



RX FFE Reference Receiver

July 2019

Tom Palkert,
Merrick Brownlee,
Ryan Latchman



- Why FFE based reference receiver
- Channel simulation results
 - TP1A VEC/VEO
 - End to end COM
- RX FFE tap weights
- Additional work needed
- COM settings

- An FFE based Reference Receiver is a reduced power option as compared to the DFE based Reference Receiver
- FFE based Reference receiver can leverage the existing TDECQ test methodology
- In the latest Phil Sun presentation with the improved Healey termination, all but two of the channels pass TP1a VEC/VEO requirements with FFE4Post at both 19mm and 30mm TX package length.
 - Improved termination to achieve passing for all channels of interest.

- TP1A simulations with 15, 19 and 30mm package traces using COM 2.70 (T-coil model) with reduced package parasitics
 - The TX termination parasitic values are still conservative and we see good returns by reducing these further since reflections are critical
 - Original $C_D=120\text{fF}$ has been reduced to 100fF
 - All channels pass TP1a VEC/VEO at 15, 19, and 30mm TX package length
- End to end COM with 19 and 30mm package traces
 - Almost all of the required channel passes whole link COM with 30mm TX package and with RX C_D reduced from original 85fF to 65fF
 - The three failures (7, 8, and 15) are marginal

Channel Summary with Reduced Parasitics

TP1a 30mm TX Package



VEC pass threshold: 10.5dB, VEO pass threshold: 10mV

ID	Channel Description	Sun Orig. VEC [dB] (VEO) if only VEO fails [mV] RX C 30mm TX, C _D =130fF	Sun w/ Healey Term. C _D =120fF, L _S =120pH, C _B =30fF TX	VEC w/ C _D =100fF, L _S =120pH, C _B =30fF TX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	6.62	6.1	6.55	Yes
2	mellitz_3ck_01_0518_C2M\10dB	10.62	10.1	10.80	No
3	mellitz_3ck_01_0518_C2M\11dB	6.61	6.1	6.61	Yes
4	mellitz_3ck_01_0518_C2M\12dB	10.38	9.8	10.20	No
5	mellitz_3ck_01_0518_C2M\13dB	6.78	6.2	6.73	Yes
6	mellitz_3ck_01_0518_C2M\14dB	9.96	9.5	9.86	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	10.31 (7.50)	9.5 (7.4)	8.99 (11.78)	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	10.07	9.1 (7.5)	8.72 (12.40)	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	7.34	6.5	6.25	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	8.52	7.5	7.45	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	7.90	7.0	7.42	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	8.16	7.6	7.69	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	8.19 (9.89)	6.5	6.92 (16.76)	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	8.52	7.4	7.77	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	8.47	8.2	8.17	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	9.41	8.8	8.69	Yes
17	ito_3ck_01\QSFP \bottom normal\	7.19	6.5	6.64	Yes
18	ito_3ck_01\QSFP \bottom worst\	8.82 (9.55)	8.2	7.41 (12.81)	TBD
19	ito_3ck_01\QSFP \top normal\	6.90	6.2	7.01	Yes
20	1\QSFP \top worst\	8.30	7.6	8.49	TBD

Channel Summary with Reduced Parasitics

TP1a 15mm TX Package



VEC pass threshold: 10.5dB

ID	Channel Description	Sun Orig. VEC [dB] RX C 15mm TX	VEC w/ $C_D=100\text{fF}$, $L_S=120\text{pH}$, $C_B=30\text{fF}$ TX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	8.80	5.39	Yes
2	mellitz_3ck_01_0518_C2M\10dB	14.28	9.73	No
3	mellitz_3ck_01_0518_C2M\11dB	8.77	5.38	Yes
4	mellitz_3ck_01_0518_C2M\12dB	14.27	9.39	No
5	mellitz_3ck_01_0518_C2M\13dB	8.74	5.52	Yes
6	mellitz_3ck_01_0518_C2M\14dB	14.00	9.40	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	7.67	6.77	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	14.08	8.88	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	9.56	5.89	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	12.66	7.69	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	8.74	5.86	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	10.77	6.00	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	9.27	5.76	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	12.51	6.82	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	12.74	6.49	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	17.66	8.13	Yes
17	ito_3ck_01\QSFP \bottom normal\	7.96	5.73	Yes
18	ito_3ck_01\QSFP \bottom worst\	9.84	6.23	TBD
19	ito_3ck_01\QSFP \top normal\	7.64	6.56	Yes
20	_3ck_01\QSFP \top worst\	9.45	7.94	TBD

