## SIMPLE SWITCHER ${ }^{\circledR}$ Power Converter High Efficiency 500 mA Step-Down Voltage Regulator

## General Description

The LM2674 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 500 mA load current with excellent line and load regulation. These devices are available in fixed output voltages of $3.3 \mathrm{~V}, 5.0 \mathrm{~V}, 12 \mathrm{~V}$, 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 LM2674 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 LM2674 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 a guaranteed $\pm 1.5 \%$ 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 $50 \mu \mathrm{~A}$ stand-by current. The output switch includes current limiting, as well as thermal shutdown for full protection under fault conditions.
To simplify the LM2674 buck regulator design procedure, there exists computer design software, LM267X Made Simple (version 6.0).

## Features

- Efficiency up to $96 \%$
- Available in SO-8, 8-pin DIP and LLP packages
- 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
- $3.3 \mathrm{~V}, 5.0 \mathrm{~V}, 12 \mathrm{~V}$, and adjustable output versions
- Adjustable version output voltage range: 1.21 V to 37 V
- $\pm 1.5 \%$ max output voltage tolerance over line and load conditions
- Guaranteed 500 mA output load current
- $0.25 \Omega$ DMOS Output Switch
- Wide input voltage range: 8 V to 40 V
- 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

Typical Application


10004101

## Connection Diagrams



TABLE 1. Package Marking and Ordering Information

| Output Voltage | Order Information | Package Marking | Supplied as: |
| :---: | :---: | :---: | :---: |
| 16 Lead LLP |  |  |  |
| 3.3 | LM2674LD-3.3 | S000AB | 1000 Units on Tape and Reel |
| 5.0 | LM2674LDX-5.0 | S000BB | 4500 Units on Tape and Reel |
| ADJ | LM2674LD-ADJ | S000CB | 1000 Units on Tape and Reel |
| SO-8 |  |  |  |
| 12 | LM2674M-12 | 2674M-12 | Shipped in Anti-Static Rails |
| 12 | LM2674MX-12 | 2674M-12 | 2500 Units on Tape and Reel |
| 3.3 | LM2674M-3.3 | 2674M-3.3 | Shipped in Anti-Static Rails |
| 3.3 | LM2674MX-3.3 | 2674M-3.3 | 2500 Units on Tape and Reel |
| 5.0 | LM2674M-5.0 | 2674M-5.0 | Shipped in Anti-Static Rails |
| 5.0 | LM2674MX-5.0 | 2674M-5.0 | 2500 Units on Tape and Reel |
| ADJ | LM2674M-ADJ | 2674M-ADJ | Shipped in Anti-Static Rails |
| ADJ | LM2674MX-ADJ | 2674M-ADJ | 2500 Units on Tape and Reel |
| DIP |  |  |  |
| 12 | LM2674N-12 | LM2674N-12 | Shipped in Anti-Static Rails |
| 3.3 | LM2674N-3.3 | LM2674N-3.3 | Shipped in Anti-Static Rails |
| 5.0 | LM2674N-5.0 | LM2674N-5.0 | Shipped in Anti-Static Rails |
| ADJ | LM2674N-ADJ | LM2674N-ADJ | Shipped in Anti-Static Rails |

## Absolute Maximum Ratings <br> (Note 1)

If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.

| Supply Voltage | 45 V | Storage Temperature Range | $-65^{\circ} \mathrm{C}$ to $+150^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: |
| ON/OFF Pin Voltage | $-0.1 \mathrm{~V} \leq \mathrm{V}_{\mathrm{SH}} \leq 6 \mathrm{~V}$ | Lead Temperature |  |
| Switch Voltage to Ground | -1V | M Package |  |
| Boost Pin Voltage | $\mathrm{V}_{\mathrm{SW}}+8 \mathrm{~V}$ | Vapor Phase (60s) | $+215^{\circ} \mathrm{C}$ |
| Feedback Pin Voltage | $-0.3 \mathrm{~V} \leq \mathrm{V}_{\mathrm{FB}} \leq 14 \mathrm{~V}$ | Infrared (15s) | $+220^{\circ} \mathrm{C}$ |
| ESD Susceptibility |  | N Package (Soldering, 10s) | $+260^{\circ} \mathrm{C}$ |
| Human Body Model (Note 2) | 2 kV | LLP Package (See AN-1187) |  |
| Power Dissipation | Internally Limited | Maximum Junction Temperature | $+150^{\circ} \mathrm{C}$ |

## Operating Ratings

| Supply Voltage | 6.5 V to 40 V |
| :--- | ---: |
| Junction Temperature Range | $-40^{\circ} \mathrm{C} \leq \mathrm{T}_{\mathrm{J}} \leq+125^{\circ} \mathrm{C}$ |

## Electrical Characteristics

LM2674-3.3 Specifications with standard type face are for $T_{j}=25^{\circ} \mathrm{C}$, and those with bold type face apply over full Operating Temperature Range.

| Symbol | Parameter | Conditions | Typical <br> $($ Note 4) | Min <br> $($ Note 5) | Max <br> $($ Note 5) | Units |
| :--- | :--- | :--- | :---: | :---: | :---: | :---: |

## LM2674-5.0

| Symbol | Parameter | Conditions | $\begin{array}{c}\text { Typical } \\ \text { (Note 4) }\end{array}$ | $\begin{array}{c}\text { Min } \\ (\text { Note 5) }\end{array}$ | $\begin{array}{c}\text { Max } \\ (\text { Note 5) }\end{array}$ | Units |
| :--- | :--- | :--- | :---: | :---: | :---: | :---: |$\}$

