds to complete the measurement if the Measurement Quality field specifies Better quality (i.e., 01b). A value of 0h indicates less than one second.
35:34	Estimated Time for Best Quality (ETBEST): This field indicates the estimated time in seconds to complete the measurement if the Measurement Quality field specifies Best quality (i.e., 10b). A value of 0h indicates less than one second.
63:36	Reserved

[Figure www](#) describes the EOM Lane Descriptor that is returned for each lane measured. The length is reported in the Descriptor Size field (refer to [Figure ttt](#)).

Figure www: EOM Lane Descriptor

Bytes	Description						
0	Reserved						
1	Measurement Status: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bits</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>7:1</td> <td>Reserved</td> </tr> <tr> <td>0</td> <td>Measurement Successful: If the measurement was successful, then this bit shall be set to '1'. If the measurement failed, then this bit shall be cleared to '0'.</td> </tr> </tbody> </table>	Bits	Description	7:1	Reserved	0	Measurement Successful: If the measurement was successful, then this bit shall be set to '1'. If the measurement failed, then this bit shall be cleared to '0'.
	Bits	Description					
7:1	Reserved						
0	Measurement Successful: If the measurement was successful, then this bit shall be set to '1'. If the measurement failed, then this bit shall be cleared to '0'.						
2	Lane: This field indicates the lane number associated with this measurement for this port.						
3	Eye: This field indicates the eye number associated with this measurement for this lane.						
5:4	Top: If the EOMIP field is set to 2h, then this field indicates the absolute value of the number of rows from the center of the eye to the top edge of the eye. This field shall be less than or equal to MAXTB. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h.						
7:6	Bottom: If the EOMIP field is set to 2h, then this field indicates the absolute value of the number of rows from the center of the eye to the bottom edge of the eye. This field shall be less than or equal to MAXTB. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h.						
9:8	Left: If the EOMIP field is set to 2h, then this field indicates the absolute value of the number of columns from the center of the eye to the left edge of the eye. This field shall be less than or equal to MAXLR. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h.						
11:10	Right: If the EOMIP field is set to 2h, then this field indicates the absolute value of the number of columns from the center of the eye to the right edge of the eye. This field shall be less than or equal to MAXLR. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h.						

Figure www: EOM Lane Descriptor

Bytes	Description										
13:12	Number of Rows (NROWS): If the EOMIP field is set to 2h, then this field indicates the number of rows in the Printable Eye field, if present. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h or the Printable Eye field is not present, then this field shall be cleared to 0h.										
15:14	Number of Columns (NCOLS): If the EOMIP field is set to 2h, then this field indicates the number of columns in the Printable Eye field, if present. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h or the Printable Eye field is not present, then this field shall be cleared to 0h.										
17:16	Vendor Specific Length (VSLEN): This field indicates the number of bytes present in the Vendor Specific field. If the EOMIP field is not set to 2h, then this field shall be cleared to 0h or the Vendor Specific field is not supported, then this field shall be cleared to 0h.										
31:18	Reserved										
End of EOM Lane Descriptor Header											
(NROWS*NCOLS+32)-1:32	<p>Printable Eye: This optional field is a series of rows of printable ASCII characters representing the vertical and horizontal position of the eye boundary.</p> <p>If the EOMIP field is not set to 2h, then this field is not present.</p> <p>If NROWS is cleared to 0h and NCOLS is cleared to 0h, then:</p> <ol style="list-style-type: none"> the Printable Eye field is not present; and the Vendor Specific field, if any, immediately follows the EOM Lane Descriptor Header. <p>The ASCII character of each byte in this field shall be:</p> <ol style="list-style-type: none"> "1" (i.e., 31h) if the position is outside of the eye; and "0" (i.e., 30h) if the position is on or inside the eye. <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Bytes</th> <th style="text-align: left;">Row</th> </tr> </thead> <tbody> <tr> <td>((Row+1)*NCOLS)-1:0</td> <td>0</td> </tr> <tr> <td>((Row+1)*NCOLS)-1:Row*NCOLS</td> <td>1</td> </tr> <tr> <td style="text-align: center;">...</td> <td style="text-align: center;">...</td> </tr> <tr> <td>((Row+1)*NCOLS)-1:Row*NCOLS</td> <td>NROWS-1</td> </tr> </tbody> </table>	Bytes	Row	((Row+1)*NCOLS)-1:0	0	((Row+1)*NCOLS)-1:Row*NCOLS	1	((Row+1)*NCOLS)-1:Row*NCOLS	NROWS-1
Bytes	Row										
((Row+1)*NCOLS)-1:0	0										
((Row+1)*NCOLS)-1:Row*NCOLS	1										
...	...										
((Row+1)*NCOLS)-1:Row*NCOLS	NROWS-1										
(NROWS*NCOLS+32)+VSLEN-1:(NROWS*NCOLS+32)	Vendor Specific: This optional field may contain vendor specific data related to this measurement. If VSLEN is cleared to 0h, then this field is not present.										
(DS-1):(NROWS*NCOLS+32)+VSLEN	Padding: The controller shall pad with all bytes cleared to 0h to a Dword boundary, where DS is the data structure size described in Figure yyy . If the data structure is already Dword aligned, then this field is not present.										

Figure zzz shows an example of a printable eye diagram with:

- Number of Rows = 32;
- Number of Columns = 22;
- MAXTB = 16;
- MAXLR = 11;
- Top = 14;
- Bottom = 16;
- Left = 11; and
- Right = 9.

Note: Coloring has been added for emphasis in this example but is not part of the log data.

Figure zzz - Example of printable eye diagram

Row / Col	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
7	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
8	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
9	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
10	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
11	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
12	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
26	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
27	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
28	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

...

<Modify portions of NVM Express Management Interface Specification 1.2b as shown below>

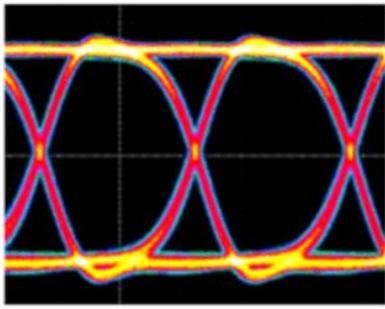
6.3 Get Log Page

<add a log to figure 122>

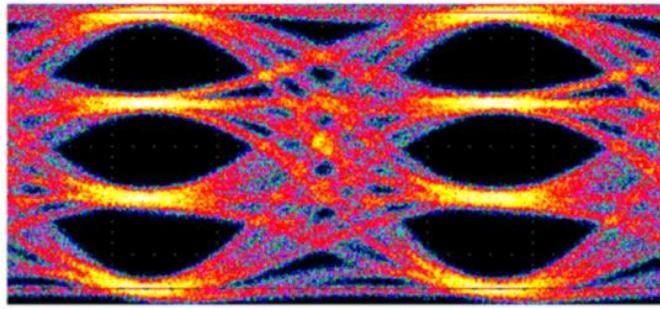
Figure 122: Management Endpoint – Log Page Support

<u>Log Page Name</u> ³	<u>Log Identifier</u>	<u>Requirements</u> ¹	
		<u>NVMe Storage Device</u>	<u>NVMe Enclosure</u>
...			
Physical Interface Receiver Eye Opening Measurement	19h	○	○
...			

<these diagrams are not part of the proposal, but are here for discussion and background>



NRZ



PAM4