Effect of pattern on Vdiffptp

(in support of comment 37)

Adee Ran, Cisco

Problem statement

- Differential pk-pk voltage (max) in Annex 10G tables refer to 120G.5.1, which eventually specifies measurements of this parameter using PRBS13Q
  - Host output is specified as 870 mV
  - Module output is specified as 900 mV (long mode) and 600 mV (short mode)
- Due to limited spectral content (longest run is 6 UI), PRBS13Q measurement after a lossy channel does not represent the true peak to peak voltage.
- Mission data (scrambled) has much richer spectral content
  - Can include runs of ≥20 UI with probability of 1e-12 (every 20 seconds), ≥26 UI once per day, ≥30 more than once per year
  - Can also have running disparity, causing baseline wander
- Unexpected large-signal events can cause Rx saturation and unpredicted FEC failures

120G.5.1 Signal levels

The signal levels are as defined in 120E.3.1.2.

120E.3.1.2 Signal levels

<...>

Unless otherwise noted, differential and common-mode signal voltages are measured with a PRBS13Q test pattern.

Cl 120G *SC* 120G.5.1 *P* 264 *L* 31 # 37

Ran, Adee Cisco systems

Comment Type TR *Comment Status* D *signal level*

This clause is referred to in Table 120G-1 and Table 120G-3 for the parameter differential PtP output voltage (max), among others.

The content is only a reference back to 120E.3.1.2: "The signal levels are as defined in 120E.3.1.2". 120E.3.1.2 does have a definition of differential signal but also states that "Unless otherwise noted, differential and common-mode signal voltages are measured with a PRBS13Q test pattern".

But PRBS13Q is not an appropriate signal for measurement of the PtP output voltage, because it has a maximum run length of 7 symbols and does not have any spectral content below 3 MHz. Much longer runs are possible in real data. Measurement with PRBS13Q over a lossy channel between the transmitter and the measurement point, without sufficient equalization, can thus yield peak-to-peak value lower than the value that real data would create.

Since there is no way to control the transmitter's swing or equalization, this may cause events of higher signal levels than the receiver expects, and cause periods of high BER, which can span many FEC symbols and cause uncorrectable codewords.

It is proposed to define the differential PtP explicitly as a requirement for any data pattern, and recommend to measure it using a pattern that contains low-frequency content, such as PRBS31Q or SSPRQ.

The definition of signal levels measurement using PRBS13Q also applies for CR/KR/C2C but in these cases the transmitter can be controlled to reduce the signal to an adequate level for the receiver, so it is less of an issue.

SuggestedRemedy

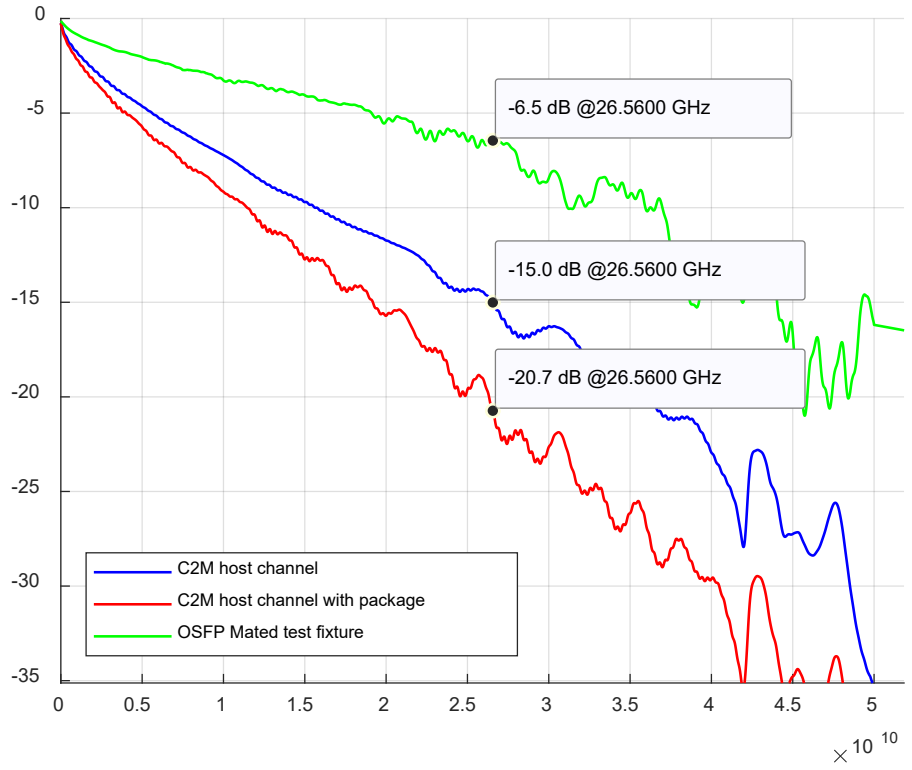
Replace the content of 120G.5.1 with the following:

"The definition of differential and common-mode signals can be found in 120E.3.1.2. The signal levels specifications for host and module outputs hold for any data pattern. It is recommended to measure differential peak to peak signal levels with PRBS31Q or SSPRQ test pattern."

