TEXAS INSTRUMENTS
LM2676
ZHCSS97H – SEPTEMBER 1998 – REVISED JUNE 2023

# LM2674 SIMPLE SWITCHER® 电源转换器、500mA、高效降压稳压器

## 1 特性

- 推出的新产品：
  - LMR36506 3V 至 65V、0.6A、200kHz 至 2.2MHz 同步转换器
- 用于加快上市速度：
  - TPSM365R6 3V 至 65V、0.6A、200kHz 至 2.2MHz 电源模块
- 效率高达 96%
- 采用 8 引脚 SOIC、PDIP 和 16 引脚 WSON 封装
- 简单且易于设计
- 只需要五个外部元件
- 使用现成的标准电感器
- 3V、5V、12V 和可调输出版本
- 可调版本输出电压范围为 1.21V 至 37V
- 在线路和负载条件下具有 ±1.5% 的最大输出电压容差
- 可确保 500mA 输出负载电流
- 0.25Ω DMOS 输出开关
- 8V 至 40V 的宽输入电压范围
- 260kHz 固定频率内部振荡器
- TTL 关断功能、低功耗待机模式
- 热关断和电流限制保护
- 使用 LM2674 并借助 WEBENCH® Power Designer 创建定制设计方案

## 2 应用

- 简单高效 (> 90%) 的降压稳压器
- 适用于线性稳压器的高效前置稳压器
- 负/正转换器

## 3 说明

LM2674 系列稳压器是采用 LMDMOS 工艺构建的单片集成电路。该系列稳压器提供降压开关稳压器的全部有效功能，能够驱动 500mA 负载电流，并具有出色的线性调整率和负载调整率。这些器件可提供 3.3V、5V、12V 固定输出电压和可调节输出电压版本。

这类稳压器不仅需要很少的外部元件，而且简单易用，还具有获得专利的内部频率补偿和固定频率振荡器。

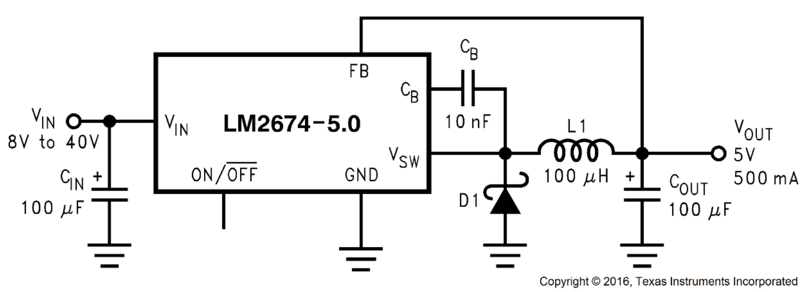
LM2674 系列在 260kHz 的开关频率下运行，因此采用的滤波器元件可比更低频率的开关稳压器所需的元件尺寸更小。由于效率非常高 (> 90%)，只需通过印刷电路板上的覆铜线迹进行散热。

数家不同的生产商提供的标准电感器系列均可与 LM2674 搭配使用。使用这些先进的 IC，此特性极大地简化了开关模式电源的设计。数据表中还包含针对在开关模式电源中工作的二极管和电容器的选择器指南。

**封装信息**

| 器件型号 | 封装(1) | 封装尺寸(2) |
|---|---|---|
| LM2674 | D（SOIC，8） | 4.90mm × 3.91mm |
| | P（PDIP，8） | 9.81mm × 6.35mm |
| | NHN（WSON，16） | 5.00mm × 5.00mm |

(1) 如需了解所有可用封装，请参阅数据表末尾的可订购产品附录。
(2) 封装尺寸（长 × 宽）为标称值，并包括引脚（如适用）。




典型应用

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## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

**Changes from Revision G (June 2016) to Revision H (June 2023)** **Page**

- 更新了整个文档中的表格、图和交叉参考的编号格式.......... 1
- 添加了与 WEBENCH 相关的信息.......... 1
- 添加了指向 LMR36506 和 TPSM365R6 产品文件夹的链接.......... 1
- 更新了*封装信息* 表.......... 1
- Updated bootstrap capacitor recommendation from 470-nF to 10-nF.......... 3
- Updated trademark information.......... 10

**Changes from Revision F (April 2013) to Revision G (June 2016)** **Page**

- 新增了 *ESD 等级* 表、*特性说明* 部分、*器件功能模式*、*应用和实现* 部分、*电源相关建议* 部分、*布局* 部分、*器件和文档支持* 部分以及*机械、封装和可订购信息* 部分.......... 1
- 删除了对计算机设计软件 ***LM267X Made Simple***（6.0 版）的所有引用.......... 1

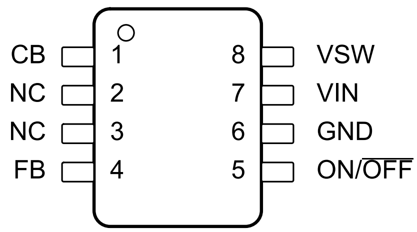
**Changes from Revision E (April 2013) to Revision F (April 2013)** **Page**

- Added information relating to WEBENCH.......... 13
- Changed layout of National Data Sheet to TI format.......... 26
- Added information relating to WEBENCH.......... 28

## 5 说明（续）

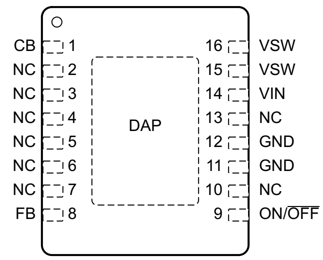
其他特性包括在额定输入电压和输出负载条件下，确保具有 ±1.5% 的输出电压容差和 ±10% 的振荡器频率容差。还具有外部关断功能，待机电流典型值为 50μA。输出开关具备电流限制以及在故障状况下提供全面保护的热关断功能。

## 6 Pin Configuration and Functions




Not to scale

**图 6-1. D or P Package 8-Pin SOIC or PDIP Top View**




Connect DAP to pin 11 and 12.

**图 6-2. NHN Package 16-Pin WSON Top View**

**表 6-1. 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, 10-nF capacitor from CB to VSW Pin. |
| 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 | 2, 3, 4, 5, 6, 7, 10, 13 | — | No connect pins |

# 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/$\overline{OFF}$ 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 | °C |
| | P package (soldering, 10 s) | | | 260 | °C |
| | 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)*.

## 7.5 Electrical Characteristics – 3.3-V Version

$T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN[3] | TYP[2] | MAX[3] | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS** (see 图 9-1)[1] | | | | | | | |
| $V_{OUT}$ | 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 |
| | | | $T_J$ = –40°C to 125°C | 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 | |
| | | | $T_J$ = –40°C to 125°C | 3.201 | | 3.399 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 86% | | |

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2674 is used as shown in 图 9-1 and 图 9-5, system performance is as specified by the system parameters section of the Electrical Characteristics.
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) All limits are used to calculate Average Outgoing Quality Level (AOQL).

## 7.6 Electrical Characteristics – 5-V Version

$T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN[3] | TYP[2] | MAX[3] | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS** (see 图 9-1)[1] | | | | | | | |
| $V_{OUT}$ | 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 |
| | | | $T_J$ = –40°C to 125°C | 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 | |
| | | | $T_J$ = –40°C to 125°C | 4.85 | | 5.15 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 90% | | |

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2674 is used as shown in 图 9-1 and 图 9-5, system performance is as specified by the system parameters section of the Electrical Characteristics.
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) All limits are used to calculate Average Outgoing Quality Level (AOQL).

## 7.7 Electrical Characteristics – 12-V Version

$T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN[3] | TYP[2] | MAX[3] | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS** (see 图 9-1)[1] | | | | | | | |
| $V_{OUT}$ | 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 |
| | | | $T_J$ = –40°C to 125°C | 11.64 | | 12.36 | |
| η | Efficiency | $V_{IN}$ = 24 V, $I_{LOAD}$ = 500 mA | | | 94% | | |

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2674 is used as shown in 图 9-1 and 图 9-5, system performance is as specified by the system parameters section of the Electrical Characteristics.
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) All limits are used to calculate Average Outgoing Quality Level (AOQL).

## 7.8 Electrical Characteristics – Adjustable Voltage Version

$T_J$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN[3] | TYP[2] | MAX[3] | UNIT |
|---|---|---|---|---|---|---|---|
| **SYSTEM PARAMETERS** (see 图 9-5)[1] | | | | | | | |
| $V_{FB}$ | Feedback voltage | $V_{IN}$ = 8 V to 40 V, $I_{LOAD}$ = 20 mA to 500 mA, $V_{OUT}$ programmed for 5 V (see 图 9-5) | $T_J$ = 25°C | 1.192 | 1.21 | 1.228 | V |
| | | | $T_J$ = –40°C to 125°C | 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 (see 图 9-5) | $T_J$ = 25°C | 1.192 | 1.21 | 1.228 | |
| | | | $T_J$ = –40°C to 125°C | 1.174 | | 1.246 | |
| η | Efficiency | $V_{IN}$ = 12 V, $I_{LOAD}$ = 500 mA | | | 90% | | |

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2674 is used as shown in 图 9-1 and 图 9-5, system performance is as specified by the system parameters section of the Electrical Characteristics.
(2) Typical numbers are at 25°C and represent the most likely norm.
(3) All limits are used to calculate Average Outgoing Quality Level (AOQL).

