TLV61224 Single-Cell, High-Efficient, Step-Up Converter in 6-Pin SC-70 Package

1 Features

- Up to 94% Efficiency at Typical Operating Conditions
- 5-µA Quiescent Current
- Operating Input Voltage From 0.7 V to 3 V
- Pass-Through Function During Shutdown
- Output Current of More Than 40 mA From a 1.2-V Input
- Typical Switch Current Rating 400 mA
- Output Overvoltage Protection
- Overtemperature Protection
- Fixed 3-V Output Voltage
- Small 6-Pin SC-70 Package

2 Applications

- Battery Powered Applications
  - 1- to 2-Cell NiMH or Alkaline
  - 1-Cell Li-Primary
- Consumer and Portable Medical Products
- Personal Care Products

3 Description

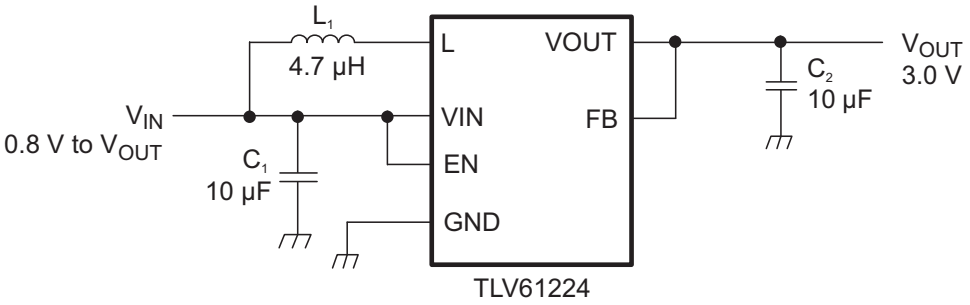
The TLV61224 device provides a power-supply solution for products powered by either a single-cell or 2-cell alkaline or NiMH, or 1-cell Li-primary battery. Possible output currents depend on the input-to-output voltage ratio. The boost converter is based on a hysteretic controller topology using synchronous rectification to obtain maximum efficiency at minimal quiescent currents. The output voltage of this device is set internally to a fixed output voltage of 3 V. The converter can be switched off by a featured enable pin. While being switched off, battery drain is minimized. The device is offered in a 6-pin SC-70 package (DCK) measuring 2 mm × 2 mm to enable small circuit layout size.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLV61224	SOT (6)	2.00 mm × 1.25 mm

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

Typical Application Schematic



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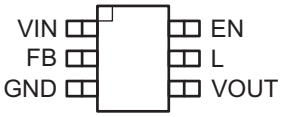
4 Revision History

Changes from Original (March 2011) to Revision A **Page**

- Added *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 Pin Configuration and Functions

DCK Package
6-Pin SOT
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
EN	6	I	Enable input (1: enabled, 0: disabled). Must be actively tied high or low.
FB	2	I	Output voltage sense input. Must be connected to V_{OUT}.
GND	3	–	Control / logic and power ground
L	5	I	Connection for Inductor
VIN	1	I	Boost converter input voltage
VOUT	4	O	Boost converter output voltage

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage(2)	VIN, L, VOUT, EN, FB	–0.3	7.5	V
Temperature	Operating junction temperature, T_J	–40	150	°C
	Storage, T_{stg}	–65	150	

(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.
(2) All voltages are with respect to network ground terminal.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1500	
		Machine model (MM)	±200	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
V_{IN}	Supply voltage at VIN	0.7		3	V
T_A	Operating free air temperature	–40		85	°C
T_J	Operating virtual junction temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC(1)		TLV61224 DCK (SOT) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	231.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	55.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	77.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	0.7	°C/W
ψ_{JB}	Junction-to-board characterization parameter	76.4	°C/W

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

6.5 Electrical Characteristics

over recommended free-air temperature range and over recommended input voltage range (typical at an ambient temperature range of 25°C) (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
DC-DC STAGE							
V_{IN}	Input voltage range			0.7		3	V
V_{IN}	Maximum minimum input voltage for start-up		$R_{Load} \geq 150\ \Omega$, $T_A = 25°C$		0.7		V
V_{OUT}	TLV61224 output voltage		$V_{IN} < V_{OUT}$	2.85	3	3.15	V
I_{LH}	Inductor current ripple				200		mA
I_{SW}	switch current limit		$V_{OUT} = 3$ V, $V_{IN} = 1.2$ V	160	400		mA
R_{DSon_HSD}	Rectifying switch ON-resistance		$V_{OUT} = 3$ V		1000		mΩ
R_{DSon_LSD}	Main switch ON-resistance		$V_{OUT} = 3$ V		600		mΩ
	Line regulation		$V_{IN} < V_{OUT}$		0.5%		
	Load regulation		$V_{IN} < V_{OUT}$		0.5%		
I_Q	Quiescent current	V_{IN}	$I_O = 0$ mA, $V_{EN} = V_{IN} = 1.2$ V, $V_{OUT} = 3$ V		0.5	1	µA
		V_{OUT}			5	10	
I_{SD}	Shutdown current	V_{IN}	$V_{EN} = 0$ V, $V_{IN} = 1.2$ V, $V_{OUT} \geq V_{IN}$		0.2	1	µA
I_{LKG_VOUT}	Leakage current into VOUT		$V_{EN} = 0$ V, $V_{IN} = 1.2$ V, $V_{OUT} = 3$ V		1		µA
I_{LKG_L}	Leakage current into L		$V_{EN} = 0$ V, $V_{IN} = 1.2$ V, $V_L = 1.2$ V, $V_{OUT} \geq V_{IN}$		0.01	0.7	µA
I_{EN}	EN input current		Clamped on GND or V_{IN} ($V_{IN} < 1.5$ V)		0.005	0.1	µA
CONTROL STAGE							
V_{IL}	Maximum EN input low voltage		$V_{IN} \leq 1.5$ V	0.2 × V_{IN}			V
V_{IH}	Minimum EN input high voltage		$V_{IN} \leq 1.5$ V			0.8 × V_{IN}	V
V_{IL}	Maximum EN input low voltage		$V_{IN} > 1.5$ V		0.4		V
V_{IH}	Minimum EN input high voltage		$V_{IN} > 1.5$ V		1.2		V
V_{UVLO}	Undervoltage lockout threshold for turnoff		V_{IN} decreasing		500		mV
	Undervoltage lockout hysteresis				50		mV
	Overvoltage protection threshold			5.5		7.5	V
	Overtemperature protection				140		°C
	Overtemperature hysteresis				20		°C

