TPS92621-Q1 具有热共享功能的单通道、汽车类、高侧 LED 驱动器

1 特性

- 符合面向汽车应用的 AEC-Q100 标准：
  - 温度等级 1：–40°C 至 125°C，T_A
- 宽输入电压范围：4.5V 至 40V
- 通过外部分流电阻器实现热共享功能
- 故障模式下具有低电源电流
- 单路高精度电流调节：
  - 高达 300mA 的电流输出
  - 在整个温度范围内精度为 ±5%
  - 通过电阻器设置电流
  - 用于亮度控制的 PWM 引脚
- 低压降：
  - 最大压降：150mA 时为 300mV
  - 最大压降：300mA 时为 600mV
- 诊断和保护
  - LED 开路，具有自动恢复功能
  - LED 接地短路，具有自动恢复功能
  - 支持诊断并具有可调阈值
  - 可配置为连带失效的故障总线
  - 热关断
- 工作结温范围：–40°C 至 150°C

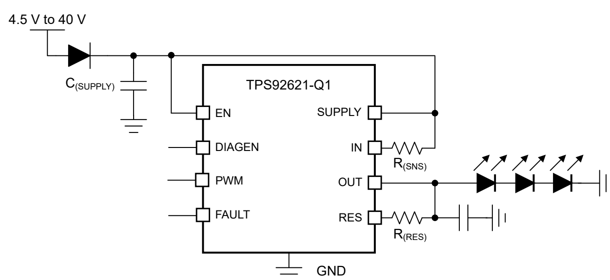


图 3-1. 典型应用图

2 应用

- 车外尾灯：尾灯、中央高位刹车灯、侧标志灯
- 车外小灯：门把手、盲点检测指示灯、充电口
- 车内灯：顶灯、阅读灯
- 通用 LED 驱动器应用

3 说明

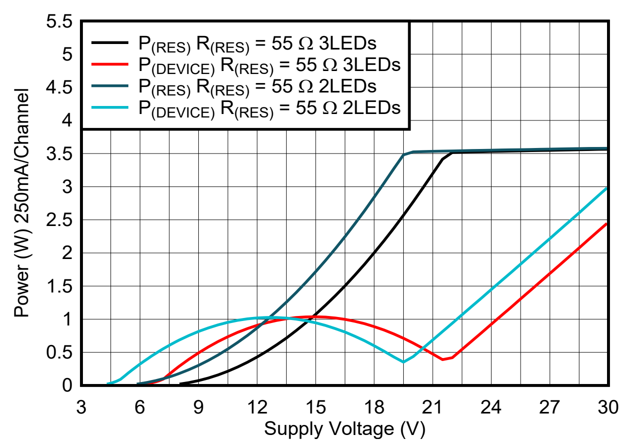
TPS92621-Q1 单通道 LED 驱动器采用独特的热管理设计，可减少器件温升。TPS92621-Q1 是由汽车电池直接供电的线性驱动器，具有宽电压范围，可输出高达 300mA 的全电流负载。分流电阻器可用来共享输出电流并由驱动器驱动。该器件具有全面的诊断功能，包括 LED 开路、LED 接地短路和器件过热保护。

TPS92621-Q1 的连带失效功能可与其他 LED 驱动器（如 TPS9261x-Q1、TPS9262x-Q1、TPS9263x-Q1 和 TPS92830-Q1 器件）配合工作，从而满足不同的要求。

封装信息

器件型号	封装(1)	封装尺寸（标称值）
TPS92621-Q1	DGN（HVSSOP，8）	3.00mm × 3.00mm

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。



器件功耗

Table of Contents

4 Revision History

注：以前版本的页码可能与当前版本的页码不同

DATE	REVISION	NOTES
August 2023	*	Initial release.

5 Pin Configuration and Functions

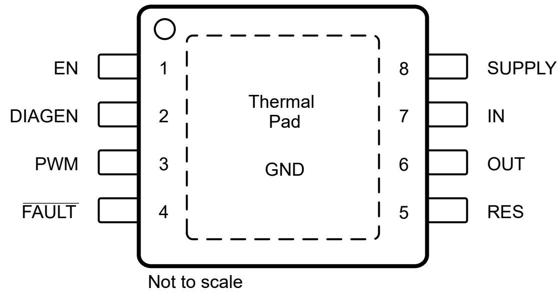


图 5-1. DGN Package 8-Pin HVSSOP With PowerPAD™ Integrated Circuit Package (Top View)

表 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	**NO.**		
EN	1	I	Device enable pin
DIAGEN	2	I	Enable pin for LED open-circuit detection to avoid false open-circuit diagnostics during low-voltage operation
PWM	3	I	PWM input
$\overline{\text{FAULT}}$	4	I/O	Fault output, support one-fails-all-fail fault bus
RES	5	O	Current output with external thermal resistor
OUT	6	O	Current output
IN	7	I	Current input
SUPPLY	8	I	Device Power Supply
DAP	—	—	Ground/ Thermal Pad

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
Supply	SUPPLY	–0.3	45	V
High-voltage input	DIAGEN, IN, EN, PWM	–0.3	$V_{(SUPPLY)} + 0.3$	V
High-voltage output	OUT, RES	–0.3	$V_{(SUPPLY)} + 0.3$	V
Fault bus	$\overline{\text{FAULT}}$	–0.3	$V_{(SUPPLY)} + 0.3$	V
T_J	Operating junction temperature	–40	150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002[1] HBM ESD Classification Level 1C		±2000	V
		Charged-device model (CDM), per AEC Q100-011 CDM ESD Classification Level C4B	All pins	±500	
			Corner pins (EN, $\overline{\text{FAULT}}$, RES, SUPPLY)	±750	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
SUPPLY	Device supply voltage	4.5		40	V
EN	Device EN pin	0		$V_{(SUPPLY)}$	
IN	Sense voltage		$V_{(SUPPLY)} - V_{(CS\_REG)}$		V
PWM	PWM inputs	0		$V_{(SUPPLY)}$	V
DIAGEN	Diagnostics enable pin	0		$V_{(SUPPLY)}$	V
OUT, RES	Driver output	0		$V_{(SUPPLY)}$	V
$\overline{\text{FAULT}}$	Fault bus	0		$V_{(SUPPLY)}$	V
Operating ambient temperature, T_A		–40		125	°C

6.4 Thermal Information

THERMAL METRIC[1]		TPS92621-Q1 DGN(HVSSOP) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	60	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	58.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	25.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	1.7	°C/W
ψ_{JB}	Junction-to-board characterization parameter	25.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	11.3	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC package thermal metrics* application report.

6.5 Electrical Characteristics

$V_{(SUPPLY)}$ = 5 V to 40 V, T_J = –40°C to +150°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
BIAS						
$V_{(POR\_rising)}$	Supply voltage POR rising threshold			3.6	4.0	V
$V_{(POR\_falling)}$	Supply voltage POR falling threshold		3.0	3.4		V
$I_{(SD)}$	Device shutdown current	$V_{(EN)}$= 0V		11.4	15.0	uA
$I_{(Quiescent)}$	Device standby ground current	PWM = HIGH		0.7	1.0	mA
$I_{(FAULT)}$	Device supply current in fault mode	PWM = HIGH, $\overline{FAULT}$ externally pulled LOW	0.21	0.27	0.35	mA
LOGIC INPUTS (DIAGEN, PWM, EN)						
$V_{IL(EN)}$	Input logic-low voltage, EN				0.7	V
$V_{IH(EN)}$	Input logic-high voltage, EN		2.0			V
$I_{(EN\_pulldown)}$	EN pulldown current	V(EN) = 12 V	1.5	2.9	4.5	uA
$V_{IL(DIAGEN)}$	Input logic-low voltage, DIAGEN		1.045	1.1	1.155	V
$V_{IH(DIAGEN)}$	Input logic-high voltage, DIAGEN		1.14	1.2	1.26	V
$V_{IL(PWM)}$	Input logic-low voltage, PWM		1.045	1.1	1.155	V
$V_{IH(PWM)}$	Input logic-high voltage, PWM		1.14	1.2	1.26	V
CONSTANT-CURRENT DRIVER						
$I_{(OUTx\_Tot)}$	Device output-current for each channel	100% duty cycle	5		300	mA
$V_{(CS\_REG)}$	Sense-resistor regulation voltage	T_A = –40°C to +125°C	144	150	156	mV
ALL $\Delta V_{(CS\_d2d)}$	Device to device mismatch	$\Delta V_{(CS\_d2d)} = 1 - V_{(CS\_REG)} / V_{nom(CS\_REG)}$	–4		+4	%
$R_{(CS\_REG)}$	Sense-resistor range		0.48		31.2	Ω
$V_{(DROPOUT)}$	Voltage dropout from IN to OUT, RES open	current setting of 150 mA	50	170	300	mV
		current setting of 300 mA	100	342	600	mV
	Voltage dropout from IN to RES, OUT open	current setting of 150 mA	100	350	600	mV
		current setting of 300 mA	100	710	1200	mV
$I_{(RES)}$	Ratio of RESx current to total current	$I_{(RES)}/I_{(OUT\_Tot)}$, $V_{(IN)} - V_{(RES)}$ > 1 V, Itotal=150mA	95			%
DIAGNOSTICS						
$V_{(OPEN\_th\_rising)}$	LED open rising threshold, $V_{(IN)} - V_{(OUT)}$		180	320	420	mV
$V_{(OPEN\_th\_falling)}$	LED open falling threshold, $V_{(IN)} - V_{(OUT)}$			510		mV
$V_{(SG\_th\_rising)}$	Channel output short-to-ground rising threshold		1.14	1.2	1.26	V
$V_{(SG\_th\_falling)}$	Channel output short-to-ground falling threshold		0.855	0.9	0.945	V
$I_{(Retry\_OUT)}$	Channel output $V_{(OUT)}$ short-to-ground retry current		0.64	1.10	1.528	mA
$I_{(Retry\_RES)}$	Channel output $V_{(RES)}$ short-to-ground retry current		0.64	1.10	1.528	mA
FAULT						
$V_{IL(FAULT)}$	Logic input low threshold				0.7	V
$V_{IH(FAULT)}$	Logic input high threshold		2			V
$t_{(FAULT\_rising)}$	Fault detection rising edge deglitch time			10		μs
$t_{(FAULT\_falling)}$	Fault detection falling edge deglitch time			20		μs
$I_{(FAULT\_pulldown)}$	$\overline{FAULT}$ internal pulldown current	$V_{(\overline{FAULT})}$ = 0.4 V	2	3	4	mA
$I_{(FAULT\_pullup)}$	$\overline{FAULT}$ internal pullup current		6	10	14	μA
$I_{(FAULT\_leakage)}$	$\overline{FAULT}$ leakage current	$V_{(\overline{FAULT})}$ = 40 V			1	μA
TIMING						
$t_{(PWM\_delay\_rising)}$	PWM rising edge delay to 10% of output current, t_1 as shown in 图 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 0.6 Ω, and $R_{(RES)}$ = 39 Ω		3.7		μs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 30 Ω and $R_{(RES)}$ = 56 Ω		2.2		μs

$V_{(SUPPLY)}$ = 5 V to 40 V, T_J = –40°C to +150°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{(PWM\_delay\_falling)}$	PWM falling edge delay to 90% of output current, t_2 as shown in 图 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 0.6 Ω, and $R_{(RES)}$ = 39 Ω		4.0		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 30 Ω and $R_{(RES)}$ = 56 Ω		3.6		µs
$t_{(Current\_rising)}$	Output current rising from 10% to 90%, t_3 as shown in 图 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 0.6 Ω, and $R_{(RES)}$ =39 Ω		1.8		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 30 Ω and $R_{(RES)}$ = 56 Ω		1.8		µs
$t_{(Current\_falling)}$	Output current falling from 90% to 10%, t4 as shown in 图 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 0.6 Ω, and $R_{(RES)}$ = 39 Ω		5.7		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 30 Ω and $R_{(RES)}$ = 56 Ω		0.3		µs
$t_{(STARTUP)}$	SUPPLY rising edge to 10% output current, t_5 as shown in 图 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 0.6 Ω, and $R_{(RES)}$ = 39 Ω		96		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 6 V, $V_{(CS\_REG)}$ = 150 mV, $R_{(SNS)}$ = 30 Ω and $R_{(RES)}$ = 56 Ω		85		µs
$t_{(OPEN\_deg)}$	LED-open fault detection deglitch time, t_6 as shown in 图 7-4			125		µs
$t_{(SG\_deg)}$	Output short-to-ground detection deglitch time, t_7 as shown in 图 7-3			125		µs
$t_{(Recover\_deg)}$	Open and Short fault recovery deglitch time, t_8 as shown in 图 7-4 and 图 7-3			125		µs
$t_{(FAULT\_deg)}$	Fault pin deglitch time			20		µs
$t_{(FAULT\_recovery)}$	Fault recovery delay time, t_9 as shown in 图 7-4 and 图 7-3			50		µs
$t_{(TSD\_deg)}$	Thermal over temperature deglitch time			50		µs
THERMAL PROTECTION						
$T_{(TSD)}$	Thermal shutdown junction temperature threshold		157	172	187	°C
$T_{(TSD\_HYS)}$	Thermal shutdown junction temperature hysteresis			15		°C

