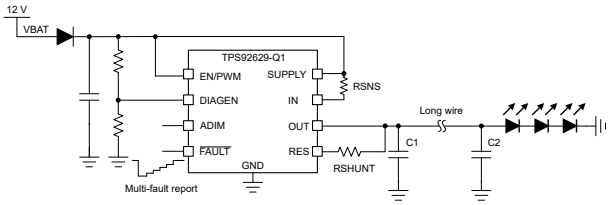
TEXAS INSTRUMENTS
TPS92629-Q1
JAJSNQ5 – MAY 2023

TPS92629-Q1 熱均衡制御機能を備えたシングル・チャネル、車載ハイ・サイド LED ドライバ

1 特長

- 車載アプリケーション用に AEC-Q100 認定済み:
  - 温度グレード 1:-40℃～125℃、T_A
- 広い入力電圧範囲:4.5V～40V
- 外部シャント抵抗による熱均衡
- 低静止電流
  - シャットダウン・モードで EN が Low のとき 10uA
  - フォルト・モード時の Low 電源電流
- シングル・チャネルの高精度電流レギュレーション:
  - 最大 250mA の出力チャネル電流
  - アナログ調光および PWM 調光制御を内蔵
  - 全温度範囲にわたって PWM 調光モードで ±5% の精度
  - アナログ調光モードで ±5% の精度を実現し、全温度範囲で最大電流を 20%～100% に抑えます
  - アナログ調光モードで ±10% の精度を実現し、全温度範囲で最大電流を 10%～20% に抑えます
- Low ドロップアウト電圧:
  - 最大ドロップアウト:350mV (150mA の場合)
  - 最大ドロップアウト:500mV (250mA の場合)
- 診断および保護機能
  - LED の開路検出と自動回復
  - LED のグランドへの短絡検出と自動回復
  - LED のバッテリへの短絡検出と自動回復
  - 可変スレッショルド付き診断イネーブルにより Low ドロップアウト動作に対応
  - 複数の異常検出出力機能を備えたより安全なシステム
  - サーマル・シャットダウン
- 動作時の接合部温度範囲:-40℃～150℃



代表的なアプリケーションの図

2 アプリケーション

- 車載用外部小型ライト:ブラインド・スポット検出インジケータ、ドア・ハンドル、充電口
- 車内照明:オーバーヘッド・コンソール、マップ・ランプ
- 車載用外部テール・ライト:リア・ランプ、センター・ハイマウント・ストップ・ランプ、サイド・マーカー
- 汎用 LED ドライバ・アプリケーション

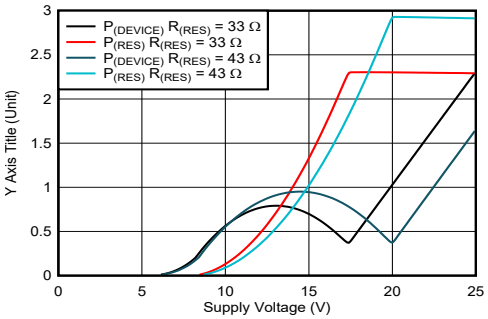
3 説明

TPS92629-Q1 シングル・チャネル LED ドライバは、デバイスの温度上昇を抑えるための独自の熱管理設計を採用しています。TPS92629-Q1 は、最大 250mA の全負荷電流を出力するために、電圧変動が大きい車載対応バッテリから直接給電するリニア・ドライバです。外付けシャント抵抗を利用して出力電流を分配し、ドライバの外で電力を消費します。本デバイスの豊富な診断機能には、LED 開路検出、LED グランドへの短絡検出、LED のバッテリへの短絡検出、デバイス過熱保護が含まれます。アナログ調光制御の高精度かつ最適化されたスルーレートにより、オフボードの長いワイヤ駆動をサポートし、EMC 性能が向上しているため、フリックやアフターイメージの問題が解消されます。 安全重視のアプリケーション向けに、フォルト・ピンを使用して、複数のフォルトをさまざまな電圧レベルで報告できます。

表 3-1. 製品情報

部品番号	パッケージ (1)	本体サイズ (公称)
TPS92629-Q1	HVSSOP (8)	3mm × 3mm

(1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。



デバイスの消費電力

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4 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

DATE	REVISION	NOTES
May 2023	*	Initial release.

5 Pin Configuration and Functions

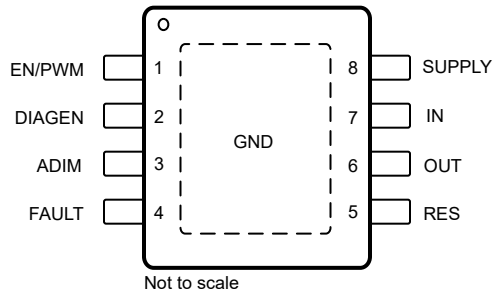


図 5-1. DGN Package 8-Pin HVSSOP With PowerPAD™ Top View

表 5-1. Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
EN/PWM	1	I	Device enable input and PWM input for OUT and RES current output ON and OFF control.
DIAGEN	2	I	Enable pin for LED open-circuit detection to avoid false open diagnostics during low-dropout operation.
ADIM	3	I	PWM input for analog dimming control.
$\overline{\text{FAULT}}$	4	O	Fault output.
RES	5	O	Channel current output with external thermal resistor.
OUT	6	O	Current output.
IN	7	I	Channel current input.
SUPPLY	8	I	Device power supply.

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, ADIM	–0.3	$V_{(SUPPLY)}$+0.3	V
High-voltage output	OUT, RES	–0.3	$V_{(SUPPLY)}$+0.3	V
Low-voltage output	$\overline{FAULT}$	-0.3	5.5	V
IN to OUT	V(IN) – V(OUT)	-0.3	45	V
SUPPLY to IN	V(SUPPLY) – V(IN)	-0.3	5	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 (SUPPLY, RES, $\overline{FAULT}$, EN/PWM)	±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
IN	Sense voltage	$V_{(SUPPLY)}$ - $V_{(CS\_REG)}$			V
EN/PWM, ADIM	PWM and ADIM inputs	0		$V_{(SUPPLY)}$	V
DIAGEN	Diagnostics enable pin	0		$V_{(SUPPLY)}$	V
OUT, RES	Driver output	0		$V_{(SUPPLY)}$	V
$\overline{FAULT}$	Multi-fault output	0		5	V
Operating ambient temperature, T_A		-40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TPS92629-Q1 DGN 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	50.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	70.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	23.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	2.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	23.8	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	7.2	°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

$V_{(SUPPLY)}$ = 4.5 V to 40 V, $V_{(EN)}$ = 3 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
$I_{(shutdown)}$	Device shutdown current, keep EN/PWM = 0 for more than 20 ms to shutdown the device	Vsupply = 12V		7	10	uA
$I_{(Quiescent)}$	Device standby ground current	PWM = HIGH	0.5	1.1	1.3	mA
$I_{(FAULT)}$	Device supply current in fault mode	PWM = HIGH, fault mode	600	720	850	uA
LOGIC INPUTS (EN/PWM, DIAGEN, ADIM)						
$V_{IL(EN)}$	Disable input logic-low voltage, EN/PWM				0.7	V
$V_{IH(EN)}$	Enable input logic-high voltage, EN/PWM		2.0			V
$V_{IL(PWM)}$	PWM input logic-low voltage, EN/PWM		2.037	2.1	2.183	V
$V_{IH(PWM)}$	PWM input logic-high voltage, EN/PWM		2.134	2.2	2.296	V
$I_{(EN/PWM)}$	Pull down current, EN/PWM		0.5	1.4	2.2	uA
$V_{IL(ADIM)}$	Input logic-low voltage, ADIM		1.065	1.12	1.17	V
$V_{IH(ADIM)}$	Input logic-high voltage, ADIM		1.20	1.26	1.32	V
$I_{(ADIM)}$	Pull down current, ADIM		1.6	2.2	2.9	uA
$V_{IL(DIAGEN)}$	Input logic-low voltage, DIAGEN		1.045	1.10	1.155	V
$V_{IH(DIAGEN)}$	Input logic-high voltage, DIAGEN		1.17	1.25	1.33	V
CONSTANT-CURRENT DRIVER						
$I_{(OUTx\_Tot)}$	Device output-current	100% duty cycle	5		250	mA
$V_{(CS\_REG)}$	Sense-resistor regulation voltage	T_A = –40°C to +125°C, 100% duty cycle, 20kHz frequency input for ADIM, $V_{(SUPPLY)}$ = 4.5 V	436	463.5	491	mV
$V_{(CS\_REG)}$	Sense-resistor regulation voltage	T_A = –40°C to +125°C, 100% duty cycle, 20kHz frequency input for ADIM, $V_{(SUPPLY)}$ = 5 V to 40 V	441.75	465.0	488.25	mV
$V_{(CS\_REG)}$	Sense-resistor regulation voltage	T_A = –40°C to +125°C, 20% duty cycle, 20kHz frequency input for ADIM	88.35	93.0	97.65	mV
$V_{(CS\_REG)}$	Sense-resistor regulation voltage	T_A = –40°C to +125°C, 10% duty cycle, 20kHz frequency input for ADIM	41.85	46.5	51.15	mV
$R_{(CS\_REG)}$	Sense-resistor range		1.74		98.2	Ω
$V_{(DROPOUT)}$	Voltage dropout from INx to OUTx, RESx open	current setting of 150 mA		200	350	mV
		current setting of 250 mA		300	500	
	Voltage dropout from INx to RESx, OUTx open	current setting of 150 mA		350	600	mV
		current setting of 250 mA		600	1000	
$I_{(RESx)}$	Ratio of RESx current to total current	$I_{(RESx)}/I_{(OUTx\_Tot)}$, $V_{(INx)} – V_{(RESx)}$ > 1 V, $I_{(total)}$ = 150 mA	95			%
$I_{(channel\_leakage)}$	Leakage current when channel is off	$V_{(SUPPLY)} – V_{(OUT)}$ = 40 V, PWM off			10	uA
DIAGNOSTICS						
$V_{(OPEN\_th\_rising)}$	LED open rising threshold, $V_{(IN)} – V_{(OUT)}$		180	300	420	mV
$V_{(OPEN\_th\_falling)}$	LED open falling threshold, $V_{(IN)} – V_{(OUT)}$			450		mV
$V_{(SG\_th\_rising)}$	Channel output short-to-ground rising threshold		1.425	1.5	1.575	V
$V_{(SG\_th\_falling)}$	Channel output short-to-ground falling threshold		1.20	1.24	1.32	V
$I_{(Retry\_OUT)}$	Channel output $V_{(OUT)}$ short-to-ground retry current		3.622	4.96	6.232	mA
$I_{(Retry\_RES)}$	Channel output $V_{(RES)}$ short-to-ground retry current		0.82	1.08	1.4	mA
$I_{(Discharge\_OUT)}$	Channel output $V_{(OUT)}$ short-to-battery discharge current	OUT short to SUPPLY	3.431	4.952	5.069	mA
FAULT						
$V_{(FAULT\_STG)}$	Output voltage level under STG fault		0.56	0.60	0.619	V
$V_{(FAULT\_STB)}$	Output voltage level under STB fault		1.072	1.105	1.134	V
$V_{(FAULT\_OPEN)}$	Output voltage level under OPEN fault		1.776	1.827	1.869	V

