

# LM2675 SIMPLE SWITCHER<sup>®</sup> Power Converter High Efficiency 1A Step-Down Voltage Regulator

Check for Samples: [LM2675](#)

## FEATURES

- Efficiency up to 96%
- Available in 8-pin SOIC and PDIP Packages and a 16-pin WSON Package
- Computer Design Software *LM267X Made Simple* (version 6.0)
- Simple and Easy to Design with
- Requires Only 5 External Components
- Uses Readily Available Standard Inductors
- 3.3V, 5.0V, 12V, and Adjustable Output Versions
- Adjustable Version Output Voltage Range: 1.21V to 37V
- $\pm 1.5\%$  Max Output Voltage Tolerance Over Line and Load Conditions
- Ensured 1A Output Load Current
- 0.25 $\Omega$  DMOS Output Switch
- Wide Input Voltage Range: 8V to 40V
- 260 kHz Fixed Frequency Internal Oscillator
- TTL Shutdown Capability, Low Power Standby Mode
- Thermal Shutdown and Current Limit Protection

## TYPICAL APPLICATIONS

- Simple High Efficiency (>90%) Step-Down (Buck) Regulator
- Efficient Pre-Regulator for Linear Regulators
- Positive-to-Negative Converter

## DESCRIPTION

The LM2675 series of regulators are monolithic integrated circuits built with a LMDMOS process. These regulators provide all the active functions for a step-down (buck) switching regulator, capable of driving a 1A load current with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5.0V, 12V, and an adjustable output version.

Requiring a minimum number of external components, these regulators are simple to use and include patented internal frequency compensation (Patent Nos. 5,382,918 and 5,514,947) and a fixed frequency oscillator.

The LM2675 series operates at a switching frequency of 260 kHz, thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Because of its very high efficiency (>90%), the copper traces on the printed circuit board are the only heat sinking needed.

A family of standard inductors for use with the LM2675 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies using these advanced ICs. Also included in the datasheet are selector guides for diodes and capacitors designed to work in switch-mode power supplies.

Other features include an ensured  $\pm 1.5\%$  tolerance on output voltage within specified input voltages and output load conditions, and  $\pm 10\%$  on the oscillator frequency. External shutdown is included, featuring typically 50  $\mu$ A stand-by current. The output switch includes current limiting, as well as thermal shutdown for full protection under fault conditions.

To simplify the LM2675 buck regulator design procedure, there exists computer design software, *LM267X Made Simple* version 6.0.



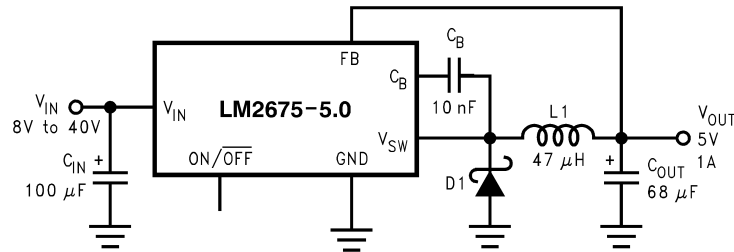
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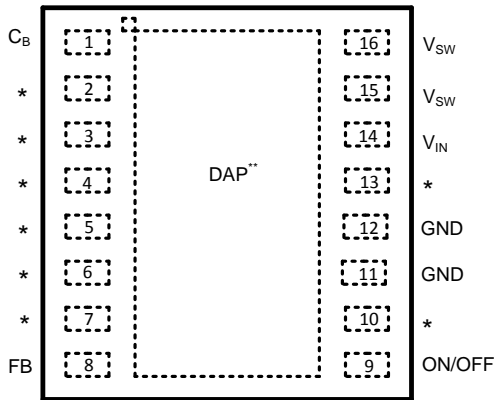
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Typical Application



Connection Diagram



\* No Connections  
 \*\*Connect to Pins 11, 12 on PCB

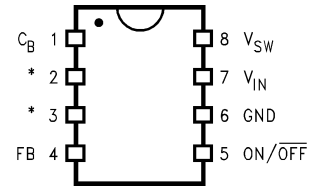


Figure 1. 16-Lead WSON Surface Mount Package  
 Top View  
 Package Drawing Number NHN0016A

Figure 2. 8-Lead SOIC/PDIP Package  
 Top View  
 Package Drawing Number D0008A/P0008E



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.

**Absolute Maximum Ratings<sup>(1)(2)</sup>**

|   |                                 |                              |
|---|---------------------------------|------------------------------|
| Supply Voltage  |                                 | 45V                          |
| ON/OFF Pin Voltage                                    |                                 | $-0.1V \leq V_{SH} \leq 6V$  |
| Switch Voltage to Ground                              |                                 | -1V                          |
| Boost Pin Voltage                                     |                                 | $V_{SW} + 8V$                |
| Feedback Pin Voltage                                  |                                 | $-0.3V \leq V_{FB} \leq 14V$ |
| ESD Susceptibility                                    |                                 |                              |
|   | Human Body Model <sup>(3)</sup> | 2 kV                         |
| Power Dissipation                                     |                                 | Internally Limited           |
| Storage Temperature Range                             |                                 | -65°C to +150°C              |
| Lead Temperature                                      |                                 |                              |
| D Package   | Vapor Phase (60s)               | +215°C                       |
|   | Infrared (15s)                  | +220°C                       |
| P Package (Soldering, 10s)                            |                                 | +260°C                       |
| WSON Package (See AN-1187 - <a href="#">SNOA401</a> ) |                                 |                              |
| Maximum Junction Temperature                          |                                 | +150°C                       |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but device parameter specifications may not be ensured under these conditions. For ensured specifications and test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
- (3) The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

**Operating Ratings**

|                            |  |
|----------------------------|--|
| Supply Voltage             | 6.5V to 40V  |
| Junction Temperature Range | $-40^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$ |

**LM2675-3.3 Electrical Characteristics**

Specifications with standard type face are for  $T_J = 25^{\circ}\text{C}$ , and those with **bold type face** apply over **full Operating Temperature Range**.

| Symbol   | Parameter      | Conditions   | Typ <sup>(1)</sup> | Min <sup>(2)</sup>  | Max <sup>(2)</sup>  | Units |
|--|----------------|--|--------------------|---------------------|---------------------|-------|
| <b>SYSTEM PARAMETERS</b> Test Circuit <a href="#">Figure 22</a> <sup>(3)</sup> |                |  |                    |                     |                     |       |
| $V_{OUT}$  | Output Voltage | $V_{IN} = 8V \text{ to } 40V, I_{LOAD} = 20 \text{ mA to } 1A$               | 3.3                | 3.251/ <b>3.201</b> | 3.350/ <b>3.399</b> | V     |
| $V_{OUT}$  | Output Voltage | $V_{IN} = 6.5V \text{ to } 40V, I_{LOAD} = 20 \text{ mA to } 500 \text{ mA}$ | 3.3                | 3.251/ <b>3.201</b> | 3.350/ <b>3.399</b> | V     |
| $\eta$   | Efficiency     | $V_{IN} = 12V, I_{LOAD} = 1A$  | 86                 |                     |                     | %     |

- (1) Typical numbers are at 25°C and represent the most likely norm.
- (2) All limits specified at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are specified via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in [Figure 22](#) and [Figure 23](#) test circuits, system performance will be as specified by the system parameters section of the Electrical Characteristics.

### LM2675-5.0 Electrical Characteristics

| Symbol   | Parameter      | Conditions   | Typ <sup>(1)</sup> | Min <sup>(2)</sup>  | Max <sup>(2)</sup>  | Units |
|--|----------------|--|--------------------|---------------------|---------------------|-------|
| <b>SYSTEM PARAMETERS</b> Test Circuit <a href="#">Figure 22</a> <sup>(3)</sup> |                |  |                    |                     |                     |       |
| V <sub>OUT</sub>   | Output Voltage | V <sub>IN</sub> = 8V to 40V, I <sub>LOAD</sub> = 20 mA to 1A       | 5.0                | 4.925/ <b>4.850</b> | 5.075/ <b>5.150</b> | V     |
| V <sub>OUT</sub>   | Output Voltage | V <sub>IN</sub> = 6.5V to 40V, I <sub>LOAD</sub> = 20 mA to 500 mA | 5.0                | 4.925/ <b>4.850</b> | 5.075/ <b>5.150</b> | V     |
| η  | Efficiency     | V <sub>IN</sub> = 12V, I <sub>LOAD</sub> = 1A                      | 90                 |                     |                     | %     |

- (1) Typical numbers are at 25°C and represent the most likely norm.
- (2) All limits specified at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are specified via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in [Figure 22](#) and [Figure 23](#) test circuits, system performance will be as specified by the system parameters section of the Electrical Characteristics.

### LM2675-12 Electrical Characteristics

| Symbol   | Parameter      | Conditions  | Typ <sup>(1)</sup> | Min <sup>(2)</sup>  | Max <sup>(2)</sup>  | Units |
|--|----------------|---|--------------------|---------------------|---------------------|-------|
| <b>SYSTEM PARAMETERS</b> Test Circuit <a href="#">Figure 22</a> <sup>(3)</sup> |                |   |                    |                     |                     |       |
| V <sub>OUT</sub>   | Output Voltage | V <sub>IN</sub> = 15V to 40V, I <sub>LOAD</sub> = 20 mA to 1A | 12                 | 11.82/ <b>11.64</b> | 12.18/ <b>12.36</b> | V     |
| η  | Efficiency     | V <sub>IN</sub> = 24V, I <sub>LOAD</sub> = 1A                 | 94                 |                     |                     | %     |

- (1) Typical numbers are at 25°C and represent the most likely norm.
- (2) All limits specified at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are specified via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in [Figure 22](#) and [Figure 23](#) test circuits, system performance will be as specified by the system parameters section of the Electrical Characteristics.

### LM2675-ADJ Electrical Characteristics

| Symbol   | Parameter        | Conditions  | Typ <sup>(1)</sup> | Min <sup>(2)</sup>  | Max <sup>(2)</sup>  | Units |
|--|------------------|---|--------------------|---------------------|---------------------|-------|
| <b>SYSTEM PARAMETERS</b> Test Circuit <a href="#">Figure 23</a> <sup>(3)</sup> |                  |   |                    |                     |                     |       |
| V <sub>FB</sub>  | Feedback Voltage | V <sub>IN</sub> = 8V to 40V, I <sub>LOAD</sub> = 20 mA to 1A<br>V <sub>OUT</sub> Programmed for 5V<br>(see Circuit of <a href="#">Figure 23</a> )       | 1.210              | 1.192/ <b>1.174</b> | 1.228/ <b>1.246</b> | V     |
| V <sub>FB</sub>  | Feedback Voltage | V <sub>IN</sub> = 6.5V to 40V, I <sub>LOAD</sub> = 20 mA to 500 mA<br>V <sub>OUT</sub> Programmed for 5V<br>(see Circuit of <a href="#">Figure 23</a> ) | 1.210              | 1.192/ <b>1.174</b> | 1.228/ <b>1.246</b> | V     |
| η  | Efficiency       | V <sub>IN</sub> = 12V, I <sub>LOAD</sub> = 1A   | 90                 |                     |                     | %     |

- (1) Typical numbers are at 25°C and represent the most likely norm.
- (2) All limits specified at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are specified via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
- (3) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in [Figure 22](#) and [Figure 23](#) test circuits, system performance will be as specified by the system parameters section of the Electrical Characteristics.

