A look into Reference receiver choices for 100G KR channels

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Background and Overview

- In Nov Plenary meeting, I presented Cisco channels and a need for Floating taps to meet target COM value of 3.0 dB (kareti_3ck_01a_1118)
  - RX FFE based Ref. receiver showed better performance compared with DFE Ref. Receiver
- Since then Task Force considered to look into DFE only reference receiver and also consider
  - Option of no floating taps
  - Reduce the range of floating taps
  - Optimize number of overall taps (Fixed + Floating)
  - At minimum consider the narrowed set of channels listed in (kochuparambil_3ck_01c_0119)

Background and Overview

- Die Capacitance modeling in COM
  - Lumped model vs other approaches
- Cd Sensitivity and explore options for Ref. Receiver.

Initial conditions for this analysis

- Cd values of 110fF and 130 fF
- Limit Package overall loss ~4 dB each side
- Present default package loss with 32 mm trace with 1.8mm PTH +Cp is ~4.3 dB at 26.6 GHz
- With these default package Gamma and Tau using package trace TX/RX lengths as 30mm/28mm for best case and 32 mm/32 mm as worst case.
- Adjusted TX FIR ranges from default config file (attaching in the back up slides)

Up to 40 Fixed taps

		Fixed Taps	
		BC	
Channel Number	Pkg Length, mm (TX/RX)	30/28	28/28
	Cd,fF	110	110
	Ref.Eq	DFE40F	DFE40F
	File_names	COM,dB	
1	HH_CABP16	6.2727	6.4114
2	HH_CABP28	3.0239	2.9993
3	NT_BP_12in_16	3.6947	3.8635
4	NT_OR_12in_28	4.4081	4.437
5	RM_CABP28	5.1927	5.177
6	UK_28Bch2_b7p5_7	3.2104	3.0733
7	UK_28CAch3_b2	4.3793	4.4225
8	UK_28OAch4	2.9748	2.9382

Up to 6 free floating taps up to 100 UI range

		Independent Floating taps	
		WC	BC
Channel Number	Pkg Length, mm (TX/RX)	32/32	30/28
	Cd,fF	130	110
	Ref.Eq	DFE24F6R100	DFE24F6R100
	File_names	COM,dB	
1	HH_CABP16	6.3031	6.6477
2	HH_CABP28	2.9017	3.2609
3	NT_BP_12in_16	4.3648	4.2467
4	NT_OR_12in_28	3.9719	4.4515
5	RM_CABP28	4.7765	5.1298
6	UK_28Bch2_b7p5_7	3.3116	3.5828
7	UK_28CAch3_b2	4.437	4.8521
8	UK_28OAch4	2.7574	3.1853

Ind. Floating tap locations
[58;43;62;60;54;52]
[64;65;63;84;87;88]
[52;55;51;60;40;53]
[25;45;44;46;57;51]
[61;81;80;25;26;30]
[49;53;54;75;74;26]
[53;49;75;54;73;26]
[72;31;70;71;38;33]

2 to 3 Banks of Floating taps (4 taps in each bank) with max Range of 80UI

		Banks of Floatiing Taps					
		BC					WC
Channel Number	Pkg Length, mm (TX/RX)	30/28	30/28	30/28	30/28	28/28	32/32
	Cd,fF	110	110	110	130	110	130
	Ref.Eq	DFE16F2B80	DFE24F2B80	DFE12F3B80	DFE24F2B80	DFE24F2B80	DFE24F2B80
	File_names	COM,dB					
1	HH_CABP16	6.1361	6.5999	6.2673	6.4661	6.5396	6.2494
2	HH_CABP28	3.1853	3.2482	3.1853	3.1478	3.2735	2.8654
3	NT_BP_12in_16	4.0551	4.1673	4.0551	4.292	4.3444	4.2895
4	NT_OR_12in_28	4.3649	4.437	4.4081	4.2792	4.466	3.9582
5	RM_CABP28	5.0673	5.1298	5.0673	4.9898	5.0829	4.7314
6	UK_28Bch2_b7p5_7	3.1603	3.4268	3.1478	3.2862	3.4526	3.1853
7	UK_28CAch3_b2	4.4225	4.6717	4.4515	4.5389	4.642	4.2934
8	UK_28OAch4	2.9017	3.1728	3.0733	3.0116	3.1478	2.7574

