TPS60151 5-V and 140-mA Charge Pump

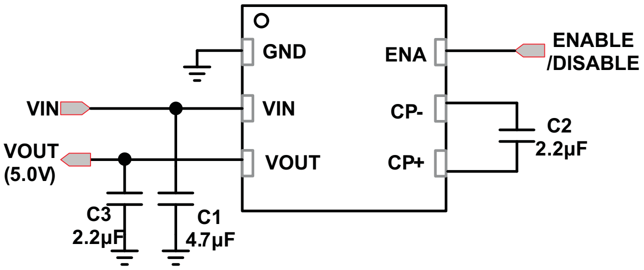
1 Features

- Input Voltage Range 2.7 V to 5.5 V
- Fixed Output Voltage of 5 V
- Maximum Output Current: 140 mA
- 1.5-MHz Switching Frequency
- Typical 90-µA Quiescent Current at No Load Condition (Skip Mode)
- Output Reverse Current Protection
- X2 Charge Pump
- Hardware Enable and Disable Function
- Built-in Soft Start
- Built-in Undervoltage Lockout Protection
- Thermal and Overcurrent Protection
- 2-mm × 2-mm 6-Pin SON-Package with 0.8-mm Height

2 Applications

- USB On the Go (OTG)
- HDMI
- Portable Communication Devices
- PCMCIA Cards
- Mobile Phones, Smart Phones
- Handheld Meters

Typical Application Schematic



3 Description

The TPS60151 is a switched capacitor voltage converter which produces a regulated, low noise, and low-ripple output voltage of 5 V from an unregulated input voltage. It maintains 5-V regulation even when V_{IN} is greater than 5 V.

The 5-V output can supply a minimum of 140-mA current.

The TPS60151 has built-in current limit and output reverse current protection that are ideal for HDMI, USB OTG and other battery powered applications.

TPS60151 operates in skip mode when the load current falls below 8 mA under typical condition. In skip mode operation, quiescent current is reduced to 90 µA.

Only 3 external capacitors are needed to generate the output voltage, thereby saving PCB space.

Inrush current is limited by the soft-start function during power on and power transient states.

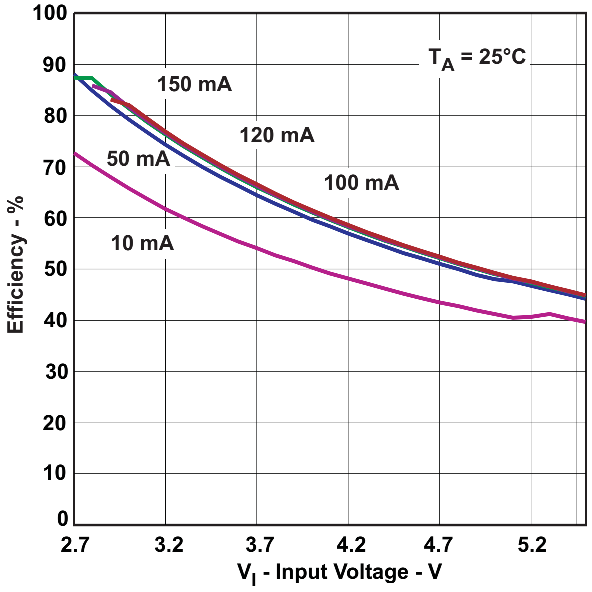
The TPS60151 operates over a free air temperature range of –40°C to 85°C. The device is available with a small 2-mm × 2-mm 6-pin SON package (QFN).

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS60151	WSON (6)	2.00 mm × 2.00 mm

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

Efficiency vs Input Voltage



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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (October 2015) to Revision B **Page**

- Added row for V_{OUT} spec -- 3.1 V ≤ V_{IN} < 5.5V 5
- Added row for $V_{OUT(skip)}$ V spec -- 3.1 V ≤ V_{IN} < 5.5V 5

Changes from Original (August 2009) to Revision A **Page**

- Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1

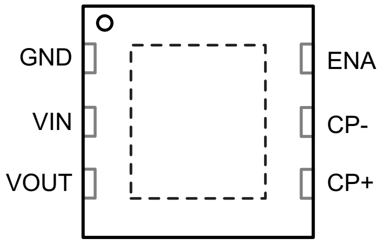
5 Device Comparison Table

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

QFN Package
6-Pin WSON
Top View



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	V
		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 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 (WSON)	
		6 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	69.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	79.8	°C/W
$R_{\theta JB}$	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
$R_{\theta JC(bot)}$	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 V, T_A = –40°C to +85°C, typical values are at T_A = 25°C, C1 = C3 = 2.2 μF, C2 = 1 μF (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 mA, Enable = V_{IN}		4.7		mA
I_{Qskip}	Skip mode operating quiescent current	I_{OUT} = 0 mA, Enable = V_{IN} (no switching)		80		μA
		I_{OUT} = 0 mA, Enable = V_{IN} (minimum switching)		90		μA
I_{SD}	Shutdown current	2.7 V ≤ V_{IN} ≤ 5.5 V, Enable = 0 V		4	10	μA
V_{OUT}	Output voltage(1)	I_{OUT} ≤ 50 mA, 2.7 V ≤ V_{IN} < 5.5V	4.8	5	5.2	V
		I_{OUT} ≤ 50 mA, 3.1 V ≤ V_{IN} < 5.5V	4.8	5	5.15	V
$V_{OUT(skip)}$ V	Skip mode output voltage	I_{OUT} = 0 mA, 2.7 V ≤ V_{IN} ≤ 5.5 V		V_{OUT} + 0.1		V
		I_{OUT} = 0 mA, 3.1 V ≤ V_{IN} ≤ 5.5 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 V ≤ V_{IN} ≤ 5.5 V	120			mA
		3.3 V < V_{IN} < 5.5 V	140			
I_{OUT_max}	Current limit	V_{OUT} = 4.5 V			500	mA
I_{OUT_short}	Short circuit current(2)	V_{OUT} = 0 V		80		mA
RIPPLE VOLTAGE						
V_R	Output ripple voltage	I_{OUT} = 140 mA		30		mV
ENABLE CONTROL						
V_{HI}	Logic high input voltage	2.7 V ≤ V_{IN} ≤ 5.5 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		°C
T_{RC}	Shutdown recovery			140		°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

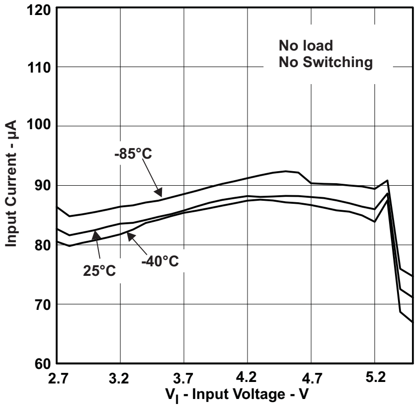


Figure 1. Quiescent Current vs Input Voltage

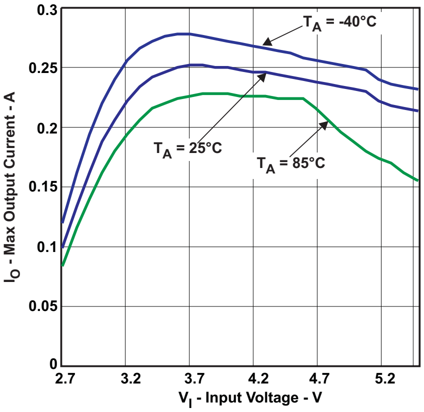


Figure 2. Maximum Output Current vs Input Voltage at Temperature

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.

