

TPS254x Eye Diagram Performance Test

Benjamin Zhao, Yongqiang Sun

ABSTRACT

An eye diagram is an important parameter in automotive applications. Good eye performance is beneficial for applications like CarPlay™, Android Auto™, and CarLife™. This application report discusses the influence of the TPS254x series devices on eye performance in automotive systems, and how to improve the eye performance.

Contents

1	Introduction	2
2	Impact of TPS254x on System Eye Performance	3
3	Improving Eye Diagram Performance	5
4	References	9

List of Figures

1	TPS254x Typical Application Circuit	2
2	Eye Diagram Without TPS254900.....	3
3	Eye Diagram With TPS254900	3
4	TPS2549 Source Impact (Lower Amplitude)	5
5	TPS2549 Source Impact Eye Diagram (Lower Amplitude)	5
6	TPS2549 Source Impact (Higher Amplitude)	5
7	TPS2549 Source Impact Eye Diagram (Higher Amplitude)	5
8	Connect Inductor in Data Lines	6
9	Eye Diagram With and Without LC Network	6
10	Bypass DP_IN and DM_IN	7
11	Bypass DP_OUT and DM_OUT	7
12	TPS254900 Connected	8
13	TPS254900 Bypassed	8
14	Eye Diagram With and Without TUSB211.....	9

List of Tables

1	TPS254x Device Bandwidth.....	4
2	Eye Diagram Test Results of TPS2546, TPS2549, and TPS254900.....	4
3	TPS254900 Eye Diagram Connected and Bypassed.....	8

Trademarks

CarPlay is a trademark of Apple.
 CarLife is a trademark of Baidu.
 Android Auto is a trademark of Google, Inc.
 All other trademarks are the property of their respective owners.

1 Introduction

The TPS254x series devices are host controllers that support USB2.0 communication, while providing overcurrent protection, overtemperature protection, cable compensation, short-to-battery protection, and more. [Figure 1](#) shows a typical application of TPS254X devices in an automotive system.

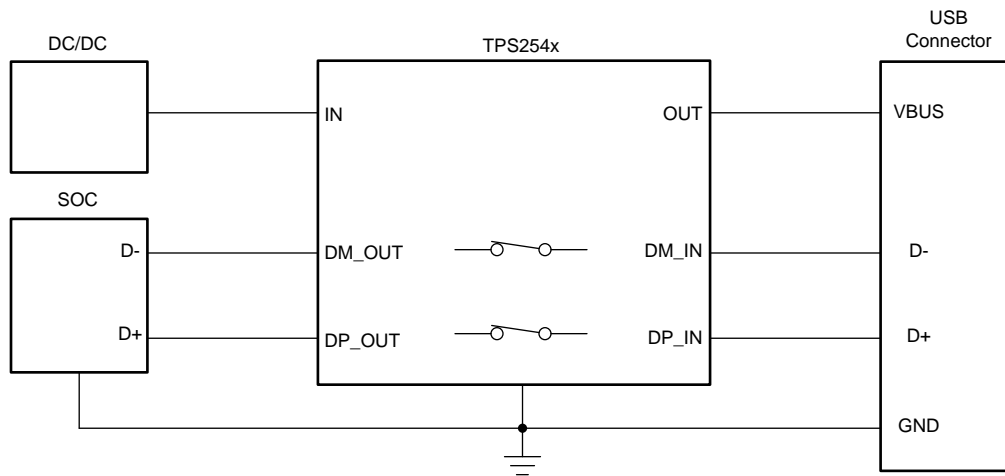


Figure 1. TPS254x Typical Application Circuit

2 Impact of TPS254x on System Eye Performance

Being interconnected, the TPS254x device impacts the eye performance of the system, due to the parasitic resistance and capacitance of internal circuits in the TPS254x. Figure 2 and Figure 3 show a comparison of one system before and after connecting the TPS254900 device. From the eye diagram test results, we see that the rising edge rate becomes slightly slower after connecting the TPS254900 device.

