TPS92612-Q1 Automotive Single-Channel LED Driver

1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Temperature Grade 1: –40°C to 125°C Ambient Operating Temperature Range
  - Device HBM ESD Classification Level H2
  - Device CDM ESD Classification Level C3B
- Single-Channel Constant-Current LED Driver With PWM Dimming
- Wide Input-Voltage Range: 4.5 V–40 V
- Constant Output Current, Adjustable by Sense Resistor
- Precision Current Regulation, Tolerance ±4.6%
- Maximum Current: 150 mA
- Heat Sharing With External Resistor
- Low Dropout Voltage (Reference-Voltage Drop Included)
  - Maximum Dropout: 150 mV at 10 mA
  - Maximum Dropout: 400 mV at 70 mA
  - Maximum Dropout: 700 mV at 150 mA
- Low Standby Current (<250 µA per Device)
- Protection:
  - LED Short-Circuit Protection With Auto-Recovery
  - Overtemperature Protection
- Operating Junction Temperature Range: –40°C to 150°C

2 Applications

- Automotive Convenience Lighting: Dome Light, Door Handles, Reading Lamp, and Miscellaneous Lamps
- Automotive Rear Lamp, Center High-Mounted Stop Lamp, Side Markers, Blind-Spot Detection Indicator, Charging Indicator
- General-Purpose LED-Driver Applications

3 Description

With LEDs being widely used in automotive applications, simple LED drivers are more and more popular. Compared to discrete solutions, a low-cost monolithic solution lowers system-level component counts and significantly improves current accuracy and reliability.

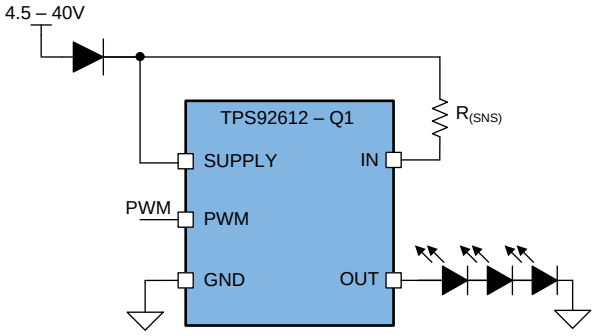
The TPS92612-Q1 device is a simple single-channel high-side LED driver operating from an automotive car battery. It is a simple and elegant solution to deliver constant current for a single LED string.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS92612-Q1	SOT-23 (5)	2.9 mm × 1.6 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Typical Application Diagram



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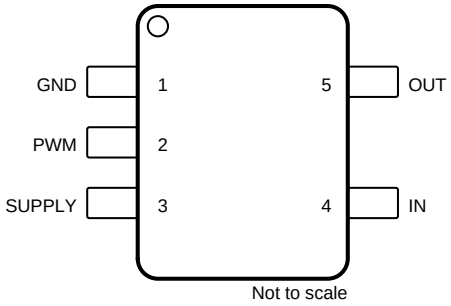
4 Revision History

DATE	REVISION	NOTE
January 2018	*	Initial release

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5 Pin Configuration and Functions

TPS92612-Q1 DBV Package
5-Pin SOT-23
Top View



Not to scale

Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
	TPS92612-Q1		
GND	1	—	Ground
IN	4	I	Current input
OUT	5	O	Constant-current output
PWM	2	I	PWM input
SUPPLY	3	I	Device supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
High-voltage input	IN, PWM, SUPPLY	–0.3	45	V
High-voltage output	OUT	–0.3	45	V
IN to OUT	$V_{(IN)} – V_{(OUT)}$	–0.3	45	V
SUPPLY to IN	$V_{(SUPPLY)} – V_{(IN)}$	–0.3	1	V
Operating junction temperature, T_J		–40	150	°C
Storage temperature, T_{stg}		–40	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002(1)	All pins	±2000	V
		Charged-device model (CDM), per AEC Q100-011	All pins	±500	
			Corner pins (3, 4, and 5)	±750	

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

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6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
SUPPLY	Device supply voltage	4.5		40	V
IN	Sense voltage	4.4		40	V
PWM	PWM inputs	0		40	V
OUT	Driver output	0		40	V
T_A	Operating ambient temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TPS92612-Q1 DBV (SOT23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	200.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	104.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	45.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	17.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	45.2	°C/W

(1) For more information about traditional and new thermal metrics, see *Semiconductor and IC Package Thermal Metrics*.

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			3.2	4	V
$V_{(POR_falling)}$	Supply voltage POR falling threshold		2.2	3		V
$I_{(Quiescent)}$	Device standby current	PWM = LOW	0.1	0.2	0.25	mA
LOGIC INPUTS (PWM)						
$V_{IL(PWM)}$	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						
$I_{(OUT)}$	Device output-current range	100% duty cycle	4		150	mA
$V_{(CS_REG)}$	Sense-resistor regulation voltage	T_A = 25°C, $V_{(SUPPLY)}$ = 4.5 V to 18 V	94	98	102	mV
		T_A = –40°C to 125°C, $V_{(SUPPLY)}$ = 4.5 V to 18 V	93.5	98	102.5	
$R_{(CS_REG)}$	Sense-resistor value				24.5	Ω
$V_{(DROPOUT)}$	Voltage dropout from SUPPLY to OUT	$V_{(CS_REG)}$ voltage included, current setting = 10 mA		120	150	mV
		$V_{(CS_REG)}$ voltage included, current setting = 70 mA		250	400	
		$V_{(CS_REG)}$ voltage included, current setting = 150 mA		430	700	
DIAGNOSTICS						
$V_{(SG_th_rising)}$	Channel output $V_{(OUT)}$ short-to-ground rising threshold		1.14	1.2	1.26	V
$V_{(SG_th_falling)}$	Channel output $V_{(OUT)}$ short-to-ground falling threshold		0.82	0.865	0.91	V
$I_{(Retry)}$	Channel output $V_{(OUT)}$ short-to-ground retry current	$V_{(OUT)}$= 0 V	0.64	1.08	1.528	mA
THERMAL PROTECTION						

