Application Report
SLVAEM8–March 2020

TPS92613-Q1 Typical Application to Achieve High Immunity to BCI (Bulk Current Injection)

Kelly Bai

ABSTRACT

This application report outlines a typical schematic and layout design for single-channel LED driver, TPS92613-Q1, to achieve high BCI (Bulk Current Injection) immunity performance with test result. The international standard this evaluation board passes is ISO11452-4 200 mA level.

Contents

1 Introduction 2
1.1 Device Overview 2
1.2 Bulk Current Injection 2
2 PCB Design Recommendation 3
2.1 Schematic Design 3
2.2 Layout Recommendation 4
3 Test Results 4
4 Summary 5
5 References 6

List of Figures

1 TPS92613-Q1 Typical Application Diagram 2
2 TPS92613-Q1 Schematic for PCB Design 3
3 TPS92613-Q1 EVM Layout Illustration for BCI Test 4
4 General Setup of BCI Test 4
5 Battery Side of BCI Test 4
6 DUT Side of BCI Test 4
7 Current Injection of BCI Test 4

List of Tables

1 Test Requirements 2
2 Acceptance Criteria 2
3 Test Results of TPS92613-Q1 EVM BCI Test 5

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2020, Texas Instruments Incorporated

1 Introduction

1.1 Device Overview

The TPS92613-Q1 device is a single-channel, high-side LED driver operating from an automotive car battery. It is a simple, yet elegant, solution to deliver constant current for a single LED string with full LED diagnostics. Figure 1 shows a typical application diagram.

Comparing to discrete solutions, the TPS92613-Q1 is a low-cost monolithic solution, which can lower system-level component count and significantly improve current accuracy and reliability.

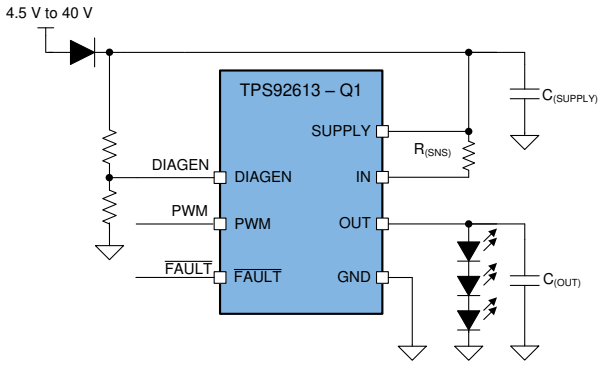

Figure 1. TPS92613-Q1 Typical Application Diagram

1.2 Bulk Current Injection

Buck Current Injection (BCI) is a method of assessing the immunity of the printed circuit board (PCB) to electromagnetic fields that are coupled onto the communications line wiring harnesses.

Testing was done according to the ISO11452-4 standard. The derailed test setup and general acceptance criteria are shown in Table 1 and Table 2, respectively.

Table 1. Test Requirements

Frequency (MHz)	Frequency Step Size (MHz)	Dwell Time (s)	Test Level (mA)	Probe Type	Probe Distance to DUT	Modulation
1 - 200	1	2	200	Open Loop	150 mm, 450 mm, 750 mm	CW
						AM
200 - 400	2	2	200	Open Loop	150 mm, 450 mm, 750 mm	CW
						AM

Table 2. Acceptance Criteria

Monitoring Parameters	Acceptance	Test Level
Supply current	Changes < ±20%	200 mA
LED	No flicker	200 mA

Copyright © 2020, Texas Instruments Incorporated

2 PCB Design Recommendation

Because the most important feature of the LED driver device is output constant current to drive LEDs, current is used for analysis.

2.1 Schematic Design

Figure 2 is the schematic of TPS92613-Q1 EVM.

- First, divide current into two parts, one is the supply current of the chip: I_{inner}, the other is the driving current of the LED: from I_{IN} to I_{out}.
- I_{inner} is used to provide current for the control module of the chip, which is sensitive to interference, so a small filter capacitor (C7) is added.
  - C7 must be added before anti-reverse diode D2. Because D2 acts as a filter to pass positive noise and block negative noise so that the common-mode noise entering the control module increases.
  - The capacitance of C7 can decrease to 100 nF.
- The driving current of the LED, I_{IN} to I_{out}, also needs a filter. So capacitor C3 and C4 is added.
  - C3 and C4 can be placed after anti-reverse diode D2, because the driving current is less sensitive than I_{inner}.

