

# ***TUSB121x USB2.0 Board Guidelines***

---

## **ABSTRACT**

The document describes the TUSB121x USB2.0 board guidelines.

---

## **Contents**

1	TUSB121x USB2.0 Product Family Board Layout Recommendations .....	2
---	---	---

## 1 TUSB121x USB2.0 Product Family Board Layout Recommendations

**Table 1. TUSB121x USB2.0 Product Family Board Layout Recommendations**

Item	USB General Considerations
1.00	USB design requires symmetrical termination and symmetrical component placement along the DP and DM paths
1.01	Place the USB host controller and major components on the unrouted board first.
1.02	Place the USB host controller, as close as possible to the transceiver device, that is, ULPI interface traces as short as possible
1.03	Route high-speed clock and high-speed USB. Route differential pairs first. Since these signals are critical and long length traces are to be avoided, it is therefore recommended to route DP/DM before routing less critical signals on the board. A similar recommendation is true for CLK, and ULPI signals which should be routed with equalized trace length.
1.04	Maintain maximum possible distance between high-speed clocks/periodic signals to high speed USB differential pairs and any connector leaving the PCB (such as I/O connectors, control, and signal headers or power connectors).
1.05	Place the USB receptacle at the board edge
1.06	Maximum TI-recommended external capacitance on DP (or DM) lines is 4 pF <ul style="list-style-type: none"> <li>• This capacitance is the sum of all external discrete components, that is, the total capacitance on DP (or DM) lines including trace capacitance can be larger than 4 pF.</li> <li>• All discrete components should be placed as close as possible to the USB receptacle.</li> </ul>
1.07	Place the low-capacitance ESD protections as close as possible to the USB receptacle, with no other external devices in between.
1.08	Common mode chokes degrade signal quality, thus they should only be used if EMI performance enhancement is absolutely necessary.
1.09	Place the common mode choke (if required to improve EMI performance) as close as possible to the USB receptacle (but after the ESD device(s)).
	<b>USB Interface (DP, DM)</b>
2.00	Separate signal traces into similar categories and route similar signal traces together, that is, DP/DM and ULPI.
2.01	Route the USB receptacle ground pin to the analog ground plane of the device with multiple via connections.
2.02	Route the DP/DM trace pair together.
2.03	For HS-capable devices, route the DP/DM signals from the device to the USB receptacle with an optimum trace length of 5 cm. Maximum trace length 1-way delay of 0.5 ns (7.5 cm for 67 ps/cm in FR-3).
2.04	Match the DP/DM trace lengths. Maximum mismatch allowable is 150 mils (~0.4 cm).
2.05	Route the DP/DM signals with 90-Ω differential impedance, and 22.5–30-Ω common-mode impedance (objective is to have $Z_{odd} \approx Z_0 = Z_{diff}/2 = 45 \Omega$ ).
2.06	Use an impedance calculator to determine the trace width and spacing required for the specific board stack up being used.
2.07	Keep the maximum possible distance between DP and DM signals from the other platform clocks, power sources and digital / analog signals
2.08	Do not route DP/DM signals over or under crystals, oscillators, clock synthesizers, magnetic devices, or ICs that use clocks.
2.09	Avoid changing the routing layer for DP/DM traces. If unavoidable, use multiple vias.
2.10	Minimize bends and corners on DP/DM traces.
2.11	When it becomes necessary to turn 90°, use two 45° turns or an arc instead of making a single 90° turn. This reduces reflections on the signal by minimizing impedance discontinuities.
2.12	Avoid creating stubs on the DP/DM traces as stubs cause signal reflections and affect global signal quality.
2.13	If stubs are unavoidable, they must be less than 200 mils (~0.5 cm).

**Table 1. TUSB121x USB2.0 Product Family Board Layout Recommendations (continued)**

Item	USB General Considerations
2.14	Route DP/DM signals over continuous VCC or GND planes, without interruption, avoiding crossing anti-etch (plane splits), which increase both inductance and radiation levels by introducing a greater loop area.
2.15	Route DP/DM signals with at least 25 mils (~0.65 mm) away from any plane splits.
2.16	Follow the 20*h thumb rule by keeping traces at least 20*(height above the plane) away from the edge of the plane (VCC or GND, depending on the plane the trace is over).
2.17	Changing signal layers is preferable to crossing plane splits if a choice must be made.
2.18	If crossing a plane split is completely unavoidable, proper placement of stitching capacitors can minimize the adverse effects on EMI and signal quality performance caused by crossing the split.
2.19	Avoid anti-etch on the ground plane.
	<b>ULPI Interface (ULPIDATA&lt;7:0&gt;, ULPICLK, ULPINXT, ULPIDIR, ULPSTP)</b>
3.00	Route ULPI 12-pin bus as a 50-Ω single-ended adapted bus.
3.01	Route ULPI 12-pin bus with minimum trace lengths and a strict maximum of 90 mm, to ensure timing. (Timing budget 600 ps maximum 1-way delay assuming 66 ps/cm.)
3.02	Route ULPI 21-pin bus equalizing paths lengths as much as possible to have equal delays.
3.03	Route ULPI 12-pin bus as clock signals and set a minimum spacing of 3 times the trace width (S < 3W).
3.04	If the 3W minimum spacing is not respected, the minimum spacing for clock signals based on EMI testing experience is 50 mils (1.27 mm).
3.05	Route ULPI 12-pin bus with a dedicated ground plane.
3.06	Place and route the ULPI monitoring buffers as close as possible from the device ULPI bus (on test boards).
	<b>USB Clock (USBCLKIN, CLK_IN1, CLK_IN0)</b>
4.00	Route the USB clock with the minimum possible trace length.
4.01	Keep the maximum possible distance between the USB clock and the other platform clocks, power sources, and digital and analog signals.
4.02	Route the USBCLKIN, CLK_IN1 and CLK_IN0 inputs as 50-Ω single-ended signals.
	<b>USB Power Supply (VBUS, REG3V3, REG1V5, VBAT)</b>
5.00	VBUS must be a power plane from the device VBUS ball to the USB receptacle, or if a power plan is not possible, VBUS must be as large as possible.
5.01	Power signals must be wide to accommodate current level.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2012, Texas Instruments Incorporated