

# Product Specification

LM2594

1.5A 150KHz 40V PWM Buck DC/DC Converter

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## Descriptions

The LM2594 regulator is monolithic integrated circuit ideally suited for easy and convenient design of a step-down switching regulator(buck converter). It is capable of driving a 1.5A load with excellent line and load regulation. This device is available in adjustable output version. It is internally compensated to minimize the number of external components to simplify the power supply design. Since LM2594 converter is a switch-mode power supply, its efficiency is significantly higher in comparison with popular three-terminal linear regulators, especially with higher input voltages. The LM2594 operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators.

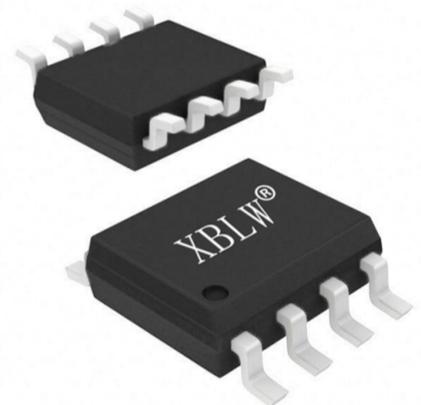
Available in a standard SOP8 Surface Mount packages. The other features include a guaranteed  $\pm 4\%$  tolerance on output voltage with in specified input voltages and output load conditions, and  $\pm 15\%$  on the oscillator frequency. External shutdown is included, featuring 50  $\mu\text{A}$  (typical) standby current. Self protection features include switch cycle-by-cycle current limit for the output switch, as well as thermal shutdown for complete protection under fault conditions.

## Features

- Adjustable Output Voltage Range 1.23V-37V
- 3.3V, 5V, 12V, and adjustable versions
- Guaranteed 1.5A Output Load Current Wide
- Input Voltage Range up to 40 V
- 150 kHz Fixed Frequency Internal Oscillator
- TTL Shutdown Capability Low Power Standby Mode, typ 50  $\mu\text{A}$
- Thermal Shutdown and Current Limit Protection
- Internal Loop Compensation
- These are Pb-Free Devices

## Applications

- Simple High-Efficiency Step-Down (Buck) Regulator
- Efficient Pre-Regulator for Linear Regulators
- On-Card Switching Regulators
- Positive to Negative Converter (Buck-Boost)
- Negative Step-Up Converters
- Power Supply for Battery Chargers



SOP-8

Figure 1. Package Types of LM2594

## Ordering Information

Product Model	Package Type	Marking	Packing	Packing Qty
LM2594M-3.3	SOP-8	LM2594M-3.3	Tape	4000Pcs/Reel
LM2594M-5.0	SOP-8	LM2594M-5.0	Tape	4000Pcs/Reel
LM2594M-12	SOP-8	LM2594M-12	Tape	4000Pcs/Reel
LM2594M-ADJ	SOP-8	LM2594M-ADJ	Tape	4000Pcs/Reel

## Pin Configurations

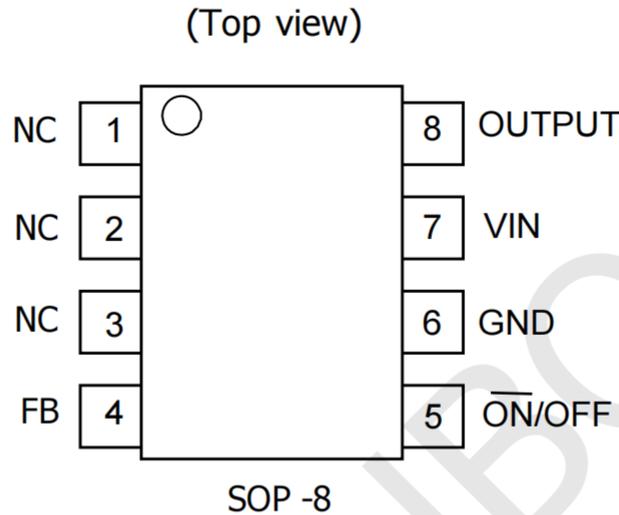


Figure 2 Pin Configuration of LM2594 (Top View)

## Pin Description

Pin Number	Pin Name	Description
1/2/3	NC	Not Connected
4	FB	This pin is the direct input of the error amplifier and the resistor network R2, R1 is connected externally to allow programming of the output voltage.
5	$\overline{\text{ON/OFF}}$	Allows the switching regulator circuit to be shut down using logic levels, thus dropping the total input supply current to approximately 50 $\mu\text{A}$ . The threshold voltage is typical. 1.6 V. Applying a voltage above this value (up to VIN) shuts the regulator off. If the voltage applied to this pin is lower than 1.6 V or if this pin is left open, the regulator will be in the "on" condition.
6	GND	Circuit ground pin. See the information about the printed circuit board layout.
7	VIN	Positive input supply for LM2594 step-down switching regulator. In order to minimize voltage transients and to supply the switching currents needed by the regulator, a suitable input bypass capacitor must be present
8	OUTPUT	Emitter of the internal switch. The saturation voltage V <sub>sat</sub> of the output switch is typically 1 V. It should be kept in mind that PCB area connected to this pin should be kept to a minimum in order to minimize coupling to sensitive circuitry

### Function Block

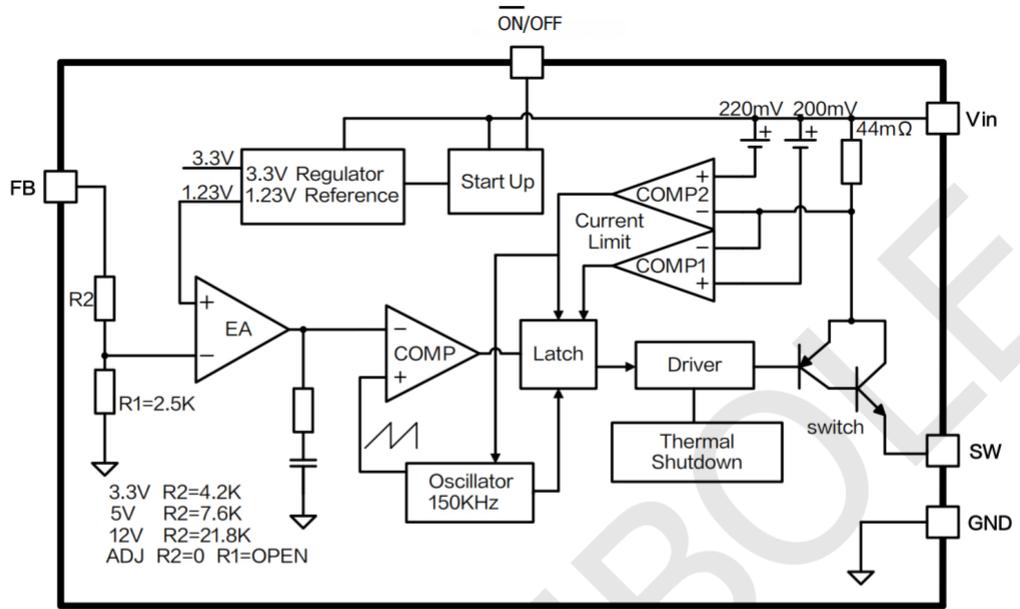


Figure 3 Function Block Diagram of LM2594

### Typical Application Circuit

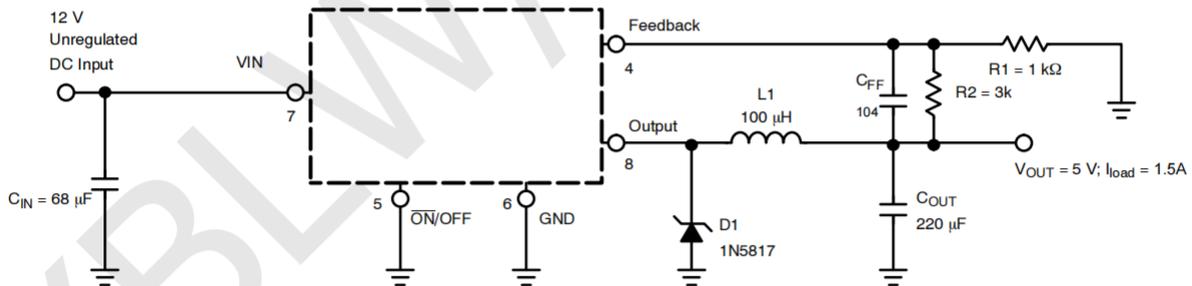


Figure4. LM2594-ADJ Typical Application Circuit (VIN=8V~40V, VOUT=5V/1.5A)

## Absolute Maximum Ratings

Note1: Stresses greater than those listed under Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Parameter	Symbol	Value	Unit
Input Voltage	$V_{IN}$	-0.3 to 45	V
Feedback Pin Voltage	$V_{FB}$	-0.3 to $V_{IN}$	V
Enable Pin Voltage	$V_{EN}$	-0.3 to $V_{IN}$	V
Switch Pin Voltage	$V_{SW}$	-0.3 to $V_{IN}$	V
Power Dissipation	$P_D$	Internally limited	mW
Operating Junction Temperature	$T_J$	-40~125	°C
Storage Temperature	$T_{STG}$	-65 to 150	°C
Lead Temperature (Soldering, 10 sec)	$T_{LEAD}$	260	°C
ESD (HBM)		2000	V
MSL		Level3	
Thermal Resistance-Junction to Ambient	$R_{\theta JA}$	85	°C / W
Thermal Resistance-Junction to Case	$R_{\theta JC}$	45	°C / W

### LM2594M-3.3 Electrical Characteristics

T<sub>a</sub> = 25°C; unless otherwise specified.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>System parameters test circuit figure6</b>						
V <sub>OUT</sub>	Output Voltage	V <sub>in</sub> = 8V to 40V I <sub>load</sub> =0.1A to 1.5A	3.168	3.3	3.432	V
η	Efficiency	V <sub>in</sub> =12V ,V <sub>out</sub> =3.3V I <sub>out</sub> =1.5A	-	78	-	%

### LM2594M-5.0 Electrical Characteristics

T<sub>a</sub> = 25°C; unless otherwise specified.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>System parameters test circuit figure7</b>						
V <sub>OUT</sub>	Output Voltage	V <sub>in</sub> = 8V to 40V I <sub>load</sub> =0.1A to 1.5A	4.8	5	5.2	V
η	Efficiency	V <sub>in</sub> =12V ,V <sub>out</sub> =5V, I <sub>out</sub> =1.5A	-	83	-	%

### LM2594M-12 Electrical Characteristics

T<sub>a</sub> = 25°C; unless otherwise specified.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>System parameters test circuit figure8</b>						
V <sub>OUT</sub>	Output Voltage	V <sub>in</sub> = 15V to 40V , I <sub>load</sub> =0.1A to 1.5A	11.52	12	12.48	V
η	Efficiency	V <sub>in</sub> =25V ,V <sub>out</sub> =12V I <sub>out</sub> =1.5A	-	85	-	%

### LM2594M-ADJ Electrical Characteristics

T<sub>a</sub> = 25°C; unless otherwise specified.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>System parameters test circuit figure9</b>						
V <sub>OUT</sub>	Output Voltage	V <sub>in</sub> = 8V to 40V I <sub>load</sub> =0.1A to 1.5A	1.193	1.23	1.267	V
η	Efficiency	V <sub>in</sub> =12V ,V <sub>out</sub> =5V, I <sub>out</sub> =1.5A	-	83	-	%

## Electrical Characteristics (DC Parameters)

$V_{in}$  = 12V for the 3.3V,5V,and Adjustable versions and  $V_{in}$ =24V for the 12V version,  $GND=0V$ ,  $V_{in}$  &  $GND$  parallel connect a 220uF/50V capacitor;  $I_{out}$ =500mA,  $T_a$  = 25°C; the others floating unless otherwise specified.

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input operation voltage	$V_{in}$		4.5		40	V
Shutdown Supply Current	$I_S$	$V_{EN}=5V$		50	200	uA
Quiescent Supply Current	$I_q$	$V_{EN} =0V, V_{FB} =V_{in}$		4.5	10	mA
Oscillator Frequency	$F_{osc}$		127	150	173	Khz
Switch Current Limit	$I_L$	$V_{FB} =0V$		4.0		A
EN Pin Threshold	$V_{EN}$	High (Regulator OFF) Low (Regulator ON)		1.4 0.8		V
EN Pin Input Leakage Current	$I_H$	$V_{EN} =2.5V$ (OFF)		8	15	uA
	$I_L$	$V_{EN} =0.5V$ (ON)		0.5	5	uA
Output Saturation Voltage	$V_{CE}$	$V_{FB}=0V$ $I_{out}=2A$		1.2	1.5	V
Max. Duty Cycle	$D_{MAX}$	$V_{FB}=0V$		95		%

Test Circuit and Layout guidelines

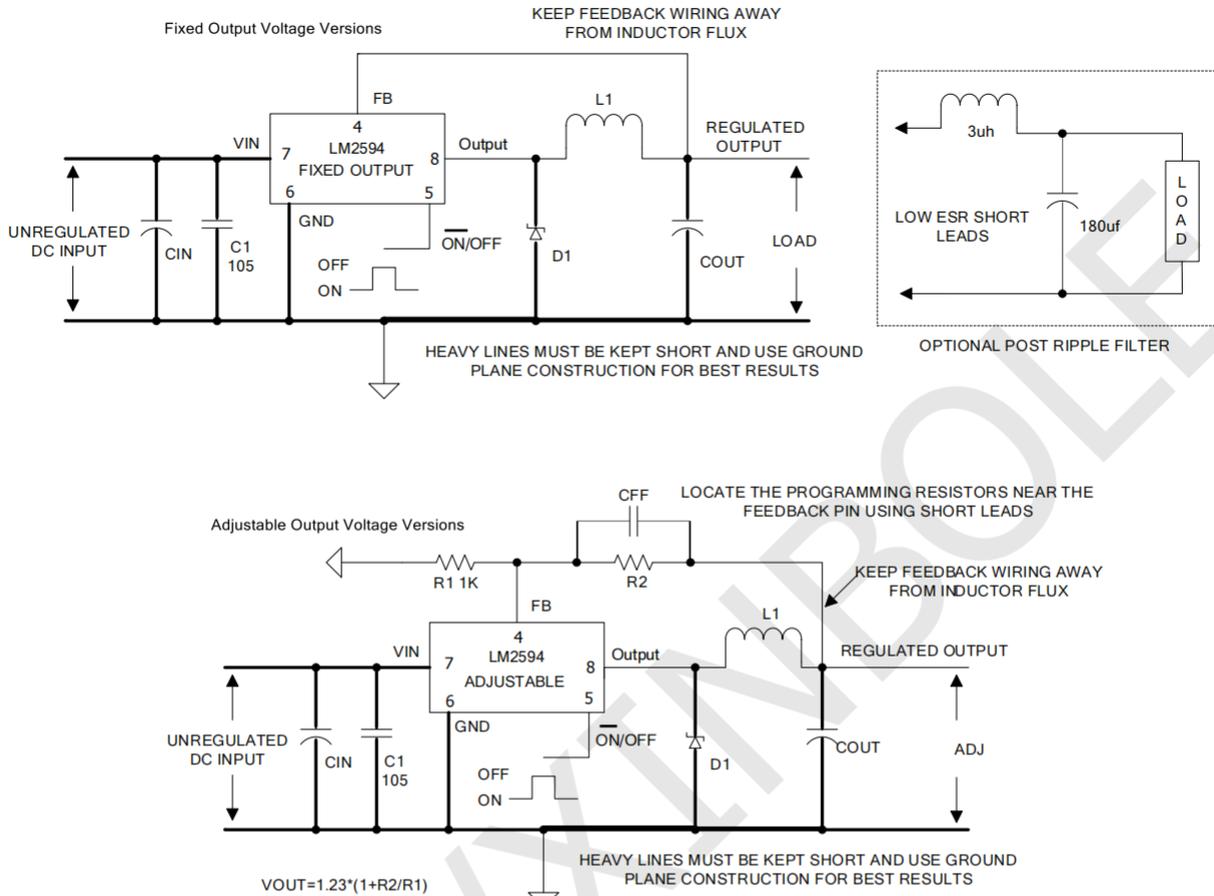


Figure4. Standard Test Circuits and Layout Guides

Select R1 to be approximately 1K, use a 1% resistor for best stability.

C1 and CFF are optional; in order to increase stability and reduce the input power line noise, C1 must be placed near to PIN1 and PIN3;

For output voltages greater than approximately 10V, an additional capacitor CFF is required.

The compensation capacitor is typically between 100 pf and 33 nf, and is wired in parallel with the output voltage setting resistor, R2. It provides additional stability for high output voltage, low input-output voltages, and/or very low ESR output capacitors, such as solid tantalum capacitors.

$CFF = 1 / (31 * 1000 * R2)$ ; This capacitor type can be ceramic, plastic, silver mica, etc. (Because of the unstable characteristics of ceramic capacitors made with Z5U material, they are not recommended.)

LM2594 Series Buck Regulator Design Procedure (Fixed Output)

Conditions			Inductor (L1) Inductance (uH)	Output Capacitor (COUT)			
Output Voltage (V)	Load Current (A)	Max Input Voltage (V)		Through Hole Electrolytic		Surface Mount Tantalum	
				Panasonic HFQ Series (uF/V)	Nichicon PL Series (uF/V)	AVX TPS Series (uF/V)	Sprague 595D Series (uF/V)
3.3	2	6	22	470/25	470/35	330/6.3	390/6.3
		10	33	330/35	330/35	330/6.3	390/6.3
		40	47	330/35	270/50	220/10	330/10
5	2	9	22	470/25	560/16	220/10	330/10
		20	68	180/35	180/35	100/10	270/10
		40	68	180/35	180/35	100/10	270/10
12	2	15	33	330/25	330/25	100/16	180/16
		20	68	180/25	180/25	100/16	120/20
		40	150	82/25	82/25	68/20	68/25

**LM2594 Series Buck Regulator Design Procedure (Adjustable Output)**

Output Voltage (V)	Through Hole Output Electrolytic			Surface Mount Output Capacitor		
	Panasonic HFQ Series (uF/V)	Nichicon PL Series (uF/V)	Feedforward Capacitor	AVX TPS Series (uF/V)	Sprague 595D Series (uF/V)	Feedforward Capacitor
2	820/35	820/35	33nF	330/6.3	470/4	33nF
4	560/35	470/35	10nF	330/6.3	390/6.3	10nF
6	470/25	470/35	3.3nF	220/10	330/10	3.3nF
9	330/25	330/25	1.5nF	100/16	180/16	1.5nF
12	330/25	330/25	1nF	100/16	180/16	1nF
15	220/25	220/35	680pF	68/20	120/20	680pF
24	220/35	150/35	560pF	33/25	33/25	220pF
28	100/50	100/50	390pF	10/35	15/50	220pF

**Schottky Diode Selection Table**

Current	Surface Mount	Through Hole	VR (The same as system maximum input voltage)				
			20V	30V	40V	50V	60V
1A		√	1N5817	1N5818	1N5819		
2A		√	1N5820	1N5821	1N5822		
		√	MBR320	MBR330	MBR340	MBR350	MBR360
	√		SS32	SS33	SS34	SS35	SS36
	√			30WQ03	30WQ04	30WQ05	
		√		31DQ03	31DQ04	31DQ05	
		√	SR302	SR303	SR304	SR305	SR306

### Typical System Application for 3.3V Version

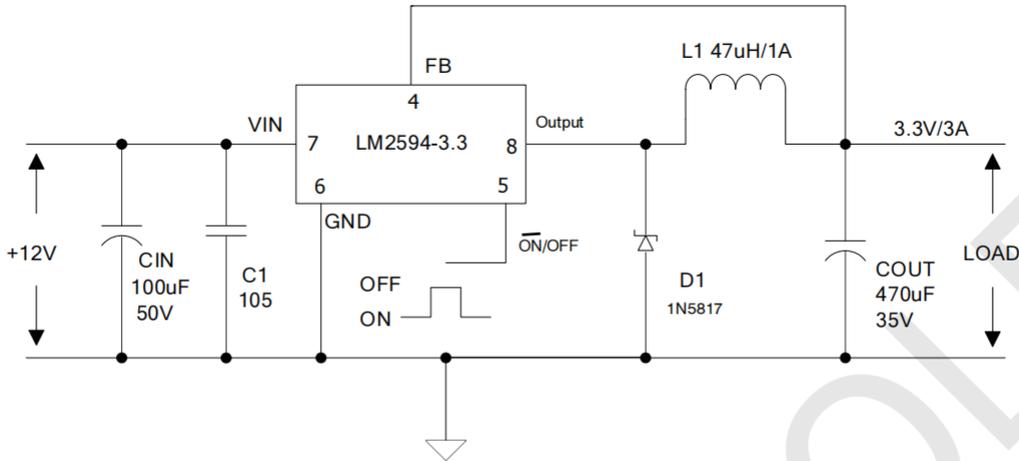


Figure5. LM2594-3.3 System Parameters Test Circuit

### Typical System Application for 5V Version

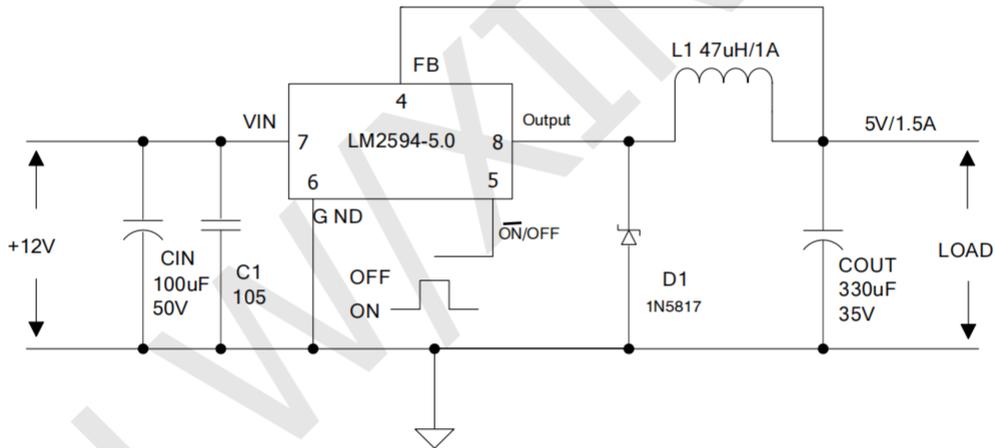


Figure6. LM2594-5.0 System Parameters Test Circuit

### Typical System Application for 12V Version

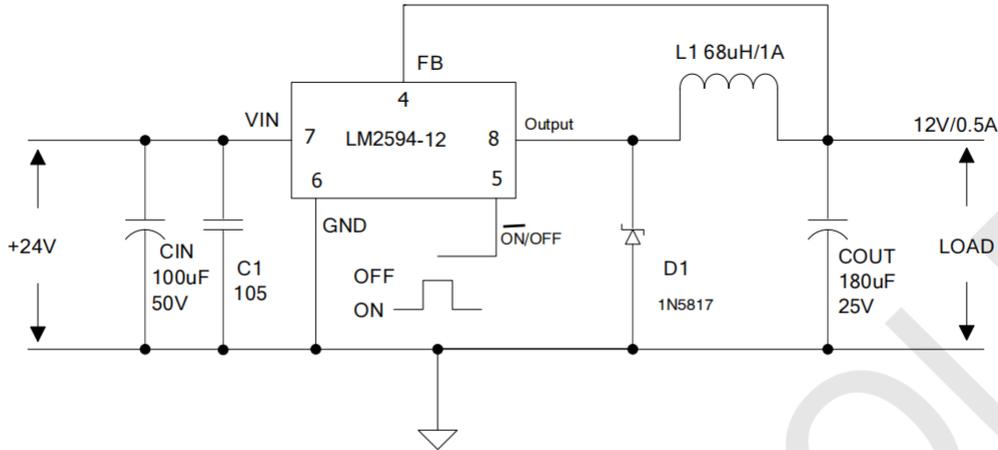


Figure 7. LM2594-12 System Parameters Test Circuit

### Typical System Application for ADJ Version

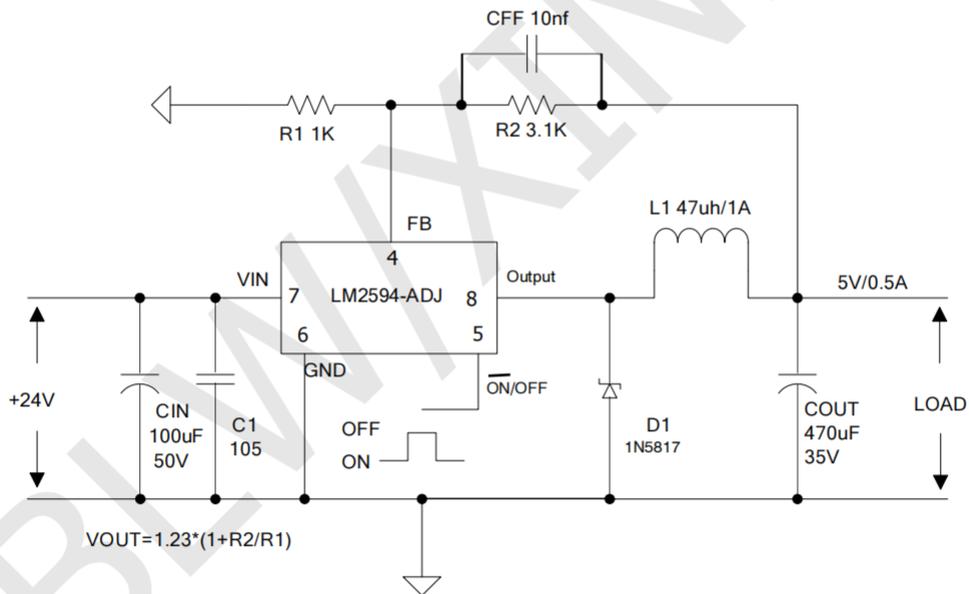
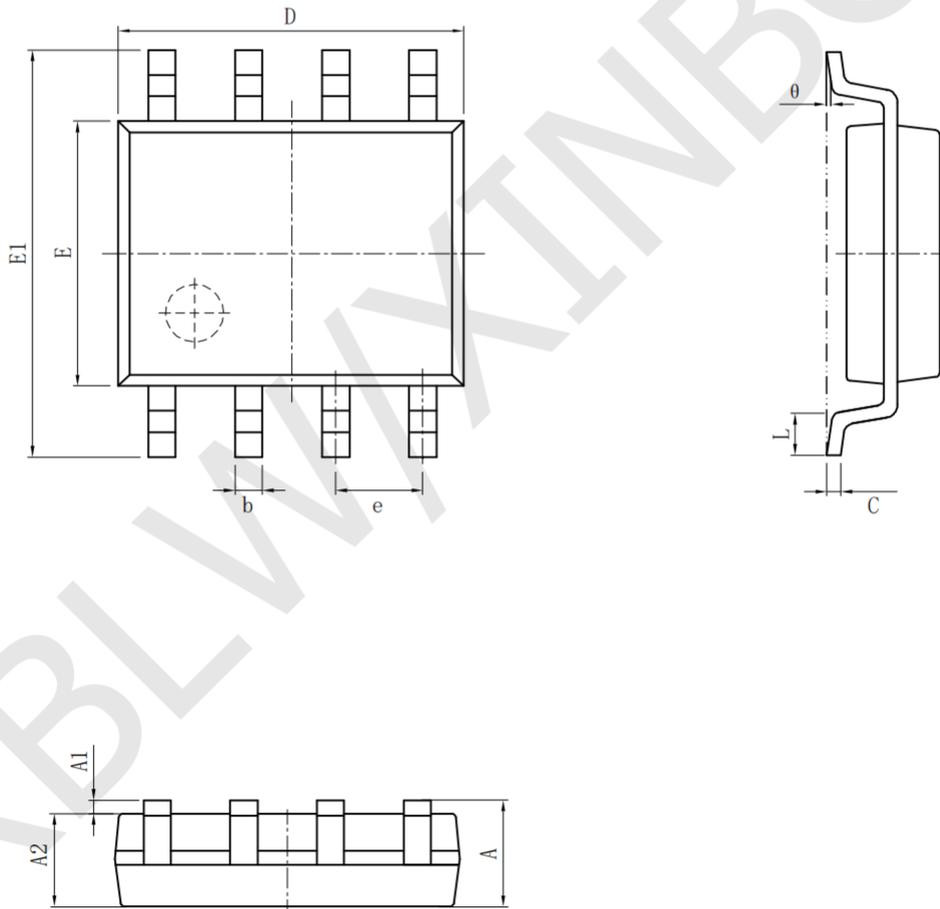


Figure 8. LM2594-ADJ System Parameters Test Circuit

## Package Information

- SOP-8

Size Symbol	Dimensions In Millimeters		Size Symbol	Dimensions In Inches	
	Min (mm)	Max (mm)		Min (in)	Max (in)
A	1.350	1.750	A	0.053	0.069
A1	0.100	0.250	A1	0.004	0.010
A2	1.350	1.550	A2	0.053	0.061
b	0.330	0.510	b	0.013	0.020
c	0.170	0.250	c	0.006	0.010
D	4.700	5.100	D	0.185	0.200
E	3.800	4.000	E	0.150	0.157
E1	5.800	6.200	E1	0.228	0.224
e	1.270 (BSC)		e	0.050 (BSC)	
L	0.400	1.270	L	0.016	0.050
θ	0°	8°	θ	0°	8°



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