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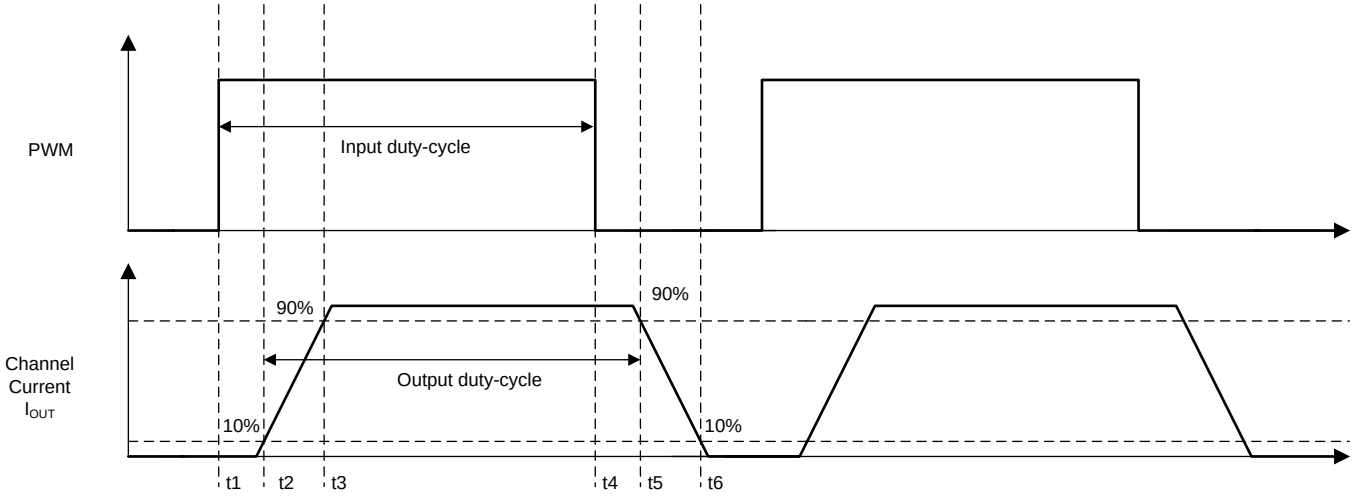
Electrical Characteristics (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$T_{(TSD)}$	Thermal shutdown junction temperature threshold			172		°C
$T_{(TSD_HYS)}$	Thermal shutdown junction temperature hysteresis			15		°C

6.6 Timing Requirements

		MIN	NOM	MAX	UNIT
$t_{(PWM_delay_rising)}$	PWM rising edge delay, 50% PWM voltage to 10% of output current, t2 – t1 as shown in Figure 1		17		µs
$t_{(PWM_delay_falling)}$	PWM falling edge delay, 50% PWM voltage to 90% of output current, t5 – t4 as shown in Figure 1		21		µs
$t_{(TSD_deg)}$	Thermal overtemperature deglitch time		60		µs
$t_{(SG_deg)}$	Channel-output short-to-ground detection deglitch time	80	125	175	µs
$t_{(Recover_deg)}$	Recovery deglitch time		16		µs



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Figure 1. Output Timing Diagram