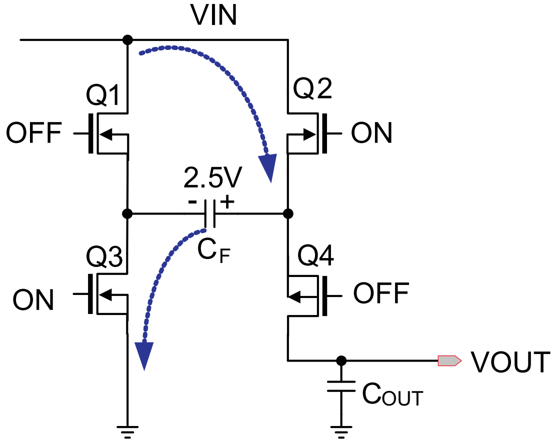


Figure 3. Charging Mode

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.

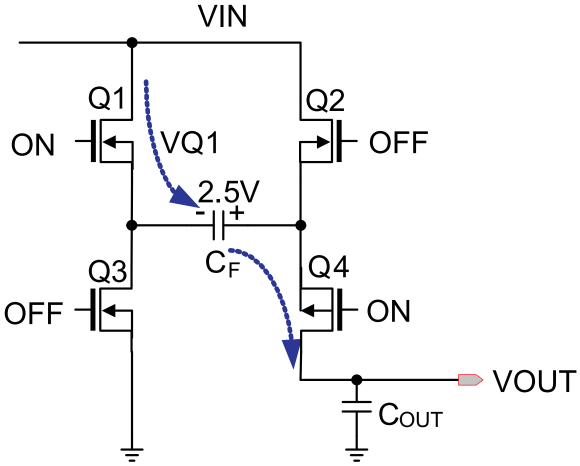


Figure 4. Discharging Mode

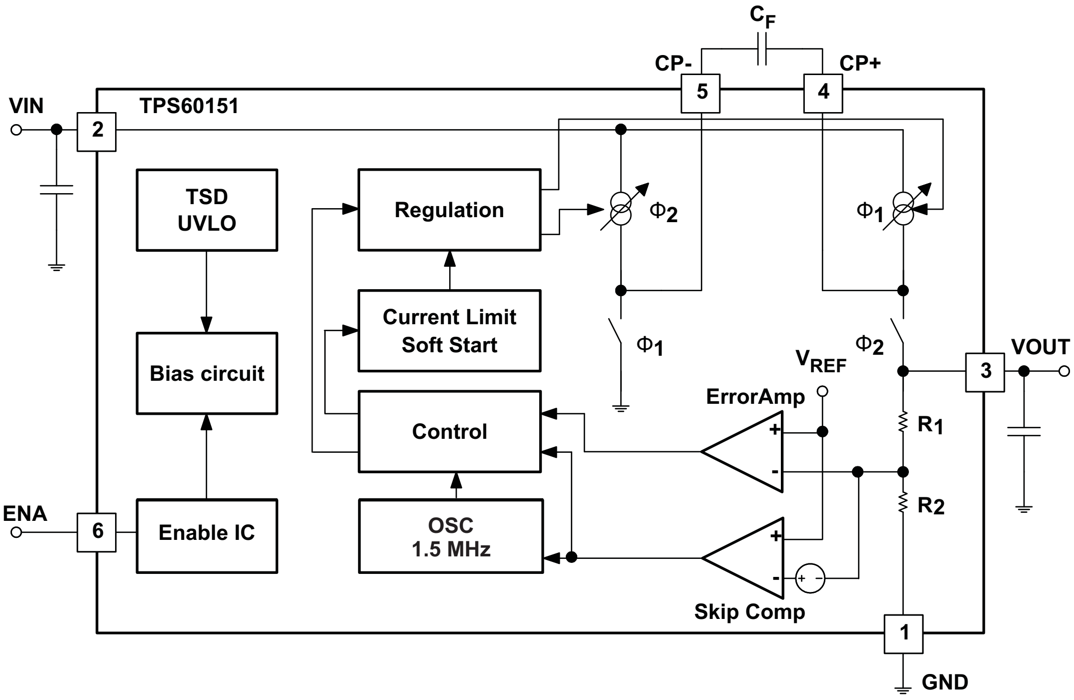
During the second half cycle, Q1 and Q4 transistors are turned on. Capacitor C_F will then be discharged to output.

The output voltage can be calculated as follows:

$$Vout = V_{IN} – VQ1 + V(C_F) - VQ4 = VIN – VQ1 + 2.5\ V - VQ4 = 5\ V.\ (Ideal) \quad (1)$$

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 μA 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.

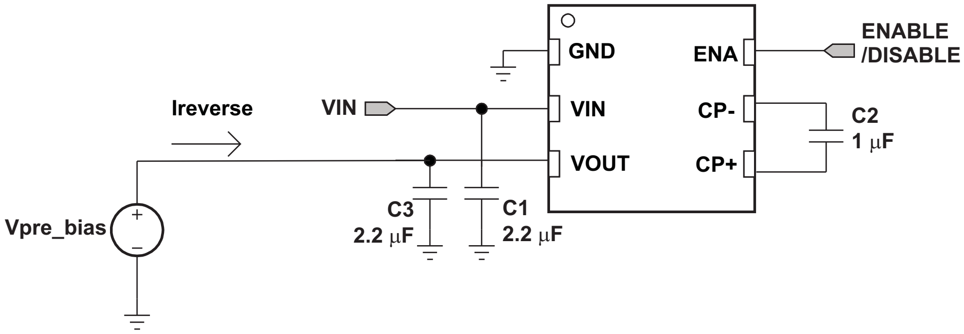


Figure 5. Output Reverse Current Test Setup

Feature Description (continued)

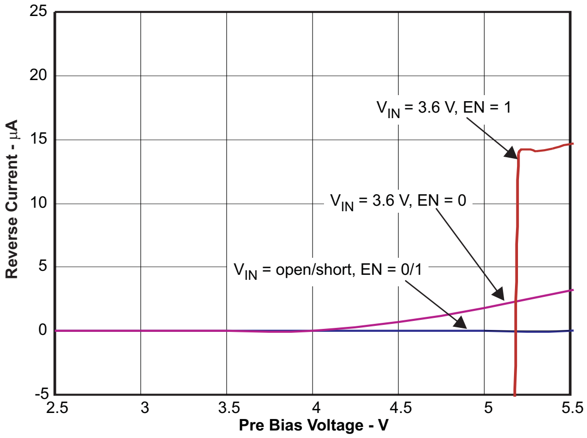


Figure 6. Reverse Current Test Results (Typical)

