

Interface SATA signals using PI2EQX3xxx SATA ReDriver™

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1.0 Introduction

The PI2EQX3xxx SATA ReDriver™ family was developed using Pericom cutting-edge technology to compensate the deterministic jitter and insertion loss caused by long traces and cables to achieve signal integrity at the end of the traces or cables.

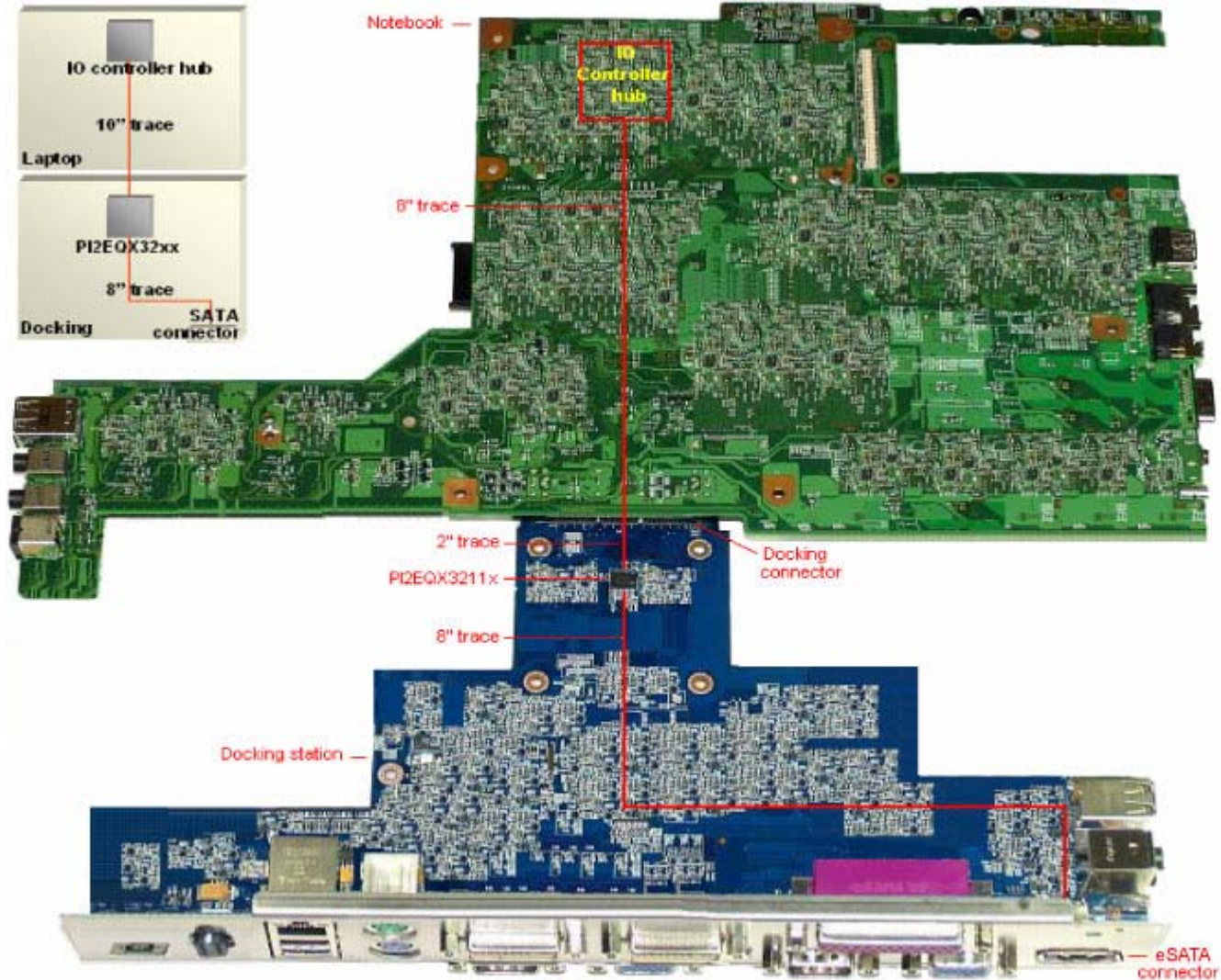


Figure 1. Example of a typical notebook-docking station using PI2EQX3211x to achieve a good Tx eye on the eSATA connector in the docking station

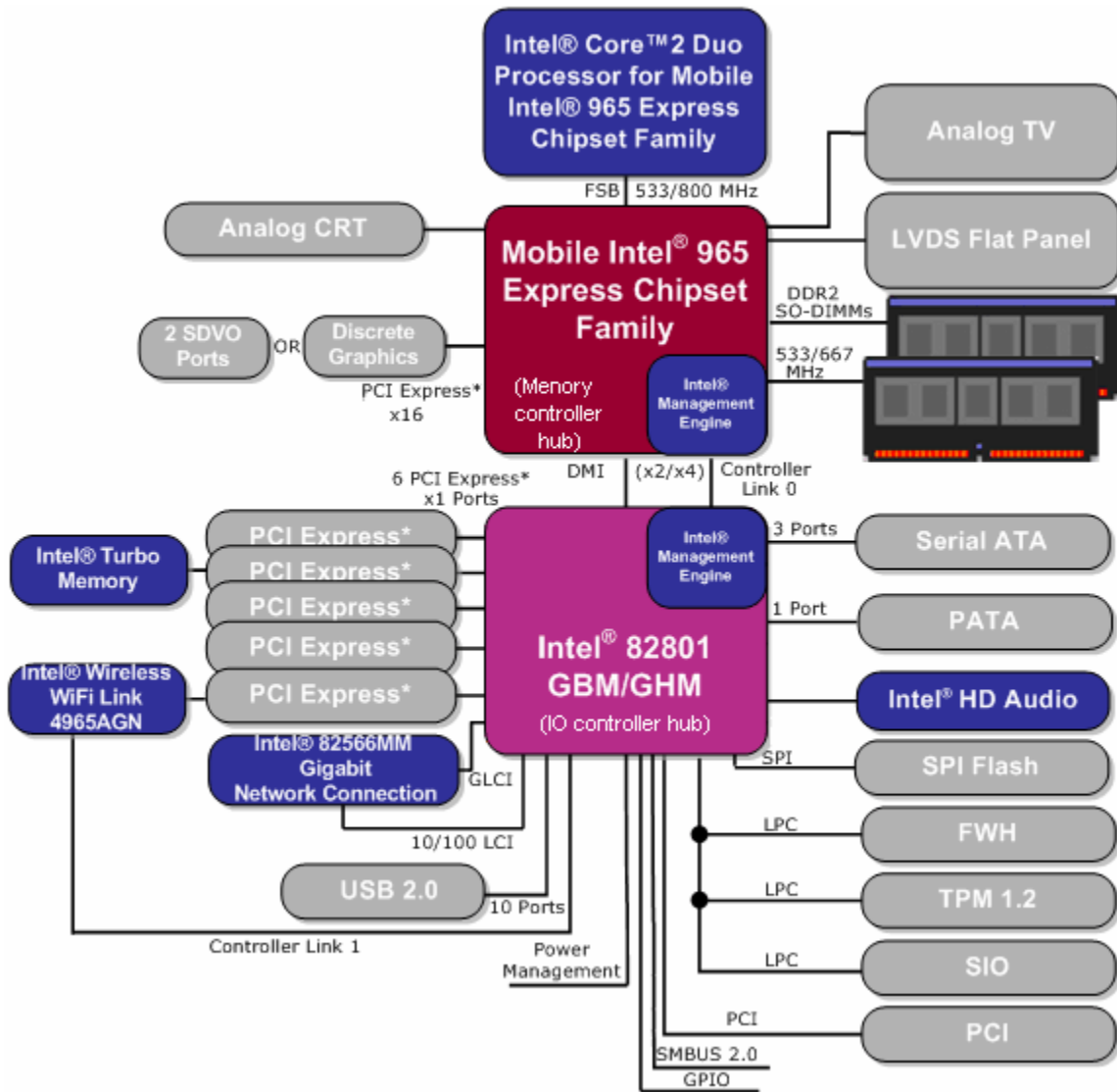


Figure 2. Intel processor and chipset for a typical-docking station, such as the example in figure 1.

Figure 2 is a diagram of the Intel processor and chipset for the notebook and docking station, such as the example in figure 1. The total trace between the SATA port in the IO controller hub in the notebook and the eSATA connector in the docking station can be about 16" to 24". The Tx eye measured at the eSATA connector in the docking station will be in bad shape if the PI2EQX3211x ReDriver™ is not used.

