TEXAS INSTRUMENTS
LM2671
JAJS559L – SEPTEMBER 1998 – REVISED JUNE 2016

# LM2671 SIMPLE SWITCHER®高効率500mA 降圧型電圧レギュレータ(追加機能付き)

## 1 特長

- 最大96%の効率
- 8ピンのSOIC、PDIP、WSONパッケージで供給
- 単純で設計が簡単
- 5個の外付け部品で動作可能
- 容易に入手可能な標準インダクタを使用
- 3.3V、5V、12V、および可変出力電圧バージョン
- 可変出力バージョンの電圧範囲: 1.21V～37V
- ラインおよび負荷条件の全域において±1.5%の最大出力電圧許容範囲
- 出力負荷電流500mAを保証
- 0.25Ω DMOS出力スイッチ
- 広い入力電圧範囲: 8V～40V
- 260kHz固定周波数の自己発振器を内臓
- TTLシャットダウン機能、低消費電力のスタンバイ・モード
- ソフトスタートおよび周波数同期
- サーマル・シャットダウンおよび電流制限保護

## 2 アプリケーション

- 単純な高効率(90%超)の降圧型(バック)レギュレータ
- リニア・レギュレータ用の高効率プリレギュレータ

## 3 概要

LM2671シリーズのレギュレータは、LMDMOSプロセスで構築されたモノリシック集積回路です。これらのレギュレータは、降圧型(バック)スイッチング・レギュレータのすべてのアクティブ機能を備えており、優れたラインおよび負荷レギュレーションで500mAの負荷電流を駆動できます。3.3V、5V、12Vの固定出力電圧と、可変出力電圧のバージョンがあります。

これらのレギュレータは、必要な外付け部品の数が最小限で、簡単に使用でき、特許取得の内部周波数補償、固定周波数発振器、外部シャットダウン、ソフトスタート、周波数同期が内蔵されています。

LM2671シリーズは260kHzのスイッチング周波数で動作するため、周波数の低いスイッチング・レギュレータに比べて小型のフィルタ部品を使用できます。非常に効率が高いため(90%超)、プリント基板の銅配線のみで十分なヒートシンクになります。

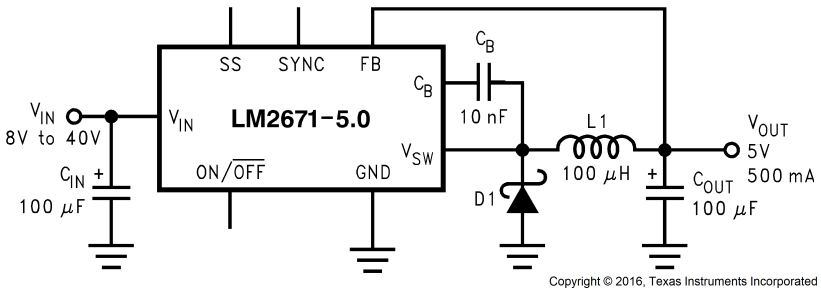
LM2671とともに使用する標準インダクタがいくつかの製造元から入手可能です。このため、これらの先進ICを使用するスイッチ・モード電源の設計が大幅に簡素化されます。データシートには、スイッチ・モード電源で動作するよう設計されたダイオードおよびコンデンサの選択ガイドも記載されています。

**製品情報(1)**

| 型番 | パッケージ | 本体サイズ(公称) |
|---|---|---|
| LM2674 | SOIC (8) | 4.90mm×3.91mm |
| | PDIP (8) | 9.81mm×6.35mm |
| | WSON (16) | 5.00mm×5.00mm |

(1) 提供されているすべてのパッケージについては、巻末の注文情報を参照してください。

**代表的なアプリケーション**




固定出力電圧バージョン用

英語版のTI製品についての情報を翻訳したこの資料は、製品の概要を確認する目的で便宜的に提供しているものです。該当する正式な英語版の最新情報は、www.ti.comで閲覧でき、その内容が常に優先されます。TIでは翻訳の正確性および妥当性につきましては一切保証いたしません。実際の設計などの前には、必ず最新版の英語版をご参照くださいますようお願いいたします。

# 目次

**1** 特長 ... 1
**2** アプリケーション ... 1
**3** 概要 ... 1
**4** 改訂履歴 ... 2
**5** **Description (continued)** ... 3
**6** **Pin Configuration and Functions** ... 3
**7** **Specifications** ... 4
7.1 Absolute Maximum Ratings ... 4
7.2 ESD Ratings ... 4
7.3 Recommended Operating Conditions ... 4
7.4 Thermal Information ... 4
7.5 Electrical Characteristics – 3.3 V ... 5
7.6 Electrical Characteristics – 5 V ... 5
7.7 Electrical Characteristics – 12 V ... 5
7.8 Electrical Characteristics – Adjustable ... 6
7.9 Electrical Characteristics – All Output Voltage Versions ... 6
7.10 Typical Characteristics ... 7
**8** **Detailed Description** ... 10
8.1 Overview ... 10
8.2 Functional Block Diagram ... 10
8.3 Feature Description ... 10
8.4 Device Functional Modes ... 11
**9** **Application and Implementation** ... 13
9.1 Application Information ... 13
9.2 Typical Applications ... 14
**10** **Power Supply Recommendations** ... 26
**11** **Layout** ... 27
11.1 Layout Guidelines ... 27
11.2 Layout Examples ... 27
**12** デバイスおよびドキュメントのサポート ... 28
12.1 ドキュメントのサポート ... 28
12.2 ドキュメントの更新通知を受け取る方法 ... 28
12.3 コミュニティ・リソース ... 28
12.4 商標 ... 28
12.5 静電気放電に関する注意事項 ... 28
12.6 Glossary ... 28
**13** メカニカル、パッケージ、および注文情報 ... 28
13.1 DAP (WSONパッケージ) ... 28

## 4 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

**Revision K (April 2013)** から **Revision L** に変更 **Page**

- 「*ESD定格*」の表、「*機能説明*」セクション、「*デバイスの機能モード*」セクション、「*アプリケーションと実装*」セクション、「*電源に関する推奨事項*」セクション、「*レイアウト*」セクション、「*デバイスおよびドキュメントのサポート*」セクション、「*メカニカル、パッケージング、および注文情報*」セクションを追加 ... 1
- コンピュータ設計用ソフトウェア***LM267X Made Simple*** (バージョン 6.0)に関する記述をすべて削除 ... 1

**Revision J (April 2013)** から **Revision K** に変更 **Page**

- Changed layout of National Data Sheet to TI format ... 27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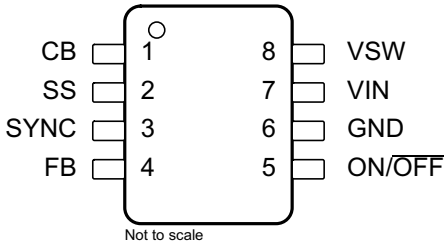
## 5 Description (continued)

Other features include a ensured ±1.5% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring typically 50-μA standby current. The output switch includes current limiting, as well as thermal shutdown for full protection under fault conditions.

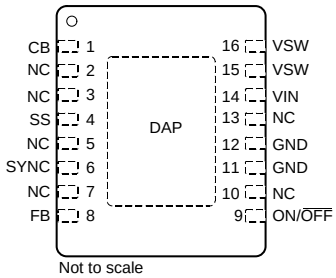
## 6 Pin Configuration and Functions

**D or P Package**
**8-Pin SOIC or PDIP**
**Top View**




Not to scale

**NHN Package**
**16-Pin WSON**
**Top View**




Not to scale

Connect DAP to pin 11 and 12

**Pin Functions**

| PIN | | | I/O | DESCRIPTION |
|---|---|---|---|---|
| NAME | SOIC, PDIP | WSON | | |
| CB | 1 | 1 | I | Bootstrap capacitor connection for high-side driver. Connect a high-quality, 100-nF capacitor from CB to VSW Pin. |
| SS | 2 | 4 | I | Soft-start Pin. Connect a capacitor from this pin to GND to control the output voltage ramp. If the feature not desired, the pin can be left floating. |
| SYNC | 3 | 6 | I | This input allows control of the switching clock frequency. If left open-circuited the regulator is switched at the internal oscillator frequency, typically 260 kHz. |
| FB | 4 | 8 | I | Feedback sense input pin. Connect to the midpoint of feedback divider to set VOUT for ADJ version or connect this pin directly to the output capacitor for a fixed output version. |
| ON/$\overline{OFF}$ | 5 | 9 | I | Enable input to the voltage regulator. High = ON and low = OFF. Pull this pin high or float to enable the regulator |
| VSW | 8 | 15, 16 | O | Source pin of the internal high-side FET. This is a switching node. Attached this pin to an inductor and the cathode of the external diode. |
| GND | 6 | 11, 12 | — | Power ground pins. Connect to system ground. Ground pins of $C_{IN}$ and $C_{OUT}$. Path to $C_{IN}$ must be as short as possible. |
| VIN | 7 | 14 | I | Supply input pin to collector pin of high-side FET. Connect to power supply and input bypass capacitors $C_{IN}$. Path from VIN pin to high frequency bypass $C_{IN}$ and GND must be as short as possible. |
| NC | — | 2, 3, 5, 7, 10, 13 | — | No connect pins |

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# 7 Specifications

## 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)(2)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| Supply voltage | | | | 45 | V |
| ON/$\overline{\text{OFF}}$ pin voltage, $V_{SH}$ | | | −0.1 | 6 | V |
| Switch voltage to ground | | | | –1 | V |
| Boost pin voltage | | | | $V_{SW}$ + 8 | V |
| Feedback pin voltage, $V_{FB}$ | | | −0.3 | 14 | V |
| Power dissipation | | | Internally Limited | | |
| Lead temperature | D package | Vapor phase (60 s) | | 215 | °C |
| | | Infrared (15 s) | | 220 | |
| | P package (soldering, 10 s) | | | 260 | |
| | WSON package | | See *AN-1187* | | |
| Maximum junction temperature | | | | 150 | °C |
| Storage temperature, $T_{stg}$ | | | −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) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

## 7.2 ESD Ratings

| | | | VALUE | UNIT |
|---|---|---|---|---|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)(2) | ±2000 | V |

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) The human body model is a 100-pF capacitor discharged through a 1.5-kΩ resistor into each pin.

## 7.3 Recommended Operating Conditions

| | MIN | MAX | UNIT |
|---|---|---|---|
| Supply voltage | 6.5 | 40 | V |
| Junction temperature, $T_J$ | –40 | 125 | °C |

## 7.4 Thermal Information

| THERMAL METRIC(1) | | LM2674 | | | UNIT |
|---|---|---|---|---|---|
| | | D (SOIC) | P (PDIP) | NHN (WSON) | |
| | | 8 PINS | 8 PINS | 16 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance(2) | 105 | 95 | — | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.
(2) Junction to ambient thermal resistance with approximately 1 square inch of printed-circuit board copper surrounding the leads. Additional copper area lowers thermal resistance further. The value $R_{\theta JA}$ for the WSON (NHN) package is specifically dependent on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, see *AN-1187 Leadless Leadframe Package (LLP)*.


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## 7.5 Electrical Characteristics – 3.3 V

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN(1) | TYP(2) | MAX(1) | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS**(3) | | | | | | | |
| $V_{OUT}$ | Output voltage | $V_{IN}$ = 8 V to 40 V, $I_{LOAD}$ = 20 mA to 500 mA | $T_J$ = 25°C | 3.251 | 3.3 | 3.35 | V |
| | | | Over full operating temperature range | 3.201 | | 3.399 | |
| | | $V_{IN}$ = 6.5 V to 40 V, $I_{LOAD}$ = 20 mA to 250 mA | $T_J$ = 25°C | 3.251 | 3.3 | 3.35 | V |
| | | | Over full operating temperature range | 3.201 | | 3.399 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 86% | | |

(1) All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2671 is used as shown in Figure 15 and Figure 21 test circuits, system performance is as specified by the system parameters section of the *Electrical Characteristics*.

## 7.6 Electrical Characteristics – 5 V

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN(1) | TYP(2) | MAX(1) | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS**(3) | | | | | | | |
| $V_{OUT}$ | Output voltage | $V_{IN}$ = 8 V to 40 V, $I_{LOAD}$ = 20 mA to 500 mA | $T_J$ = 25°C | 4.925 | 5 | 5.075 | V |
| | | | Over full operating temperature range | 4.85 | | 5.15 | |
| | | $V_{IN}$ = 6.5 V to 40 V, $I_{LOAD}$ = 20 mA to 250 mA | $T_J$ = 25°C | 4.925 | 5 | 5.075 | V |
| | | | Over full operating temperature range | 4.85 | | 5.15 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 90% | | |

(1) All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2671 is used as shown in Figure 15 and Figure 21 test circuits, system performance is as specified by the system parameters section of the *Electrical Characteristics*.

## 7.7 Electrical Characteristics – 12 V

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN(1) | TYP(2) | MAX(1) | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS**(3) | | | | | | | |
| $V_{OUT}$ | Output voltage | $V_{IN}$ = 15 V to 40 V, $I_{LOAD}$ = 20 mA to 500 mA | $T_J$ = 25°C | 11.82 | 12 | 12.18 | V |
| | | | Over full operating temperature range | 11.64 | | 12.36 | |
| η | Efficiency | $V_{IN}$ = 24 V, $I_{LOAD}$ = 500 mA | | | 94% | | |

(1) All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2671 is used as shown in Figure 15 and Figure 21 test circuits, system performance is as specified by the system parameters section of the *Electrical Characteristics*.

