Channel Requirements for FPD-Link III ADAS chipsets: DS90UB953, 954, 960, 933, 934, 964

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Rev	Last updated by	Date	Note
0.1	TKC	7/27/2017	First draft.
0.2	TKC	8/8/2017	Add 2G table 4
0.3	TKC	8/9/2017	update in-line connectors info
0.4	TKC	8/17/2017	preliminary
0.5	TKC	8/23/2017	correct typo on STP intrapair skew- 250 ps -> 150ps
0.6	TKC	9/21/2017	Add DS90UB933-934
0.7	TKC	10/24/2017	correct error in page 4, Table 2B, return loss
0.8	TF, LK	5/1/2018	Update S11 recommendations for coax in Table 2, 2A, 2B Change crosstalk recommendations to nominal
0.8.1	DT	3/15/2021	Add Shielding effectiveness for coax in Table 2B

Operating Frequency Range - 4Gbps

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			Back-channel (from DES to SER)				Forward channel (from SER to DES)			Cable reach		
SER	DES	Clock mode	Bit time (ns)	Line rate (Mbps)	f_{BCMIN} (MHz)	f_{BCMAX} (MHz)	max line rate (Mbps)	$f_{FC-NYQUIST}$ (MHz)	$f_{FC-FRAME}$ (MHz)	DACAR462 coax	DACAR535 STQ	Comment
DS90UB953	DS90UB954	SYNC	10	50	25	50	4200	2100	105	15m	10m	Validated
DS90UB935	DS90UB936	SYNC	20	25	12.5	25	2100	1050	52.5	15m	10m	
DS90UB953	DS90UB954	EXT clock	50	10	5	10	4200	2100	105	15m	10m	
DS90UB953	DS90UB960	SYNC	10	50	25	50	4200	2100	105	15m	10m	Design target
DS90UB935	DS90UB960	SYNC	20	25	12.5	25	2100	1050	52.5	15m	10m	
DS90UB953	DS90UB960	EXT clock	50	10	5	10	4200	2100	105	15m	10m	

Table1. Frequency range of FPD-Link III DS90UB953/954 and its compatible devices (f_{BC-MIN} to $f_{FC-NYQUIST}$)

How to use this Channel Requirement:

step 1: Determine the frequency range (fBC-MIN to fFC-NYQUIST) from Table 1

step 2: Depends on types of testing (transmission channel, PCB, cable assembly), apply limits from the appropriate tables from fBC-MIN to fFC-NYQUIST

	Testing Transmission Channel Requirement	*Testing PCB Budget*	*Testing cable assembly Budget*
Coax	*Table 2*	*Table 2A*	*Table 2B*
STP or STQ	*Table 3*	*Table 3A*	*Table 3B*

Operating Frequency Range - 2Gbps

			Back-channel (from DES to SER)				Forward channel (from SER to DES)			Cable reach	
SER	DES	SER Clock mode	Bit time (ns)	Line rate (Mbps)	f_{BCMIN} (MHz)	f_{BCMAX} (MHz)	max line rate (Mbps)	$f_{FC-NYQUIST}$ (MHz)	$f_{FC-FRAME}$ (MHz)	DACAR462 coax	DACAR535 STQ
DS90UB953	DS90UB964	EXT clock	50	10	5	10	1870	935	46.75	15m	15m
DS90UB953	DS90UB934	EXT clock	200	2.5	1.25	2.5	1870	935	66.79	15m	15m
DS90UB933	DS90UB954	PCLK	200	2.5	1.25	2.5	1870	935	66.79	15m	15m
DS90UB913A	DS90UB954	PCLK	200	2.5	1.25	2.5	1400	700	50.00	15m	15m
DS90UB933	DS90UB934	PCLK	200	2.5	1.25	2.5	1870	935	66.79	15m	15m
DS90UB933	DS90UB960	PCLK	200	2.5	1.25	2.5	1870	935	66.79	15m	15m
DS90UB913A	DS90UB960	PCLK	200	2.5	1.25	2.5	1400	700	50.00	15m	15m

Table1. Frequency range of FPD-Link III DS90UB953/954 and its compatible devices (f_{BC-MIN} to $f_{FC-NYQUIST}$)

How to use this Channel Requirement:

step 1: Determine the frequency range (fBC-MIN to fFC-NYQUIST) from Table 1

step 2: Depends on types of testing (transmission channel, PCB, cable assembly), apply limits from the appropriate tables

	Testing Transmission Channel	*Testing PCB*	*Testing cable assembly*
Coax	*Table 2*	*Table 2A*	*Table 2B*
STP or STQ	*Table 4*	*Table 4A*	*Table 4B*

