A tap-weight refinement to the KR (receive) Reference Equalizer Model

Athos Kasapi, Cadence

November 2019

802.3ck November Plenary Meeting, Hawaii USA

Contributors

- Upen Reddy Kareti (Cisco)

Supporters

- Ilya Lyubomirsky, Arash Farhoodfar (Inphi)
- Ali Ghiasi (Ghiasi Quantum)
- Piers Dawe (Mellanox)
- (more tbd)

Acknowledgments

- Ali Ghiasi
- Upen Reddy Kareti
- Piers Dawe

Outline

- Summary of the existing tap-weight constraints in the KR reference receiver model
- What do we see with the study group backplane channels?
- What does this mean for receiver equalizers?
- Proposal: normalized tail-weight constraint.

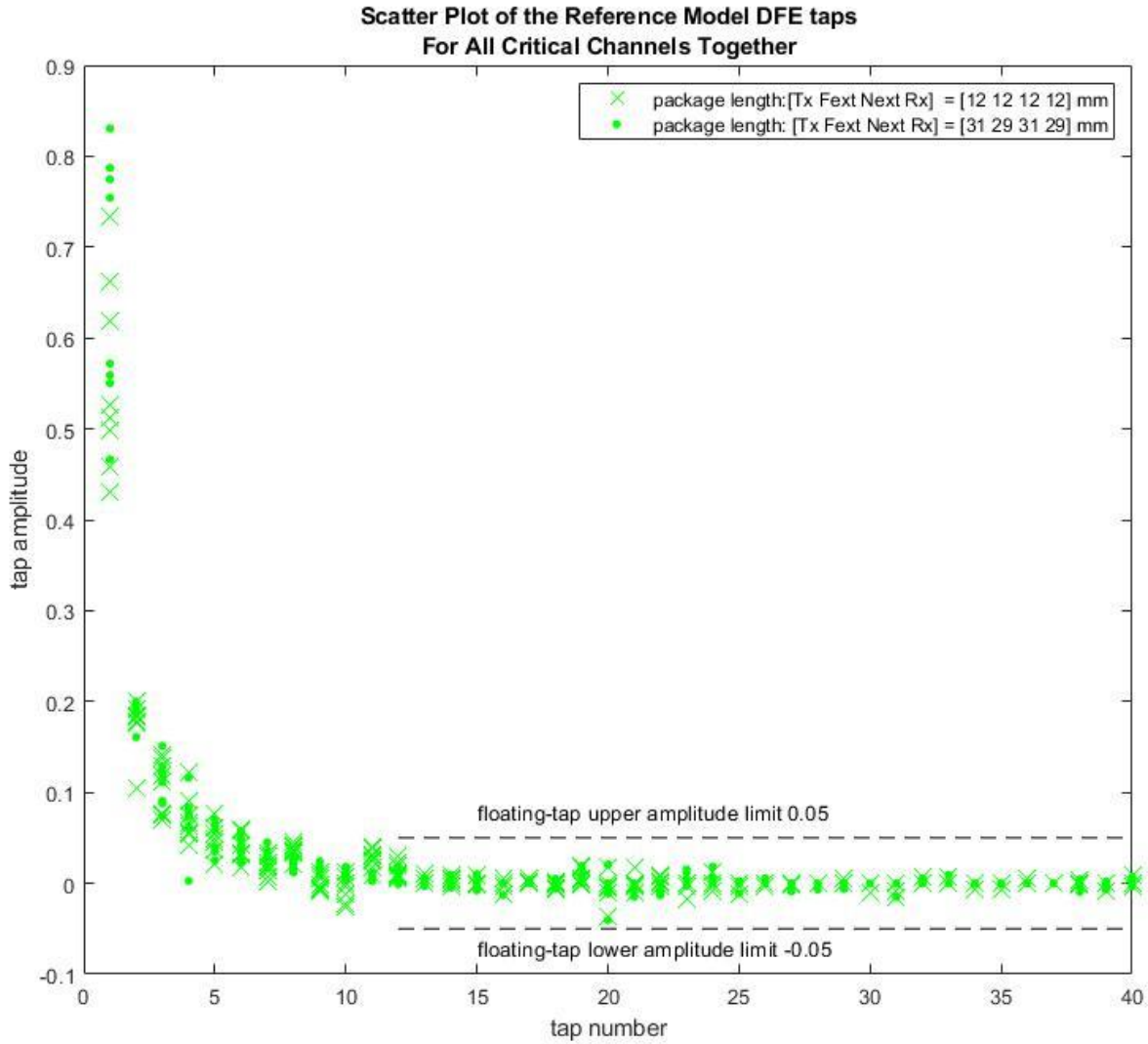
Summary of the existing tap-weight constraints in the KR reference receiver model

