

TPS6224X-Q1 車載用2.25MHz 300mA降圧型コンバータ、TSOT23パッケージ

1 特長

- 下記内容でAEC-Q100認定済み
 - デバイス温度グレード1: 動作時接合部温度範囲 –40°C~125°C
- 出力電流: 最大300mA
- V_{IN} 範囲: 2V~6V
- PWMモードで2.25MHz固定周波数動作
- 軽負荷電流時のパワーセーブ・モード
- PWMモードでの出力電圧精度: $\pm 1.5\%$
- 固定出力電圧
 - 1.80V TPS62243-Q1
 - 1.25V TPS62244-Q1
- 静止電流: 15 μ A (標準値)
- 100%デューティ・サイクル動作による最小のドロップアウト電圧
- TSOT 23 (5) 2.90mm \times 1.60mmパッケージで供給

2 アプリケーション

- リモート・キーレス・エントリ(RKE)
- パッシブ・エントリ/パッシブ・スタート(PEPS)
- 先進運転支援システム(ADAS)
 - フロント・カメラ、サラウンド・ビュー、駐車支援

3 概要

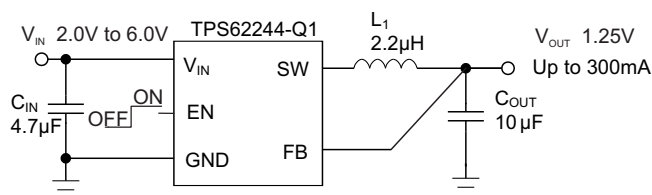
TPS6224x-Q1は固定出力電圧で最大300mAの出力電流を供給できる、高効率の同期整流DC/DC降圧型コンバータです。低消費電力を実現しており、リモート・キーレス・エントリ(RKE)やパッシブ・エントリ/パッシブ・スタート(PEPS)のキーフォブおよび基地局といった、バッテリー駆動/常時オンの車載アプリケーションに適しています。2V~6Vの入力電圧範囲により、Li-MnO₂コイン電池、リチウムイオン電池、2セル(2S)および3セル(3S)のアルカリ電池、3.3Vおよび5Vの入力電圧レールを電源とするアプリケーションに対応します。TPS6224x-Q1は、高負荷電流時には2.25MHzの固定スイッチング周波数で動作し、軽負荷電流時にはパワーセーブ・モードでの動作に移行するため、全負荷電流範囲にわたって高効率と低消費電力を維持できます。パワーセーブ・モードは、出力電圧リップルが小さくなるように最適化されています。シャットダウン・モードでは、消費電流が1 μ A未満に低下します。小型のインダクタとコンデンサを使用してソリューション・サイズを小さくすることができるTPS6224x-Q1は、5ピンのTSOT23パッケージで供給されます。

製品情報⁽¹⁾

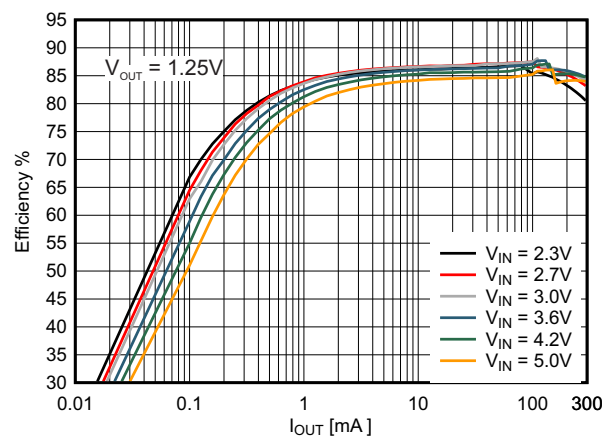
型番	パッケージ	本体サイズ(公称)
TPS6224X-Q1	TSOT (5)	2.90mm \times 1.60mm

(1) 提供されているすべてのパッケージについては、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。

標準アプリケーション回路図



効率と出力電流との関係



目次

1	特長	1	8.4	Device Functional Modes.....	8
2	アプリケーション	1	9	Application and Implementation	10
3	概要	1	9.1	Application Information.....	10
4	改訂履歴	2	9.2	Typical Application.....	10
5	Device Comparison Table	3	10	Power Supply Recommendations	14
6	Pin Configuration and Functions	3	11	Layout	15
7	Specifications	3	11.1	Layout Guidelines.....	15
7.1	Absolute Maximum Ratings.....	3	11.2	Layout Example.....	15
7.2	ESD Ratings.....	4	12	デバイスおよびドキュメントのサポート.....	16
7.3	Recommended Operating Conditions.....	4	12.1	デベロッパー・ネットワークの製品に関する免責事項.....	16
7.4	Thermal Information.....	4	12.2	ドキュメントの更新通知を受け取る方法.....	16
7.5	Electrical Characteristics.....	5	12.3	コミュニティ・リソース.....	16
7.6	Typical Characteristics.....	6	12.4	商標.....	16
8	Detailed Description	7	12.5	静電気放電に関する注意事項.....	16
8.1	Overview.....	7	12.6	Glossary.....	16
8.2	Functional Block Diagram.....	7	13	メカニカル、パッケージ、および注文情報.....	16
8.3	Feature Description.....	8	13.1	Package Option Addendum.....	17

4 改訂履歴

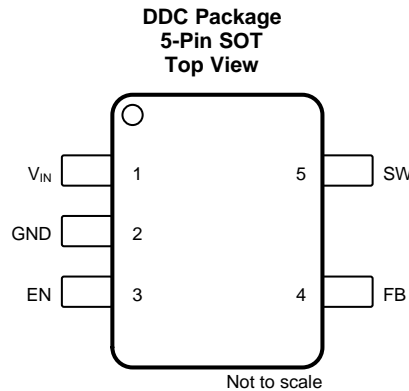
日付	改訂内容	注
2018年3月	*	初版

5 Device Comparison Table

PART NUMBER ⁽¹⁾	FIXED OUTPUT VOLTAGES [V]	OPERATING MODE
TPS62243-Q1	1.80 V	PFM/PWM with automatic transition
TPS62244-Q1	1.25 V	PFM/PWM with automatic transition

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

6 Pin Configuration and Functions



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
EN	3	I	This is the enable pin of the device. Pulling this pin to low forces the device into shutdown mode. Pulling this pin to high enables the device. This pin must be terminated.
FB	4	I	Feedback Pin for the internal regulation loop. Connect the external resistor divider to this pin. In case of fixed output voltage option, connect this pin directly to the output capacitor.
GND	2	PWR	GND supply pin.
SW	5	O	This is the switch pin and is connected to the internal MOSFET switches. Connect the inductor to this terminal.
V _{IN}	1	PWR	V _{IN} power supply pin.

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

		MIN	MAX	UNIT
V _I	Input voltage ⁽²⁾	-0.3	7	V
	Voltage at EN	-0.3	V _{IN} + 0.3, ≤7	V
	Voltage on SW	-0.3	7	V
	Peak output current	Internally limited		A
T _J	Maximum operating junction temperature	-40	150	°C
T _{stg}	Storage temperature	-65	150	°C

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

7.2 ESD Ratings

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 ⁽¹⁾	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±750	

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

7.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V _I	Supply voltage, VIN	2	6	V
I _{OUT}	Output current, 2.3V < VIN < 6V		300	mA
	Output current, 2V ≤ VIN ≤ 2.3V		150	mA
L	Inductance	1.5	4.7	μH
C _{OUT}	Output capacitance	4.7	10	μF
T _J	Operating junction temperature	–40	125	°C

7.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPS6224X-Q1	UNIT
		DDC (TSOT 23)	
		5 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	193.7	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	40.7	°C/W
R _{θJB}	Junction-to-board thermal resistance	35	°C/W
ψ _{JT}	Junction-to-top characterization parameter	0.9	°C/W
ψ _{JB}	Junction-to-board characterization parameter	34.7	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