## 7.9 Electrical Characteristics – All Output Voltage Versions

$T_J$ = 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 voltage versions | | | 2.5 | 3.6 | mA |
| | | $V_{FEEDBACK}$ = 15 V for 12-V versions | | | 2.5 | | mA |
| $I_{STBY}$ | Standby quiescent current | ON/ $\overline{OFF}$ pin = 0 V | $T_J$ = 25°C | | 50 | 100 | μA |
| | | | $T_J$ = –40°C to 125°C | | | 150 | |
| $I_{CL}$ | Current limit | $T_J$ = 25°C | | 0.62 | 0.8 | 1.2 | A |
| | | $T_J$ = –40°C to 125°C | | 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 |
| | | | $T_J$ = –40°C to 125°C | | | 0.6 | |
| $f_O$ | Oscillator frequency | Measured at switch pin | $T_J$ = 25°C | | 260 | | kHz |
| | | | $T_J$ = –40°C to 125°C | 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 threshold | Turnon threshold, rising[1] | $T_J$ = 25°C | | 1.4 | | V |
| | | | $T_J$ = –40°C to 125°C | 0.8 | | 2 | |
| $I_{S/D}$ | ON/ $\overline{OFF}$ pin current | ON/ $\overline{OFF}$ pin = 0 V | $T_J$ = 25°C | | 20 | | μA |
| | | | $T_J$ = –40°C to 125°C | 7 | | 37 | |

(1) The ON/ $\overline{OFF}$ pin is internally pulled up to 7 V and can be left floating for always-on operation.

## 7.10 Typical Characteristics

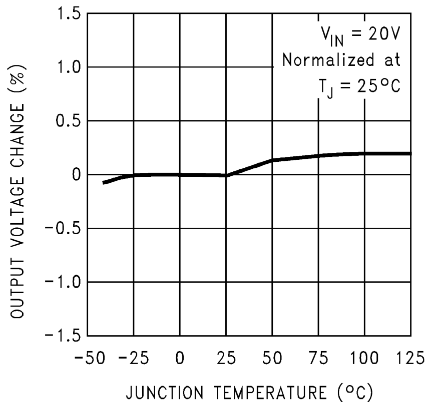



图 7-1. Normalized Output Voltage

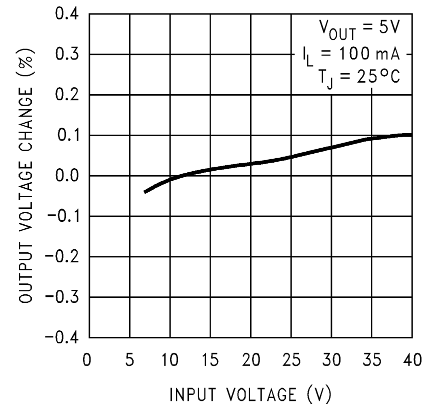



图 7-2. Line Regulation

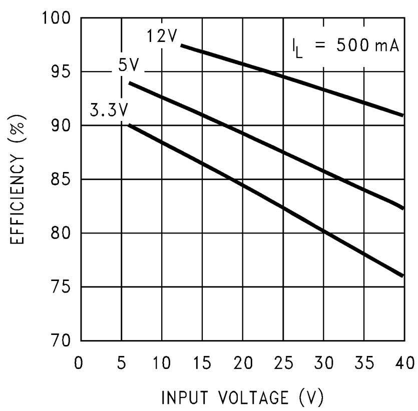



图 7-3. Efficiency

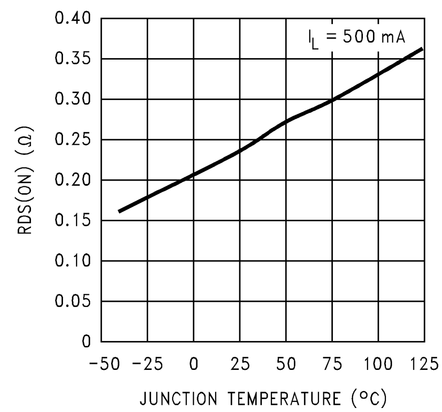



图 7-4. Drain-to-Source Resistance

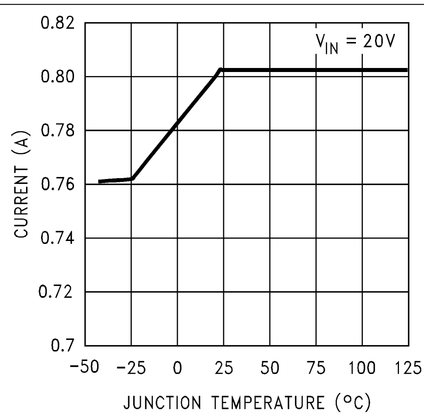



图 7-5. Switch Current Limit

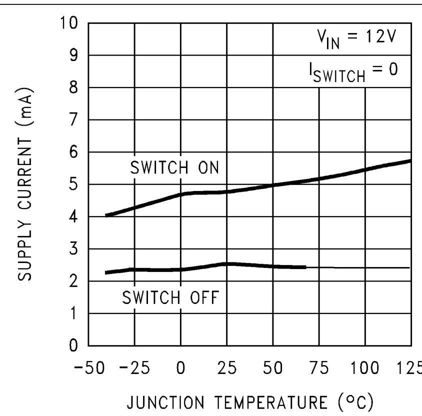



图 7-6. Operating Quiescent Current

## 7.10 Typical Characteristics (continued)

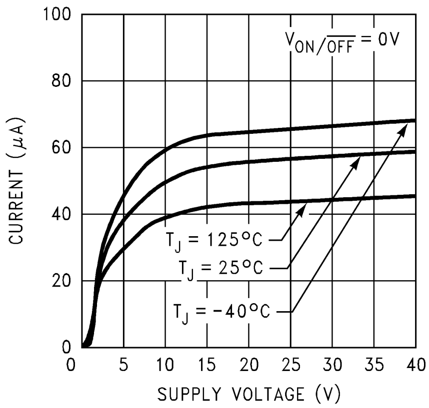



图 7-7. Standby Quiescent Current

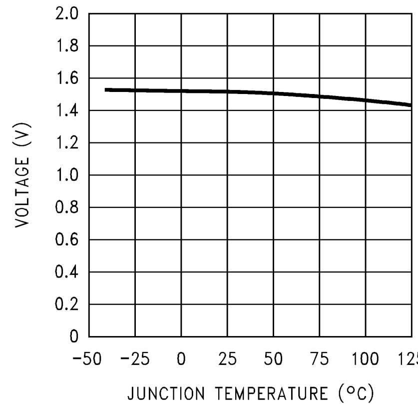



图 7-8. ON/ $\overline{\text{OFF}}$ Threshold Voltage

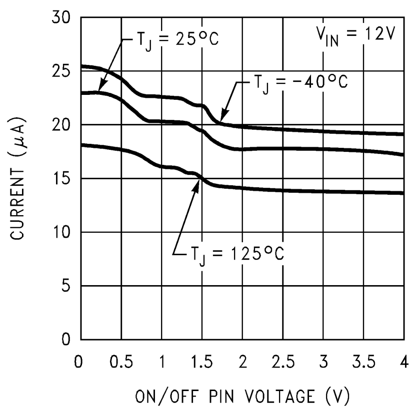



图 7-9. ON/ $\overline{\text{OFF}}$ Pin Current (Sourcing)

