

Loop Characteristic Evaluation and Optimization of TPS2583x-Q1

Kevin Cheng

ABSTRACT

TPS2583x-Q1 is a high integrated USB Type-C and BC1.2 charging port controller that includes a synchronous DC/DC converter. With cable droop compensation, the VBUS voltage remains constant regardless of load current, ensuring connected portable devices are charged at optimal current and voltage. Because the output of USB Type-C and BC1.2 is based on the 5 V, the voltage feedback resistors are integrated in the IC; also due to voltage compensation circuit, it is difficult to test and evaluate the loop characteristics of the system. This application report is mainly about TPS2583x-Q1 Loop Characteristic Evaluation and Design. The test hardware in this application report is based on <http://www.ti.com/tool/TPS25831Q1EVM-062>.

Contents

1	Introduction	2
2	Loop Test Method of TPS2583x-Q1	3
3	How to improve the loop characteristic of TPS2583x-Q1	5
4	Summary	6
5	References	6

List of Figures

1	TPS2583x-Q1 System Without Cable Compensation Function	2
2	TPS2583x-Q1 System With Cable Compensation Function	2
3	Setup of Loop Test	3
4	Loop Result of TPS2583x-Q1 System Without Cable Compensation	4
5	Load Transient Result of TPS2583x-Q1 Without Cable Compensation	4
6	Load Transient Result of TPS2583x-Q1 With Cable Compensation	5

List of Tables

1	Overshoot and Undershoot Result	5
2	Loop Result vs Inductor	5
3	Loop Result vs Cout	6

1 Introduction

1.1 Loop Introduction of TPS2583x-Q1

TPS2583x-Q1 integrated a wide Vin buck DCDC to generate 5 V output. It is no different from the normal DCDC when it is without the cable compensation function (no Rsns, Rimon=0), as shown in Figure 1.

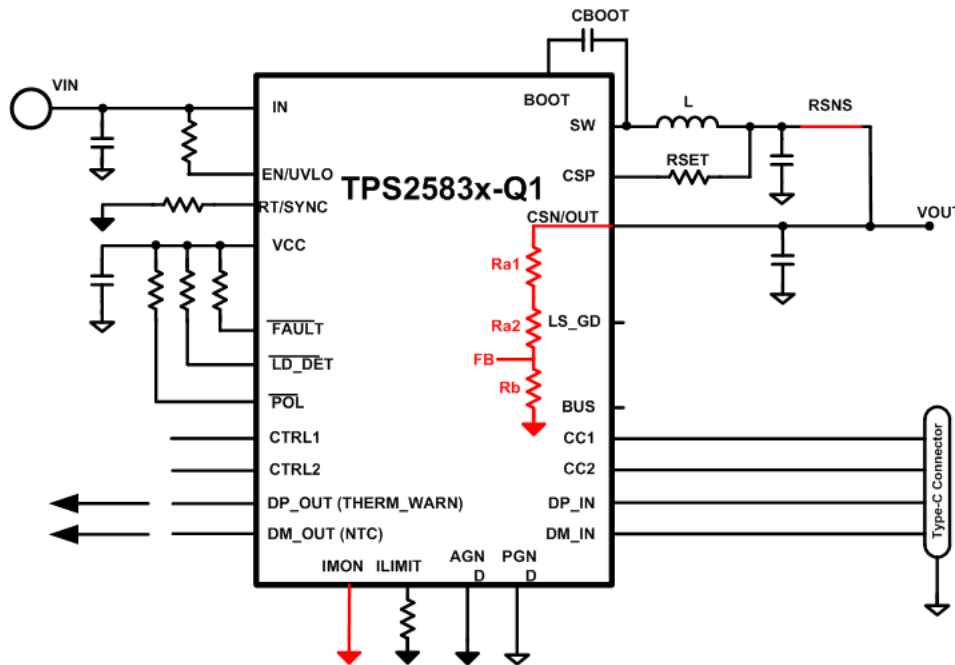


Figure 1. TPS2583x-Q1 System Without Cable Compensation Function

When it uses the cable compensation function, as shown in Figure 2, it adds another current feedback loop.

