



TPS60151 5V、140mA のチャージ・ポンプ

1 特長

- 2.7V ~ 5.5V の入力電圧範囲
- 固定出力電圧: 5V
- 最大出力電流: 140mA
- スイッチング周波数: 1.5MHz
- 無負荷状態 (スキップ・モード) の静止電流: 90 μ A (標準値)
- 出力逆電流保護
- X2 チャージ・ポンプ
- ハードウェアのイネーブルおよびディセーブル機能
- ソフト・スタート内蔵
- 低電圧誤動作防止保護機能を内蔵
- 熱および過電流保護機能
- 2mm $\times$ 2mm、高さ 0.8mm の 6 ピン SON パッケージ

2 アプリケーション

- USB On the Go (OTG)
- HDMI
- ポータブル通信デバイス
- PCMCIA カード
- 携帯電話、スマートフォン
- ハンドヘルド・メータ

3 概要

TPS60151 は、非安定の入力電圧から低ノイズ、低リップルのレギュレートされた 5V の出力電圧を生成する、スイッチド・キャパシタ方式の電圧コンバータです。 V_{IN} が 5V より高い場合でも、5V のレギュレーションを維持します。

5V 出力は、最小 140mA の電流を供給可能です。

TPS60151 には電流制限および出力逆電流保護が内蔵されているため、HDMI、USB OTG、その他バッテリー駆動のアプリケーションに最適です。

標準の状況で負荷電流が 8mA を下回ると、TPS60151 はスキップ・モードで動作します。スキップ・モード動作では、静止電流が 90 μ A に低減されます。

出力電圧の生成には 3 つの外付けコンデンサしか必要としないため、PCB の面積を削減できます。

ソフト・スタート機能によって、電源オンおよび電力過渡状態時の突入電流が制限されます。

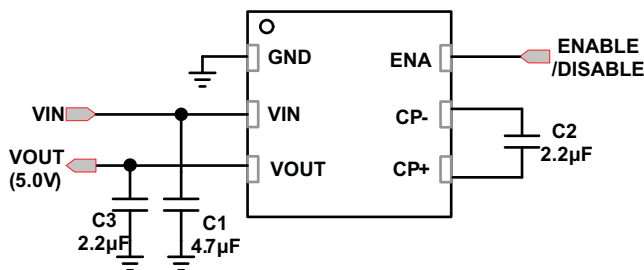
TPS60151 は、-40 $^{\circ}$ C ~ 85 $^{\circ}$ C の自由気流温度範囲で動作します。このデバイスは、小型の 2mm $\times$ 2mm、6 ピンの SON パッケージ (QFN) で供給されます。

製品情報⁽¹⁾

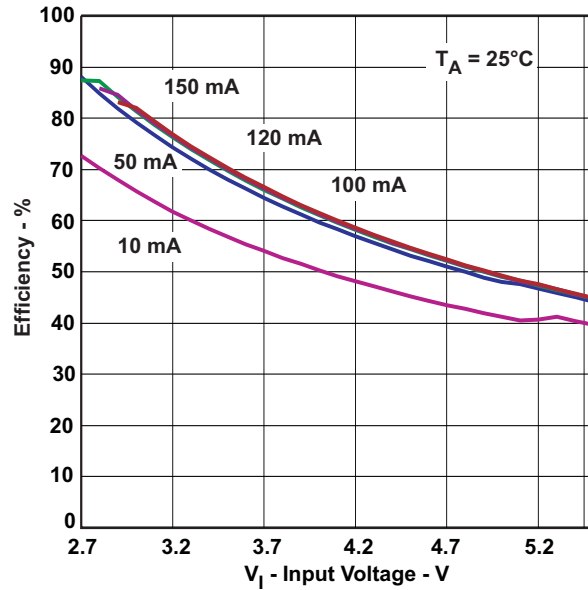
型番	パッケージ	本体サイズ(公称)
TPS60151	WSON (6)	2.00mm $\times$ 2.00mm

(1) 利用可能なすべての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。

代表的なアプリケーションの回路図



効率と入力電圧との関係



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4 改訂履歴

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。

Revision A (October 2015) から Revision B に変更	Page
• Added row for V_{OUT} spec -- $3.1\text{ V} \leq V_{IN} < 5.5\text{ V}$	6
• Added row for $V_{OUT(skip)}$ V spec -- $3.1\text{ V} \leq V_{IN} < 5.5\text{ V}$	6

2009年8月発行のものから更新	Page
• 「ピン構成および機能」セクション、「ESD定格」表、「機能説明」セクション、「デバイスの機能モード」セクション、「アプリケーションと実装」セクション、「電源に関する推奨事項」セクション、「レイアウト」セクション、「デバイスおよびドキュメントのサポート」セクション、「メカニカル、パッケージ、および注文情報」セクション 追加.....	1

TPS60151

JAJS523B – SEPTEMBER 2009 – REVISED JANUARY 2019

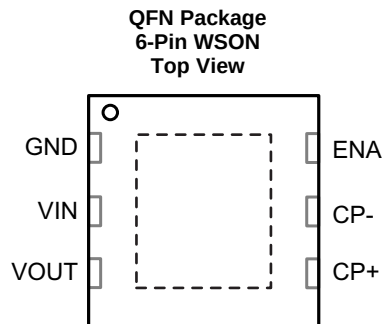
www.ti.com

5 Device Comparison Table

PART NUMBER ⁽¹⁾	OUTPUT VOLTAGE	PACKAGE DESIGNATOR	ORDERING	PACKAGE MARKING
TPS60151	5 V	DRV	TPS60151DRV	OCN

(1) The DRV (2 mm × 2 mm 6-pin SON) package is available in tape on reel. Add R suffix to order quantities of 3000 parts per reel and T suffix to order quantities with 250 parts per reel.

6 Pin Configuration and Functions



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
GND	1	–	Ground
VIN	2	IN	Supply voltage input
VOUT	3	OUT	Output, connect to the output capacitor
CP+	4	–	Connect to the flying capacitor
CP–	5	–	Connect to the flying capacitor
ENA	6	IN	Hardware enable/disable pin (High = Enable)

7 Specifications

7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) ⁽¹⁾

		MIN	MAX	UNIT
V _{IN}	Input voltage (all pins)	−0.3	7	V
T _A	Operating temperature	−40	85	°C
T _J	Maximum operating junction temperature		150	°C
T _{stg}	Storage temperature	−55	150	°C

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

7.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾⁽²⁾	±2000
		Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽³⁾	±500

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) The Human body model (HBM) is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. The testing is done according to JEDECs EIA/JESD22-A114.
(3) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V _{IN}	Input voltage	2.7		5.5	V
T _A	Operating ambient temperature	−40		85	°C
T _J	Operating junction temperature	−40		125	°C
C _{IN}	Input capacitor	2.2			μF
C _{OUT}	Output capacitor	2.2			μF
C _F	Flying capacitor	1.0			μF

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPS60151	UNIT
		DRV (WSN)	
		6 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	69.1	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	79.8	°C/W
R _{θJB}	Junction-to-board thermal resistance	38.6	°C/W
ψ _{JT}	Junction-to-top characterization parameter	1.2	°C/W
ψ _{JB}	Junction-to-board characterization parameter	38.4	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	9.2	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

7.5 Electrical Characteristics

$V_{IN} = 3.6\text{ V}$, $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$, typical values are at $T_A = 25^\circ\text{C}$, $C_1 = C_3 = 2.2\text{ }\mu\text{F}$, $C_2 = 1\text{ }\mu\text{F}$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER STAGE						
V_{IN}	Input voltage range		2.7		5.5	V
V_{UVLO}	Undervoltage lockout threshold			1.9	2.1	V
I_Q	Operating quiescent current	$I_{OUT} = 140\text{ mA}$, Enable = V_{IN}		4.7		mA
I_{Qskip}	Skip mode operating quiescent current	$I_{OUT} = 0\text{ mA}$, Enable = V_{IN} (no switching)		80		μA
		$I_{OUT} = 0\text{ mA}$, Enable = V_{IN} (minimum switching)		90		μA
I_{SD}	Shutdown current	$2.7\text{ V} \leq V_{IN} \leq 5.5\text{ V}$, Enable = 0 V		4	10	μA
V_{OUT}	Output voltage ⁽¹⁾	$I_{OUT} \leq 50\text{ mA}$, $2.7\text{ V} \leq V_{IN} < 5.5\text{ V}$	4.8	5	5.2	V
		$I_{OUT} \leq 50\text{ mA}$, $3.1\text{ V} \leq V_{IN} < 5.5\text{ V}$	4.8	5	5.15	V
$V_{OUT(skip)}$	Skip mode output voltage	$I_{OUT} = 0\text{ mA}$, $2.7\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	$V_{OUT} + 0.1$			V
		$I_{OUT} = 0\text{ mA}$, $3.1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	$V_{OUT} + 0.1$		5.25	V
F_{SW}	Switching frequency			1.5		MHz
t_{SS}	Soft-start time	From the rising edge of enable to 90% output		150		μs
OUTPUT CURRENT						
I_{OUT_nom}	Maximum output current	V_{OUT} remains between 4.8 V and 5.2 V, $3.1\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	120			mA
		$3.3\text{ V} < V_{IN} < 5.5\text{ V}$	140			
I_{OUT_max}	Current limit	$V_{OUT} = 4.5\text{ V}$			500	mA
I_{OUT_short}	Short circuit current ⁽²⁾	$V_{OUT} = 0\text{ V}$		80		mA
RIPPLE VOLTAGE						
V_R	Output ripple voltage	$I_{OUT} = 140\text{ mA}$		30		mV
ENABLE CONTROL						
V_{HI}	Logic high input voltage	$2.7\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	1.3		V_{IN}	V
V_{LI}	Logic low input voltage		-0.2		0.4	V
I_{HI}	Logic high input current				1	μA
I_{LI}	Logic low input current				1	μA
THERMAL SHUTDOWN						
T_{SD}	Shutdown temperature			160		$^\circ\text{C}$
T_{RC}	Shutdown recovery			140		$^\circ\text{C}$

(1) When in skip mode, output voltage can exceed V_{OUT} spec because $V_{OUT(skip)} = V_{OUT} + 0.1$.