$V_{(SUPPLY)}$ = 4.5 V to 40 V, $V_{(EN)}$ = 3 V, T_J = –40°C to +150°C unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(FAULT\_TSD)}$	Output voltage level under TSD fault		2.725(1)	2.798(1)	2.862(1)	V
$V_{(Normal)}$	Output voltage level under normal mode	$V_{(SUPPLY)}$ = 4.5 V	3.8	4.2	4.6	V
$V_{(Normal)}$	Output voltage level under normal mode	$V_{(SUPPLY)}$ = 5 V to 40 V	4.55	4.8	5.1	V
$I_{(FAULT\_pull\_up)}$	$\overline{FAULT}$ ouput current capability	open, stb, stg or tsd fault			250	uA
$I_{(FAULT\_pull\_up\_limit)}$	$\overline{FAULT}$ ouput current limit	open, stb, stg or tsd fault	300			uA
$I_{(FAULT\_pulldown)}$	$\overline{FAULT}$ internal pull down current in stage 1, as shown in 図 7-5	open, stb, stg or tsd fault, $V_{(\overline{FAULT})}$ = 0.4 V	1	1.2	1.5	mA
$t_{(discharge)}$	Discharge time for open and short to battery detection, as shown in 図 7-5	open or stb fault	500	730	1000	us
TIMING						
$t_{(Device\_enable)}$	Device enable time, t_5 as shown in 図 7-1			86		µs
$t_{(Device\_disable)}$	Device disable time, t_8 as shown in 図 7-1			20		ms
$t_{(STARTUP)}$	SUPPLY rising edge to 10% output current, t_6 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		135		µs
$t_{(ADIM\_delay\_rising)}$	ADIM rising edge delay to 10% of output current, t_9 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		55		µs
$t_{(ADIM\_delay\_falling)}$	ADIM falling edge delay to 90% of output current, t_{10} as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		60		µs
$t_{(ADIM\_current\_rising)}$	output current rising time, t_7 as shown in 図 7-1	5% current to 98% target current under analog dimming mode		1		ms
$t_{(ADIM\_current\_falling)}$	output current rising time, t_{11} as shown in 図 7-1	98% current to 5% target current under analog dimming mode		1		ms
$t_{(PWM\_delay\_rising)}$	PWM rising edge delay to 10% of output current, t_1 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		3		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 82 Ω and $R_{(RESx)}$ = 91 Ω		2.4		µs
$t_{(PWM\_delay\_falling)}$	PWM falling edge delay to 90% of output current, t_3 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		2.8		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 82 Ω and $R_{(RESx)}$ = 91 Ω		2.8		µs
$t_{(Current\_rising)}$	Output current rising from 10% to 90%, t_2 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		1.7		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 82 Ω and $R_{(RESx)}$ = 91 Ω		1.3		µs
$t_{(Current\_falling)}$	Output current falling from 90% to 10%, t_4 as shown in 図 7-1	$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 3.0 Ω and $R_{(RESx)}$ = 91 Ω		5.7		µs
		$V_{(SUPPLY)}$ = 12 V, $V_{(OUT)}$ = 3 V, $V_{(CS\_REG)}$ = 450 mV, $R_{(SNSx)}$ = 82 Ω and $R_{(RESx)}$ = 91 Ω		0.27		µs
$t_{(OPEN\_deg)}$	LED-open fault detection deglitch time, t_6 as shown in 図 7-3			125		µs
$t_{(SG\_deg)}$	Output short-to-ground detection deglitch time, t_7 as shown in 図 7-2			125		µs
$t_{(Recover\_deg)}$	Open and Short fault recovery deglitch time, t_8 as shown in 図 7-2 and 図 7-3			125		µs
$t_{(FAULT\_recovery)}$	Fault recovery delay time, t_9 as shown in 図 7-2 and 図 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

(1) Ensured by design.

6.6 Typical Characteristics

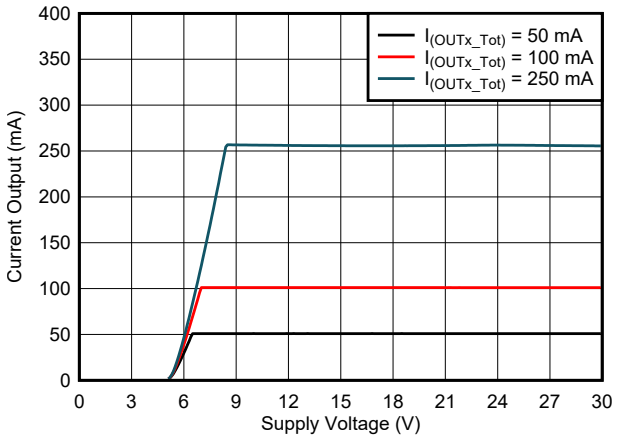


図 6-1. Output Current vs Supply Voltage

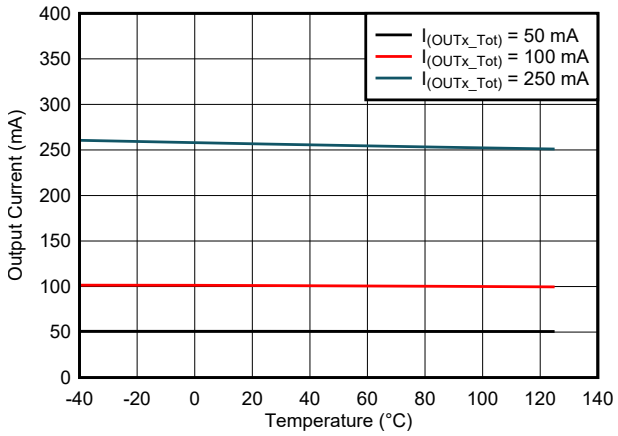


図 6-2. Output Current vs Temperature

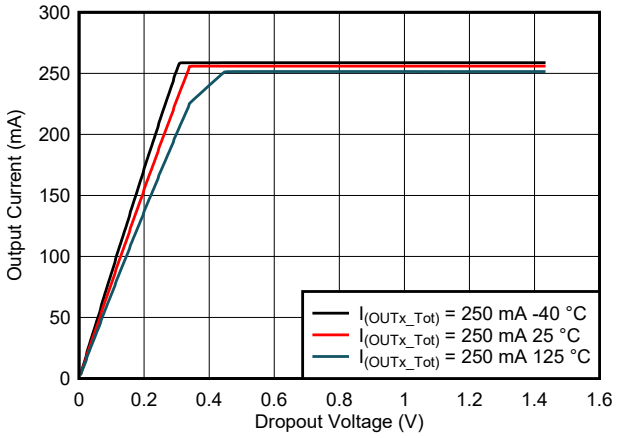


図 6-3. Output Current vs Dropout Voltage

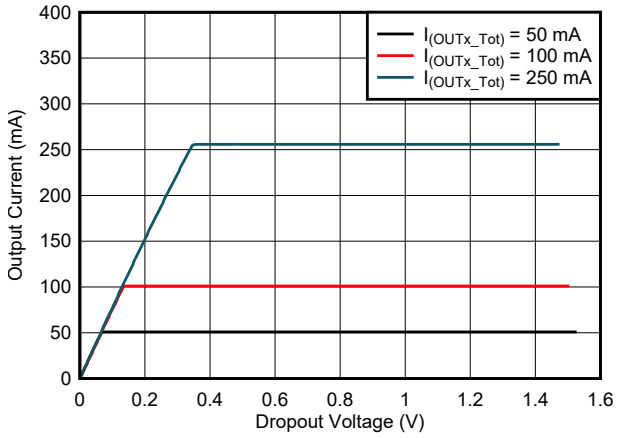


図 6-4. Output Current vs Dropout Voltage

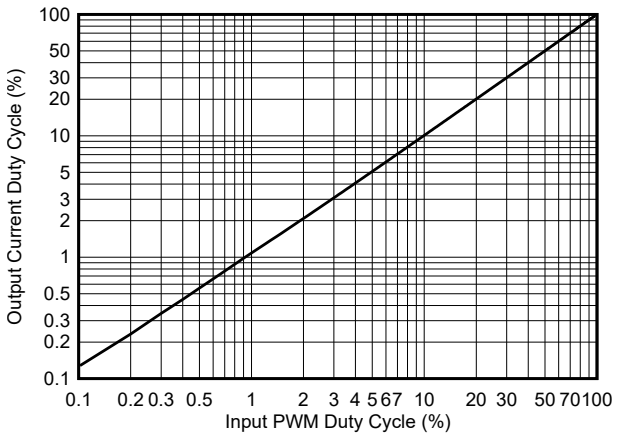


図 6-5. PWM Output Duty Cycle vs PWM Input Duty Cycle

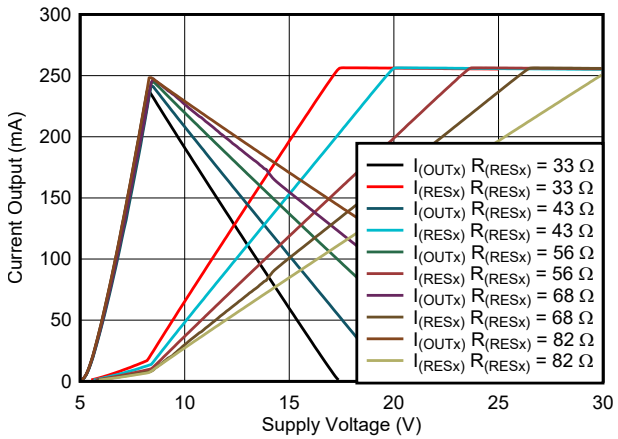


図 6-6. Output Current Distribution vs Supply Voltage

6.6 Typical Characteristics (continued)

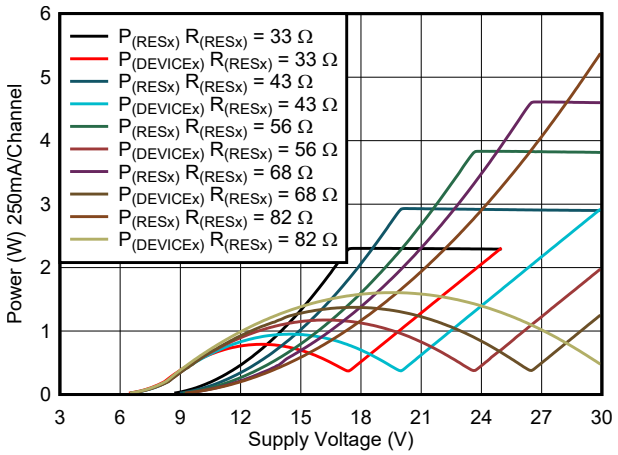


図 6-7. Power Dissipation vs Supply Voltage

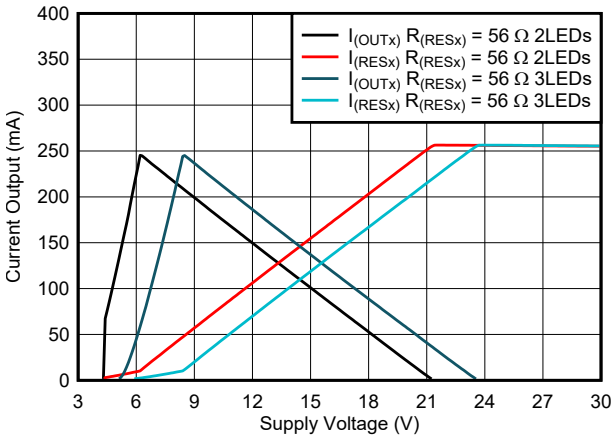


図 6-8. Output Current Distribution vs Supply Voltage

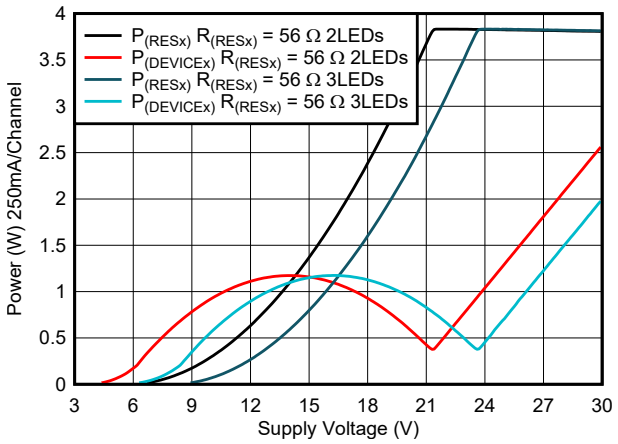
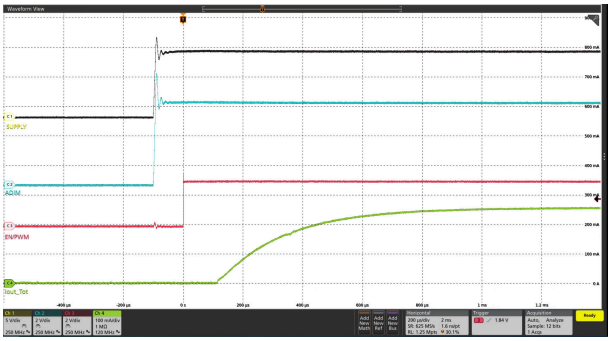
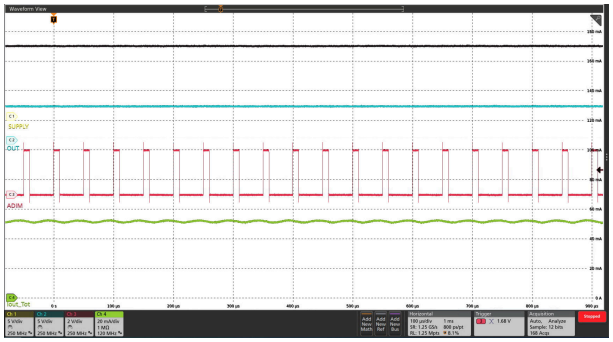


