IEEE802.3dj Modal ERL Proposal

Addressing d2.3 comments 40, 41, 42

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Agenda

Slides are overview bullets with detailed text to right

❑ Update s-parameter reference in 178A.1.2

❑ Propose new section 178A.3 for Modal Effective Return Loss

❑ Modal ERL Requirements

Update for 178A.1.2
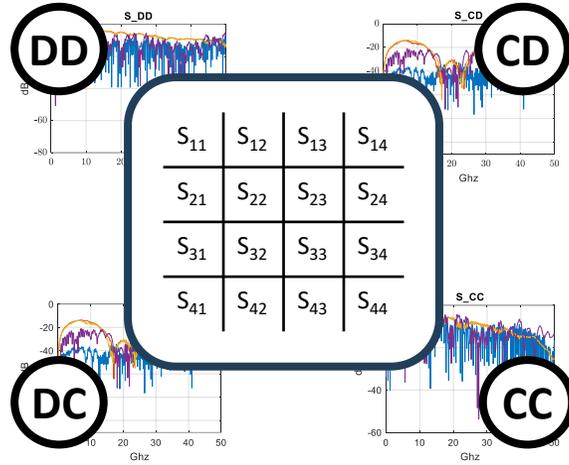
178A.1.2 Channel

Each signal path and modal parameter of the channel is measured according to the guidance given in 178A.1.3 to obtain the differential-mode scattering matrix $S(f)$, common-mode scattering matrix $S_{cc}(f)$, common-mode to differential-mode scattering matrix $S_{cd}(f)$, differential-mode to common-mode scattering matrix $S_{dc}(f)$, defined by Equation (178A–1) at each measurement frequency f.

$$S(f) = \begin{bmatrix} s_{11}(f) & s_{12}(f) \\ s_{22}(f) & s_{22}(f) \end{bmatrix}$$
(178A-1a)

$$S_{CC}(f) = \begin{bmatrix} s_{cc11}(f) & s_{cc12}(f) \\ s_{cc22}(f) & s_{cc22}(f) \end{bmatrix}$$
(178A-1b)

$$S_{CD}(f) = \begin{bmatrix} s_{cd11}(f) & s_{cd12}(f) \\ s_{cd22}(f) & s_{cd22}(f) \end{bmatrix}$$
(178A-1c)

$$S_{DC}(f) = \begin{bmatrix} s_{dc11}(f) & s_{dc12}(f) \\ s_{dc22}(f) & s_{dc22}(f) \end{bmatrix}$$
(178A-1c)

Adjust 178A.1.2 for modal references

☐ Define modal S-parameters $(S_{DD}\ S_{CC}\ S_{CD}\ S_{DC})$ in 178A.1.2 to support referencing for calculations of modal ERL/SCMR

☐ Using $S(f)$ as $S_{DD}(f)$ for backward compatibility

Add section to 178A for Modal ERL

❑ Define names for modal
ERL parameters

178A.3 Modal Effective Return Loss

Modal Effective Return Loss (ERL_{CC}, ERL_{CD}, ERL_{DC}) are figures of merit for the modal electromagnetic wave reflections from a device or a channel input or output. Where:

ERL_{CC} is common-mode to common-mode effective return loss, derived from the return loss measurement $S_{CC11}(f)$

ERL_{CD} is common-mode to differential-mode effective return loss, derived from the return loss measurement $S_{CD11}(f)$

ERL_{DC} is common-mode to common-mode effective return loss, derived from the return loss measurement $S_{DC11}(f)$

ERL_{CC}, ERL_{CD}, and ERL_{DC} shall be calculated using the method described in this annex.

The parameters used to calculate ERL_{CC}, ERL_{CD}, ERL_{DC} are listed in Table 178A–14. The values assigned to these parameters are defined by the Physical Layer specification that invokes the modal ERL method.

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Modal Pulse Time-Domain Reflection (PDTR)

❑ Define names for modal $PTDR$ signals, like $PTDR$ used for ERL

❑ Reference modal S-parameter naming as defined in 178A.1.2

178A.3.1 Pulse time-domain reflection signals

ERL_{CC}, ERL_{CD}, and ERL_{DC} are derived respectively from unity pulse time-domain reflection signals $PTDR_{CC}(t)$, $PTDR_{CD}(t)$, and $PTDR_{DC}$. $PTDR_{CC}(t)$, $PTDR_{CD}(t)$, and $PTDR_{DC}$ are defined at the test points defined in the Physical Layer specification that invokes the modal ERL method. $PTDR_{CC}(t)$, $PTDR_{CD}(t)$, and $PTDR_{DC}$ may be acquired directly from an appropriately filtered time domain reflectometer (TDR), or derived mathematically from measured scattering parameters $S(f)$, $S_{cc}(f)$, $S_{cc}(f)$, and $S_{cc}(f)$, cascaded with transmitter and receiver filters, according to the procedure in this subclause. See 178A.1.2 for scattering parameters measurement recommendations including frequency step, start frequency, and stop frequency.

