

Trying to understand TDECQ

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The issue

During the January Interim meeting of 802.3cu, “TDECQ-10logCeq” was removed from the transmitter specs:

- Having the effect of increasing the potential range of compliant transmitters

However “SECQ-10LogCeq” was not removed from the receiver specs:

- Meaning that receivers are only required to operate with (and be tested against) a more restricted range of transmitters

This means that in D2.0 we introduced a potential interoperability gap (where a fully compliant transmitter and a fully compliant receiver might not interoperate).

There are two ways to address this:

- Reinstate “TDECQ-10LogCeq” on the transmitter
- Remove “SECQ-10LogCeq” from the receiver

TDECQ Overview

TDECQ can be viewed as a component penalty comprising the sum of two individual penalties*:

$$\text{TDECQ} = K + C$$

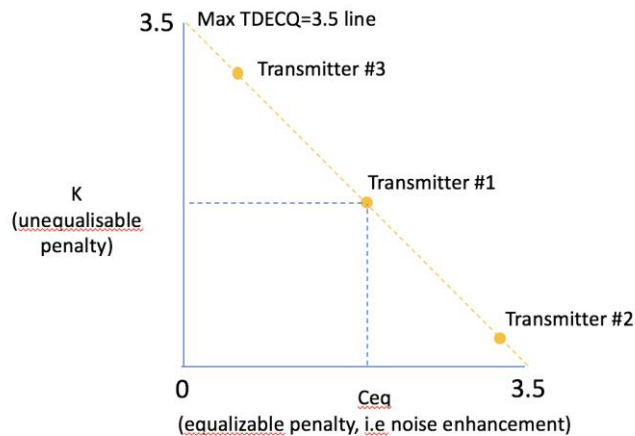
K =unequalizable penalty (penalty from impairments on the link that cannot be equalized, i.e. random noise)

C =equalizer penalty (penalty introduced by the equalizer itself, often called “noise enhancement”, and the harder the equalizer has to work to compensate for equalizable impairments on the link the higher the penalty)

$C=0$: equalizer is doing nothing

$C>1$: working as traditional linear equalizer (HPF), and the higher the number the harder it is working

$C<1$: probably atypical situation where the equalizer is really operating as a LPF (restricting bandwidth)

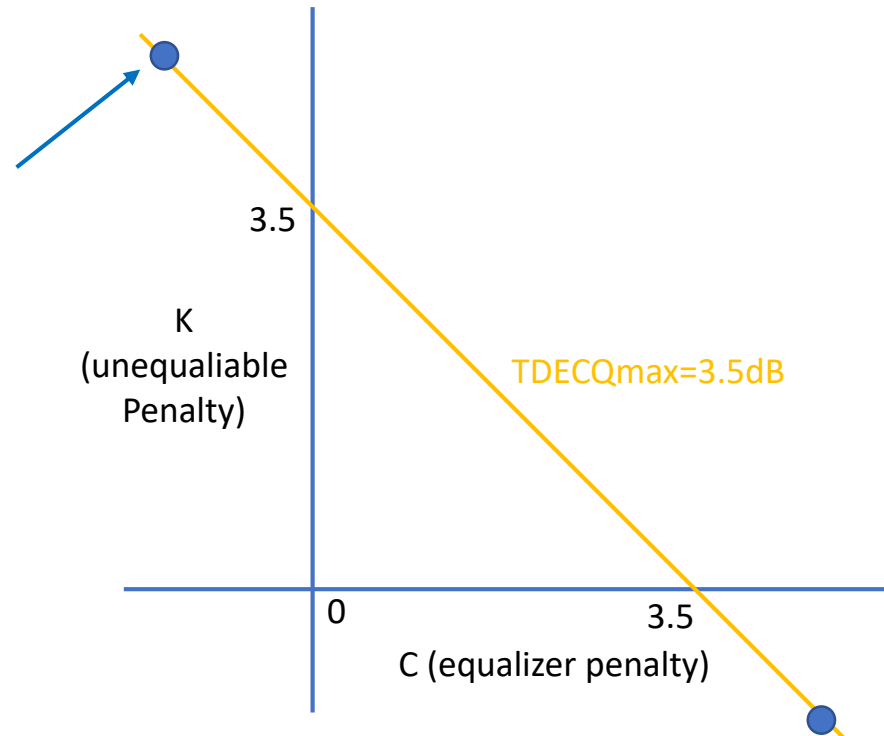


- TDECQ can therefore be plotted on a 2D graph as shown
- Transmitters #1,#2,#3 all have the same TDECQ value, but are very different.
- Transmitter #3 has a lot of unequalizable penalty
- Transmitter #2 has a lot of equalizable penalty
- A receiver has to work with all these transmitters
- A receiver therefore cannot be simply tested at a single TDECQ point

TDECQ as a point constraint ?