Consider applying similar changes in 162, 163, and 120F, with editorial license.

Simulation experiment

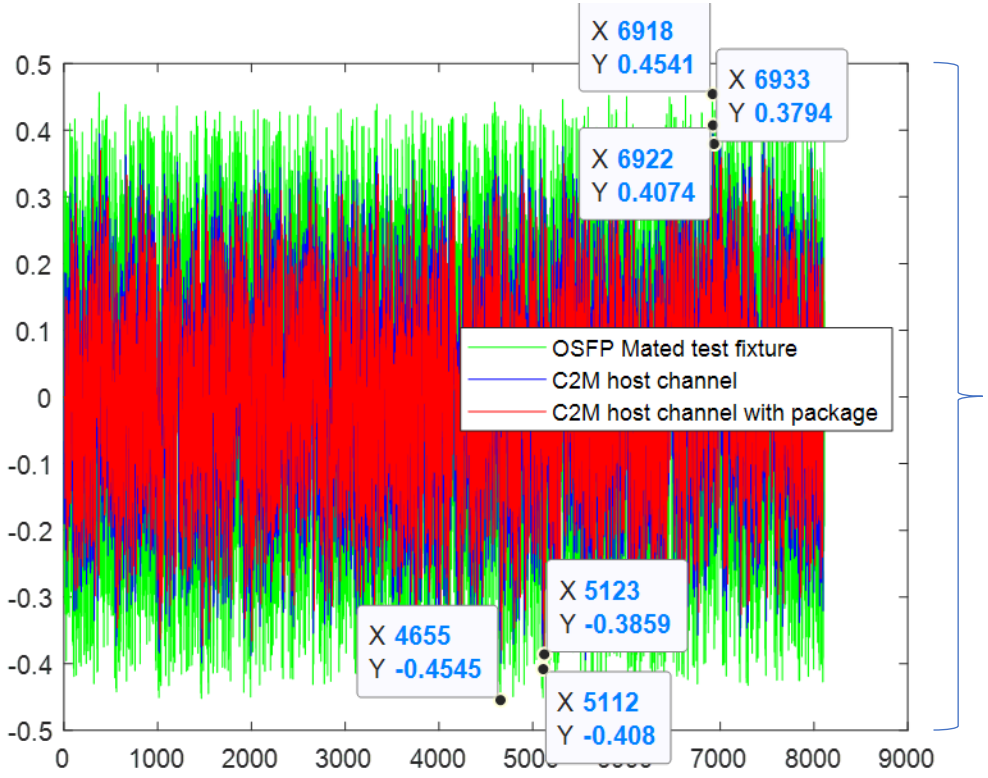
- Simulated channels
  - Channel3 from lim_3ck_01_0319_c2m (-15 dB) – near-maximum C2M channel
  - Same with 31 mm Tx package (-20.7 dB)
  - OSFP Mated Test Fixture from kocsis_3ck_02_0719_MTFosfp (6.5 dB) – representing minimal C2M channel
- Patterns
  - PRBS13Q
  - SSPRQ
- Launch PtP is 1 V, No Tx equalization
  - FFE constraints can only decrease the peak-to-peak voltage
- “True PtP” is the asymptote of the step response, which includes DC loss



PRBS13Q

Channel	min/max with PRBS13Q [mV]	% of true PtP	True PtP if 900 mV is measured [mV]
C2M Host channel	-408, +407	84%	1042
C2M Host channel +COM 31 mm pkg	-386, +386	79%	1100
OSFP Mated Test Fixture	-455, +458	93%	957

Measurement with PRBS13Q is much lower than the launch PtP and is channel dependent.
With scrambled data the signal can reach the launch voltage.
The dynamic range that the receiver will need to handle can't be deduced from the measurement.