## LM2674-12

| Symbol | Parameter | Conditions | Typical <br> $($ Note 4) | Min <br> $($ Note 5) | Max <br> $($ Note 5) | Units |
| :--- | :--- | :--- | :---: | :---: | :---: | :---: |


| Symbol | Parameter | Conditions | Typ (Note 4) | $\begin{gathered} \text { Min } \\ (\text { Note 5) } \end{gathered}$ | $\begin{gathered} \text { Max } \\ \text { (Note 5) } \end{gathered}$ | Units |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| SYSTEM PARAMETERS Test Circuit Figure 3 (Note 3) |  |  |  |  |  |  |
| $\mathrm{V}_{\mathrm{FB}}$ | Feedback Voltage | $\begin{array}{\|l} \hline \mathrm{V}_{\text {IN }}=8 \mathrm{~V} \text { to } 40 \mathrm{~V}, \mathrm{I}_{\text {LOAD }}=20 \mathrm{~mA} \text { to } 500 \mathrm{~mA} \\ \mathrm{~V}_{\text {OUT }} \text { Programmed for } 5 \mathrm{~V} \\ \text { (see Circuit of Figure 3) } \\ \hline \end{array}$ | 1.210 | 1.192/1.174 | 1.228/1.246 | V |
| $\overline{\mathrm{V}} \mathrm{FB}$ | Feedback Voltage | $\begin{aligned} & \mathrm{V}_{\text {IN }}=6.5 \mathrm{~V} \text { to } 40 \mathrm{~V}, \mathrm{I}_{\text {LOAD }}=20 \mathrm{~mA} \text { to } 250 \mathrm{~mA} \\ & \mathrm{~V}_{\text {OUT }} \text { Programmed for } 5 \mathrm{~V} \\ & \text { (see Circuit of Figure 3) } \end{aligned}$ | 1.210 | 1.192/1.174 | 1.228/1.246 | V |
| $\eta$ | Efficiency | $\mathrm{V}_{\mathrm{IN}}=12 \mathrm{~V}, \mathrm{I}_{\text {LOAD }}=500 \mathrm{~mA}$ | 90 |  |  | \% |

## All Output Voltage Versions

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

| Symbol | Parameters | Conditions | Typ | Min | Max | Units |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| DEVICE PARAMETERS |  |  |  |  |  |  |
| $\mathrm{I}_{\mathrm{Q}}$ | Quiescent Current | $\mathrm{V}_{\text {FEEDBACK }}=8 \mathrm{~V}$ <br> For 3.3V, 5.0V, and ADJ Versions | 2.5 |  | 3.6 | mA |
|  |  | $\mathrm{V}_{\text {FEEDBACK }}=15 \mathrm{~V}$ <br> For 12V Versions | 2.5 |  |  | mA |
| $\mathrm{I}_{\text {STBY }}$ | Standby Quiescent Current | ON/OFF Pin = 0V | 50 |  | 100/150 | $\mu \mathrm{A}$ |
| ${ }_{\text {l }}$ | Current Limit |  | 0.8 | 0.62/0.575 | 1.2/1.25 | A |
| $\mathrm{I}_{\mathrm{L}}$ | Output Leakage Current | $\begin{aligned} & \mathrm{V}_{\text {IN }}=40 \mathrm{~V}, \text { ON/OFF Pin }=0 \mathrm{~V} \\ & \mathrm{~V}_{\text {SWITCH }}=0 \mathrm{~V} \end{aligned}$ | 1 |  | 25 | $\mu \mathrm{A}$ |
|  |  | $\mathrm{V}_{\text {SWITCH }}=-1 \mathrm{~V}$, ON/OFF Pin $=0 \mathrm{~V}$ | 6 |  | 15 | mA |
| $\mathrm{R}_{\mathrm{DS}(\mathrm{ON})}$ | Switch On-Resistance | $\mathrm{I}_{\text {SWITCH }}=500 \mathrm{~mA}$ | 0.25 |  | 0.40/0.60 | $\Omega$ |
| $\mathrm{f}_{\mathrm{O}}$ | Oscillator Frequency | Measured at Switch Pin | 260 | 225 | 275 | kHz |
| D | Maximum Duty Cycle |  | 95 |  |  | \% |
|  | Minimum Duty Cycle |  | 0 |  |  | \% |
| $\mathrm{I}_{\text {BIAS }}$ | Feedback Bias Current | $\begin{aligned} & \mathrm{V}_{\text {FEEDBACK }}=1.3 \mathrm{~V} \\ & \text { ADJ Version Only } \\ & \hline \end{aligned}$ | 85 |  |  | nA |
| $\mathrm{V}_{\text {S/D }}$ | ON/OFF Pin Voltage Theshold | Turn-On Threshold, Rising (Note 7) | 1.4 | 0.8 | 2.0 | V |
| $\mathrm{I}_{\text {S/D }}$ | ON/OFF Pin Current | ON/OFF Pin = 0V | 20 | 7 | 37 | $\mu \mathrm{A}$ |
| $\theta_{\text {JA }}$ | Thermal Resistance | N Package, Junction to Ambient (Note 6) M Package, Junction to Ambient (Note 6) | $\begin{gathered} \hline 95 \\ 105 \end{gathered}$ |  |  | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |

Note 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 guaranteed under these conditions. For guaranteed specifications and test conditions, see the Electrical Characteristics.
Note 2: The human body model is a 100 pF capacitor discharged through a $1.5 \mathrm{k} \Omega$ resistor into each pin.
Note 3: External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2674 is used as shown in Figures 2, 3 test circuits, system performance will be as specified by the system parameters section of the Electrical Characteristics.
Note 4: Typical numbers are at $25^{\circ} \mathrm{C}$ and represent the most likely norm.
Note 5: All limits guaranteed 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 guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
Note 6: 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 (version 6.0) software. The value $\theta_{J-A}$ for the LLP (LD) 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 LLP package, refer to Application Note AN-1187.
Note 7: The ON/OFF pin is internally pulled up to 7 V and can be left floating for always-on operation.