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6.7 Typical Characteristics

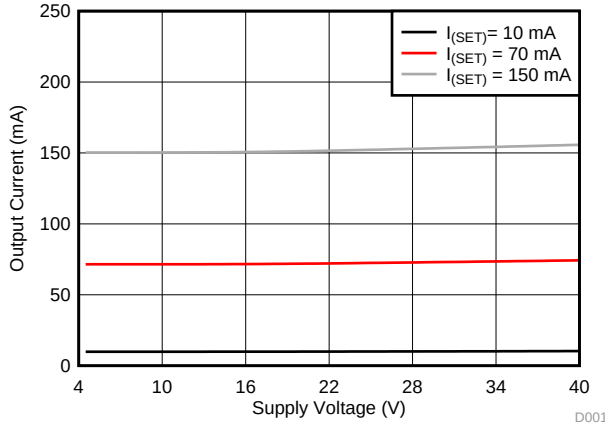


Figure 2. Output Current vs Supply Voltage

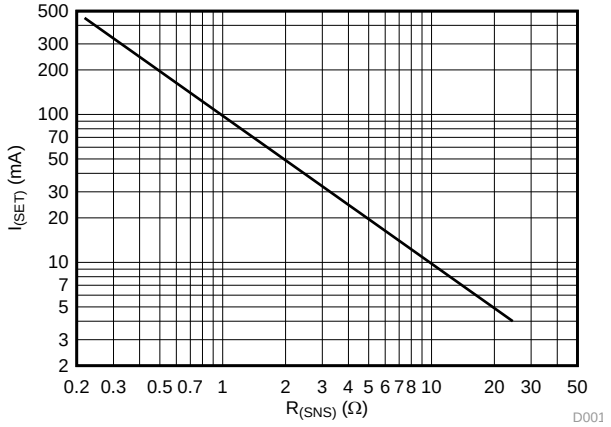


Figure 3. Output Current vs Current-Sense Resistor

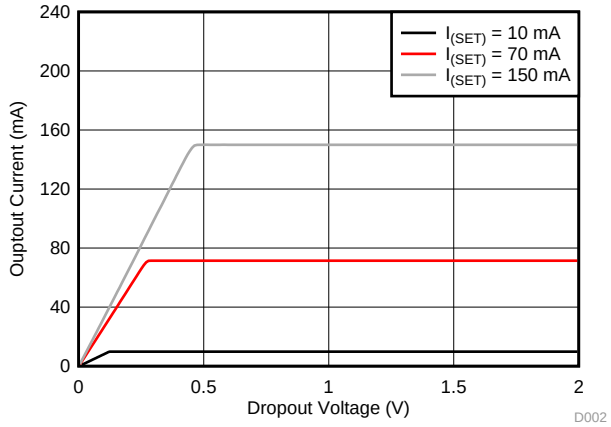


Figure 4. Output Current vs Dropout Voltage

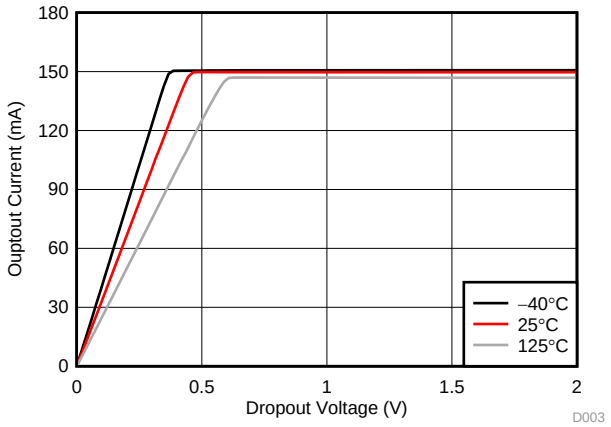


Figure 5. Output Current vs Temperature

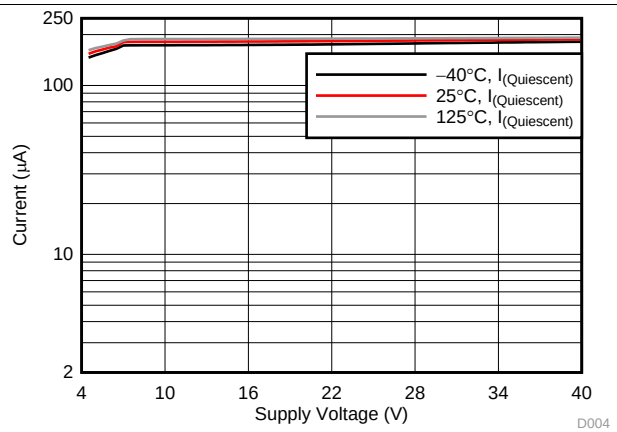


Figure 6. Quiescent Current vs Input Voltage

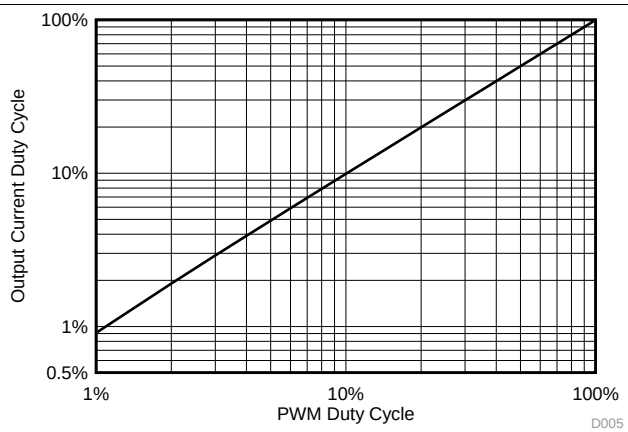
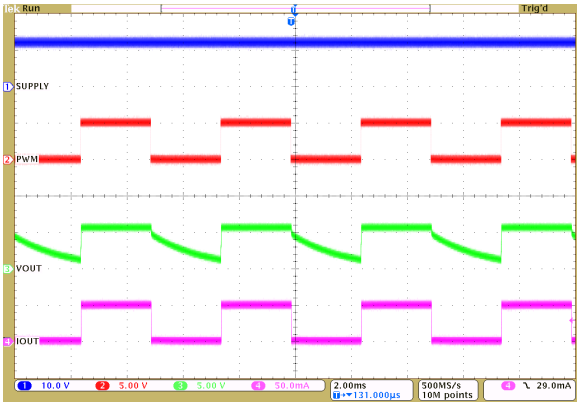


Figure 7. PWM Output Duty Cycle vs Input Duty Cycle

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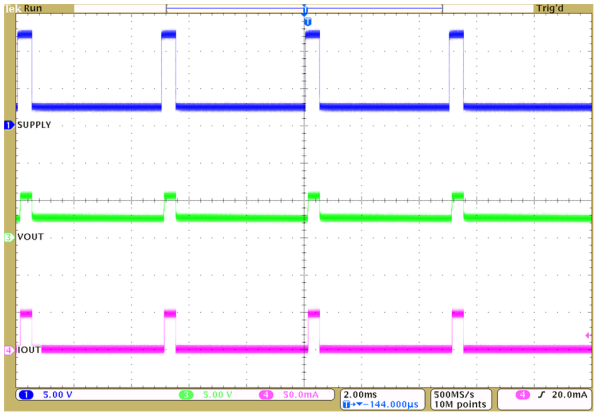
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Typical Characteristics (continued)