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

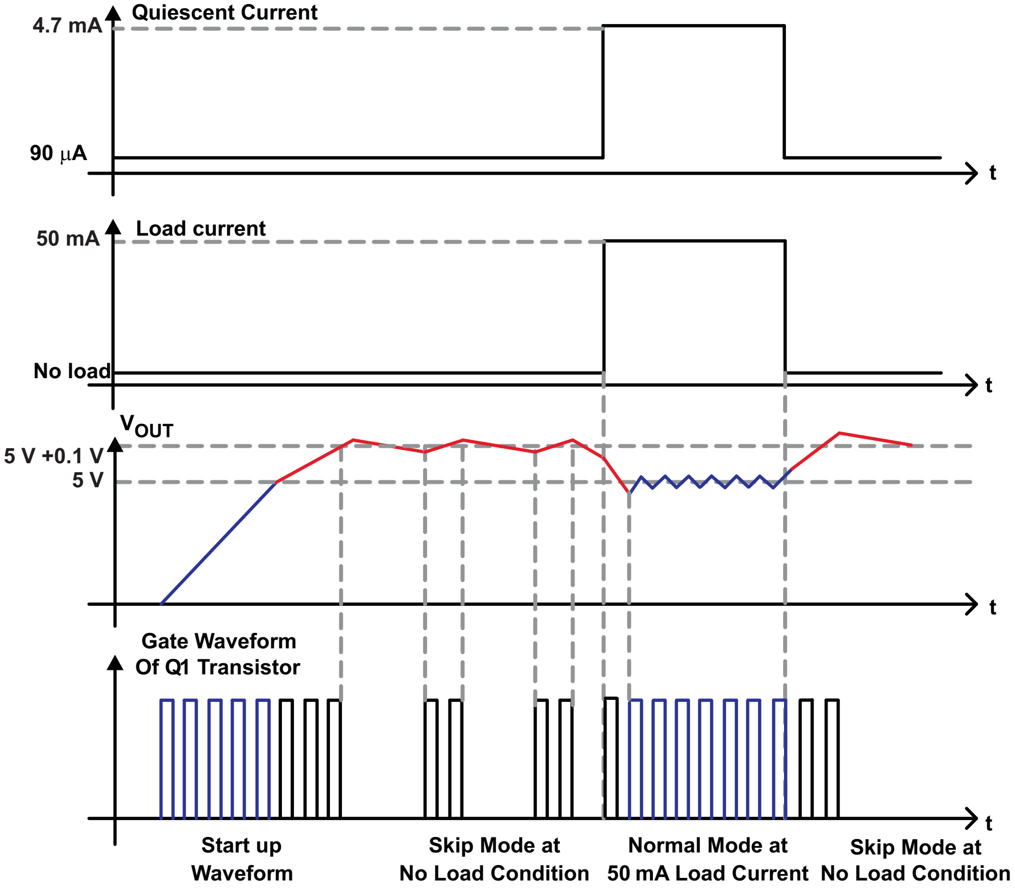


Figure 7. Normal Mode and Skip Mode Operation

The TPS60151 has skip mode operation as shown in Figure 7. The TPS60151 enters skip mode if the output voltage reaches 5 V + 0.1 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 V + 0.1 V, the TPS60151 begins switching to increase output voltage until the output reaches 5 V + 0.1 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*k*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)

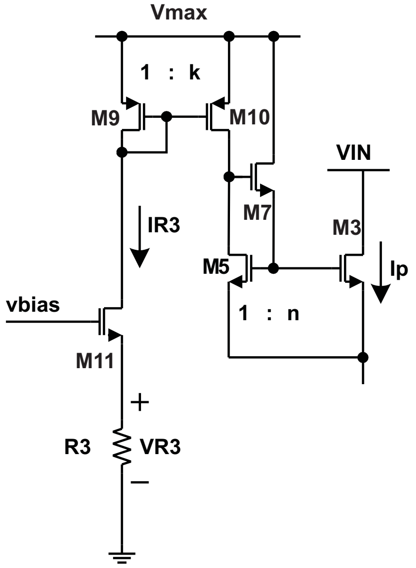


Figure 8. Current Limit

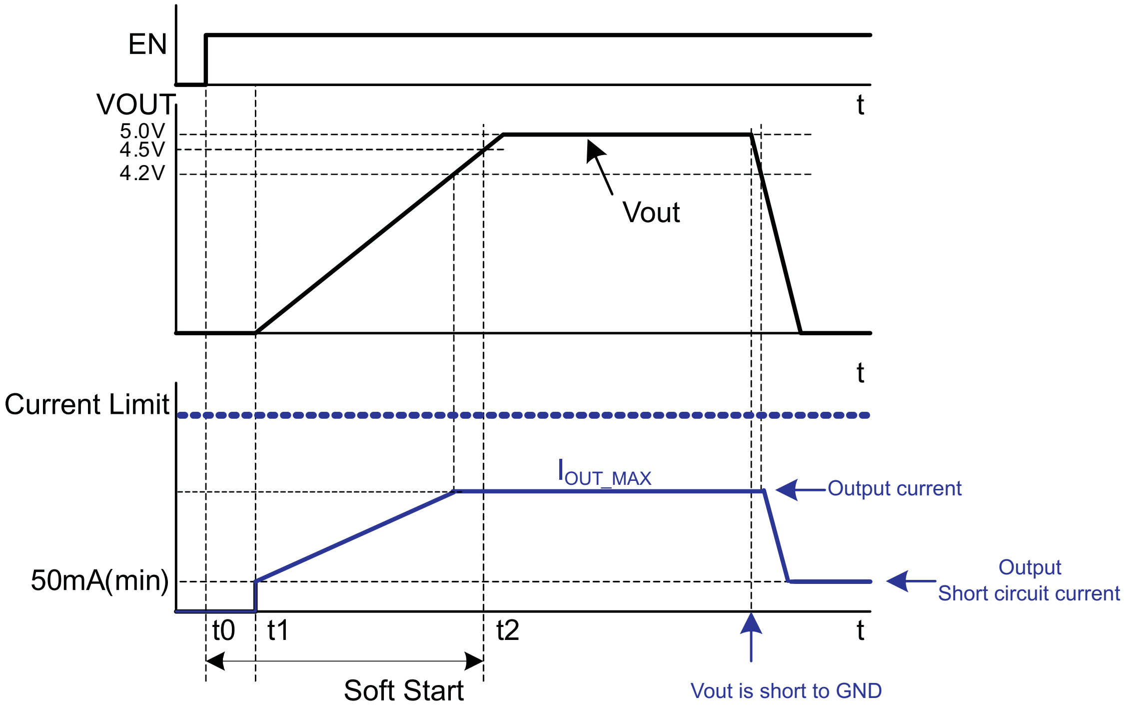


Figure 9. Maximum Output Current Capability and Short Circuit Protection

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.

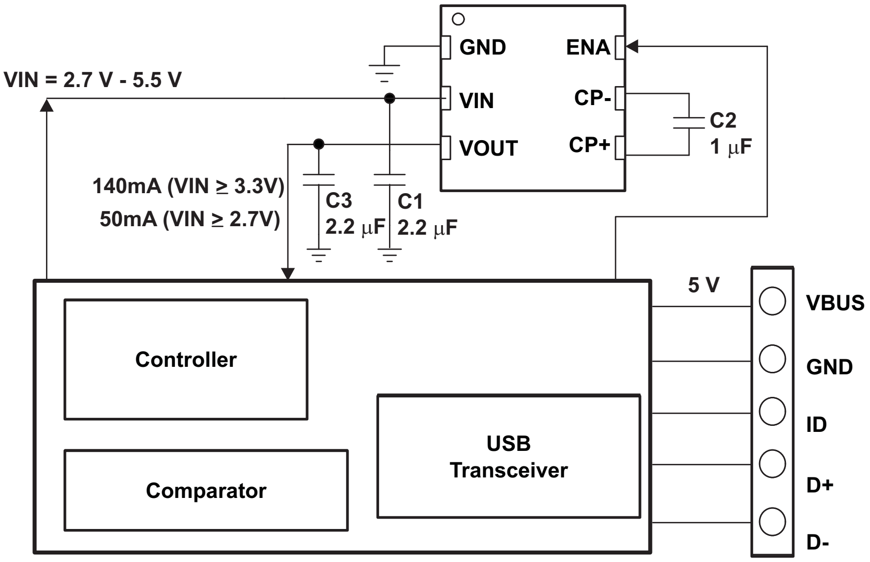


Figure 10. Application Circuit for OTG System

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)

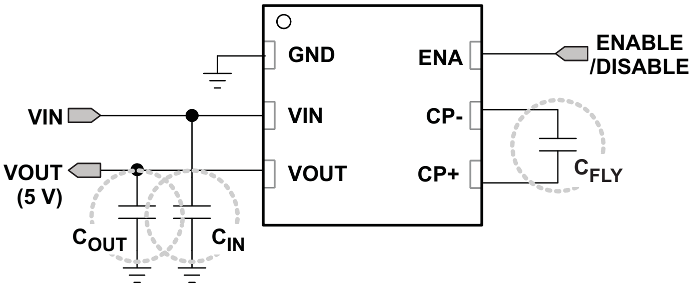


Figure 11. Capacitors

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

$$Q_{charging} = c \times v = C_{FLY} \times \Delta V_{CFLY},$$

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

Both equation should be same,

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

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

If I_{LOAD} = 140 mA, f = 1.5 MHz, and ΔV_{CFLY} = 100 mV, the minimum value of the flying capacitor should be 1 μF.

