3A Step Down Voltage Regulator

DESCRIPTION

The GP2596 series are high efficiency step-down switching regulator built in all the required active functions. It is capable of driving up to 3A load with excellent line and load regulations. This device is available in fixed output voltages of 3.3V, 5V, and adjustable output version.

The GP2596 operating on a 150kHz fixed switching frequency offers a high efficiency replacement for popular three-terminal linear regulators. This easy to use chip requires only a minimum number of external components. It reduces not only the area of PCB but also the size of the heat sink.

The ± 4% tolerance on output voltage within specified input voltages and output load conditions is guaranteed. The oscillator frequency accuracy is within ±10%. Pull high Enable pin shutdown the chip, featuring 80μA(typical) standby current. The Output Driver includes cycle-by-cycle current limitation, as well as thermal shutdown for full protection under fault conditions.

FEATURES

- **Wide input voltage range up to 40V**
- **Guaranteed 3A output current**
- **3.3V, 5V and adjustable output versions**
- **Internal oscillator of 150 KHz fixed frequency**
- **Wide adjustable version output voltage range, from 1.2V to 37V**
- **±4% maximum over line and load conditions**
- **TTL shutdown capability**
- Low standby current, typical 80μA, when Enable pin pull high
- Only 4 external components required
- Built-in thermal shut down and current limit protection

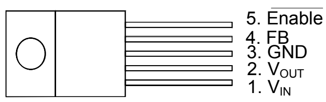
APPLICATIONS

- LCD Monitors
- ADD-ON Cards Switching Regulators
- High Efficiency Step-Down Regulators
- Portable DVD players
- Pre-regulator for Linear Regulators

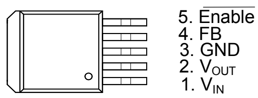
- **Voltage Options:**

GP2596-3.3 – 3.3V Fixed
GP2596-5.0 – 5.0V Fixed
GP2596-ADJ – Adjustable Output

PACKAGE PIN OUT



5-Pin Plastic TO-220
(Top View)



5-Pin Plastic TO-263 Surface Mount
(Top View)

ORDER INFORMATION

Temperature Range	P	5 Pin Plastic TO-220	D	5 Pin Plastic TO-263
-40°C≤ T_J ≤ 125°C	**GP2596-ADJP**		**GP2596-ADJD**	
	GP2596-ADJPF		**GP2596-ADJDF**	
	GP2596-X.XP		**GP2596-X.XD**	
	GP2596-X.XPF		**GP2596-X.XDF**	

Note: All surface-mount packages are available in Tape & Reel. Append the letter "T" to part number (i.e. GP2596-X.XDDFT). The letter "F" is marked for Lead Free process.