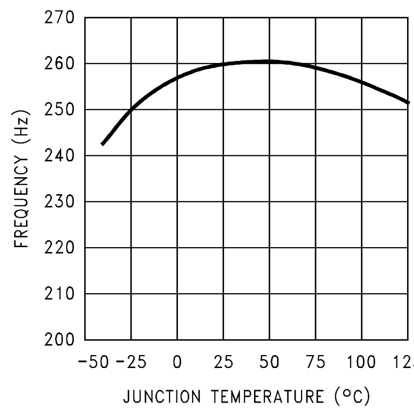



图 7-10. Switching Frequency

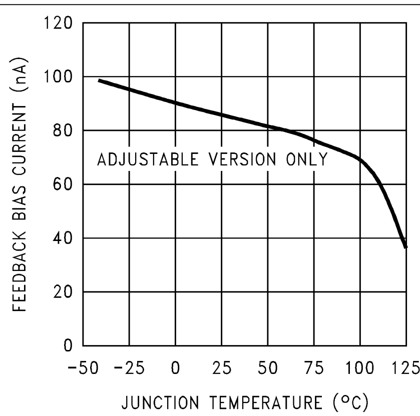



图 7-11. Feedback Pin Bias Current

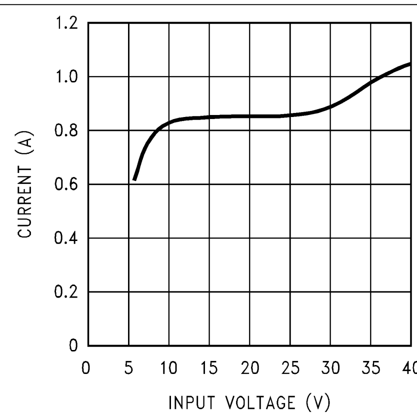



图 7-12. Peak Switch Current

## 7.10 Typical Characteristics (continued)

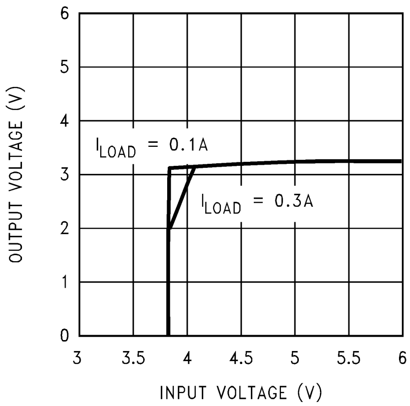



**图 7-13. Dropout Voltage, 3.3-V Version**

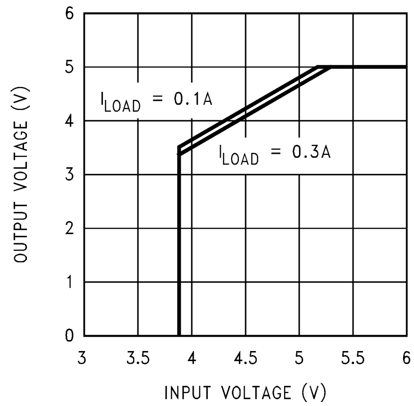


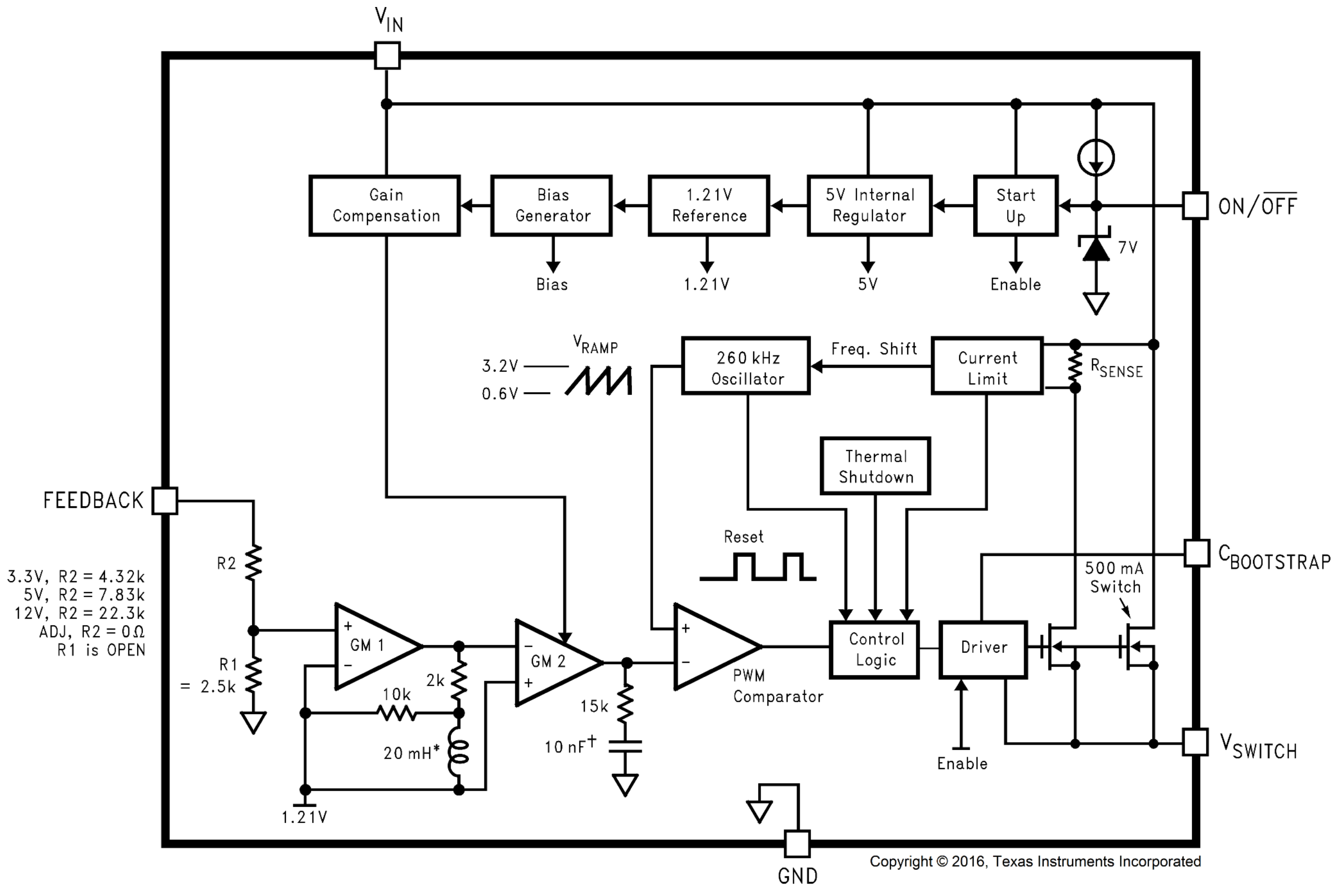

**图 7-14. Dropout Voltage, 5-V Version**

# 8 Detailed Description

## 8.1 Overview

The LM2674 SIMPLE SWITCHER® power converter regulator is an easy-to-use non-synchronous step-down DC-DC converter with a wide input voltage range up to 40 V. The LM2674 is capable of delivering up to 0.5-A DC load current with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. The family requires few external components and the pin arrangement was designed for simple, optimum PCB layout.

## 8.2 Functional Block Diagram






## 8.3 Feature Description

### 8.3.1 Adjustable Output Voltage

The voltage regulation loop in the LM2674 regulates output voltage by maintaining the voltage on FB pin (VFB) to be the same as the internal REF voltage (VREF). A resistor divider pair is required to program the ratio from output voltage VOUT to VFB. The resistor is connected from the VOUT of the LM2674 to ground with the mid-point connecting to the FB pin. The voltage reference system produces a precise voltage reference over temperature. The internal REF voltage is 1.21 V typically. To program the output voltage of the LM2674 to be a certain value VOUT, R1 can be calculated with a selected R2 (see *Adjustable Output Voltage Typical Application*). R2 is in the range from 10 kΩ to 100 kΩ is recommended for most applications. If the resistor divider is not connected properly, output voltage cannot be regulated because the feedback loop is broken. If the FB pin is shorted to ground, the output voltage is driven close to VIN, because the regulator sees very low voltage on the FB pin and tries to regulator it up. The load connected to the output can be damaged under such a condition. Do not short FB pin to ground when the LM2674 is enabled. It is important to route the feedback trace away from the noisy area of the PCB. For more layout recommendations, see *Layout*.

## 8.4 Device Functional Modes

### 8.4.1 Shutdown Mode

The ON/ $\overline{\text{OFF}}$ pin provides electrical ON and OFF control for the LM2674. When the voltage of this pin is lower than 1.4 V, the device is in shutdown mode. The typical standby current in this mode is 50 µA.

### 8.4.2 Active Mode

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

# 9 Application and Implementation

备注

以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

## 9.1 Application Information

The LM2674 is a step-down DC-DC regulator. The LM2674 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 LM2674. Alternately, the WEBENCH® software can 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, observing a large hysteresis in the current limit is possible. 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 can cause the inductor to saturate.
3. Thereafter, after 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*, as the output tries to recover, the output capacitor charging current can be 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 can 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.

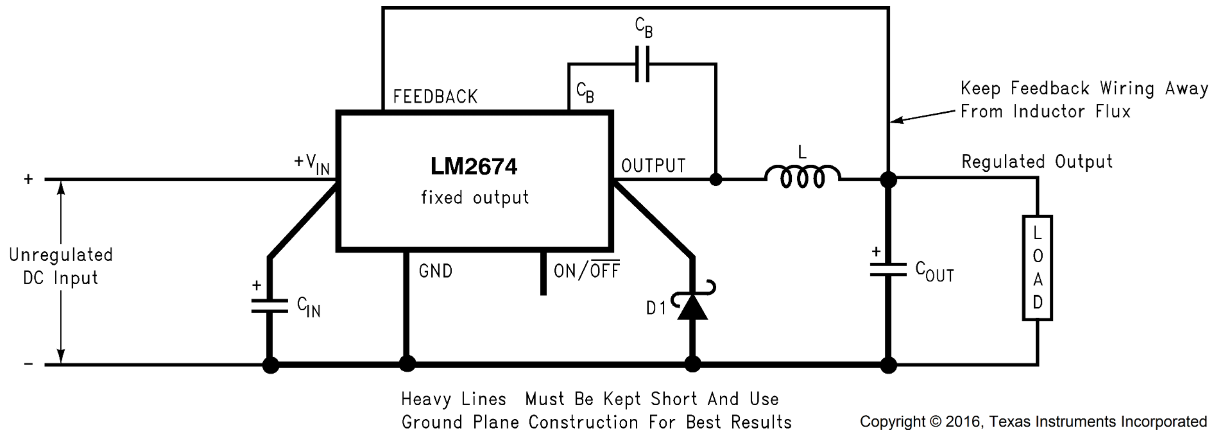
备注

Even with these components, for a device 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.

## 9.2 Typical Applications

### 9.2.1 Fixed Output Voltage Typical Application






$C_{IN}$ = 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

**图 9-1. Fixed Output Voltage Version**

#### *9.2.1.1 Design Requirements*

表 9-1 lists the design parameters of this example.

**表 9-1. 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 Custom Design with WEBENCH® Tools

Click here to create a custom design using the LM2674 devices with the WEBENCH Power Designer.

1. Start by entering the input voltage ($V_{IN}$), output voltage ($V_{OUT}$), and output current ($I_{OUT}$) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at www.ti.com/WEBENCH.