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

$$V_{OUT(RIPPLE)} = \frac{I_{LOAD(MAX)}}{(2 \times f \times C_{OUT})} + 2I_{LOAD(MAX)} \times ESR_{COUT} \tag{4}$$

The minimum output capacitance for all output levels is 2.2 μF 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:

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

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

9.2.3 Application Curves

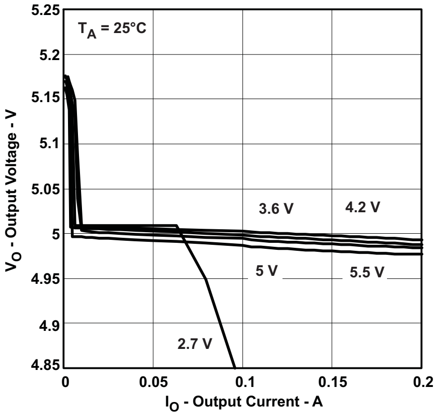


Figure 12. Output Voltage vs Output Current

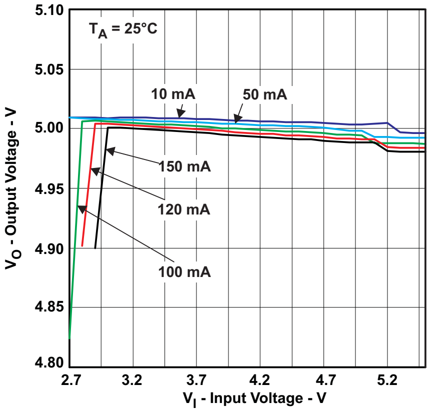


Figure 13. Output Voltage vs Input Voltage

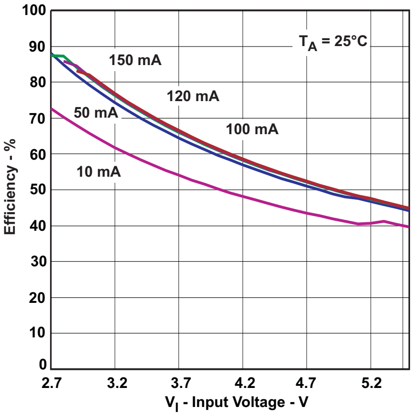
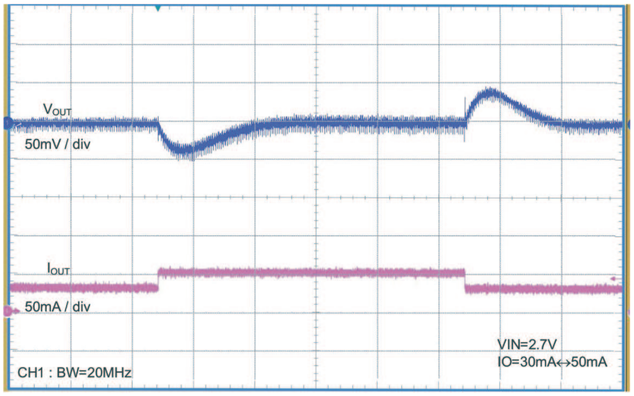
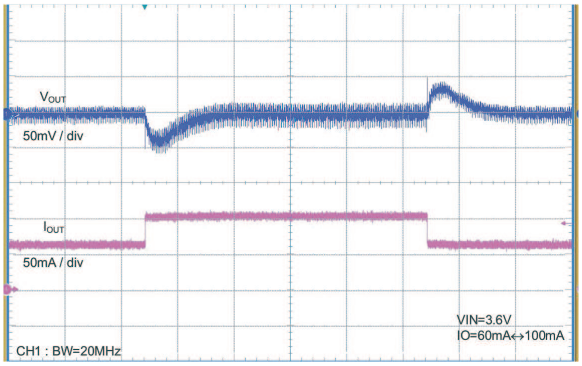