6.6 Typical Characteristics

Table 1. Table of Graphs

		FIGURE
Minimum of Maximum Output Current	vs Input Voltage	Figure 1
Efficiency	vs Output Current, V_{IN} = [1.2 V; 2.4 V]	Figure 2
	vs Input Voltage, I_{OUT} = [100 uA; 1 mA; 10 mA; 50 mA]	Figure 3
Input Current	vs Input Voltage at No Output Load, Device Enabled	Figure 4
Output Voltage	vs Output Current, V_{IN} = [1.2 V; 2.4 V]	Figure 5
	vs Input Voltage, Device Disabled, R_{LOAD} = [1 kΩ; 10 kΩ]	Figure 6

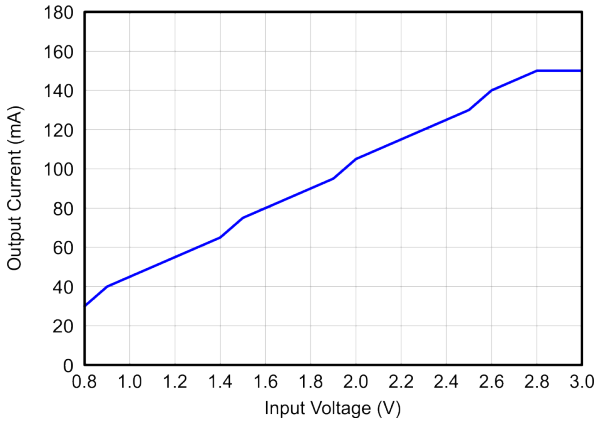


Figure 1. Minimum of Maximum Output Current vs Input Voltage

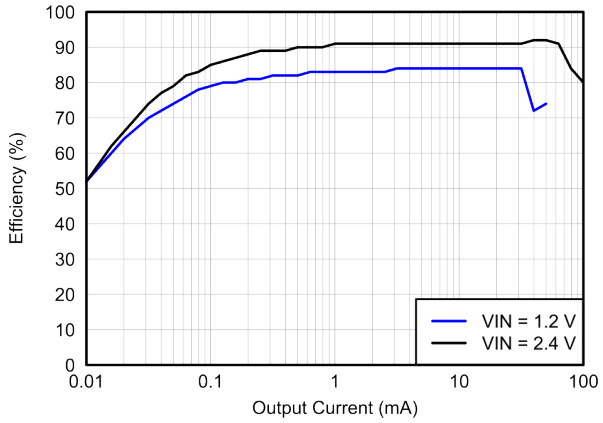


Figure 2. Efficiency vs Output Current

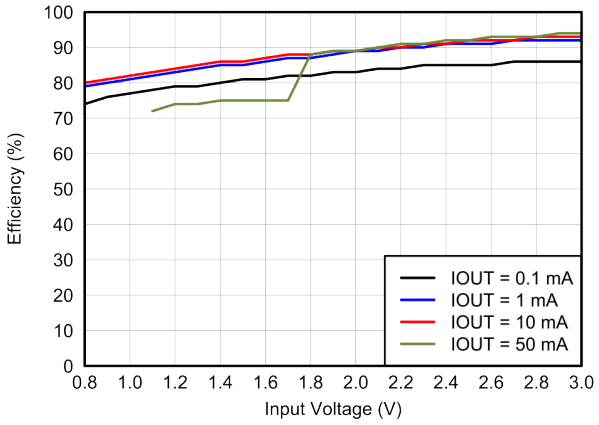


Figure 3. Efficiency vs Input Voltage

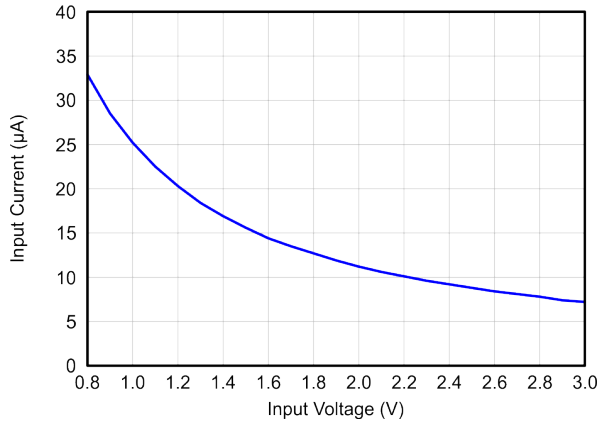


Figure 4. Input Current vs Input Voltage at No Output Load, Device Enabled

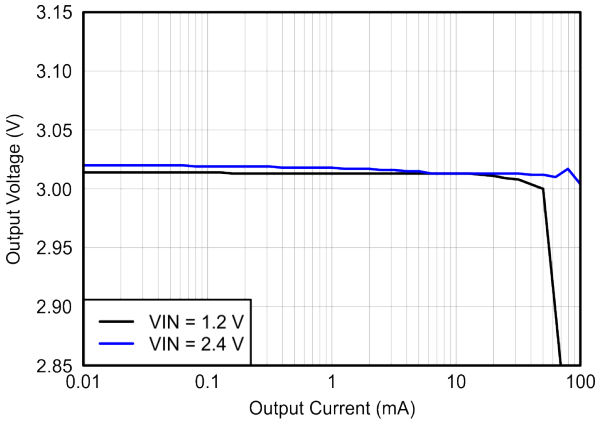


Figure 5. Output Voltage vs Output Current

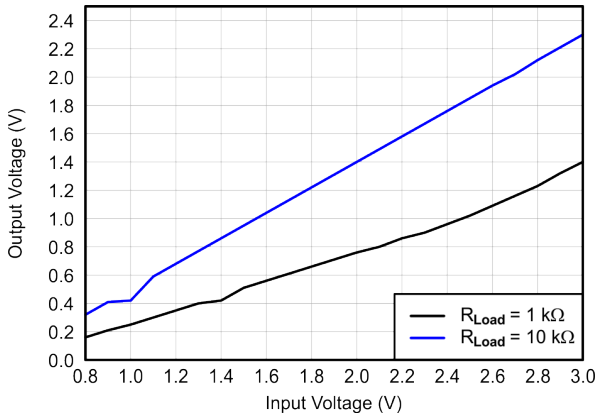


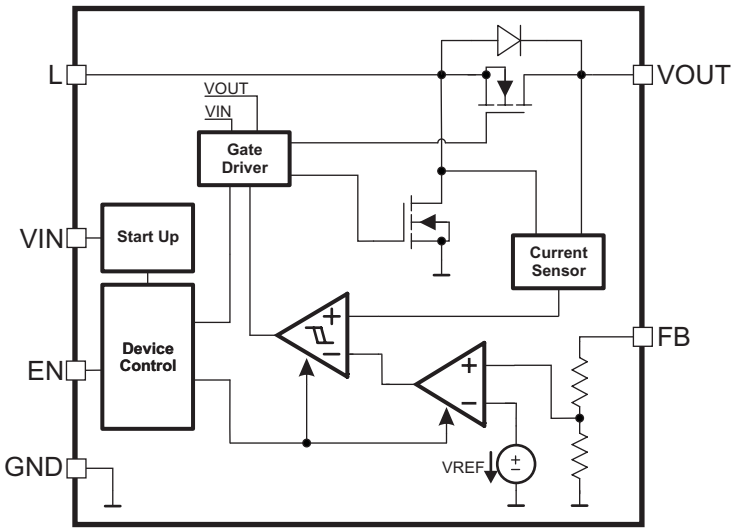
Figure 6. Output Voltage vs input Voltage, Device Disabled

7 Detailed Description

7.1 Overview