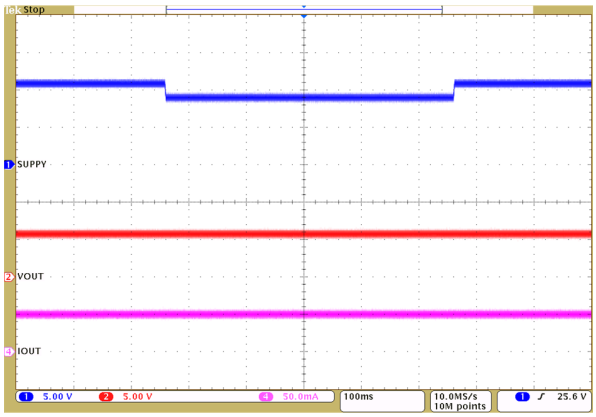
Ch. 1 = $V_{(SUPPLY)}$ Ch. 2 = $V_{(PWM)}$ Ch. 3 = $I_{(OUT)}$
Ch. 4 = $V_{(OUT)}$ $f_{(PWM)}$ = 200 Hz Duty-cycle = 50%

Figure 8. PWM Dimming via External Input



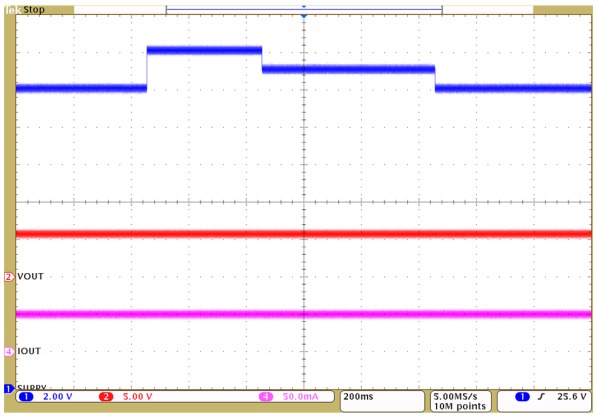
Ch. 1 = $V_{(SUPPLY)}$ Ch. 3 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$
$f_{(PWM)}$ = 1000 Hz Duty-cycle = 10%
SUPPLY dimming between 2.5 V and 12 V

Figure 9. PWM Dimming via Power Supply



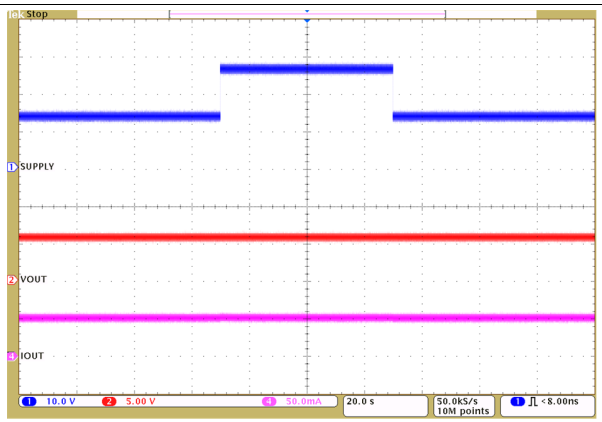
Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 10. Transient Undervoltage



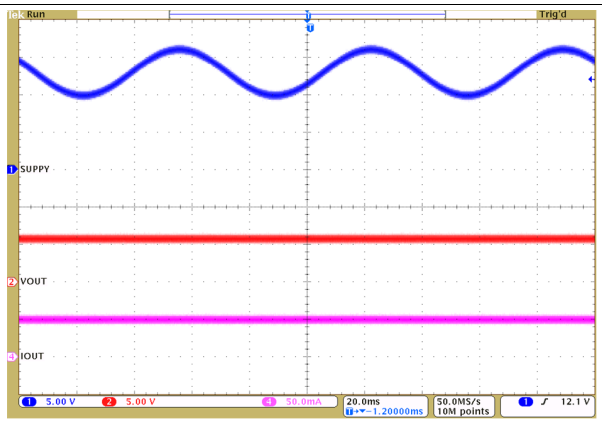
Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 11. Transient Overvoltage



Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 12. Jump Start

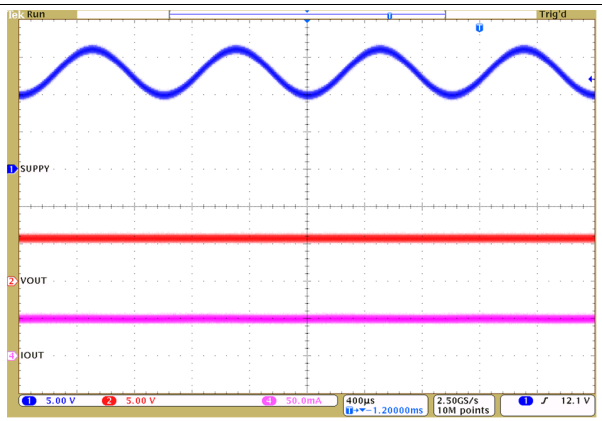


Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 13. Superimposed Alternating Voltage, 15 Hz

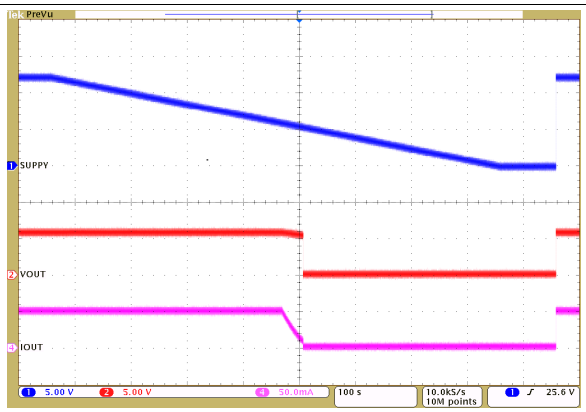
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Typical Characteristics (continued)