図 6-9. Power Dissipation vs Supply Voltage



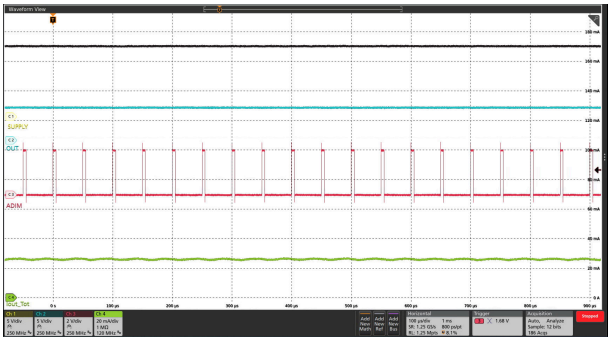
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(ADIM)}$ Ch3 = $V_{(EN/PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-10. Power Up Sequence



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

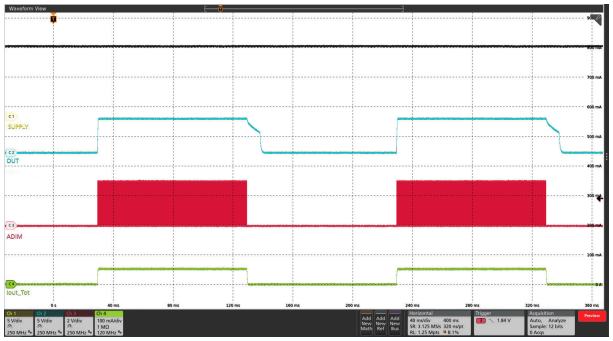
図 6-11. Analog Dimming at 20 kHz



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

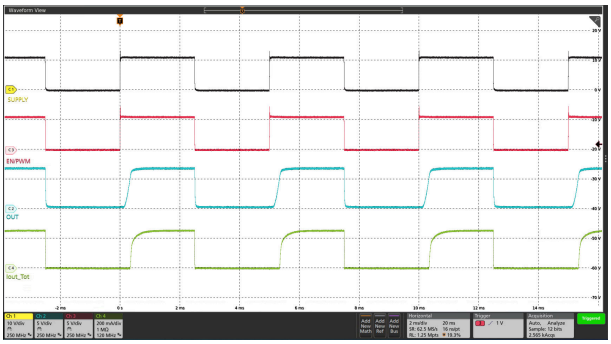
図 6-12. Analog Dimming at 20 kHz

6.6 Typical Characteristics (continued)



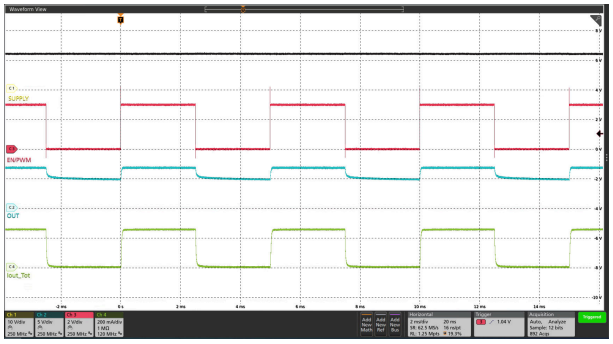
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(ADIM)}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-13. Flash Dimming



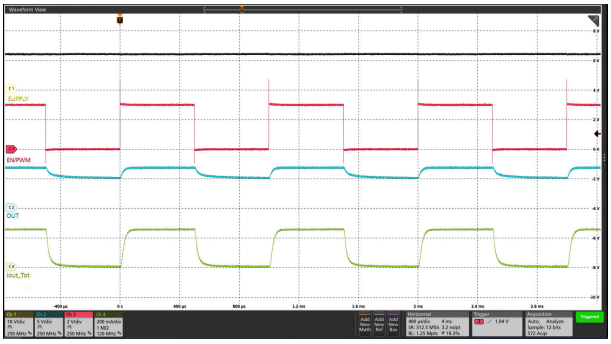
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(EN/PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-14. Supply Dimming at 200 Hz



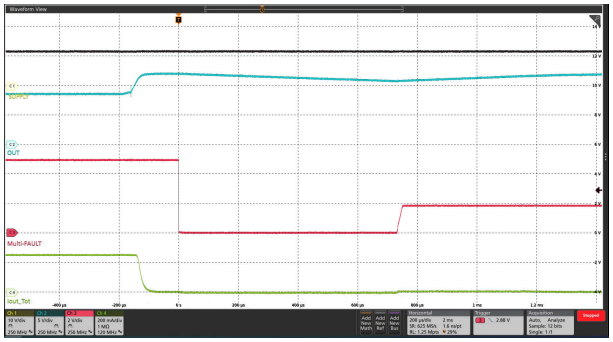
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(EN/PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-15. PWM Dimming at 200 Hz



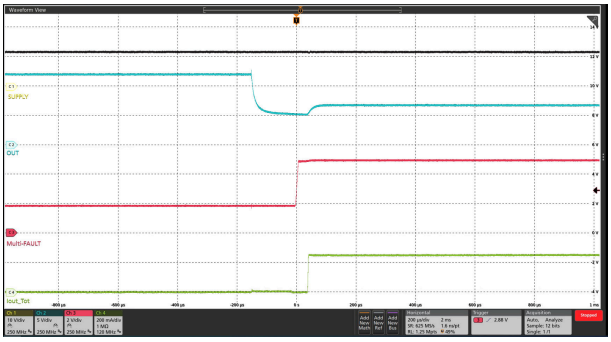
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(EN/PWM)}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-16. PWM Dimming at 1 kHz



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

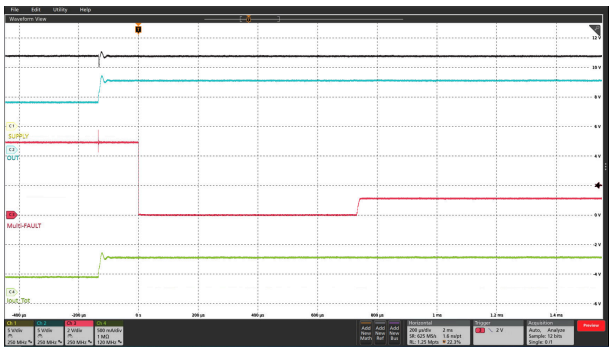
図 6-17. LED Open Protection



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

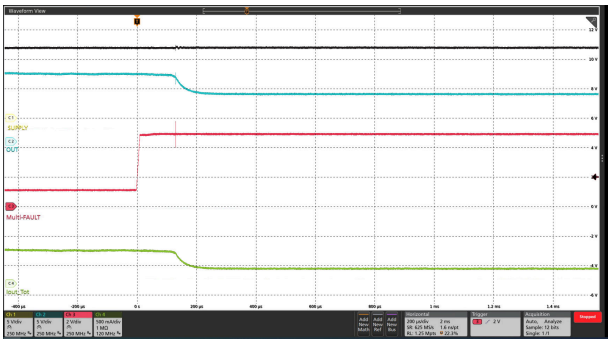
図 6-18. LED Open Protection Recovery

6.6 Typical Characteristics (continued)



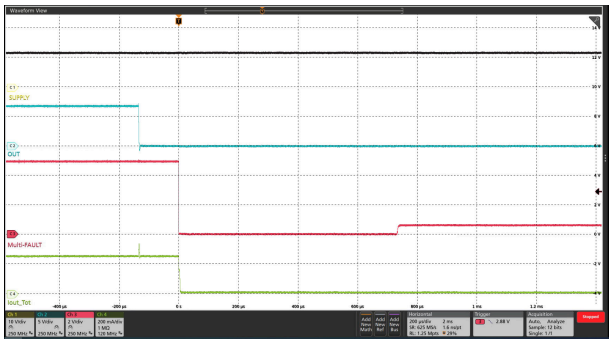
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-19. LED Short to Battery Protection



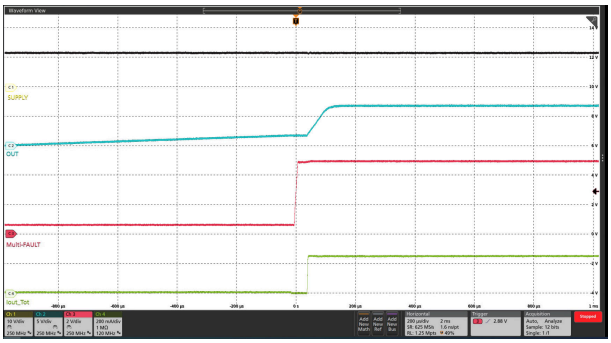
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-20. LED Short to Battery Protection Recovery



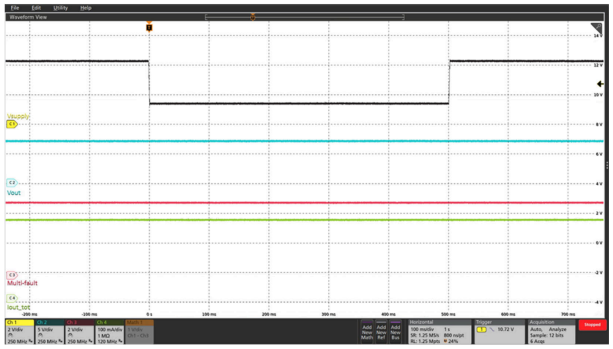
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-21. LED Short-Circuit Protection



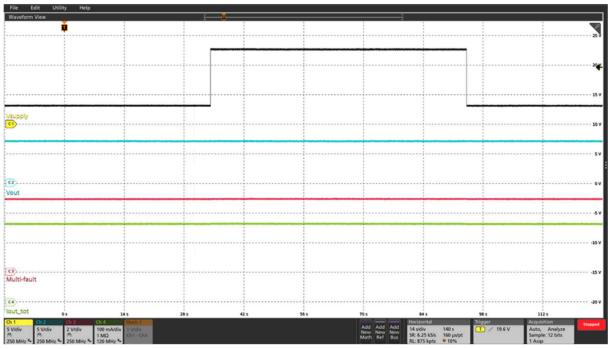
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-22. LED Short-Circuit Protection Recovery