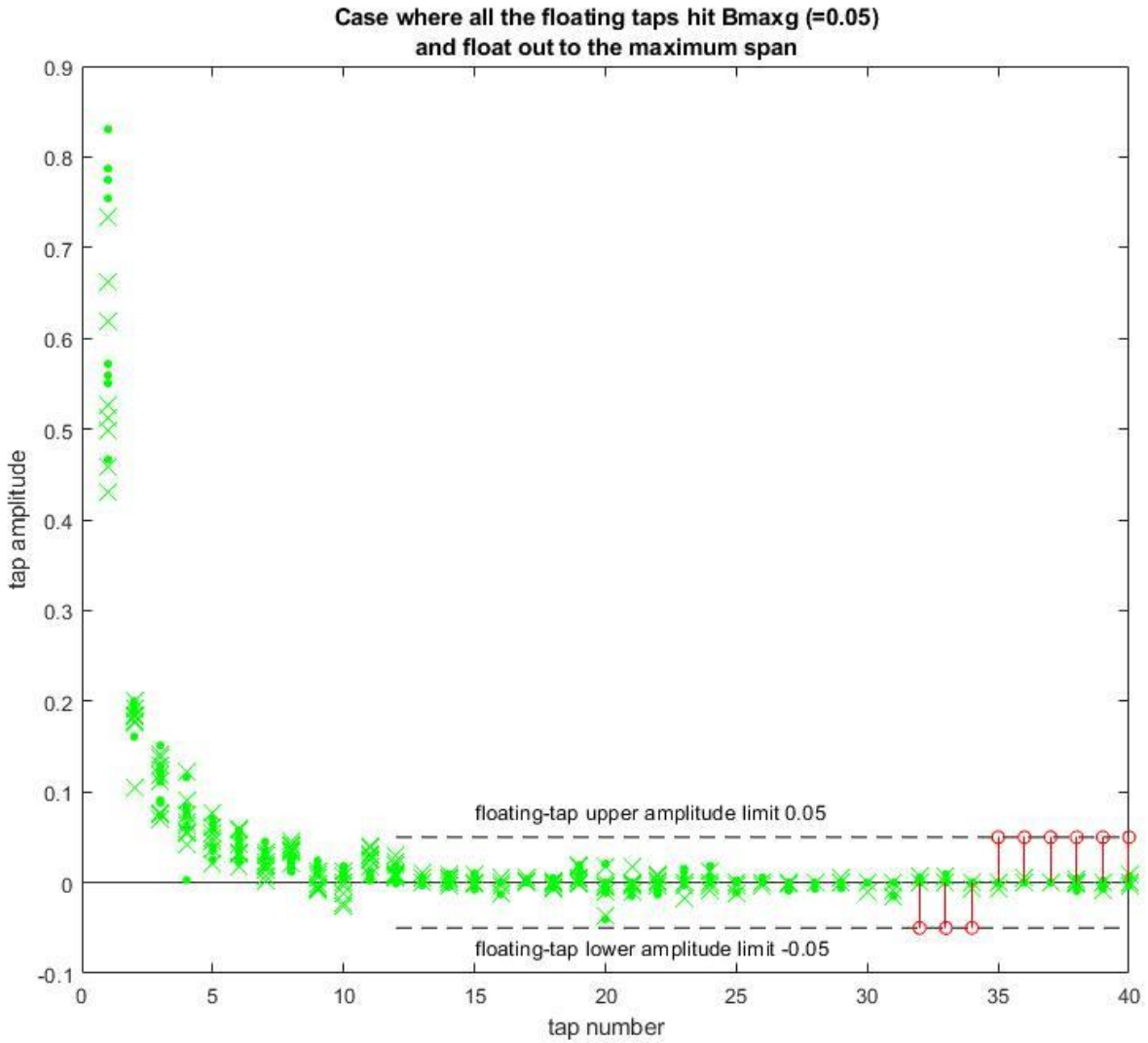
Parameter	Symbol	Value	Units
…			
Decision feedback equalizer (DFE) length	Nb	12	UI
Normalized DFE coefficient magnitude limit N=1 N=2 to Nb		 0.85 0.2	
Number of DFE floating tap groups	N_bg	3	
Number of DFE floating taps per group	N_bf	3	
UI span for floating taps	N_f	40	UI
Max DFE value for floating taps	Bmaxg	0.05	