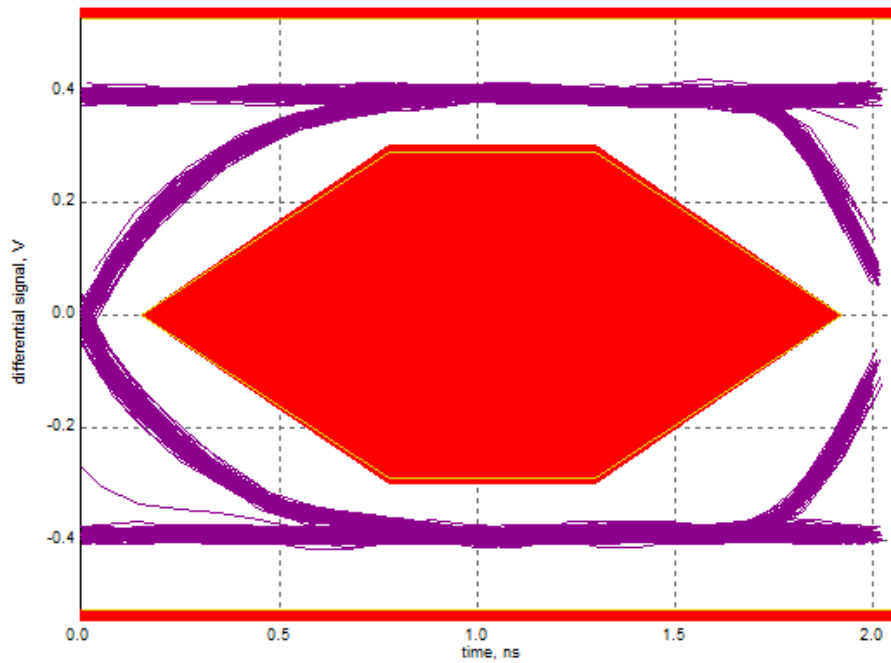


Figure 2. Eye Diagram Without TPS254900

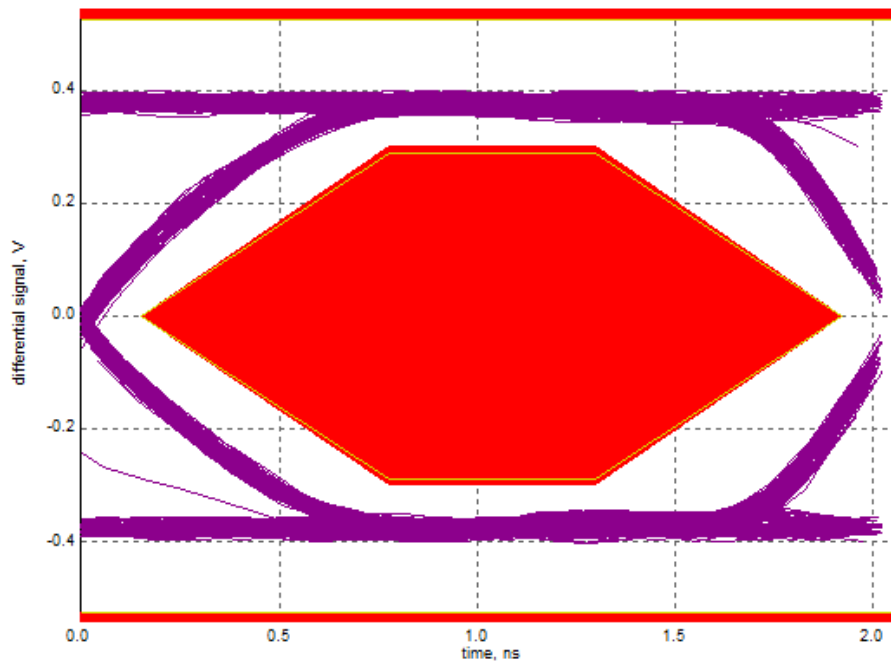


Figure 3. Eye Diagram With TPS254900

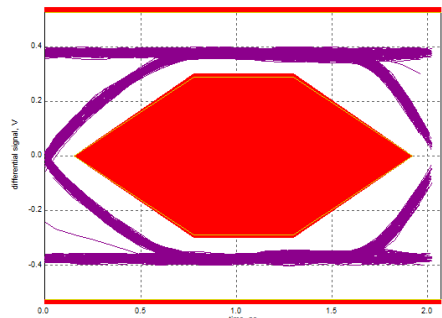
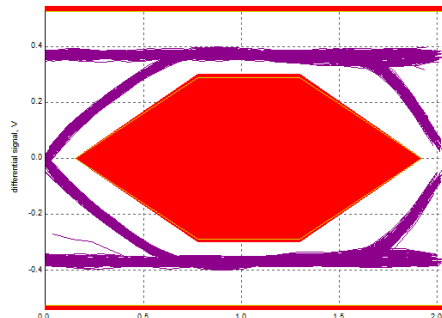
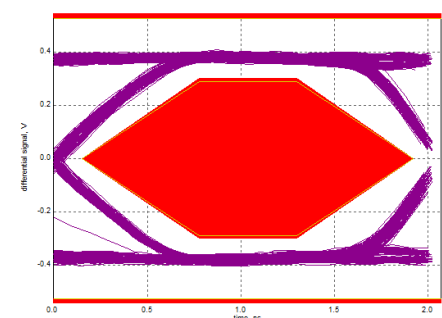
The higher the bandwidth of the TPS254x, the lower the impact on eye performance. The