

# LM2677 SIMPLE SWITCHER® High Efficiency 5-A Step-Down Voltage Regulator with Sync

## 1 Features

- Efficiency up to 92%
- Simple and Easy to Design Using Off-the-Shelf External Components
- 100-mΩ DMOS Output Switch
- 3.3-V, 5-V, and 12-V Fixed Output and Adjustable (1.2 V to 37 V) Versions
- 50-µA Standby Current When Switched OFF
- ±2% Maximum Output Tolerance Over Full Line and Load Conditions
- Wide Input Voltage Range: 8 V to 40 V
- External Sync Clock Capability (280 kHz to 400 kHz)
- 260-kHz Fixed Frequency Internal Oscillator
- 40°C to 125°C Operating Junction Temperature Range

## 2 Applications

- Simple to Design, High Efficiency (> 90%) Step-Down Switching Regulators
- Efficient System Preregulator for Linear Voltage Regulators
- Battery Chargers
- Communications and Radio Equipment Regulator With Synchronized Clock Frequency

## 3 Description

The LM2677 series of regulators are monolithic integrated circuits which provide all of the active functions for a step-down (buck) switching regulator capable of driving up to 5-A loads with excellent line and load regulation characteristics. High efficiency (>90%) is obtained through the use of a low on-resistance DMOS power switch. The series consists of fixed output voltages of 3.3-V, 5-V, and 12-V and an adjustable output version.

The SIMPLE SWITCHER® concept provides for a complete design using a minimum number of external components. The switching clock frequency can be provided by an internal fixed frequency oscillator (260 kHz) or from an externally provided clock in the range of 280 kHz to 400 kHz, which allows the use of physically smaller-sized components. A family of standard inductors for use with the LM2677 are available from several manufacturers to greatly simplify the design process. The external Sync clock provides direct and precise control of the output ripple frequency for consistent filtering or frequency spectrum positioning.

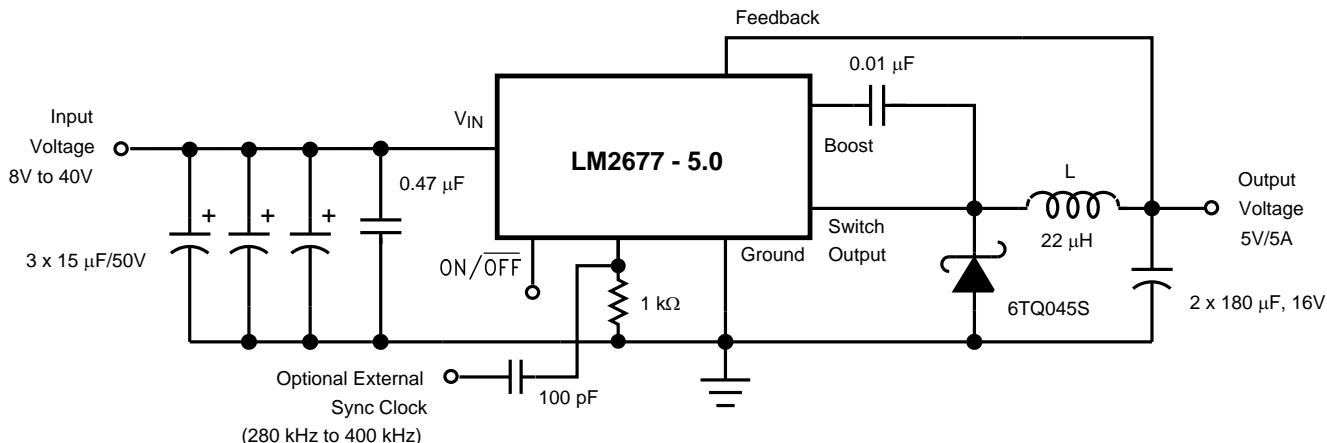
The LM2677 series also has built-in thermal shutdown, current-limiting, and an ON/OFF control input that can power down the regulator to a low 50-µA quiescent-current standby condition. The output voltage is ensured to a ±2% tolerance.

### Device Information<sup>(1)</sup>

| PART NUMBER | PACKAGE    | BODY SIZE (NOM)    |
|-------------|------------|--------------------|
| LM2677      | TO-263 (7) | 10.16 mm × 8.69 mm |
|             | TO-220 (7) | 10.16 mm × 8.94 mm |
|             | VSON (14)  | 6.10 mm × 5.10 mm  |

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

### Typical Application



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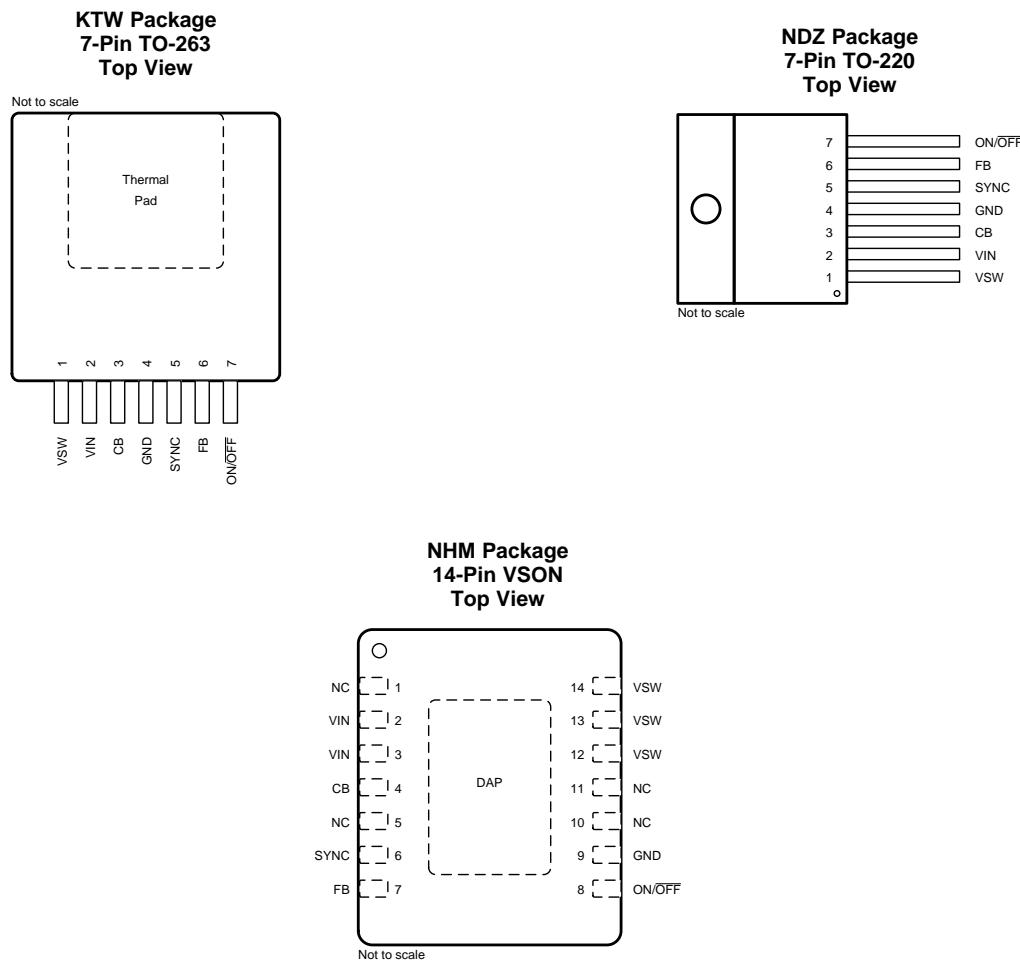
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## 4 Revision History

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

| Changes from Revision I (June 2012) to Revision J  | Page |
|--|------|
| • Added <i>ESD Ratings</i> table, <i>Feature Description</i> section, <i>Device Functional Modes</i> , <i>Application and Implementation</i> section, <i>Power Supply Recommendations</i> section, <i>Layout</i> section, <i>Device and Documentation Support</i> section, and <i>Mechanical, Packaging, and Orderable Information</i> section ..... | 1    |
| • Deleted Manufacturers' Contact Numbers tables .....  | 18   |

## 5 Pin Configuration and Functions



### Pin Functions

| PIN             |                |              | I/O | DESCRIPTION  |
|-----------------|----------------|--------------|-----|--|
| NAME            | TO-263, TO-220 | VSON         |     |  |
| CB              | 3              | 4            | I   | Boot-strap capacitor connection for high-side driver. Connect a high quality 100-nF capacitor from CB to V <sub>SW</sub> pin.  |
| FB              | 6              | 7            | I   | Feedback sense input pin. Connect to the midpoint of feedback divider to set V <sub>OUT</sub> for ADJ version or connect this pin directly to the output capacitor for a fixed output version.   |
| GND             | 4              | 9            | —   | Power ground pins. Connect to system ground. Ground pins of C <sub>IN</sub> and C <sub>OUT</sub> . Path to C <sub>IN</sub> must be as short as possible.   |
| NC              | —              | 1, 5, 10, 11 | —   | No connect pins  |
| ON/OFF          | 7              | 8            | I   | Enable input to the voltage regulator. High = ON and low = OFF. Pull this pin high or float to enable the regulator.   |
| SYNC            | 5              | 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.  |
| V <sub>IN</sub> | 2              | 2, 3         | I   | Supply input pin to collector pin of high side FET. Connect to power supply and input bypass capacitors C <sub>IN</sub> . Path from V <sub>IN</sub> pin to high frequency bypass C <sub>IN</sub> and GND must be as short as possible. |
| V <sub>SW</sub> | 1              | 12, 13, 14   | 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.  |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over recommended operating junction temperature range of  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  (unless otherwise noted)<sup>(1)(2)</sup>

|   |                    | MIN                | MAX          | UNIT |
|---|--------------------|--------------------|--------------|------|
| Input supply voltage                    |                    |                    | 45           | V    |
| ON/OFF pin voltage                      |                    | -0.1               | 6            | V    |
| Switch voltage to ground <sup>(3)</sup> |                    | -1                 | $V_{IN}$     | V    |
| Boost pin voltage                       |                    |                    | $V_{SW} + 8$ | V    |
| Feedback pin voltage                    |                    | -0.3               | 14           | V    |
| Power dissipation                       |                    | Internally limited |              |      |
| Soldering temperature                   | Wave (4 s)         | 260                |              |      |
|   | Infrared (10 s)    | 240                |              |      |
|   | Vapor phase (75 s) | 219                |              |      |
| 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.
- (3) The switch voltage to ground specification applies to DC voltage. An extended negative voltage limit of  $-10\text{ V}$  applies to a pulse of up to 20 ns,  $-6\text{ V}$  of 60 ns, and  $-3\text{ V}$  of up to 100 ns.

### 6.2 ESD Ratings

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

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

### 6.3 Recommended Operating Conditions

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

|       |                      | MIN | MAX | UNIT |
|-------|----------------------|-----|-----|------|
|       | Supply voltage       | 8   | 40  | V    |
| $T_J$ | Junction temperature | -40 | 125 | °C   |

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | LM2677             |              |            | UNIT |
|-------------------------------|--|--------------------|--------------|------------|------|
|                               |  | KTW (TO-263)       | NDZ (TO-220) | NHM (VSON) |      |
|                               |  | 7 PINS             | 7 PINS       | 14 PINS    |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | See <sup>(2)</sup> | 56           | —          | —    |
|                               |  | See <sup>(3)</sup> | 35           | —          | —    |
|                               |  | See <sup>(4)</sup> | 26           | —          | —    |
|                               |  | See <sup>(5)</sup> | —            | 65         | —    |
|                               |  | See <sup>(6)</sup> | —            | 45         | —    |
|                               |  | See <sup>(7)</sup> | —            | —          | 55   |
|                               |  | See <sup>(8)</sup> | —            | —          | 29   |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 2                  | 2            | —          | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | —                  | —            | —          | °C/W |
| $\psi_{JT}$                   | Junction-to-top characterization parameter   | —                  | —            | —          | °C/W |
| $\psi_{JB}$                   | Junction-to-board characterization parameter | —                  | —            | —          | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case (bottom) thermal resistance | —                  | —            | —          | °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 for the 7-pin DDPACK/TO-263 mounted horizontally against a PC board area of 0.136 square inches (the same size as the DDPACK/TO-263 package) of 1 oz. (0.0014 in. thick) copper.
- (3) Junction to ambient thermal resistance for the 7-pin DDPACK/TO-263 mounted horizontally against a PC board area of 0.4896 square inches (3.6 times the area of the DDPACK/TO-263 package) of 1 oz. (0.0014 in. thick) copper.
- (4) Junction to ambient thermal resistance for the 7-pin DDPACK/TO-263 mounted horizontally against a PC board copper area of 1.0064 square inches (7.4 times the area of the DDPACK/TO-263 package) of 1 oz. (0.0014 in. thick) copper. Additional copper area reduces thermal resistance further.
- (5) Junction to ambient thermal resistance (no external heat sink) for the 7-pin TO-220 package mounted vertically, with ½ inch leads in a socket, or on a PC board with minimum copper area.
- (6) Junction to ambient thermal resistance (no external heat sink) for the 7-pin TO-220 package mounted vertically, with ½ inch leads soldered to a PC board containing approximately 4 square inches of (1 oz.) copper area surrounding the pins.
- (7) Junction to ambient thermal resistance for the 14-pin VSON mounted on a PC board copper area equal to the die attach paddle.
- (8) Junction to ambient thermal resistance for the 14-lead VSON mounted on a PC board copper area using 12 vias to a second layer of copper equal to die attach paddle. Additional copper area reduces thermal resistance further. For layout recommendations, refer to Application Note, [AN-1187 Leadless Leadframe Package \(LLP\)](#).

## 6.5 Electrical Characteristics – 3.3 V

$T_J = 25^\circ\text{C}$ , sync pin open circuited (unless otherwise noted)

| PARAMETER                          | TEST CONDITIONS   | MIN <sup>(1)</sup>                              | TYP <sup>(2)</sup> | MAX <sup>(1)</sup> | UNIT  |
|------------------------------------|---|---|--------------------|--------------------|-------|
| $V_{\text{OUT}}$<br>Output voltage | $V_{\text{IN}} = 8 \text{ V to } 40 \text{ V}, 100 \text{ mA} \leq I_{\text{OUT}} \leq 5 \text{ A}$ | $T_J = 25^\circ\text{C}$                        | 3.234              | 3.3                | 3.366 |
|                                    |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 3.201              |                    | 3.399 |
| $\eta$<br>Efficiency               | $V_{\text{IN}} = 12 \text{ V}, I_{\text{LOAD}} = 5 \text{ A}$                                       |   | 82%                |                    |       |

- (1) All limits are ensured at room temperature and at temperature extremes. All room temperature limits are 100% tested during production with  $T_A = T_J = 25^\circ\text{C}$ . All limits at temperature extremes are ensured through correlation using standard Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (2) Typical values are determined with  $T_A = T_J = 25^\circ\text{C}$  and represent the most likely norm.

