Floating Tap Incorporation Proposal for Annex 93A

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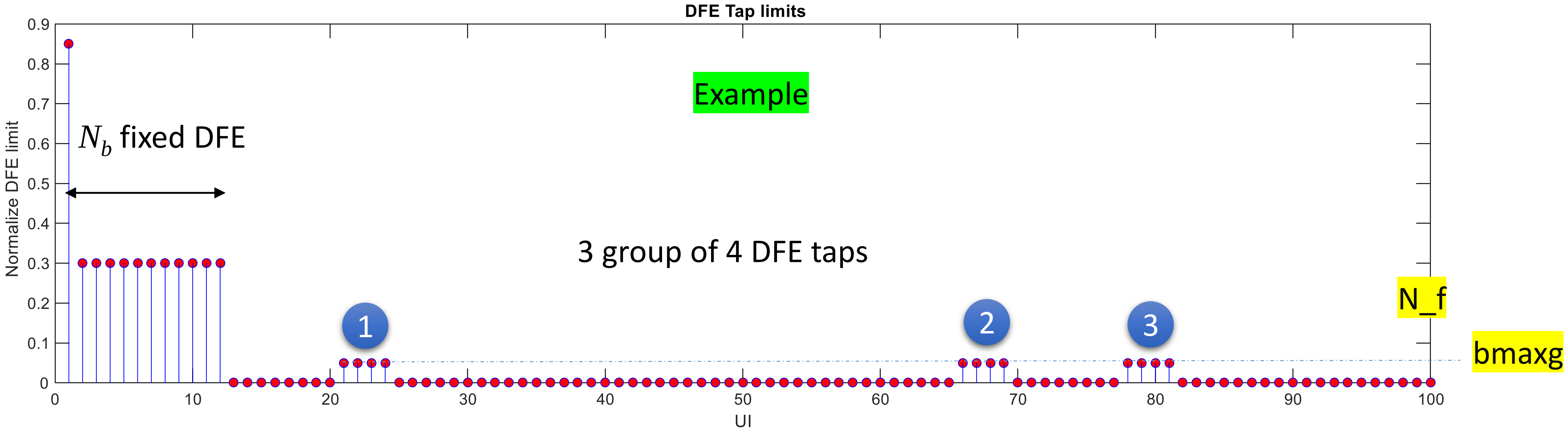
Problem

- Many channels have significant, but deterministic, ISI at timing locations outside of the temporal reach of a fixed tap DFE.

Introduction to Parameters for Floating Tap and Example Values

Floating Tap Parameters in spreadsheet	Example Value	Information
N_bg	3	0, 1, 2 … N_{bg} groups
N_bf	4	taps per group (UI)
N_f	100	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps

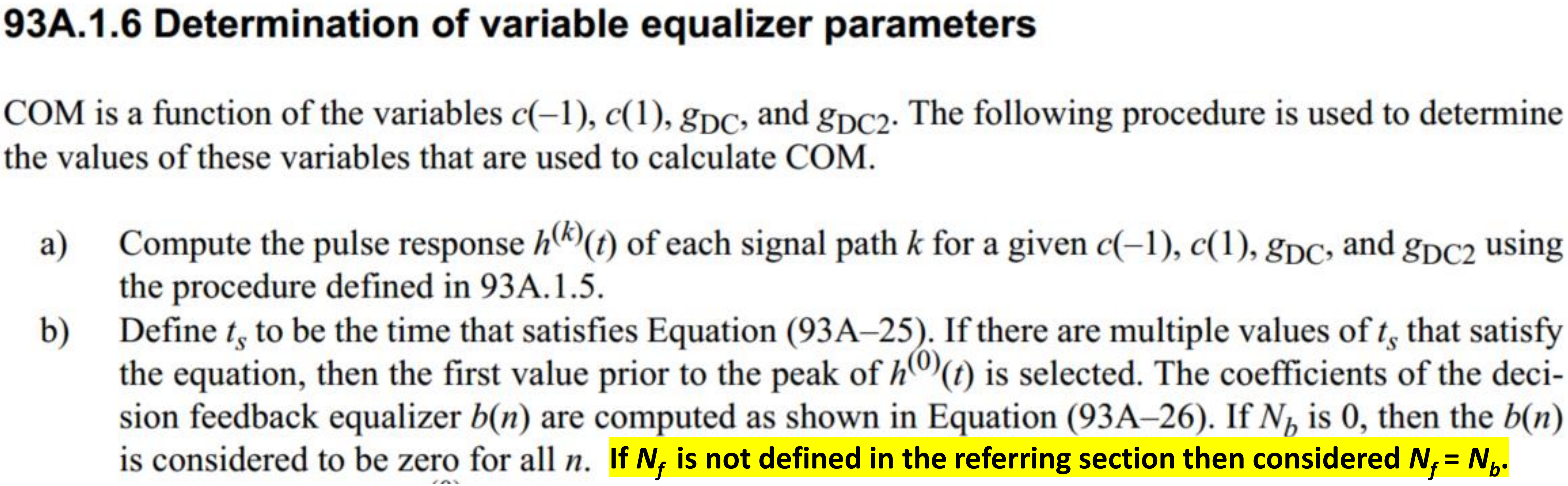


Annex 93A Change Overview

Implementation of floating DFE taps in Annex 93A

- ☐ Add a few parameters which represent aspects of floating taps in a DFE
- ☐ Small change to equation 93A-27
- ☐ Add a few lines describing how to determine the location of the floating DFE taps in 93A.1.6
  - Based on the few added parameters
- ☐ Referring section calls out these parameters