What do we see with the study group backplane channels?

- First consider the ‘Critical’ channels (heck_3ck_01b_0719), using COM 2.75 and the parameter spreadsheet config_com_ieee8023_93a=3ck_KR_mellitz_01_100219.xls

	IL (dB)	Filename Group
Heck2	15.2	Cable_BKP_16dB_0p75m_more_isi
Mellitz1	26.3	CaBP_BGAVia_Opt2_28dB
Tracy1	15.7	Std_BP_12inch_Meg7
Tracy2	12.2	DPO_IL_12dB
Kareti1	27.7	OAch4
Kareti3	28.5	CAch3_b2
Kareti5	28.9	Bch2_b7p5_7
Heck3	29.0	Cable_BKP_28dB_0p75


Scatter Plot of the Reference Model DFE taps
For All Critical Channels Together
package length:[Tx Fext Next Rx] = [12 12 12 12] mm
package length: [Tx Fext Next Rx] = [31 29 31 29] mm
floating-tap upper amplitude limit 0.05
floating-tap lower amplitude limit -0.05
tap amplitude
tap number
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
5
10
15
20
25
30
35
40



Allowed Reference Equalizer Floating-taps – example of worst case.

Reference Equalizer Taps observed for all Critical Channels and both package options.

What does this mean for receiver equalizers?

- In order to support the allowable worst-case channels permitted by the present reference equalizer, receiver architectures will burn extra power in order to support the case where all the floating taps assume their maximum allowable magnitude (0.05) and float to the edge of the allowed 40-tap span.

Proposal: normalized tail-weight constraint.

- There are any number of ways to avoid the situation of many large tap weights piled at the back.

- From the SNR point-of-view, symbols outside of the equalizer span just generate noise, and they do it independently of each other.

  - The total noise generated by out-of-span symbols is approximately proportional to the RMS sum of their corresponding tap weights. :

$$\text{RSS\_tail}(n\_1, n\_2) \equiv \left(\sum_{k=n\_1}^{n\_2} c_k^2\right)^{1/2}$$

- The form of this constraint is essentially equivalent to $u_b(n_1, n_2)$ as defined in 93A.2 (a generalization of RSS_DFE4)

- This naturally applies to the reference model as the constraint:

  RSS_tail(n_1, n_2) < RSS_tail_max(n_1, n_2)

- What is an appropriate value of RSS_tail_max? A look at the critical channels yields the following…