## 6.6 Electrical Characteristics – 5 V

$T_J = 25^\circ\text{C}$ , sync pin open circuited (unless otherwise noted)

| PARAMETER                          | TEST CONDITIONS   | MIN <sup>(1)</sup>                              | TYP <sup>(2)</sup> | MAX <sup>(1)</sup> | UNIT |
|------------------------------------|---|---|--------------------|--------------------|------|
| $V_{\text{OUT}}$<br>Output voltage | $V_{\text{IN}} = 8 \text{ V to } 40 \text{ V}, 100 \text{ mA} \leq I_{\text{OUT}} \leq 5 \text{ A}$ | $T_J = 25^\circ\text{C}$                        | 4.9                | 5                  | 5.1  |
|                                    |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 4.85               |                    | 5.15 |
| $\eta$<br>Efficiency               | $V_{\text{IN}} = 12 \text{ V}, I_{\text{LOAD}} = 5 \text{ A}$                                       |   | 84%                |                    |      |

- (1) All limits are ensured at room temperature and at temperature extremes. All room temperature limits are 100% tested during production with  $T_A = T_J = 25^\circ\text{C}$ . All limits at temperature extremes are ensured through correlation using standard Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (2) Typical values are determined with  $T_A = T_J = 25^\circ\text{C}$  and represent the most likely norm.

## 6.7 Electrical Characteristics – 12 V

$T_J = 25^\circ\text{C}$ , sync pin open circuited (unless otherwise noted)

| PARAMETER                          | TEST CONDITIONS   | MIN <sup>(1)</sup>                              | TYP <sup>(2)</sup> | MAX <sup>(1)</sup> | UNIT  |
|------------------------------------|---|---|--------------------|--------------------|-------|
| V <sub>OUT</sub><br>Output voltage | $V_{IN} = 15 \text{ V to } 40 \text{ V}$ , $100 \text{ mA} \leq I_{OUT} \leq 5 \text{ A}$ | $T_J = 25^\circ\text{C}$                        | 11.76              | 12                 | 12.24 |
|                                    |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 11.64              |                    | 12.36 |
| $\eta$<br>Efficiency               | $V_{IN} = 24 \text{ V}$ , $I_{LOAD} = 5 \text{ A}$  |   |                    | 92%                |       |

(1) All limits are ensured at room temperature and at temperature extremes. All room temperature limits are 100% tested during production with  $T_A = T_J = 25^\circ\text{C}$ . All limits at temperature extremes are ensured through correlation using standard standard Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

(2) Typical values are determined with  $T_A = T_J = 25^\circ\text{C}$  and represent the most likely norm.

## 6.8 Electrical Characteristics – Adjustable

$T_J = 25^\circ\text{C}$ , sync pin open circuited (unless otherwise noted)

| PARAMETER                           | TEST CONDITIONS  | MIN <sup>(1)</sup>                              | TYP <sup>(2)</sup> | MAX <sup>(1)</sup> | UNIT  |
|-------------------------------------|--|---|--------------------|--------------------|-------|
| V <sub>FB</sub><br>Feedback voltage | $V_{IN} = 8 \text{ V to } 40 \text{ V}$ , $100 \text{ mA} \leq I_{OUT} \leq 5 \text{ A}$ ,<br>$V_{OUT}$ programmed for 5 V | $T_J = 25^\circ\text{C}$                        | 1.186              | 1.21               | 1.234 |
|                                     |  | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 1.174              |                    | 1.246 |
| $\eta$<br>Efficiency                | $V_{IN} = 12 \text{ V}$ , $I_{LOAD} = 5 \text{ A}$   |   |                    | 84%                |       |

(1) All limits are ensured at room temperature and at temperature extremes. All room temperature limits are 100% tested during production with  $T_A = T_J = 25^\circ\text{C}$ . All limits at temperature extremes are ensured through correlation using standard standard Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

(2) Typical values are determined with  $T_A = T_J = 25^\circ\text{C}$  and represent the most likely norm.

## 6.9 Electrical Characteristics – All Output Voltage Versions

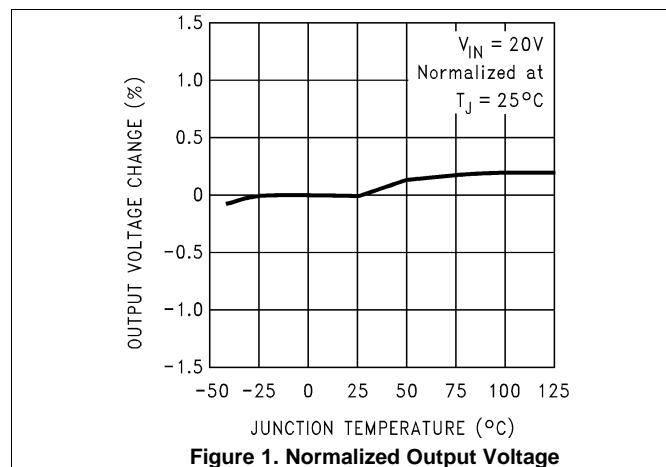
$T_J = 25^\circ\text{C}$ ,  $V_{IN} = 12 \text{ V}$  for the 3.3-V, 5-V, and Adjustable versions,  $V_{IN} = 24 \text{ V}$  for the 12-V version, sync pin open circuited (unless otherwise noted)

| PARAMETER                                       | TEST CONDITIONS   | MIN <sup>(1)</sup>                              | TYP <sup>(2)</sup> | MAX <sup>(1)</sup> | UNIT          |
|---|---|---|--------------------|--------------------|---------------|
| I <sub>Q</sub><br>Quiescent current             | $V_{FEEDBACK} = 8 \text{ V}$ for 3.3-V, 5-V, and adjustable versions, $V_{FEEDBACK} = 15 \text{ V}$ for 12-V versions |   | 4.2                | 6                  | mA            |
| I <sub>STBY</sub><br>Standby quiescent current  | ON/OFF pin = 0 V  | $T_J = 25^\circ\text{C}$                        | 50                 | 100                | $\mu\text{A}$ |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |                    | 150                |               |
| I <sub>CL</sub><br>Current limit                | $T_J = 25^\circ\text{C}$  | 6.1   | 7                  | 8.3                | A             |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 5.75               | 8.75               |               |
| I <sub>L</sub><br>Output leakage current        | $V_{IN} = 40 \text{ V}$ , ON/OFF pin = 0 V  |   | 1                  | 200                | $\mu\text{A}$ |
|   |   | $V_{SWITCH} = 0 \text{ V}$                      |                    | 15                 |               |
|   | $V_{SWITCH} = -1 \text{ V}$   |   | 6                  |                    | mA            |
|   |   |   |                    |                    |               |
| R <sub>DS(ON)</sub><br>Switch on-resistance     | I <sub>SWITCH</sub> = 5 A   | $T_J = 25^\circ\text{C}$                        | 0.12               | 0.14               | $\Omega$      |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |                    | 0.225              |               |
| f <sub>0</sub><br>Oscillator frequency          | Measured at switch pin  | $T_J = 25^\circ\text{C}$                        | 260                |                    | kHz           |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 225                | 280                |               |
| D<br>Duty cycle                                 |   | Maximum duty cycle                              | 91%                |                    |               |
|   |   | Minimum duty cycle                              | 0%                 |                    |               |
| I <sub>BIAS</sub><br>Feedback bias current      | $V_{FEEDBACK} = 1.3 \text{ V}$ , ADJ version only   |   | 85                 |                    | nA            |
| V <sub>ON/OFF</sub><br>ON/OFF threshold voltage |   | $T_J = 25^\circ\text{C}$                        |                    | 1.4                | V             |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ | 0.8                | 2                  |               |
| I <sub>ON/OFF</sub><br>ON/OFF input current     | ON/OFF input = 0 V  | $T_J = 25^\circ\text{C}$                        | 20                 |                    | $\mu\text{A}$ |
|   |   | $T_J = -40^\circ\text{C to } 125^\circ\text{C}$ |                    | 45                 |               |
| F <sub>SYNC</sub><br>Synchronization frequency  | $V_{SYNC}(\text{pin 5}) = 3.5 \text{ V}$ , 50% duty cycle   |   | 400                |                    | kHz           |
| V <sub>SYNC</sub><br>SYNC threshold voltage     |   |   | 1.4                |                    | V             |

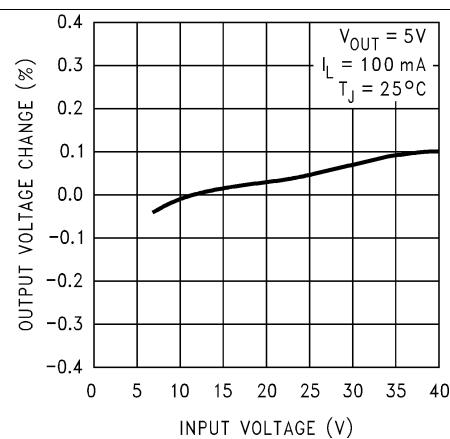
(1) All limits are ensured at room temperature and at temperature extremes. All room temperature limits are 100% tested during production with  $T_A = T_J = 25^\circ\text{C}$ . All limits at temperature extremes are ensured through correlation using standard standard Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

(2) Typical values are determined with  $T_A = T_J = 25^\circ\text{C}$  and represent the most likely norm.

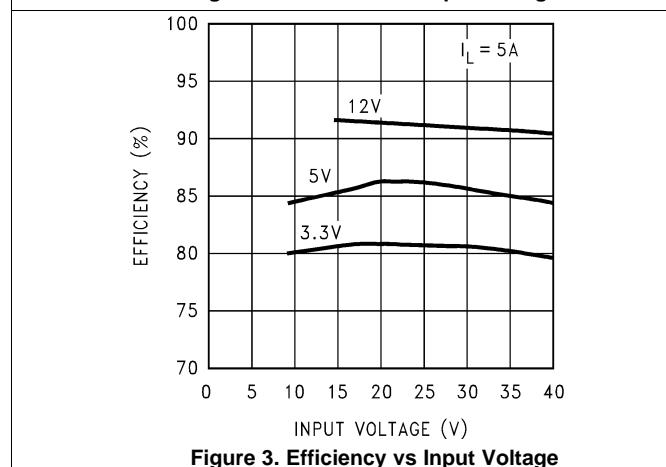
## 6.10 Typical Characteristics



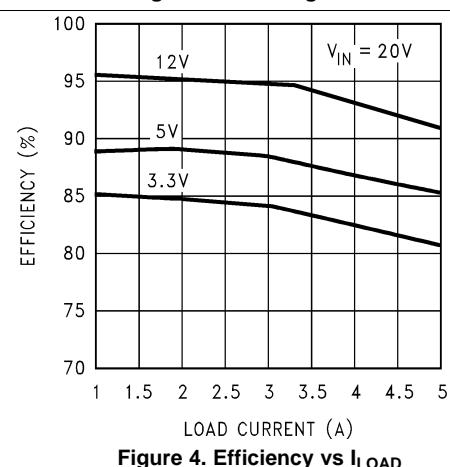
**Figure 1. Normalized Output Voltage**



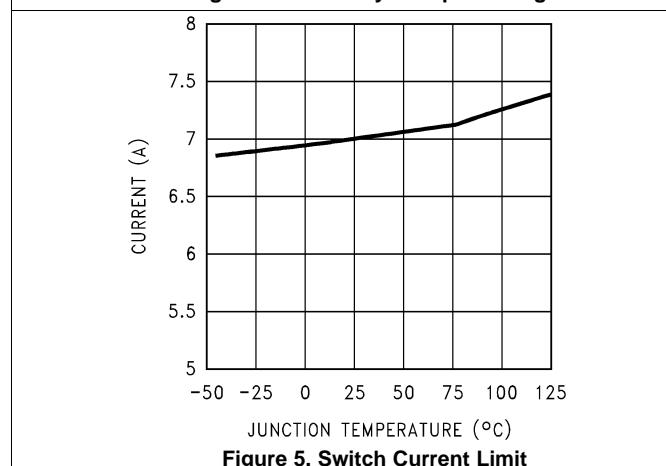
**Figure 2. Line Regulation**



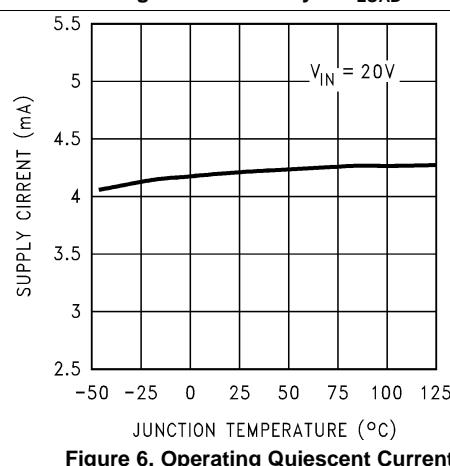
**Figure 3. Efficiency vs Input Voltage**



**Figure 4. Efficiency vs  $I_{LOAD}$**

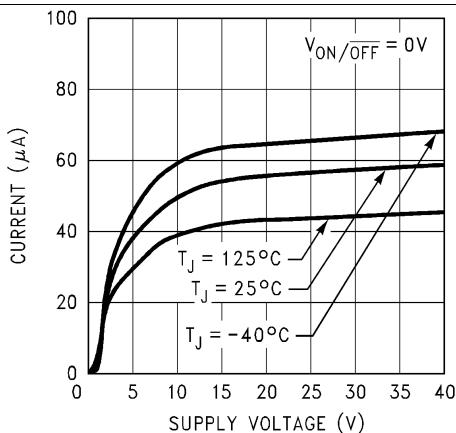


**Figure 5. Switch Current Limit**

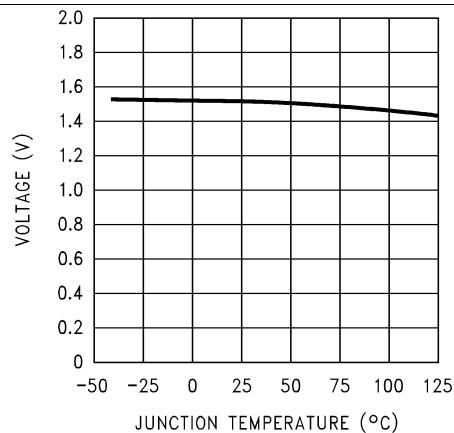


**Figure 6. Operating Quiescent Current**

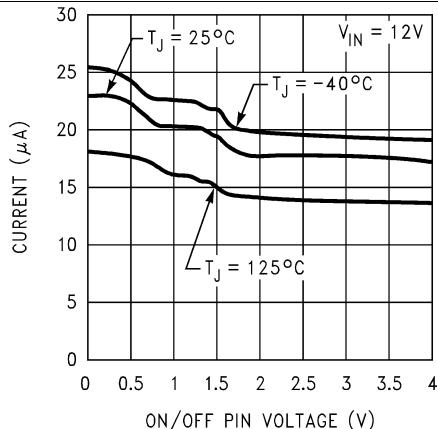
## Typical Characteristics (continued)