## Typical Performance Characteristics





Drain-to-Source Resistance


10004106
Operating Quiescent Current


10004108


10004109

ON/OFF Pin
Current (Sourcing)


0004111

## ON/OFF Threshold

 Voltage


Peak Switch Current



10004116

## Typical Performance Characteristics



A: $\mathrm{V}_{\mathrm{Sw}}$ Pin Voltage, $10 \mathrm{~V} /$ div.
B: Inductor Current, 0.2 A/div
C: Output Ripple Voltage, $50 \mathrm{mV} /$ div AC-Coupled

$$
\text { Horizontal Time Base: } 1 \mu \mathrm{~s} / \mathrm{div}
$$

Load Transient Response for Continuous Mode
$\mathrm{V}_{\mathrm{IN}}=20 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=5 \mathrm{~V}$,
$\mathrm{L}=100 \mu \mathrm{H}, \mathrm{C}_{\text {OUT }}=100 \mu \mathrm{~F}, \mathrm{C}_{\text {oUT }} \mathrm{ESR}=0.1 \Omega$


10004120

[^0]B: Load Current: 100 mA to 500 mA Load Pulse

## Horizontal Time Base: $\mathbf{5 0} \boldsymbol{\mu s} / \mathrm{div}$

10004118

A: $\mathrm{V}_{\mathrm{SW}}$ Pin Voltage, $10 \mathrm{~V} /$ div.
B: Inductor Current, $0.5 \mathrm{~A} / \mathrm{div}$
C: Output Ripple Voltage, 20 mV /div AC-Coupled

## Horizontal Time Base: $1 \mu \mathrm{~s} / \mathrm{div}$

Load Transient Response for Discontinuous Mode

$$
\mathrm{V}_{\mathrm{IN}}=20 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=5 \mathrm{~V},
$$

$\mathrm{L}=47 \mu \mathrm{H}, \mathrm{C}_{\text {OUT }}=68 \mu \mathrm{~F}, \mathrm{C}_{\text {OUT }} \mathrm{ESR}=50 \mathrm{~m} \Omega$


10004121

[^1]Horizontal Time Base: $\mathbf{2 0 0} \mu \mathrm{s} / \mathrm{div}$

## Block Diagram



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

FIGURE 1.

## Test Circuit and Layout Guidelines



Ground Plane Construction For Best Results
10004122
$\mathrm{C}_{\text {IN }}-22 \mu \mathrm{~F}, 50 \mathrm{~V}$ Tantalum, Sprague "199D Series"
$\mathrm{C}_{\text {OUT }}-47 \mu \mathrm{~F}, 25 \mathrm{~V}$ Tantalum, Sprague " 595 D Series"
D1-3.3A, 50V Schottky Rectifier, IR 30WQ05F
L1-68 $\mu \mathrm{H}$ Sumida \#RCR110D-680L
$C_{B}-0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$ Ceramic
FIGURE 2. Standard Test Circuits and Layout Guides Fixed Output Voltage Versions

$\mathrm{C}_{\text {IN }}-22 \mu \mathrm{~F}, 50 \mathrm{~V}$ Tantalum, Sprague "199D Series"
C OUt $-47 \mu \mathrm{~F}, 25 \mathrm{~V}$ Tantalum, Sprague "595D Series"
D1-3.3A, 50V Schottky Rectifier, IR 30WQ05F
L1-68 $\mu \mathrm{H}$ Sumida \#RCR110D-680L
R1-1.5 k $\Omega, 1 \%$
$\mathrm{C}_{\mathrm{B}}-0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$ Ceramic
For a 5 V output, select R2 to be $4.75 \mathrm{k} \Omega, 1 \%$

$$
V_{\text {OUT }}=V_{\text {REF }}\left(1+\frac{R_{2}}{R_{1}}\right)
$$

where $\mathrm{V}_{\text {REF }}=1.21 \mathrm{~V}$

$$
R_{2}=R_{1}\left(\frac{V_{O U T}}{V_{R E F}}-1\right)
$$

Use a $1 \%$ resistor for best stability.
FIGURE 3. Standard Test Circuits and Layout Guides Adjustable Output Voltage Versions