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## 7.8 Electrical Characteristics – Adjustable

Specifications are for $T_J$ = 25°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | | MIN(1) | TYP(2) | MAX(1) | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS**(3) | | | | | | | |
| $V_{FB}$ | Feedback voltage | $V_{IN}$ = 8 V to 40 V, $I_{LOAD}$ = 20 mA to 500 mA $V_{OUT}$ programmed for 5 V | $T_J$ = 25°C | 1.192 | 1.21 | 1.228 | V |
| | | | Over full operating temperature range | 1.174 | | 1.246 | |
| | | $V_{IN}$ = 6.5 V to 40 V, $I_{LOAD}$ = 20 mA to 250 mA $V_{OUT}$ programmed for 5 V | $T_J$ = 25°C | 1.192 | 1.21 | 1.228 | V |
| | | | Over full operating temperature range | 1.174 | | 1.246 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 90% | | |

(1) All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2671 is used as shown in Figure 15 and Figure 21 test circuits, system performance is as specified by the system parameters section of the *Electrical Characteristics*.

## 7.9 Electrical Characteristics – All Output Voltage Versions

Specifications are for $T_J$ = 25°C, $V_{IN}$ = 12 V for the 3.3-V, 5-V, and Adjustable versions and $V_{IN}$ = 24 V for the 12-V version, and $I_{LOAD}$ = 100 mA (unless otherwise noted).

| PARAMETERS | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **DEVICE PARAMETERS** | | | | | | | |
| $I_Q$ | Quiescent current | $V_{FEEDBACK}$ = 8 V for 3.3-V, 5-V, and adjustable versions | | | 2.5 | 3.6 | mA |
| | | $V_{FEEDBACK}$ = 15 V for 12-V versions | | | 2.5 | | |
| $I_{STBY}$ | Standby quiescent current | ON/$\overline{OFF}$ pin = 0 V | $T_J$ = 25°C | | 50 | 100 | µA |
| | | | Over full operating temperature range | | | 150 | |
| $I_{CL}$ | Current limit | $T_J$ = 25°C | | 0.62 | 0.8 | 1.2 | A |
| | | Over full operating temperature range | | 0.575 | | 1.25 | |
| $I_L$ | Output leakage current | $V_{IN}$ = 40 V, ON/$\overline{OFF}$ pin = 0 V $V_{SWITCH}$ = 0 V | | | 1 | 25 | µA |
| | | $V_{SWITCH}$ = −1 V, ON/$\overline{OFF}$ pin = 0 V | | | 6 | 15 | mA |
| $R_{DS(ON)}$ | Switch ON-resistance | $I_{SWITCH}$ = 500 mA | $T_J$ = 25°C | | 0.25 | 0.4 | Ω |
| | | | Over full operating temperature range | | | 0.6 | |
| $f_O$ | Oscillator frequency | Measured at switch pin | $T_J$ = 25°C | | 260 | | kHz |
| | | | Over full operating temperature range | 225 | | 275 | |
| D | Maximum duty cycle | | | | 95% | | |
| | Minimum duty cycle | | | | 0% | | |
| $I_{BIAS}$ | Feedback bias current | $V_{FEEDBACK}$ = 1.3 V (adjustable version only) | | | 85 | | nA |
| $V_{S/D}$ | ON/$\overline{OFF}$ pin voltage thresholds | $T_J$ = 25°C | | | 1.4 | | V |
| | | Over full operating temperature range | | 0.8 | | 2 | |
| $I_{S/D}$ | ON/$\overline{OFF}$ pin current | ON/$\overline{OFF}$ pin = 0 V | $T_J$ = 25°C | | 20 | | µA |
| | | | Over full operating temperature range | 7 | | 37 | |
| $F_{SYNC}$ | Synchronization frequency | $V_{SYNC}$ = 3.5 V, 50% duty cycle | | | 400 | | kHz |
| $V_{SYNC}$ | Synchronization threshold voltage | | | | 1.4 | | V |
| $V_{SS}$ | Soft-start voltage | $T_J$ = 25°C | | | 0.63 | | V |
| | | Over full operating temperature range | | 0.53 | | 0.73 | |
| $I_{SS}$ | Soft-start current | $T_J$ = 25°C | | | 4.5 | | µA |
| | | Over full operating temperature range | | 1.5 | | 6.9 | |


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## 7.10 Typical Characteristics

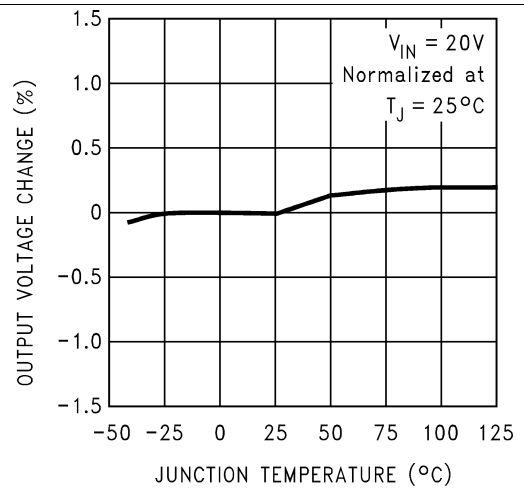


**Figure 1. Normalized Output Voltage**

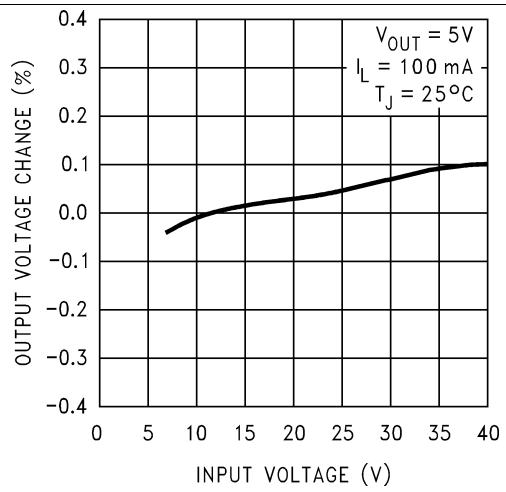


**Figure 2. Line Regulation**

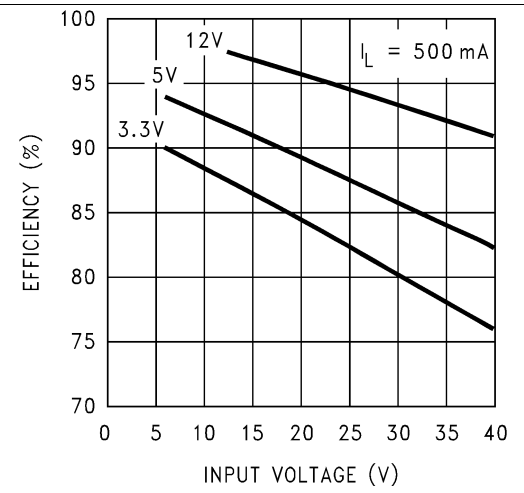


**Figure 3. Efficiency**

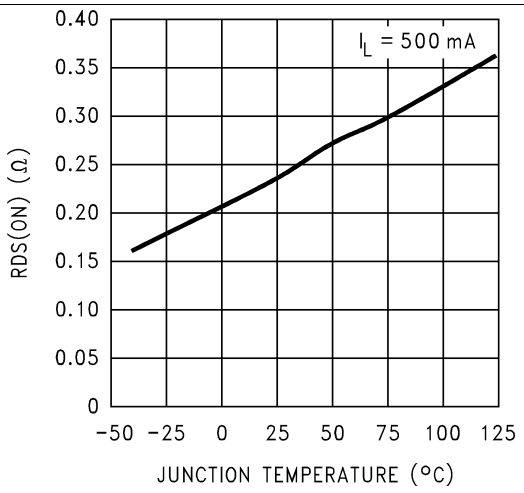


**Figure 4. Drain-to-Source Resistance**

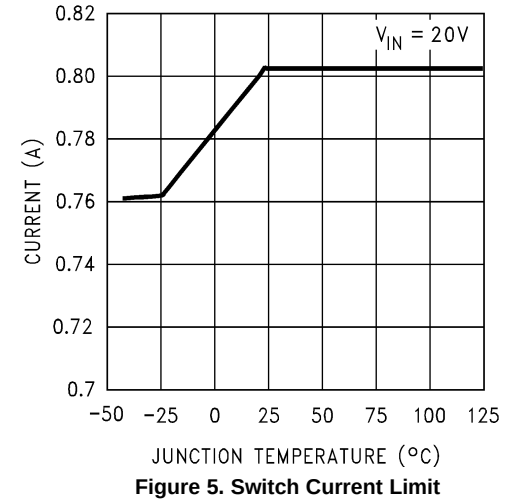


**Figure 5. Switch Current Limit**

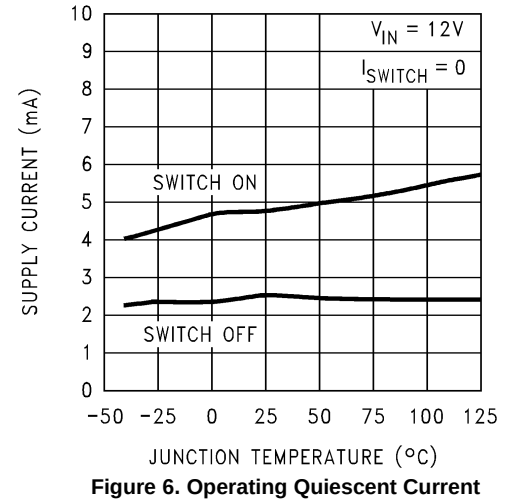


**Figure 6. Operating Quiescent Current**

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## Typical Characteristics (continued)

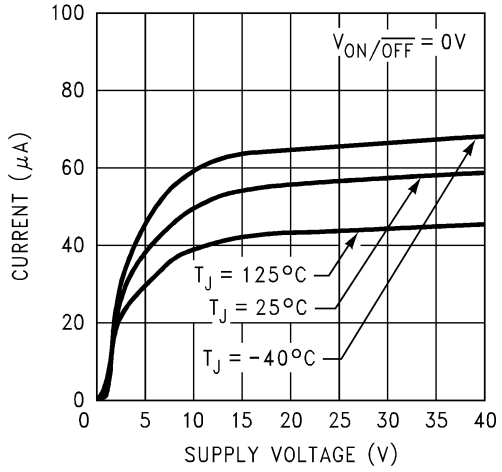


**Figure 7. Standby Quiescent Current**

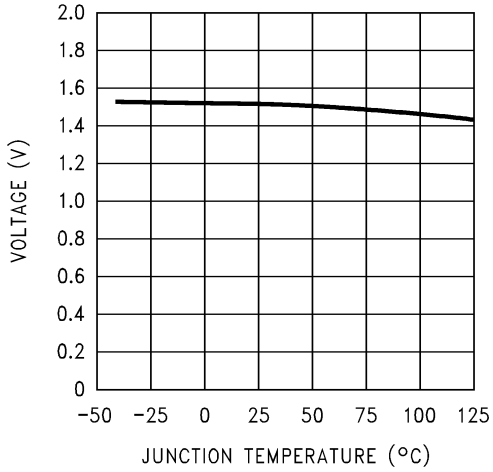


**Figure 8. ON/$\overline{OFF}$ Threshold Voltage**

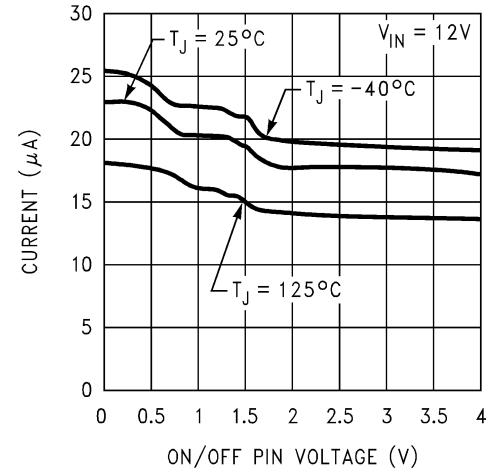


**Figure 9. ON/$\overline{OFF}$ Pin Current (Sourcing)**

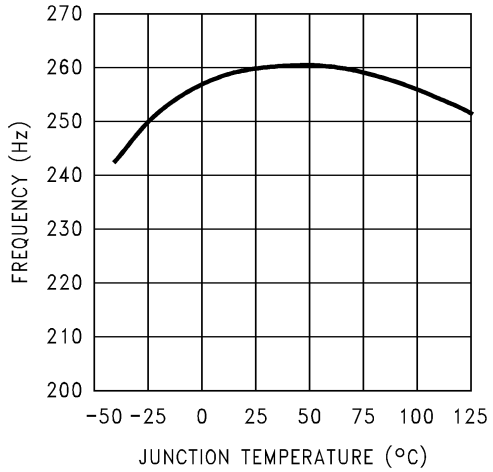


**Figure 10. Switching Frequency**

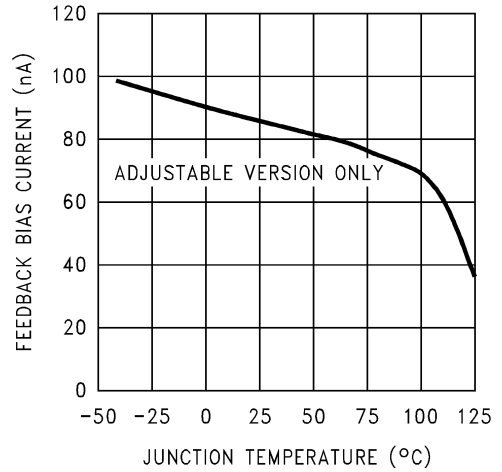


**Figure 11. Feedback Pin Bias Current**

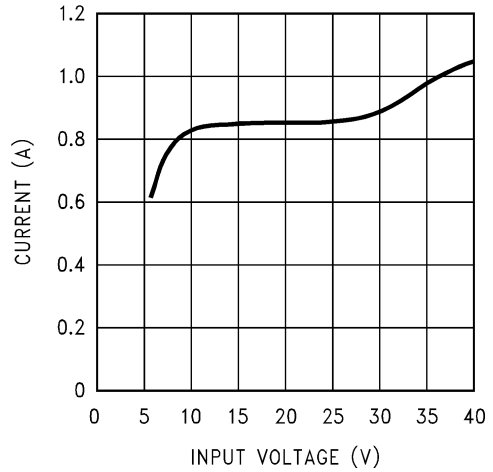


**Figure 12. Peak Switch Current**


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## Typical Characteristics (continued)

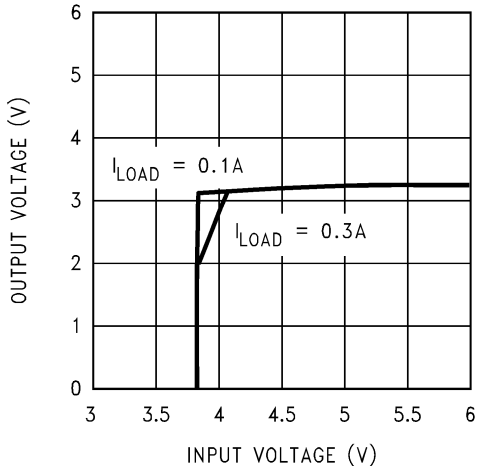


**Figure 13. Dropout Voltage – 3.3-V Option**

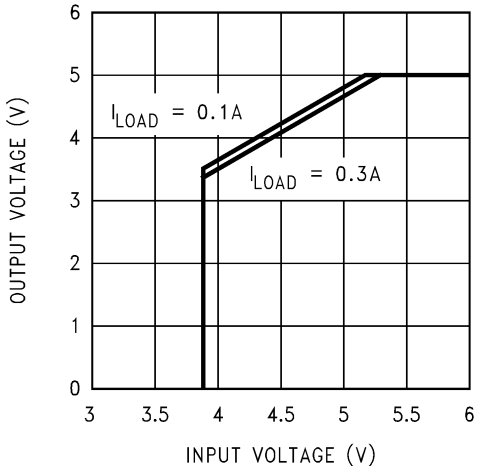


**Figure 14. Dropout Voltage – 5-V Option**

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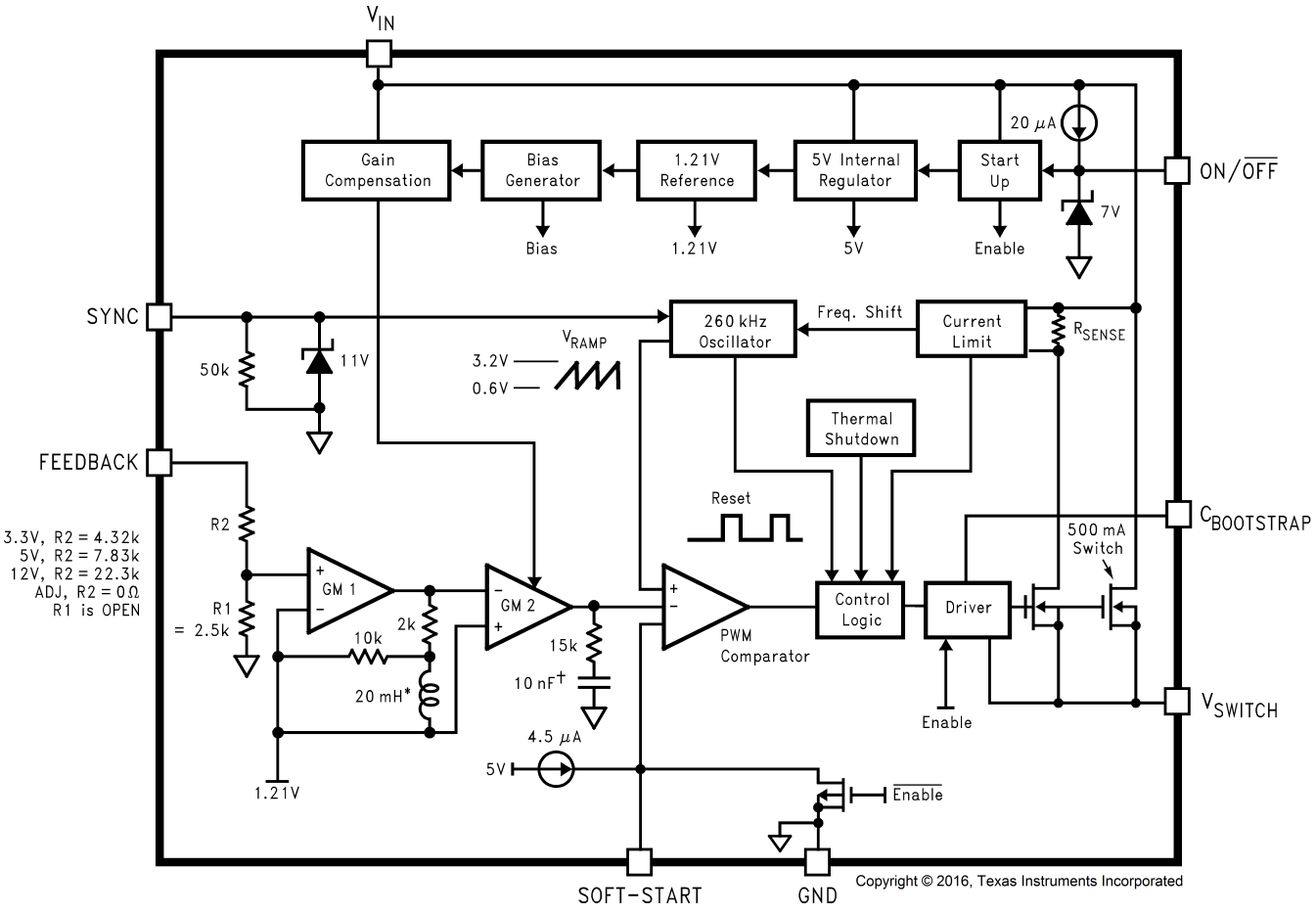
# 8 Detailed Description

## 8.1 Overview

The LM2671 provides all of the active functions required for a step-down (buck) switching regulator. The internal power switch is a DMOS power MOSFET to provide power supply designs with high current capability, up to 0.5 A, and highly efficient operation.

The LM2671 is part of the SIMPLE SWITCHER® family of power converters. A complete design uses a minimum number of external components, which have been predetermined from a variety of manufacturers. Using either this data sheet or TI's WEBENCH® design tool, a complete switching power supply can be designed quickly. Also, see *LM2670 SIMPLE SWITCHER® High Efficiency 3A Step-Down Voltage Regulator with Sync* for additional applications information.

## 8.2 Functional Block Diagram




## 8.3 Feature Description

### 8.3.1 Switch Output

This is the output of a power MOSFET switch connected directly to the input voltage. The switch provides energy to an inductor, an output capacitor and the load circuitry under control of an internal pulse-width-modulator (PWM). The PWM controller is internally clocked by a fixed 260-kHz oscillator. In a standard step-down application the duty cycle (Time ON/Time OFF) of the power switch is proportional to the ratio of the power supply output voltage to the input voltage. The voltage on the $V_{SW}$ pin cycles between $V_{IN}$ (switch ON) and below ground by the voltage drop of the external Schottky diode (switch OFF).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## Feature Description (continued)

### 8.3.2 Input

The input voltage for the power supply is connected to the $V_{IN}$ pin. In addition to providing energy to the load the input voltage also provides bias for the internal circuitry of the LM2671. For ensured performance the input voltage must be in the range of 6.5 V to 40 V. For best performance of the power supply the $V_{IN}$ pin must always be bypassed with an input capacitor placed close to this pin and GND.

### 8.3.3 C Boost

A capacitor must be connected from the $C_B$ pin to the $V_{SW}$ pin. This capacitor boosts the gate drive to the internal MOSFET above $V_{IN}$ to fully turn it ON. This minimizes conduction losses in the power switch to maintain high efficiency. The recommended value for C Boost is 0.01 μF.

### 8.3.4 Ground

This is the ground reference connection for all components in the power supply. In fast-switching, high-current applications such as those implemented with the LM2671, TI recommends that a broad ground plane be used to minimize signal coupling throughout the circuit.

### 8.3.5 Sync

This input allows control of the switching clock frequency. If left open-circuited the regulator is switched at the internal oscillator frequency, typically 260 kHz. An external clock can be used to force the switching frequency and thereby control the output ripple frequency of the regulator. This capability provides for consistent filtering of the output ripple from system to system as well as precise frequency spectrum positioning of the ripple frequency which is often desired in communications and radio applications. This external frequency must be greater than the LM2671 internal oscillator frequency, which could be as high as 275 kHz, to prevent an erroneous reset of the internal ramp oscillator and PWM control of the power switch. The ramp oscillator is reset on the positive going edge of the sync input signal. TI recommends that the external TTL or CMOS compatible clock (between 0 V and a level greater than 3 V) be ac coupled to the SYNC pin through a 100-pF capacitor and a 1-kΩ resistor to ground.

When the SYNC function is used, current limit frequency foldback is not active. Therefore, the device may not be fully protected against extreme output short-circuit conditions.

### 8.3.6 Feedback

This is the input to a two-stage high gain amplifier, which drives the PWM controller. Connect the FB pin directly to the output for proper regulation. For the fixed output devices (3.3-V, 5-V and 12-V outputs), a direct wire connection to the output is all that is required as internal gain setting resistors are provided inside the LM2671. For the adjustable output version two external resistors are required to set the DC output voltage. For stable operation of the power supply it is important to prevent coupling of any inductor flux to the feedback input.

### 8.3.7 ON/OFF

This input provides an electrical ON/OFF control of the power supply. Connecting this pin to ground or to any voltage less than 0.8 V is completely turn OFF the regulator. The current drain from the input supply when OFF is only 50 μA. The ON/OFF input has an internal pullup current source of approximately 20 μA and a protection clamp Zener diode of 7 V to ground. When electrically driving the ON/$\overline{\text{OFF}}$ pin the high voltage level for the ON condition must not exceed the 6 V absolute maximum limit. When ON/OFF control is not required this pin must be left open.

## 8.4 Device Functional Modes

### 8.4.1 Shutdown Mode

The ON/$\overline{\text{OFF}}$ pin provides electrical ON and OFF control for the LM2671. When the voltage of this pin is lower than 1.4 V, the device enters shutdown mode. The typical standby current in this mode is 50 μA.

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## Device Functional Modes (continued)

### 8.4.2 Active Mode

When the voltage of the ON/$\overline{\text{OFF}}$ pin is higher than 1.4 V, the device starts switching and the output voltage rises until it reaches a normal regulation voltage.


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# 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

The LM2671 is a step-down DC-DC regulator. The device is typically used to convert a higher DC voltage to a lower DC voltage with a maximum output current of 0.5 A. The following design procedure can be used to select components for the LM2671. Alternately, the WEBENCH® software may be used to generate complete designs. When generating a design, the WEBENCH software uses iterative design procedure and accesses comprehensive databases of components. See ti.com for more details.

When the output voltage is greater than approximately 6 V, and the duty cycle at minimum input voltage is greater than approximately 50%, the designer must exercise caution in selection of the output filter components. When an application designed to these specific operating conditions is subjected to a current limit fault condition, it may be possible to observe a large hysteresis in the current limit. This can affect the output voltage of the device until the load current is reduced sufficiently to allow the current limit protection circuit to reset itself.

Under current limiting conditions, the LM267x is designed to respond in the following manner:

1. At the moment when the inductor current reaches the current limit threshold, the ON-pulse is immediately terminated. This happens for any application condition.
2. However, the current limit block is also designed to momentarily reduce the duty cycle to below 50% to avoid subharmonic oscillations, which could cause the inductor to saturate.
3. Therefore, once the inductor current falls below the current limit threshold, there is a small relaxation time during which the duty cycle progressively rises back above 50% to the value required to achieve regulation.

If the output capacitance is sufficiently *large*, it might be possible that as the output tries to recover, the output capacitor charging current is large enough to repeatedly re-trigger the current limit circuit before the output has fully settled. This condition is exacerbated with higher output voltage settings because the energy requirement of the output capacitor varies as the square of the output voltage (½ CV2), thus requiring an increased charging current. A simple test to determine if this condition might exist for a suspect application is to apply a short circuit across the output of the converter, and then remove the shorted output condition. In an application with properly selected external components, the output recovers smoothly. Practical values of external components that have been experimentally found to work well under these specific operating conditions are $C_{OUT}$ = 47 µF, L = 22 µH.

**NOTE**

Even with these components, for a device's current limit of ICLIM, the maximum load current under which the possibility of the large current limit hysteresis can be minimized is ICLIM/2.

For example, if the input is 24 V and the set output voltage is 18 V, then for a desired maximum current of 1.5 A, the current limit of the chosen switcher must be confirmed to be at least 3 A. Under extreme overcurrent or short-circuit conditions, the LM267X employs frequency foldback in addition to the current limit. If the cycle-by-cycle inductor current increases above the current limit threshold (due to short circuit or inductor saturation for example) the switching frequency is automatically reduced to protect the IC. Frequency below 100 kHz is typical for an extreme short-circuit condition.