Figure 14. Efficiency vs Input Voltage



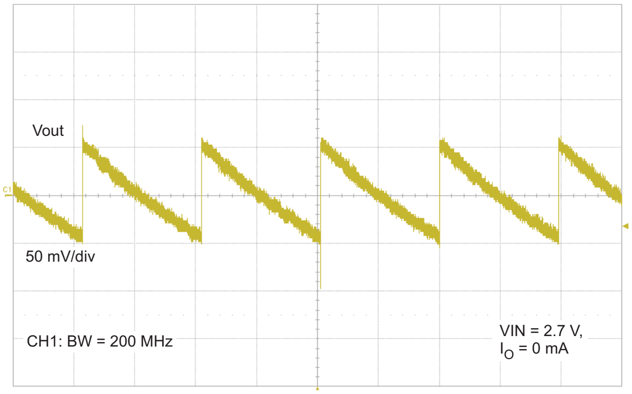
20 µs/div

Figure 15. Load Transient Response
V_{IN} = 2.7 V, Io = 30 mA to 50 mA



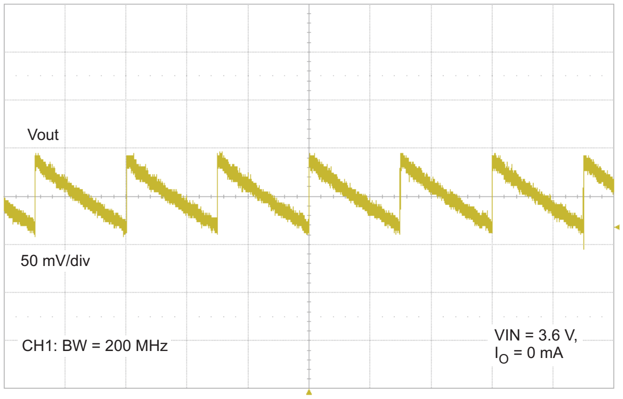
20 µs/div

Figure 16. Load Transient Response
V_{IN} = 3.6 V, Io = 60 mA to 100 mA



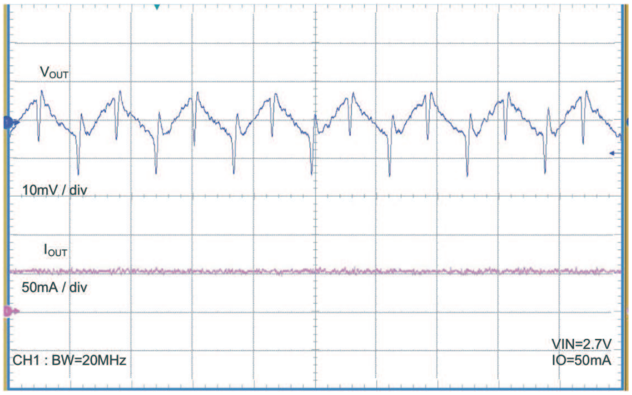
5 ms/div

Figure 17. Output Ripple
V_{CC} = 2.7 V, Io = 0 mA



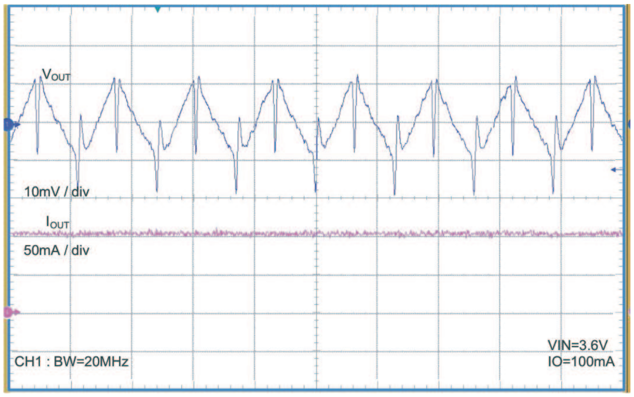
5 ms/div

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



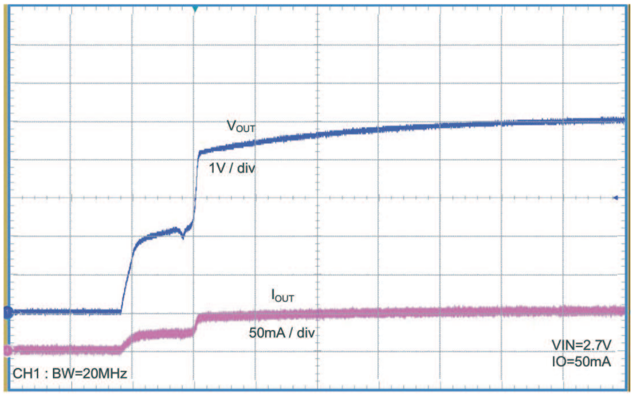
500 ns/div

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



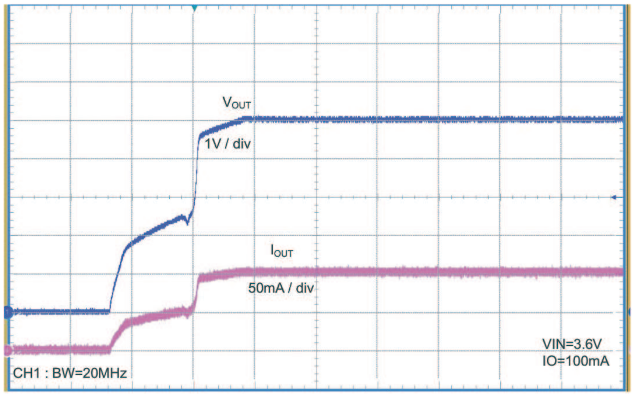
500 ns/div

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



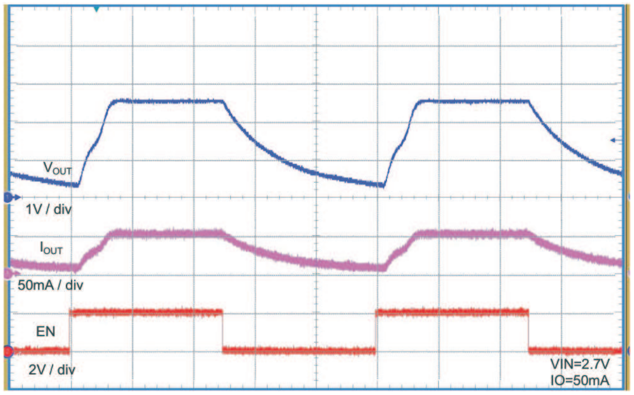
1 ms/div

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



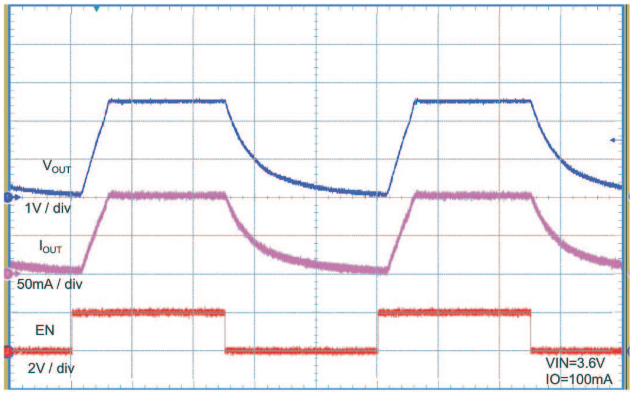
1 ms/div

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



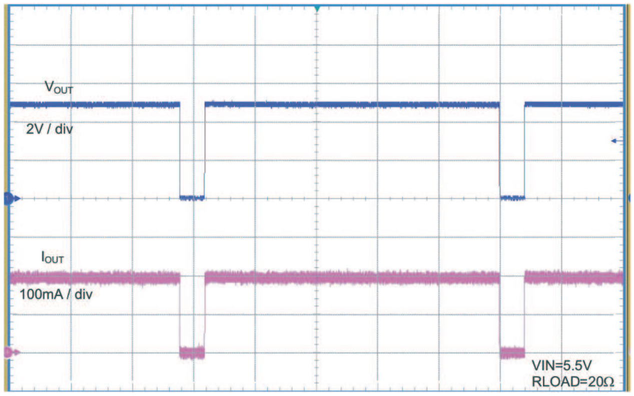
200 µs/div

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



200 µs/div

Figure 24. Enable / Disable
V_{IN} = 3.6 V, Io = 100 mA



50 ms/div

Figure 25. Thermal Shutdown Operation
V_{IN} = 5.5 V, R_{LOAD}= 20 Ω

9.3 System Example

9.3.1 Circuit for Driving White LEDs

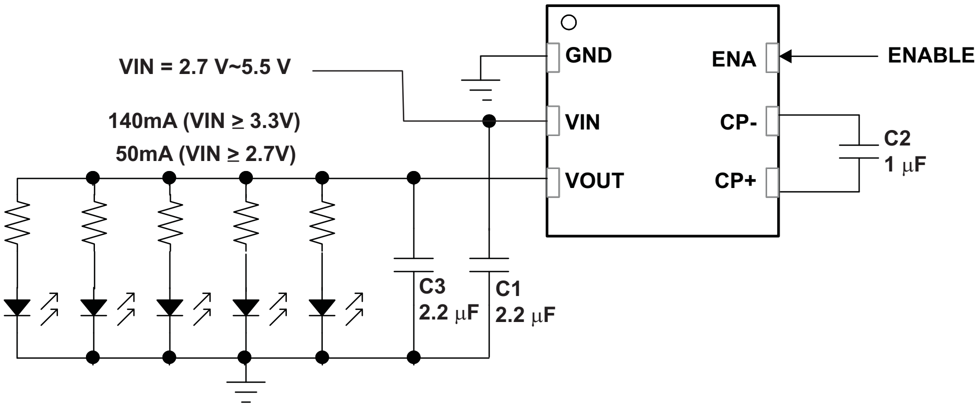


Figure 26. Application Circuit for Driving White LEDs

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

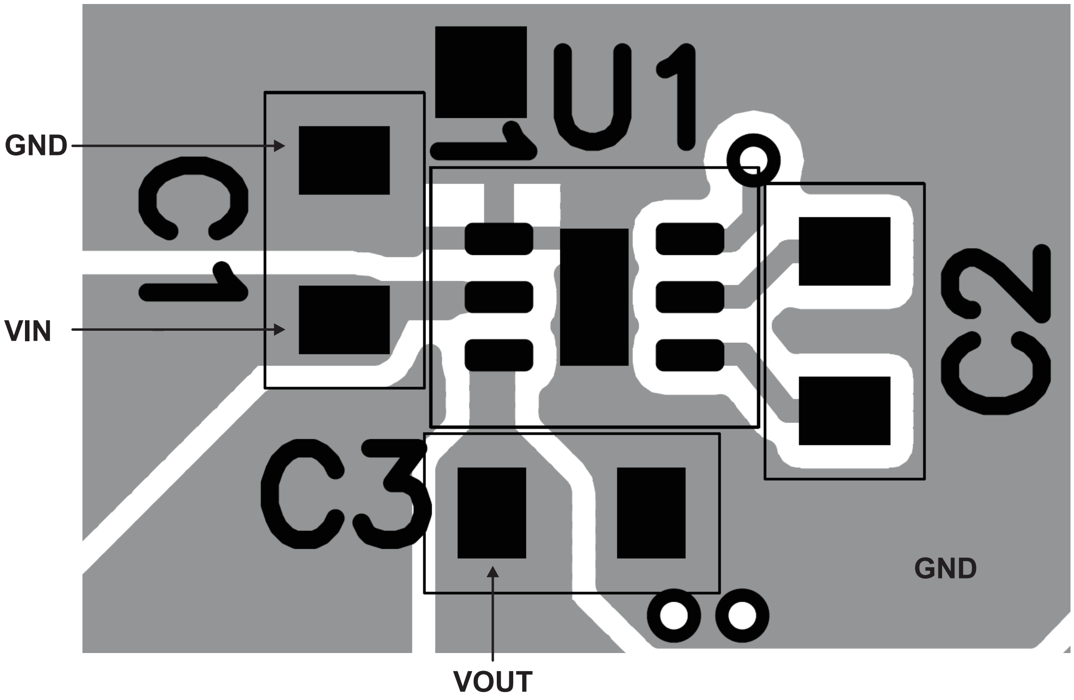


Figure 27. Recommended PCB Layout

12 Device and Documentation Support

12.1 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.