6.6 Typical Characteristics

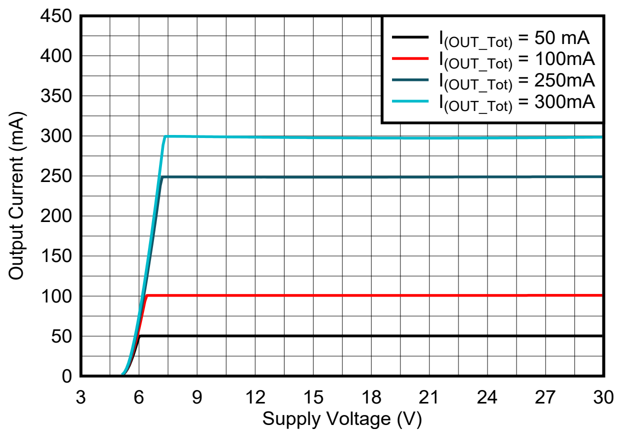


图 6-1. Output Current vs Supply Voltage

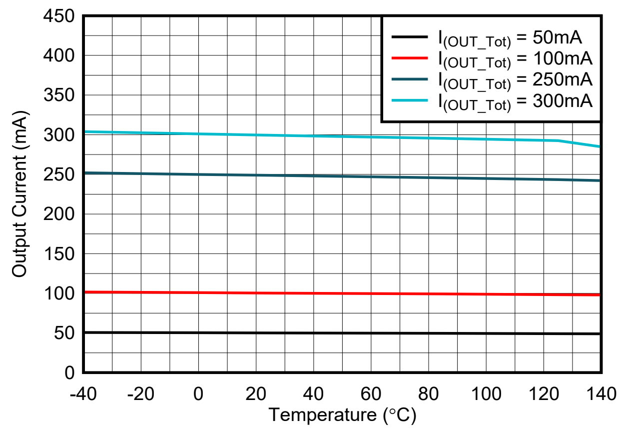


图 6-2. Output Current vs Temperature

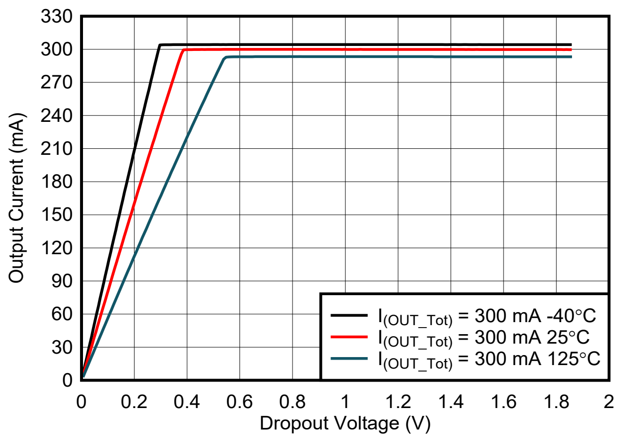


图 6-3. Output Current vs Dropout Voltage

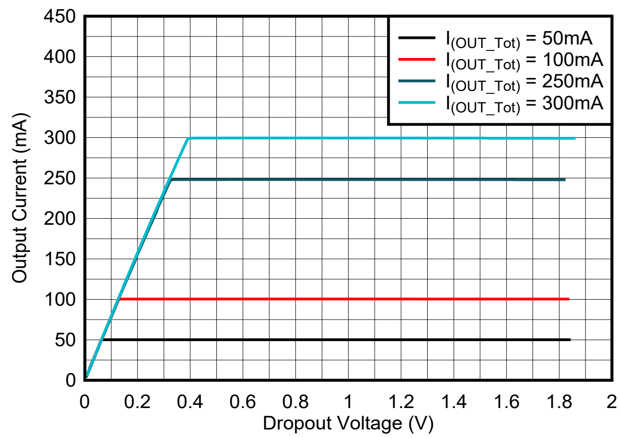


图 6-4. Output Current vs Dropout Voltage

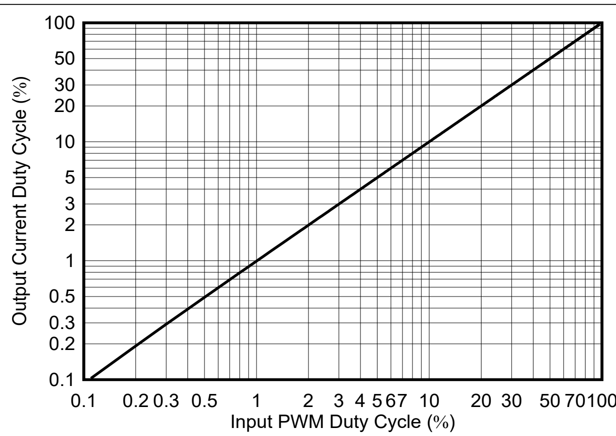


图 6-5. PWM Output Duty Cycle vs PWM Input Duty Cycle

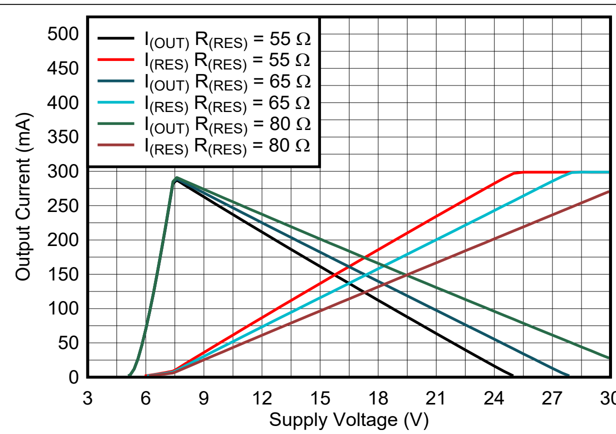


图 6-6. Output Current Distribution vs Supply Voltage

6.6 Typical Characteristics (continued)

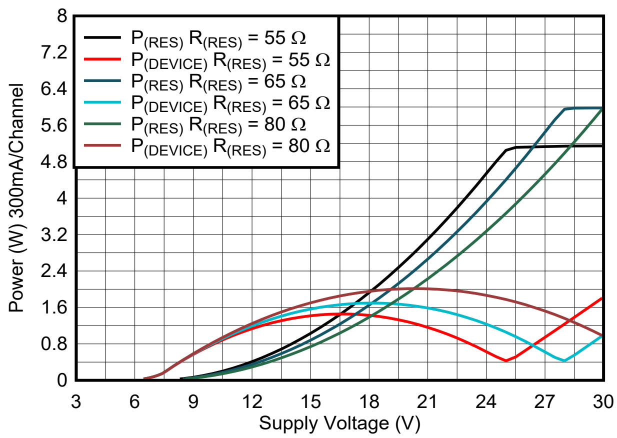


图 6-7. Power Dissipation vs Supply Voltage

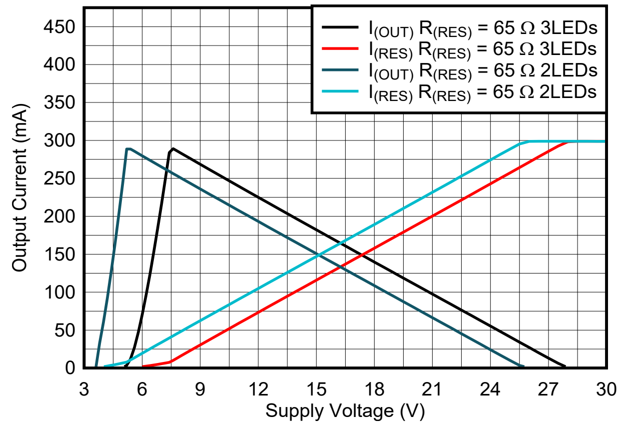


图 6-8. Output Current Distribution vs Supply Voltage

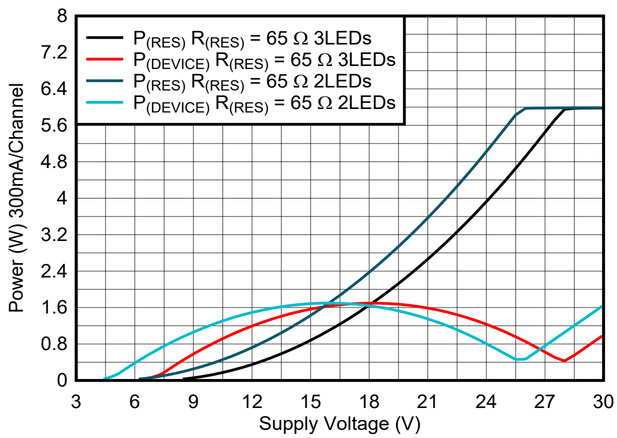
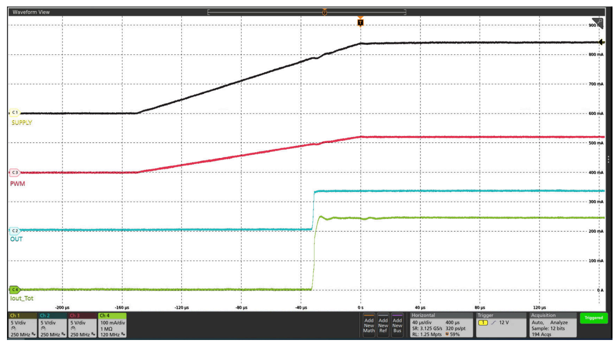
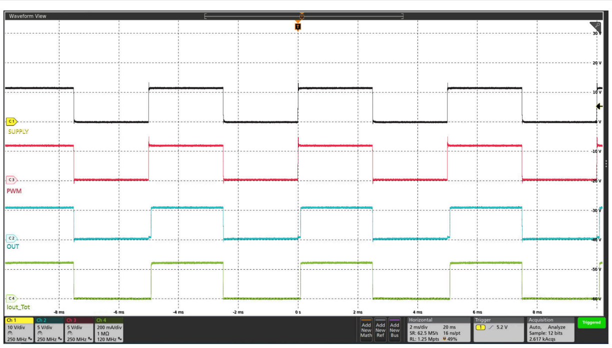


图 6-9. Power Dissipation vs Supply Voltage



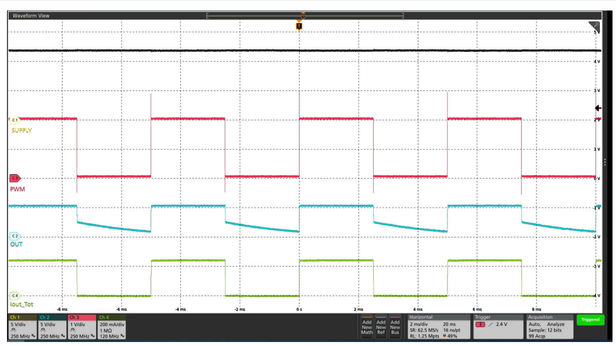
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

图 6-10. Power-Up Sequence



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

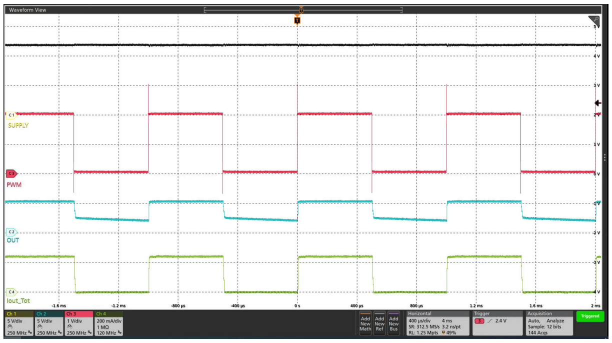
图 6-11. Supply Dimming at 200 Hz



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

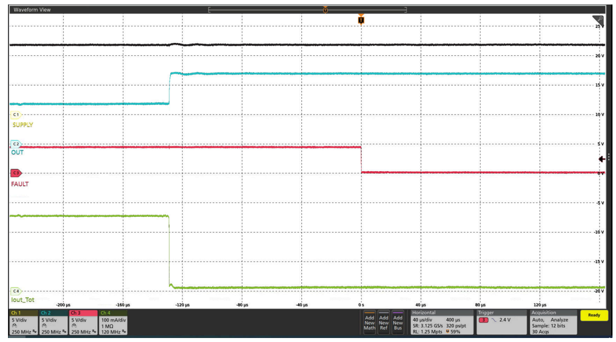
图 6-12. PWM Dimming at 200 Hz

6.6 Typical Characteristics (continued)



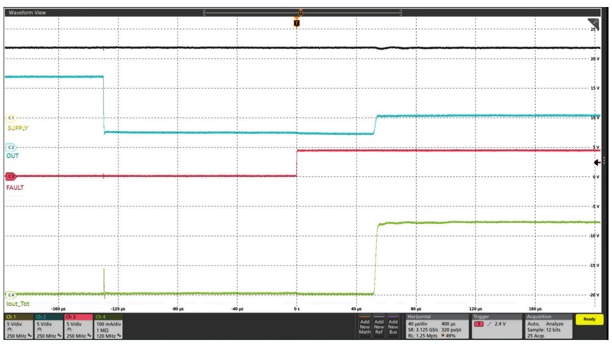
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