Add parameter N_f which is the total reach of the DFE including floating taps



93A.1.6 Determination of variable equalizer parameters

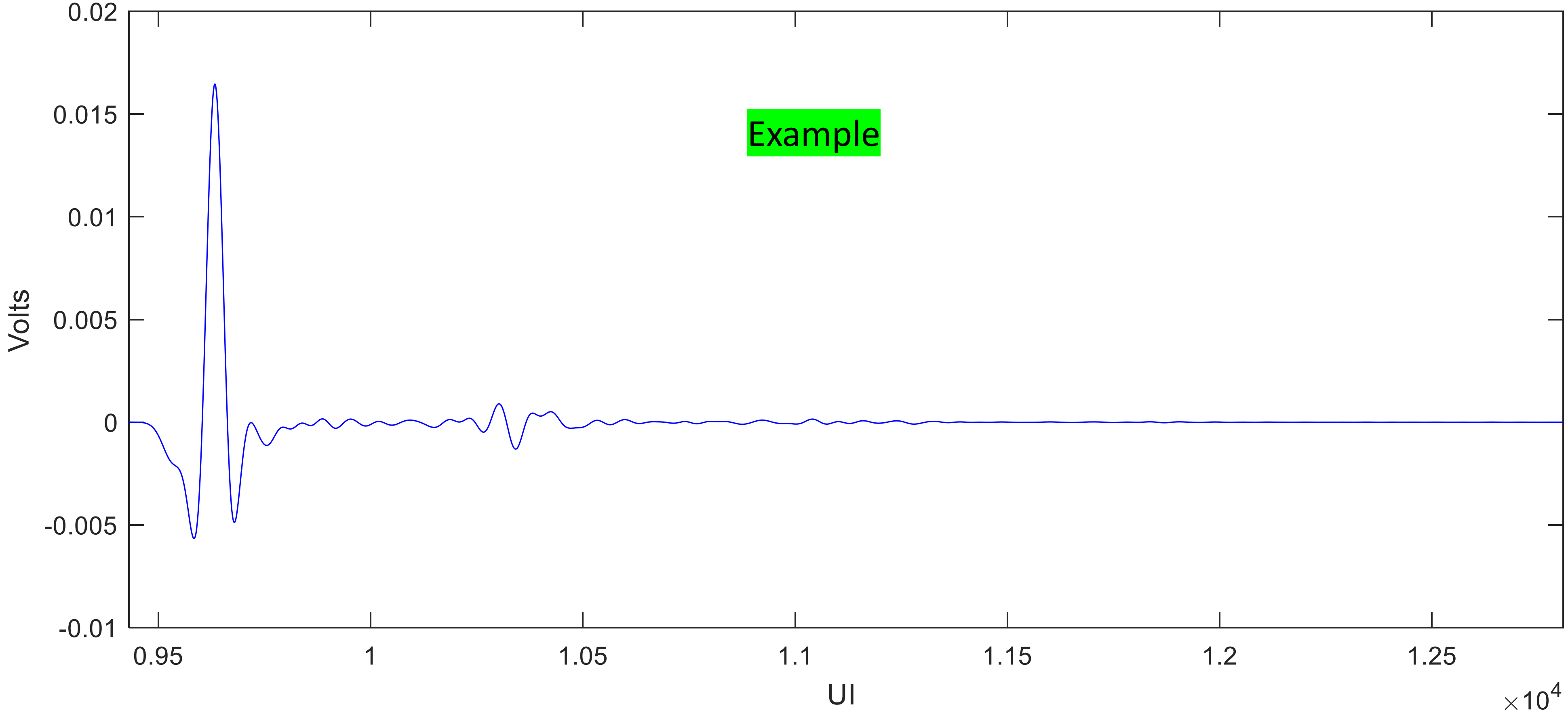
COM is a function of the variables $c(-1)$, $c(1)$, g_{DC}, and g_{DC2}. The following procedure is used to determine the values of these variables that are used to calculate COM.

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

b) Define t_s to be the time that satisfies Equation (93A–25). If there are multiple values of t_s that satisfy the equation, then the first value prior to the peak of $h^{(0)}(t)$ is selected. The coefficients of the decision feedback equalizer $b(n)$ are computed as shown in Equation (93A–26). If N_b is 0, then the $b(n)$ is considered to be zero for all n. **If N_f is not defined in the referring section then considered $N_f = N_b$.**