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

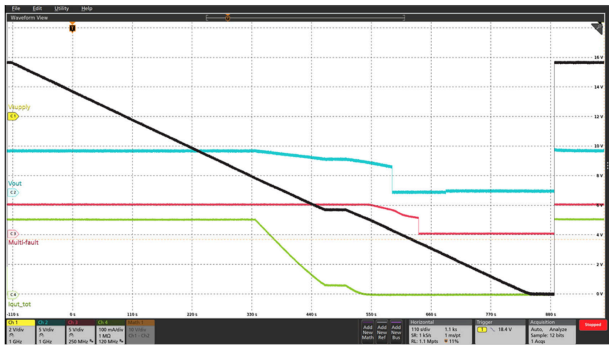
図 6-23. Transient Undervoltage



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

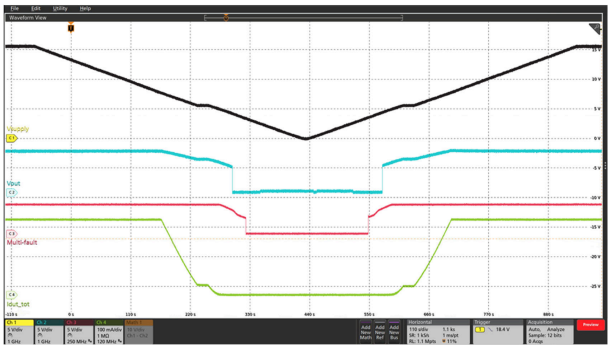
図 6-24. Transient Overvoltage

6.6 Typical Characteristics (continued)



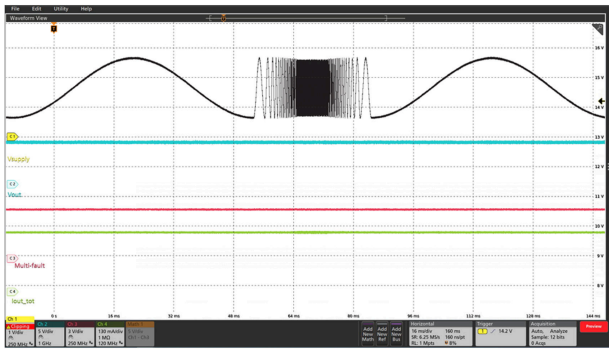
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-25. Slow Decrease and Quick Increase of Supply Voltage



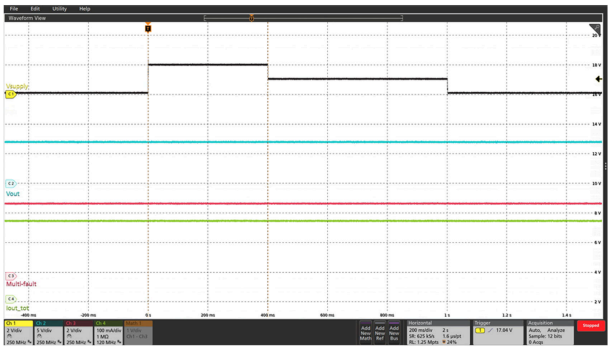
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$

図 6-26. Slow Decrease and Slow Increase of Supply Voltage



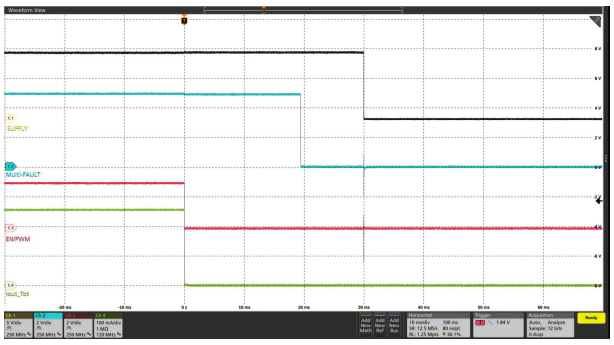
Ch1 = $V_{(SUPPLY)}$ Ch2 = $V_{(OUT)}$ Ch3 = $V_{(\overline{FAULT})}$
Ch4 = $I_{(OUT\_Tot)}$ DIAGEN = High when Supply > 8 V

図 6-27. Superimposed Alternating Voltage



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

図 6-28. Jump Start



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

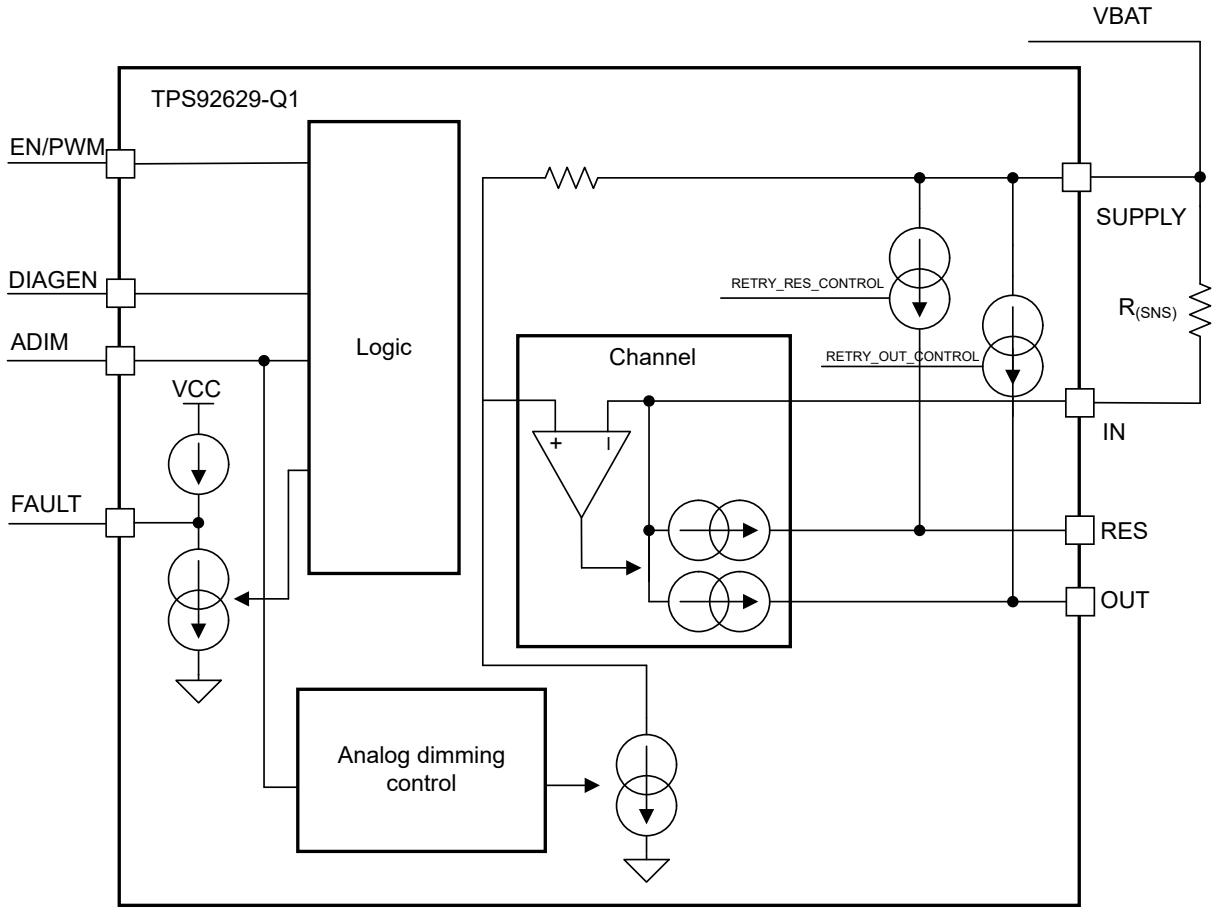
図 6-29. Power off Sequence

7 Detailed Description

7.1 Overview

The TPS92629-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 250 mA current to LED with limited power dissipation on the device. The channel current output can be set by external $R_{(SNSx)}$ resistors. Current flows from the supply through the $R_{(SNSx)}$ resistor into the integrated current regulation circuit and to the LEDs through OUTx pin and RESx pin. TPS92629-Q1 device supports both supply control and PWM control to turn LED ON and OFF. The LED brightness is also adjustable by input PWM duty cycle applied on ADIM pin to achieve analog dimming control. The output current slew rate is optimized for improved EMC performance in analog dimming mode. The TPS92629-Q1 provides full diagnostics to keep the system operating reliably including LED open/short-to-ground/short-to-battery circuit detection, supply POR and thermal shutdown protection. The LED fault detection is optimized to support big output capacitor in analog dimming mode within wide current range for better stability and noise immunity in the off board long wire driving applicaton. TPS92629-Q1 device is in a HVSSOP package with total 8 leads.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Power Supply (SUPPLY)

7.3.1.1 Power-On Reset (POR)

The TPS92629-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 Supply Current in Fault Mode

The TPS92629-Q1 device consumes minimal quiescent current, $I_{(FAULT)}$, into SUPPLY in fault mode.

If device detects an internal fault, it pulls down the $\overline{FAULT}$ pin firstly to generate a falling edge by an internal typical 1.2-mA constant current as a fault interrupt trigger signal.

7.3.2 Enable and Shutdown

The TPS92629-Q1 is enabled when the voltage applied on PWM/EN pin is higher than $V_{IH(EN)}$. Once the PWM/EN pin voltage is higher than $V_{IH(PWM)}$, the device can only be shutdown by keeping the EN/PWM voltage lower than $V_{IL(EN)}$ for more than $t_{(Device\_disable)}$. The typical value of $t_{(Device\_disable)}$ is 20 ms. The TPS92629-Q1 turns on channel current output when the voltage applied on PWM/EN pin is higher than $V_{IH(PWM)}$ and turns off current output when the voltage applied on PWM/EN pin is lower than $V_{IL(PWM)}$.

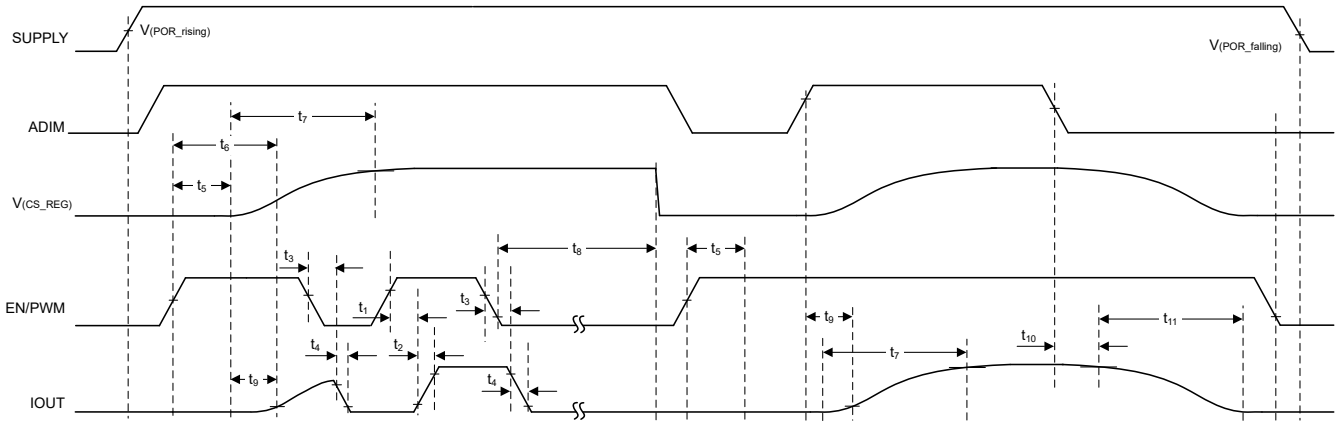


図 7-1. Power On Sequence and PWM Dimming Timing

7.3.3 Constant-Current Output and Setting (IN)

The TPS92629-Q1 device is a high-side current driver for driving LEDs. The device controls each 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, the current value for each channel can be calculated by using 式 1.

