LM2575 1-A Simple Step-Down Switching Voltage Regulator

1 Features

- Adjustable With a Range of 1.23 V to 37 V and ±4% Regulation (Max) Over Line, Load, and Temperature Conditions
- Specified 1-A Output Current
- Wide Input Voltage Range 4.75 V to 40 V
- Uses Readily Available Standard Inductors
- 52-kHz (Typical) Fixed-Frequency Internal Oscillator
- TTL Shutdown Capability With 50-μA (Typical) Standby Current
- High Efficiency…as High as 88% (Typical)
- Thermal Shutdown and Current-Limit Protection With Cycle-by-Cycle Current Limiting
- For the Full Offering of Voltages (Including Fixed-Output Options) and Packages (Including TO-263), See TL2575 Data Sheet, SLVS638

2 Applications

- Simple High-Efficiency Step-Down (Buck) Regulator
- Pre-Regulator for Linear Regulators
- On-Card Switching Regulators
- Positive-to-Negative Converter (Buck-Boost)

3 Description

The LM2575 device greatly simplifies the design of switching power supplies by conveniently providing all the active functions needed for a step-down (buck) switching regulator in an integrated circuit. Accepting a wide input voltage range and available in an adjustable output version, the LM2575 has an integrated switch capable of delivering 1 A of load current, with excellent line and load regulation. The device also offers internal frequency compensation, a fixed-frequency oscillator, cycle-by-cycle current limiting, and thermal shutdown. In addition, a manual shutdown is available through an external $\overline{\text{ON}}$/OFF pin.

The LM2575 represents a superior alternative to popular three-terminal linear regulators. Due to its high efficiency, it significantly reduces the size of the heat sink and, in many cases, no heat sink is required. Optimized for use with standard series of inductors available from several different manufacturers, the LM2575 greatly simplifies the design of switch-mode power supplies by requiring a minimal addition of only four to six external components for operation.

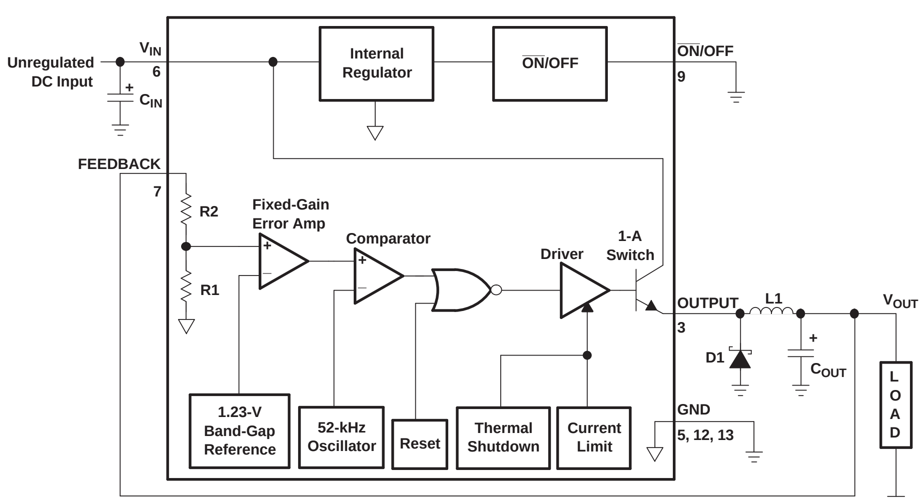
The LM2575 is characterized for operation over the virtual junction temperature range of –40°C to 125°C.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM2575N	PDIP (16)	19.30 mm × 6.35 mm

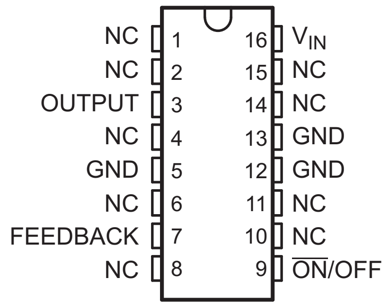
(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic



R1 = Open, R2 = 0 Ω

5 Pin Configuration and Functions



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
FEEDBACK	7	I	Output voltage sense
GND	5	—	Ground pins, all pins must be connect to ground.
	12		
	13		
$\overline{\text{ON}}$/OFF	9	I	Active low enable
OUTPUT	3	O	Switch output
VIN	16	I	Input voltage supply pin
NC	1	—	Not connected internally, pins can be connected to circuit ground plane for improved thermal performance.
	2		
	4		
	6		
	8		
	10		
	11		
	14		
	15		

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{IN}	Supply voltage	–0.3	42	V
	$\overline{\text{ON}}$/OFF pin input voltage	–0.3	V_{IN}	V
	Output voltage to GND (steady-state)		–1	V
T_J	Maximum junction temperature		150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101, all pins[2]	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_{IN}	Supply voltage	4.75	40	V
T_J	Operating virtual junction temperature	–40	125	°C

6.4 Thermal Information

THERMAL METRIC[1]		LM2575 N (PDIP) 16 PINS	UNIT
$R_{θJA}$	Junction-to-ambient thermal resistance	67	°C/W
$R_{θJC(top)}$	Junction-to-case (top) thermal resistance	51	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

6.5 Electrical Characteristics

I_{LOAD} = 200 mA, V_{IN} = 12 V (unless otherwise noted) (see Figure 16)

PARAMETER		TEST CONDITIONS	T_J	MIN	TYP	MAX	UNIT
V_{OUT}	Feedback voltage	V_{OUT} = 5 V, I_{LOAD} = 0.2 A	25°C	1.217	1.23	1.243	V
		8 V ≤ V_{IN} ≤ 40 V, V_{OUT} = 5 V, 0.2 A ≤ I_{LOAD} ≤ 1 A	25°C	1.193	1.23	1.267	
			Full range	1.18		1.28	
η	Efficiency	V_{IN} = 12 V, V_{OUT} = 5 V, I_{LOAD} = 1 A	25°C		77%		
I_{IB}	Feedback bias current	V_{OUT} = 5 V	25°C		50	100	nA
			Full range			500	
f_o	Oscillator frequency[1]		25°C	47	52	58	kHz
			Full range	42		63	
V_{SAT}	Saturation voltage	I_{OUT} = 1 A[2]	25°C		0.9	1.2	V
			Full range			1.4	
	Maximum duty cycle[3]		25°C	93%	98%		
I_{CL}	Peak current[1] [2]		25°C	1.7	2.8	3.6	A
			Full range	1.3		4	
I_L	Output leakage current	V_{IN} = 40[4], Output = 0 V	25°C			2	mA
		V_{IN} = 40[4], Output = –1 V			7.5	30	
I_Q	Quiescent current[4]		25°C		5	10	mA
I_{STBY}	Standby quiescent current	OFF ($\overline{ON}$/OFF pin = 5 V)	25°C		50	200	μA

(1) In the event of an output short or an overload condition, self-protection features lower the oscillator frequency to ~18 kHz and the minimum duty cycle from 5% to ~2%. The resulting output voltage drops to ~40% of its nominal value, causing the average power dissipated by the IC to lower.
(2) Output is not connected to diode, inductor, or capacitor. Output is sourcing current.
(3) Feedback is disconnected from output and connected to 0 V.
(4) To force the output transistor off, FEEDBACK is disconnected from output and connected to 12 V.

Electrical Characteristics (continued)

I_{LOAD} = 200 mA, V_{IN} = 12 V (unless otherwise noted) (see Figure 16)

PARAMETER		TEST CONDITIONS	T_J	MIN	TYP	MAX	UNIT
V_{IH}	$\overline{ON}$/OFF logic input level	OFF (V_{OUT} = 0 V)	25°C	2.2	1.4		V
			Full range	2.4			
V_{IL}		ON (V_{OUT} = nominal voltage)	25°C		1.2	1	
			Full range			0.8	
I_{IH}	$\overline{ON}$/OFF input current	OFF ($\overline{ON}$/OFF pin = 5 V)	25°C		12	30	μA
I_{IL}		ON ($\overline{ON}$/OFF pin = 0 V)			0	10	

6.6 Typical Characteristics

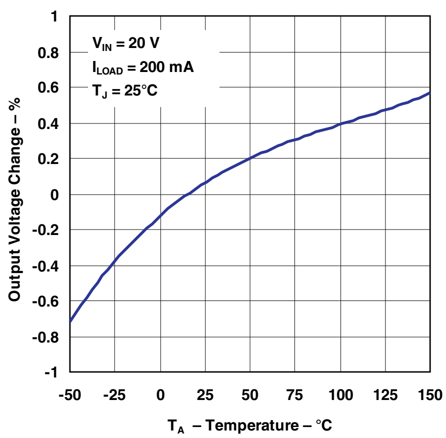


Figure 1. Normalized Output Voltage

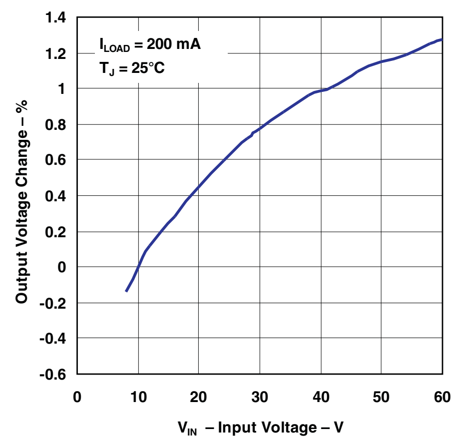


Figure 2. Line Regulation

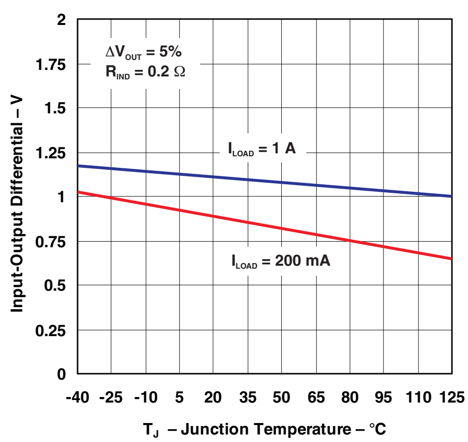


Figure 3. Dropout Voltage

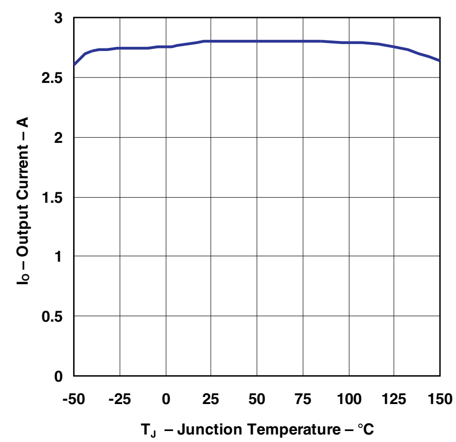


Figure 4. Current Limit

Typical Characteristics (continued)

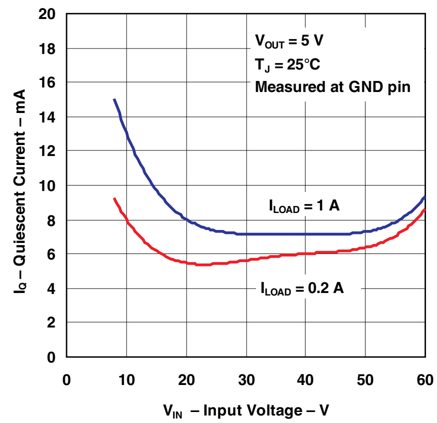


Figure 5. Quiescent Current

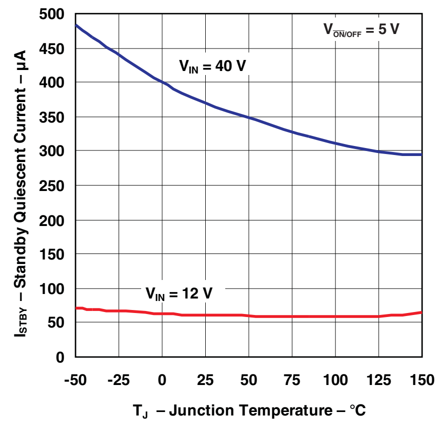


Figure 6. Standby Quiescent Current

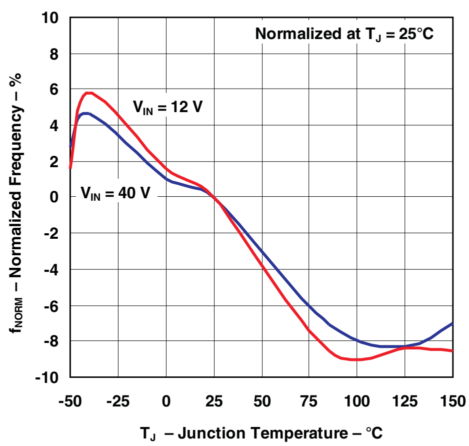


Figure 7. Oscillator Frequency

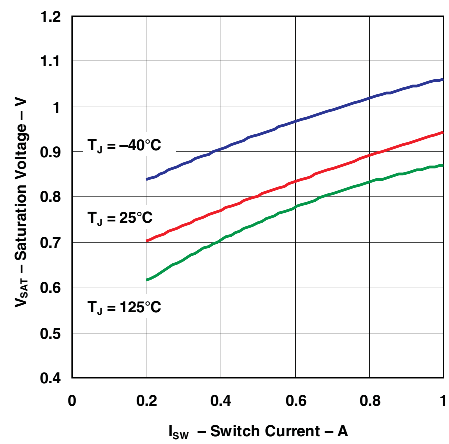


Figure 8. Switch Saturation Voltage

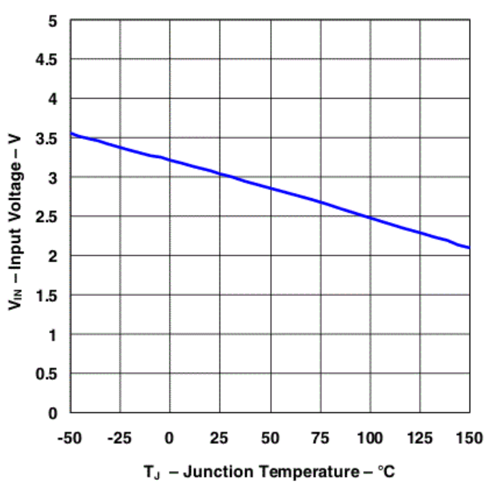


Figure 9. Minimum Operating Voltage

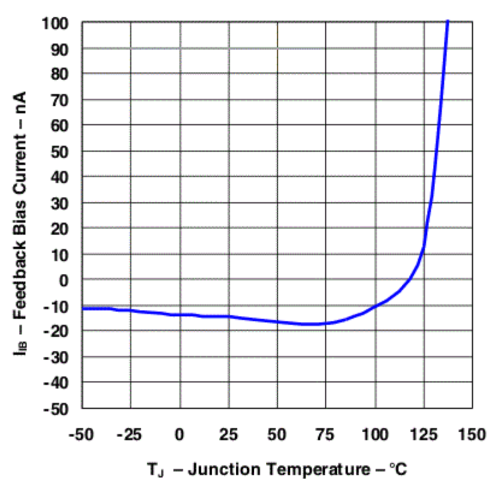


Figure 10. FEEDBACK Current

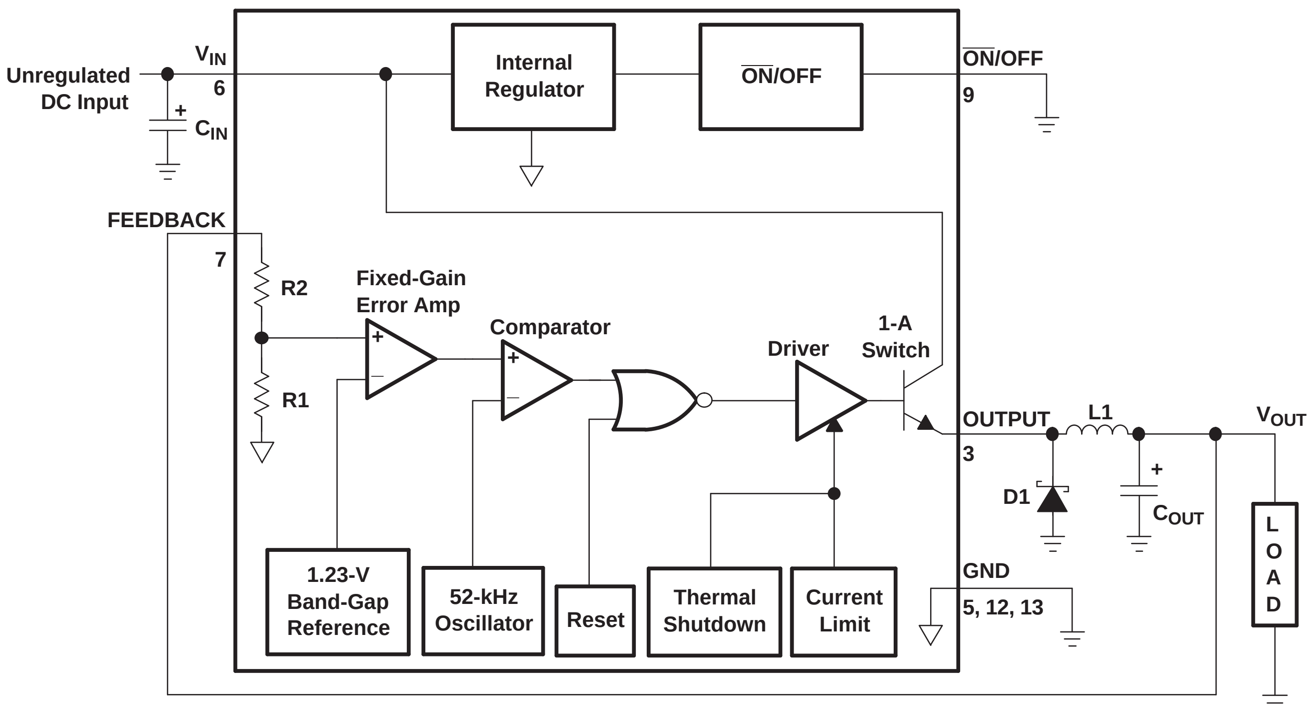
7 Detailed Description

7.1 Overview

The LM2575 provides all the active functions needed for a step-down (buck) switching regulator in an integrated circuit. The wide input-voltage range is 4.75 V to 40 V. The output voltage is programmable by two external resistors. No external frequency compensation is needed. The integrated switch is capable of delivering 1 A of load current, with excellent line and load regulation. The fixed 52-kHz output has cycle-by-cycle current limiting, and thermal shutdown. In addition, a manual shutdown is available through an external $\overline{\text{ON}}$/OFF pin.

The LM2575 is characterized for operation over the virtual junction temperature range of –40°C to 125°C.

7.2 Functional Block Diagram



R1 = Open, R2 = 0 Ω

7.3 Feature Description

7.3.1 Feedback Connection

FEEDBACK must be connected between the two programming resistors. Again, both of these resistors must be in close proximity to the regulator, and each must be less than 100 kΩ to minimize noise pickup.

7.3.2 $\overline{\text{ON}}$/OFF Input

$\overline{\text{ON}}$/OFF should be grounded or be a low-level TTL voltage (typically < 1.6 V) for normal operation. To shut down the LM2575 device and place in standby mode, a high-level TTL or CMOS voltage should be supplied to this pin. $\overline{\text{ON}}$/OFF must not be left open and safely can be pulled up to V_{IN} with or without a pullup resistor.

7.3.3 Fault Protection

In the event of an output short or an overload condition, self-protection features lower the oscillator frequency to approximately 18 kHz and the minimum duty cycle from 5% to approximately 2%. The resulting output voltage drops to approximately 40% of its nominal value, causing the average power dissipated by the IC to lower.

8 Application and Implementation

NOTE

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

8.1 Application Information

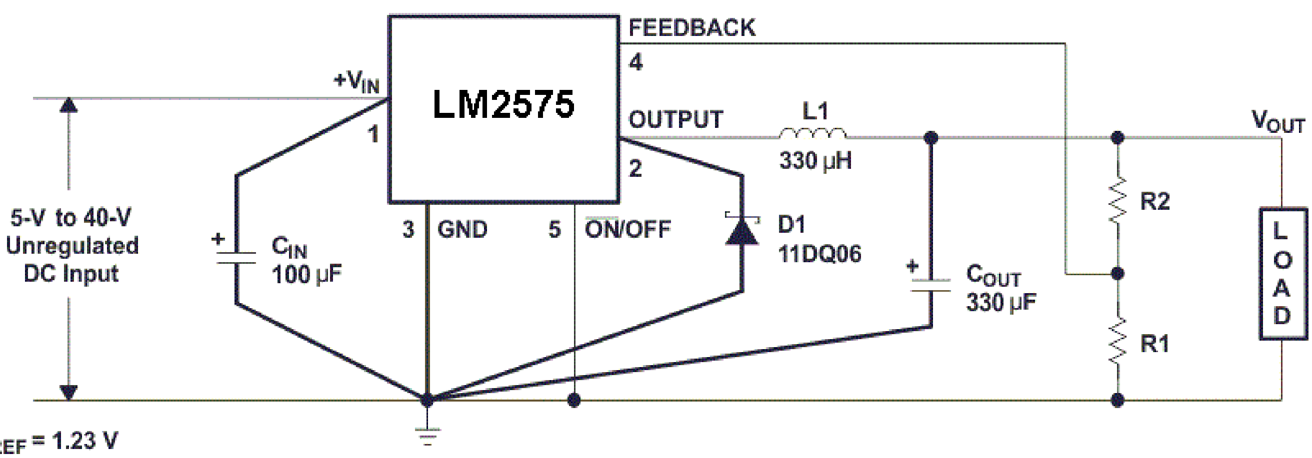
The limited component count and internal frequency compensation makes the LM2575 easy use. Output voltage is set by two external resistors.

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right)$$

where

- V_{REF} = 1.23 V (1)

8.2 Typical Application



V_{REF} = 1.23 V
$V_{OUT} = V_{REF}$ (1 + R2 / R1) = 5 V
C_{IN} = 100 µF, Aluminum Electrolytic
C_{OUT} = 330 µF, Aluminum Electrolytic
D1 = Schottky
L1 = 330 µH (for 5-V V_{IN} with 3.3-V V_{OUT}, use 100 µH)

Figure 11. Buck Regulator With User Programmable Output Voltage

8.2.1 Design Requirements

Output voltage is set by R1 and R2. Output voltage must be between V_{REF} and (V_{IN}[minimum] – V_{SAT}) × Duty Cycle [maximum].

VSAT maximum and duty cycle maximum are specified in the *Electrical Characteristics* table.

8.2.2 Detailed Design Procedure

8.2.2.1 Input Capacitor (C_{IN})

For stability concerns, an input bypass capacitor (electrolytic, C_{IN} ≥ 47 µF) must be located as close as possible to the regulator. For operating temperatures below –25°C, C_{IN} may need to be larger in value. In addition, because most electrolytic capacitors have decreasing capacitances and increasing ESR as temperature drops, adding a ceramic or solid tantalum capacitor in parallel increases the stability in cold temperatures.

Table 1. Diode Selection Guide

V_R	SCHOTTKY		FAST RECOVERY	
	1A	3A	1A	3A
20 V	1N5817 MBR120P SR102	1N5820 MBR320 SR302	The following diodes are all rated to 100 V: 11DF1 MUR110 HER102	The following diodes are all rated to 100 V: 31DF1 MURD310 HER302
30 V	1N5818 MBR130P 11DQ03 SR103	1N5821 MBR330 31DQ03 SR303		
40 V	1N5819 MBR140P 11DQ04 SR104	IN5822 MBR340 31DQ04 SR304		
50 V	MBR150 11DQ05 SR105	MBR350 31DQ05 SR305		
60 V	MBR160 11DQ06 SR106	MBR360 31DQ06 SR306		

8.2.2.11 Inductor Selection Guide

Figure 12 shows the inductor value selection guide for continuous-mode operation

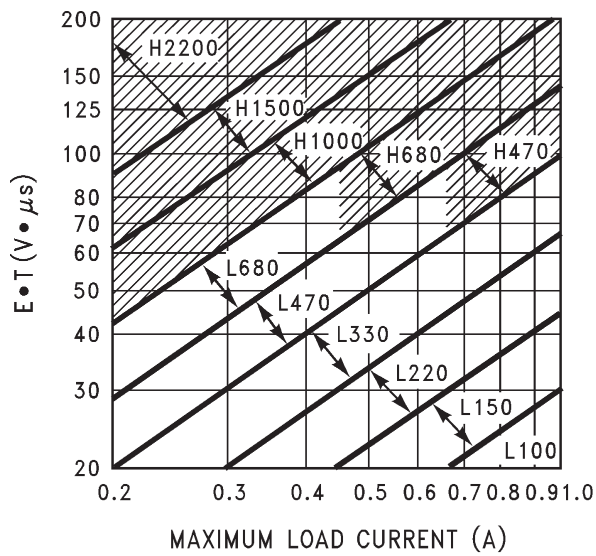
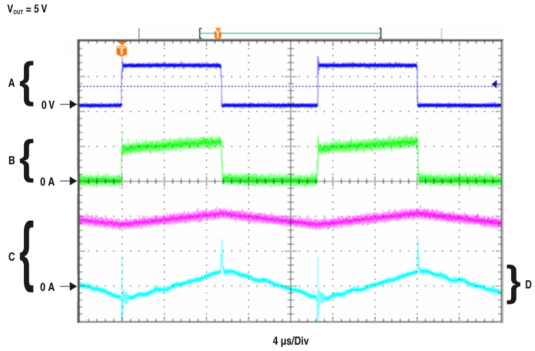


Figure 12. LM2575 Inductor Selection

8.2.3 Application Curves



A. Output pin voltage, 10 V/Div
B. Output pin current, 1 A/Div
C. Inductor current, 0.5 A/Div
D. VOUT ripple voltage, 20 mV/Div

Figure 13. Switching Waveforms

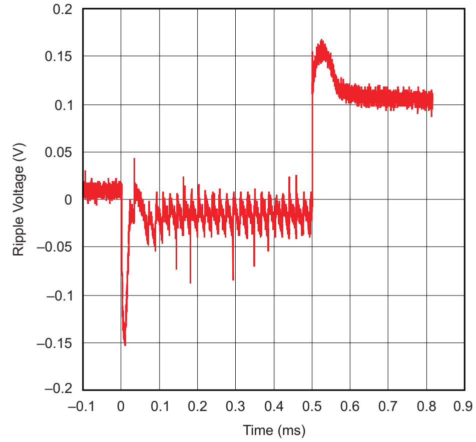


Figure 14. Load Transient Response

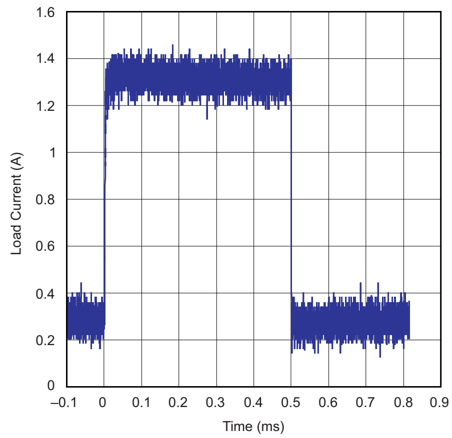


Figure 15. Load Transient Response

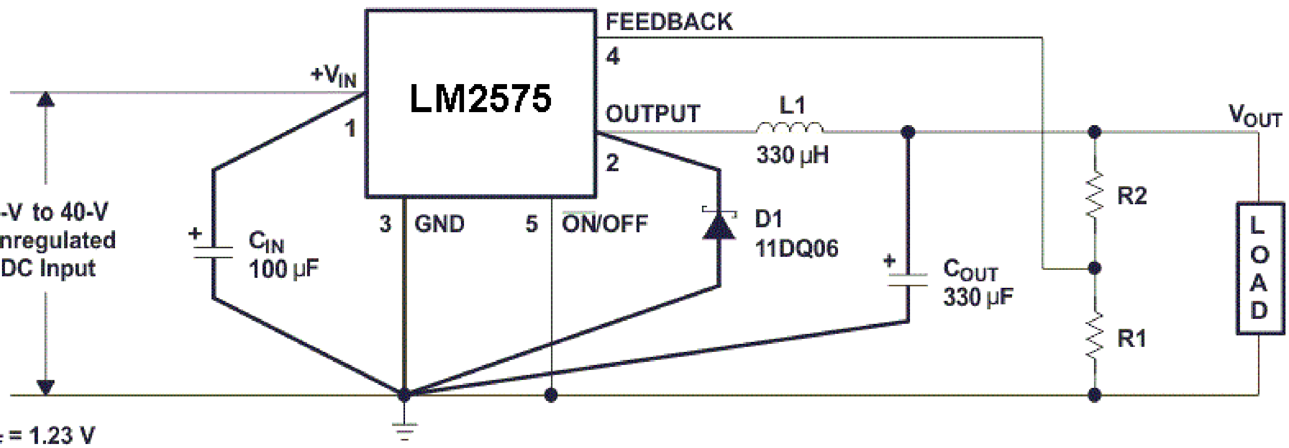
9 Power Supply Recommendations

This device operates with a power supply range of 4.75 V to 40 V. A 100-µF decoupling capacitor is recommended on the input to filter noise.

10 Layout

10.1 Layout Guidelines

With any switching regulator, circuit layout plays an important role in circuit performance. Wiring and parasitic inductances, as well as stray capacitances, are subjected to rapidly switching currents, which can result in unwanted voltage transients. To minimize inductance and ground loops, the length of the leads indicated by heavy lines (see Figure 16) must be minimized. Optimal results can be achieved by single-point grounding or by ground-plane construction. For the same reasons, the two programming resistors used in the adjustable version must be located as close as possible to the regulator to keep the sensitive feedback wiring short.



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$V_{OUT} = V_{REF}$ (1 + R2 / R1) = 5 V
C_{IN} = 100 µF, Aluminum Electrolytic
C_{OUT} = 330 µF, Aluminum Electrolytic
D1 = Schottky
L1 = 330 µH (for 5-V V_{IN} with 3.3-V V_{OUT}, use 100 µH)

Figure 16. Test Circuit and Layout Guidelines

10.2 Layout Example

The large ground copper area helps heat transfer especially when many vias to ground plane are used.

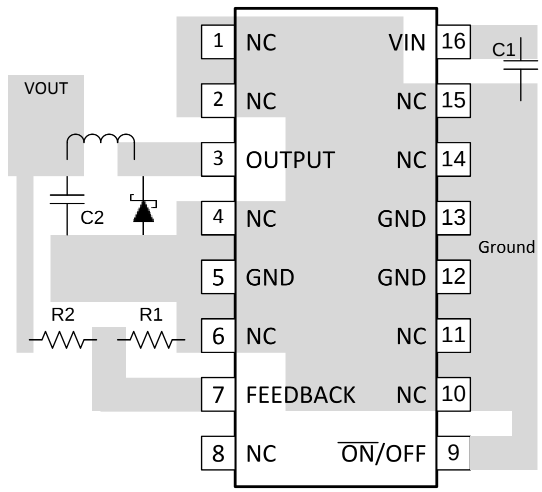

Figure 17. Layout Diagram