



Genesys Logic, Inc.

USB 3.1 Hub Controller

Design Guide

Revision 1.10
Apr. 24, 2017



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Genesys Logic, Inc.

12F., No. 205, Sec. 3, Beixin Rd., Xindian Dist. 231,

New Taipei City, Taiwan

Tel : (886-2) 8913-1888

Fax : (886-2) 6629-6168

<http://www.genesyslogic.com>

Revision History

Revision	Date	Description
1.00	03/15/2016	Formal release
1.10	04/24/2017	Add RTERM reference resistance description

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1. INTRODUCTION

The purpose of this document is to provide suggestions for the design of circuit and PCB layout regarding the USB 3.1 Hub Controllers of Genesys Logic Inc.

2. CIRCUIT DESIGN AND PCB LAYOUT GUIDELINES

2.1 AC Coupling Capacitors

PHY is a component where the transmitter and receiver are located and operated together. The AC coupling capacitors are associated with the transmitter.

Differential Pairs	Capacitor
USB 3.1 SS TX P/N	0.1uF

The AC coupling Capacitor should be placed by closing to Connector. The capacitor body size should be less than or equal to 0603 (**0402 is recommended**). And AC coupling capacitor must be placed symmetrically. (as shown in **Fig. 2.1**)

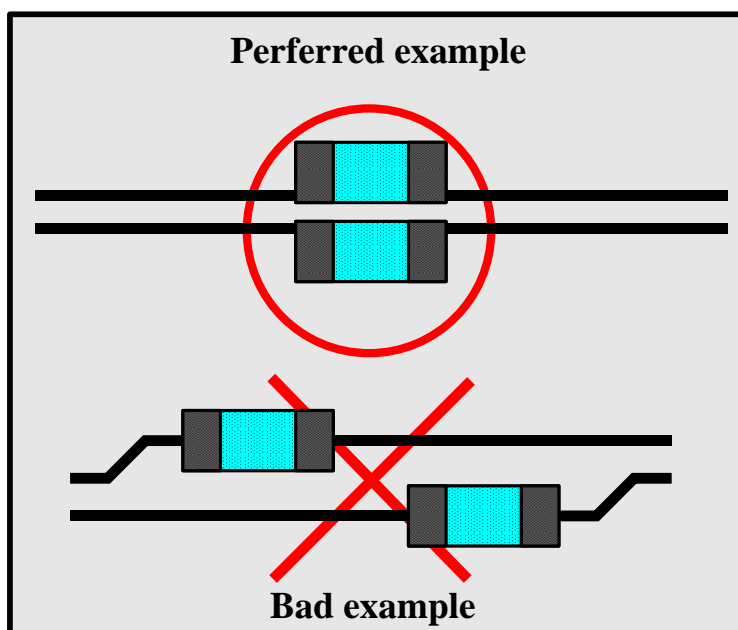


Figure 2.1

2.2 PCB Layer and Material

2.2.1 4-Layer PCB

Four (4) layers and FR4 PCB are recommended to use. Besides, *the traces of differential signals must be entirely routed over ground plane.*

PCB Layer	Trace Net Name
Top	SS Differential Pair Trace (Hub IC should be placed in the same layer)
Inner 1	GND
Inner 2	POWER,GND
Bottom	HS Difference Pair , Control Signal

2.2.2 2-Layer PCB

PCB Layer	Trace Net Name
Top	SS Differential Pair Trace (Hub IC should be placed in the same layer)
Bottom	HS Difference Pair , Control Signal

2.3 Differential Pairs Trace

2.3.1 Differential Pair Impedance

The differential impedance requirement must be **90 Ohm \pm 10 %** and trace width / spacing may be different by PCB material characteristic base on PCB Vendor suggest.

2.3.2 Differential Trace

Keep the trace length of SS TX/RX or HS D+/D- from USB connector to chip as short as possible. And the differential pairs trace routing must be symmetrical. **USB 3.1 & USB 2.0 differential trace MUST use different layer to avoid cross routing.** Make the differential signal trace GND plane via holes as more as possible to keep GND plane solid with adjacent GND layer.

2.3.3 Differential Trace Length Preliminary Guidelines

Differential Pairs	Signal Referencing	Trace Mismatch Tolerance	Maximum Total Length
USB 3.1 SSTXP/N, SSRXP/N	Ground	$\leq 5\text{mil}$	9 inches
USB 2.0 DP/DM	Ground	$\leq 50\text{mil}$	9 inches

2.3.4 Trace Bend

When traces are encountered, please **use 45° bends** (or turns) of traces. The inner air gap of a bend, **A** should be ≥ 20 mils and the angles between traces should be greater than **135 degrees**. ($\alpha \geq 135^\circ$) and the length of **B** and **C** should be **minimized**.

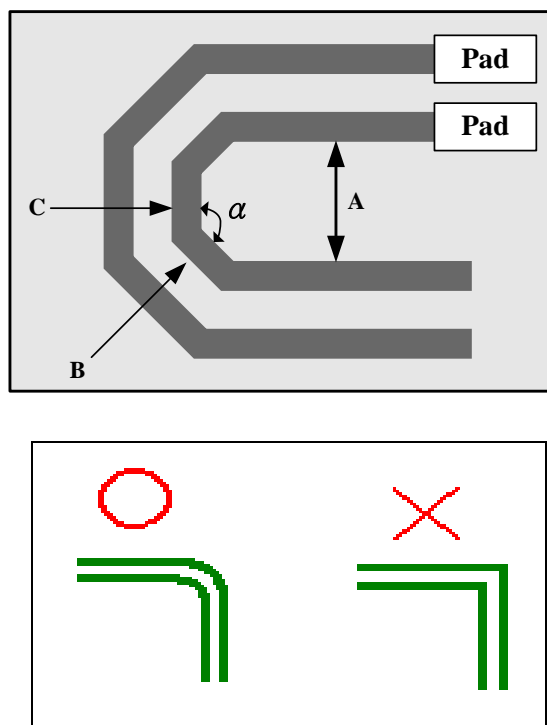


Figure 2.2

2.3.5 Reference Plane

Make sure that the differential trace layer and adjacent layer are with solid GND plane. The differential pair trace must be **kept in the outer layer**, and have a **continual full ground plane** at **neighbor layer** for reference. (See Fig. 2.3)

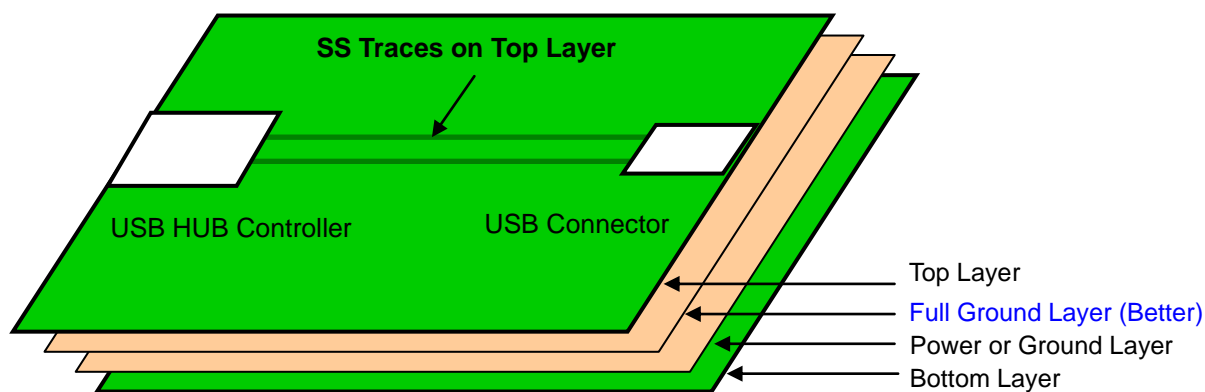


Figure 2.3

A differential pair should *avoid discontinuation in the reference plane*, such as *splits* and *voids*. When a signal need *changes layers*, must keep the *same reference plane* and the *ground stitching via* should be placed by *closing to the signal via*. A *minimum of 2 stitching via* per pair of signals is recommended. Never route a trace so that it straddles a plane split. (See Fig. 2.4)

