On ACT peak-to-peak voltage levels

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Introduction

- This presentation provides more information related to comments #241 and #340
- These comments refer to too high peak-to-peak voltage being defined in Table 201-11 on page 125
- The motivation for reducing the peak-to-peak voltage is to reduce the dynamic range of the received signal, to better utilize ADC, etc.

Background

Table 201–10—Transmit Power, high speed mode

	Transmit power, -T1		Transmit power, -V1	
Transmit Rate	Min (dBm)	Max (dBm)	Min (dBm)	Max (dBm)
10G	-1	2	-4	-1
5G	-1	2	-4	-1
2.5G	-4	-1	-7	-4

Table 201–11—Transmit peak-to-peak voltage limits, high speed mode

Transmit Rate	-T1 Max (V)	-V1 Max (V)
10G	1.7	0.85
5G	1.3	0.65
2.5G	1.0	0.5

- Tables 201-10 and 201-11 define the transmit power and maximum peak-to-peak voltage at MDI, respectively
- Comparing the values in these two tables gives a Crest Factors in the range from 1.6 to 3, which is too high

Crest Factor

	Transmit power, -T1		Transmit power, -V1	
Transmit Rate	Min (dBm)	Max (dBm)	Min (dBm)	Max (dBm)
10G	-1	2	-4	-1
5G	-1	2	-4	-1
2.5G	-4	-1	-7	-4

RMS Voltage, -T1		RMS Voltage, -V1	
Min (mV)	Max (mV)	Min (mV)	Max (mV)
282	398	141	199
282	398	141	199
200	282	100	141

P-P Voltage, -T1		P-P Voltage, -V1	
Min (mV)	Max (mV)	Min (mV)	Max (mV)
1700	1700	850	850
1300	1300	650	650
1000	1000	500	500

	Crest Factor, -T1		Crest Factor, -V1	
Transmit Rate				
10G	3.0	2.1	3.0	2.1
5G	2.3	1.6	2.3	1.6
2.5G	2.5	1.8	2.5	1.8

- The Crest Factor is the ratio between the peak voltage and the RMS voltage [1]
- For PAM2 signals the Crest Factor is 1 and for PAM4 the Crest Factor is ~1.34
- The values in Tables 201-10 and 201-11 correspond to Crest Factors from 1.6 to 3

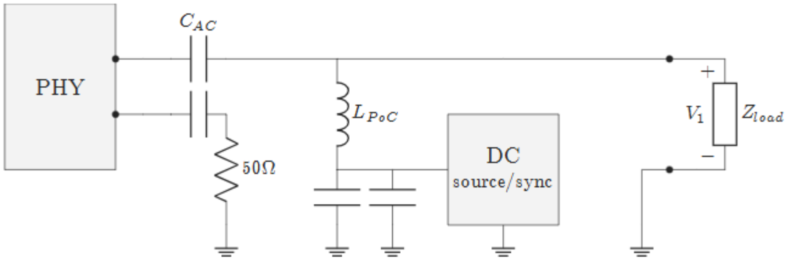
[1] https://en.wikipedia.org/wiki/Crest_factor

Transfer Function PCB with PoC

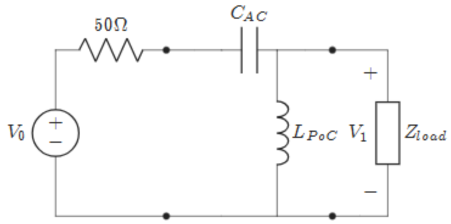
- For 802.3dm signaling the primary source of increased Crest Factor is the PoC circuitry on the PCB
- The Transfer function for the circuit on the right is

$$H_{pcb}(s) = \frac{s^2 L_{PoC} \cdot Z_{load} \cdot C_{AC}}{s^2 L_{PoC} \cdot (50\Omega + Z_{load}) \cdot C_{AC} + s(L_{PoC} + 50\Omega \cdot C_{AC} \cdot Z_{load}) + Z_{load}} \qquad \text{(par-2)}$$