REF.EQ: e.g., DFE24F2B80 denotes DFE with 24 fixed taps 2 banks(4 taps each) of floating taps reaching up to 80UI

Die Capacitance modeling in COM

- Lumped model representation in COM and its adverse effects is presented in the following presentations
  - Is a Lumped Cd Model Accurate? UPDATE - Karthik Gopalakrishnan, et al..
  - Impacts of CDR Bandwidth & T-Coil in CEI-112G-XSR Transceiver Design. oif2019.152.00 - Nhat Nguyen, et al..

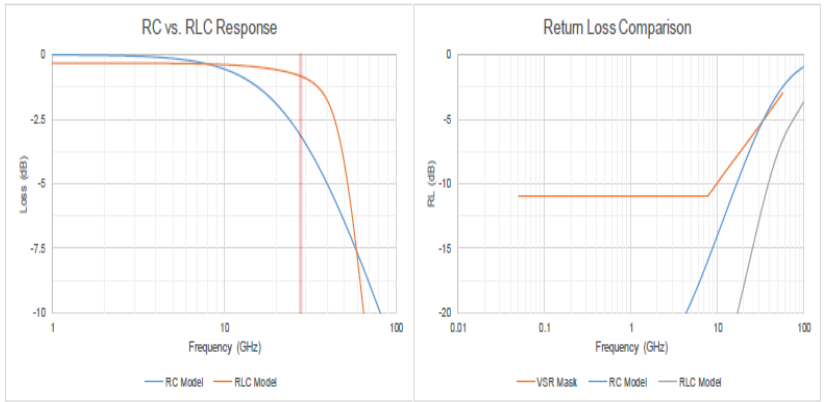
a) Better modeling is needed

b) If lumped model is to be used

consider 70 fF – 85 fF instead of

130 fF

Comparison: Bandwidth & Return Loss



Frequency Response, TX to RX w/o Channel

Return Loss at RX Pins

With Cd = 70fF – max tap range 40 UI

		Fixed Taps	Banks of Floatiing Taps		
Channel Number	Pkg Length, mm (TX/RX)	30/28	30/28	30/28	30/28
	Cd,fF	70	70	70	70
	Ref. Sheet	t_40Fcd70fF	m_24F2B40cd70fF	n_16F2B40cd70fF	o_12F3B40cd70fF
	Ref.Eq	DFE40F	DFE24F2B40	DFE16F2B40	DFE12F3B40
	File_names				
1	HH_CABP16	6.558	6.4844	6.3211	6.3933
2	HH_CABP28	3.2356	3.1728	3.0856	3.1353
3	NT_BP_12in_16	3.6871	3.6411	3.6182	3.6182
4	NT_OR_12in_28	4.6272	4.6125	4.5977	4.5977
5	RM_CABP28	5.4492	5.3521	5.304	5.304
6	UK_28Bch2_b7p5_7	3.3626	3.3371	3.2482	3.2482
7	UK_28CAch3_b2	4.6866	4.6569	4.583	4.583
8	UK_28OAch4	3.2104	3.1728	3.0116	3.0733

With Cd = 90fF – max tap range 40 UI

		Fixed Taps	Banks of Floatiing Taps		
Channel Number	Pkg Length, mm (TX/RX)	30/28	30/28	30/28	30/28
	Cd,fF	90	90	90	90
	Ref. Sheet	s_40Fcd90fF	p_24F2B40cd90fF	q_16F2B40cd90fF	r_12F3B40cd90fF
	Ref.Eq	DFE40F	DFE24F2B40	DFE16F2B40	DFE12F3B40
	File_names				
1	HH_CABP16	6.4452	6.3843	6.2043	6.2639
2	HH_CABP28	3.1105	3.0856	3.0485	3.0485
3	NT_BP_12in_16	3.9605	4.0668	4.0341	4.045
4	NT_OR_12in_28	4.5243	4.4951	4.466	4.466
5	RM_CABP28	5.32	5.2244	5.177	5.177
6	UK_28Bch2_b7p5_7	3.3371	3.3116	3.223	3.223
7	UK_28CAch3_b2	4.5389	4.4951	4.4225	4.4225
8	UK_28OAch4	3.1105	3.0609	2.9017	2.9626