2.0 Why Use the SATA ReDriver™?

The following examples (1-3) show the effect of trace loss on SATA signal and the advantages of using the SATA ReDriver™, such as the PI2EQX32xx family products, to improve signal integrity:

Example 1: Use of PI2EQX32xx for Notebook and Docking Station with Long Trace

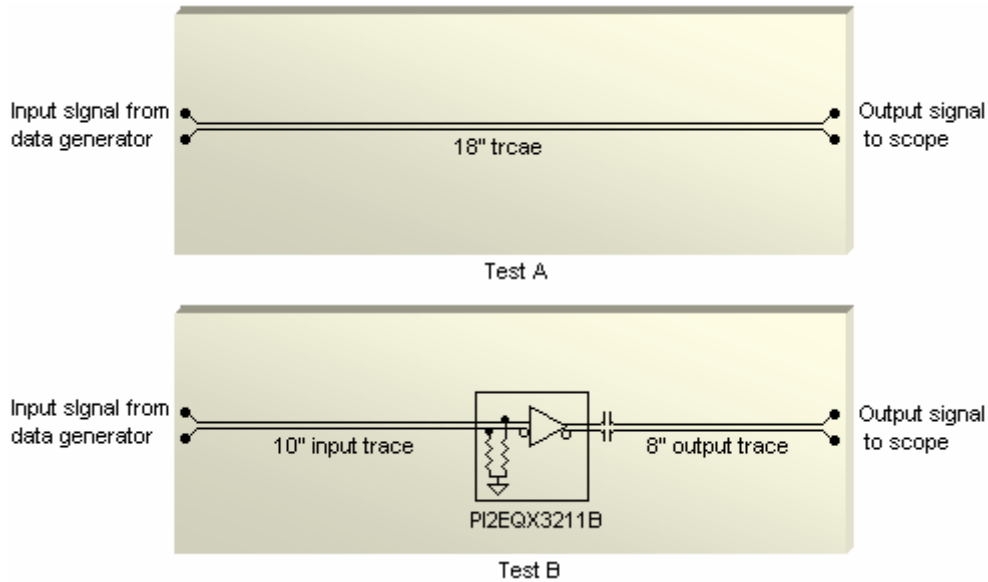


Figure 3. “Test A” and “Test B” (shown above) are the SATA Tx eye comparisons between using and not using PI2EQX3211B for the notebook-docking station application in figure 1.

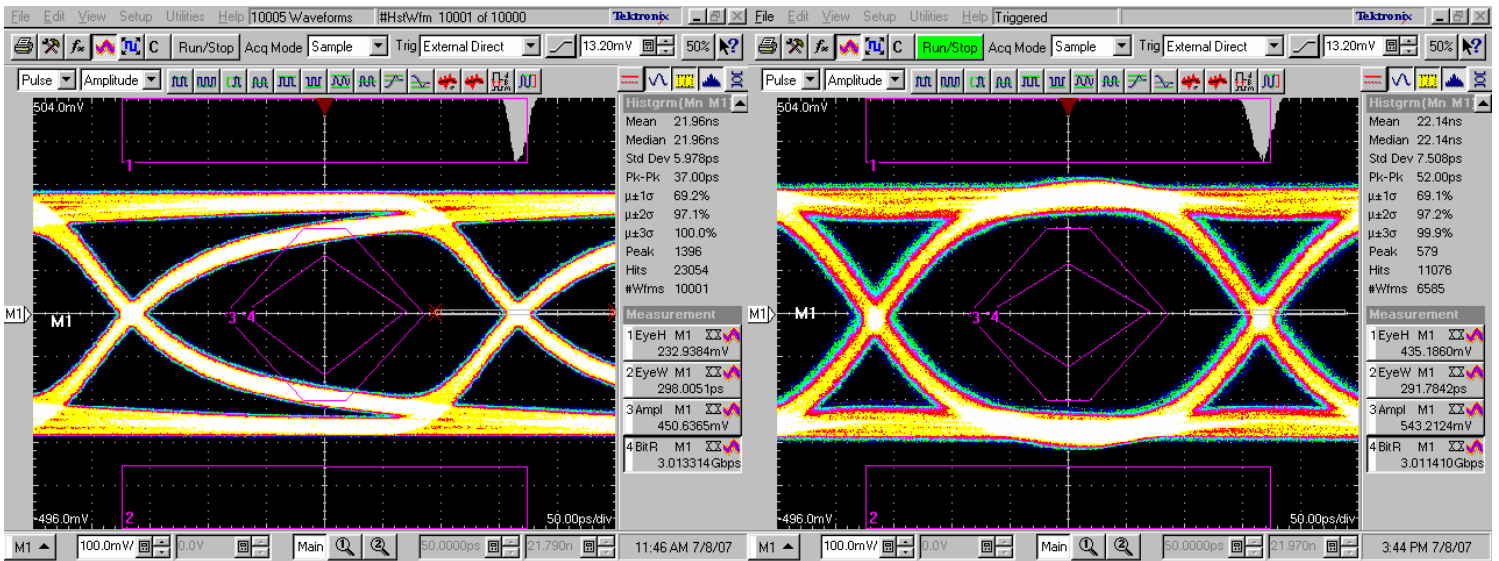


Figure 4. The waveforms above are comparing the SATA Tx eyes without (left, “test A” in figure 3) and with (right, “test B” in figure 3) the PI2EQX3211B. These waveforms are tested with 3.5db equalization, -3.5db de-emphasis and 1.2x swing, at 3Gbps.

The tests in figure 3 and figure 4 above have demonstrated that a SATA ReDriver™, such as the PI2EQX3211x family, is necessary for the notebook-docking station application in figure 1.

The left eye diagram in figure 4 shows the data eye has a slower rise time due to high frequency loss along the FR4 trace. The figure 4 eye diagram on the right shows how a SATA ReDriver™ with good equalizer and output de-emphasis control can restore the high frequency loss and improve data signal integrity.

Example 2, Using PI2EQX32xx for the Backplane or Other System Applications with Long Trace

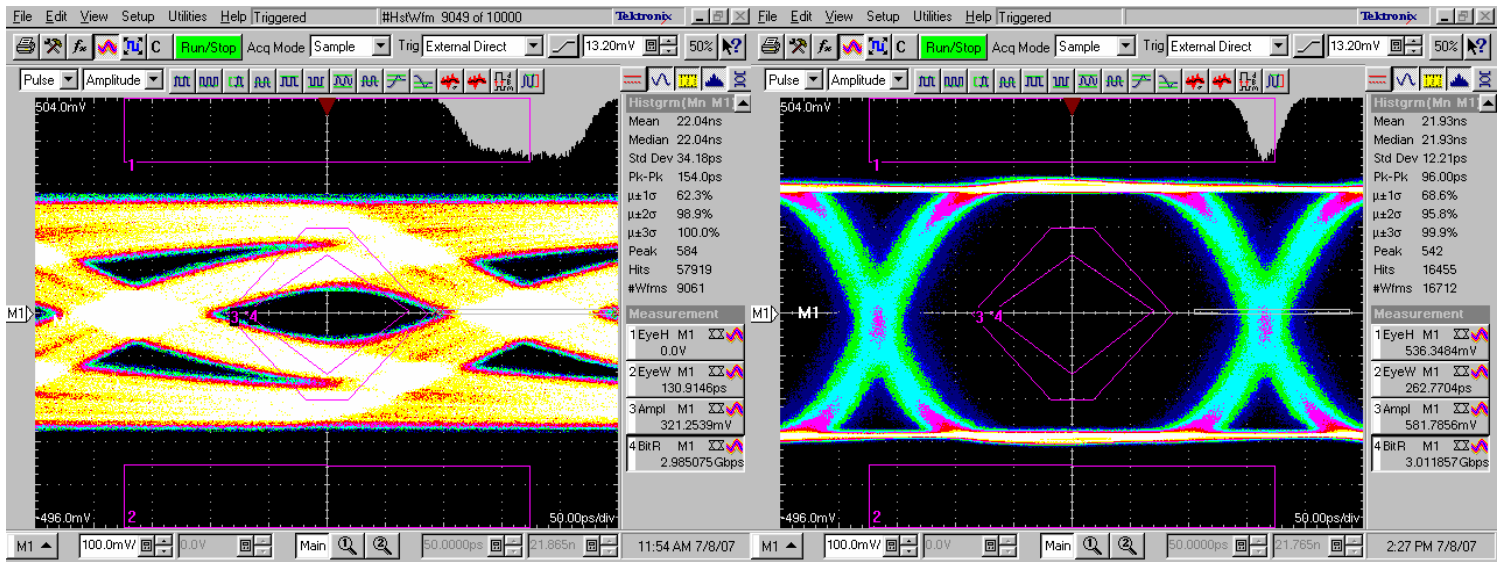
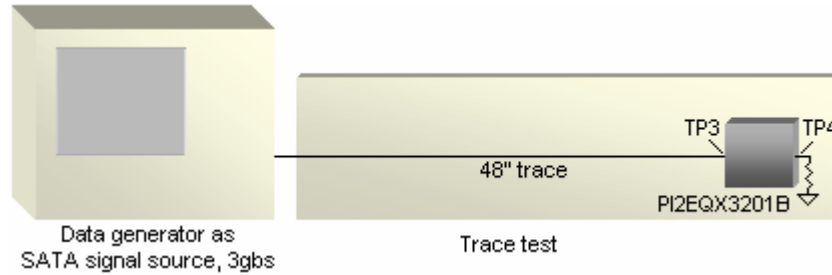


Figure 5, the Rx eye on the left (TP3 in the “trace test” above) has touched the Rx eye template while the Tx eye on the right (TP4) has passed the Tx eye test after re-driven by the PI2EQX3201B. Tested with 6.5db equalization, 0db de-emphasis and 1x swing, at 3Gbps.