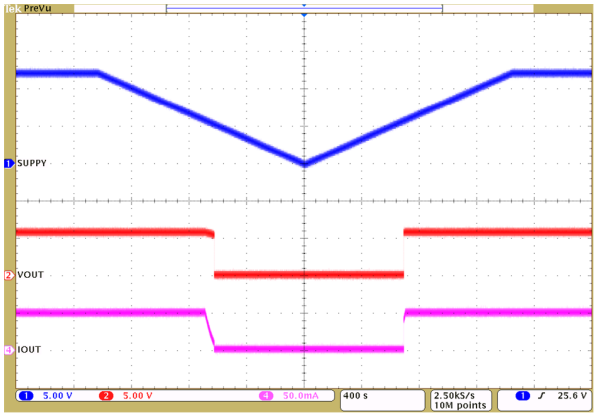
Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 14. Superimposed Alternating Voltage, 1kHz



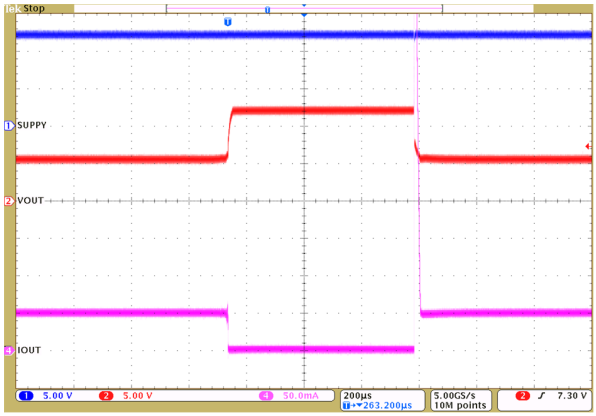
Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 15. Slow Decrease, Quick Increase of Supply Voltage



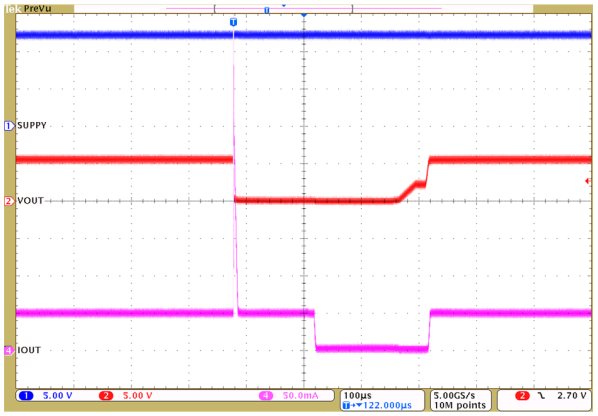
Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 16. Slow Decrease and Slow Increase of Supply Voltage



Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 17. LED Open-Circuit and Recovery



Ch. 1 = SUPPLY Ch. 2 = $V_{(OUT)}$ Ch. 4 = $I_{(OUT)}$

Figure 18. LED Short-Circuit Protection and Recovery

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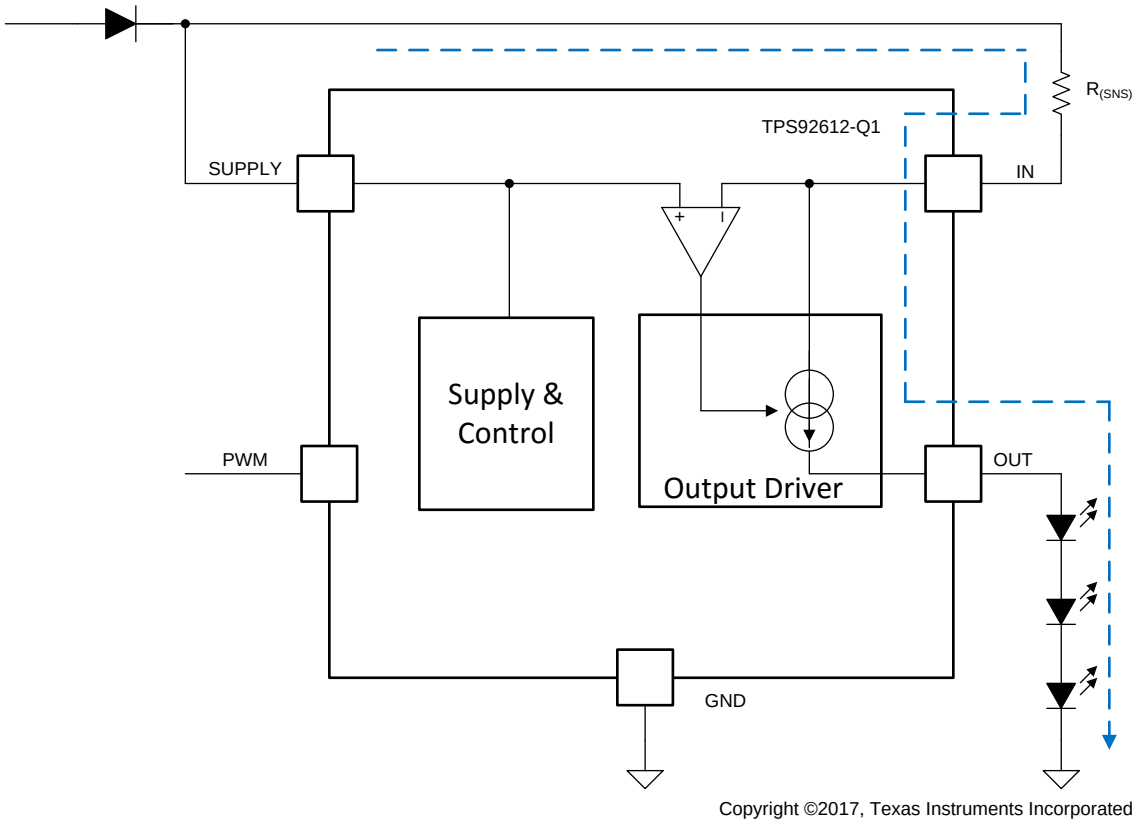
7 Detailed Description

7.1 Overview

The TPS92612-Q1 device is the one of a family of single-channel linear LED drivers. The device provides a simple current source with protection for automotive LED applications.