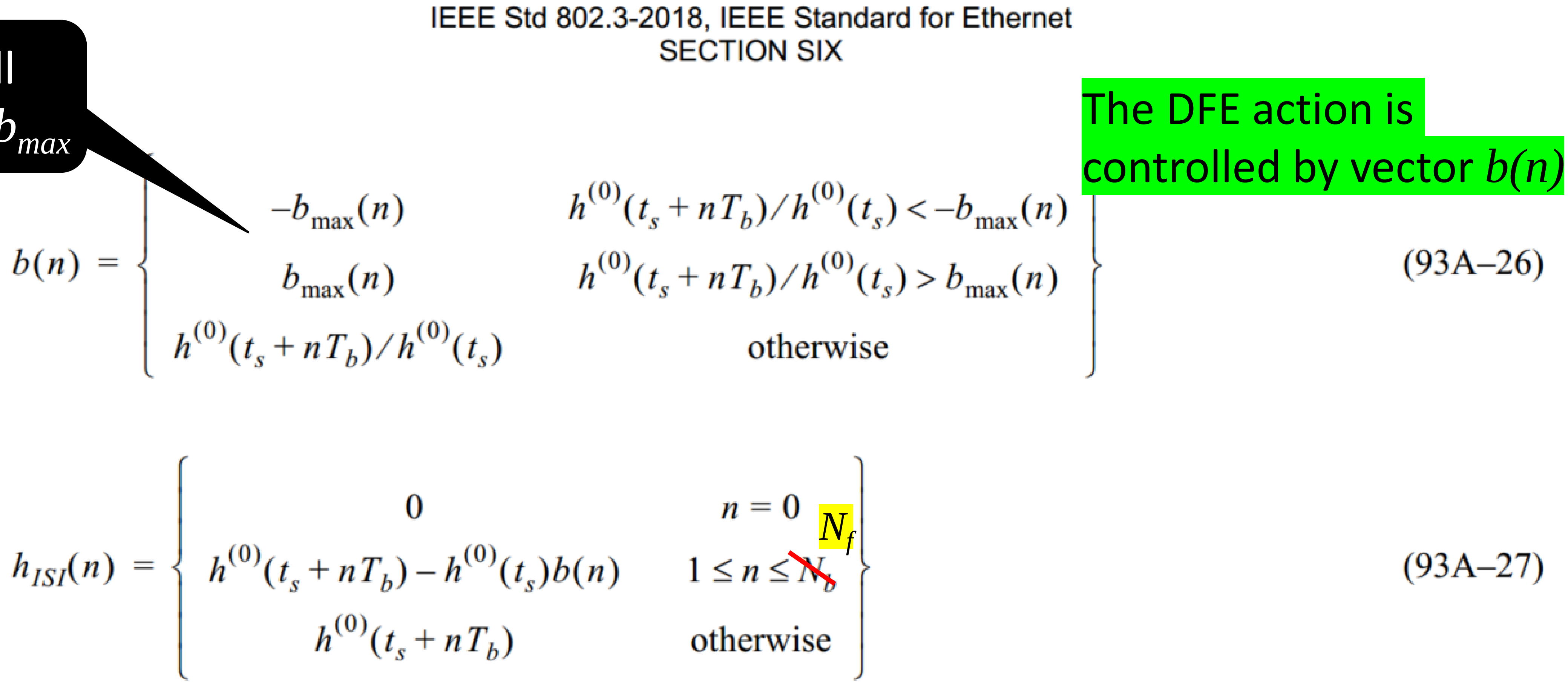
$h^{(0)}(t)$ is the Pulse Response, PR (Reference Background)

- ❑ With all the linear filters applied



Adjust h_{isi} equation 93A-27

We will leverage b_{max}



IEEE Std 802.3-2018, IEEE Standard for Ethernet
SECTION SIX

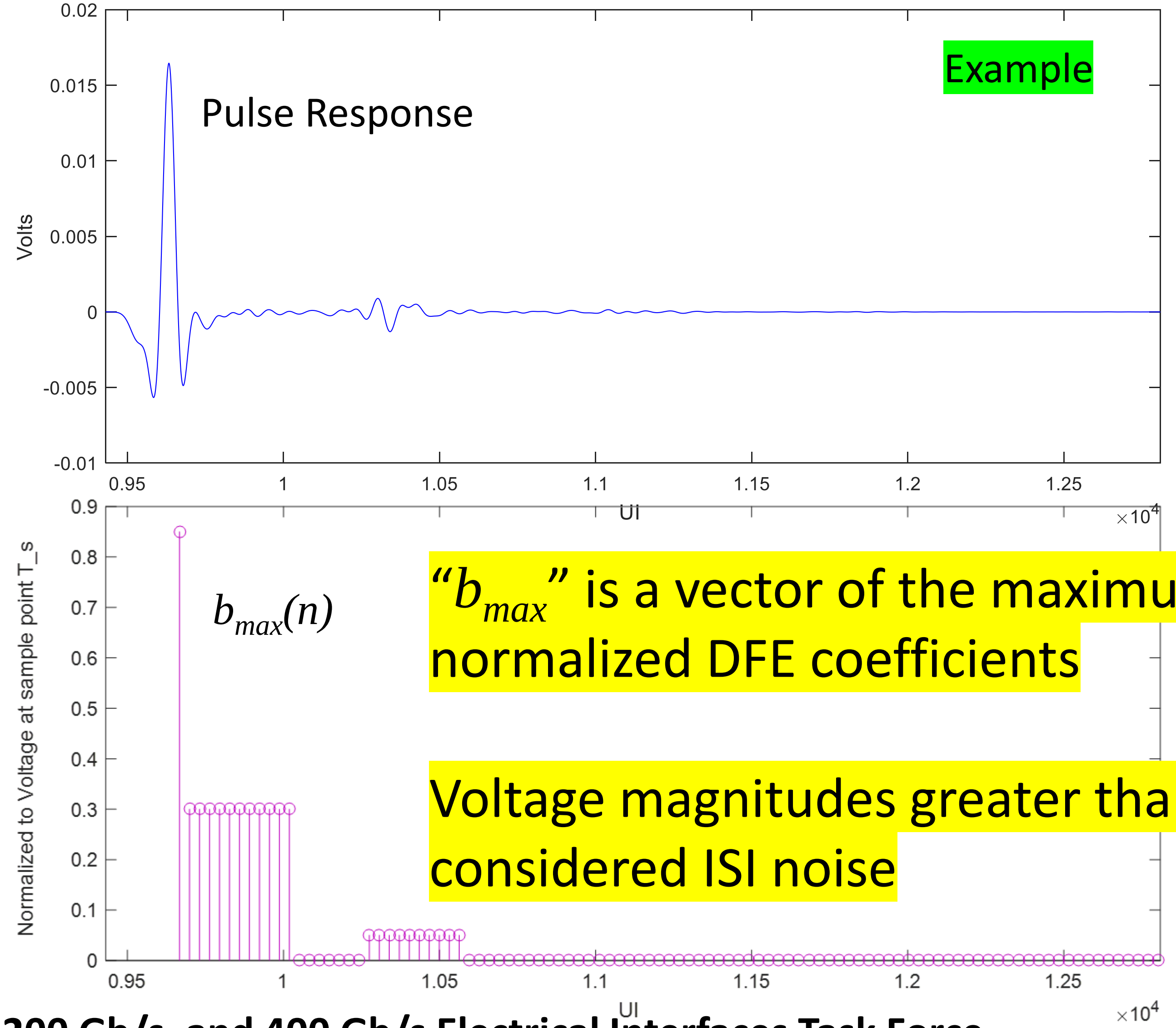
The DFE action is controlled by vector $b(n)$