### All Output Voltage Versions Electrical Characteristics

Specifications with standard type face are for T<sub>J</sub> = 25°C, and those with **bold type face** apply over **full Operating Temperature Range**. Unless otherwise specified, V<sub>IN</sub> = 12V for the 3.3V, 5V, and Adjustable versions and V<sub>IN</sub> = 24V for the 12V version, and I<sub>LOAD</sub> = 100 mA.

| Symbol                   | Parameters                | Conditions   | Typ  | Min              | Max             | Units |
|--------------------------|---------------------------|--|------|------------------|-----------------|-------|
| <b>DEVICE PARAMETERS</b> |                           |  |      |                  |                 |       |
| I <sub>Q</sub>           | Quiescent Current         | V <sub>FEEDBACK</sub> = 8V<br>For 3.3V, 5.0V, and ADJ Versions | 2.5  |                  | 3.6             | mA    |
|                          |                           | V <sub>FEEDBACK</sub> = 15V<br>For 12V Versions                | 2.5  |                  |                 | mA    |
| I <sub>STBY</sub>        | Standby Quiescent Current | ON/OFF Pin = 0V  | 50   |                  | 100/ <b>150</b> | μA    |
| I <sub>CL</sub>          | Current Limit             |  | 1.55 | 1.25/ <b>1.2</b> | 2.1/ <b>2.2</b> | A     |

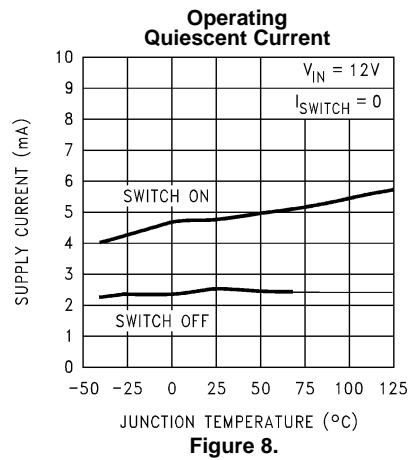
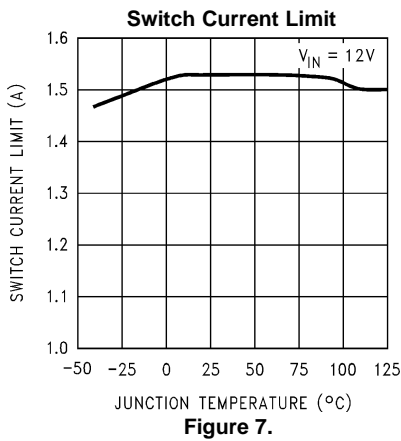
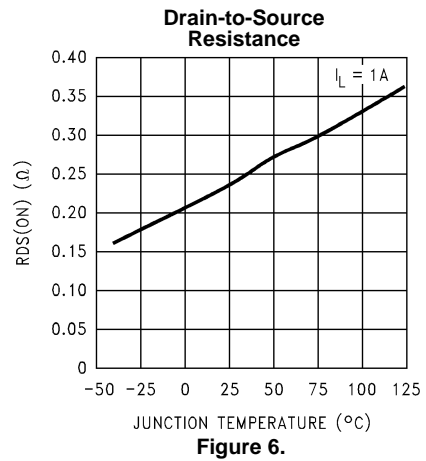
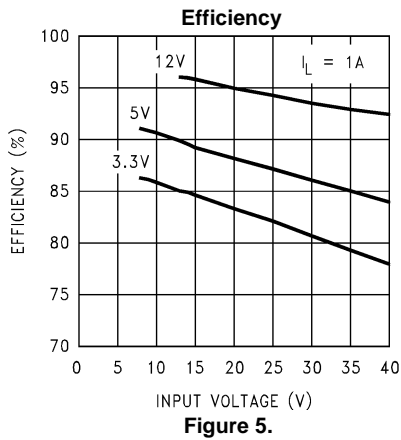
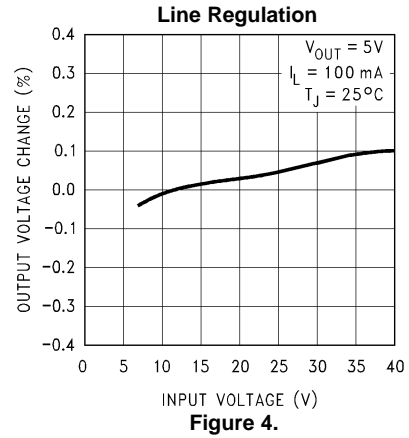
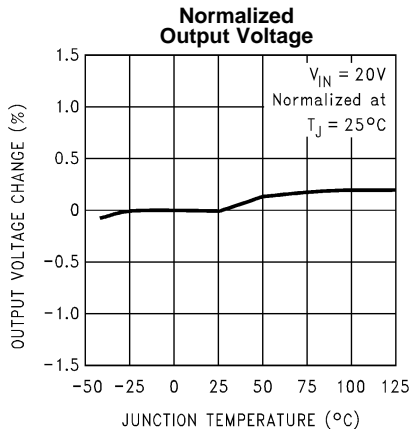
**All Output Voltage Versions Electrical Characteristics (continued)**

Specifications with standard type face are for  $T_J = 25^\circ\text{C}$ , and those with **bold type face** apply over **full Operating Temperature Range**. Unless otherwise specified,  $V_{IN} = 12\text{V}$  for the 3.3V, 5V, and Adjustable versions and  $V_{IN} = 24\text{V}$  for the 12V version, and  $I_{LOAD} = 100\text{ mA}$ .

| Symbol        | Parameters                   | Conditions  | Typ  | Min        | Max               | Units              |
|---------------|------------------------------|---|------|------------|-------------------|--------------------|
| $I_L$         | Output Leakage Current       | $V_{IN} = 40\text{V}$ , ON/OFF Pin = 0V<br>$V_{SWITCH} = 0\text{V}$ | 1    |            | 25                | $\mu\text{A}$      |
|               |                              | $V_{SWITCH} = -1\text{V}$ , ON/OFF Pin = 0V                         | 6    |            | 15                | mA                 |
| $R_{DS(ON)}$  | Switch On-Resistance         | $I_{SWITCH} = 1\text{A}$  | 0.25 |            | 0.30/ <b>0.50</b> | $\Omega$           |
| $f_O$         | Oscillator Frequency         | Measured at Switch Pin  | 260  | <b>225</b> | <b>275</b>        | kHz                |
| D             | Maximum Duty Cycle           |   | 95   |            |                   | %                  |
|               | Minimum Duty Cycle           |   | 0    |            |                   | %                  |
| $I_{BIAS}$    | Feedback Bias Current        | $V_{FEEDBACK} = 1.3\text{V}$<br>ADJ Version Only                    | 85   |            |                   | nA                 |
| $V_{S/D}$     | ON/OFF Pin Voltage Thesholds |   | 1.4  | <b>0.8</b> | <b>2.0</b>        | V                  |
| $I_{S/D}$     | ON/OFF Pin Current           | ON/OFF Pin = 0V   | 20   | <b>7</b>   | <b>37</b>         | $\mu\text{A}$      |
| $\theta_{JA}$ | Thermal Resistance           | P Package, Junction to Ambient <sup>(1)</sup>                       | 95   |            |                   | $^\circ\text{C/W}$ |
|               |                              | D Package, Junction to Ambient <sup>(1)</sup>                       | 105  |            |                   |                    |

- (1) Junction to ambient thermal resistance with approximately 1 square inch of printed circuit board copper surrounding the leads. Additional copper area will lower thermal resistance further. See [Application Information](#) section in the application note accompanying this datasheet and the thermal model in **LM267X Made Simple** software (version 6.0). The value  $\theta_{J-A}$  for the WSON (NHN) package is specifically dependent on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, refer to Application Note AN-1187 ([SNOA401](#)).

Typical Performance Characteristics



Typical Performance Characteristics (continued)

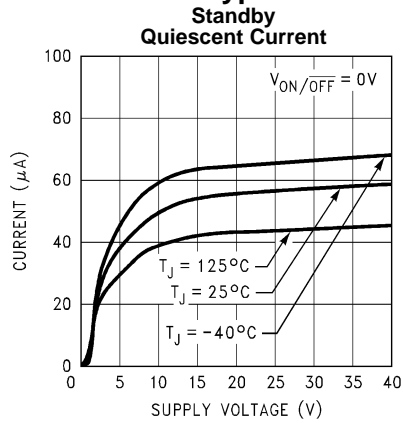


Figure 9.

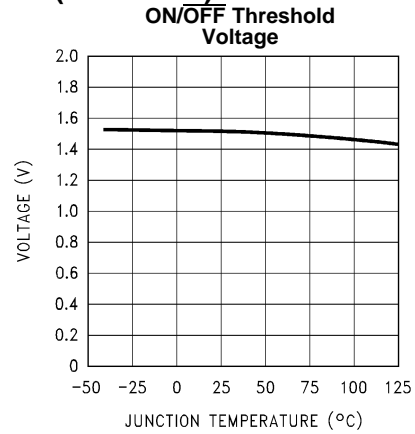


Figure 10.

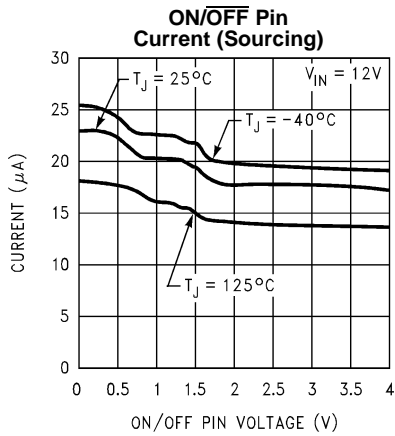


Figure 11.

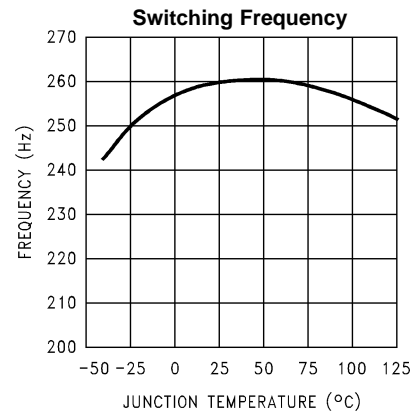


Figure 12.