- The derivation of this transfer function and the corresponding discreate transfer function is shown on slide 8
- These transfer functions can be used to evaluate the Crest Factor of the transmit signal at the MDI
- Such evaluation shows that the Crest Factor is typically less than **1.7** for PAM4 signals and **1.3** for PAM2 signals



PoC and AC-coupling Circuit



Equivalent Simplified Circuit

Peak-to-Peak Values with Reduced Crest Factor

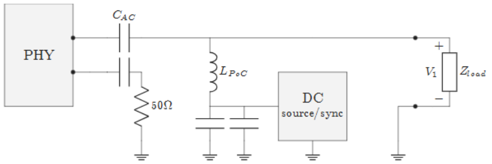
	RMS Voltage, -T1		RMS Voltage, -V1			P-P Voltage, -T1		P-P Voltage, -V1	
Transmit Rate	Min (mV)	Max (mV)	Min (mV)	Max (mV)	Crest Factor	Min (mV)	Max (mV)	Min (mV)	Max (mV)
10G	282	398	141	199	1.7	959	1353	479	677
5G	282	398	141	199	1.3	733	1035	367	517
2.5G	200	282	100	141	1.3	520	733	260	367

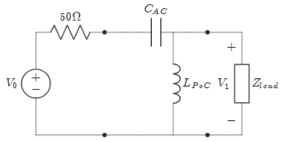
Proposed Peak-to-Peak values

Replace values in Table 201-11 with the following

Transmit Rate	-T1 Max (V)	-V1 Max (V)
10G	1.30	0.65
5G	1.00	0.50
2.5G	0.80	0.40

Derivations of Simplified PCB Transfer Function





The transfer function from the PHY chip to MDI, for the simplified diagrams above, is

$$H_{pcb}(s) = \frac{V_1(s)}{V_0(s)} = \frac{sL_{PoC} \cdot Z_{load}}{(sL_{PoC} + Z_{load})(50\Omega + \frac{1}{sC_{AC}}) + sL_{PoC} \cdot Z_{load}} \quad \text{(par-1)}$$

This can be rewritten as

$$H_{pcb}(s) = \frac{s^2 L_{PoC} \cdot Z_{load} \cdot C_{AC}}{s^2 L_{PoC} \cdot (50\Omega + Z_{load}) \cdot C_{AC} + s(L_{PoC} + 50\Omega \cdot C_{AC} \cdot Z_{load}) + Z_{load}} \quad \text{(par-2)}$$

or

$$H_{pcb}(s) = \frac{s^2 b_2}{s^2 a_2 + s a_1 + a_0} \quad \text{(par-3)}$$

where

$$\begin{aligned} b_2 &= L_{PoC} \cdot Z_{load} \cdot C_{AC}, \\ a_2 &= L_{PoC} \cdot (50\Omega + Z_{load}) \cdot C_{AC}, \\ a_1 &= L_{PoC} + 50\Omega \cdot C_{AC} \cdot Z_{load}, \text{ and} \\ a_0 &= Z_{load} \end{aligned} \quad \text{(par-4)}$$

The Laplace domain (s-domain) can be converted to Z-domain through bi-linear transformation:

$$s = \frac{2}{T_s} \frac{z-1}{z+1} \quad \text{(par-5)}$$

Substituting this into (par-3) gives

$$H_{pcb}(z) = \frac{b_2(z^2 - 2z + 1)}{z^2 A_2 + z A_1 + A_0} \quad \text{(par-6)}$$

where

$$\begin{aligned} A_2 &= a_2 + a_1 \frac{T_s}{2} + a_0 \frac{T_s^2}{4}, \\ A_1 &= a_0 \frac{T_s}{2} - 2a_2, \text{ and} \\ A_0 &= a_2 - a_1 \frac{T_s}{2} + a_0 \frac{T_s^2}{4} \end{aligned} \quad \text{(par-7)}$$

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