$$b(n) = \begin{cases} -b_{\max}(n) & h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) < -b_{\max}(n) \\ b_{\max}(n) & h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) > b_{\max}(n) \\ h^{(0)}(t_s + nT_b)/h^{(0)}(t_s) & \text{otherwise} \end{cases} \qquad (93A\text{–}26)$$

$$h_{ISI}(n) = \begin{cases} 0 & n = 0 \\ h^{(0)}(t_s + nT_b) - h^{(0)}(t_s)b(n) & 1 \le n \le \overset{N_f}{\cancel{N_b}} \\ h^{(0)}(t_s + nT_b) & \text{otherwise} \end{cases} \qquad (93A\text{–}27)$$

From here, $h_{isi}(n)$ is used to compute ISI noise for computing COM for every combination of linear filter settings

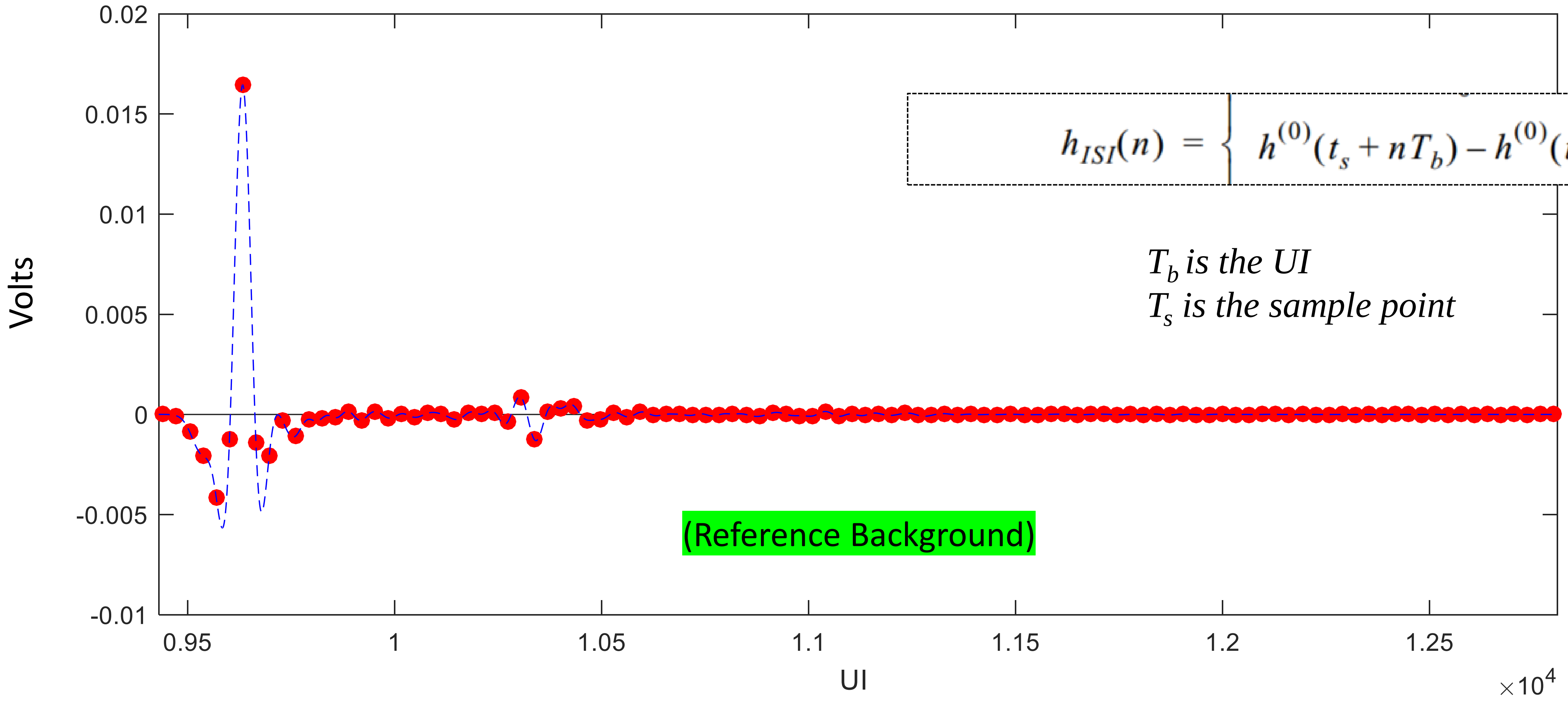
The “n” in $b_{max}(n)$ is in reference to the PR