#### 9.2.1.2.2 Inductor Selection (L1)

1. Select the correct inductor value selection guide from 图 9-10, 图 9-11, or 图 9-12 (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 图 9-11.
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 图 9-11, 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 表 9-7. Each manufacturer makes a different style of inductor to allow flexibility in meeting various design requirements. Listed below are some of the differentiating characteristics of each manufacturer's inductors:
   - *Schott:* 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 can 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. The inductance value required is 47 μH. From 表 9-7, 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).

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

Select an output capacitor from the output capacitor 表 9-2. 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 表 9-2. 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 the following:

- 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.

表 9-2. 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 |

#### 9.2.1.2.4 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 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 LM2674. The most stressful condition for this diode is a shorted output condition. Refer to 表 9-3. 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.

表 9-3. Schottky Diode Selection Table

| $V_R$ | 500-mA DIODES | | 3-A DIODES | |
|---|---|---|---|---|
| | SURFACE MOUNT | THROUGH-HOLE | SURFACE MOUNT | THROUGH-HOLE |
| 20V | SK12 | 1N5817 | SK32 | 1N5820 |
| | B120 | SR102 | | SR302 |
| 30V | SK13 | 1N5818 | SK33 | 1N5821 |
| | B130 | 11DQ03 | 30WQ03F | 31DQ03 |
| | MBRS130 | SR103 | | |

**表 9-3. Schottky Diode Selection Table (continued)**

| $V_R$ | 500-mA DIODES | | 3-A DIODES | |
|---|---|---|---|---|
| | SURFACE MOUNT | THROUGH-HOLE | SURFACE MOUNT | THROUGH-HOLE |
| 40V | SK14 | 1N5819 | SK34 | 1N5822 |
| | B140 | 11DQ04 | 30BQ040 | MBR340 |
| | MBRS140 | SR104 | 30WQ04F | 31DQ04 |
| | 10BQ040 | | MBRS340 | SR304 |
| | 10MQ040 | | MBRD340 | |
| | 15MQ040 | | | |
| 50V | SK15 | MBR150 | SK35 | MBR350 |
| | B150 | 11DQ05 | 30WQ05F | 31DQ05 |
| | 10BQ050 | SR105 | | SR305 |

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 LM2674 using short leads and short printed-circuit traces.

#### 9.2.1.2.5 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 图 9-2 show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors can be required to increase the total minimum RMS current rating to suit the application requirements.

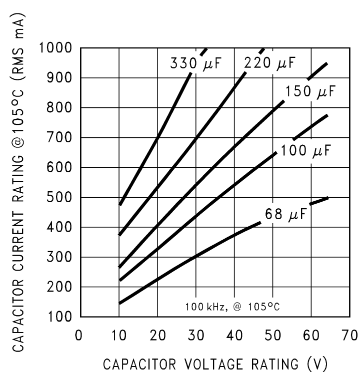



**图 9-2. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)**

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. 表 9-4 and 表 9-5 show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. TI 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.

表 9-4. AVX TPS

| RECOMMENDED APPLICATION VOLTAGE(1) | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 3.3 | 6.3 |
| 5 | 10 |
| 10 | 20 |
| 12 | 25 |
| 15 | 35 |

表 9-5. Sprague 594D

| RECOMMENDED APPLICATION VOLTAGE(1) | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 2.5 | 4 |
| 3.3 | 6.3 |
| 5 | 10 |
| 8 | 16 |
| 12 | 20 |
| 18 | 25 |
| 24 | 35 |
| 29 | 50 |

(1) Recommended Application Voltage for AVX TPS and Sprague 594D Tantalum Chip Capacitors Derated for 85°C

Use caution when using only ceramic capacitors for input bypassing, because it can 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 an RMS current rating of at least 250 mA is required. The curves shown in 图 9-2 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.

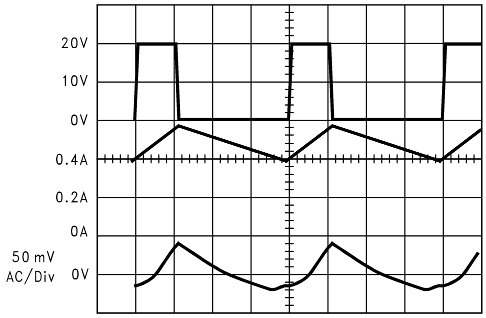
For a through-hole design, a 100-µF, 16-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) is adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS and the Nichicon WF or UR and the NIC Components NACZ series can 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 表 9-4, and the Sprague 594D series datasheet, a Sprague 594D 15-µF, 25-V capacitor is adequate.

#### 9.2.1.2.6 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.

#### *9.2.1.3 Application Curves*



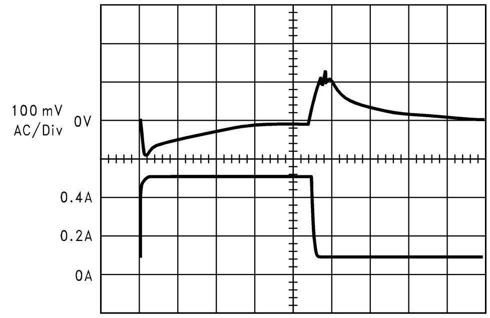

Continuous mode switching waveforms $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, $I_{LOAD}$ = 500 mA L = 100 μH, $C_{OUT}$ = 100 μF, $C_{OUT}$ESR = 0.1 Ω

A: $V_{SW}$ pin voltage = 10 V/div

B: Inductor current = 0.2 A/div

C: Output ripple voltage = 50 mV/div ac-coupled

**图 9-3. Horizontal Time Base: 1 μs/div**



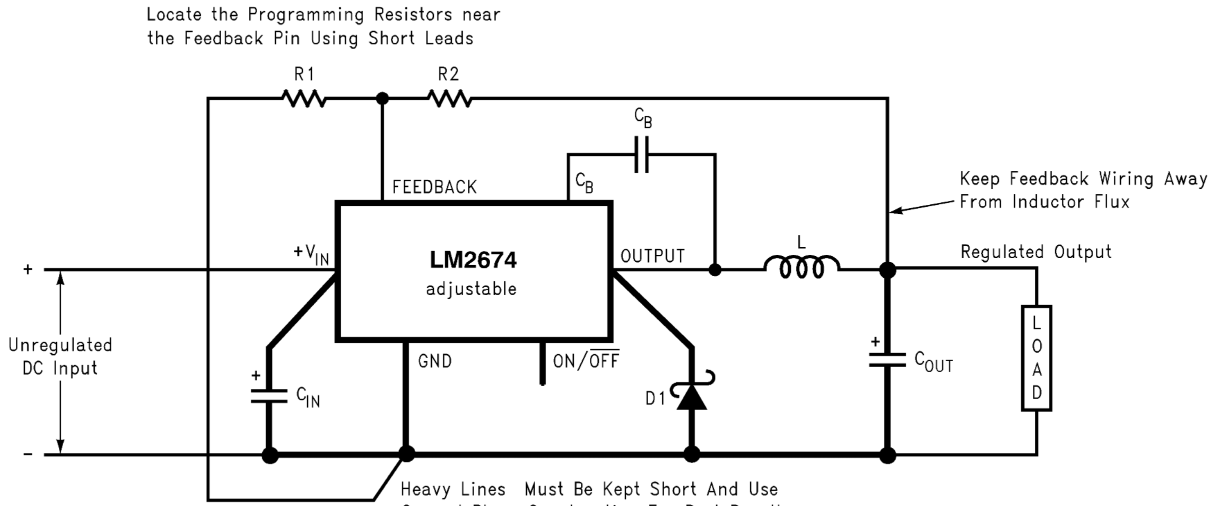

Load transient response for continuous mode $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, L = 100 μH, $C_{OUT}$ = 100 μF, $C_{OUT}$ESR = 0.1 Ω

A: Output voltage = 100 mV/div, ac-coupled

B: Load current = 100-mA to 500-mA load pulse

**图 9-4. Horizontal Time Base: 50 μs/div**

### 9.2.2 Adjustable Output Voltage Typical Application






$C_{IN}$ = 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

For a 5-V output, select R2 to be 4.75 kΩ, 1%

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

where $V_{REF}$ = 1.21 V

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

Use a 1% resistor for best stability.

**图 9-5. Adjustable Output Voltage Version**

#### *9.2.2.1 Design Requirements*

表 9-6 lists the design parameters of this example.

**表 9-6. Design Parameters**

| PARAMETER | VALUE |
|---|---|
| Regulated output voltage, $V_{OUT}$ | 20 |
| Maximum input voltage, $V_{IN}$(max) | 28 |
| Maximum load current, $I_{LOAD}$(max) | 500 |
| 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 图 9-5.

Use the following formula to select the appropriate resistor values.

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

where

- $V_{REF}$ = 1.21 V

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.)

$$R_2 = R_1 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) \tag{2}$$

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

$$R_2 = R_1 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) = 1\ k\Omega \left( \frac{20V}{1.23V} - 1 \right) \tag{3}$$

where

- $R_2$ = 1k (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 方程式 4.

   $$E \cdot T = (V_{IN(MAX)} - V_{OUT} - V_{SAT}) \cdot \frac{V_{OUT} + V_D}{V_{IN(MAX)} - V_{SAT} + V_D} \cdot \frac{1000}{260}\ (V \cdot \mu s) \tag{4}$$

   where

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

   Calculate the inductor Volt • microsecond constant (E • T) with 方程式 5.

   $$E \cdot T = (28 - 20 - 0.25) \cdot \frac{20 + 0.5}{28 - 0.25 + 0.5} \cdot \frac{1000}{260}\ (V \cdot \mu s)$$
   $$E \cdot T = (7.75) \cdot \frac{20.5}{28.25} \cdot 3.85\ (V \cdot \mu s) = 21.6\ (V \cdot \mu s) \tag{5}$$

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 图 9-13.

