LM2675 SIMPLE SWITCHER® Power Converter, High-Efficiency, 1A, Step-Down Voltage Regulator

1 Features

- Efficiency up to 96%
- Available in 8-pin SOIC, PDIP, and 16-pin WSON package
- Requires only 5 external components
- 3.3V, 5V, 12V, and adjustable output versions
- 1.21V to 37V adjustable version output voltage range
- ±1.5% maximum output voltage tolerance over line and load conditions
- Specified 1A output load current
- 8V to 40V wide input voltage range
- 260kHz fixed frequency internal oscillator
- TTL shutdown capability, low-power standby mode
- Thermal shutdown and current limit protection
- Create a custom design using the LM2675 with the WEBENCH® Power Designer

2 Applications

- Simple high-efficiency (> 90%) step-down (buck) regulator
- Efficient preregulator for linear regulators
- Positive-to-negative converter

3 Description

The LM2675 series of regulators are monolithic integrated DC-DC converter 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, 5V, 12V, and an adjustable output version.

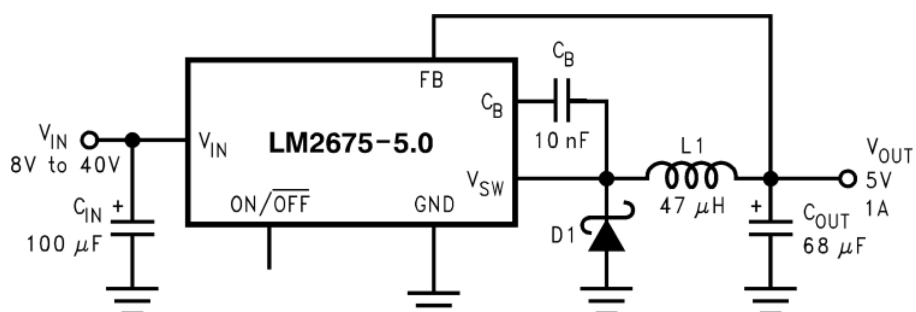
Requiring a minimum number of external components, these regulators are simple to use and include patented internal frequency compensation and a fixed frequency oscillator.

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

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
LM2675	D (SOIC, 8)	4.9mm × 6mm
	P (PDIP, 8)	9.81mm × 9.43mm
	NHN (WSON, 16)	5mm × 5mm

(1) For more information, see Section 10.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Typical Application

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 data sheet are selector guides for diodes and capacitors designed to work in switch-mode power supplies.

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

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4 Pin Configuration and Functions

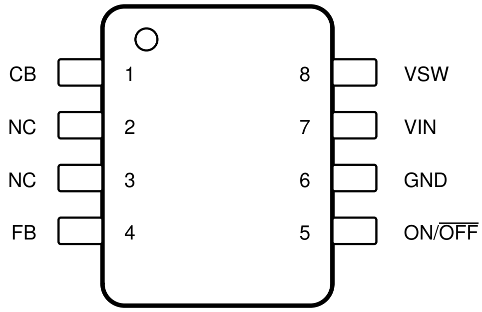


Figure 4-1. D or P Package, 8-Pin SOIC or PDIP (Top View)

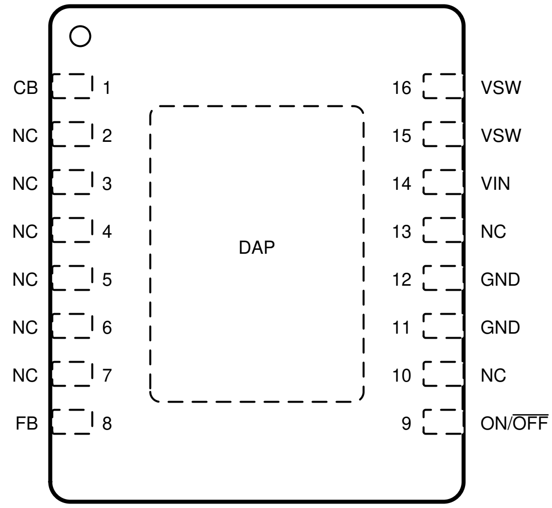


Figure 4-2. NHN Package, 16-Pin WSON (Top View)

Table 4-1. Pin Functions

PIN			TYPE[1]	DESCRIPTION
NAME	D, P	NHN		
C_B	1	1	I	Boot-strap capacitor connection for high-side driver. Connect a high quality 470-nF capacitor from C_B to V_{SW} pin.
FB	4	8	I	Feedback sense input pin. Connect to the midpoint of feedback divider to set VOUT for adjustable version or connect this pin directly to the output capacitor for a fixed output version.
GND	6	11, 12	—	Power ground pins. Connect to system ground. Ground pins of C_{IN} and C_{OUT}. Path to C_{IN} must be as short as possible.
NC	2, 3	2, 3, 4, 5, 6, 7, 10, 13	—	No connect pins.
ON/ $\overline{\text{OFF}}$	5	9	I	Enable input to the voltage regulator. High = ON and low = OFF. Pull this pin high or float to enable the regulator.
V_{IN}	7	14	I	Supply input pin to collector pin of high side FET. Connect to power supply and input bypass capacitors C_{IN}. Path from VIN pin to high frequency bypass C_{IN} and GND must be as short as possible.
V_{SW}	8	15, 16	O	Source pin of the internal High Side FET. This is a switching node. Attached this pin to an inductor and the cathode of the external diode.
DAP	—	—	—	All DAP, tab, and paddle connections are at ground potential and must be connected to system ground to allow for correct thermal and electrical performance.

(1) I = input, O = output

5 Specifications

5.1 Absolute Maximum Ratings

over recommended operating junction temperature range of –40°C to 125°C (unless otherwise noted)[1] [2]

			MIN	MAX	UNIT
Supply voltage				45	V
ON/ $\overline{OFF}$ pin voltage, V_{SH}			–0.1	6	V
Switch voltage to ground				–1	V
Boost pin voltage				V_{SW} + 8	V
Feedback pin voltage, V_{FB}			–0.3	14	V
Power dissipation			Internally limited		
Lead temperature	D package	Vapor phase (60 s)		215	°C
		Infrared (15 s)		220	
	P package (soldering, 10 s)			260	
	NHN package		See *AN-1187*		
Maximum junction temperature, T_J				150	°C
Storage temperature, T_{stg}			–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.
(2) If Military/Aerospace specified devices are required, contact the Texas Instruments Sales Office/ Distributors for availability and specifications.

5.2 ESD Ratings

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

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

5.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
	Supply voltage	6.5	40	V
T_J	Temperature	–40	125	°C

5.4 Thermal Information

THERMAL METRIC[1] [2]		LM2675			UNIT
		SOIC (D)	PDIP (P)	NHN (WSON)	
		8 PINS	8 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance[3]	105	95	—	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	—	—	—	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	—	—	—	°C/W
ψ_{JT}	Junction-to-top characterization parameter	—	—	—	°C/W
ψ_{JB}	Junction-to-board characterization parameter	—	—	—	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application note.
(2) Thermal resistances were simulated on 4-layer JEDEC board.

(3) Junction-to-ambient thermal resistance with approximately 1 square inch of printed-circuit board copper surrounding the leads. Additional copper area lowers thermal resistance further. See *Section 7.1* in the application note accompanying this data sheet. The value $R_{\theta JA}$ for the WSON (NHN) package is specifically dependent on PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, refer to *AN-1187 Leadless Leadframe Package (LLP)* application note.

5.4.1 Electrical Characteristics – 3.3 V

T_J = 25°C (unless otherwise noted; see Figure 7-1)[1]

PARAMETER		TEST CONDITIONS		MIN[2]	TYP[3]	MAX[2]	UNIT
V_{OUT}	Output voltage	V_{IN} = 8 V to 40 V, I_{LOAD} = 20 mA to 1 A	T_J = 25°C	3.251	3.3	3.35	V
			T_J = –40°C to 125°C	3.201		3.399	
		V_{IN} = 6.5 V to 40 V, I_{LOAD} = 20 mA to 500 mA	T_J = 25°C	3.251	3.3	3.35	
			T_J = –40°C to 125°C	3.201		3.399	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 1 A			86%		

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in Figure 7-1 test circuits, system performance is as specified by the system parameters section of *Electrical Characteristics*.
(2) All limits specified at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(3) Typical numbers are at 25°C and represent the most likely norm.

5.5 Electrical Characteristics – 5 V

T_J = 25°C (unless otherwise noted; see Figure 7-1)[1]

PARAMETER		TEST CONDITIONS		MIN[2]	TYP[3]	MAX[2]	UNIT
V_{OUT}	Output voltage	V_{IN} = 8 V to 40 V, I_{LOAD} = 20 mA to 1 A	T_J = 25°C	4.925	5	5.075	V
			T_J = –40°C to 125°C	4.85		5.15	
		V_{IN} = 6.5 V to 40 V, I_{LOAD} = 20 mA to 500 mA	T_J = 25°C	4.925	5	5.075	
			T_J = –40°C to 125°C	4.85		5.15	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 1 A			90%		

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in Figure 7-1 test circuits, system performance is as specified by the system parameters section of *Electrical Characteristics*.
(2) All limits specified at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(3) Typical numbers are at 25°C and represent the most likely norm.

5.6 Electrical Characteristics – 12 V

T_J = 25°C (unless otherwise noted; see Figure 7-1)[1]

PARAMETER		TEST CONDITIONS		MIN[2]	TYP[3]	MAX[2]	UNIT
V_{OUT}	Output voltage	V_{IN} = 15 V to 40 V, I_{LOAD} = 20 mA to 1 A	T_J = 25°C	11.82	12	12.18	V
			T_J = –40°C to 125°C	11.64		12.36	
η	Efficiency	V_{IN} = 24 V, I_{LOAD} = 1 A			94%		

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in Figure 7-1 test circuits, system performance is as specified by the system parameters section of *Electrical Characteristics*.
(2) All limits specified at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(3) Typical numbers are at 25°C and represent the most likely norm.

5.7 Electrical Characteristics – Adjustable

T_J = 25°C (unless otherwise noted; see Figure 7-1)[1]

PARAMETER		TEST CONDITIONS		MIN[2]	TYP[3]	MAX[2]	UNIT
V_{FB}	Feedback voltage	V_{IN} = 8 V to 40 V, I_{LOAD} = 20 mA to 1 A, V_{OUT} programmed for 5 V (see Figure 7-1)	T_J = 25°C	1.192	1.21	1.228	V
			T_J = –40°C to 125°C	1.174		1.246	
		V_{IN} = 6.5 V to 40 V, I_{LOAD} = 20 mA to 500 mA, V_{OUT} programmed for 5 V (see Figure 7-1)	T_J = 25°C	1.192	1.21	1.228	
			T_J = –40°C to 125°C	1.174		1.246	
η	Efficiency	V_{IN} = 12 V, I_{LOAD} = 1 A			90%		

(1) External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator performance. When the LM2675 is used as shown in Figure 7-1 test circuits, system performance is as specified by the system parameters section of *Electrical Characteristics*.
(2) All limits specified at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(3) Typical numbers are at 25°C and represent the most likely norm.