TYPICAL APPLICATION

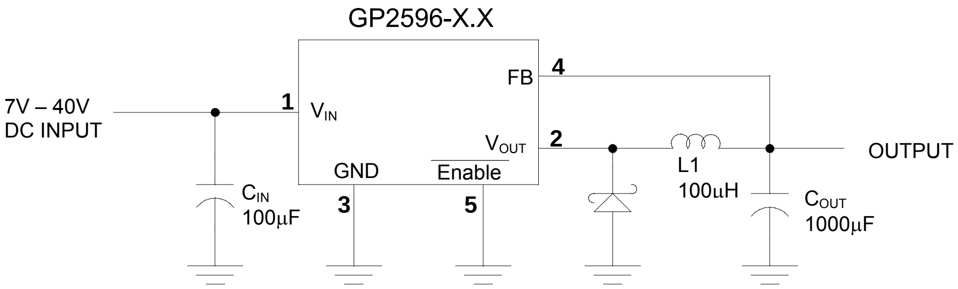


Figure 1. Fixed Output Voltage application circuit

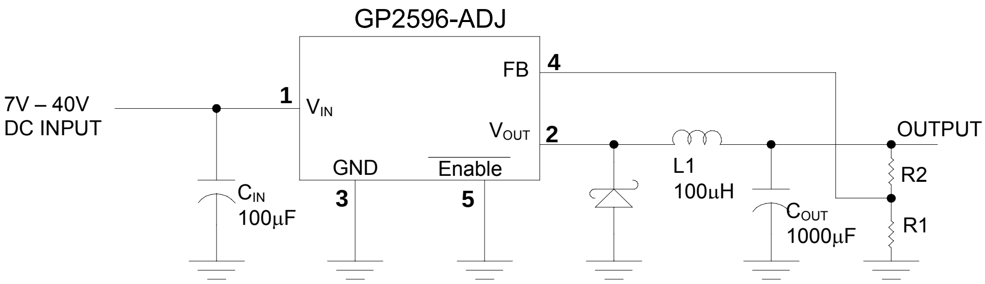


Figure 2. Adjustable Output Voltage application circuit

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

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

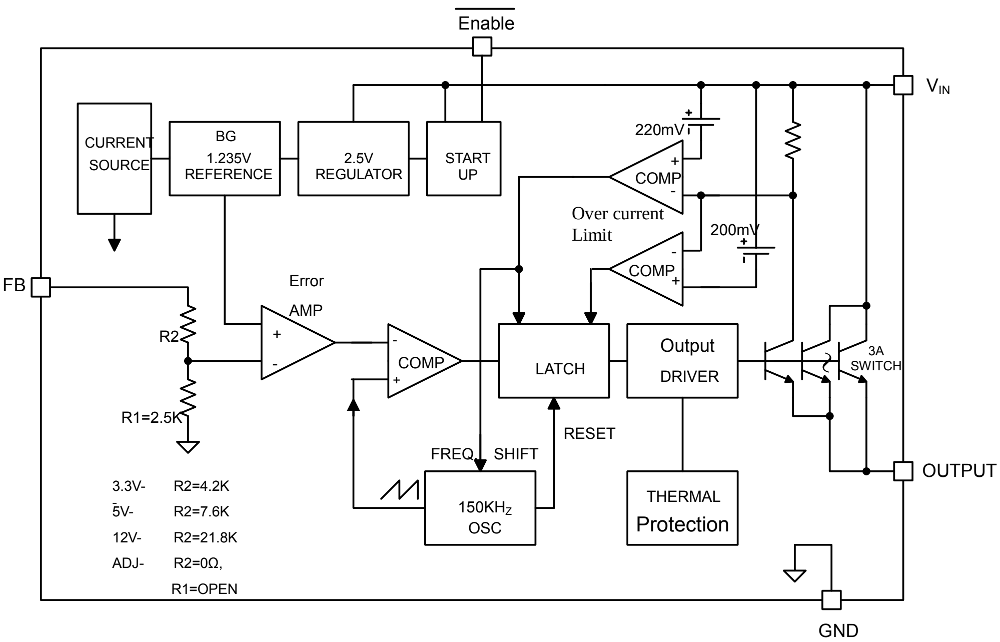
V_{REF} = 1.23V, R1 between 1K and 5K

ABSOLUTE MAXIMUM RATINGS (Note 1)	
Input Voltage, V_{IN}	45V
$\overline{\text{Enable}}$ Pin Input Voltage	$-0.3V \le V \le V_{IN}$
Operating Junction Temperature, T_J	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (soldiering, 10 seconds)	260°C
Note 1: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.	

RECOMMENDED OPERATING RATINGS	
Temperature Range	$-40°C \le T_J \le 125°C$
Input Voltage, V_{IN}	40V(Max.)

THERMAL DATA	
P, D PACKAGE:	
Thermal Resistance-Junction to Tab, θ_{JT}	3.0 °C /W
Thermal Resistance-Junction to Ambient, θ_{JA}	45 °C /W
Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$. The θ_{JA} number is guideline for the thermal performance of the device and PCB system. All of the above assume no ambient airflow.	