“b_{max}” is a vector of the maximum allowable normalized DFE coefficients

Voltage magnitudes greater than “$bmax$” are considered ISI noise

$h^{(0)}(t_s + n\ T_b)$
is the sampled pulse response (red dots)



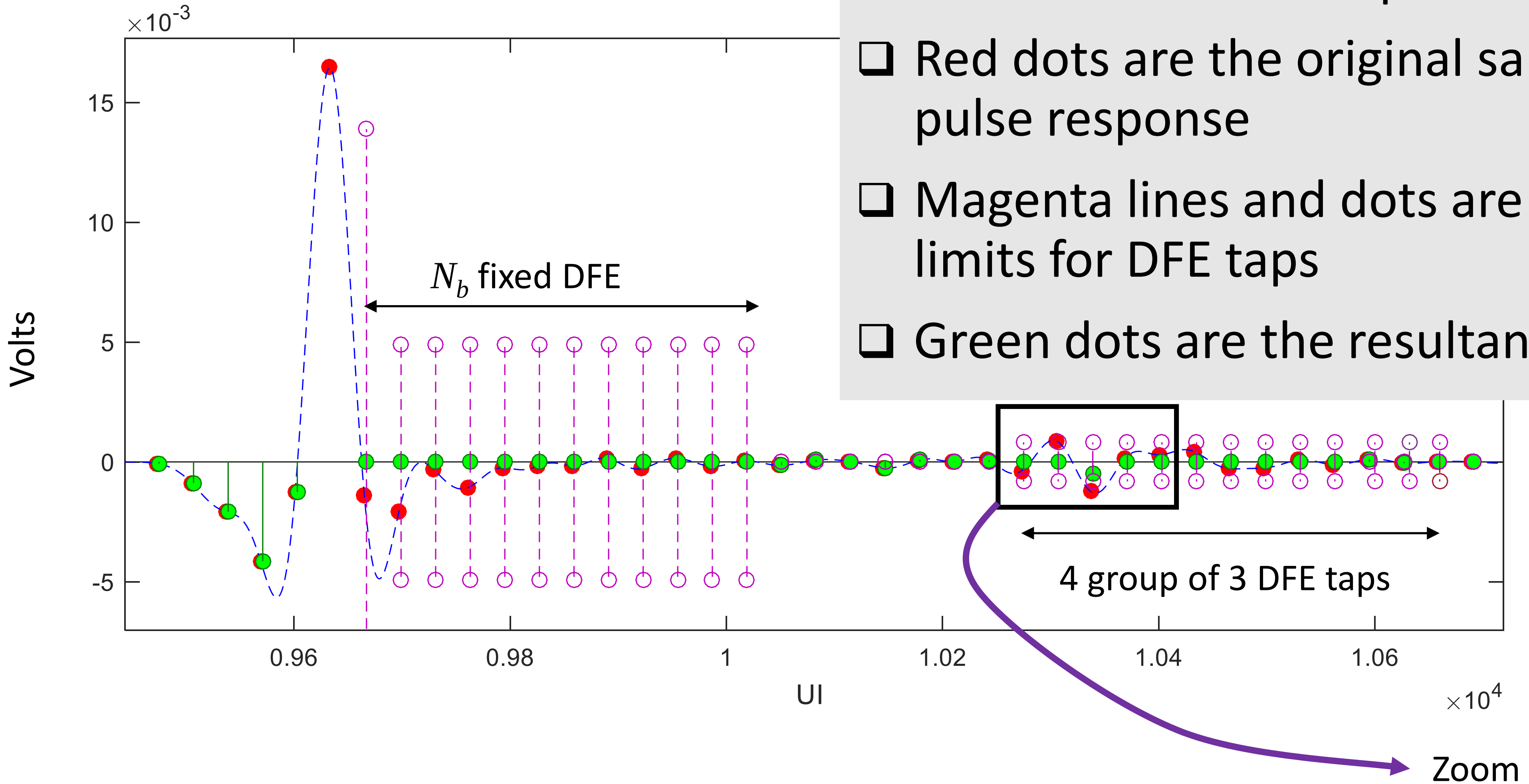
$$h_{ISI}(n) = \{ \ h^{(0)}(t_s + nT_b) - h^{(0)}(t_s)b(n)$$

T_b *is the UI*
T_s *is the sample point*

(Reference Background)