Modal ERL parameters

❑ Add parameter definitions needed for modal ERL, using ERL parameters as the basis

Table 178A–14—ERL parameters

Parameter	Reference	Symbol	Units
Signaling rate	93A.1.1	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	93A.1.6	L	—
Length of the reflection signal	—	N	UI
Number of samples per unit interval	93A.1.6	M	—
Equalizer length associated with reflection signal	178A.3.2	N_{bx}	UI
Incremental available signal loss factor	178A.3.2	β_x	GHz
Permitted reflection from a transmission line external to the device under test	178A.3.2	ρ_x	—
Target detector error ratio	93A.1.7	DER_0	—

Modal Pulse Time-Domain Reflections

☐ Using the filtered return loss functions compute modal $PTDR$ using ERL $PTDR$ as the basis

☐ Reference modal S-parameter naming as defined in 178A.1.2
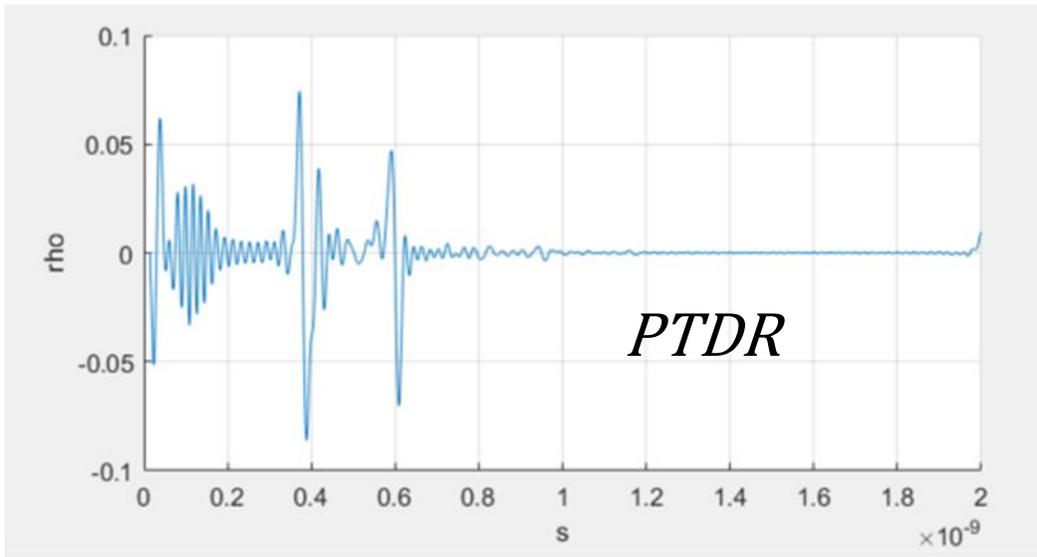
The filtered modal return losses functions $H_{ccii}(f)$, $H_{cdii}(f)$, and $H_{dcii}(f)$, are defined by Equations (178A–61)

$$H_{ccii}(f) = H_t(f)\, s_{ccii}(f)\, H_r(f) \qquad (178A–61a)$$

$$H_{cdii}(f) = H_t(f)\, s_{cdii}(f)\, H_r(f) \qquad (178A–61b)$$

$$H_{dcii}(f) = H_t(f)\, s_{dcii}(f)\, H_r(f) \qquad (178A–61c)$$

Where:

f	is the frequency in GHz
$H_t(f)$	is the input rise time transfer function defined in 178A.1.6.2
$H_r(f)$	is the receiver noise filter transfer function defined in 178A.1.6.3
i	is the port index of the scattering parameters, 1 or 2
$s_{ccii}(f)$	is the channel common-mode return loss
$s_{cdii}(f)$	is the channel common-mode to differential-mode return loss
$s_{dcii}(f)$	is the channel differential-mode to common-mode return loss

The modal pulse TDR signals $PTDR_{cc}(t)$, $PTDR_{cd}(t)$, and $PTDR_{dc}(t)$ are defined by Equation (178A–62).

