# G5ULM2596

## Simple Switcher Power converter 150kHz 3A Step-Down Voltage Regulator

## Description

The G5ULM2596 series of regulators are monolithic integrated circuits that provide all active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. These devices are available in fixed output voltage 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 internal frequency compensation and a fixed-frequency oscillator.

The G5ULM2596 series 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 5-lead TO-263 package with several different lead bend options.

A standard series if inductors are available from several different manufactures optimized for use with the G5ULM2596 series. This feature greatly simplifies the design of switch-mode power supplies. Other feature include a guaranteed ±4% to tolerance on output voltage under specified input voltages and output load conditions, and ±15% on the oscillator frequency. External shutdown is included, featuring 80uA standby current. Self protection features include a two stage frequency reducing current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

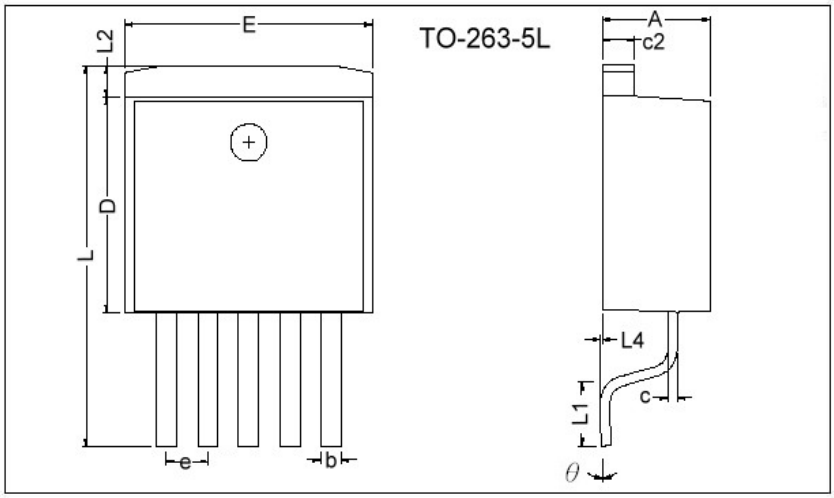
## Features

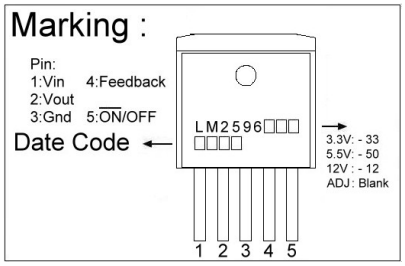
- 3.3V, 5.0V, 12V and adjustable output versions
- Adjustable version output voltage range , 1.2V to 37V ±4% max over line and load conditions
- Guaranteed 3A output current
- Input voltage range up to 40V
- Efficient pre-regulator for linear regulators
- Requires only 4 external components
- 150kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

## Applications

- Simple high-efficiency step-down (buck) regulator
- On-card switching regulators
- Positive to negative converter

## Package Dimensions




| REF. | Millimeter | | REF. | Millimeter | |
|---|---|---|---|---|---|
| | Min. | Max. | | Min. | Max. |
| A | 4.40 | 4.80 | c2 | 1.25 | 1.45 |
| b | 0.66 | 0.91 | L2 | 1.27 REF. | |
| L4 | 0.00 | 0.30 | D | 8.6 | 9.0 |
| c | 0.36 | 0.5 | e | 1.70 REF. | |
| L1 | 2.29 | 2.79 | L | 14.6 | 15.8 |
| E | 9.80 | 10.4 | θ | 0° | 8° |