The output current can be set by an external $R_{(SNS)}$ resistor. Current flows from the supply through the $R_{(SNS)}$ resistor into the internal current source and to the LEDs.

7.2 Functional Block Diagram



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7.3 Feature Description

7.3.1 Device Bias

7.3.1.1 Power-On Reset (POR)

The TPS92612-Q1 device has an internal power-on-reset (POR) function. When power is applied to SUPPLY, the internal POR holds the device in the reset condition until $V_{(SUPPLY)}$ reaches $V_{(POR_rising)}$.

7.3.2 Constant-Current Driver

The TPS92612-Q1 device has a high-side constant-current integrated driver. The device senses channel current with an external high-side current-sense resistor, $R_{(SNS)}$. A current-regulation loop drives an internal transistor and regulates the current-sense voltage at the current-sense resistor to $V_{(CS_REG)}$. When the output driver is in regulation, the output current can be set by the current-sense resistor using the following equation.

$$I_{(OUT)} = \frac{V_{(CS_REG)}}{R_{(SNS)}} \quad (1)$$

Feature Description (continued)

7.3.3 PWM Dimming

The TPS92612-Q1 device supports PWM dimming via PWM input dimming and supply dimming.

The PWM input functions as an enable for the output current. When the PWM input is low, the device also disables the diagnostic features.

Supply dimming applies PWM dimming on the power input. For an accurate PWM threshold, TI recommends using a resistor divider on the PWM input stage to set the PWM threshold higher than $V_{(POR_rising)}$.

7.3.4 Protection

7.3.4.1 Short-to-GND Protection

The TPS92612-Q1 device has LED short-to-GND protection. Short-to-GND detection monitors the output voltage when the channel is in the ON state. Once a short-to-GND LED failure is detected, the device turns off the output channel and retries automatically, ignoring the PWM input. If the retry mechanism detects removal of the LED short-to-GND fault, the device resumes normal operation.

The device monitors the $V_{(OUT)}$ voltage and compares it with the internal reference voltage to detect a short-to-GND failure. If $V_{(OUT)}$ falls below $V_{(SG_th_falling)}$ longer than the deglitch time of $t_{(SG_deg)}$, the device asserts the short-to-GND fault. During the deglitching time period, if $V_{(OUT)}$ rises above $V_{(SG_th_rising)}$, the timer is reset.

Once the device has detected a short-to-GND fault, the device turns off the output channel and retries automatically with a small current. When retrying, the device sources a small current $I_{(retry)}$ from IN to OUT to pull up the LED loads continuously. Once auto retry detects output voltage rising above $V_{(SG_th_rising)}$, the device clears the short-to-GND fault and resumes normal operation.

7.3.4.2 Overtemperature Protection

The TPS92612-Q1 device monitors device junction temperature. When the junction temperature reaches thermal shutdown threshold $T_{(TSD)}$, the output shuts down. Once the junction temperature falls below $T_{(TSD)} - T_{(TSD_HYS)}$, the device resumes normal operation.

7.4 Device Functional Modes

7.4.1 Undervoltage Lock Out, $V_{(SUPPLY)} < V_{(POR_rising)}$

When the device is in undervoltage lockout mode, the TPS92612-Q1 device disables all functions until the supply rises above the 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.

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8 Application and Implementation

NOTE

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. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

In automotive lighting applications, thermal performance is always a design challenge for linear LED drivers.

To increase current-driving capability, the TPS92612-Q1 device supports heat sharing using an external parallel resistor as shown in Figure 21. This technique provides the low-cost solution of using external resistors to dissipate heat due to high input voltage, and still keeps high accuracy of the total current output.

8.2 Typical Application

8.2.1 Single-Channel LED Driver

The TPS92612-Q1 device can be a good fit for many automotive lighting applications.

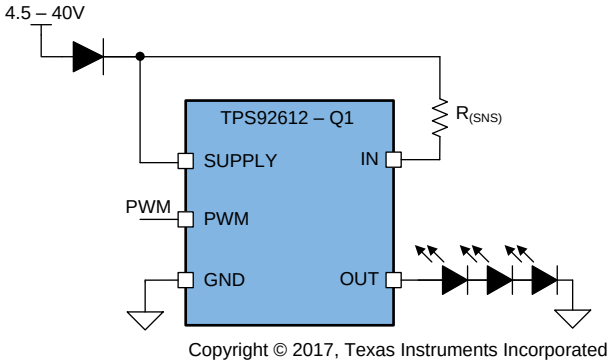


Figure 19. Typical Application Diagram

8.2.1.1 Design Requirements

Input voltage range 9 V to 16 V, LED maximum forward voltage V_{fmax} = 2.5 V, minimum forward voltage V_{fmin} = 1.9 V, current $I_{(LED)}$ = 50 mA.

8.2.1.2 Detailed Design Procedure

Current setting by the sense resistor is as described in Equation 1.

$$R_{(SNS)} = \frac{R_{(CS_REG)}}{I_{(LED)}} = 1.96\ \Omega \tag{2}$$

LED-string maximum forward voltage = 3 × 2.5 V = 7.5 V.