## LM2674 Series Buck Regulator Design Procedure (Fixed Output)

| PROCEDURE (Fixed Out | EXAMPLE (Fixed Ou |
| :---: | :---: |
| To simplify the buck regulator design procedure, National Semiconductor is making available computer design software to be used with the SIMPLE SWITCHER line of switching regulators. <br> LM267X Made Simple (version 6.0)is available on Windows ${ }^{\circledR}$ 3.1, NT, or 95 operating systems. <br> Given: <br> $\mathrm{V}_{\text {OUT }}=$ Regulated Output Voltage (3.3V, 5 V , or 12 V ) <br> $\mathrm{V}_{\text {IN }}(\max )=$ Maximum DC Input Voltage <br> $\mathrm{I}_{\text {LOAD }}($ max $)=$ Maximum Load Current <br> 1. Inductor Selection (L1) <br> A. Select the correct inductor value selection guide from Figure 4 , Figure 5 or Figure 6 (output voltages of $3.3 \mathrm{~V}, 5 \mathrm{~V}$, or 12 V respectively). For all other voltages, see the design procedure for the adjustable version. <br> 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). <br> C. Select an appropriate inductor from the four manufacturer's part numbers listed in Figure 8. Each manufacturer makes a different style of inductor to allow flexibility in meeting various design requirements. Listed below are some of the differentiating | Given: $\begin{aligned} & \mathrm{V}_{\text {OUT }}=5 \mathrm{~V} \\ & \mathrm{~V}_{\text {IN }}(\max )=12 \mathrm{~V} \\ & \mathrm{I}_{\text {LOAD }}(\max )=500 \mathrm{~mA} \end{aligned}$ <br> 1. Inductor Selection (L1) <br> A. Use the inductor selection guide for the 5 V version shown in Figure 5. <br> B. From the inductor value selection guide shown in Figure 5, the inductance region intersected by the 12 V horizontal line and the 500 mA vertical line is $47 \mu \mathrm{H}$, and the inductor code is L13. <br> C. The inductance value required is $47 \mu \mathrm{H}$. From the table in Figure 8, go to the L13 line and choose an inductor part number from any of the four manufacturers shown. (In most instances, both through hole and surface mount inductors are available.) |

Schott: ferrite EP core inductors; these have very low leakage magnetic fields to reduce electro-magnetic interference (EMI) and are the lowest power loss inductors
Renco: ferrite stick core inductors; benefits are typically lowest cost inductors and can withstand $\mathrm{E} \cdot \mathrm{T}$ and transient peak currents above rated value. Be aware that these inductors have an external magnetic field which may generate more EMI than other types of inductors.
Pulse: powered iron toroid core inductors; these can also be low cost and can withstand larger than normal $\mathrm{E} \bullet \mathrm{T}$ and transient peak currents. Toroid inductors have low EMI.
Coilcraft: ferrite drum core inductors; these are the smallest physical size inductors, available only as SMT components. Be aware that these inductors also generate EMI-but less than stick inductors.
Complete specifications for these inductors are available from the respective manufacturers. A table listing the manufacturers' phone numbers is located in Figure 9.

## 2. Output Capacitor Selection ( $\mathrm{C}_{\mathrm{OUT}}$ )

A. Select an output capacitor from the output capacitor table in Figure 10. Using the output voltage and the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor value and voltage rating.

## 2. Output Capacitor Selection ( $\mathrm{C}_{\mathrm{OUT}}$ )

A. Use the 5.0 V section in the output capacitor table in Figure 10. Choose a capacitor value and voltage rating from the line that contains the inductance value of $47 \mu \mathrm{H}$. The capacitance and voltage rating values corresponding to the $47 \mu \mathrm{H}$ inductor are the:


## 4. Input Capacitor ( $\mathrm{C}_{\mathrm{IN}}$ )

Thertant parameters for the input capacitor are the input volur 12 V a voltage of 12 V , an aluminum electrolytic capacitor with a voltage rating greater than $15 \mathrm{~V}\left(1.25 \times \mathrm{V}_{\text {IN }}\right)$ would be needed. The next higher capacitor voltage rating is 16 V .
The RMS current rating requirement for the input capacitor in a buck regulator is approximately $1 / 2$ the DC load current. In this example, witha 00 mAload, a capacitorwinan RMS currentrating be used to select an appropriate input capacitor. From the curves, locate the 16 V line and note which capacitor values have RMS current ratings greater than 250 mA .
For a through hole design, a $100 \mu \mathrm{~F} / 16 \mathrm{~V}$ electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Addtionaly, for a complete surface 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 Figure $\mu \mathrm{F}, 25 \mathrm{~V}$ capacitor is adequate.

| PROCEDURE (Fixed Output Voltage Version) | EXAMPLE (Fixed Output Voltage Version) |
| :--- | :--- |
| 5. Boost Capacitor ( $\mathrm{C}_{\mathrm{B}}$ ) | 5. Boost Capacitor (C $\mathrm{C}_{\mathrm{B}}$ ) |
| This capacitor develops the necessary voltage to turn the switch |  |
| gate on fully. All applications should use a $0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$ ceramic |  |
| capacitor. |  |

## Inductor Value Selection Guides

(For Continuous Mode Operation)