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

where

- The duty cycle on ADIM pin controls the $V_{(CS\_REG)}$ proportionally when the ADIM pin frequency is higher than 10kHz
- $V_{(CS\_REG)}$ = 463.5 mV for the typical value when the ADIM pin duty cycle is 100%

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 TPS92629-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 TPS92629-Q1 device provides two current output paths for each channel. 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 $R_{(SNSx)}$ 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 TPS92629-Q1.

The integrated independent current regulation in TPS92629-Q1 dynamically adjusts the output current on both OUT and RES output to maintain the stable summed current for LED. The TPS92629-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 Brightness Control (EN/PWM and ADIM)

The TPS92629-Q1 has integrated PWM and analog dimming control. The pulse width modulation (PWM) input of the TPS92629-Q1 functions as enable for the output current. When the voltage applied on the PWM pin is higher than $V_{IH(PWM)}$, the relevant 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 TPS92629-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 図 8-1 for typical PWM dimming application.

The PWM input of TPS92629-Q1 controls the output channel for both OUT and RES. Power On Sequence and PWM Dimming Timing illustrates the timing for PWM input and current output.

The TPS92629-Q1 achieves the analog dimming by inputting the PWM duty cycle to the ADIM pin. The duty cycle on ADIM pin controls the average value of $V_{(CS\_REG)}$ proportionally when the ADIM pin frequency is higher than 10kHz. Therefore, the output current is proportional to the ADIM pin duty cycle in analog dimming mode. 20kHz input PWM frequency for ADIM pin is recommended for the small output current ripple. When the ADIM pin and PWM pin are high, the LED fault diagnositc will be enabled. If the ADIM pin keeps low for more than 100us, the LED fault diagnositc will be disabled. The output current slew rate is optimized to typical value 1ms in analog dimming mode for EMC improvement.

The detailed information and value of each time period in Power On Sequence and PWM Dimming Timing is described in TIMING section of electrical characteristics table.

7.3.6 Diagnostics

The TPS92629-Q1 device provides advanced diagnostics and fault-protection features for automotive exterior lighting systems. The device is able to detect and protect fault from LED-string short-to-GND, LED-string open-circuit, LED-string short-to-battery and junction over-temperature scenarios. The multiple fault could be reported out by different voltage levels through fault pins for safety critical applications.

7.3.6.1 LED Short-to-GND Detection

The TPS92629-Q1 device has LED short-to-GND detection. The LED short-to-GND detection monitors the output voltage when the output current is enabled. Once 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 TPS92629-Q1 monitors both $V_{(OUT)}$ voltage and $V_{(RES)}$ voltage of each 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 $\overline{FAULT}$ pin. During the deglitching time period, if $V_{(OUTx)}$ and $V_{(RESx)}$ rises above $V_{(SG\_th\_rising)}$, the timer is reset.

Once the TPS92629-Q1 has asserted a short-to-GND fault, the device turns off the faulty 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. 図 7-2 illustrates the timing for LED short-circuit detection, protection, retry and recovery.

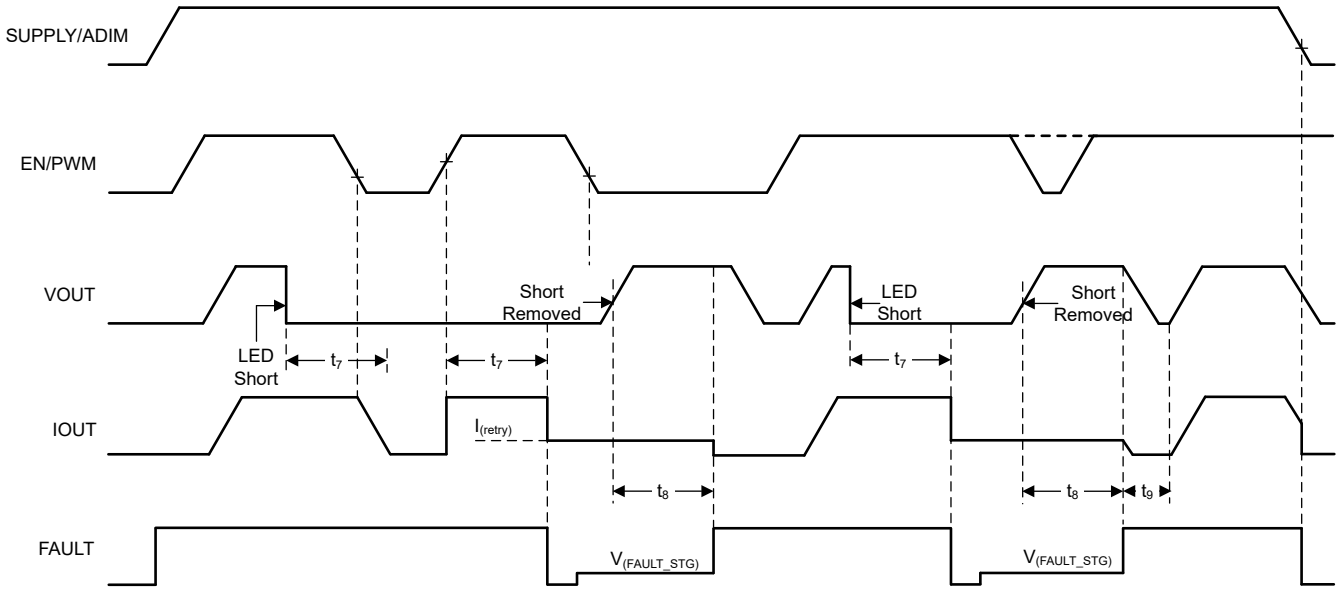


図 7-2. LED Short-to-GND Detection and Recovery Timing Diagram

The detailed information and value of each time period in 図 7-2 is described in TIMING section of electrical characteristics table.

7.3.6.2 LED Open-Circuit and Short-to-Battery Detection

The TPS92629-Q1 device has LED open-circuit detection and output short-to-battery detection. The LED open-circuit detection and output short-to-battery detection monitor the output voltage when the current output is enabled. The LED open-circuit detection and output short-to-battery are only enabled when DIAGEN is HIGH. Compared with the traditional detection method, output short-to-battery fault and LED open-circuit fault could be identified.

The TPS92629-Q1 monitors dropout-voltage differences between the IN and OUT pins for LED channel when PWM is HIGH and ADIM is HIGH. The voltage difference $V_{(INx)} – V_{(OUTx)}$ is compared with the internal reference voltage $V_{(OPEN\_th\_rising)}$ to detect an LED open-circuit and output short-to-battery incident. If $V_{(OUTx)}$ rises and causes $V_{(INx)} – V_{(OUTx)}$ less than the $V_{(OPEN\_th\_rising)}$ voltage longer than the deglitch time of $t_{(OPEN\_deg)}$, the device asserts fault immediately and pulls down the fault pin firstly. During the deglitch time period, if V(OUTx) falls and makes V(INx) – V(OUTx) larger than V(OPEN_th_falling), the deglitch timer is reset. After the falling edge of fault pin, there is a discharge time $t_{(discharge)}$ to identify whether it is output short-to-battery fault or LED open-circuit fault. During the discharge stage, $I_{(Discharge\_OUT)}$ flows into the out pin. At the end of discharge stage, the voltage difference $V_{(INx)} – V_{(OUTx)}$ is compared with the internal reference voltage $V_{(OPEN\_th\_falling)}$. When $V_{(INx)} – V_{(OUTx)}$ is bigger than $V_{(OPEN\_th\_falling)}$, the LED open-circuit fault is reported. Otherwise, output short-to-battery fault is reported.

The TPS92629-Q1 shuts down the output current regulation for the error channel after LED open-circuit fault or output short-to-battery 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 $\overline{\text{FAULT}}$ pin. 図 7-3 illustrates the timing for LED open-circuit detection, protection, retry and recovery.

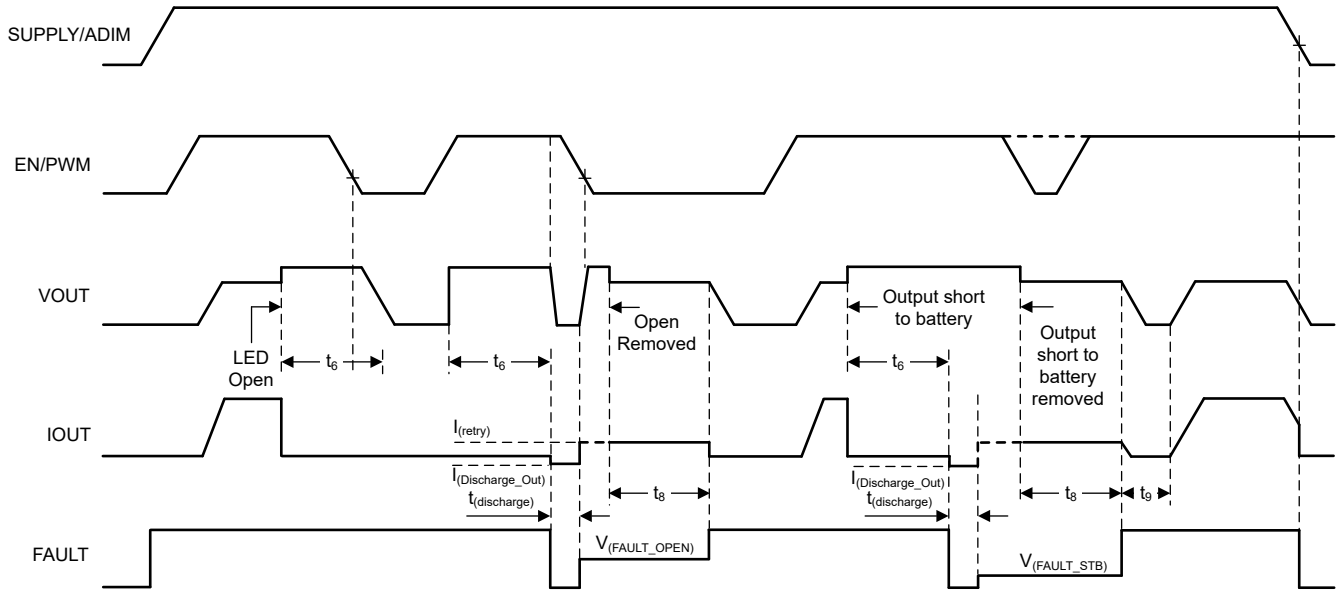


図 7-3. LED Open-Circuit Detection and Recovery Timing Diagram

The detailed information and value of each time period in 図 7-3 is described in TIMING section of electrical characteristics table.

7.3.6.3 LED Open-Circuit and Short-to-Battery Detection Enable (DIAGEN)

The TPS92629-Q1 device supports the DIAGEN pin with an accurate threshold to disable the LED open-circuit and output short-to-battery detection. The DIAGEN pin can be used to enable or disable LED open-circuit detection and output short-to-battery detection based on SUPPLY pin voltage sensed by an external resistor divider as illustrated in 図 7-4. When the voltage applied on DIAGEN pin is higher than the threshold $V_{IH(DIAGEN)}$, the device enables LED open-circuit and output short-to-battery detection. When $V_{(DIAGEN)}$ is lower than the threshold $V_{IL(DIAGEN)}$, the device disables LED open-circuit and output short-to-battery detection.

Only LED open-circuit and output short-to-battery 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. The SUPPLY threshold voltage can be calculated by using 式 2.