The TLV61224 device is a high-performance, high-efficient boost converter. To achieve high-efficiency, the power stage is implemented as a synchronous boost topology. Two actively controlled low R_{DSon} power MOSFETs are used to achieve power switching.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Controller Circuit

The device is controlled by a hysteretic current-mode controller. This controller regulates the output voltage by keeping the inductor ripple current constant in the range of 200 mA and adjusting the offset of this inductor current depending on the output load. If the required average input current is lower than the average inductor current defined by this constant ripple, the inductor current becomes discontinuous to keep the efficiency high at low-load conditions.

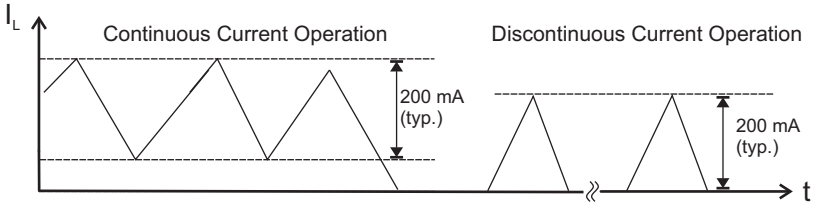


Figure 7. Hysteretic Current Operation

The output voltage V_{OUT} is monitored through the internal feedback network, which is connected to the voltage error amplifier. To regulate the output voltage, the voltage error amplifier compares this feedback voltage to the internal voltage reference and adjusts the required offset of the inductor current accordingly.