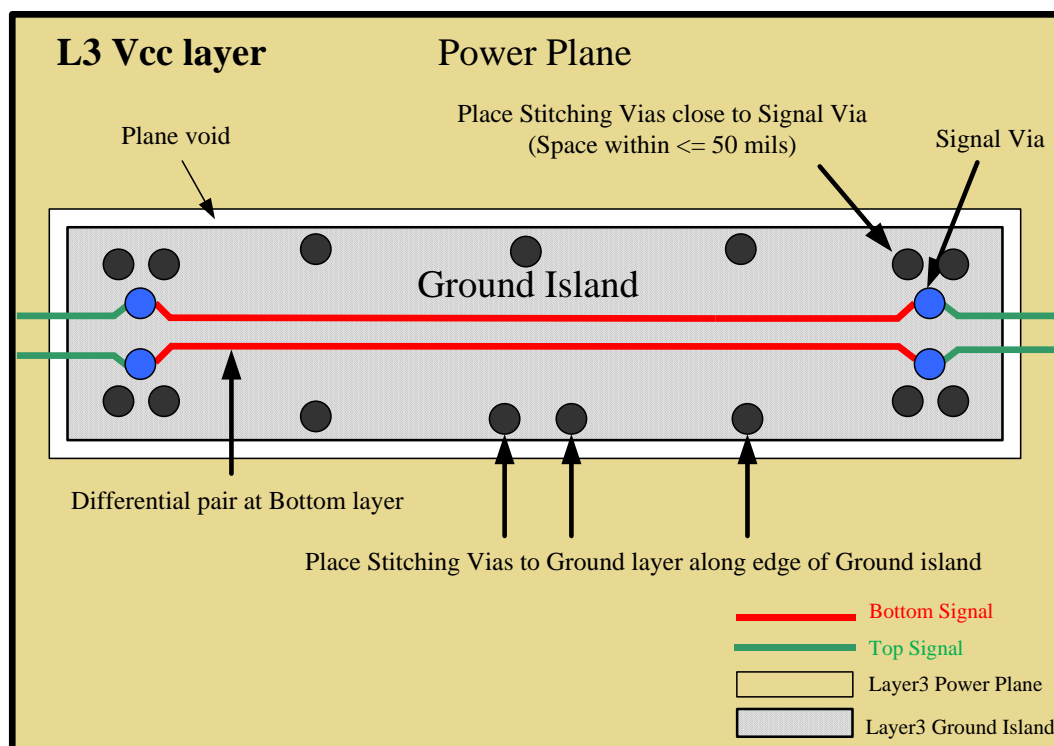


Figure 2.4

2.3.6 Signal Return Path

An incorrect signal return path is one of the most common sources for noise coupling and EMI problems.

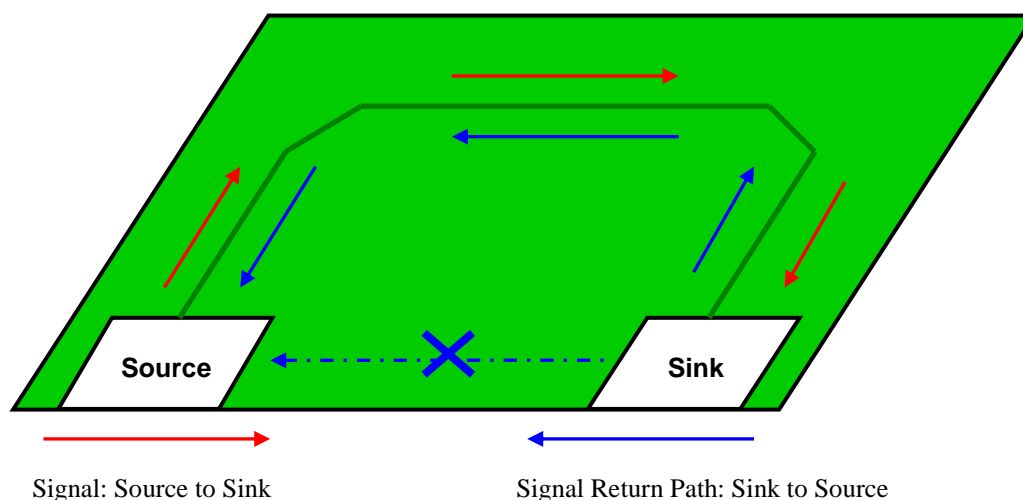
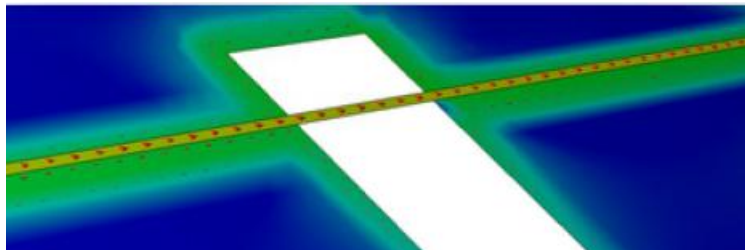


Figure 2.5 Return Current tries to follow the Signal Path

A signal should not be routed over a split plane as the return path is not able to follow the signal trace. If a plane is split between a sink and source, route the signal trace around it. If the forward and return paths of a signal are separated, the area between them acts as a loop antenna.



The Amount of Radiation with Slit (Measurement Result)

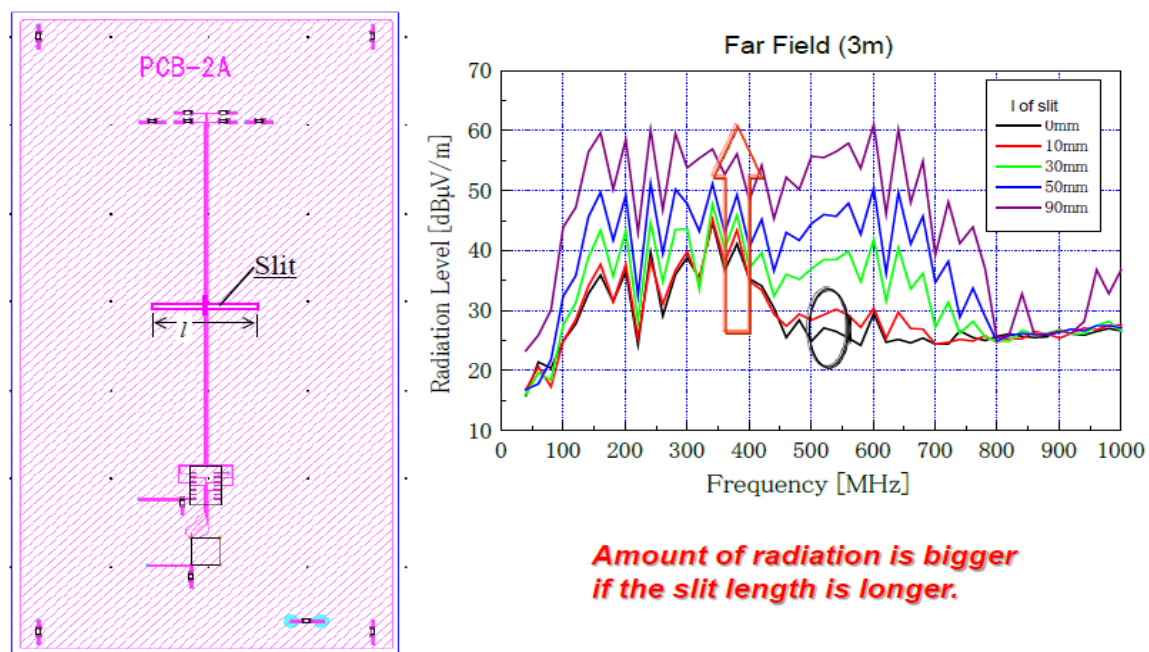


Figure 2.6 Avoid Routing over Split Planes

2.3.7 Differential Pair Layout

The routing of a differential pair must be kept as *same length*, *same width*, *same layer* and *fixed space gap*, and also be kept as *symmetric* as possible (as shown in Fig. 2.7).