7.5 Electrical Characteristics

$T_J = -40^{\circ}\text{C}$ to 125°C , typical values are at $T_J = 25^{\circ}\text{C}$, unless otherwise noted. Specifications apply for condition $V_{IN} = 3.6\text{ V}$.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY						
I_Q	Operating quiescent current	$I_{OUT} = 0\text{ mA}$. Pulse frequency modulation (PFM) mode enabled, device not switching	15			μA
		$I_{OUT} = 0\text{ mA}$. PFM mode enabled, device switching, $V_{OUT} = 1.25\text{ V}$	18.5			
I_{SD}	Shutdown current	$EN = \text{GND}$, $T_J = 25^{\circ}\text{C}$	0.1	1		μA
		$EN = \text{GND}$	10			
UVLO	Undervoltage lockout threshold	Falling	1.85			V
		Rising	1.95			
ENABLE, MODE						
V_{IH}	High-level input voltage, EN	$2\text{ V} \leq V_{IN} \leq 6\text{ V}$	1	V_{IN}		V
V_{IL}	Low-level input voltage, EN	$2\text{ V} \leq V_{IN} \leq 6\text{ V}$,	0	0.35		V
I_{IN}	Input bias current, EN	$EN, \text{MODE} = \text{GND}$ or V_{IN}	0.01		1	μA
POWER SWITCH						
$R_{DS(on)}$	High-side MOSFET ON-resistance	$V_{IN} = V_{GS} = 3.6\text{ V}$, $T_J = 25^{\circ}\text{C}$	240		480	m Ω
	Low-side MOSFET ON-resistance		180		380	
I_{LIMF}	Forward current limit MOSFET high-side and low-side	$V_{IN} = V_{GS} = 3.6\text{ V}$,	0.54		0.95	A
TSD	Thermal shutdown	Increasing junction temperature	140		$^{\circ}\text{C}$	
	Thermal shutdown hysteresis	Decreasing junction temperature	20		$^{\circ}\text{C}$	
OSCILLATOR						
f_{SW}	Oscillator frequency	$2\text{ V} \leq V_{IN} \leq 6\text{ V}$, PWM Mode	2	2.25	2.5	MHz
OUTPUT						
V_{OUT}	Output voltage	TPS62244 Q1 (fixed V_{OUT})	1.25		V	
		TPS62243 Q1 (fixed V_{OUT})	1.80		V	
V_{REF}	Internal reference voltage		600		mV	
V_{FB}	Feedback voltage	PWM operation, $2\text{ V} \leq V_{IN} \leq 6\text{ V}$, in fixed output voltage versions $V_{FB} = V_{OUT}$; See ⁽¹⁾ , $T_J = 25^{\circ}\text{C}$	-1.5%	0%	1.5%	
		PWM operation, $2\text{ V} \leq V_{IN} \leq 6\text{ V}$, in fixed output voltage versions $V_{FB} = V_{OUT}$; See ⁽¹⁾	-1.5%	2.5%		
	Feedback voltage PFM mode	Device in PFM mode			0%	
	Load regulation	PWM mode			-0.5	
$t_{Start\ up}$	Start-up time	Time from active EN to reach 95% of V_{OUT} nominal	500		μs	
t_{Ramp}	V_{OUT} ramp UP time	Time to ramp from 5% to 95% of V_{OUT}	250		μs	
I_{lkg}	Leakage current into SW pin	$V_{IN} = 3.6\text{ V}$, $V_{IN} = V_{OUT} = V_{SW}$, $EN = \text{GND}$, $T_J = 25^{\circ}\text{C}$ ⁽²⁾	0.1		1	μA
		$V_{IN} = 3.6\text{ V}$, $V_{IN} = V_{OUT} = V_{SW}$, $EN = \text{GND}$, ⁽²⁾	10			

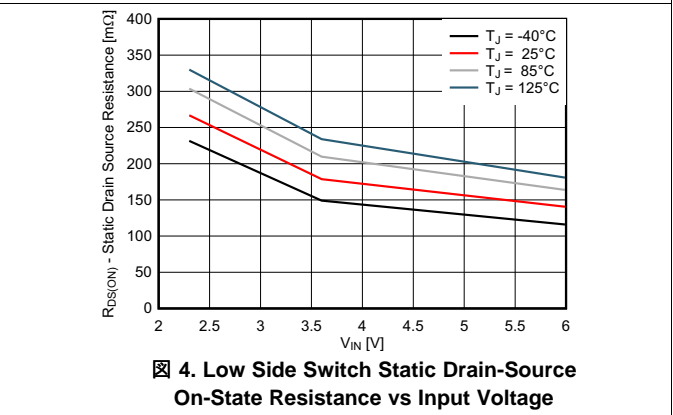
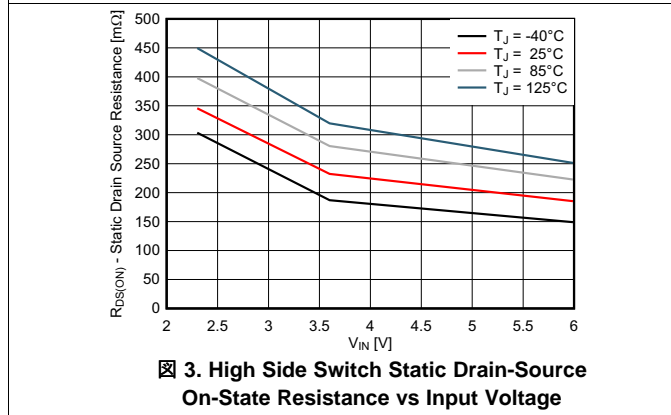
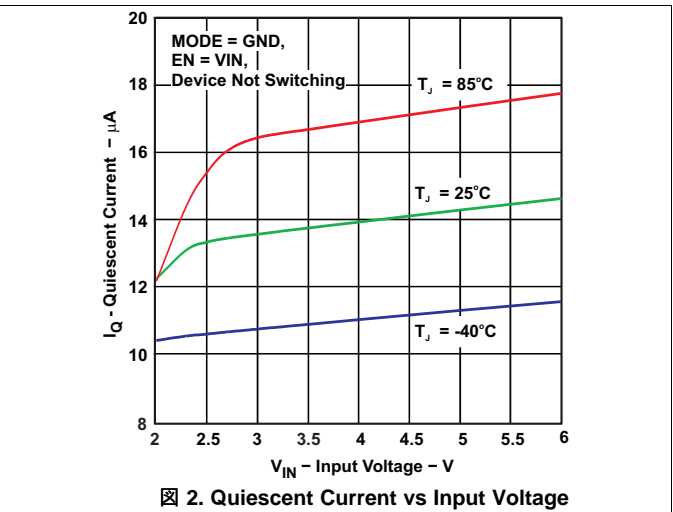
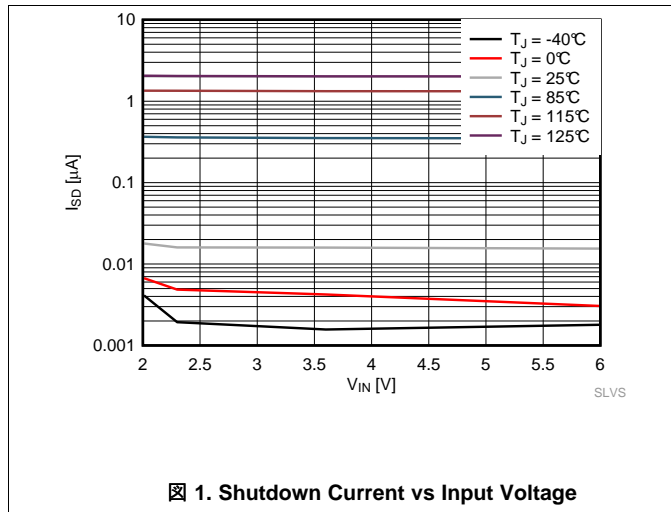
(1) For $V_{IN} = V_O + 0.6$

(2) The internal resistor divider network is disconnected from FB pin.