Feature Description (continued)

7.3.2 Start-up

After the EN pin is tied high, the device starts to operate. If the input voltage is not high enough to supply the control circuit properly, a start-up oscillator starts to operate the switches. During this phase the switching frequency is controlled by the oscillator and the maximum switch current is limited. As soon as the device has built up the output voltage to about 1.8 V (high enough for supplying the control circuit) the device switches to its normal hysteretic current mode operation. The start-up time depends on input voltage, load current, and output capacitance.

7.3.3 Operation at Output Overload

If the inductor current is in normal boost operation, the current reaches the internal switch current limit threshold. The main switch is turned off to stop a further increase of the input current.

In this case, the output voltage decreases because with limited input current it is no longer possible to provide sufficient power to the output to maintain the programmed output voltage.

If the output voltage drops below the input voltage, the back-gate diode of the rectifying switch gets forward-biased and current starts flowing through it. This diode cannot be turned off, so the current finally is only limited by the remaining DC resistances. As soon as the output load decreases to a value the converter can supply, the converter resumes normal operation providing the set output voltage.

7.3.4 Undervoltage Lockout

An implemented undervoltage lockout function (UVLO) stops the operation of the converter if the input voltage drops below the typical UVLO threshold. This function is implemented to prevent malfunctioning of the converter and protect batteries against deep discharge.

7.3.5 Overvoltage Protection

If, for any reason, the output voltage is not fed back properly to the input of the voltage amplifier, control of the output voltage will not work anymore. Therefore, overvoltage protection is implemented to avoid the output voltage exceeding critical values for the device and possibly for the system it is supplying. For this protection the output voltage of the TLV61224 device is also monitored internally. If the output voltage of the device reaches the internally programmed threshold, the voltage amplifier regulates the output voltage to this value.

7.3.6 Overtemperature Protection

The device has a built-in temperature sensor which monitors the internal IC junction temperature. If the temperature exceeds the programmed threshold (see *Electrical Characteristics*), the device stops operating. As soon as the IC temperature has decreased below the programmed threshold, it starts operating again. To prevent unstable operation close to the region of overtemperature threshold, a built-in hysteresis is implemented.

7.4 Device Functional Modes

7.4.1 Device Enable and Shutdown Mode

The device is enabled when EN pin is set high and shut down when EN is low. During shutdown, the converter stops switching and all internal control circuitry is turned off. In this case, the input voltage is connected to the output through the back-gate diode of the rectifying MOSFET. This means that voltage will always exist at the output, which can be as high as the input voltage or lower depending on the load.

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

The TLV61224 device is intended for systems which are powered by a single-cell battery to up to two Alkaline, NiCd, or NiMH cells with a typical terminal voltage from 0.7 V to 3 V and can output 3-V voltage. Additionally, any other voltage source with a typical output voltage from 0.7 V to 3 V can be used with the TLV61224 device.

8.2 Typical Application

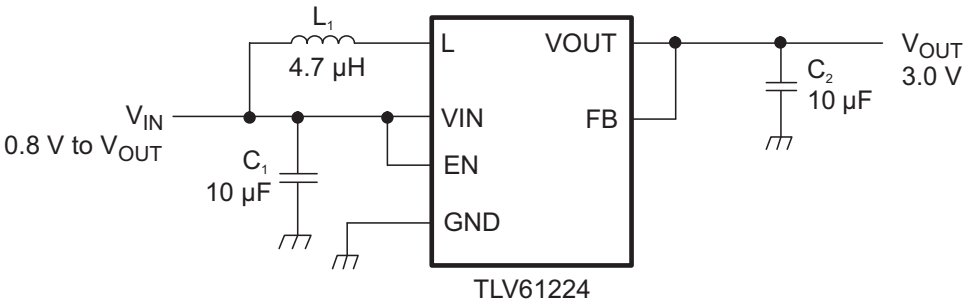


Figure 8. Typical Application Schematic

8.2.1 Design Requirements

In this example, TLV61224 device is used to design a 3-V power supply with up to 15-mA output current capability. The TLV61224 device can be powered by a single-cell battery to up to two Alkaline, NiCd, or NiMH cells with a typical terminal voltage from 0.7 V to 3 V. The input voltage range is from 0.8 V to 1.5 V for single-cell Alkaline battery input design.

8.2.2 Detailed Design Procedure

8.2.2.1 Programming the Output Voltage

At fixed voltage versions, the output voltage is programmed by an internal resistor divider. The FB pin is used to sense the output voltage. To configure the devices properly, the FB pin must be connected directly to VOUT.

8.2.2.2 Inductor Selection

To make sure that the TLV61224 devices can operate, a suitable inductor must be connected between pin VIN and pin L. Inductor values of 4.7 µH show good performance over the whole input and output voltage range.

Due to the fixed inductor current ripple control the switching frequency is defined by the inductor value. For a given switching frequency, input and output voltage the required inductance can be estimated using Equation 1.

$$L = \frac{1}{f \times 200\ mA} \times \frac{V_{IN} \times (V_{OUT} - V_{IN})}{V_{OUT}} \quad (1)$$

Using inductor values greater than 4.7 µH can improve efficiency because greater values cause lower switching frequency and less switching losses. TI does not recommend using inductor values less than 2.2 µH.

To ensure reliable operation of the TLV61224 device under all load conditions, TI recommends using inductors with a current rating of 400 mA or higher. This will cover normal operation including current peaks during line and load transients.