   E • T = 21.6 (V • μs)
3. On the horizontal axis, select the maximum load current.

   $I_{LOAD}$(max) = 500 mA
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 图 9-13, 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 表 9-7. For information on the different types of inductors, see the inductor selection in the fixed output voltage design procedure.

   From 表 9-7, locate line L20, and select an inductor part number from the list of manufacturers' part numbers.

表 9-7. Inductor Manufacturers' Part Numbers

| IND. REF. DESG. | INDUCTANCE (μH) | CURRENT (A) | SCHOTT | | 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 |

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

1. Select an output capacitor from the capacitor code selection guide in 表 9-8. 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 表 9-8. 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 in 表 9-9. There are two solid tantalum (surface-mount) capacitor manufacturers and four electrolytic (through-hole) capacitor manufacturers to choose from. TI recommends that both the manufacturers and the manufacturer's series that are listed in the table be used. From the output capacitor selection in 表 9-9, 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 the following:

   - 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
     - 20-μF, 35-V Panasonic HFQ series

Other manufacturers or other types of capacitors can 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. Refer to the capacitor manufacturers' data sheet for this information.

表 9-8. 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 |

### 表 9-8. Capacitor Code Selection Guide (continued)

| CASE STYLE[(1)] | OUTPUT VOLTAGE (V) | INDUCTANCE (µH) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 22 | 33 | 47 | 68 | 100 | 150 | 220 |
| 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 and TH = Through hole

### 表 9-9. Output Capacitor Selection Table

| CAP. REF. DESG. # | 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) |
| 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/[(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 | See[(2)] | 150/35 | 150/35 | 150/35 |
| C22 | 33/35 | 22/35 | See[(2)] | 120/35 | 120/35 | 120/35 |
| C23 | See[(2)] | See[(2)] | See[(2)] | 220/50 | 100/50 | 120/50 |
| C24 | See[(2)] | See[(2)] | See[(2)] | 150/50 | 100/50 | 120/50 |
| C25 | See[(2)] | See[(2)] | See[(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 LM2674. The most stressful condition for this diode is a shorted output condition. Schottky diodes provide the best performance, and in this example a 500-mA, 40-V Schottky diode is a good choice. If the circuit must withstand a continuous shorted output, TI recommends a higher current (at least 1.2 A) 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. The Schottky diode must be placed close to the LM2674 using short leads and short printed-circuit traces.

#### 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 图 9-2 show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors can be required to increase the total minimum RMS current rating to suit the application requirements.

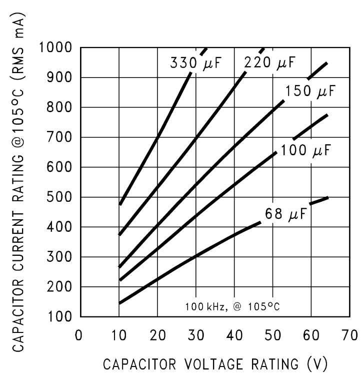



图 9-6. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)

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. 表 9-10 and 表 9-5 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.

表 9-10. AVX TPS

| RECOMMENDED APPLICATION VOLTAGE(1) | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 3.3 | 6.3 |
| 5 | 10 |
| 10 | 20 |

**表 9-10. AVX TPS (continued)**

| RECOMMENDED APPLICATION VOLTAGE(1) | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 12 | 25 |
| 15 | 35 |

(1) Recommended Application Voltage for AVX TPS and Sprague 594D Tantalum Chip Capacitors Derated for 85°C

**表 9-11. Sprague 594D**

| RECOMMENDED APPLICATION VOLTAGE(1) | VOLTAGE RATING |
|---|---|
| 85°C RATING | |
| 2.5 | 4 |
| 3.3 | 6.3 |
| 5 | 10 |
| 8 | 16 |
| 12 | 20 |
| 18 | 25 |
| 24 | 35 |
| 29 | 50 |

(1) Recommended Application Voltage for AVX TPS and Sprague 594D Tantalum Chip Capacitors Derated for 85°C

Use caution when using only ceramic capacitors for input bypassing, because it can 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 an RMS current rating of at least 250 mA is required. The curves shown in 图 9-2 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.

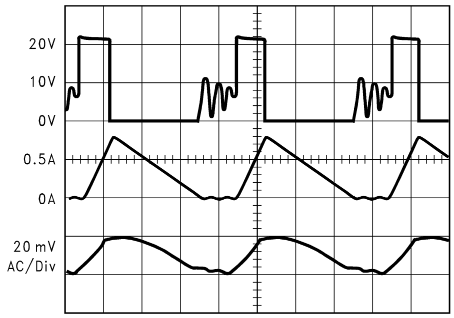
For a through-hole design, a 68-µF, 35-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) is adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS, and the Nichicon WF or UR and the NIC Components NACZ series can 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 note 1 of 表 9-5, and the Sprague 594D series datasheet, 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.

#### *9.2.2.3 Application Curves*



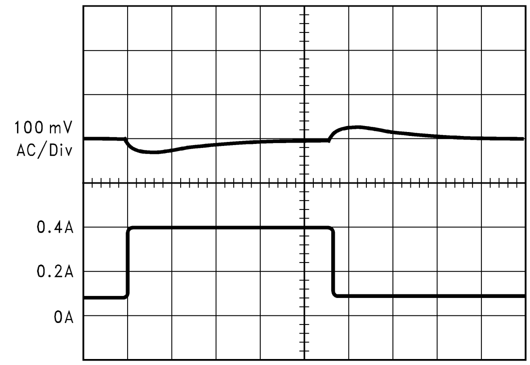

Discontinuous mode switching waveforms $V_{IN}$ = 20 V, $V_{OUT}$ = 5 V, $I_{LOAD}$ = 300 mA, L = 15 µH, $C_{OUT}$ = 68 µF (2×), $C_{OUT}$ESR = 25 mΩ

A: $V_{SW}$ pin voltage = 10 V/div

B: Inductor current = 0.5 A/div

C: Output ripple voltage = 20 mV/div ac-coupled

**图 9-7. Horizontal Time Base: 1 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

**图 9-8. Horizontal Time Base: 200 µs/div**

### 9.2.3 Typical Application for All Output Voltage Versions

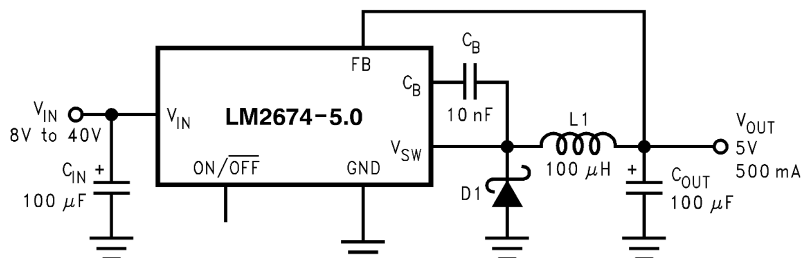





**图 9-9. Typical Application**

#### *9.2.3.1 Application Curves*

for continuous mode operation

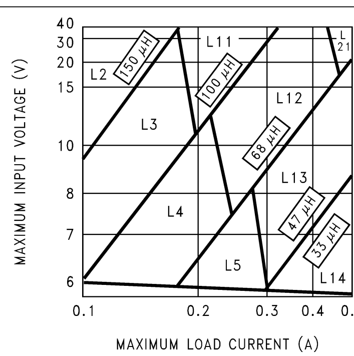



**图 9-10. LM2674, 3.3-V Version**

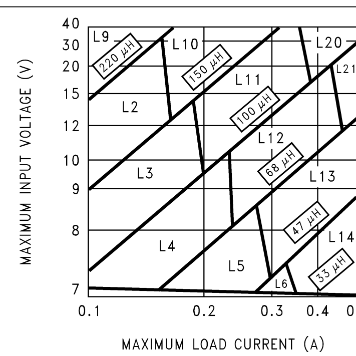



**图 9-11. LM2674, 5-V Version**

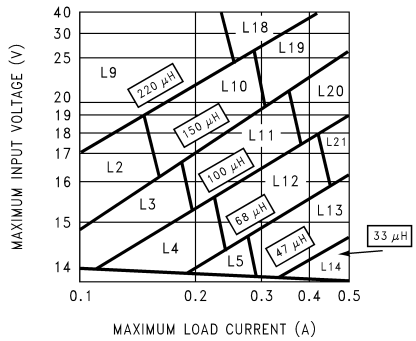



图 9-12. LM2674, 12-V Version

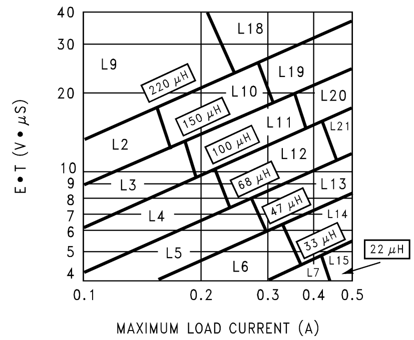



图 9-13. LM2674, Adjustable Version

## 9.3 Power Supply Recommendations

The LM2674 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.

## 9.4 Layout

### 9.4.1 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 图 9-1 and 图 9-5) 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.