12.2 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.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.3 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.4 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.5 Glossary

SLYZ022 — *TI Glossary*.

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

13 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
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
TPS60151DRVT	Active	Production	WSON (DRV) | 6	250 | SMALL T&R	Yes	NIPDAU | NIPDAUAG | NIPDAU	Level-1-260C-UNLIM	-40 to 85	OCN
TPS60151DRVT.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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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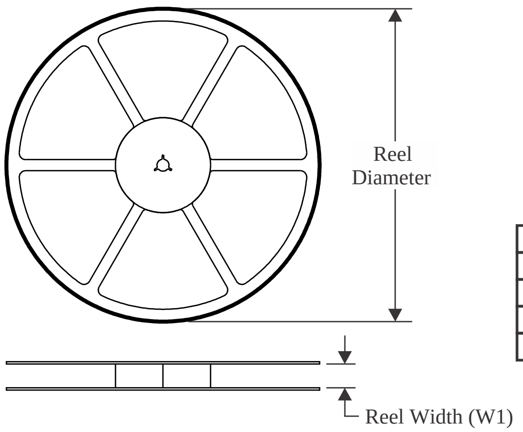
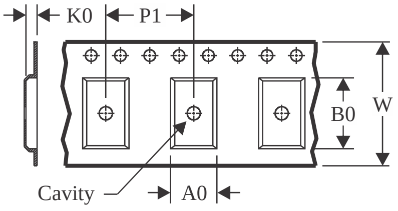
TAPE AND REEL INFORMATION

REEL DIMENSIONS

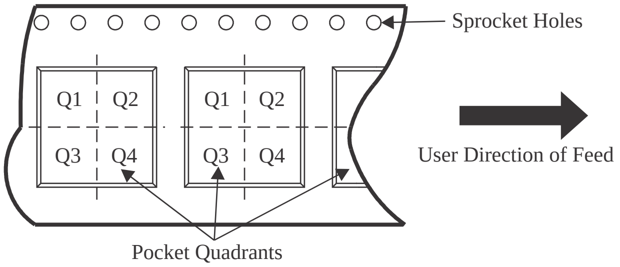


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

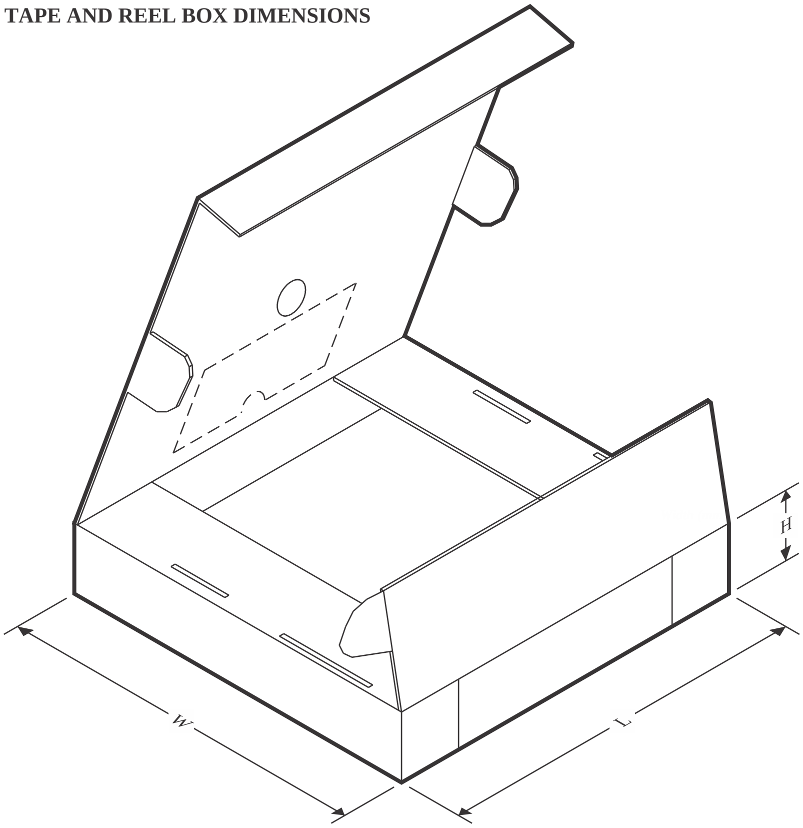
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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	WSON	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRVR	WSON	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRVRG4	WSON	DRV	6	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TPS60151DRVT	WSON	DRV	6	250	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2

TAPE AND REEL BOX DIMENSIONS



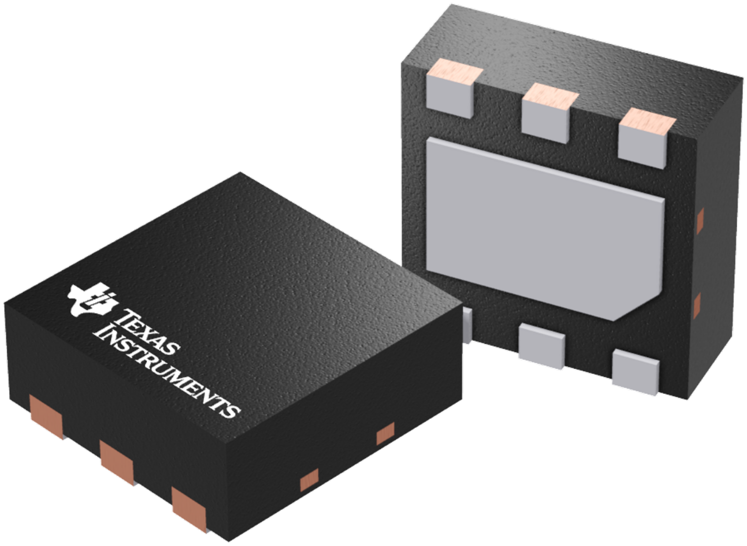
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS60151DRVR	WSON	DRV	6	3000	213.0	191.0	35.0
TPS60151DRVR	WSON	DRV	6	3000	182.0	182.0	20.0
TPS60151DRVRG4	WSON	DRV	6	3000	182.0	182.0	20.0
TPS60151DRVT	WSON	DRV	6	250	182.0	182.0	20.0