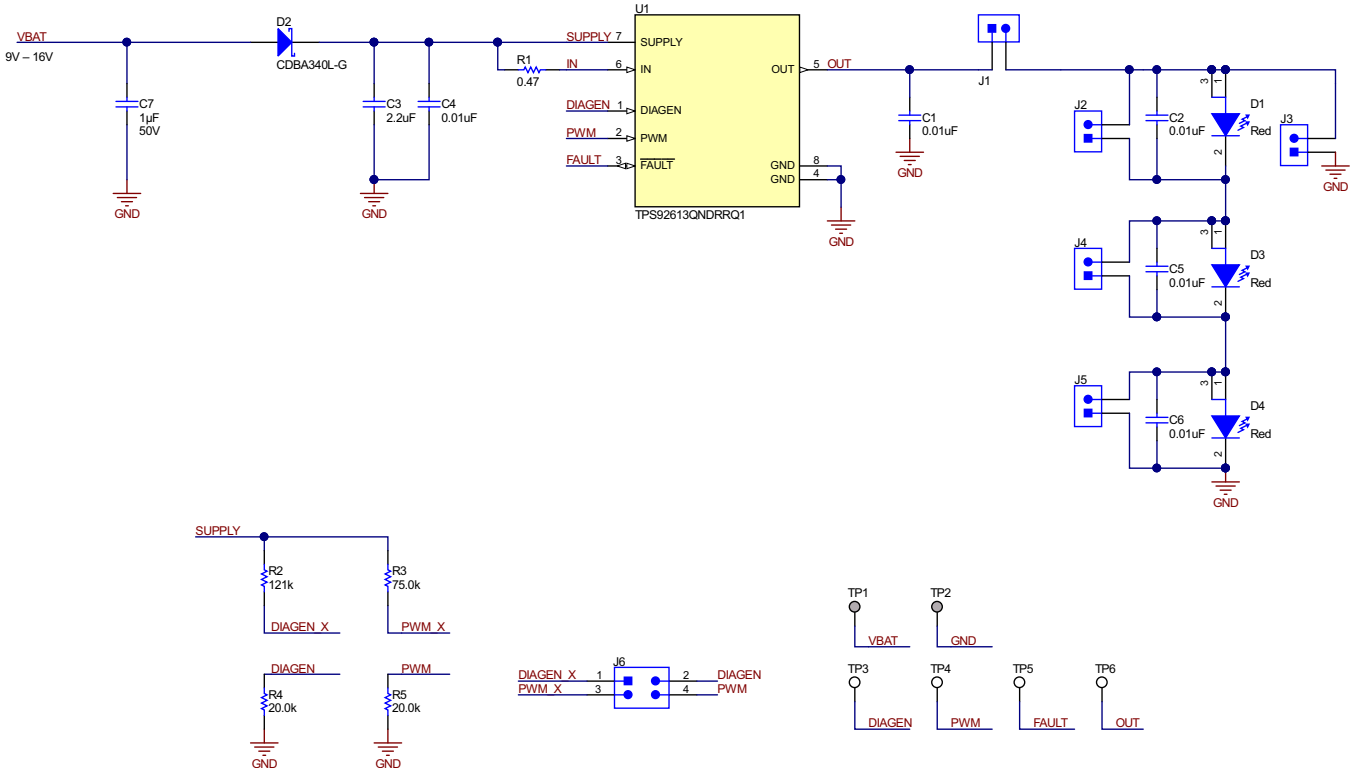

Figure 2. TPS92613-Q1 Schematic for PCB Design

Copyright © 2020, Texas Instruments Incorporated

2.2 Layout Recommendation

Figure 3 is the layout of TPS92613-Q1 EVM.