Channel Summary with Reduced Parasitics

TP1a 19mm TX Package



VEC pass threshold: 10.5dB

ID	Channel Description	Sun w/ Healey Term. $C_D=120\text{fF}$, $L_S=120\text{pH}$, $C_B=30\text{fF}$ TX	VEC w/ $C_D=100\text{fF}$, $L_S=120\text{pH}$, $C_B=30\text{fF}$ TX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	6.7	6.21	Yes
2	mellitz_3ck_01_0518_C2M\10dB	10.6	10.20	No
3	mellitz_3ck_01_0518_C2M\11dB	6.7	6.22	Yes
4	mellitz_3ck_01_0518_C2M\12dB	10.2	9.68	No
5	mellitz_3ck_01_0518_C2M\13dB	6.9	6.35	Yes
6	mellitz_3ck_01_0518_C2M\14dB	9.9	9.60	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	11.7	10.51	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	9.9	9.14	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	7.5	6.70	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	8.5	7.8	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	7.6	6.80	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	8.4	7.31	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	6.6	6.18	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	7.6	6.81	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	9	7.89	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	8.5	7.72	Yes
17	ito_3ck_01\QSFP \bottom normal\	6.7	6.19	Yes
18	ito_3ck_01\QSFP \bottom worst\	8.2	6.58	TBD
19	ito_3ck_01\QSFP \top normal\	6.4	6.63	Yes
20	ito_3ck_01\QSFP \top worst\	7.8	7.96	TBD

Channel Summary with Reduced Parasitics

Whole Link, 30mm TX Package



ID	Channel Description	Sun Orig. COM [dB] RX C 30mm/8mm C _D =130/85fF TX/RX	COM w/ C _D =100/65fF, L _S =120/120pH, C _B =30/30fF TX/RX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	2.83	4.97	Yes
2	mellitz_3ck_01_0518_C2M\10dB	1.58	2.19	No
3	mellitz_3ck_01_0518_C2M\11dB	2.79	4.89	Yes
4	mellitz_3ck_01_0518_C2M\12dB	1.79	2.41	No
5	mellitz_3ck_01_0518_C2M\13dB	2.62	4.83	Yes
6	mellitz_3ck_01_0518_C2M\14dB	2.04	2.55	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	1.38	2.86	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	1.79	2.55	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	2.65	4.29	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	2.73	3.23	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	1.22	3.29	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	0.74	3.24	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	3.75	5.34	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	3.24	5.05	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	0.34	2.70	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	2.98	4.27	Yes
17	ito_3ck_01\QSFP \bottom normal\	3.07	4.79	Yes
18	ito_3ck_01\QSFP \bottom worst\	1.94	3.95	TBD
19	ito_3ck_01\QSFP \top normal\	3.36	4.59	Yes
20	ito_3ck_01\QSFP \top worst\	2.21	3.52	TBD