图 6-13. PWM Dimming at 1 kHz



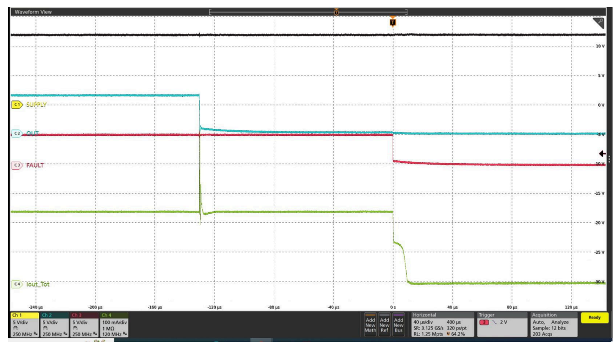
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

图 6-14. LED Open Protection



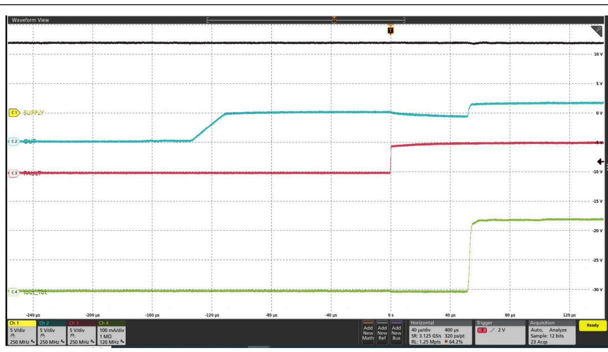
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

图 6-15. LED Open Protection Recovery



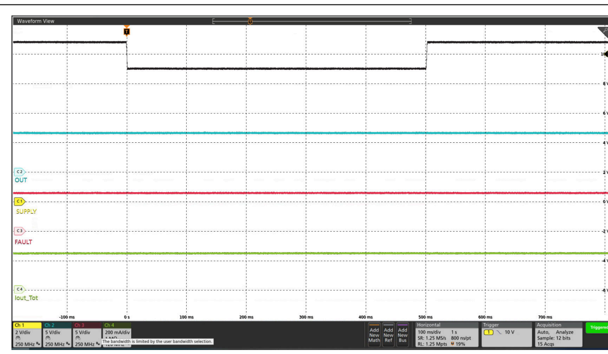
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

图 6-16. LED Short-Circuit Protection



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

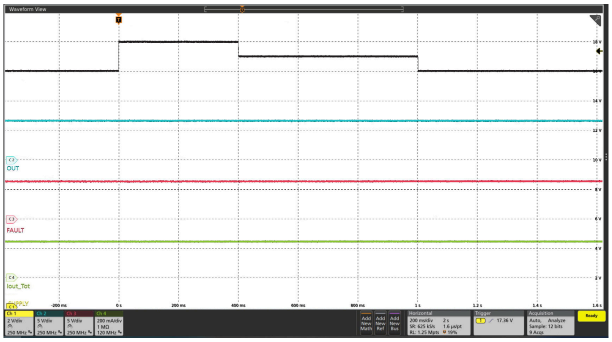
图 6-17. LED Short-Circuit Protection Recovery



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

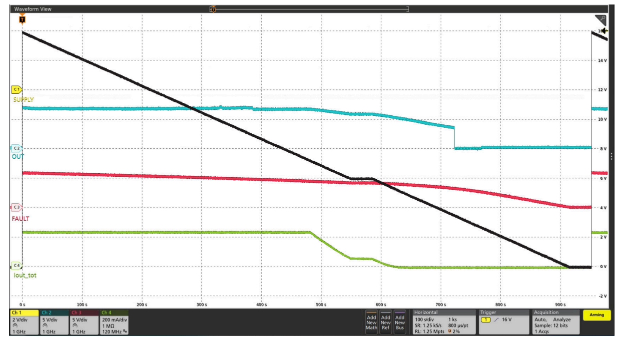
图 6-18. Transient Undervoltage

6.6 Typical Characteristics (continued)



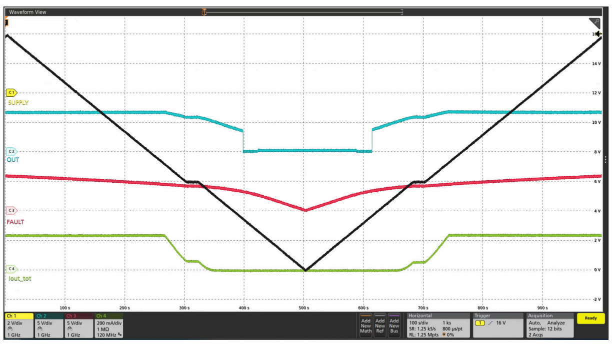
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

图 6-19. Transient Overvoltage



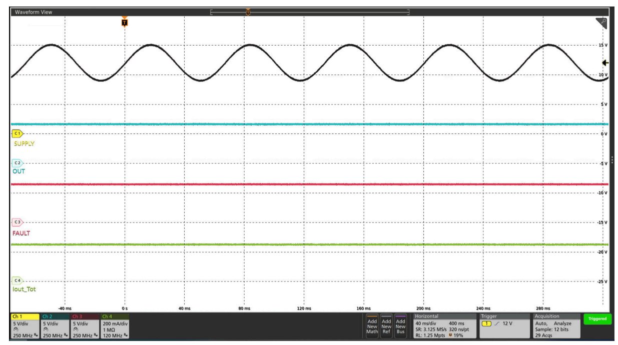
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

图 6-20. Slow Decrease and Quick Increase of Supply Voltage



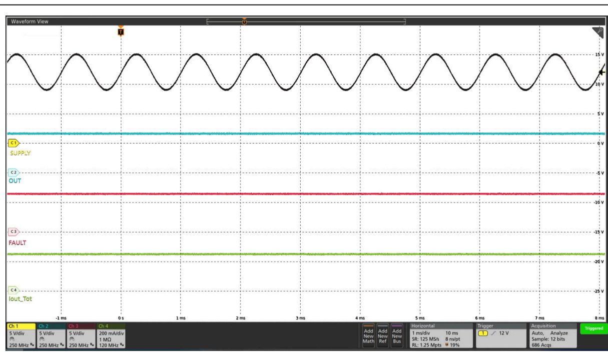
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

图 6-21. Slow Decrease and Slow Increase of Supply Voltage



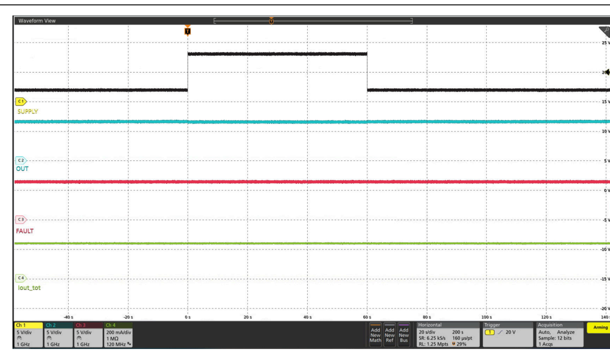
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

图 6-22. Superimposed Alternating Voltage 15 Hz



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

图 6-23. Superimposed Alternating Voltage 1 kHz



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

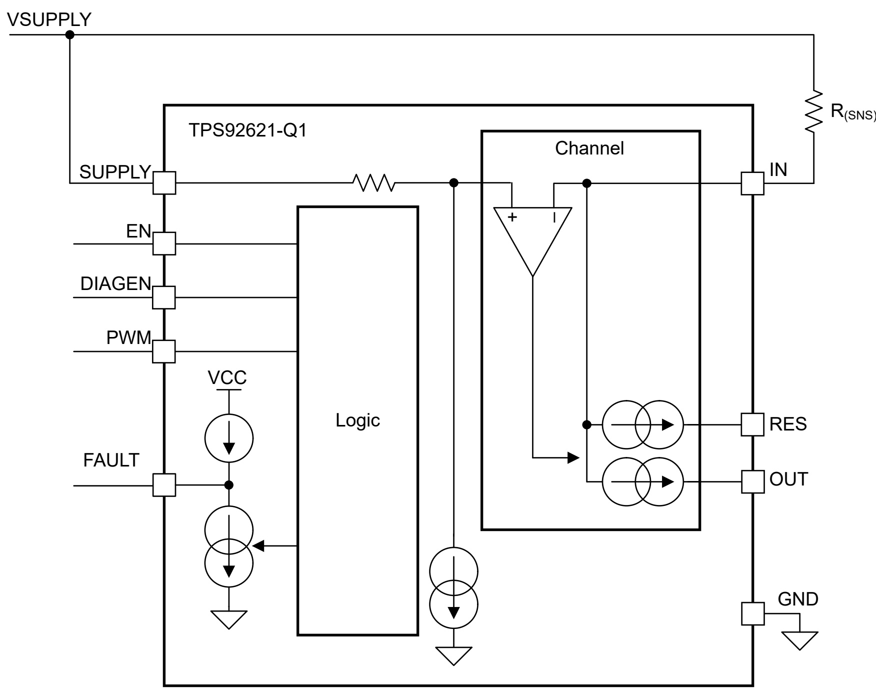
图 6-24. Jump Start

7 Detailed Description

7.1 Overview

The TPS92621-Q1 is a single channel, high-side linear LED driver supporting external thermal sharing resistor to achieve the controllable junction temperature rising. The device can be directly powered by automotive battery and output full load up to 300 mA current to LED with limited power dissipation on the device. The current output can be set by external $R_{(SNS)}$ resistors. Current flows from the supply through the $R_{(SNS)}$ resistor into the integrated current regulation circuit and to the LEDs through OUT pin and RES pin. TPS92621-Q1 device supports both supply control and PWM control to turn LED ON and OFF. The LED brightness is also adjustable by voltage duty cycle applied on either SUPPLY or PWM pins with frequency above 100 Hz. The TPS92621-Q1 provides full diagnostics to keep the system operating reliably including LED open and short-circuit detection, supply POR and thermal shutdown protection. TPS92621-Q1 device is in a HTSSOP package with total 8 leads. The TPS92621-Q1 can be used with other TPS9261x-Q1, TPS9262x-Q1, TPS9263x-Q1 and TPS92830-Q1 family devices together to achieve one-fails-all-fail protection by tying all $\overline{FAULT}$ pins together as a fault bus.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Power Supply (SUPPLY)

7.3.1.1 Power-On Reset (POR)

The TPS92621-Q1 device has an internal power-on-reset (POR) function. When power is applied to the SUPPLY pin, the internal POR circuit holds the device in reset state until $V_{(SUPPLY)}$ is above $V_{(POR\_rising)}$

7.3.1.2 Suppply Current in Fault Mode

The TPS92621-Q1 device consumes minimal quiescent current, $I_{(FAULT)}$, into SUPPLY when the $\overline{FAULT}$ pin is externally pulled LOW. At the same time, the device shuts down the output.

If device detects an internal fault, it pulls down the $\overline{FAULT}$ pin by an internal typical 3-mA constant current as a fault indication to the fault bus.

7.3.2 Enable and Shutdown(EN)

The TPS92621-Q1 device starts to operate as long as the SUPPLY voltage is higher than $V_{(POR\_rising)}$. The TPS92621-Q1 shuts down when SUPPLY voltage is lower than $V_{(POR\_falling)}$.

The TPS92621-Q1 device has an enable input. When EN is low, the device is in sleep mode with ultra low shutdown current $I_{(SD)}$. This low current helps to save system-level current consumption in applications where battery voltage directly connects to the device without high-side switches.

7.3.3 Constant-Current Output and Setting (IN)

The TPS92621-Q1 device is a high-side current driver for driving LEDs. The device controls output current through regulating the voltage drop on an external high-side current-sense resistor, $R_{(SNS)}$. An integrated error amplifier drives an internal power transistor to maintain the voltage drop on the current-sense resistor $R_{(SNS)}$ to $V_{(CS\_REG)}$ and therefore regulates the current output to target value. When the output current is in regulation, use Equation 1 to calculate the current value.

$$I_{(OUTx\_Tot)} = \frac{V_{(CS\_REG)}}{R_{(SNSx)}} \tag{1}$$

where

- $V_{(CS\_REG)}$ = 150 mV

When the supply voltage drops below total LED string forward voltage plus required headroom voltage, the sum of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$, the TPS92621-Q1 is not able to deliver enough current output as set by the value of $R_{(SNS)}$, and the voltage across the current-sense resistor $R_{(SNS)}$ is less than $V_{(CS\_REG)}$.