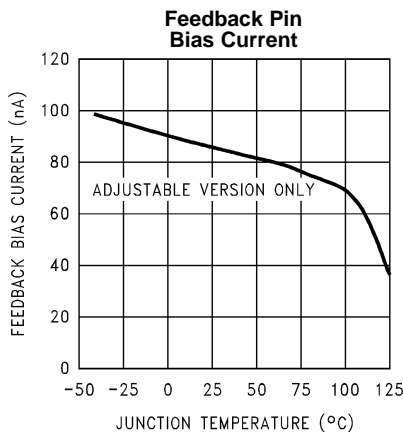


Figure 13.

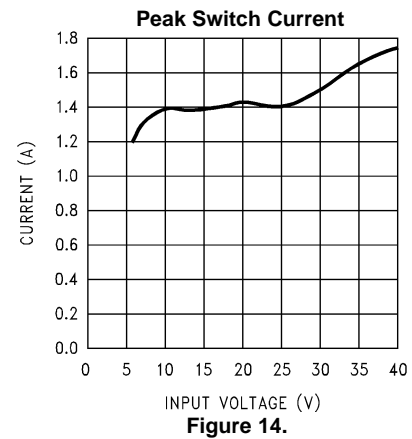


Figure 14.

Typical Performance Characteristics (continued)

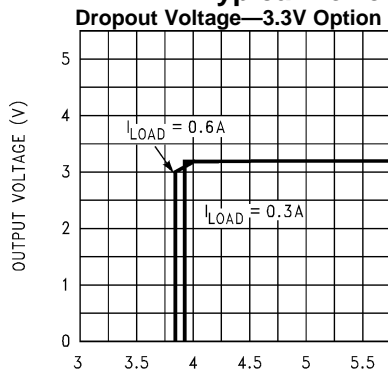


Figure 15. m

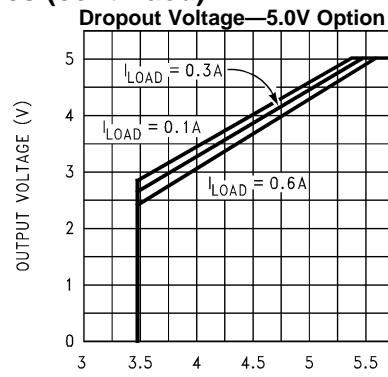
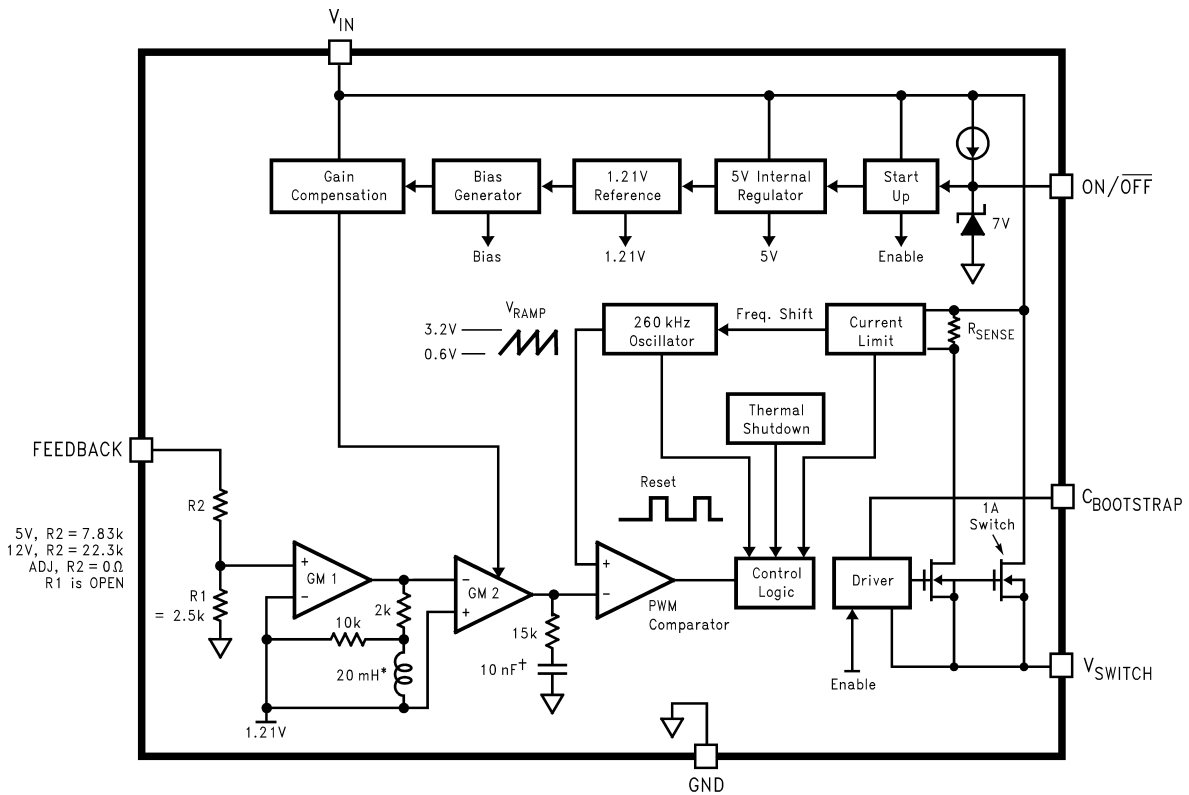


Figure 16.

Block Diagram



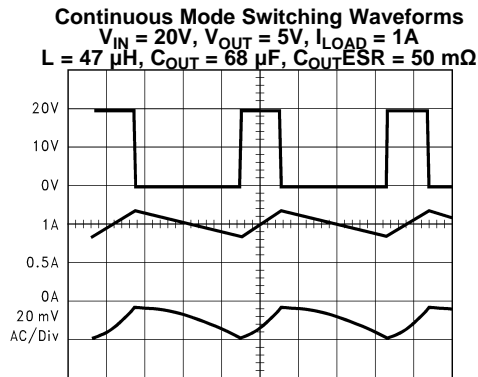
\* Active Inductor Patent Number 5,514,947  
† Active Capacitor Patent Number 5,382,918

Figure 17.

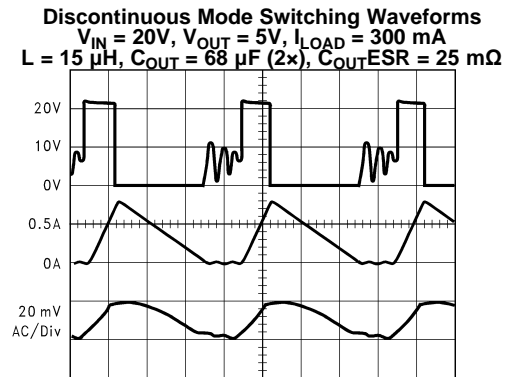


## Typical Performance Characteristics

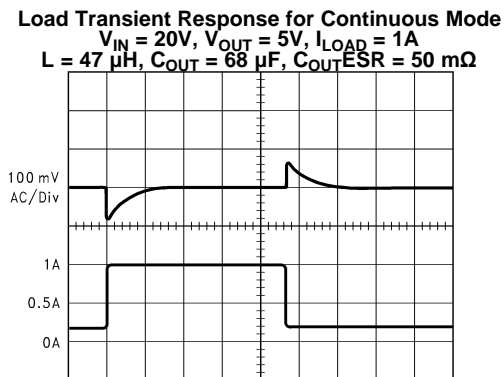
(Circuit of [Figure 22](#))



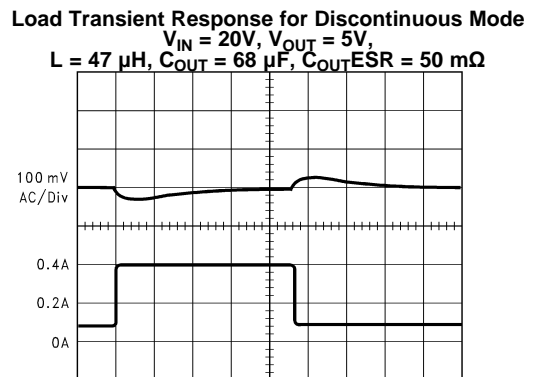
A:  $V_{SW}$  Pin Voltage, 10 V/div.  
 B: Inductor Current, 0.5 A/div  
 C: Output Ripple Voltage, 20 mV/div AC-Coupled  
**Figure 18. Horizontal Time Base: 1  $\mu s$ /div**



A:  $V_{SW}$  Pin Voltage, 10 V/div.  
 B: Inductor Current, 0.5 A/div  
 C: Output Ripple Voltage, 20 mV/div AC-Coupled  
**Figure 19. Horizontal Time Base: 1  $\mu s$ /div**

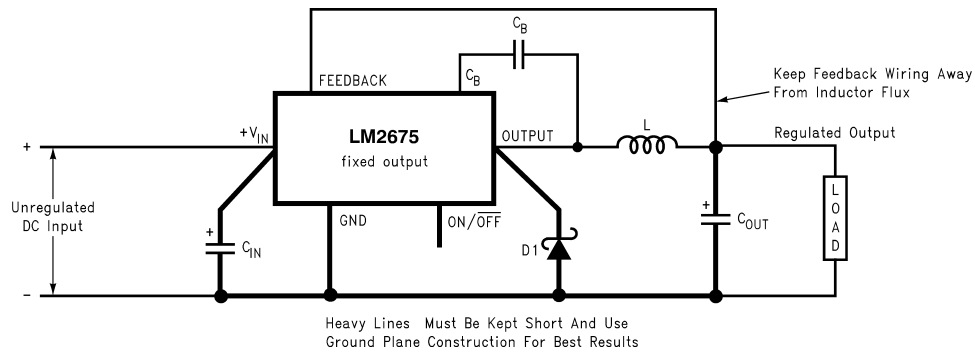


A: Output Voltage, 100 mV/div, AC-Coupled.  
 B: Load Current: 200 mA to 1A Load Pulse  
**Figure 20. Horizontal Time Base: 50  $\mu s$ /div**