TPS2546 device has the highest bandwidth in the TPS254x series products; TPS254900 has a higher bandwidth than TPS2549. [Table 1](#) lists the -3 dB bandwidth of the TPS254x series products.

Table 1. TPS254x Device Bandwidth

Part Number	Bandwidth (GHz)
TPS2546	2.6
TPS254900	0.940
TPS2549	0.925

[Table 2](#) lists the eye diagram test results of the TPS2546, TPS254900, and TPS2549 devices. From the test results, we know that the TPS2546 device has the best eye performance, due to its highest bandwidth.

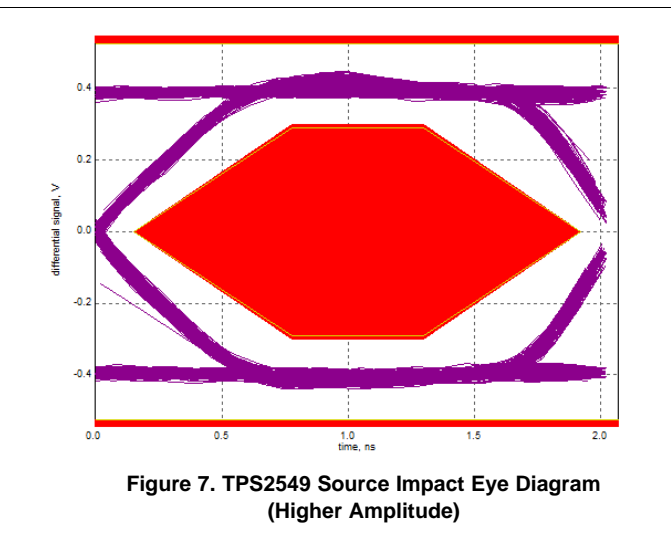
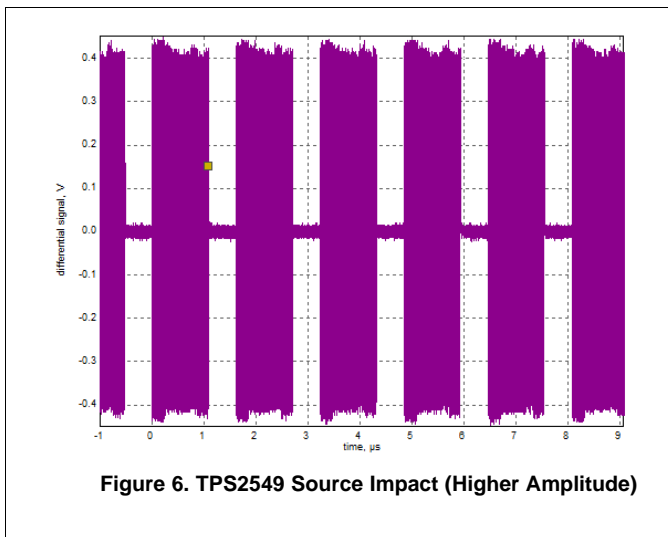
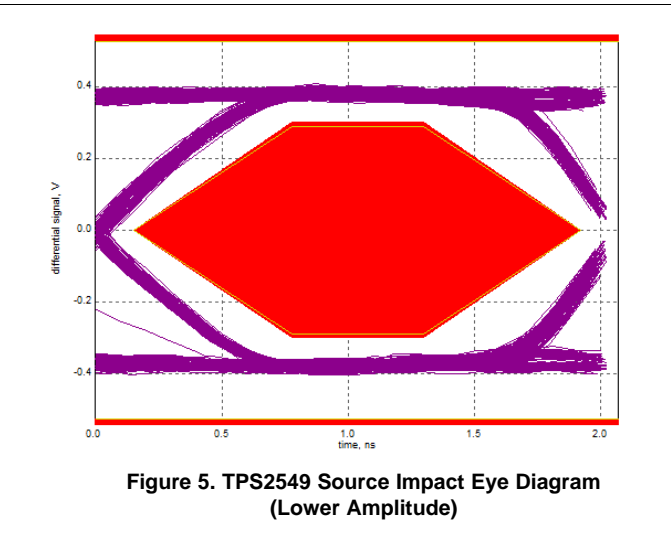
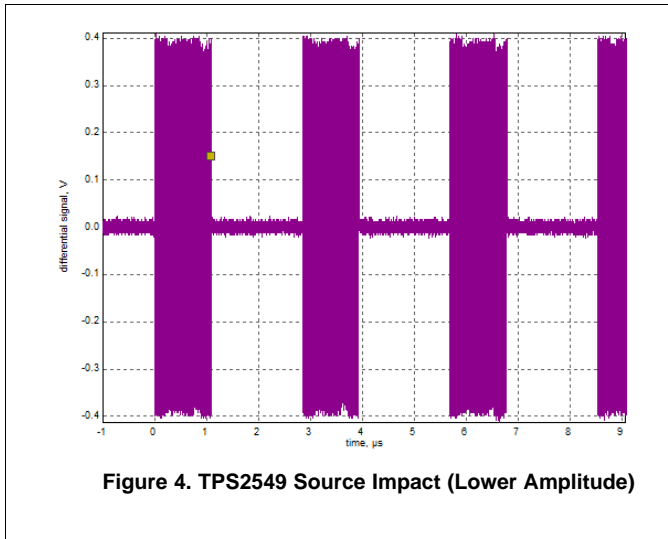
Table 2. Eye Diagram Test Results of TPS2546, TPS2549, and TPS254900