- A single TDECQ_{max} spec by itself itself does not constrain where on the TDECQ_{max} line that a given transmitter sits
- Therefore theoretically the range over which a receiver has to work is unbounded

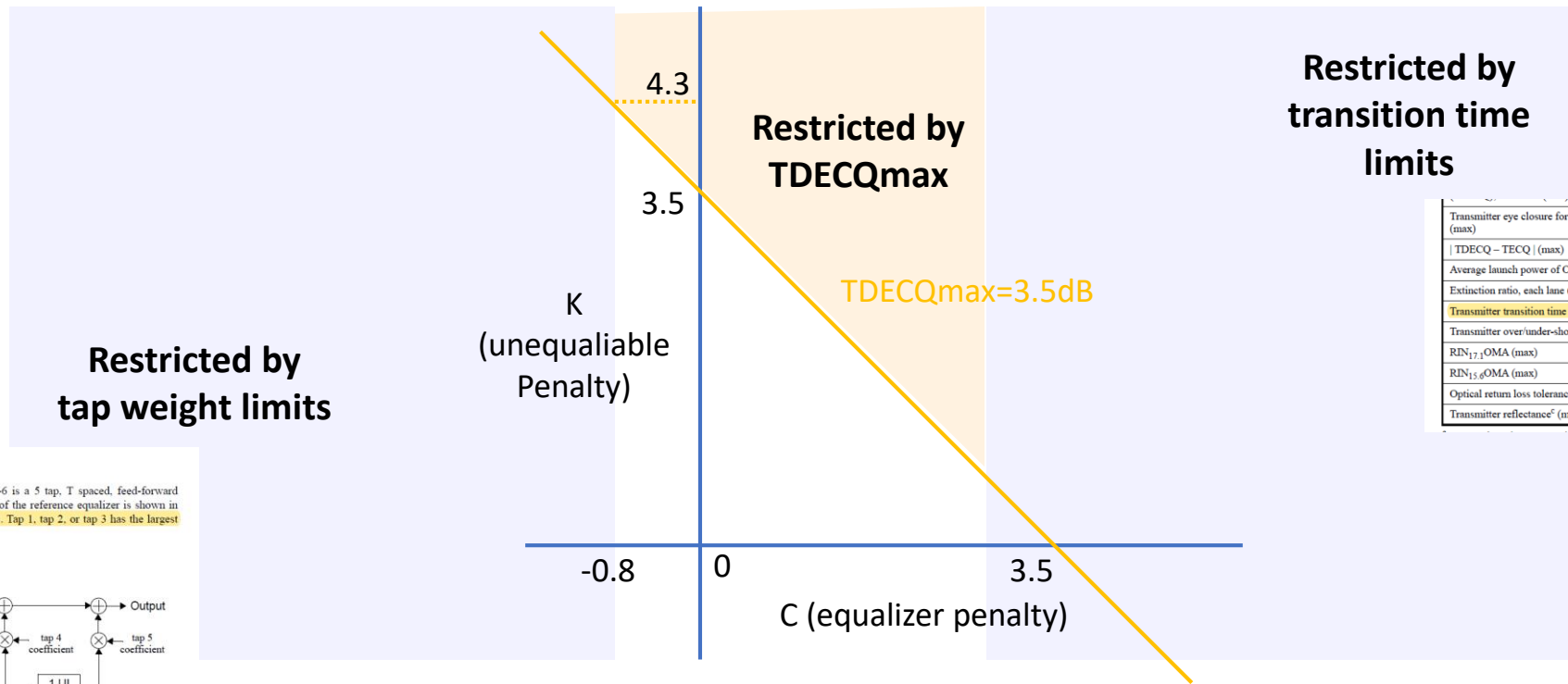
A transmitter could sit up here:
with $K \gg 3.5\text{dB}$
as long as $C \ll 0$



A transmitter could sit down here:
with $C \gg 3.5\text{dB}$
as long as $K \ll 0$

TDECQ – Additional constraints

- Additional constraints are necessary to bound the range over which a receiver has to operate
- These were added in 802.3cd (tap weight limits and transition time)