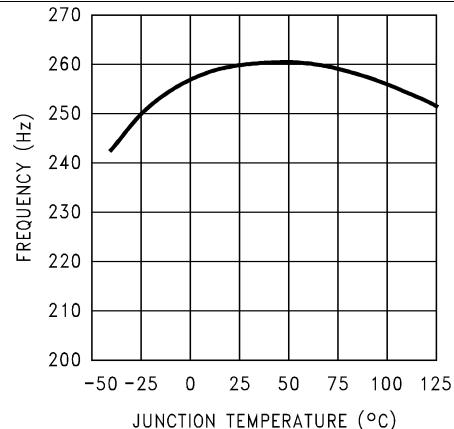
**Figure 7. Standby Quiescent Current**



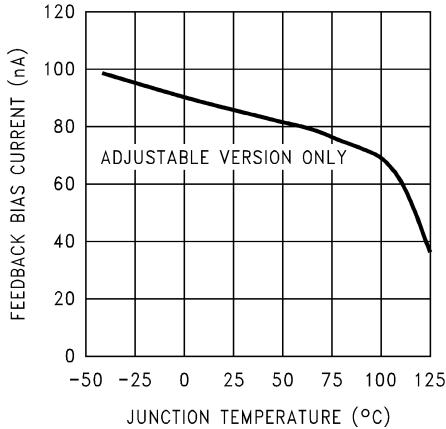
**Figure 8. ON/OFF Threshold Voltage**



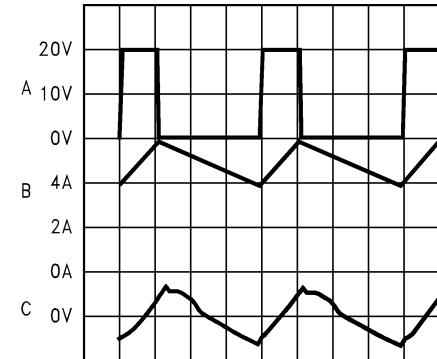
**Figure 9. ON/OFF Pin Current (Sourcing)**



**Figure 10. Switching Frequency**



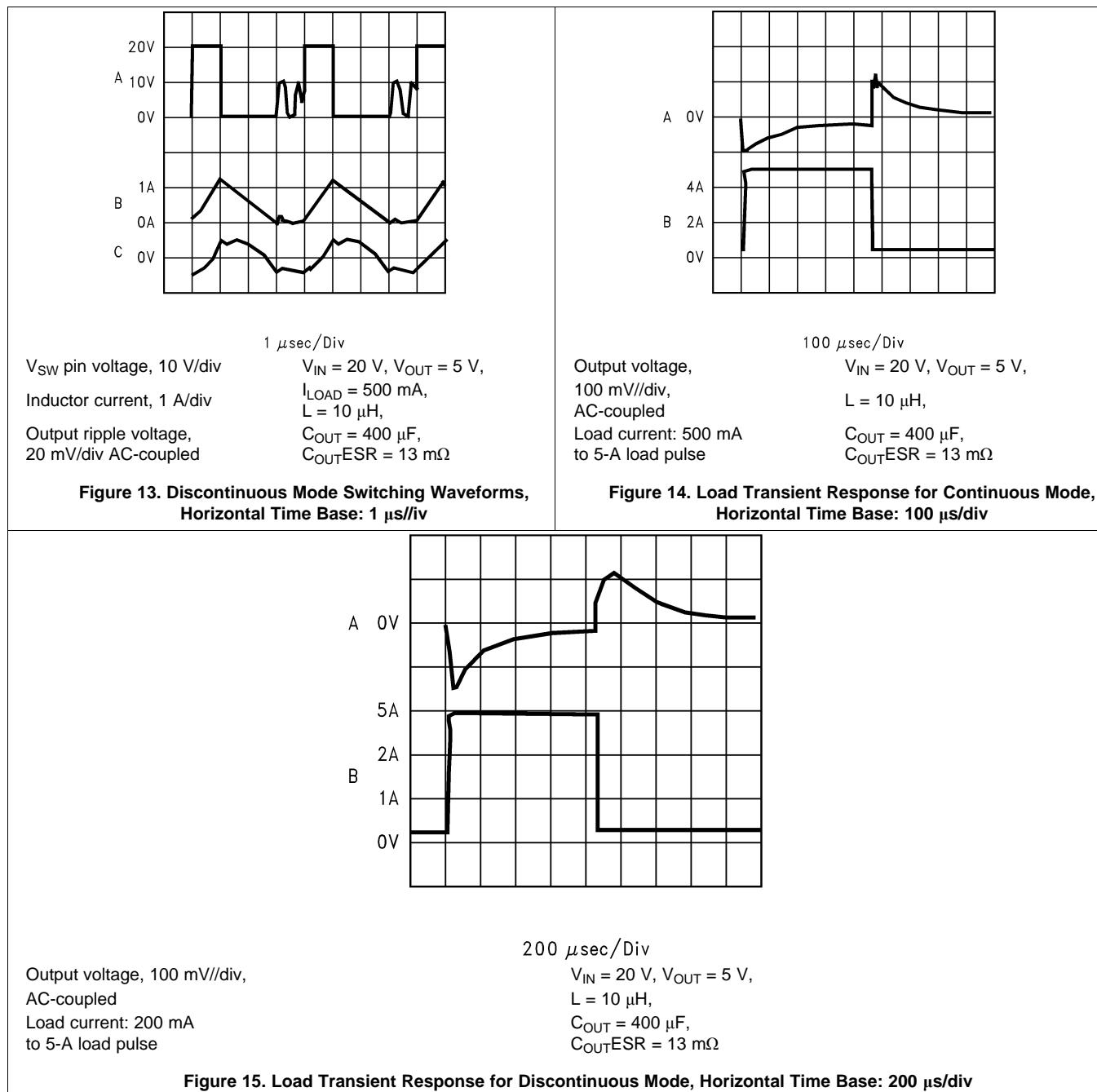
**Figure 11. Feedback Pin Bias Current**



V<sub>SW</sub> pin voltage, 10 V/div  
 Inductor current, 2 A/div  
 Output ripple voltage,  
 20 mV/div AC-coupled

**Figure 12. Continuous Mode Switching Waveforms,  
Horizontal Time Base: 1  $\mu$ s/div**

### Typical Characteristics (continued)



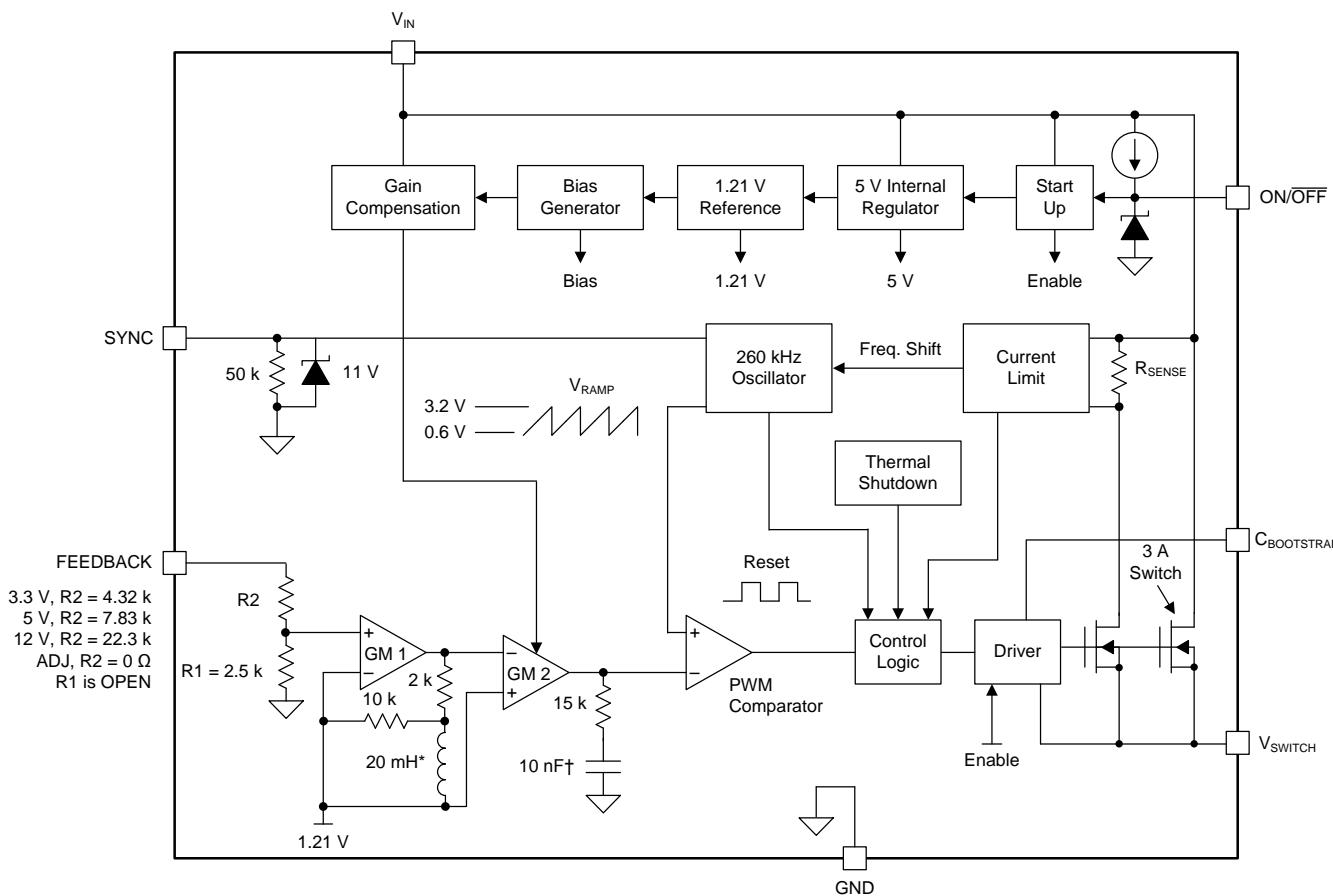
## 7 Detailed Description

### 7.1 Overview

The LM2677 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 5 A, and highly efficient operation.

The LM2677 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.

### 7.2 Functional Block Diagram



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### 7.3 Feature Description

#### 7.3.1 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 pin 1 switches between  $V_{IN}$  (switch ON) and below ground by the voltage drop of the external Schottky diode (switch OFF).

## Feature Description (continued)

### 7.3.2 CBoost

A capacitor must be connected from pin 3 to the switch output, pin 1. This capacitor boosts the gate driver 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 CBoost is 0.01  $\mu$ F.

### 7.3.3 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 LM2677, TI recommends using a broad ground plane to minimize signal coupling throughout the circuit.

### 7.3.4 Sync

This input allows control of the switching clock frequency. If left open-circuited the regulator is switched at the internal oscillator frequency, from 225 kHz to 280 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 LM2677 internal oscillator frequency, which could be as high as 280 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 ac-coupling the external TTL or CMOS compatible clock (between 0 V and a level greater than 3 V) to the sync input through a 100-pF capacitor and a 1-k $\Omega$  resistor to ground at pin 5 as shown in [Figure 16](#).

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 (see [Additional Application Information](#)).

### 7.3.5 Feedback

This is the input to a two-stage, high-gain amplifier, which drives the PWM controller. It is necessary to connect pin 6 to the actual output of the power supply to set the dc output voltage. 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 LM2677. 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.

### 7.3.6 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 completely turns OFF the regulator. The current drain from the input supply when OFF is only 50  $\mu$ A. Pin 7 has an internal pullup current source of approximately 20  $\mu$ A and a protection clamp Zener diode of 7 V to ground. When electrically driving the ON/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 pin 7 must be left open circuited.

### 7.3.7 DAP (VSON Package)

The die attach pad (DAP) must be connected to PCB ground plane. For CAD and assembly guidelines, see application note, [AN-1187 Leadless Leadframe Package \(LLP\)](#).

## 7.4 Device Functional Modes

### 7.4.1 Shutdown Mode

The ON/OFF pin provides electrical ON and OFF control for the LM2677. When the voltage of this pin is lower than 1.4 V, the device is shutdown mode. The typical standby current in this mode is 20  $\mu$ A.

### 7.4.2 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.

## 8 Application and Implementation

### NOTE

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

### 8.1 Application Information

#### 8.1.1 Inductor

The inductor is the key component in a switching regulator. For efficiency the inductor stores energy during the switch ON time and then transfers energy to the load while the switch is OFF.

Nomographs are used to select the inductance value required for a given set of operating conditions. The nomographs assume that the circuit is operating in continuous mode (the current flowing through the inductor never falls to zero). The magnitude of inductance is selected to maintain a maximum ripple current of 30% of the maximum load current. If the ripple current exceeds this 30% limit the next larger value is selected.

The inductors offered have been specifically manufactured to provide proper operation under all operating conditions of input and output voltage and load current. Several part types are offered for a given amount of inductance. Both surface mount and through-hole devices are available. The inductors from each of the three manufacturers have unique characteristics.

Renco: ferrite stick core inductors; benefits are typically lowest cost and can withstand ripple and transient peak currents above the rated value. These inductors have an external magnetic field, which may generate EMI.

Pulse Engineering: powdered iron toroid core inductors; these also can withstand higher than rated currents and, being toroid inductors, has low EMI.

Coilcraft: ferrite drum core inductors; these are the smallest physical-size inductors and are available only as surface mount components. These inductors also generate EMI but less than stick inductors.

#### 8.1.2 Output Capacitor

The output capacitor acts to smooth the dc output voltage and also provides energy storage. Selection of an output capacitor, with an associated equivalent series resistance (ESR), impacts both the amount of output ripple voltage and stability of the control loop.

The output ripple voltage of the power supply is the product of the capacitor ESR and the inductor ripple current. The capacitor types recommended in the [Input and Output Capacitor Codes](#) were selected for having low ESR ratings.

In addition, both surface mount tantalum capacitors and through-hole aluminum electrolytic capacitors are offered as solutions.

Impacting frequency stability of the overall control loop, the output capacitance, in conjunction with the inductor, creates a double pole inside the feedback loop. In addition the capacitance and the ESR value create a zero. These frequency response effects together with the internal frequency compensation circuitry of the LM2677 modify the gain and phase shift of the closed loop system.

As a general rule for stable switching regulator circuits it is desired to have the unity gain bandwidth of the circuit to be limited to no more than one-sixth of the controller switching frequency. With the fixed 260-kHz switching frequency of the LM2677, the output capacitor is selected to provide a unity gain bandwidth of 40 kHz maximum. Each recommended capacitor value has been chosen to achieve this result.

In some cases multiple capacitors are required either to reduce the ESR of the output capacitor, to minimize output ripple (a ripple voltage of 1% of  $V_{out}$  or less is the assumed performance condition), or to increase the output capacitance to reduce the closed loop unity gain bandwidth (to less than 40 kHz). When parallel combinations of capacitors are required it has been assumed that each capacitor is the exact same part type.

## Application Information (continued)

The RMS current and working voltage (WV) ratings of the output capacitor are also important considerations. In a typical step-down switching regulator, the inductor ripple current (set to be no more than 30% of the maximum load current by the inductor selection) is the current that flows through the output capacitor. The capacitor RMS current rating must be greater than this ripple current. The voltage rating of the output capacitor must be greater than 1.3 times the maximum output voltage of the power supply. If operation of the system at elevated temperatures is required, the capacitor voltage rating may be de-rated to less than the nominal room temperature rating. Careful inspection of the manufacturer's specification for de-rating of working voltage with temperature is important.