10004126
FIGURE 4. LM2674-3.3


FIGURE 5. LM2674-5.0


10004128
FIGURE 6. LM2674-12


10004129

| Ind. Ref. Desg. | Inducta nce ( $\mu \mathrm{H}$ ) | Current <br> (A) | Schott |  | Renco |  | Pulse Engineering |  | Coilcraft |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Through Hole | Surface Mount | Through Hole | Surface Mount | Through Hole | Surface Mount | Surface Mount |
| L2 | 150 | 0.21 | 67143920 | 67144290 | RL-5470-4 | RL1500-150 | PE-53802 | PE-53802-S | DO1608-154 |
| L3 | 100 | 0.26 | 67143930 | 67144300 | RL-5470-5 | RL1500-100 | PE-53803 | PE-53803-S | DO1608-104 |
| L4 | 68 | 0.32 | 67143940 | 67144310 | RL-1284-68-43 | RL1500-68 | PE-53804 | PE-53804-S | DO1608-683 |
| L5 | 47 | 0.37 | 67148310 | 67148420 | RL-1284-47-43 | RL1500-47 | PE-53805 | PE-53805-S | DO1608-473 |
| L6 | 33 | 0.44 | 67148320 | 67148430 | RL-1284-33-43 | RL1500-33 | PE-53806 | PE-53806-S | DO1608-333 |
| L7 | 22 | 0.52 | 67148330 | 67148440 | RL-1284-22-43 | RL1500-22 | PE-53807 | PE-53807-S | DO1608-223 |
| L9 | 220 | 0.32 | 67143960 | 67144330 | RL-5470-3 | RL1500-220 | PE-53809 | PE-53809-S | DO3308-224 |
| L10 | 150 | 0.39 | 67143970 | 67144340 | RL-5470-4 | RL1500-150 | PE-53810 | PE-53810-S | DO3308-154 |
| L11 | 100 | 0.48 | 67143980 | 67144350 | RL-5470-5 | RL1500-100 | PE-53811 | PE-53811-S | DO3308-104 |
| L12 | 68 | 0.58 | 67143990 | 67144360 | RL-5470-6 | RL1500-68 | PE-53812 | PE-53812-S | DO3308-683 |
| L13 | 47 | 0.70 | 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 |

## FIGURE 8. Inductor Manufacturers' Part Numbers

| Coilcraft Inc. | Phone | $(800) 322-2645$ |
| :--- | :--- | :--- |
|  | FAX | $(708) 639-1469$ |
| Coilcraft Inc., Europe | Phone | +441236730595 |
|  | FAX | +441236730627 |
| Pulse Engineering Inc. | Phone | $(619) 674-8100$ |
|  | FAX | $(619) 674-8262$ |
| Pulse Engineering Inc., <br> Europe | Phone | +3539324107 |
|  | FAX | +3539324459 |
|  | Phone | $(800) 645-5828$ |
| Schott Corp. | Phone | $(516) 586-5562$ |
|  | FAX | $(612) 475-1173$ |

FIGURE 9. Inductor Manufacturers' Phone Numbers

| Output Voltage (V) | Inductance ( $\mu \mathrm{H}$ ) | Output Capacitor |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Surface Mount |  | Through Hole |  |  |  |
|  |  | Sprague 594D Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | AVX TPS <br> Series <br> ( $\mu \mathrm{F} / \mathrm{V}$ ) | Sanyo OS-CON <br> SA Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | Sanyo MV-GX <br> Series <br> ( $\mu \mathrm{F} / \mathrm{V}$ ) | Nichicon PL Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | Panasonic HFQ Series ( $\mu \mathrm{F} / \mathrm{V}$ ) |
| 3.3 | 22 | 120/6.3 | 100/10 | 100/10 | 330/35 | 330/35 | 330/35 |
|  | 33 | 120/6.3 | 100/10 | 68/10 | 220/35 | 220/35 | 220/35 |
|  | 47 | 68/10 | 100/10 | 68/10 | 150/35 | 150/35 | 150/35 |
|  | 68 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
|  | 100 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
|  | 150 | 120/6.3 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| 5.0 | 22 | 100/16 | 100/10 | 100/10 | 330/35 | 330/35 | 330/35 |
|  | 33 | 68/10 | 10010 | 68/10 | 220/35 | 220/35 | 220/35 |
|  | 47 | 68/10 | 100/10 | 68/10 | 150/35 | 150/35 | 150/35 |
|  | 68 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
|  | 100 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
|  | 150 | 100/16 | 100/10 | 100/10 | 120/35 | 120/35 | 120/35 |
| 12 | 22 | 120/20 | (2x) 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 |

FIGURE 10. Output Capacitor Table

| Nichicon Corp. | Phone | $(847)$ 843-7500 |
| :--- | :--- | :--- |
|  | FAX | $(847)$ 843-2798 |
| Panasonic | Phone | $(714) 373-7857$ |
|  | FAX | $(714) 373-7102$ |
| AVX Corp. | Phone | $(845) 448-9411$ |


|  | FAX | $(845) 448-1943$ |
| :--- | :--- | :--- |
| Sprague/Vishay | Phone | $(207) 324-4140$ |
|  | FAX | $(207) 324-7223$ |
| Sanyo Corp. | Phone | $(619) 661-6322$ |
|  | FAX | $(619) 661-1055$ |

FIGURE 11. Capacitor Manufacturers' Phone Numbers

| $\mathrm{V}_{\mathrm{R}}$ | 500mA 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 |

FIGURE 12. Schottky Diode Selection Table

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

FIGURE 13. Diode Manufacturers' Phone Numbers


FIGURE 14. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)

AVX TPS

| Recommended <br> Application Voltage | Voltage <br> Rating |
| :---: | :---: |
| $+\mathbf{8 5}^{\circ} \mathbf{C}$ Rating |  |
| 3.3 | 6.3 |
| 5 | 10 |
| 10 | 20 |
| 12 | 25 |
| 15 | 35 |

Sprague 594D

| Recommended <br> Application Voltage | Voltage <br> Rating |
| :---: | :---: |
| $+\mathbf{8 5}^{\circ} \mathbf{C}$ Rating |  |
| 2.5 | 4 |
| 3.3 | 6.3 |
| 5 | 10 |
| 8 | 16 |
| 12 | 20 |
| 18 | 25 |
| 24 | 35 |
| 29 | 50 |

FIGURE 15. Recommended Application Voltage for AVX TPS and Sprague 594D Tantalum Chip Capacitors Derated for $85^{\circ} \mathrm{C}$.