Part Number	Eye Diagram	Rising Edge Rate	Falling Edge Rate
TPS2546		877.77 V / μ s	874.51 V / μ s
TPS254900		832.88 V / μ s	830.53 V / μ s
TPS2549		785.57 V / μ s	783.08 V / μ s

3 Improving Eye Diagram Performance

3.1 Improving Source Drive Capability

Figure 4 to Figure 7 show the impact of the source amplitude on the TPS2549 eye diagram. A higher amplitude source signal results in a more open eye. In actual applications, customers can configure the registers of the host controller to adjust the signal amplitude.



3.2 Using Inductors and Capacitors to Improve Eye Performance

Figure 8 shows the LC network diagram used to improve the system eye performance. Figure 9 shows the test results before and after connecting the LC network.

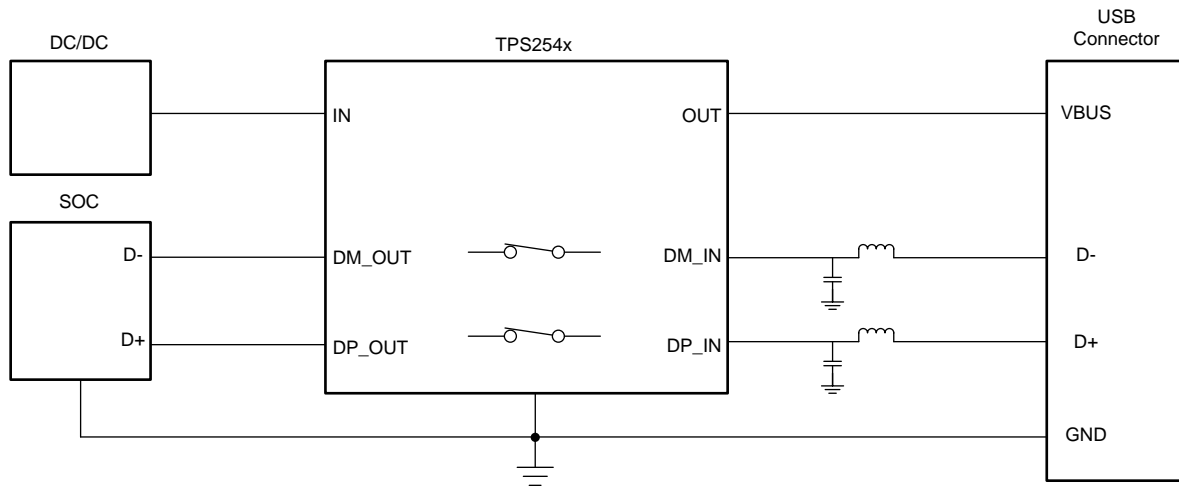


Figure 8. Connect Inductor in Data Lines

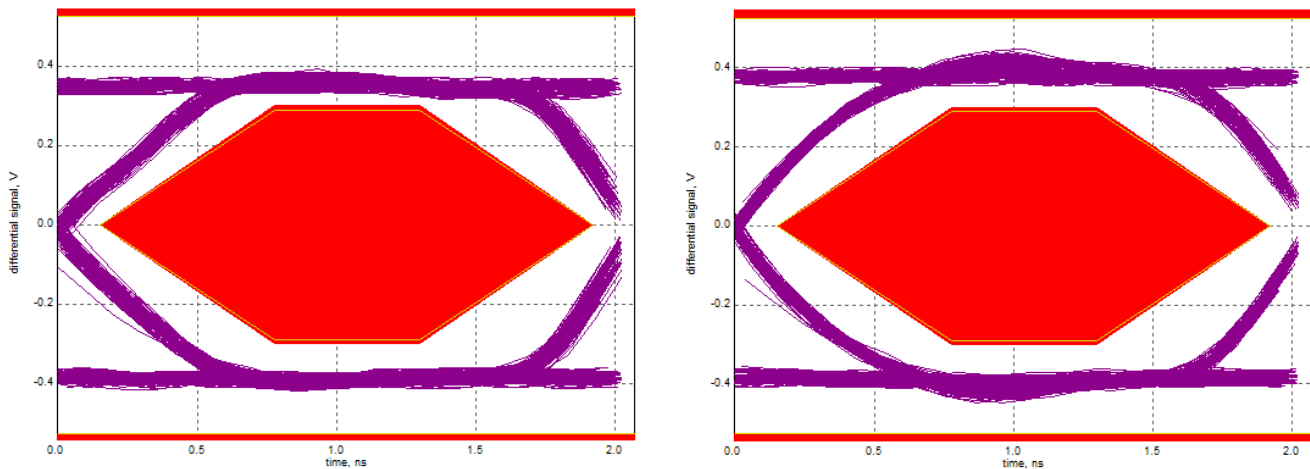


Figure 9. Eye Diagram With and Without LC Network

3.3 Bypassing TPS254x to Improve Eye Performance

Figure 10 and Figure 11 show two ways to bypass the TPS254x device. In these methods, the TPS254x only implements BC1.2 primary detection and secondary detection. The eye performance will be improved because the TPS254x device is not connected in the data lines.