			Table 2A - Recommendations			Table 2 - Requirements			Table 2B - Recommendations			
			PCB Budget (with PoC)			Total Channel Requirement			Coax cable assembly - Budget			
Parameter	**C_{AC}**	**Frequency**	**MIN**	**NOM**	**MAX**	**MIN**	**NOM**	**MAX**	**MIN**	**NOM**	**MAX**	**UNIT**
Return loss, S11		f=1 - 100 MHz			-20			-16			-20	dB
		f=0.1 to 1 GHz			-12 + 8*log(f)			-9 + 7*log(f)			-12 + 8*log(f)	dB
		f=1 - 2.1 GHz			-12			-9			-12	dB
Insertion Loss, S21		f=1MHz		>-0.35		-1.4				>-0.7		
		f=5MHz		>-0.35		-2.3				>-1.6		
		f=10MHz		>-0.35		-2.5				>-1.8		dB
		f=50MHz		>-0.35		-3.5				>-2.5		dB
		f=100MHz		>-0.35		-4.5				>-3.9		dB
		f=500 MHz		>-0.35		-9.5				>-8.7		dB
		f=1.0 GHz		>-0.6		-14				>-12.8		dB
		f=2.1 GHz		>-1.2		-21.6				>-19.2		dB
Far end crosstalk		f < 2.1 GHz					-30			-30		dB
Near end crosstalk		f<100MHz					-30			-30		dB
Impedance	PCB trace		45	50	55							Ω
	landing pad and component		40	50	60							Ω
	cable					45	50	55	45	50	55	Ω
	connector region					40	50	62.5	40	50	62.5	Ω
Shielding effectiveness	Cable assembly									≥45		dB
In-line connectors	< 4m 4-6m 6-15m						≤ 1 ≤2 ≤4			≤1 ≤2 ≤4		
Cable reach	test with DACAR462						15			15		m

Note 1: The transmission channel after aging and mechanical stress testing should meet the Transmission Channel Requirements

Note 2: Below Nyquist frequency, the transmission channel should be free of resonance that creates sharp drops in insertion loss and abrupt changes in the channel's group delay. The maximum insertion loss of the channel is dependent on the drive capability of the SER, and the analog front end's capability of the DES.

Note 3: The total transmission channel from SER to DES is the combined contribution from the SER-board, cable assembly and the DES-board. The PCB insertion loss budget in this table assumes the use of 2-inch FR4 board trace and the associated circuit components. Higher insertion loss for the PCB is possible but with the trade-off in lower insertion loss for the cable assembly. Likewise, shorter board traces reduces PCB insertion loss, and correspondingly allow higher cable insertion loss.

Note 3. Impedance is measured with TDR launch at an edge rate equals to the nominal edge rate of SER output.

PoC Network Requirements

4Gbps PoC Network: SYNC clock mode	MIN	NOM	MAX	UNIT
Frequency range	25		2100	MHz
Total DC resistance		<1.75		Ω
Inductance(1)		10		µH
PoC interference pulse due to dc current change				
30/60 Hz at V_{POC} (switcher input)			500	mVpp
pulse slew rate	200			µs/V
PoC interference from switching noise				
0.5 - 50MHz sinusoidal			TBD	mVpp

Note 1. A PoC network is built with several inductors in series to form a wide band inductor. Consult TI datasheet or other literature for recommendations.

2Gbps PoC Network: EXT PCLK	MIN	NOM	MAX	UNIT
Frequency range	1.25		1000	MHz
Total DC resistance		<1.75		Ω
Inductance(1)		110		µH
PoC interference pulse due to dc current change				
30/60 Hz at V_{POC} (switcher input)			500	mVpp
pulse slew rate	200			V/µs
PoC interference from switching noise				
0.5 - 50MHz sinusoidal			TBD	mVpp

Note 1. A PoC inductor is built with several inductors in series to form a wide band inductor. Consult TI datasheet or other literature for recommendations.