Typical Application (continued)

Table 2 lists the inductor series from different suppliers that have been used with the TLV61224 converter:

Table 2. List of Inductors

VENDOR	INDUCTOR SERIES
Coilcraft	EPL3015
	EPL2010
Murata	LQH3NP
Tajo Yuden	NR3015
Wurth Elektronik	WE-TPC Typ S

8.2.2.3 Capacitor Selection

8.2.2.3.1 *Input Capacitor*

TI recommends at least a 10-µF input capacitor to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. TI recommends placing a ceramic capacitor as close as possible to the VIN and GND pins of the IC.

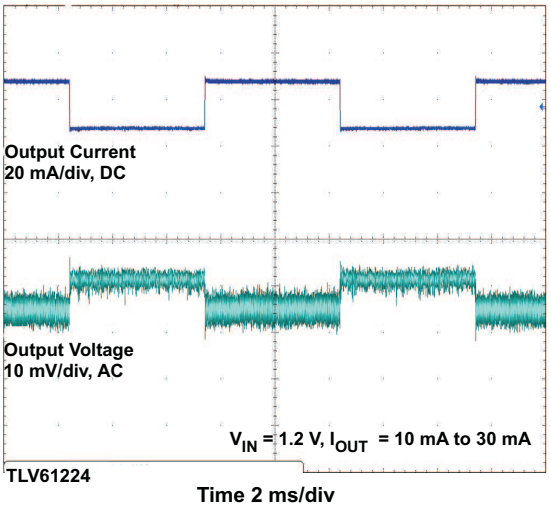
8.2.2.3.2 *Output Capacitor*

For the output capacitor C_2, TI recommends placing small ceramic capacitors as close as possible to the VOUT and GND pins of the IC. There are no minimum output capacitor ESR requirements for maintaining control loop stability. If, for any reason, the application requires the use of large capacitors which cannot be placed close to the IC, TI recommends using a small ceramic capacitor with a capacitance value in the range of 2.2 µF in parallel to the large capacitor. This small capacitor should be placed as close as possible to the VOUT and GND pins of the IC.

A minimum capacitance value of 4.7 µF should be used; TI recommends a value of 10 µF. Use Equation 2 to calculate the required output capacitance in case an inductor with a value greater than 4.7 µH has been selected.

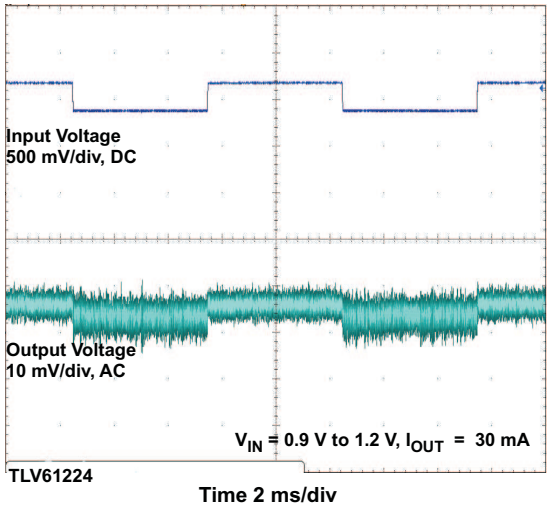
$$C_2 \geq \frac{L}{2} \times \frac{\mu F}{\mu H} \quad (2)$$

8.2.3 Application Curves



Time 2 ms/div

Figure 9. Load Transient Response



Time 2 ms/div

Figure 10. Line Transient Response

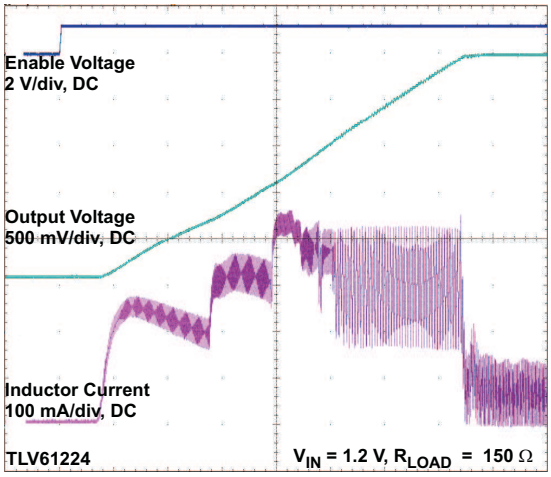


Figure 11. Start-Up After Enable

Table 3 lists the components used for the waveform measurements.

Table 3. List of Components:

COMPONENT REFERENCE	PART NUMBER	MANUFACTURER	VALUE
C_1	GRM188R60J106ME84D	Murata	10 µF, 6.3 V
C_2	GRM188R60J106ME84D	Murata	10 µF, 6.3 V
L_1	EPL3015-472MLB	Coilcraft	4.7 µH

9 Power Supply Recommendations

The power supply can be 1-cell or 2-cell alkaline, NiCd or NiMH batteries. The input supply should be well regulated with the rating of TLV61224 device. If the input supply is located more than a few inches from the device, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. An electrolytic or tantalum capacitor with a value of 47 µF is a typical choice.