(2) TPS60151 has internal protection circuit to protect IC when V_{OUT} shorted to GND.

7.6 Typical Characteristics

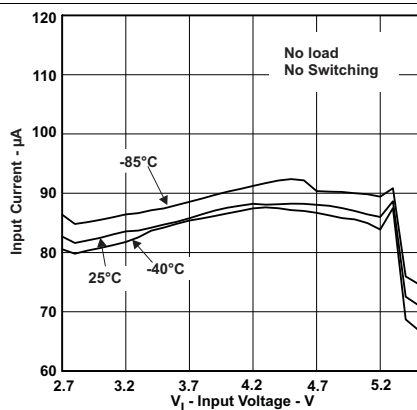


Figure 1. Quiescent Current vs Input Voltage

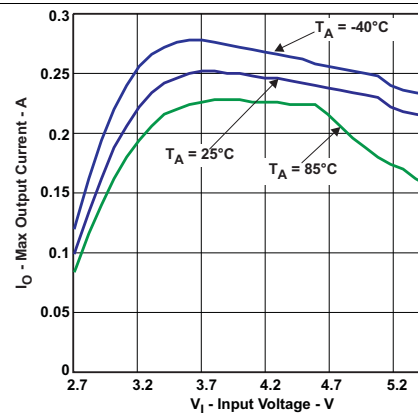


Figure 2. Maximum Output Current vs Input Voltage at Temperature

8 Detailed Description

8.1 Overview

The TPS60151, regulated charge pump, provides a regulated output voltage for various input voltages. The TPS60151 regulates the voltage across the flying capacitor to 2.5 V and controls the voltage drop of Q1 and Q2 while a conversion clock with 50% duty cycle drives the FETs.

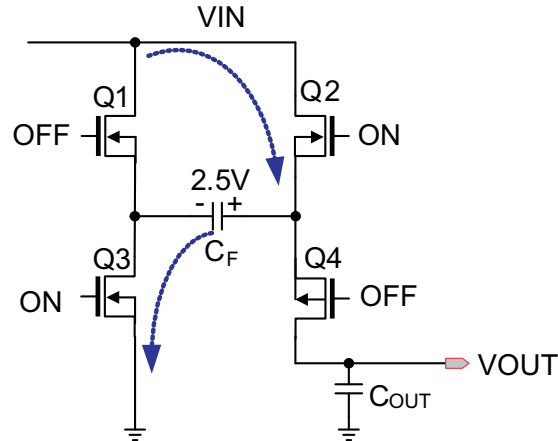


Figure 3. Charging Mode

During the first half cycle, Q2 and Q3 transistors are turned on and flying capacitor, C_F , will be charged to 2.5 V ideally.

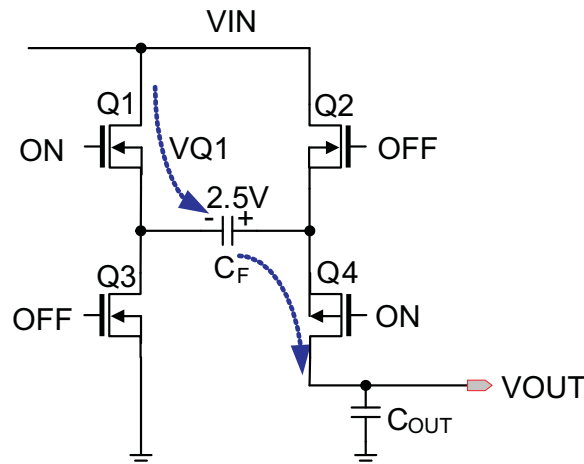


Figure 4. Discharging Mode

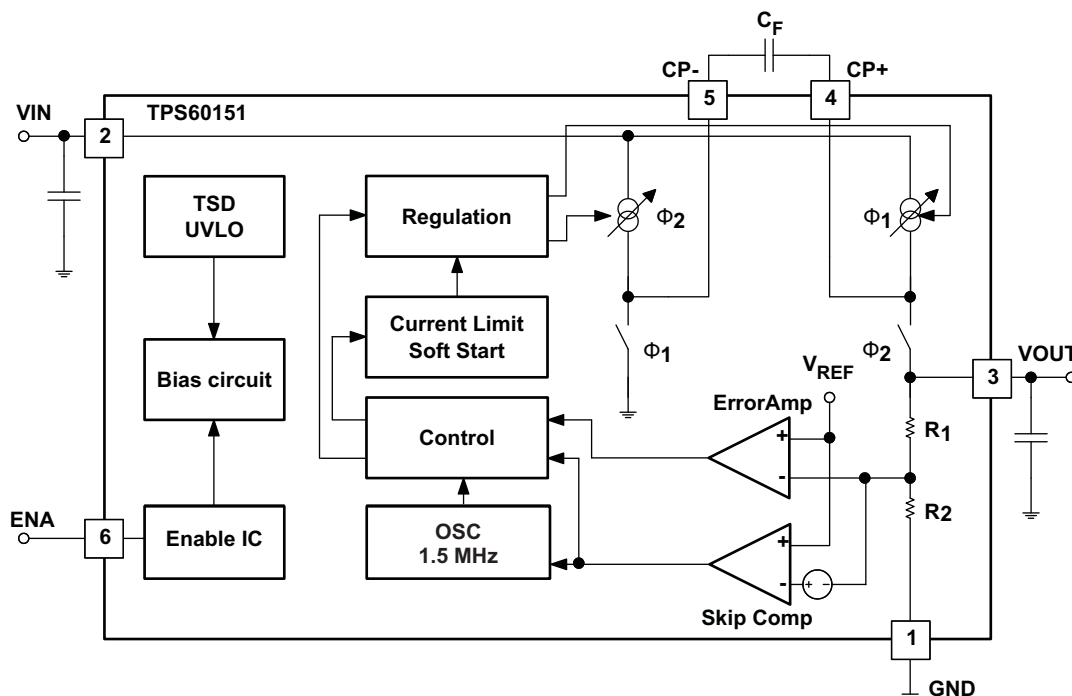
During the second half cycle, Q1 and Q4 transistors are turned on. Capacitor C_F will then be discharged to output.

The output voltage can be calculated as follows:

$$V_{out} = V_{IN} - V_{Q1} + V(C_F) - V_{Q4} = V_{IN} - V_{Q1} + 2.5 \text{ V} - V_{Q4} = 5 \text{ V. (Ideal)} \quad (1)$$

The output voltage is regulated by output feedback and an internally compensated voltage control loop.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Enable

An enable pin on the regulator is used to place the device into an energy-saving shutdown mode. In this mode, the output is disconnected from the input and the input quiescent current is reduced to 10 μ A maximum.

8.3.2 Output Reverse Current Protection

Applications like HDMI or USB OTG generally do not tolerate output reverse current that can drain power from connected devices. Special considerations were put in place to prevent that from happening. [Figure 5](#) is a testing circuit; and, [Figure 6](#) shows reverse current protection test results under various conditions.

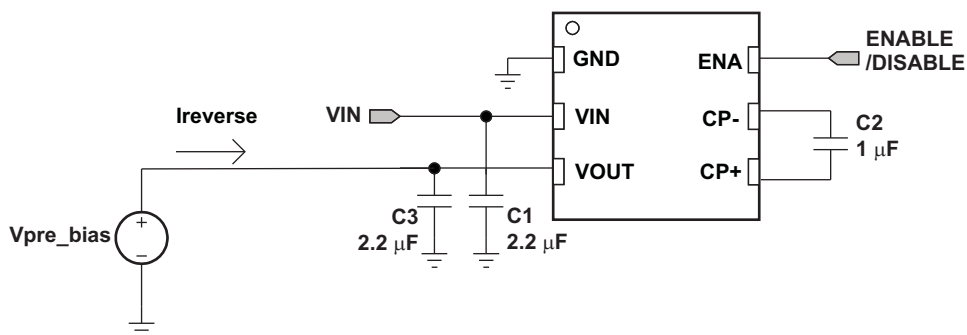


Figure 5. Output Reverse Current Test Setup

Feature Description (continued)

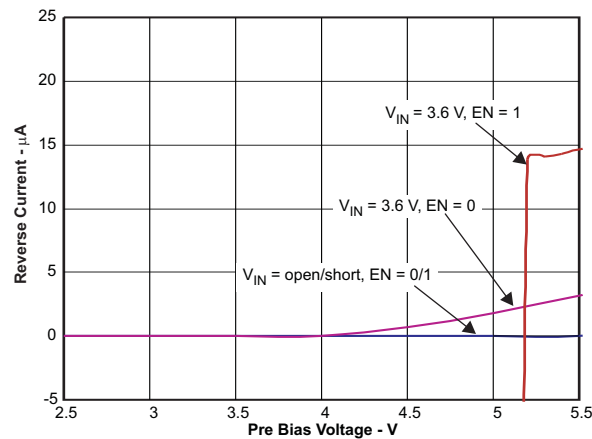


Figure 6. Reverse Current Test Results (Typical)

8.3.3 Undervoltage Lockout

When the input voltage drops, the undervoltage lockout prevents misoperation by switching off the device. The converter starts operation again when the input voltage exceeds the threshold, provided the enable pin is high.