BLOCK DIAGRAM

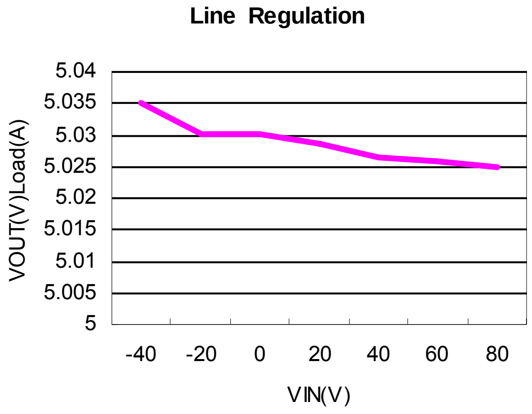


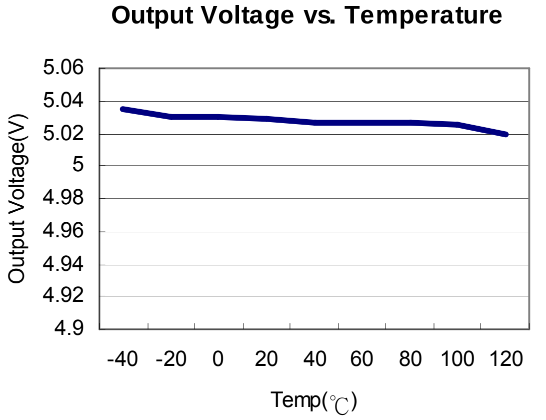
DC ELECTRICAL CHARACTERISTICS								
Unless otherwise specified, these specifications apply V_{IN} = 12V, I_{LOAD} = 0.5A and the operating ambient temperatures T_J = 25°C.								
Parameter		Symbol	Test Conditions		GP2596-X.X Min	Typ	Max	Units
Output Voltage (Note 1)	GP2596-3.3	V_{OUT}	Test circuit of Figure 1		3.234	3.300	3.366	V
	GP2596-5.0				4.900	5.000	5.100	
Output Voltage (Note 1)	GP2596-3.3	V_{OUT}	0.2A ≤ I_{LOAD} ≤ 3A Test circuit of Figure 1	4.75V ≤ V_{IN} ≤ 40V	3.168	3.300	3.432	V
	GP2596-5.0			7V ≤ V_{IN} ≤ 40V	4.800	5.000	5.200	
Output Voltage (Note 1)	GP2596-3.3	V_{OUT}	0.2A ≤ I_{LOAD} ≤ 3A, -40°C ≤ T_J ≤ 125°C Test circuit of Figure 1	4.75V ≤ V_{IN} ≤ 40V	3.135	3.300	3.482	V
	GP2596-5.0			7V ≤ V_{IN} ≤ 40V	4.750	5.000	5.250	
Feedback Voltage (Note 1)	GP2596-ADJ	V_{OUTFB}	Test circuit of Figure 2	V_{OUT} = 5V	1.217	1.230	1.243	V
Feedback Voltage (Note 1)	GP2596-ADJ	V_{OUTFB}	7V ≤ V_{IN} ≤ 40V, V_{OUT} = 5V, Test circuit of Figure 2	0.2A ≤ I_{LOAD} ≤ 3A	1.193	1.230	1.267	V
Feedback Voltage (Note 1)	GP2596-ADJ	V_{OUTFB}	7V ≤ V_{IN} ≤ 40V, V_{OUT} = 5V, Test circuit of Figure 2	0.2A ≤ I_{LOAD} ≤ 3A, -40°C ≤ T_J ≤ 125°C	1.180	1.230	1.286	V
Efficiency	GP2596-3.3	η	0.2A ≤ I_{LOAD} ≤ 3A, 4.75V ≤ V_{IN} ≤ 40V, V_{OUT} = 3.3V			73		%
	GP2596-5.0		0.2A ≤ I_{LOAD} ≤ 3A, 7V ≤ V_{IN} ≤ 40V, V_{OUT} = 5V			80		
	GP2596-ADJ		0.2A ≤ I_{LOAD} ≤ 3A, 7V ≤ V_{IN} ≤ 40V, V_{OUT} = 5V			80		
Oscillator Frequency		f_{OSC}	(Note 2)	T_J = 25°C	127	150	173	kHz
				-40°C ≤ T_J ≤ 125°C	110	150	173	
Quiescent Current		I_Q	(Note 3)			5	10	mA
Standby Current		I_{STBY}	$\overline{\text{Enable}}$ = 5V			80	200	μA
Saturation Voltage		V_{SAT}	I_{LOAD} = 3A (Note 4)	T_J = 25°C		1.16	1.4	V
				-40°C ≤ T_J ≤ 125°C			2.0	
Feedback Bias Current		I_{FB}	V_{OUT} = 5V (ADJ version only)	T_J = 25°C		10	50	nA
				-40°C ≤ T_J ≤ 125°C			100	
Duty Cycle (ON)		DC	(Note 5)			100		%
Current Limit		I_{LIMIT}	(Note 2, 4)	T_J = 25°C	3.6	4.5	7	A
				-40°C ≤ T_J ≤ 125°C	3.4	4.5	7.5	
Output Leakage Current		I_{LEAK}	(Note 3)	V_{OUT} = 0V		0.3	2	mA
				V_{OUT} = -1V			20	
$\overline{\text{Enable}}$ Threshold Voltage		V_{IH}	V_{OUT} = 0V	T_J = 25°C	0.6	1.4		V
				-40°C ≤ T_J ≤ 125°C	0.6			
		V_{IL}	V_{OUT} = Normal Output Voltage	T_J = 25°C		1.3	2.0	
				-40°C ≤ T_J ≤ 125°C			2.0	
$\overline{\text{Enable}}$ Input Current		I_{IH}	$\overline{\text{Enable}}$ = 2.5V			5	15	μA
		I_{IL}	$\overline{\text{Enable}}$ = 0.5V			0.02	5	