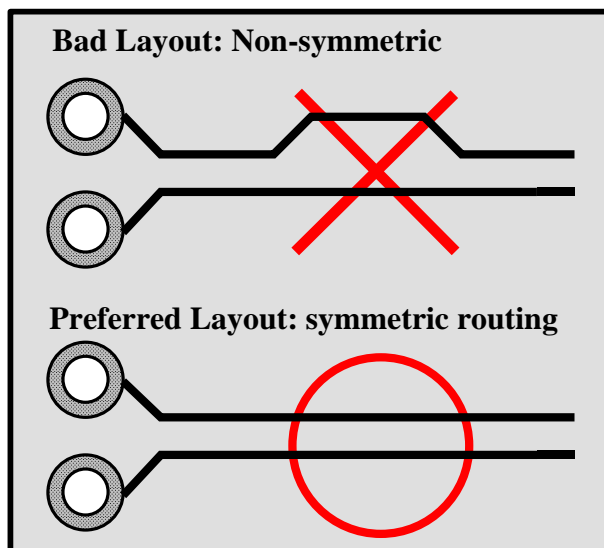


Figure 2.7

When vias are used, they should always be placed in same location and symmetric (as shown in Fig. 2.8).

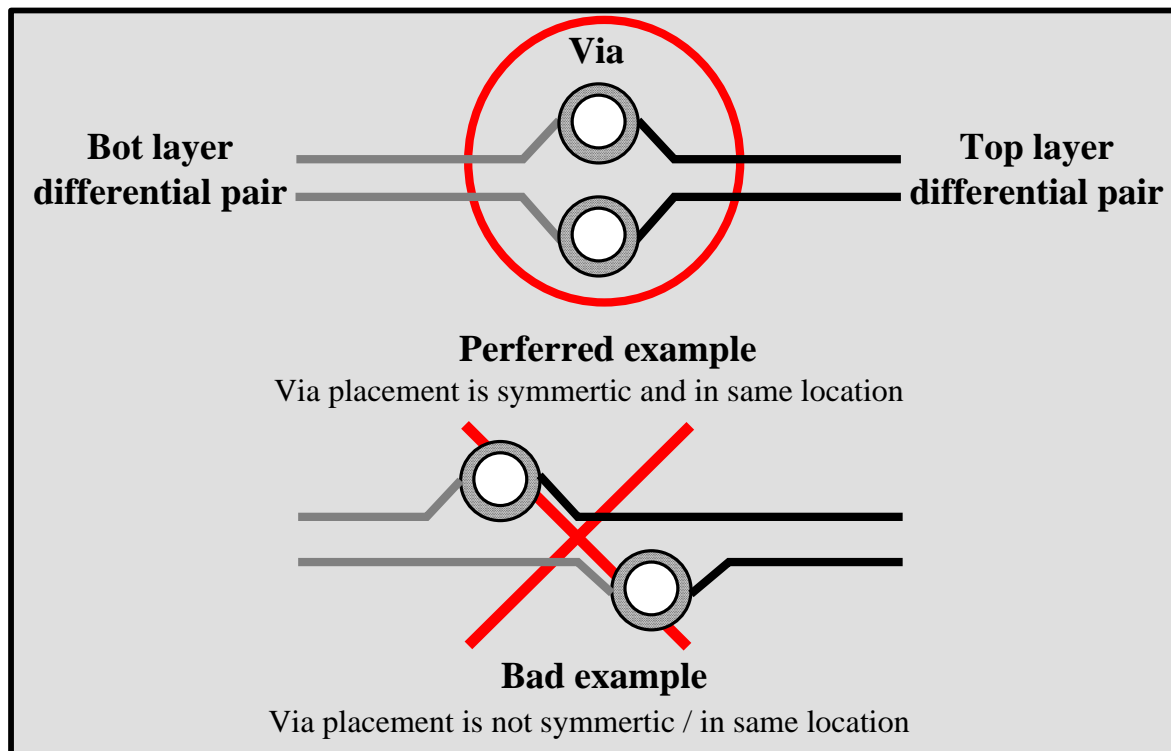


Figure 2.8

2.3.8 Avoid Stub on Differential Traces

Please avoid unexpected stubs. If the Test Pin is needed to be put on the differential pair trace, please make sure there is no stub on any signal trace (as shown in **Fig. 2.9**).

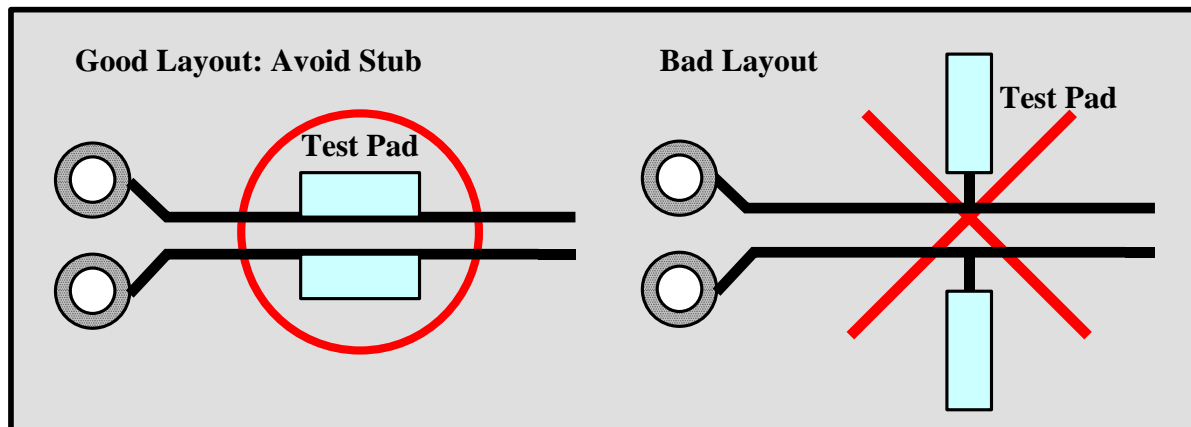


Figure 2.9

2.3.9 SS Trace Swap

If cross trace is needed to make the layout easier, SS differential trace (TXP /TXN or RXP / RXN) N&P can be swapped. As shown in **Fig 2.10**

- Pin TXN of the IC can be connected to TXP of the connector.
- Pin TXP of the IC can be connected to TXN of the connector.
- Pin RXN of the IC can be connected to RXP of the connector.
- Pin RXP of the IC can be connected to RXN of the connector.