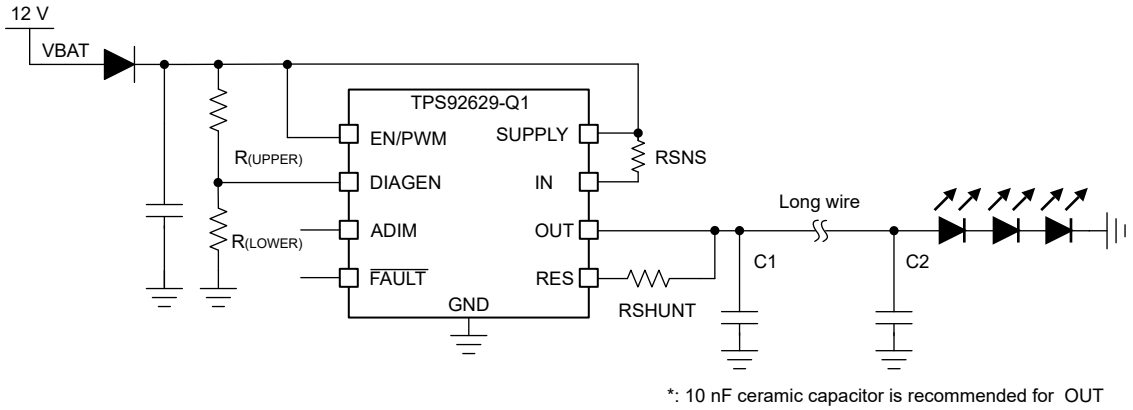


図 7-4. Application Schematic For DIAGEN

$$V_{(SUPPLY\_DIAGEN\_th\_falling)} = V_{IL(DIAGEN)} \times \left(1 + \frac{R_{(UPPER)}}{R_{(LOWER)}}\right) \quad (2)$$

where

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

7.3.6.4 Overtemperature Protection

The TPS92629-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 to $V_{(FAULT\_TSD)}$.

7.3.6.5 Low Dropout Operation

When the supply voltage drops below LED string total forward voltage plus headroom voltage at required current, the TPS92629-Q1 device operates in low-dropout conditions to deliver current output as close as possible to target value. The actual current output 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 TPS92629-Q1 is designed to operate in low-dropout condition, the open-circuit and output short-to-battery diagnostics must be disabled by pulling the DIAGEN pin voltage lower than $V_{IL(DIAGEN)}$. Otherwise, the TPS92629-Q1 detects an open-circuit fault or output short-to-battery fault and reports a fault on the $\overline{FAULT}$ pin. The DIAGEN pin is used to avoid false diagnostics due to low supply voltage.

7.3.7 Multi Fault Report

The multiple fault could be reported out by the different voltage level through fault pins. The fault pin will be pulled down firstly for $t_{(discharge)}$ time in order to generate a falling edge trigger signal for the ADC of MCU. The $t_{(discharge)}$ time is also used as discharge process for LED open-circuit detection and output short-to-battery detection. After the discharge process, the fault pin will be pulled up to a specific voltage level according to the detected fault to achieve multiple fault report for safety critical system, as shown in 図 7-5

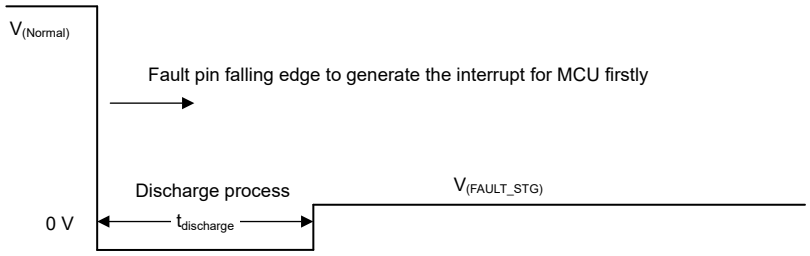


図 7-5. Multiple fault report timing sequence

7.3.8 FAULT Table

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

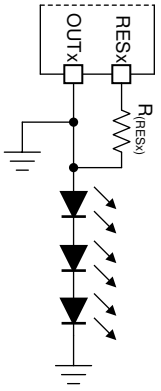
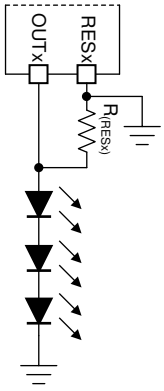
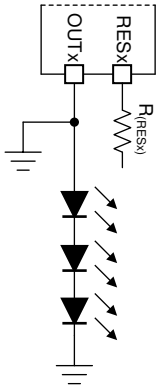
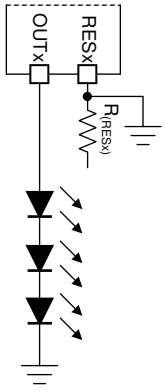
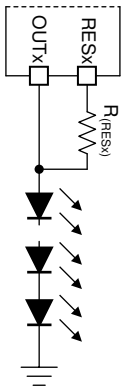
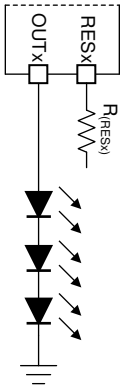
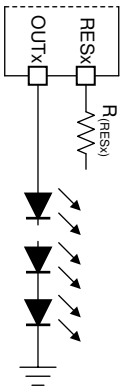
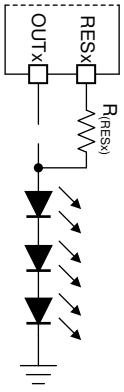
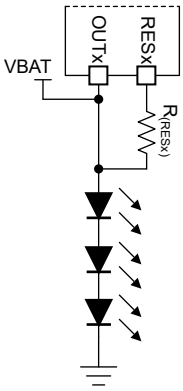
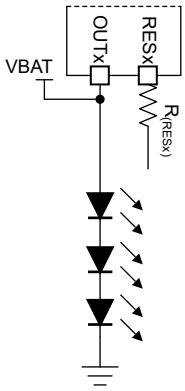
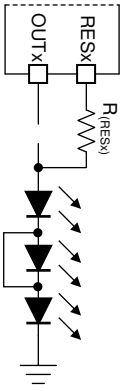
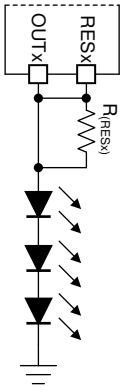
FAULT TYPE	DETECTION MECHANISM	CONTROL INPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
Open-circuit	$V_{(IN)} - V_{(OUT)} < V_{(OPEN\_th\_rising)}$, $V_{(IN)} - V_{(OUT)} > V_{(OPEN\_th\_falling)}$ at the end of discharge process	EN/PWM = H, ADIM = H	$t_{(OPEN\_deg)}$	Pull up to $V_{(FAULT\_OPEN)}$	Device turns failed output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
Short-to-battery	$V_{(IN)} - V_{(OUT)} < V_{(OPEN\_th\_rising)}$, $V_{(IN)} - V_{(OUT)} <= V_{(OPEN\_th\_falling)}$ at the end of discharge process	EN/PWM = H, ADIM = H	$t_{(OPEN\_deg)}$	Pull up to $V_{(FAULT\_STB)}$	Device turns failed 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/PWM = H, ADIM = H	$t_{(SG\_deg)}$	Pull up to $V_{(FAULT\_STG)}$	Device turns failed output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
Overtemperature	$T_J > T_{(TSD)}$		$t_{(TSD\_deg)}$	Pull up to $V_{(FAULT\_TSD)}$	Device turns all output channels off.	Auto recovery

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

FAULT TYPE	DETECTION MECHANISM	CONTROL INPUT	DEGLITCH TIME	FAULT BUS	FAULT HANDLING ROUTINE	FAULT RECOVERY
Open-circuit or short-to-battery	Ignored					
Short-to-ground	$V_{(OUT)} < V_{(SG\_th\_falling)}$ OR $V_{(RES)} < V_{(SG\_th\_falling)}$	EN/PWM = H, ADIM = H	$t_{(SG\_deg)}$	Pull up to $V_{(FAULT\_STG)}$	Device turns output off and retries with constant current $I_{(retry)}$, ignoring the PWM input.	Auto recovery
Overtemperature	$T_J > T_{(TSD)}$		$t_{(TSD\_deg)}$	Pull up to $V_{(FAULT\_TSD)}$	Device turns all output channels off.	Auto recovery

7.3.9 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**
			
Short to battery Fault	Short to battery Fault	LED Open Fault	No Fault

7.3.10 IO Pins Inner Connection

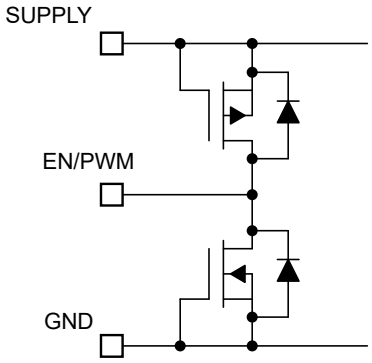


図 7-6. EN/PWM Pin

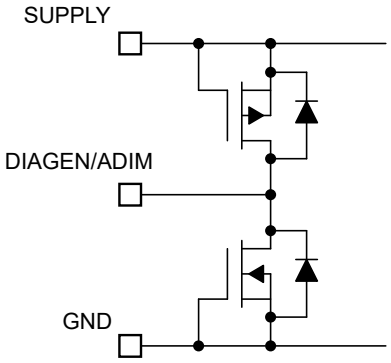


図 7-7. DIAGEN/ADIM Pin

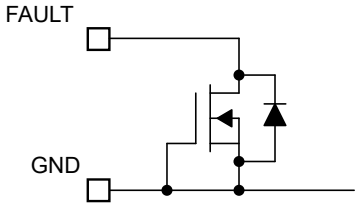


図 7-8. $\overline{\text{FAULT}}$ Pin

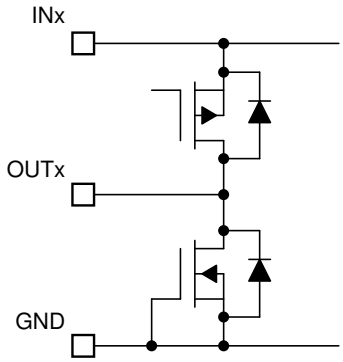


図 7-9. OUTx Pins

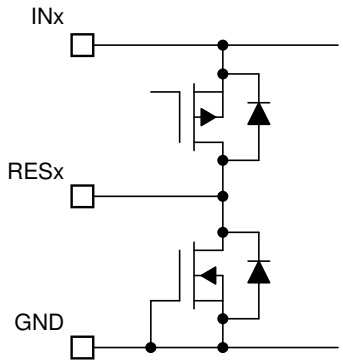


図 7-10. RESx Pins

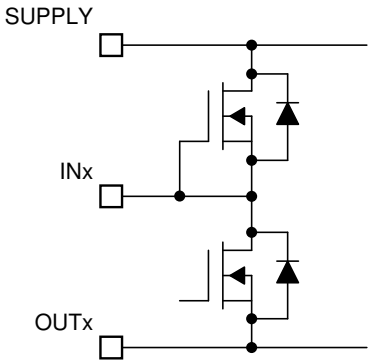


図 7-11. INx Pins

7.4 Device Functional Modes

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

When the device is in undervoltage lockout status, the TPS92629-Q1 device disables all functions until the supply rises above the $V_{(POR\_rising)}$ threshold.

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

The device drives an LED string in normal operation. With enough voltage drop across SUPPLY and OUT, the device is able to 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 or short-to-battery fault. TI recommends only enabling the open-circuit and short-to-battery detection when the voltage across the IN and OUTx is higher than the maximum voltage of LED open rising threshold to avoid a false open-circuit or short-to-battery detection.