Observations and Recommendations ..1

- With Cd = 110fF and TX+RX Pkg Loss ~8 dB
  - Choice of 2 to 3 banks of floating taps is possible instead of 6 independent floating taps
  - Overall taps (Fixed + floating) can be reduced to 24 (DFE12F3B80)
  - With some constraints 40 fixed tap solutions are coming very close to COM target value of 3.0 dB
- Recommendation
  - *Use 24 fixed and at least 2 banks (4 taps each) up to 80 UI range (DFE24F2B80)*

Observations and Recommendations ..2

- Reduced Cd lumped models (70- 90 fF) to represent high bandwidth die model opens simpler Ref.Receiver
  - Fixed taps approach can be limited max range of 40 UI
  - Floating taps can also be limited 40 UI range

- Recommendations
  - *Consider replacing Lumped die model representation in COM to higher Bandwidth model or use 70 -90 fF Cap model.*
  - *Use 24 fixed and at least 2 banks (4 taps each) up to 40 UI range (DFE24F2B40)*

Back Up Slides

Supporting Data

Comparison of Ref. Receiver options

		Fixed Taps		Banks of Floatiing Taps						Independent Floating taps	
		BC		BC					WC	WC	BC
Channel Number	Pkg Length, mm (TX/RX)	30/28	28/28	30/28	30/28	30/28	30/28	28/28	32/32	32/32	30/28
	Cd,fF	110	110	110	110	110	130	110	130	130	110
	Ref.Eq	DFE40F	DFE40F	DFE16F2B80	DFE24F2B80	DFE12F3B80	DFE24F2B80	DFE24F2B80	DFE24F2B80	DFE24F6R100	DFE24F6R100
	File_names	COM,dB									
1	HH_CABP16	6.2727	6.4114	6.1361	6.5999	6.2673	6.4661	6.5396	6.2494	6.3031	6.6477
2	HH_CABP28	3.0239	2.9993	3.1853	3.2482	3.1853	3.1478	3.2735	2.8654	2.9017	3.2609
3	NT_BP_12in_16	3.6947	3.8635	4.0551	4.1673	4.0551	4.292	4.3444	4.2895	4.3648	4.2467
4	NT_OR_12in_28	4.4081	4.437	4.3649	4.437	4.4081	4.2792	4.466	3.9582	3.9719	4.4515
5	RM_CABP28	5.1927	5.177	5.0673	5.1298	5.0673	4.9898	5.0829	4.7314	4.7765	5.1298
6	UK_28Bch2_b7p5_7	3.2104	3.0733	3.1603	3.4268	3.1478	3.2862	3.4526	3.1853	3.3116	3.5828
7	UK_28CAch3_b2	4.3793	4.4225	4.4225	4.6717	4.4515	4.5389	4.642	4.2934	4.437	4.8521
8	UK_28OAch4	2.9748	2.9382	2.9017	3.1728	3.0733	3.0116	3.1478	2.7574	2.7574	3.1853

COM Configuration Parameters

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.1e-4 1.1e-4]	nF	[TX RX]
z_p select	[2]		[test cases to run]
z_p (TX)	[12 30; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 30; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 30; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 28; 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=.694
A_fe	0.413	V	vp/vf=.694
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.5		min
c(-1)	[-0.3:0.02:0]		[min:step:max]
c(-2)	[-0.04:0.02:0.12]		[min:step:max]
c(-3)	[-0.06:0.02:0.04]		[min:step:max]
c(1)	[-0.2:0.05:0.05]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	21.25	GHz	
f_p1	21.25	GHz	
f_p2	53.125	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.6640625	GHz	

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_WG_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	0	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	2000	
beta_x	0	set to zero for a channel
rho_x	**0.2**	
fixture delay time	0	enter sec
Gx	1	simpler Grr algorthm
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

Floating Tap Control		
N_bg	**0**	**0 1 2 or 3 groups**
N_bf	*4*	taps per group
N_bmax	80	UI span for floating taps
bmaxg	0.1	max DFE value for floating taps