7.6 Typical Characteristics

表 1. Table of Graphs

		FIGURE
Shutdown Current into VIN	vs Input Voltage	☒ 1
Quiescent Current	vs Input Voltage	☒ 2
Static Drain-Source On-State Resistance	vs Input Voltage	☒ 3
		☒ 4



8 Detailed Description

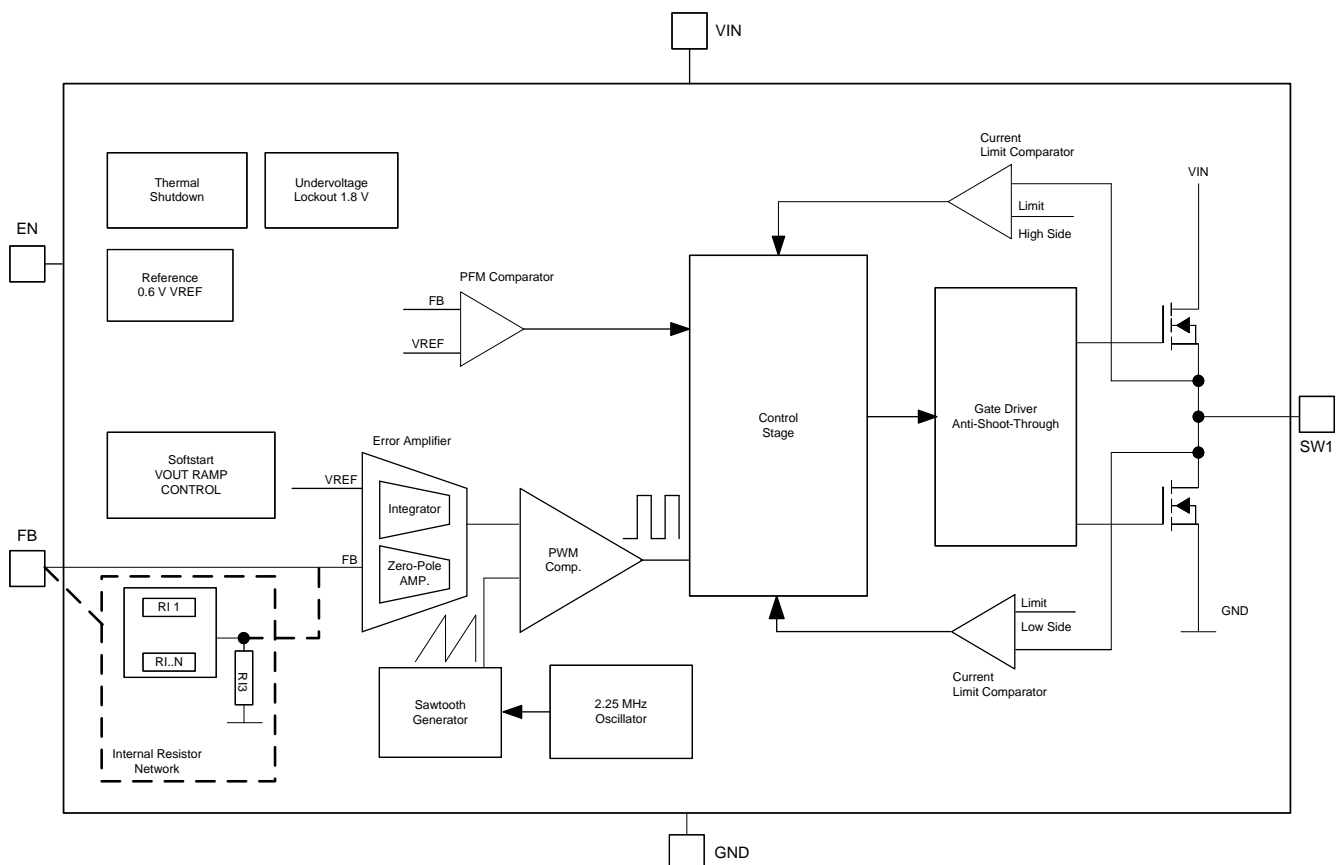
8.1 Overview

The TPS6224X-Q1 step-down converter typically operates with 2.25-MHz fixed-frequency pulse width modulation (PWM) at moderate to heavy load currents. At light load currents, the converter can automatically enter power save mode and then operates in PFM mode.

During PWM operation, the converter uses a unique fast-response voltage-mode control scheme with input voltage feed-forward to achieve good line and load regulation, allowing the use of small ceramic input and output capacitors. At the beginning of each clock cycle initiated by the clock signal, the high-side MOSFET switch is turned on. The current then flows from the input capacitor through the high-side MOSFET switch through the inductor to the output capacitor and load. During this phase, the current ramps up until the PWM comparator trips and the control logic turns off the switch. The current limit comparator also turns off the switch if the current limit of the high-side MOSFET switch is exceeded. After a dead time preventing shoot-through current, the low-side MOSFET rectifier is turned on and the inductor current ramps down. The current then flows from the inductor to the output capacitor and to the load. It returns back to the inductor through the low-side MOSFET rectifier.

The next cycle is initiated by the clock signal again turning off the low-side MOSFET rectifier and turning on the high-side MOSFET switch.

8.2 Functional Block Diagram



Copyright © 2016, Texas Instruments Incorporated

8.3 Feature Description

8.3.1 Undervoltage Lockout

The undervoltage lockout circuit prevents the device from malfunctioning at low input voltages and from excessive discharge of the battery and disables the output stage of the converter. The undervoltage lockout threshold is typically 1.85 V with falling V_{IN} .

8.3.2 Enable

The device is enabled by setting the EN pin to high. During the start-up time ($t_{Start\ up}$), the internal circuits are settled and the soft-start circuit is activated. The EN input can be used to control power sequencing in a system with various DC-DC converters. The EN pin can be connected to the output of another converter, to drive the EN pin high and sequence supply rails. With EN pin = GND, the device enters shutdown mode in which all circuits are disabled. In fixed-output voltage versions, the internal resistor divider network is then disconnected from FB pin.

8.3.3 Thermal Shutdown

As soon as the junction temperature, T_J , exceeds 140°C (typical) the device goes into thermal shutdown. In this mode, the high-side and low-side MOSFETs are turned off. The device continues its operation when the junction temperature falls below the thermal shutdown hysteresis.

8.4 Device Functional Modes

8.4.1 Soft Start

The TPS6224X-Q1 device has an internal soft-start circuit that controls the ramp up of the output voltage. The output voltage ramps up from 5% to 95% of its nominal value within typical 250 μ s. This limits the inrush current in the converter during ramp up and prevents possible input voltage drops when using a battery or high impedance power source. The soft-start circuit is enabled within the start-up time, $t_{Start\ up}$.

8.4.2 Power Save Mode

The power save mode is enabled. If the load current decreases, the converter enters power save mode operation automatically. During power save mode, the converter skips switching and operates with reduced frequency in PFM mode with a minimum-quiescent current to maintain high efficiency.

The transition from PWM mode to PFM mode occurs once the inductor current in the low-side MOSFET switch becomes zero, which indicates discontinuous conduction mode.

During the power save mode, a PFM comparator monitors the output voltage. As the output voltage falls below the PFM comparator threshold of V_{OUT} nominal, the device starts a PFM current pulse. The high-side MOSFET switch turns on, and the inductor current ramps up. After the on-time expires, the switch turns off and the low-side MOSFET switch turns on until the inductor current becomes zero.

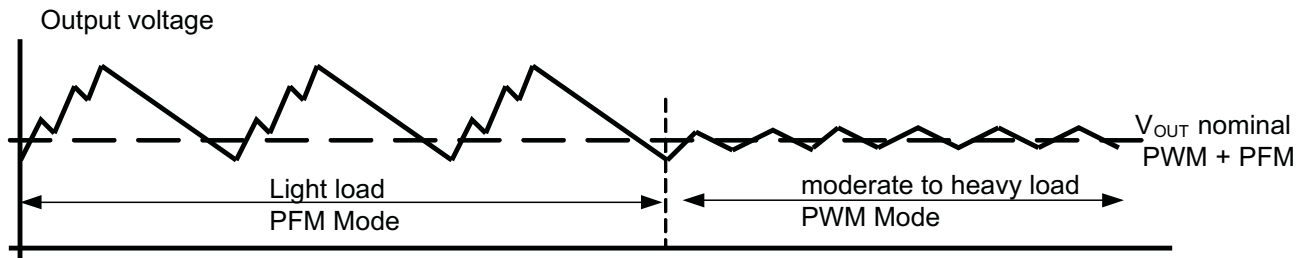
The converter effectively delivers a current to the output capacitor and the load. If the load is below the delivered current, the output voltage rises. If the output voltage is equal to or greater than the PFM comparator threshold, the device stops switching and enters a sleep mode with typical 15- μ A current consumption.

If the output voltage is still below the PFM comparator threshold, a sequence of further PFM current pulses are generated until the PFM comparator threshold is reached. The converter starts switching again once the output voltage drops below the PFM comparator threshold.