10 Layout

10.1 Layout Guidelines

As for all switching power supplies, the layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems. Therefore, use wide and short traces for the main current path and for the power ground paths. The input and output capacitor, as well as the inductor should be placed as close as possible to the IC.

To lay out the ground, TI recommends using short traces as well, separated from the power ground traces. This avoids ground shift problems, which can occur due to superimposition of power ground current and control ground current. Assure that the ground traces are connected close to the device GND pin.

10.2 Layout Example

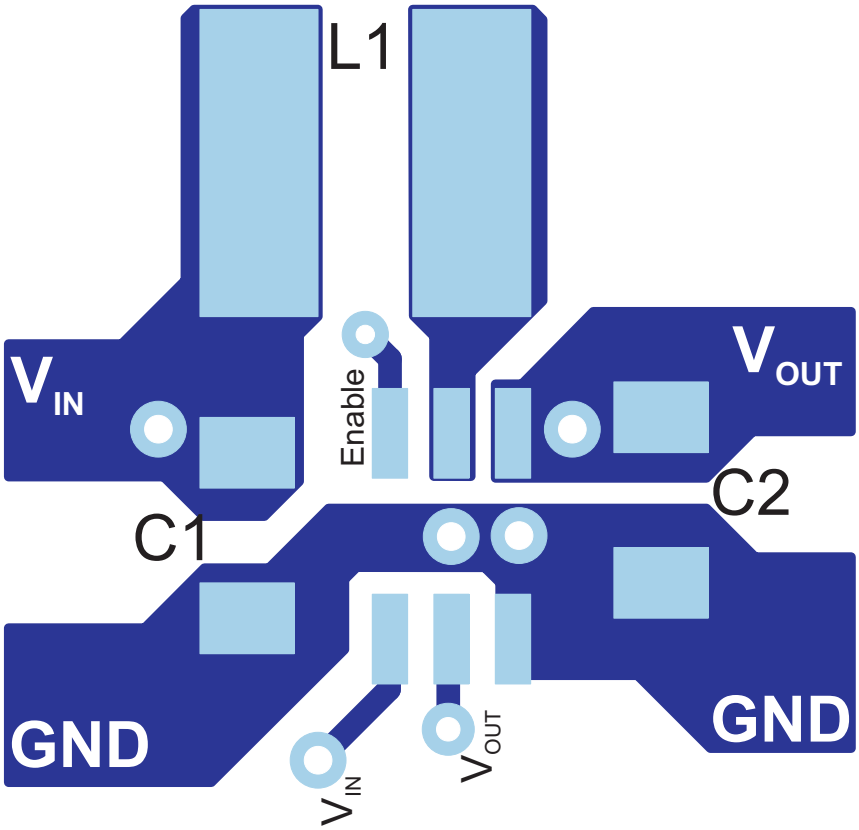


Figure 12. PCB Layout Suggestion

10.3 Thermal Considerations

Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power-dissipation limits of a given component.

Three basic approaches for enhancing thermal performance are listed below.

- Improving the power-dissipation capability of the PCB design
- Improving the thermal coupling of the component to the PCB
- Introducing airflow in the system

For more details on how to use the thermal parameters in the dissipation ratings table, check the *Thermal Characteristics of Linear and Logic Packages Using JEDEC PCB Designs* application note (SZZA017) and the *Semiconductor and IC Package Thermal Metrics* application note (SPRA953).

11 Device and Documentation Support

11.1 Device Support

11.1.1 Third-Party Products Disclaimer

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11.2 Documentation Support

11.2.1 Related Documentation

- *Thermal Characteristics of Linear and Logic Packages Using JEDEC PCB Designs*, SZZA017
- *Semiconductor and IC Package Thermal Metrics*, SPRA953

11.3 Community Resource

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.

11.4 Trademarks

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

11.5 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.

11.6 Glossary

SLYZ022 — *TI Glossary*.

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

12 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)
TLV61224DCKR	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC
TLV61224DCKR.A	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC
TLV61224DCKRG4	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC
TLV61224DCKRG4.A	Active	Production	SC70 (DCK) | 6	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC
TLV61224DCKT	Active	Production	SC70 (DCK) | 6	250 | SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC
TLV61224DCKT.A	Active	Production	SC70 (DCK) | 6	250 | SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	QXC

(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.

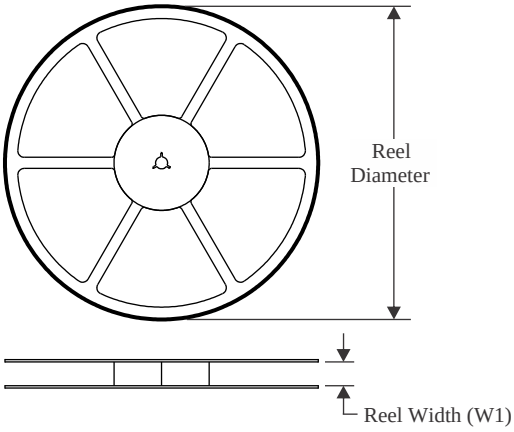
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

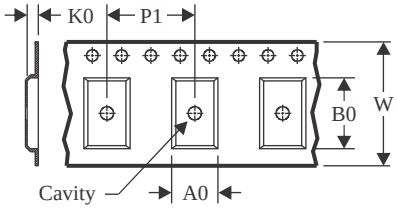
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

