Annex 93A

(normative)

Specification methods for electrical channels

93A.1 Channel Operating Margin

Insert new row into Table 93A–1 (as modified by IEEE Std 802.3bs-201x) below the row for parameter "Transmitter equalizer, minimum cursor coefficient" (unmodified rows are not shown):

Table 93A–1—COM parameters

Parameter	Reference	Symbol	Units
Transmitter equalizer, 2nd pre-cursor coefficient[a] Minimum value Maximum value Step size	93A.1.4.2	$c(-2)$	 — — —

[a]Some clauses that invoke this method do not provide a value for $c(-2)$. See 93A.1.4.2.

Change Table 93A–2 (as modified by IEEE Std 802.3by-2016 and IEEE Std 802.3bs-201x) as follows (some unmodified rows are not shown):

Table 93A–2—Physical Layer specifications that employ COM

Physical Layer	Parameter values
…	…
25GAUI C2C (Annex 109A)	Table 83D–6
50GBASE-CR (Clause 136)	Table 136–15
50GBASE-KR (Clause 137)	Table 137–5
LAUI-2 C2C (Annex 135B)	Table 83D–6
50GAUI-2 C2C (Annex 135D)	Table 83D–6
50GAUI-1 C2C (Annex 135F)	Table 120D–8
100GBASE-CR4 (Clause 92)	Table 93–8
100GBASE-CR2 (Clause 136)	Table 136–15

Table 93A–2—Physical Layer specifications that employ COM

Physical Layer	Parameter values
100GBASE-KR4 (Clause 93)	Table 93–8
100GBASE-KP4 (Clause 94)	Table 94–17
100GBASE-KR2 (Clause 137)	Table 137–5
CAUI-4 C2C (Annex 83D)	Table 83D–6
100GAUI-4 C2C (Annex 135D)	Table 83D–6
100GAUI-2 C2C (Annex 135F)	Table 120D–8
200GBASE-CR4 (Clause 136)	Table 136–15
200GBASE-KR4 (Clause 137)	Table 137–5
200GAUI-8 C2C (Annex 120B)	Table 83D–6[a]
…	…

[a]With the exceptions given in 120B.4.

93A.1.4 Filters

93A.1.4.2 Transmitter equalizer

Change the text of 93A.1.4.2 as follows:

$H_{ffe}(f)$ is defined by Equation (93A–21) and is intended to represent the transmitter equalizer. If k corresponds to a near-end crosstalk path, then $c(-2)$, $c(-1)$, and $c(1)$ are all zero regardless of the values used for the other paths. The value of the "cursor" coefficient $c(0)$ is set to ~~1 − |c(−1)| − |c(1)|~~ $1 - |c(-2)| - |c(-1)| - |c(1)|$ for any value of $c(-2)$, $c(-1)$ and $c(1)$. If the value of $c(0)$ is less than the specified minimum value, the corresponding combination of $c(-2)$, $c(-1)$, and $c(1)$ is considered invalid and is not used to calculate COM.

Replace Equation (93A–21) with the following equation:

$$H_{ffe}(f) = \sum_{i=-2}^{1} c(i)\exp\left(-j2\pi(i+2)\frac{f}{f_b}\right) \quad (93A–21)$$

93A.1.6 Determination of variable equalizer parameters

Change the first paragraph of 93A.1.6 (as modified by IEEE Std 802.3bs-201x) and item a) as follows:

COM is a function of the variables $c(-2)$, $c(-1)$, $c(1)$, g_{DC}, and g_{DC2}. The following procedure is used to determine the values of these variables that are used to calculate COM.

a) Compute the pulse response $h_{(k)}(t)$ of each signal path k for a given $c(-2)$, $c(-1)$, $c(1)$, g_{DC}, and g_{DC2} using the procedure defined in 93A.1.5.

Change the last paragraph of 93A.1.6 (as modified by IEEE Std 802.3bs-201x) as follows:

The FOM is calculated for each permitted combination of $c(-2)$, $c(-1)$, $c(1)$, g_{DC}, and g_{DC2} values per Table 93A–1, where any parameters not provided by the clause that invokes this method are set to 0. The combination of values that maximizes the FOM, including the corresponding value of t_s, is used for the calculation of the interference and noise amplitude in 93A.1.7 and the calculation of COM in 93A.1.

Insert new subclause 93A.5 after 93A.4:

93A.5 Effective Return Loss

Effective Return Loss (ERL) is a figure of merit for the electromagnetic wave reflection from a device or a channel input or output. ERL shall be calculated using the method described in this annex.

The parameters used to calculate ERL are listed in Table 93A–4. The values assigned to these parameters are defined by the Physical Layer specification that invokes the ERL method.