With a fast single-threshold comparator, the output-voltage ripple during PFM mode operation can be kept to a minimum. The PFM pulse is time controlled, allowing the user to modify the charge transferred to the output capacitor by the value of the inductor. The resulting PFM output voltage ripple and PFM frequency both depend on the size of the output capacitor and the inductor value. Increasing output capacitor values and inductor values minimize the output ripple. The PFM frequency decreases with smaller inductor values and increases with larger values.

If the output current cannot be supported in PFM mode, the device exits PFM mode and enters PWM mode.

Device Functional Modes (continued)



☒ 5. Power Save Mode

8.4.2.1 100% Duty Cycle Low Dropout Operation

The device starts to enter 100% duty-cycle mode once the input voltage comes close to the nominal output voltage. To maintain the output voltage, the high-side MOSFET switch is turned on 100% for one or more cycles.

With further decreasing V_{IN} the high-side MOSFET switch is turned on completely. In this case, the converter offers a low input-to-output voltage difference. This is particularly useful in battery-powered applications to achieve longest operation time by taking full advantage of the entire battery voltage range.

The minimum input voltage to maintain regulation depends on the load current and output voltage, and can be calculated as:

$$V_{INmin} = V_{Omax} + I_{Omax} (R_{DS(on)max} + R_L)$$

where

- I_{Omax} = maximum output current plus inductor ripple current
- $R_{DS(on)max}$ = maximum P-channel switch $R_{DS(on)}$
- R_L = DC resistance of the inductor
- V_{Omax} = nominal output voltage plus maximum output voltage tolerance

(1)

8.4.3 Short-Circuit Protection

The high-side and low-side MOSFET switches are short-circuit protected with maximum switch current equal to I_{LIMF} . The current in the switches is monitored by current limit comparators. Once the current in the high-side MOSFET switch exceeds the threshold of its current limit comparator, it turns off and the low-side MOSFET switch is activated to ramp down the current in the inductor and high-side MOSFET switch. The high-side MOSFET switch can only turn on again once the current in the low-side MOSFET switch has decreased below the threshold of its current limit comparator.

9 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The following section discusses the design of the external components to complete the power supply design by using typical applications as a reference.

9.2 Typical Application

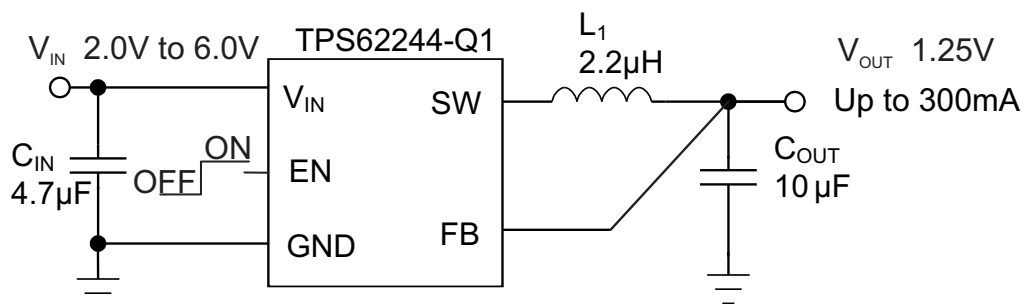


图 6. TPS62244Q1, Fixed 1.25 V V_{OUT}

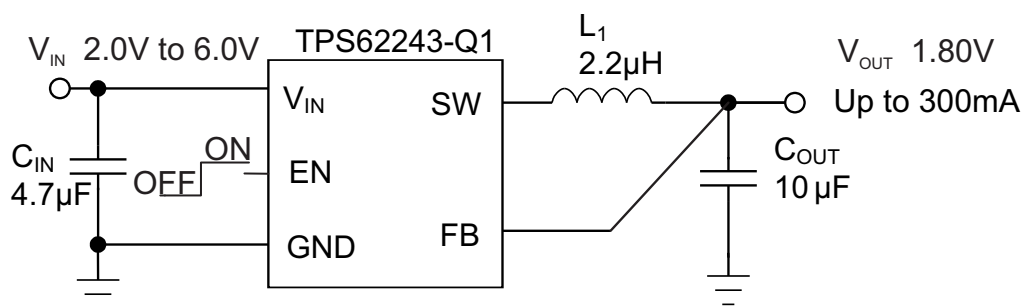


图 7. TPS62243Q1, Fixed 1.80 V V_{OUT}

9.2.1 Design Requirements

The device operates over an input voltage range from 2 V to 6 V. The output voltage setting is fixed.

9.2.2 Detailed Design Procedure

表 2 shows the list of components for the [Application Curves](#). Users must verify and validate these components for suitability with their application before using the components.

表 2. List of Components

VALUE	COMPONENT REFERENCE	PART NUMBER	MANUFACTURER ⁽¹⁾
4.7 μ F, 6.3 V. X5R Ceramic	C_{IN}	GRM188R60J475K	Murata
10 μ F, 6.3 V. X5R Ceramic	C_{OUT}	GRM188R60J106M	Murata
2.2 μ H, 110 m Ω	L_1	LPS3015	Coilcraft

(1) See [Third-party Products Disclaimer](#)

9.2.2.1 Output Filter Design (Inductor and Output Capacitor)

The TPS6224X-Q1 device is designed to operate with inductors in the range of 1.5 μH to 4.7 μH and with output capacitors in the range of 4.7 μF to 22 μF . The device is optimized for operation with a 2.2- μH inductor and 10- μF output capacitor.

Larger or smaller inductor values can be used to optimize the performance of the device for specific operation conditions. For stable operation, the L and C values of the output filter may not fall below 1- μH effective Inductance and 3.5- μF effective capacitance.

9.2.2.1.1 Inductor Selection

The inductor value has a direct effect on the ripple current. The selected inductor must be rated for its DC resistance and saturation current (表 3). The inductor ripple current (ΔI_L) decreases with higher inductance and increases with higher V_I or V_O .

The inductor selection also has an impact on the output voltage ripple in the PFM mode. Higher inductor values lead to lower-output voltage ripple and higher PFM frequency, and lower inductor values lead to a higher-output voltage ripple with lower PFM frequency.

式 2 calculates the maximum inductor current in PWM mode under static load conditions. The saturation current of the inductor should be rated higher than the maximum inductor current as calculated with 式 3. This is the recommendation because during heavy-load transients the inductor current rises above the calculated value.

$$\Delta I_L = V_{\text{OUT}} \times \frac{1 - \frac{V_{\text{OUT}}}{V_{\text{IN}}}}{L \times f} \quad (2)$$

$$I_{L\text{max}} = I_{\text{OUTmax}} + \frac{\Delta I_L}{2}$$

where

- f = Switching frequency (2.25-MHz typical)
- L = Inductor value
- ΔI_L = Peak-to-Peak inductor ripple current
- $I_{L\text{max}}$ = Maximum inductor current (3)

A more conservative approach is to select the inductor current rating just for the maximum switch current limit $I_{L\text{LIMF}}$ of the converter.

Accepting larger values of ripple current allows the use of low inductance values, but results in higher output voltage ripple, greater core losses, and lower output current capability.

The total losses of the coil strongly impact the efficiency of the DC-DC conversion and consist of both the losses in the DC resistance (R_{DC}) and the following frequency-dependent components:

- The losses in the core material (magnetic hysteresis loss, especially at high switching frequencies)
- Additional losses in the conductor from the skin effect (current displacement at high frequencies)
- Magnetic field losses of the neighboring windings (proximity effect)
- Radiation losses

表 3. List of Inductors

INDUCTANCE (μH)	DIMENSIONS (mm)	PART NUMBER	MANUFACTURER ⁽¹⁾
2	2.5 × 2 × 1	MIPS2520D2R2	FDK
2	2.5 × 2 × 1.2	MIPSA2520D2R2	FDK
2.2	2.5 × 2 × 1	KSLI-252010AG2R2	Hitachi Metals
2.2	2.5 × 2 × 1.2	LQM2HPN2R2MJ0L	Murata
2.2	3 × 3 × 1.4	LPS3015	Coilcraft

(1) See [Third-party Products Disclaimer](#)

9.2.2.1.2 Output Capacitor Selection

The advanced fast-response voltage-mode control scheme of the TPS6224X-Q1 device allows the use of tiny ceramic capacitors. Ceramic capacitors with low-ESR values have the lowest-output voltage ripple and are recommended. The output capacitor requires either an X7R or X5R dielectric. Y5V and Z5U dielectric capacitors, aside from their wide variation in capacitance over temperature, become resistive at high frequencies.

