Green Power Semiconductor, Inc.

# GP2576

## 3A Step Down Voltage Regulator

### DESCRIPTION

The GP2576 is a 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 an adjustable output version.

The GP2576 offers a high efficiency replacement for popular three-terminal linear regulators. It requires only a minimum number of external components. Substantially, it reduces not only the area of board size 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 70µA(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 52 KHz fixed frequency**
- **Wide adjustable version output voltage range, from 1.23V to 37V ±4% maximum over line and load conditions**
- Low standby current, typical 70µA, when Enable pin pull high
- Only 4 external components required
- Thermal shut down and current limit protection built in

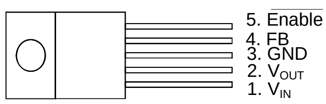
### APPLICATIONS

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

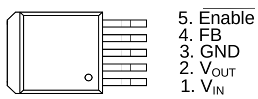
- **Voltage Options:**

GP2576-3.3 – 3.3V Fixed
GP2576-5.0 – 5.0V Fixed
GP2576-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 — Plastic TO-220 5-pin | D — Plastic TO-263 5-pin |
|---|---|---|
| -40°C≤ $T_J$ ≤ 125°C | **GP2576-ADJP** | **GP2576-ADJD** |
| | **GP2576-ADJPF** | **GP2576-ADJDF** |
| | **GP2576-X.XP** | **GP2576-X.XD** |
| | **GP2576-X.XPF** | **GP2576-X.XDF** |

Note: The surface mount packages is available in Tape & Reel. Append the letter “T” to part number (i.e. GP2576-X.XDDFT). The letter “F” is marked for Lead Free process.