## LM2674 Series Buck Regulator Design Procedure (Adjustable Output)

| PROCEDURE (Adjustable Output Voltage Version) |  |
| :--- | :--- |
| To simplify the buck regulator design procedure, National |  |
| Semiconductor is making available computer design software to be |  |
| used with the SIMPLE SWITCHER line of switching regulators. |  |
| LM267X Made Simple (version 6.0) is available for use on |  |
| Windows 3.1, NT, or 95 operating systems. |  |
| Given: | Giver |

$\mathrm{V}_{\text {OUT }}=$ Regulated Output Voltage
$\mathrm{V}_{\text {IN }}(\max )=$ Maximum Input Voltage
$\mathrm{I}_{\text {LOAD }}($ max $)=$ Maximum Load Current
$\mathrm{F}=$ Switching Frequency (Fixed at a nominal 260 kHz ).

1. Programming Output Voltage (Selecting $R_{1}$ and $R_{2}$, as shown in Figure 3)
Use the following formula to select the appropriate resistor values.

$$
\begin{gathered}
V_{\text {OUT }}=V_{\text {REF }}\left(1+\frac{R_{2}}{R_{1}}\right) \\
\text { where } V_{\text {REF }}=1.21 \mathrm{~V}
\end{gathered}
$$

Select a value for $R_{1}$ between $240 \Omega$ and $1.5 \mathrm{k} \Omega$. The lower resistor values minimize noise pickup in the sensitive feedback pin. (For the lowest temperature coefficient and the best stability with time, use $1 \%$ metal film resistors.)

$$
R_{2}=R_{1}\left(\frac{V_{O U T}}{V_{R E F}}-1\right)
$$

## 2. Inductor Selection (L1)

A. Calculate the inductor Volt • microsecond constant E •T (V• $\mu \mathrm{s}$ ), from the following formula:

$$
E \cdot T=\left(V_{I N(M A X)}-V_{O U T}-V_{S A T}\right) \cdot \frac{V_{\text {OUT }}+V_{D}}{V_{I N(M A X)}-V_{S A T}+V_{D}} \cdot \frac{1000}{260}(V \cdot \mu \mathrm{~s})
$$

where $\mathrm{V}_{\mathrm{SAT}}=$ internal switch saturation voltage $=0.25 \mathrm{~V}$ and $\mathrm{V}_{\mathrm{D}}=$ diode forward voltage drop $=0.5 \mathrm{~V}$
B. Use the $\mathrm{E} \cdot \mathrm{T}$ value from the previous formula and match it with the $\mathrm{E} \cdot \mathrm{T}$ number on the vertical axis of the Inductor Value Selection Guide shown in Figure 7.
C. On the horizontal axis, select the maximum load current.
D. Identify the inductance region intersected by the $E \cdot T$ value and the Maximum Load Current value. Each region is identified by an inductance value and an inductor code (LXX).
E. Select an appropriate inductor from the four manufacturer's part numbers listed in Figure 8. For information on the different types of inductors, see the inductor selection in the fixed output voltage design procedure.
3. Output Capacitor Selection ( $\mathrm{C}_{\mathrm{OUT}}$ )
A. Select an output capacitor from the capacitor code selection guide in Figure 16. Using the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor code corresponding to the desired output voltage.

EXAMPLE (Adjustable Output Voltage Version)

## Given:

$$
\begin{aligned}
& \mathrm{V}_{\text {OUT }}=20 \mathrm{~V} \\
& \mathrm{~V}_{\mathrm{IN}}(\max )=28 \mathrm{~V} \\
& \mathrm{I}_{\text {LOAD }}(\max )=500 \mathrm{~mA} \\
& \mathrm{~F}=\text { Switching Frequency (Fixed at a nominal } 260 \mathrm{kHz} \text { ). }
\end{aligned}
$$

1. Programming Output Voltage (Selecting $R_{1}$ and $R_{2}$, as shown in Figure 3)
Select $R_{1}$ to be $1 \mathrm{k} \Omega, 1 \%$. Solve for $R_{2}$.

$$
R_{2}=R_{1}\left(\frac{V_{\text {OUT }}}{V_{\text {REF }}}-1\right)=1 \mathrm{k} \Omega\left(\frac{20 \mathrm{~V}}{1.23 \mathrm{~V}}-1\right)
$$

$R_{2}=1 \mathrm{k}(16.53-1)=15.53 \mathrm{k} \Omega$, closest $1 \%$ value is $15.4 \mathrm{k} \Omega$.
$R_{2}=15.4 \mathrm{k} \Omega$.

## 2. Inductor Selection (L1)

A. Calculate the inductor Volt • microsecond constant $(E \bullet T)$,
$E \cdot T=(28-20-0.25) \cdot \frac{20+0.5}{28-0.25+0.5} \cdot \frac{1000}{260}(V \cdot \mu \mathrm{~s})$ $E \cdot T=(7.75) \cdot \frac{20.5}{28.25} \cdot 3.85(V \cdot \mu \mathrm{~s})=21.6(V \cdot \mu \mathrm{~s})$
B. $E \cdot T=21.6(V \cdot \mu \mathrm{~s})$
C. $\mathrm{I}_{\text {LOAD }}(\max )=500 \mathrm{~mA}$
D. From the inductor value selection guide shown in Figure 7, the inductance region intersected by the $21.6(\mathrm{~V} \bullet \mu \mathrm{~s})$ horizontal line and the 500 mA vertical line is $100 \mu \mathrm{H}$, and the inductor code is L20.
E. From the table in Figure 8, locate line L20, and select an inductor part number from the list of manufacturers part numbers.