Transmission Channel Requirements and PCB/Cable budget - STP/STQ, 4Gb/s

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			Table 3A - Recommendations			Table 3 - Requirements				Table 3B - Recommendations			
			PCB Budget			Transmission Channel Requirement				Cable assembly- Budget			
Parameter	**C_{AC}**	**Frequency**	**MIN**	**NOM**	**MAX**	**Frequency**	**MIN**	**NOM**	**MAX**	**MIN**	**NOM**	**MAX**	**UNIT**
Return loss, SDD11		f=1 - 5MHz			-25	f=1-5MHz			-20			-20	dB
		f=10-100MHz			-25	f=10-100MHz			-20+20f			-20+20f	dB
		f=0.1-1 GHz			-26.4 + 14.4f	f=0.1 - 0.5 GHz			-20+20f			-20+20f	dB
		f=1 - 2.5 GHz			-12	f=0.5 - 2.5 GHz			-10			-10	dB
Insertion Loss, SDD21		f=1MHz		>-0.3		f=1MHz	-1.1				>-0.5		
		f=5MHz		>-0.3		f=5MHz	-1.4				>-0.8		
		f=10MHz		>-0.3		f=10MHz	-1.6				>-1.0		dB
		f=50MHz		>-0.3		f=50MHz	-2.7				>-2.1		dB
		f=100MHz		>-0.3		f=100MHz	-3.4				>-2.8		dB
		f=500 MHz		>-0.3		f=500 MHz	-7.8				>-7.2		dB
		f=1.0 GHz		>-0.5		f=1.0 GHz	-12				>-11		dB
		f=2.1 GHz		>-0.8		f=2.1 GHz	-19.6				>-18		dB
Insertion loss to far end crosstalk ratio		f<2.1 GHz					20			20			dB
Near end crosstalk		f<200MHz							-30			-30	dB
Impedance	PCB trace		90	100	110								Ω
	landing pad and component		80	100	120								Ω
	cable						85	100	115	85	100	115	Ω
	connector region						80	100	125	80	100	125	Ω
Intra-pair skew		100-300 MHz							250			250	ps
		300-500 MHz							150			150	ps
		500 - 1.5 GHz							100			100	ps
		1.5 - 2.1 GHz							40			40	ps
in-line connectors		<6m 6-10m						0 ≤2			0 ≤2		
Cable reach	test with DACAR535-2							10			10		m

Note 1: The transmission channel after aging and mechanical stress testing should meet the Transmission Channel Requirement

Note 2: Below Nyquist frequency, the transmission channel should be free of resonance that creates sharp drops in insertion loss and abrupt changes in the channel's group delay. The maximum insertion loss of the channel is dependent on the drive capability of the SER, and the analog front end's capability of the DES.

Note 3: The total transmission channel from SER to DES is the combined contribution from the SER-board, cable assembly and the DES-board. The PCB insertion loss budget in this table assumes the us of 2-inch FR4 board trace and the associated circuit components. Higher insertion loss for the PCB is possible but with the trade-off in lower insertion loss for the cable assembly. Likewise, shorter board traces reduces PCB insertion loss, and correspondingly allow higher cable insertion loss.

			Table 4A - Recommendations			Table 4 - Requirements				Table 4B - Recommendations			
			PCB Budget			Transmission Channel Requirement				Cable assembly- Budget			
Parameter	**C_{AC}**	**Frequency**	**MIN**	**NOM**	**MAX**	**Frequency**	**MIN**	**NOM**	**MAX**	**MIN**	**NOM**	**MAX**	**UNIT**
Return loss, SDD11		f=1 - 5MHz			-25	f=1-5MHz			-20			-20	dB
		f=10-100MHz			-25	f=10-100MHz			-20+20f			-20+20f	dB
		f=0.1-1 GHz			-26.4 + 14.4f	f=0.1 - 0.5 GHz			-20+20f			-20+20f	dB
		f=1 - 2.5 GHz			-12	f=0.5 - 2.5 GHz			-10			-10	dB
Insertion Loss, SDD21		f=1MHz		>-0.3		f=1MHz	-1.35				>-0.75		dB
		f=5MHz		>-0.3		f=5MHz	-1.8				>-1.2		dB
		f=10MHz		>-0.3		f=10MHz	-2.1				>-1.5		dB
		f=50MHz		>-0.3		f=50MHz	-3.8				>-3.2		dB
		f=100MHz		>-0.3		f=100MHz	-4.9				>-4.3		dB
		f=500 MHz		>-0.3		f=500 MHz	-11.3				>-10.7		dB
		f=1.0 GHz		>-0.5		f=1.0 GHz	-17.3				>-16.3		dB
													dB
Insertion loss to far end crosstalk ratio		f<1.0 GHz					20			20			dB
Near end crosstalk		f<200MHz							-30			-30	dB
Impedance	PCB trace		90	100	110								Ω
	landing pad and component		80	100	120								Ω
	cable						85	100	115	85	100	115	Ω
	connector region						80	100	125	80	100	125	Ω
Intra-pair skew		100-300 MHz							250			250	ps
		300-500 MHz							150			150	ps
		500 - 1.5 GHz							100			100	ps
in-line connectors		<6m 6-15m						0 ≤2			0 ≤2		
Cable reach	test with DACAR535-2							15			15		m

Note 1: The transmission channel after aging and mechanical stress testing should meet the Transmission Channel Requirement

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