The left eye diagram in figure 5 indicates a typical eye closure after a 48” long trace. This is an ideal test case for long trace without connectors. In practical application such as back-plane with long trace and connectors to external mass storage or extension board, the equalizer in the PI2EQX32xx ReDriver™ will compensate the deterministic jitter caused by the long trace, as well as the discontinuities from connectors and via. The right eye diagram in figure 5 indicates the eye diagram at the output of EQX3201B, which has well restored the eye pattern.

Example 3, Using PI2EQX32xx for Long Cable Application

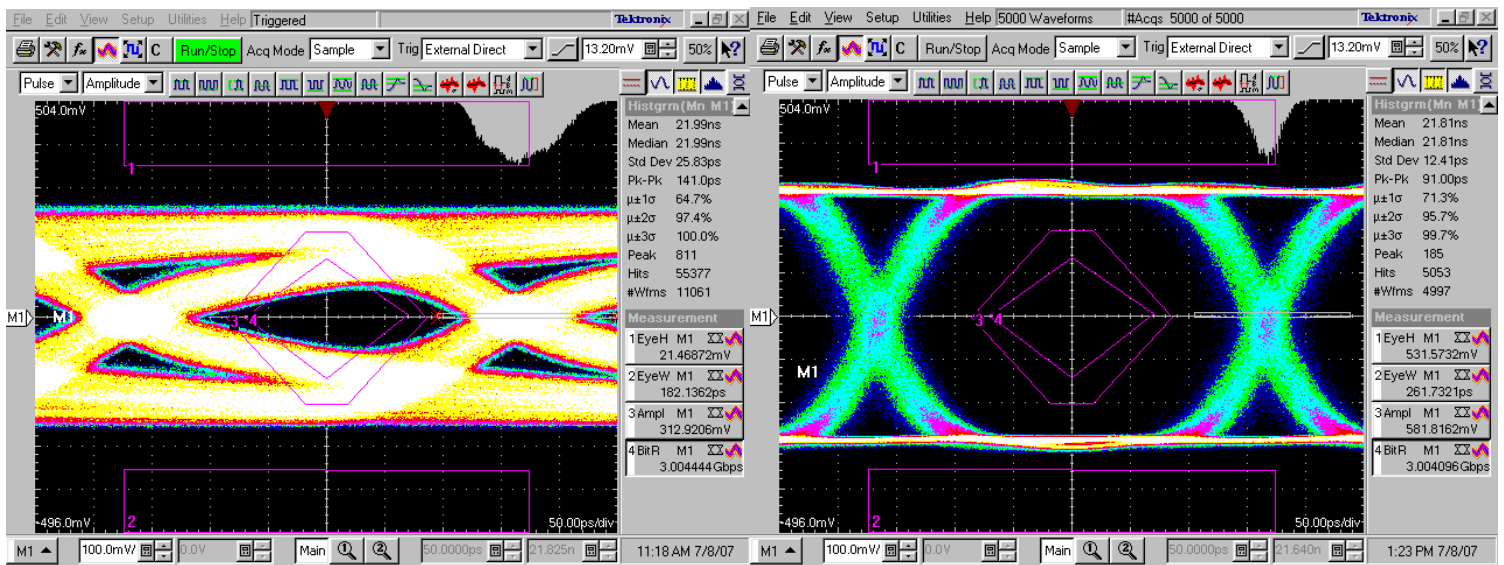
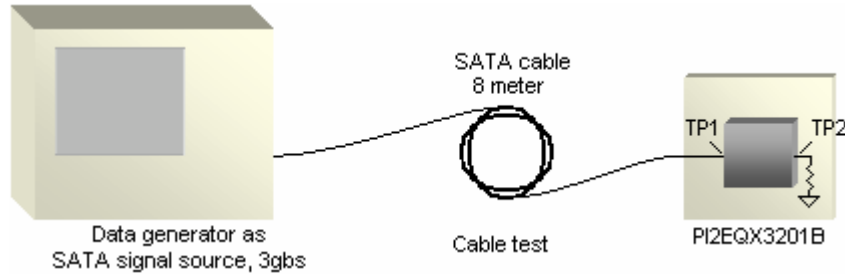


Figure 6, the Rx eye on the left (TP1 in the “cable test” above) has touched the Rx eye template while the Tx eye on the right (TP2) has passed the Tx eye test after re-driven by the PI2EQX3201B. Tested with 6.5db equalization, 0db de-emphasis and 1x swing, at 3gbs.

The test result in figure 6 demonstrates the performance of the PI2EQX301B for the applications using long cable.

2.1 Summary

The examples above have suggested why the SATA ReDriver™, such as the EQX32xx SATA ReDriver™ family, is necessary for the applications as in the examples above and many other applications alike.

3.0 The Complete Solution

Pericom provides a complete application solution to help the system designers for facilitating the SATA interface design using the PI2EQX3xxx family, including:

- How to choose the SATA ReDriver™ for various SATA and SAS applications
- Detailed reference schematics, PCB layout guidance
- Demonstration kits
- Technical sustaining, including on-site technical support from field application engineers, technical support from application engineers for conference calls and customer visit when needed
- Complete SATA ReDriver™ family covers most of the major SATA and SAS related standards and applications as in the table 1 (see page 7).

4.0 How to select the PI2EQX32xx ReDriver for various applications

Applications	Standards	Recommended PI2EQX3xxx devices and features	Package
Laptop docking station	SATAi (G1-1.5g, G2-3.0g) SATAm (G1-1.5g, G2-3.0g)	PI2EQX3201B, PI2EQX3251B (flexible EQ and De-emphasis settings)	TQFN-36
		PI2EQX3211B (reduced pin-count, low cost, for output trace within 6")	SSOP-20
		PI2EQX3211C (reduced pin-count, low cost, for output trace longer than 6")	SSOP-20
		PI2EQX3421 (1:2 mux demux, flexible EQ setting)	TQFN-28
		PI2EQX3431 (small package, flexible EQ setting)	TQFN-20
Desktop, server, Backplane	SATAi (G1-1.5g, G2-3.0g) SATAm (G1-1.5g, G2-3.0g) SATAx (G1-1.5g, G2-3.0g) SAS (G1-1.5g, G2-3.0g)	PI2EQX3201A/B, PI2EQX3251B (flexible EQ and De-emphasis settings)	TQFN-36
		PI2EQX3211A/B (reduced pin-count, low cost, for output trace within 6")	SSOP-20
		PI2EQX3211C (reduced pin-count, low cost, for output trace longer than 6")	SSOP-20
		PI2EQX3421 (1:2 mux demux, flexible EQ setting)	TQFN-28
		PI2EQX3431 (small package, flexible EQ setting)	TQFN-20
		PI2EQX3202A/B (4 channels, flexible EQ and De-emphasis settings)	LFBGA-84
Cable	SATAi (G1-1.5g, G2-3.0g) SATAm (G1-1.5g, G2-3.0g) SATAx (G1-1.5g, G2-3.0g) SAS (G1-1.5g, G2-3.0g)	PI2EQX3201A/B, PI2EQX3251A/B (flexible EQ and De-emphasis settings)	TQFN-36
		PI2EQX3211A/B (reduced pin-count, low cost, for output trace within 6")	SSOP-20
		PI2EQX3211C (reduced pin-count, low cost, for output trace longer than 6")	SSOP-20
		PI2EQX3421 (1:2 mux demux, flexible EQ setting)	TQFN-28
		PI2EQX3431 (small package, flexible EQ setting)	TQFN-20
		PI2EQX3202A/B (4 channels, flexible EQ and De-emphasis settings)	LFBGA-84
SAS	SAS (G1-1.5g, G2-3.0g)	PI2EQX3201A, PI2EQX3251A (flexible EQ and De-emphasis settings)	TQFN-36
		PI2EQX3211A (reduced pin-count, low cost, for output trace within 6")	SSOP-20
		PI2EQX3421 (1:2 mux demux, flexible EQ setting, low power)	TQFN-28
		PI2EQX3431 (small package, flexible EQ setting, low power)	TQFN-20
		PI2EQX3202A (4 channels, flexible EQ and De-emphasis settings)	LFBGA-84