5.8 Electrical Characteristics – All Output Voltage Versions

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

PARAMETER		TEST CONDITIONS		MIN[1]	TYP[2]	MAX[1]	UNIT
I_Q	Quiescent current	$V_{FEEDBACK}$ = 8 V for 3.3 V, 5 V, and adjustable versions			2.5	3.6	mA
		$V_{FEEDBACK}$ = 15 V for 12 V versions			2.5		mA
I_{STBY}	Standby quiescent current	ON/ $\overline{\text{OFF}}$ Pin = 0 V	T_J = 25°C		50	100	μA
			T_J = –40°C to 125°C			150	
I_{CL}	Current limit	T_J = 25°C		1.25	1.55	2.1	A
		T_J = –40°C to 125°C		1.2		2.2	
I_L	Output leakage current	V_{SWITCH} = 0 V, ON/ $\overline{\text{OFF}}$ Pin = 0 V, V_{IN} = 40 V			1	25	μA
		V_{SWITCH} = −1 V, ON/ $\overline{\text{OFF}}$ Pin = 0 V			6	15	mA
$R_{DS(ON)}$	Switch on-resistance	I_{SWITCH} = 1 A	T_J = 25°C		0.25	0.3	Ω
			T_J = –40°C to 125°C			0.5	
f_O	Oscillator frequency	Measured at switch pin	T_J = 25°C		260		kHz
			T_J = –40°C to 125°C	225		275	
D	Minimum duty cycle	T_J = 25°C			95%		
		T_J = –40°C to 125°C			0%		
I_{BIAS}	Feedback bias current	$V_{FEEDBACK}$ = 1.3 V, adjustable version only			85		nA
$V_{S/D}$	ON/ $\overline{\text{OFF}}$ pin voltage	T_J = 25°C			1.4		V
		T_J = –40°C to 125°C		0.8		2	
$I_{S/D}$	ON/ $\overline{\text{OFF}}$ pin current	ON/ $\overline{\text{OFF}}$ Pin = 0 V	T_J = 25°C		20		μA
			T_J = –40°C to 125°C	7		37	

(1) All limits specified at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are specified through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).
(2) Typical numbers are at 25°C and represent the most likely norm.

5.9 Typical Characteristics

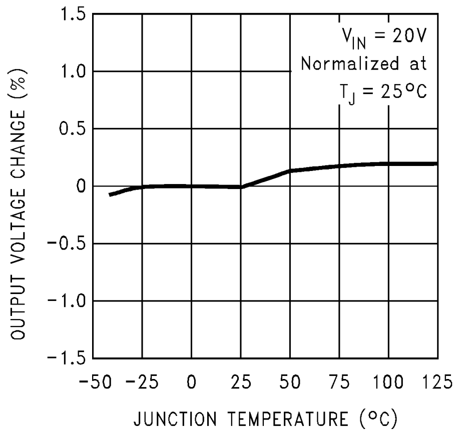


Figure 5-1. Normalized Output Voltage

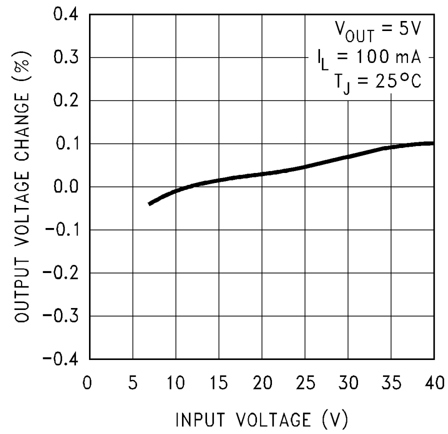


Figure 5-2. Line Regulation

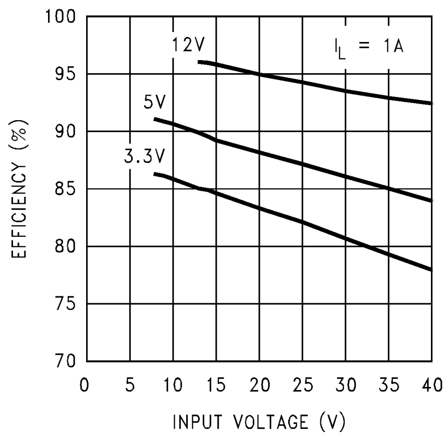


Figure 5-3. Efficiency

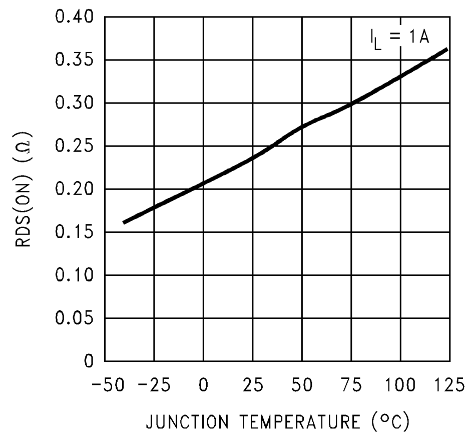


Figure 5-4. Drain-to-Source Resistance

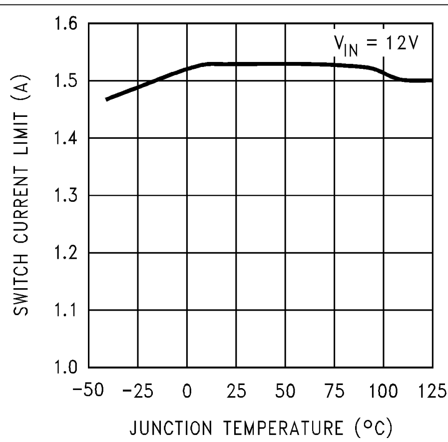


Figure 5-5. Switch Current Limit

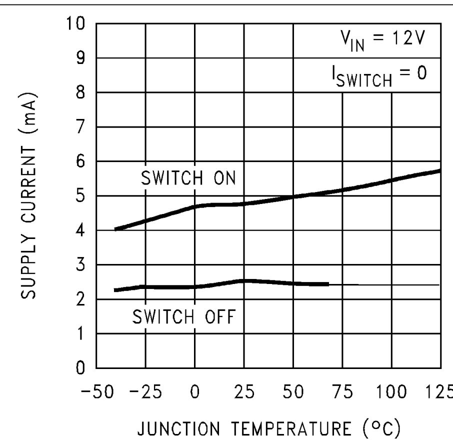


Figure 5-6. Operating Quiescent Current

5.9 Typical Characteristics (continued)

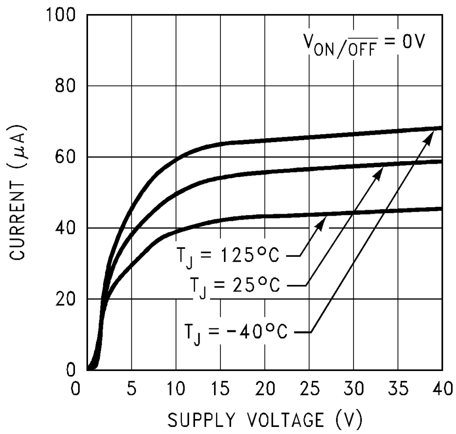


Figure 5-7. Standby Quiescent Current

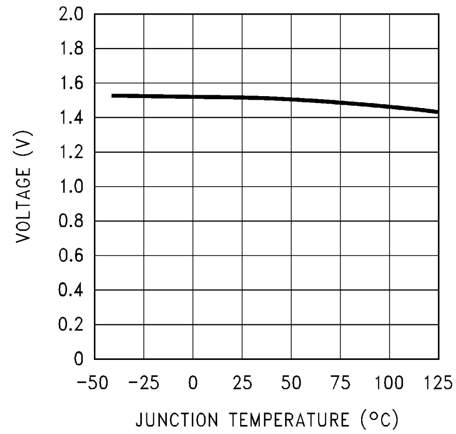


Figure 5-8. ON/ $\overline{\text{OFF}}$ Threshold Voltage

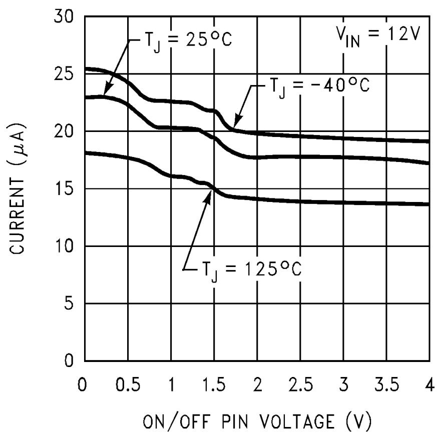


Figure 5-9. ON/ $\overline{\text{OFF}}$ Pin Current (Sourcing)

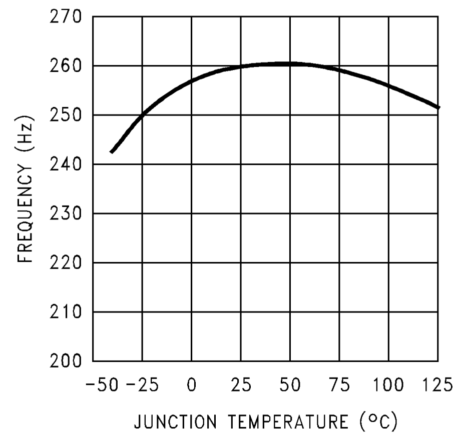


Figure 5-10. Switching Frequency

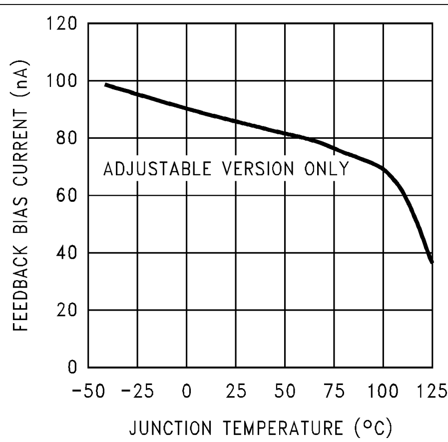


Figure 5-11. Feedback Pin Bias Current

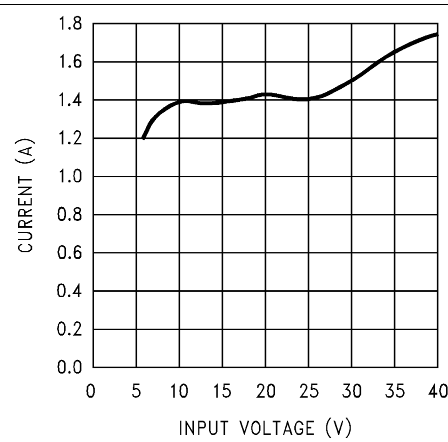


Figure 5-12. Peak Switch Current

5.9 Typical Characteristics (continued)

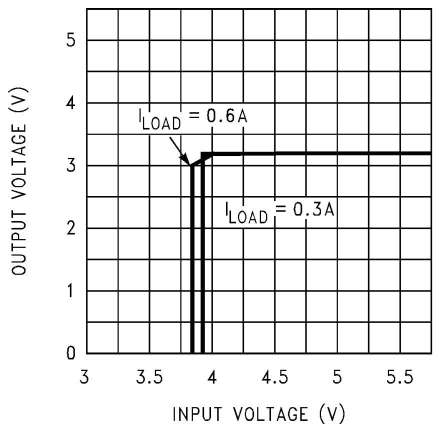


Figure 5-13. Dropout Voltage, 3.3-V Option

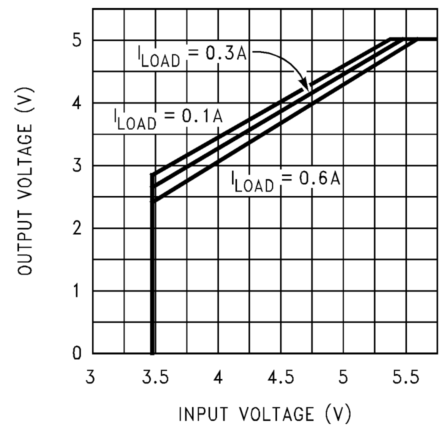
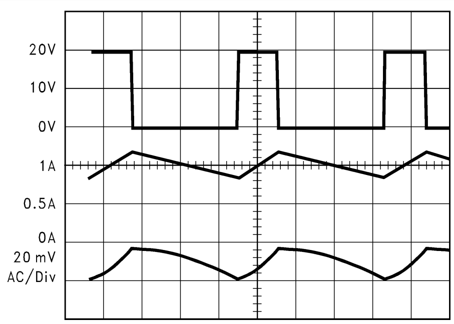


Figure 5-14. Dropout Voltage, 5-V Option

5.10 Typical Characteristics – Fixed Output Voltage Versions

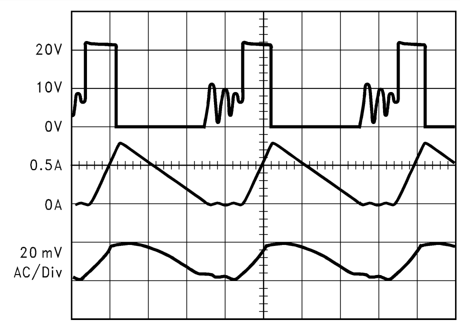
see Figure 7-1



V_{SW} pin voltage, 10 V/div
Inductor current, 0.5 A/div
Output ripple voltage, 20 mV/div AC-coupled

V_{IN} = 20 V, V_{OUT} = 5 V,
I_{LOAD} = 1 A, L = 47 µH,
C_{OUT} = 68 µF, C_{OUT}ESR = 50 mΩ

Figure 5-15. Continuous Mode Switching Waveforms, Horizontal Time Base: 1 µs/div



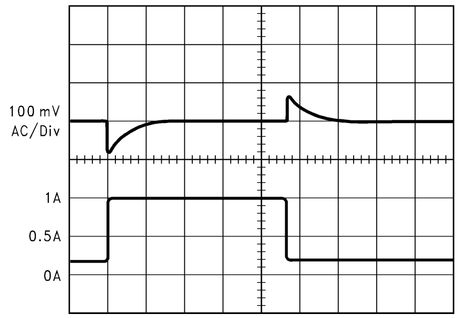
V_{SW} pin voltage, 10 V/div
Inductor current, 0.5 A/div
Output ripple voltage, 20 mV/div AC-coupled

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

Figure 5-16. Discontinuous Mode Switching Waveforms, Horizontal Time Base: 1 µs/div

5.10 Typical Characteristics – Fixed Output Voltage Versions (continued)

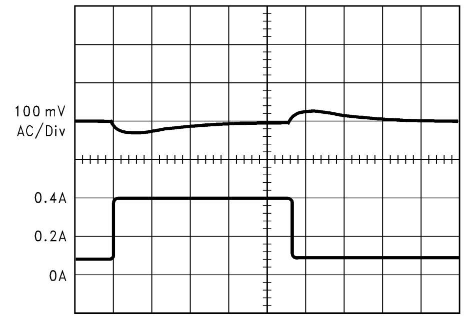
see Figure 7-1



Output voltage, 100 mV/div, AC-coupled
Load current: 200-mA to 1-A load pulse

V_{IN} = 20 V, V_{OUT} = 5 V, I_{LOAD} = 1 A, L = 47 µH, C_{OUT} = 68 µF, C_{OUT}ESR = 50 mΩ

Figure 5-17. Load Transient Response for Continuous Mode, Horizontal Time Base: 50 µs/div



Output voltage, 100 mV/div, AC-coupled
Load current: 100-mA to 400-mA load pulse

V_{IN} = 20 V, V_{OUT} = 5 V, L = 47 µH, C_{OUT} = 68 µF (2×), C_{OUT}ESR = 50 mΩ

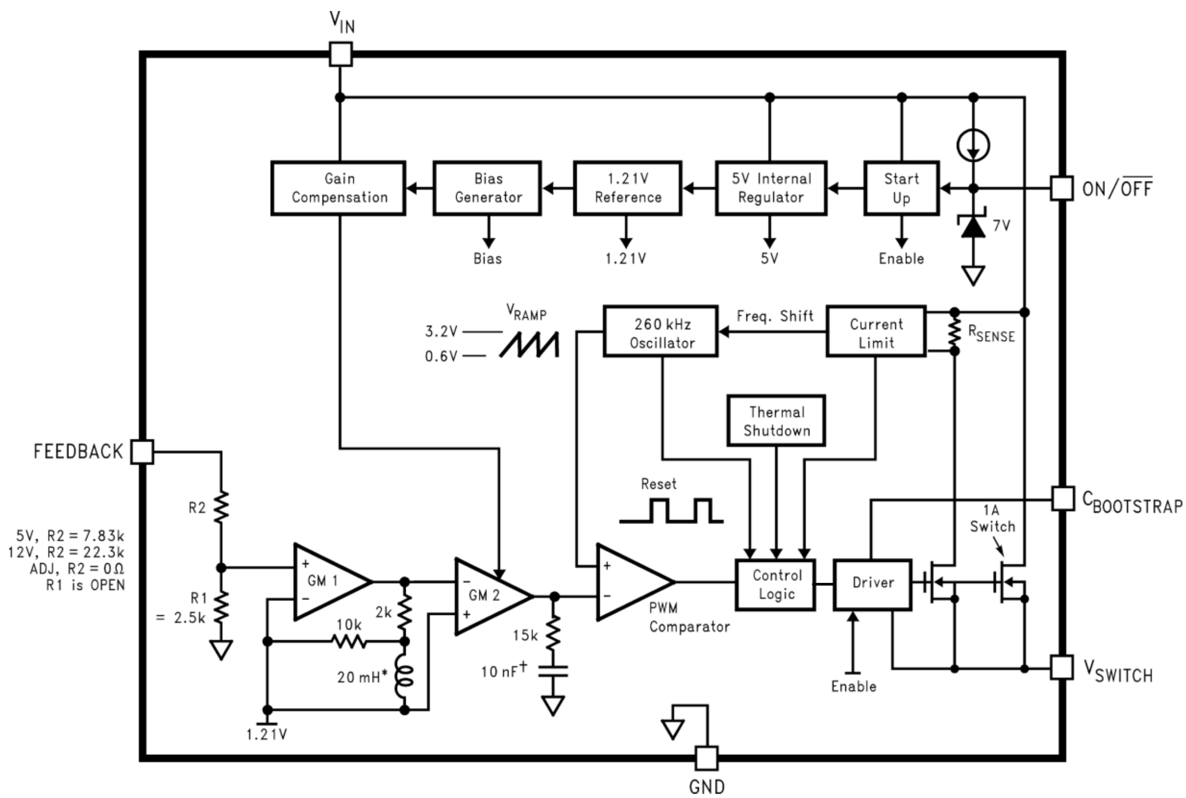
Figure 5-18. Load Transient Response for Discontinuous Mode, Horizontal Time Base: 200 µs/div

6 Detailed Description

6.1 Overview

The LM2675 provides all of the active functions required for a step-down (buck) switching regulator. The internal power switch is a DMOS power MOSFET to provide power supply designs with high current capability, up to 1 A, and highly efficient operation. The LM2675 is part of the SIMPLE SWITCHER® power converters family. A complete design uses a minimum number of external components, which have been predetermined from a variety of manufacturers. Using either this data sheet or TI's WEBENCH® design tool, a complete switching power supply can be designed quickly. See *LM2670 SIMPLE SWITCHER® High Efficiency 3A Step-Down Voltage Regulator with Sync* data sheet for additional application information.

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Adjustable Output Voltage

The voltage regulation loop in the LM2675 regulates output voltage by maintaining the voltage on FB pin (V_{FB}) to be the same as the internal REF voltage (V_{REF}). A resistor divider pair is needed to program the ratio from output voltage V_{OUT} to V_{FB}. The resistor is connected from the V_{OUT} of the LM2674 to ground with the mid-point connecting to the FB pin. The voltage reference system produces a precise voltage reference over temperature. The internal REF voltage is typically 1.21 V. To program the output voltage of the LM2675 to be a certain value V_{OUT}, R1 can be calculated with a selected R2. See *Section 7.2.2.2.1* for adjustable output voltage typical application. The recommended range for R2 in most application is from 10 kΩ to 100 kΩ. If the resistor divider is not connected properly, output voltage cannot be regulated because the feedback loop is broken. If the FB pin is shorted to ground, the output voltage is driven close to VIN, because the regulator sees very low voltage on the FB pin and tries to regulate it. The load connected to the output can be damaged under such a condition. Do not short FB pin to ground when the LM2675 is enabled. It is important to route the feedback trace away from the noisy area of the PCB. For more layout recommendations, see *Section 7.4*.

6.4 Device Functional Modes

6.4.1 Shutdown Mode

The ON/ $\overline{\text{OFF}}$ pin provides electrical ON and OFF control for the LM2674. When the voltage of this pin is lower than 1.4 V, the device is in shutdown mode. The typical standby current in this mode is 20 µA.

6.4.2 Active Mode

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

7 Application and Implementation

Note

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

7.1 Application Information

The LM2675 is a step-down DC-DC regulator. The device is typically used to convert a higher DC voltage to a lower DC voltage with a maximum output current of 1 A. The following design procedure can be used to select components for the LM2675. Alternately, the WEBENCH® software can be used to generate complete designs. When generating a design, the WEBENCH software uses iterative design procedure and accesses comprehensive databases of components. See ti.com for more details.

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

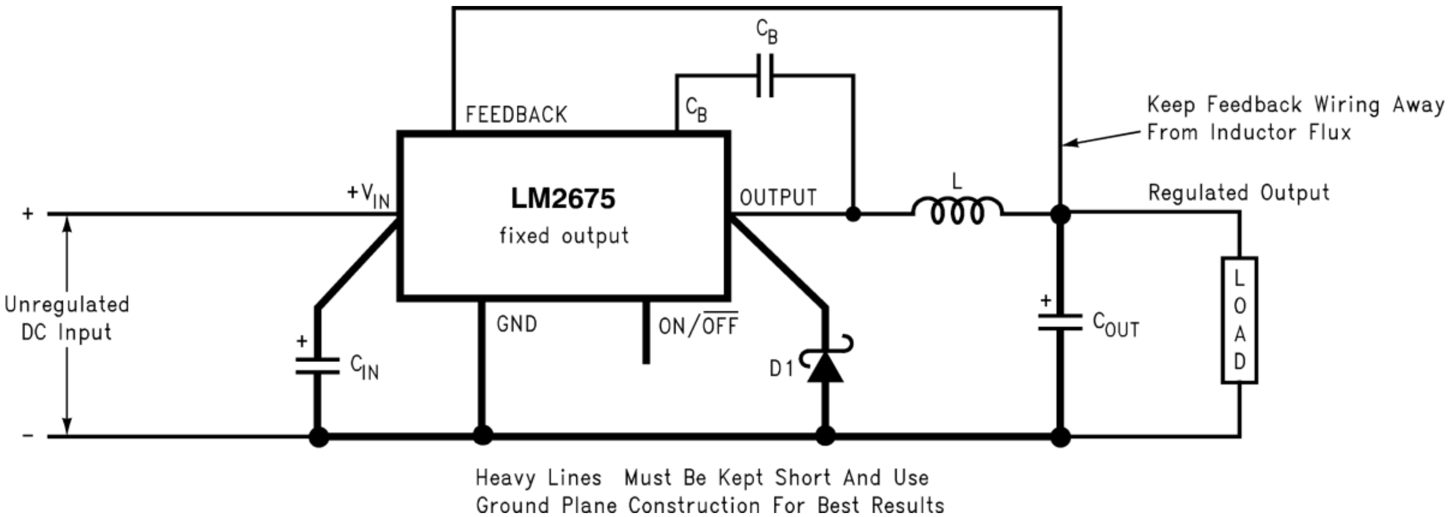
Under current limiting conditions, the LM2675 is designed to respond in the following manner:

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

If the output capacitance is sufficiently *large*, it can be possible that as the output tries to recover, the output capacitor charging current is large enough to repeatedly re-trigger the current limit circuit before the output has fully settled. This condition is exacerbated with higher output voltage settings because the energy requirement of the output capacitor varies as the square of the output voltage (½ CV2), thus requiring an increased charging current. A simple test to determine if this condition might exist for a suspect application is to apply a short circuit across the output of the converter, and then remove the shorted output condition. In an application with properly selected external components, the output recovers smoothly. Practical values of external components that have been experimentally found to work well under these specific operating conditions are COUT = 47 µF,
L = 22 µH. It must be noted that even with these components, for a device's current limit of I_{CLIM}, the maximum load current under which the possibility of the large current limit hysteresis can be minimized is $I_{CLIM}/2$. For example, if the input is 24 V and the set output voltage is 18 V, then for a desired maximum current of 1.5 A, the current limit of the chosen switcher must be confirmed to be at least 3 A. Under extreme overcurrent or short-circuit conditions, the LM2675 employs frequency foldback in addition to the current limit. If the cycle-by-cycle inductor current increases above the current limit threshold (due to short circuit or inductor saturation for example) the switching frequency is automatically reduced to protect the IC. Frequency below 100 kHz is typical for an extreme short-circuit condition.

7.2 Typical Application

7.2.1 Fixed Output Voltage Application



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

Figure 7-1. Fixed Output Voltage Schematic

7.2.1.1 Design Requirements

Table 7-1 lists the design requirements for the fixed output voltage application.

Table 7-1. Design Parameters

PARAMETER	VALUE
Regulated output voltage, V_{OUT}	5 V
Maximum input voltage, V_{IN}(max)	12 V
Maximum load current, I_{LOAD}(max)	1 A

7.2.1.2 Detailed Design Procedure

7.2.1.2.1 Custom Design with WEBENCH® Tools

Click here to create a custom design using the LM2675 devices with the WEBENCH Power Designer.

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

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

In most cases, these actions are available:

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

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

7.2.1.2.2 Inductor Selection (L1)

Select the correct inductor value selection guide from Figure 7-3, Figure 7-4, or Figure 7-5 (output voltages of 3.3 V, 5 V, or 12 V respectively). For all other voltages, see *Section 7.2.2.2*. Use the inductor selection guide for the 5-V version shown in Figure 7-4.

From the inductor value selection guide, identify the inductance region intersected by the maximum input voltage line and the maximum load current line. Each region is identified by an inductance value and an inductor code (LXX). From the inductor value selection guide shown in Figure 7-4, the inductance region intersected by the 12-V horizontal line and the 1-A vertical line is 33 µH, and the inductor code is L23.

Select an appropriate inductor from the four manufacturer's part numbers listed in Table 7-2. Each manufacturer makes a different style of inductor to allow flexibility in meeting various design requirements. The inductance value required is 33 µH. From the table in Table 7-2, 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.

Table 7-2. 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	0.7	67144000	67144380	RL-5470-7	RL1500-47	PE-53813	PE-53813-S	DO3308-473
L14	33	0.83	67148340	67148450	RL-1284-33-43	RL1500-33	PE-53814	PE-53814-S	DO3308-333
L15	22	0.99	67148350	67148460	RL-1284-22-43	RL1500-22	PE-53815	PE-53815-S	DO3308-223
L18	220	0.55	67144040	67144420	RL-5471-2	RL1500-220	PE-53818	PE-53818-S	DO3316-224
L19	150	0.66	67144050	67144430	RL-5471-3	RL1500-150	PE-53819	PE-53819-S	DO3316-154
L20	100	0.82	67144060	67144440	RL-5471-4	RL1500-100	PE-53820	PE-53820-S	DO3316-104
L21	68	0.99	67144070	67144450	RL-5471-5	RL1500-68	PE-53821	PE-53821-S	DO3316-683
L22	47	1.17	67144080	67144460	RL-5471-6	—	PE-53822	PE-53822-S	DO3316-473
L23	33	1.4	67144090	67144470	RL-5471-7	—	PE-53823	PE-53823-S	DO3316-333
L24	22	1.7	67148370	67148480	RL-1283-22-43	—	PE-53824	PE-53824-S	DO3316-223
L27	220	1	67144110	67144490	RL-5471-2	—	PE-53827	PE-53827-S	DO5022P-224
L28	150	1.2	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

7.2.1.2.3 Output Capacitor Selection (C_{OUT})

Select an output capacitor from Table 7-3. Using the output voltage and the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor value and voltage rating. The capacitor list contains through-hole electrolytic capacitors from four different capacitor manufacturers and surface mount tantalum capacitors from two different capacitor manufacturers. TI recommends using both the manufacturers and the manufacturer's series that are listed in the table.

Use the 5-V section in Table 7-3. Choose a capacitor value and voltage rating from the line that contains the inductance value of 33 µH. The capacitance and voltage rating values corresponding to the 33-µH inductor are the surface mount and through hole.

Surface mount:

- 68-µF, 10-V Sprague 594D series
- 100-µF, 10-V AVX TPS series

Through hole:

- 68-µF, 10-V Sanyo OS-CON SA series
- 220-µF, 35-V Sanyo MV-GX series
- 220-µF, 35-V Nichicon PL series
- 220-µF, 35-V Panasonic HFQ series

Table 7-3. Output Capacitor Table

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

7.2.1.2.4 Catch Diode Selection (D1)

In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, 1-D (D is the switch duty cycle, which is approximately the output voltage divided by the input voltage). The largest value of the catch diode average current occurs at the maximum load current and maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than the maximum average current. However, if the power supply design must withstand a continuous output short, the diode must have a current rating equal to the maximum current limit of the LM2675. The most stressful condition for this diode is a shorted output condition (see Table 7-4). In this example, a 1-A, 20-V Schottky diode provides the best performance. If the circuit must withstand a continuous shorted output, TI recommends a Schottky diode of higher current.

The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage. Because of the 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.

Table 7-4. Schottky Diode Selection Table

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

7.2.1.2.5 Input Capacitor (C_{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 must be located close to the IC using short leads. In addition, the RMS current rating of the input capacitor must be selected to be at least ½ the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. Figure 7-2 shows typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors can be required to increase the total minimum RMS current rating to suit the application requirements.

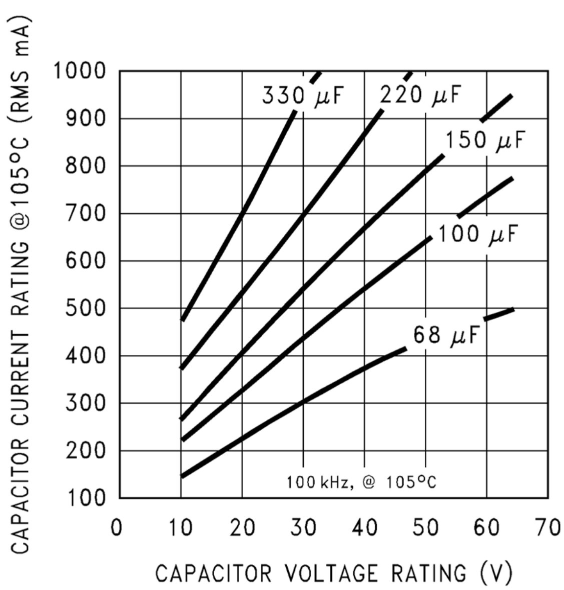


Figure 7-2. RMS Current Ratings for Low ESR Electrolytic Capacitors (Typical)

For an aluminum electrolytic capacitor, the voltage rating must be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating must be twice the maximum input voltage. Table 7-3 shows the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. TI also recommends that they be surge current tested by the manufacturer.

The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line.

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

The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 12 V, an aluminum electrolytic capacitor with a voltage rating greater than 15 V ($1.25 \times V_{IN}$) can 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 ½ the DC load current. In this example, with a 1-A load, a capacitor with a RMS current rating of at least 500 mA is needed. The curves shown in Figure 7-2 can be used to select an appropriate input capacitor. From the curves, locate the 16-V line and note which capacitor values have RMS current ratings greater than 500 mA.

For a through hole design, a 330-µF, 16-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) can 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 can be considered.

For surface-mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking Table 7-5, and the Sprague 594D series data sheet, a Sprague 594D 15-µF, 25-V capacitor is adequate.

Table 7-5. Sprague 594D

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

7.2.1.2.6 Boost Capacitor (C_B)

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

7.2.1.3 Application Curves

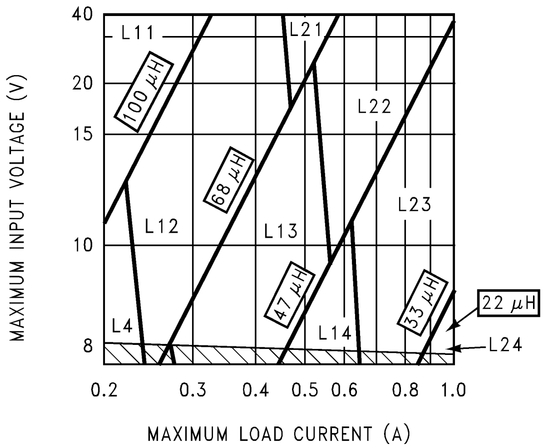


Figure 7-3. LM2675, 3.3-V Output

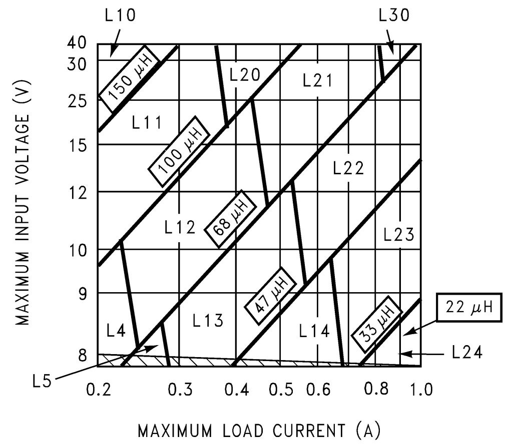


Figure 7-4. LM2675, 5-V Output

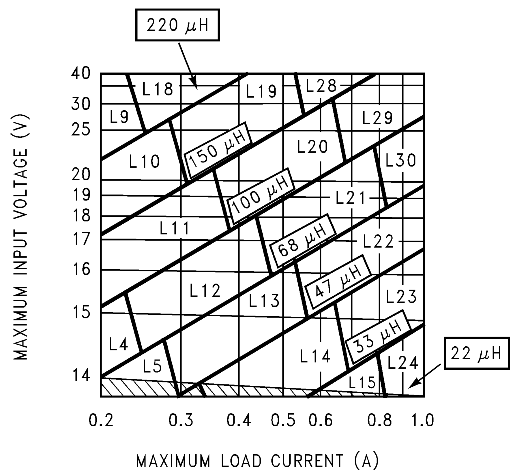
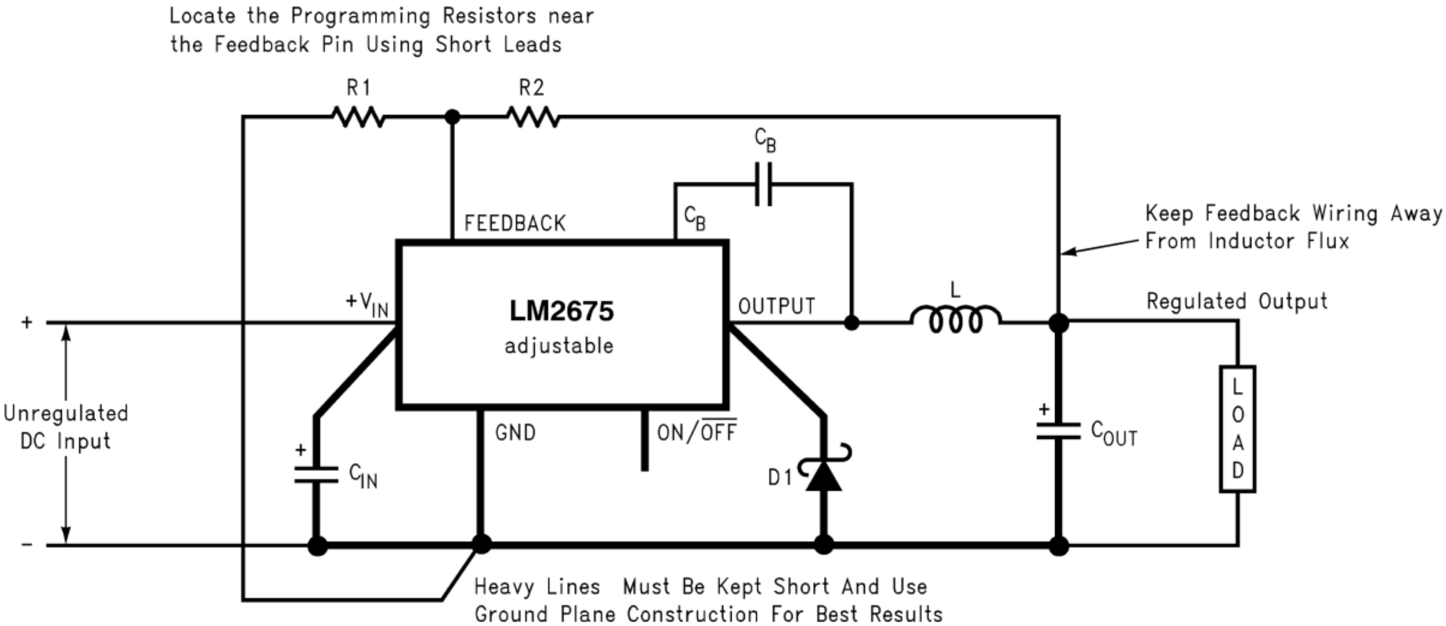


Figure 7-5. LM2675, 12-V Output

7.2.2 Adjustable Output Voltage Application



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

Figure 7-6. Adjustable Output Voltage Schematic

7.2.2.1 Design Requirements

Table 7-1 lists the design requirements for the adjustable output voltage application.

Table 7-6. Design Parameters

PARAMETER	VALUE
Regulated output voltage, V_{OUT}	20 V
Maximum input voltage, V_{IN}(max)	28 V
Maximum load current, I_{LOAD}(max)	1 A
Switching frequency, F	Fixed at a nominal 260 kHz

7.2.2.2 Detailed Design Procedure

7.2.2.2.1 Programming Output Voltage

Selecting R_1 and R_2, as shown in *Figure 7-1*.

Use Equation 1 to select the appropriate resistor values.

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

where

- V_{REF} = 1.21 V

Select R_1 to be 1 kΩ, 1%. Solve for R_2 using Equation 2.

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right) = 1\,k\Omega\left(\frac{20\ V}{1.23\ V} - 1\right) \tag{2}$$

Select a value for R_1 between 240 Ω and 1.5 kΩ. The lower resistor values minimize noise pickup in the sensitive feedback pin. For the lowest temperature coefficient and the best stability with time, use 1% metal film resistors with Equation 3.

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right) \tag{3}$$

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

R_2 = 15.4 kΩ.

7.2.2.2.2 Inductor Selection (L1)

Calculate the inductor Volt × microsecond constant E × T (V × μs) from Equation 4.

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

where

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

Calculate the inductor Volt × microsecond constant (E × T) with Equation 5.

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

Use the E × T value from the previous formula and match it with the E × T number on the vertical axis of the inductor value selection guide in Figure 7-7. E × T = 21.6 (V × μs).

On the horizontal axis, select the maximum load current (I_{LOAD}(max) = 1 A).

Identify the inductance region intersected by the E × T value and the maximum load current value. Each region is identified by an inductance value and an inductor code (LXX). From the inductor value selection guide shown in Figure 7-7, the inductance region intersected by the 21.6 (V × μs) horizontal line and the 1-A vertical line is 68 μH, and the inductor code is L30.

Select an appropriate inductor from the four manufacturer's part numbers listed in Table 7-2. For information on the different types of inductors, see the inductor selection in the fixed output voltage design procedure. From Table 7-2, locate line L30, and select an inductor part number from the list of manufacturers' part numbers.

7.2.2.2.3 Output Capacitor Selection (C_{OUT})

Select an output capacitor from the capacitor code selection guide in Table 7-7. Using the inductance value found in the inductor selection guide, step 1, locate the appropriate capacitor code corresponding to the desired output voltage. Use the appropriate row of the capacitor code selection guide, in Table 7-7. For this example, use the 15 V to 20 V row. The capacitor code corresponding to an inductance of 68 μH is C20.

Table 7-7. Capacitor Code Selection Guide

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

(1) SM = surface mount, TH = through hole

Select an appropriate capacitor value and voltage rating, using the capacitor code, from the output capacitor selection table in Table 7-8. There are two solid tantalum (surface mount) capacitor manufacturers and four electrolytic (through hole) capacitor manufacturers to choose from. TI recommends using both the manufacturers and the manufacturer's series that are listed in Table 7-8. From Table 7-8, 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 and through hole.

Surface mount:

- 33-μF, 25-V Sprague 594D Series
- 33-μF, 25-V AVX TPS Series

Through hole:

- 33-μF, 25-V Sanyo OS-CON SC Series
- 120-μF, 35-V Sanyo MV-GX Series
- 120-μF, 35-V Nichicon PL Series
- 120-μF, 35-V Panasonic HFQ Series

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

Table 7-8. Output Capacitor Selection Table

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

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

7.2.2.2.4 Catch Diode Selection (D1)

In normal operation, the average current of the catch diode is the load current times the catch diode duty cycle, 1-D (D is the switch duty cycle, which is approximately V_{OUT}/V_{IN}). The largest value of the catch diode average current occurs at the maximum input voltage (minimum D). For normal operation, the catch diode current rating must be at least 1.3 times greater than the maximum average current. However, if the power supply design must withstand a continuous output short, the diode must have a current rating greater than the maximum current limit of the LM2675. The most stressful condition for this diode is a shorted output condition (see Table 7-4). Schottky diodes provide the best performance, and in this example a 1-A, 40-V Schottky diode can be a good choice. If the circuit must withstand a continuous shorted output, TI recommends a Schottky diode of higher current (at least 2.2 A).

The reverse voltage rating of the diode must be at least 1.25 times the maximum input voltage. Because of the fast switching speed and low forward voltage drop, Schottky diodes provide the best performance and efficiency. The Schottky diode must be placed close to the LM2675 using short leads and short printed circuit traces.

7.2.2.2.5 Input Capacitor (C_{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 must be located close to the IC using short leads. In addition, the RMS current rating of the input capacitor must be selected to be at least ½ the DC load current. The capacitor manufacturer data sheet must be checked to assure that this current rating is not exceeded. The curves shown in Figure 7-2 show typical RMS current ratings for several different aluminum electrolytic capacitor values. A parallel connection of two or more capacitors can be required to increase the total minimum RMS current rating to suit the application requirements.

For an aluminum electrolytic capacitor, the voltage rating must be at least 1.25 times the maximum input voltage. Caution must be exercised if solid tantalum capacitors are used. The tantalum capacitor voltage rating must be twice the maximum input voltage. Table 7-9 and Table 7-5 show the recommended application voltage for AVX TPS and Sprague 594D tantalum capacitors. TI recommends that they be surge current tested by the manufacturer. The TPS series available from AVX, and the 593D and 594D series from Sprague are all surge current tested. Another approach to minimize the surge current stresses on the input capacitor is to add a small inductor in series with the input supply line.

Table 7-9. AVX TPS

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

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

The important parameters for the input capacitor are the input voltage rating and the RMS current rating. With a maximum input voltage of 28 V, an aluminum electrolytic capacitor with a voltage rating of at least 35 V (1.25 × V_{IN}) can 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 1-A load, a capacitor with a RMS current rating of at least 500 mA is needed. The curves shown in Figure 7-2 can be used to select an appropriate input capacitor. From the curves, locate the 35-V line and note which capacitor values have RMS current ratings greater than 500 mA.

For a through hole design, a 330-μF, 35-V electrolytic capacitor (Panasonic HFQ series, Nichicon PL, Sanyo MV-GX series or equivalent) can 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 can be considered.

For surface mount designs, solid tantalum capacitors can be used, but caution must be exercised with regard to the capacitor surge current rating and voltage rating. In this example, checking Table 7-5, and the Sprague 594D series data sheet, a Sprague 594D 15-μF, 50-V capacitor is adequate.

7.2.2.2.6 Boost Capacitor (C_B)

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

7.2.2.3 Application Curve

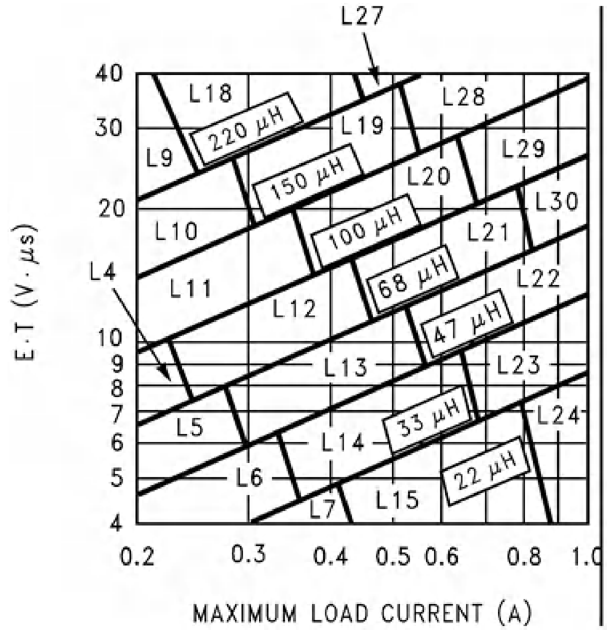


Figure 7-7. LM2675, Adjustable Output

7.3 Power Supply Recommendations

The input voltage for the power supply is connected to the VIN pin. In addition to providing energy to the load the input voltage also provides bias for the internal circuitry of the LM2675. For ensured performance, the input voltage must be in the range of 6.5 V to 40 V. The VIN pin must always be bypassed with an input capacitor located close to this pin and GND.

7.4 Layout

7.4.1 Layout Guidelines

Layout is very important in switching regulator designs. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by heavy lines (in Figure 7-1 and Figure 7-6) must be wide printed circuit traces and must be kept as short as possible. For best results, external components must be placed as close to the switcher IC as possible using ground plane construction or single-point grounding.

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

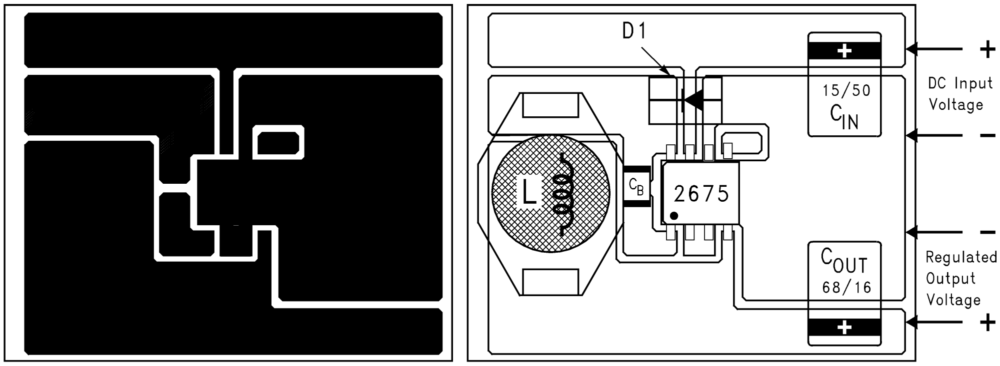
When using the adjustable version, take special care as to the location of the feedback resistors and the associated wiring. Physically locate both resistors near the IC, and route the wiring away from the inductor, especially an open-core type of inductor.

7.4.1.1 WSON Package Devices

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

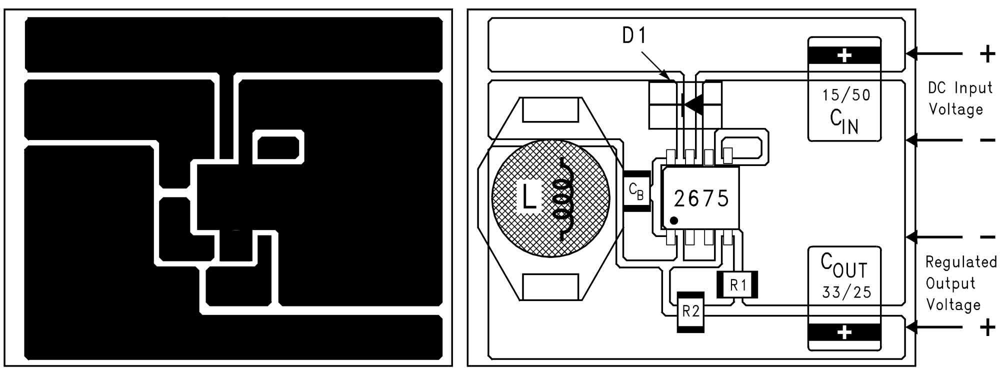
The die attach pad (DAP) can and must be connected to PCB Ground plane or island. For CAD and assembly guidelines see *AN-1187 Leadless Leadframe Package (LLP)*.

7.4.2 Layout Examples



C_{IN} = 15-µF, 50-V, Solid Tantalum Sprague *594D series*
C_{OUT} = 68-µF, 16-V, Solid Tantalum Sprague *594D series*
D1 = 1-A, 40-V Schottky Rectifier, surface mount
L1 = 33-µH, L23, Coilcraft DO3316
C_B = 0.01-µF, 50-V ceramic

Figure 7-8. Typical Surface Mount PC Board Layout, Fixed Output



C_{IN} = 15-µF, 50-V, Solid Tantalum Sprague *594D series*
C_{OUT} = 33-µF, 25-V, Solid Tantalum Sprague *594D series*
D1 = 1-A, 40-V Schottky Rectifier, surface mount
L1 = 68-µH, L30, Coilcraft DO3316
C_B = 0.01-µF, 50-V ceramic
R1 = 1k, 1%
R2 = Use formula in *Section 7.2.2.2*

Figure 7-9. Typical Surface Mount PC Board Layout, Adjustable Output

8 Device and Documentation Support

8.1 Device Support

8.1.1 Development Support

For development support see the following:

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

8.1.1.1 Custom Design with WEBENCH® Tools

Click here to create a custom design using the LM2675 devices with the WEBENCH Power Designer.

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

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

In most cases, these actions are available:

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

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

8.2 Documentation Support

8.2.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *AN-1187 Leadless Leadframe Package (LLP)* application note
- Texas Instruments, *LM2670 SIMPLE SWITCHER® High Efficiency 3A Step-Down Voltage Regulator with Sync* data sheet

8.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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8.6 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.7 Glossary

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

9 Revision History

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

Changes from Revision F (June 2016) to Revision G (June 2025) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document 1
- Added WEBENCH information 1
- Added DAP connection information..4
- Added information relating to WEBENCH... 14
- Added information relating to WEBENCH... 15
- Added information relating to WEBENCH... 29

Changes from Revision E (June 2005) to Revision F (June 2016) **Page**

- Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section................... 1
- Deleted all instances of the computer design software *LM267X Made Simple* (version 6.0)............................ 1

10 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM2675LD-5.0/NOPB	Active	Production	WSON (NHN) | 16	1000 | SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 125	S000FB
LM2675LD-5.0/NOPB.B	Active	Production	WSON (NHN) | 16	1000 | SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 125	S000FB
LM2675LD-ADJ/NOPB	Active	Production	WSON (NHN) | 16	1000 | SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 125	S000GB
LM2675LD-ADJ/NOPB.B	Active	Production	WSON (NHN) | 16	1000 | SMALL T&R	Yes	SN	Level-3-260C-168 HR	-40 to 125	S000GB
LM2675M-12/NOPB	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M-12
LM2675M-12/NOPB.B	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M-12
LM2675M-3.3/NOPB	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M3.3
LM2675M-3.3/NOPB.B	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M3.3
LM2675M-5.0/NOPB	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M5.0
LM2675M-5.0/NOPB.B	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M5.0
LM2675M-ADJ/NOPB	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 MADJ
LM2675M-ADJ/NOPB.B	Active	Production	SOIC (D) | 8	95 | TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 MADJ
LM2675MX-12/NOPB	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M-12
LM2675MX-12/NOPB.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M-12
LM2675MX-3.3/NOPB	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M3.3
LM2675MX-3.3/NOPB.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M3.3
LM2675MX-5.0/NOPB	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 M5.0
LM2675MX-5.0/NOPB.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 M5.0

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM2675MX-ADJ/NOPB	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	2675 MADJ
LM2675MX-ADJ/NOPB.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2675 MADJ
LM2675N-12/NOPB	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-12
LM2675N-12/NOPB.B	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-12
LM2675N-3.3/NOPB	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-3.3
LM2675N-3.3/NOPB.B	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-3.3
LM2675N-5.0/NOPB	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-5.0
LM2675N-5.0/NOPB.B	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-5.0
LM2675N-ADJ/NOPB	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-ADJ
LM2675N-ADJ/NOPB.B	Active	Production	PDIP (P) | 8	40 | TUBE	Yes	NIPDAU	Level-1-NA-UNLIM	-40 to 125	LM2675 N-ADJ

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

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

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

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

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

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

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

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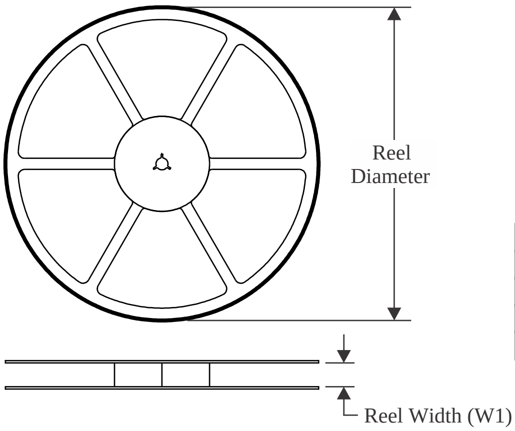
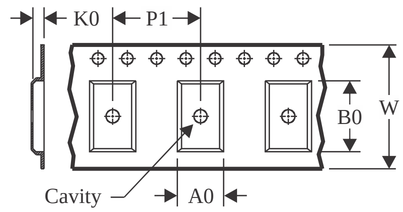
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

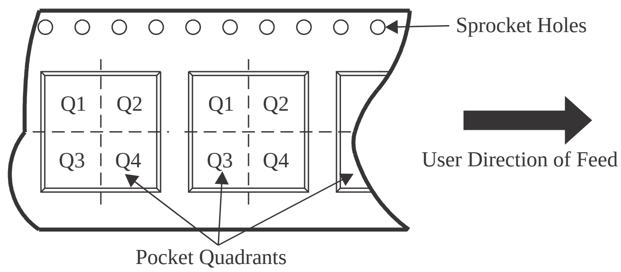


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

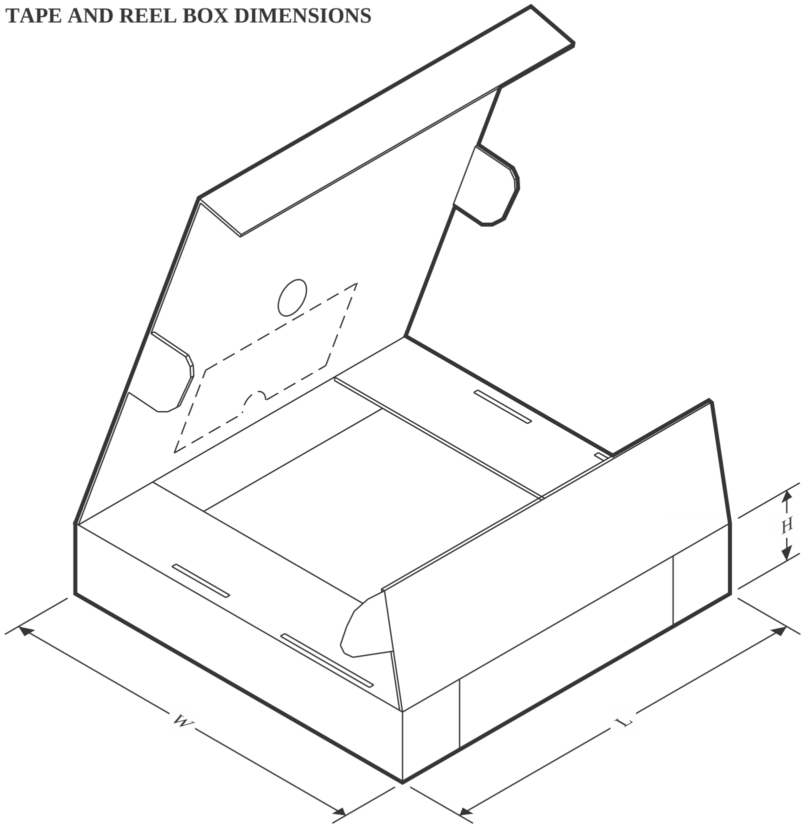
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM2675LD-5.0/NOPB	WSON	NHN	16	1000	177.8	12.4	5.3	5.3	1.3	8.0	12.0	Q1
LM2675LD-ADJ/NOPB	WSON	NHN	16	1000	177.8	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/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

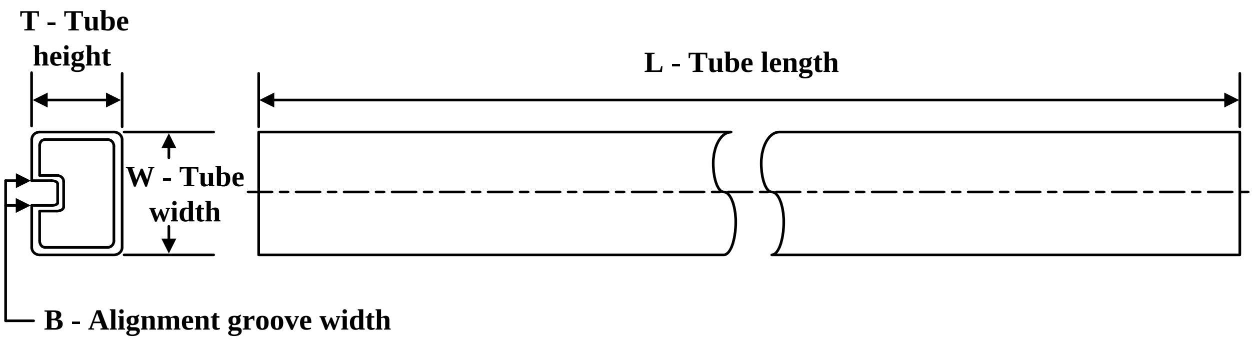
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

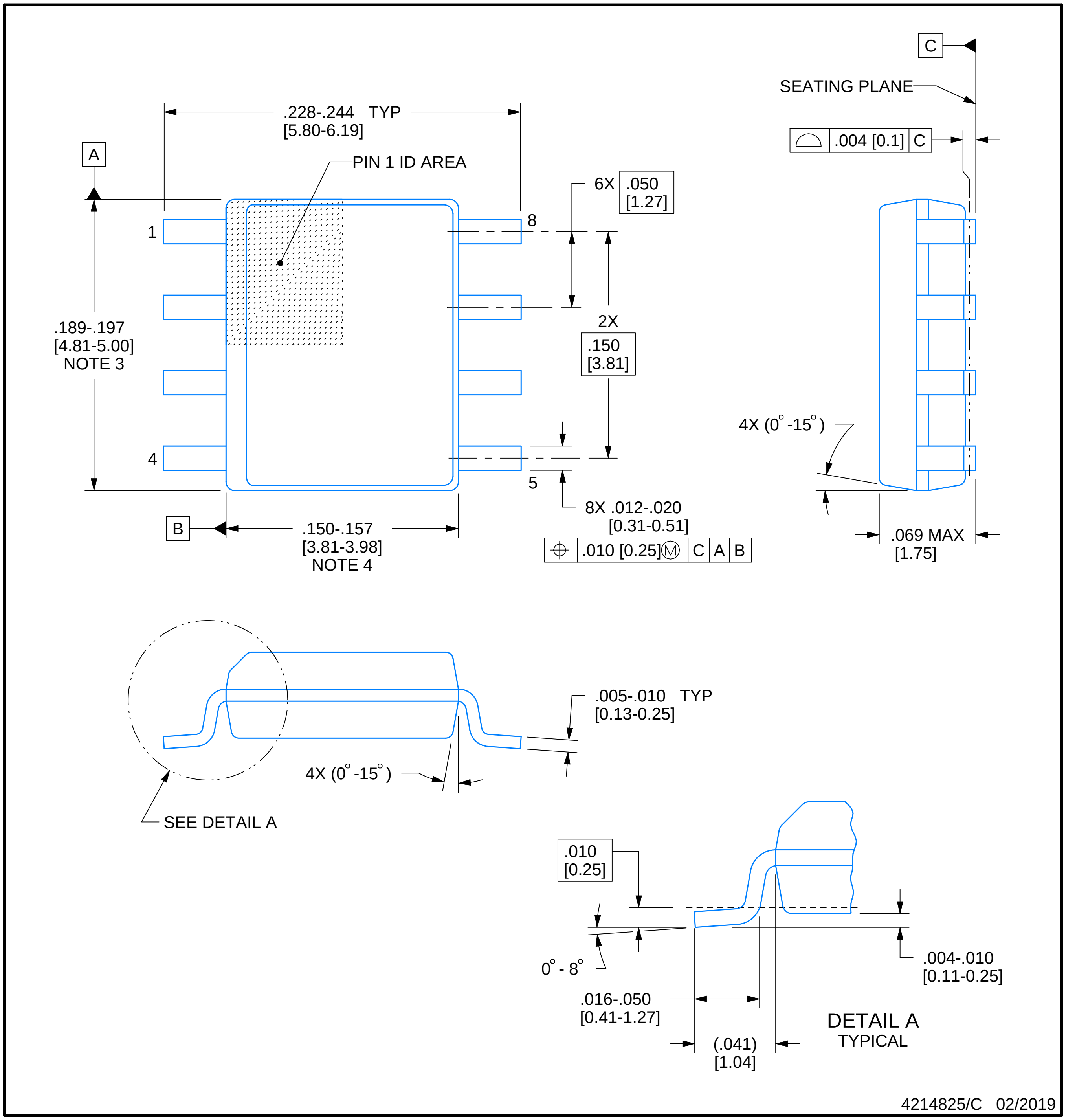
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM2675LD-5.0/NOPB	WSON	NHN	16	1000	208.0	191.0	35.0
LM2675LD-ADJ/NOPB	WSON	NHN	16	1000	208.0	191.0	35.0
LM2675MX-12/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM2675MX-3.3/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM2675MX-5.0/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM2675MX-ADJ/NOPB	SOIC	D	8	2500	367.0	367.0	35.0

TUBE



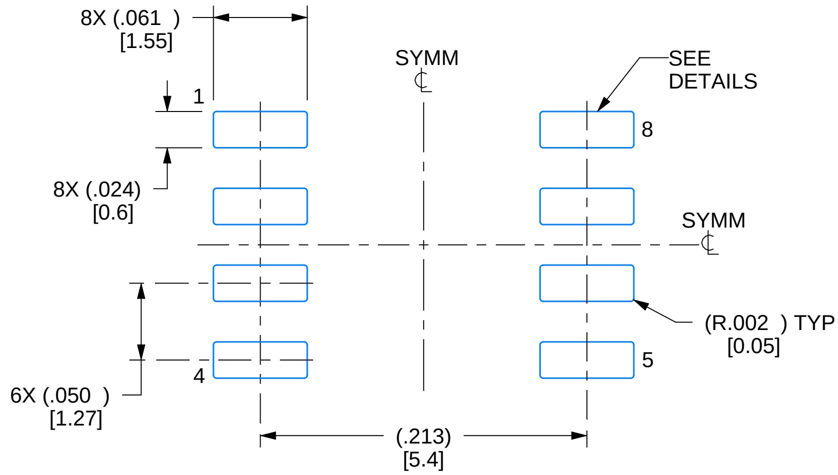
*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM2675M-12/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM2675M-12/NOPB.B	D	SOIC	8	95	495	8	4064	3.05
LM2675M-3.3/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM2675M-3.3/NOPB.B	D	SOIC	8	95	495	8	4064	3.05
LM2675M-5.0/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM2675M-5.0/NOPB.B	D	SOIC	8	95	495	8	4064	3.05
LM2675M-ADJ/NOPB	D	SOIC	8	95	495	8	4064	3.05
LM2675M-ADJ/NOPB.B	D	SOIC	8	95	495	8	4064	3.05
LM2675N-12/NOPB	P	PDIP	8	40	502	14	11938	4.32
LM2675N-12/NOPB.B	P	PDIP	8	40	502	14	11938	4.32
LM2675N-3.3/NOPB	P	PDIP	8	40	502	14	11938	4.32
LM2675N-3.3/NOPB.B	P	PDIP	8	40	502	14	11938	4.32
LM2675N-5.0/NOPB	P	PDIP	8	40	502	14	11938	4.32
LM2675N-5.0/NOPB.B	P	PDIP	8	40	502	14	11938	4.32
LM2675N-ADJ/NOPB	P	PDIP	8	40	502	14	11938	4.32
LM2675N-ADJ/NOPB.B	P	PDIP	8	40	502	14	11938	4.32

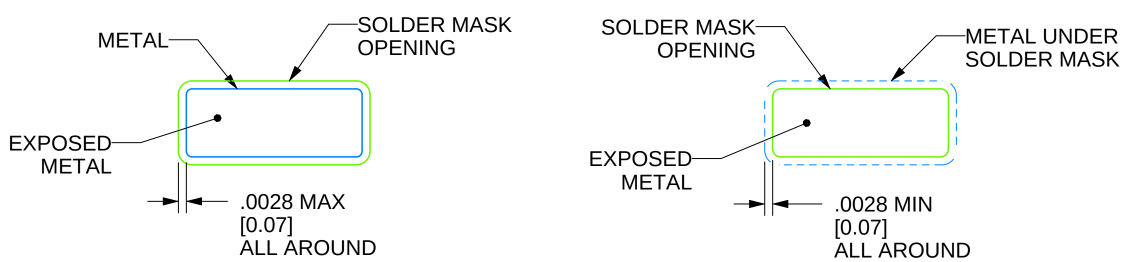


NOTES:

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



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



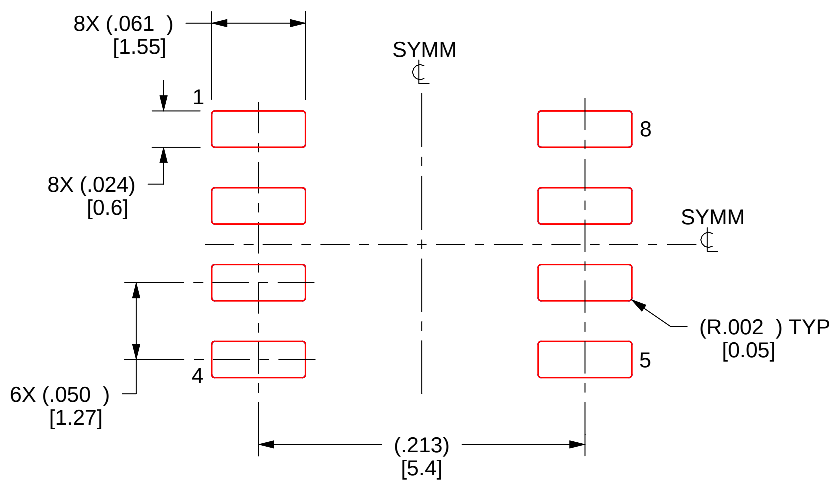
NON SOLDER MASK DEFINED

SOLDER MASK DEFINED

SOLDER MASK DETAILS

NOTES: (continued)

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



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

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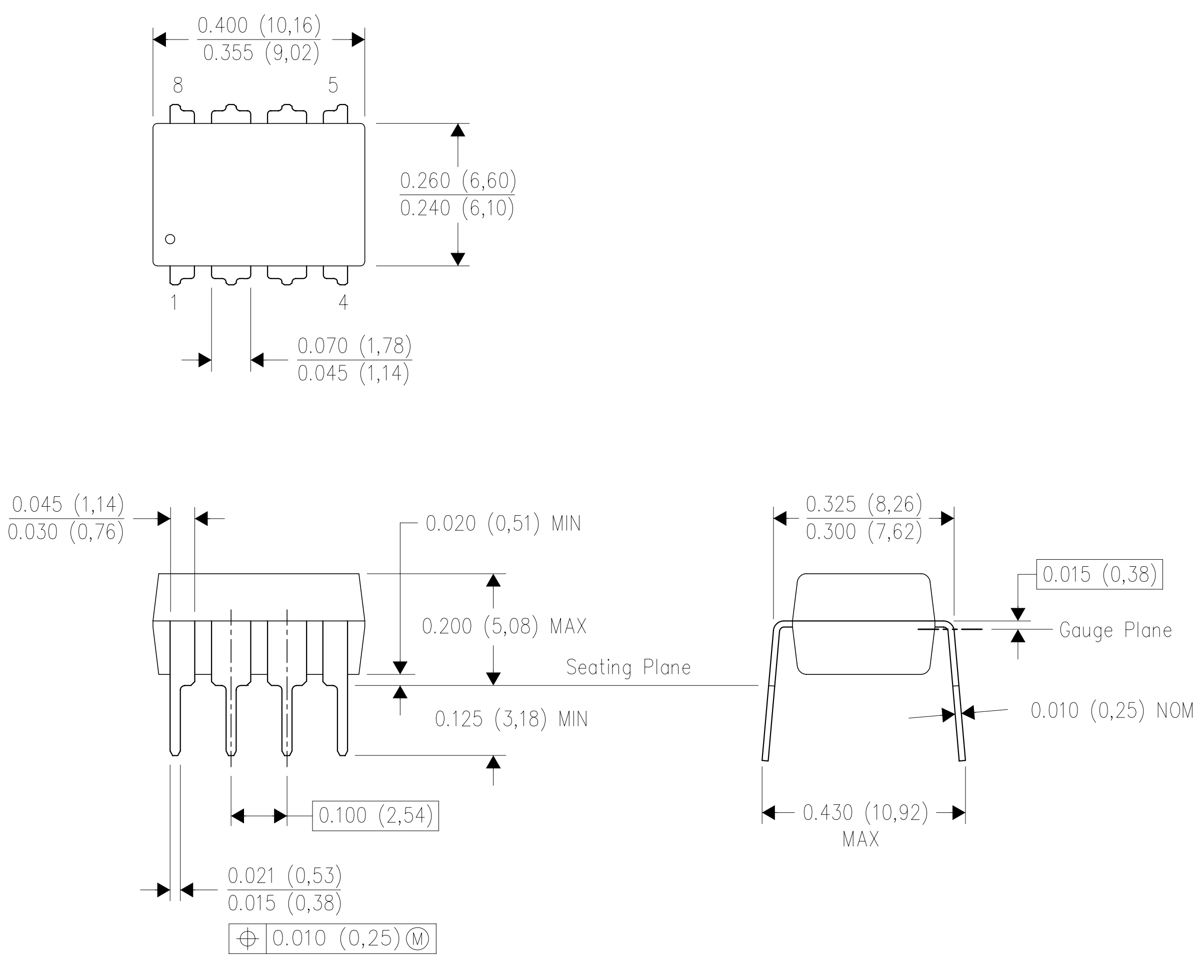
NOTES: (continued)

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

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



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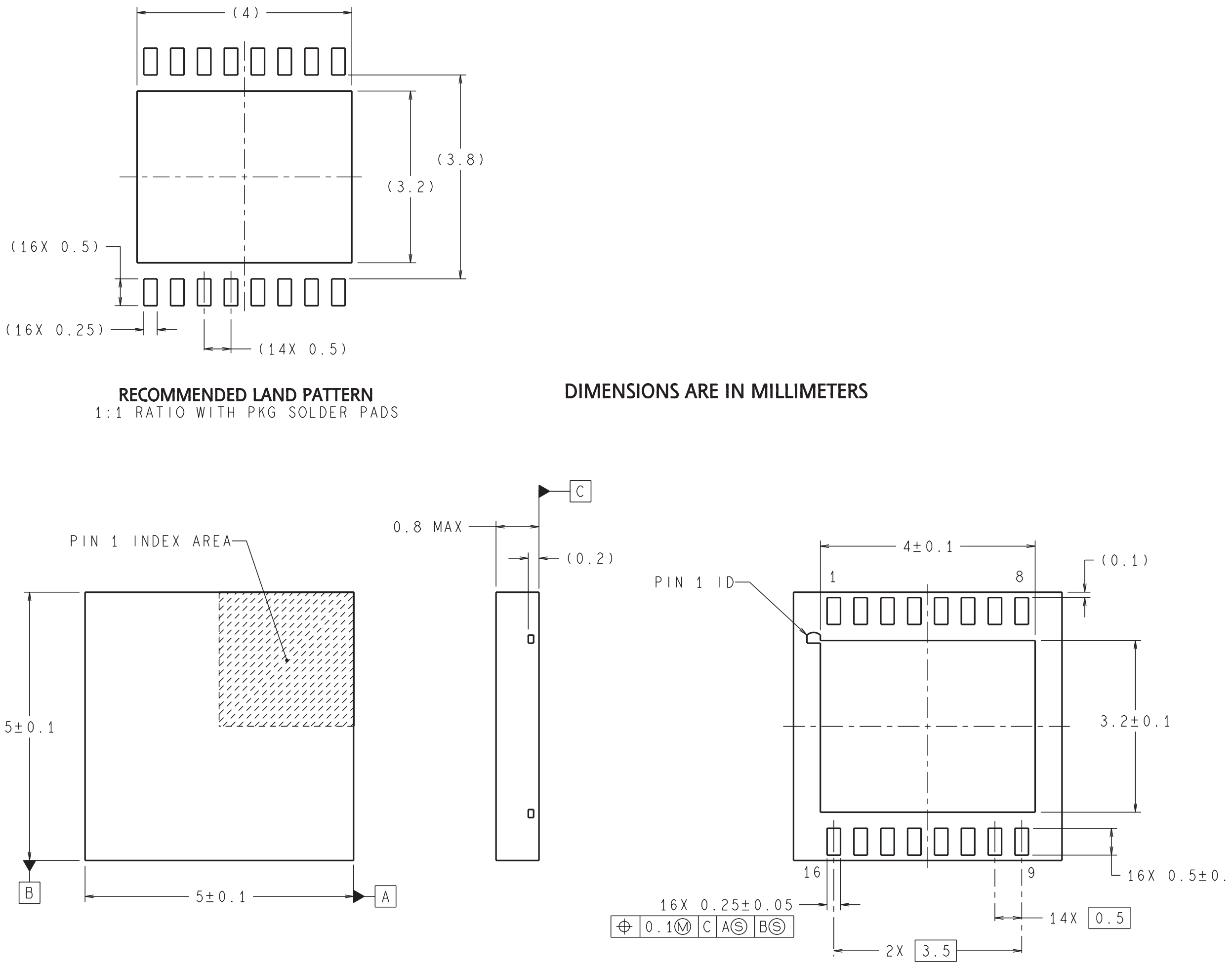
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

NHN0016A



LDA16A (REV A)