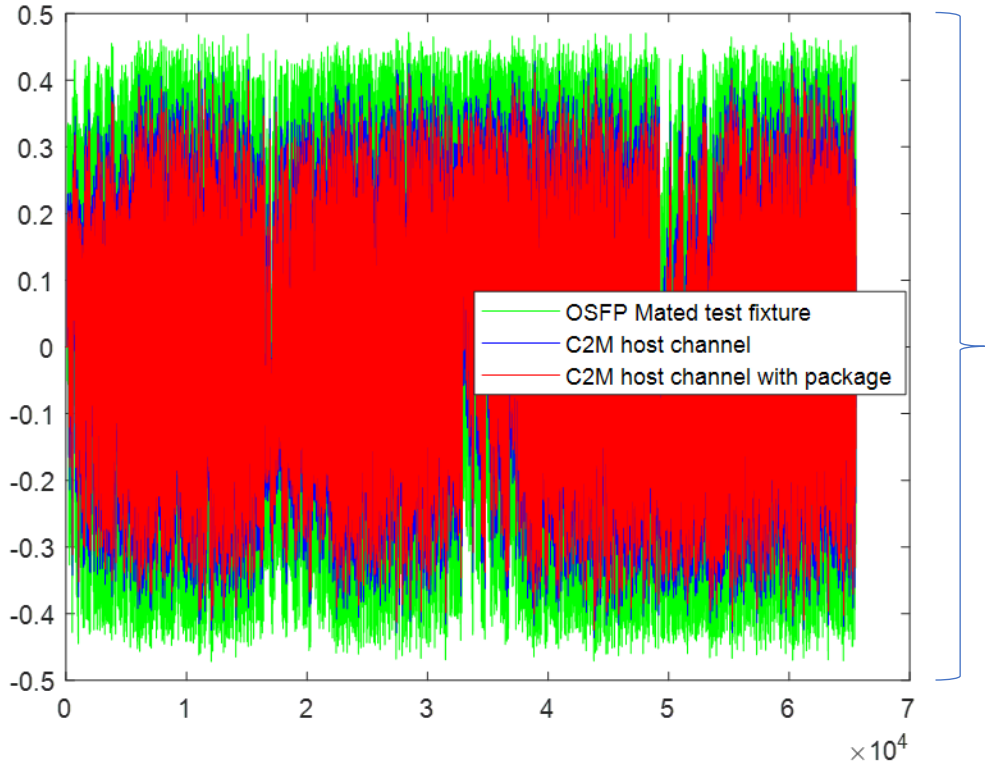


SSPRQ

Channel	min/max with SSPRQ [mV]	% of true PtP	True PtP if 900 mV is measured [mV]
C2M Host channel	-436, +436	90%	974
C2M Host channel +COM 31 mm pkg	-424, +424	87%	1001
OSFP Mated Test Fixture	-471, +471	96%	928

Note: SSPRQ includes 14-UI runs of both “0” and “3” symbols, therefore its PtP is expected to be equal to that of PRBS31Q (but is much faster to simulate)

Measurement with PRBS31Q or SSPRQ is still lower than the real PtP that the signal may reach.
But the channel dependence is smaller.

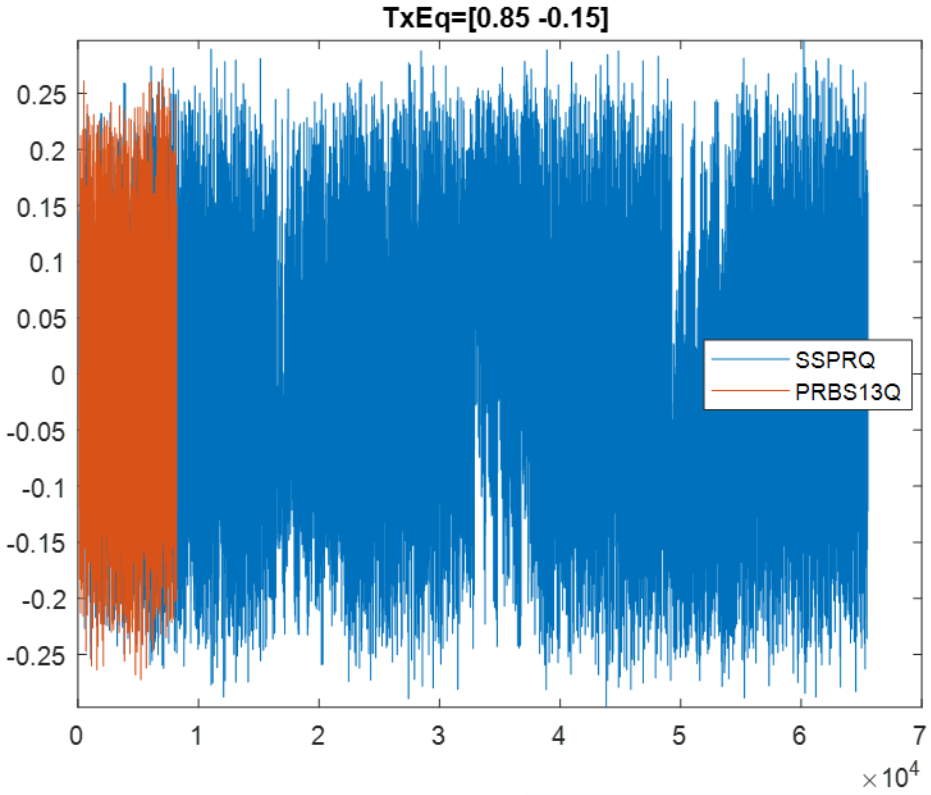


But in practice Tx equalization will be used?