7.3.4 Thermal Sharing Resistor (OUT and RES)

The TPS92621-Q1 device provides single current output path. Current flows from the supply through the $R_{(SNS)}$ resistor into the integrated current regulation circuit and to the LEDs through OUT pin and RES pin. The current output on both OUT pin and RES pin is independently regulated to achieve total required current output. The summed current of OUT and RES is equal to the current through the $R_{(SNS)}$ resistor in the channel. The OUT connects to anode of LEDs load in serial directly, however RES connects to the LEDs through an external resistor to share part of the power dissipation and reduce the thermal accumulation in TPS92621-Q1.

The integrated independent current regulation in TPS92621-Q1 dynamically adjusts the output current on both OUT and RES output to maintain the stable summed current for LED. The TPS92621-Q1 always regulates the current output to the RES pin as much as possible until the RES current path is saturated, and the rest of required current is regulated out of the OUT. As a result, the most of the current to LED outputs through the RES pin when the voltage dropout is large between SUPPLY and LED required total forward voltage. In the opposite case, the most of the current to LED outputs through the OUT pin when the voltage headroom is relative low between SUPPLY and LED required forward voltage.

7.3.5 PWM Control (PWM)

The pulse width modulation (PWM) input of the TPS92621-Q1 functions as enable for the output current. When the voltage applied on the PWM pin is higher than $V_{IH(PWM)}$, the output current is enabled. When the voltage applied on PWM pin is lower than $V_{IL(PWM)}$, the output current is disabled as well as the diagnostic features. Besides output current enable and disable function, the PWM input of TPS92621-Q1 also supports adjustment of the average current output for brightness control if the frequency of applied PWM signal is higher than 100 Hz, which is out of visible frequency range of human eyes. TI recommends a 200-Hz PWM signal with 1% to 100% duty cycle input for brightness control. Please refer to 图 8-4 for typical PWM dimming application.

The TPS92621-Q1 device has one PWM input pin: PWM to control current output channel. PWM input controls the output channel for both OUT and RES. 图 7-1 illustrates the timing for PWM input and current output.

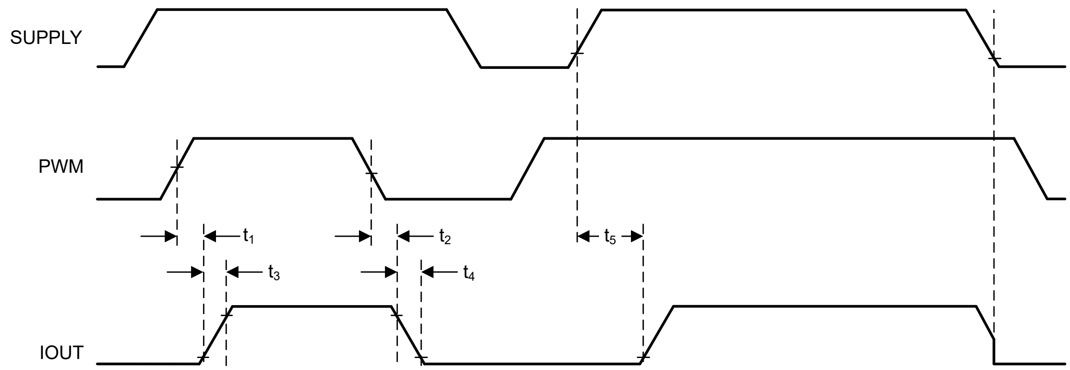


图 7-1. Power-On Sequence and PWM Dimming Timing

The detailed information and value of each time period in 图 7-1 is described in *Electrical Characteristics* section.

7.3.6 Supply Control

The TPS92621-Q1 can support supply control to turn ON and OFF output current. When the voltage applied on the SUPPLY pin is higher than the LED string forward voltage plus needed headroom voltage at required current, and the EN pin, PWM pin voltage is high, the output current is turned ON and well regulated. However, if the voltage applied on the SUPPLY pin is lower than $V_{(POR\_falling)}$, the output current is turned OFF. With this feature, the power supply voltage in designed pattern can control the output current ON and OFF. The brightness is adjustable if the ON and OFF frequency is fast enough. Because of the high accuracy design of PWM threshold in TPS92621-Q1, TI recommends a resistor divider on the PWM pin to set the SUPPLY threshold higher than LED forward voltage plus required headroom voltage as shown in 图 7-2. The headroom voltage is basically the summation of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$. When the voltage on the PWM pin is higher than $V_{IH(PWM)}$, the output current is turned ON. However, when the voltage on the PWM is lower than $V_{IL(PWM)}$, the output current is turned OFF. Use Equation 2 to calculate the SUPPLY threshold voltage.

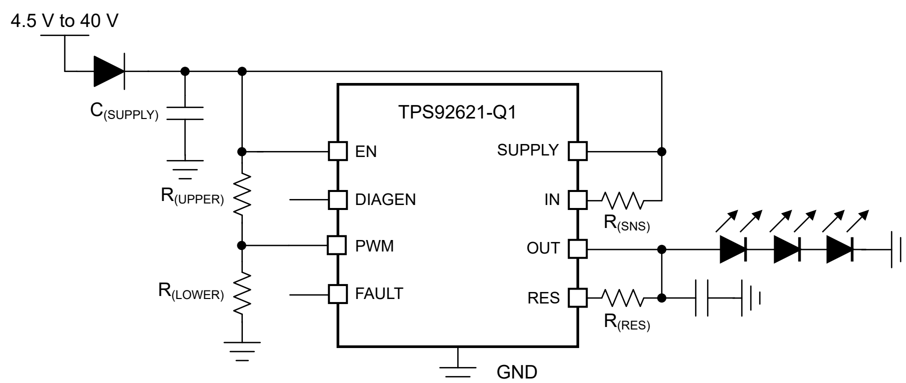


图 7-2. Application Schematic for Supply Control LED Brightness

$$V_{(SUPPLY\_PWM\_th\_rising)} = V_{IH(PWM)} \times \left(1 + \frac{R_{(UPPER)}}{R_{(LOWER)}}\right) \quad (2)$$

where

- $V_{IH(PWM)}$ = 1.26 V (maximum)

7.3.7 Diagnostics

The TPS92621-Q1 device provides advanced diagnostics and fault-protection features for automotive exterior lighting systems. The device can detect and protect fault from LED-string short-to-GND, LED-string open-circuit and junction overtemperature scenarios. The device also supports a one-fails-all-fail fault bus design that can flexibly fit different regulatory requirements.

7.3.7.1 LED Short-to-GND Detection

The TPS92621-Q1 device has LED short-to-GND detection. The LED short-to-GND detection monitors the output voltage when the output current is enabled. After a short-to-GND LED failure is detected, the device turns off the faulty channel and retries automatically, regardless of the state of the PWM input. If the retry mechanism detects the removal of the LED short-to-GND fault, the device resumes to normal operation.

The TPS92621-Q1 monitors both $V_{(OUT)}$ voltage and $V_{(RES)}$ voltage of LED channel and compares it with the internal reference voltage to detect a short-to-GND failure. If $V_{(OUT)}$ or $V_{(RES)}$ voltage falls below $V_{(SG\_th\_falling)}$ longer than the deglitch time of $t_{(SG\_deg)}$, the device asserts the short-to-GND fault and pulls low the $\overline{\text{FAULT}}$ pin. During the deglitching time period, if $V_{(OUT)}$ and $V_{(RES)}$ rises above $V_{(SG\_th\_rising)}$, the timer is reset.

After the TPS92621-Q1 has asserted a short-to-GND fault, the device turns off the output channel and retries automatically with a small current. During retrying, the device sources a small current $I_{(Retry)}$ from SUPPLY to OUT and RES to pull up the LED loads continuously. After auto-retry detects output voltage rising above $V_{(SG\_th\_rising)}$, it clears the short-to-GND fault and resumes to normal operation. 图 7-3 illustrates the timing for LED short-circuit detection, protection, retry and recovery.

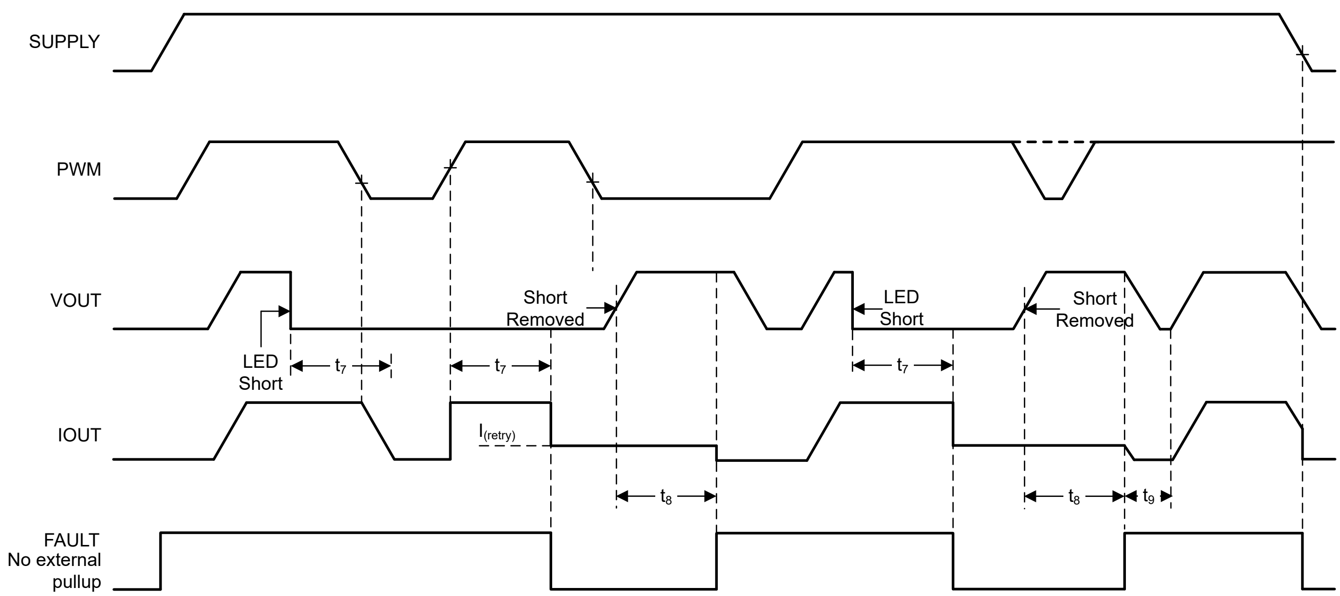


图 7-3. LED Short-to-GND Detection and Recovery Timing Diagram

The detailed information and value of each time period in 图 7-3 is described in *Electrical Characteristics* section.

7.3.7.2 LED Open-Circuit Detection

The TPS92621-Q1 device has LED open-circuit detection. The LED open-circuit detection monitors the output voltage when the current output is enabled. The LED open-circuit detection is only enabled when DIAGEN is HIGH. A short-to-battery fault is also detected and recognized as an LED open-circuit fault.

The TPS92621-Q1 monitors dropout-voltage differences between the IN and OUT pins for LED channel when PWM is HIGH. The voltage difference $V_{(IN)}$ – $V_{(OUT)}$ is compared with the internal reference voltage $V_{(OPEN\_th\_rising)}$ to detect an LED open-circuit incident. If $V_{(OUT)}$ rises and causes $V_{(IN)}$ – $V_{(OUT)}$ less than the $V_{(OPEN\_th\_rising)}$ voltage longer than the deglitch time of $t_{(OPEN\_deg)}$, the device asserts an open-circuit fault. After a LED open-circuit failure is detected, the internal constant-current sink pulls down the $\overline{\text{FAULT}}$ pin voltage. During the deglitch time period, if $V_{(OUT)}$ falls and makes $V_{(IN)}$ – $V_{(OUT)}$ larger than $V_{(OPEN\_th\_falling)}$, the deglitch timer is reset.

The TPS92621-Q1 shuts down the output current regulation after LED open-circuit fault is detected. The device sources a small current $I_{(Retry)}$ from SUPPLY to OUT and RES when DIAGEN input is logic High. After the fault condition is removed, the device resumes normal operation and releases the FAULT pin. 图 7-4 illustrates the timing for LED open-circuit detection, protection, retry and recovery.