Package length
[Tx, Fext, Next, Rx] =[12,12,12,12] mm

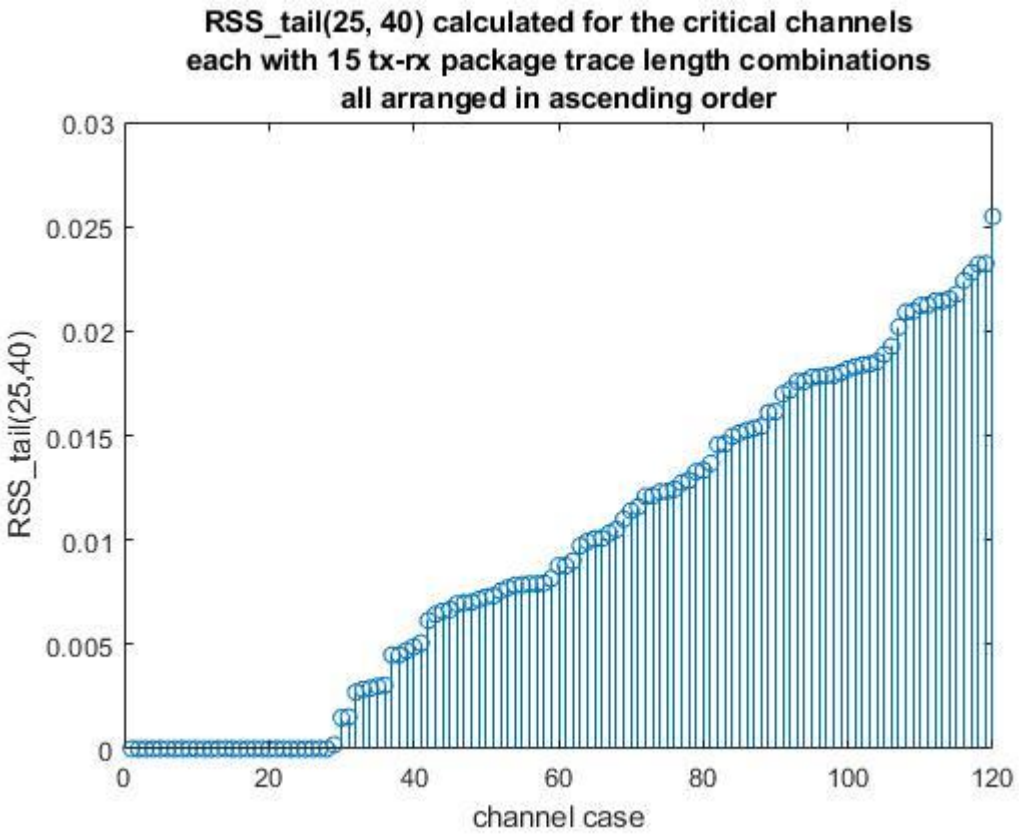
Channel	RSS_tail(25,40)
heck2	0.018
Heck3	0
Mellitz1	0.005
Tracy1	0.008
Tracy2	0.013
kareti1	0.022
kareti3	0
kareti5	0

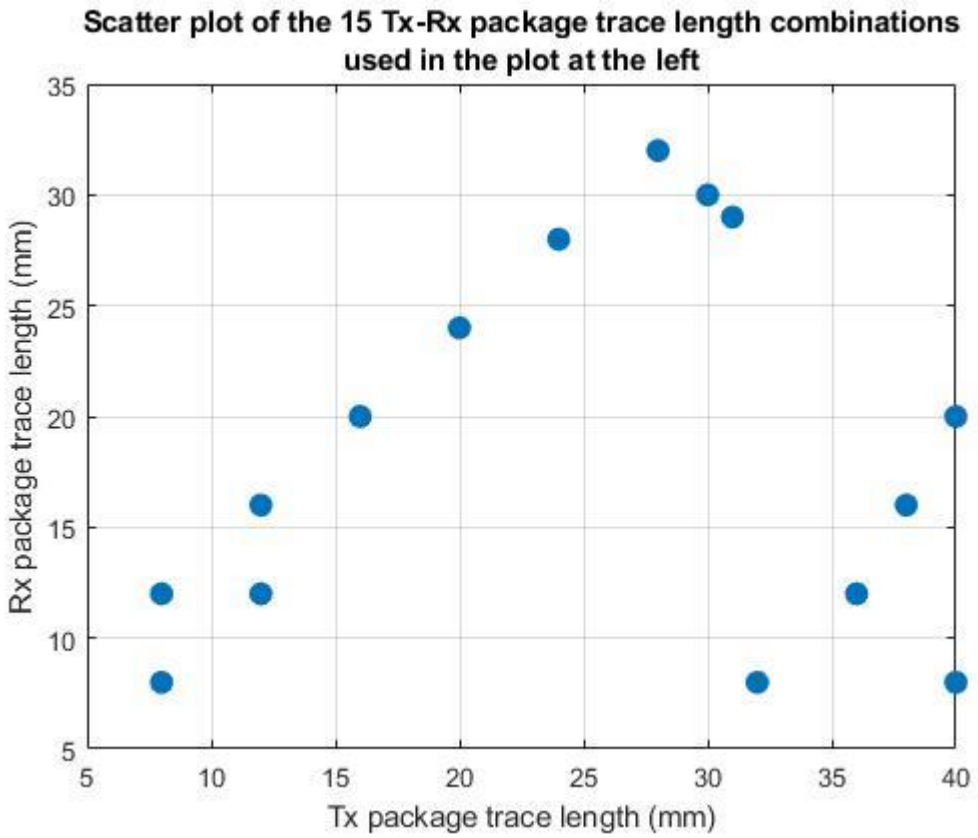
Package length
[Tx, Fext, Next, Rx] =[31,29,31,29] mm