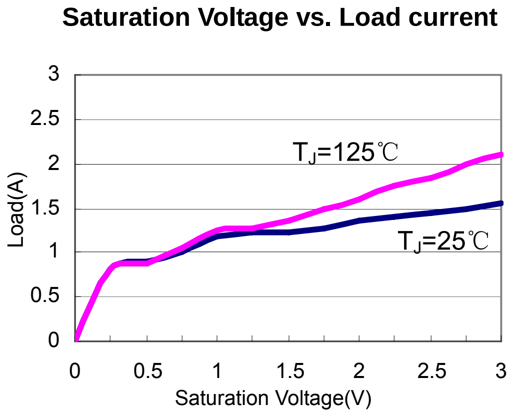
Note 1： Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.
Note 2： The human body model test condition is a 100 pF capacitor discharged through a 1.5k resister into each pin.
Note 3： Typical numbers are at 25°C and represent the most likely normal condition.
Note 4： All limits guaranteed at room temperature and at temperature extremes. All room temperature limits are 100% production tested. All limits at temperature extremes are design guaranteed.
Note 5： External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator system performance.
Note 6： The switching frequency is reduced when the second stage current limit is activated. The amount of reduction is determined by the current over-loading.
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 3.3V, 5V, and the ADJ. version, and 15Vfor the 12V version, to force the output transistor switch OFF.
Note 10：VIN＝40V