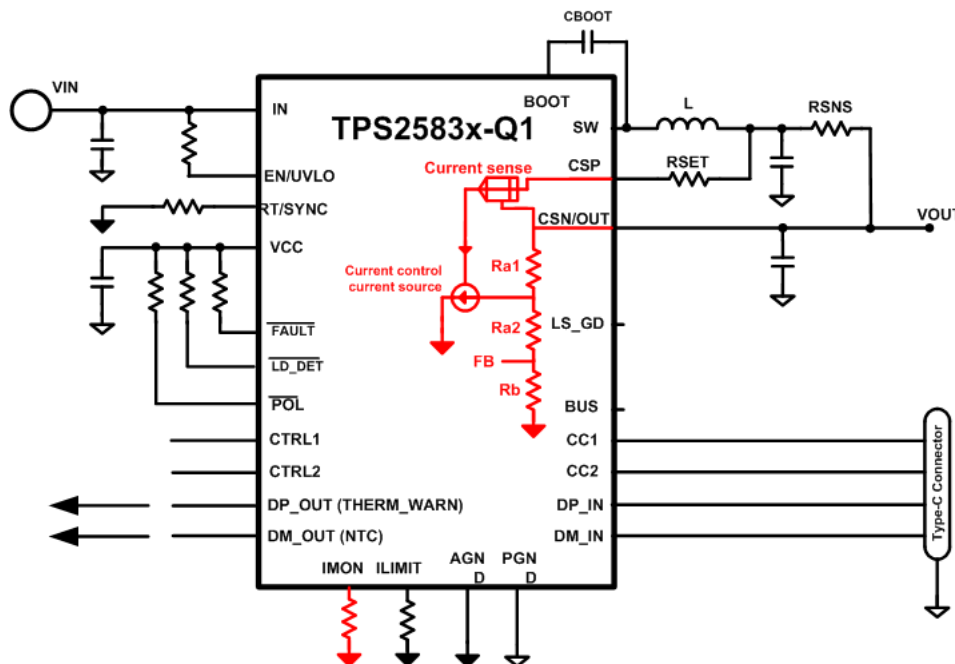


Figure 2. TPS2583x-Q1 System With Cable Compensation Function

2 Loop Test Method of TPS2583x-Q1

2.1 Test the Loop Characteristics Without Cable Compensation Function

When the cable compensation function is disabled, the frequency response analyzer can be used to measure the loop characteristics of TPS2583x-Q1, setup as shown in Figure 3. You can get its crossover frequency, phase margin and gain margin. For this test, you need to do some modifications based on the TPS25831Q1EVM:

1. Change Rsns(R4) and Rimon(R16) to 0 Ω
2. Remove External FET Q1
3. Cut the wire between Vout and CSN/OUT, and add a 20 Ω resistor between it.