At nominal load current, the device operates in PWM mode and the RMS ripple current is calculated as in 式 4:

$$I_{\text{RMSC}_{\text{OUT}}} = V_{\text{OUT}} \times \frac{1 - \frac{V_{\text{OUT}}}{V_{\text{IN}}}}{L \times f} \times \frac{1}{2 \times \sqrt{3}} \quad (4)$$

At nominal load current, the device operates in PWM mode and the overall output voltage ripple is the sum of the voltage spike caused by the output capacitor ESR plus the voltage ripple caused by charging and discharging the output capacitor as in 式 5:

$$\Delta V_{\text{OUT}} = V_{\text{OUT}} \times \frac{1 - \frac{V_{\text{OUT}}}{V_{\text{IN}}}}{L \times f} \times \left(\frac{1}{8 \times C_{\text{OUT}} \times f} + \text{ESR} \right) \quad (5)$$

At light load currents, the converter operates in power save mode and the output voltage ripple depends on the output capacitor and inductor value. Larger output capacitor and inductor values minimize the voltage ripple in PFM mode and tighten DC output accuracy in PFM mode.

9.2.2.1.3 Input Capacitor Selection

The buck converter has a natural pulsating input current; therefore, a low-ESR input capacitor is required for best input voltage filtering and minimizing the interference with other circuits caused by high-input voltage spikes. For most applications, a 4.7- μF to 10- μF ceramic capacitor is recommended (表 4). Because ceramic capacitors lose up to 80% of their initial capacitance at 5 V, TI recommends using a 10- μF input capacitor for input voltages greater than 4.5 V. The input capacitor can be increased without any limit for better input voltage filtering.

Take care when using only small ceramic input capacitors. When a ceramic capacitor is used at the input, and the power is being supplied through long wires, such as from a wall adapter, a load step at the output, or V_{IN} step on the input, can induce ringing at the VIN pin. The ringing can couple to the output and be mistaken as loop instability, or could even damage the part by exceeding the maximum ratings.

表 4. List of Capacitors

CAPACITANCE (μF)	DIMENSIONS (mm)	PART NUMBER	MANUFACTURER ⁽¹⁾
4.7	0603: 1.6 × 0.8 × 0.8	GRM188R60J475K	Murata
10	0603: 1.6 × 0.8 × 0.8	GRM188R60J106M69D	Murata

(1) See [Third-party Products Disclaimer](#)

9.2.3 Application Curves

The conditions for below application curves are $V_{IN} = 3.0V$, $V_{OUT} = 1.25V$ and the components listed in 表 2, unless otherwise noted.