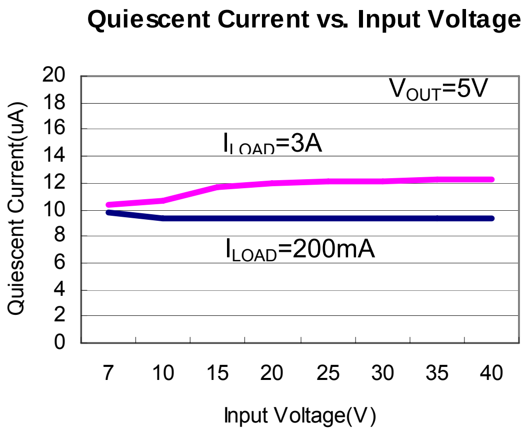
CHARACTERIZATION CURVES

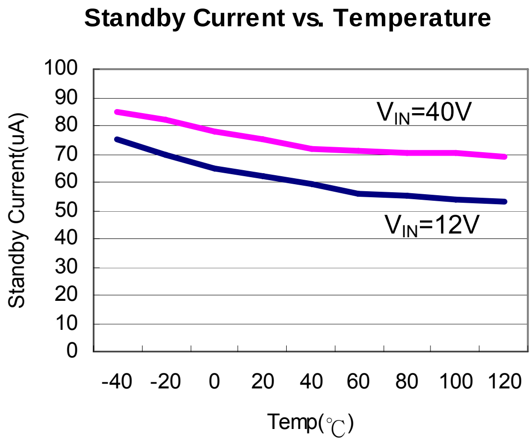
Test circuits of Figure 1 and 2, T_J =25°C, unless otherwise specified.

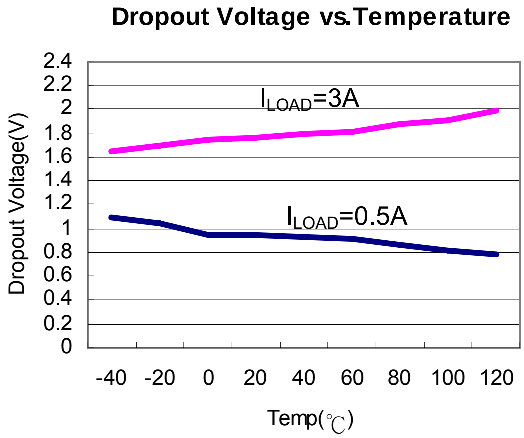








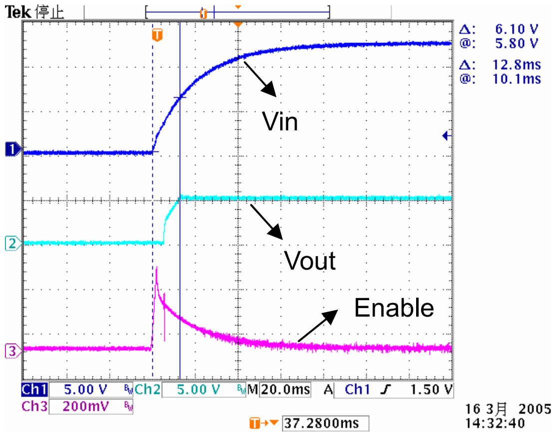




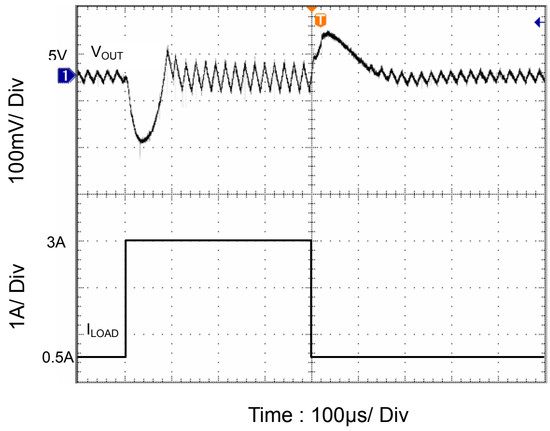
CHARACTERIZATION CURVES

Test circuits of Figure 1 and 2, T_J =25°C, unless otherwise specified.