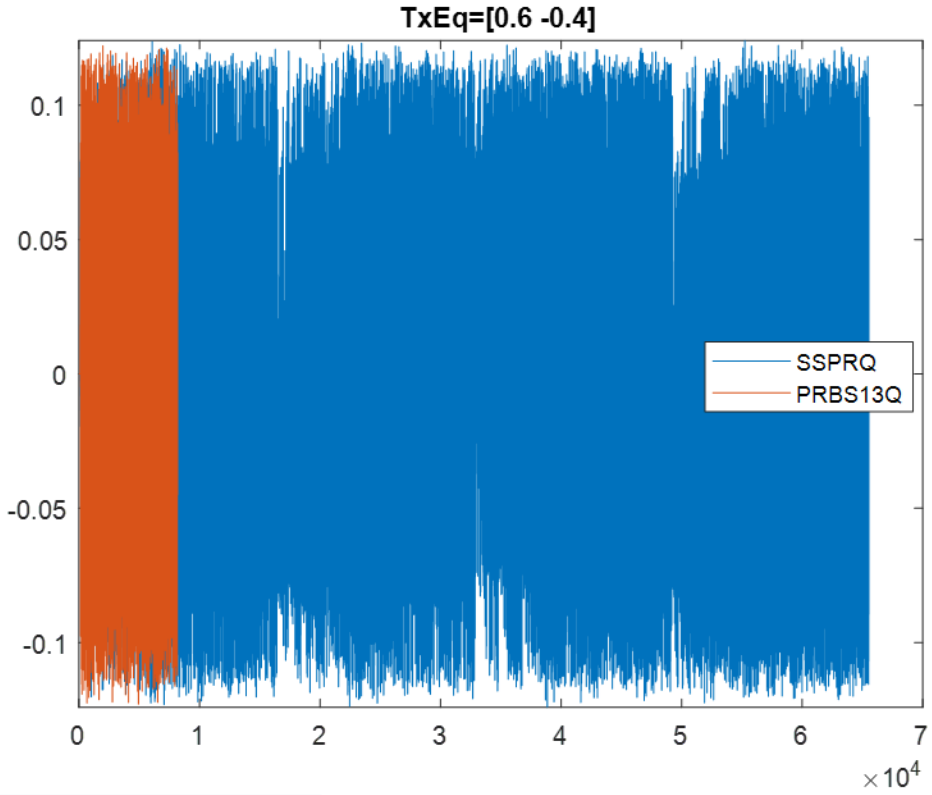
- Tx equalization is not specified explicitly for hosts or modules
  - No characteristics, no control
- Its effect on PtP of scrambled data cannot be determined from the PtP of PRBS13Q
  - Range of each pattern is reduced differently depending on equalization
- We do not expect Tx equalization to fully equalize the channel
  - The reference Rx CTLE+DFE assume Rx does most of the work
  - With high-loss host channels, voltages at the module input with scrambled data will be higher than with PRBS13Q

Comparison of SSPRQ and PRBS13Q with different Tx equalization

Mild Tx equalization (reasonable)



Strong Tx equalization (not expected)



Axes min/max match the SSPRQ range

What about CR/KR/C2C

- The measurement is with PRBS13Q in these specifications too
- However, these interfaces also have a specified “Transmitter steady-state voltage, vf (max)” of 0.6 V which is a stronger specification (based on the linear fit pulse response with N_p=200)
  - C2M does not have this specification
- Also, Tx equalization is fully controllable and the P2P can be reduced as required by the receiver
  - Unlike C2M where the Tx is not controllable (at least in 802.3 specifications)
- For consistency, it would be better to improve these specifications too

Goals of the proposed changes

- State that the diff PtP specification holds for any data pattern
  - The difference between “valid” and “any” data pattern is negligible
  - PtP is easy to guarantee by design
  - However, accurate measurement of PtP of scrambled data is excessively long
- Recommend measurement with PRBS31Q or SSPRQ
  - Although these patterns may not reach the PtP, they are short enough to be measurable, and better than PRBS13Q for this purpose
- The change is required for C2M; preferably also for other interfaces