8.3.4 Thermal Shutdown Protection

The regulator has thermal shutdown circuitry that protects it from damage caused by overload conditions. The thermal protection circuitry disables the output when the junction temperature reached approximately 160°C, allowing the device to cool. When the junction temperature cools to approximately 140°C, the output circuitry is automatically re-enabled. Continuously running the regulator into thermal shutdown can degrade reliability. The regulator also provides current limit to protect itself and the load.

8.4 Device Functional Modes

8.4.1 Soft Start

An internal soft start limits the inrush current when the device is being enabled.

Device Functional Modes (continued)

8.4.2 Normal Mode and Skip Mode Operation

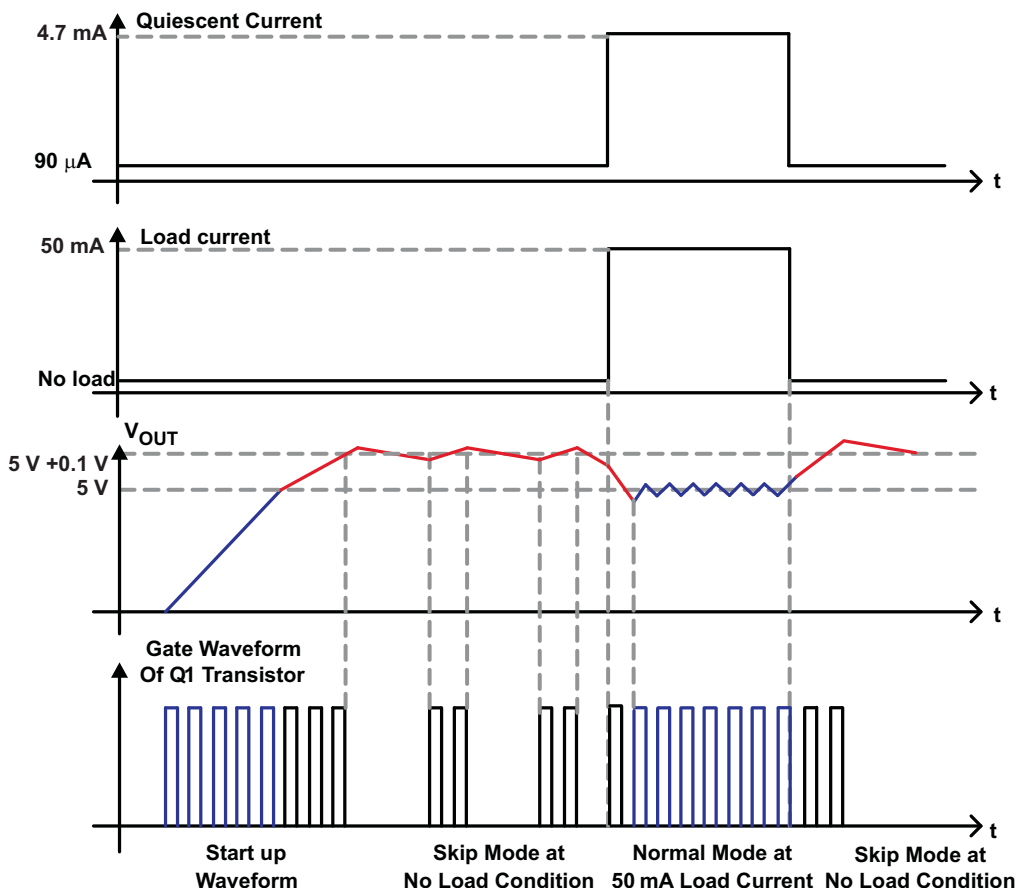


Figure 7. Normal Mode and Skip Mode Operation

The TPS60151 has skip mode operation as shown in Figure 7. The TPS60151 enters skip mode if the output voltage reaches $5\text{ V} + 0.1\text{ V}$ and the load current is below 8 mA (typical). In skip mode, the TPS60151 disables the oscillator and decreases the pre-bias current of the output stage to reduce the power consumption. Once the output voltage dips below threshold voltage, $5\text{ V} + 0.1\text{ V}$, the TPS60151 begins switching to increase output voltage until the output reaches $5\text{ V} + 0.1\text{ V}$. When the output voltage dips below 5 V , the TPS60151 returns to normal pulse width modulation (PWM) mode; thereby re-enabling the oscillator and increasing the pre-bias current of the output stage to supply output current.

The skip threshold voltage and current depend on input voltage and output current conditions.

8.4.3 Over-current Protection and Short-Circuit Protection

The TPS60151 has internal short circuit protection to protect the IC when the output is over loaded or shorted to ground. Figure 8 illustrates the protection circuit. I_P is directly related to I_{OUT} and the maximum I_P is clamped by $IR3 \cdot k \cdot n$. The TPS60151 ensures a current limit of 500 mA or less which is mandated by the HDMI electrical specification. To further avoid damage when output is shorted to ground, the short circuit protection circuitry senses the output voltage and adjusts V_{bias} down to clamp the maximum output current to a lower value –80 mA (typical).

Device Functional Modes (continued)

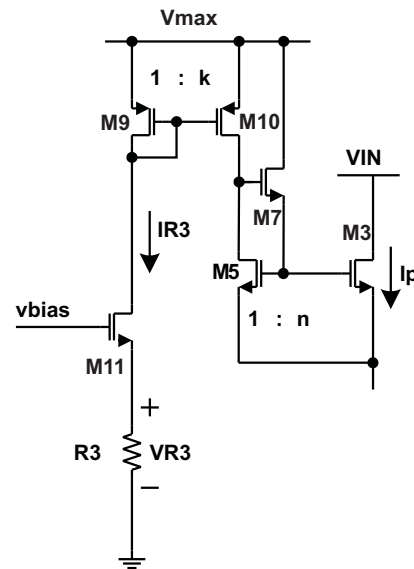


Figure 8. Current Limit

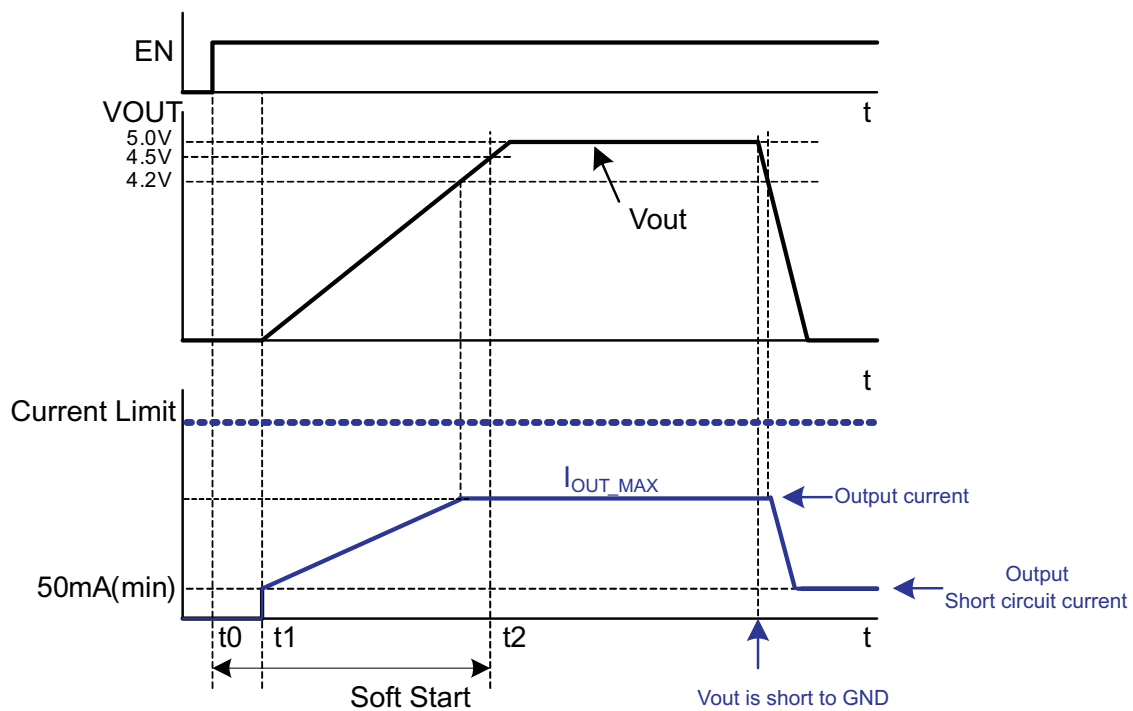


Figure 9. Maximum Output Current Capability and Short Circuit Protection

9 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.