### 8.1.3 Input and Output Capacitor Codes

**Table 1. Surface-Mount Capacitors<sup>(1)</sup>**

| CAPACITOR<br>REFERENCE<br>CODE | AVX TPS SERIES |        |          | SPRAGUE 594D SERIES |        |          | KEMET T495 SERIES |        |          |
|--------------------------------|----------------|--------|----------|---------------------|--------|----------|-------------------|--------|----------|
|                                | C (μF)         | WV (V) | IRMS (A) | C (μF)              | WV (V) | IRMS (A) | C (μF)            | WV (V) | IRMS (A) |
| C1                             | 330            | 6.3    | 1.15     | 120                 | 6.3    | 1.1      | 100               | 6.3    | 0.82     |
| C2                             | 100            | 10     | 1.1      | 220                 | 6.3    | 1.4      | 220               | 6.3    | 1.1      |
| C3                             | 220            | 10     | 1.15     | 68                  | 10     | 1.05     | 330               | 6.3    | 1.1      |
| C4                             | 47             | 16     | 0.89     | 150                 | 10     | 1.35     | 100               | 10     | 1.1      |
| C5                             | 100            | 16     | 1.15     | 47                  | 16     | 1        | 150               | 10     | 1.1      |
| C6                             | 33             | 20     | 0.77     | 100                 | 16     | 1.3      | 220               | 10     | 1.1      |
| C7                             | 68             | 20     | 0.94     | 180                 | 16     | 1.95     | 33                | 20     | 0.78     |
| C8                             | 22             | 25     | 0.77     | 47                  | 20     | 1.15     | 47                | 20     | 0.94     |
| C9                             | 10             | 35     | 0.63     | 33                  | 25     | 1.05     | 68                | 20     | 0.94     |
| C10                            | 22             | 35     | 0.66     | 68                  | 25     | 1.6      | 10                | 35     | 0.63     |
| C11                            | —              | —      | —        | 15                  | 35     | 0.75     | 22                | 35     | 0.63     |
| C12                            | —              | —      | —        | 33                  | 35     | 1        | 4.7               | 50     | 0.66     |
| C13                            | —              | —      | —        | 15                  | 50     | 0.9      | —                 | —      | —        |

(1) Assumes worst case maximum input voltage and load current for a given inductance value

**Table 2. Through-Hole Capacitors<sup>(1)</sup>**

| CAPACITOR<br>REFERENCE<br>CODE | SANYO OS-CON SA SERIES |        |          | SANYO MV-GX SERIES |        |          | NICHICON PL SERIES |        |          | PANASONIC HFQ SERIES |        |          |
|--------------------------------|------------------------|--------|----------|--------------------|--------|----------|--------------------|--------|----------|----------------------|--------|----------|
|                                | C (μF)                 | WV (V) | IRMS (A) | C (μF)             | WV (V) | IRMS (A) | C (μF)             | WV (V) | IRMS (A) | C (μF)               | WV (V) | IRMS (A) |
| C1                             | 47                     | 6.3    | 1        | 1000               | 6.3    | 0.8      | 680                | 10     | 0.8      | 82                   | 35     | 0.4      |
| C2                             | 150                    | 6.3    | 1.95     | 270                | 16     | 0.6      | 820                | 10     | 0.98     | 120                  | 35     | 0.44     |
| C3                             | 330                    | 6.3    | 2.45     | 470                | 16     | 0.75     | 1000               | 10     | 1.06     | 220                  | 35     | 0.76     |
| C4                             | 100                    | 10     | 1.87     | 560                | 16     | 0.95     | 1200               | 10     | 1.28     | 330                  | 35     | 1.01     |
| C5                             | 220                    | 10     | 2.36     | 820                | 16     | 1.25     | 2200               | 10     | 1.71     | 560                  | 35     | 1.4      |
| C6                             | 33                     | 16     | 0.96     | 1000               | 16     | 1.3      | 3300               | 10     | 2.18     | 820                  | 35     | 1.62     |
| C7                             | 100                    | 16     | 1.92     | 150                | 35     | 0.65     | 3900               | 10     | 2.36     | 1000                 | 35     | 1.73     |
| C8                             | 150                    | 16     | 2.28     | 470                | 35     | 1.3      | 6800               | 10     | 2.68     | 2200                 | 35     | 2.8      |
| C9                             | 100                    | 20     | 2.25     | 680                | 35     | 1.4      | 180                | 16     | 0.41     | 56                   | 50     | 0.36     |
| C10                            | 47                     | 25     | 2.09     | 1000               | 35     | 1.7      | 270                | 16     | 0.55     | 100                  | 50     | 0.5      |
| C11                            | —                      | —      | —        | 220                | 63     | 0.76     | 470                | 16     | 0.77     | 220                  | 50     | 0.92     |
| C12                            | —                      | —      | —        | 470                | 63     | 1.2      | 680                | 16     | 1.02     | 470                  | 50     | 1.44     |
| C13                            | —                      | —      | —        | 680                | 63     | 1.5      | 820                | 16     | 1.22     | 560                  | 50     | 1.68     |
| C14                            | —                      | —      | —        | 1000               | 63     | 1.75     | 1800               | 16     | 1.88     | 1200                 | 50     | 2.22     |
| C15                            | —                      | —      | —        | —                  | —      | —        | 220                | 25     | 0.63     | 330                  | 63     | 1.42     |

(1) Assumes worst case maximum input voltage and load current for a given inductance value

Table 2. Through-Hole Capacitors<sup>0</sup> (continued)

| CAPACITOR<br>REFERENCE<br>CODE | SANYO OS-CON SA SERIES |        |             | SANYO MV-GX SERIES |        |             | NICHICON PL SERIES |        |             | PANASONIC HFQ SERIES |        |             |
|--------------------------------|------------------------|--------|-------------|--------------------|--------|-------------|--------------------|--------|-------------|----------------------|--------|-------------|
|                                | C (μF)                 | WV (V) | IRMS<br>(A) | C (μF)             | WV (V) | IRMS<br>(A) | C (μF)             | WV (V) | IRMS<br>(A) | C (μF)               | WV (V) | IRMS<br>(A) |
| C16                            | —                      | —      | —           | —                  | —      | —           | 220                | 35     | 0.79        | 1500                 | 63     | 2.51        |
| C17                            | —                      | —      | —           | —                  | —      | —           | 560                | 35     | 1.43        | —                    | —      | —           |
| C18                            | —                      | —      | —           | —                  | —      | —           | 2200               | 35     | 2.68        | —                    | —      | —           |
| C19                            | —                      | —      | —           | —                  | —      | —           | 150                | 50     | 0.82        | —                    | —      | —           |
| C20                            | —                      | —      | —           | —                  | —      | —           | 220                | 50     | 1.04        | —                    | —      | —           |
| C21                            | —                      | —      | —           | —                  | —      | —           | 330                | 50     | 1.3         | —                    | —      | —           |
| C22                            | —                      | —      | —           | —                  | —      | —           | 100                | 63     | 0.75        | —                    | —      | —           |
| C23                            | —                      | —      | —           | —                  | —      | —           | 390                | 63     | 1.62        | —                    | —      | —           |
| C24                            | —                      | —      | —           | —                  | —      | —           | 820                | 63     | 2.22        | —                    | —      | —           |
| C25                            | —                      | —      | —           | —                  | —      | —           | 1200               | 63     | 2.51        | —                    | —      | —           |

### 8.1.4 Input Capacitor

Fast changing currents in high-current switching regulators place a significant dynamic load on the unregulated power source. An input capacitor helps to provide additional current to the power supply as well as smooth out input voltage variations.

Like the output capacitor, the key specifications for the input capacitor are RMS current rating and working voltage. The RMS current flowing through the input capacitor is equal to one-half of the maximum dc load current so the capacitor must be rated to handle this. Paralleling multiple capacitors proportionally increases the current rating of the total capacitance. The voltage rating must also be selected to be 1.3 times the maximum input voltage. Depending on the unregulated input power source, under light load conditions the maximum input voltage could be significantly higher than normal operation and must be considered when selecting an input capacitor.

The input capacitor must be placed very close to the input pin of the LM2677. Due to relative high-current operation with fast transient changes, the series inductance of input connecting wires or PCB traces can create ringing signals at the input terminal which could possibly propagate to the output or other parts of the circuitry. It may be necessary in some designs to add a small valued (0.1 μF to 0.47 μF) ceramic type capacitor in parallel with the input capacitor to prevent or minimize any ringing.

### 8.1.5 Catch Diode

When the power switch in the LM2677 turns OFF, the current through the inductor continues to flow. The path for this current is through the diode connected between the switch output and ground. This forward biased diode clamps the switch output to a voltage less than ground. This negative voltage must be greater than -1 V, so TI recommends a low voltage drop (particularly at high current levels) Schottky diode. Total efficiency of the entire power supply is significantly impacted by the power lost in the output catch diode. The average current through the catch diode is dependent on the switch duty cycle (D) and is equal to the load current times (1-D). Use of a diode rated for much higher current than is required by the actual application helps to minimize the voltage drop and power loss in the diode.

During the switch ON-time the diode is reversed biased by the input voltage. The reverse voltage rating of the diode must be at least 1.3 times greater than the maximum input voltage.

### 8.1.6 Boost Capacitor

The boost capacitor creates a voltage used to overdrive the gate of the internal power MOSFET. This improves efficiency by minimizing the on-resistance of the switch and associated power loss. For all applications, TI recommends using a 0.01-μF, 50-V ceramic capacitor.

### 8.1.7 SYNC Components

When synchronizing the LM2677 with an external clock TI recommends connecting the clock to pin 5 through a series 100-pF capacitor, and connecting a 1-k $\Omega$  resistor to ground from pin 5. This RC network creates a short 100-nS pulse on each positive edge of the clock to reset the internal ramp oscillator. The reset time of the oscillator is approximately 300 nS.

### 8.1.8 Additional Application Information

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. Thereafter, 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 may 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 ( $\frac{1}{2} CV^2$ ), 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  $C_{OUT} = 47 \mu F$ ,  $L = 22 \mu H$ . It must be noted that even with these components, for a device's current limit of  $I_{CLIM}$ , the maximum load current under which the possibility of the large current limit hysteresis can be minimized is  $I_{CLIM}/2$ . 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 over-current 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.

## 8.2 Typical Application

### 8.2.1 Fixed Output Voltage Applications

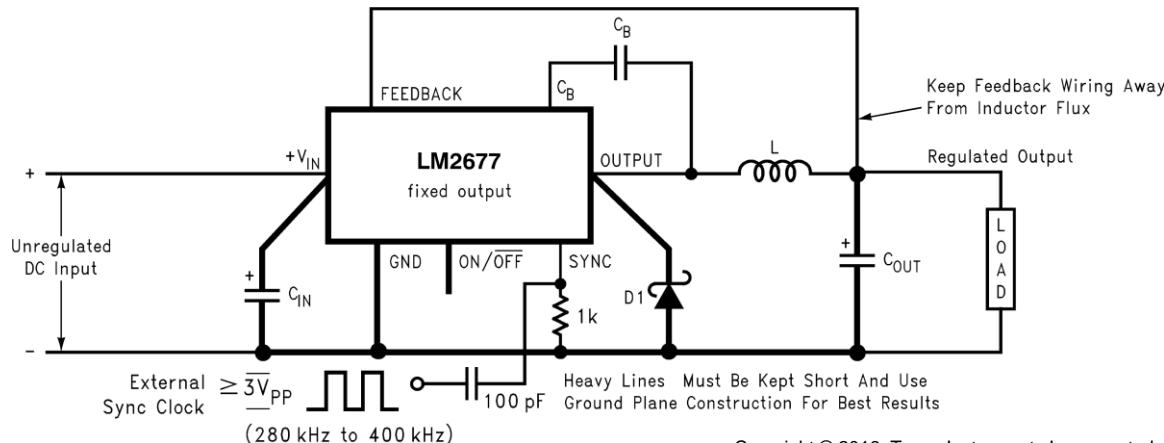


Figure 16. Basic Circuit For Fixed Output Voltage Applications

#### 8.2.1.1 Design Requirements

Table 3 lists the design requirements for the adjustable output voltage application.

Table 3. Design Parameters

| PARAMETER                                    | VALUE |
|--|-------|
| Required output voltage, $V_{OUT}$           | 3.3 V |
| Maximum DC input voltage, $V_{IN\_MAX}$      | 16 V  |
| Maximum output load current, $I_{LOAD\_MAX}$ | 2.5 A |

#### 8.2.1.2 Detailed Design Procedure

A system logic power supply bus of 3.3 V is to be generated from a wall adapter which provides an unregulated DC voltage of 13 V to 16 V. The maximum load current is 2.5 A. Through-hole components are preferred.

Step 1: Select an LM2677T, 3.3 V. The output voltage has a tolerance of  $\pm 2\%$  at room temperature and  $\pm 3\%$  over the full operating temperature range.

Step 2: Use the nomograph for the 3.3 V device, Figure 17. The intersection of the 16-V horizontal line ( $V_{in\_max}$ ) and the 2.5-A vertical line ( $I_{load\_max}$ ) indicates that L33, a 22- $\mu$ H inductor, is required. From Table 4, L33 in a through-hole component is available from Renco with part number RL-1283-22-43 or part number PE-53933 from Pulse Engineering.