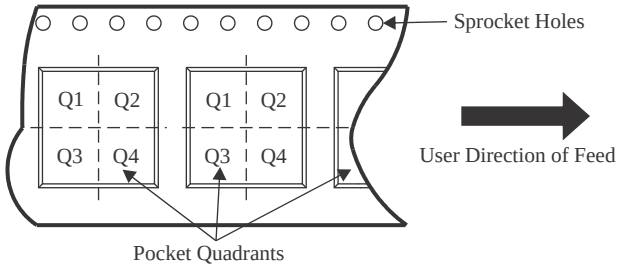


TAPE DIMENSIONS



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

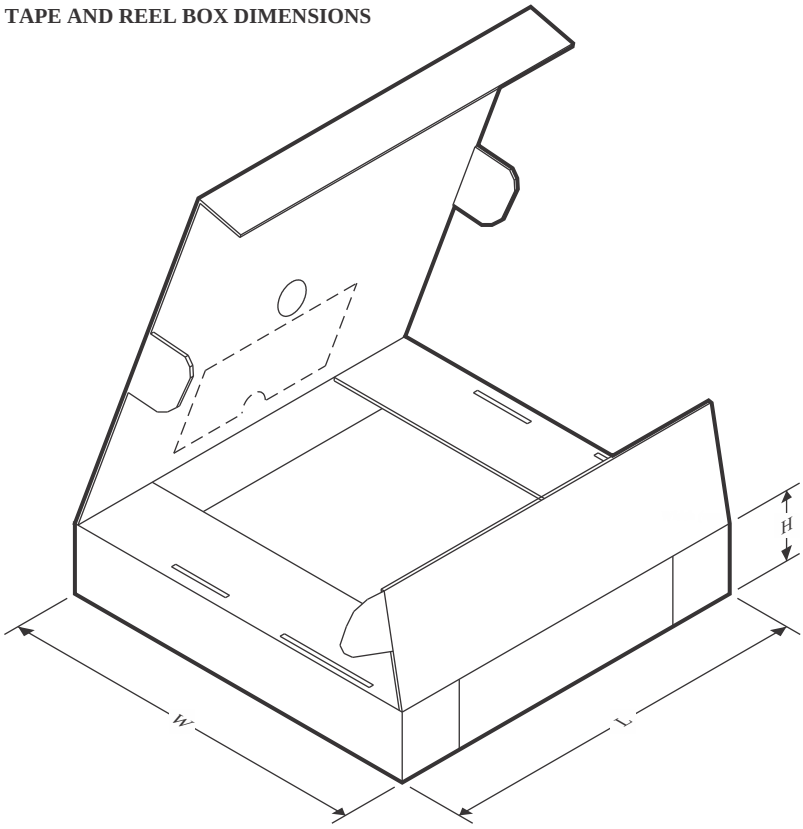
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TLV61224DCKR	SC70	DCK	6	3000	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3
TLV61224DCKRG4	SC70	DCK	6	3000	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3
TLV61224DCKT	SC70	DCK	6	250	179.0	8.4	2.2	2.5	1.2	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

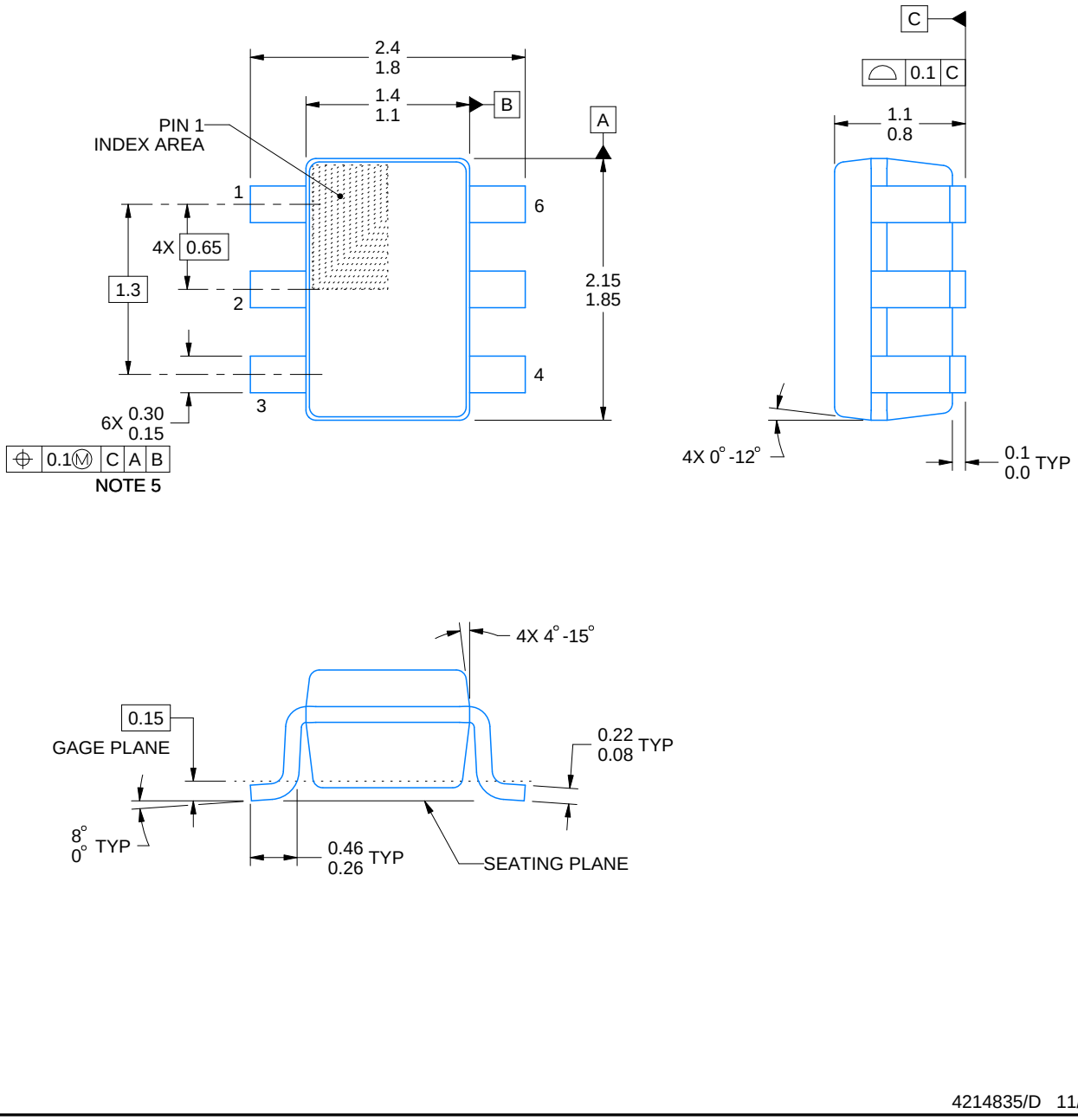
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV61224DCKR	SC70	DCK	6	3000	200.0	183.0	25.0
TLV61224DCKRG4	SC70	DCK	6	3000	200.0	183.0	25.0
TLV61224DCKT	SC70	DCK	6	250	200.0	183.0	25.0