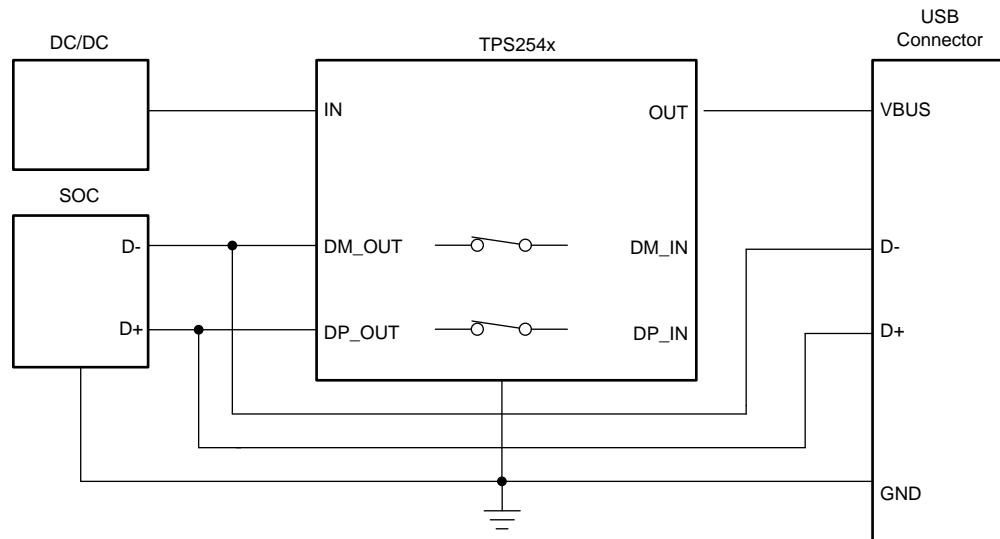


Figure 10. Bypass DP_IN and DM_IN

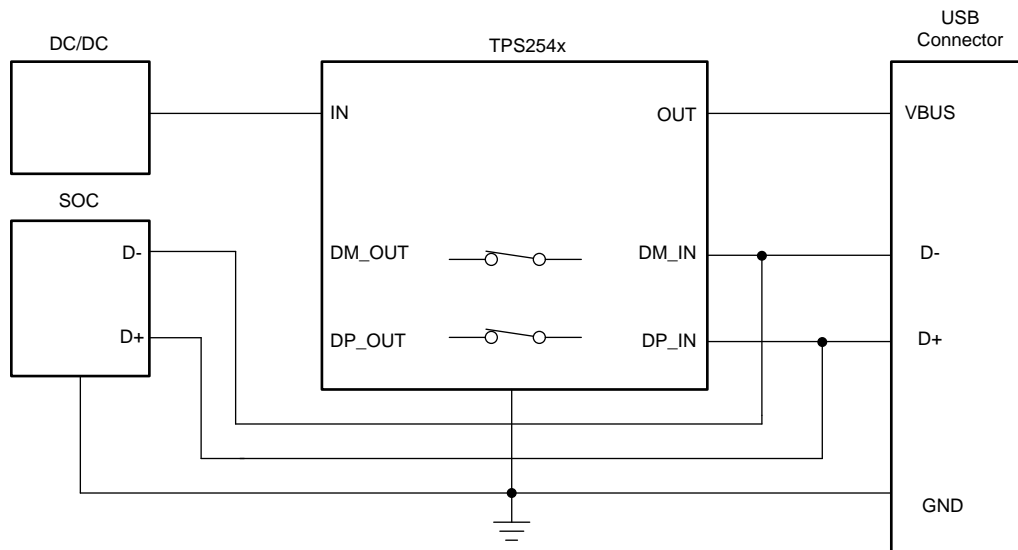


Figure 11. Bypass DP_OUT and DM_OUT

Table 3 shows a comparison of the TPS254900 eye diagram when connected and bypassed.

Table 3. TPS254900 Eye Diagram Connected and Bypassed

TPS254900 Status	Rising Edge Rate	Falling Edge Rate
Connected	862.90 V / μ s	915.84 V / μ s
Bypassed	902.54 V / μ s	900.24 V / μ s

Figure 12 and Figure 13 show the eye diagrams of the TPS254900 in connected and bypassed states.