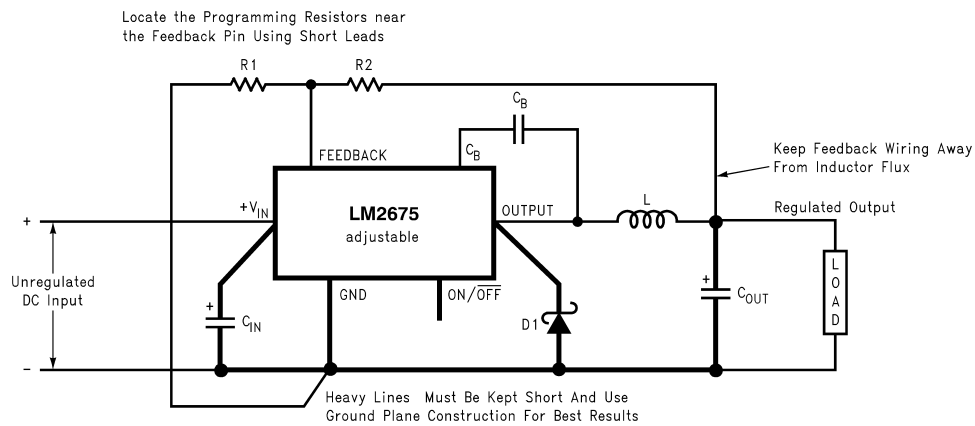
A: Output Voltage, 100 mV/div, AC-Coupled.  
 B: Load Current: 100 mA to 400 mA Load Pulse  
**Figure 21. Horizontal Time Base: 200  $\mu s$ /div**

### Test Circuit and Layout Guidelines



$C_{IN}$  - 22  $\mu$ F, 50V Tantalum, Sprague "199D Series"  
 $C_{OUT}$  - 47  $\mu$ F, 25V Tantalum, Sprague "595D Series"  
 D1 - 3.3A, 50V Schottky Rectifier, IR 30WQ05F  
 L1 - 68  $\mu$ H Sumida #RCR110D-680L  
 $C_B$  - 0.01  $\mu$ F, 50V Ceramic

**Figure 22. Standard Test Circuits and Layout Guides Fixed Output Voltage Versions**



$C_{IN}$  - 22  $\mu$ F, 50V Tantalum, Sprague "199D Series"  
 $C_{OUT}$  - 47  $\mu$ F, 25V Tantalum, Sprague "595D Series"  
 D1 - 3.3A, 50V Schottky Rectifier, IR 30WQ05F  
 L1 - 68  $\mu$ H Sumida #RCR110D-680L  
 $R_1$  - 1.5 k $\Omega$ , 1%  
 $C_B$  - 0.01  $\mu$ F, 50V Ceramic  
 For a 5V output, select  $R_2$  to be 4.75 k $\Omega$ , 1%

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

where  $V_{REF} = 1.21V$

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

Use a 1% resistor for best stability.

**Figure 23. Standard Test Circuits and Layout Guides Adjustable Output Voltage Version**

**LM2675 Series Buck Regulator Design Procedure (Fixed Output)**

| PROCEDURE (Fixed Output Voltage Version)  | EXAMPLE (Fixed Output Voltage Version)  |
|---|---|
| <p>To simplify the buck regulator design procedure, Texas Instruments is making available computer design software to be used with the SIMPLE SWITCHER line of switching regulators. <b>LM267X Made Simple</b> version 6.0 is available on Windows® 3.1, NT, or 95 operating systems.</p>   |   |
| <b>Given:</b>   | <b>Given:</b>   |
| $V_{OUT}$ = Regulated Output Voltage (3.3V, 5V, or 12V)   | $V_{OUT}$ = 5V  |
| $V_{IN(max)}$ = Maximum DC Input Voltage  | $V_{IN(max)}$ = 12V   |
| $I_{LOAD(max)}$ = Maximum Load Current  | $I_{LOAD(max)}$ = 1A  |
| <b>1. Inductor Selection (L1)</b>   | <b>1. Inductor Selection (L1)</b>   |
| <p><b>A.</b> Select the correct inductor value selection guide from <a href="#">Figure 24</a>, <a href="#">Figure 25</a> or <a href="#">Figure 26</a> (output voltages of 3.3V, 5V, or 12V respectively). For all other voltages, see the design procedure for the adjustable version.</p>  | <p><b>A.</b> Use the inductor selection guide for the 5V version shown in <a href="#">Figure 25</a>.</p>  |
| <p><b>B.</b> From the inductor value selection guide, identify the inductance region intersected by the Maximum Input Voltage line and the Maximum Load Current line. Each region is identified by an inductance value and an inductor code (LXX).</p>  | <p><b>B.</b> From the inductor value selection guide shown in <a href="#">Figure 25</a>, the inductance region intersected by the 12V horizontal line and the 1A vertical line is 33 <math>\mu</math>H, and the inductor code is L23.</p>   |
| <p><b>C.</b> Select an appropriate inductor from the four manufacturer's part numbers listed in <a href="#">Inductor Value Selection Guides</a>. Each manufacturer makes a different style of inductor to allow flexibility in meeting various design requirements. Listed below are some of the differentiating characteristics of each manufacturer's inductors:</p>  | <p><b>C.</b> The inductance value required is 33 <math>\mu</math>H. From the table in <a href="#">Table 1</a>, go to the L23 line and choose an inductor part number from any of the four manufacturers shown. (In most instances, both through hole and surface mount inductors are available.)</p>  |
| <p><i>Schott:</i> ferrite EP core inductors; these have very low leakage magnetic fields to reduce electro-magnetic interference (EMI) and are the lowest power loss inductors</p>  |   |
| <p><i>Renco:</i> ferrite stick core inductors; benefits are typically lowest cost inductors and can withstand E•T and transient peak currents above rated value. Be aware that these inductors have an external magnetic field which may generate more EMI than other types of inductors.</p>   |   |
| <p><i>Pulse:</i> powdered iron toroid core inductors; these can also be low cost and can withstand larger than normal E•T and transient peak currents. Toroid inductors have low EMI.</p>   |   |
| <p><i>Coilcraft:</i> ferrite drum core inductors; these are the smallest physical size inductors, available only as SMT components. Be aware that these inductors also generate EMI—but less than stick inductors.</p>  |   |
| <p>Complete specifications for these inductors are available from the respective manufacturers. A table listing the manufacturers' phone numbers is located in <a href="#">Table 2</a>.</p>   |   |
| <b>2. Output Capacitor Selection (C<sub>OUT</sub>)</b>  | <b>2. Output Capacitor Selection (C<sub>OUT</sub>)</b>  |
| <p><b>A.</b> Select an output capacitor from the output capacitor table in <a href="#">Table 3</a>. Using the output voltage and the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor value and voltage rating.</p>   | <p><b>A.</b> Use the 5.0V section in the output capacitor table in <a href="#">Table 3</a>. Choose a capacitor value and voltage rating from the line that contains the inductance value of 33 <math>\mu</math>H. The capacitance and voltage rating values corresponding to the 33 <math>\mu</math>H inductor are the:</p>   |
| <p>The capacitor list contains through-hole electrolytic capacitors from four different capacitor manufacturers and surface mount tantalum capacitors from two different capacitor manufacturers. It is recommended that both the manufacturers and the manufacturer's series that are listed in the table be used. A table listing the manufacturers' phone numbers is located in <a href="#">Table 2</a>.</p> | <p>Surface Mount:<br/>                     68 <math>\mu</math>F/10V Sprague 594D Series.<br/>                     100 <math>\mu</math>F/10V AVX TPS Series.<br/>                     Through Hole:<br/>                     68 <math>\mu</math>F/10V Sanyo OS-CON SA Series.<br/>                     220 <math>\mu</math>F/35V Sanyo MV-GX Series.<br/>                     220 <math>\mu</math>F/35V Nichicon PL Series.<br/>                     220 <math>\mu</math>F/35V Panasonic HFQ Series.</p> |

| PROCEDURE (Fixed Output Voltage Version)  | EXAMPLE (Fixed Output Voltage Version)  |
|---|---|
| <p><b>3. Catch Diode Selection (D1)</b></p> <p><b>A.</b> In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, <math>1-D</math> (<math>D</math> is the switch duty cycle, which is approximately the output voltage divided by the input voltage). The largest value of the catch diode average current occurs at the maximum load current and maximum input voltage (minimum <math>D</math>). For normal operation, the catch diode current rating must be at least 1.3 times greater than its maximum average current. However, if the power supply design must withstand a continuous output short, the diode should have a current rating equal to the maximum current limit of the LM2675. The most stressful condition for this diode is a shorted output condition.</p> <p><b>B.</b> The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage.</p> <p><b>C.</b> Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best performance and efficiency. This Schottky diode must be located close to the LM2675 using short leads and short printed circuit traces.</p>  | <p><b>3. Catch Diode Selection (D1)</b></p> <p><b>A.</b> Refer to the table shown in <a href="#">Table 5</a>. In this example, a 1A, 20V Schottky diode will provide the best performance. If the circuit must withstand a continuous shorted output, a higher current Schottky diode is recommended.</p>   |
| <p><b>4. Input Capacitor (<math>C_{IN}</math>)</b></p> <p>A low ESR aluminum or tantalum bypass capacitor is needed between the input pin and ground to prevent large voltage transients from appearing at the input. This capacitor should be located close to the IC using short leads. In addition, the RMS current rating of the input capacitor should be selected to be at least <math>\frac{1}{2}</math> the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. The curves shown in <a href="#">Figure 28</a> show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors may be required to increase the total minimum RMS current rating to suit the application requirements. For an aluminum electrolytic capacitor, the voltage rating should be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating should be twice the maximum input voltage. The tables in <a href="#">Table 3</a> show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. It is also recommended that they be surge current tested by the manufacturer. The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line. Use caution when using ceramic capacitors for input bypassing, because it may cause severe ringing at the <math>V_{IN}</math> pin.</p> | <p><b>4. Input Capacitor (<math>C_{IN}</math>)</b></p> <p>The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 12V, an aluminum electrolytic capacitor with a voltage rating greater than 15V (<math>1.25 \times V_{IN}</math>) would be needed. The next higher capacitor voltage rating is 16V. The RMS current rating requirement for the input capacitor in a buck regulator is approximately <math>\frac{1}{2}</math> the DC load current. In this example, with a 1A load, a capacitor with a RMS current rating of at least 500 mA is needed. The curves shown in <a href="#">Figure 28</a> can be used to select an appropriate input capacitor. From the curves, locate the 16V line and note which capacitor values have RMS current ratings greater than 500 mA. For a through hole design, a 330 <math>\mu</math>F/16V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS and the Nichicon WF or UR and the NIC Components NACZ series could be considered. For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking <a href="#">Table 8</a>, and the Sprague 594D series datasheet, a Sprague 594D 15 <math>\mu</math>F, 25V capacitor is adequate.</p> |
| <p><b>5. Boost Capacitor (<math>C_B</math>)</b></p> <p>This capacitor develops the necessary voltage to turn the switch gate on fully. All applications should use a 0.01 <math>\mu</math>F, 50V ceramic capacitor.</p>   | <p><b>5. Boost Capacitor (<math>C_B</math>)</b></p> <p>For this application, and all applications, use a 0.01 <math>\mu</math>F, 50V ceramic capacitor.</p>   |