Table 1, choosing the PI2EQX3xxx ReDriver™ for various SATA and SAS applications

5.0 How to Choose Between PI2EQX3211B and PI2EQX3211C

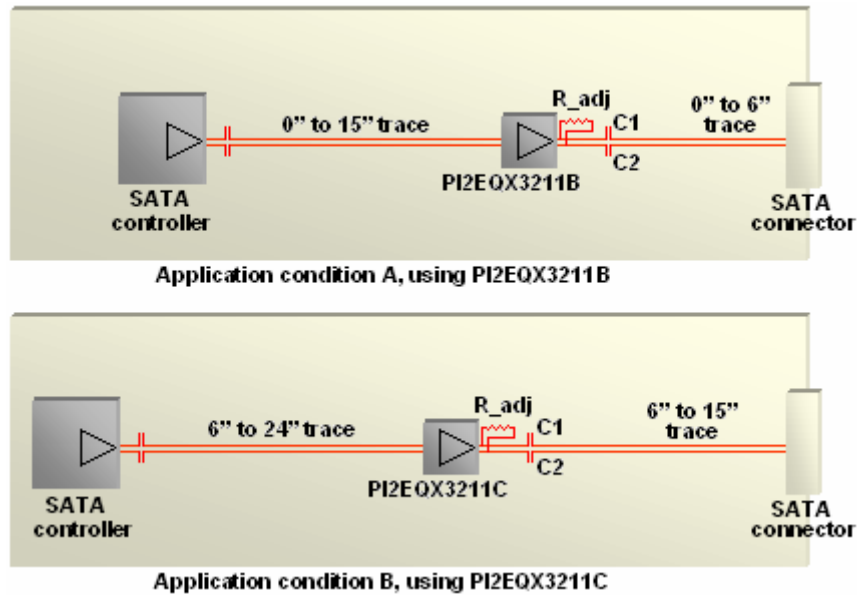


Figure 7, select PI2EQX3211B and PI2EQX3211C in different application condition while adjust R_adj for optimized Tx eye at SATA connector

PI2EQX3211B and PI2EQX3211C have fixed equalizer, de-emphasis and output voltage swing, but could be fine tuned to meet the transmit eye requirement by using an external R_{adj} resistor across the differential outputs.

Figure 7 shows a typical application on notebook or notebook with docking station:

- When there is a short output trace, 0" to 6", use PI2EQX3211B without de-emphasis.
- When there is a long output trace, 6" to 15", use PI2EQX3211C with fixed -2.5db de-emphasis to compensate the deterministic jitter caused by the long trace.
- Use 470ohm (in size of 0402) R_{adj} as default for PI2EQX3211B and use 750ohm as default for PI2EQX3211C. If the Tx eye at the SATA connector is not optimized, adjust R_{adj} (in the range of 330ohm to 620ohm for PI2EQX3211B and 500ohm to 850ohm for PI2EQX3211C) till the Tx eye at the SATA connector is optimized.
 - Locate the R_{adj} as close to the output pins of PI2EQX3211B/C as possible, within 2-3mm preferred.
 - There is no need to add the R_{adj} to the input of PI2EQX3211B/C between the PI2EQX3211B/C and SATA connector.
 - There is no need to add the R_{adj} to the output of PI2EQX3211B/C between the PI2EQX3211B/C and SATA controller.

6.0 The Applications Using PI2EQX3xx Family

6.1 Application example 1

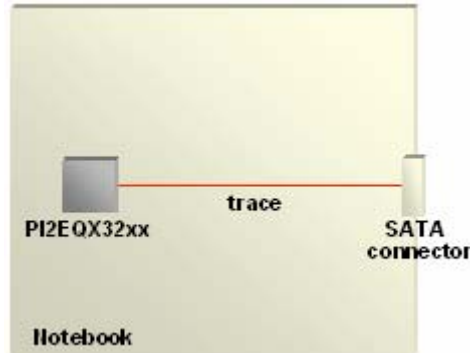


Figure 8, use PI2EQX3211x in a notebook with long trace (4" to 20") to achieve the optimized Tx eye at the SATA connector.

Please refer to figure 7 when choosing between PI2EQX3211B and PI2EQX3211C depending on the output trace length, or PI2EQX3431 for low power.

6.2 Application example 2

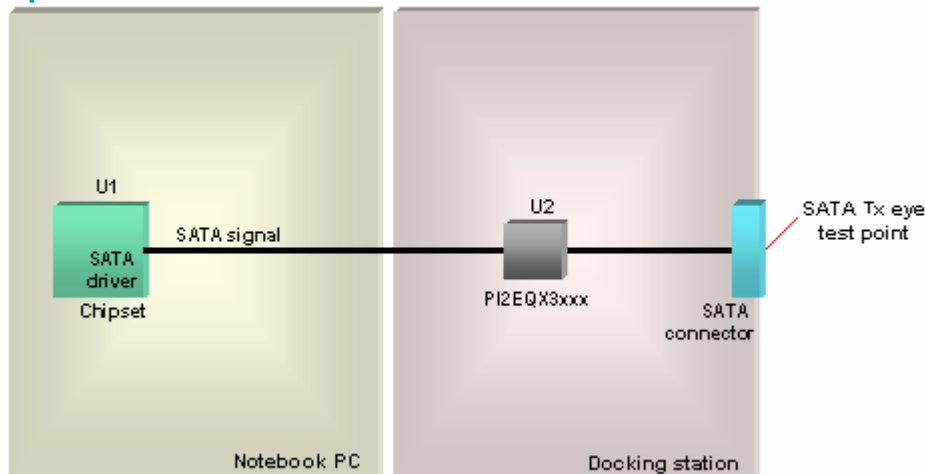


Figure 9, use the PI2EQX3211B, PI2EQX3211C and PI2EQX3431 (low power) for laptop and docking station application with long trace, similar as figure 1

Please refer to figure 7 for choosing between PI2EQX3211B and PI2EQX3211C depending on the output trace length.

6.3 Application example 3

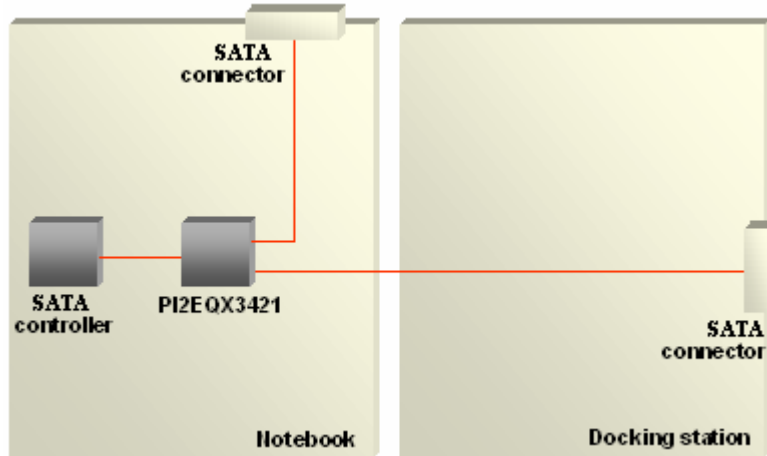


Figure 10, use the PI2EQX3421 (low power) as a mux for the laptop and docking station application

6.4 Application example 4

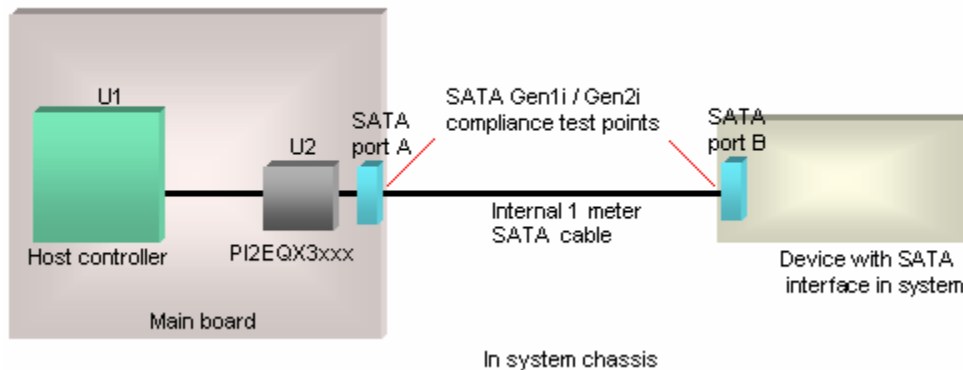


Figure 11, use the PI2EQX32xx for the internal 1-meter SATA cable application

The SATA ReDriver™ PI2EQX32xx in figure 11 will achieve the quality eye pattern result (SATA Gen1i and Gen2i) measured at the SATA port A (Tx eye) and SATA port B (Rx eye).

6.5 Application example 5

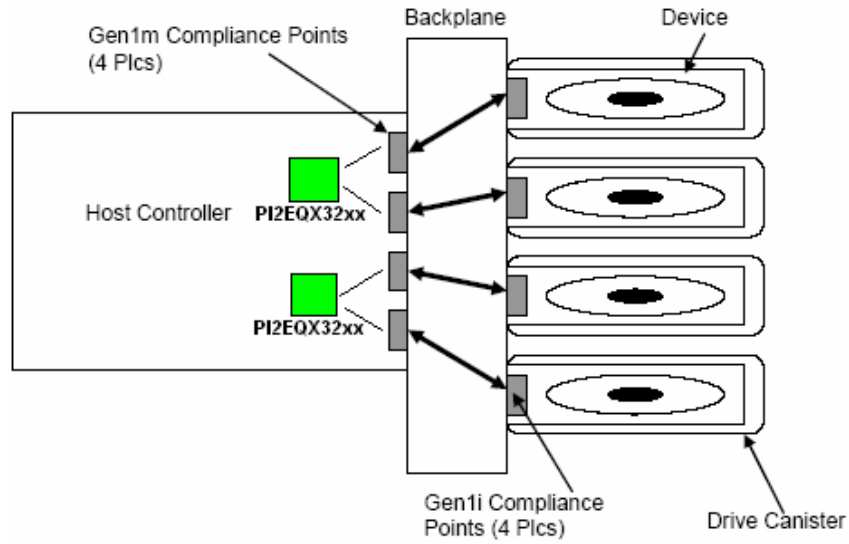


Figure 12, use PI2EQX32xx for backplane application

6.6 Application example 6

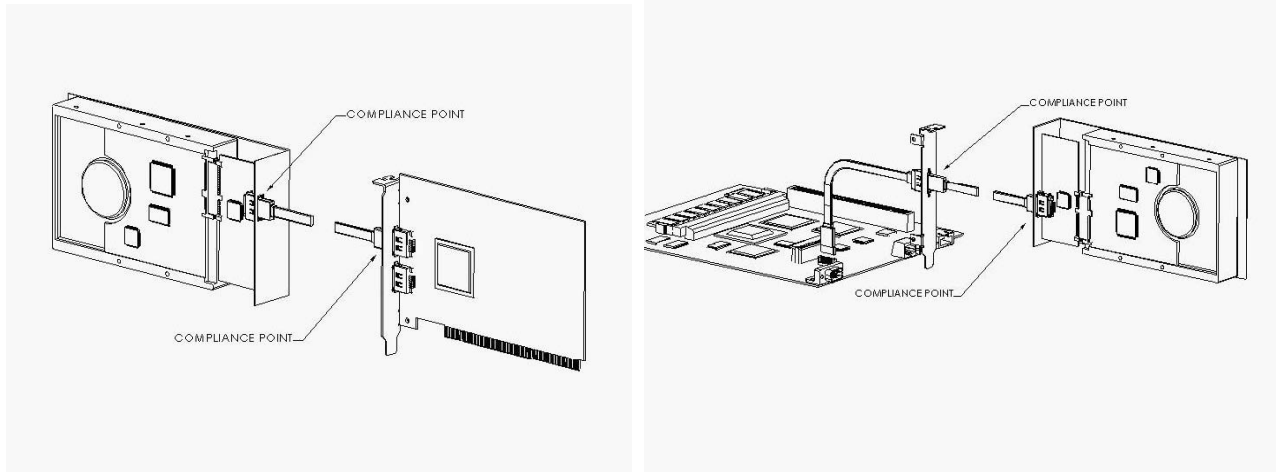


Figure 13, use PI2EQX32xx for the external long cable application, from 1 meter to 8 meter.

6.7 Application example 7

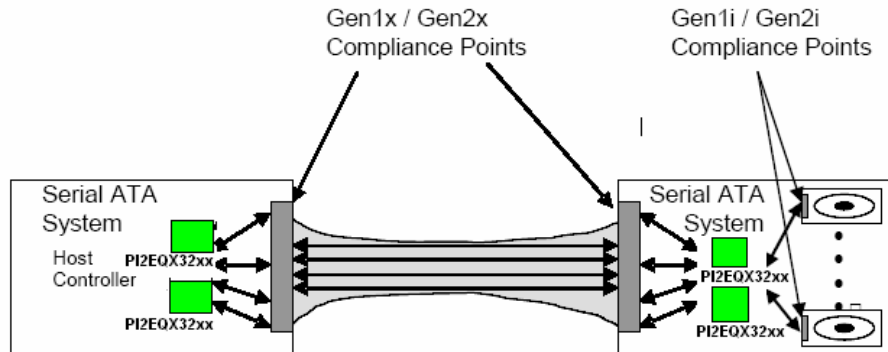


Figure 14, use PI2EQX32xx for the system-to-system application using long cable

7.0 The Recommended Settings of the PI2EQX3xxx ReDriver™ Family

7.1 The Settings of PI2EQX32xx for Various Input Trace Lengths

Input and output trace lengths		For PI2EQX32xx, 3.0gbs		
Input	Output	Swing	De-emphasis	Equalization
1.3"	0"-2"	0.8x to 1x	0db-1.5db	0db
13"	0"-2"	0.8x to 1x	0db-1.5db	1.5db
19"	0"-2"	0.8x to 1x	0db-1.5db	2.5db
24"	0"-2"	0.8x to 1x	0db-1.5db	3.5db
30"	0"-2"	0.8x to 1x	0db-1.5db	5.5db
35"	0"-2"	0.8x to 1x	0db-1.5db	7.5db
40"	0"-2"	0.8x to 1x	0db-1.5db	7.5db

Table 2, the settings of the PI2EQX32XX family for various input trace lengths.

7.2 The Settings of PI2EQX32XX for Various Output Trace Lengths

Input and output trace lengths		For PI2EQX32xx, 3.0gbs		
Input	Output	Swing	De-emphasis	Equalization
0"-2"	1.3"	0.8x to 1x	-1.5db	0db-1.5db
0"-2"	13"	1x to 1.2x	-3.5db	0db-1.5db
0"-2"	19"	1x to 1.2x	-3.5db	0db-1.5db
0"-2"	24"	1x to 1.2x	-3.5db	0db-1.5db
0"-2"	30"	1.2x to 1.4x	-4.5db	0db-1.5db
0"-2"	35"	1.2x to 1.4x	-4.5db	0db-1.5db
0"-2"	40"	1.2x to 1.4x	-6.5db	0db-1.5db

Table 3, the settings for PI2EQX32XX versus various output trace lengths.

7.3 The Settings of PI2EQX32XX for Various Input and Output Trace Length Combinations

Input and output trace lengths		For PI2EQX32xx, 3.0gbs		
Input	Output	Swing	De-emphasis	Equalization
16"	16"	1x to 1.2x	-3.5db	3.5db
24"	24"	1x to 1.2x	-4.5db	4.5db
32"	32"	1x to 1.4x	-4.5db	6.5db

Table 4, the settings for PI2EQX32XX versus various input and output trace length combinations.

For cable applications, use the settings in the table 2 to table 4 above and multiply the trace length by 3.5 - 6.5 times (depends on the quality and type of the cable) as for the equivalent length of the cable.

For instance, the settings for a 40" FR4 trace can be translated into the length for a cable as: 40" x 6.5 = 260" (6.6 meter) 26AWG SATA cable.