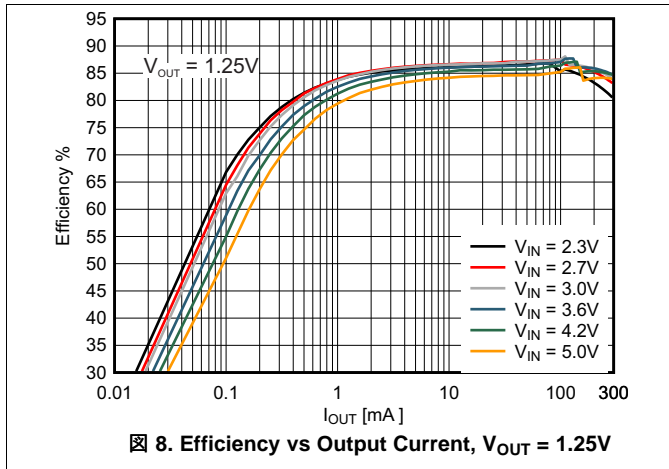


图 8. Efficiency vs Output Current, $V_{OUT} = 1.25V$

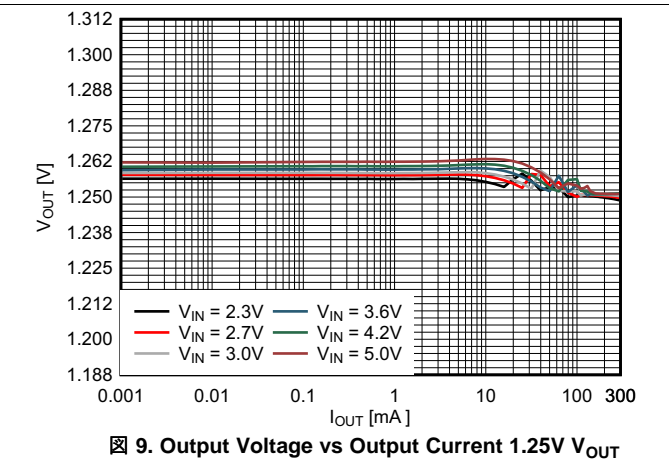


图 9. Output Voltage vs Output Current 1.25V V_{OUT}

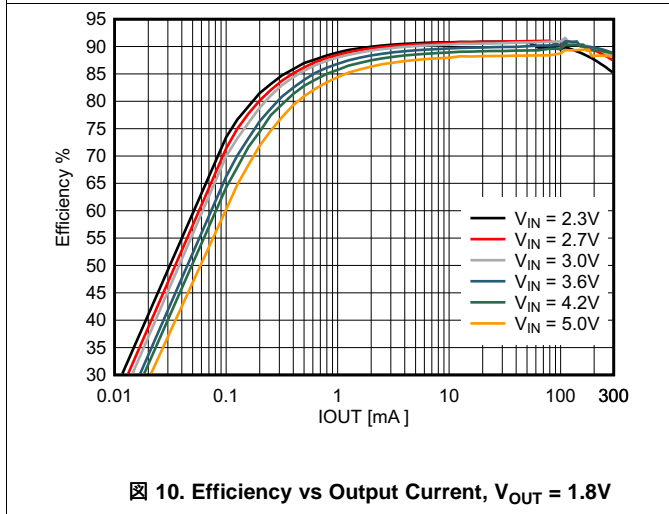


图 10. Efficiency vs Output Current, $V_{OUT} = 1.8V$

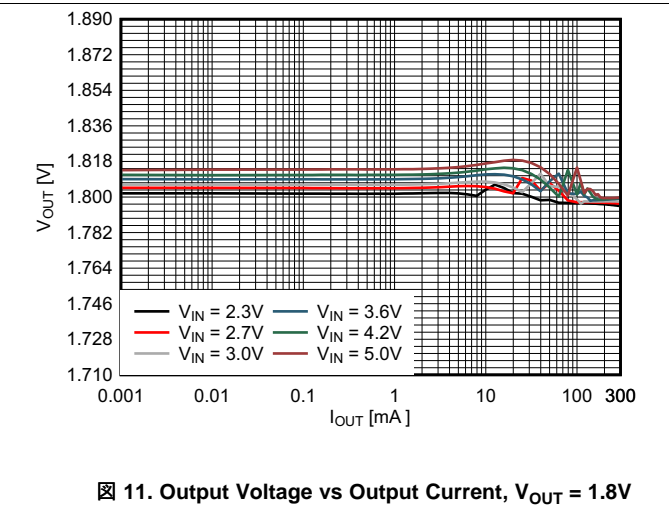


图 11. Output Voltage vs Output Current, $V_{OUT} = 1.8V$

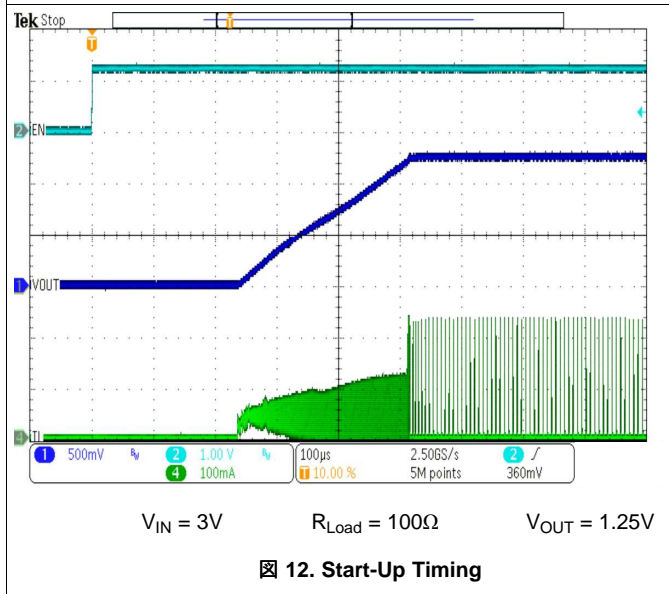


图 12. Start-Up Timing

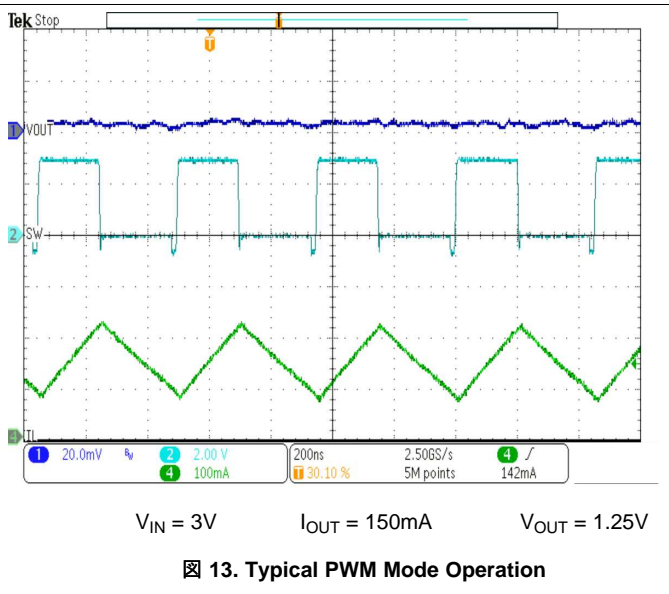
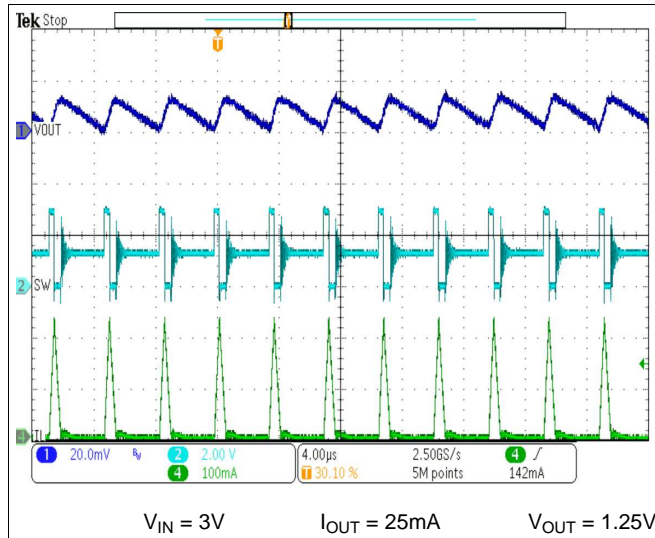
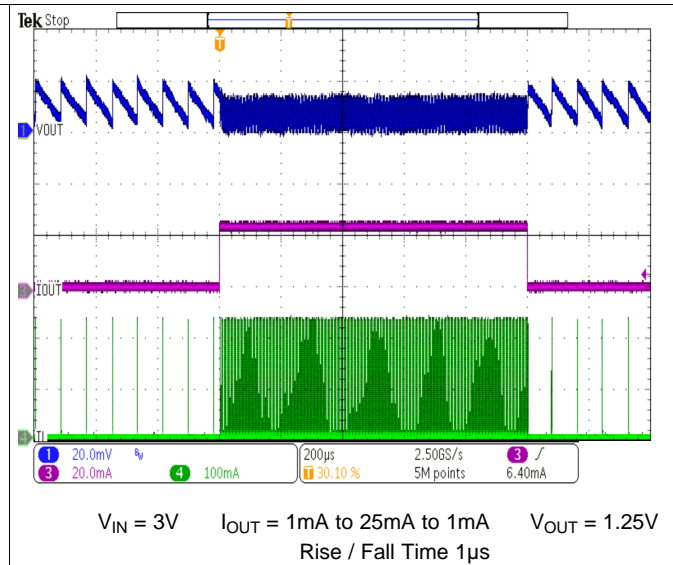


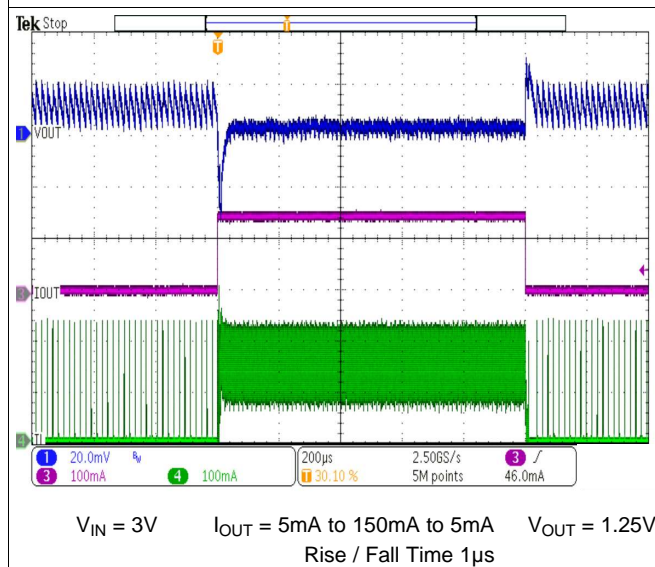
图 13. Typical PWM Mode Operation



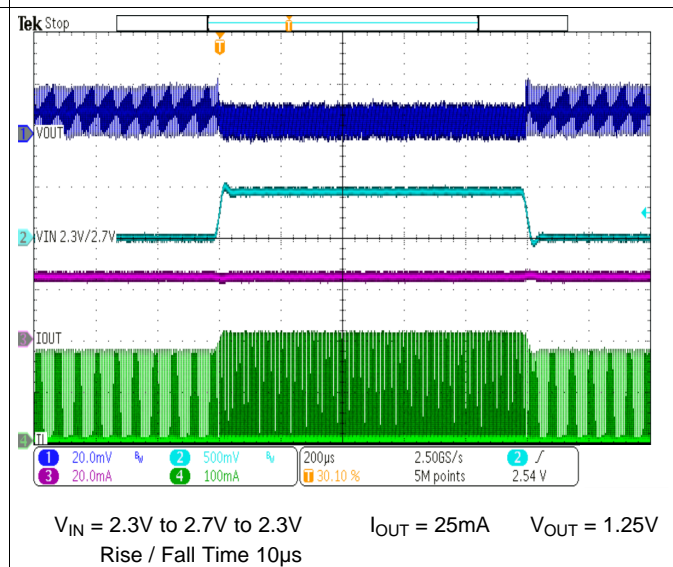
⊠ 14. Typical PFM Mode Operation



⊠ 15. Load Transient PFM Mode



⊠ 16. Load Transient PFM / PWM Mode



⊠ 17. Line Transient PFM Mode

10 Power Supply Recommendations

The TPS6224X-Q1 device has no special requirements for its input power supply. The input power supply output current must be rated according to the supply voltage, output voltage, and output current of the TPS6224X-Q1.

11 Layout

11.1 Layout Guidelines

As for all switching power supplies, the layout is an important step in the design. Proper function of the device demands careful attention to PCB layout. To get the specified performance, the board layout must be carefully done. If not carefully done, the regulator could show poor line or load regulation, and additional stability issues as well as EMI problems. [Figure 18](#) shows an example of layout design with the TLV62242-Q1 device.

- Providing a low-inductance, low-impedance ground path is critical. Therefore, use wide and short traces for the main current paths. The input capacitor as well as the inductor and output capacitor must be placed as close as possible to the IC pins.
- The FB line must be connected directly to the output capacitor and the FB line must be routed away from noisy components and traces (for example, the SW line).
- Because of the small package of this converter and the overall small solution size, the thermal performance of the PCB layout is important. For good thermal performance, PCB design of at least four layers is recommended.