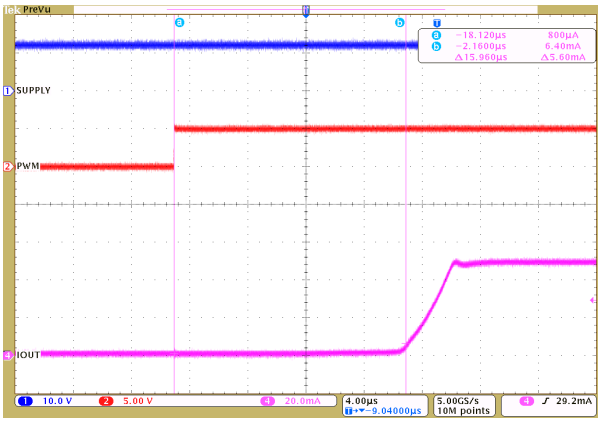
Total device power consumption at worst case is with 16-V input and LEDs at minimal forward voltage.

$$\begin{aligned} P_{(Max)} &= (V_{(SUPPLY)} - V_{(CS_REG)} - V_{(OUT)}) \times I_{(LED)} + V_{(SUPPLY)} \times I_{(Quiescent)} \\ &= (16 - 3 \times 1.9 - 0.098) \times 0.05 + 16 \times 0.00025 = 0.5141\ W \end{aligned} \tag{3}$$

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Typical Application (continued)

8.2.1.3 Application Curve

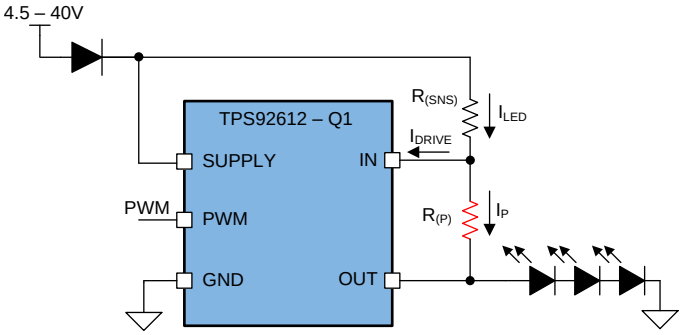


Ch. 1 = $V_{(OUT)}$ Ch. 2 = $V_{(PWM)}$ Ch. 4 = $I_{(OUT)}$

Figure 20. Output Current With PWM Input

8.2.2 Single-Channel LED Driver With Heat Sharing

Using parallel resistors, thermal performance can be improved by balancing current between the TPS92612-Q1 device and the external resistors as follows. As the current-sense resistor controls the total LED string current, the LED string current $I_{(LED)}$ is set by $V_{(CS_REG)}$ / $R_{(SNS)}$, while the TPS92612-Q1 current $I_{(DRIVE)}$ and parallel resistor current $I_{(P)}$ combine to the total current.



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Figure 21. Heat Sharing With a Parallel Resistor

8.2.2.1 Design Requirements

The input voltage range is 9 V to 16 V, LED maximum forward voltage V_{fmax} = 2.5 V, minimum forward voltage V_{fmin} = 1.9 V, current $I_{(LED)}$ = 100 mA.

8.2.2.2 Detailed Design Procedure

In linear LED driver applications, the input voltage variation contributes to most of the thermal concerns. The resistor current, as indicated by Ohm's law, depends on the voltage across the external resistors. The TPS92612-Q1 device controls the driver current $I_{(DRIVE)}$ to attain the desired total current. If $I_{(P)}$ increases, the TPS92612-Q1 device decreases $I_{(DRIVE)}$ to compensate, and vice versa.

While in low-dropout mode, the voltage across the $R_{(P)}$ resistor may be close to zero, so that almost no current can flow through the external resistor $R_{(P)}$.

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Typical Application (continued)

When the input voltage is high, parallel-resistor current $I_{(P)}$ is proportional to the voltage across the parallel resistor, $R_{(P)}$. The parallel resistor, $R_{(P)}$, takes the majority of the total string current, generating maximum heat. The device must prevent current from draining out to ensure current regulation capability.

In this case, the parallel resistor value must be carefully calculated to ensure that 1) enough output current is achieved in low-dropout mode, 2) thermal dissipation for both the TPS92612-Q1 device and the resistor is within their thermal dissipation limits, and 3) device current in the high-voltage mode is above the minimal output-current requirement.

Current setting by the sense resistor is as described in Equation 1.

$$R_{(SNS)} = \frac{V_{(CS_REG)}}{I_{(OUT)}} = 0.98\ \Omega \tag{4}$$

LED-string maximum forward voltage = 3 × 2.5 V = 7.5 V.

Parallel resistor $R_{(P)}$ is recommended to consume 1/2 of the total current at maximum supply voltage.

$$R_{(P)} = \frac{V_{(SUPPLY)} - V_{(CS_REG)} - V_{(OUT)}}{0.5 \times I_{(LED)}} = \frac{16 - 0.098 - 3 \times 1.9}{0.5 \times 0.1} \approx 200\ \Omega \tag{5}$$

Total device power consumption is maximum with 16-V input and LEDs at minimal forward voltage.