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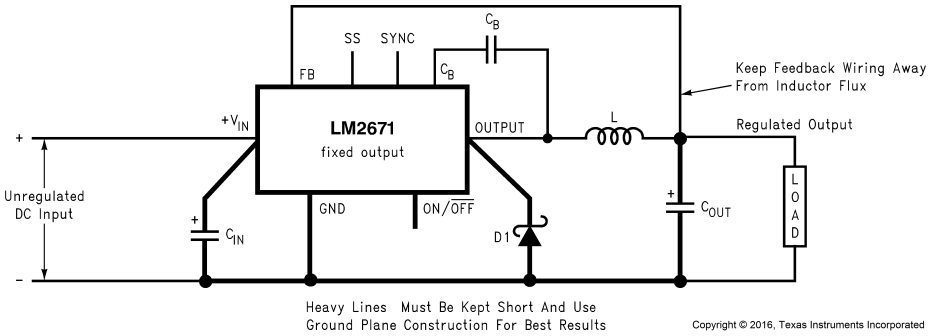
## 9.2 Typical Applications

### 9.2.1 Fixed Output Voltage Version




$C_{IN}$ = 22-µF, 50-V Tantalum, Sprague *199D Series*
$C_{OUT}$ = 47-µF, 25-V Tantalum, Sprague *595D Series*
D1 = 3.3-A, 50-V Schottky Rectifier, IR 30WQ05F
L1 = 68-µH Sumida #RCR110D-680L
$C_B$ = 0.01-µF, 50-V ceramic

**Figure 15. Typical Application for Fixed Output Voltage Versions**

#### *9.2.1.1 Design Requirements*

Table 1 lists the design parameters for this example.

**Table 1. Design Parameters**

| PARAMETER | VALUE |
|---|---|
| Regulated output voltage (3.3 V, 5 V, or 12 V), $V_{OUT}$ | 5 V |
| Maximum DC input voltage, $V_{IN}$(max) | 12 V |
| Maximum load current, $I_{LOAD}$(max) | 500 mA |

#### *9.2.1.2 Detailed Design Procedure*

##### 9.2.1.2.1 Inductor Selection (L1)

1. Select the correct inductor value selection guide from Figure 17 and Figure 18 or Figure 19 (output voltages of 3.3 V, 5 V, or 12 V respectively). For all other voltages, see the design procedure for the adjustable version. Use the inductor selection guide for the 5-V version shown in Figure 18.
2. From the inductor value selection guide, identify the inductance region intersected by the maximum input voltage line and the maximum load current line. Each region is identified by an inductance value and an inductor code (LXX). From the inductor value selection guide shown in Figure 18, the inductance region intersected by the 12-V horizontal line and the 500-mA vertical line is 47 µH, and the inductor code is L13.
3. Select an appropriate inductor from the four manufacturer's part numbers listed in Table 2. Each manufacturer makes a different style of inductor to allow flexibility in meeting various design requirements. See the following for some of the differentiating characteristics of each manufacturer's inductors:
   - *Schottky:* ferrite EP core inductors; these have very low leakage magnetic fields to reduce electro-magnetic interference (EMI) and are the lowest power loss inductors
   - *Renco:* ferrite stick core inductors; benefits are typically lowest cost inductors and can withstand E•T and transient peak currents above rated value. Be aware that these inductors have an external magnetic field which may generate more EMI than other types of inductors.
   - *Pulse:* powered iron toroid core inductors; these can also be low cost and can withstand larger than normal E•T and transient peak currents. Toroid inductors have low EMI.
   - *Coilcraft:* ferrite drum core inductors; these are the smallest physical size inductors, available only as SMT components. Be aware that these inductors also generate EMI—but less than stick inductors.

Complete specifications for these inductors are available from the respective manufacturers.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The inductance value required is 47 μH. From the table in Table 2, go to the L13 line and choose an inductor part number from any of the four manufacturers shown. In most instances, both through hole and surface mount inductors are available.

**Table 2. Inductor Manufacturers' Part Numbers**

| IND. REF. DESG. | INDUCTANCE (μH) | CURRENT (A) | SCHOTTKY | | RENCO | | PULSE ENGINEERING | | COILCRAFT |
|---|---|---|---|---|---|---|---|---|---|
| | | | THROUGH HOLE | SURFACE MOUNT | THROUGH HOLE | SURFACE MOUNT | THROUGH HOLE | SURFACE MOUNT | SURFACE MOUNT |
| L2 | 150 | 0.21 | 67143920 | 67144290 | RL-5470-4 | RL1500-150 | PE-53802 | PE-53802-S | DO1608-154 |
| L3 | 100 | 0.26 | 67143930 | 67144300 | RL-5470-5 | RL1500-100 | PE-53803 | PE-53803-S | DO1608-104 |
| L4 | 68 | 0.32 | 67143940 | 67144310 | RL-1284-68-43 | RL1500-68 | PE-53804 | PE-53804-S | DO1608-683 |
| L5 | 47 | 0.37 | 67148310 | 67148420 | RL-1284-47-43 | RL1500-47 | PE-53805 | PE-53805-S | DO1608-473 |
| L6 | 33 | 0.44 | 67148320 | 67148430 | RL-1284-33-43 | RL1500-33 | PE-53806 | PE-53806-S | DO1608-333 |
| L7 | 22 | 0.52 | 67148330 | 67148440 | RL-1284-22-43 | RL1500-22 | PE-53807 | PE-53807-S | DO1608-223 |
| L9 | 220 | 0.32 | 67143960 | 67144330 | RL-5470-3 | RL1500-220 | PE-53809 | PE-53809-S | DO3308-224 |
| L10 | 150 | 0.39 | 67143970 | 67144340 | RL-5470-4 | RL1500-150 | PE-53810 | PE-53810-S | DO3308-154 |
| L11 | 100 | 0.48 | 67143980 | 67144350 | RL-5470-5 | RL1500-100 | PE-53811 | PE-53811-S | DO3308-104 |
| L12 | 68 | 0.58 | 67143990 | 67144360 | RL-5470-6 | RL1500-68 | PE-53812 | PE-53812-S | DO3308-683 |
| L13 | 47 | 0.7 | 67144000 | 67144380 | RL-5470-7 | RL1500-47 | PE-53813 | PE-53813-S | DO3308-473 |
| L14 | 33 | 0.83 | 67148340 | 67148450 | RL-1284-33-43 | RL1500-33 | PE-53814 | PE-53814-S | DO3308-333 |
| L15 | 22 | 0.99 | 67148350 | 67148460 | RL-1284-22-43 | RL1500-22 | PE-53815 | PE-53815-S | DO3308-223 |
| L18 | 220 | 0.55 | 67144040 | 67144420 | RL-5471-2 | RL1500-220 | PE-53818 | PE-53818-S | DO3316-224 |
| L19 | 150 | 0.66 | 67144050 | 67144430 | RL-5471-3 | RL1500-150 | PE-53819 | PE-53819-S | DO3316-154 |
| L20 | 100 | 0.82 | 67144060 | 67144440 | RL-5471-4 | RL1500-100 | PE-53820 | PE-53820-S | DO3316-104 |
| L21 | 68 | 0.99 | 67144070 | 67144450 | RL-5471-5 | RL1500-68 | PE-53821 | PE-53821-S | DO3316-683 |

#### 9.2.1.2.2 Output Capacitor Selection ($C_{OUT}$)

Select an output capacitor from the output capacitor table in Table 9. Using the output voltage and the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor value and voltage rating.

Use the 5-V section in the output capacitor table in Table 9. Choose a capacitor value and voltage rating from the line that contains the inductance value of 47 μH. The capacitance and voltage rating values corresponding to the 47-μH inductor are:

- Surface mount:
  - 68-μF, 10-V Sprague 594D series
  - 100-μF, 10-V AVX TPS series
- Through hole:
  - 68-μF, 10-V Sanyo OS-CON SA series
  - 150-μF, 35-V Sanyo MV-GX series
  - 150-μF, 35-V Nichicon PL series
  - 150-μF, 35-V Panasonic HFQ series

The capacitor list contains through-hole electrolytic capacitors from four different capacitor manufacturers and surface mount tantalum capacitors from two different capacitor manufacturers. TI recommends that both the manufacturers and the manufacturer's series that are listed in the table be used.

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**Table 3. Output Capacitor Table**

| OUTPUT VOLTAGE (V) | INDUCTANCE (µH) | OUTPUT CAPACITOR | | | | | |
|---|---|---|---|---|---|---|---|
| | | SURFACE MOUNT | | THROUGH HOLE | | | |
| | | SPRAGUE 594D SERIES (µF/V) | AVX TPS SERIES (µF/V) | SANYO OS-CON SA SERIES (µF/V) | SANYO MV-GX SERIES (µF/V) | NICHICON PL SERIES (µF/V) | PANASONIC HFQ SERIES (µF/V) |
| 3.3 | 22 | 120/6.3 | 100/10 | 100/10 | 330/35 | 330/35 | 330/35 |
| | 33 | 120/6.3 | 100/10 | 68/10 | 220/35 | 220/35 | 220/35 |
| | 47 | 68/10 | 100/10 | 68/10 | 150/35 | 150/35 | 150/35 |
| | 68 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| | 100 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| | 150 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| 5 | 22 | 100/16 | 100/10 | 100/10 | 330/35 | 330/35 | 330/35 |
| | 33 | 68/10 | 10010 | 68/10 | 220/35 | 220/35 | 220/35 |
| | 47 | 68/10 | 100/10 | 68/10 | 150/35 | 150/35 | 150/35 |
| | 68 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| | 100 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| | 150 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| 12 | 22 | 120/20 | (2×) 68/20 | 68/20 | 330/35 | 330/35 | 330/35 |
| | 33 | 68/25 | 68/20 | 68/20 | 220/35 | 220/35 | 220/35 |
| | 47 | 47/20 | 68/20 | 47/20 | 150/35 | 150/35 | 150/35 |
| | 68 | 47/20 | 68/20 | 47/20 | 120/35 | 120/35 | 120/35 |
| | 100 | 47/20 | 68/20 | 47/20 | 120/35 | 120/35 | 120/35 |
| | 150 | 47/20 | 68/20 | 47/20 | 120/35 | 120/35 | 120/35 |
| | 220 | 47/20 | 68/20 | 47/20 | 120/35 | 120/35 | 120/35 |

#### 9.2.1.2.3 Catch Diode Selection (D1)

1. In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, 1-D (D is the switch duty cycle, which is approximately the output voltage divided by the input voltage). The largest value of the catch diode average current occurs at the maximum load current and maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than its maximum average current. However, if the power supply design must withstand a continuous output short, the diode must have a current rating equal to the maximum current limit of the LM2671. The most stressful condition for this diode is a shorted output condition (refer to Table 4). In this example, a 1-A, 20-V Schottky diode provides the best performance. If the circuit must withstand a continuous shorted output, TI recommends a higher-current Schottky diode.
2. The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage.
3. Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best performance and efficiency. This Schottky diode must be placed close to the LM2671 using short leads and short printed-circuit traces.


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**Table 4. Schottky Diode Selection Table**

| $V_R$ | 1-A DIODES | | 3-A DIODES | |
|---|---|---|---|---|
| | SURFACE MOUNT | THROUGH HOLE | SURFACE MOUNT | THROUGH HOLE |
| 20 V | SK12 | 1N5817 | SK32 | 1N5820 |
| | B120 | SR102 | — | SR302 |
| 30 V | SK13 | 1N5818 | SK33 | 1N5821 |
| | B130 | 11DQ03 | 30WQ03F | 31DQ03 |
| | MBRS130 | SR103 | — | — |
| 40 V | SK14 | 1N5819 | SK34 | 1N5822 |
| | B140 | 11DQ04 | 30BQ040 | MBR340 |
| | MBRS140 | SR104 | 30WQ04F | 31DQ04 |
| | 10BQ040 | — | MBRS340 | SR304 |
| | 10MQ040 | — | MBRD340 | — |
| | 15MQ040 | — | — | — |
| 50 V | SK15 | MBR150 | SK35 | MBR350 |
| | B150 | 11DQ05 | 30WQ05F | 31DQ05 |
| | 10BQ050 | SR105 | — | SR305 |

#### 9.2.1.2.4 Input Capacitor ($C_{IN}$)

A low ESR aluminum or tantalum bypass capacitor is required between the input pin and ground to prevent large voltage transients from appearing at the input. This capacitor must be placed close to the IC using short leads. In addition, the RMS current rating of the input capacitor must be selected to be at least ½ the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. The curves shown in Figure 16 show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors may be required to increase the total minimum RMS current rating to suit the application requirements.

For an aluminum electrolytic capacitor, the voltage rating must be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating must be twice the maximum input voltage. Table 5 and Table 6 show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. TI also recommends that they be surge current tested by the manufacturer. The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line.

**Table 5. AVX TPS**

| RECOMMENDED APPLICATION VOLTAGE | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 3.3 | 6.3 |
| 5 | 10 |
| 10 | 20 |
| 12 | 25 |
| 15 | 35 |

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**Table 6. Sprague 594D**

| RECOMMENDED APPLICATION VOLTAGE | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 2.5 | 4 |
| 3.3 | 6.3 |
| 5 | 10 |
| 8 | 16 |
| 12 | 20 |
| 18 | 25 |
| 24 | 35 |
| 29 | 50 |

Use caution when using ceramic capacitors for input bypassing, because it may cause severe ringing at the $V_{IN}$ pin. The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 12 V, an aluminum electrolytic capacitor with a voltage rating greater than 15 V ($1.25 \times V_{IN}$) is required. The next higher capacitor voltage rating is 16 V.