- C7 should be placed through VBAT and GND so as to filter the interference over input voltage and the "control ground" of the chip directly
- Design the "Control ground" as wide as possible
- Add C3 and C4 among the path from the power input to power GND
- Connect "Power ground" and "control ground" in a region away from the socket on the PCB board

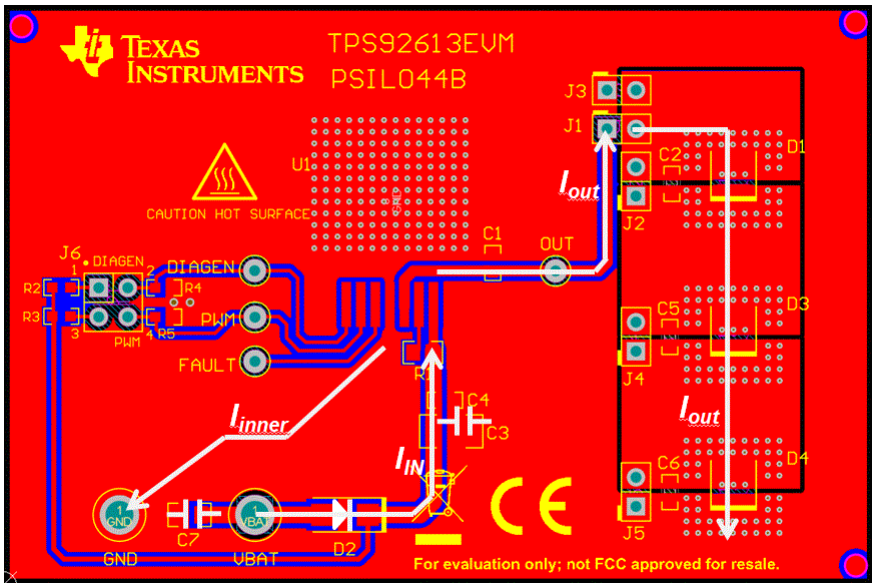

Figure 3. TPS92613-Q1 EVM Layout Illustration for BCI Test

3 Test Results

Figure 4 to Figure 7 show the equipment and DUT configuration of the BCI test.