On/Off Delay time



Load transient response



Application Information

Input Capacitors (C_{IN})

It is recommend that V_{IN} must be bypassed with at least a 100µF electrolytic capacitor for stability. Also, it is strongly recommended the capacitor's leads must be cut short, and located near the regulator as possible.

For low operating temperature range, for instance, below -25°C, the input capacitor value may need to be larger. This is due to the capacitance value of electrolytic capacitors decreases and the ESR increases with lower temperatures and age. Paralleling a ceramic or solid tantalum capacitor will increase the regulator stability at cold temperatures.

Output Capacitors (C_{OUT})

An output capacitor is required to filter the output voltage and is needed for loop stability. The capacitor should be located near the GP2596 as possible and design short PC board traces. Low ESR types capacitors are recommended for low output ripple voltage and good stability. Generally, low value or low voltage (less than 12V) electrolytic capacitors usually have higher ESR numbers. For instance, the lower capacitor values (220µF–1000µF) will yield typically 50 mV to 150 mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20 mV to 50 mV.

The amount of output ripple voltage is primarily a function of the ESR (Equivalent Series Resistance) of the output capacitor and the amplitude of the inductor ripple current (ΔI_{IND}).

Output Ripple Voltage = (ΔI_{IND}) × (ESR of C_{OUT})

Some capacitors called "high-frequency," "low-inductance," or "low ESR." are recommended to use to further reduce the output ripple voltage to 10 mV or 20 mV. However, very low ESR capacitors, such as Tantalum capacitors, should be carefully evaluated.

Catch Diode

This diode is required to provide a return path for the inductor current when the switch is off. It should be located close to the GP2596 using short leads and short printed circuit traces as possible.

To satisfy the need of fast switching speed and low forward voltage drop, Schottky diodes are widely used to provide the best efficiency, especially in low output voltage switching regulators (less than 5V). Besides, fast-Recovery, high-efficiency, or ultra-fast recovery diodes are also suitable. But some types with an abrupt turn-off characteristic may cause instability and EMI problems. A fast-recovery diode with soft recovery characteristics will be a better selection.

Application Information (contd.)

Output Voltage Ripple and Transients

The output ripple voltage is mainly caused by the inductor saw tooth ripple current which multiplied by the ESR of the output capacitor.

The output voltage of a switching power supply will contain a saw tooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and it may also contain short voltage spikes at the peaks of the saw tooth waveform.

Owing to the fast switching operation, and the parasitic inductance of the output filter capacitor, there is voltage spikes presenting at the peaks of the saw tooth waveform. Cautions must be taken for stray capacitance, wiring inductance, and even the scope probes used for transients evaluation. Shortening the lead length and PCB traces is to minimize these voltage spikes. An additional small LC filter (20μH & 100μF) (as shown in Figure 3 below) may provide a 10X reduction in output ripple voltage and transients.

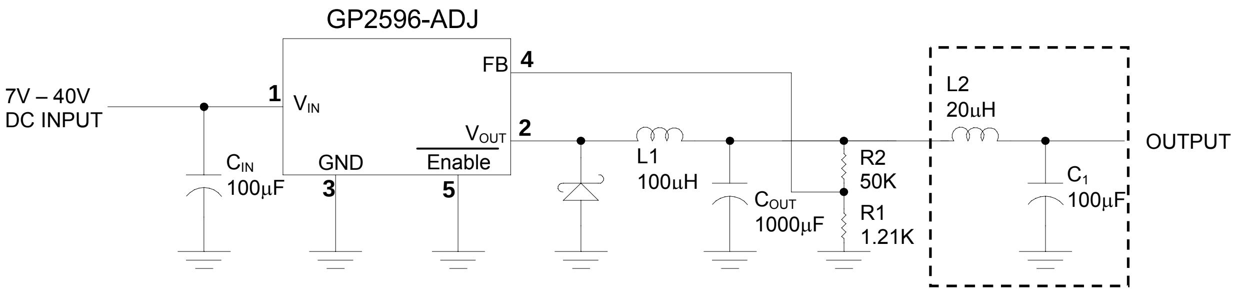


Figure 3. LC Filter for Low Output Ripple

Inductor Selection

The GP2596 can be used for either continuous or discontinuous modes of operation. Each mode has different operating characteristics, which can affect the regulator performance and requirements.