9.1 Application Information

Most of today's battery-powered portable electronics allow and/or require data transfer with a PC. One of the fastest data transfer protocols is via USB OTG. As Figure 10 shows, the USB OTG circuitry in the portable device requires a 5-V power rail and up to 140mA of current. The HDMI specification calls for a 5-V power rail that can source 55mA or more current. The TPS60151 may be used to provide a 5-V power rail in a battery powered system.

Alternatively, low-cost portable electronics with small LCD displays require a low-cost solution for providing the WLED backlight. As shown in Figure 26, the TPS60151 can also be used to drive several WLEDs in parallel, with the help of ballast resistors.

9.2 Typical Application

Figure 10 shows USB OTG circuitry.

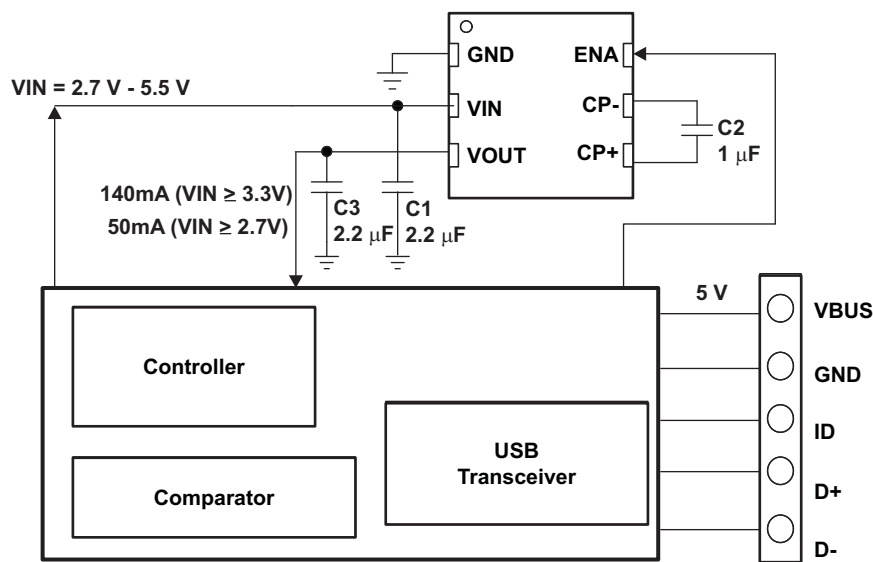


Figure 10. Application Circuit for OTG System

9.2.1 Design Requirements

The design guideline provides a component selection to operate the device within the recommended operating conditions.

9.2.2 Detailed Design Procedure

9.2.2.1 Capacitor Selection

For minimum output voltage ripple, the output capacitor (C_{OUT}) should be a surface-mount ceramic capacitor. Tantalum capacitors generally have a higher effective series resistance (ESR) and may contribute to higher output voltage ripple. Leaded capacitors also increase ripple due to the higher inductance of the package itself. To achieve the best operation with low input voltage and high load current, the input and flying capacitors (C_{IN} and C_{FLY} , respectively) should also be surface-mount ceramic types.

Typical Application (continued)

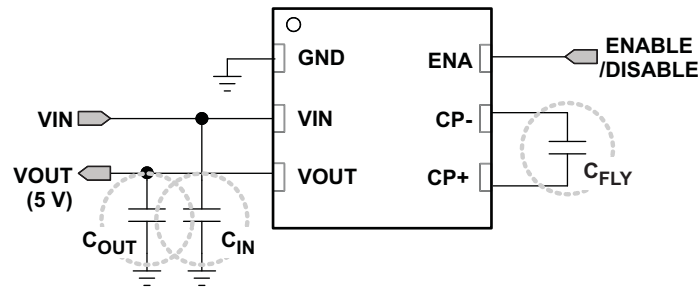


Figure 11. Capacitors

Generally, C_{FLY} can be calculated by the following simple equation,

$$Q_{\text{charging}} = C \times V = C_{FLY} \times \Delta V_{CFLY},$$

$$Q_{\text{discharging}} = i_{\text{discharge}} \times t = 2 \times I_{\text{LOAD(MAX)}} \times \left(\frac{T}{2}\right), \text{ half duty.} \quad (2)$$

Both equation should be same, $\therefore 2 \times I_{\text{LOAD(MAX)}} \times \left(\frac{T}{2}\right) = C_{FLY} \times \Delta V_{CFLY}$

$$\therefore C_{FLY} \geq \frac{2 \times I_{\text{LOAD(MAX)}} \times \left(\frac{T}{2}\right)}{\Delta V_{CFLY}} = \frac{I_{\text{LOAD(MAX)}}}{\Delta V_{CFLY} \times f} \quad (3)$$

If $I_{\text{LOAD}} = 140 \text{ mA}$, $f = 1.5 \text{ MHz}$, and $\Delta V_{CFLY} = 100 \text{ mV}$, the minimum value of the flying capacitor should be $1 \mu\text{F}$.

Output capacitance, C_{OUT} , is also strongly related to output ripple voltage and loop stability,

$$V_{\text{OUT(RIPPLE)}} = \frac{I_{\text{LOAD(MAX)}}}{(2 \times f \times C_{\text{OUT}})} + 2I_{\text{LOAD(MAX)}} \times \text{ESR}_{\text{COUT}} \quad (4)$$

The minimum output capacitance for all output levels is $2.2 \mu\text{F}$ due to control stability. Larger ceramic capacitors or low ESR capacitors can be used to lower the output ripple voltage.

Table 1. Suggested Capacitors (Input / Output / Flying Capacitor)

VALUE	DIELECTRIC MATERIAL	PACKAGE SIZE	RATED VOLTAGE
4.7 μF	X5R or X7R	0603	10 V
2.2 μF	X5R or X7R	0603	10 V

The efficiency of the charge pump regulator varies with the output voltage, the applied input voltage and the load current.

The approximate efficiency in normal operating mode is given by:

$$\text{Efficiency(\%)} = \frac{\text{PD(out)}}{\text{PD(in)}} \times 100 = \frac{V_{\text{OUT}} \times I_{\text{OUT}}}{V_{\text{IN}} \times I_{\text{IN}}} \times 100, I_{\text{IN}} = 2 \times I_{\text{OUT}} + I_{\text{Q}} \quad (5)$$

$$\text{Efficiency(\%)} = \frac{V_{\text{OUT}}}{2 \times V_{\text{IN}}} \times 100 (I_{\text{IN}} = 2 \times I_{\text{OUT}}) \quad \text{Quiescent current was neglected.} \quad (6)$$

9.2.3 Application Curves

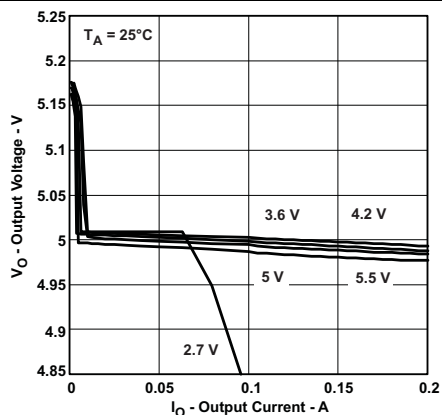


Figure 12. Output Voltage vs Output Current

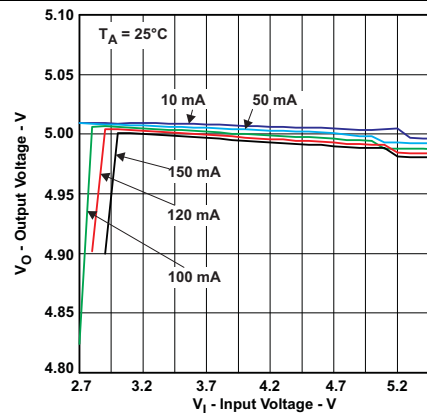


Figure 13. Output Voltage vs Input Voltage

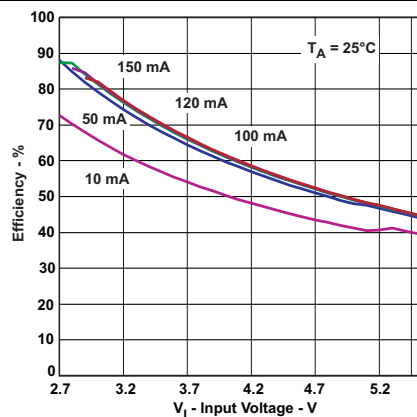


Figure 14. Efficiency vs Input Voltage

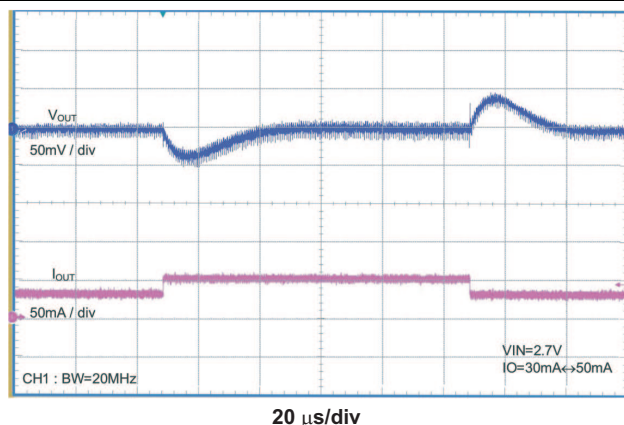


Figure 15. Load Transient Response
 $V_{IN} = 2.7 \text{ V}$, $I_O = 30 \text{ mA}$ to 50 mA