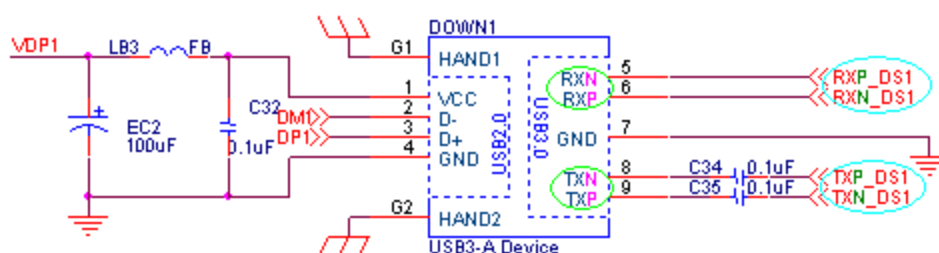
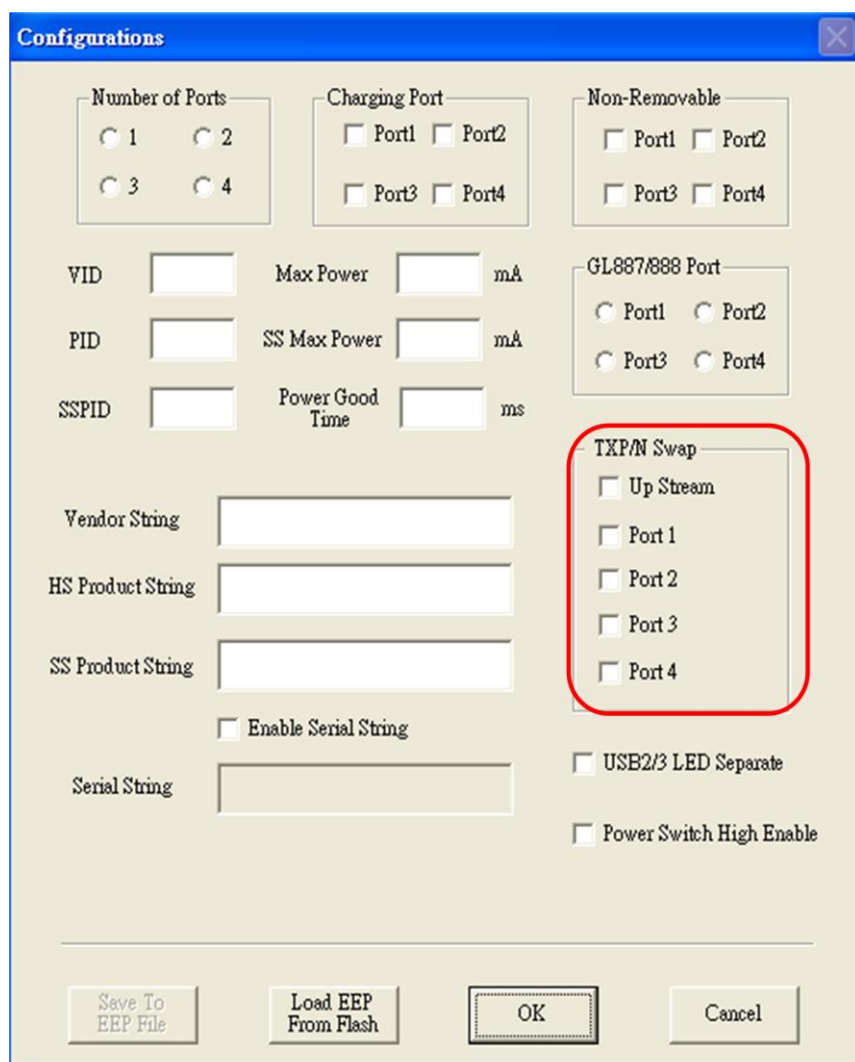


Figure 2.10

Note:

1. Because some devices may not support RXN/RXP swap function, it is **NOT** recommended swap Hub TXN and TXP traces for better compatibility.
2. If TXN and TXP swap function is needed for layout concern, Hub firmware needs to be modified accordingly. The “TXP/N Swap” function **MUST** be selected in Configuration of the Genesys Logic USB 3.1 Hub FW ISP Tool at the same time. Choose the port whose TXN and TXP traces is swapped. (as shown in **Fig 2.11**)



The image shows a 'Configurations' dialog box with various settings for a USB 3.1 Hub. The settings are organized into several sections:

- Number of Ports:** Radio buttons for 1, 2, 3, and 4 ports.
- Charging Port:** Checkboxes for Port1, Port2, Port3, and Port4.
- Non-Removable:** Checkboxes for Port1, Port2, Port3, and Port4.
- VID:** A text input field.
- PID:** A text input field.
- SSPID:** A text input field.
- Max Power:** A text input field followed by 'mA'.
- SS Max Power:** A text input field followed by 'mA'.
- Power Good Time:** A text input field followed by 'ms'.
- Vendor String:** A text input field.
- HS Product String:** A text input field.
- SS Product String:** A text input field.
- Enable Serial String:** A checkbox.
- Serial String:** A text input field.
- GL887/888 Port:** Radio buttons for Port1, Port2, Port3, and Port4.
- TKP/N Swap:** A section highlighted with a red border, containing:
 - ☐ Up Stream
 - ☐ Port 1
 - ☐ Port 2
 - ☐ Port 3
 - ☐ Port 4
- USB2/3 LED Separate:** A checkbox.
- Power Switch High Enable:** A checkbox.

At the bottom of the dialog are four buttons: 'Save To EEP File', 'Load EEP From Flash', 'OK', and 'Cancel'.

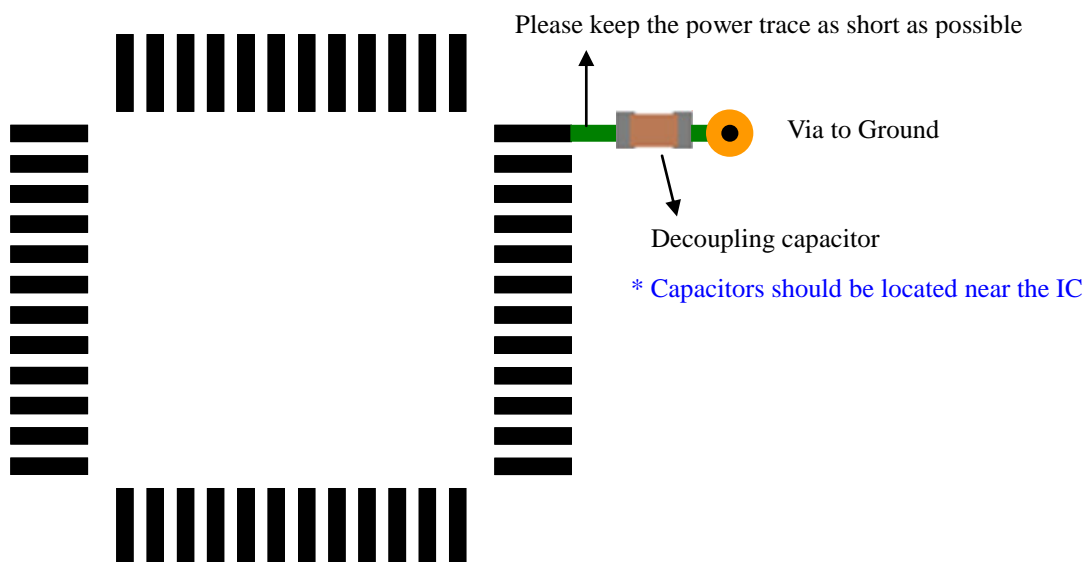
Figure 2.11

2.4 Circuit and Component Placement

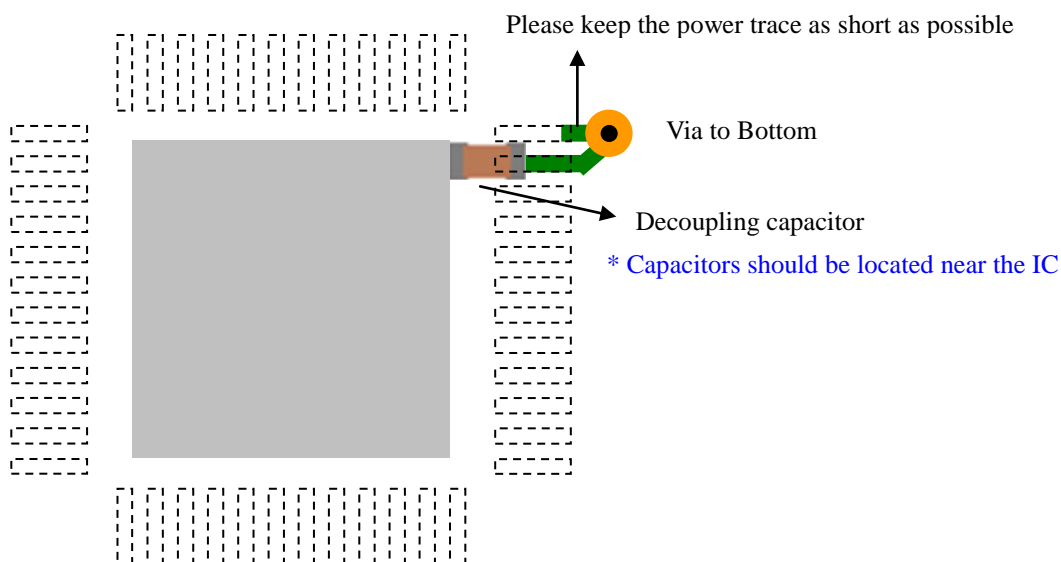
2.4.1 Decoupling Capacitors

Please place the 0.1uF decoupling capacitor as close as possible to the UBS 3.1 Hub power pins.

An example of decoupling capacitor positioning on top layer:



An example of decoupling capacitor positioning on Bottom layer:



2.4.2 RTERM Reference Resistor

GL3520/GL3521 RTERM reference resistor uses 680 ohm $\pm 1\%$ and please place it as close as possible to the IC.