Channel Summary with Reduced Parasitics

Whole Link, 19mm TX Package



ID	Channel Description	Sun w/ Healey Term. $C_D=120fF/120fF$, $L_S=120/120pH$, $C_B=30/30fF$, 19/8mm TX/RX	COM w/ $C_D=100/65fF$, $L_S=120/120pH$, $C_B=30/30fF$ TX/RX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	3.65	4.74	Yes
2	mellitz_3ck_01_0518_C2M\10dB	1.45	2.05	No
3	mellitz_3ck_01_0518_C2M\11dB	3.65	4.74	Yes
4	mellitz_3ck_01_0518_C2M\12dB	1.80	2.29	No
5	mellitz_3ck_01_0518_C2M\13dB	3.60	4.62	Yes
6	mellitz_3ck_01_0518_C2M\14dB	1.90	2.43	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	0.80	2.20	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	1.05	2.33	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	2.35	4.00	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	2.20	3.12	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	2.70	3.80	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	2.20	3.44	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	3.85	4.92	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	3.40	4.40	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	2.00	3.19	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	2.70	3.68	Yes
17	ito_3ck_01\QSFP \bottom normal\	3.30	4.82	Yes
18	ito_3ck_01\QSFP \bottom worst\	2.10	4.04	TBD
19	ito_3ck_01\QSFP \top normal\	3.85	4.39	Yes
20	ito_3ck_01\QSFP \top worst\	2.75	3.43	TBD

Channel Summary with Reduced Parasitics Whole Link, 19 and 30mm TX Package



ID	Channel Description	Sun Orig. COM [dB] RX C 30mm/8mm C _D =130/85fF TX/RX	C _D =100/65fF, L _S =120/120pH, C _B =30/30fF 30/8mm TX/RX	Sun RX C w/ Healey Term. C _D =120fF/120fF, L _S =120/120pH, C _B =30/30fF, 19/8mm TX/RX	C _D =100/65fF, L _S =120/120pH, C _B =30/30fF 19/8mm TX/RX	Need to pass?
1	mellitz_3ck_01_0518_C2M\9dB	2.83	4.97	3.65	4.74	Yes
2	mellitz_3ck_01_0518_C2M\10dB	1.58	2.19	1.45	2.05	No
3	mellitz_3ck_01_0518_C2M\11dB	2.79	4.89	3.65	4.74	Yes
4	mellitz_3ck_01_0518_C2M\12dB	1.79	2.41	1.80	2.29	No
5	mellitz_3ck_01_0518_C2M\13dB	2.62	4.83	3.60	4.62	Yes
6	mellitz_3ck_01_0518_C2M\14dB	2.04	2.55	1.90	2.43	No
7	tracy_100GEL_02_0118\long_barrel_via\TX5	1.38	2.86	0.80	2.20	TBD
8	tracy_100GEL_02_0118\long_barrel_via\TX6	1.79	2.55	1.05	2.33	TBD
9	tracy_100GEL_06_0118\Microvia\RX6	2.65	4.29	2.35	4.00	Yes
10	tracy_100GEL_06_0118\Microvia\RX5	2.73	3.23	2.20	3.12	TBD
11	lim_3ck_01_0319_QDD_new_pad\ch1	1.22	3.29	2.70	3.80	Yes
12	lim_3ck_01_0319_QDD_new_pad\ch2	0.74	3.24	2.20	3.44	Yes
13	lim_3ck_01_0319_QDD_legacy_pad\ch3	3.75	5.34	3.85	4.92	Yes
14	lim_3ck_01_0319_QDD_legacy_pad\ch4	3.24	5.05	3.40	4.40	Yes
15	lim_3ck_01_0319_QDD_new_pad\ch5	0.34	2.70	2.00	3.19	TBD
16	lim_3ck_01_0319_QDD_legacy_pad\ch6	2.98	4.27	2.70	3.68	Yes
17	ito_3ck_01\QSFP \bottom normal\	3.07	4.79	3.30	4.82	Yes
18	ito_3ck_01\QSFP \bottom worst\	1.94	3.95	2.10	4.04	TBD
19	ito_3ck_01\QSFP \top normal\	3.36	4.59	3.85	4.39	Yes
20	ito_3ck_01\QSFP \top worst\	2.21	3.52	2.75	3.43	TBD

-
- Based on Dudek presentation we need to perform additional simulations on short channels.
 - Need to evaluate use of fewer taps
 - May need additional definition of TX FIR optimization.