11.2 Layout Example

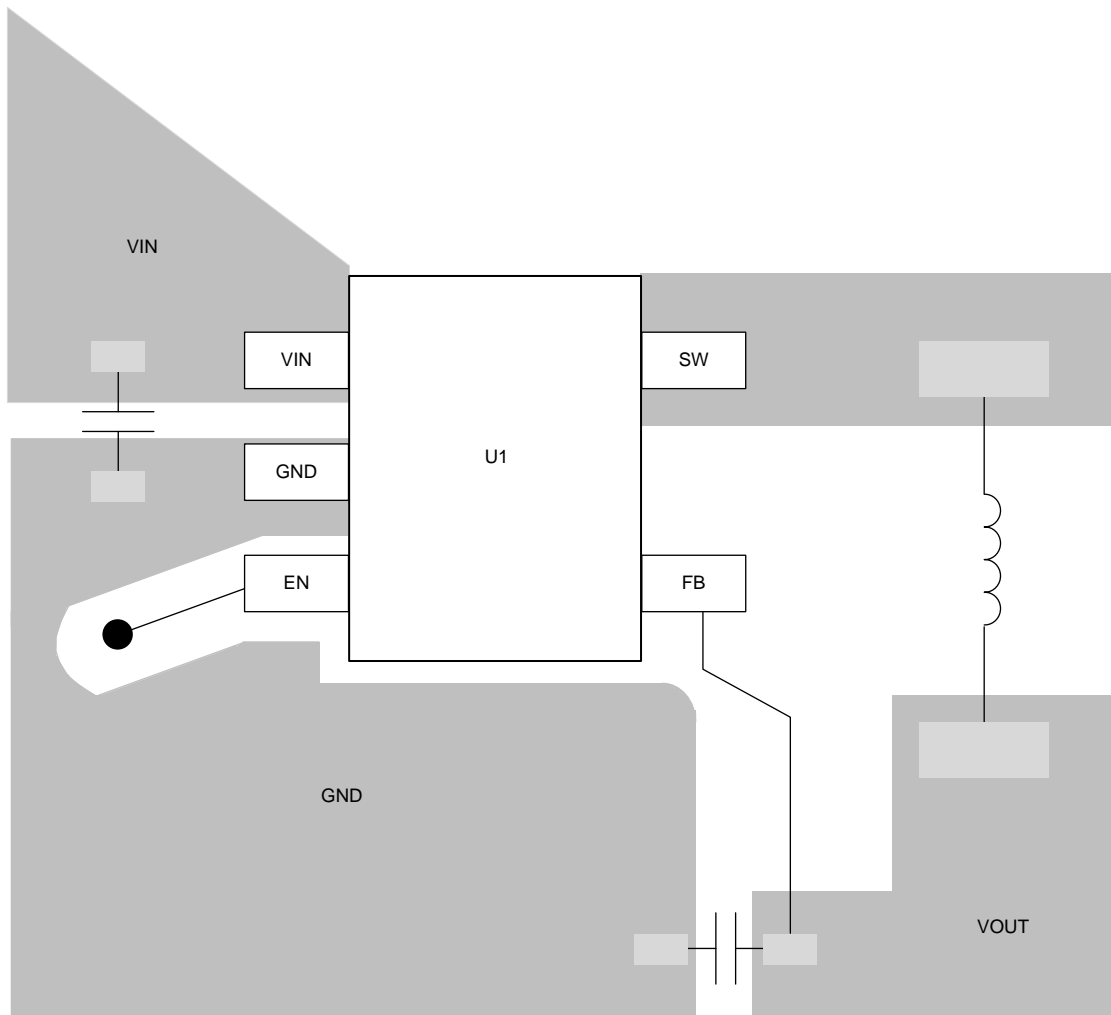


Figure 18. Suggested Layout for Fixed Output Voltage

12 デバイスおよびドキュメントのサポート

12.1 デベロッパー・ネットワークの製品に関する免責事項

デベロッパー・ネットワークの製品またはサービスに関するTIの出版物は、単独またはTIの製品、サービスと一緒に提供される場合に関係なく、デベロッパー・ネットワークの製品またはサービスの適合性に関する是認、デベロッパー・ネットワークの製品またはサービスの是認の表明を意味するものではありません。

12.2 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。右上の隅にある「通知を受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

12.3 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](#).

TI E2E™オンライン・コミュニティ TIのE2E (*Engineer-to-Engineer*) コミュニティ。エンジニア間の共同作業を促進するために開設されたものです。e2e.ti.comでは、他のエンジニアに質問し、知識を共有し、アイデアを検討して、問題解決に役立てることができます。

設計サポート TIの設計サポート役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

12.4 商標

E2E is a trademark of Texas Instruments.

12.5 静電気放電に関する注意事項



これらのデバイスは、限定的なESD(静電破壊)保護機能を内蔵しています。保存時または取り扱い時は、MOSゲートに対する静電破壊を防止するために、リード線同士をショートさせておくか、デバイスを導電フォームに入れる必要があります。

12.6 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。

13.1 Package Option Addendum

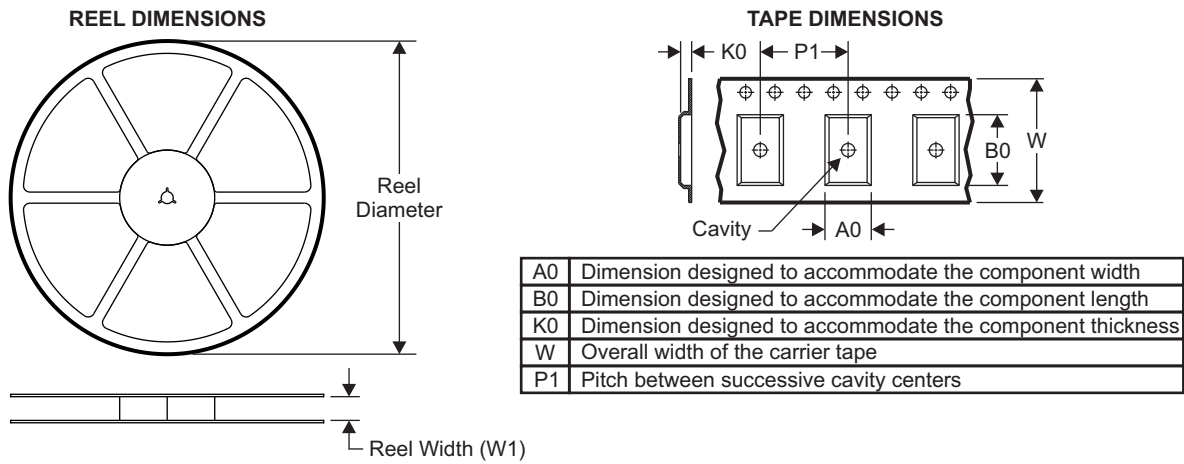
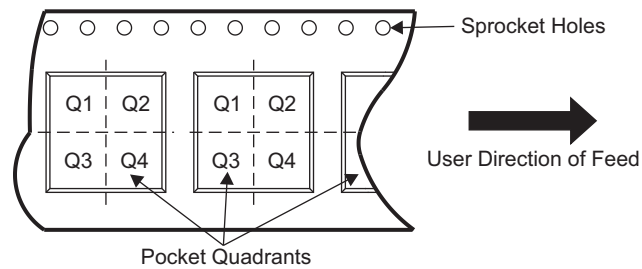
13.1.1 Packaging Information

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish ⁽³⁾	MSL Peak Temp ⁽⁴⁾	Op Temp (°C)	Device Marking ⁽⁵⁾⁽⁶⁾
TPS62243QDDCRQ1	PREVIEW	SOT-23-THIN	DDC	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 115	1I3Z
TPS62244QDDCRQ1	PREVIEW	SOT-23-THIN	DDC	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 115	1I2Z

- (1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PRE_PROD Unannounced device, not in production, not available for mass market, nor on the web, samples not available.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.
- (2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)
- (3) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.
- (4) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.
- (5) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device
- (6) Multiple Device markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