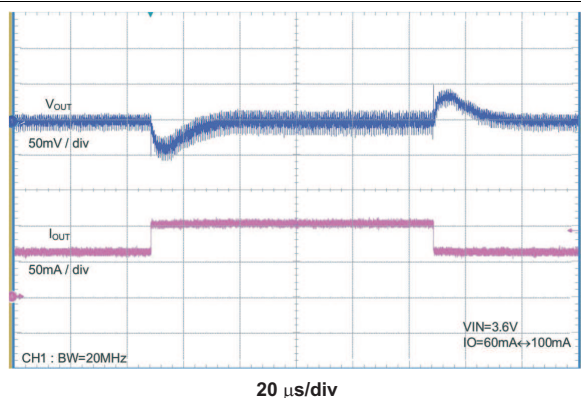


Figure 16. Load Transient Response
 $V_{IN} = 3.6 \text{ V}$, $I_O = 60 \text{ mA}$ to 100 mA

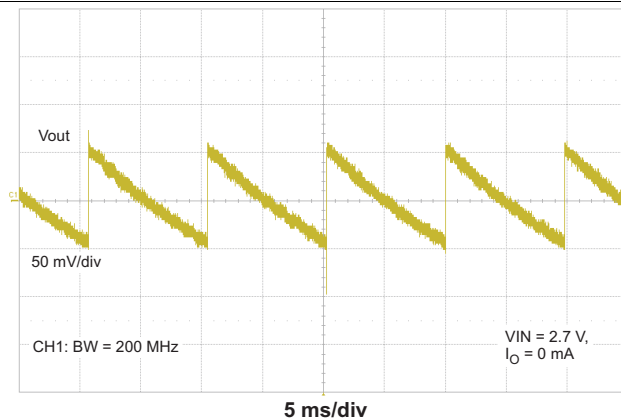


Figure 17. Output Ripple
 $V_{CC} = 2.7 \text{ V}$, $I_O = 0 \text{ mA}$

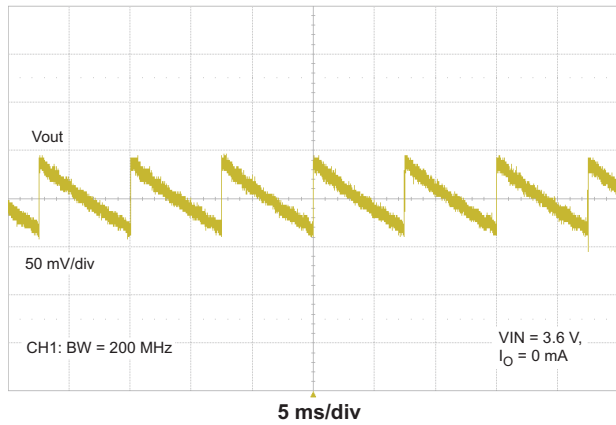


Figure 18. Load Transient
V_{CC} = 3.6 V, I_o = 0 mA

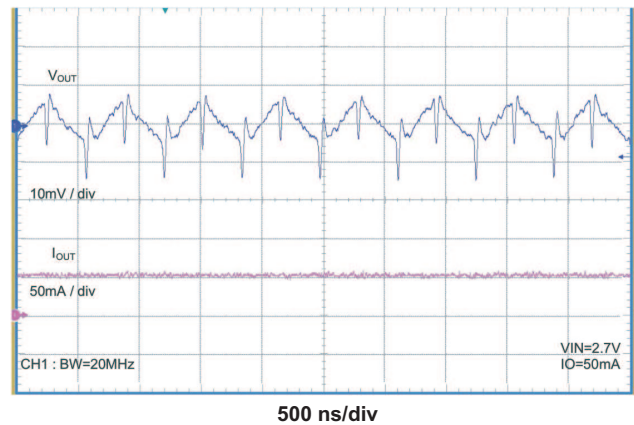


Figure 19. Output Ripple Voltage (Normal Mode)
V_{IN} = 2.7 V, I_o = 50 mA

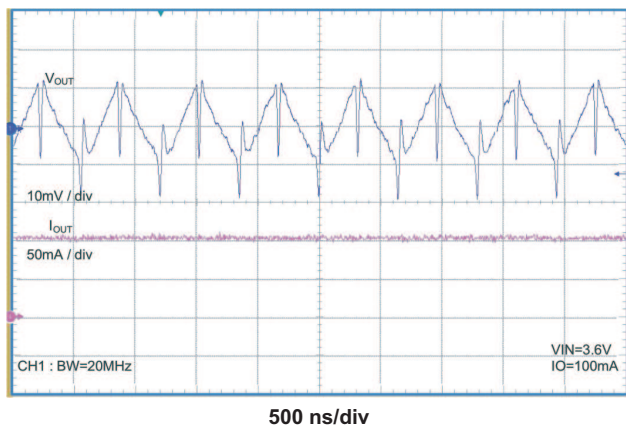


Figure 20. Output Ripple (Normal Mode)
V_{IN} = 3.6 V, I_o = 100 mA

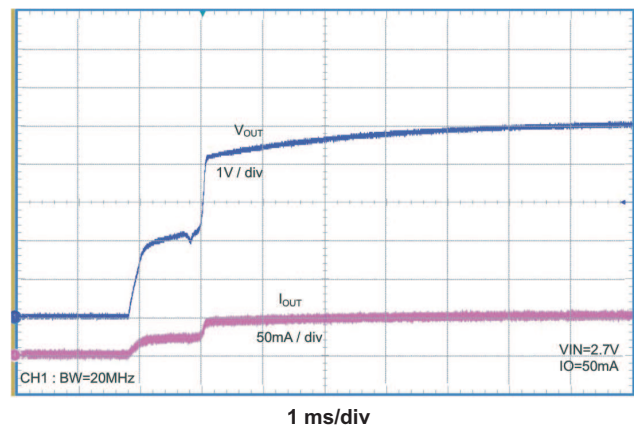


Figure 21. Power On
V_{IN} = 2.7 V, I_o = 50 mA

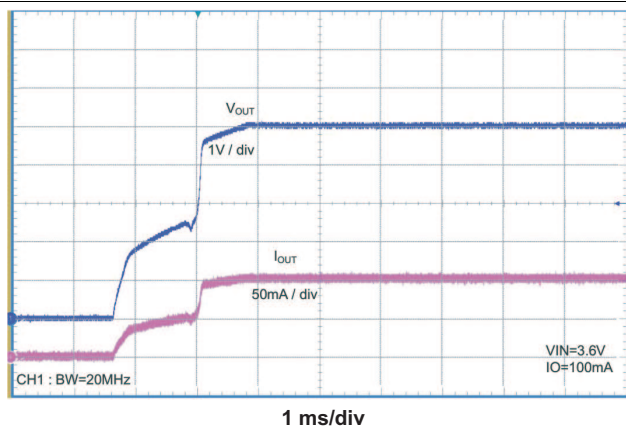


Figure 22. Power On
V_{IN} = 3.6 V, I_o = 100 mA

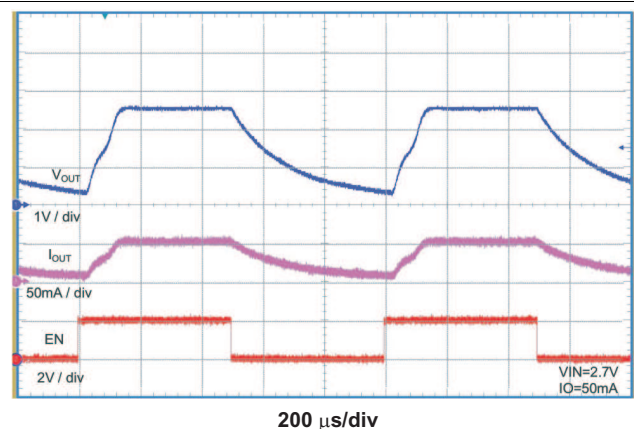
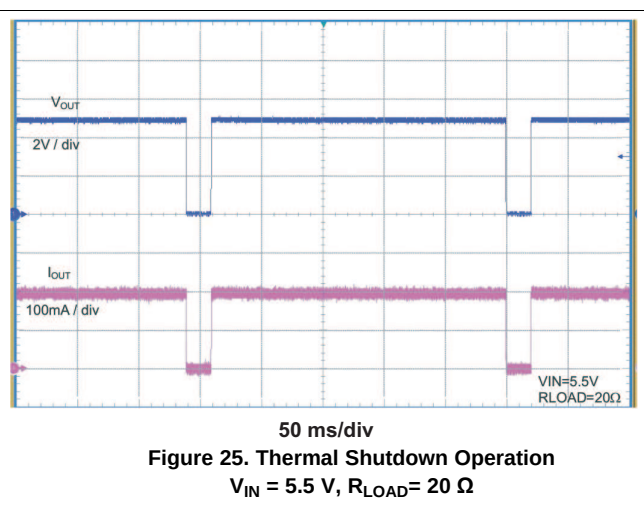
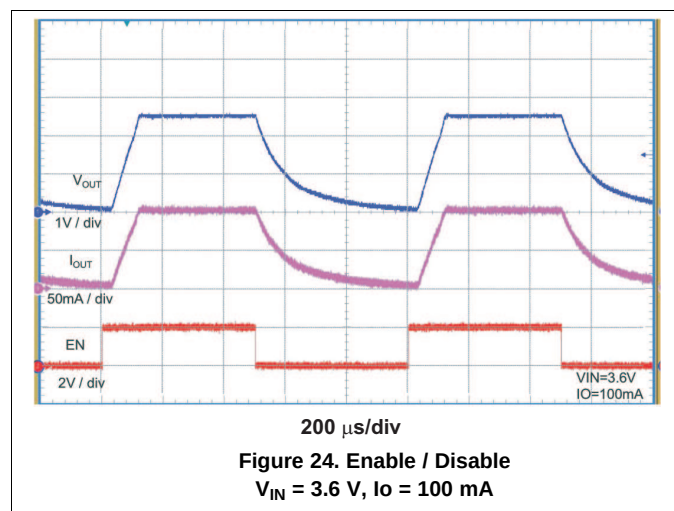
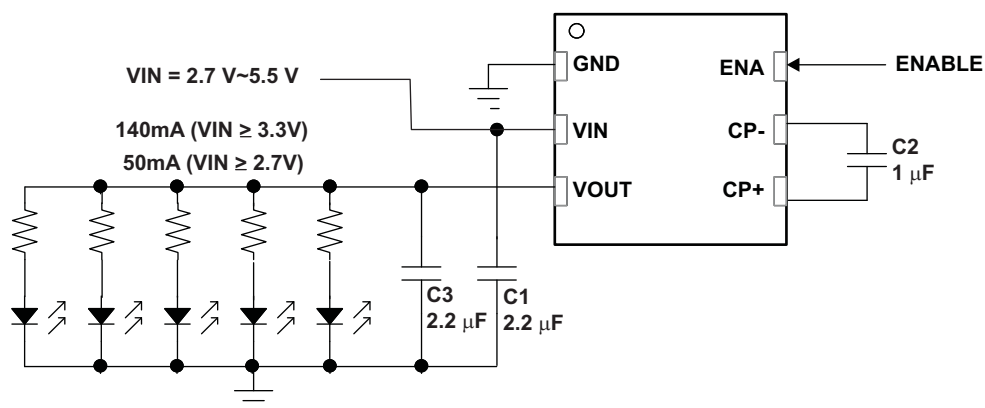


Figure 23. Enable / Disable
V_{IN} = 2.7 V, I_o = 50 mA



9.3 System Example

9.3.1 Circuit for Driving White LEDs



10 Power Supply Recommendations

The TPS60151 has no special requirements for its input power supply. The input power supply's output current needs to be rated according to the supply voltage, output voltage and output current of the TPS60151.

11 Layout

11.1 Layout Guidelines

Large transient currents flow in the VIN, VOUT, and GND traces. To minimize both input and output ripple, keep the capacitors as close as possible to the regulator using short, direct circuit traces.

11.2 Layout Example

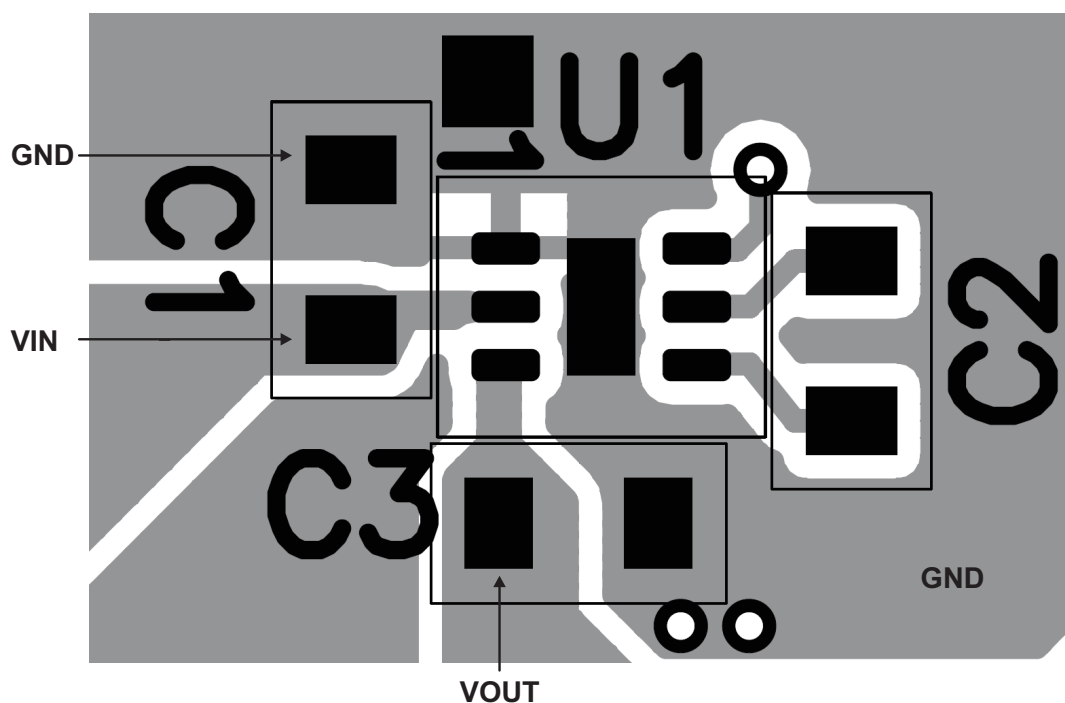