$$PTDR_{cc}(t) = \int_{-\infty}^{\infty} X(f) H_{ccii}(f) \exp(j2\pi ft)\, df \qquad (178A–62a)$$

$$PTDR_{cd}(t) = \int_{-\infty}^{\infty} X(f) H_{cdii}(f) \exp(j2\pi ft)\, df \qquad (178A–62b)$$

$$PTDR_{dc}(t) = \int_{-\infty}^{\infty} X(f) H_{dcii}(f) \exp(j2\pi ft)\, df \qquad (178A–62c)$$

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

$PTDR$

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Effective modal reflection waveforms

❑ Compute effective modal reflection waveforms, $R_{eff}(t)$, from modal $PTDR$ using 93A gating functions (G_{rr} and G_{loss})
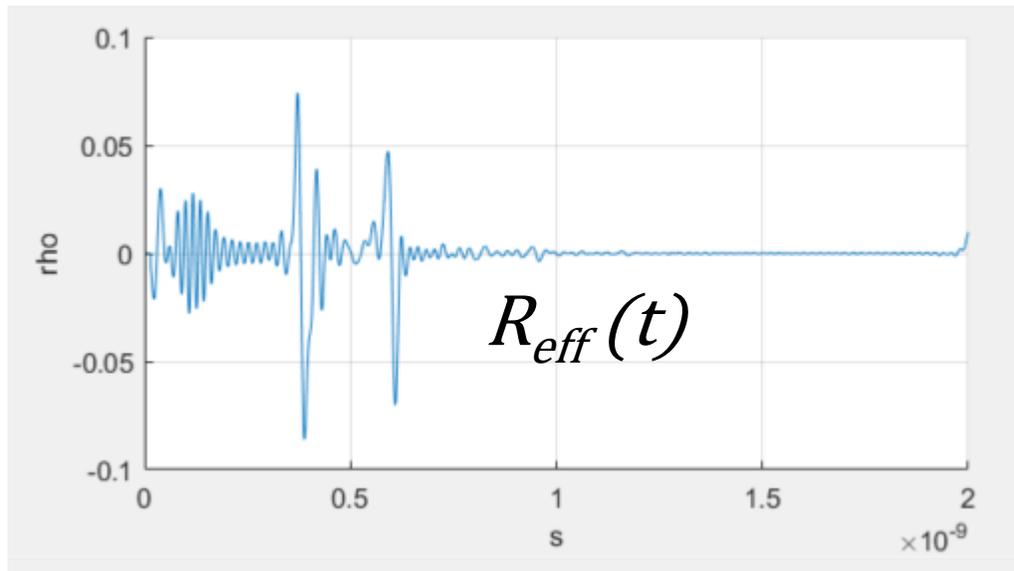
178A.3.2 Effective reflection waveform

The effective modal reflection waveforms $R_{cceff}(t)$, $R_{cdeff}(t)$, and $R_{dceff}(t)$ are computed by time gating and weighting the PTDR waveforms $PTDR_{cc}(t)$, $PTDR_{cc}(t)$, and $PTDR_{cc}(t)$ per Equation (178A–63). $R_{cceff}(t)$, $R_{cdeff}(t)$, and $R_{dceff}(t)$ are pure numbers.

$$R_{cceff}(t) = PTDR_{cc}(t) \times G_{rr}(t) \times G_{loss}(t) \qquad \text{(178A–63a)}$$

$$R_{cdeff}(t) = PTDR_{cd}(t) \times G_{rr}(t) \times G_{loss}(t) \qquad \text{(178A–63b)}$$

$$R_{dceff}(t) = PTDR_{dc}(t) \times G_{rr}(t) \times G_{loss}(t) \qquad \text{(178A–63c)}$$
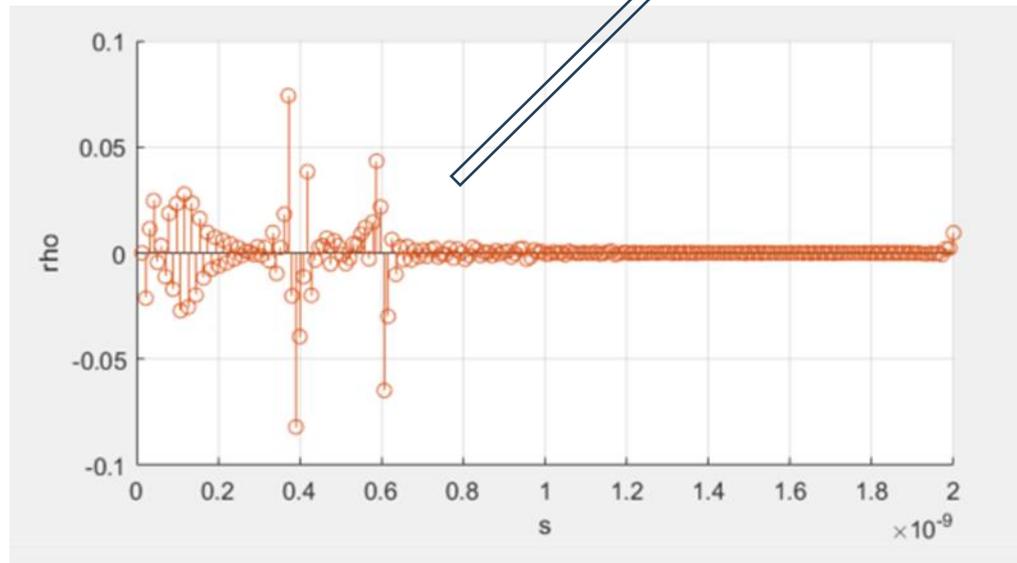
Where:

$G_{rr}(t)$	is defined in Equation (93a-61)
$G_{loss}(t)$	is defined in Equation (93a-62)

$R_{eff}(t)$

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Sample Variances

❑ Compute reflection variance for each reflection sample offset

σ

178A.3.3 Sampled effective reflection

The sampled modal effective reflection for each phase m is computed per Equation (178A–64).

$$h_{cc}^{(m)}(n) = R_{cceff}\left(t_{fx} + \frac{n+m/M}{f_b}\right)$$ (178A–64a)

$$h_{cd}^{(m)}(n) = R_{cdeff}\left(t_{fx} + \frac{n+m/M}{f_b}\right)$$ (178A–64b)

$$h_{dc}^{(m)}(n) = R_{dceff}\left(t_{fx} + \frac{n+m/M}{f_b}\right)$$ (178A–64c)

where

n	is an integer ranging from 0 to N–1
m	is an integer ranging from 0 to M–1
N and M	are supplied by the clause that invokes this method

The standard deviation of the distributions of the modal reflection signals for each phase m for s is defined by Equation (178A–65).

$$\sigma_{cch}^{(m)} = \sqrt{\sum_{n=1}^{N}\left(h_{cc}^{(m)}(n)\right)^2}$$ (178A–65a)

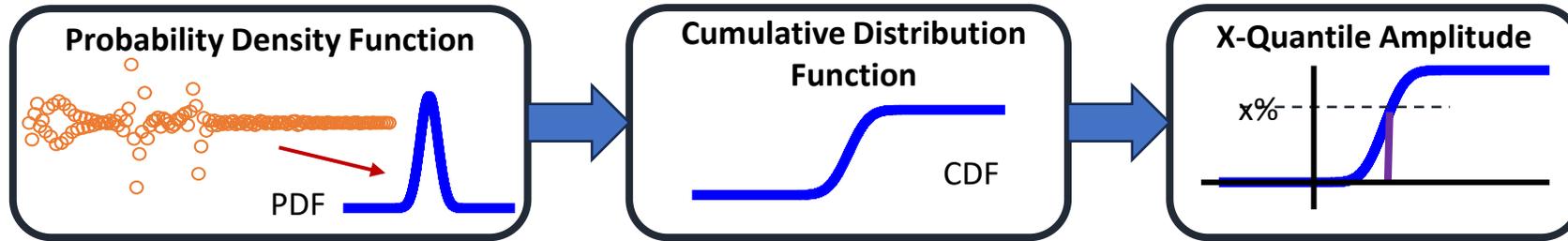$$\sigma_{cdh}^{(m)} = \sqrt{\sum_{n=1}^{N}\left(h_{cd}^{(m)}(n)\right)^2}$$ (178A–65b)

$$\sigma_{dch}^{(m)} = \sqrt{\sum_{n=1}^{N}\left(h_{dc}^{(m)}(n)\right)^2}$$ (178A–65c)

where

m	is an integer ranging from 0 to M–1
N and M	are supplied by the clause that invokes this method

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Computing the Effective Reflection at a Probability

☐ Use the reflection sample with the worst variance

☐ Compute the reflection PDF, then statistically integrate to get the reflection CDF.