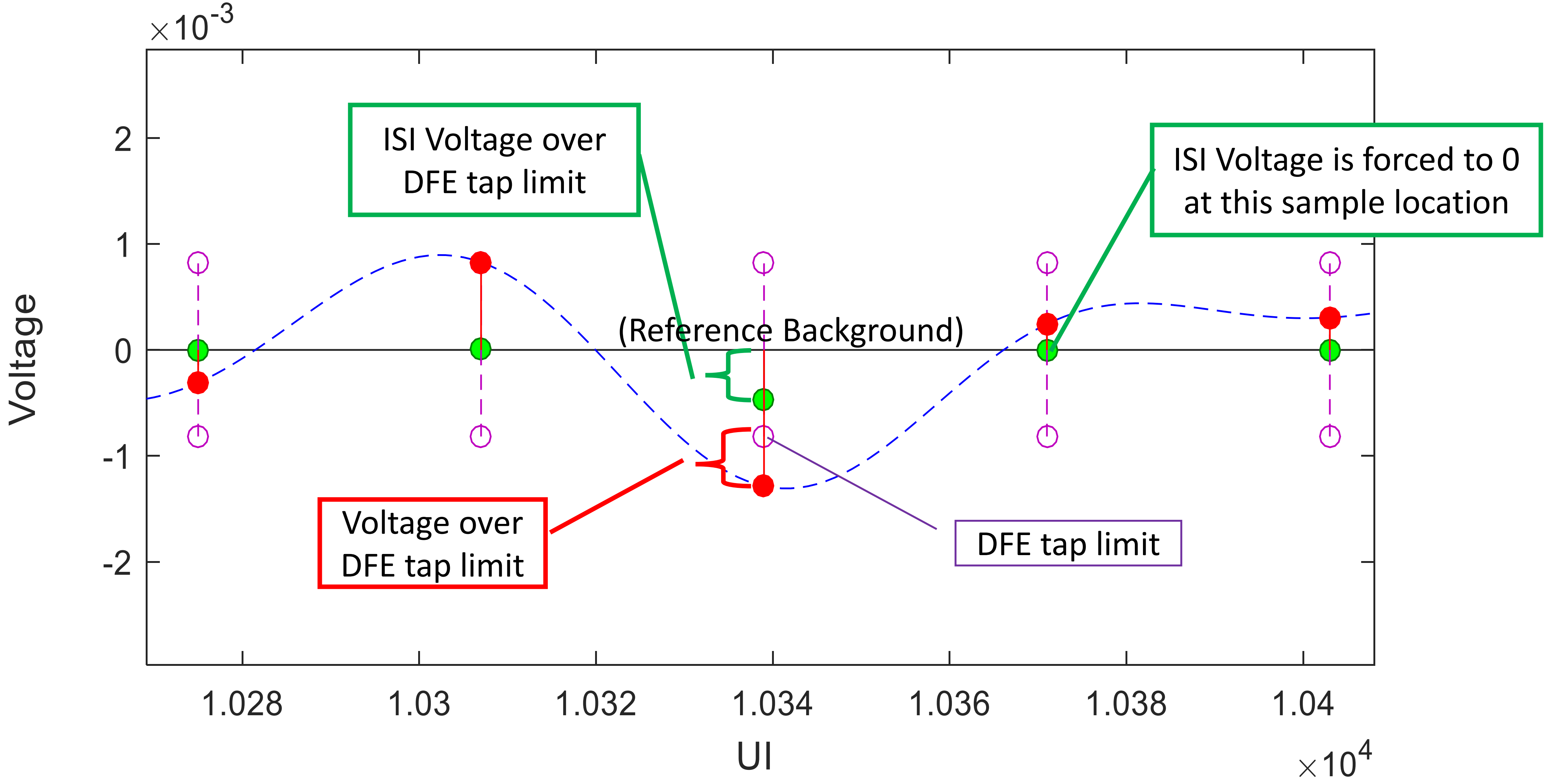
Example of 3 groups of 4 DFE taps

- Blue dashed is the equalize PR
- Red dots are the original sampled pulse response
- Magenta lines and dots are the limits for DFE taps
- Green dots are the resultant $h_{isi}(n)$



Zoom on next slide

Example of Residual ISI over the b_{max} limit (Reference Background)