**Inductor Value Selection Guides**  
(For Continuous Mode Operation)

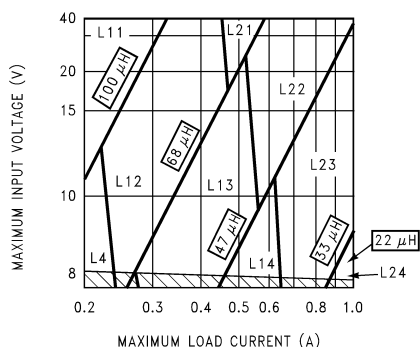


Figure 24. LM2675-3.3

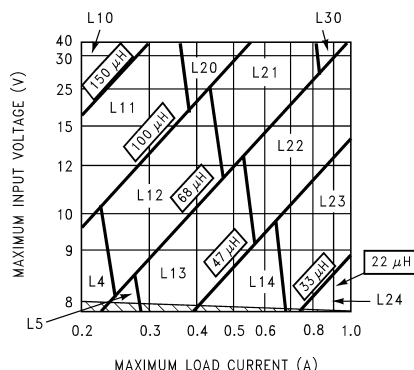


Figure 25. LM2675-5.0

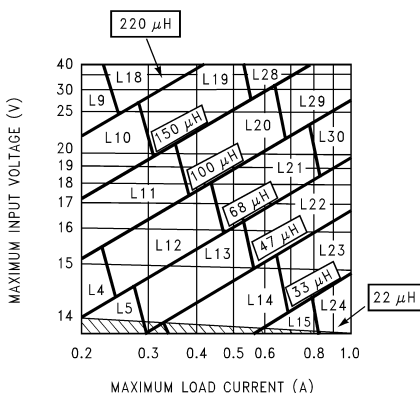


Figure 26. LM2675-12

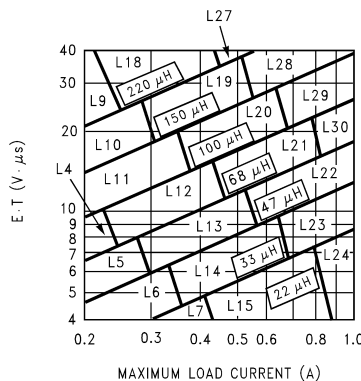


Figure 27. LM2675-ADJ

Table 1. Inductor Manufacturers' Part Numbers

| Ind. Ref. Desg. | Inductance (μH) | Current (A) | Schott       |               | Renco         |               | Pulse Engineering |               | Coilcraft     |
|-----------------|-----------------|-------------|--------------|---------------|---------------|---------------|-------------------|---------------|---------------|
|                 |                 |             | Through Hole | Surface Mount | Through Hole  | Surface Mount | Through Hole      | Surface Mount | Surface Mount |
|                 |                 |             |              |               |               |               |                   |               |               |
| L4              | 68              | 0.32        | 67143940     | 67144310      | RL-1284-68-43 | RL1500-68     | PE-53804          | PE-53804-S    | DO1608-683    |
| L5              | 47              | 0.37        | 67148310     | 67148420      | RL-1284-47-43 | RL1500-47     | PE-53805          | PE-53805-S    | DO1608-473    |
| L6              | 33              | 0.44        | 67148320     | 67148430      | RL-1284-33-43 | RL1500-33     | PE-53806          | PE-53806-S    | DO1608-333    |
| L7              | 22              | 0.52        | 67148330     | 67148440      | RL-1284-22-43 | RL1500-22     | PE-53807          | PE-53807-S    | DO1608-223    |
| L9              | 220             | 0.32        | 67143960     | 67144330      | RL-5470-3     | RL1500-220    | PE-53809          | PE-53809-S    | DO3308-224    |
| L10             | 150             | 0.39        | 67143970     | 67144340      | RL-5470-4     | RL1500-150    | PE-53810          | PE-53810-S    | DO3308-154    |
| L11             | 100             | 0.48        | 67143980     | 67144350      | RL-5470-5     | RL1500-100    | PE-53811          | PE-53811-S    | DO3308-104    |
| L12             | 68              | 0.58        | 67143990     | 67144360      | RL-5470-6     | RL1500-68     | PE-53812          | PE-53812-S    | DO3308-683    |
| L13             | 47              | 0.70        | 67144000     | 67144380      | RL-5470-7     | RL1500-47     | PE-53813          | PE-53813-S    | DO3308-473    |
| L14             | 33              | 0.83        | 67148340     | 67148450      | RL-1284-33-43 | RL1500-33     | PE-53814          | PE-53814-S    | DO3308-333    |
| L15             | 22              | 0.99        | 67148350     | 67148460      | RL-1284-22-43 | RL1500-22     | PE-53815          | PE-53815-S    | DO3308-223    |
| L18             | 220             | 0.55        | 67144040     | 67144420      | RL-5471-2     | RL1500-220    | PE-53818          | PE-53818-S    | DO3316-224    |
| L19             | 150             | 0.66        | 67144050     | 67144430      | RL-5471-3     | RL1500-150    | PE-53819          | PE-53819-S    | DO3316-154    |
| L20             | 100             | 0.82        | 67144060     | 67144440      | RL-5471-4     | RL1500-100    | PE-53820          | PE-53820-S    | DO3316-104    |
| L21             | 68              | 0.99        | 67144070     | 67144450      | RL-5471-5     | RL1500-68     | PE-53821          | PE-53821-S    | DO3316-683    |
| L22             | 47              | 1.17        | 67144080     | 67144460      | RL-5471-6     | —             | PE-53822          | PE-53822-S    | DO3316-473    |

**Table 1. Inductor Manufacturers' Part Numbers (continued)**

| Ind. Ref. Desg. | Inductance (μH) | Current (A) | Schott   |          | Renco         |         | Pulse Engineering |            | Coilcraft   |
|-----------------|-----------------|-------------|----------|----------|---------------|---------|-------------------|------------|-------------|
|                 |                 |             | Through  | Surface  | Through       | Surface | Through           | Surface    | Surface     |
|                 |                 |             | Hole     | Mount    | Hole          | Mount   | Hole              | Mount      | Mount       |
| L23             | 33              | 1.40        | 67144090 | 67144470 | RL-5471-7     | —       | PE-53823          | PE-53823-S | DO3316-333  |
| L24             | 22              | 1.70        | 67148370 | 67148480 | RL-1283-22-43 | —       | PE-53824          | PE-53824-S | DO3316-223  |
| L27             | 220             | 1.00        | 67144110 | 67144490 | RL-5471-2     | —       | PE-53827          | PE-53827-S | DO5022P-224 |
| L28             | 150             | 1.20        | 67144120 | 67144500 | RL-5471-3     | —       | PE-53828          | PE-53828-S | DO5022P-154 |
| L29             | 100             | 1.47        | 67144130 | 67144510 | RL-5471-4     | —       | PE-53829          | PE-53829-S | DO5022P-104 |
| L30             | 68              | 1.78        | 67144140 | 67144520 | RL-5471-5     | —       | PE-53830          | PE-53830-S | DO5022P-683 |

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

|                                       |       |                  |
|---------------------------------------|-------|------------------|
| <b>Coilcraft Inc.</b>                 | Phone | (800) 322-2645   |
|                                       | FAX   | (708) 639-1469   |
| <b>Coilcraft Inc., Europe</b>         | Phone | +44 1236 730 595 |
|                                       | FAX   | +44 1236 730 627 |
| <b>Pulse Engineering Inc.</b>         | Phone | (619) 674-8100   |
|                                       | FAX   | (619) 674-8262   |
| <b>Pulse Engineering Inc., Europe</b> | Phone | +353 93 24 107   |
|                                       | FAX   | +353 93 24 459   |
| <b>Renco Electronics Inc.</b>         | Phone | (800) 645-5828   |
|                                       | FAX   | (516) 586-5562   |
| <b>Schott Corp.</b>                   | Phone | (612) 475-1173   |
|                                       | FAX   | (612) 475-1786   |

**Table 3. Output Capacitor Table**

| Output Voltage (V) | Inductance (μH) | Output Capacitor |         |              |             |           |            |
|--------------------|-----------------|------------------|---------|--------------|-------------|-----------|------------|
|                    |                 | Surface Mount    |         | Through Hole |             |           |            |
|                    |                 | Sprague          | AVX TPS | Sanyo OS-CON | Sanyo MV-GX | Nichicon  | Panasonic  |
|                    |                 | 594D Series      | Series  | SA Series    | Series      | PL Series | HFQ Series |
|                    |                 | (μF/V)           | (μF/V)  | (μF/V)       | (μF/V)      | (μF/V)    | (μF/V)     |
| <b>3.3</b>         | 22              | 120/6.3          | 100/10  | 100/10       | 330/35      | 330/35    | 330/35     |
|                    | 33              | 120/6.3          | 100/10  | 68/10        | 220/35      | 220/35    | 220/35     |
|                    | 47              | 68/10            | 100/10  | 68/10        | 150/35      | 150/35    | 150/35     |
|                    | 68              | 120/6.3          | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |
|                    | 100             | 120/6.3          | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |
|                    | 150             | 120/6.3          | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |
| <b>5.0</b>         | 22              | 100/16           | 100/10  | 100/10       | 330/35      | 330/35    | 330/35     |
|                    | 33              | 68/10            | 100/10  | 68/10        | 220/35      | 220/35    | 220/35     |
|                    | 47              | 68/10            | 100/10  | 68/10        | 150/35      | 150/35    | 150/35     |
|                    | 68              | 100/16           | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |
|                    | 100             | 100/16           | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |
|                    | 150             | 100/16           | 100/10  | 100/10       | 120/35      | 120/35    | 120/35     |