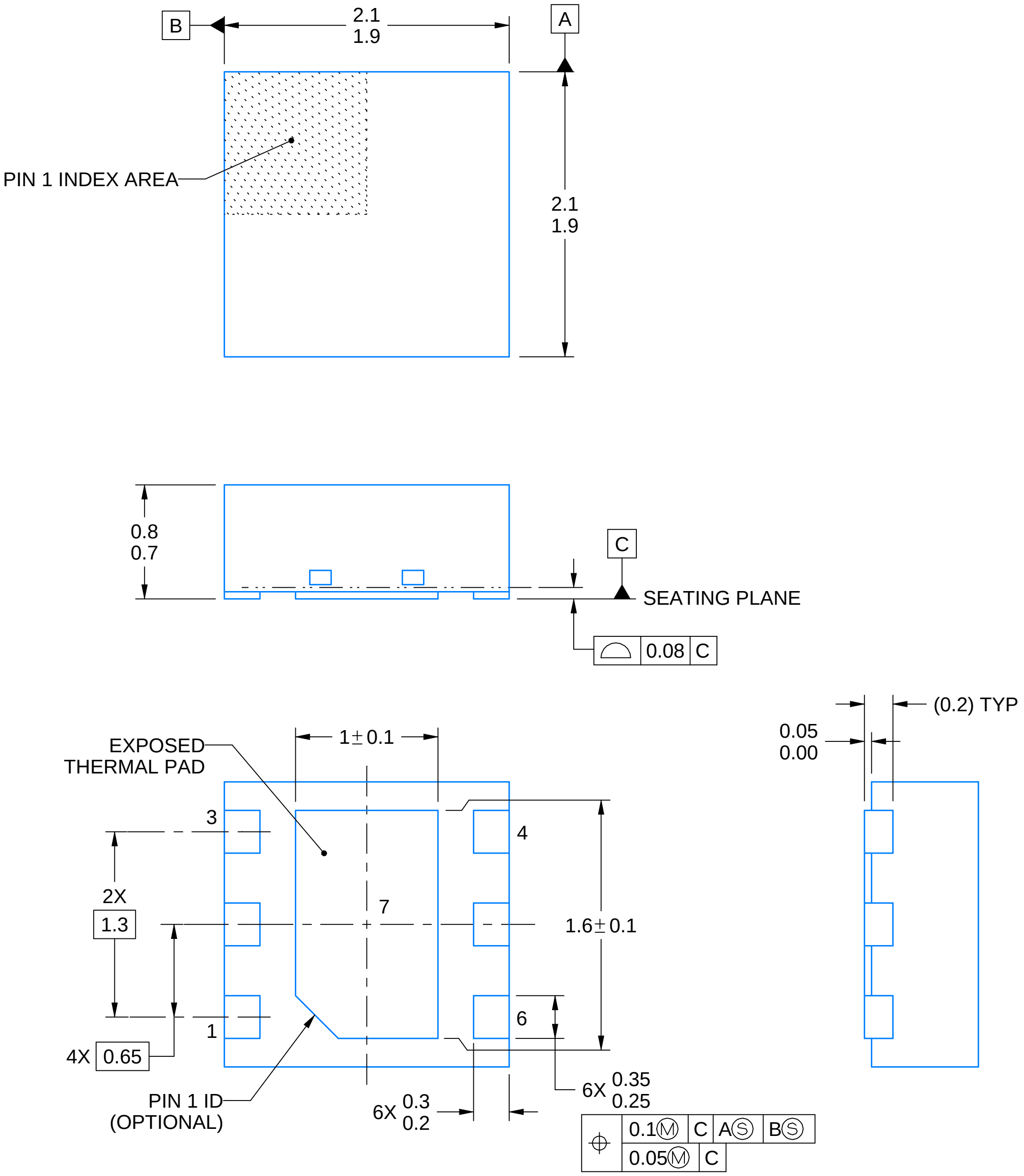
DRV 6

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

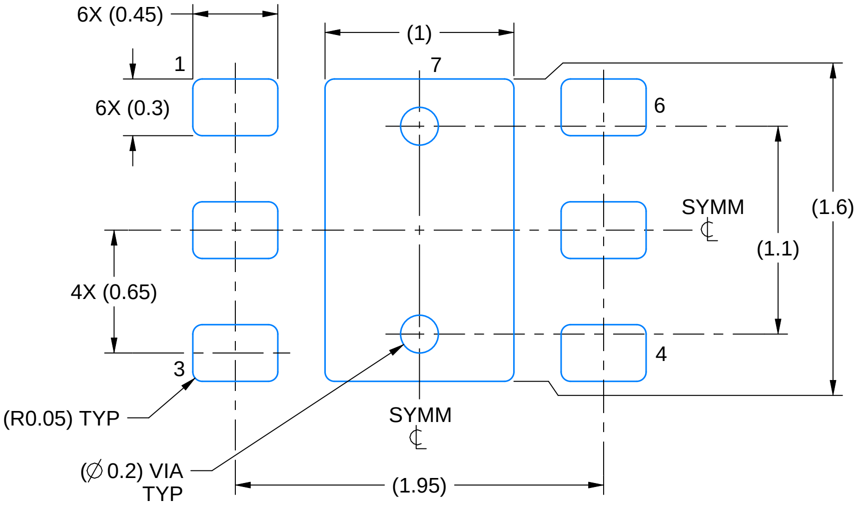


Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

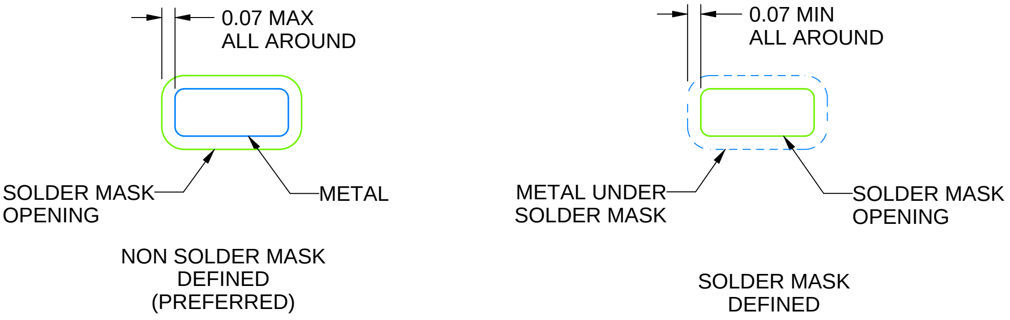


NOTES:

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.



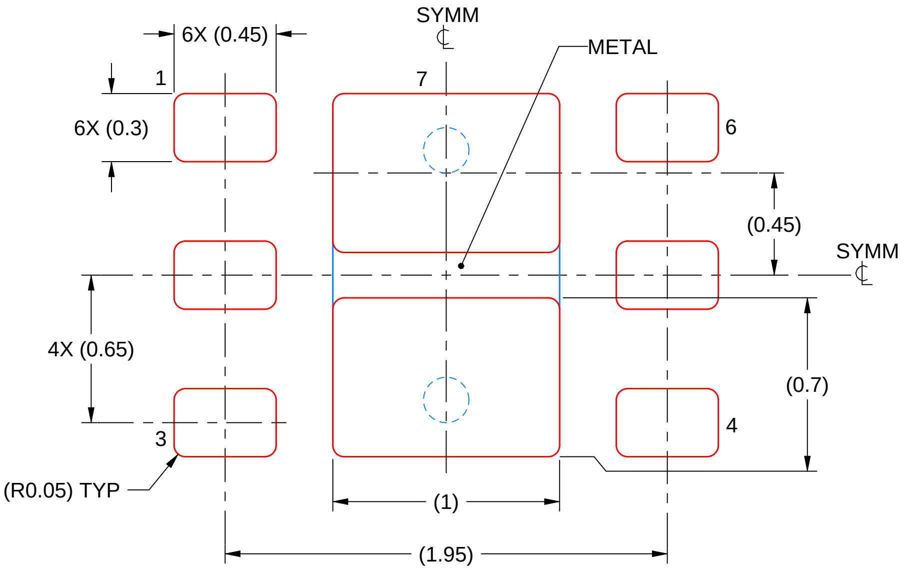
LAND PATTERN EXAMPLE
SCALE:25X



SOLDER MASK DETAILS

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/slua271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.