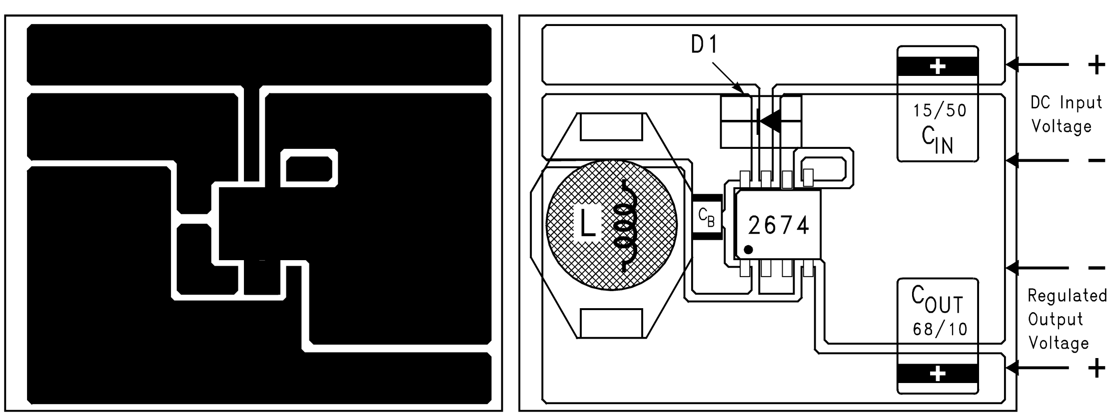
When using the adjustable version, take special care as to the location of the feedback resistors and the associated wiring. Physically place both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor.

#### *9.4.1.1 WSON Package Devices*

The LM2674 is offered in the 16-pin WSON surface mount package to allow for increased power dissipation compared to the 8-pin SOIC and PDIP.

The die attach pad (DAP) must be connected to PCB ground plane. For CAD and assembly guidelines refer to *AN-1187 Leadless Leadframe Package (LLP)* application report.

### 9.4.2 Layout Examples




$C_{IN}$ = 15- µ F, 25-V, Solid Tantalum Sprague *594D series*

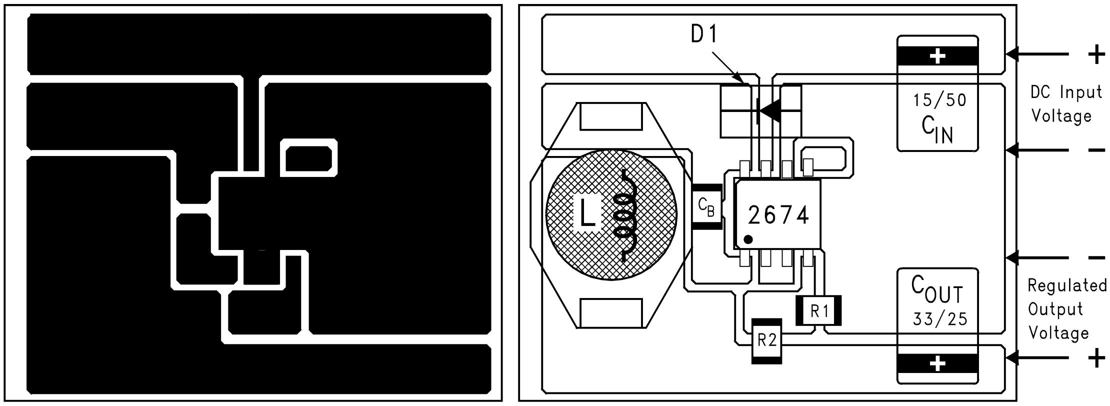
$C_{OUT}$ = 68- µ F, 10-V, Solid Tantalum Sprague *594D series*

D1 = 1-A, 40-V Schottky Rectifier, Surface Mount

L1 = 47-μH, L13, Coilcraft DO3308

$C_B$ = 0.01-μF, 50-V Ceramic

**图 9-14. 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 = 1k, 1%

R2 = Use formula in *Detailed Design Procedure*

**图 9-15. Typical Surface-Mount PCB Layout, Adjustable Output (4x Size)**

# 10 Device and Documentation Support

## 10.1 Device Support

### 10.1.1 Development Support

For development support see the following:

- For TI's WEBENCH Design Environment, visit the WEBENCH Design Center

#### *10.1.1.1 Custom Design with WEBENCH® Tools*

Click here to create a custom design using the LM2674 devices with the WEBENCH Power Designer.

1. Start by entering the input voltage ($V_{IN}$), output voltage ($V_{OUT}$), and output current ($I_{OUT}$) requirements.
2. Optimize the design for key parameters such as efficiency, footprint, and cost using the optimizer dial.
3. Compare the generated design with other possible solutions from Texas Instruments.

The WEBENCH Power Designer provides a customized schematic along with a list of materials with real-time pricing and component availability.

In most cases, these actions are available:

- Run electrical simulations to see important waveforms and circuit performance
- Run thermal simulations to understand board thermal performance
- Export customized schematic and layout into popular CAD formats
- Print PDF reports for the design, and share the design with colleagues

Get more information about WEBENCH tools at www.ti.com/WEBENCH.

## 10.2 Documentation Support

### 10.2.1 Related Documentation

For related documentation see the following:

Texas Instruments, *AN-1187 Leadless Leadframe Package (LLP)* application report

## 10.3 接收文档更新通知

要接收文档更新通知，请导航至 ti.com 上的器件产品文件夹。点击*订阅更新* 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

## 10.4 支持资源

TI E2E™ 支持论坛是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

## 10.5 Trademarks

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## 10.6 静电放电警告

静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

### 10.7 术语表

TI 术语表　　本术语表列出并解释了术语、首字母缩略词和定义。

## 11 Mechanical, Packaging, and Orderable Information

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

## PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package \| Pins | Package qty \| Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|---|---|---|---|---|---|---|---|---|---|
| LM2674LD-ADJ/NOPB | Active | Production | WSON (NHN) \| 16 | 1000 \| SMALL T&R | Yes | SN | Level-3-260C-168 HR | -40 to 125 | S000CB |
| LM2674LDX-5.0/NOPB | Active | Production | WSON (NHN) \| 16 | 4500 \| LARGE T&R | Yes | SN | Level-3-260C-168 HR | -40 to 125 | S000BB |
| LM2674M-12/NOPB | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M-12 |
| LM2674M-3.3/NOPB | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M3.3 |
| LM2674M-5.0/NOPB | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M5.0 |
| LM2674M-ADJ/NOPB | Active | Production | SOIC (D) \| 8 | 95 \| TUBE | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 MADJ |
| LM2674MX-12/NOPB | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M-12 |
| LM2674MX-3.3/NOPB | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M3.3 |
| LM2674MX-5.0/NOPB | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 M5.0 |
| LM2674MX-ADJ/NOPB | Active | Production | SOIC (D) \| 8 | 2500 \| LARGE T&R | Yes | NIPDAU \| SN | Level-1-260C-UNLIM | -40 to 125 | 2674 MADJ |
| LM2674N-3.3/NOPB | Active | Production | PDIP (P) \| 8 | 40 \| TUBE | Yes | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2674 N-3.3 |
| LM2674N-5.0/NOPB | Active | Production | PDIP (P) \| 8 | 40 \| TUBE | Yes | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2674 N-5.0 |
| LM2674N-ADJ/NOPB | Active | Production | PDIP (P) \| 8 | 40 \| TUBE | Yes | NIPDAU | Level-1-NA-UNLIM | -40 to 125 | LM2674 N-ADJ |

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

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

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

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

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

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

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

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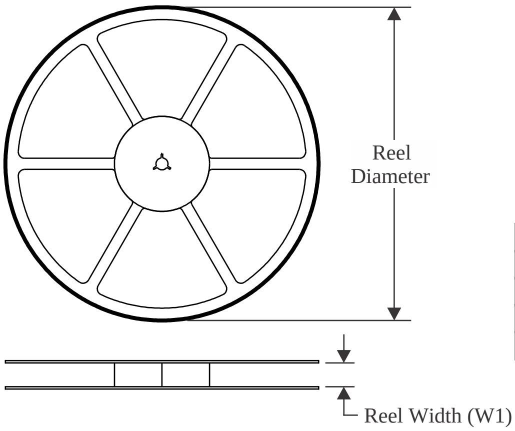
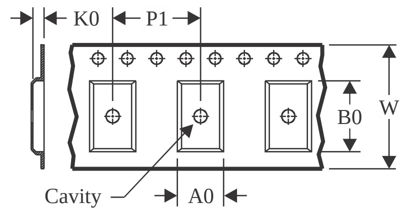
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