Transmitter eye closure for PAM4 (TECQ), each lane (max)	3.4	3.5	dB
TDECQ – TECQ (max)	2.5	2.5	dB
Average launch power of OFF transmitter, each lane (max)	-16	-16	dBm
Extinction ratio, each lane (min)	3.5	3.5	dB
Transmitter transition time (max)		17	ps
Transmitter over/under-shoot (max)	12	12	%
RIN _{17,1} OMA (max)	-136	—	dB/Hz
RN _{15,6} OMA (max)	—	-136	dB/Hz
Optical return loss tolerance (max)	17.1	15.6	dB
Transmitter reflectance ^c (max)		-26	dB

151.8.5.4 TDECQ reference equalizer

The reference equalizer for 400GBASE-FR4 and 400GBASE-LR4-6 is a 5 tap, T spaced, feed-forward equalizer (FFE), where T is the symbol period. A functional model of the reference equalizer is shown in Figure 151-5. The sum of the equalizer tap coefficients is equal to 1. Tap 1, tap 2, or tap 3 has the largest magnitude tap coefficient, which is constrained to be at least 0.8.

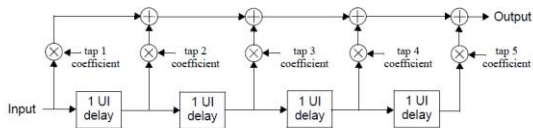
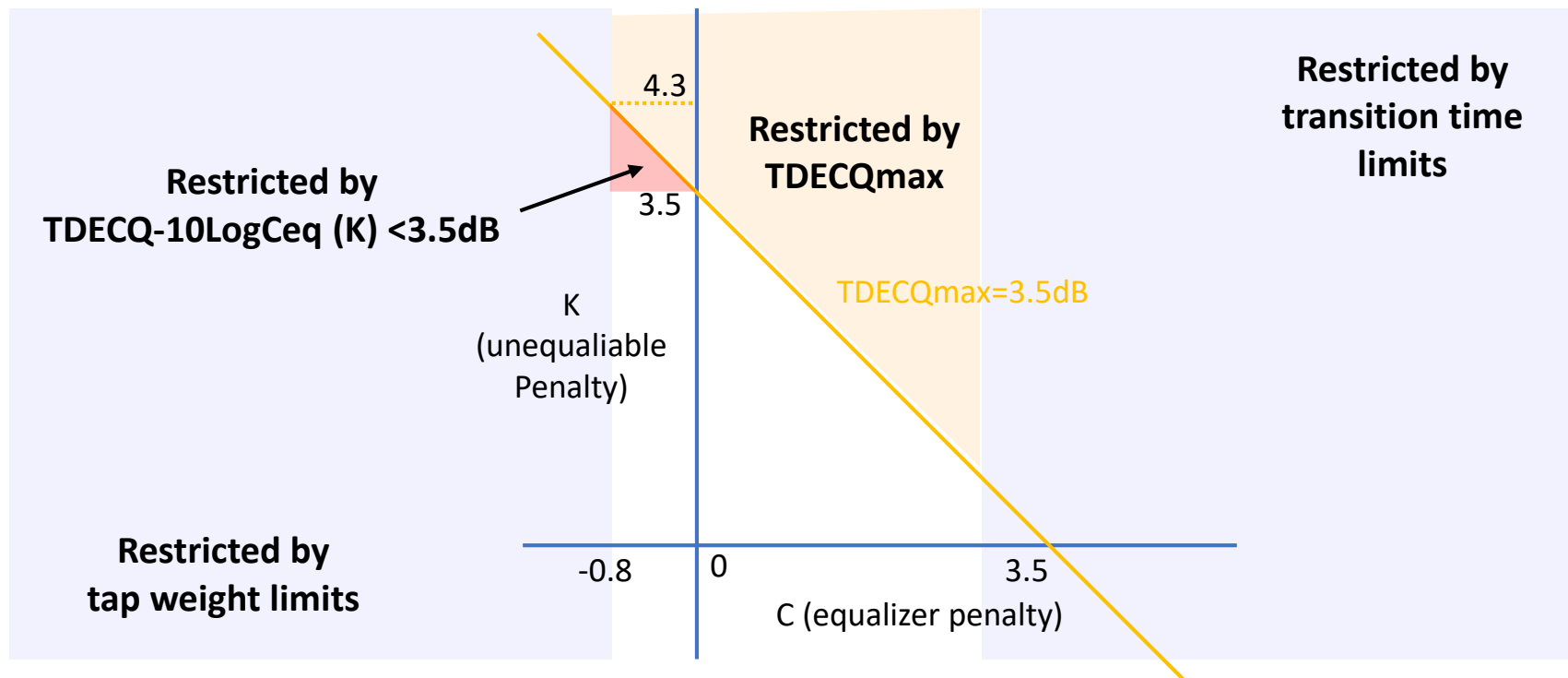