With relatively heavy load currents, the circuit operates in the continuous mode (inductor current always flowing), but under light load conditions, the circuit will altered to the discontinuous mode (inductor current falls to zero for a period of time). For light loads (less than approximately 300 mA) it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode.

Inductors are available in different styles such as toroid, pot core, E-frame, bobbin core, etc., as well as different core materials, such as ferrites and powdered iron. The least expensive, the bobbin core type consists of wire wrapped on a ferrite rod core. This type of construction makes for an inexpensive inductor, however, since the magnetic flux is not completely contained within the core, it generates more electromagnetic interference (EMI). This EMI may cause problem in sensitive circuits, or can give incorrect scope readings because of inducing voltages in the scope probe.

An inductor should not be operated beyond its maximum rated current because it may saturate. When an inductor begins to saturate, the inductance decreases rapidly and the inductor begins to look mainly resistive (the DC resistance of the winding). This will cause the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this should be well considered when selecting inductor.

Application Information

Feedback Connection

In fixed output voltage version, the FB (feedback) pin must be connected to V_{OUT}. For the adjustable version, it is important to place the output voltage ratio resistors close to GP2576 as possible in order to minimize the noise introduction.

$\overline{\text{Enable}}$

It is required that the $\overline{\text{Enable}}$ must not be left open. For normal operation, connect this pin to a "LOW" voltage (typically, below 1.6V). On the other hand, for standby mode, connect this pin with a "HIGH" voltage. This pin can be safely pulled up to $+V_{IN}$ without a resistor in series with it.

Grounding

To maintain output voltage stability, the power ground connections must be Low-Impedance. For the 5-lead TO-220 and TO-263 style package, both the tab and pin 3 are ground and either connection may be used.

Heat Sink and Thermal Consideration

Although the GP2596 requires only a small heat sink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances θ_{JA} and θ_{JC}, total power dissipation can be estimated as follows:

$$P_D = (V_{IN} \times I_Q)+(V_{OUT} / V_{IN})(I_{LOAD} \times V_{SAT});$$

When no heat sink used application, the junction temperature rise can be determined by the following:

$$\Delta T_J = P_D \times \theta_{JA};$$

With the ambient temperature, the actual junction temperature will be:

$$T_J = \Delta T_J + T_A ;$$

If the actual operating junction temperature is out of the safe operating junction temperature (typically 125°C), then a heat sink is required. When using a heat sink, the junction temperature rising will be reduced by the following:

$$\Delta T_J = P_D \times (\theta_{JC} + \theta_{interface} + \theta_{Heat\ sink});$$

From the above equation, it is important to choose a heat sink with adequate size and thermal resistance, so that to maintain the regulator's junction temperature below the maximum operating temperature.

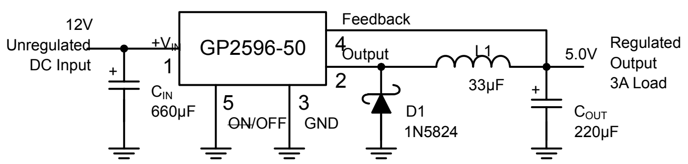


Figure 4. 5V Vout application circuit

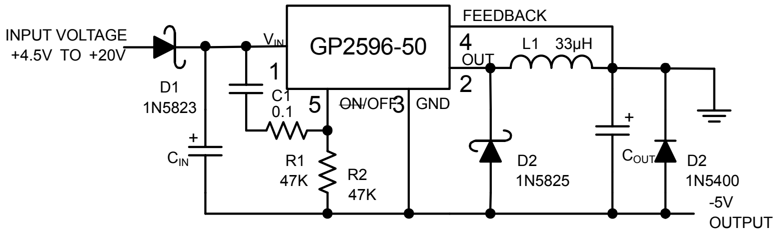
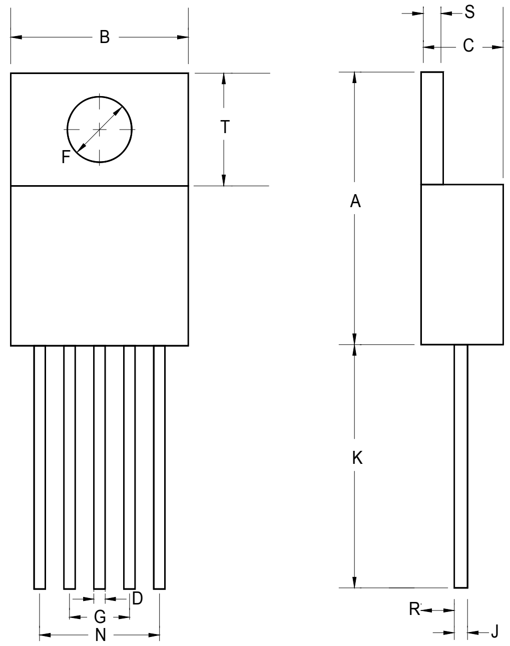


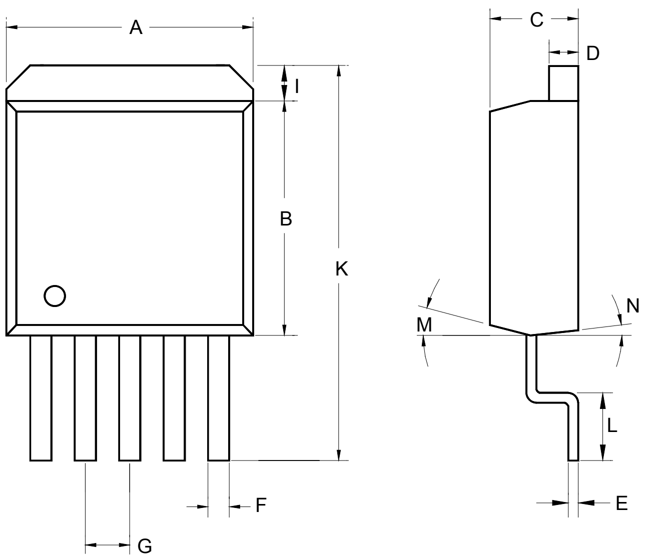
Figure 5. –5V Vout application circuit

5-Pin Plastic TO-220 (P)



	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.560	-	0.650	14.23	-	16.51
B	0.380	-	0.420	9.66	-	10.66
C	0.140	-	0.190	3.56	-	4.82
D	0.018	-	0.035	0.46	-	0.89
F	0.140	-	0.160	3.56	-	4.06
G	0.134	-	-	3.40	-	-
J	0.012	-	0.045	0.31	-	1.14
K	0.500	-	0.580	12.70	-	14.73
N	0.268 TYP			6.80 TYP		
R	0.080	-	0.115	2.04	-	2.92
S	0.045	-	0.055	1.14	-	1.39
T	0.230	-	0.270	5.85	-	6.85

5-Pin Surface Mount TO-263 (D)



	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.395	-	0.420	10.03	-	10.67
B	0.325	-	0.361	8.25	-	9.17
C	0.171	-	0.181	4.34	-	4.59
D	0.045	-	0.055	1.14	-	1.40
E	0.013	-	0.017	0.330	-	0.432
F	0.029	-	0.035	0.737	-	0.889
G	0.062	-	0.072	1.57	-	1.83
I	-	-	0.065	-	-	1.65
K	0.575		0.635	14.60		16.13
L	0.090		0.110	2.29		2.79
M	7°			7°		
N	3°			3°		

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