ERL Capable of DFE Floating Tap

Mau-Lin Wu, Yu-Yun Chang MediaTek

IEEE 802.3ck Task Force

Supporters

- Your name here!

Outline

- Background and motivation
- Recap of ERL and DFE floating tap
- Apply DFE floating tap to ERL
- Proposal and next step

Background and Motivation

- ERL (Effective Return Loss) - proposed & developed in IEEE 802.3cd
  - replace 'differential output return loss (min)' and '$\boldsymbol{SNR_{ISI}}$ (min)'
  - consider DFE capability
- **DFE floating tap** - adopted as reference RX of KR & CR in IEEE 802.3ck D1p0
- 'ERL is very sensitive across $\boldsymbol{N_{bx}}$ boundary' - issue raised in wu_3ck_02a_1119

Our Solution?

Modify ERL to include DFE ‘floating tap’

Recap ERL in 802.3cd – $G_{rr}(t)$

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

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

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

Source: IEEE 802.3cd-2018, 93A.5.2

Recap ERL in 802.3cd – $G_{loss}(t)$

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

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

where

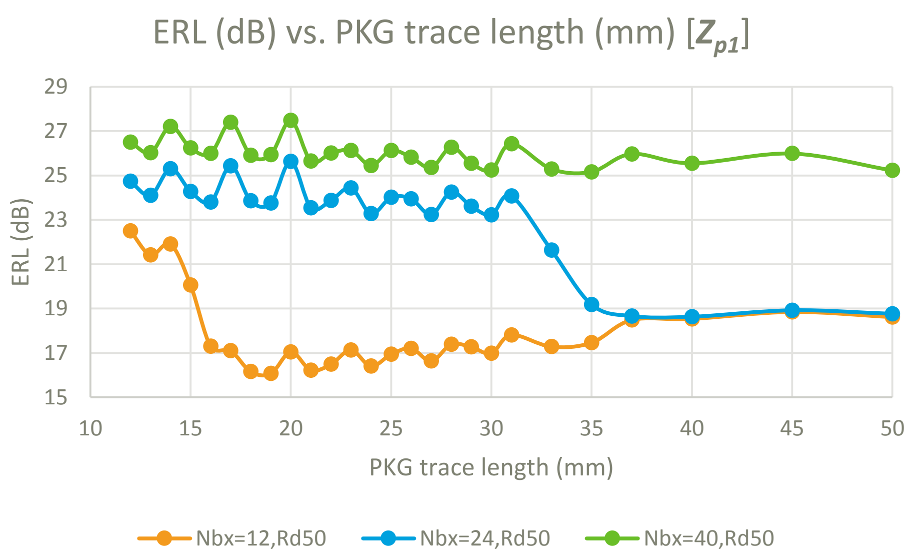
t	is the time in ns starting from the peak of the injected pulse
T_{fx}	is twice the propagation delay in ns associated with the test fixture, obtained by measurement or inspection
β_x, f_b, N_{bx}	are supplied by the clause that invokes this method

Source: IEEE 802.3cd-2018, 93A.5.2

N_{bx} Trade off

$$G_{rr}(t) = \left\{ \rho_x(1+\rho_x)\exp\left(-\frac{[(t-T_{fx})f_b-(N_{bx}+1)]^2}{(N_{bx}+1)^2}\right) \quad T_{fx} \le t < T_{fx} + \frac{N_{bx}+1}{f_b} \right. \qquad (93A–61)$$