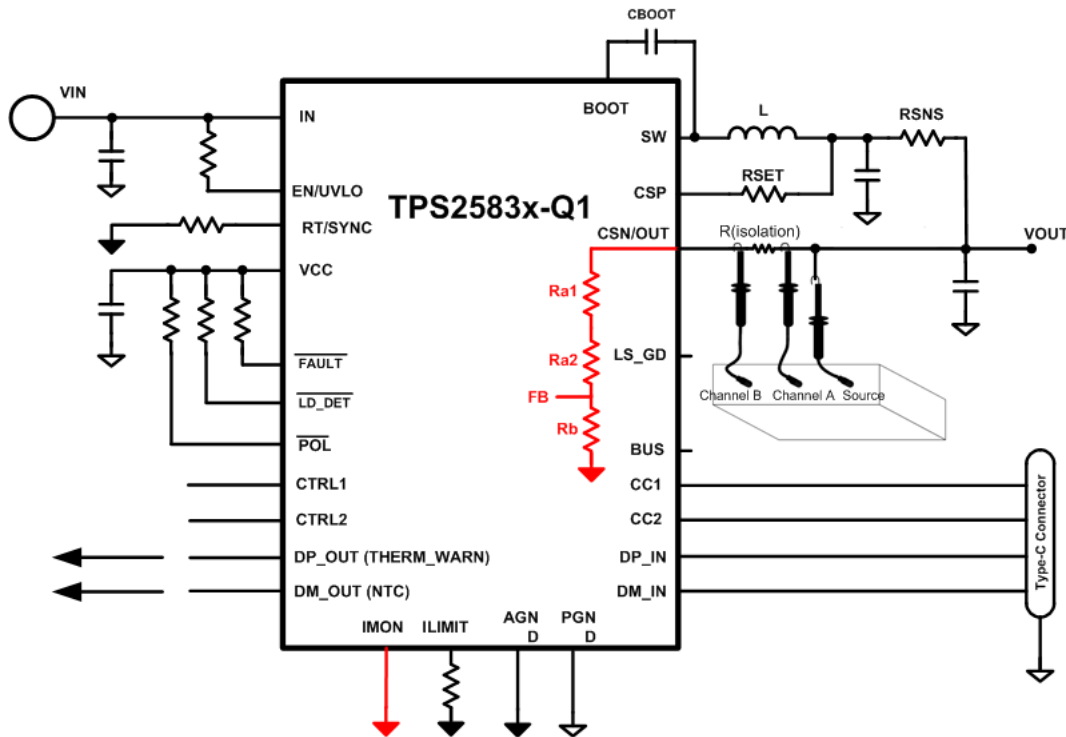


Figure 3. Setup of Loop Test

Figure 4 shows the test result. The crossover frequency is 39.25 kHz, phase margin is 44.914°, gain margin is 13.52dB.