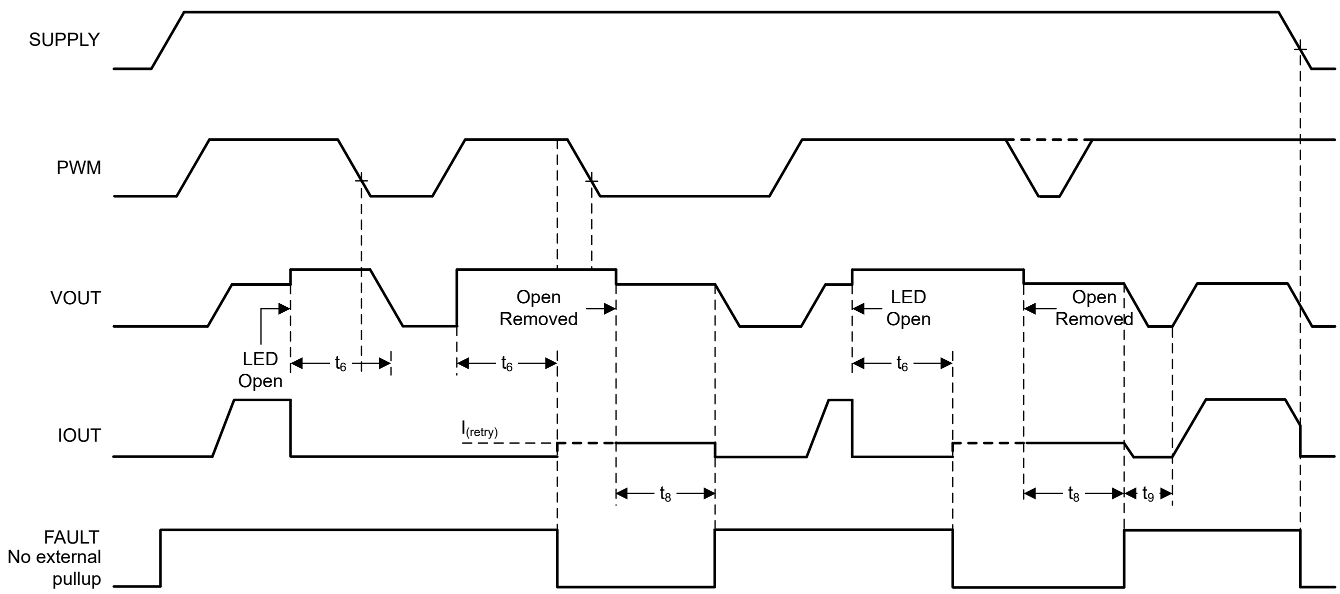


图 7-4. LED Open-Circuit Detection and Recovery Timing Diagram

The detailed information and value of each time period in 图 7-4 is described in *Electrical Characteristics* section.

7.3.7.3 LED Open-Circuit Detection Enable (DIAGEN)

The TPS92621-Q1 device supports the DIAGEN pin with an accurate threshold to disable the LED open-circuit. The DIAGEN pin can be used to enable or disable LED open-circuit detection based on SUPPLY pin voltage sensed by an external resistor divider as illustrated in 图 7-5. When the voltage applied on DIAGEN pin is higher than the threshold $V_{IH(DIAGEN)}$, the device enables LED open-circuit detection. When $V_{(DIAGEN)}$ is lower than the threshold $V_{IL(DIAGEN)}$, the device disables LED open-circuit detection.

Only LED open-circuit detection can be disabled by pulling down the DIAGEN pin. The LED short-to-GND detection and overtemperature protection cannot be turned off by pulling down the DIAGEN pin. Use Equation 3 to calculate the SUPPLY threshold voltage.

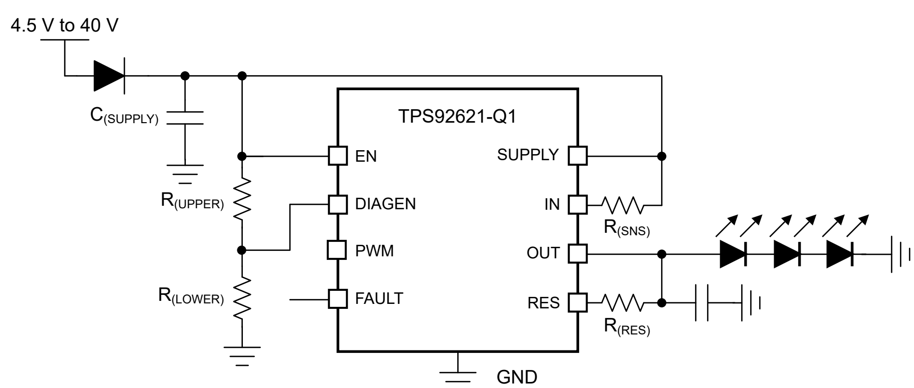


图 7-5. Application Schematic For DIAGEN

$$V_{(SUPPLY\_DIAGEN\_th\_falling)} = V_{IL(DIAGEN)} \times \left(1 + \frac{R_{(UPPER)}}{R_{(LOWER)}}\right) \tag{3}$$

where

- $V_{IL(DIAGEN)}$ = 1.045 V (minimum)

7.3.7.4 Overtemperature Protection

The TPS92621-Q1 device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold $T_{(TSD)}$, the output shuts down. After the junction temperature falls below $T_{(TSD)} - T_{(TSD\_HYS)}$, the device recovers to normal operation. During overtemperature protection, the $\overline{FAULT}$ pin is pulled low.

7.3.7.5 Low Dropout Operation

When the supply voltage drops below LED string total forward voltage plus headroom voltage at required current, the TPS92621-Q1 device operates in low-dropout condition to deliver output current as close as possible to target value. The actual output current is less than preset value due to insufficient headroom voltage for power transistor. As a result, the voltage across the sense resistor fails to reach the regulation target. The headroom voltage is the summation of $V_{(DROPOUT)}$ and $V_{(CS\_REG)}$.

If the TPS92621-Q1 is designed to operate in low-dropout condition, the open-circuit diagnostics must be disabled by pulling the DIAGEN pin voltage lower than $V_{IL(DIAGEN)}$. Otherwise, the TPS92621-Q1 detects an open-circuit fault and reports a fault on the $\overline{FAULT}$ pin. The DIAGEN pin is used to avoid false diagnostics due to low supply voltage.

7.3.8 FAULT Bus Output With One-Fails-All-Fail

During normal operation, The $\overline{FAULT}$ pin of TPS92621-Q1 is weakly pulled up by an internal pullup current source, $I_{(FAULT\_pullup)}$. If any fault scenario occurs, the $\overline{FAULT}$ pin is strongly pulled low by the internal pulldown current sink, $I_{(FAULT\_pulldown)}$ to report out the fault alarm.

Meanwhile, the TPS92621-Q1 also monitors the $\overline{FAULT}$ pin voltage internally. If the $\overline{FAULT}$ pin of the TPS92621-Q1 is pulled low by external current sink below $V_{IL(FAULT)}$, the current output is turned off even though there is no fault detected on owned output. The device does not resume to normal operation until the $\overline{FAULT}$ pin voltage rises above $V_{IH(FAULT)}$.

Based on this feature, the TPS92621-Q1 device is able to construct a FAULT bus by tying $\overline{FAULT}$ pins from multiple TPS92621-Q1 devices to achieve one-fails-all-fail function as 图 7-6 showing. The lower side TPS92621-Q1 (B) detects any kind of LED fault and pulls low the $\overline{FAULT}$ pin. The low voltage on $\overline{FAULT}$ pin is detected by upper side TPS92621-Q1 (A) because the $\overline{FAULT}$ pins of two devices are connected. The upper side TPS92621-Q1 (A) turns off output current as a result. If the $\overline{FAULT}$ pins of each TPS92621-Q1 are all connected to drive the base of an external PNP transistor as illustrated in 图 7-7, the one-fails-all-fail function is disabled and only the faulty channel device is turned off.

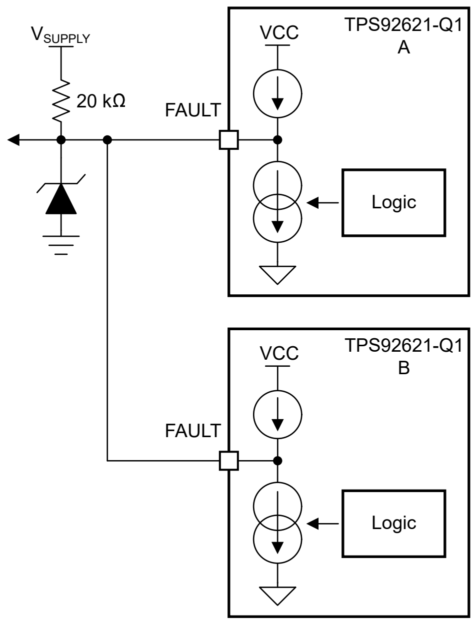


图 7-6. FAULT Bus for One-Fails-All-Fail Application

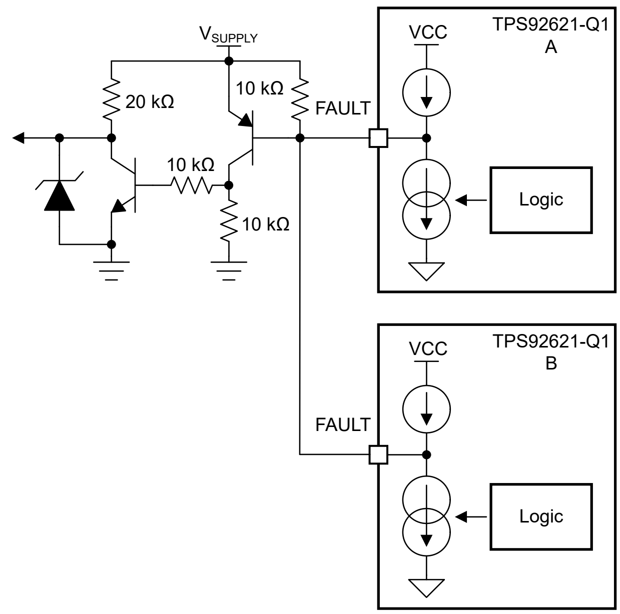


图 7-7. FAULT Bus for One-Fails-Others-On Application

7.3.9 FAULT Table

表 7-1. Fault Table With DIAGEN = HIGH (Full Function)

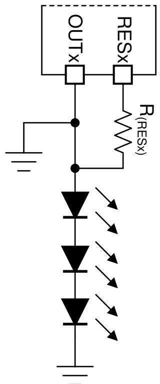
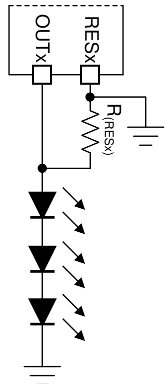
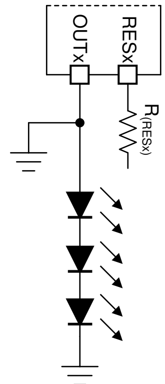
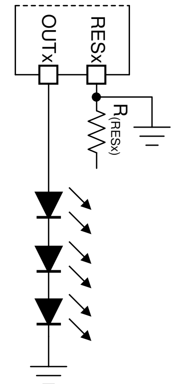
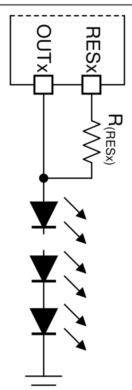
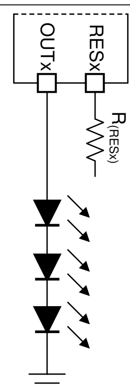
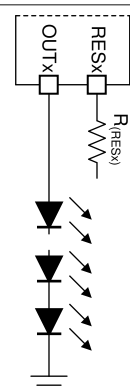
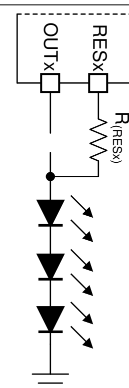
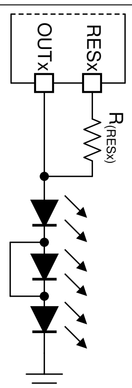
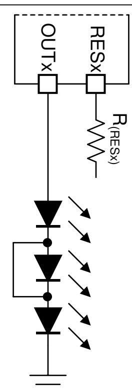
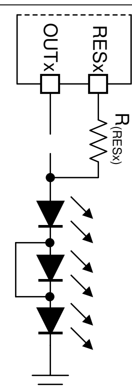
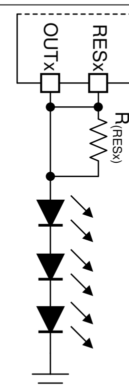
FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CONTROL INPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
$\overline{FAULT}$ = H	Open circuit or short-to-supply	$V_{(IN)} - V_{(OUT)} < V_{(OPEN\_th\_rising)}$	EN = H and PWM = H	$t_{(OPEN\_deg)}$	Constant-current pulldown	Device turns output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Short-to-ground	$V_{(OUT)} < V_{(SG\_th\_falling)}$ OR $V_{(RES)} < V_{(SG\_th\_falling)}$	EN = H and PWM = H	$t_{(SG\_deg)}$	Constant-current pulldown	Device turns output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Overtemperature	$T_J > T_{(TSD)}$	EN = H	$t_{(TSD\_deg)}$	Constant-current pulldown	Device turns output channel off.	Auto recovery
$\overline{FAULT}$ = L	Fault is detected	Device turns channel off and keeps retry. After the $\overline{Fault}$ pin is released, output channel is turned on after $t_{(FAULT\_recovery)}$ time.					
	No fault is detected	Device turns output channel off.					