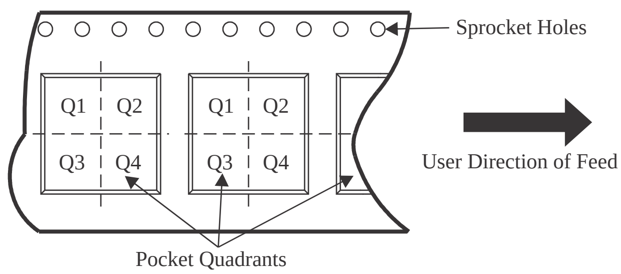



**TAPE DIMENSIONS**




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

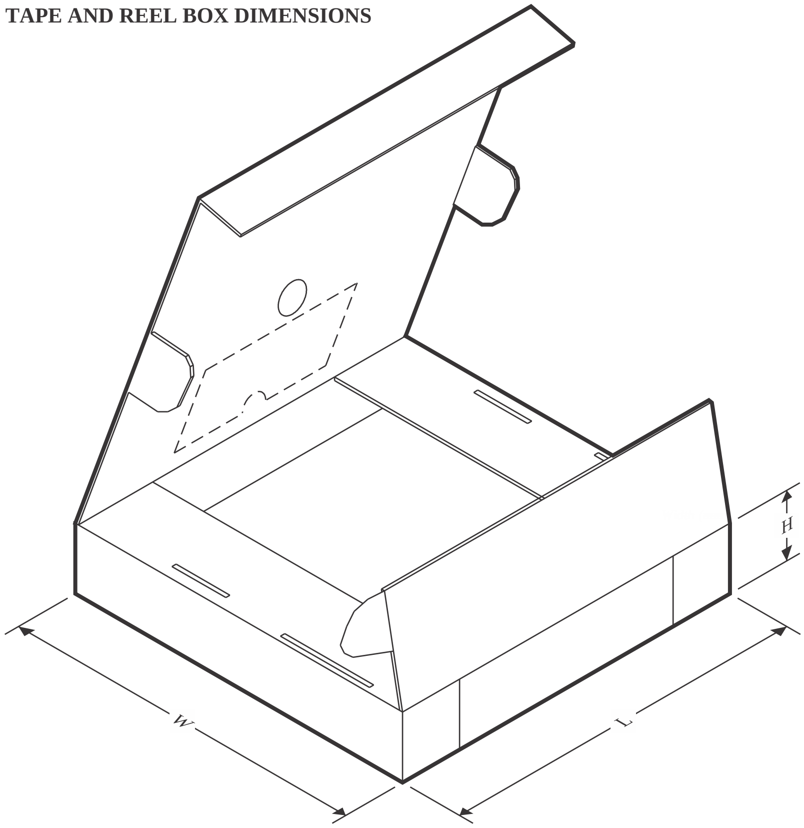
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM2674LD-ADJ/NOPB | WSON | NHN | 16 | 1000 | 178.0 | 12.4 | 5.3 | 5.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LM2674LDX-5.0/NOPB | WSON | NHN | 16 | 4500 | 330.0 | 12.4 | 5.3 | 5.3 | 1.3 | 8.0 | 12.0 | Q1 |
| LM2674MX-12/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2674MX-3.3/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2674MX-5.0/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |
| LM2674MX-ADJ/NOPB | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.5 | 5.4 | 2.0 | 8.0 | 12.0 | Q1 |

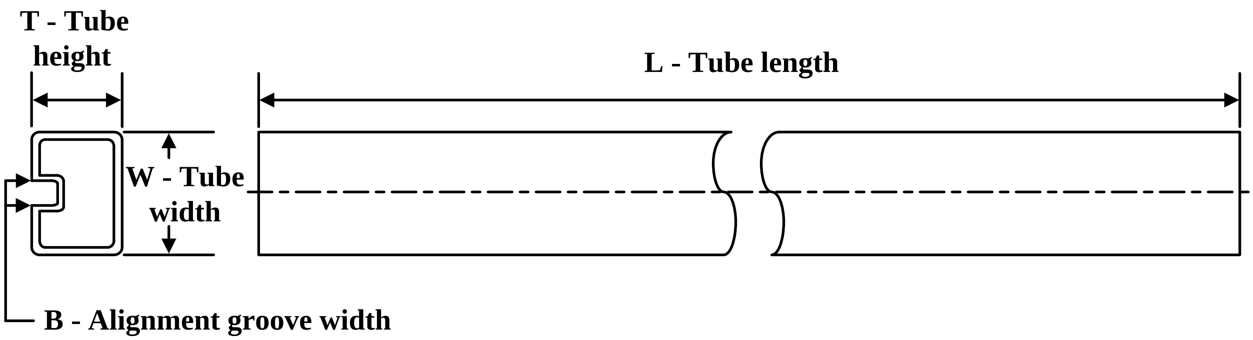
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM2674LD-ADJ/NOPB | WSON | NHN | 16 | 1000 | 208.0 | 191.0 | 35.0 |
| LM2674LDX-5.0/NOPB | WSON | NHN | 16 | 4500 | 356.0 | 356.0 | 36.0 |
| LM2674MX-12/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2674MX-3.3/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2674MX-5.0/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| LM2674MX-ADJ/NOPB | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |

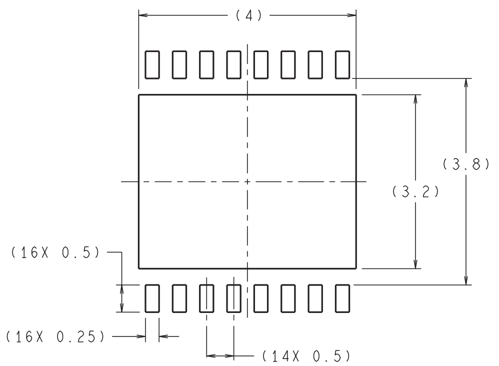
## TUBE




*All dimensions are nominal

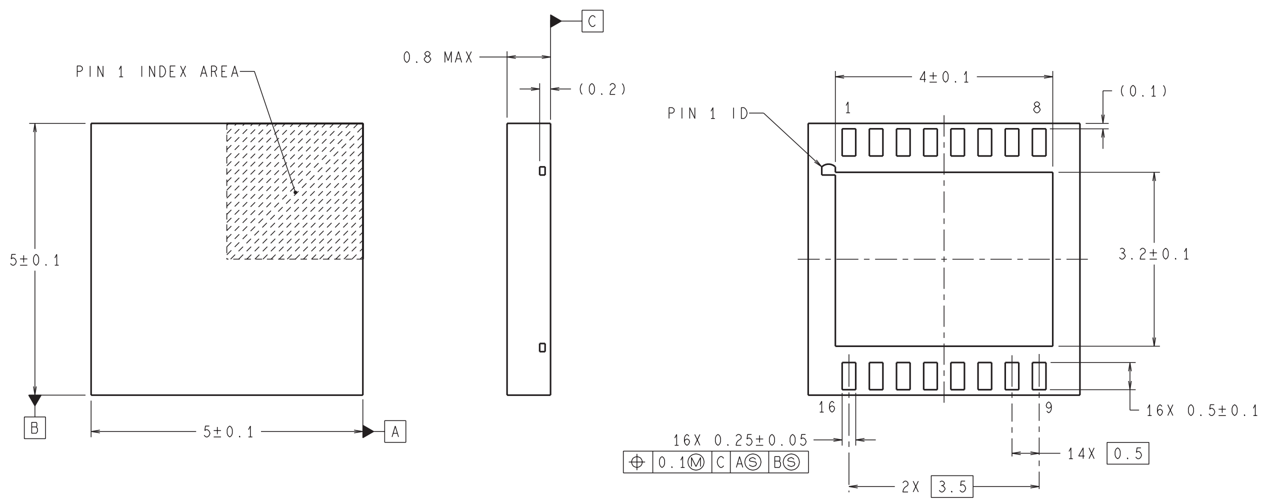
| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| LM2674M-12/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2674M-3.3/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2674M-5.0/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2674M-ADJ/NOPB | D | SOIC | 8 | 95 | 495 | 8 | 4064 | 3.05 |
| LM2674N-3.3/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM2674N-5.0/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |
| LM2674N-ADJ/NOPB | P | PDIP | 8 | 40 | 502 | 14 | 11938 | 4.32 |

