TRANSMITTER CONTROL FOR MODULE OUTPUT IN THE AUI-C2M INTERFACES

(COMMENT #60)

Adee Ran, Intel

Comment

Cl **120G** *SC* **120G.3.2** *P* **224** *L* **37** # 60

Ran, Adee Intel

Comment Type **T** *Comment Status* **D**

Signal swing and Tx equalization are important in PAM4 since the receiver has a limited linear range. A large swing at the host input may prevent linear operation and detection of PAM4. Attenuation has been used in past Rx designs, but it is becoming harder to implement with the large bandwidth requirements for 100G.

The current module output specifications have limited information about output swing and ISI (only implicitly through far-end eye height and far-end precursor ISI ratio, which are defined with a single channel), and do not mention any control of the Tx setting. With the large range of C2M host channels, it is unlikely that a fixed Tx setting will be usable for all hosts.

Actual modules even in 50G have some control of equalization and swing. There are indications that this control is required for actual operation.

If we ignore this capability in the specifications, some hosts may not be able to operate with the settings used for module output compliance; this means the module compliance specs are useless and measuring them is a waste of time.

The standard should at least mention the module's Tx control capabilities (with reference to external documents) and preferably define requirements for them, with management variables and control registers. It will be beneficial if the Tx specifications include these capabilities.

SuggestedRemedy

A presentation is planned with further details.

Why?

- PAM4 detection requires good linearity and equalization.
- CR links have high loss and require strong equalization, including in the Tx (pre-emphasis), which creates low swing Rx input
- C2M links have medium to low loss.
- The module does not know what host channel it is plugged into. Without a way to control its output, it will be fixed for some setting (maybe optimizing “far-end” characteristics with the reference Rx).
- Practical host Rx implementations may be different from the reference Rx and may prefer different Tx characteristics.

Detailed Example: dual-purpose CR/C2M host

- A CR link over a 2 m cable may have ~240 mV diff PtP at the Rx output.
  - Assuming 800 mV launch, 10.5 dB pre-emphasis (Tx coefficients [-0.05, 0.1, -0.3, 0.55, 0])
  - More equalization and amplification are likely required in the Rx.
- Modules may be configured to support longest host channels using the maximum output swing allowed (900 mV PtP per Table 120G–4) perhaps with some pre-emphasis.
- If the same module is plugged into a host with minimum loss, the full 900 mV PtP will be seen at the host Rx input, and the signal will be over-equalized.
- With such high swing the signal may exceed the linear region of the Rx.
  - Designing for large dynamic range, tunable gain, *and* high bandwidth is not easy.
  - Dual-purpose host ports may cost more (e.g. power).
- The host Rx may function much better if it is allowed to reduce the module output and disable the pre-emphasis.

How to solve the contradiction?

- With module output control, the module can be set to output swing within the host Rx linear region and with suitable equalization, for a wider variety of host channels.
- This can simplify SERDES design for a dual-purpose host Rx.
- As shown in the following slides, module output control is defined in at least one external specification (CMIS).
  - We can use this specification as a starting point, or just refer to it.

Module control as described in the CMIS document (1)

6.2.4.2 Rx Output Emphasis Control

The Rx Output Emphasis Control is a four-bit field per lane. Refer to Table 8-34 to determine if the module supports Rx Output Emphasis Control. Refer to Table 8-30 for the maximum Rx output emphasis supported by the module. Rx output emphasis is defined at the appropriate test point defined by the relevant standard. The code values and the corresponding output equalization are defined as follows:

Table 6-5 Rx Output Emphasis Codes

Code Value	Bit pattern	Post-Cursor Equalization	Pre-Cursor Equalization
0	0000b	No Equalization	No Equalization
1	0001b	1 dB	0.5 dB
2	0010b	2 dB	1.0 dB
3	0011b	3 dB	1.5 dB
4	0100b	4 dB	2.0 dB
5	0101b	5 dB	2.5 dB
6	0110b	6 dB	3.0 dB
7	0111b	7 dB	3.5 dB
8-10	1000b-1010b	Reserved	Reserved
11-15	1011b-1111b	Custom	Custom

Note: The pre-cursor equalizer settings in dB approximates to
Pre EQ (dB)=-20*log10((1-C(-1)/(C(-1)+C(0)+C(1)))
The post-cursor equalizer settings in dB approximates to
Post EQ (dB)=-20*log10(1-C(1)/(C(-1)+C(0)+C(1)))

Module control as described in the CMIS document (2)

6.2.4.3 Rx Output Amplitude Control

The Rx Output Amplitude Control is a four-bit field per lane. The output amplitude is measured with no equalization enabled. Refer to Table 8-34 to determine if the module supports Rx Output Amplitude Control and Table 8-30 to determine which codes are supported. Output amplitude is defined at the appropriate test point defined by the relevant standard. The code values and the corresponding output amplitude are defined as follows:

Table 6-6 Rx Output Amplitude Codes

Code Value	Bit pattern	Output Amplitude
0	0000b	100-400 mV (P-P)
1	0001b	300-600 mV (P-P)
2	0010b	400-800 mV (P-P)
3	0011b	600-1200 mV (P-P)
4-14	0100b-1110b	Reserved
15	1111b	Custom

Discussion

- As described above, with no control on module output, designing host Rx to support both long CR and short C2M may be very challenging, possibly limiting implementations.
  - Example: ports that support only CR or only C2M?
  - Tradeoff between Technical Feasibility and Broad Market Potential?
- Offline discussions show agreement that module output control is helpful but it is has not been mandatory (or even declared optional) in previous C2M specifications.
  - It is not obvious that all modules do/will implement this control unless it is addressed in Ethernet.
- If we add output control as a feature, should it be mandatory or optional?
  - If mandatory, then the module output characteristics will depend on its setting. We will have to define new normative measurements and limits.
    - This will take time; It may be preferable to address it in later drafts?
    - Is there consensus for mandatory?
  - Defining an optional feature may be enough for addressing TF/BMP?
    - Reference to external document may be sufficient, with possible details added in later drafts

Possible change (as optional feature)

- Add a subclause under **120G.3.2 Module output characteristics** with content as follows:

120G.3.2.1 Module output control (optional)

The module may optionally provide control of its output equalization and amplitude. If implemented, this functionality may be used by the host management to optimize the module output signal for the specific host channel and receiver.

An example of a management interface which provides control of module output is described in sections 6.2.4.2 and 6.2.4.3 of the Common Management Interface Specification (CMIS)[1].

Usage of the management interface for controlling module output is outside the scope of this standard.

[1] CMIS specifications are available at http://www.qsfp-dd.com/wp-content/uploads/2019/05/QSFP-DD-CMIS-rev4p0.pdf.

- Add a corresponding PICS item where appropriate.

DISCUSSION