Channel	RSS_tail(25,40)
heck2	0.009
Heck3	0
Mellitz1	0
Tracy1	0.008
Tracy2	0.012
kareti1	0.022
kareti3	0.003
kareti5	0.013

Maximum for RSS_tail shown in red

- A closer look at the critical channels, this time sweeping the Tx/Rx package trace lengths (underlying data contributed by U. Reddy Kareti):





For the critical channels swept over the 15 package lengths:

the largest observed value of RSS_tail(25,40) is 0.0255.

Note that according to the present reference equalizer model having 9 floating taps of magnitude up to 0.05, the largest allowed value of RSS_tail(25,40) is

sqrt(9) * 0.05 = 0.15

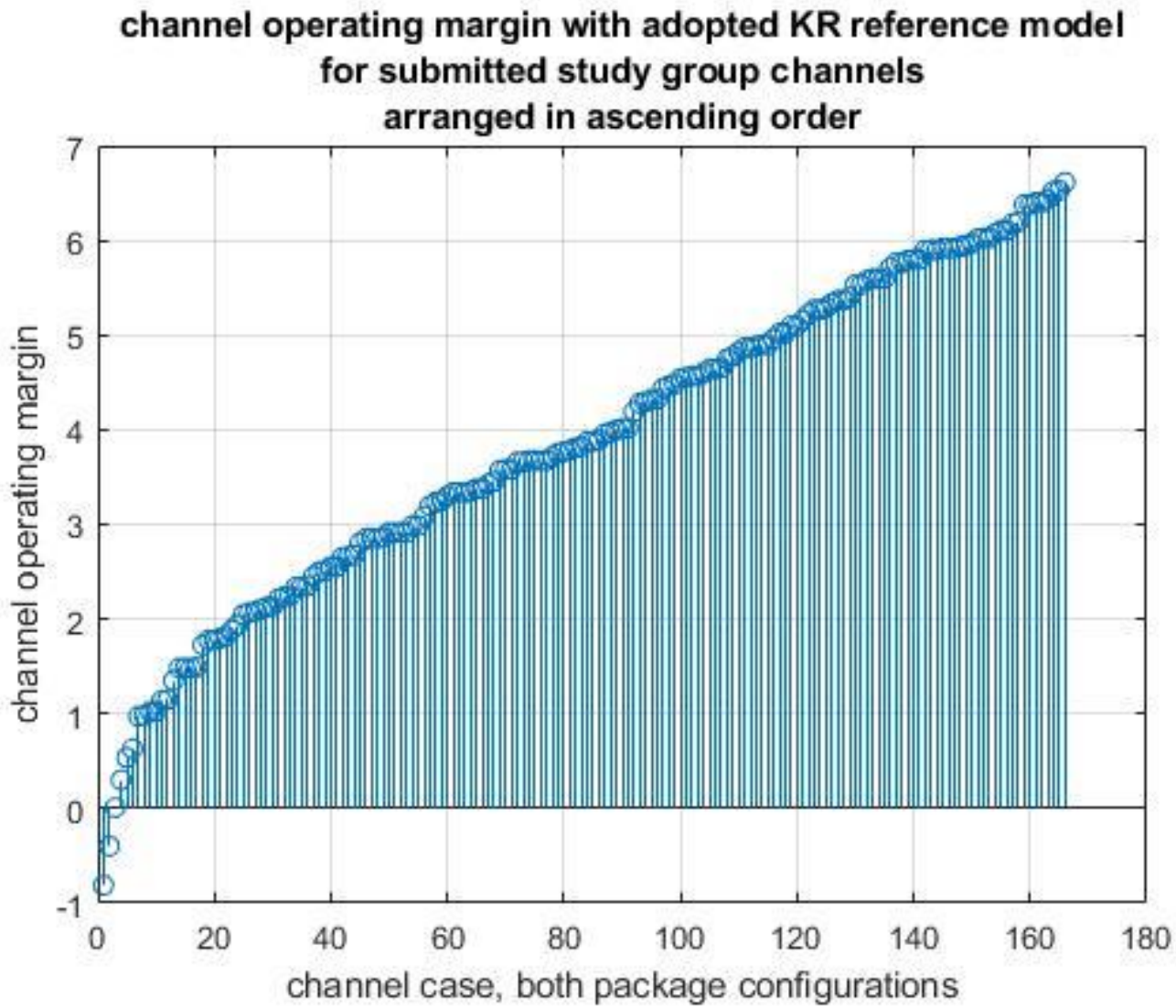
This is almost 6x what is actually needed to handle the critical channels and forces more complex/power-hungry equalizer architecture.