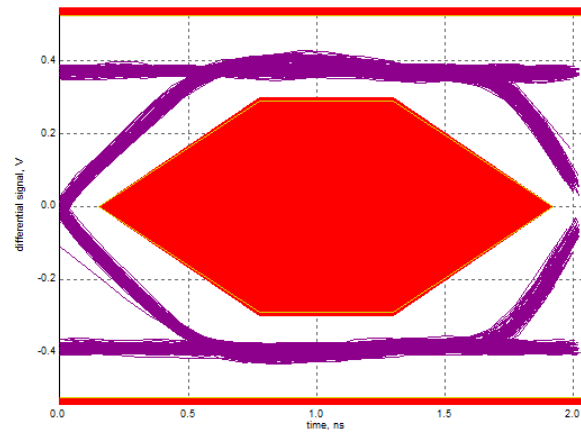


Figure 12. TPS254900 Connected

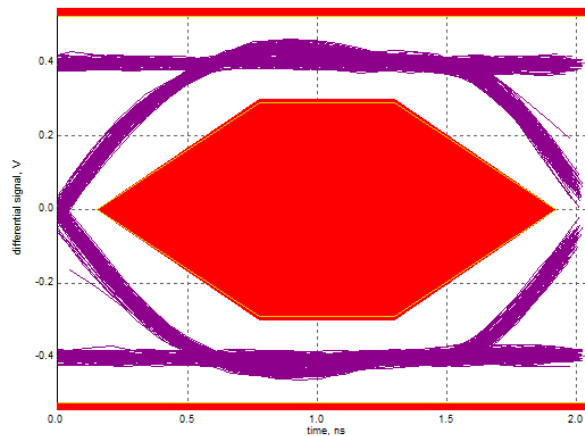


Figure 13. TPS254900 Bypassed

3.4 Using Redrivers to Improve Eye Performance

Another effective way to improve eye performance is to add a redriver. The TUSB211 device is a USB, high-speed signal conditioner designed to compensate for ISI signal loss in a transmission channel. [Figure 14](#) shows the test results of the TPS2549 eye diagram before and after connecting the TUSB211, based on the real PCB of the customer.

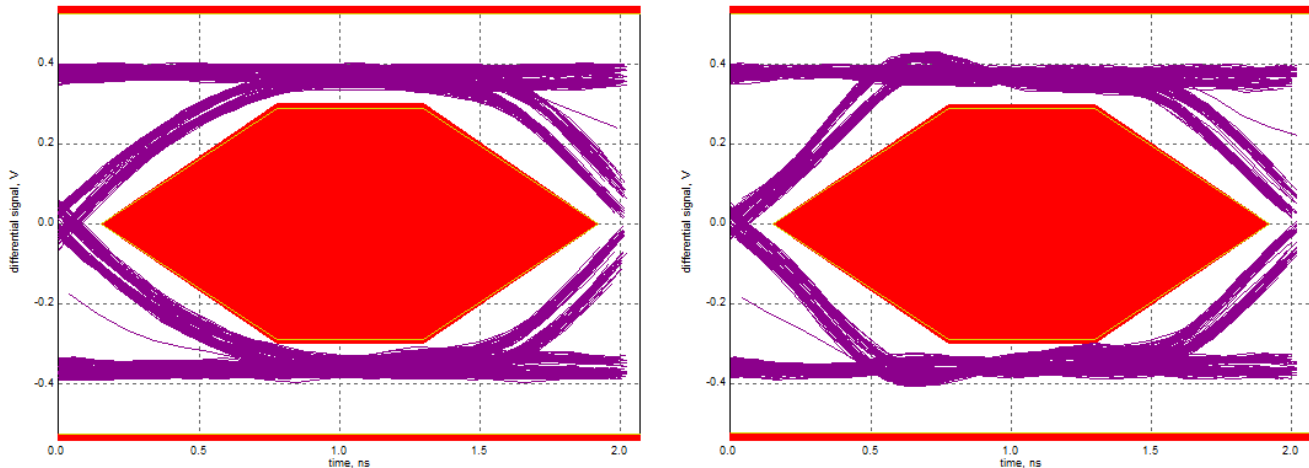


Figure 14. Eye Diagram With and Without TUSB211

However, eye diagram performance is a system-level parameter. Eye diagram performance can be influenced by the host controller, PCB routes, cables, USB connectors, common chokes, TVS, and so on. Any negligence of these factors will result in bad eye performance. Some recommendations when designing a system follow:

- Route D+ and D– as differential pairs according to the USB2.0 specification.
- The differential impedance from D+ and D– routes to ground must be 90 Ω.
- Ensure the ground plane is not split, to ensure continuity of differential impedance.
- Route the D+ and D– lines as short as possible to minimize the voltage drop and parasitic inductance.
- Minimize the use of vias in the D+ and D– data lines.
- Use certified cables and USB connectors.

4 References

- Texas Instruments, [TPS2549 USB Charging Port Controller and Power Switch With Cable Compensation](#), data sheet
- Texas Instruments, [TPS254900-Q1 Automotive USB Host Charger With Short-to-VBATT Protection](#), data sheet
- Texas Instruments, [TUSB211 USB 2.0 High Speed Signal Conditioner](#), data sheet
- Texas Instruments, [TPS254xEVM-064](#), user's guide

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated