

ON Semiconductor

Is Now

onsemi™

To learn more about onsemi™, please visit our website at
www.onsemi.com

onsemi and **onsemi** and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi** product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** reserves the right to make changes at any time to any products or information herein, without notice. The information herein is provided "as-is" and **onsemi** makes no warranty, representation or guarantee regarding the accuracy of the information, product features, availability, functionality, or suitability of its products for any particular purpose, nor does **onsemi** assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using **onsemi** products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by **onsemi**. "Typical" parameters which may be provided in **onsemi** data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. **onsemi** does not convey any license under any of its intellectual property rights nor the rights of others. **onsemi** products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use **onsemi** products for any such unintended or unauthorized application, Buyer shall indemnify and hold **onsemi** and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of the part. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner. Other names and brands may be claimed as the property of others.



Is Now Part of



ON Semiconductor®

To learn more about ON Semiconductor, please visit our website at

www.onsemi.com

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.



AN-9073

High-Speed USB Switch Layout Considerations

Introduction

This document is intended to aid a systems designer adding a High-Speed (HS) USB device to an application. In most cases, boards are routed using an autorouter that may or may not take high-speed phenomenon into consideration. The end result generally produces non-optimal performance or outright failure. Proper design rules for autorouting can get the best possible result, but even the most sophisticated algorithms still may not produce the desired layout. Hand routing is still commonly used to route sensitive nets in difficult layout conditions. In either case, the layout rules discussed in this application note should be followed.

There are many tradeoffs when designing a circuit board. Usually the type and cost of the application dictate parameters such as size, board material, stackup, and component density... all which play a role in the performance of a high-speed system.

Knowing which nodes are sensitive and may fall victim to high-speed phenomenon is important and, as a result, should be prioritized in a design. The most sensitive nets should be considered first and given priority when placing components and selecting routing layers. Typically, these lines are the high-speed data and clock lines and usually run in the hundreds of megahertz and above.

Transmission Lines

The key of high-speed signals is the transmission line. If a particular net's impedance is known, a transmission line may be constructed to properly transfer the energy from source to destination with minimal loss and to reduce negative side effects, such as crosstalk and EMI. There are many types of transmission line structures to consider, all with tradeoffs that may decide which is best. In many cases, the board stackup dictates the structure. The goal of the transmission line is to transfer energy in a signal with minimal loss using controlled impedance.

Controlling Impedance

Ideally, a signal launched from a source is absorbed at the destination with no changes in wave shape or amplitude. This, of course, is not possible due to physical nature of the connectors, board traces, IC packages, etc. where the impedance of these items is not perfectly matched to the driver or receiver. The reality, is that every component in the path of the signal has characteristics that are not perfectly matched. The result of these imperfections commonly surface as reflections and can negatively impact jitter, crosstalk, and EMI. Reflections may be observed as softening of an edge transition and may produce a reduced eye opening at the device's receiver. These negative effects require that components are strategically placed and transmission lines are routed with care.

Selecting a Transmission Line Structure

The first consideration in selecting a transmission line structure is determining whether the transmission is single-ended or differential. This is important because the common-mode noise rejection characteristics of differential transmissions make it the obvious choice for porting high-speed data. Differential data is best transported in a differential transmission line structure (rather than two single-ended transmission lines). This is typically accomplished using a "coupled" transmission line where the odd-mode impedance is the dominant factor.

Microstrip or Stripline?

In most applications, the choice of transmission line comes down to microstrip or stripline, where microstrip generally exists on the external layers of the stackup (top or bottom) and stripline is buried between layers. In general:

1. Microstrip is less capacitive and therefore less lossy than stripline. It's a good choice for high-speed nets where placing a via in the signal path is unacceptable.
2. Stripline is a good choice for lower EMI and interference from surface components and routes. It is also a better choice for densely populated boards where board real-estate is at a premium. If more routing is required, add more layers.

Guidelines for Successful USB Switch Board Routing

1. USB switches should be placed as close to the USB controller as possible. There should be no more than 1 inch between the controller and USB switch. For best results, this distance should be kept to less than $\frac{1}{4}$ of the transmission electrical length ($<18\text{mm}$). The distance from USB switch to USB connector should be <1 inch to minimize system signal loss.
2. The D+D- lines should be routed using an impedance calculator to ensure they achieve 90Ω differential impedance. Shorter traces usually mean less loss, less chance of picking up stray noise, and may radiate less EMI.
3. Select the best transmission line for the application. In the case of a densely populated board (such as a laptop computer), an edge-coupled differential stripline would be the right choice.
4. Terminations are critically important in a transmission line and differ among driver and receiver topologies. Some applications require a source or “back” termination, some require receiver or “far end” terminations, and some require both. In all cases, the termination components must be placed as close as possible to their respective pins. For this reason, many high-speed circuits have on-chip terminations to aid in the process.
5. Minimize the use of vias and keep high-speed lines on certain planes in the stackup. Vias are an interruption in the impedance of the transmission line and should be avoided. Choosing a stripline scheme generally forces the use of at least two vias, one on each end to get the signal to and from the surface. Moving to another plane for the convenience of the route should be avoided.
6. If lines must be crossed in a stripline stackup, cross orthogonally to avoid noise coupling (traces running in parallel couple).
7. When space allows, GND copper should be run adjacent to the transmission lines to help isolate from noise sources. The distance from the transmission line to the GND should be considered in the impedance calculation. Anything (GND, power, components, etc.) close to the transmission line could alter the impedance of the transmission line and create a discontinuity.
8. When routing high-speed lines, be aware of trace length. This is especially important for differential traces and parallel data where timing is critical. It is not uncommon to require lengths to be matched to within a millimeter.
9. Avoid sharp bends in PCB traces; a chamfer or rounding is generally preferred.
10. When decoupling power pins, the choice of a low-ESR capacitor placed at or very near the power pin is critical. Where sensitive analog circuits are being powered, a tuned PI filter should be used to negate the effects of switching power supplies and other noise sources.



Related Datasheets

[FSUSB30 — Low Power, Two-Port, High-Speed USB 2.0 \(480Mbps\) Switch](#)

[FSUSB31 — Low-Power, Single-Port High-Speed USB 2.0 \(480Mbps\) Switch](#)

[FSUSB40 — Low-Power, Two-Port, Hi-Speed, USB2.0 \(480Mbps\) Switch](#)

[FSUSB42 — Low-Power, Two-Port, Hi-Speed, USB2.0 \(480Mbps\) UART Switch](#)

[FSA221 — USB2.0 High-Speed \(480Mbps\) and Audio Switches with Negative Signal Capability](#)

[FSA321 — USB2.0 Hi-Speed \(480Mbps\) and Audio Switches with Negative Signal Capability and Built-in Termination on Unselected Audio Paths](#)

[FSA9280A / FSA9288A USB Port Multimedia Switch, Featuring Automatic Select and Accessory Detection](#)

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800-282-9855 Toll Free
USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910
Japan Customer Focus Center
Phone: 81-3-5817-1050

ON Semiconductor Website: www.onsemi.com
Order Literature: <http://www.onsemi.com/orderlit>
For additional information, please contact your local
Sales Representative