8.0 The Board Design and Layout Guidance for the SATA ReDriver™ PI2EQX3xxx

8.1 The Trace Width and Clearance

- The trace length miss-matching shall be less than 5 mils for the "+" and "-" traces in the same pairs
- Match the length between the pairs less than 3 inches
- Use wider trace width, with 100ohm differential impedance, to minimize the loss for long routes
- More pair-to-pair spacing for minimal crosstalk
- Target differential Zo of 100ohm ±20%

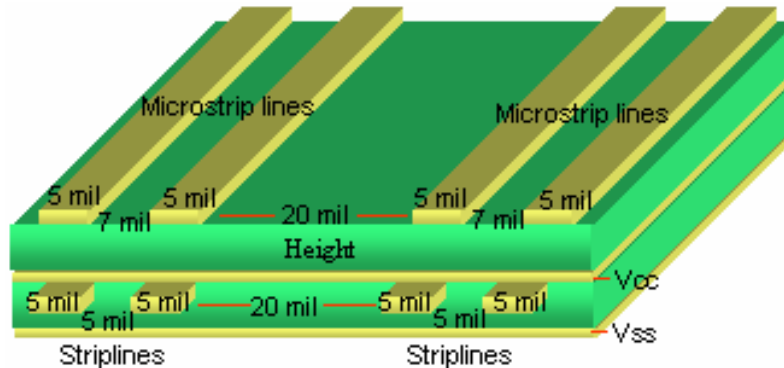


Figure 15, the trace width and clearance

8.2 The PCB Layers Stackup

- No new PCB technology required. Use FR4 is fine.
- Using standard 4 to 8 layers stack-up with 0.062 inch thick PCB.
- For micro strip lines, using ½ OZ Cu plated is ok.
- For strip line in 6 plus players, using 1 OZ Cu is better.

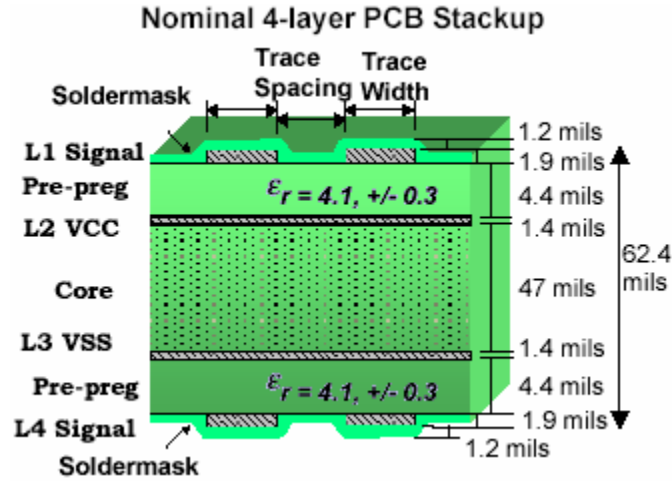


Figure 16, the stackup

8.3 The Layout Guidance for the Trace Routings

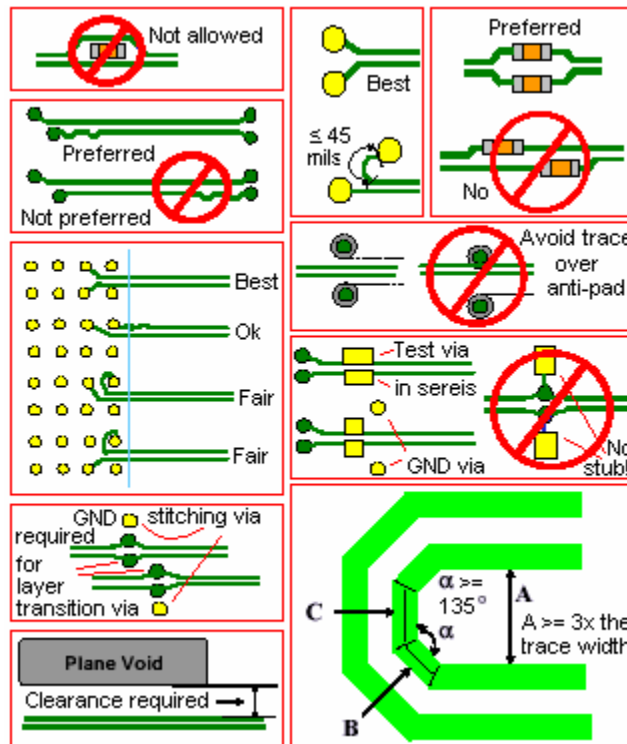


Figure 17, The layout guidance for the trace routings

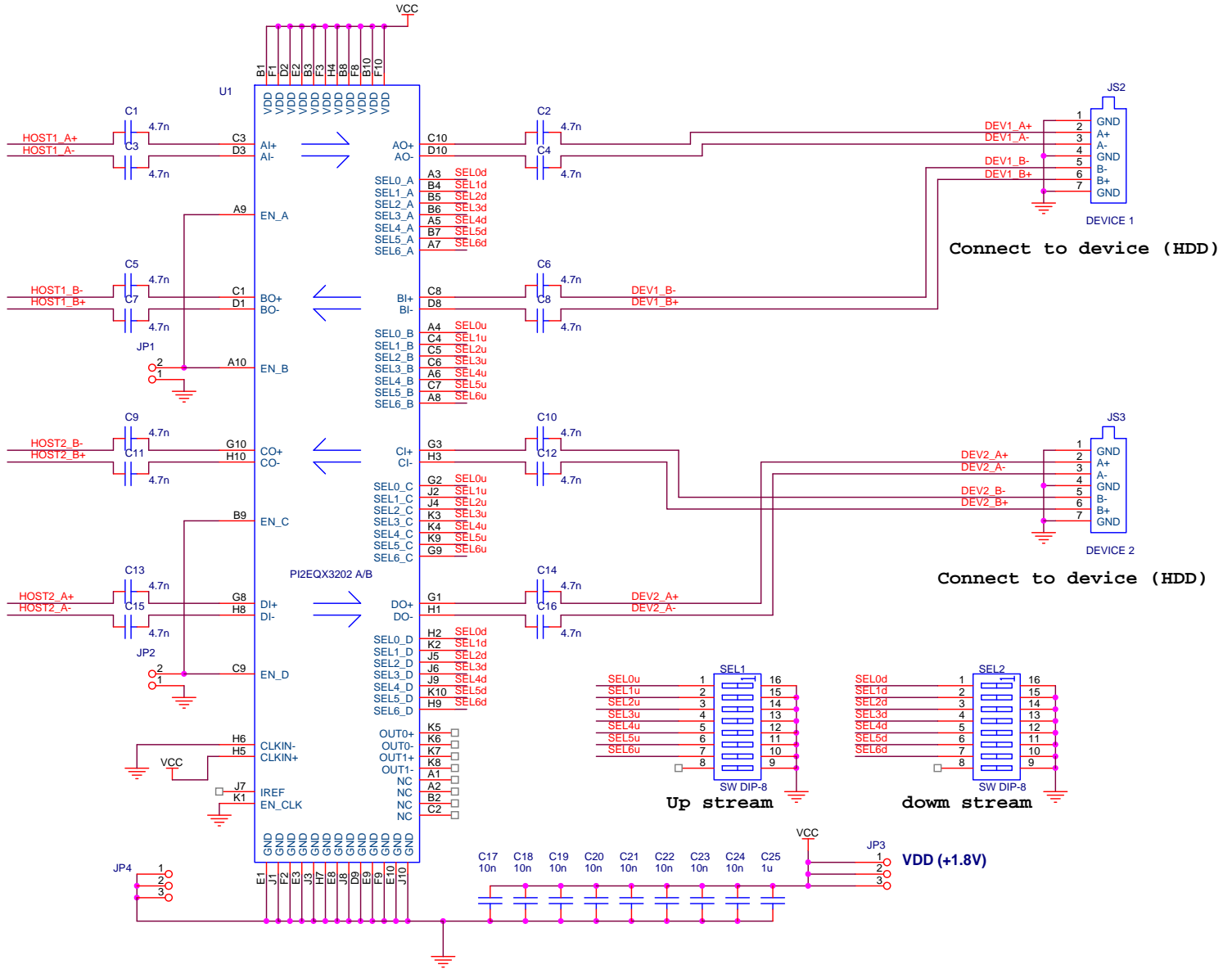
8.4 The Topology and Layout Guidance for the PI2EQXxxx Family

- Use Vdd de-coupling capacitors, 0.1uf to 0.22uf in size of 0402, for all the Vdd pins of the PI2EQX32xx, as close to the Vdd pins as possible, within 2-3mm if feasible.
- Use dedicated Vdd and GND planes for to minimize the jitters coupled between channel trough power sources.
- The differential traces shall be away from the strong EMI source and devices, such as the single-ended TTL traces and devices, with at least 30mil to 50mil space.
- No other components shall piggy ride on the differential traces.
- Locate the PI2EQX3xxx device as close to the SATA connector as possible, 5" to 7" traces between the PI2EQX32xx and the SATA connector is allowed, but with 2" to 3" is preferred.