Table 4. Inductor Manufacturer Part Numbers<sup>(1)</sup>

| INDUCTOR<br>REF.<br># | INDUCTANCE<br>( $\mu$ H) | CURRENT<br>(A) | RENCO         |                  | PULSE ENGINEERING |                  | COILCRAFT        |
|-----------------------|--------------------------|----------------|---------------|------------------|-------------------|------------------|------------------|
|                       |                          |                | THROUGH HOLE  | SURFACE<br>MOUNT | THROUGH<br>HOLE   | SURFACE<br>MOUNT | SURFACE<br>MOUNT |
| L23                   | 33                       | 1.35           | RL-5471-7     | RL1500-33        | PE-53823          | PE-53823S        | DO3316-333       |
| L24                   | 22                       | 1.65           | RL-1283-22-43 | RL1500-22        | PE-53824          | PE-53824S        | DO3316-223       |
| L25                   | 15                       | 2.00           | RL-1283-15-43 | RL1500-15        | PE-53825          | PE-53825S        | DO3316-153       |
| L29                   | 100                      | 1.41           | RL-5471-4     | RL-6050-100      | PE-53829          | PE-53829S        | DO5022P-104      |
| L30                   | 68                       | 1.71           | RL-5471-5     | RL6050-68        | PE-53830          | PE-53830S        | DO5022P-683      |
| L31                   | 47                       | 2.06           | RL-5471-6     | RL6050-47        | PE-53831          | PE-53831S        | DO5022P-473      |
| L32                   | 33                       | 2.46           | RL-5471-7     | RL6050-33        | PE-53932          | PE-53932S        | DO5022P-333      |
| L33                   | 22                       | 3.02           | RL-1283-22-43 | RL6050-22        | PE-53933          | PE-53933S        | DO5022P-223      |

(1) Assumes worst case maximum input voltage and load current for a given inductance value

**Table 4. Inductor Manufacturer Part Numbers<sup>0</sup> (continued)**

| INDUCTOR<br>REF.<br># | INDUCTANCE<br>( $\mu$ H) | CURRENT<br>(A) | RENCO         |                  | PULSE ENGINEERING |                  | COILCRAFT        |
|-----------------------|--------------------------|----------------|---------------|------------------|-------------------|------------------|------------------|
|                       |                          |                | THROUGH HOLE  | SURFACE<br>MOUNT | THROUGH<br>HOLE   | SURFACE<br>MOUNT | SURFACE<br>MOUNT |
| L34                   | 15                       | 3.65           | RL-1283-15-43 | —                | PE-53934          | PE-53934S        | DO5022P-153      |
| L38                   | 68                       | 2.97           | RL-5472-2     | —                | PE-54038          | PE-54038S        | —                |
| L39                   | 47                       | 3.57           | RL-5472-3     | —                | PE-54039          | PE-54039S        | —                |
| L40                   | 33                       | 4.26           | RL-1283-33-43 | —                | PE-54040          | PE-54040S        | —                |
| L41                   | 22                       | 5.22           | RL-1283-22-43 | —                | PE-54041          | P0841            | —                |
| L44                   | 68                       | 3.45           | RL-5473-3     | —                | PE-54044          | —                | —                |
| L45                   | 10                       | 4.47           | RL-1283-10-43 | —                | —                 | P0845            | DO5022P-103HC    |
| L46                   | 15                       | 5.60           | RL-1283-15-43 | —                | —                 | P0846            | DO5022P-153HC    |
| L47                   | 10                       | 5.66           | RL-1283-10-43 | —                | —                 | P0847            | DO5022P-103HC    |
| L48                   | 47                       | 5.61           | RL-1282-47-43 | —                | —                 | P0848            | —                |
| L49                   | 33                       | 5.61           | RL-1282-33-43 | —                | —                 | P0849            | —                |

Step 3: Use [Table 5](#) to determine an output capacitor. With a 3.3-V output and a 22- $\mu$ H inductor there are four through-hole output capacitor solutions with the number of same type capacitors to be paralleled and an identifying capacitor code given. [Table 1](#) provides the actual capacitor characteristics. Any of the following choices works in the circuit:

- 1 × 220- $\mu$ F, 10-V Sanyo OS-CON (code C5)
- 1 × 1000- $\mu$ F, 35-V Sanyo MV-GX (code C10)
- 1 × 2200- $\mu$ F, 10-V Nichicon PL (code C5)
- 1 × 1000- $\mu$ F, 35-V Panasonic HFQ (code C7)

**Table 5. Output Capacitors for Fixed Output Voltage Application<sup>(1)</sup>**

| OUTPUT<br>VOLTAGE (V) | INDUCTANCE<br>( $\mu$ H) | SURFACE MOUNT      |                       |                     |                       |                    |                       |
|-----------------------|--------------------------|--------------------|-----------------------|---------------------|-----------------------|--------------------|-----------------------|
|                       |                          | AVX TPS SERIES     |                       | SPRAGUE 594D SERIES |                       | KEMET T495 SERIES  |                       |
|                       |                          | NO. <sup>(2)</sup> | C CODE <sup>(3)</sup> | NO. <sup>(2)</sup>  | C Code <sup>(3)</sup> | NO. <sup>(2)</sup> | C CODE <sup>(3)</sup> |
| 3.3                   | 10                       | 5                  | C1                    | 5                   | C1                    | 5                  | C2                    |
|                       | 15                       | 4                  | C1                    | 4                   | C1                    | 4                  | C3                    |
|                       | 22                       | 3                  | C2                    | 2                   | C7                    | 3                  | C4                    |
|                       | 33                       | 1                  | C1                    | 2                   | C7                    | 3                  | C4                    |
| 5                     | 10                       | 4                  | C2                    | 4                   | C6                    | 4                  | C4                    |
|                       | 15                       | 3                  | C3                    | 2                   | C7                    | 3                  | C5                    |
|                       | 22                       | 3                  | C2                    | 2                   | C7                    | 3                  | C4                    |
|                       | 33                       | 2                  | C2                    | 2                   | C3                    | 2                  | C4                    |
|                       | 47                       | 2                  | C2                    | 1                   | C7                    | 2                  | C4                    |
| 12                    | 10                       | 4                  | C5                    | 3                   | C6                    | 5                  | C9                    |
|                       | 15                       | 3                  | C5                    | 2                   | C7                    | 4                  | C9                    |
|                       | 22                       | 2                  | C5                    | 2                   | C6                    | 3                  | C8                    |
|                       | 33                       | 2                  | C5                    | 1                   | C7                    | 3                  | C8                    |
|                       | 47                       | 2                  | C4                    | 1                   | C6                    | 2                  | C8                    |
|                       | 68                       | 1                  | C5                    | 1                   | C5                    | 2                  | C7                    |
|                       | 100                      | 1                  | C4                    | 1                   | C5                    | 1                  | C8                    |

(1) Assumes worst case maximum input voltage and load current for a given inductance value

(2) No. represents the number of identical capacitor types to be connected in parallel

(3) C Code indicates the Capacitor Reference number in [Table 1](#) for identifying the specific component from the manufacturer.

Step 4: Use [Table 6](#) to select an input capacitor. With 3.3-V output and 22- $\mu$ H there are three through-hole solutions. These capacitors provide a sufficient voltage rating and an rms current rating greater than 1.25 A (1/2  $I_{load\ max}$ ). Again using [Table 1](#) for specific component characteristics the following choices are suitable:

- 1 × 1000- $\mu$ F, 63-V Sanyo MV-GX (code C14)
- 1 × 820- $\mu$ F, 63-V Nichicon PL (code C24)
- 1 × 560- $\mu$ F, 50-V Panasonic HFQ (code C13)

**Table 6. Input Capacitors for Fixed Output Voltage Application<sup>(1)</sup>**

| OUTPUT VOLTAGE (V) | INDUCTANCE ( $\mu$ H) | SURFACE MOUNT                 |                       |                     |                       |                    |                       |
|--------------------|-----------------------|-------------------------------|-----------------------|---------------------|-----------------------|--------------------|-----------------------|
|                    |                       | AVX TPS SERIES <sup>(2)</sup> |                       | SPRAGUE 594D SERIES |                       | KEMET T495 SERIES  |                       |
|                    |                       | NO. <sup>(3)</sup>            | C CODE <sup>(4)</sup> | NO. <sup>(3)</sup>  | C CODE <sup>(4)</sup> | NO. <sup>(3)</sup> | C CODE <sup>(4)</sup> |
| 3.3                | 10                    | 3                             | C7                    | 2                   | C10                   | 3                  | C9                    |
|                    | 15                    | *                             | *                     | 3                   | C13                   | 4                  | C12                   |
|                    | 22                    | *                             | *                     | 2                   | C13                   | 3                  | C12                   |
|                    | 33                    | *                             | *                     | 2                   | C13                   | 3                  | C12                   |
| 5                  | 10                    | 3                             | C4                    | 2                   | C6                    | 3                  | C9                    |
|                    | 15                    | 4                             | C9                    | 3                   | C12                   | 4                  | C10                   |
|                    | 22                    | *                             | *                     | 3                   | C13                   | 4                  | C12                   |
|                    | 33                    | *                             | *                     | 2                   | C13                   | 3                  | C12                   |
|                    | 47                    | *                             | *                     | 1                   | C13                   | 2                  | C12                   |
| 12                 | 10                    | 4                             | C9                    | 2                   | C10                   | 4                  | C10                   |
|                    | 15                    | 4                             | C8                    | 2                   | C10                   | 4                  | C10                   |
|                    | 22                    | 4                             | C9                    | 3                   | C12                   | 4                  | C10                   |
|                    | 33                    | *                             | *                     | 3                   | C13                   | 4                  | C12                   |
|                    | 47                    | *                             | *                     | 2                   | C13                   | 3                  | C12                   |
|                    | 68                    | *                             | *                     | 2                   | C13                   | 2                  | C12                   |
|                    | 100                   | *                             | *                     | 1                   | C13                   | 2                  | C12                   |

(1) Assumes worst case maximum input voltage and load current for a given inductance value

(2) \* Check voltage rating of capacitors to be greater than application input voltage.

(3) No. represents the number of identical capacitor types to be connected in parallel

(4) C Code indicates the Capacitor Reference number in [Table 1](#) for identifying the specific component from the manufacturer.

Step 5: From [Table 7](#) a 3-A Schottky diode must be selected. For through-hole components, 20-V rated diodes are sufficient and 2 part types are suitable, 1N5820 and SR302.

**Table 7. Schottky Diode Selection Table**

| REVERSE VOLTAGE (V) | SURFACE MOUNT |             | THROUGH HOLE |             |
|---------------------|---------------|-------------|--------------|-------------|
|                     | 3 A           | 5 A OR MORE | 3 A          | 5 A OR MORE |
| 20                  | SK32          | —           | 1N5820       | —           |
|                     |               | —           | SR302        | —           |
| 30                  | SK33          | MBRD835L    | 1N5821       | —           |
|                     | 30WQ03F       |             | 31DQ03       | —           |
| 40                  | SK34          | MBRB1545CT  | 1N5822       | —           |
|                     | 30BQ040       | 6TQ045S     | MBR340       | MBR745      |
|                     | 30WQ04F       | —           | 31DQ04       | 80SQ045     |
|                     | MBRS340       | —           | SR403        | 6TQ045      |
|                     | MBRD340       | —           | —            | —           |
| 50 or more          | SK35          | —           | MBR350       | —           |
|                     | 30WQ05F       | —           | 31DQ05       | —           |
|                     | —             | —           | SR305        | —           |

Step 6: A 0.01- $\mu$ F capacitor is used for CBoost.

### 8.2.1.3 Application Curves

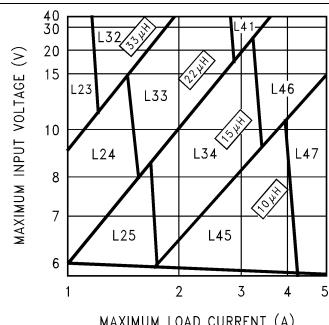


Figure 17. LM2677, 3.3 V

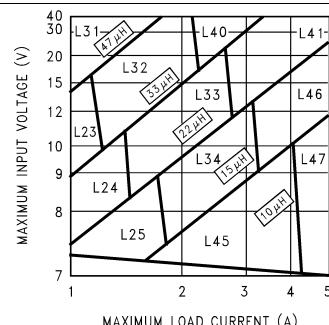


Figure 18. LM2677, 5 V

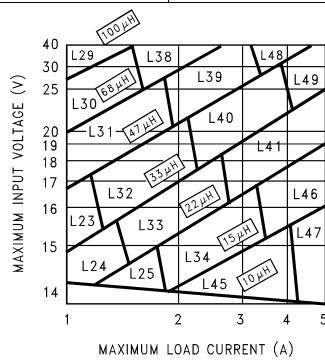
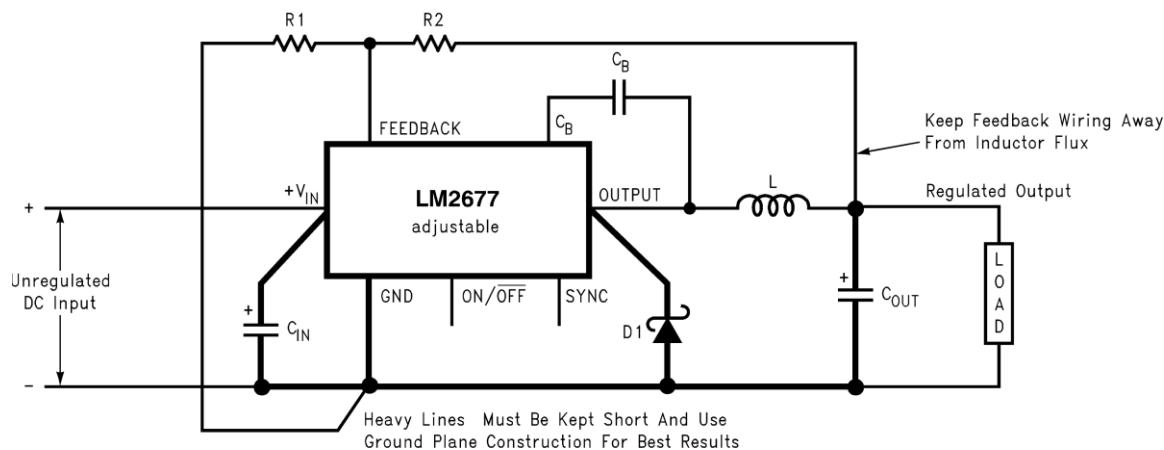


Figure 19. LM2677, 12 V

### 8.2.2 Adjustable Output Voltage Applications

Locate the Programming Resistors near the Feedback Pin Using Short Leads



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Figure 20. Basic Circuit For Adjustable Output Voltage Applications

### 8.2.2.1 Design Requirements

Table 8 lists the design requirements for the adjustable output voltage application.

**Table 8. Design Parameters**

| PARAMETER                                    | VALUE  |
|--|--------|
| Required output voltage, $V_{OUT}$           | 14.8 V |
| Maximum DC input voltage, $V_{IN\_MAX}$      | 28 V   |
| Maximum output load current, $I_{LOAD\_MAX}$ | 2 A    |

### 8.2.2.2 Detailed Design Procedure

In this example it is desired to convert the voltage from a two-battery automotive power supply (voltage range of 20 V to 28 V, typical in large truck applications) to the 14.8 VDC alternator supply typically used to power electronic equipment from single battery 12-V vehicle systems. The load current required is 2 A maximum. It is also desired to implement the power supply with all surface mount components.

Step 1: Select an LM2677S-ADJ to set the output voltage to 14.9 V that chooses between two required resistors (R1 and R2 in Figure 20). For the adjustable device, the output voltage is set by Equation 1.

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

where

- $V_{FB}$  is the feedback voltage of typically 1.21 V

(1)

A recommended value to use for R1 is 1K. In this example then R2 is determined with Equation 2.

$$R_2 = R_1 \left( \frac{V_{OUT}}{V_{FB}} - 1 \right) = 1 \text{ k}\Omega \left( \frac{12.8 \text{ V}}{1.21 \text{ V}} - 1 \right)$$
(2)

$$R_2 = 11.2 \text{ k}\Omega$$

The closest standard 1% tolerance value to use is 11.3 kΩ. This sets the nominal output voltage to 14.88 V which is within 0.5% of the target value.

Step 2: To use the nomograph for the adjustable device, Figure 21, requires a calculation of the inductor Volt•microsecond constant ( $E \times T$  expressed in  $\text{V} \times \mu\text{s}$ ) from Equation 3.