COM Configuration TP1a



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	[100e-6 0e-6]	nF	[TX RX]
L_s	[120e-3 0e-3]	nH	[TX RX]
C_b	[30e-6 0e-6]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[30; 1.8]	mm	[test cases]
z_p (NEXT)	[0; 0]	mm	[test cases]
z_p (FEXT)	[30; 1.8]	mm	[test cases]
z_p (RX)	[0; 0]	mm	[test cases]
C_p	[87e-6 0e-6]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 50]	Ohm	[TX RX]
A_v	0.41	V	
A_fe	0.41	V	
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.3 : 0.02 : 0]		[min:step:max]
c(-2)	[0 : 0.02 : 0.1]		[min:step:max]
c(-3)	[-0.04 : 0.02 : 0]		[min:step:max]
c(1)	[-0.1 : 0.05 : 0]		[min:step:max]
N_b	0	UI	
b_max(1)	0.5		
b_max(2..N_b)	0.3		
g_DC	[-14:1:-3]	dB	[min:step:max]
f_z	12.58	GHz	
f_p1	20	GHz	
f_p2	28	GHz	
g_DC_HP	[-3:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
ffe_pre_tap_len	0	UI	
ffe_post_tap_len	4	UI	
ffe_tap_step_size	0		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.3		
ffe_post_tap1_max	0.3		
ffe_tapn_max	0.125		

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	C2M_1218		
COM_CONTRIBUTION	1		logical
Operational			
COM Pass threshold	3.8		dB
ERL Pass threshold	10.5		dB
DER_0	1.00E-05		
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	400		
TDR Butterworth	1		logical
beta_x	0.00E+00		
rho_x	0.32		
fixture delay time	0		
TDR_W_TXPKG	1		
Receiver testing			
RX_CALIBRATION	0		logical
Sigma BBN step	5.00E-03		V
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	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5; 92.5 92.5]	Ohm
Table 92-12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
board_tl_tau	5.790E-03	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	119	mm
z_bp (NEXT)	119	mm
z_bp (FEXT)	119	mm
z_bp (RX)	119	mm

COM Configuration Whole Link



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	[100e-6 65e-6]	nF	[TX RX]
L_s	[120e-3 120e-3]	nH	[TX RX]
C_b	[30e-6 30e-6]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[30; 1.8]	mm	[test cases]
z_p (NEXT)	[8; 0]	mm	[test cases]
z_p (FEXT)	[30; 1.8]	mm	[test cases]
z_p (RX)	[8; 0]	mm	[test cases]
C_p	[87e-6 75e-6]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 45]	Ohm	[TX RX]
A_v	0.41	V	
A_fe	0.41	V	
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.3 : 0.02 : 0]		[min:step:max]
c(-2)	[0 : 0.02 : 0.1]		[min:step:max]
c(-3)	[-0.04 : 0.02 : 0]		[min:step:max]
c(1)	[-0.1 : 0.05 : 0]		[min:step:max]
N_b	0	UI	
b_max(1)	0.6		
b_max(2..N_b)	0.2		
g_DC	[-14:1:-3]	dB	[min:step:max]
f_z	12.58	GHz	
f_p1	20	GHz	
f_p2	28	GHz	
g_DC_HP	[-3:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
ffe_pre_tap_len	0	UI	
ffe_post_tap_len	4	UI	
ffe_tap_step_size	0		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.3		
ffe_post_tap1_max	0.3		
ffe_tapn_max	0.125		

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	C2M_1218	
COM_CONTRIBUTION	1	logical
Operational		
COM Pass threshold	3.8	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-05	
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	300	
TDR_Butterworth	1	logical
beta_x	0.00E+00	
rho_x	0.32	
fixture delay time	0	
TDR_W_TXPKG	1	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	32.5	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	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5; 92.5 92.5]	Ohm
Table 92-12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
board_tl_tau	5.790E-03	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	119	mm
z_bp (NEXT)	119	mm
z_bp (FEXT)	119	mm
z_bp (RX)	132	mm