ISI Voltage over DFE tap limit

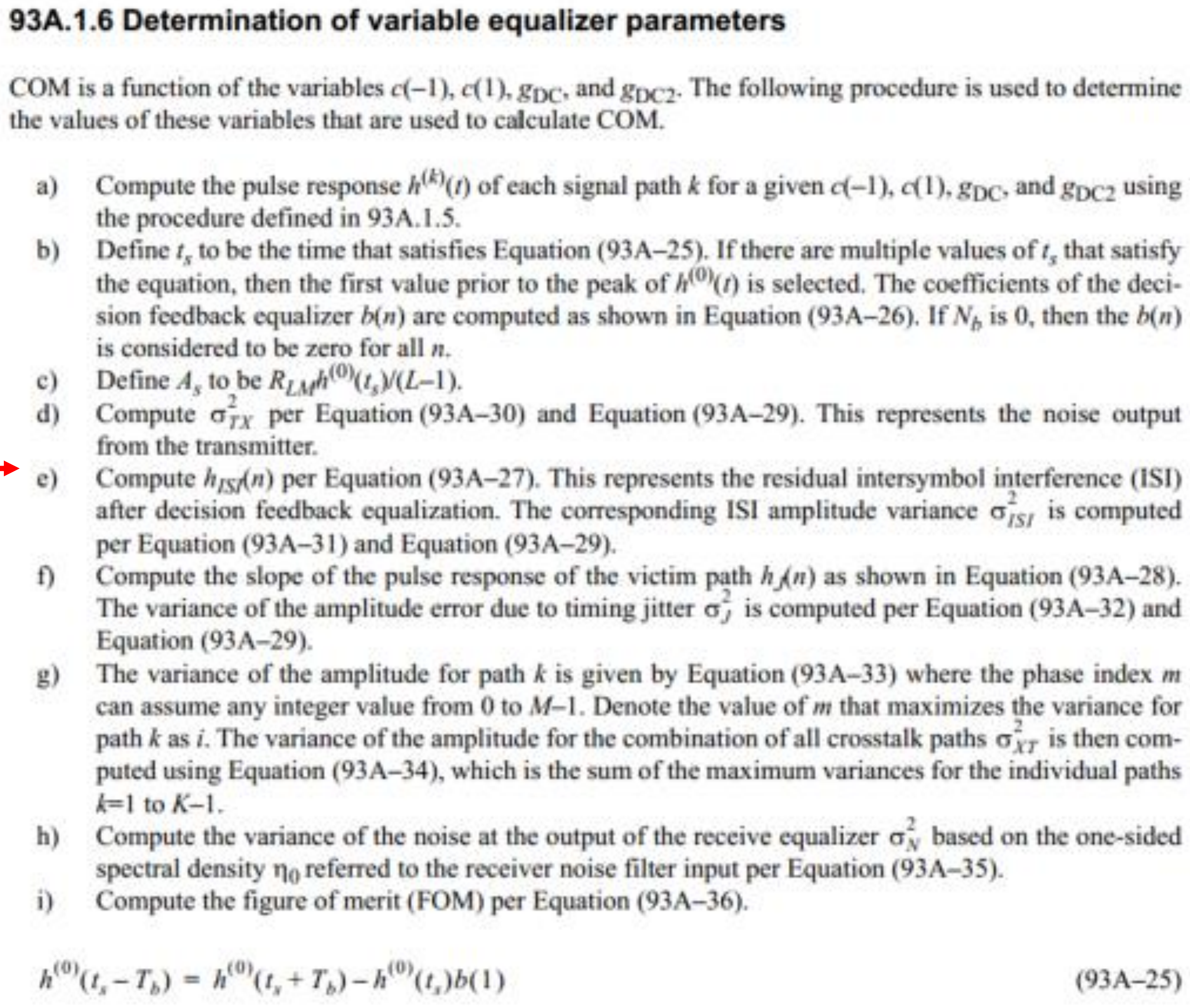
ISI Voltage is forced to 0 at this sample location

Voltage over DFE tap limit

DFE tap limit

Insert steps for adjusting $b_{max}(n)$ in 93A.1.6

Insert rules to determine $b_{max}(n)$ here



93A.1.6 Determination of variable equalizer parameters

COM is a function of the variables $c(-1)$, $c(1)$, 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 $c(-1)$, $c(1)$, g_{DC}, and g_{DC2} using the procedure defined in 93A.1.5.

b) Define t_s to be the time that satisfies Equation (93A–25). If there are multiple values of t_s that satisfy the equation, then the first value prior to the peak of $h^{(0)}(t)$ is selected. The coefficients of the decision feedback equalizer $b(n)$ are computed as shown in Equation (93A–26). If N_b is 0, then the $b(n)$ is considered to be zero for all n.

c) Define A_s to be $R_{LM}h^{(0)}(t_s)/(L-1)$.

d) Compute σ_{TX}^2 per Equation (93A–30) and Equation (93A–29). This represents the noise output from the transmitter.

e) Compute $h_{ISI}(n)$ per Equation (93A–27). This represents the residual intersymbol interference (ISI) after decision feedback equalization. The corresponding ISI amplitude variance σ_{ISI}^2 is computed per Equation (93A–31) and Equation (93A–29).

f) Compute the slope of the pulse response of the victim path $h_J(n)$ as shown in Equation (93A–28). The variance of the amplitude error due to timing jitter σ_J^2 is computed per Equation (93A–32) and Equation (93A–29).

g) The variance of the amplitude for path k is given by Equation (93A–33) where the phase index m can assume any integer value from 0 to $M-1$. Denote the value of m that maximizes the variance for path k as i. The variance of the amplitude for the combination of all crosstalk paths σ_{XT}^2 is then computed using Equation (93A–34), which is the sum of the maximum variances for the individual paths $k=1$ to $K-1$.

h) Compute the variance of the noise at the output of the receive equalizer σ_N^2 based on the one-sided spectral density η_0 referred to the receiver noise filter input per Equation (93A–35).

i) Compute the figure of merit (FOM) per Equation (93A–36).

$$h^{(0)}(t_s - T_b) = h^{(0)}(t_s + T_b) - h^{(0)}(t_s)b(1) \qquad (93A–25)$$

Rules for Floating Tap Determination of $b(n)$

$$h_{ISI}(n) = \begin{cases} 0 & n = 0 \\ h^{(0)}(t_s + nT_b) - h^{(0)}(t_s)b(n) & 1 \le n \le \overset{N_f}{\cancel{N_b}} \\ h^{(0)}(t_s + nT_b) & \text{otherwise} \end{cases}$$