Results for the larger channel set

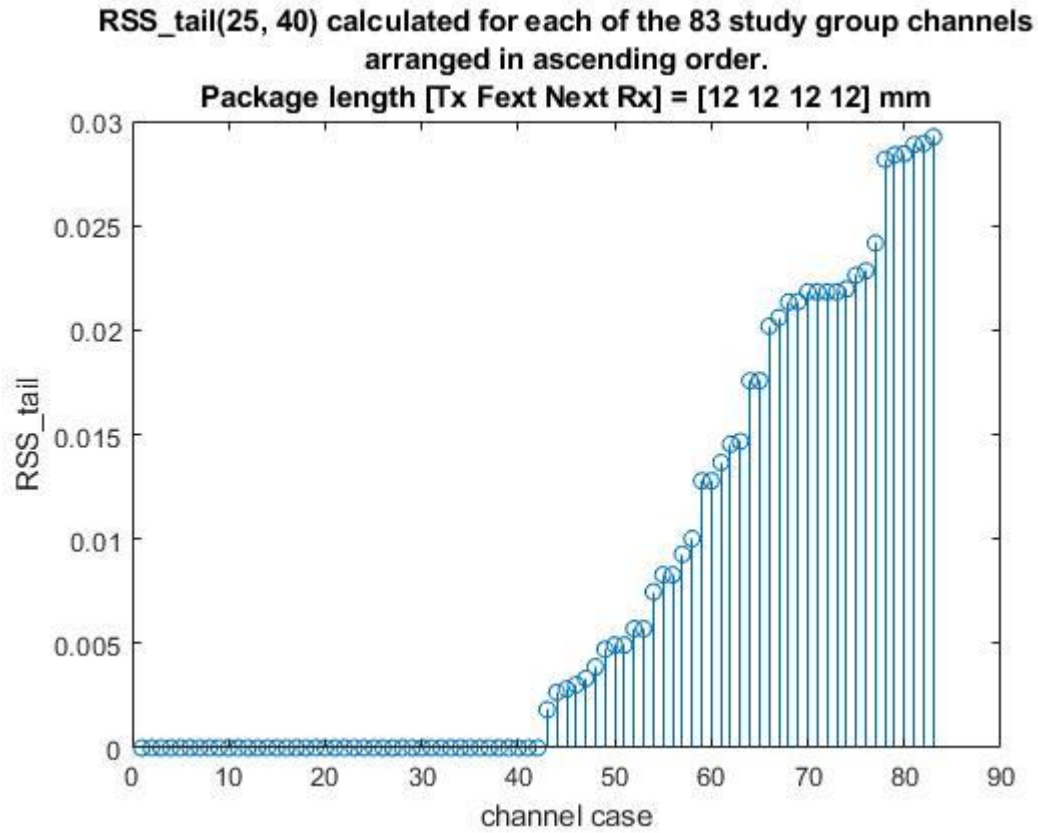
- The critical channels are a relatively small subset of the channels submitted to the 802.3ck backplane study group.