表 7-2. Fault Table With DIAGEN = LOW (Full Function)

FAULT BUS STATUS	FAULT TYPE	DETECTION MECHANISM	CURRENT OUTPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
$\overline{FAULT}$ = H	Open circuit or short-to-supply	Ignored					
	Short-to-ground	$V_{(OUT)} < V_{(SG\_th\_falling)}$ OR $V_{(RES)} < V_{(SG\_th\_falling)}$	EN = H and PWM = H	$t_{(SG\_deg)}$	Constant-current pulldown	Device turns output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
	Overtemperature	$T_J > T_{(TSD)}$	EN = H	$t_{(TSD\_deg)}$	Constant-current pulldown	Device turns output channel off.	Auto recovery
$\overline{FAULT}$ = L	Fault is detected	Device turns channel off and keeps retry. After the $\overline{Fault}$ pin is released, output channel is turned on after $t_{(FAULT\_recovery)}$ time.					
	No fault is detected	Device turns output channel off.					

7.3.10 LED Fault Summary

表 7-3. LED Connection Fault Summary

Case 1	Case 2	Case 3	Case 4
			
LED Short-to-GND Fault	LED Short-to-GND Fault	LED Short-to-GND Fault	LED Short-to-GND Fault
Case 5	**Case 6**	**Case 7**	**Case 8**
			
LED Open Fault	No Fault	LED Open Fault	LED Open Fault
Case 9	**Case 10**	**Case 11**	**Case 12**
			
No Fault	No Fault	LED Open Fault	No Fault

7.3.11 IO Pins Inner Connection

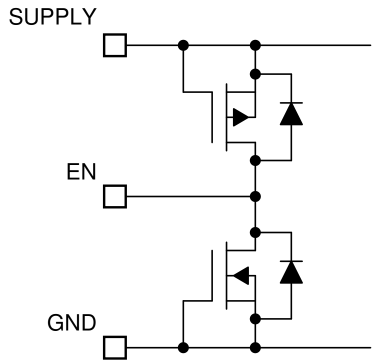


图 7-8. EN Pin

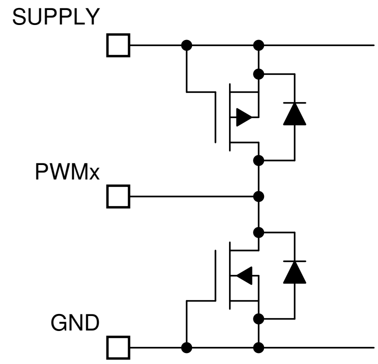


图 7-9. PWM Pin

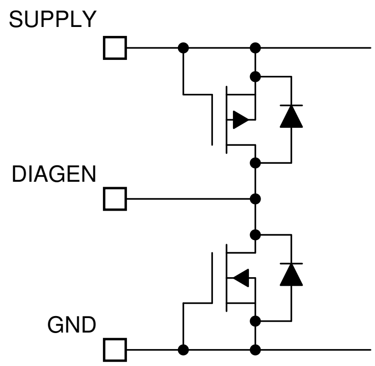


图 7-10. DIAGEN Pin

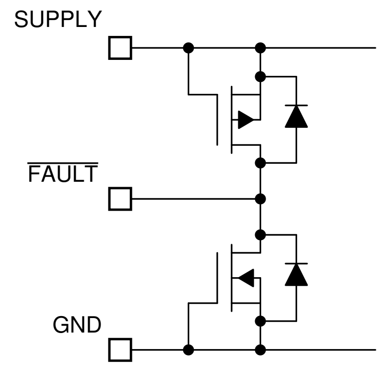


图 7-11. $\overline{\text{FAULT}}$ Pin

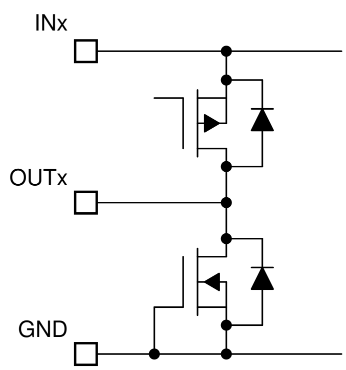


图 7-12. OUT Pin

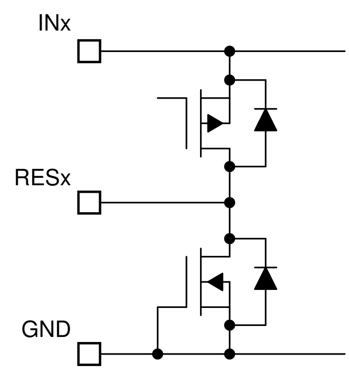


图 7-13. RES Pin

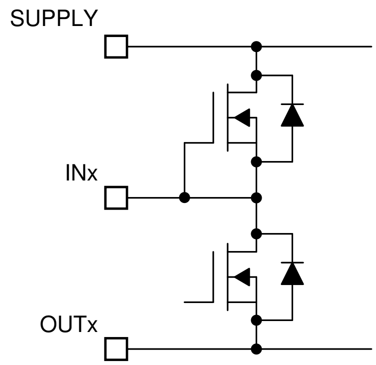


图 7-14. IN Pin

7.4 Device Functional Modes

7.4.1 Undervoltage Lockout, $V_{(SUPPLY)} < V_{(POR\_rising)}$

When the device is in undervoltage lockout status, the TPS92621-Q1 device disables all functions until the supply rises above the $V_{(POR\_rising)}$ threshold.

7.4.2 Normal Operation $V_{(SUPPLY)} \geqslant 4.5$ V

The device drives an LED string in normal operation. With enough voltage drop across SUPPLY and OUT, the device can drive the output in constant-current mode.

7.4.3 Low-Voltage Dropout Operation

When the device drives an LED string in low-dropout operation, if the $V_{(DROPOUT)}$ is less than the open-circuit detection threshold, the device can report a false open-circuit fault. TI recommends only enabling the open-circuit detection when the voltage across the IN and OUT is higher than the maximum voltage of LED open rising threshold to avoid a false open-circuit detection.

7.4.4 Fault Mode

When the TPS92621-Q1 detects a fault, the device tries to pull down the $\overline{\text{FAULT}}$ pin with a constant current. If the FAULT bus is pulled down, the device switches to fault mode and consumes a fault current of $I_{(FAULT)}$.

8 Application and Implementation

备注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI' s customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

In automotive lighting applications, thermal performance and LED diagnostics are always design challenges for linear LED drivers.

The TPS92621-Q1 device is capable of detecting LED open-circuit and LED short-circuits. To increase current driving capability, the TPS92621-Q1 device supports using an external shunt resistor to help dissipate heat as the following section, Thermal Sharing Resistor (OUTx and RESx) describes. This method provides a low-cost solution of using external resistors to minimize thermal accumulation on the device itself due to large voltage difference between input voltage and LED string forward voltage, while still keeping high accuracy of the total current output.

8.2 Typical Applications

8.2.1 BCM Controlled Rear Lamp With One-Fails-All-Fail Setup

The multiple TPS92621-Q1 devices are capable of driving different functions for automotive rear lamp including stop, turn indicator, tail, fog, reverse and center-high-mounted-stop-lamp. The one-fails-all-fail single lamp mode can be easily achieved by FAULT bus by shorting the $\overline{\text{FAULT}}$ pins.

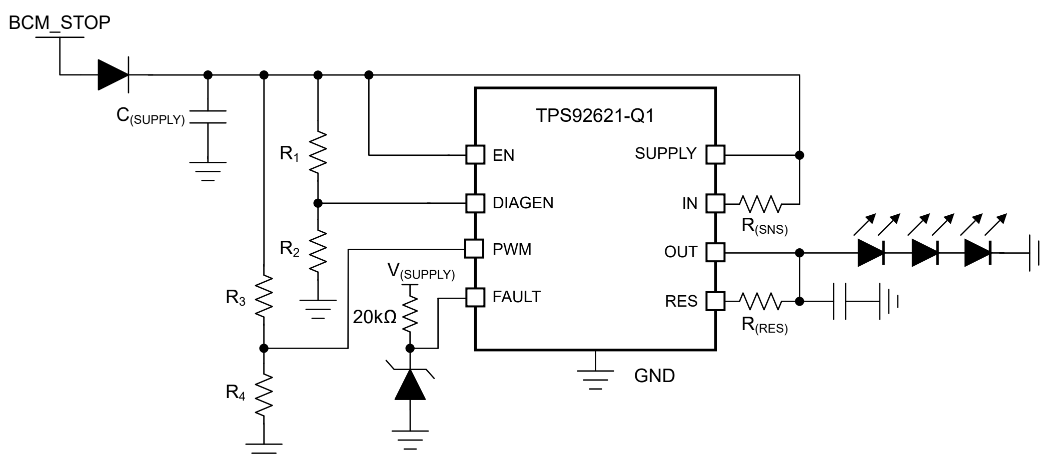


图 8-1. Typical Application Schematic

8.2.1.1 Design Requirements

Input voltage range is from 9 V to 16 V, and 3 LEDs in one string are required to achieve stop function. The LED maximum forward voltage, V_{F_MAX} is 2.5 V for each LED, while the minimum forward voltage, V_{F_MIN} is 1.9 V. The current requirement for each LED, $I_{(LED)}$ is 130 mA. The LED brightness and ON/OFF control is manipulated by body control module (BCM) directly by connecting and disconnecting the power supply to the LED load.

8.2.1.2 Detailed Design Procedure

Step 1: Use Equation 4 to determine the current sensing resistor, $R_{(SNS)}$.

$$R_{(SNSx)} = \frac{V_{(CS\_REG)}}{I_{(OUTx\_Tot)}} \quad (4)$$

where

- $V_{(CS\_REG)}$ = 150 mV (typical)
- $I_{(OUT\_Tot)}$ = 130 mA

According to design requirements, the $R_{(SNS)}$ = 1.15 Ω. Two resistors in parallel can be used to achieve equivalent resistance when sense resistor is not a standard decade resistance value.

Step 2: Design the current distribution between $I_{(OUT)}$ and $I_{(RES)}$, and use Equation 5 to calculate the current sharing resistor, $R_{(RES)}$. The $R_{(RES)}$ value actually decides the current distribution for $I_{(OUT)}$ path and $I_{(RES)}$ path. TI recommends the current sharing resistor $R_{(RES)}$ to consume 50% of the total current at typical supply operating voltage.

$$R_{(RESx)} = \frac{V_{(SUPPLY)} - V_{(OUTx)}}{I_{(OUTx\_Tot)} \times 0.5} \quad (5)$$

where

- $V_{(SUPPLY)}$ = 12 V (typical)
- $I_{(OUT\_Tot)}$ = 130 mA

The calculated result for $R_{(RES)}$ resistor value including $R_{(RES)}$ is 85.4 Ω when $V_{(OUT)}$ is typical 3 × 2.15 V = 6.45 V.

Step 3: Design the threshold voltage of SUPPLY to enable the LED open-circuit diagnostics, and calculate voltage divider resistor value for R_1 and R_2 on DIAGEN pin.

The maximum forward voltage of LED-string is 3 × 2.5 V = 7.5 V. To avoid the open-circuit fault reported in low-dropout operation conditions, additional headroom between SUPPLY and OUT must be considered. The TPS92621-Q1 device must disable open-circuit detection when the supply voltage is below LED-string maximum forward voltage plus $V_{(OPEN\_th\_rising)}$ and $V_{(CS\_REG)}$. Use Equation 6 to calculate the voltage divider resistor, R_1 and R_2 value.

$$R_1 = \left(\frac{V_{(OPEN\_th\_rising)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IL(DIAGEN)}} - 1 \right) \times R_2 \quad (6)$$

where

- $V_{(OPEN\_th\_rising)}$ = 420 mV (maximum)
- $V_{(CS\_REG)}$ = 156 mV (maximum)
- $V_{IL(DIAGEN)}$ = 1.045 V (minimum)
- R_2 = 10 kΩ (recommended)

The calculated result for R_1 is 67.3 kΩ when $V_{(OUT)}$ maximum voltage is 7.5 V and $V_{(CS\_REG)}$ is 156 mV.

Step 4: Design the threshold voltage of SUPPLY to turn on and off each channel of LED, and calculate voltage divider resistor value for R_3 and R_4 on PWM input pin.

The minimum forward voltage of LED string is 3 × 1.9 V = 5.7 V. To make sure the current output on each of LED-string is normal, the LED-string must be turned off until SUPPLY voltage is higher than LED minimum required forward voltage plus dropout voltage between IN to OUT and $V_{(CS\_REG)}$. Use Equation 7 to calculate the voltage divider resistor, R_3 and R_4 value.