☐ Determine the reflection amplitude corresponding to the x-quantile

- the point where the CDF equals x%
- I.e. x% is the DER_0 probability

178A.3.4 x-quantile of the reflection distributions

The modal reflection signal distributions $p_{cc}(y)$, $p_{cd}(y)$, and $p_{dc}(y)$ are computed from the sampled effective reflection using the procedure defined in 93A.1.7.1, with $h_{cc}(n) = h_{cc}^{(m)}(n)$, $h_{cd}(n) = h_{cd}^{(m)}(n)$, or $h_{dc}(n) = h_{dc}^{(m)}(n)$, where m respectively maximizes $\sigma_{cch}^{(m)}$, $\sigma_{cdh}^{(m)}$ or $\sigma_{dch}^{(m)}$. The corresponding cumulative distribution functions $P_{cc}(y)$, $P_{cd}(y)$, and $P_{dc}(y)$ are calculated from replacing $p(y)$ respectively with $p_{cc}(y)$, $p_{cd}(y)$, and $p_{dc}(y)$ in Equation (93A−37). The x-quantile of the distributions, $P_{cc}^{-1}(x)$, $P_{cd}^{-1}(x)$, and $P_{dc}^{-1}(x)$, is the value of y that satisfies the relationship $P_{cc}^{-1}(x) = x$, $P_{cd}^{-1}(x) = x$, or $P_{dc}^{-1}(x) = x$.

Report Modal ERL in dB

❑ Modal ERL is the dB of
  the reflection amplitude

178A.3.5 modal ERL

Modal ERLs are defined

$$ERL_{cc} = 20 \times \log 10\left(P_{cc}^{-1}(DER_0)\right)$$ (178A–66a)

$$ERL_{cd} = 20 \times \log 10\left(P_{cd}^{-1}(DER_0)\right)$$ (178A–66b)

$$ERL_{dc} = 20 \times \log 10\left(P_{dc}^{-1}(DER_0)\right)$$ (178A–66c)

where DER_0 is the target detector error ratio.

Modal ERL Requirements: Overview

❑ The modal return-loss mask shall remain informative in this draft revision.

❑ A minimum modal ERL requirement is proposed for inclusion in the corresponding normative tables of the relevant clause sections.

❑ Subsequent slides provide the detailed informative notes and proposed normative requirements

Propose Informative Notes in Respective Table Sections

section	tx			rx			channel tx or rx		
	ERLcc	ERLdc	ERLcd	ERLcc	ERLdc	ERLcd	ERLcc	ERLdc	ERLcd
178.9.2 Transmitter characteristics	✓								
178.9.3 Receiver characteristics						✓			
178.10 Channel characteristics									✓
179.9.4 Transmitter characteristics	✓	✓							
179.9.5 Receiver characteristics						✓			
179.11 Cable assembly characteristics							✓		✓
176C.6.3 Transmitter characteristics	✓	✓							
176C.6.4 Receiver characteristics						✓			
176C.7 Channel characteristics									✓
176D.6.4 Host output characteristics	✓	✓							
176D.6.5 Module output characteristics	✓	✓							
176D.6.6 Host input characteristics						✓			
176D.6.7 Module input characteristics						✓			

key
At note to respecive table that "The mask is informative"

Proposal for informative notes—not normative requirements—to be inserted into the respective tables across the IEEE 802.3dj draft.

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Propose Minimum Modal ERL Requirement for Respective Sections

Aligned to data in mellitz_3dj_01b_2601, mellitz_3dj_adhoc_01a_251030, & mellitz_3dj_adhoc_01a_250829

section	tx			rx			channel tx or rx		
	ERLcc	ERLdc	ERLcd	ERLcc	ERLdc	ERLcd	ERLcc	ERLdc	ERLcd
178.9.2 Transmitter characteristics	2 dB	17 db	17 db						
178.9.3 Receiver characteristics				2 dB	17 db	17 db			
178.10 Channel characteristics							2 dB	17 db	17 db
179.9.4 Transmitter characteristics	2 dB	17 db	17 db						
179.9.5 Receiver characteristics				2 dB	17 db	17 db			
179.11 Cable assembly characteristics							2 dB	17 db	17 db
176C.6.3 Transmitter characteristics	2 dB	17 db	17 db						
176C.6.4 Receiver characteristics				2 dB	17 dB	17 dB			
176C.7 Channel characteristics							2 dB	17 db	17 db
176D.6.4 Host output characteristics	2 dB	17 db	17 db						
176D.6.5 Module output characteristics	2 dB	17 db	17 db						
176D.6.6 Host input characteristics				2 dB	17 db	17 db			
176D.6.7 Module input characteristics				2 dB	17 db	17 db			

key
add new row in table of section

Proposal for minimum modal ERL requirements—to be added as table entries into the respective tables across the IEEE 802.3dj draft.

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Thank You!