# NHN0016A

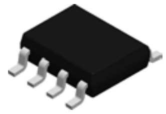



RECOMMENDED LAND PATTERN
1:1 RATIO WITH PKG SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS



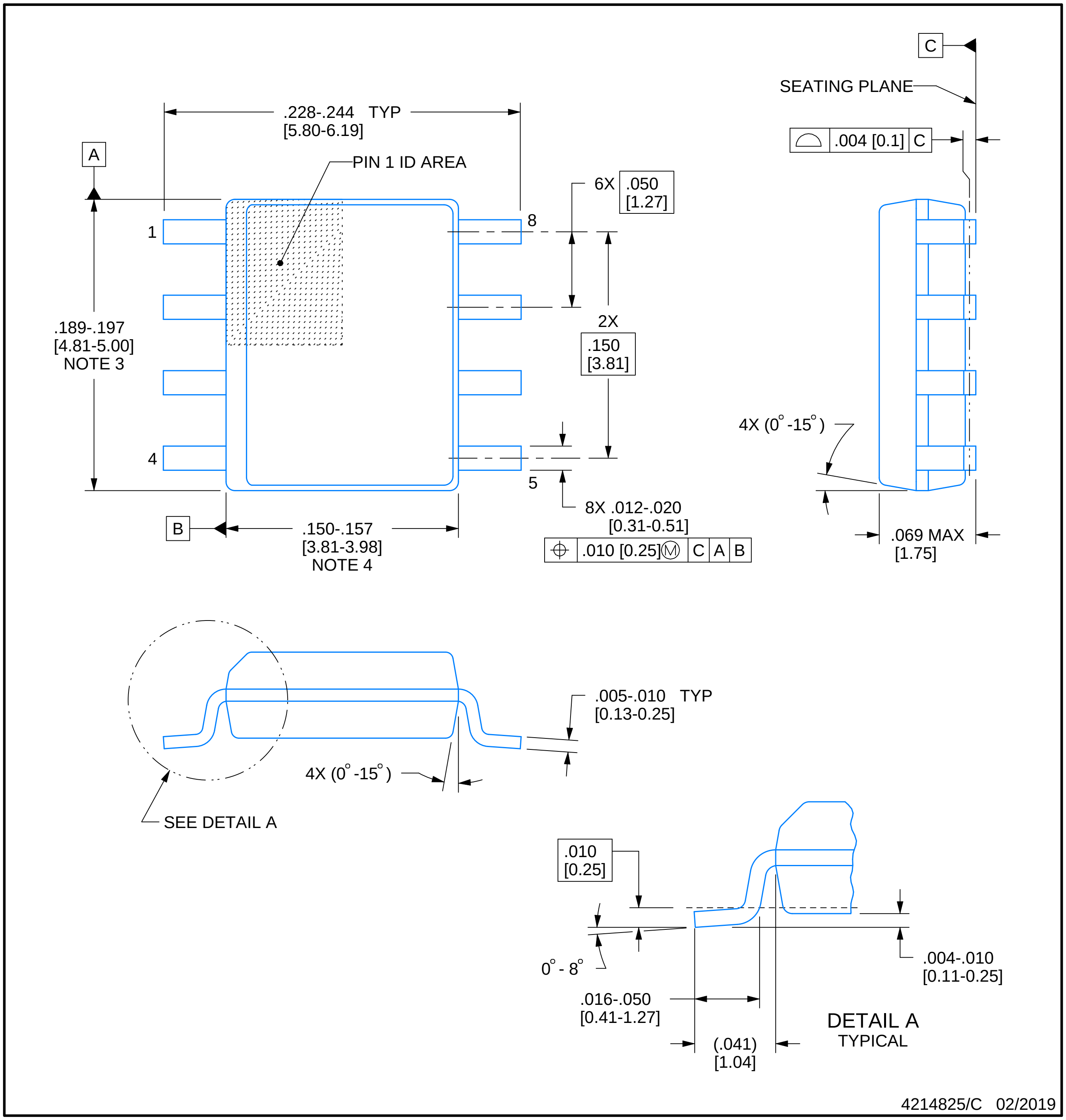

LDA16A (REV A)



# D0008A

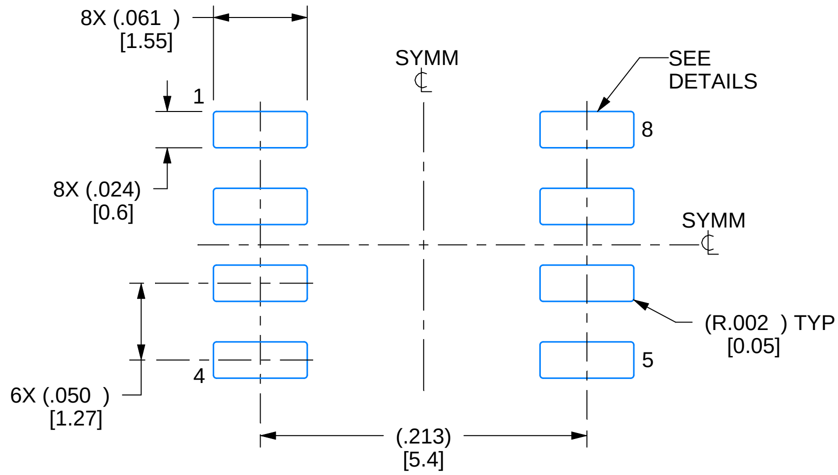
## SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

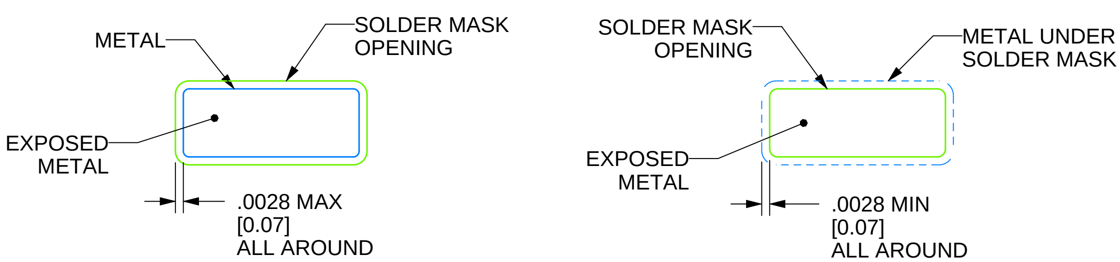



NOTES:

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




NON SOLDER MASK DEFINED

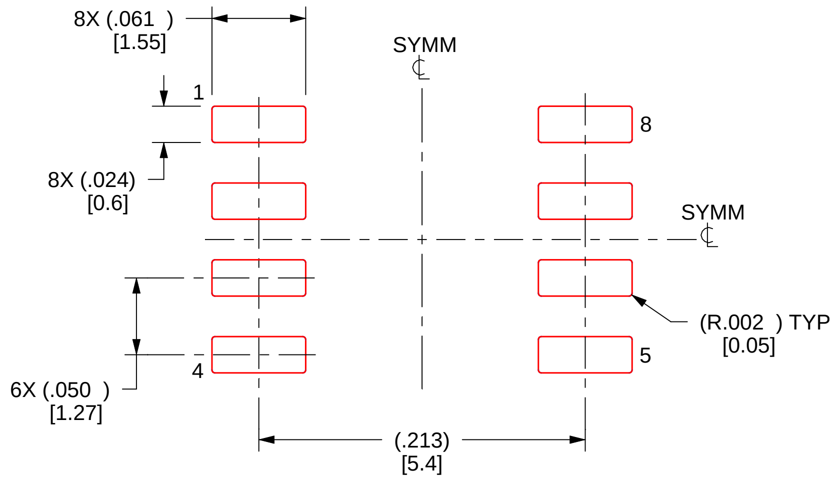
SOLDER MASK DEFINED

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.



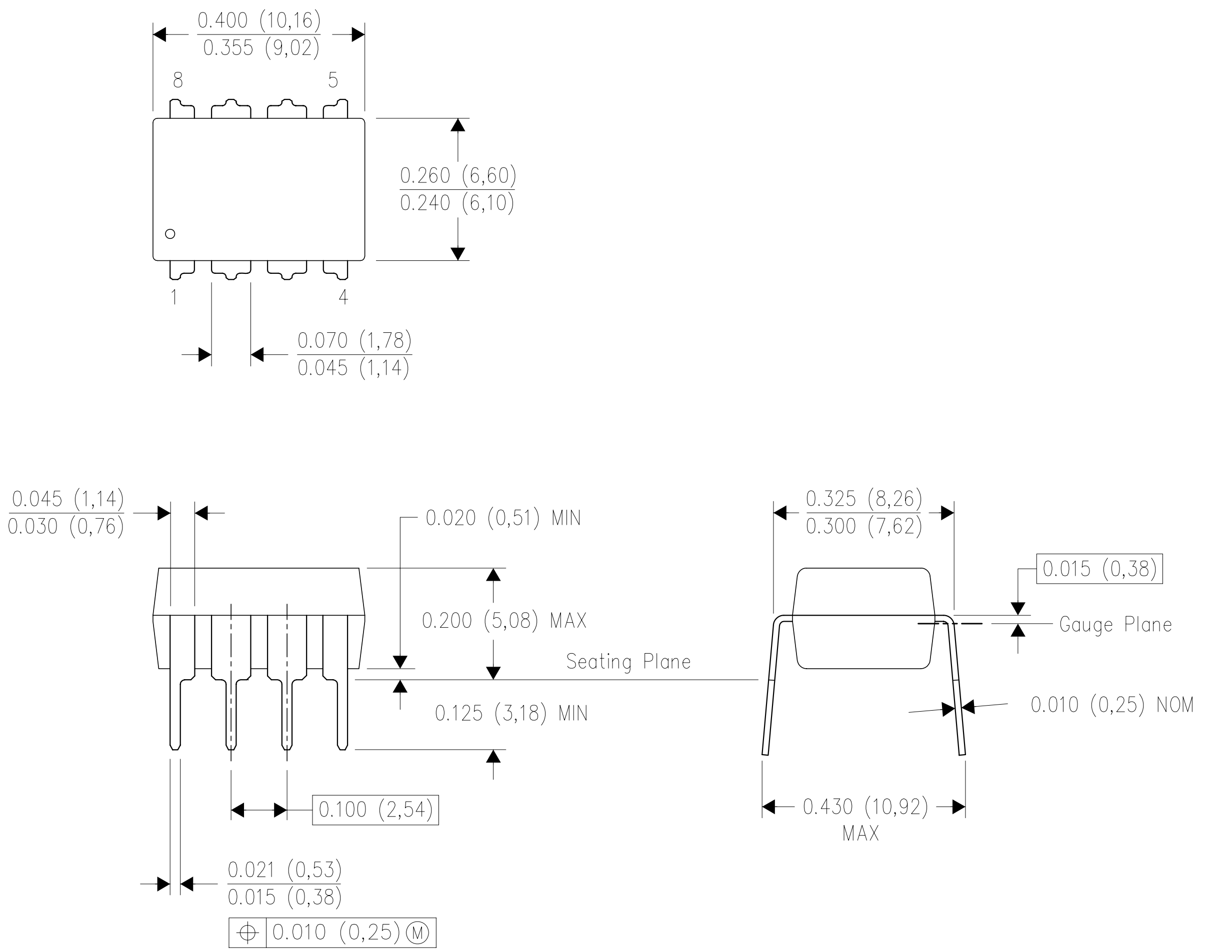

SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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.

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.