## TYPICAL APPLICATION

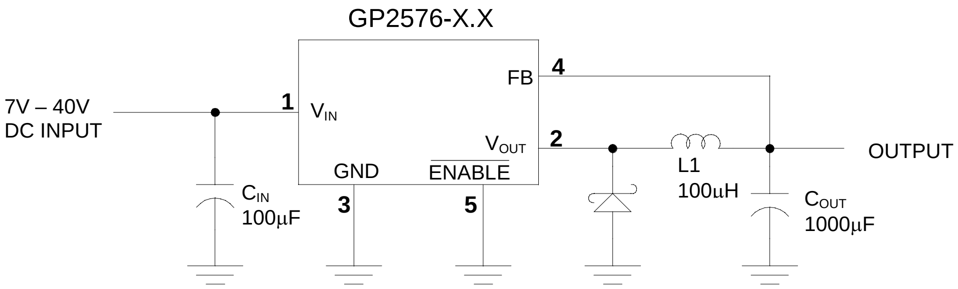



**Figure 1. Fixed Output Voltage application circuit**

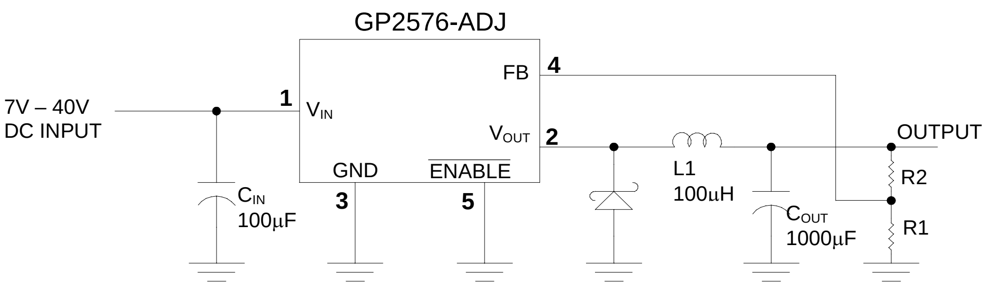



**Figure 2. Adjustable Output Voltage application circuit**

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

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

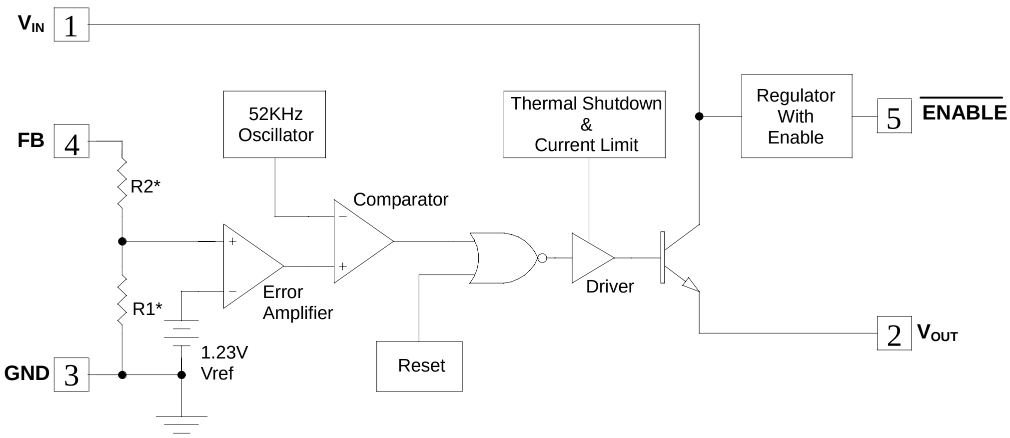
$V_{REF}$ = 1.23V, R1 between 1K and 5K

| ABSOLUTE MAXIMUM RATINGS (Note 1) | |
|---|---|
| Input Voltage, $V_{IN}$ | 45V |
| $\overline{\text{Enable}}$ Pin Input Voltage | $-0.3V \leq V \leq V_{IN}$ |
| 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 | $-40°C \leq T_J \leq 125°C$ |
| Input Voltage, $V_{IN}$ | 40V(Max.) |

| THERMAL DATA | |
|---|---|
| **P, DD PACKAGE**: | |
| Thermal Resistance-Junction to Tab, $\theta_{JT}$ | 3.0°C /W |
| Thermal Resistance-Junction to Ambient, $\theta_{JA}$ | 45°C /W |
| Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.<br>The $\theta_{JA}$ numbers are guidelines for the thermal performance of the device and PC-board system.<br>All of the above assume no ambient airflow. | |

## BLOCK DIAGRAM




**$V_{OUT}$ = 3.3V : R2/R1 = 1.7**
**$V_{OUT}$ = 5.0V : R2/R1 = 3.1**
**$V_{OUT}$ = Adjustable : R2 = 0**
**R1 = Open**

**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 | | GP2576-X.X Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|
| Output Voltage (Note 1) | GP2576-3.3 | $V_{OUT}$ | Test circuit of Figure 1 | | 3.234 | 3.300 | 3.366 | V |
| | GP2576-5.0 | | | | 4.900 | 5.000 | 5.100 | |
| Output Voltage (Note 1) | GP2576-3.3 | $V_{OUT}$ | 0.5A ≤ $I_{LOAD}$ ≤ 3A Test circuit of Figure 1 | 6V ≤$V_{IN}$ ≤ 40V | 3.168 | 3.300 | 3.432 | V |
| | GP2576-5.0 | | | 8V ≤$V_{IN}$ ≤ 40V | 4.800 | 5.000 | 5.200 | |
| Output Voltage (Note 1) | GP2576-3.3 | $V_{OUT}$ | 0.5A ≤ $I_{LOAD}$ ≤ 3A, -40°C ≤ $T_J$ ≤ 125°C Test circuit of Figure 1 | 6V ≤$V_{IN}$ ≤ 40V | 3.135 | 3.300 | 3.482 | V |
| | GP2576-5.0 | | | 8V ≤$V_{IN}$ ≤ 40V | 4.750 | 5.000 | 5.250 | |
| Feedback Voltage (Note 1) | GP2576-ADJ | $V_{OUTFB}$ | Test circuit of Figure 2 | $V_{OUT}$ = 5V | 1.217 | 1.230 | 1.243 | V |
| Feedback Voltage (Note 1) | GP2576-ADJ | $V_{OUTFB}$ | 8V ≤$V_{IN}$ ≤ 40V, $V_{OUT}$ = 5V, Test circuit of Figure 2 | 0.5A ≤ $I_{LOAD}$ ≤ 3A | 1.193 | 1.230 | 1.267 | V |
| Feedback Voltage (Note 1) | GP2576-ADJ | $V_{OUTFB}$ | 8V ≤$V_{IN}$ ≤ 40V, $V_{OUT}$ = 5V, Test circuit of Figure 2 | 0.5A ≤ $I_{LOAD}$ ≤ 3A, -40°C≤ $T_J$ ≤ 125°C | 1.180 | 1.230 | 1.286 | V |
| Efficiency | GP2576-3.3 | η | $I_{LOAD}$ = 3A | | | 75 | | % |
| | GP2576-5.0 | | | | | 77 | | |
| | GP2576-ADJ | | $I_{LOAD}$ = 3A, $V_{OUT}$ = 5V | | | 77 | | |
| Oscillator Frequency | | $f_{OSC}$ | (Note 2) | $T_J$ = 25°C | 47 | 52 | 58 | kHz |
| | | | | -40°C ≤ $T_J$ ≤ 125°C | 42 | 52 | 63 | |
| Quiescent Current | | $I_Q$ | (Note 3) | | | 5 | 10 | mA |
| Standby Current | | $I_{STBY}$ | $\overline{\text{ENABLE}}$ = 5V | | | 70 | 200 | µA |
| Saturation Voltage | | $V_{SAT}$ | $I_{LOAD}$ = 3A (Note 4) | $T_J$ = 25°C | | 1.4 | 1.8 | V |
| | | | | -40°C ≤ $T_J$ ≤ 125°C | | | 2.0 | |
| Feedback Bias Current | | $I_{FB}$ | $V_{OUT}$ = 5V (ADJ version only) | $T_J$ = 25°C | | 50 | 100 | nA |
| | | | | -40°C ≤ $T_J$ ≤ 125°C | | | 500 | |
| Duty Cycle (ON) | | Dc | (Note 5) | | 93 | 98 | | % |
| Current Limit | | $I_{LIMIT}$ | (Note 2, 4) | $T_J$ = 25°C | 4.2 | 7 | 8.8 | A |
| | | | | -40°C ≤ $T_J$ ≤ 125°C | 3.5 | 7.2 | 9 | |
| Output Leakage Current | | $I_{LEAK}$ | (Note 3) | $V_{OUT}$ = 0V | | 0.3 | 2 | mA |
| | | | | $V_{OUT}$ = -1V | | 9 | 20 | |
| $\overline{\text{ENABLE}}$ Threshold Voltage | | $V_{IH}$ | $V_{OUT}$ = 0V | $T_J$ = 25°C | 2.2 | 1.4 | | V |
| | | | | -40°C ≤$T_J$ ≤125°C | 2.4 | | | |
| | | $V_{IL}$ | $V_{OUT}$ = Normal Output Voltage | $T_J$ = 25°C | | 1.2 | 1.0 | |
| | | | | -40°C ≤ $T_J$ ≤ 125°C | | | 0.8 | |
| $\overline{\text{ENABLE}}$ Input Current | | $I_{IH}$ | $\overline{\text{ENABLE}}$ = 5V | | | 12 | 30 | µA |
| | | $I_{IL}$ | $\overline{\text{ENABLE}}$ = 0V | | | 0 | 10 | |