7.4.4 Fault Mode

When the TPS92629-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

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 TPS92629-Q1 device is capable of detecting LED open-circuit and LED short-circuits. To increase current driving capability, the TPS92629-Q1 device supports using an external shunt resistor to help dissipate heat as the following section, *Thermal Sharing Resistor (OUT and RES)*, 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 Using Analog Dimming Controlled By MCU for Blind Spot Detection

The TPS92629-Q1 device is able to achieve analog dimming by PWM input at ADIM pin. 20kHz PWM frequency is selected here for the ADIM input for small output current ripple. The fault pin is connected to the ADC of MCU through a resistor divider to report different kind of fault for safety critical system, like blind spot detection.

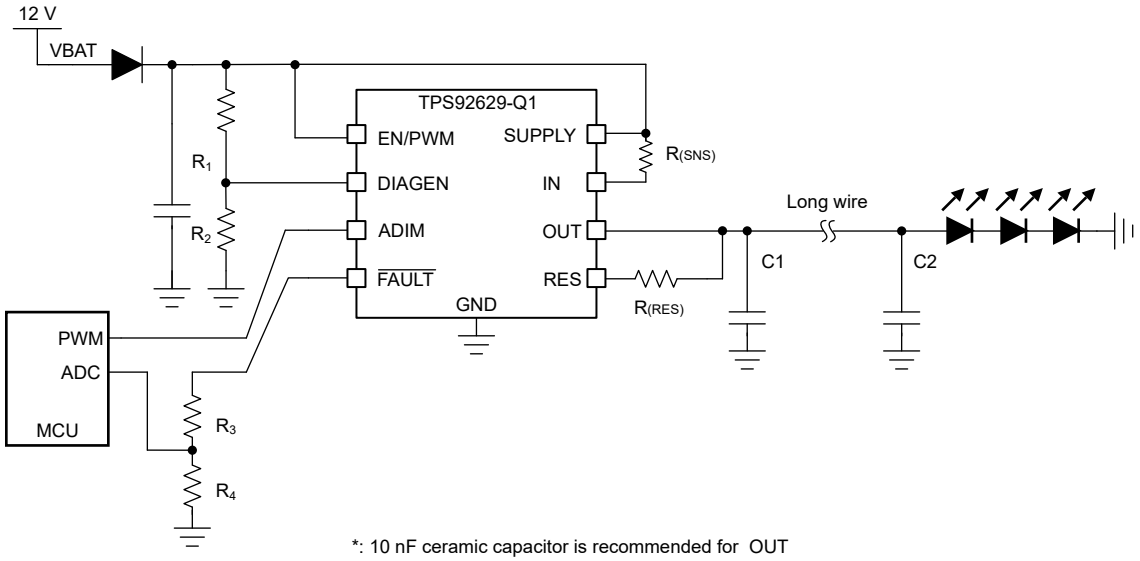


図 8-1. Typical Application Schematic

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 analog dimming for different brightness control and flash dimming control. 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. Maximum LED current is 100 mA

8.2.1.2 Detailed Design Procedure

Step 1: Determine the current sensing resistor, $\mathbf{R_{(SNSx)}}$ by using 式 3.

$$R_{(SNSx)} = \frac{V_{(CS\_REG)}}{I_{(OUTx\_Tot)}} \tag{3}$$

where

- $V_{(CS\_REG)}$ = 463.5 mV (typical)
- $I_{(OUTx\_Tot)}$ = 100 mA

According to design requirements, output current for the LED channel is 100 mA so that the calculated $R_{(SNS)}$ = 4.63 Ω and a 4.64 Ω resistor is selected.

Step 2: Design the current distribution between $I_{(OUTx)}$ and $I_{(RESx)}$, and calculate the current sharing resistor, $\mathbf{R_{(RESx)}}$, by using 式 4. The $R_{(RESx)}$ value actually decides the current distribution for $I_{(OUTx)}$ path and $I_{(RESx)}$ path, basic principle is to design the $R_{(RESx)}$ to consume appropriate 50% total power dissipation at typical supply operating voltage.

$$R_{(RESx)} = \frac{V_{(SUPPLY)} - V_{(OUTx)}}{I_{(OUTx\_Tot)} \times 0.5} \tag{4}$$

where

- $V_{(SUPPLY)}$ = 12 V (typical)
- $I_{(OUTx\_Tot)}$ = 100 mA (maximum)

The calculated result for $R_{(RES)}$ resistor value is 108 Ω when $V_{(OUTx)}$ is typical 3 × 2.2 V = 6.6 V. A 107 Ω resistor is selected

Step 3: Design the threshold voltage of SUPPLY to enable the LED open-circuit, and calculate voltage divider resistor value for **R1** and **R2** on DIAGEN pin.

The maximum forward voltage of LED-string is 3 × 2.5 V = 7.5 V. To avoid the open-circuit fault or short-to-battery fault reported in low-dropout operation conditions, additional headroom between SUPPLY and OUTx must be considered. TheTPS92629-Q1 device must disable open-circuit and short-to-battery detection when the supply voltage is below LED-string maximum forward voltage plus $V_{(OPEN\_th\_rising)}$ and $V_{(CS\_REG)}$. The voltage divider resistor, R1 and R2 value can be calculated by 式 5.

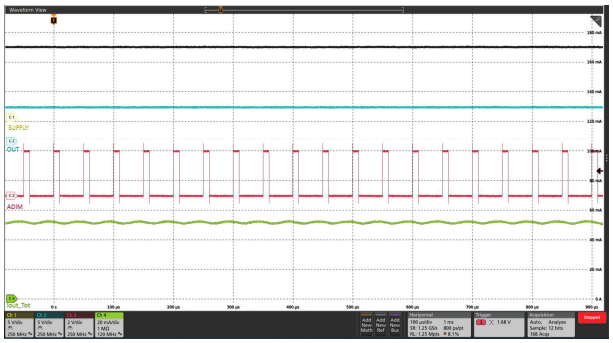
$$R_1 = \left(\frac{V_{(OPEN\_th\_rising)} + V_{(CS\_REG)} + V_{(OUTx)}}{V_{IL(DIAGEN)}} - 1 \right) \times R_2 \tag{5}$$

where

- $V_{(OPEN\_th\_rising)}$ = 420 mV (maximum)
- $V_{(CS\_REG)}$ = 489 mV (maximum)
- $V_{IL(DIAGEN)}$ = 1.045 V (minimum)
- R_2 = 10 kΩ (recommended)

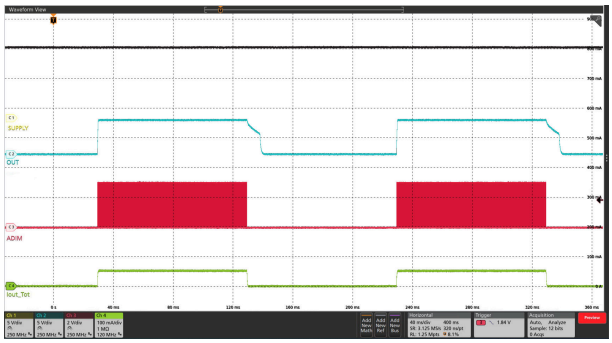
The calculated result for R1 is 70.5 kΩ when $V_{(OUTx)}$ maximum voltage is 7.5 V and $V_{(CS\_REG)}$ is 420 mV. A 70.6 kΩ resistor is selected

8.2.1.3 Application Curves



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

図 8-2. Analog dimming at 20 kHz



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

図 8-3. Flash dimming control

8.3 Power Supply Recommendations

The TPS92629-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 TPS92629-Q1 layout.

- TI recommends large thermal dissipation area in both top and bottom layers of PCB. The copper pouring area in same layer with TPS92629-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 TPS92629-Q1 device with more than 20-mm distance, because $R_{(RESx)}$ resistors are dissipating some amount of the power as well as the TPS92629-Q1. Place two heat source components apart to reduce the thermal accumulation concentrated at small PCB area. The large copper pouring area is also required surrounding the $R_{(RESx)}$ resistors for helping thermal dissipating.

The noise immunity is the secondary consideration for TPS92629-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 $R_{(SNSx)}$ resistor as close as possible to the INx pins with the shortest PCB track to SUPPLY pin.

8.4.2 Layout Example

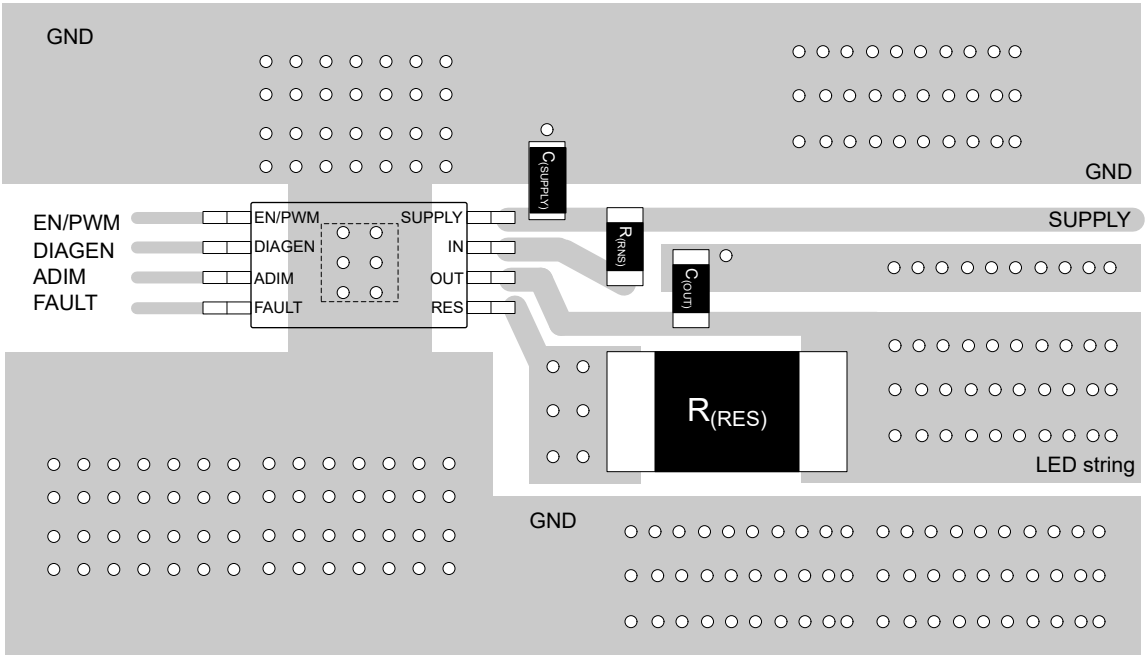


図 8-4. TPS92629-Q1 Example Layout Diagram

9 Device and Documentation Support

9.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、ti.com のデバイス製品フォルダを開いてください。「更新の通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

9.2 サポート・リソース

TI E2E™ サポート・フォーラムは、エンジニアが検証済みの回答と設計に関するヒントをエキスパートから迅速かつ直接得ることができる場所です。既存の回答を検索したり、独自の質問をしたりすることで、設計で必要な支援を迅速に得ることができます。

リンクされているコンテンツは、該当する貢献者により、現状のまま提供されるものです。これらは TI の仕様を構成するものではなく、必ずしも TI の見解を反映したものではありません。TI の使用条件を参照してください。

9.3 Trademarks

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すべての商標は、それぞれの所有者に帰属します。

9.4 静電気放電に関する注意事項

この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

9.5 用語集

テキサス・インスツルメンツ用語集　　この用語集には、用語や略語の一覧および定義が記載されています。

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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS92629QDGNRQ1	ACTIVE	HVSSOP	DGN	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	2TKT	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