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

where

- $V_{SAT}$  is the voltage drop across the internal power switch which is  $R_{ds(ON)}$  times  $I_{load}$

(3)

In this example, this would be typically  $0.15 \Omega \times 2 \text{ A}$  or  $0.3 \text{ V}$  and  $V_D$  is the voltage drop across the forward biased Schottky diode, typically  $0.5 \text{ V}$ . The switching frequency of  $260 \text{ kHz}$  is the nominal value to use to estimate the ON-time of the switch during which energy is stored in the inductor. For this example  $E \times T$  is found with Equation 4 and Equation 5.

$$E \times T = (28 - 14.8 - 0.3) \times \frac{14.8 + 0.5}{28 - 0.3 + 0.5} \times \frac{1000}{260} (\text{V} \times \mu\text{s})$$
(4)

$$E \times T = (12.9 \text{ V}) \times \frac{15.3}{28.2} \times 3.85 (\text{V} \times \mu\text{s}) = 26.9 (\text{V} \times \mu\text{s})$$
(5)

Using Figure 21, the intersection of  $27 \text{ V} \times \mu\text{s}$  horizontally and the  $2\text{-A}$  vertical line ( $I_{load \ max}$ ) indicates that L38, a  $68\text{-}\mu\text{H}$  inductor, must be used. L38 in a surface mount component is available from Pulse Engineering with part number PE-54038S.

Step 3: Use [Table 9](#) and [Table 10](#) to determine an output capacitor. With a 14.8-V output the 12.5-V to 15-V row is used and with a 68- $\mu$ H inductor there are three surface mount output capacitor solutions. [Table 1](#) provides the actual capacitor characteristics based on the C Code number. Any of the following choices can be used:

- 1 × 33- $\mu$ F, 20-V AVX TPS (code C6)
- 1 × 47- $\mu$ F, 20-V Sprague 594 (code C8)
- 1 × 47- $\mu$ F, 20-V Kemet T495 (code C8)

**Table 9. Surface-Mount Output Capacitors**

| OUTPUT VOLTAGE (V) | INDUCTANCE<br>( $\mu$ H) | AVX TPS SERIES      |                       | SPRAGUE 594D SERIES |                       | KEMET T495 SERIES  |                       |
|--------------------|--------------------------|---------------------|-----------------------|---------------------|-----------------------|--------------------|-----------------------|
|                    |                          | NO. <sup>(1)</sup>  | C CODE <sup>(2)</sup> | NO. <sup>(1)</sup>  | C CODE <sup>(2)</sup> | NO. <sup>(1)</sup> | C CODE <sup>(2)</sup> |
| 1.21 to 2.50       | 33 <sup>(3)</sup>        | 7                   | C1                    | 6                   | C2                    | 7                  | C3                    |
|                    | 47 <sup>(3)</sup>        | 5                   | C1                    | 4                   | C2                    | 5                  | C3                    |
| 2.5 to 3.75        | 33 <sup>(3)</sup>        | 4                   | C1                    | 3                   | C2                    | 4                  | C3                    |
|                    | 47 <sup>(3)</sup>        | 3                   | C1                    | 2                   | C2                    | 3                  | C3                    |
| 3.75 to 5          | 22                       | 4                   | C1                    | 3                   | C2                    | 4                  | C3                    |
|                    | 33                       | 3                   | C1                    | 2                   | C2                    | 3                  | C3                    |
|                    | 47                       | 2                   | C1                    | 2                   | C2                    | 2                  | C3                    |
| 5 to 6.25          | 22                       | 3                   | C2                    | 1                   | C3                    | 3                  | C4                    |
|                    | 33                       | 2                   | C2                    | 2                   | C3                    | 2                  | C4                    |
|                    | 47                       | 2                   | C2                    | 2                   | C3                    | 2                  | C4                    |
|                    | 68                       | 1                   | C2                    | 1                   | C3                    | 1                  | C4                    |
| 6.25 to 7.5        | 22                       | 3                   | C2                    | 1                   | C4                    | 3                  | C4                    |
|                    | 33                       | 2                   | C2                    | 1                   | C3                    | 2                  | C4                    |
|                    | 47                       | 1                   | C3                    | 1                   | C4                    | 1                  | C6                    |
|                    | 68                       | 1                   | C2                    | 1                   | C3                    | 1                  | C4                    |
| 7.5 to 10          | 33                       | 2                   | C5                    | 1                   | C6                    | 2                  | C8                    |
|                    | 47                       | 1                   | C5                    | 1                   | C6                    | 2                  | C8                    |
|                    | 68                       | 1                   | C5                    | 1                   | C6                    | 1                  | C8                    |
|                    | 100                      | 1                   | C4                    | 1                   | C5                    | 1                  | C8                    |
| 10 to 12.5         | 33                       | 1                   | C5                    | 1                   | C6                    | 2                  | C8                    |
|                    | 47                       | 1                   | C5                    | 1                   | C6                    | 2                  | C8                    |
|                    | 68                       | 1                   | C5                    | 1                   | C6                    | 1                  | C8                    |
|                    | 100                      | 1                   | C5                    | 1                   | C6                    | 1                  | C8                    |
| 12.5 to 15         | 33                       | 1                   | C6                    | 1                   | C8                    | 1                  | C8                    |
|                    | 47                       | 1                   | C6                    | 1                   | C8                    | 1                  | C8                    |
|                    | 68                       | 1                   | C6                    | 1                   | C8                    | 1                  | C8                    |
|                    | 100                      | 1                   | C6                    | 1                   | C8                    | 1                  | C8                    |
| 15 to 20           | 33                       | 1                   | C8                    | 1                   | C10                   | 2                  | C10                   |
|                    | 47                       | 1                   | C8                    | 1                   | C9                    | 2                  | C10                   |
|                    | 68                       | 1                   | C8                    | 1                   | C9                    | 2                  | C10                   |
|                    | 100                      | 1                   | C8                    | 1                   | C9                    | 1                  | C10                   |
| 20 to 30           | 33                       | 2                   | C9                    | 2                   | C11                   | 2                  | C11                   |
|                    | 47                       | 1                   | C10                   | 1                   | C12                   | 1                  | C11                   |
|                    | 68                       | 1                   | C9                    | 1                   | C12                   | 1                  | C11                   |
|                    | 100                      | 1                   | C9                    | 1                   | C12                   | 1                  | C11                   |
| 30 to 37           | 10                       | —                   | —                     | 4                   | C13                   | 8                  | C12                   |
|                    | 15                       | —                   | —                     | 3                   | C13                   | 5                  | C12                   |
|                    | 22                       | No values available |                       | 2                   | C13                   | 4                  | C12                   |
|                    | 33                       |                     |                       | 1                   | C13                   | 3                  | C12                   |
|                    | 47                       | —                   | —                     | 1                   | C13                   | 2                  | C12                   |
|                    | 68                       | —                   | —                     | 1                   | C13                   | 2                  | C12                   |

(1) No. represents the number of identical capacitor types to be connected in parallel

(2) C Code indicates the Capacitor Reference number in [Table 1](#) for identifying the specific component from the manufacturer.

(3) Set to a higher value for a practical design solution.

**Table 10. Through-Hole Output Capacitors**

| OUTPUT VOLTAGE (V) | INDUCTANCE E (μH) | SANYO OS-CON SA SERIES |                       | SANYO MV-GX SERIES |                       | NICHICON PL SERIES |                       | PANASONIC HFQ SERIES |                       |
|--------------------|-------------------|------------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|----------------------|-----------------------|
|                    |                   | NO. <sup>(1)</sup>     | C CODE <sup>(2)</sup> | NO. <sup>(1)</sup> | C CODE <sup>(2)</sup> | NO. <sup>(1)</sup> | C CODE <sup>(2)</sup> | NO. <sup>(1)</sup>   | C CODE <sup>(2)</sup> |
| 1.21 to 2.50       | 33 <sup>(3)</sup> | 2                      | C3                    | 5                  | C1                    | 5                  | C3                    | 3                    | C                     |
|                    | 47 <sup>(3)</sup> | 2                      | C2                    | 4                  | C1                    | 3                  | C3                    | 2                    | C5                    |
| 2.5 to 3.75        | 33 <sup>(3)</sup> | 1                      | C3                    | 3                  | C1                    | 3                  | C1                    | 2                    | C5                    |
|                    | 47 <sup>(3)</sup> | 1                      | C2                    | 2                  | C1                    | 2                  | C3                    | 1                    | C5                    |
| 3.75 to 5          | 22                | 1                      | C3                    | 3                  | C1                    | 3                  | C1                    | 2                    | C5                    |
|                    | 33                | 1                      | C2                    | 2                  | C1                    | 2                  | C1                    | 1                    | C5                    |
|                    | 47                | 1                      | C2                    | 2                  | C1                    | 1                  | C3                    | 1                    | C5                    |
| 5 to 6.25          | 22                | 1                      | C5                    | 2                  | C6                    | 2                  | C3                    | 2                    | C5                    |
|                    | 33                | 1                      | C4                    | 1                  | C6                    | 2                  | C1                    | 1                    | C5                    |
|                    | 47                | 1                      | C4                    | 1                  | C6                    | 1                  | C3                    | 1                    | C5                    |
|                    | 68                | 1                      | C4                    | 1                  | C6                    | 1                  | C1                    | 1                    | C5                    |
| 6.25 to 7.5        | 22                | 1                      | C5                    | 1                  | C6                    | 2                  | C1                    | 1                    | C5                    |
|                    | 33                | 1                      | C4                    | 1                  | C6                    | 1                  | C3                    | 1                    | C5                    |
|                    | 47                | 1                      | C4                    | 1                  | C6                    | 1                  | C1                    | 1                    | C5                    |
|                    | 68                | 1                      | C4                    | 1                  | C2                    | 1                  | C1                    | 1                    | C5                    |
| 7.5 to 10          | 22                | 1                      | C7                    | 1                  | C6                    | 1                  | C14                   | 1                    | C5                    |
|                    | 33                | 1                      | C7                    | 1                  | C6                    | 1                  | C14                   | 1                    | C5                    |
|                    | 47                | 1                      | C7                    | 1                  | C2                    | 1                  | C14                   | 1                    | C2                    |
|                    | 68                | 1                      | C7                    | 1                  | C2                    | 1                  | C14                   | 1                    | C2                    |
| 10 to 12.5         | 100               | 1                      | C7                    | 1                  | C2                    | 1                  | C14                   | 1                    | C2                    |
|                    | 33                | 1                      | C7                    | 1                  | C6                    | 1                  | C14                   | 1                    | C5                    |
|                    | 47                | 1                      | C7                    | 1                  | C2                    | 1                  | C14                   | 1                    | C5                    |
|                    | 68                | 1                      | C7                    | 1                  | C2                    | 1                  | C9                    | 1                    | C2                    |
| 12.5 to 15         | 100               | 1                      | C7                    | 1                  | C2                    | 1                  | C9                    | 1                    | C2                    |
|                    | 33                | 1                      | C9                    | 1                  | C10                   | 1                  | C15                   | 1                    | C2                    |
|                    | 47                | 1                      | C9                    | 1                  | C10                   | 1                  | C15                   | 1                    | C2                    |
|                    | 68                | 1                      | C9                    | 1                  | C10                   | 1                  | C15                   | 1                    | C2                    |
| 15 to 20           | 100               | 1                      | C9                    | 1                  | C10                   | 1                  | C15                   | 1                    | C2                    |
|                    | 33                | 1                      | C10                   | 1                  | C7                    | 1                  | C15                   | 1                    | C2                    |
|                    | 47                | 1                      | C10                   | 1                  | C7                    | 1                  | C15                   | 1                    | C2                    |
|                    | 68                | 1                      | C10                   | 1                  | C7                    | 1                  | C15                   | 1                    | C2                    |
| 20 to 30           | 100               | 1                      | C10                   | 1                  | C7                    | 1                  | C15                   | 1                    | C2                    |
|                    | 33                | —                      | —                     | 1                  | C7                    | 1                  | C16                   | 1                    | C2                    |
|                    | 47                | No values available    |                       | 1                  | C7                    | 1                  | C16                   | 1                    | C2                    |
|                    | 68                |                        |                       | 1                  | C7                    | 1                  | C16                   | 1                    | C2                    |
| 30 to 37           | 100               | —                      | —                     | 1                  | C7                    | 1                  | C16                   | 1                    | C2                    |
|                    | 10                | —                      | —                     | 1                  | C12                   | 1                  | C20                   | 1                    | C10                   |
|                    | 15                | —                      | —                     | 1                  | C11                   | 1                  | C20                   | 1                    | C11                   |
|                    | 22                | No values available    |                       | 1                  | C11                   | 1                  | C20                   | 1                    | C10                   |
|                    | 33                |                        |                       | 1                  | C11                   | 1                  | C20                   | 1                    | C10                   |
|                    | 47                | —                      | —                     | 1                  | C11                   | 1                  | C20                   | 1                    | C10                   |
|                    | 68                | —                      | —                     | 1                  | C11                   | 1                  | C20                   | 1                    | C10                   |

(1) No. represents the number of identical capacitor types to be connected in parallel

(2) C Code indicates the Capacitor Reference number in [Table 1](#) for identifying the specific component from the manufacturer.

(3) Set to a higher value for a practical design solution.

## NOTE

When using the adjustable device in low voltage applications (less than 3-V output), if the nomograph, [Figure 21](#), selects an inductance of 22  $\mu$ H or less, [Table 9](#) does not provide an output capacitor solution. With these conditions the number of output capacitors required for stable operation becomes impractical. TI recommends using either a 33- $\mu$ H or 47- $\mu$ H inductor and the output capacitors from [Table 9](#).

Step 4: An input capacitor for this example requires at least a 35-V WV rating with an rms current rating of 1 A (1/2  $I_{out}$  max). From [Table 1](#) it can be seen that C12, a 33- $\mu$ F, 35-V capacitor from Sprague, has the required voltage/current rating of the surface mount components.

Step 5: From Table 7 a 3-A Schottky diode must be selected. For surface mount diodes with a margin of safety on the voltage rating one of five diodes can be used:

- SK34
- 30BQ040
- 30WQ04F
- MBRS340
- MBRD340

Step 6: A  $0.01\text{-}\mu\text{F}$  capacitor is used for  $C_{\text{boost}}$ .

### 8.2.2.3 Application Curve

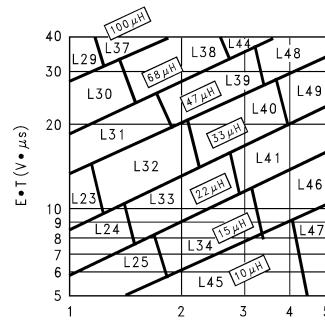


Figure 31. LM2677 Adjustable

## 9 Power Supply Recommendations

Power supply design using the LM2677 is greatly simplified by using recommended external components. A wide range of inductors, capacitors, and Schottky diodes from several manufacturers have been evaluated for use in designs that cover the full range of capabilities (input voltage, output voltage, and load current) of the LM2677. A simple design procedure using nomographs and component tables provided in this data sheet leads to a working design with very little effort.

The individual components from the various manufacturers called out for use are still just a small sample of the vast array of components available in the industry. While these components are recommended, they are not exclusively the only components for use in a design. After a close comparison of component specifications, equivalent devices from other manufacturers could be substituted for use in an application.