KR ERL analysis of wu_3ck_02a_1119

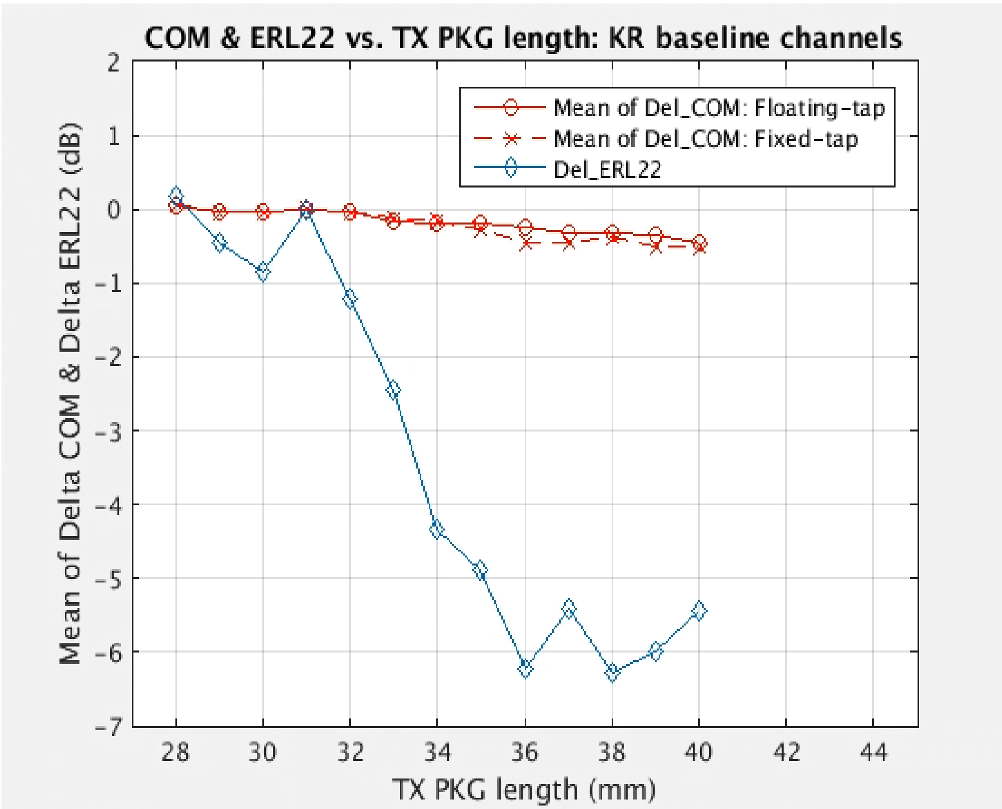


- $G_{rr}(t)$ applies to the range of fixed N_{bx} -tap DFE
  - Small N_{bx}=N_b: **too pessimistic**
  - Large N_{bx}=N_f: **too optimistic**
  - N_{bx}**=24**, proposed by Rich for device (mellitz_3ck_01_1119): only covers PKG trace length <= 30 mm

Issue: ERL is very sensitive across N_{bx} boundary

ERL vs. COM – Sensitivity of PKG Length

COM vs. ERL in wu_3ck_02a_1119

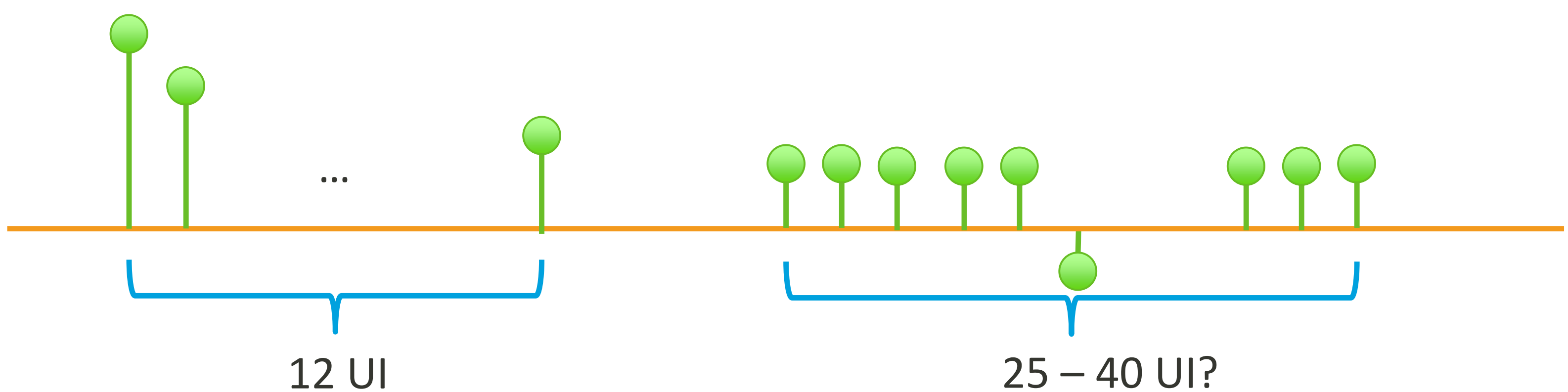


- ERL - too sensitive @ Zp1 = 32 ~ 36 mm
  - 6 dB drop
  - COM is much less sensitive < 0.5 dB drop
  - Reflection of 32 mm is at boundary of N_{bx} = 24
- Solution
  - **ERL capable of DFE floating tap**

Recap – DFE Floating Tap

Table 163–10—COM parameter values *(continued)*

Parameter	Symbol	Value	Units
Decision feedback equalizer (DFE) length	N_b	12	UI
Normalized DFE coefficient magnitude limit $n = 1$ $n = 2$ $n = 3$ to N_b	$b_{max}(n)$	 0.85 0.3 0.2	—
Number of DFE floating tap banks	N_{bg}	3	—
Number of DFE floating taps per bank	N_{bf}	3	—
DFE floating tap span	N_f	40	UI
Normalized coefficient magnitude limit for DFE floating taps	b_{gmax}	0.05	—
DFE floating tap tail root-sum-of-squares limit	σ_{tmax}	0.03	—
DFE floating tap tail starting position	N_{ts}	25	—