## Typical Application (Fixed Output Voltage Version)

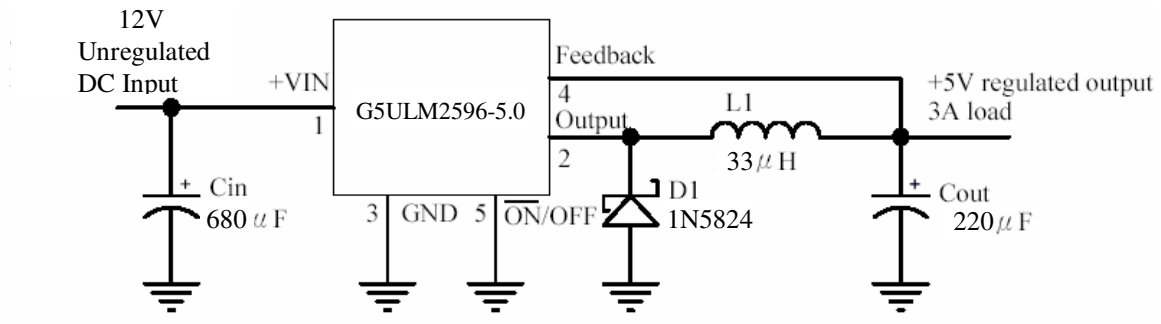
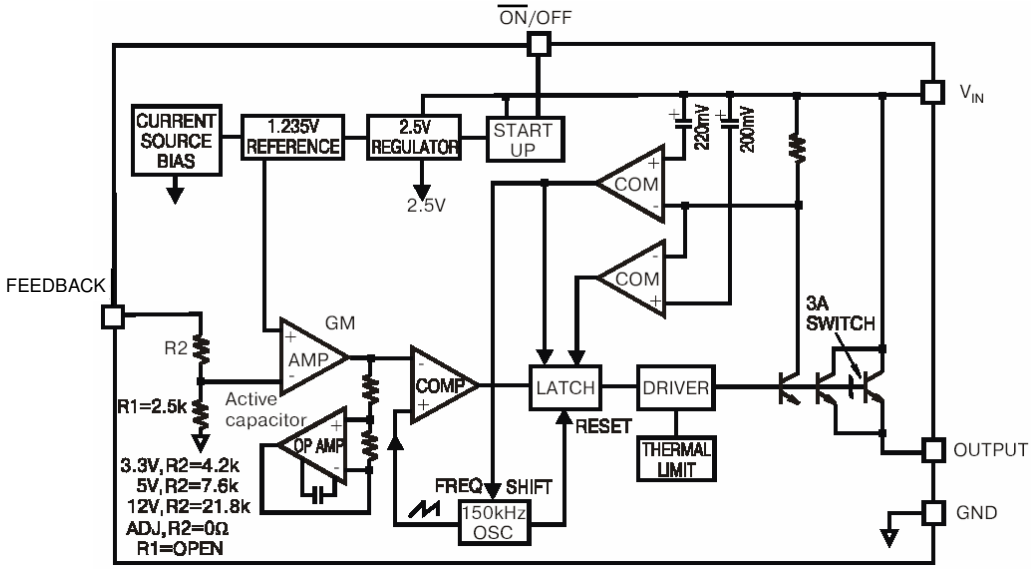



**Figure. 1**

## Block Diagram




## Pin Function

| Pin Name | Pin# | Function |
|---|---|---|
| +VIN | 1 | This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching current needed by regulator. |
| Output | 2 | Internal switch. The voltage at this pin switches between (+VIN – VSAT) and approximately -0.5V, with a duty cycle of approximately VOUT/VIN. To minimize coupling to sensitive circuit, the PC board copper area connected to this pin should be keep to a minimum. |
| Ground | 3 | Circuit ground |
| Feedback | 4 | Senses the regulated output voltage to complete the feedback loop |
| $\overline{ON}$/OFF | 5 | Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 80 μA. Pulling this pin below a threshold voltage of approximately 1.3V turns the regulator on, and pulling this pin above 1.3V (up to a maximum of 25V) shuts the regulator down. If this shutdown feature is not needed, ON/OFF pin can be wired to the ground pin or it can be left open, in either case the regulator will be in the ON condition. |

## Absolute Maximum Ratings (Note1)

| Parameter | Ratings | Unit |
|---|---|---|
| Maximum Supply Voltage | 45 | V |
| $\overline{ON}$/OFF pin input Voltage | -0.3≤ V ≤+25 | V |
| Feedback pin Voltage | -0.3≤ V ≤+25 | V |
| Output Voltage to ground (steady state) | -1 | V |
| Power dissipation | Internally Limited | |
| Storage Temperature | -65 ~ +150 | ℃ |
| Maximum junction temperature | +150 | ℃ |
| Minimum ESD rating (C=100pF, R=1.5kΩ) | 2k | V |
| Lead temperature (soldering, 10seconds) | +260 | ℃ |

## Operating Ratings

| Parameter | Ratings | Unit |
|---|---|---|
| Temperature range | -40≤ TJ ≤ +125 | ℃ |
| Supply Voltage | 4.5 ~ 40 | V |

## G5ULM2596-3.3 Electrical Characteristics

Specifications with standard type face are for $T_J$=25 ℃, and those with **boldface type** apply over **full operating temperature range**

| Parameter | Symbol | Conditions | Min (Note4) | Typ (Note3) | Max (Note4) | Unit |
|---|---|---|---|---|---|---|
| **System Parameters** (Note5) **Test Circuit Figure 2** | | | | | | |
| Output Voltage | $V_{OUT}$ | 4.75V ≤ $V_{IN}$ ≤40V<br>0.2A≤ $I_{LOAD}$ ≤3A | 3.168/**3.135** | 3.3 | 3.432/**3.465** | V |
| Efficiency | η | $V_{IN}$=12V, $I_{LOAD}$=3A | | 73 | | % |

## G5ULM2596-5.0 Electrical Characteristics

Specifications with standard type face are for $T_J$=25 ℃, and those with **boldface type** apply over **full operating temperature range**

| Parameter | Symbol | Conditions | Min (Note4) | Typ (Note3) | Max (Note4) | Unit |
|---|---|---|---|---|---|---|
| **System Parameters** (Note5) **Test Circuit Figure 2** | | | | | | |
| Output Voltage | $V_{OUT}$ | 7V ≤ $V_{IN}$ ≤40V<br>0.2A≤ $I_{LOAD}$ ≤3A | 4.80/**4.75** | 5.0 | 5.20/**5.25** | V |
| Efficiency | η | $V_{IN}$=12V, $I_{LOAD}$=3A | | 80 | | % |

## G5ULM2596-12 Electrical Characteristics

Specifications with standard type face are for $T_J$=25 ℃, and those with **boldface type** apply over **full operating temperature range**

| Parameter | Symbol | Conditions | Min (Note4) | Typ (Note3) | Max (Note4) | Unit |
|---|---|---|---|---|---|---|
| **System Parameters** (Note5) **Test Circuit Figure 2** | | | | | | |
| Output Voltage | $V_{OUT}$ | 15V ≤ $V_{IN}$ ≤40V<br>0.2A≤ $I_{LOAD}$ ≤3A | 11.52/**11.40** | 12 | 12.48/**12.60** | V |
| Efficiency | η | $V_{IN}$=15V, $I_{LOAD}$=3A | | 90 | | % |

## G5ULM2596 Electrical Characteristics

Specifications with standard type face are for $T_J$=25 ℃, and those with **boldface type** apply over **full operating temperature range**

| Parameter | Symbol | Conditions | Min (Note4) | Typ (Note3) | Max (Note4) | Unit |
|---|---|---|---|---|---|---|
| **System Parameters** (Note5) **Test Circuit Figure 2** | | | | | | |
| Output Voltage | $V_{OUT}$ | 4.5≤ $V_{IN}$ ≤40V, 0.2A≤ $I_{LOAD}$ ≤3A<br>$V_{OUT}$=3V, Circuit of Figure 2 | 1.180/**1.168** | 1.230 | 1.280/**1.292** | V |
| Efficiency | η | $V_{IN}$=12V, $I_{LOAD}$=3A, $V_{OUT}$=3V | | 77 | | % |

## All Output Voltage Version Electrical Characteristics

Specifications with standard type face are for $T_J$=25 ℃, and those with **boldface type** apply over **full operating temperature range**.

Unless otherwise specified, $V_{IN}$=12V for the 3.3V, 5.0V and Adjustable versions, $V_{IN}$=24V for 12V version. $I_{LOAD}$=0.5A

| Parameter | Symbol | Conditions | Min (Note4) | Typ (Note3) | Max (Note4) | Unit |
|---|---|---|---|---|---|---|
| Feedback bias current | $I_b$ | $V_{FB}$=1.3V (adjustable version only) | - | 10 | 50/**00** | nA |
| Oscillator frequency | $f_O$ | (Note 6) | 127/**110** | 150 | 173/**173** | kHz |
| Saturation voltage | $V_{SAT}$ | $I_{LOAD}$=3A (Note 7, 8) | - | 1.16 | 1.4/**1.5** | V |
| Maximum duty cycle (ON)<br>(OFF) | DC | (Note 8)<br>(Note 9) | - | 100<br>0 | - | % |
| Current limit | $I_{CL}$ | Peak Current (Note 7, 8) | 3.6/**3.4** | 4.5 | 6.9/**7.5** | A |
| Output leakage current | $I_L$ | Output=0V(Note 7, 9) | - | - | 50 | uA |
| | | Output=-1V (Note 10) | - | 2 | 30 | mA |
| Quiescent current | $I_Q$ | (Note 9) | - | 5 | 10 | mA |
| Standby quiescent current | $I_{STBY}$ | ON/OFF pin=5V (OFF)(Note 10) | - | 80 | 200/**250** | uA |
| Thermal Resistance | $\theta_{JC}$ | Junction to Case | - | 2 | - | ℃/W |
| | $\theta_{JA}$ | Junction to Ambient (Note 11)<br>Junction to Ambient (Note 12)<br>Junction to Ambient (Note 13) | - | 50<br>30<br>20 | - | ℃/W |

| **$\overline{ON}$/OFF Control** Test Circuit Figure 2 | | | | | | |
|---|---|---|---|---|---|---|
| $\overline{ON}$/OFF pin logic input Threshold Voltage | | | - | 1.3 | - | V |
| | $V_{IH}$ | High (Regulator OFF) | 2.0 | - | - | |
| | $V_{IL}$ | Low (Regulator ON) | - | - | 0.6 | |
| $\overline{ON}$/OFF pin input current | $I_H$ | $V_{LOGIC}$=2.5V ( Regulator OFF) | - | 5 | 15 | uA |
| | $I_L$ | $V_{LOGIC}$=0.5V ( Regulator ON) | - | 0.02 | 5 | |

Note 1: Absolute Maximum Rating indicate limits beyond which damage to the device may occur. Operating Rating indicate conditions for which the device is intended to be functional, but do not guaranteed specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: The human body mode is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

Note 3: Typical number are at 25℃ and represent the most likely norm.

Note 4: All limits guaranteed at room temperature (standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) method. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note 5: External component such as the catch diode, inductor, input and output capacitors, and voltage programming resistor can affect switching regulator system performance. When the G5ULM2596 is used as shutdown in the Figure 1 test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 6: The switching frequency is reduced when the second stage current limit is activated. The amount of reduction is determined by the severity of current over-load.

Note 7: No diode, inductor or capacitor connected to output pin.

Note 8: Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

Note 9: Feedback pin removed from output and connected to 12V for the Adjustable, 3.3V and 5V versions, and 15V for the 12V version, to force the output transistor switch OFF.

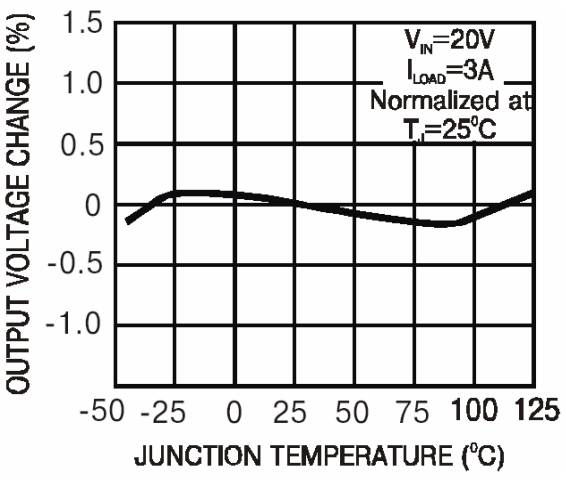
Note 10: $V_{IN}$=40V.

Note 11: Junction to ambient thermal resistance with the TO -263 package tab soldered to a single sided printed circuit board with 0.5 $in^2$ of (1 oz.) copper area.

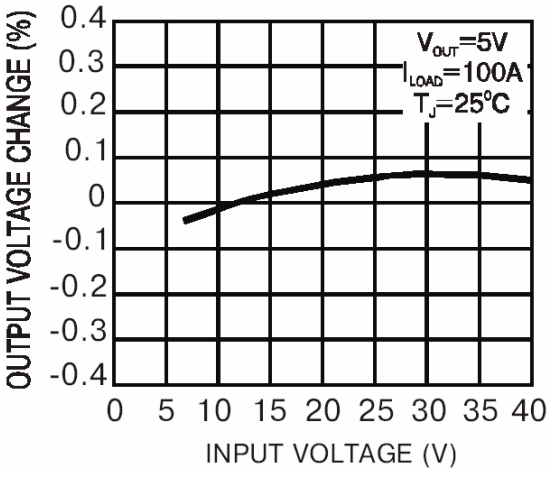
Note 12: Junction to ambient thermal resistance with the TO -263 package tab soldered to a single sided printed circuit board with 2.5 $in^2$ of (1 oz.) copper area.

Note 13: Junction to ambient thermal resistance with the TO -263 package tab soldered to a double sided printed circuit board with 3.0 $in^2$ of (1 oz.) copper area on the G5ULM2596 side of the board, and approximately 16$in^2$ of copper on the other side of the p-c board.

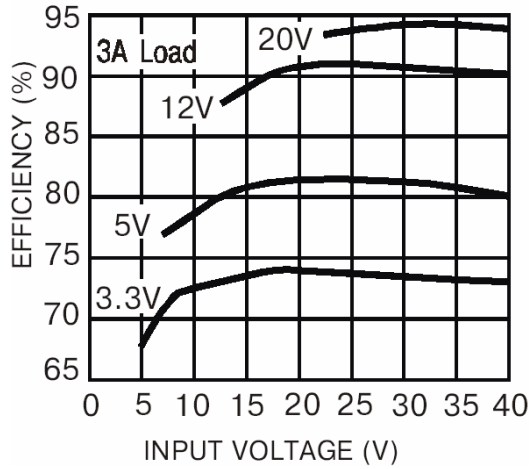
## Typical Performance Characteristics (circuit of Figure 2)



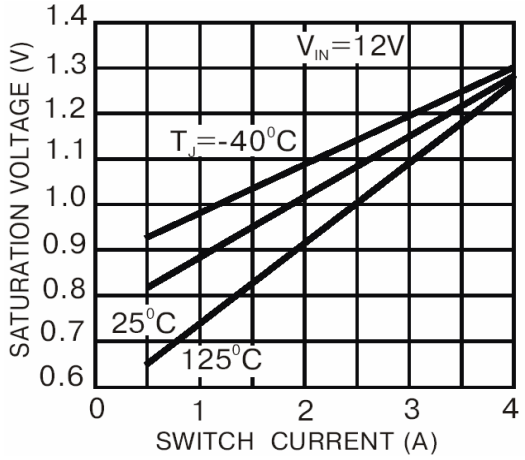

**Normalized Output Voltage**



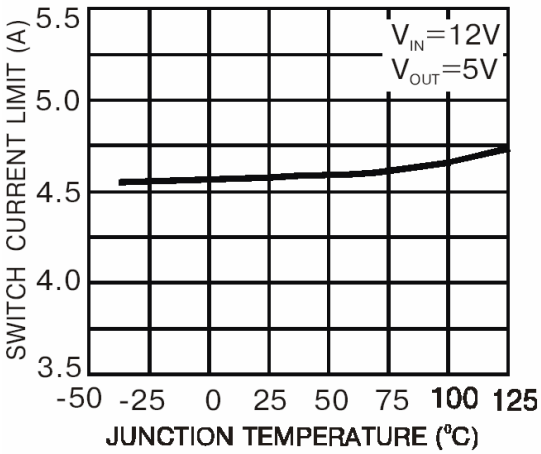

**Line Regulator**



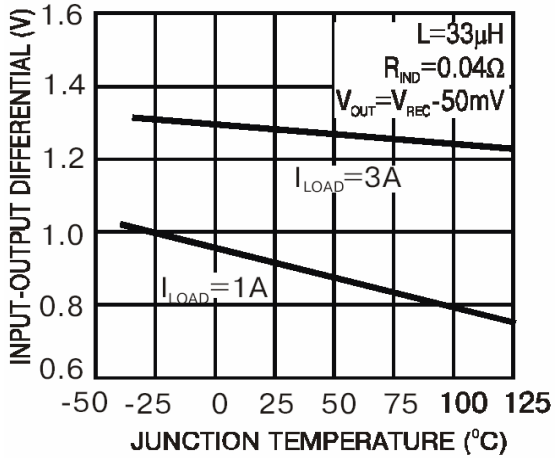

**Efficiency**



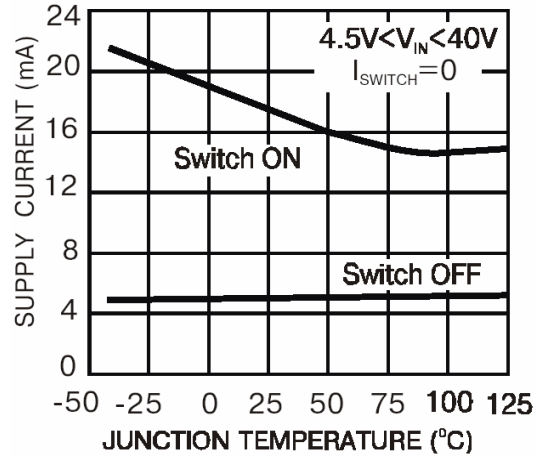

**Switch Saturation Voltage**



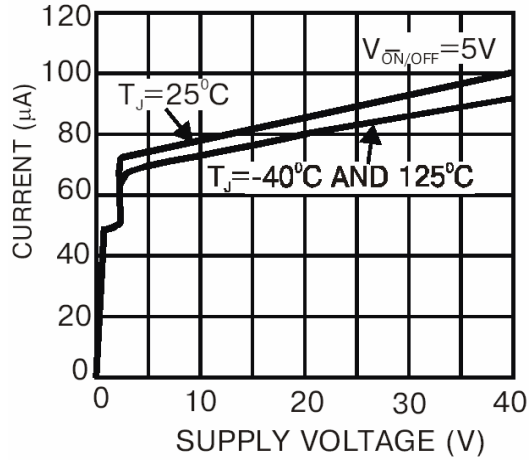

**Switch Current Limit**



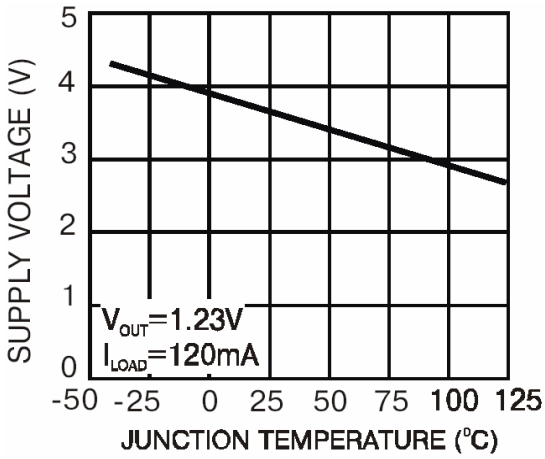

**Dropout Voltage**



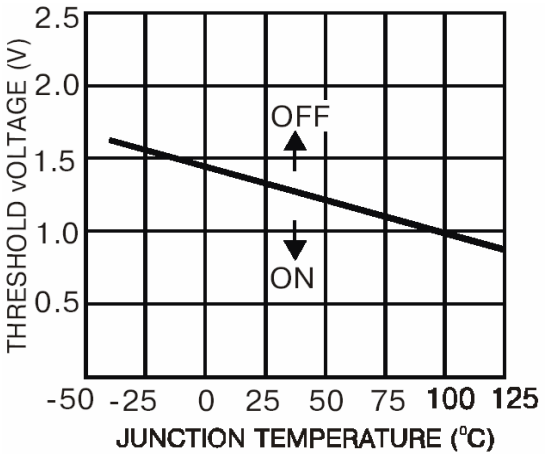

**Operating Quiescent Current**



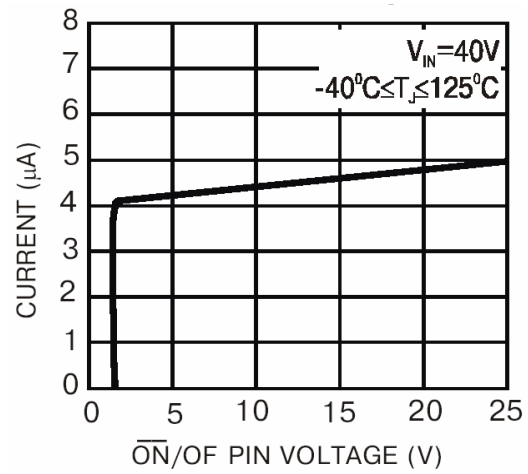

**Shutdown Quiescent Current**



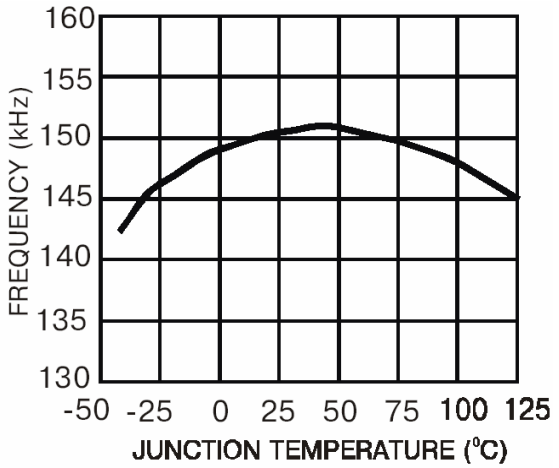

**Minimum Operating Supply Voltage**



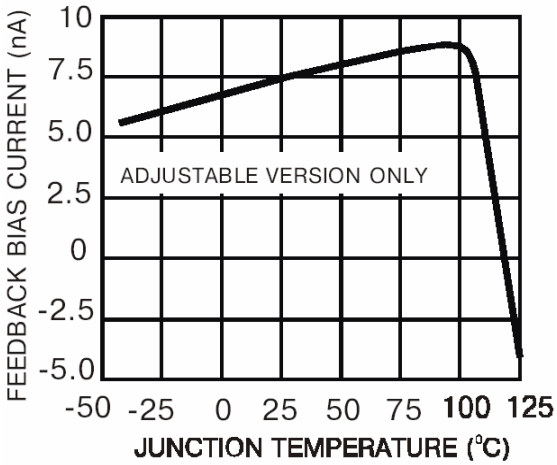

**$\overline{ON}$/OFF Threshold Voltage**




**$\overline{ON}$/OFF Pin Current (Sinking)**

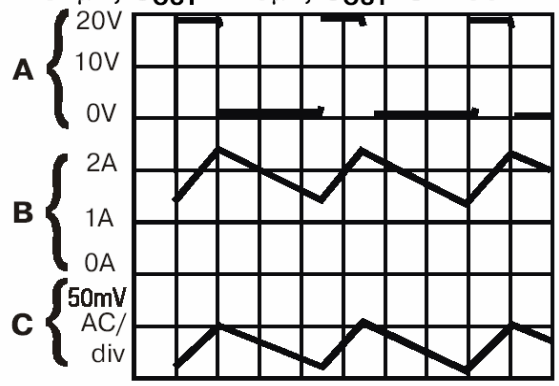



**Switching Frequency**




**Feedback Pin Bias Current**

$V_{IN}$=20V, $V_{OUT}$=5V, $I_{LOAD}$=2A
L=32μH, $C_{OUT}$=220μF, $C_{OUT}$ESR=50mΩ

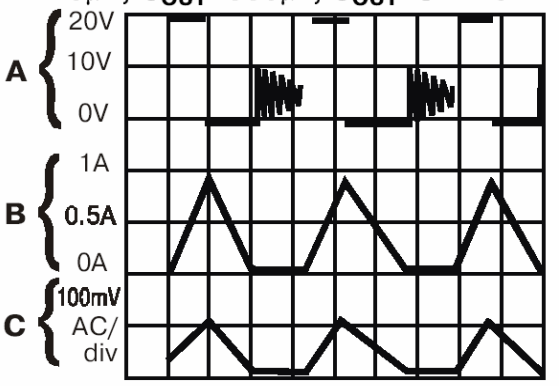



A: Output Pin Voltage, 10V/div
B: Inductor Current 1A/div
C: Output Ripple Voltage, 50mV/div

**Horizontal Time Base: 2μs/div**

**Continuous Mode Switching Waveforms**

$V_{IN}$=20V, $V_{OUT}$=5V, $I_{LOAD}$=500mA
L=10μH, $C_{OUT}$=330μF, $C_{OUT}$ESR=45mΩ

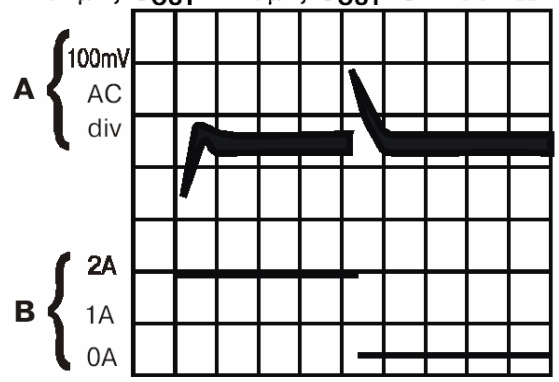



A: Output Pin Voltage, 10V/div
B: Inductor Current 1A/div
C: Output Ripple Voltage, 100mV/div

**Horizontal Time Base: 2μs/div**

**Discontinuous Mode Switching Waveforms**

$V_{IN}$=20V, $V_{OUT}$=5V, $I_{LOAD}$=500mA to 2A
L=32μH, $C_{OUT}$=220μF, $C_{OUT}$ESR=50mΩ

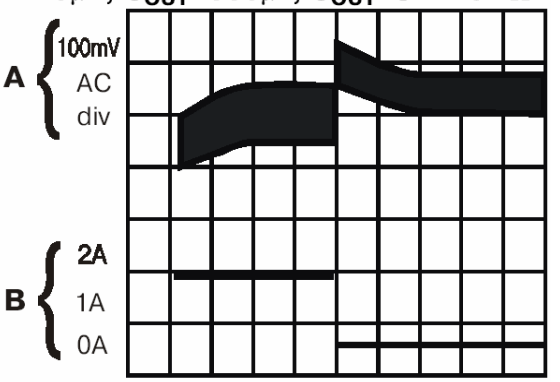



A: Output Voltage, 100mV/div.(AC)
B: 500mA to 2A Load Pulse

**Horizontal Time Base: 100μs/div**

**Load Transient Response for Continuous Mode**

$V_{IN}$=20V, $V_{OUT}$=5V, $I_{LOAD}$=500mA to 2A
L=10μH, $C_{OUT}$=330μF, $C_{OUT}$ESR=45mΩ




A: Output Voltage, 100mV/div. (AC)
B: 500mA to 2A Load Pulse

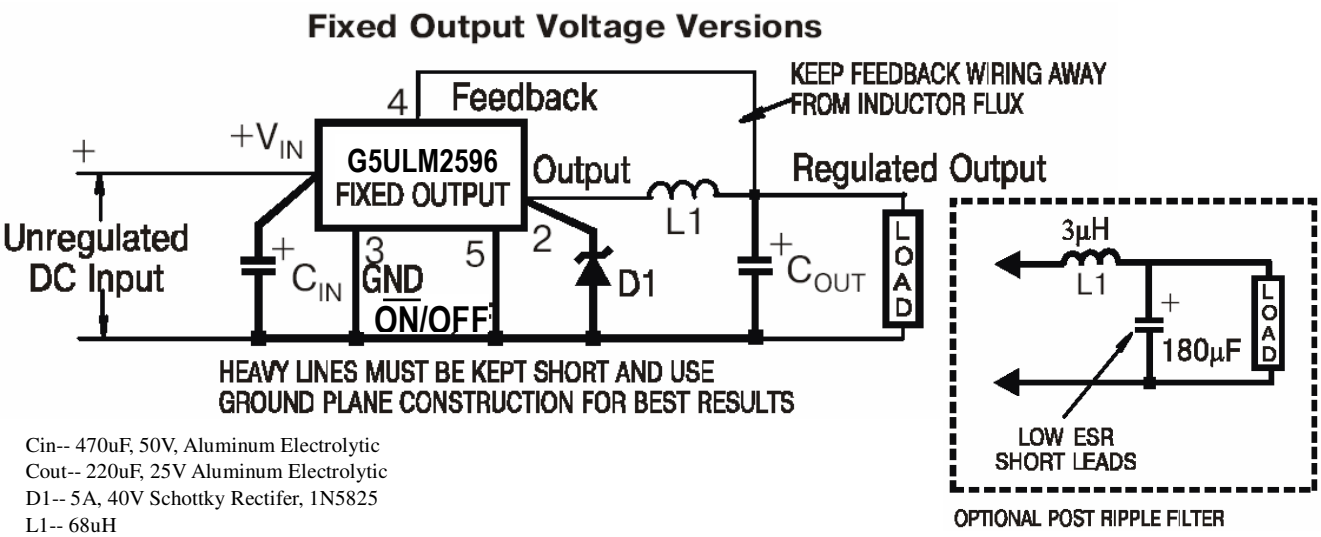
**Horizontal Time Base: 200μs/div**

**Load Transient Response for Discontinuous Mode**

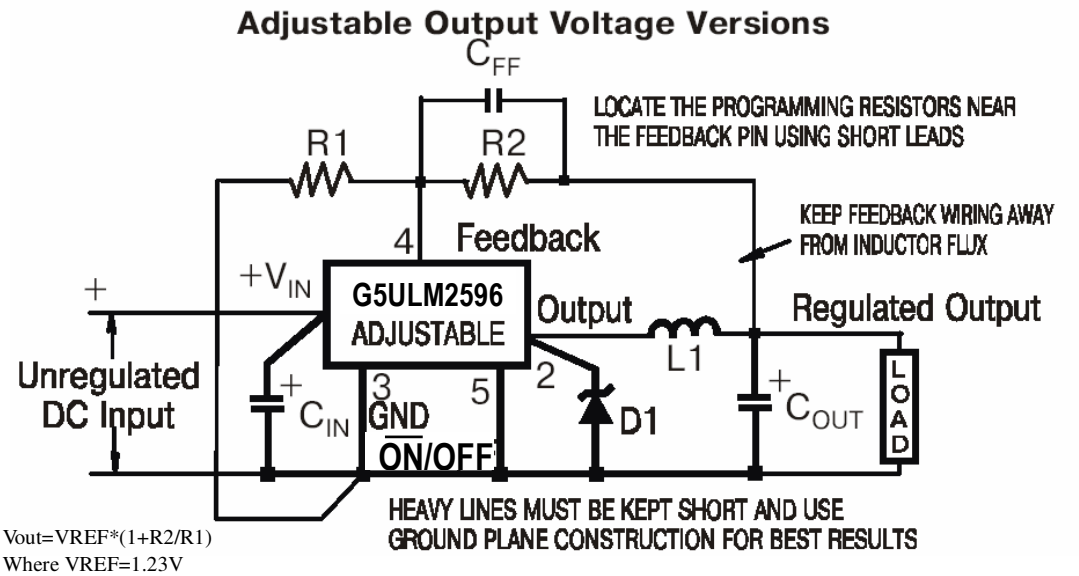
## Test Circuit and layout Guidelines

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by **heavy lines should be wide printed circuit traces and should be kept as short as possible.** For best results, external components should be located as close to the switcher IC as possible using ground plane construction or single point grounding.

If **open core inductors are used,** special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC groundpath and COUT wiring can cause problems. When using the Adjustable version, special care must be taken 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.




Cin-- 470uF, 50V, Aluminum Electrolytic
Cout-- 220uF, 25V Aluminum Electrolytic
D1-- 5A, 40V Schottky Rectifer, 1N5825
L1-- 68uH




Vout=VREF*(1+R2/R1)
Where VREF=1.23V
R2=R1*(Vout/VREF-1)
Select R1 to be approximately 1kΩ, use a 1% resistor for best stability.
Cin-- 470uF, 50V, Aluminum Electrolytic
Cout-- 220uF, 35V Aluminum Electrolytic
D1-- 5A, 40V Schottky Rectifer, 1N5825
L1-- 68uH

**Figure 2 Standard Test Circuits and Layout**

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