The input voltage for the power supply is connected to pin 2. In addition to providing energy to the load the input voltage also provides bias for the internal circuitry of the LM2677. For ensured performance the input voltage must be in the range of 8 V to 40 V. For best performance of the power supply the input pin must always be bypassed with an input capacitor placed close to pin 2.

## 10 Layout

### 10.1 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 16](#) and [Figure 20](#)) 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 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.

#### 10.1.1 VSON Package Devices

The LM2677 is offered in the 14-pin VSON surface mount package to allow for a significantly decreased footprint with equivalent power dissipation compared to the TO-220 or TO-263. For details on mounting and soldering specifications, see application note, [AN-1187 Leadless Leadframe Package \(LLP\)](#).

## 10.2 Layout Example

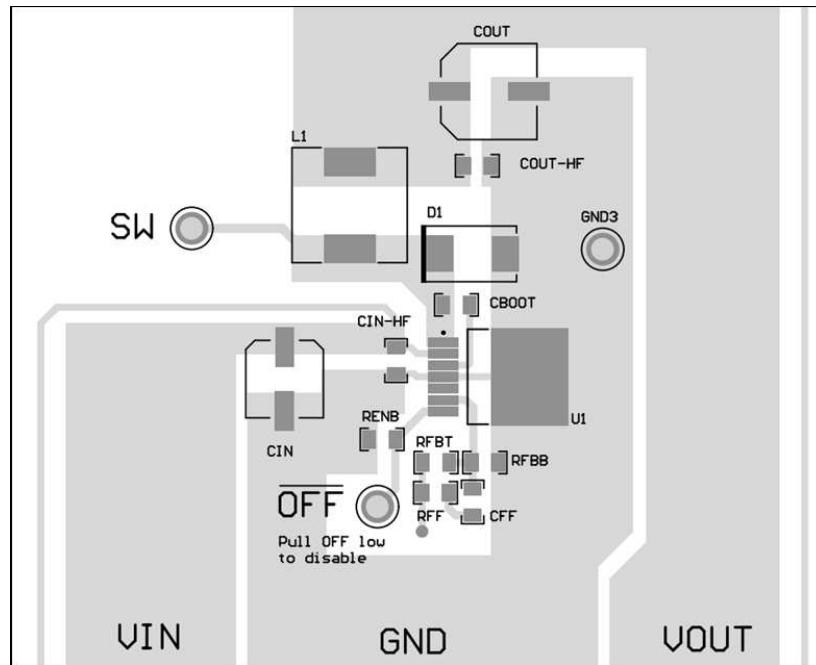


Figure 22. LM2677 Sample Layout

## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation see the following:

[AN-1187 Leadless Leadframe Package \(LLP\) \(SNOA401\)](#)

### 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

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

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

### 11.4 Trademarks

E2E is a trademark of Texas Instruments.

SIMPLE SWITCHER is a registered trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

### 11.5 Electrostatic Discharge Caution



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

### 11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 12 Mechanical, Packaging, and Orderable Information

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

**PACKAGING INFORMATION**

| Orderable part number | Status<br>(1) | Material type<br>(2) | Package   Pins         | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------|---------------|----------------------|------------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LM2677S-12/NOPB       | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-12          |
| LM2677S-12/NOPB.B     | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-12          |
| LM2677S-3.3/NOPB      | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-3.3         |
| LM2677S-3.3/NOPB.B    | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-3.3         |
| LM2677S-5.0/NOPB      | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-5.0         |
| LM2677S-5.0/NOPB.B    | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-5.0         |
| LM2677S-ADJ/NOPB      | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-ADJ         |
| LM2677S-ADJ/NOPB.B    | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 45   TUBE             | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-ADJ         |
| LM2677SD-3.3/NOPB     | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0002YB             |
| LM2677SD-3.3/NOPB.B   | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0002YB             |
| LM2677SD-5.0/NOPB     | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0002ZB             |
| LM2677SD-5.0/NOPB.B   | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0002ZB             |
| LM2677SD-ADJ/NOPB     | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0003AB             |
| LM2677SD-ADJ/NOPB.B   | Active        | Production           | VSON (NHM)   14        | 250   SMALL T&R       | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | S0003AB             |
| LM2677SX-12/NOPB      | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-12          |
| LM2677SX-12/NOPB.B    | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-12          |
| LM2677SX-3.3/NOPB     | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-3.3         |
| LM2677SX-3.3/NOPB.B   | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-3.3         |
| LM2677SX-5.0/NOPB     | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-5.0         |

| Orderable part number | Status<br>(1) | Material type<br>(2) | Package   Pins         | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------|---------------|----------------------|------------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| LM2677SX-5.0/NOPB.B   | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-5.0         |
| LM2677SX-ADJ/NOPB     | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-ADJ         |
| LM2677SX-ADJ/NOPB.B   | Active        | Production           | DDPAK/TO-263 (KTW)   7 | 500   LARGE T&R       | ROHS Exempt | SN                                   | Level-3-245C-168 HR               | -40 to 125   | LM2677S-ADJ         |
| LM2677T-12/NOPB       | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-12          |
| LM2677T-12/NOPB.B     | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-12          |
| LM2677T-3.3/NOPB      | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-3.3         |
| LM2677T-3.3/NOPB.B    | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-3.3         |
| LM2677T-5.0/NOPB      | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-5.0         |
| LM2677T-5.0/NOPB.B    | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-5.0         |
| LM2677T-ADJ/NOPB      | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-ADJ         |
| LM2677T-ADJ/NOPB.B    | Active        | Production           | TO-220 (NDZ)   7       | 45   TUBE             | Yes         | SN                                   | Level-1-NA-UNLIM                  | -40 to 125   | LM2677T-ADJ         |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

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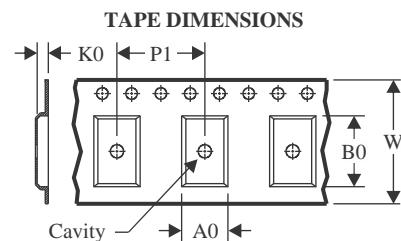
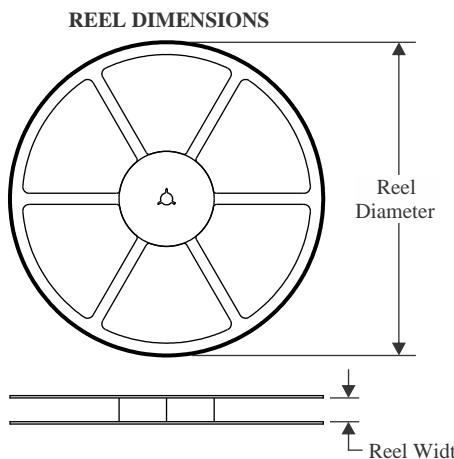
<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature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

<sup>(6)</sup> **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.

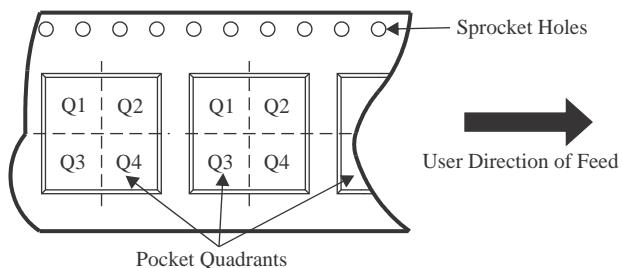
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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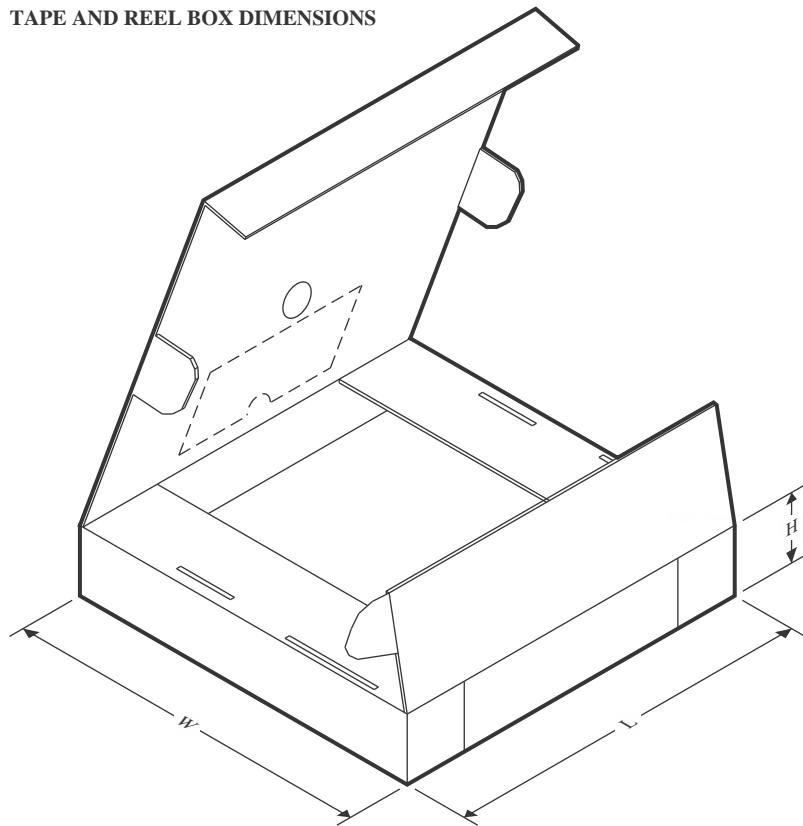
**TAPE AND REEL INFORMATION**


|    |   |
|----|---|
| 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**


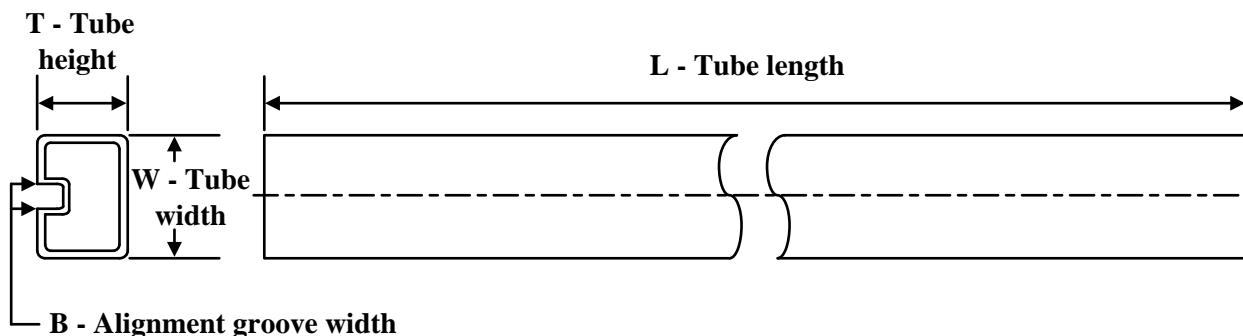
\*All dimensions are nominal

| 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 |
|-------------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2677SD-3.3/NOPB | VSON         | NHM             | 14   | 250 | 178.0              | 16.4               | 5.3     | 6.3     | 1.5     | 12.0    | 16.0   | Q1            |
| LM2677SD-5.0/NOPB | VSON         | NHM             | 14   | 250 | 178.0              | 16.4               | 5.3     | 6.3     | 1.5     | 12.0    | 16.0   | Q1            |
| LM2677SD-ADJ/NOPB | VSON         | NHM             | 14   | 250 | 178.0              | 16.4               | 5.3     | 6.3     | 1.5     | 12.0    | 16.0   | Q1            |
| LM2677SX-12/NOPB  | DDPAK/TO-263 | KTW             | 7    | 500 | 330.0              | 24.4               | 10.75   | 14.85   | 5.0     | 16.0    | 24.0   | Q2            |
| LM2677SX-3.3/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 330.0              | 24.4               | 10.75   | 14.85   | 5.0     | 16.0    | 24.0   | Q2            |
| LM2677SX-5.0/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 330.0              | 24.4               | 10.75   | 14.85   | 5.0     | 16.0    | 24.0   | Q2            |
| LM2677SX-ADJ/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 330.0              | 24.4               | 10.75   | 14.85   | 5.0     | 16.0    | 24.0   | Q2            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| LM2677SD-3.3/NOPB | VSON         | NHM             | 14   | 250 | 210.0       | 185.0      | 35.0        |
| LM2677SD-5.0/NOPB | VSON         | NHM             | 14   | 250 | 210.0       | 185.0      | 35.0        |
| LM2677SD-ADJ/NOPB | VSON         | NHM             | 14   | 250 | 210.0       | 185.0      | 35.0        |
| LM2677SX-12/NOPB  | DDPAK/TO-263 | KTW             | 7    | 500 | 356.0       | 356.0      | 45.0        |
| LM2677SX-3.3/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 356.0       | 356.0      | 45.0        |
| LM2677SX-5.0/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 356.0       | 356.0      | 45.0        |
| LM2677SX-ADJ/NOPB | DDPAK/TO-263 | KTW             | 7    | 500 | 356.0       | 356.0      | 45.0        |