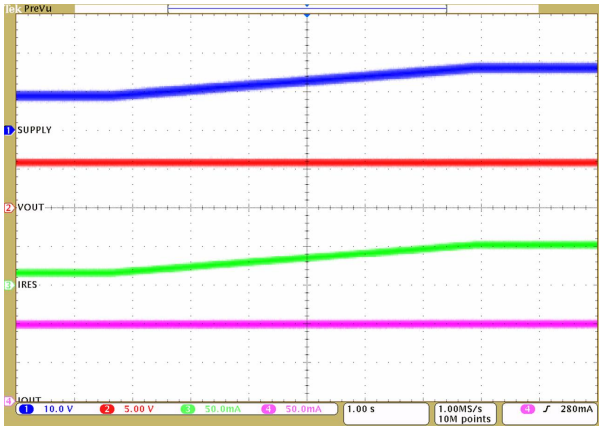
$$P_{(DEV_MAX)} = \left(V_{(SUPPLY)} - V_{(CS_REG)} - V_{(OUT)}\right) \times \left(I_{(LED)} - \frac{V_{(SUPPLY)} - V_{(CS_REG)} - V_{(OUT)}}{R_{(P)}}\right) + V_{(SUPPLY)} \times I_{(Quiescent)}$$

$$= (16 - 0.098 - 3 \times 1.9) \times \left(0.1 - \frac{16 - 0.098 - 3 \times 1.9}{200}\right) + 16 \times 0.00025 = 0.504\ W \tag{6}$$

Resistor $R_{(P)}$ maximum power consumption is at 16-V input.

$$R_{(RP_MAX)} = \frac{\left(V_{(SUPPLY)} - V_{(CS_REG)} - V_{(OUT)}\right)^2}{R_{(P)}} = \frac{(16 - 0.098 - 3 \times 1.9)^2}{200} = 0.52\ W \tag{7}$$

8.2.2.3 Application Curves



Ch. 1 = $V_{(SUPPLY)}$ Ch. 2 = $V_{(OUT)}$ Ch. 3 = $I_{(P)}$
Ch. 4 = $I_{(LED)}$
Supply voltage increases from 9 V to 16 V

Figure 22. Constant Output Current With Increasing Supply Voltage

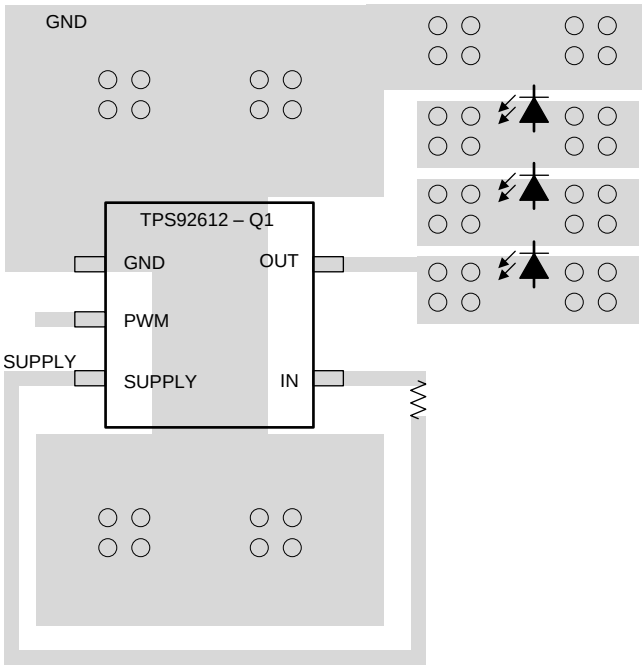
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9 Layout

9.1 Layout Guidelines

Thermal dissipation is the primary consideration for TPS92612-Q1 layout. TI recommends good thermal dissipation area beneath the device for better thermal performance.

9.2 Layout Example



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Figure 23. TPS92612-Q1 Example Layout Diagram

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10 Device and Documentation Support

10.1 Documentation Support

10.1.1 Related Documentation

For related documentation see the following:

- *TPS92610-Q1 Automotive Single-Channel Linear LED Driver*
- *TPS92611-Q1 Automotive Single-Channel Linear LED Driver*
- *TPS92610-Q1 EVM User's Guide*
- *How to Calculate TPS92630-Q1 Maximum Output Current for Automotive Exterior Lighting Applications*
- *Automotive Linear LED Driver Reference Design for Center High-Mounted Stop Lamp (CHMSL)*
- *Automotive Linear LED Driver Reference Design for Center High-Mounted Stop Lamp (CHMSL)*

10.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

10.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

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10.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

10.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

11 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 device. This data is subject to change without notice and without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PTPS92612QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples
TPS92612QDBVRQ1	PREVIEW	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	Call TI	Level-2-260C-1 YEAR	-40 to 125	1J6F	

(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.

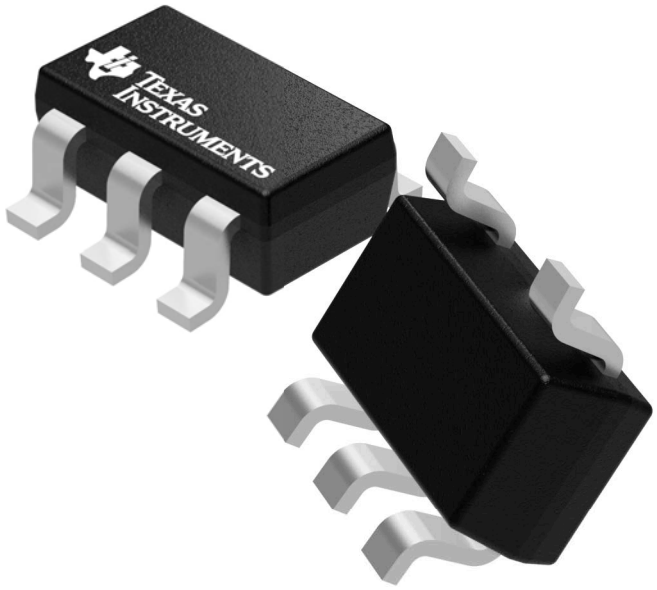
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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DBV 5 SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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