$\xrightarrow{} h_{nf}(n)$

☐ Define post cursor ISI vector as $h_{nf}(n) = h_{ISI}(n),\ 1 \le n \le N_f$

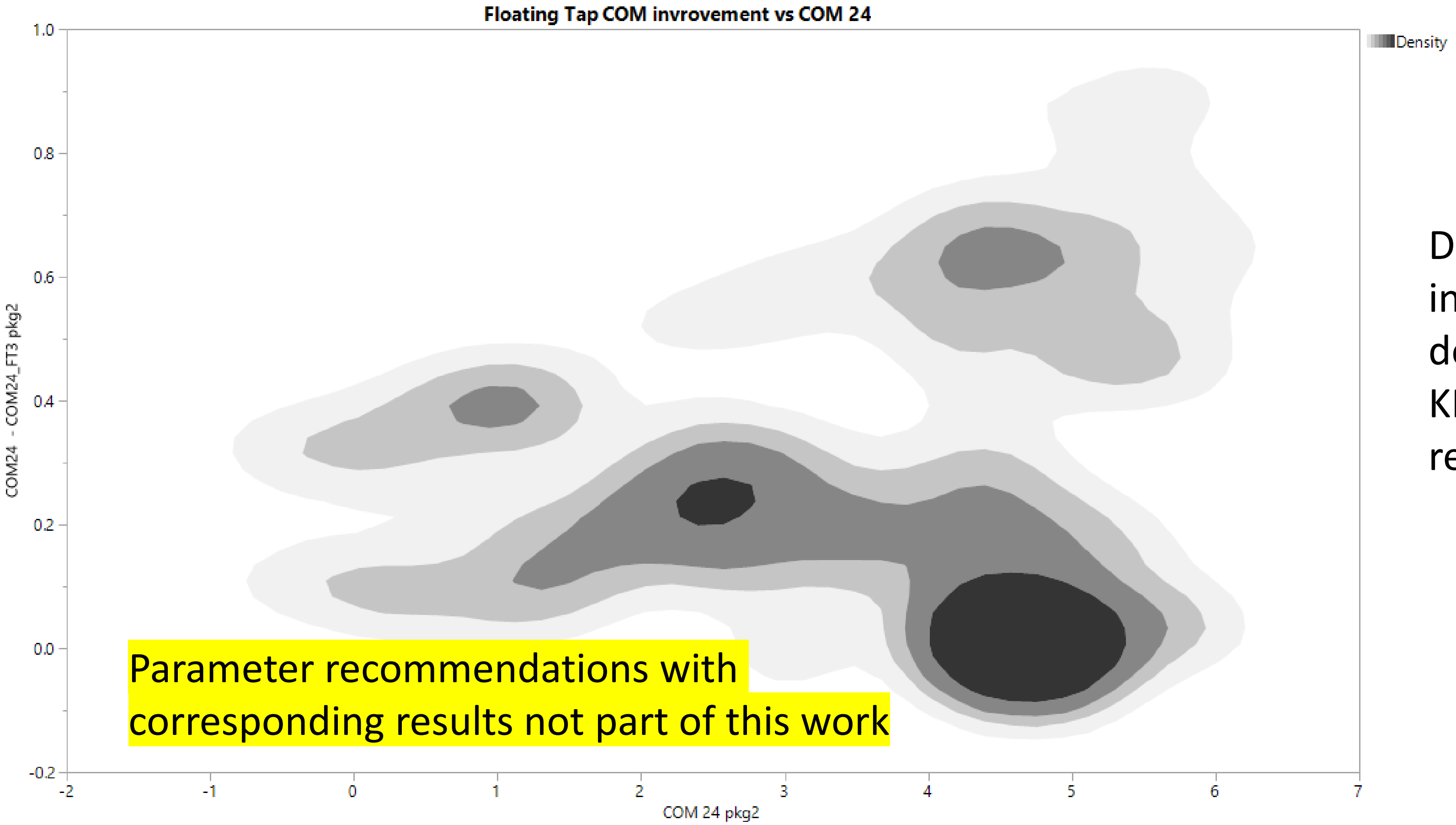
☐ $b(1 \ldots N_b)$ *is* as specified in referring section *(no change from prior)*

Determine the location of non-zero $b(n)$ corresponding to each of N_{bg} groups

1. Initially *set* $b(N_b+1 \ldots N_f) = 0$
2. Determine the value for N_{gx} which "minimizes" the $\sum h_{nf}(n)^2$
   - Where $b(N_{gx} \ldots N_{gx}+N_{gf}) = b_{maxg}$ and $N_b+1 \le N_{gx} \le N_f - N_{gx}$
   - I.e. set b_{max} for all the taps in the group
3. Find N_{gx} for each of N_{bg} groups by repeating step 2 not including locations $N_{gx} \ldots N_{gx}+N_{gf}$

Floating taps can improve COM up to to ½ dB compared to channels with DFE24 (fixed) COM which are near 3 dB

COM Floating Tap improvement (dB)
Tap 12 fixed, 3 groups of 4 taps



Parameter recommendations with corresponding results not part of this work

COM using 24 fixed tap (dB)

Darker contours indicates population density of the 118 KR channels in the region

Summary

- ❑ Floating can be added to Annex 93A (COM)
- ❑ Only a few simple alterations to Annex 93A (COM) are required to implement floating DFE taps.
- ❑ Referring sections need only to specify 4 parameters, N_{bg}, N_{bf}, N_f and b_{maxg}

Thank You!