GL3523/GL3523-S RTERM reference resistor uses 20k ohm $\pm 1\%$ and please place it as close as possible to the IC.

2.4.3 Crystal Circuit

1. 50ppm precision class is recommended for the X'tal.
2. Keep the distance between crystal and the IC less than 1cm to avoid triggering high frequency oscillation on PCB. If over 1cm is unavoidable in the design, place the capacitors and the resistor as close as possible to the IC. Recommend less than 1cm if possible. And the resistor needs to be between the IC and the capacitor. See **Fig. 2.12**

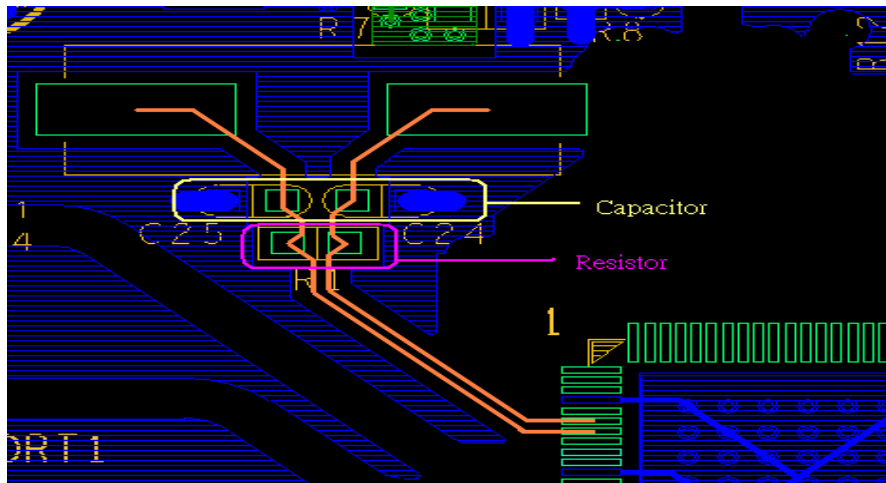


Figure 2.12

3. Do not route X1 and X2 underneath the IC. In this case, it may cause noise on PCB and will trigger high frequency oscillation.
4. The crystal traces shall be symmetrical and parallel in order to get better oscillation wave form and better EMI protection (as shown in **Fig. 2.13**).

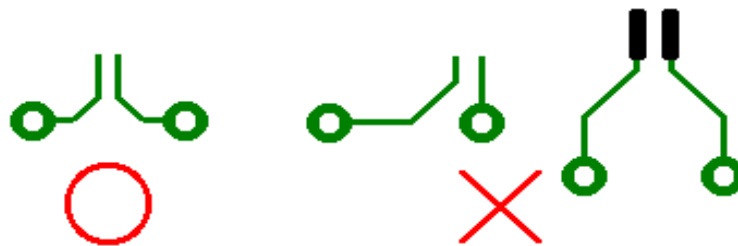


Figure 2.13

2.4.4 Reset Circuit

Keep the Reset circuit placement as close as possible to the IC.

2.5 Power Source

Make sure that the DC to DC converter output voltage is 1.2V. Follow the PCB layout guidelines for optimal performance of UP1722PDE6.

1. For the main current paths, keep their traces short, direct and wide.
2. Put the input/output capacitors as close as possible to the device pins.
3. LX node is with high frequency voltage swing and should be kept in small area. Keep analog components away from LX node to prevent stray capacitive noise pick-up.
4. Keep the connect feedback network behind the output capacitors. Place the feedback components near the UP1722PDE6 and keep the loop area small. .
5. A ground plane is preferred, but if not available, keep the signal and power grounds segregated with small signal components returning to the GND pin at one point. They should not share the high current path of C_{IN} or C_{OUT} .
6. Flood all unused areas on all layers with copper. Flooding with copper will reduce the temperature rise of power components. These copper areas should be connected to VIN or GND.

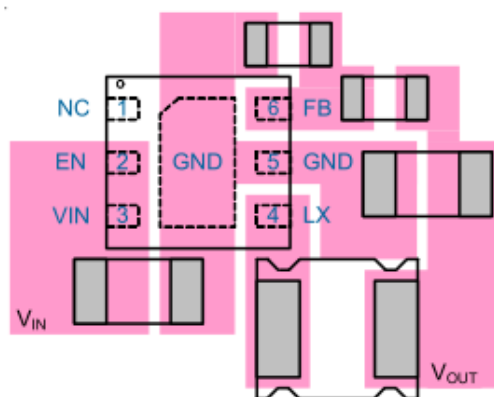


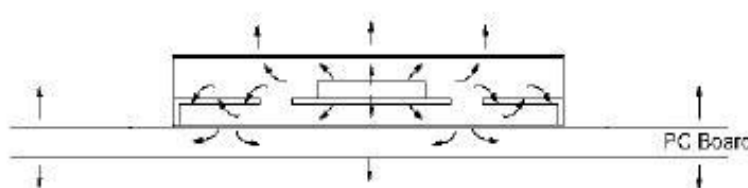
Figure 2.14

2.6 Power Trace of Charging Downstream Port

USB3.1 Hub allows BC1.2 portable devices to draw up to 1.5A from each charging downstream ports (CDP) by compliant with USB Battery Charging Specification rev1.2, so ***the width of charging downstream port VBUS trace is better to > 60mils*** to support enough current to avoid voltage drop. And the total power adapter or system power source should also consider how many CDPs support to provide enough current for fast charging. For example, if the design supports four charging downstream ports, the 5V power supply must be capable of delivering total 6Amps.

2.7 Thermal Reduction

Optimum layout suggestion for thermal sensitive design: The copper under chip GND area is through via holes and inner 2 (GND layer) to reach heat sink effect.

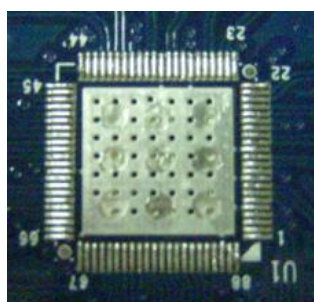


The two paths of heat dissipation shown in the above figure are as follows:

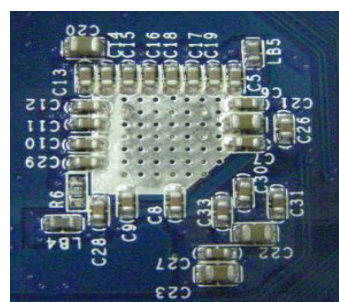
1. IC chip → Package → Atmosphere
2. IC chip → Package → lead → PC board → Atmosphere

Figure 2.15

To prevent temperature surge on silicon surface under worst environment, it is strong recommended to use following layout option to increase the efficiency of silicon heat spreading. The copper under chip GND area must be appeared on bottom layer and drill more through holes (0.5mm) to reduce chip thermal impact.



Top View



Bottom View

Chip ground VIA

Diameter — 0.5mm

VIA to VIA gap — 50 mil

2.8 Trace Width and Adjacent Space Gap

2.8.1 USB 3.1

The edge-to-edge spacing of adjacent pairs should be greater than 20 mils at least. The differential pair traces should be kept at least 20 mils away from the edge of the Power or GND plane (trace), signal trace and vias.

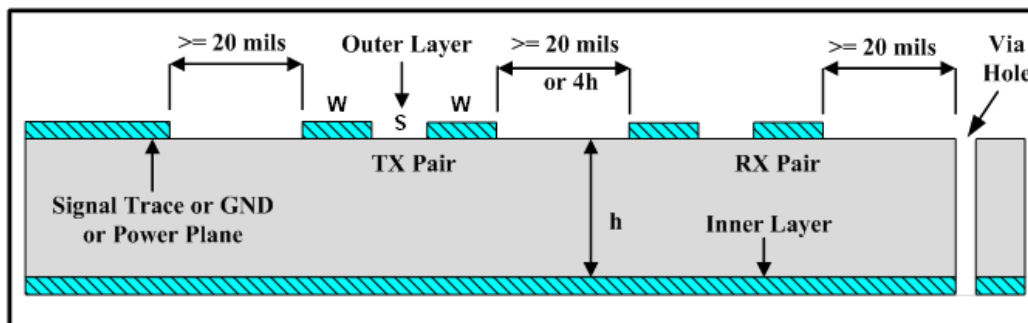


Figure 2.16

*Note: Different Port differential signal trace Gap ≥ 20 mils or use GND plane isolate, The GND plane and differential signal trace Gap ≥ 20 mils.