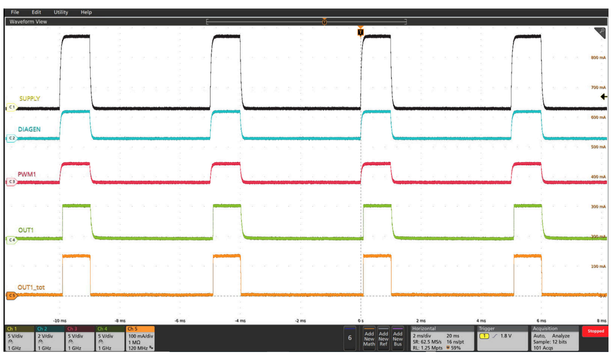
$$R_3 = \left(\frac{V_{(DROPOUT)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IH(PWM)}} - 1 \right) \times R_4 \quad (7)$$

where

- $V_{(DROPOUT)}$ = 300 mV (typical)
- $V_{(CS\_REG)}$ = 156 mV (maximum)
- $V_{IH(PWM)}$ = 1.26 V (maximum)
- R_4 = 10 kΩ (recommended)

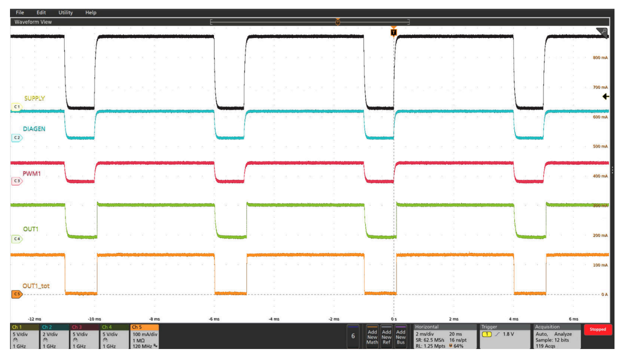
The calculated result for R_3 is 38.9 kΩ when $V_{(OUT)}$ minimum voltage is 5.7 V and $V_{(CS\_REG)}$ is 156 mV.

8.2.1.3 Application Curves



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(DIAGEN)}$ Ch3 = $V_{(PWM1)}$
Ch4 = $V_{(OUT1)}$ Ch5 = $I_{(OUT\_Tot)}$

图 8-2. 200-Hz Supply Dimming 20% Brightness



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(DIAGEN)}$ Ch3 = $V_{(PWM1)}$
Ch4 = $V_{(OUT1)}$ Ch5 = $I_{(OUT\_Tot)}$

图 8-3. 200-Hz Supply Dimming 80% Brightness

8.2.2 Independent PWM Controlled Rear Lamp By MCU

The TPS92621-Q1 device can drive the output channel by PWM input pin. The PWM input signals comes from MCU to achieve sequential turn indicator feature.

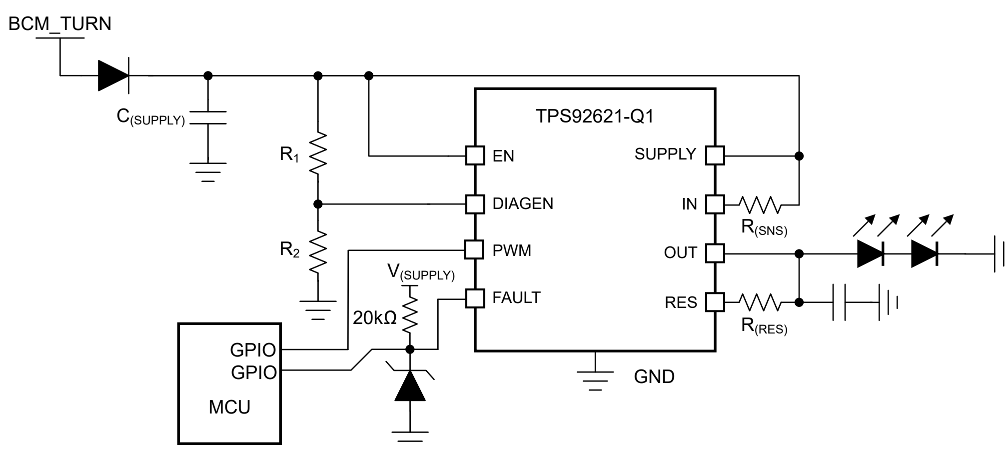


图 8-4. Typical Application Schematic

8.2.2.1 Design Requirements

Input voltage range is from 9 V to 16 V, and 2 LEDs in one string are required to achieve turn indicator function. The LED maximum forward voltage, V_{F_MAX} is 2.5 V for each LED, however the minimum forward voltage,

V_{F_MIN} is 1.9 V. Each LED current is 130 mA and each output channel is independent controlled by MCU through individual GPIO.

8.2.2.2 Detailed Design Procedure

Step 1: Use Equation 8 to determine the current sensing resistor, $R_{(SNS\ )}$.

$$R_{(SNSx)} = \frac{V_{(CS\_REG)}}{I_{(OUTx\_Tot)}} \quad (8)$$

where

- $V_{(CS\_REG)}$ = 150 mV (typical)
- $I_{(OUT\_Tot)}$ = 130 mA

According to design requirements, the calculated $R_{(SNS)}$ = 1.15 Ω.

Step 2: Design the current distribution between $I_{(OUT)}$ and $I_{(RES)}$, and use Equation 9 to calculate the current sharing resistor, $R_{(RES)}$. The $R_{(RES)}$ value actually decides the current distribution for $I_{(OUT\ )}$ path and $I_{(RES)}$ path, basic principle is to design the $R_{(RES)}$ to consume appropriate 50% total power dissipation at typical supply operating voltage.

$$R_{(RESx)} = \frac{V_{(SUPPLY)} - V_{(OUTx)}}{I_{(OUTx\_Tot)} \times 0.5} \quad (9)$$

where

- $V_{(SUPPLY)}$ = 12 V (typical)
- $I_{(OUTx\_Tot)}$ = 130 mA

The calculated result for $R_{(RES)}$ resistor value is 117 Ω when $V_{(OUT)}$ is typical 2 × 2.2 V = 4.4 V.

Step 3: Design the threshold voltage of SUPPLY to enable the LED open circuit, and calculate voltage divider resistor value for R_1 and R_2 on the DIAGEN pin.

The maximum forward voltage of LED-string is 2 × 2.5 V = 5 V. To avoid the open-circuit fault reported in low-dropout operation conditions, additional headroom between SUPPLY and OUTx must be considered. The TPS92621-Q1 device must disable open-circuit detection when the supply voltage is below LED-string maximum forward voltage plus $V_{(OPEN\_th\_rising)}$ and $V_{(CS\_REG)}$. Use Equation 10 to calculate the voltage divider resistor, R_1 and R_2 value.

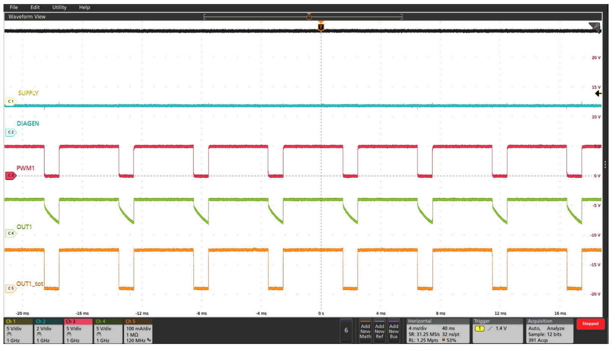
$$R_1 = \left(\frac{V_{(OPEN\_th\_rising)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IL(DIAGEN)}} - 1 \right) \times R_2 \quad (10)$$

where

- $V_{(OPEN\_th\_rising)}$ = 420 mV (maximum)
- $V_{(CS\_REG)}$ = 156 mV (maximum)
- $V_{IL(DIAGEN)}$ = 1.045 V (minimum)
- R_2 = 10 kΩ (recommended)

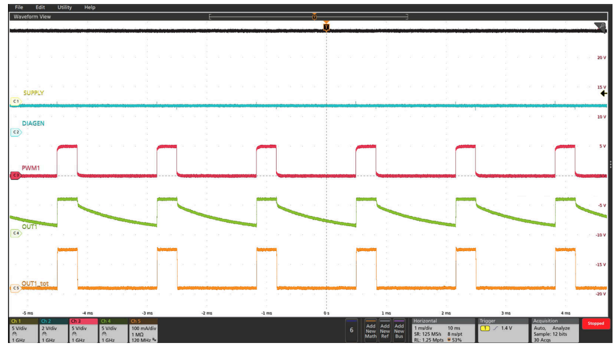
The calculated result for R_1 is 43.4 kΩ when $V_{(OUT)}$ maximum voltage is 5 V and $V_{(CS\_REG)}$ is 156 mV.

8.2.2.3 Application Curves



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(DIAGEN)}$ Ch3 = $V_{(PWM1)}$
Ch4 = $V_{(OUT1)}$ Ch5 = $I_{(OUT\_Tot)}$

图 8-5. 200-Hz PWM Dimming at 80% Duty Cycle



Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(DIAGEN)}$ Ch3 = $V_{(PWM1)}$
Ch4 = $V_{(OUT1)}$ Ch5 = $I_{(OUT\_Tot)}$

图 8-6. 600-Hz PWM Dimming at 20% Duty Cycle

8.3 Power Supply Recommendations

The TPS92621-Q1 is designed to operate from an automobile electrical power system within the range specified in Power Supply. The $V_{(SUPPLY)}$ input must be protected from reverse voltage and voltage dump condition over 40 V. The impedance of the input supply rail must be low enough that the input current transient does not cause drop below LED string required forward voltage. If the input supply is connected with long wires, additional bulk capacitance can be required in addition to normal input capacitor.

8.4 Layout

8.4.1 Layout Guidelines

Thermal dissipation is the primary consideration for TPS92621-Q1 layout.

- TI recommends large thermal dissipation area in both top and bottom layers of PCB. The copper pouring area in same layer with TPS92621-Q1-Q1 footprint must directly cover the thermal pad land of the device with wide connection as much as possible. The copper pouring in opposite PCB layer or inner layers must be connected to thermal pad directly through multiple thermal vias.
- TI recommends to place $R_{(RES)}$ resistors away from the TPS92621-Q1 device with more than 20-mm distance, because $R_{(RES)}$ resistors are dissipating some amount of the power as well as the TPS92621-Q1. The large copper pouring area is also required surrounding the $R_{(RES)}$ resistors for helping thermal dissipating.

The noise immunity is the secondary consideration for TPS92621-Q1 layout.

- TI recommends to place the noise decoupling capacitors for SUPPLY pin as close as possible to the pins.
- TI recommends to place the $R_{(SNS)}$ resistor as close as possible to the IN pins with the shortest PCB track to SUPPLY pin.

8.4.2 Layout Example

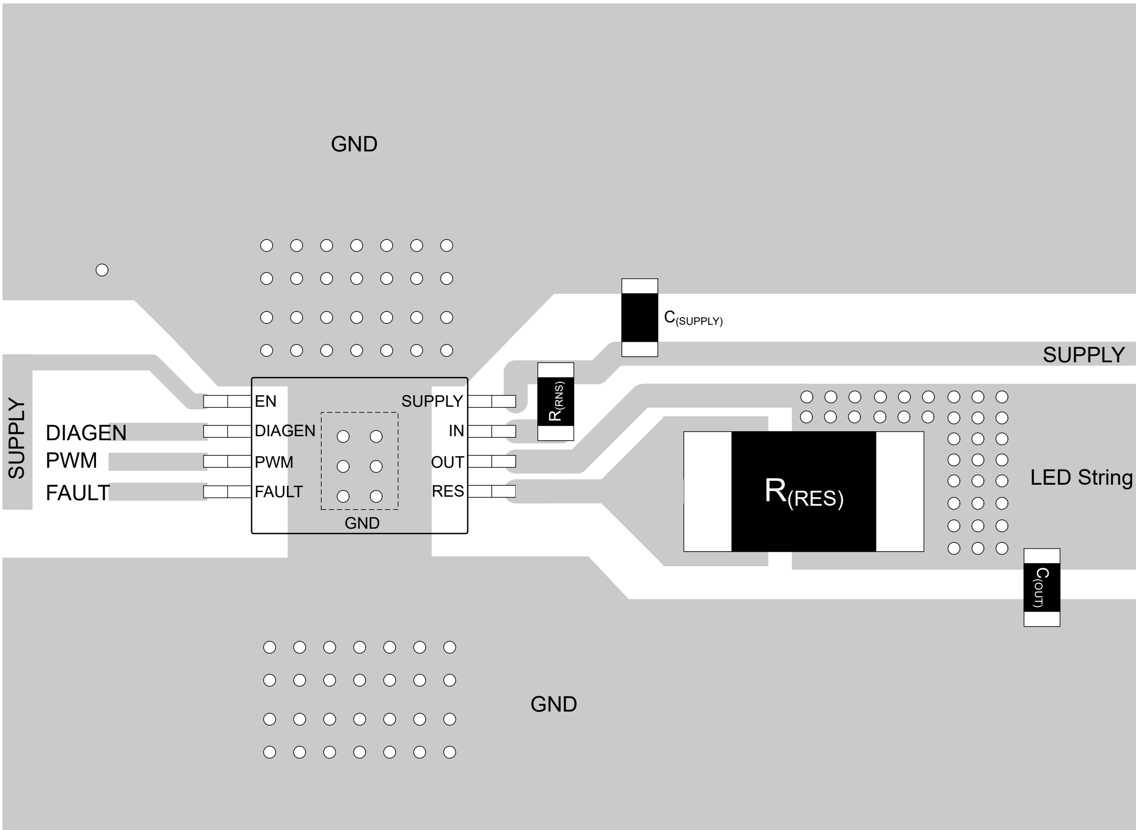


图 8-7. TPS92621-Q1 Example Layout Diagram

9 Device and Documentation Support

9.1 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

9.2 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

9.5 术语表

TI 术语表　　本术语表列出并解释了术语、首字母缩略词和定义。

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS92621QDGNRQ1	Active	Production	HVSSOP (DGN) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	26291
TPS92621QDGNRQ1.A	Active	Production	HVSSOP (DGN) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	26291