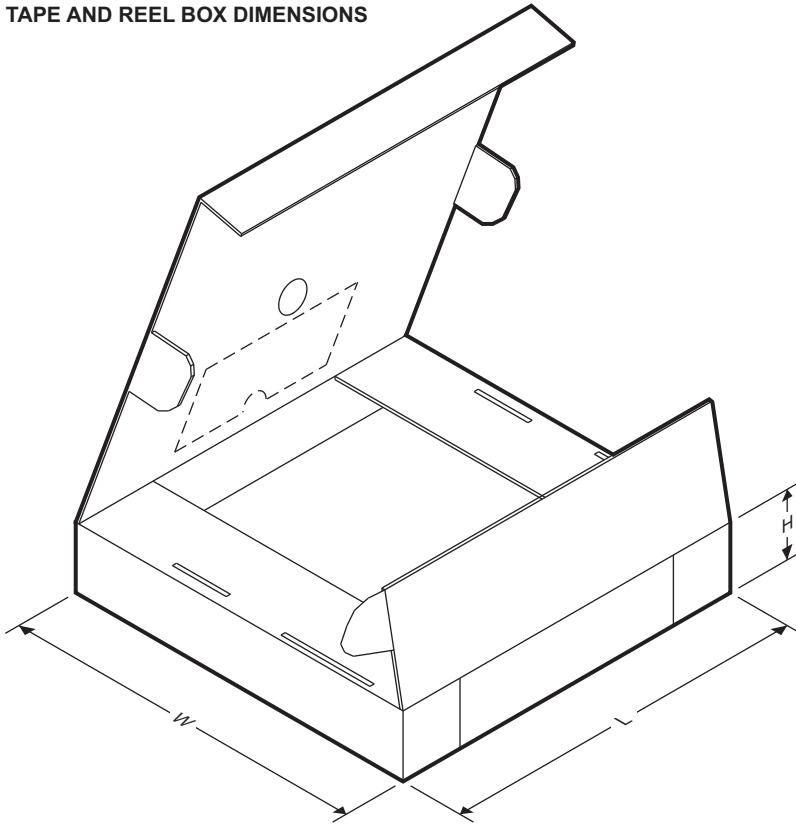
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

13.1.2 Tape and Reel Information

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


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
TPS62243QDDCRQ1	SOT-23-THIN	DDC	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS62244QDDCRQ1	SOT-23-THIN	DDC	5	3000	179.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS62243QDDCRQ1	SOT-23-THIN	DDC	5	3000	203.0	2.3.0	35.0
TPS62244QDDCRQ1	SOT-23-THIN	DDC	5	3000	203.0	2.3.0	35.0

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS62243QDDCRQ1	ACTIVE	SOT-23-THIN	DDC	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	113Z	Samples
TPS62244QDDCRQ1	ACTIVE	SOT-23-THIN	DDC	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	112Z	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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

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

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.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



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
TPS62243QDDCRQ1	SOT-23-THIN	DDC	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPS62244QDDCRQ1	SOT-23-THIN	DDC	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

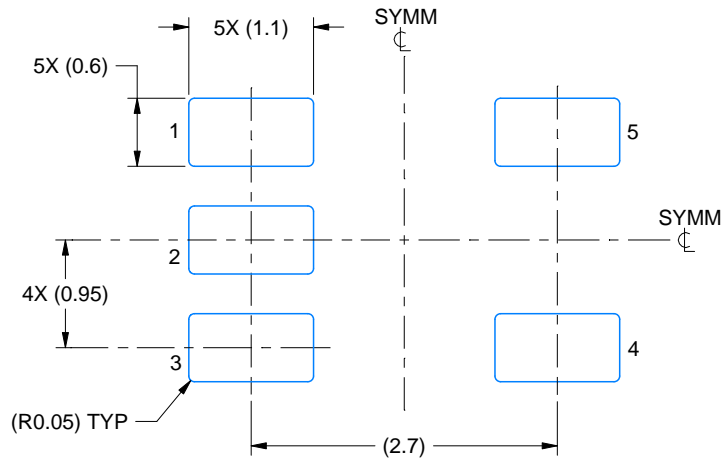
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS62243QDDCRQ1	SOT-23-THIN	DDC	5	3000	213.0	191.0	35.0
TPS62244QDDCRQ1	SOT-23-THIN	DDC	5	3000	213.0	191.0	35.0

EXAMPLE BOARD LAYOUT

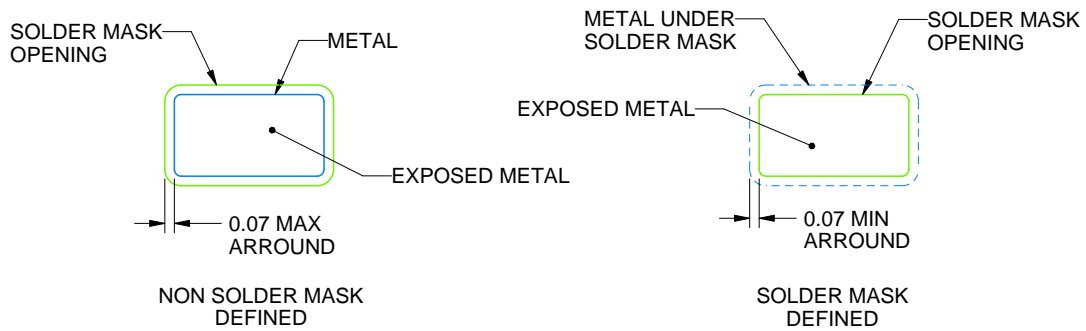
DDC0005A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPLODED METAL SHOWN
SCALE:15X



SOLDERMASK DETAILS

4220752/B 06/2024

NOTES: (continued)

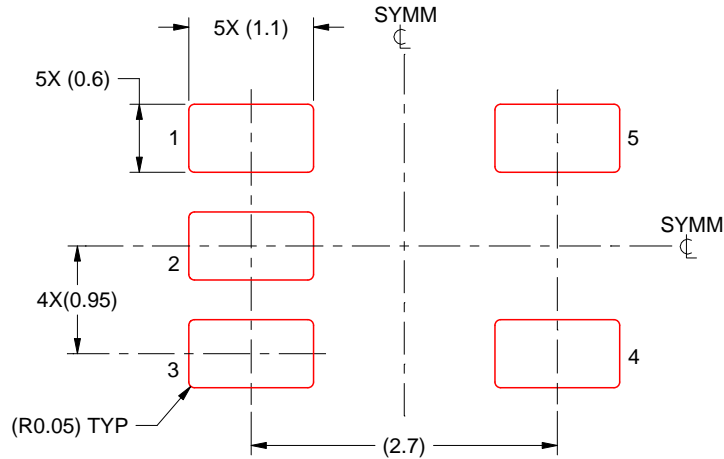
- 4. Publication IPC-7351 may have alternate designs.
- 5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DDC0005A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

4220752/B 06/2024

NOTES: (continued)

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

重要なお知らせと免責事項

TI は、技術データと信頼性データ (データシートを含みます)、設計リソース (リファレンス・デザインを含みます)、アプリケーションや設計に関する各種アドバイス、Web ツール、安全性情報、その他のリソースを、欠陥が存在する可能性のある「現状のまま」提供しており、商品性および特定目的に対する適合性の黙示保証、第三者の知的財産権の非侵害保証を含むいかなる保証も、明示的または黙示的にかかわらず拒否します。

これらのリソースは、TI 製品を使用する設計の経験を積んだ開発者への提供を意図したものです。(1) お客様のアプリケーションに適した TI 製品の選定、(2) お客様のアプリケーションの設計、検証、試験、(3) お客様のアプリケーションに該当する各種規格や、その他のあらゆる安全性、セキュリティ、規制、または他の要件への確実な適合に関する責任を、お客様のみが単独で負うものとし、

上記の各種リソースは、予告なく変更される可能性があります。これらのリソースは、リソースで説明されている TI 製品を使用するアプリケーションの開発の目的でのみ、TI はその使用をお客様に許諾します。これらのリソースに関して、他の目的で複製することや掲載することは禁止されています。TI や第三者の知的財産権のライセンスが付与されている訳ではありません。お客様は、これらのリソースを自身で使用した結果発生するあらゆる申し立て、損害、費用、損失、責任について、TI およびその代理人を完全に補償するものとし、TI は一切の責任を拒否します。

TI の製品は、[TI の販売条件](#)、または [ti.com](#) やかかる TI 製品の関連資料などのいずれかを通じて提供する適用可能な条項の下で提供されています。TI がこれらのリソースを提供することは、適用される TI の保証または他の保証の放棄の拡大や変更を意味するものではありません。

お客様がいかなる追加条項または代替条項を提案した場合でも、TI はそれらに異議を唱え、拒否します。

郵送先住所 : Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated