

## 1.Description

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The LM2594(HV) is a 150 KHz fixed frequency PWM buck (step-down)DC/DC converter, capable of driving a 1.5A load with high efficiency, low ripple and excellent line and load regulation. Requiring a minimum number of external components, the regulator is simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The PWM control circuit is able to adjust the duty ratio linearly from 0 to 100%. An enable function, an over current protection function is built inside. When second current limit function happens, the operation frequency will be reduced from 150KHz to 50KHz. An internal compensation block is built in to minimize external component count.

## 2.Features

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- Wide 4.5V to 60V Input Voltage Range
- 3.3V,5V,12V, and adjustable versions
- Output Adjustable from 1.23V to 37V  
(57V for the HV Version)
- Maximum Duty Cycle 100%
- Minimum Drop Out 1.5V
- Fixed 150KHz Switching Frequency
- 1.5A Constant Output Current Capability
- Internal Optimize Power Transistor
- High efficiency
- Excellent line and load regulation
- TTL shutdown capability  
ON/OFF pin with hysteresis function
- Built in thermal shutdown function
- Built in current limit function
- Built in second current limit function
- Available in SOP-8 package

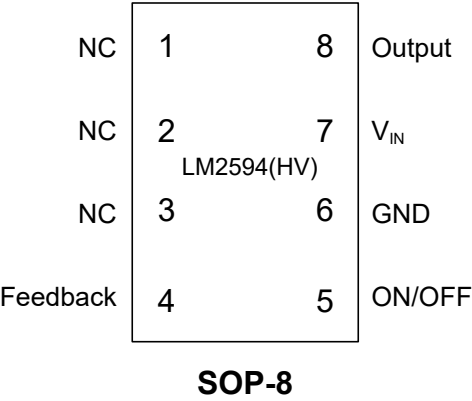
## 3.Applications

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- LCD Monitor and LCD TV
- Digital Photo Frame
- Set-up Box
- ADSL Modem
- Telecom / Networking Equipment



4.Pinning Information



Pin Descriptions

| Pin Number | Pin Name | Description                                                                                                                                                                                                      |
|------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2, 3    | NC       | NO connection                                                                                                                                                                                                    |
| 7          | $V_{IN}$ | Supply Voltage input Pin.LM2594(HV) operates from a 4.5V to 40V DC voltage. Bypass $V_{IN}$ to GND with asuitably large capacitor to eliminate noise on the input                                                |
| 8          | Output   | Power Switch Output Pin (SW). Output is the switch node that supplies power to the output.                                                                                                                       |
| 6          | GND      | Ground Pin. Care must be taken in layout. This pinshould be placed outside of the Schottky Diode tooutput capacitor ground path to prevent switching current spikes from inducing voltage noise into LM2594(HV). |
| 4          | Feedback | Feedback Pin (FB). Through an extemal resistor divider network, Feedback senses the output voltage and regulates it. The feedback threshold voltage is 1.23V                                                     |
| 5          | ON/OFF   | Enable Pin. Drive ON/OFF pin low to turn on thedevice, drive it high to turn it off. Floating is default low.                                                                                                    |



## 5.Function Block

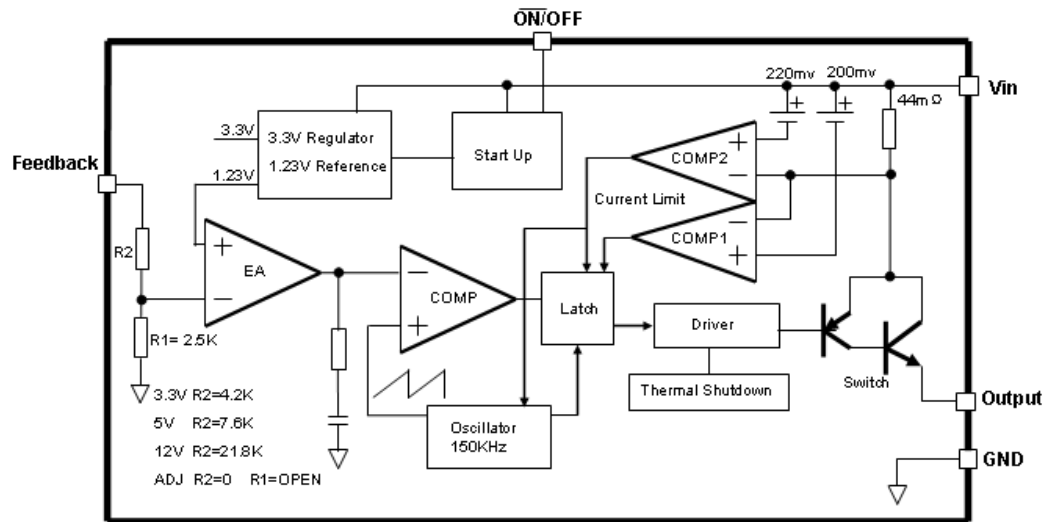


Figure1. Function Block Diagram of LM2594(HV)

## 6.Typical Application Circuit

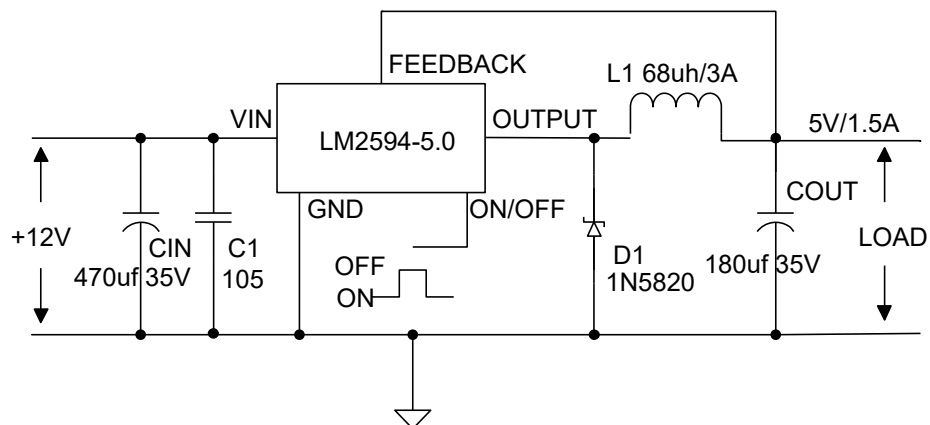


Figure2. LM2594(HV) Typical Application Circuit 12V-5V/1.5A



## 7. Absolute Maximum Ratings (Note 1)

| Parameter                                                               |            | Symbol       | Value              | Value |
|-------------------------------------------------------------------------|------------|--------------|--------------------|-------|
| Input Voltage                                                           | LM2594     | $V_{IN}$     | -0.3 to 45         | V     |
|                                                                         | LM2594(HV) |              | -0.3 to 63         | V     |
| Feedback Pin Voltage                                                    |            | $V_{FB}$     | -0.3 to 25         | V     |
| ON/OFF Pin Voltage                                                      |            | $V_{ON/OFF}$ | -0.3 to 25         | V     |
| Power Dissipation                                                       |            | $P_D$        | Internally limited | mW    |
| Thermal Resistance (SOP-8) (Junction to Ambient, No Heatsink, Free Air) |            | $R_{JA}$     | 100                | °C/W  |
| Operating Junction Temperature                                          |            | $T_J$        | -40 to 125         | °C    |
| Storage Temperature                                                     |            | $T_{STG}$    | -65 to 150         | °C    |
| Lead Temperature (Soldering, 10 sec)                                    |            | $T_{LEAD}$   | 260                | °C    |
| ESD (HBM)                                                               |            |              | 2000               | V     |

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.

## 8. Recommended Operating Conditions

| Parameter      |            | Min | Max | Value |
|----------------|------------|-----|-----|-------|
| Supply voltage | LM2594     | 4.5 | 40  | V     |
|                | LM2594(HV) | 4.5 | 60  | V     |
| Temperature    |            | -40 | 125 | °C    |



## 9.1 Electrical Characteristics

$T_A=25^{\circ}\text{C}$ , unless otherwise specified.

| Parameter                                                      | Symbol    | Conditions                                                                                   | Min.  | Typ. | Max.  | Units |
|----------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------|-------|------|-------|-------|
| <b>System Parameters Test Circuit Figure 5, LM2594(HV)-3.3</b> |           |                                                                                              |       |      |       |       |
| Output Voltage                                                 | $V_{OUT}$ | $V_{IN}=4.75\text{V to }40\text{V, }60\text{V(HV)}$<br>$I_{LOAD}=0.2\text{A to }1.5\text{A}$ | 3.168 | 3.3  | 3.432 | V     |
| Efficiency                                                     | $\eta$    | $V_{IN}=12\text{V, }V_{OUT}=3.3\text{V, }I_{OUT}=1.5\text{A}$                                |       | 75   |       | %     |
| <b>System Parameters Test Circuit Figure 5, LM2594(HV)-5.0</b> |           |                                                                                              |       |      |       |       |
| Output Voltage                                                 | $V_{OUT}$ | $V_{IN}=7\text{V to }40\text{V, }60\text{V(HV)}$<br>$I_{LOAD}=0.2\text{A to }1.5\text{A}$    | 4.8   | 5    | 5.2   | V     |
| Efficiency                                                     | $\eta$    | $V_{IN}=12\text{V, }V_{OUT}=5\text{V, }I_{OUT}=1.5\text{A}$                                  |       | 82   |       | %     |
| <b>System Parameters Test Circuit Figure 5, LM2594(HV)-12</b>  |           |                                                                                              |       |      |       |       |
| Output Voltage                                                 | $V_{OUT}$ | $V_{IN}=15\text{V to }40\text{V, }60\text{V(HV)}$<br>$I_{LOAD}=0.2\text{A to }1.5\text{A}$   | 11.52 | 12   | 12.48 | V     |
| Efficiency                                                     | $\eta$    | $V_{IN}=25\text{V, }V_{OUT}=12\text{V, }I_{OUT}=1.5\text{A}$                                 |       | 90   |       | %     |
| <b>System Parameters Test Circuit Figure 5, LM2594(HV)-ADJ</b> |           |                                                                                              |       |      |       |       |
| Output Voltage                                                 | $V_{OUT}$ | $V_{IN}=4.5\text{V to }40\text{V, }57\text{V(HV)}$<br>$I_{LOAD}=0.2\text{A to }1.5\text{A}$  | 1.193 | 1.23 | 1.267 | V     |
| Efficiency                                                     | $\eta$    | $V_{IN}=12\text{V, }V_{OUT}=3\text{V, }I_{OUT}=1.5\text{A}$                                  |       | 74   |       | %     |



## 9.2 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,  $I_{OUT}=500mA$ ,  $T_A=25^{\circ}C$ , the others floating unless otherwise specified.

| Parameter                 | Symbol       | Conditions                        | Min. | Typ. | Max. | Units   |
|---------------------------|--------------|-----------------------------------|------|------|------|---------|
| Shutdown Supply Current   | $I_{STBY}$   | $V_{ON/OFF}=5V$                   |      | 80   | 200  | $\mu A$ |
| Quiescent Supply Current  | $I_Q$        | $V_{ON/OFF}=0V$ , $V_{FB}=V_{IN}$ |      | 2    | 10   | mA      |
| Oscillator Frequency      | $F_{OSC}$    |                                   | 117  | 150  | 183  | Khz     |
| Switch Current Limit      | $I_L$        | $V_{FB}=0$                        |      | 2    |      | A       |
| ON/OFF Pin Threshold      | $V_{ON/OFF}$ | High (Regulator OFF)              |      | 1.4  |      | V       |
|                           |              | Low (Regulator ON)                |      | 0.8  |      | V       |
| ON/OFF Pin Input          | $I_H$        | $V_{ON/OFF}=2.5V(OFF)$            |      | 5    | 15   | $\mu A$ |
| Leakage Current           | $I_L$        | $V_{ON/OFF}=0.5V(ON)$             |      | 0.2  | 5    | $\mu A$ |
| Output Saturation Voltage | $V_{CE}$     | $V_{FB}=0$ , $I_{OUT}=1.5A$       |      | 1.2  | 1.4  | V       |
| Max. Duty Cycle           | $D_{MAX}$    | $V_{FB}=0$                        |      | 100  |      | %       |



## 10. Test Circuit and Layout Guidelines

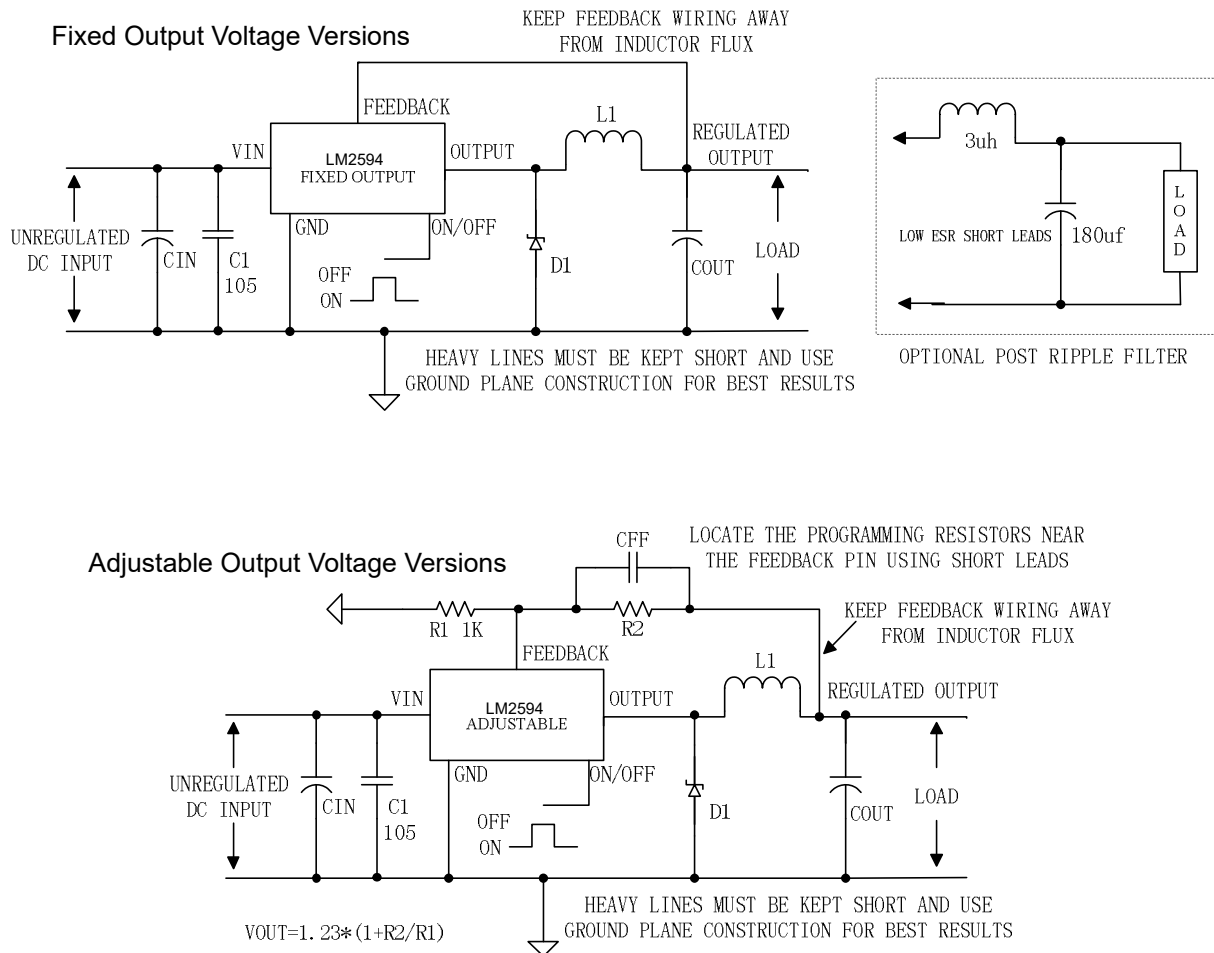


Figure3. Standard Test Circuits and Layout Guides

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, CIN and C1 must be placed near to PIN1 and PIN5~8; 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).



## 11.Series Buck Regulator Desing Procedure (Fixed Output)

| Conditions         |                  |                       | Inductor (L1)   | Output Capacitor (COUT)     |                           |                        |                            |
|--------------------|------------------|-----------------------|-----------------|-----------------------------|---------------------------|------------------------|----------------------------|
|                    |                  |                       |                 | Through Hole Electrolytic   |                           | Surface Mount Tantalum |                            |
| Output Voltage (V) | Load Current (A) | Max Input Voltage (V) | Inductance (uh) | Panasonic HFQ Series (uf/V) | Nichicon PL Series (uf/V) | AVX TPS Series (uf/V)  | Sprague 595D Series (uf/V) |
| 3.3                | 1.5              | 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                  | 1.5              | 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                 | 1.5              | 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                      |

## 12.Series Buck Regulator Desing Procedure (Adjustable Output)

| Output Voltage (V) | Through Hole Output Capacitor |                           |                       | Surface Mount Output Capacitor |                            |                       |
|--------------------|-------------------------------|---------------------------|-----------------------|--------------------------------|----------------------------|-----------------------|
|                    | Panasonic HFQ Series (μF/V)   | Nichicon PL Series (μF/V) | Feedforward capacitor | AVX TPS Series (μF/V)          | Sprague 595D Series (μF/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                        | 470/25                    | 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                 | 220/35                        | 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                 |





13.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 |        |        |
| 3A      |               | √            | 1N5820                                        | 1N5821 | 1N5822 |        |        |
|         |               | √            | MBR320                                        | MBR330 | MBR340 | MBR350 | MBR360 |
|         | √             |              | SK32                                          | SK33   | SK34   | SK35   | SK36   |
|         | √             |              |                                               | 30WQ03 | 30WQ04 | 30WQ05 |        |
|         |               | √            |                                               | 31DQ03 | 31DQ04 | 31DQ05 |        |
|         |               | √            | SR302                                         | SR303  | SR304  | SR305  | SR306  |



## 14.1 Typical System Application for 3.3V Version

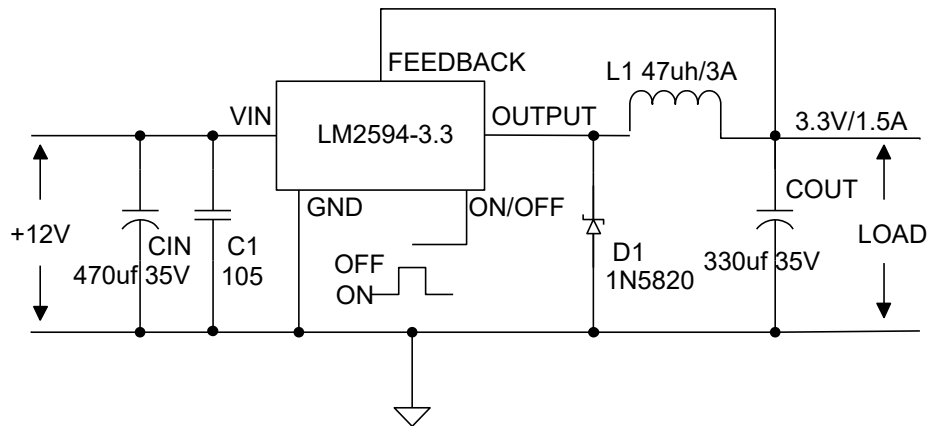


Figure4. LM2594(HV)-3.3 System Parameters Test Circuit

## 14.2 Typical System Application for 5V Version

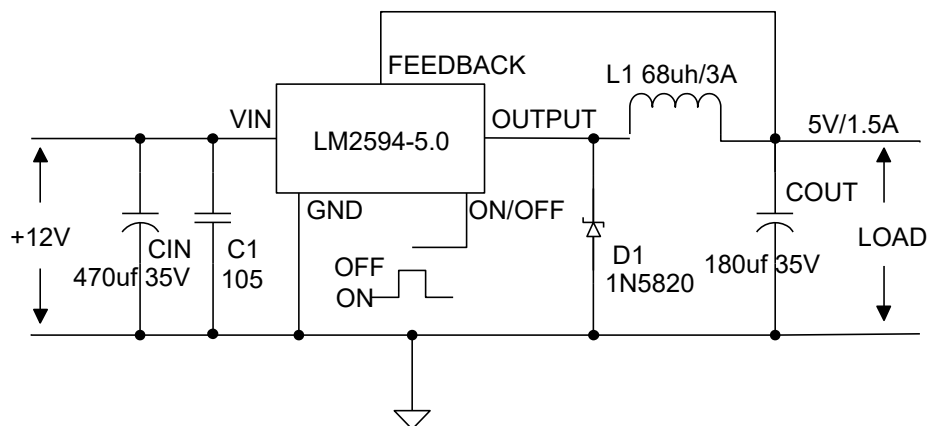


Figure5 LM2594(HV)-5.0 System Parameters Test Circuit



## 14.3 Typical System Application for 12V Version

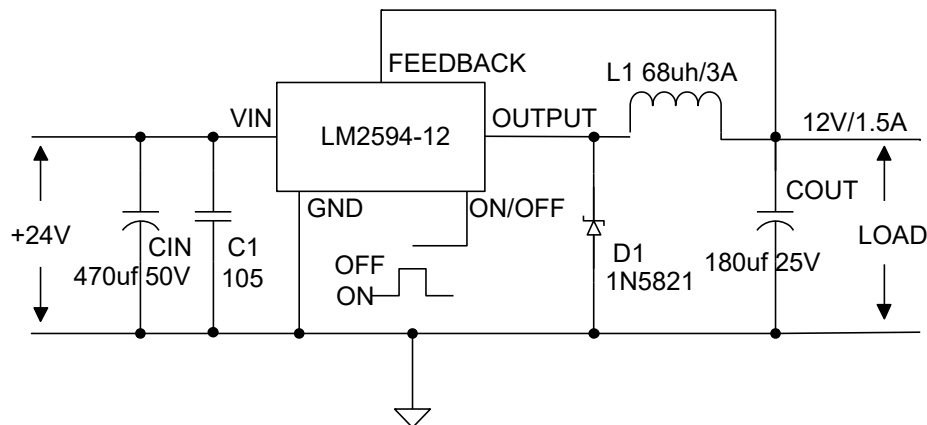


Figure6. LN2594(HV)-12 System Parameters Test Circuit

## 14.4 Typical System Application for ADJ Version

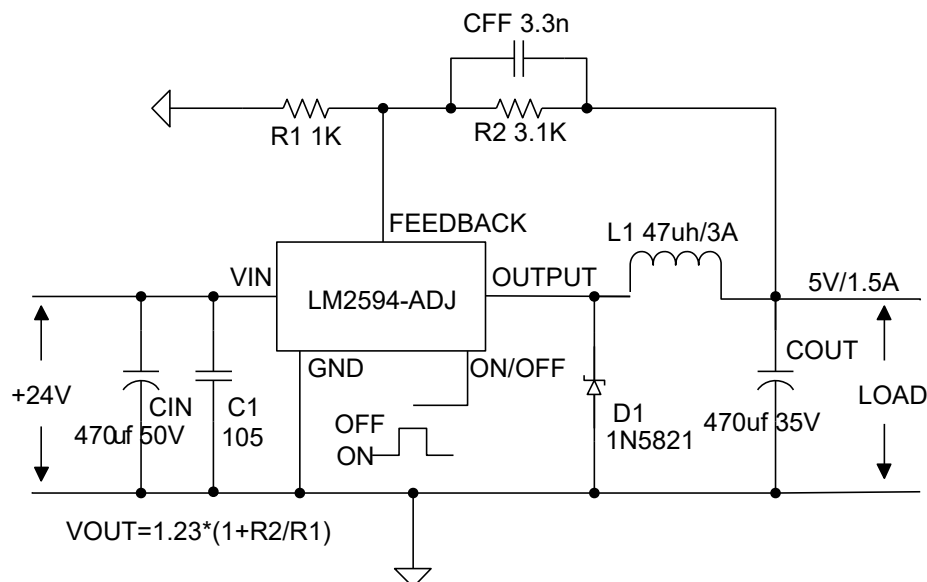
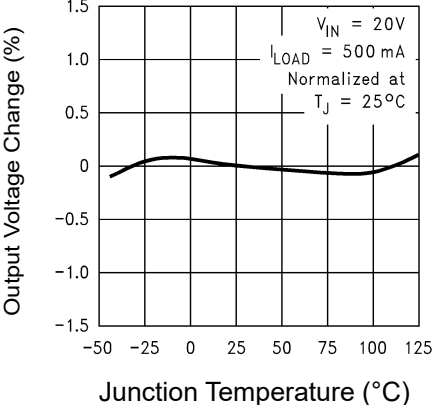
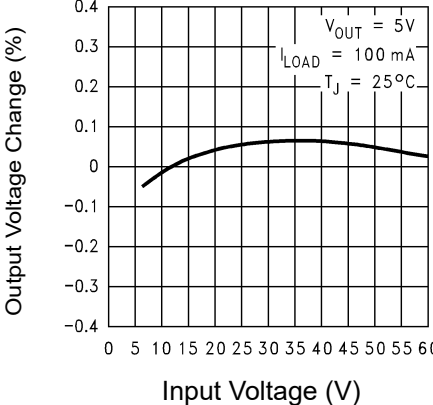
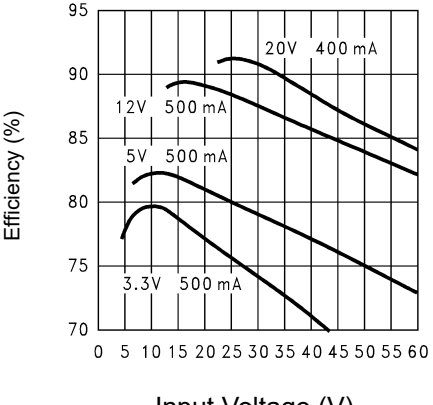
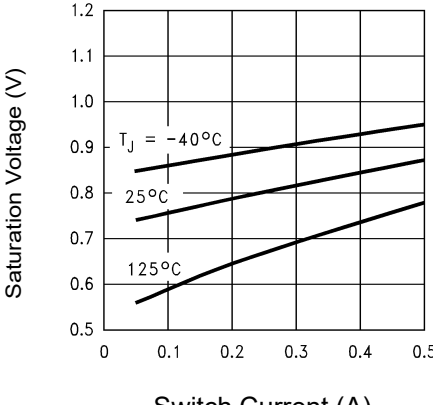
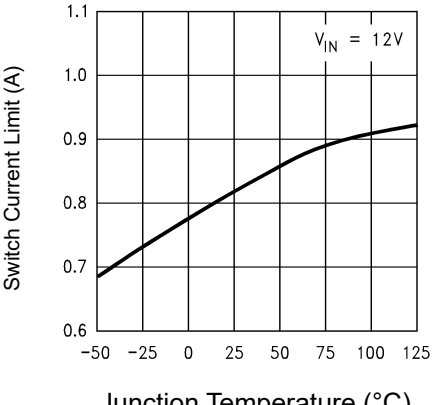
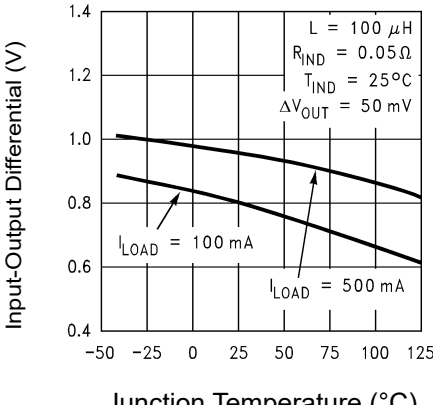


Figure7. LM2594(HV)-ADJ System Parameters Test Circuit



15.1 Typical Characteristic

|                                                                                     |                                                                                      |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|    |    |
| Figure 1: Normalized Output Voltage                                                 | Figure 2: Line Regulation                                                            |
|   |   |
| Figure 3: Efficiency                                                                | Figure 4: Switch Saturation Voltage                                                  |
|  |  |
| Figure 5: Switch Current Limit                                                      | Figure 6: Dropout Voltage                                                            |



## 15.2 Typical Characteristic

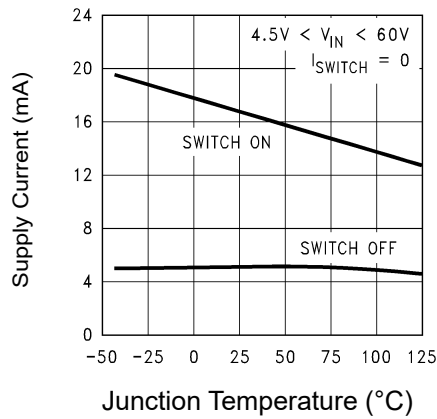


Figure 7: Quiescent Current

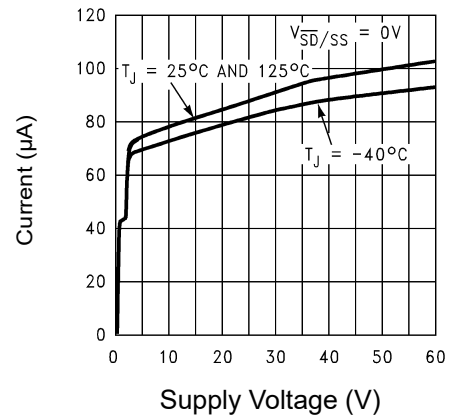


Figure 8: Standby Quiescent Current

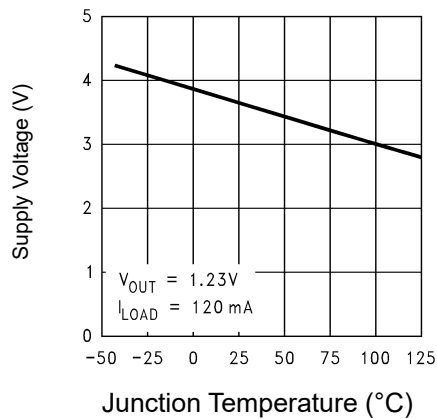


Figure 9: Minimum Operating Supply Voltage

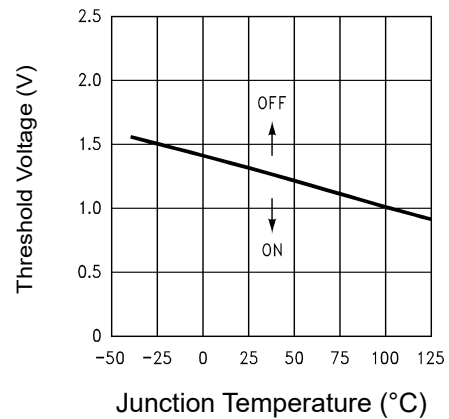
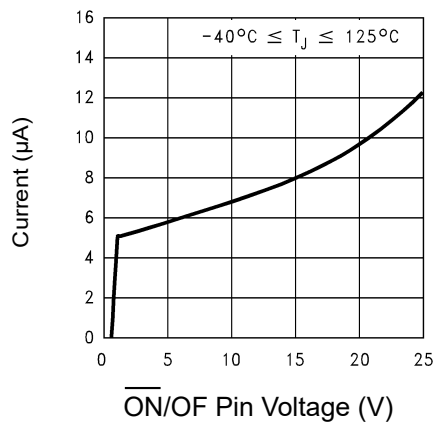
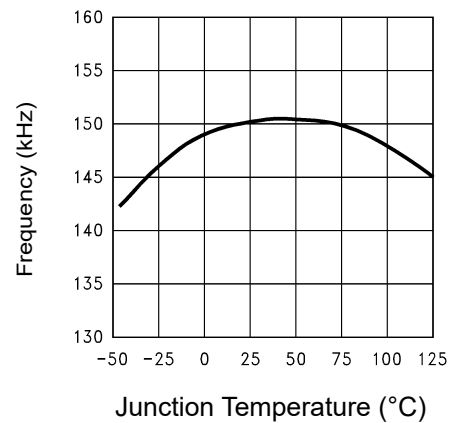
Figure 10:  $\overline{\text{ON}}$ /OFF Threshold VoltageFigure 11:  $\overline{\text{ON}}$ /OFF Pin Current (Sinking)

Figure 12: Switching Frequency



### 15.3 Typical Characteristic

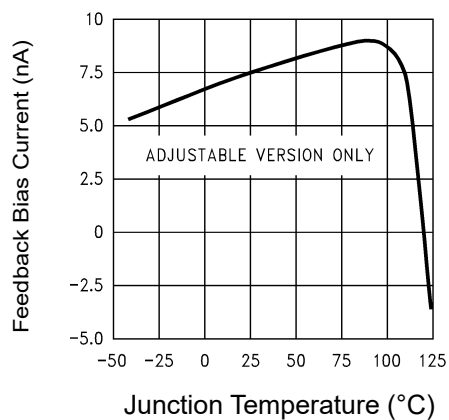
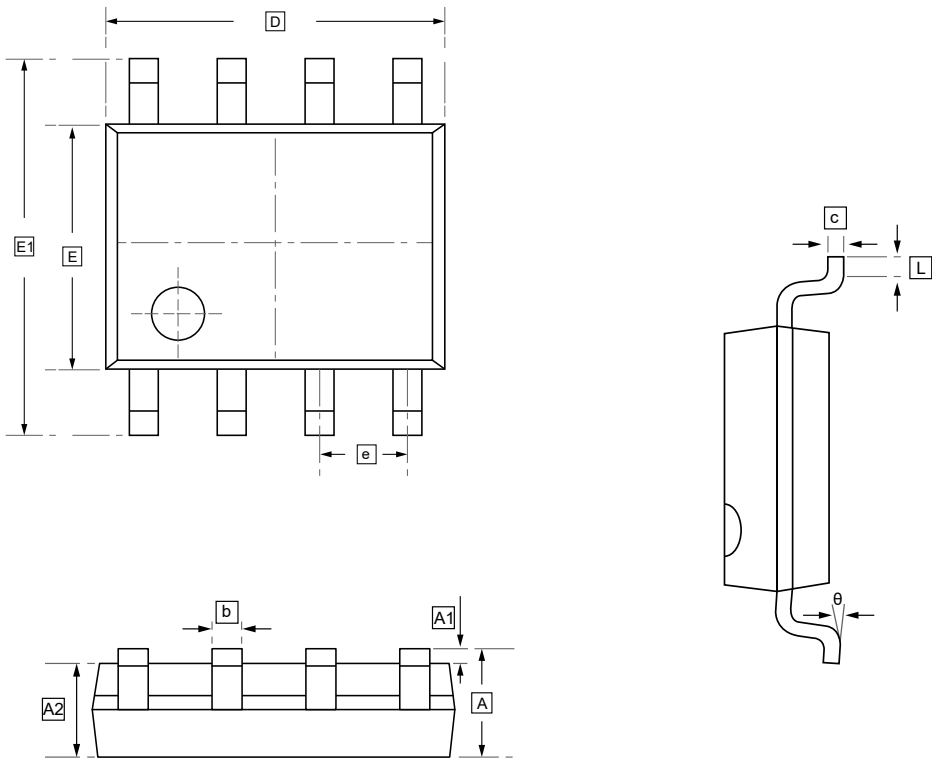


Figure 13: Feedback Pin Bias Current



16.SOP-8 Package Outline Dimensions

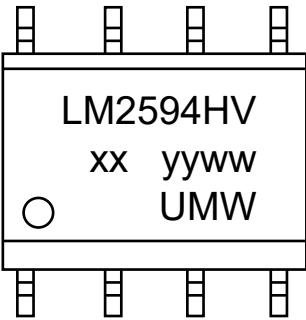


DIMENSIONS (mm are the original dimensions)

| Symbol | A     | A1    | A2    | b     | c     | D     | E     | E1    | e     | L     | θ  |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| Min    | 1.350 | 0.000 | 1.350 | 0.330 | 0.170 | 4.700 | 3.800 | 5.800 | 1.270 | 0.400 | 0° |
| Max    | 1.750 | 0.100 | 1.550 | 0.510 | 0.250 | 5.100 | 4.000 | 6.200 | BSC   | 1.270 | 8° |



17.Ordering Information



yy: Year Code  
ww: Week Code  
xx: Voltage

| Order Code        | Marking      | Package | Base QTY | Delivery Mode | Delivery Mode  |
|-------------------|--------------|---------|----------|---------------|----------------|
| UMW LM2594M-5.0   | LM2594-5.0   | SOP-8   | 2500     | Tape and reel | -20°C to +85°C |
| UMW LM2594M-ADJ   | LM2594-ADJ   | SOP-8   | 2500     | Tape and reel | -20°C to +85°C |
| UMW LM2594M-3.3   | LM2594-3.3   | SOP-8   | 2500     | Tape and reel | -20°C to +85°C |
| UMW LM2594M-12    | LM2594-12    | SOP-8   | 2500     | Tape and reel | -20°C to +85°C |
| UMW LM2594HVM-5.0 | LM2594HV-5.0 | SOP-8   | 2500     | Tape and reel | -40°C to +85°C |
| UMW LM2594HVM-ADJ | LM2594HV-ADJ | SOP-8   | 2500     | Tape and reel | -40°C to +85°C |
| UMW LM2594HVM-12  | LM2594HV-12  | SOP-8   | 2500     | Tape and reel | -40°C to +85°C |
| UMW LM2594HVM-3.3 | LM2594HV-3.3 | SOP-8   | 2500     | Tape and reel | -40°C to +85°C |





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