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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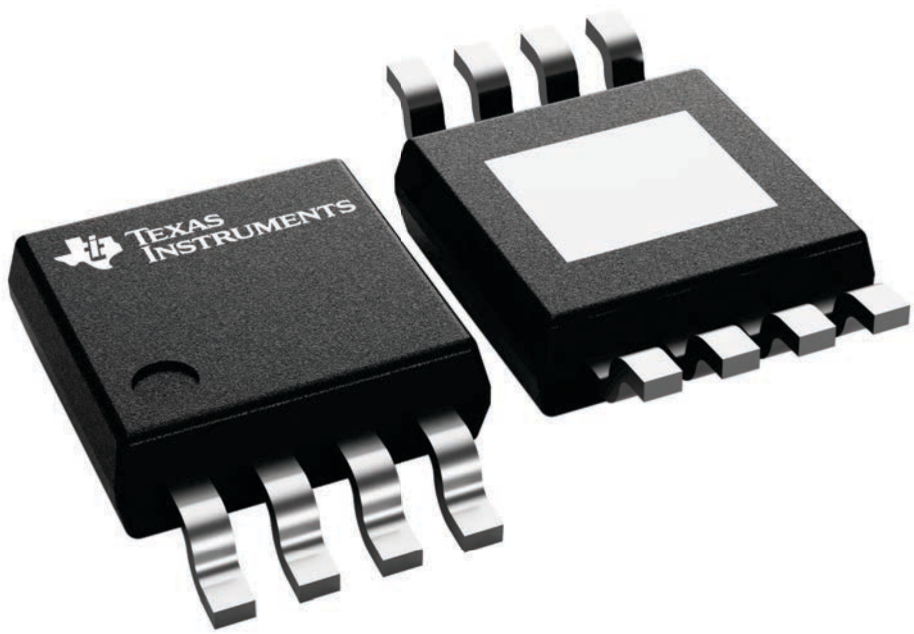
DGN 8

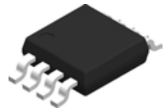
PowerPAD™ HVSSOP - 1.1 mm max height

3 x 3, 0.65 mm pitch

SMALL OUTLINE PACKAGE

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



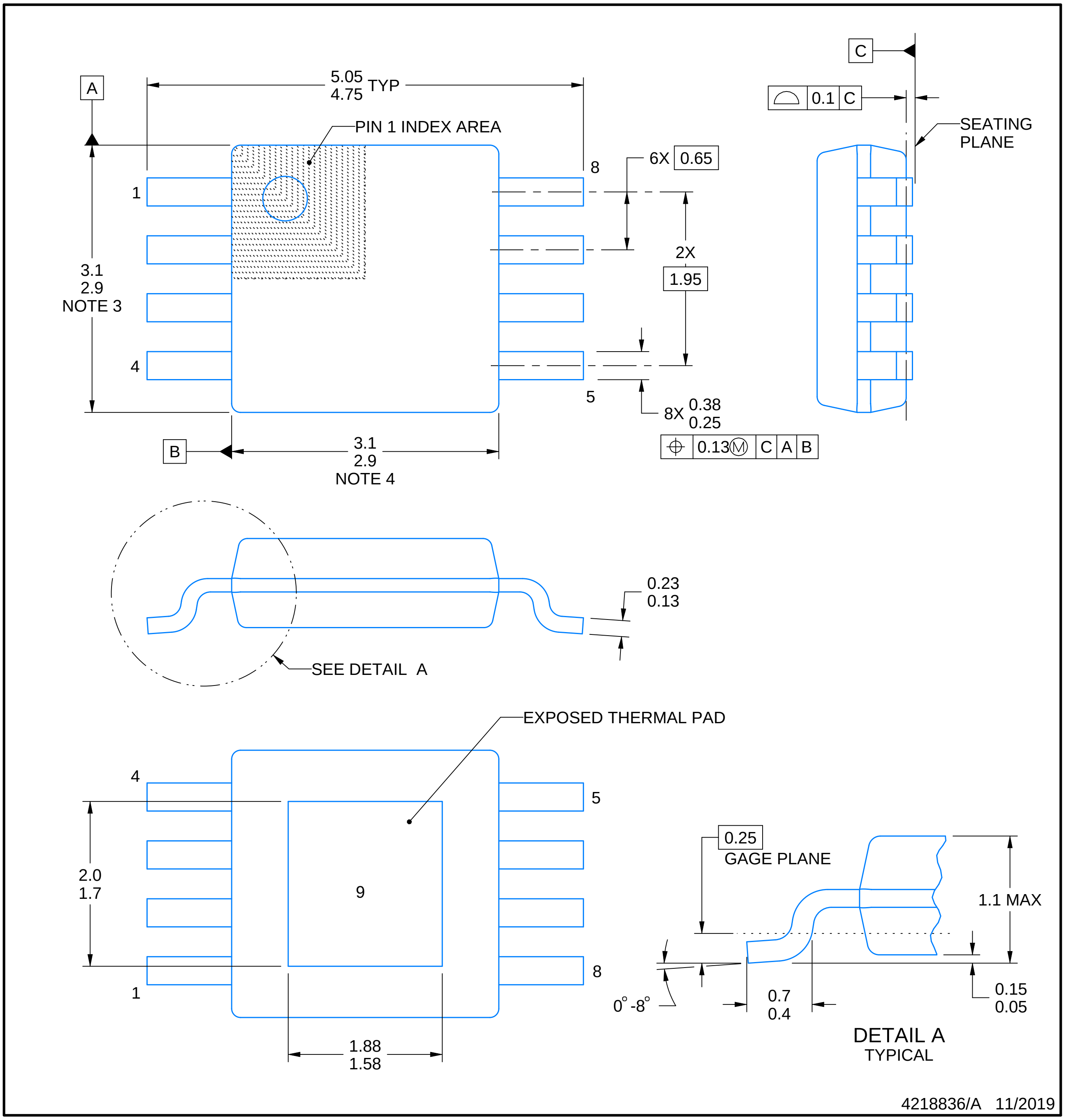


PACKAGE OUTLINE

DGN0008A

PowerPAD™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



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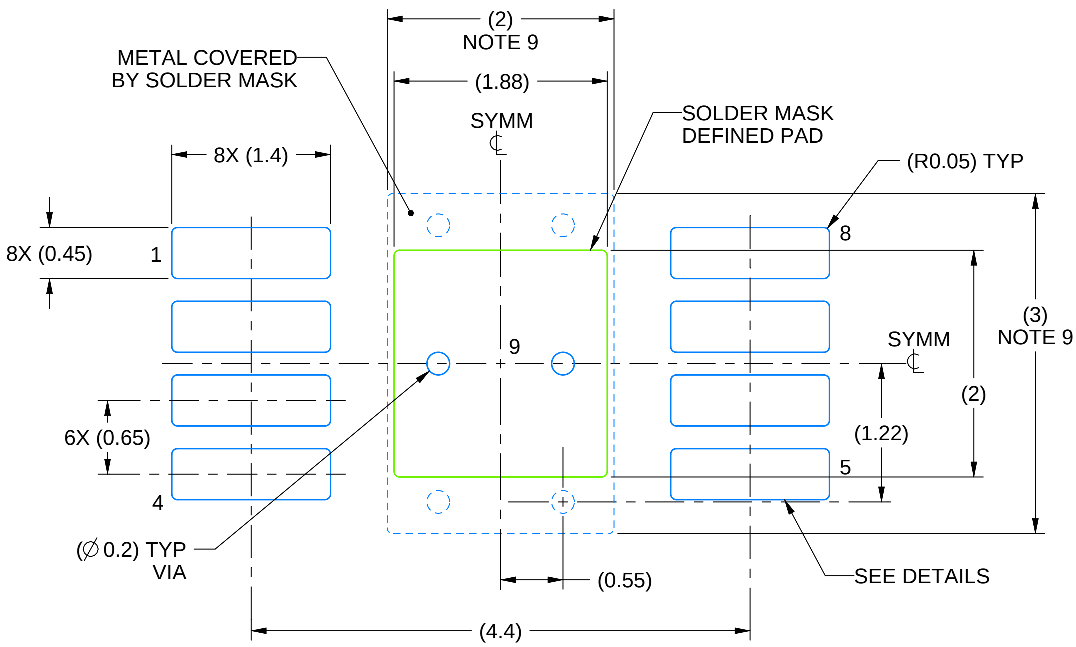
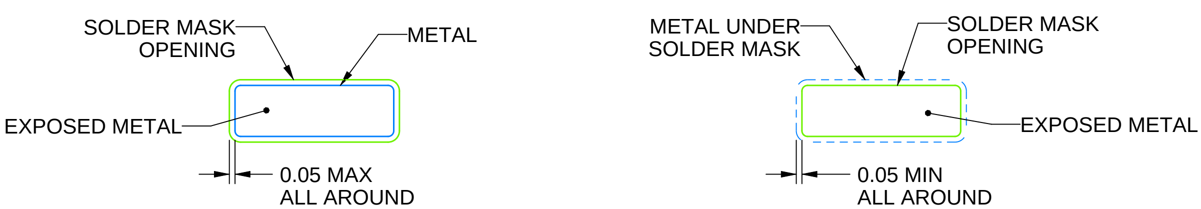
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



NON-SOLDER MASK
DEFINED
(PREFERRED)

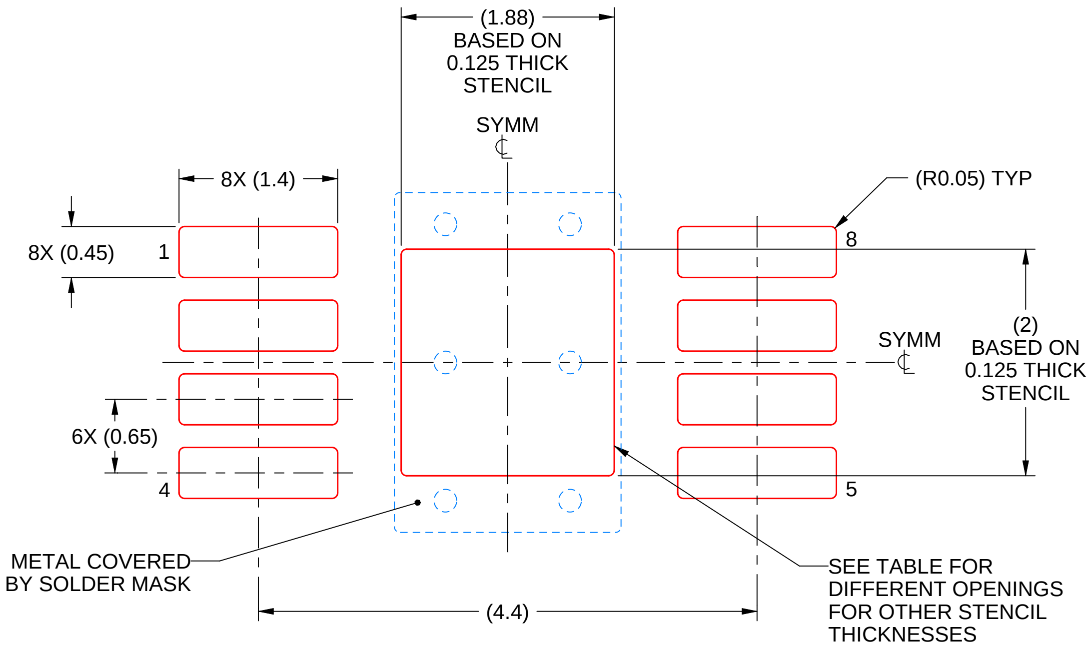
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4218836/A 11/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
EXPOSED PAD 9:
100% PRINTED SOLDER COVERAGE BY AREA
SCALE: 15X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	2.10 X 2.24
0.125	1.88 X 2.00 (SHOWN)
0.15	1.72 X 1.83
0.175	1.59 X 1.69

4218836/A 11/2019

NOTES: (continued)

10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
11. Board assembly site may have different recommendations for stencil design.

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