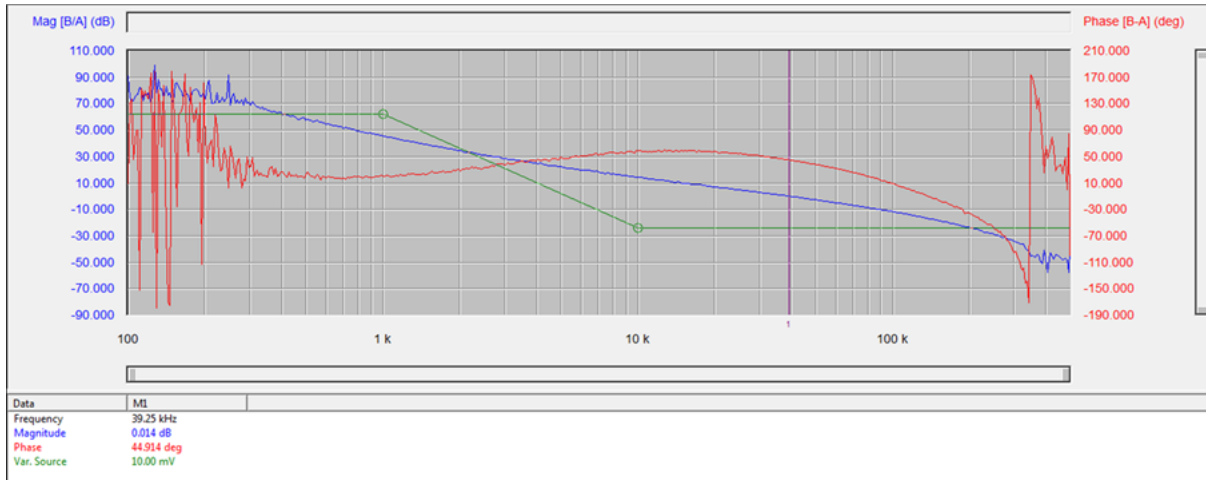


Figure 4. Loop Result of TPS2583x-Q1 System Without Cable Compensation

2.2 Evaluating Loop Characteristics With Cable Compensation Function

When the cable compensation function is used, the setup shown in Figure 3 cannot cut off the loop completely. This method cannot measure the loop characteristic correctly when the cable compensation function is enabled. For this case, fast load transient is used to evaluate loop characteristics. Generally speaking, when the phase margin is greater than 45°, the overshoot of the load transient will be smaller, and the overshoot callback will be smooth [1]. For poor loop design, its overshoot of load transient will be higher, and the overshoot callback may have ringing. The load transient performance of TPS2583x-Q1 is compared with and without cable compensation function. Figure 5 is the load transient result of no cable compensation function. Figure 6 is the load transient result with cable compensation function. The overshoots and undershoots are summarized in Table 1.