## 3. Output Capacitor Selection ( $\mathrm{C}_{\mathrm{OUT}}$ )

A. Use the appropriate row of the capacitor code selection guide, in Figure 16. For this example, use the $15-20 \mathrm{~V}$ row. The capacitor code corresponding to an inductance of $100 \mu \mathrm{H}$ is C20.

## PROCEDURE (Adjustable Output Voltage Version)

B. Select an appropriate capacitor value and voltage rating, using the capacitor code, from the output capacitor selection table in Figure 17. 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 Figure 11.

## 4. Catch Diode Selection (D1)

A. 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 $\mathrm{V}_{\mathrm{OUT}} / \mathrm{V}_{\mathrm{IN}}$ ). The largest value of the catch diode average current occurs at the maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than its maximum average current. However, if the power supply design must withstand a continuous output short, the diode should have a current rating greater than the maximum current limit of the LM2674. The most stressful condition for this diode is a shorted output condition.
B. The reverse voltage rating of the diode should be at least 1.25 times the maximum input voltage.
C. 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 LM2674 using short leads and short printed circuit traces.

## EXAMPLE (Adjustable Output Voltage Version)

B. From the output capacitor selection table in Figure 17, 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:
Surface Mount:
$33 \mu \mathrm{~F} / 25 \mathrm{~V}$ Sprague 594D Series.
$33 \mu \mathrm{~F} / 25 \mathrm{~V}$ AVX TPS Series.
Through Hole:
$33 \mu \mathrm{~F} / 25 \mathrm{~V}$ Sanyo OS-CON SC Series.
$120 \mu \mathrm{~F} / 35 \mathrm{~V}$ Sanyo MV-GX Series.
$120 \mu \mathrm{~F} / 35 \mathrm{~V}$ Nichicon PL Series.
$120 \mu F / 35 V$ Panasonic HFQ Series.
Other manufacturers or other types of capacitors may also be used, provided the capacitor specifications (especially the 100 kHz ESR) closely match the characteristics of the capacitors listed in the output capacitor table. Refer to the capacitor manufacturers' data sheet for this information.

## 4. Catch Diode Selection (D1)

A. Refer to the table shown in Figure 12. Schottky diodes provide the best performance, and in this example a $500 \mathrm{~mA}, 40 \mathrm{~V}$ Schottky diode would be a good choice. If the circuit must withstand a continuous shorted output, a higher current (at least 1.2A) Schottky diode is recommended.

## PROCEDURE (Adjustable Output Voltage Version)

## 5. Input Capacitor ( $\mathrm{C}_{\text {IN }}$ )

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 $1 / 2$ the DC load current. The capacitor manufacturer data sheet mus be checked to assure that this current rating is not exceeded. The curves shown in Figure 14 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 Figure 15 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 only ceramic capacitors for input bypassing, because it may cause severe ringing at the $\mathrm{V}_{\mathrm{IN}}$ pin.

## 6. Boost Capacitor ( $\mathrm{C}_{\mathrm{B}}$ )

This capacitor develops the necessary voltage to turn the switch gate on fully. All applications should use a $0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$ ceramic capacitor.

EXAMPLE (Adjustable Output Voltage Version)

## 5. Input Capacitor ( $\mathrm{C}_{\mathrm{IN}}$ )

The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 28 V , an aluminum electrolytic capacitor with a voltage rating of at least $35 \mathrm{~V}\left(1.25 \times \mathrm{V}_{\text {IN }}\right)$ would be needed.
The RMS current rating requirement for the input capacitor in a buck regulator is approximately $1 / 2$ the DC load current. In this example, with a 500 mA load, a capacitor with an RMS current rating of at least 250 mA is needed. The curves shown in Figure 14 can be used to select an appropriate input capacitor. From the curves, locate the 35 V line and note which capacitor values have RMS current ratings greater than 250 mA .
For a through hole design, a $68 \mu \mathrm{~F} / 35 \mathrm{~V}$ electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) would be adequate. Other types or other manufacturers' capacitors can be used provided the RMS ripple current ratings are adequate. Additionally, for a complete surface mount design, electrolytic capacitors such as the Sanyo CV-C or CV-BS, and the Nichicon WF or UR and the NIC Components NACZ series could be considered.
For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking Figure 15, and the Sprague 594D series datasheet, a Sprague 594D 15 $\mu \mathrm{F}, 50 \mathrm{~V}$ capacitor is adequate.

## 6. Boost Capacitor ( $\mathrm{C}_{\mathrm{B}}$ )

For this application, and all applications, use a $0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$ ceramic capacitor.

| Case <br> Style (Note 8) | Output Voltage (V) | Inductance ( $\mu \mathrm{H}$ ) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 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 |