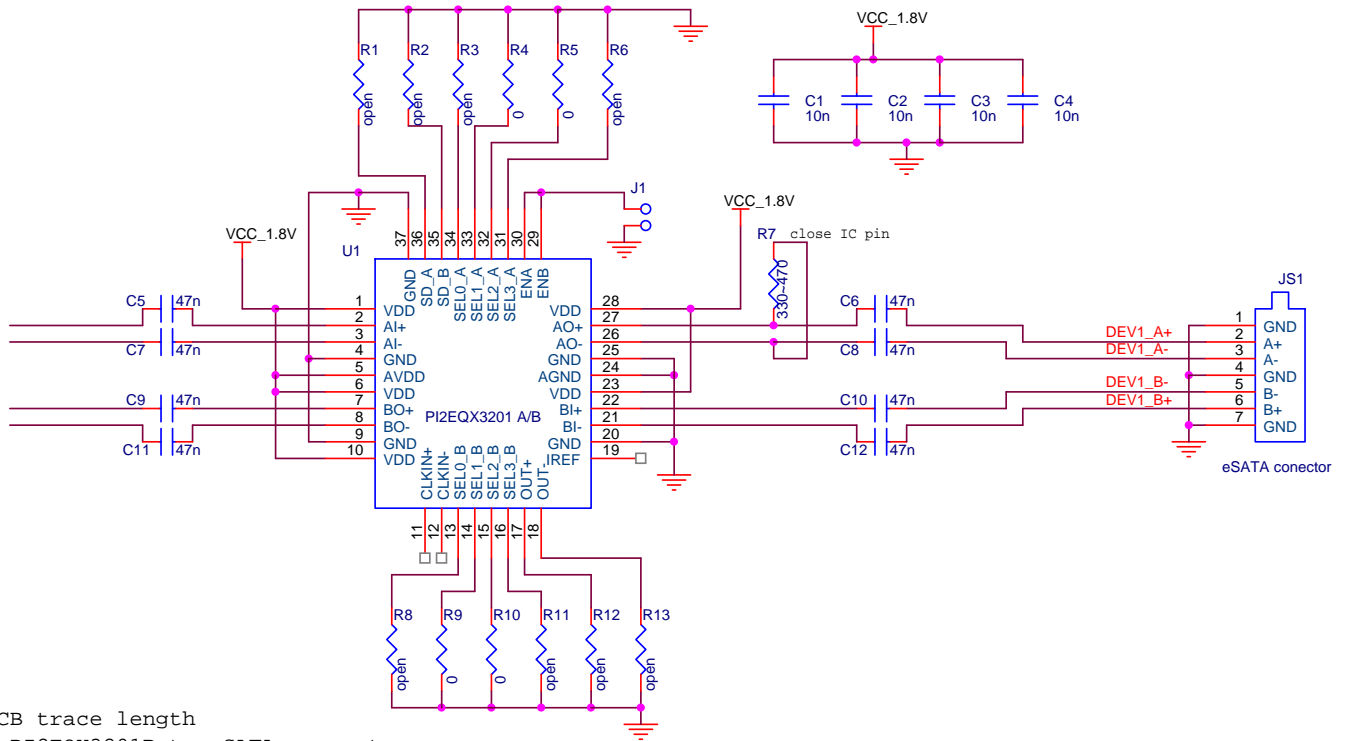
9.0 Appendix

Application Reference Schematics

9.1 PI2EQX3202A/B



9.2 PI2EQX3201A PI2EQX3201B



Note 1: PCB trace length

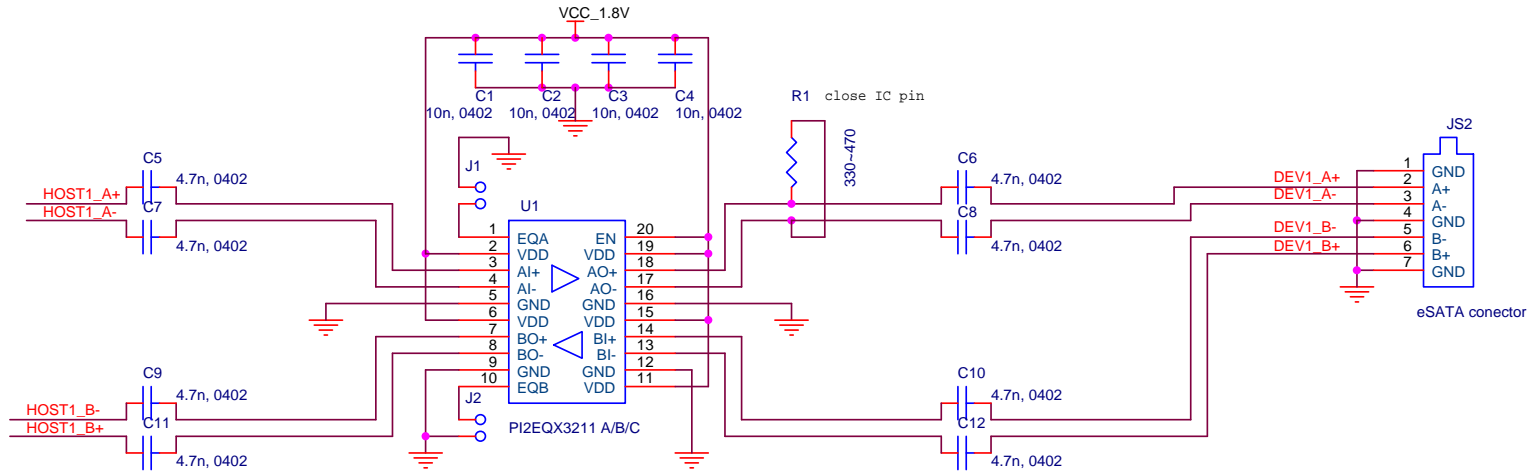
- 1) From PI2EQX3201B to eSATA connector
 - 0.3 ~ 6 inch when Diff 100 ohms PCB trace is width 4 mil /space 8 mil
 - 0.3 ~ 12 inch when width 9 mil /space 10 mil
- 2) From SATA controller to PI2EQX3201B
 - 1~12 inch when Diff 100 ohms PCB trace is width 4 mil /space 8 mil
 - 1~24 inch when width 9 mil /space 10 mil

Note 2: PI2EQX3201A is for SAS application

Note 3: All capacitor and resistor size 0402

Note 4: R1, R2, R13, R14 is use for footprint PIEQX3251B compatible.

9.3 PI2EQX3211A/B/C



Note 1: All capacitor and resistor size 0402

Note 2: PI2EQX3211B:

Diff 100 ohms PCB trace 4 mil width (space 8 mil), IC to eSATA connector < 4 inch
PCB trace 9 mil width (space 8 mil), IC to eSATA connector < 6 inch

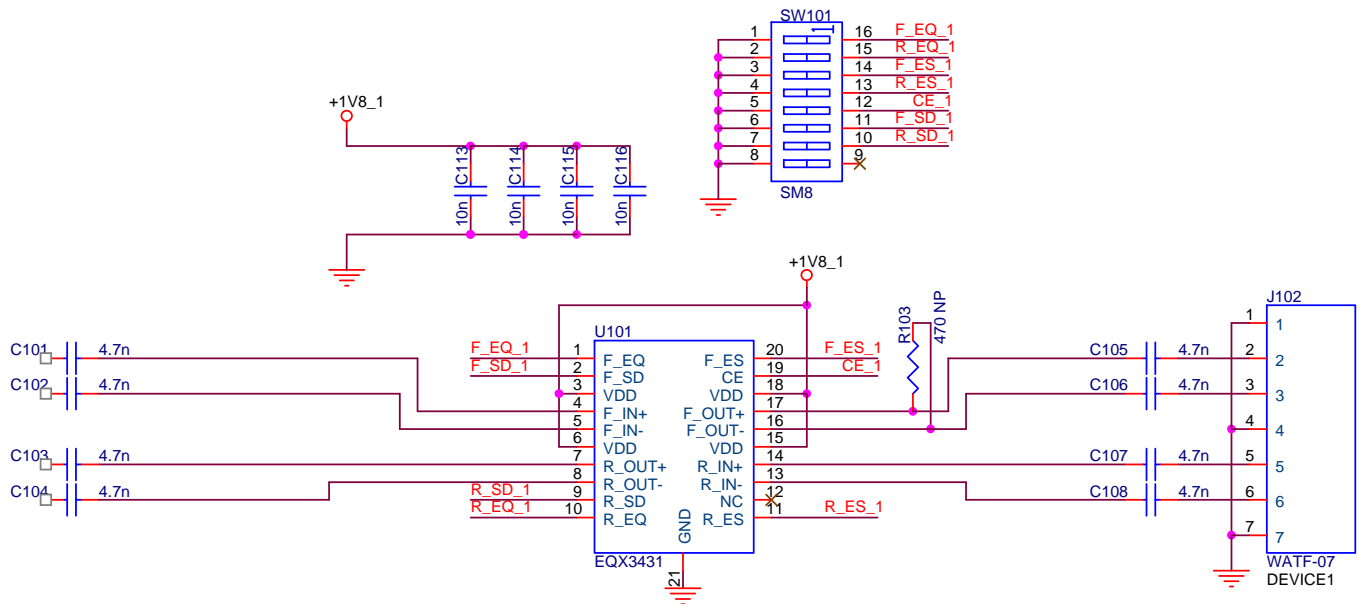
Note 3: PI2EQX3211C:

Diff 100 ohms PCB trace 4 mil width (space 8 mil), IC to eSATA connector 4~8 inch
PCB trace 9 mil width (space 8 mil), IC to eSATA connector 6~12 inch

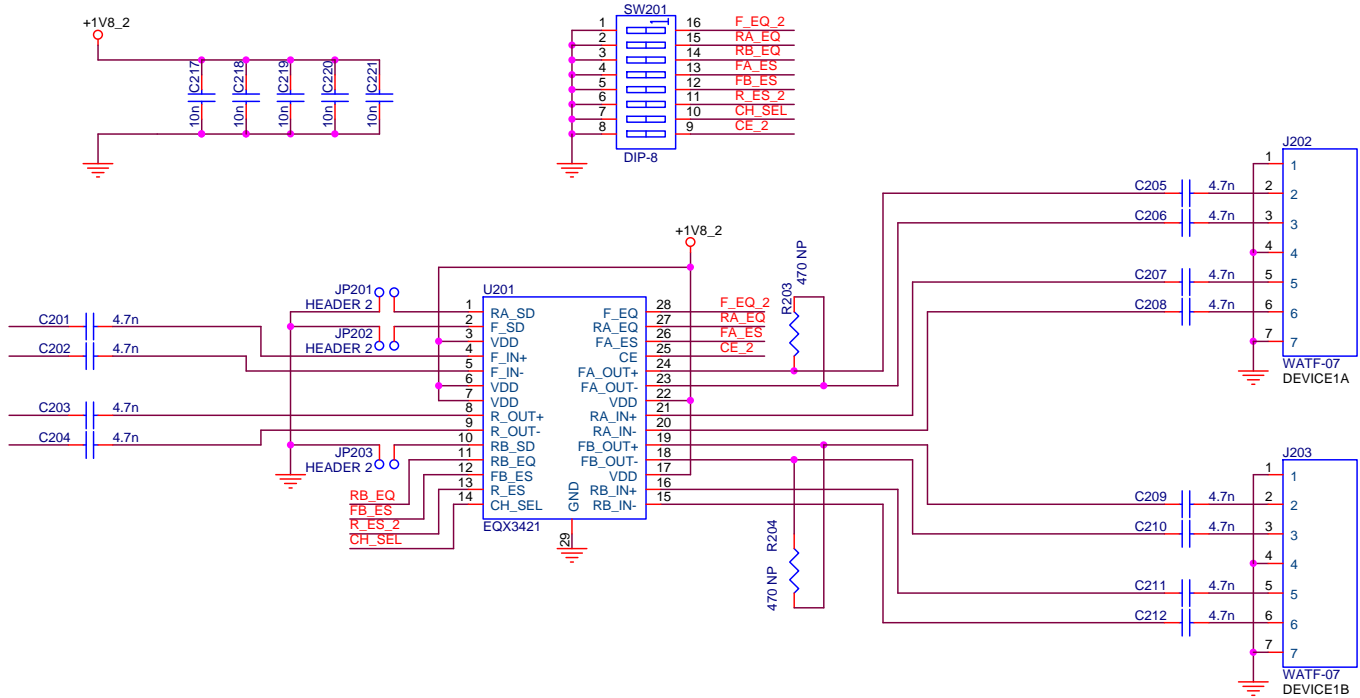
Note 4: PI2EQX3211CA:

Fos SAS application

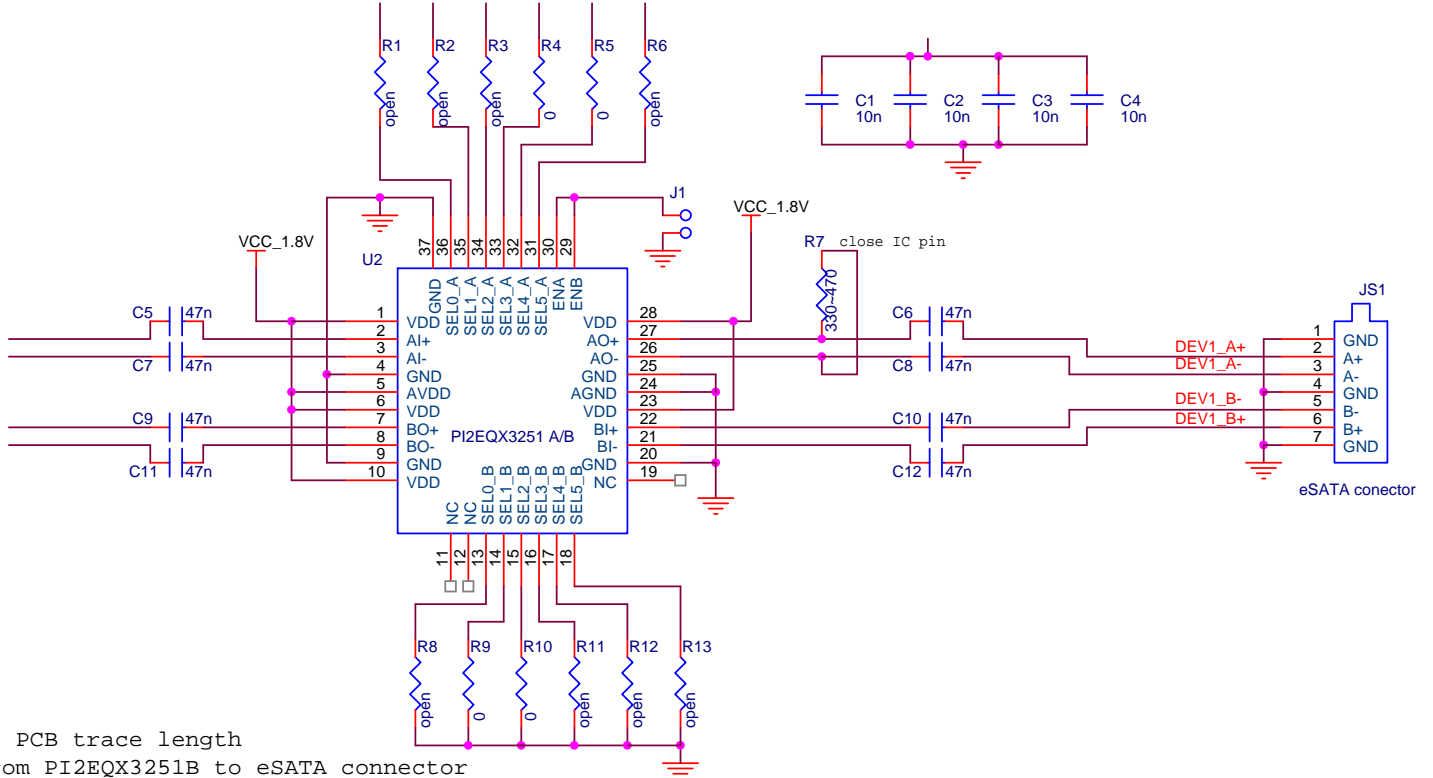
9.4 PI2EQX3431



9.5 PI2EQX3421



9.6 PI2EQX3251A/B



Note 1: PCB trace length

- 1) From PI2EQX3251B to eSATA connector
 - 0.3 ~ 6 inch when Diff 100 ohms PCB trace is width 4 mil /space 8 mil
 - 0.3 ~ 12 inch when width 9 mil /space 10 mil
- 2) From SATA controller to PI2EQX3251B
 - 1~12 inch when Diff 100 ohms PCB trace is width 4 mil /space 8 mil
 - 1~24 inch when width 9 mil /space 10 mil

Note 2: PI2EQX3251A is for SAS application

Note 3: All capacitor and resistor size 0402

Note 4: R1, R2, R13, R14 is use for footprint PIEQX3251B compatible.