Figure 27. Recommended PCB Layout

12 デバイスおよびドキュメントのサポート

12.1 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。右上の「アラートを受け取る」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。

12.2 コミュニティ・リソース

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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12.5 Glossary

[SLYZ022](#) — TI Glossary.

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

13 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS60151DRVR	Active	Production	WSON (DRV) 6	3000 LARGE T&R	Yes	NIPDAU NIPDAUAG NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVR.A	Active	Production	WSON (DRV) 6	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVR.B	Active	Production	WSON (DRV) 6	3000 LARGE T&R	-	NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVRG4	Active	Production	WSON (DRV) 6	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVRG4.A	Active	Production	WSON (DRV) 6	3000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVVT	Active	Production	WSON (DRV) 6	250 SMALL T&R	Yes	NIPDAU NIPDAUAG NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVVT.A	Active	Production	WSON (DRV) 6	250 SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN

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

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

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

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

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

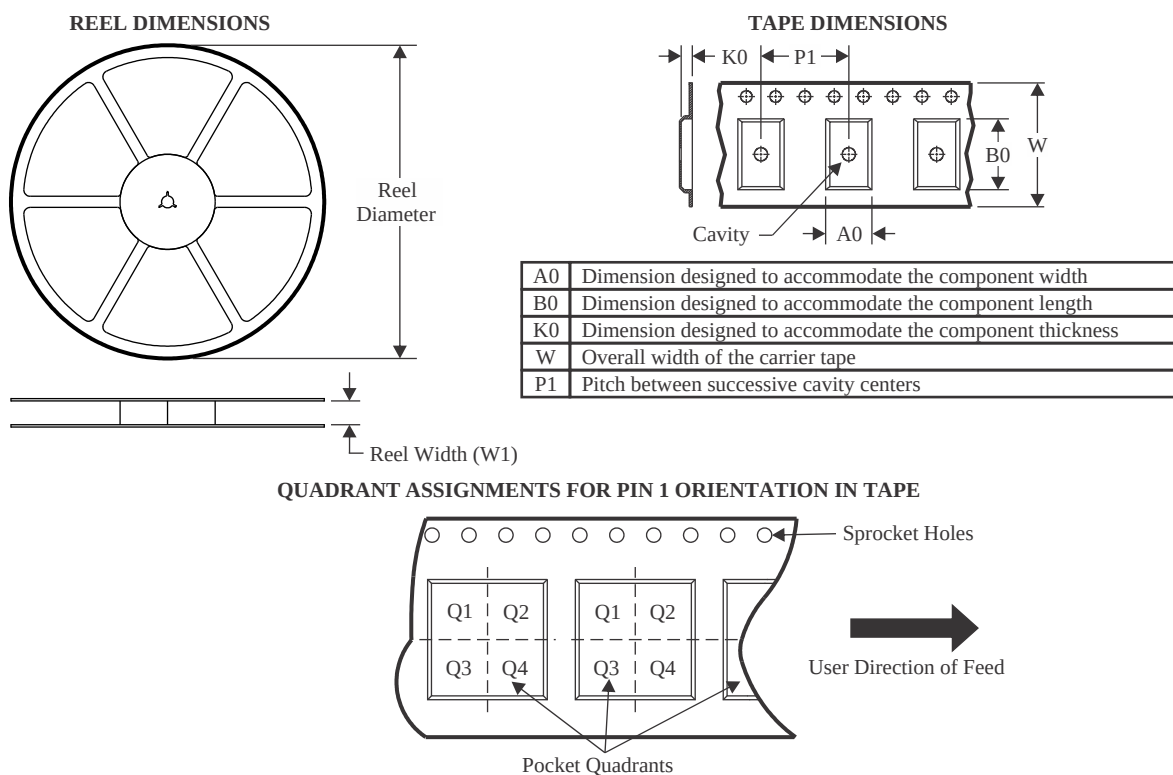
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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