2.8.2 USB 2.0

The GND of the signal lines shall have spacing of at least 20mil with the signal lines.

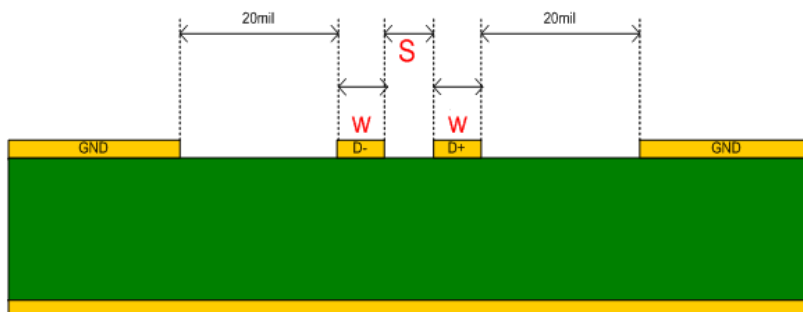


Figure 2.17

2.8.3 Recommend Width and Space for USB 2.0 & USB3.1 Trace

Please refer to the following table for the recommended width and spacing on 4-layer PCB setting:

*Note: The trace width (W) / spacing (S) may be different by PCB material characteristic base on PCB Vendor suggest.

Differential Pair	Setting 1	Setting 2
Trace width (W)	6mil	8mil
Intra pair spacing (S)	6mil	7mil
Target impedance	90 Ohm \pm 10 %	

1. The layout trace diagram of 1.2V DC/DC converter is described as **Fig. 2.18**. Please route the UP1722PDE6 power trace first, and then place GPIO (PAMBER#). The width of SW 1.2V power trace line is recommended to be 40 mils. The trace of FB is recommended to be as short as possible, and not to be routed through the layer of EMI protection. There is large current passing though the pin 2 of UP1722PDE6. This pin has to be connected with the ground of C_{IN} and C_{OUT} , and the trace has to be wide. Increase the amount of via holes at the ground of pin 2. Increase via holes at the ground connected with C_{IN} , C_{OUT} , and the pin 2 of UP1722PDE6, and widen the trace. Please also refer to Section 3.4 Power Source for more information.
2. The layout trace diagram of 1.2V or 3.3V power trace is described as **Fig. 2.19**. Please route the power trace first, and then place GPIO (PAMBER#). The width of DVDD12 power trace line is recommended to be 40 mils, and the width of DVDD33 power trace line is to be 30 mils.



2.10 GL3521 Layout Notice

1. The layout trace diagram of 1.2V power is described as **Fig. 2.20**. The width of SW 1.2V power trace line is recommended to be 40 mils. The trace of FB is recommended to be as short as possible, and not to be routed through the layer of EMI protection. Please also refer to Section 3.4 Power Source for more information. The resistor divider R1 and R2 must be connected between the (+) plate of C_{OUT} and a ground line terminated near GND. The SW should be connected to inductor by wide and short trace, and keep sensitive components away from this trace. There is large current passing through the pin 88 GND of GL3521. This pin has to be connected with the ground of C_{IN} and C_{OUT} , and the trace has to be wide. Increase the amount of via holes at the ground of pin 88. Increase via holes at the ground of C_{IN} and C_{OUT} .
2. The layout trace diagram of 1.2V or 3.3V power trace is described as **Fig. 2.21**. The width of DVDD12 power trace line is recommended to be 40 mils, and the width of DVDD33 power trace line is to be 30 mils.
3. Please reduce at least 2 vias when the 5V or 12V power trace is needed to go through different layers. Please refer to the **Fig. 2.22** for more detailed information.