PACKAGE OUTLINE

DCK0006A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



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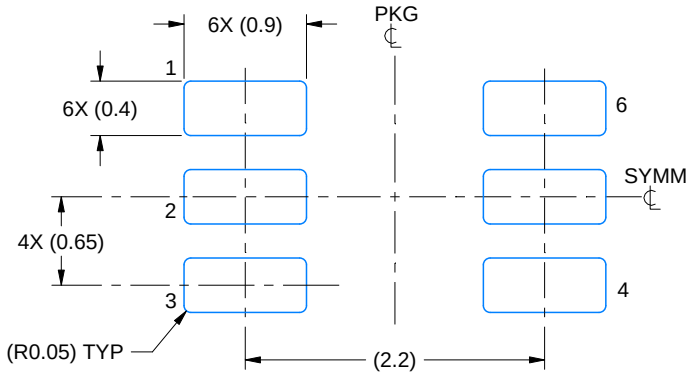
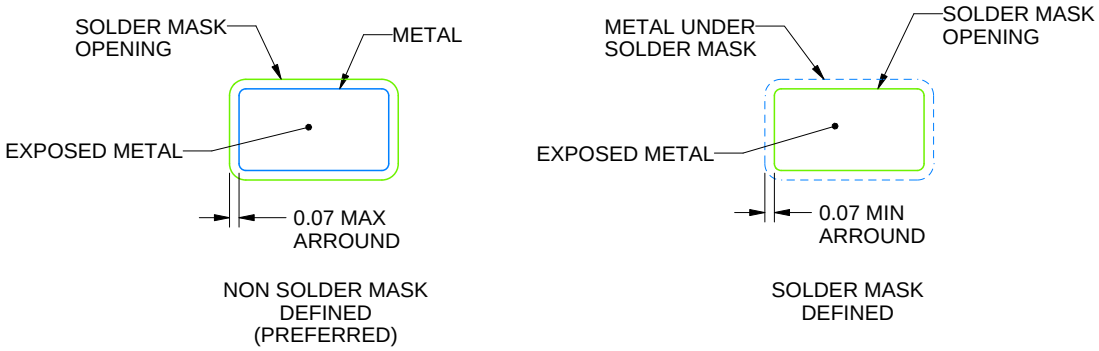
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Falls within JEDEC MO-203 variation AB.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



SOLDER MASK DETAILS

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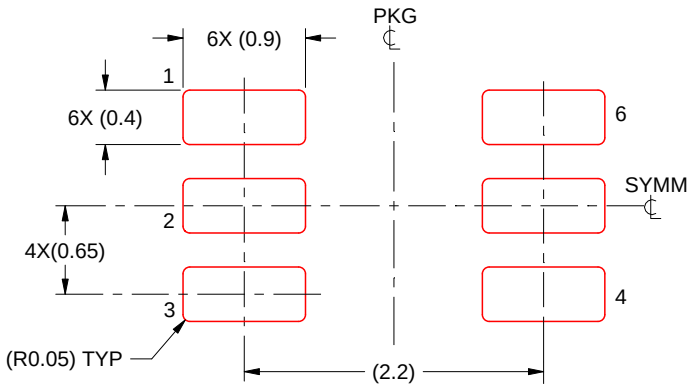
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

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NOTES: (continued)

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

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