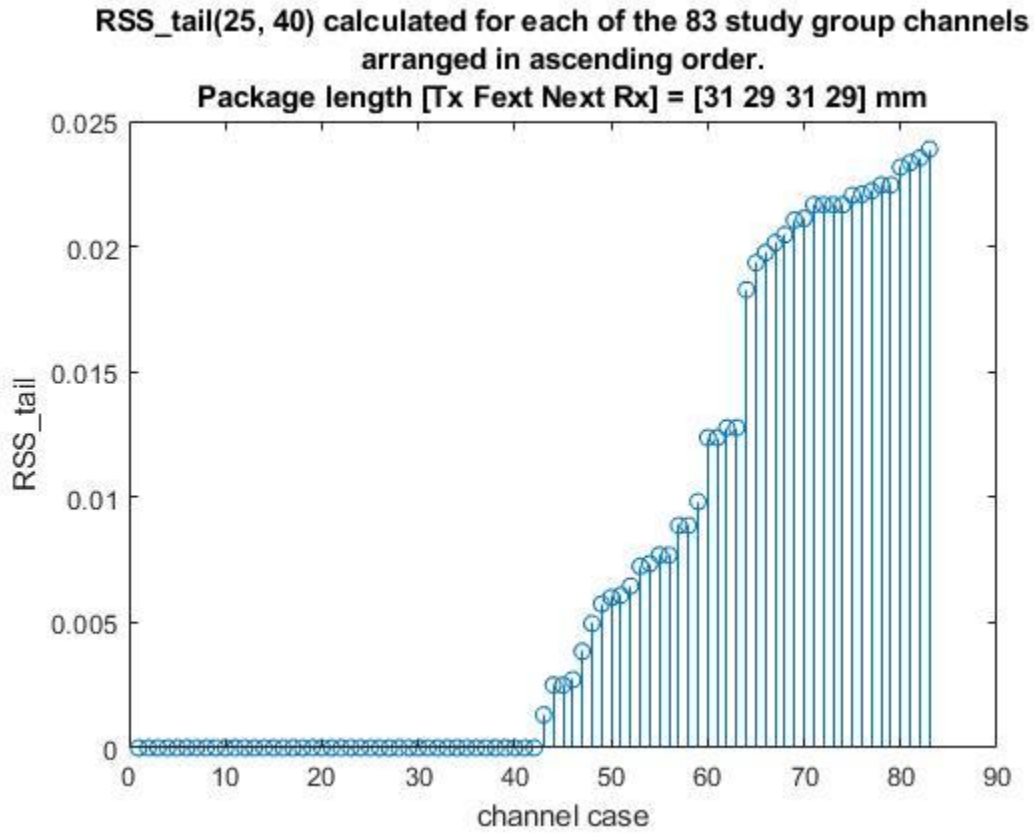
- A more complete picture can had be had by considering all the channels submitted to the KR study group – traditional, orthogonal, cabled backplane. These were submitted by Upen Reddy Kareti (July 17, 2018), Nathan Tracy/ Arturo Pachon (Jan 16, 2019), Howard Heck (Jan 16, 2019), Rich Mellitz (15 Aug 2018) and total more than 80 sets of channels.

- All channels were submitted, without regard to COM achieved with the reference model.



Comment: the adopted KR baseline cannot achieve 3 dB of COM for more than 25% of the submitted channels.





Conclusion: even for the full set of channels, RSS_tail(20,40) < 0.03

- There is a great deal of room to specify RSS_tail_max and still pass all of the critical channels over a wide range of package lengths, as well as all of the submitted channels at the COM-script default package lengths

- All of this may be summarized with the specific proposal:

$$RSS\_tail\_max(25,40) <= 0.03$$

Thank you!