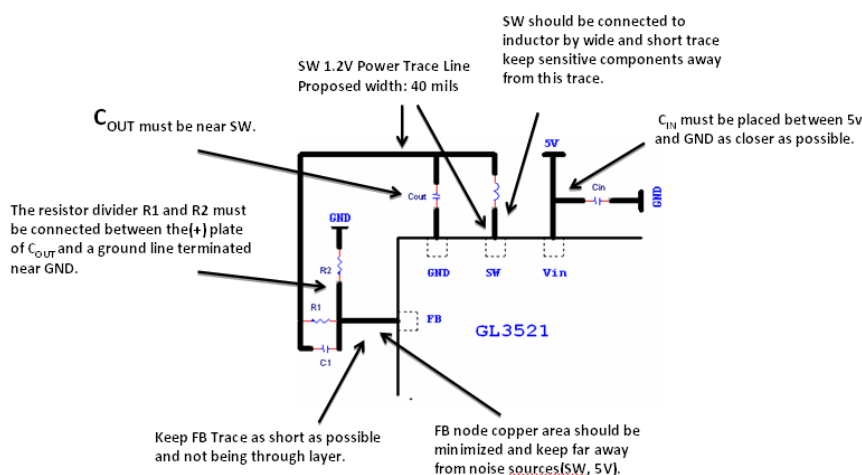


Figure 2.20

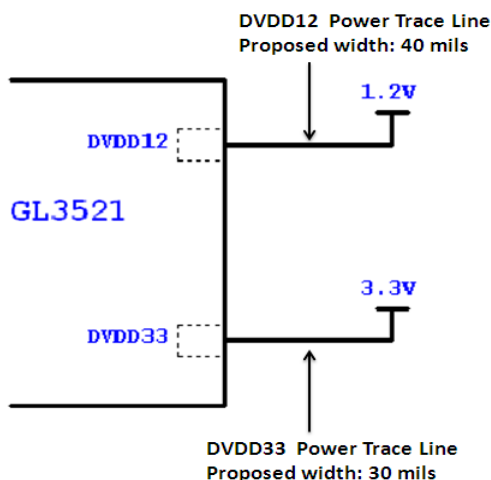


Figure 2.21

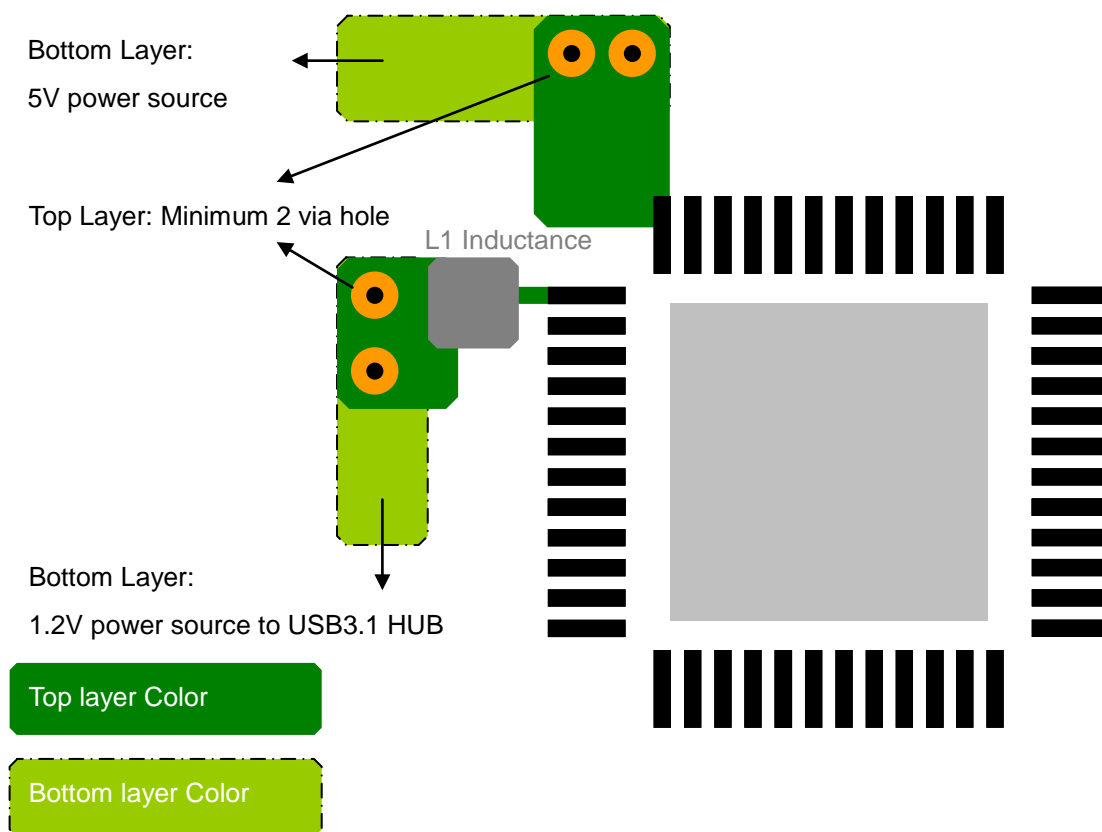


Figure 2.22

3. SYSTEM DESIGN GUIDELINE

3.1 System Design Overview

In order to cover the wide range of expected application, two compliance channels are defined for electric compliance testing. And, these two compliance channels (back channel and front channel) are used to check the channel loss and reflection effect of Device or Upstream port of HUB. The figure below shows the compliance channel designs for hosts, devices and cables. The host and cable compliance channels are used in testing of device/HUB (UP) designs. The device and cable compliance channels are used for testing of host/HUB (DP) designs.

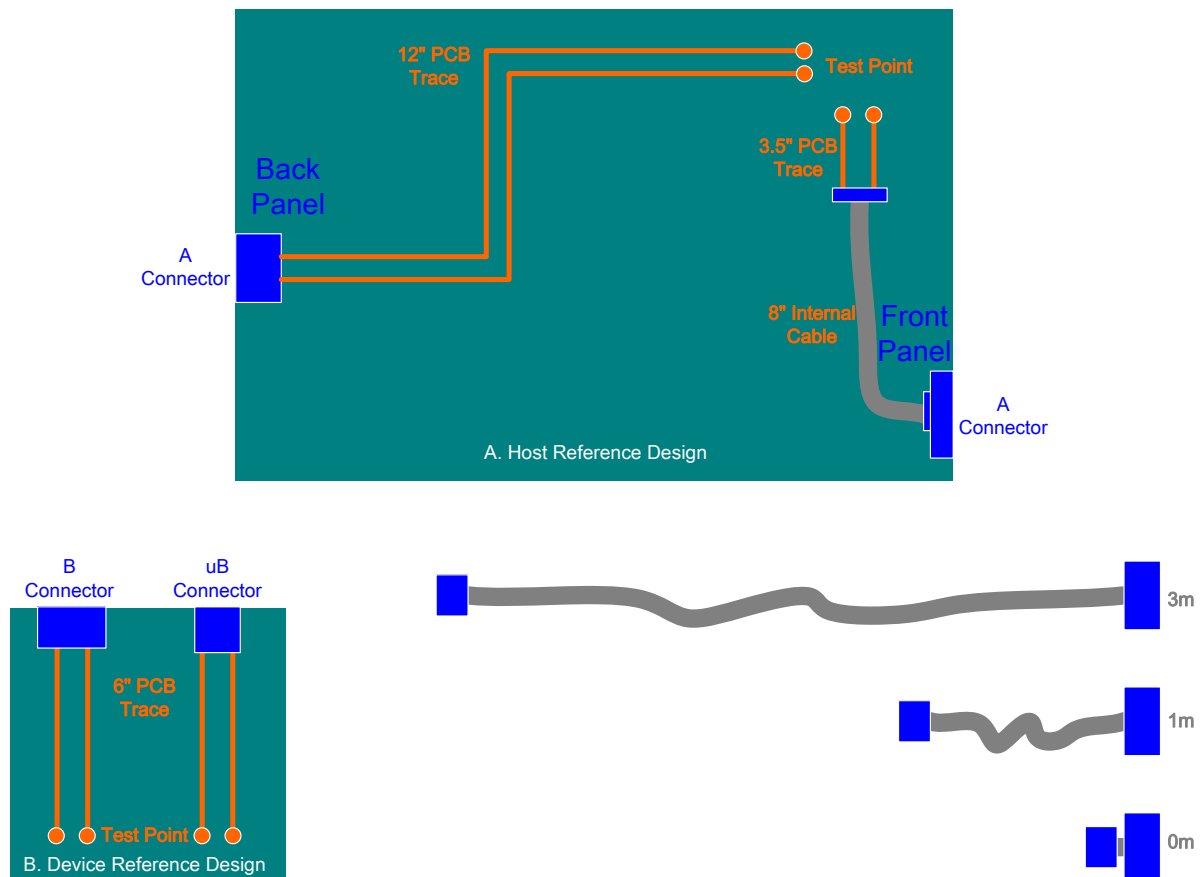


Figure 3.1 Compliance Channel

3.2 Channel Description – with a Cable

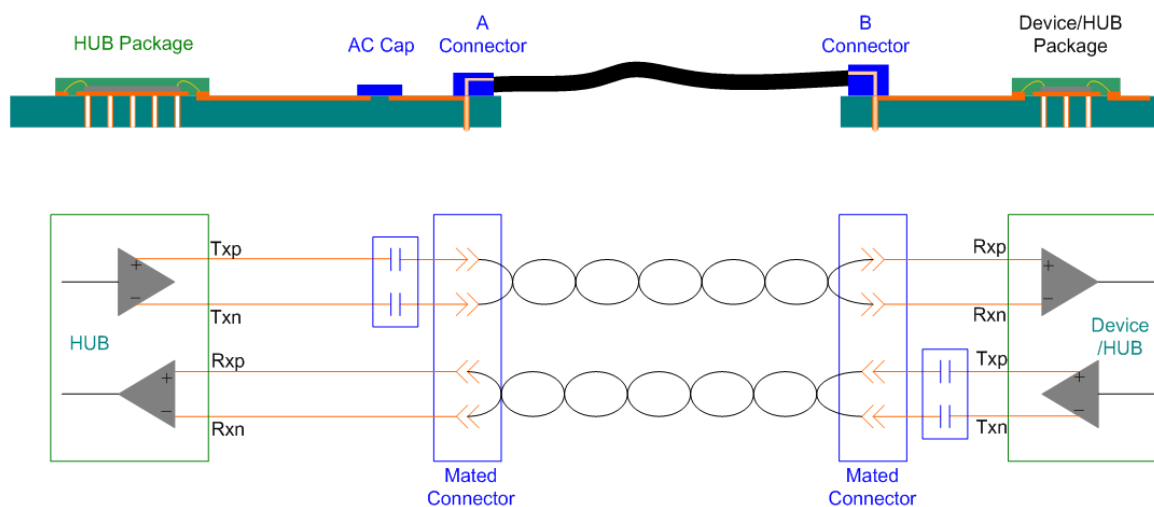


Figure 3.2 Channel Model with a Cable

Fig. 3.2 shows the channel topology (with a cable). The insertion loss of 8/7/8 FR4 trace is around 0.296dB per inch (2.5G signal & PCB trace w/o via). The insertion loss of 34AWG cable is around 4.4dB per meter. So, the worst case of total insertion loss is around -20dB (It is equal to 9-inch (-2.664dB) + 3m (-13.2dB) + 6-inch (-1.776dB) + -2dB (-1dB/mated connectors)), and also need to take care about crosstalk (NEXT, FEXT). Finally, the HUB PCB design must pass compliance channel testing.