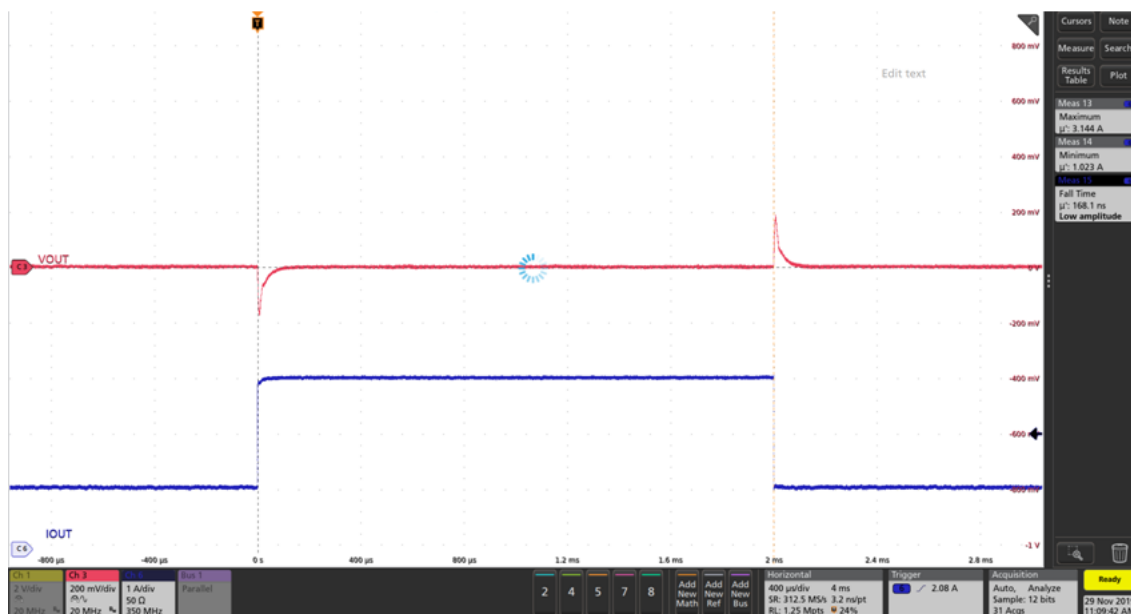


Figure 5. Load Transient Result of TPS2583x-Q1 Without Cable Compensation

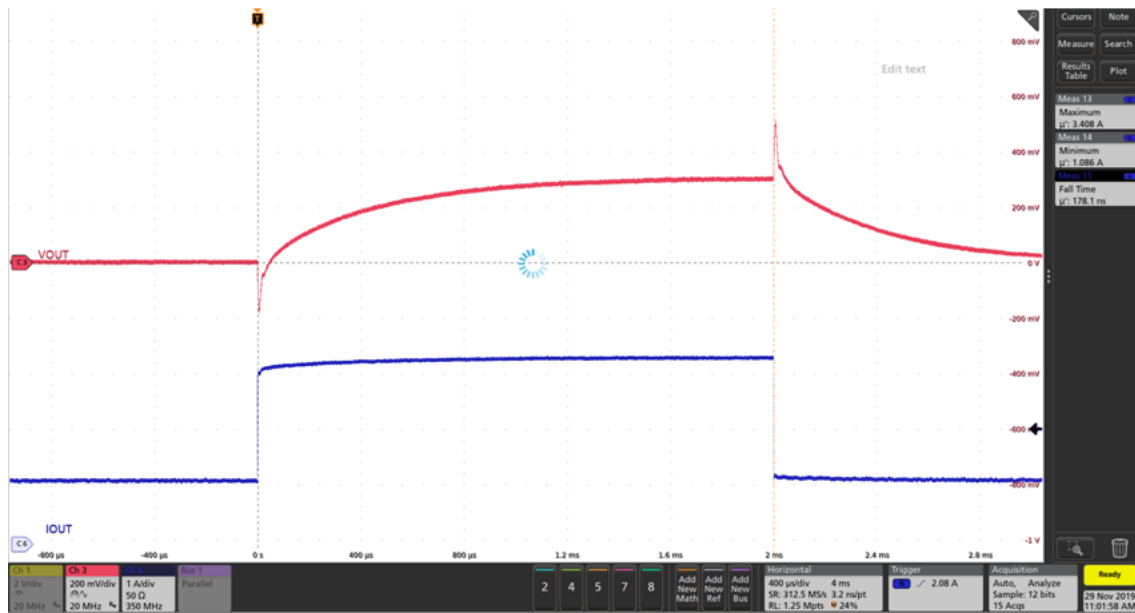


Figure 6. Load Transient Result of TPS2583x-Q1 With Cable Compensation

Table 1. Overshoot and Undershoot Result

	Overshoot (mV)	Undershoot (mV)
No cable compensation	192.2	175.6
With cable compensation	201.2	183.6

3 How to improve the loop characteristic of TPS2583x-Q1

Usually, 45° phase margin is enough to ensure the stable of system, but some customer want to have higher phase margin. To improve the phase margin, there two options:

- Reducing the power inductor is a specific way to improve the phase margin, but as we all know that reduce the power inductor will increase the inductor current ripple, customer need trade off those two performance. When the inductor decreases to a certain extent, we need to increase the frequency to keep low current ripple of the inductance. Table 2 is the loop test result of different inductor under 400 kHz and 2.2 MHz of TPS2583x-Q1 without cable compensation.

Table 2. Loop Result vs Inductor

Vin(V)	I_load(A)	Cout (μF)	Fsw (kHz)	Inductor(uH)	Fcross(kHz)	Phase Margin(°C)	Gain Margin(dB)
13.5	3	66	400	10	39.3	44.9	-13.52
				8.2	41.9	50.4	-14.22
				6.8	38.9	53.2	-14.65
			2200	2.2	37.25	67.923	-16.868

- Increasing output capacitance. According to our test results, the phase margin of TPS2583x system can be increased by appropriately increasing the capacitance.

- [Table 3](#) is the test result of different output capacitance values.

Table 3. Loop Result vs Cout

Vin(V)	I _{load} (A)	Inductor (μH)	Fsw (kHz)	Cout(uF)	Fcross(kHz)	Phase Margin(°C)	Gain Margin(dB)
13.5	3	8.2	400	44	55.4	41.8	-13.32
				66	41.9	50.4	-14.22
				88	30.6	56.4	-16.59

4 Summary

- The loop characteristic of TPS2583x-Q1 EVM is crossover frequency is 39.25 kHz, phase margin is 44.914°, gain margin is 13.52dB.
- The loop characteristic of TPS2583x-Q1 with and without cable compensation function is almost the same, so you can evaluate the loop characteristics by measuring the loop characteristic of TPS2583x-Q1 without cable compensation function.
- The loop characteristic can be improved by decreasing the power inductor and increasing the output capacitance; however, it should be noted that the switching frequency needs to be increased to ensure that the inductance current is within a reasonable range when the inductor is too small.

5 References

1. Boost E, Damped R . Switch-Mode Power Supplies Spice Simulations and Practical Designs P.197[J]. Eetimes Com, 2014.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2020, Texas Instruments Incorporated