Source: IEEE 802.3ck D1p0

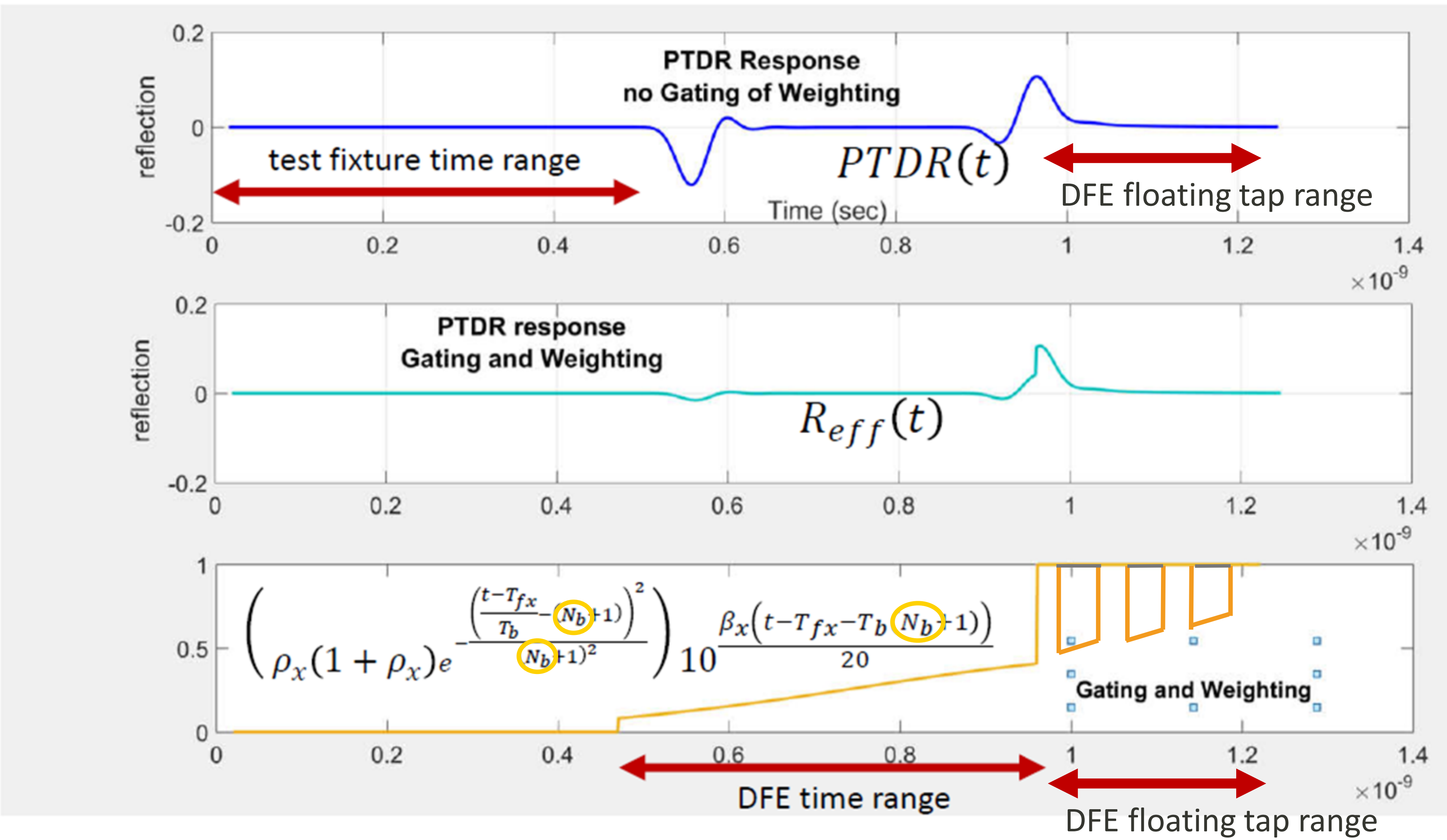
ERL Cable of Floating Tap – Procedure

ERL Cable of Floating Tap – Procedure

- Set $\boldsymbol{N_{bx}}$=$\boldsymbol{N_f}$ for $G_{rr}(t)$ & $G_{loss}(t)$
- Decide the locations of DFE floating tap
  - Follow similar procedure in 93A.1.6 & 93A.1.6.1 in 802.3ck D1p0
  - Apply $\boldsymbol{PDTR(t)}$, instead of $b(n)$
- Modify $G_{rr}(t)$ by considering floating tap
  - Set ${G_{rr}}^{(0)}(t) = G_{rr}(t)$
  - Set $G_{rr}(t)$ as below (93A-61a)
    - $$G_{rr}(t) = \begin{cases} 0 & t < T_{fx} \\ 1 & T_{fx} \le t < T_{fx} + \frac{N_f+1}{f_b} \\ 1 & t \ge T_{fx} + \frac{N_f+1}{f_b} \end{cases}$$
  - For locations covered by DFE, including fixed and floating taps, set $G_{rr}(t) = {G_{rr}}^{(0)}(t)$

ERL Cable of Floating Tap – Demo

Effective reflection waveform, $R_{eff}(t)$, is used to compute ERL



Source: mellitz_3cd_01_0118

Proposal

- Adopt the procedures in slide 12 for **DFE floating tap ERL calculations**
  - KR & CR

- Next steps…
  - **Modify COM code**
  - **Correlation analysis**

MEDIATEK

everyday genius