3.3 Channel Description – without a Cable

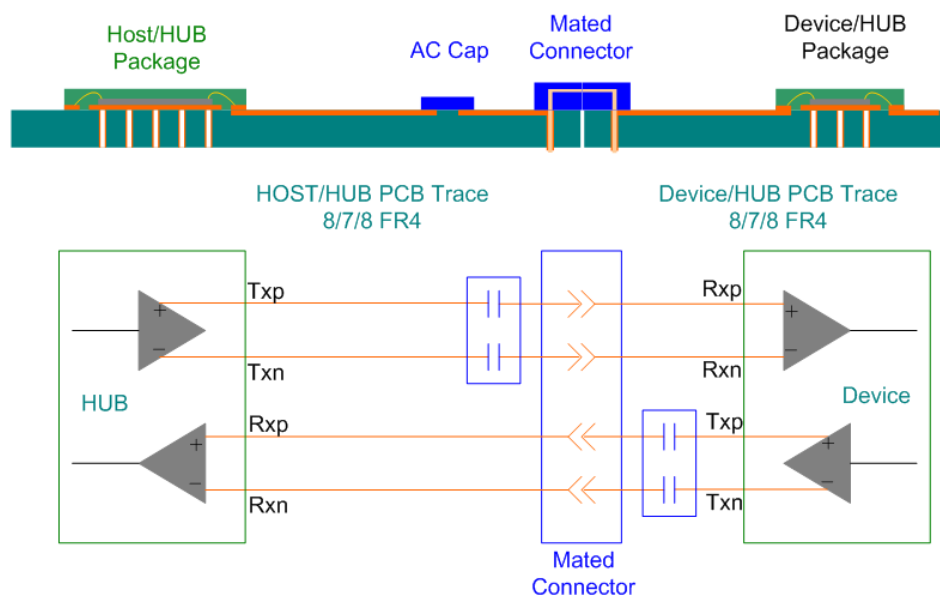


Figure 3.3 Channel Model without a Cable

Fig. 3.3 shows the channel topology (without a cable). The insertion loss of 8/7/8 FR4 trace is around 0.296dB per inch (2.5G signal & PCB trace w/o via). Based on the previous case description, the max insertion loss is 20dB (including PCB trace, PCB via and connector). However, as described in the first section, the performance is determined by channel loss, reflection, crosstalk, and the most of reflection and crosstalk are caused by connector design. So, keeping 9 -inch and 6-inch FR4 trace length can gain much margin.

3.4 Hub Trace on Mother Board

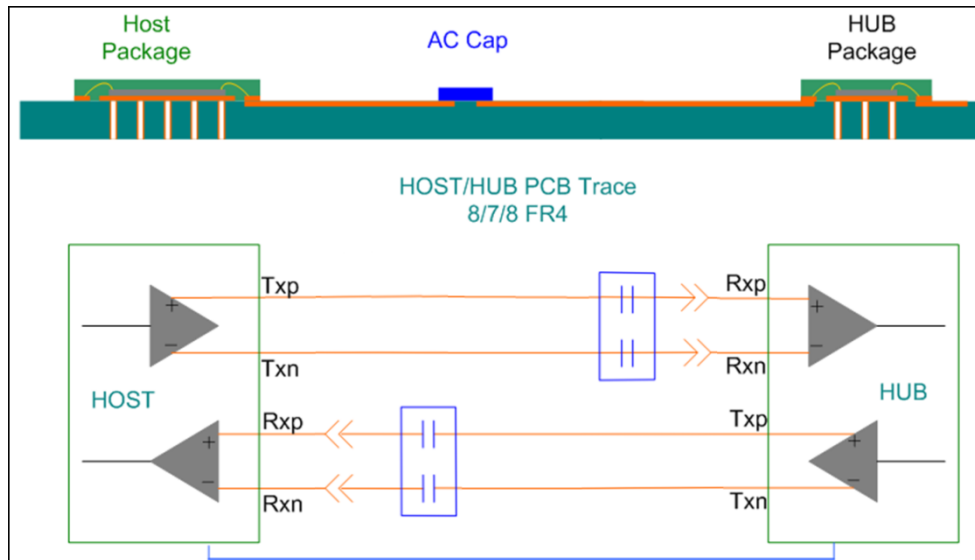


Figure 3.4 Hub Upstream Port Connected to Host

Fig. 3.4 The recommended length of Hub trace is up to 9 -inch on the mother board. However, if the Host trace length is less than 9- inch, use the shorter one of these two numbers.

4. ESD PROTECTION

4.1 Hub

It is suggested to add ESD protection component (ex. TVS) between the connector and IC to provide better ESD protection (as shown in **Fig. 4.1**).

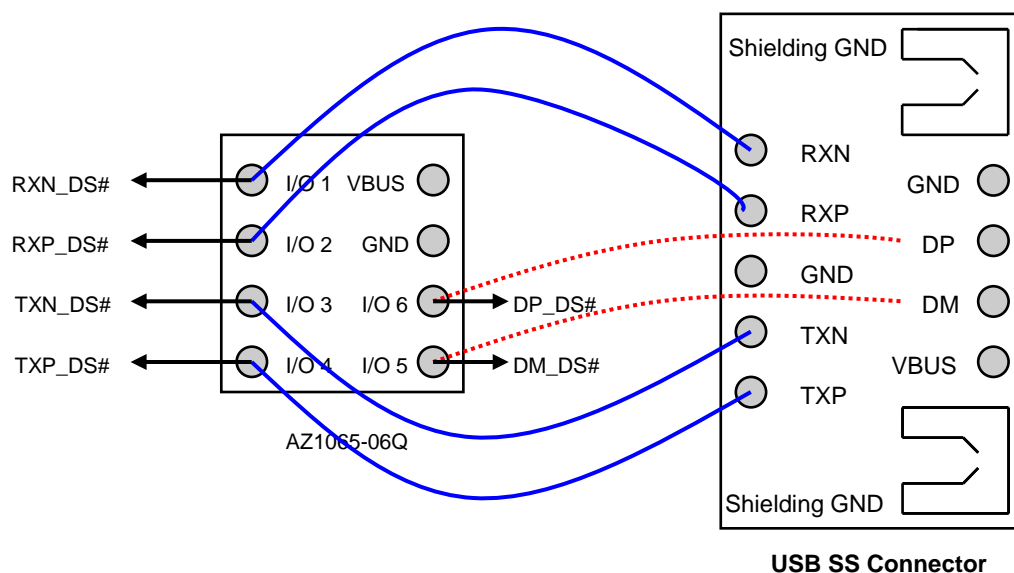


Figure 4.1

4.2 Hub with External Charger IC

Fig. 4.2 shows the suggested layout guide if the external charger IC is implemented for battery charging function.

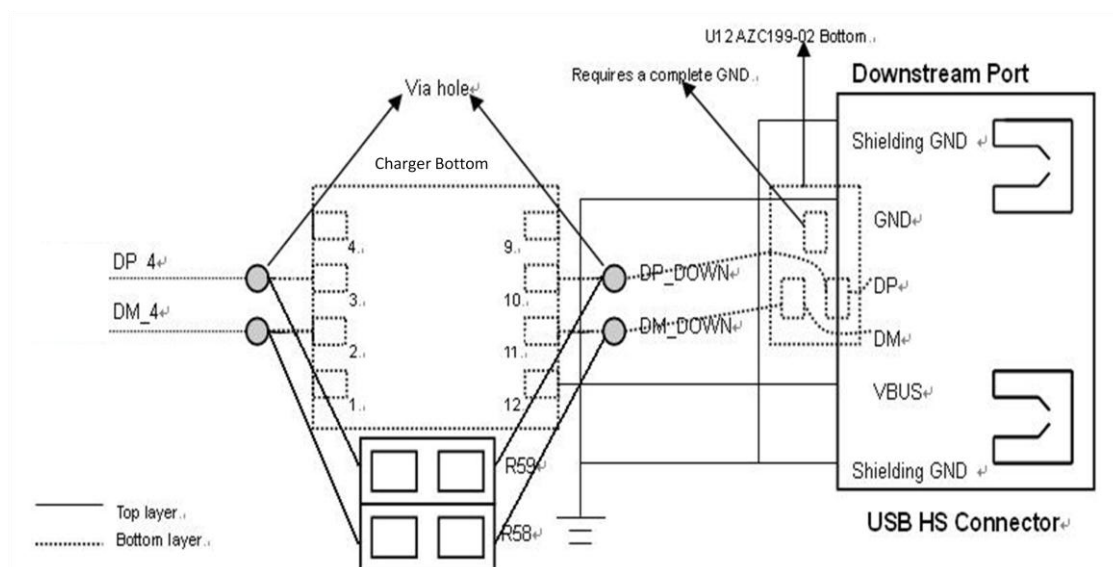


Figure 4.2