**Table 3. Output Capacitor Table (continued)**

| Output Voltage (V) | Inductance ( $\mu$ H) | Output Capacitor |                     |              |              |              |              |
|--------------------|-----------------------|------------------|---------------------|--------------|--------------|--------------|--------------|
|                    |                       | Surface Mount    |                     | Through Hole |              |              |              |
|                    |                       | Sprague          | AVX TPS             | Sanyo OS-CON | Sanyo MV-GX  | Nichicon     | Panasonic    |
|                    |                       | 594D Series      | Series              | SA Series    | Series       | PL Series    | HFQ Series   |
|                    |                       | ( $\mu$ F/V)     | ( $\mu$ F/V)        | ( $\mu$ F/V) | ( $\mu$ F/V) | ( $\mu$ F/V) | ( $\mu$ F/V) |
| 12                 | 22                    | 120/20           | (2 $\times$ ) 68/20 | 68/20        | 330/35       | 330/35       | 330/35       |
|                    | 33                    | 68/25            | 68/20               | 68/20        | 220/35       | 220/35       | 220/35       |
|                    | 47                    | 47/20            | 68/20               | 47/20        | 150/35       | 150/35       | 150/35       |
|                    | 68                    | 47/20            | 68/20               | 47/20        | 120/35       | 120/35       | 120/35       |
|                    | 100                   | 47/20            | 68/20               | 47/20        | 120/35       | 120/35       | 120/35       |
|                    | 150                   | 47/20            | 68/20               | 47/20        | 120/35       | 120/35       | 120/35       |
|                    | 220                   | 47/20            | 68/20               | 47/20        | 120/35       | 120/35       | 120/35       |

**Table 4. Capacitor Manufacturers' Phone Numbers**

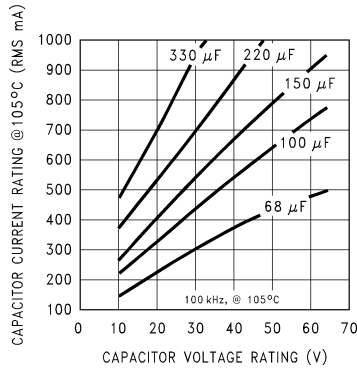
|                |       |                |
|----------------|-------|----------------|
| Nichicon Corp. | Phone | (847) 843-7500 |
|                | FAX   | (847) 843-2798 |
| Panasonic      | Phone | (714) 373-7857 |
|                | FAX   | (714) 373-7102 |
| AVX Corp.      | Phone | (803) 448-9411 |
|                | FAX   | (803) 448-1943 |
| Sprague/Vishay | Phone | (207) 324-4140 |
|                | FAX   | (207) 324-7223 |
| Sanyo Corp.    | Phone | (619) 661-6322 |
|                | FAX   | (619) 661-1055 |

**Table 5. Schottky Diode Selection Table**

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

**Table 6. Diode Manufacturers' Phone Numbers**

|                                      |       |                |
|--------------------------------------|-------|----------------|
| <b>International Rectifier Corp.</b> | Phone | (310) 322-3331 |
|                                      | FAX   | (310) 322-3332 |
| <b>Motorola, Inc.</b>                | Phone | (800) 521-6274 |
|                                      | FAX   | (602) 244-6609 |
| <b>General Instruments Corp.</b>     | Phone | (516) 847-3000 |
|                                      | FAX   | (516) 847-3236 |
| <b>Diodes, Inc.</b>                  | Phone | (805) 446-4800 |
|                                      | FAX   | (805) 446-4850 |



**Figure 28. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)**

**Table 7. AVX TPS**

| Recommended Application Voltage | Voltage Rating |
|---------------------------------|----------------|
| <b>+85°C Rating</b>             |                |
| 3.3                             | 6.3            |
| 5                               | 10             |
| 10                              | 20             |
| 12                              | 25             |
| 15                              | 35             |

**Table 8. Sprague 594D**

| Recommended Application Voltage | Voltage Rating |
|---------------------------------|----------------|
| <b>+85°C Rating</b>             |                |
| 2.5                             | 4              |
| 3.3                             | 6.3            |
| 5                               | 10             |
| 8                               | 16             |
| 12                              | 20             |
| 18                              | 25             |
| 24                              | 35             |
| 29                              | 50             |



**LM2675 Series Buck Regulator Design Procedure (Adjustable Output)**

| PROCEDURE (Adjustable Output Voltage Version)  | EXAMPLE (Adjustable Output Voltage Version)  |
|--|--|
| <p>To simplify the buck regulator design procedure, Texas Instruments is making available computer design software to be used with the SIMPLE SWITCHER line of switching regulators. <b>LM267X Made Simple</b> version 6.0 is available for use on Windows® 3.1, NT, or 95 operating systems.</p>  |  |
| <p><b>Given:</b></p> <ul style="list-style-type: none"> <li>• <math>V_{OUT}</math> = Regulated Output Voltage</li> <li>• <math>V_{IN(max)}</math> = Maximum Input Voltage</li> <li>• <math>I_{LOAD(max)}</math> = Maximum Load Current</li> <li>• <math>F</math> = Switching Frequency (Fixed at a nominal 260 kHz).</li> </ul>  | <p><b>Given:</b></p> <ul style="list-style-type: none"> <li>• <math>V_{OUT} = 20V</math></li> <li>• <math>V_{IN(max)} = 28V</math></li> <li>• <math>I_{LOAD(max)} = 1A</math></li> <li>• <math>F =</math> Switching Frequency (Fixed at a nominal 260 kHz).</li> </ul>                                     |
| <p><b>1. Programming Output Voltage</b> (Selecting <math>R_1</math> and <math>R_2</math>, as shown in Figure 23)</p>   | <p><b>1. Programming Output Voltage</b> (Selecting <math>R_1</math> and <math>R_2</math>, as shown in Figure 23)</p>   |
| <p>Use the following formula to select the appropriate resistor values.</p> $V_{OUT} = V_{REF} \left( 1 + \frac{R_2}{R_1} \right) \text{ where } V_{REF} = 1.21V$  | <p>Select <math>R_1</math> to be 1 k<math>\Omega</math>, 1%. Solve for <math>R_2</math>.</p> $R_2 = R_1 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) = 1 \text{ k}\Omega \left( \frac{20V}{1.23V} - 1 \right)$   |
| <p>Select a value for <math>R_1</math> between 240<math>\Omega</math> and 1.5 k<math>\Omega</math>. The lower resistor values minimize noise pickup in the sensitive feedback pin. (For the lowest temperature coefficient and the best stability with time, use 1% metal film resistors.)</p> $R_2 = R_1 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right)$  | <p><math>R_2 = 1k (16.53 - 1) = 15.53 \text{ k}\Omega</math>, closest 1% value is 15.4 k<math>\Omega</math>.<br/> <math>R_2 = 15.4 \text{ k}\Omega</math>.</p>   |
| <p><b>2. Inductor Selection (L1)</b></p>   | <p><b>2. Inductor Selection (L1)</b></p>   |
| <p><b>A.</b> Calculate the inductor Volt • microsecond constant <math>E \cdot T</math> (<math>V \cdot \mu s</math>), from the following formula:</p> $E \cdot T = (V_{IN(MAX)} - V_{OUT} - V_{SAT}) \cdot \frac{V_{OUT} + V_D}{V_{IN(MAX)} - V_{SAT} + V_D} \cdot \frac{1000}{260} (V \cdot \mu s)$ <p>where</p> <ul style="list-style-type: none"> <li>• <math>V_{SAT}</math> = internal switch saturation voltage = 0.25V</li> <li>• <math>V_D</math> = diode forward voltage drop = 0.5V</li> </ul> | <p><b>A.</b> Calculate the inductor Volt • microsecond constant (<math>E \cdot T</math>),</p> $E \cdot T = (28 - 20 - 0.25) \cdot \frac{20 + 0.5}{28 - 0.25 + 0.5} \cdot \frac{1000}{260} (V \cdot \mu s)$ $E \cdot T = (7.75) \cdot \frac{20.5}{28.25} \cdot 3.85 (V \cdot \mu s) = 21.6 (V \cdot \mu s)$ |
| <p><b>B.</b> Use the <math>E \cdot T</math> value from the previous formula and match it with the <math>E \cdot T</math> number on the vertical axis of the Inductor Value Selection Guide shown in Figure 27.</p>   | <p><b>B.</b> <math>E \cdot T = 21.6 (V \cdot \mu s)</math></p>   |
| <p><b>C.</b> On the horizontal axis, select the maximum load current.</p>  | <p><b>C.</b> <math>I_{LOAD(max)} = 1A</math></p>   |
| <p><b>D.</b> Identify the inductance region intersected by the <math>E \cdot T</math> value and the Maximum Load Current value. Each region is identified by an inductance value and an inductor code (LXX).</p>   | <p><b>D.</b> From the inductor value selection guide shown in Figure 27, the inductance region intersected by the 21.6 (<math>V \cdot \mu s</math>) horizontal line and the 1A vertical line is 68 <math>\mu H</math>, and the inductor code is L30.</p>   |
| <p><b>E.</b> Select an appropriate inductor from the four manufacturer's part numbers listed in Table 1. For information on the different types of inductors, see the inductor selection in the fixed output voltage design procedure.</p>   | <p><b>E.</b> From the table in Table 1, locate line L30, and select an inductor part number from the list of manufacturers part numbers.</p>   |
| <p><b>3. Output Capacitor Selection (<math>C_{OUT}</math>)</b></p>   | <p><b>3. Output Capacitor Selection (<math>C_{OUT}</math>)</b></p>   |
| <p><b>A.</b> Select an output capacitor from the capacitor code selection guide in Table 9. Using the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor code corresponding to the desired output voltage.</p>   | <p><b>A.</b> Use the appropriate row of the capacitor code selection guide, in Table 9. For this example, use the 15–20V row. The capacitor code corresponding to an inductance of 68 <math>\mu H</math> is C20.</p>   |