The RMS current rating requirement for the input capacitor in a buck regulator is approximately ½ the DC load current. In this example, with a 500-mA load, a capacitor with a RMS current rating of at least 250 mA is required. The curves shown in Figure 16 can be used to select an appropriate input capacitor. From the curves, locate the 16-V line and note which capacitor values have RMS current ratings greater than 250 mA.

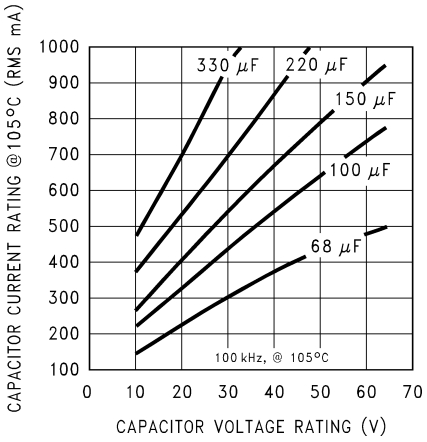


**Figure 16. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)**

For a through-hole design, a 100-µF, 16-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS and the Nichicon WF or UR and the NIC Components NACZ series could be considered.

For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking the Sprague 594D series datasheet, a Sprague 594D 15-µF, 25-V capacitor is adequate.

#### 9.2.1.2.5 Boost Capacitor ($C_B$)

This capacitor develops the necessary voltage to turn the switch gate on fully. All applications must use a 0.01-µF, 50-V ceramic capacitor. For this application, and all applications, use a 0.01-µF, 50-V ceramic capacitor.


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#### 9.2.1.2.6 Soft-Start Capacitor ($C_{SS}$) – Optional

This capacitor controls the rate at which the device starts up. The formula for the soft-start capacitor $C_{SS}$ is Equation 1.

$$C_{SS} \approx (I_{SS} \cdot t_{SS}) / [V_{SSTH} + 2.6V \cdot (\frac{V_{OUT} + V_{SCHOTTKY}}{V_{IN}})] \quad (1)$$

where

- $I_{SS}$= soft-start current (4.5 µA typical)
- $t_{SS}$= soft-start time (selected)
- $V_{SSTH}$= soft-start threshold voltage (0.63 V typical)
- $V_{OUT}$= output voltage (selected)
- $V_{SCHOTTKY}$= schottky diode voltage drop (0.4 V typical)
- $V_{IN}$= input voltage (selected)

For this application, selecting a start-up time of 10 ms and using Equation 2 for $C_{SS}$.

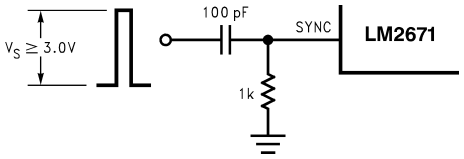
$$C_{SS} \approx (4.5\ \mu A \cdot 10\ ms) / [0.63V + 2.6V \cdot (\frac{5V + 0.4V}{12V})]$$
$$= 25\ nF \approx 0.022\ \mu F. \quad (2)$$

If this feature is not desired, leave this pin open. With certain soft-start capacitor values and operating conditions, the LM2671 can exhibit an overshoot on the output voltage during turnon. Especially when starting up into no load or low load, the soft-start function may not be effective in preventing a larger voltage overshoot on the output. With larger loads or lower input voltages during start-up this effect is minimized. In particular, avoid using soft-start capacitors between 0.033 µF and 1 µF.

#### 9.2.1.2.7 Frequency Synchronization (optional)

The LM2671 (oscillator) can be synchronized to run with an external oscillator, using the sync pin (pin 3). By doing so, the LM2671 can be operated at higher frequencies than the standard frequency of 260 kHz. This allows for a reduction in the size of the inductor and output capacitor.

As shown in the drawing below, a signal applied to a RC filter at the sync pin causes the device to synchronize to the frequency of that signal. For a signal with a peak-to-peak amplitude of 3 V or greater, a 1-kΩ resistor and a 100-pF capacitor are suitable values.




For all applications, use a 1-kΩ resistor and a 100-pF capacitor for the RC filter.

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### 9.2.1.3 Application Curves

for continuous mode operation

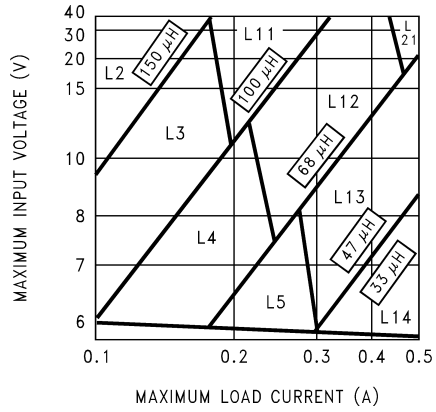



**Figure 17. LM2671-3.3**

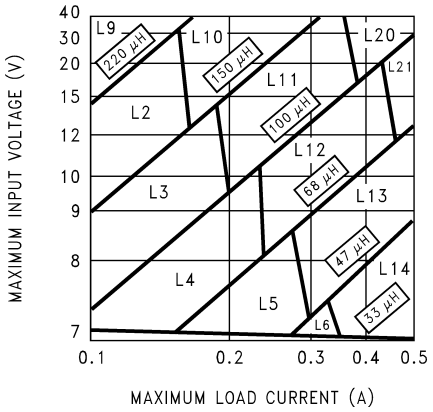



**Figure 18. LM2671-5**

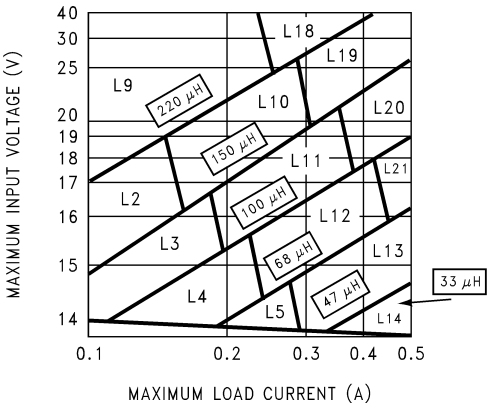



**Figure 19. LM2671-12**

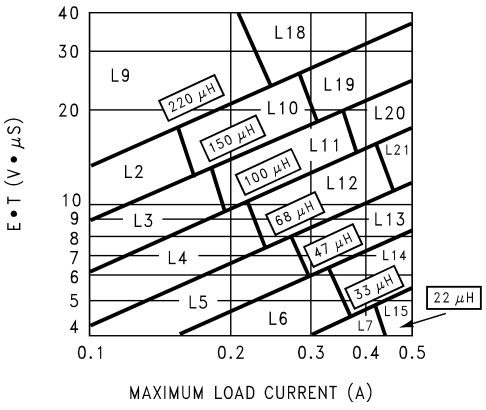
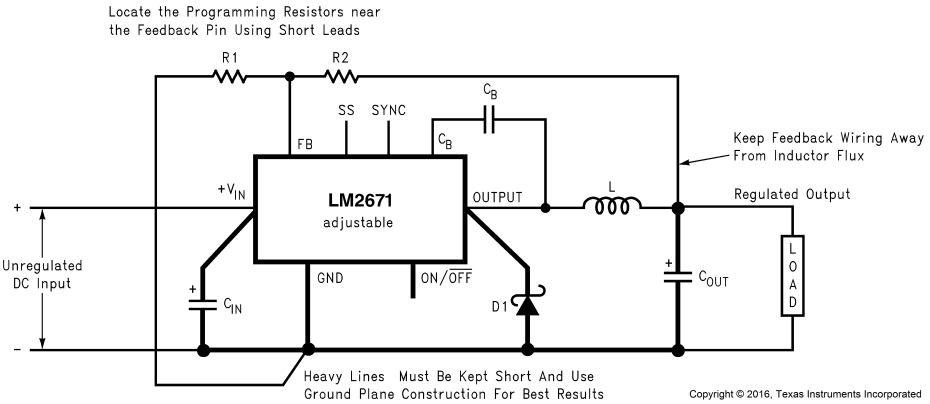



**Figure 20. LM2671-ADJ**

## 9.2.2 Adjustable Output Voltage Version




$C_{IN}$ = 22-µF, 50-V Tantalum, Sprague *199D Series*
$C_{OUT}$ = 47-µF, 25-V Tantalum, Sprague *595D Series*
D1 = 3.3-A, 50-V Schottky Rectifier, IR 30WQ05F
L1 = 68-µH Sumida #RCR110D-680L
R1 =1.5 kΩ, 1%
$C_B$ = 0.01-µF, 50-V ceramic

**Figure 21. Typical Application for Adjustable Output Voltage Versions**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#### 9.2.2.1 Design Requirements

Table 7 lists the design parameters for this example.

**Table 7. Design Parameters**

| PARAMETER | VALUE |
|---|---|
| Regulated output voltage, $V_{OUT}$ | 20 V |
| Maximum input voltage, $V_{IN}$(max) | 28 V |
| Maximum load current, $I_{LOAD}$(max) | 500 mA |
| Switching frequency, F | Fixed at a nominal 260 kHz |

#### 9.2.2.2 Detailed Design Procedure

##### 9.2.2.2.1 Programming Output Voltage

Select $R_1$ and $R_2$, as shown in Figure 21.

Use the following formula to select the appropriate resistor values.

$$V_{OUT} = V_{REF} \left(1 + \frac{R_2}{R_1}\right)$$

where

- $V_{REF}$ = 1.21 V

(3)

Select $R_1$ to be 1 kΩ, 1%. Solve for $R_2$.

$$R_2 = R_1 \left(\frac{V_{OUT}}{V_{REF}} - 1\right) = 1\,k\Omega \left(\frac{20V}{1.23V} - 1\right)$$

(4)

Select a value for $R_1$ between 240 Ω and 1.5 kΩ. The lower resistor values minimize noise pickup in the sensitive feedback pin. For the lowest temperature coefficient and the best stability with time, use 1% metal film resistors.

$$R_2 = R_1 \left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

(5)

$R_2$ = 1 kΩ (16.53 − 1) = 15.53 kΩ, closest 1% value is 15.4 kΩ.

$R_2$ = 15.4 kΩ.

##### 9.2.2.2.2 Inductor Selection (L1)

1. Calculate the inductor Volt • microsecond constant E • T (V • μs) from Equation 6.

$$E \cdot T = (V_{IN(MAX)} - V_{OUT} - V_{SAT}) \cdot \frac{V_{OUT} + V_D}{V_{IN(MAX)} - V_{SAT} + V_D} \cdot \frac{1000}{260} \quad (V \cdot \mu s)$$

where

- $V_{SAT}$ = internal switch saturation voltage = 0.25 V
- $V_D$ = diode forward voltage drop = 0.5 V

(6)

Calculate the inductor Volt • microsecond constant (E • T) with Equation 7.

$$E \cdot T = (28 - 20 - 0.25) \cdot \frac{20 + 0.5}{28 - 0.25 + 0.5} \cdot \frac{1000}{260} \quad (V \cdot \mu s)$$

$$E \cdot T = (7.75) \cdot \frac{20.5}{28.25} \cdot 3.85\,(V \cdot \mu s) = 21.6\,(V \cdot \mu s)$$

(7)

2. Use the E • T value from the previous formula and match it with the E • T number on the vertical axis of the inductor value selection guide shown in Figure 20.

E • T = 21.6 (V • μs)

(8)

3. On the horizontal axis, select the maximum load current in Equation 9.

$I_{LOAD}$(max) = 500 mA

(9)

4. Identify the inductance region intersected by the E • T value and the maximum load current value. Each region is identified by an inductance value and an inductor code (LXX). From the inductor value selection guide shown in Figure 20, the inductance region intersected by the 21.6 (V • μs) horizontal line and the 500-mA vertical line is 100 μH, and the inductor code is L20.
5. Select an appropriate inductor from the four manufacturer's part numbers listed in Table 2. For information

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on the different types of inductors, see the inductor selection in the fixed output voltage design procedure. From the table in Table 2, locate line L20, and select an inductor part number from the list of manufacturers' part numbers.

#### 9.2.2.2.3 Output Capacitor Selection ($C_{OUT}$)

1. Select an output capacitor from the capacitor code selection guide in Table 8. Using the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor code corresponding to the desired output voltage. Use the appropriate row of the capacitor code selection guide, in Table 8. For this example, use the 15-V to 20-V row. The capacitor code corresponding to an inductance of 100 μH is C20.
2. Select an appropriate capacitor value and voltage rating, using the capacitor code, from the output capacitor selection table in Table 9. There are two solid tantalum (surface mount) capacitor manufacturers and four electrolytic (through hole) capacitor manufacturers to choose from. TI recommends using the manufacturers and the manufacturer's series that are listed in the table.

   From the output capacitor selection table in Table 9, choose a capacitor value (and voltage rating) that intersects the capacitor code(s) selected in section A, C20.

   The capacitance and voltage rating values corresponding to the capacitor code C20 are:
   - Surface mount:
     - 33-μF, 25-V Sprague 594D series
     - 33-μF, 25-V AVX TPS series
   - Through hole:
     - 33-μF, 25-V Sanyo OS-CON SC series
     - 120-μF, 35-V Sanyo MV-GX series
     - 120-μF, 35-V Nichicon PL series
     - 120-μF, 35-V Panasonic HFQ series

Other manufacturers or other types of capacitors may also be used, provided the capacitor specifications (especially the 100-kHz ESR) closely match the characteristics of the capacitors listed in the output capacitor table. See the capacitor manufacturers' data sheet for this information.