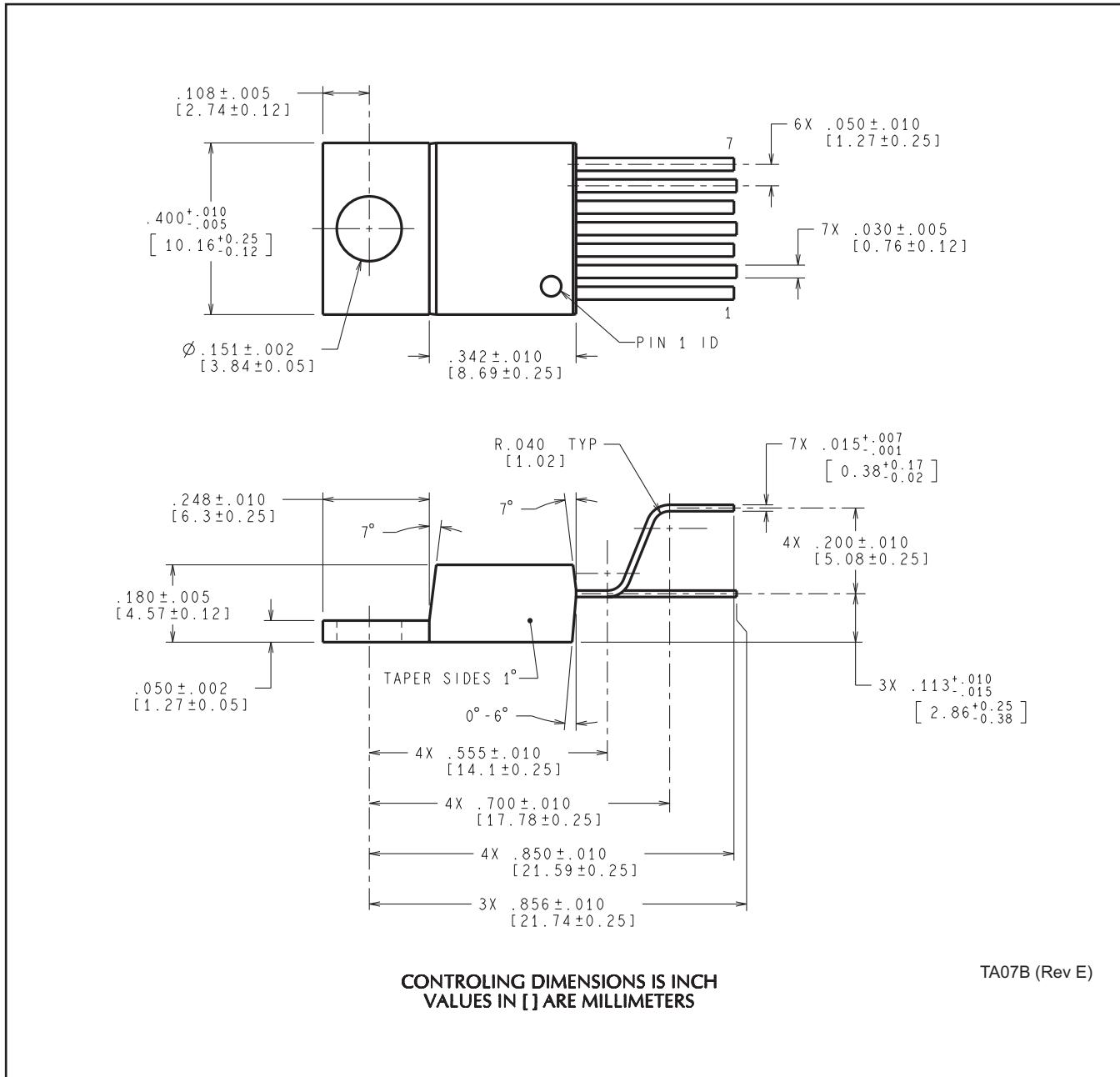
**TUBE**


\*All dimensions are nominal

| Device             | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm)  | B (mm) |
|--------------------|--------------|--------------|------|-----|--------|--------|---------|--------|
| LM2677S-12/NOPB    | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-12/NOPB.B  | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-3.3/NOPB   | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-3.3/NOPB.B | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-5.0/NOPB   | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-5.0/NOPB.B | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-ADJ/NOPB   | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677S-ADJ/NOPB.B | KTW          | TO-263       | 7    | 45  | 502    | 25     | 8204.2  | 9.19   |
| LM2677T-12/NOPB    | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-12/NOPB.B  | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-3.3/NOPB   | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-3.3/NOPB.B | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-5.0/NOPB   | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-5.0/NOPB.B | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-ADJ/NOPB   | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |
| LM2677T-ADJ/NOPB.B | NDZ          | TO-220       | 7    | 45  | 502    | 30     | 30048.2 | 10.74  |

## MECHANICAL DATA

NDZ0007B



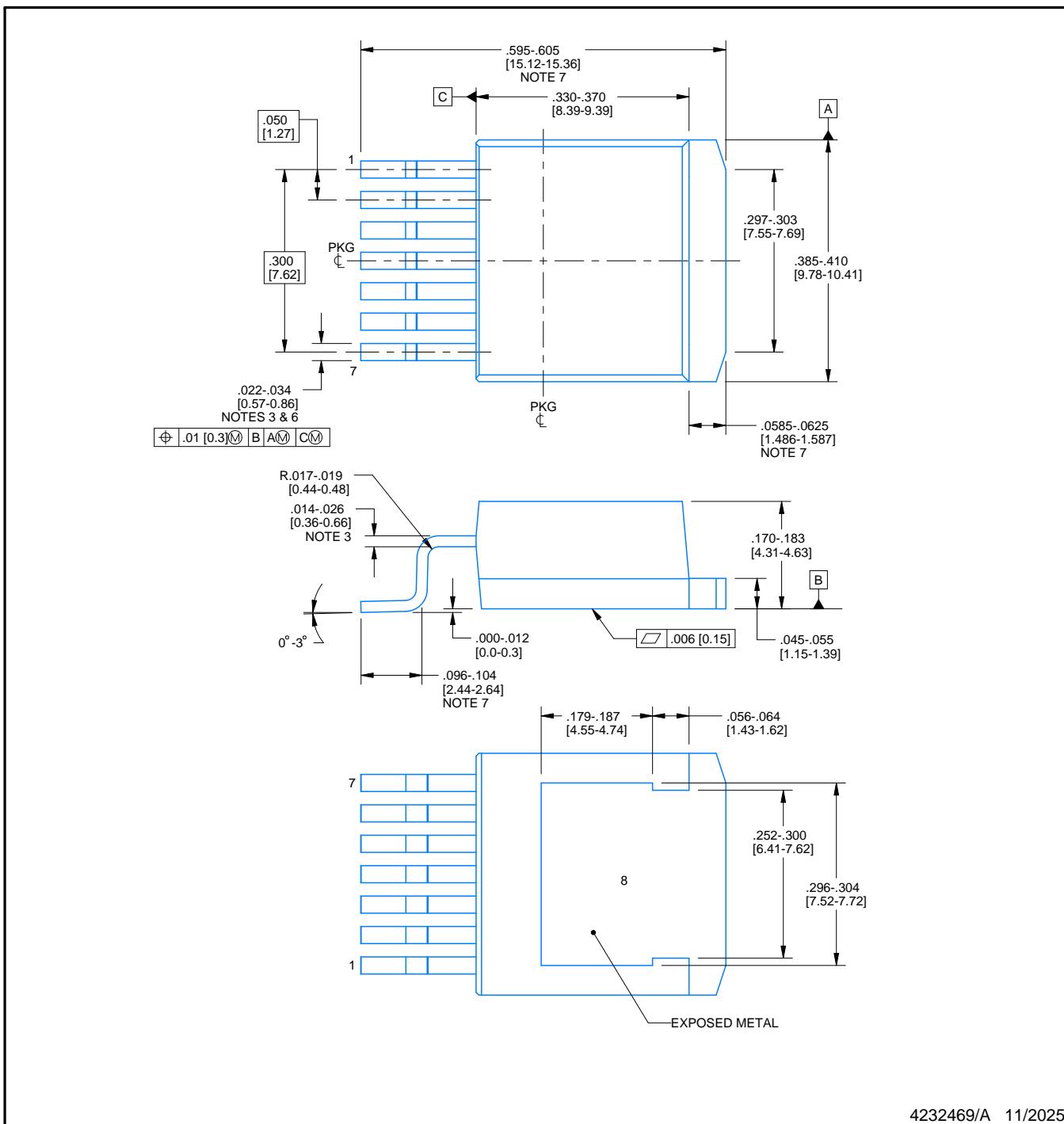
# PACKAGE OUTLINE

KTW0007A



TO-263 - 5 mm max height

TRANSISTOR OUTLINE



4232469/A 11/2025

NOTES:

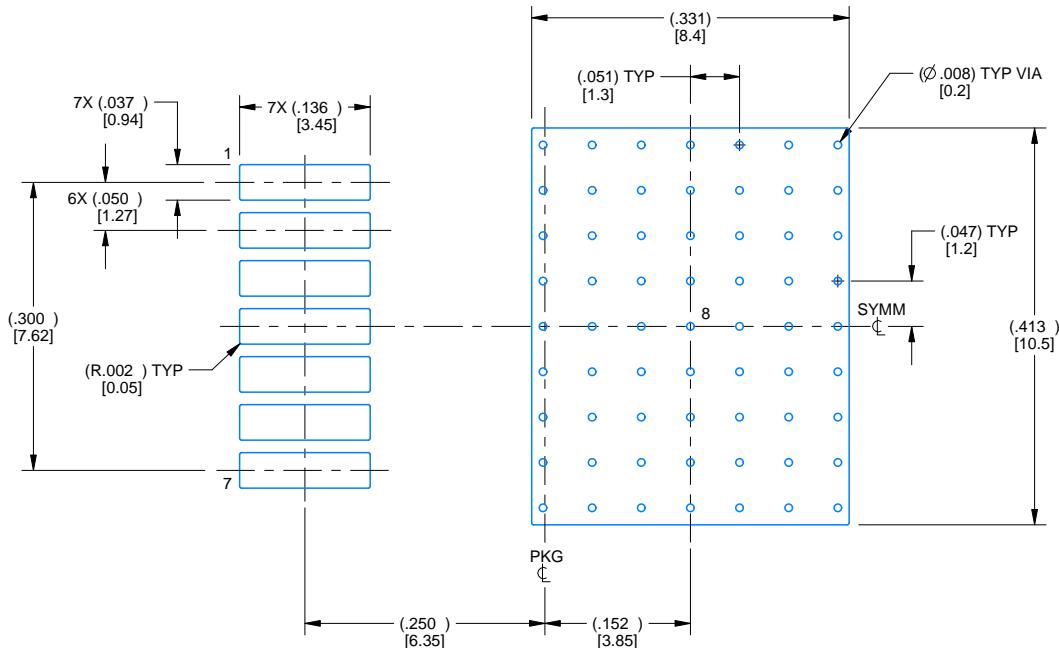
1. All linear dimensions are in inches [millimeters]. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead width and height dimensions apply to the plated lead.
4. Leads are not allowed above the Datum B.
5. Stand-off height is measured from lead tip with reference to Datum B.
6. Lead width dimension does not include dambar protrusion. Allowable dambar protrusion shall not cause the lead width to exceed the maximum bdimension by more than 0.003".
7. Falls within JEDEC MO-169 with the exception of the dimensions indicated.

## EXAMPLE BOARD LAYOUT

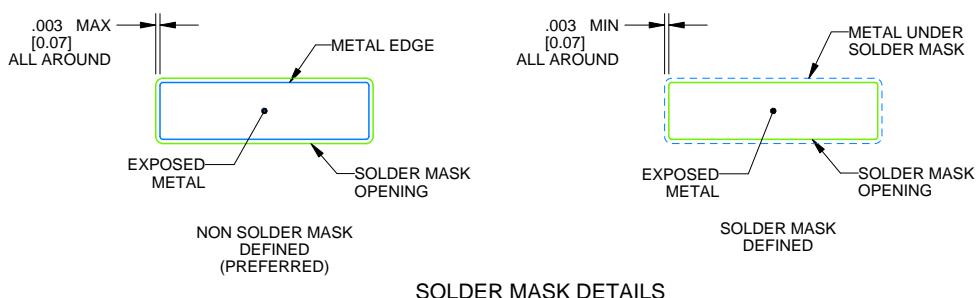
**KTW0007A**

## TO-263 - 5 mm max height

## TRANSISTOR OUTLINE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 5X



4232469/A 11/2025

#### NOTES: (continued)

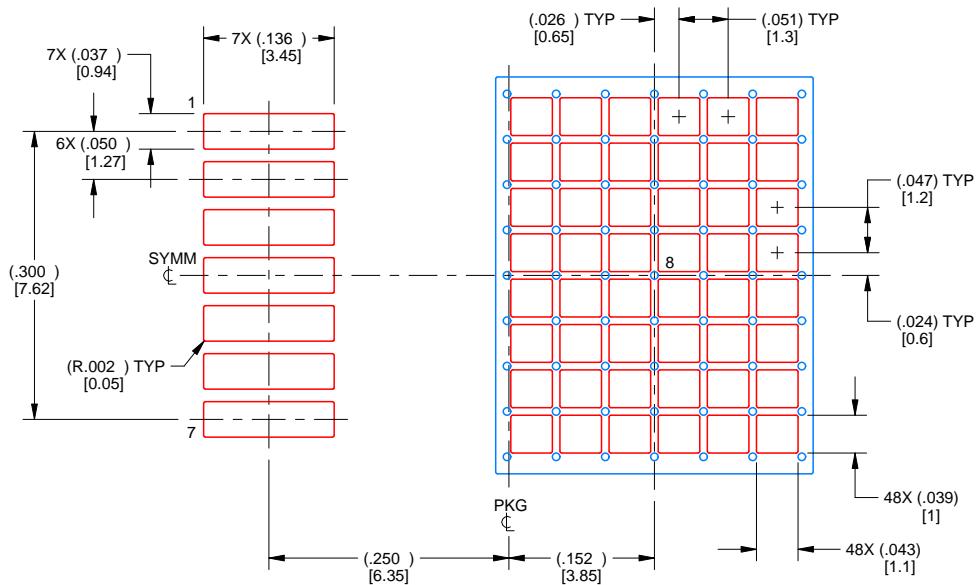
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002([www.ti.com/lit/slm002](http://www.ti.com/lit/slm002)) and SLMA004 ([www.ti.com/lit/slma004](http://www.ti.com/lit/slma004)).
9. Vias are optional depending on application, refer to device data sheet. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

KTW0007A

TO-263 - 5 mm max height

TRANSISTOR OUTLINE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE: 5X

PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
PAD 8: 60%

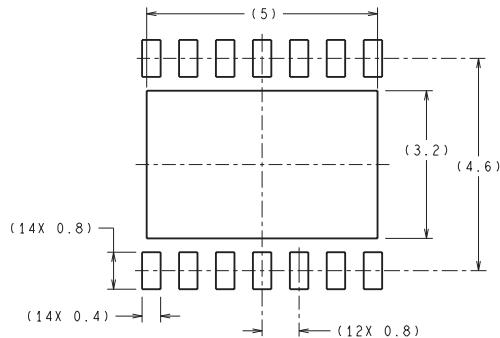
4232469/A 11/2025

NOTES: (continued)

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

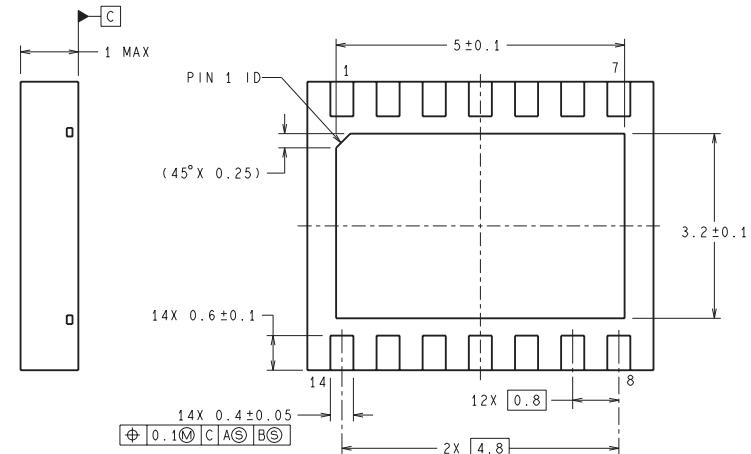
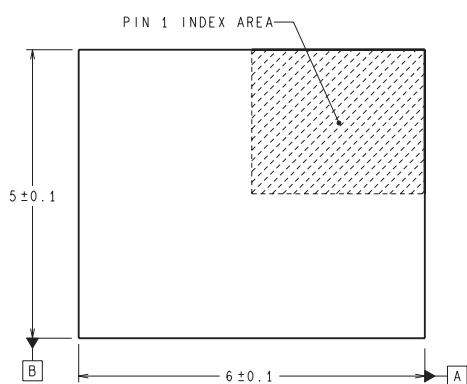
## MECHANICAL DATA

NHM0014A



**DIMENSIONS ARE IN MILLIMETERS**  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

#### RECOMMENDED LAND PATTERN



SRC14A (Rev A)

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