| PROCEDURE (Adjustable Output Voltage Version)   | EXAMPLE (Adjustable Output Voltage Version)  |
|---|--|
| <p><b>B.</b> Select an appropriate capacitor value and voltage rating, using the capacitor code, from the output capacitor selection table in <a href="#">Table 10</a>. There are two solid tantalum (surface mount) capacitor manufacturers and four electrolytic (through hole) capacitor manufacturers to choose from. It is recommended that both the manufacturers and the manufacturer's series that are listed in the table be used. A table listing the manufacturers' phone numbers is located in <a href="#">Table 4</a>.</p>   | <p><b>B.</b> From the output capacitor selection table in <a href="#">Table 10</a>, choose a capacitor value (and voltage rating) that intersects the capacitor code(s) selected in section A, C20. The capacitance and voltage rating values corresponding to the capacitor code C20 are the:</p> <p>Surface Mount:<br/> 33 <math>\mu</math>F/25V Sprague 594D Series.<br/> 33 <math>\mu</math>F/25V AVX TPS Series.</p> <p>Through Hole:<br/> 33 <math>\mu</math>F/25V Sanyo OS-CON SC Series.<br/> 120 <math>\mu</math>F/35V Sanyo MV-GX Series.<br/> 120 <math>\mu</math>F/35V Nichicon PL Series.<br/> 120 <math>\mu</math>F/35V Panasonic HFQ Series.</p> <p>Other manufacturers or other types of capacitors may also be used, provided the capacitor specifications (especially the 100 kHz ESR) closely match the characteristics of the capacitors listed in the output capacitor table. Refer to the capacitor manufacturers' data sheet for this information.</p>  |
| <p><b>4. Catch Diode Selection (D1)</b></p> <p><b>A.</b> In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, 1-D (D is the switch duty cycle, which is approximately <math>V_{OUT}/V_{IN}</math>). The largest value of the catch diode average current occurs at the maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than its maximum average current. However, if the power supply design must withstand a continuous output short, the diode should have a current rating greater than the maximum current limit of the LM2675. The most stressful condition for this diode is a shorted output condition.</p>  | <p><b>4. Catch Diode Selection (D1)</b></p> <p><b>A.</b> Refer to the table shown in <a href="#">Table 5</a>. Schottky diodes provide the best performance, and in this example a 1A, 40V Schottky diode would be a good choice. If the circuit must withstand a continuous shorted output, a higher current (at least 2.2A) Schottky diode is recommended.</p>  |
| <p><b>B.</b> The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage.</p>   |  |
| <p><b>C.</b> Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best performance and efficiency. The Schottky diode must be located close to the LM2675 using short leads and short printed circuit traces.</p>  |  |
| <p><b>5. Input Capacitor (C<sub>IN</sub>)</b></p> <p>A low ESR aluminum or tantalum bypass capacitor is needed between the input pin and ground to prevent large voltage transients from appearing at the input. This capacitor should be located close to the IC using short leads. In addition, the RMS current rating of the input capacitor should be selected to be at least ½ the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. The curves shown in <a href="#">Figure 28</a> show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors may be required to increase the total minimum RMS current rating to suit the application requirements.</p> <p>For an aluminum electrolytic capacitor, the voltage rating should be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating should be twice the maximum input voltage. <a href="#">Table 7</a> and <a href="#">Table 8</a> show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. It is also recommended that they be surge current tested by the manufacturer. The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line. Use caution when using ceramic capacitors for input bypassing, because it may cause severe ringing at the V<sub>IN</sub> pin.</p> | <p><b>5. Input Capacitor (C<sub>IN</sub>)</b></p> <p>The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 28V, an aluminum electrolytic capacitor with a voltage rating of at least 35V (<math>1.25 \times V_{IN}</math>) would be needed. The RMS current rating requirement for the input capacitor in a buck regulator is approximately ½ the DC load current. In this example, with a 1A load, a capacitor with a RMS current rating of at least 500 mA is needed. The curves shown in <a href="#">Figure 28</a> can be used to select an appropriate input capacitor. From the curves, locate the 35V line and note which capacitor values have RMS current ratings greater than 500 mA.</p> <p>For a through hole design, a 330 <math>\mu</math>F/35V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS, and the Nichicon WF or UR and the NIC Components NACZ series could be considered.</p> <p>For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking <a href="#">Table 8</a>, and the Sprague 594D series datasheet, a Sprague 594D 15 <math>\mu</math>F, 50V capacitor is adequate.</p> |
| <p><b>6. Boost Capacitor (C<sub>B</sub>)</b></p>  | <p><b>6. Boost Capacitor (C<sub>B</sub>)</b></p>   |
| <p>This capacitor develops the necessary voltage to turn the switch gate on fully. All applications should use a 0.01 <math>\mu</math>F, 50V ceramic capacitor.</p>   | <p>For this application, and all applications, use a 0.01 <math>\mu</math>F, 50V ceramic capacitor.</p>  |

**Table 9. Capacitor Code Selection Guide**

| Case Style <sup>(1)</sup> | Output Voltage (V) | Inductance (μH) |     |     |     |     |     |     |
|---------------------------|--------------------|-----------------|-----|-----|-----|-----|-----|-----|
|                           |                    | 22              | 33  | 47  | 68  | 100 | 150 | 220 |
| SM and TH                 | 1.21–2.50          | —               | —   | —   | —   | C1  | C2  | C3  |
| SM and TH                 | 2.50–3.75          | —               | —   | —   | C1  | C2  | C3  | C3  |
| SM and TH                 | 3.75–5.0           | —               | —   | C4  | C5  | C6  | C6  | C6  |
| SM and TH                 | 5.0–6.25           | —               | C4  | C7  | C6  | C6  | C6  | C6  |
| SM and TH                 | 6.25–7.5           | C8              | C4  | C7  | C6  | C6  | C6  | C6  |
| SM and TH                 | 7.5–10.0           | C9              | C10 | C11 | C12 | C13 | C13 | C13 |
| SM and TH                 | 10.0–12.5          | C14             | C11 | C12 | C12 | C13 | C13 | C13 |
| SM and TH                 | 12.5–15.0          | C15             | C16 | C17 | C17 | C17 | C17 | C17 |
| SM and TH                 | 15.0–20.0          | C18             | C19 | C20 | C20 | C20 | C20 | C20 |
| SM and TH                 | 20.0–30.0          | C21             | C22 | C22 | C22 | C22 | C22 | C22 |
| TH                        | 30.0–37.0          | C23             | C24 | C24 | C25 | C25 | C25 | C25 |

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

**Table 10. Output Capacitor Selection Table**

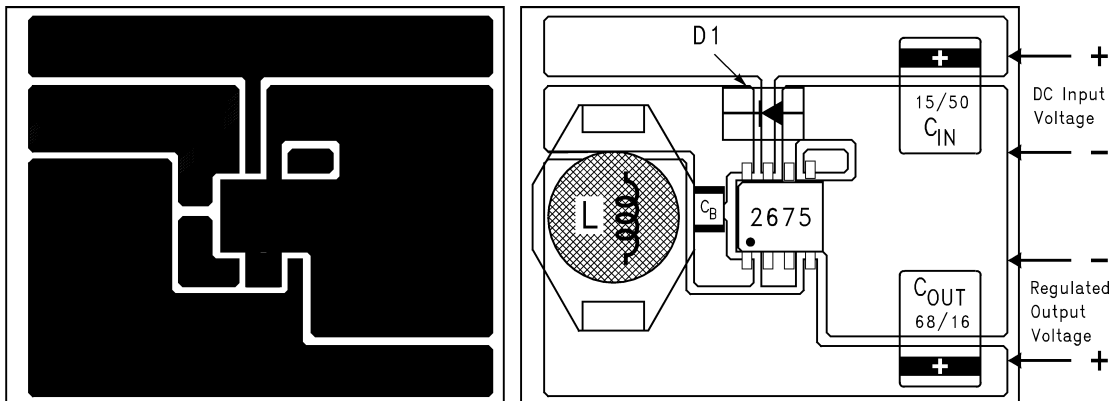
| Cap. Ref. Desg. # | Output Capacitor |                |                      |             |           |            |
|-------------------|------------------|----------------|----------------------|-------------|-----------|------------|
|                   | Surface Mount    |                | Through Hole         |             |           |            |
|                   | Sprague          | AVX TPS        | Sanyo OS-CON         | Sanyo MV-GX | Nichicon  | Panasonic  |
|                   | 594D Series      | Series         | SA Series            | Series      | PL Series | HFQ Series |
|                   | (μF/V)           | (μF/V)         | (μF/V)               | (μF/V)      | (μF/V)    | (μF/V)     |
| C1                | 120/6.3          | 100/10         | 100/10               | 220/35      | 220/35    | 220/35     |
| C2                | 120/6.3          | 100/10         | 100/10               | 150/35      | 150/35    | 150/35     |
| C3                | 120/6.3          | 100/10         | 100/35               | 120/35      | 120/35    | 120/35     |
| C4                | 68/10            | 100/10         | 68/10                | 220/35      | 220/35    | 220/35     |
| C5                | 100/16           | 100/10         | 100/10               | 150/35      | 150/35    | 150/35     |
| C6                | 100/16           | 100/10         | 100/10               | 120/35      | 120/35    | 120/35     |
| C7                | 68/10            | 100/10         | 68/10                | 150/35      | 150/35    | 150/35     |
| C8                | 100/16           | 100/10         | 100/10               | 330/35      | 330/35    | 330/35     |
| C9                | 100/16           | 100/16         | 100/16               | 330/35      | 330/35    | 330/35     |
| C10               | 100/16           | 100/16         | 68/16                | 220/35      | 220/35    | 220/35     |
| C11               | 100/16           | 100/16         | 68/16                | 150/35      | 150/35    | 150/35     |
| C12               | 100/16           | 100/16         | 68/16                | 120/35      | 120/35    | 120/35     |
| C13               | 100/16           | 100/16         | 100/16               | 120/35      | 120/35    | 120/35     |
| C14               | 100/16           | 100/16         | 100/16               | 220/35      | 220/35    | 220/35     |
| C15               | 47/20            | 68/20          | 47/20                | 220/35      | 220/35    | 220/35     |
| C16               | 47/20            | 68/20          | 47/20                | 150/35      | 150/35    | 150/35     |
| C17               | 47/20            | 68/20          | 47/20                | 120/35      | 120/35    | 120/35     |
| C18               | 68/25            | (2x) 33/25     | 47/25 <sup>(1)</sup> | 220/35      | 220/35    | 220/35     |
| C19               | 33/25            | 33/25          | 33/25 <sup>(1)</sup> | 150/35      | 150/35    | 150/35     |
| C20               | 33/25            | 33/25          | 33/25 <sup>(1)</sup> | 120/35      | 120/35    | 120/35     |
| C21               | 33/35            | (2x) 22/25     | <sup>(2)</sup>       | 150/35      | 150/35    | 150/35     |
| C22               | 33/35            | 22/35          | <sup>(2)</sup>       | 120/35      | 120/35    | 120/35     |
| C23               | <sup>(2)</sup>   | <sup>(2)</sup> | <sup>(2)</sup>       | 220/50      | 100/50    | 120/50     |
| C24               | <sup>(2)</sup>   | <sup>(2)</sup> | <sup>(2)</sup>       | 150/50      | 100/50    | 120/50     |
| C25               | <sup>(2)</sup>   | <sup>(2)</sup> | <sup>(2)</sup>       | 150/50      | 82/50     | 82/50      |

(1) The SC series of Os-Con capacitors (others are SA series)