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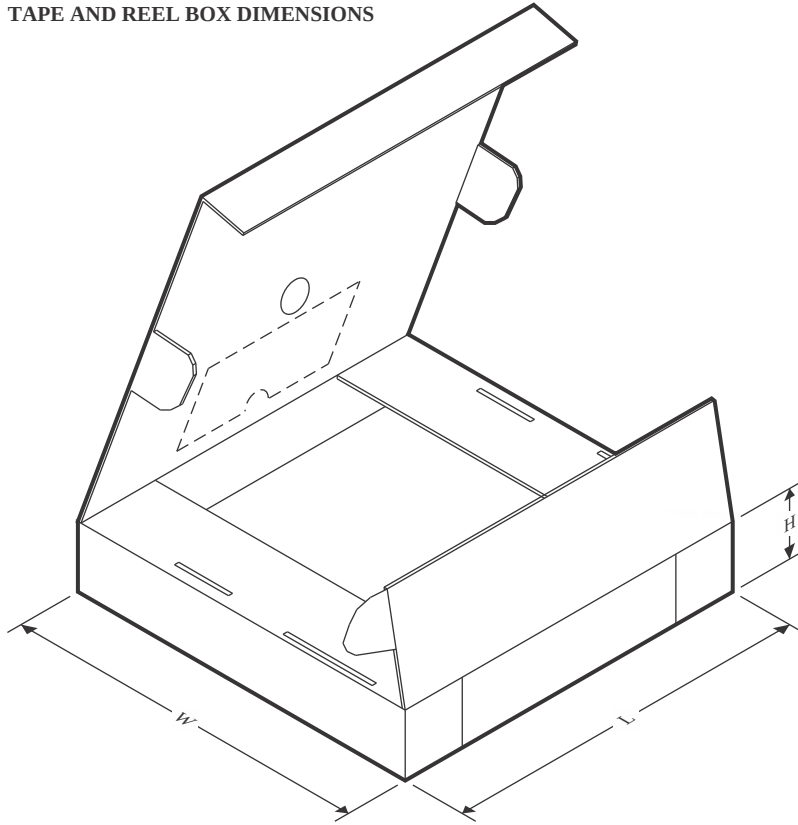
TAPE AND REEL INFORMATION



*All dimensions are nominal

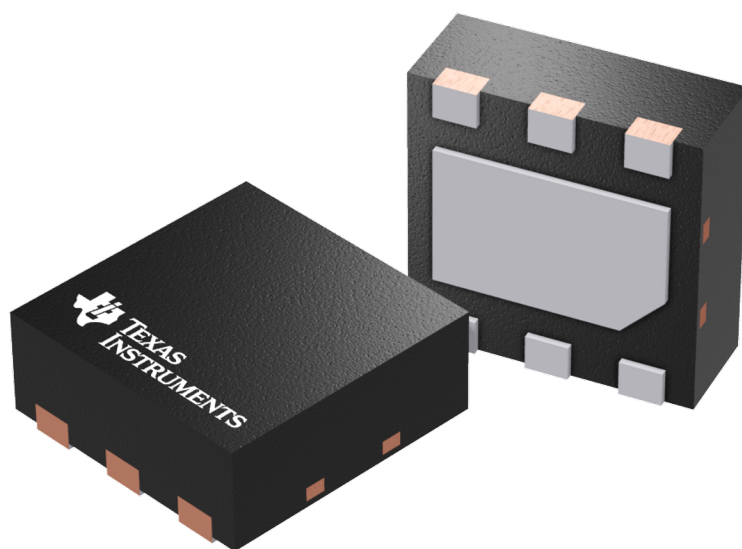
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS60151DRVR	WSO	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRVR	WSO	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRVRG4	WSO	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRV	WSO	DRV	6	250	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS

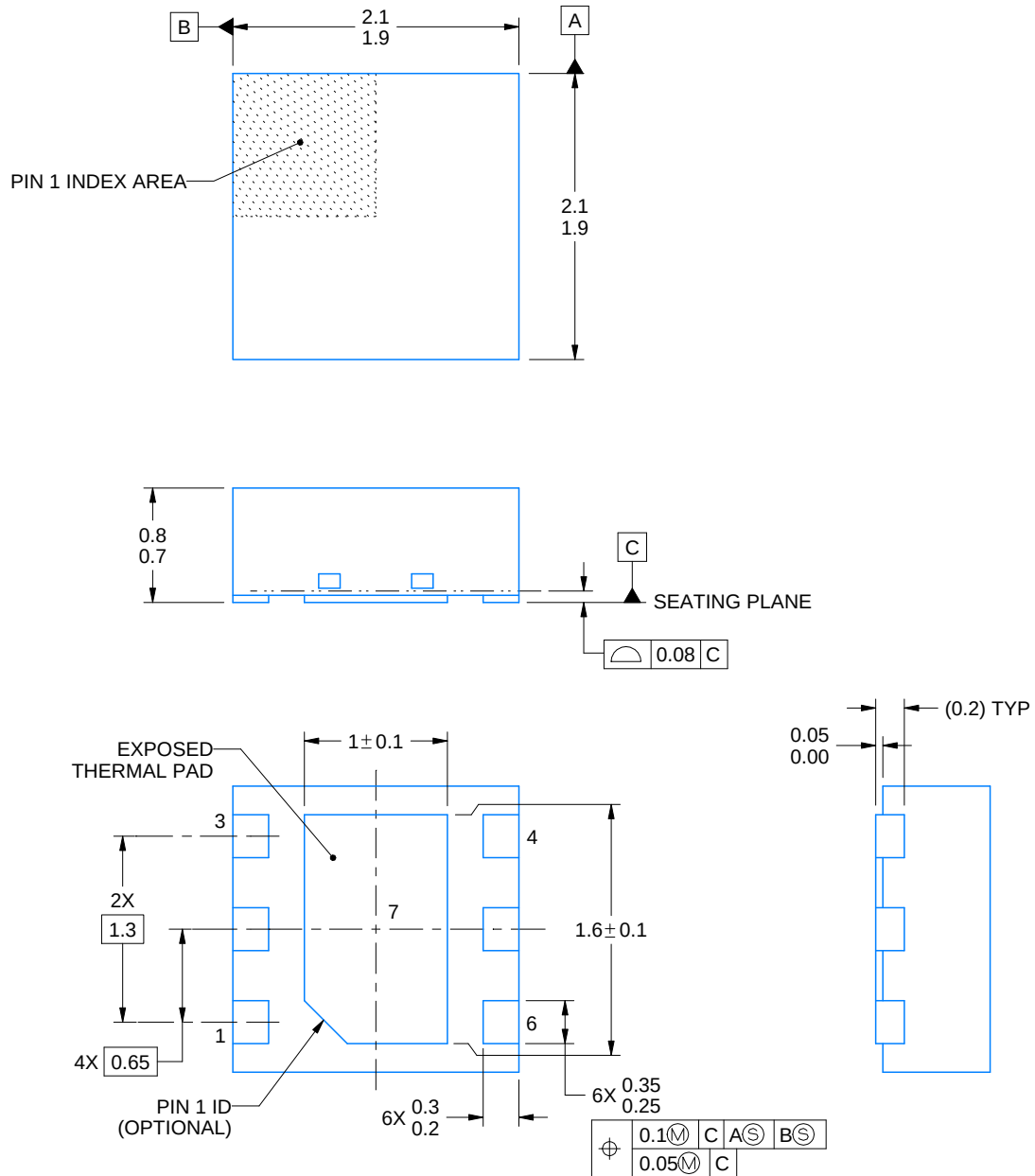
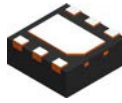


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS60151DRVR	WSN	DRV	6	3000	182.0	182.0	20.0
TPS60151DRVR	WSN	DRV	6	3000	213.0	191.0	35.0
TPS60151DRVRG4	WSN	DRV	6	3000	182.0	182.0	20.0
TPS60151DRVVT	WSN	DRV	6	250	182.0	182.0	20.0



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4222173/B 04/2018

NOTES:

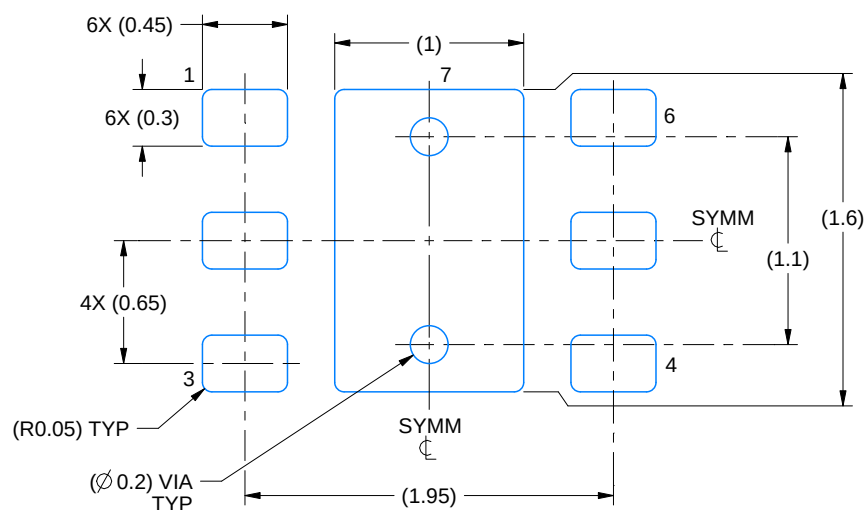
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

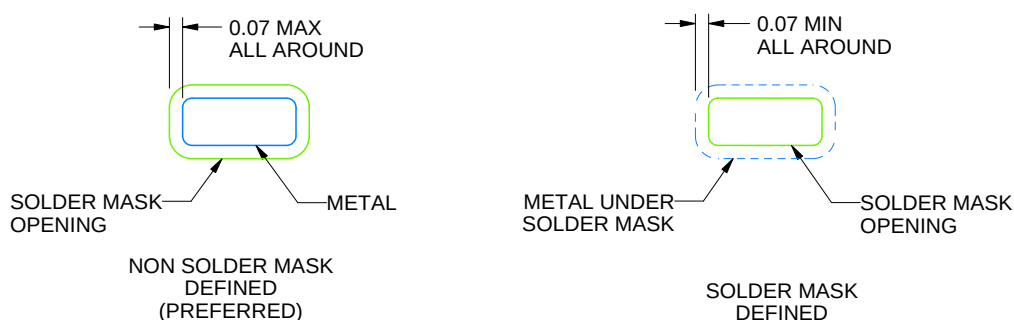
DRV0006A

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
SCALE:25X



SOLDER MASK DETAILS

4222173/B 04/2018

NOTES: (continued)

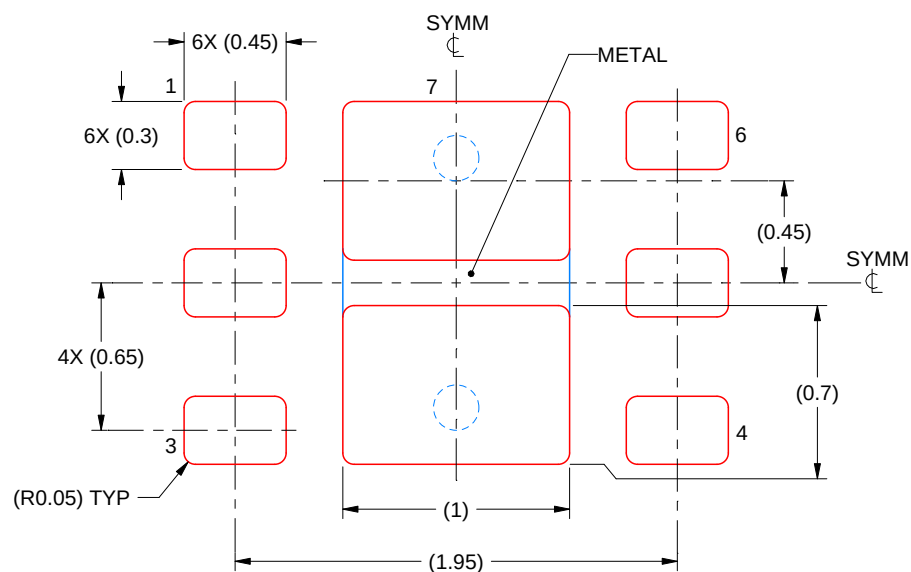
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

EXAMPLE STENCIL DESIGN

DRV0006A

WSO - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:30X

4222173/B 04/2018

NOTES: (continued)

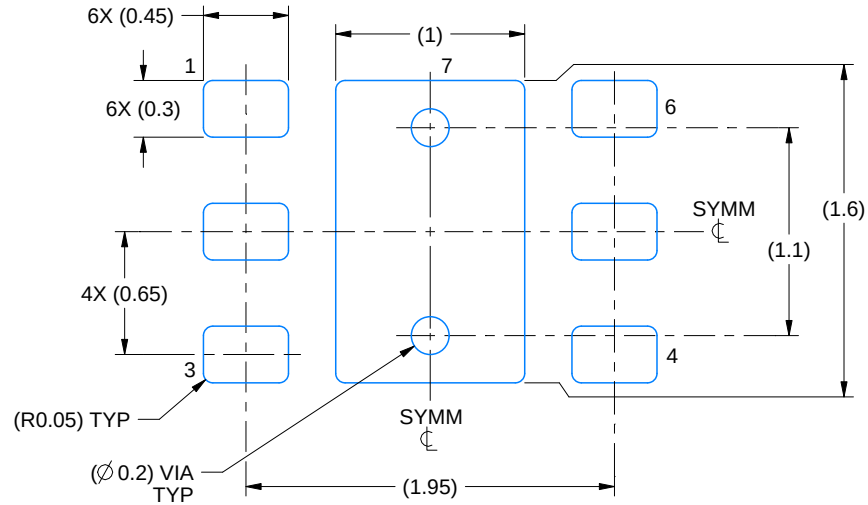
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

EXAMPLE BOARD LAYOUT

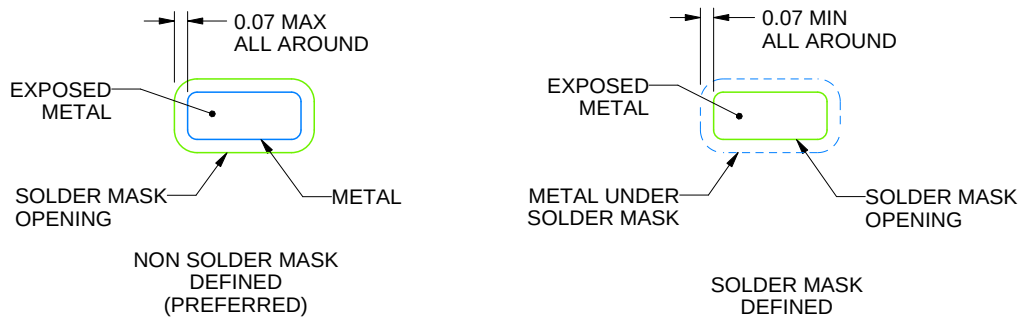
DRV0006D

WSN - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:25X



SOLDER MASK DETAILS

4225563/A 12/2019

NOTES: (continued)

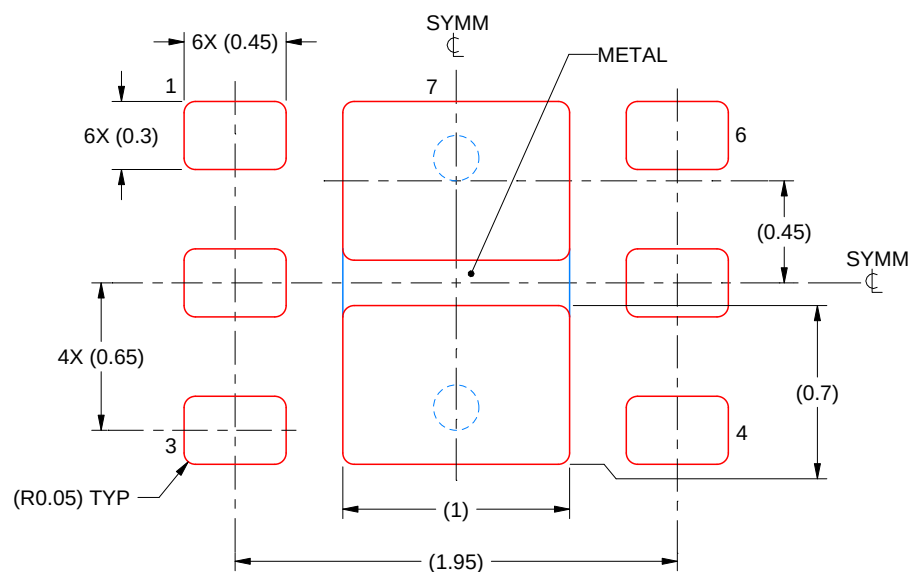
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slue271).
- Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

EXAMPLE STENCIL DESIGN

DRV0006D

WSO - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD #7
88% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:30X

4225563/A 12/2019

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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