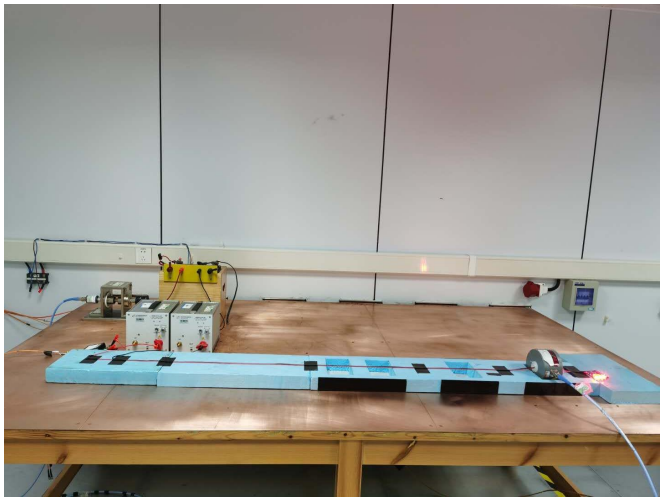

Figure 4. General Setup of BCI Test

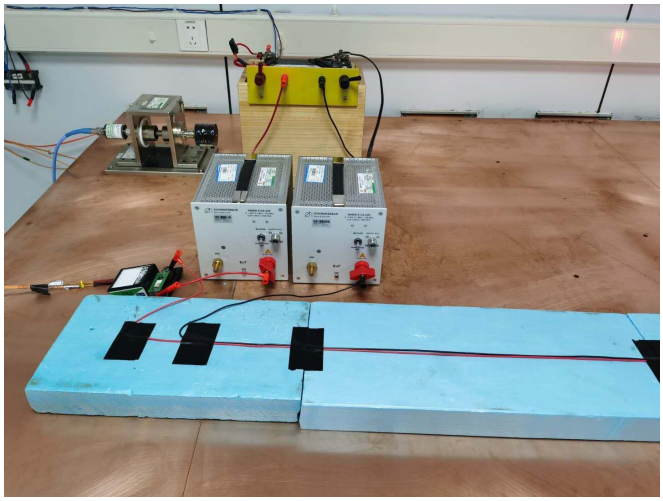

Figure 5. Battery Side of BCI Test

Copyright © 2020, Texas Instruments Incorporated

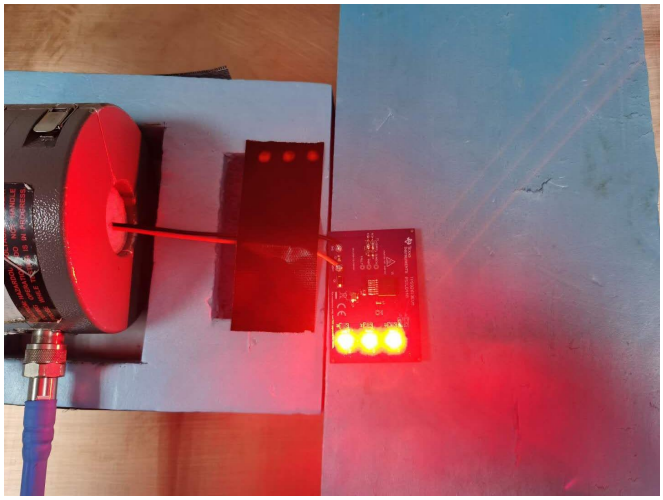

Figure 6. DUT Side of BCI Test

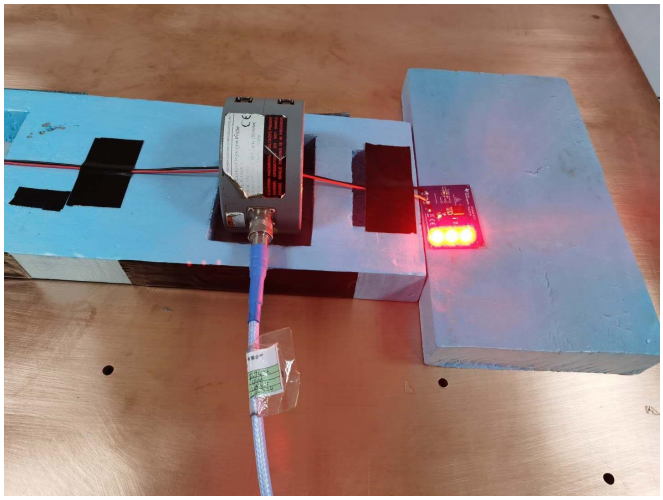

Figure 7. Current Injection of BCI Test

Table 3 lists the detailed results of the BCI test. The highest output current is 235 mA in 150-mm distance, the deviation is:

(235 – 204) / 204 = 15% < ±20%

Meanwhile no visible flicker was observed during the test. The DUT board passes the BCI test with function A result.

Table 3. Test Results of TPS92613-Q1 EVM BCI Test

Frequency (MHz)	Probe to DUT (mm)			Frequency (MHz)	Probe to DUT (mm)		
	150	450	750		150	450	750
1 to 150	204 mA	204 mA	204 mA	280	204 mA	204 mA	204 mA
160	204 mA	204 mA	204 mA	290	204 mA	204 mA	204 mA
170	208 mA	208 mA	204 mA	300	211 mA	204 mA	210 mA
180	208 mA	208 mA	204 mA	310	211 mA	204 mA	204 mA
190	204 mA	204 mA	204 mA	320	211 mA	204 mA	204 mA
200	204 mA	204 mA	204 mA	330	211 mA	204 mA	204 mA
210	204 mA	204 mA	204 mA	340	211 mA	204 mA	204 mA
220	204 mA	204 mA	204 mA	350	211 mA	204 mA	204 mA
230	204 mA	204 mA	204 mA	360	235 mA	220 mA	204 mA
240	204 mA	204 mA	204 mA	370	215 mA	211 mA	204 mA
250	204 mA	204 mA	204 mA	380	207 mA	204 mA	204 mA
260	204 mA	204 mA	204 mA	390	205 mA	204 mA	204 mA
270	204 mA	204 mA	204 mA	400	205 mA	204 mA	204 mA

The jumper J1 to J6 is removed during the test to avoid the unexpected radiated noise coupling during the test. The jumpers in the EVM are only for evaluation convenience, and normally they are not required in a real application.

4 Summary

This application report introduces layout precautions of TPS92613-Q1 for better BCI immunity performance. The international standard this evaluation board passes is ISO11452-4 200-mA level. The filter capacitor C7 before the anti-reverse diode D2 is used to give cleaner power to the control module of the chip; the filter capacitor C3 and C4 is used to give cleaner driving current for LEDs. They need to be directly connected to “control ground” and “power ground”, respectively.

Copyright © 2020, Texas Instruments Incorporated

5 References

- Texas Instruments, *TPS92613-Q1 Automotive Single-Channel LED Driver Data Sheet*
- Texas Instruments, *TPS92613-Q1 Evaluation Module User's Guide*

Copyright © 2020, Texas Instruments Incorporated

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