**Table 8. Capacitor Code Selection Guide**

| CASE STYLE (1) | OUTPUT VOLTAGE (V) | INDUCTANCE (μH) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 22 | 33 | 47 | 68 | 100 | 150 | 220 |
| SM and TH | 1.21–2.5 | — | — | — | — | C1 | C2 | C3 |
| SM and TH | 2.5–3.75 | — | — | — | C1 | C2 | C3 | C3 |
| SM and TH | 3.75–5 | — | — | C4 | C5 | C6 | C6 | C6 |
| SM and TH | 5–6.25 | — | C4 | C7 | C6 | C6 | C6 | C6 |
| SM and TH | 6.25–7.5 | C8 | C4 | C7 | C6 | C6 | C6 | C6 |
| SM and TH | 7.5–10 | C9 | C10 | C11 | C12 | C13 | C13 | C13 |
| SM and TH | 10–12.5 | C14 | C11 | C12 | C12 | C13 | C13 | C13 |
| SM and TH | 12.5–15 | C15 | C16 | C17 | C17 | C17 | C17 | C17 |
| SM and TH | 15–20 | C18 | C19 | C20 | C20 | C20 | C20 | C20 |
| SM and TH | 20–30 | C21 | C22 | C22 | C22 | C22 | C22 | C22 |
| TH | 30–37 | C23 | C24 | C24 | C25 | C25 | C25 | C25 |

(1) SM - Surface Mount, TH - Through Hole


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**Table 9. Output Capacitor Selection Table**

| OUTPUT CAPACITOR | | | | | | |
|---|---|---|---|---|---|---|
| CAP. REF. DESG. # | SURFACE MOUNT | | THROUGH HOLE | | | |
| | SPRAGUE 594D SERIES (µF/V) | AVX TPS SERIES (µF/V) | SANYO OS-CON SA SERIES (µF/V) | SANYO MV-GX SERIES (µF/V) | NICHICON PL SERIES (µF/V) | PANASONIC HFQ SERIES (µF/V) |
| C1 | 120/6.3 | 100/10 | 100/10 | 220/35 | 220/35 | 220/35 |
| C2 | 120/6.3 | 100/10 | 100/10 | 150/35 | 150/35 | 150/35 |
| C3 | 120/6.3 | 100/10 | 100/35 | 120/35 | 120/35 | 120/35 |
| C4 | 68/10 | 100/10 | 68/10 | 220/35 | 220/35 | 220/35 |
| C5 | 100/16 | 100/10 | 100/10 | 150/35 | 150/35 | 150/35 |
| C6 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| C7 | 68/10 | 100/10 | 68/10 | 150/35 | 150/35 | 150/35 |
| C8 | 100/16 | 100/10 | 100/10 | 330/35 | 330/35 | 330/35 |
| C9 | 100/16 | 100/16 | 100/16 | 330/35 | 330/35 | 330/35 |
| C10 | 100/16 | 100/16 | 68/16 | 220/35 | 220/35 | 220/35 |
| C11 | 100/16 | 100/16 | 68/16 | 150/35 | 150/35 | 150/35 |
| C12 | 100/16 | 100/16 | 68/16 | 120/35 | 120/35 | 120/35 |
| C13 | 100/16 | 100/16 | 100/16 | 120/35 | 120/35 | 120/35 |
| C14 | 100/16 | 100/16 | 100/16 | 220/35 | 220/35 | 220/35 |
| C15 | 47/20 | 68/20 | 47/20 | 220/35 | 220/35 | 220/35 |
| C16 | 47/20 | 68/20 | 47/20 | 150/35 | 150/35 | 150/35 |
| C17 | 47/20 | 68/20 | 47/20 | 120/35 | 120/35 | 120/35 |
| C18 | 68/25 | (2×) 33/25 | 47/25 (1) | 220/35 | 220/35 | 220/35 |
| C19 | 33/25 | 33/25 | 33/25 (1) | 150/35 | 150/35 | 150/35 |
| C20 | 33/25 | 33/25 | 33/25 (1) | 120/35 | 120/35 | 120/35 |
| C21 | 33/35 | (2×) 22/25 | (2) | 150/35 | 150/35 | 150/35 |
| C22 | 33/35 | 22/35 | (2) | 120/35 | 120/35 | 120/35 |
| C23 | (2) | (2) | (2) | 220/50 | 100/50 | 120/50 |
| C24 | (2) | (2) | (2) | 150/50 | 100/50 | 120/50 |
| C25 | (2) | (2) | (2) | 150/50 | 82/50 | 82/50 |

(1) The SC series of Os-Con capacitors (others are SA series)
(2) The voltage ratings of the surface mount tantalum chip and Os-Con capacitors are too low to work at these voltages.

#### 9.2.2.2.4 Catch Diode Selection (D1)

1. In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, 1-D (D is the switch duty cycle, which is approximately $V_{OUT}/V_{IN}$). The largest value of the catch diode average current occurs at the maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than its maximum average current. However, if the power supply design must withstand a continuous output short, the diode must have a current rating greater than the maximum current limit of the LM2671. The most stressful condition for this diode is a shorted output condition.

   Refer to the table shown in Table 4. Schottky diodes provide the best performance, and in this example a 1-A, 40-V Schottky diode would be a good choice. If the circuit must withstand a continuous shorted output, a higher current (at least 1.2 A) Schottky diode is recommended.
2. The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage.
3. Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best performance and efficiency. The Schottky diode must be placed close to the LM2671 using short leads and short printed-circuit traces.

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#### 9.2.2.2.5 Input Capacitor ($C_{IN}$)

A low ESR aluminum or tantalum bypass capacitor is required between the input pin and ground to prevent large voltage transients from appearing at the input. This capacitor must be placed close to the IC using short leads. In addition, the RMS current rating of the input capacitor must be selected to be at least ½ the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. The curves shown in Figure 16 show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors may be required to increase the total minimum RMS current rating to suit the application requirements.

For an aluminum electrolytic capacitor, the voltage rating must be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating must be twice the maximum input voltage. The Table 10 and Table 11 show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. TI also recommends that they be surge current tested by the manufacturer. The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line.

**Table 10. AVX TPS**

| RECOMMENDED APPLICATION VOLTAGE | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 3.3 | 6.3 |
| 5 | 10 |
| 10 | 20 |
| 12 | 25 |
| 15 | 35 |

**Table 11. Sprague 594D**

| RECOMMENDED APPLICATION VOLTAGE | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 2.5 | 4 |
| 3.3 | 6.3 |
| 5 | 10 |
| 8 | 16 |
| 12 | 20 |
| 18 | 25 |
| 24 | 35 |
| 29 | 50 |

Use caution when using ceramic capacitors for input bypassing, because it may cause severe ringing at the $V_{IN}$ pin.

The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 28 V, an aluminum electrolytic capacitor with a voltage rating of at least 35 V ($1.25 \times V_{IN}$) is required.

The RMS current rating requirement for the input capacitor in a buck regulator is approximately ½ the DC load current. In this example, with a 500-mA load, a capacitor with a RMS current rating of at least 250 mA is required. The curves shown in Figure 22 can be used to select an appropriate input capacitor. From the curves, locate the 35-V line and note which capacitor values have RMS current ratings greater than 250 mA.


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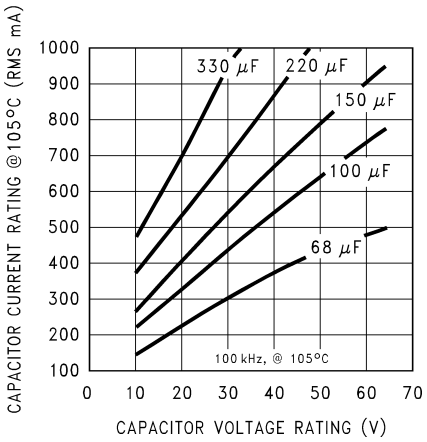


**Figure 22. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)**

For a through-hole design, a 68-µF, 35-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS and the Nichicon WF or UR and the NIC Components NACZ series could be considered.

For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking the Sprague 594D series data sheet, a Sprague 594D 15-µF, 50-V capacitor is adequate.

#### 9.2.2.2.6 Boost Capacitor ($C_B$)

This capacitor develops the necessary voltage to turn the switch gate on fully. All applications must use a 0.01-µF, 50-V ceramic capacitor. For this application, and all applications, use a 0.01-µF, 50-V ceramic capacitor.

If the soft-start and frequency synchronization features are desired, look at steps 6 and 7 in *Detailed Design Procedure*.

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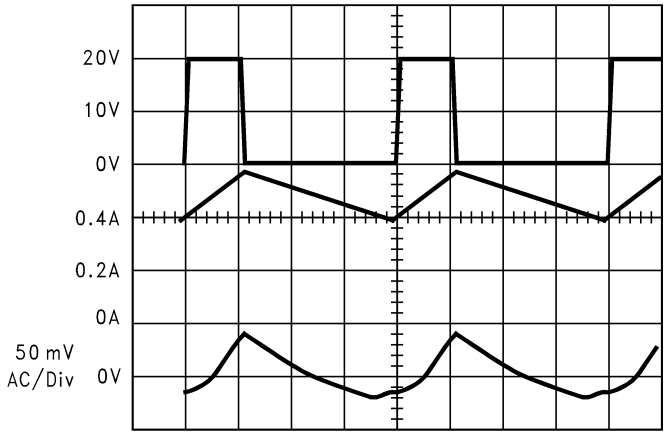
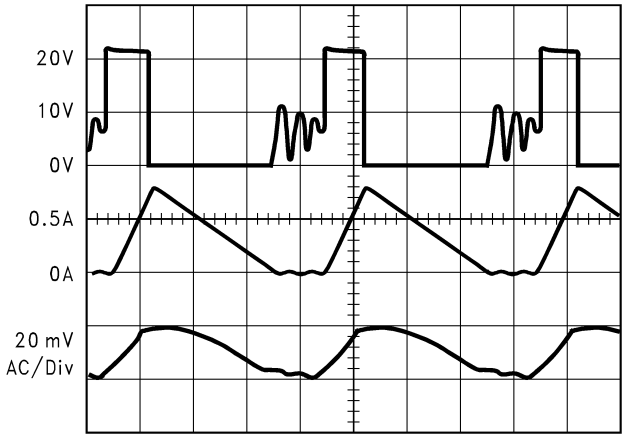
### 9.2.2.3 Application Curves



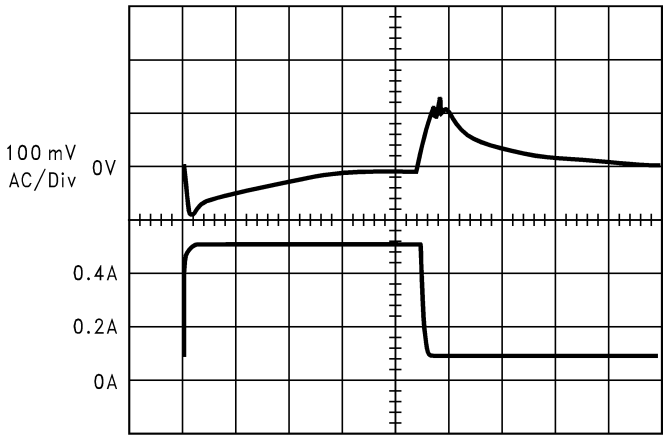

Continuous Mode Switching Waveforms, $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, $I_{LOAD}$ = 500 mA, L = 100 µH, $C_{OUT}$ = 100 µF, $C_{OUT}$ESR = 0.1 Ω
A: $V_{SW}$ pin voltage, 10 V/div.
B: Inductor current, 0.2 A/div
C: Output ripple voltage, 50 mV/div ac-coupled

**Figure 23. Horizontal Time Base: 1 µs/div**



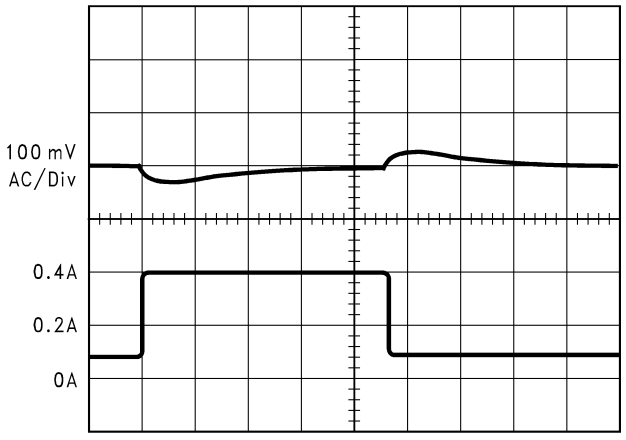

Discontinuous Mode Switching Waveforms, $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, $I_{LOAD}$ = 300 mA, L = 15 µH, $C_{OUT}$ = 68 µF (2×), $C_{OUT}$ESR = 25 mΩ
A: $V_{SW}$ pin voltage, 10 V/div.
B: Inductor current, 0.5 A/div
C: Output ripple voltage, 20 mV/div ac-coupled

**Figure 24. Horizontal Time Base: 1 µs/div**




Load Transient Response for Continuous Mode, $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, L = 100 µH, $C_{OUT}$ = 100 µF, $C_{OUT}$ESR = 0.1 Ω
A: Output voltage, 100 mV/div, ac-coupled
B: Load current: 100-mA to 500-mA load pulse

**Figure 25. Horizontal Time Base: 50 µs/div**




Load Transient Response for Discontinuous Mode, $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, L = 47 µH, $C_{OUT}$ = 68 µF, $C_{OUT}$ESR = 50 mΩ
A: Output voltage, 100 mV/div, ac-coupled
B: Load current: 100-mA to 400-mA load pulse

**Figure 26. Horizontal Time Base: 200 µs/div**

## 10 Power Supply Recommendations

The LM2671 is designed to operate from an input voltage supply up to 40 V. This input supply must be well regulated and able to withstand maximum input current and maintain a stable voltage.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# 11 Layout

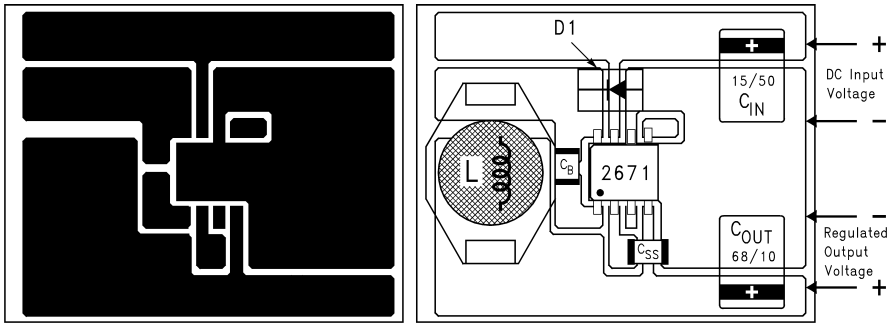
## 11.1 Layout Guidelines

Layout is very important in switching regulator designs. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by heavy lines (in Figure 15 and Figure 21) must be wide printed-circuit traces and must be kept as short as possible. For best results, external components must be placed as close to the switcher IC as possible using ground plane construction or single point grounding.