GENERIC PACKAGE VIEW

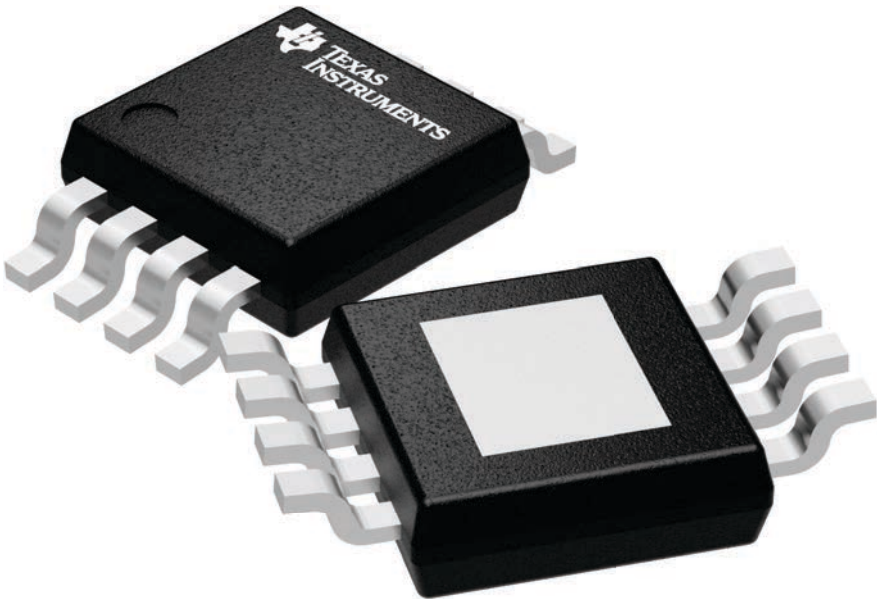
DGN 8

PowerPAD VSSOP - 1.1 mm max height

3 x 3, 0.65 mm pitch

SMALL OUTLINE PACKAGE

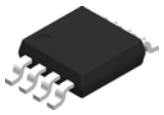
This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4225482/A

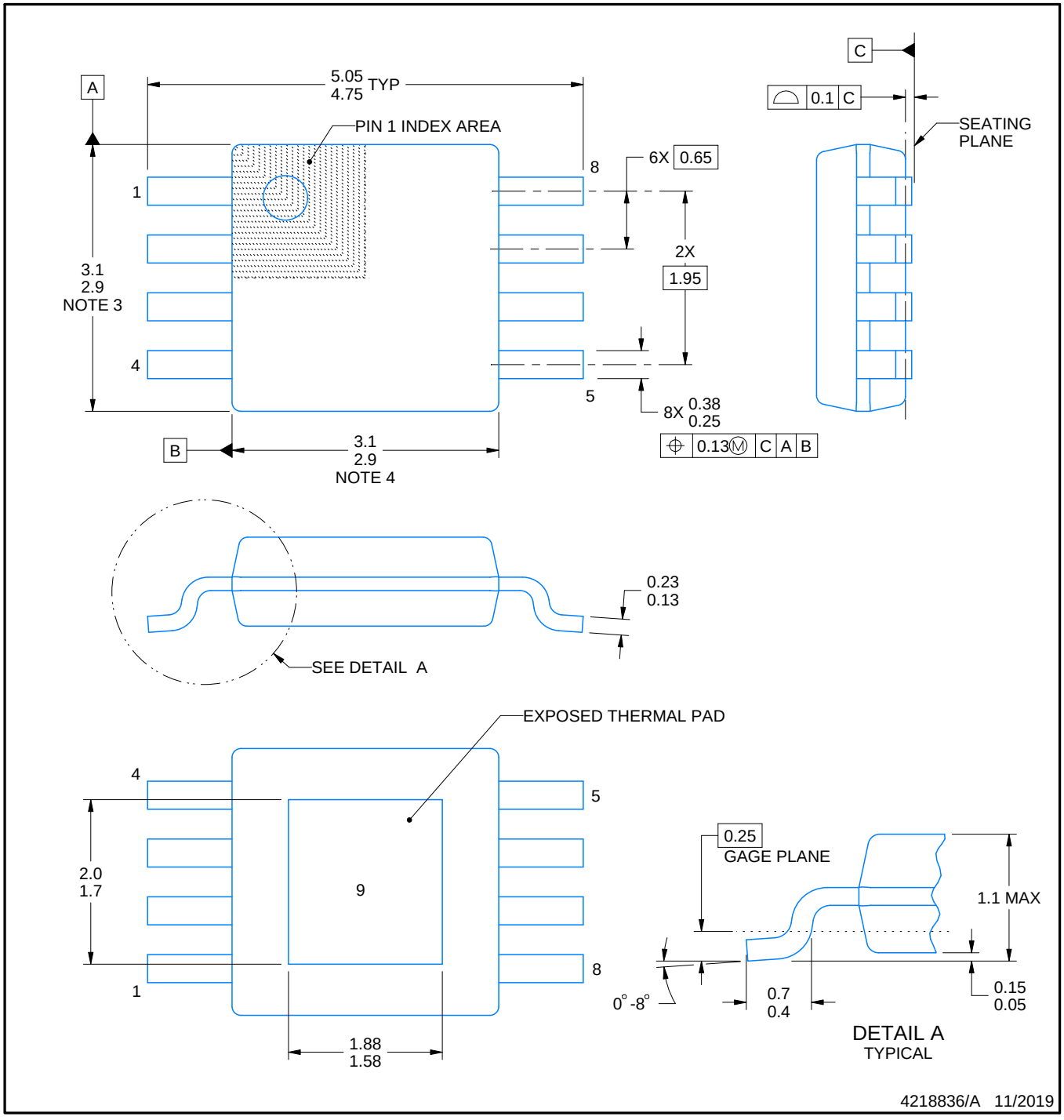
PACKAGE OUTLINE

DGN0008A



PowerPAD™ VSSOP - 1.1 mm max height

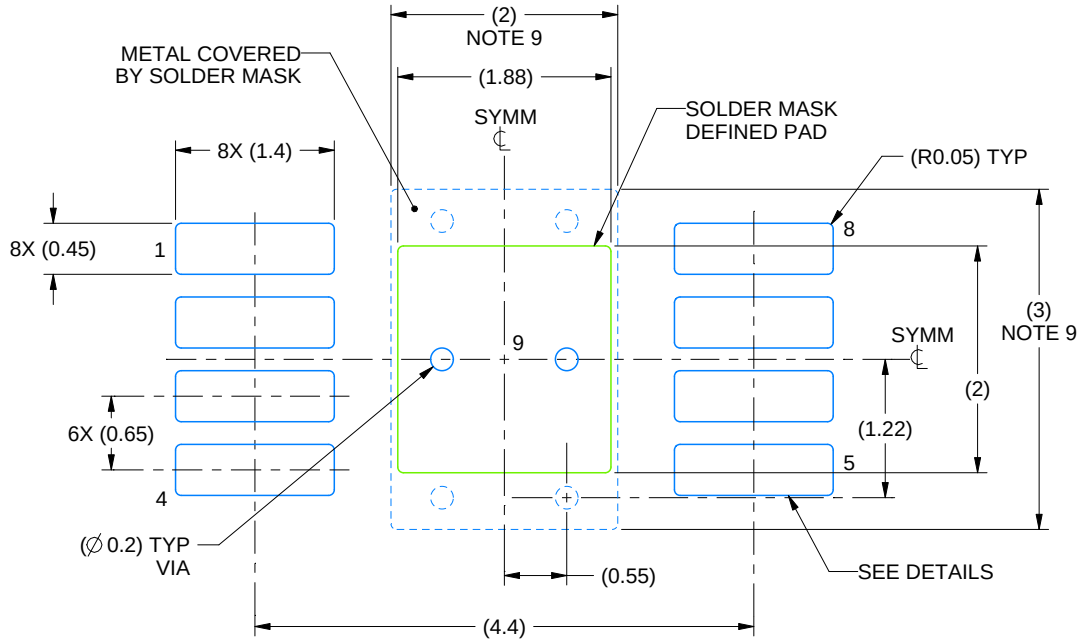
SMALL OUTLINE PACKAGE



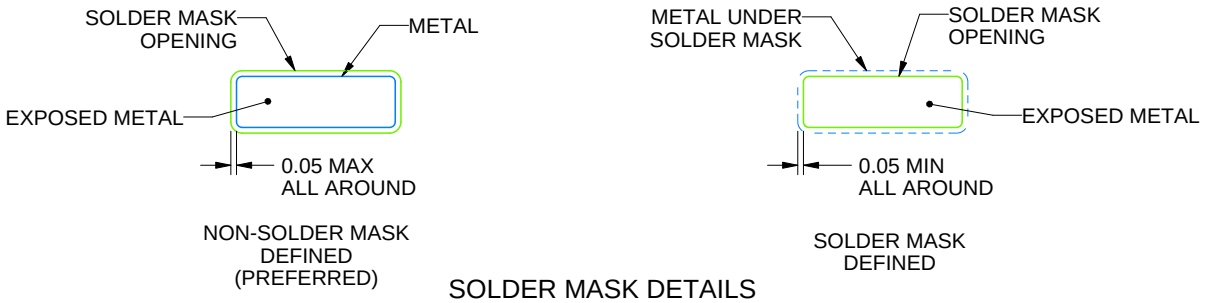
PowerPAD is a trademark of Texas Instruments.

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



SOLDER MASK DETAILS

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NOTES: (continued)

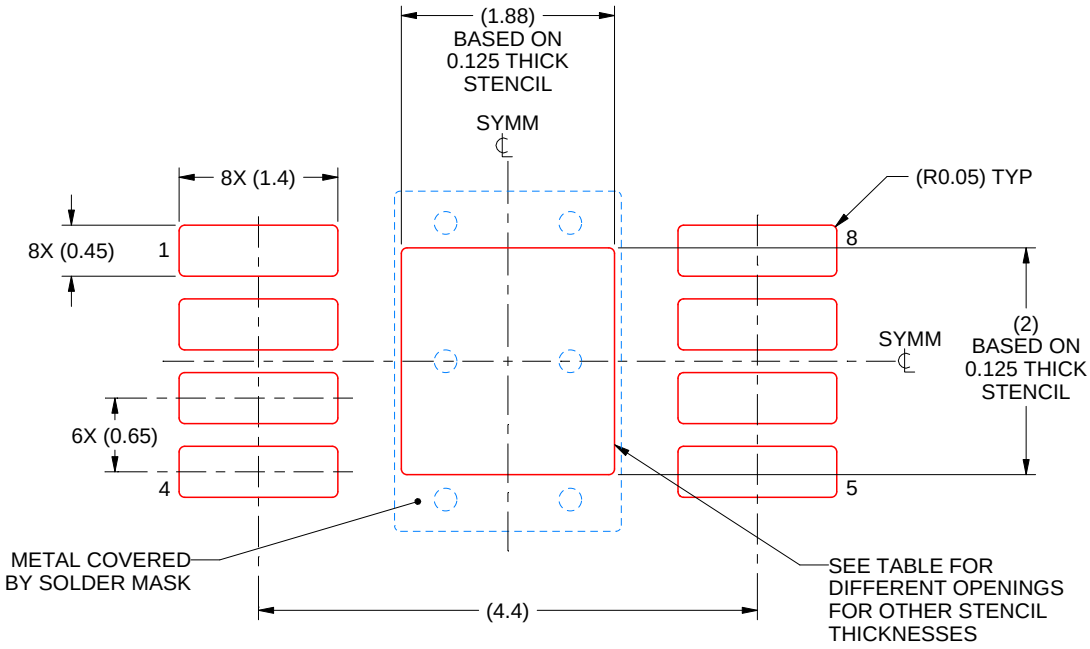
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It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

EXAMPLE STENCIL DESIGN

DGN0008A

PowerPAD™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



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

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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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