Note 8: SM - Surface Mount, TH - Through Hole
FIGURE 16. Capacitor Code Selection Guide

| Output Capacitor |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Cap. <br> Ref. <br> Desg. <br> \# | Surface Mount |  | Through Hole |  |  |  |
|  | Sprague 594D Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | AVX TPS <br> Series <br> ( $\mu \mathrm{F} / \mathrm{V}$ ) | Sanyo OS-CON SA Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | Sanyo MV-GX <br> Series <br> ( $\mu \mathrm{F} / \mathrm{V}$ ) | Nichicon PL Series ( $\mu \mathrm{F} / \mathrm{V}$ ) | Panasonic HFQ Series ( $\mu \mathrm{F} / \mathrm{V}$ ) |
| 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 (Note 9) | 220/35 | 220/35 | 220/35 |
| C19 | 33/25 | 33/25 | 33/25 (Note 9) | 150/35 | 150/35 | 150/35 |
| C20 | 33/25 | 33/25 | 33/25 (Note 9) | 120/35 | 120/35 | 120/35 |
| C21 | 33/35 | (2x) $22 / 25$ | (Note 10) | 150/35 | 150/35 | 150/35 |
| C22 | 33/35 | 22/35 | (Note 10) | 120/35 | 120/35 | 120/35 |
| C23 | (Note 10) | (Note 10) | (Note 10) | 220/50 | 100/50 | 120/50 |
| C24 | (Note 10) | (Note 10) | (Note 10) | 150/50 | 100/50 | 120/50 |
| C25 | (Note 10) | (Note 10) | (Note 10) | 150/50 | 82/50 | 82/50 |

Note 9: The SC series of Os-Con capacitors (others are SA series)
Note 10: The voltage ratings of the surface mount tantalum chip and Os-Con capacitors are too low to work at these voltages.
FIGURE 17. Output Capacitor Selection Table

## Application Information

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


10004136
$\mathrm{C}_{\mathrm{IN}}-15 \mu \mathrm{~F}, 25 \mathrm{~V}$, Solid Tantalum Sprague, "594D series"
$\mathrm{C}_{\text {OUt }}-68 \mu \mathrm{~F}, 10 \mathrm{~V}$, Solid Tantalum Sprague, "594D series"
D1-1A, 40V Schottky Rectifier, Surface Mount
L1-47 $\mu \mathrm{H}$, L13, Coilcraft DO3308
$\mathrm{C}_{\mathrm{B}}-0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$, Ceramic
TYPICAL SURFACE MOUNT PC BOARD LAYOUT, ADJUSTABLE OUTPUT (4X SIZE)


10004137
$\mathrm{C}_{\mathrm{IN}}-15 \mu \mathrm{~F}, 50 \mathrm{~V}$, Solid Tantalum Sprague, " 594 D series"
Cout $-33 \mu \mathrm{~F}, 25 \mathrm{~V}$, Solid Tantalum Sprague, "594D series"
D1-1A, 40V Schottky Rectifier, Surface Mount
L1-100 $\mu \mathrm{H}, \mathrm{L} 20$, Coilcraft DO3316
$\mathrm{C}_{\mathrm{B}}-0.01 \mu \mathrm{~F}, 50 \mathrm{~V}$, Ceramic
R1-1k, 1\%
R2 - Use formula in Design Procedure
FIGURE 18. 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 2 and Figure 3) 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 $\mathrm{C}_{\text {OUT }}$ wiring can cause problems.
When using the adjustable version, special care must be taken as to the location of the feedback resistors and the asso-
ciated wiring. Physically locate both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor.

## LLP Package Devices

The LM2674 is offered in the 16 lead LLP surface mount package to allow for increased power dissipation compared to the SO-8 and DIP.

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 at http:// power.national.com.

Physical Dimensions inches (millimeters) unless otherwise noted

$6 \times(1.27) \longrightarrow$
RECOMMENDED LAND PATTERN


CONTROLLING DIMENSION IS MILLIMETER
dimensions in in f for reference only
8-Lead (0.150 Wide) Molded Small Outline Package, JEDEC Order Number LM2674M-3.3, LM2674M-5.0,

LM2674M-12 or LM2674M-ADJ NS Package Number M08A


DIMENSIONS ARE IN MILLIMETERS


16-Lead LLP Surface Mount Package
NS Package Number LDA16A


## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to Tl's terms and conditions of sale supplied at the time of order acknowledgment.
TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with Tl's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.
TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.
TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. Tl is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.
Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.
TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.
TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.
TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.
Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

| Products |  | Applications |  |
| :---: | :---: | :---: | :---: |
| Audio | www.ti.com/audio | Automotive and Transportation | www.ti.com/automotive |
| Amplifiers | amplifier.ti.com | Communications and Telecom | www.ti.com/communications |
| Data Converters | dataconverter.ti.com | Computers and Peripherals | www.ti.com/computers |
| DLP® Products | www.dlp.com | Consumer Electronics | www.ti.com/consumer-apps |
| DSP | dsp.ti.com | Energy and Lighting | www.ti.com/energy |
| Clocks and Timers | www.ti.com/clocks | Industrial | www.ti.com/industrial |
| Interface | interface.ti.com | Medical | www.ti.com/medical |
| Logic | logic.ti.com | Security | www.ti.com/security |
| Power Mgmt | power.ti.com | Space, Avionics and Defense | www.ti.com/space-avionics-defense |
| Microcontrollers | microcontroller.ti.com | Video and Imaging | www.ti.com/video |
| RFID | www.ti-rfid.com |  |  |
| OMAP Mobile Processors | www.ti.com/omap |  |  |
| Wireless Connectivity | www.ti.com/wirelessconnectivity |  |  |
|  | TI E2E Commu | y Home Page | e2e.ti.com |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2012, Texas Instruments Incorporated


[^0]:    A: Output Voltage, $100 \mathrm{mV} / \mathrm{div}$, AC-Coupled.

[^1]:    A: Output Voltage, $100 \mathrm{mV} / \mathrm{div}$, AC-Coupled
    B: Load Current: 100 mA to 400 mA Load Pulse