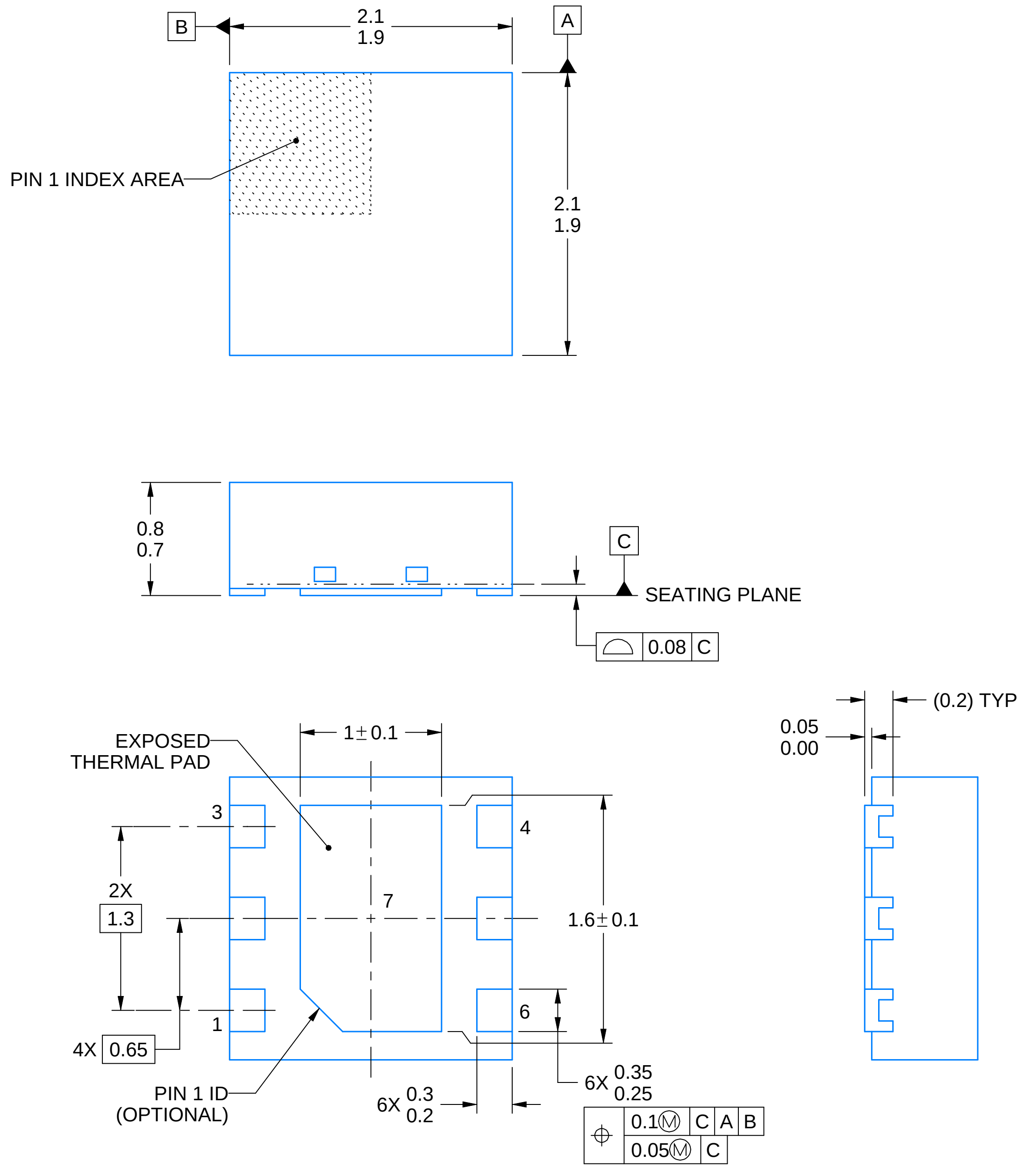


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

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

NOTES: (continued)

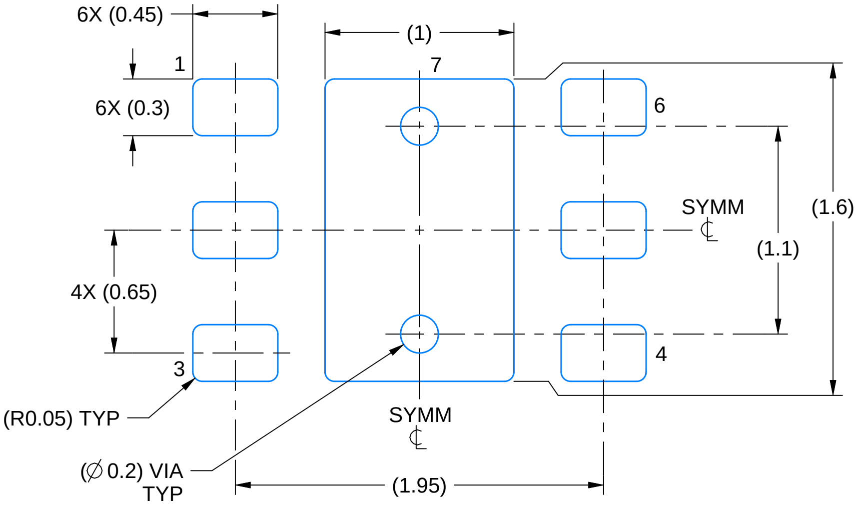
6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.



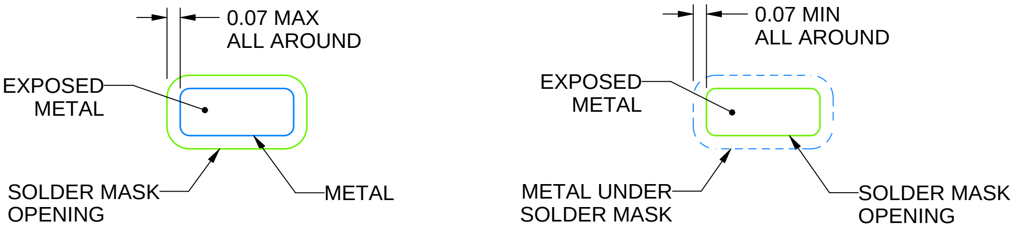
4225563/A 12/2019

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:25X



NON SOLDER MASK
DEFINED
(PREFERRED)

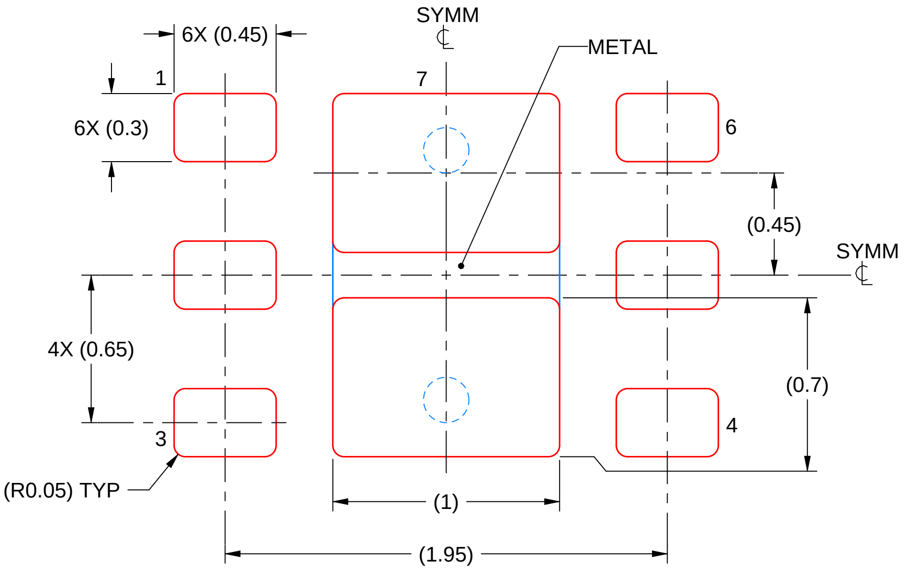
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4225563/A 12/2019

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/slua271).
5. Vias are optional depending on application, refer to device data sheet. If some or all are implemented, recommended via locations are shown.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

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

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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