Table 93A–4—ERL parameters (renumber)

Parameter	Reference	Symbol	Units
Signaling rate		f_b	GBd
Transition time associated with a pulse	93A.2	T_r	ns
Receiver 3 dB bandwidth	93A.1.4.1	f_r	GHz
Number of signal levels		L	—
Length of the reflection signal		N	UI
Number of samples per unit interval		M	—
Equalizer length associated with reflection signal		N_{bx}	UI
Incremental available signal loss factor		β_x	GHz
Permitted reflection from a transmission line external to the device under test		ρ_x	—
Target detector error ratio		DER_0	—

93A.5.1 Pulse time-domain reflection signal

ERL is derived from a unity pulse time-domain reflection signal, PTDR(t). PTDR(t) is defined at the test points defined in the Physical Layer specification that invokes the ERL method. PTDR(t) may be acquired directly from an appropriately filtered time domain reflectometer (TDR), or derived mathematically from measured differential scattering parameters $S(f)$ (see 93A.1.1) and transmitter and receiver filters, according to the procedure in this subclause.

The filtered return loss, $H_{ii}(f)$, is defined by Equation (93A–58).

$$H_{ii}(f) = H_t(f)s_{ii}(f)H_r(f) \tag{93A–58}$$

Where
- f is the frequency in GHz
- $H_r(f)$ is defined by Equation (93A–20)
- $H_t(f)$ is defined by Equation (93A–46)
- i is the port index of the scattering parameters, 1 or 2.

The pulse TDR signal, PTDR(t), is defined by Equation (93A–59).

$$PTDR(t) = \int_{-\infty}^{\infty} X(f)H_{ii}(f)\exp(j2\pi ft)df \tag{93A–59}$$

Where
- t is the time in ns starting from the peak of the injected pulse
- $X(f)$ is defined by Equation (93A-23) with A_t set to 1.

93A.5.2 Effective reflection waveform

The effective reflection waveform, $R_{eff}(t)$, is computed by time gating and weighting the PTDR waveform, PTDR(t), according to Equation (93A–60). $R_{eff}(t)$ is a pure number.

$$R_{eff}(t) = PTDR(t) \times G_{rr}(t) \times G_{loss}(t) \tag{93A–60}$$

Where $G_{rr}(t)$ and $G_{loss}(t)$ are time gating weighting functions defined in Equation (93A–61) and Equation (93A–62) with t in nanoseconds.

$$G_{rr}(t) = \begin{cases} 0 & t < T_{fx} \\ \rho_x(1+\rho_x)\exp\left(-\dfrac{[(t-T_{fx})f_b-(N_{bx}+1)]^2}{(N_{bx}+1)^2}\right) & T_{fx} \le t < T_{fx} + \dfrac{N_{bx}+1}{f_b} \\ \rho_x(1+\rho_x) & t \ge T_{fx} + \dfrac{N_b+1}{f_b} \end{cases} \tag{93A–61}$$

Where
- t is the time in ns starting from the peak of the injected pulse
- T_{fx} is twice the propagation delay in ns associated with the test fixture, obtained by measurement or inspection
- ρ_x, f_b, N_{bx} are supplied by the clause that invokes this method.

$$G_{loss}(t) = \begin{cases} 0 & t < T_{fx} \\ 10^{\frac{\frac{\beta_x}{f_b}[(t - T_{fx})f_b - (N_{bx} + 1)]}{20}} & T_{fx} \le t < T_{fx} + \dfrac{N_{bx}+1}{f_b} \\ 1 & t \ge T_{fx} + \dfrac{N_{bx}+1}{f_b} \end{cases} \tag{93A–62}$$

Where

t is the time in ns starting from the peak of the injected pulse

T_{fx} is twice the propagation delay in ns associated with the test fixture, obtained by measurement or inspection

β_x, f_b, N_{bx} are supplied by the clause that invokes this method.

93A.5.3 Sampled effective reflection

The sampled effective reflection for each phase m is computed per Equation (93A–63).

$$h^{(m)}(n) = R_{eff}\left(T_{fx} + \frac{n + m/M}{f_b}\right) \tag{93A–63}$$

Where n is an integer ranging from 1 to N and m is an integer ranging from 1 to M.

The standard deviation of the distribution of the reflection signal for each phase m, $\sigma^{(m)}{}_h$, is defined by Equation (93A–64).

$$\sigma^{(m)}{}_h = \sqrt{\sum_{n=1}^{N} h^{(m)}(n)^2}\ \text{dB} \tag{93A–64}$$

Where m is an integer ranging from 1 to M.

93A.5.4 x-quantile of the reflection distribution

The reflection signal distribution $p(y)$ is computed from the sampled effective reflection using the procedure defined in 93A.1.7.1, with $h(n) = h^{(m)}(n)$, where m maximizes $\sigma^{(m)}{}_h$. The value of L in Equation (93A–39) is supplied by the clause that invokes this method. The corresponding cumulative distribution function $P(y)$ is calculated from $p(y)$ using Equation (93A–37).

The x-quantile of the distribution, $P^{-1}(x)$, is the value of y that satisfies the relationship $P(y)=x$.

93A.5.5 ERL

ERL is defined as $20 \times \log_{10} P^{-1}(DER_0)$ where DER_0 is the target detector error ratio.