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

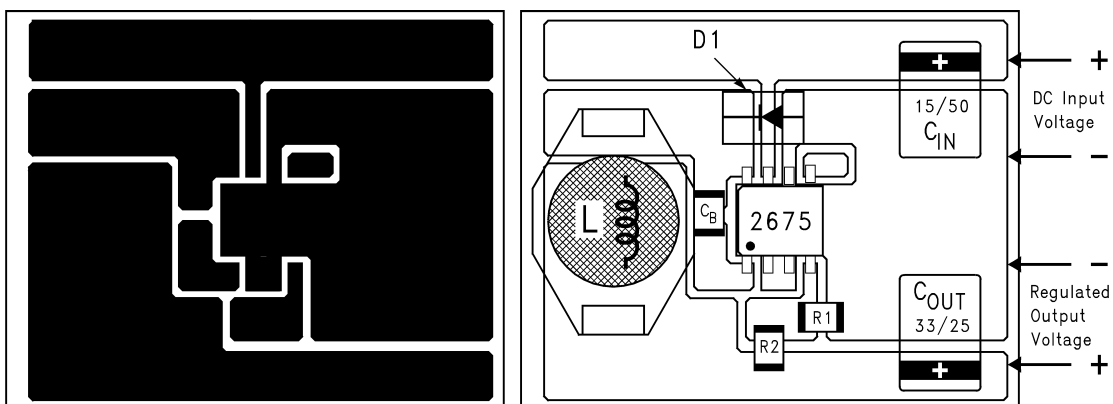
## APPLICATION INFORMATION

### TYPICAL SURFACE MOUNT PC BOARD LAYOUT, FIXED OUTPUT (4X SIZE)



$C_{IN}$  - 15  $\mu$ F, 50V, Solid Tantalum Sprague, "594D series"  
 $C_{OUT}$  - 68  $\mu$ F, 16V, Solid Tantalum Sprague, "594D series"  
 D1 - 1A, 40V Schottky Rectifier, Surface Mount  
 L1 - 33  $\mu$ H, L23, Coilcraft DO3316  
 $C_B$  - 0.01  $\mu$ F, 50V, Ceramic

### TYPICAL SURFACE MOUNT PC BOARD LAYOUT, ADJUSTABLE OUTPUT (4X SIZE)



$C_{IN}$  - 15  $\mu$ F, 50V, Solid Tantalum Sprague, "594D series"  
 $C_{OUT}$  - 33  $\mu$ F, 25V, Solid Tantalum Sprague, "594D series"  
 D1 - 1A, 40V Schottky Rectifier, Surface Mount  
 L1 - 68  $\mu$ H, L30, Coilcraft DO3316  
 $C_B$  - 0.01  $\mu$ F, 50V, Ceramic  
 R1 - 1k, 1%  
 R2 - Use formula in Design Procedure

**Figure 29. PC Board Layout**

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 22](#) and [Figure 23](#)) should be **wide printed circuit traces and should be kept as short as possible**. For best results, external components should be located as close to the switcher IC as possible using ground plane construction or single point grounding.

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

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

### **WSON PACKAGE DEVICES**

The LM2675 is offered in the 16 lead WSON surface mount package to allow for increased power dissipation compared to the SOIC and PDIP.

The Die Attach Pad (DAP) can and should be connected to PCB Ground plane/island. For CAD and assembly guidelines refer to Application Note AN-1187 ([SNOA401](#)).

**PACKAGING INFORMATION**

| Orderable Device   | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|--------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2675LD-5.0       | NRND          | WSON         | NHN                | 16   | 1000           | TBD                        | Call TI                 | Call TI              | -40 to 125   | S000FB                  |                         |
| LM2675LD-5.0/NOPB  | ACTIVE        | WSON         | NHN                | 16   | 1000           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-3-260C-168 HR  | -40 to 125   | S000FB                  | <a href="#">Samples</a> |
| LM2675LD-ADJ/NOPB  | ACTIVE        | WSON         | NHN                | 16   | 1000           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-3-260C-168 HR  | -40 to 125   | S000GB                  | <a href="#">Samples</a> |
| LM2675LDX-ADJ/NOPB | OBSOLETE      | WSON         | NHN                | 16   |                | TBD                        | Call TI                 | Call TI              | -40 to 125   | S000GB                  |                         |
| LM2675M-12         | NRND          | SOIC         | D                  | 8    | 95             | TBD                        | Call TI                 | Call TI              | -40 to 125   | 2675<br>M-12            |                         |
| LM2675M-12/NOPB    | ACTIVE        | SOIC         | D                  | 8    | 95             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M-12            | <a href="#">Samples</a> |
| LM2675M-3.3/NOPB   | ACTIVE        | SOIC         | D                  | 8    | 95             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M3.3            | <a href="#">Samples</a> |
| LM2675M-5.0        | NRND          | SOIC         | D                  | 8    | 95             | TBD                        | Call TI                 | Call TI              | -40 to 125   | 2675<br>M5.0            |                         |
| LM2675M-5.0/NOPB   | ACTIVE        | SOIC         | D                  | 8    | 95             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M5.0            | <a href="#">Samples</a> |
| LM2675M-ADJ        | NRND          | SOIC         | D                  | 8    | 95             | TBD                        | Call TI                 | Call TI              | -40 to 125   | 2675<br>MADJ            |                         |
| LM2675M-ADJ/NOPB   | ACTIVE        | SOIC         | D                  | 8    | 95             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>MADJ            | <a href="#">Samples</a> |
| LM2675MX-12/NOPB   | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M-12            | <a href="#">Samples</a> |
| LM2675MX-3.3       | NRND          | SOIC         | D                  | 8    |                | TBD                        | Call TI                 | Call TI              | -40 to 125   | 2675<br>M3.3            |                         |
| LM2675MX-3.3/NOPB  | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M3.3            | <a href="#">Samples</a> |
| LM2675MX-5.0/NOPB  | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>M5.0            | <a href="#">Samples</a> |
| LM2675MX-ADJ       | LIFEBUY       | SOIC         | D                  | 8    | 2500           | TBD                        | Call TI                 | Call TI              | -40 to 125   | 2675<br>MADJ            |                         |
| LM2675MX-ADJ/NOPB  | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 125   | 2675<br>MADJ            | <a href="#">Samples</a> |
| LM2675N-12/NOPB    | ACTIVE        | PDIP         | P                  | 8    | 40             | Green (RoHS<br>& no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | -40 to 125   | LM2675<br>N-12          | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2675N-3.3/NOPB | ACTIVE        | PDIP         | P               | 8    | 40          | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | -40 to 125   | LM2675<br>N-3.3         | <a href="#">Samples</a> |
| LM2675N-5.0/NOPB | ACTIVE        | PDIP         | P               | 8    | 40          | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | -40 to 125   | LM2675<br>N-5.0         | <a href="#">Samples</a> |
| LM2675N-ADJ/NOPB | ACTIVE        | PDIP         | P               | 8    | 40          | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-NA-UNLIM     | -40 to 125   | LM2675<br>N-ADJ         | <a href="#">Samples</a> |

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

**ACTIVE:** Product device recommended for new designs.

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

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

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

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

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

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

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**TAPE AND REEL INFORMATION**

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


\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2675LD-5.0      | WSON         | NHN             | 16   | 1000 | 178.0              | 12.4               | 5.3     | 5.3     | 1.3     | 8.0     | 12.0   | Q1            |
| LM2675LD-5.0/NOPB | WSON         | NHN             | 16   | 1000 | 178.0              | 12.4               | 5.3     | 5.3     | 1.3     | 8.0     | 12.0   | Q1            |
| LM2675LD-ADJ/NOPB | WSON         | NHN             | 16   | 1000 | 178.0              | 12.4               | 5.3     | 5.3     | 1.3     | 8.0     | 12.0   | Q1            |
| LM2675MX-12/NOPB  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |
| LM2675MX-3.3/NOPB | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |
| LM2675MX-5.0/NOPB | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |
| LM2675MX-ADJ      | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |
| LM2675MX-ADJ/NOPB | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2675LD-5.0      | WSON         | NHN             | 16   | 1000 | 210.0       | 185.0      | 35.0        |
| LM2675LD-5.0/NOPB | WSON         | NHN             | 16   | 1000 | 213.0       | 191.0      | 55.0        |
| LM2675LD-ADJ/NOPB | WSON         | NHN             | 16   | 1000 | 213.0       | 191.0      | 55.0        |
| LM2675MX-12/NOPB  | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| LM2675MX-3.3/NOPB | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| LM2675MX-5.0/NOPB | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| LM2675MX-ADJ      | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |
| LM2675MX-ADJ/NOPB | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |

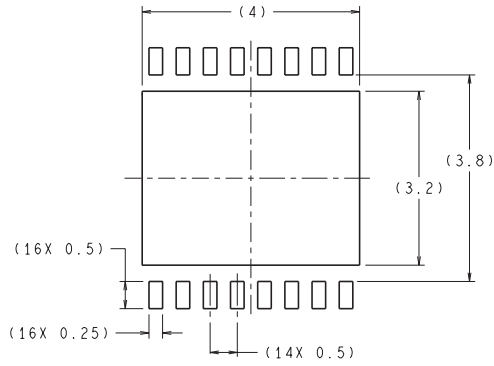
P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



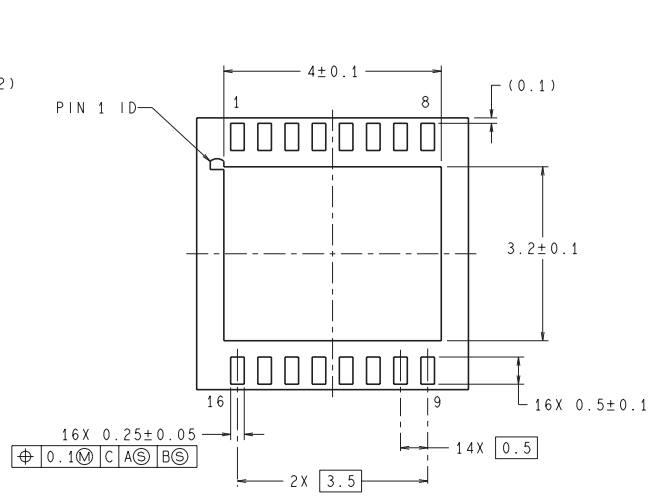
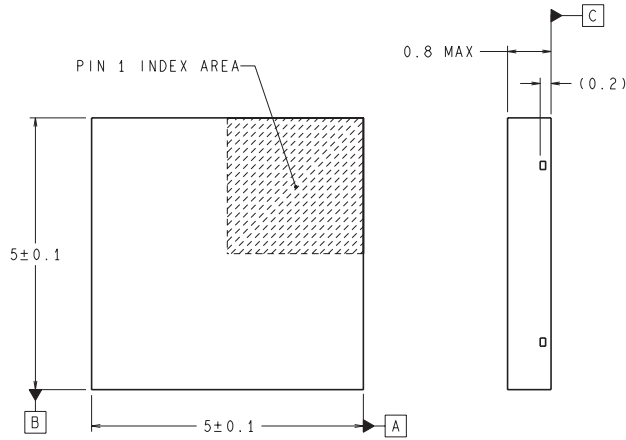
- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

NHN0016A



**RECOMMENDED LAND PATTERN**  
1:1 RATIO WITH PKG SOLDER PADS

DIMENSIONS ARE IN MILLIMETERS



LDA16A (REV A)



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|                               |  |
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