If open core inductors are used, take special care as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC ground path, and $C_{OUT}$ wiring can cause problems.

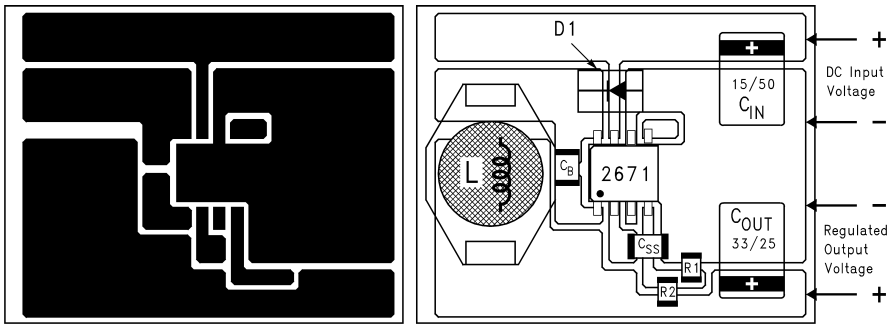
When using the adjustable version, take special care as to the location of the feedback resistors and the associated wiring. Physically place both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor.

## 11.2 Layout Examples




$C_{IN}$ = 15-µF, 25-V Solid Tantalum Sprague, *594D series*
$C_{OUT}$ = 68-µF, 10-V Solid Tantalum Sprague, *594D series*
D1 = 1-A, 40-V Schottky Rectifier, surface mount
L1 = 47-µH, L13 Coilcraft DO3308
$C_B$ = 0.01-µF, 50-V ceramic

**Figure 27. Typical Surface Mount PCB Layout, Fixed Output (4x Size)**




$C_{IN}$ = 15 µF, 50 V Solid Tantalum Sprague, *594D series*
$C_{OUT}$ = 33 µF, 25 V Solid Tantalum Sprague, *594D series*
D1 = 1-A, 40-V Schottky Rectifier, surface mount
L1 = 100-µH, L20 Coilcraft DO3316
$C_B$ = 0.01-µF, 50-V ceramic
R1 = 1 kΩ, 1%
R2 = Use formula in *Detailed Design Procedure*

**Figure 28. Typical Surface Mount PCB Layout, Adjustable Output (4x Size)**

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# 12 デバイスおよびドキュメントのサポート

## 12.1 ドキュメントのサポート

### 12.1.1 関連資料

関連資料については、以下を参照してください。

- *『AN-1187 リードレス・リードフレーム・パッケージ(LLP)』*
- *『LM2670 SIMPLE SWITCHER® 高効率3A降圧型、同期機能付き電圧レギュレータ』*

## 12.2 ドキュメントの更新通知を受け取る方法

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## 12.3 コミュニティ・リソース

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**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.

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## 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。これらの情報は、指定のデバイスに対して提供されている最新のデータです。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 DAP (WSONパッケージ)

PCBのグランド・プレーンには、ダイ取り付けパッド(DAP)を接続でき、また必ず接続する必要があります。CADおよび組み立てガイドラインについては、*『AN-1187 リードレス・リードフレーム・パッケージ(LLP)』*を参照してください。


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## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LM2671LD-ADJ | LIFEBUY | WSON | NHN | 16 | 1000 | Non-RoHS & Green | Call TI | Level-1-235C-UNLIM | -40 to 125 | S0008B | |
| LM2671LD-ADJ/NOPB | ACTIVE | WSON | NHN | 16 | 1000 | RoHS & Green | SN | Level-3-260C-168 HR | -40 to 125 | S0008B | Samples |
| LM2671M-12/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M-12 | Samples |
| LM2671M-3.3/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M3.3 | Samples |
| LM2671M-5.0 | LIFEBUY | SOIC | D | 8 | 95 | Non-RoHS & Green | Call TI | Level-1-235C-UNLIM | -40 to 125 | 2671 M5.0 | |
| LM2671M-5.0/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M5.0 | Samples |
| LM2671M-ADJ | LIFEBUY | SOIC | D | 8 | 95 | Non-RoHS & Green | Call TI | Level-1-235C-UNLIM | -40 to 125 | 2671 MADJ | |
| LM2671M-ADJ/NOPB | ACTIVE | SOIC | D | 8 | 95 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 MADJ | Samples |
| LM2671MX-12/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M-12 | Samples |
| LM2671MX-3.3/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M3.3 | Samples |
| LM2671MX-5.0/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 M5.0 | Samples |
| LM2671MX-ADJ/NOPB | ACTIVE | SOIC | D | 8 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | 2671 MADJ | Samples |
| LM2671N-12/NOPB | ACTIVE | PDIP | P | 8 | 40 | RoHS & Green | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2671 N-12 | Samples |
| LM2671N-3.3/NOPB | ACTIVE | PDIP | P | 8 | 40 | RoHS & Green | Call TI \| NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2671 N-3.3 | Samples |
| LM2671N-5.0/NOPB | ACTIVE | PDIP | P | 8 | 40 | RoHS & Green | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2671 N-5.0 | Samples |
| LM2671N-ADJ/NOPB | ACTIVE | PDIP | P | 8 | 40 | RoHS & Green | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2671 N-ADJ | 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.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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

(6) Lead 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.

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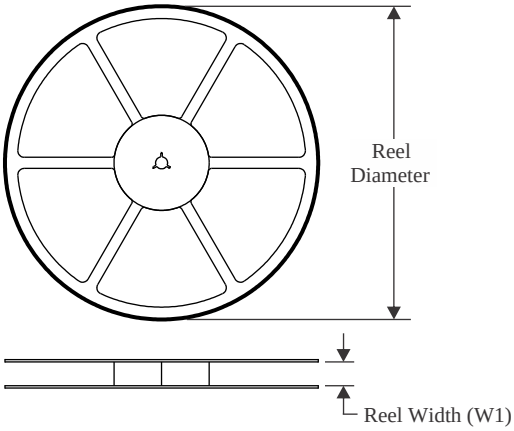
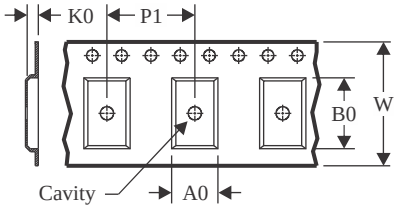
## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

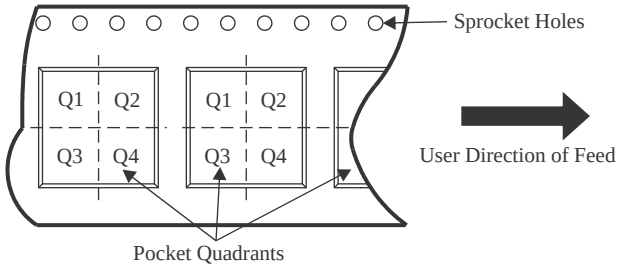



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

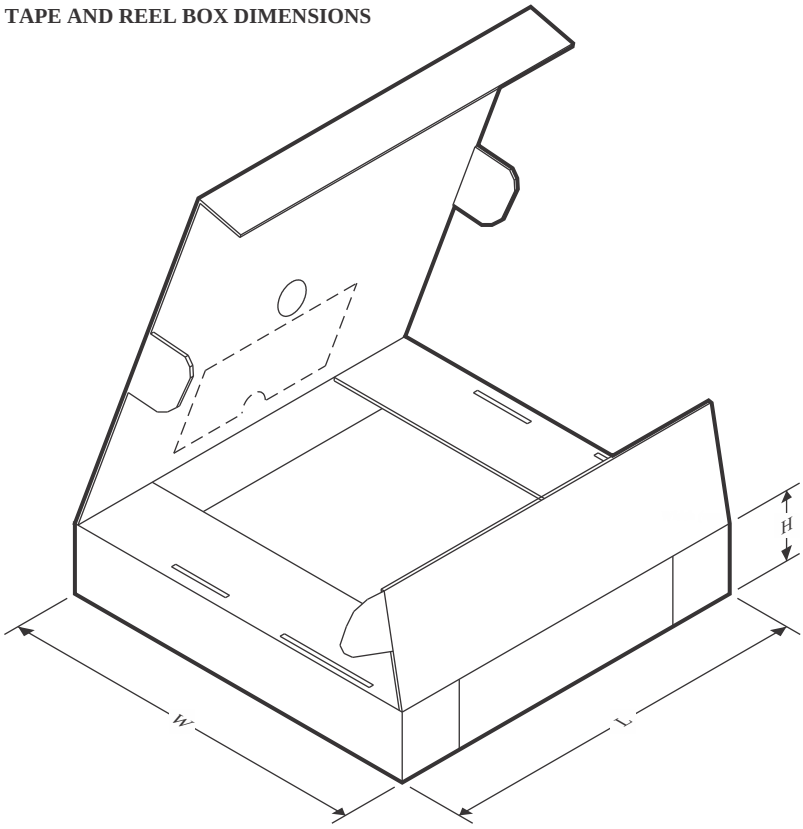
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM2671LD-ADJ | WSON | NHN | 16 | 1000 | 178.0 | 12.4 | 5.3 | 5.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LM2671LD-ADJ/NOPB | WSON | NHN | 16 | 1000 | 178.0 | 12.4 | 5.3 | 5.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LM2671MX-12/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2671MX-3.3/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2671MX-5.0/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2671MX-ADJ/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

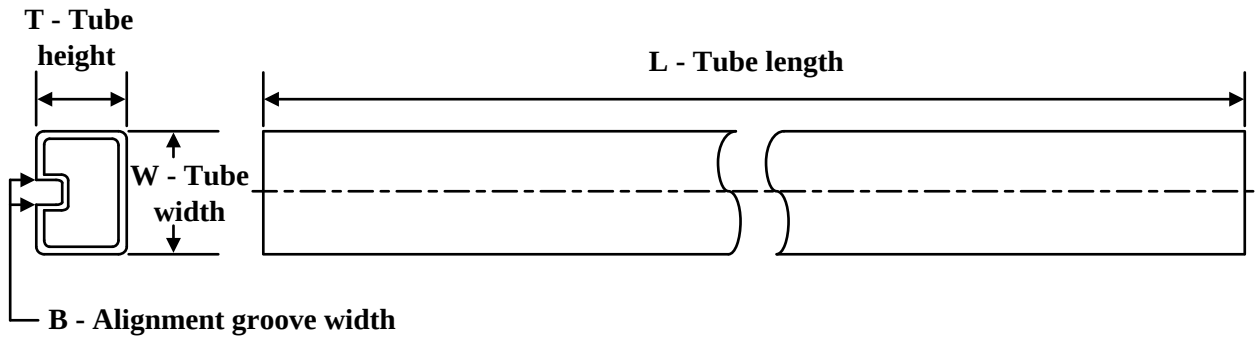
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

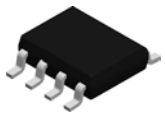
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM2671LD-ADJ | WSON | NHN | 16 | 1000 | 210.0 | 185.0 | 35.0 |
| LM2671LD-ADJ/NOPB | WSON | NHN | 16 | 1000 | 208.0 | 191.0 | 35.0 |
| LM2671MX-12/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2671MX-3.3/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2671MX-5.0/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2671MX-ADJ/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

## TUBE




*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM2671M-12/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-3.3/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-5.0 | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-5.0 | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-5.0/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-ADJ | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-ADJ | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671M-ADJ/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2671N-12/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM2671N-3.3/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM2671N-5.0/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM2671N-ADJ/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |

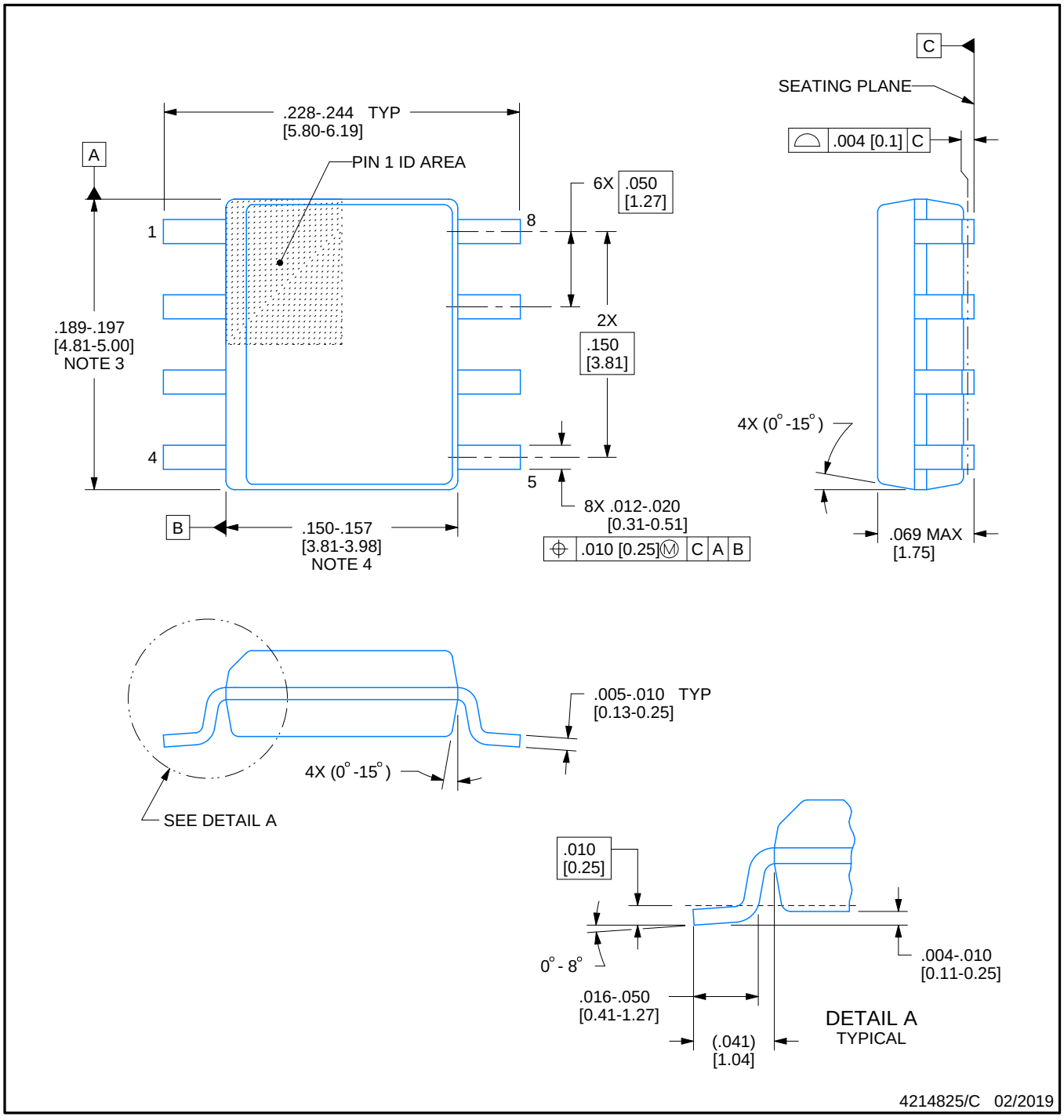


# PACKAGE OUTLINE

## D0008A

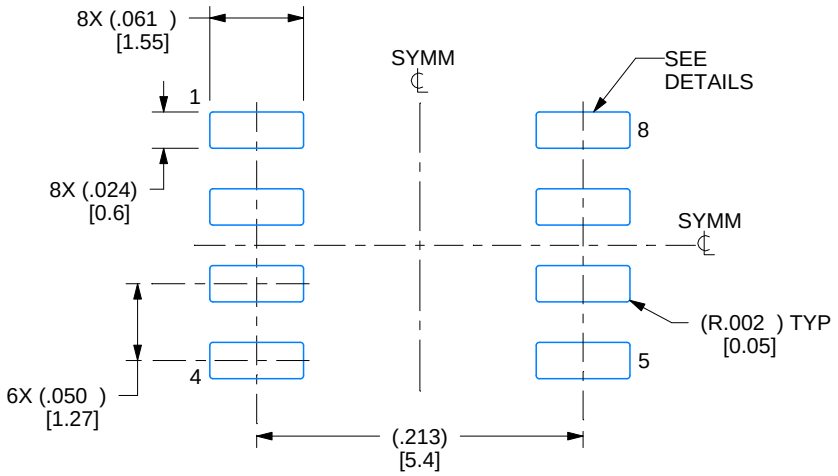
## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

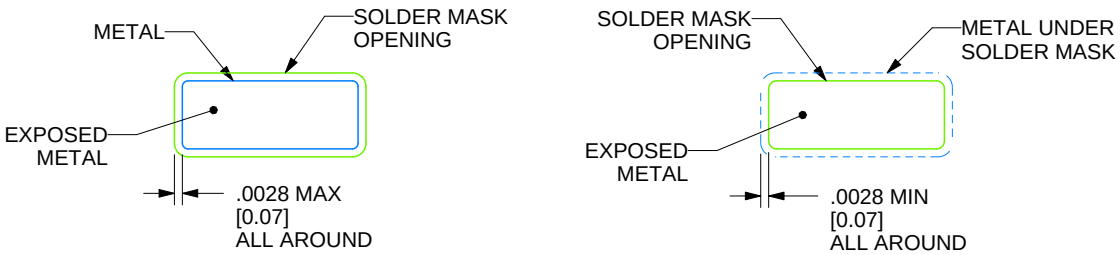



NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X




SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

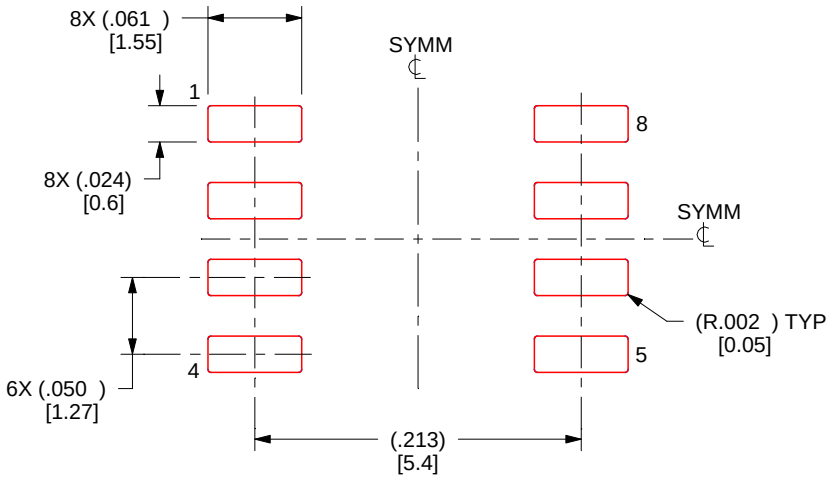
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

## D0008A

## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



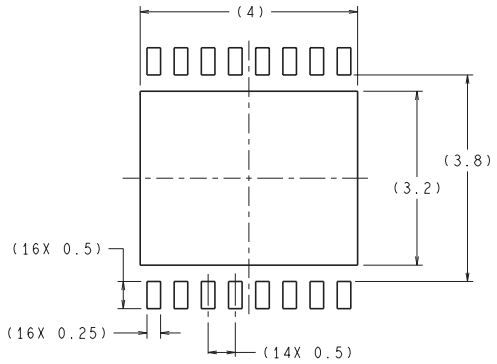

SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

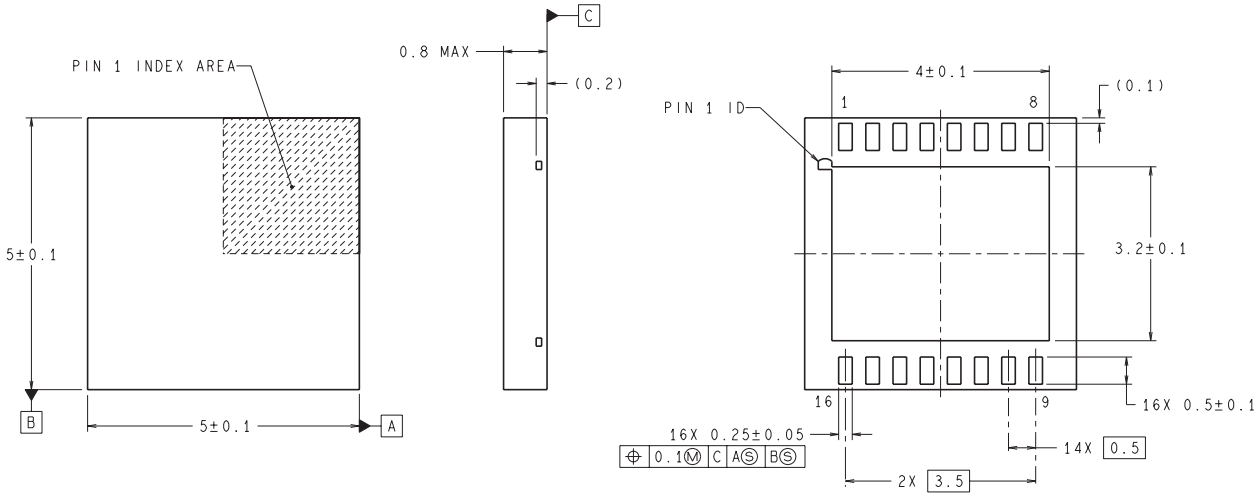
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

# NHN0016A



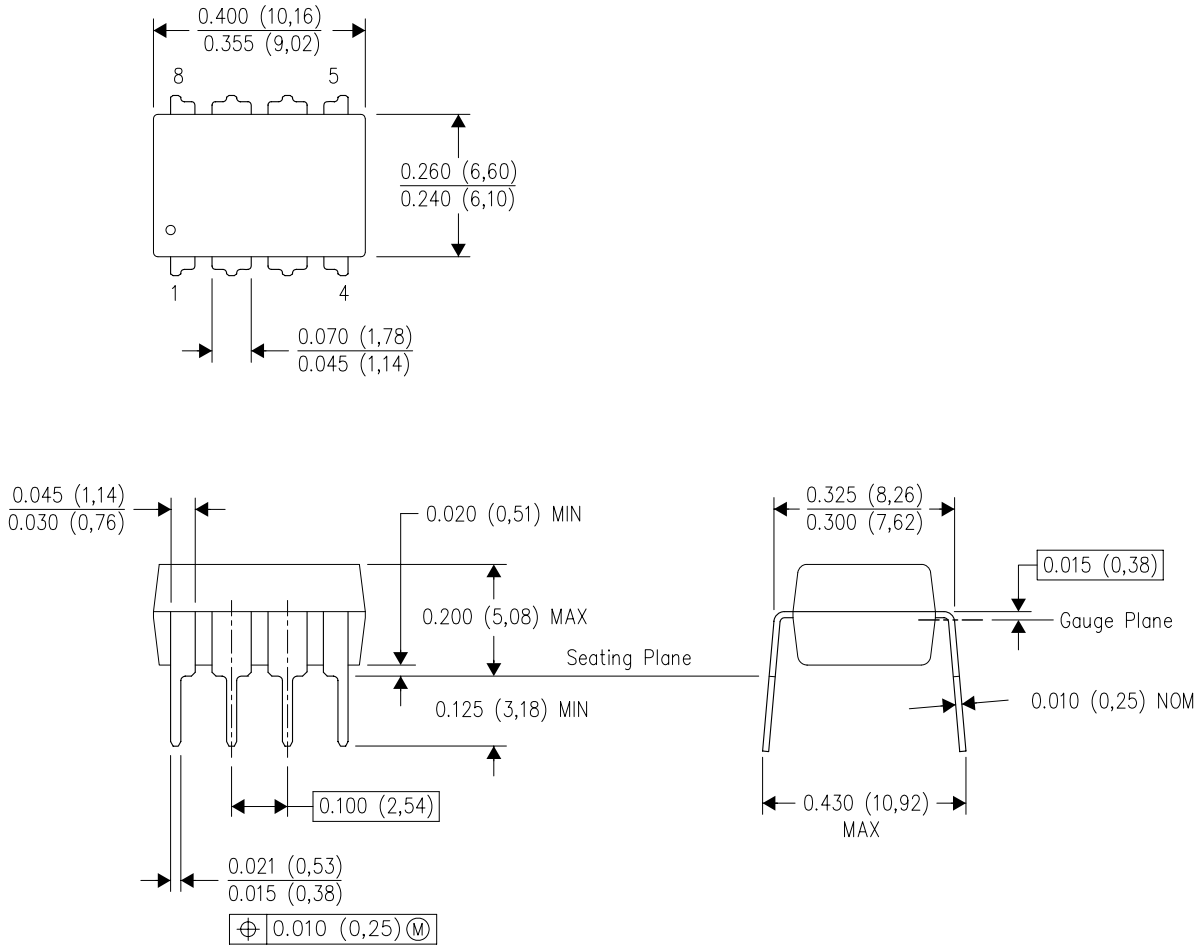

RECOMMENDED LAND PATTERN
1:1 RATIO WITH PKG SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS




LDA16A (REV A)

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

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