Figure 151-5—TDECQ reference equalizer functional model

TDECQ-10LogCeq

- An additional incremental constraint on transmitters (red shaded area) and hence range over which a receiver has to operate
- It essentially bounds the unequalizable penalty at 3.5dB rather than 4.3 dB

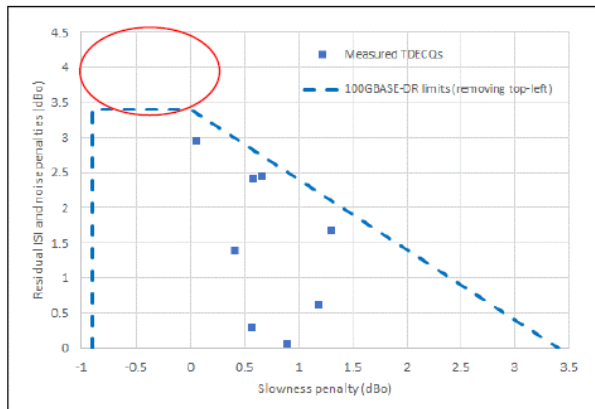


TDECQ-10LogCeq – why add this constraint?

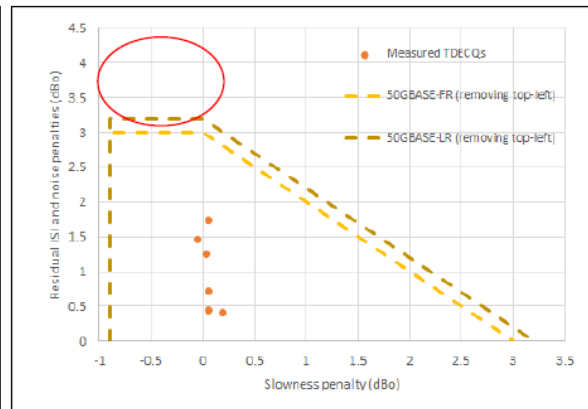
2. Constraining $TDECQ_{max}$ in upper left region

Propose to bound the top-left region by adding a limit equivalent to $TDECQ - 10 \cdot \log_{10}(Ceq)$

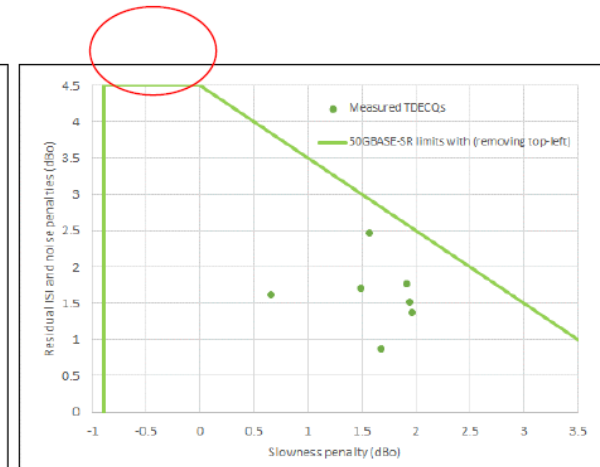
- Aligned with the proposed $TDECQ_{max}$ increase in previous slide
- Negligible impact to Tx yield



100GBASE-DR: limit to 3.4dB



50GBASE-FR: limit to 3dB
50GBASE-LR: limit to 3.2dB



50GBASE-SR, 100GBASE-SR2
and 200GBASE-SR4: limit to 4.5dB

Why add this constraint?

- Very difficult region to verify SRS compliance
- Adds additional equalizer power and design complexity to receiver
- Real transmitters not expected to be realizable in this region

Summary

Adding a TDECQ-10LogCeq (K) limit provides an incremental benefit (currently unquantified) to the receiver:

- further restricts the range over which a receiver has to operate and be tested
- simplifies SRS testing

Adding a TDECQ-10LogCeq (K) limit appears to have no impact on the transmitter:

- zero impact on yield (not expect to see any real transmitters in this region)
- zero impact on test time (since it falls out for free as part of the TDECQ test)

If these assumptions are correct then what is the downside ?

(Note: This presentation does not argue against the inclusion of a separate “overshoot” test)

Final thought ...

Now we can debate the absolute benefit of TDECQ-10LogCeq, but it is certainly not