Note 1: The switching regulator system performance can be affected by the external components such as the catch diode, inductor, input and output capacitors.

Note 2: The internal circuit designed when the event of fault conditions such as output short or overload present, the oscillator frequency reduces to approximately 11kHz. And the regulated output voltage will drop approximately 40% from the nominal output voltage. This self-protection feature lowers the average power dissipation by lowering the minimum duty cycle from 5% down to approximately 2%.

Note 3: For these parameters, FB is removed from $V_{OUT}$ and connected to +12V to force the output transistor off.

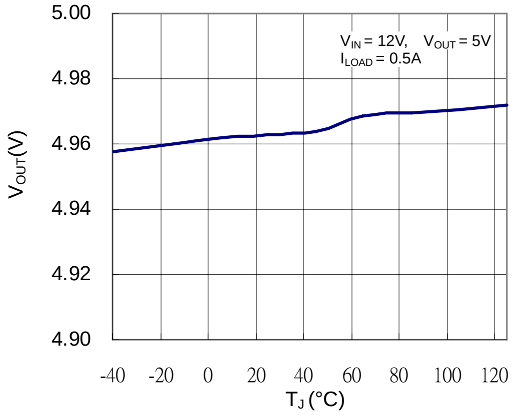
Note 4: $V_{OUT}$ pin sourcing current. No diode, inductor or capacitor connect to $V_{OUT}$.

Note 5: FB is removed from $V_{OUT}$ and connected to 0V.

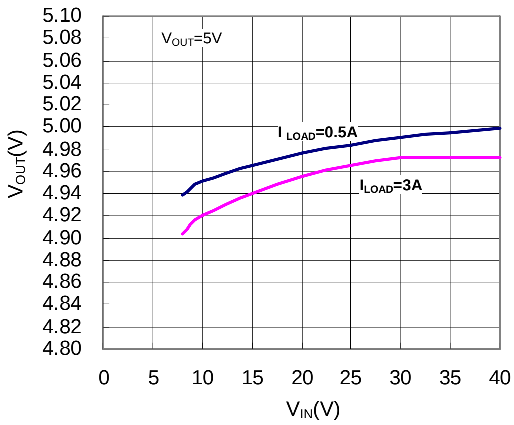
## CHARACTERIZATION CURVES

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

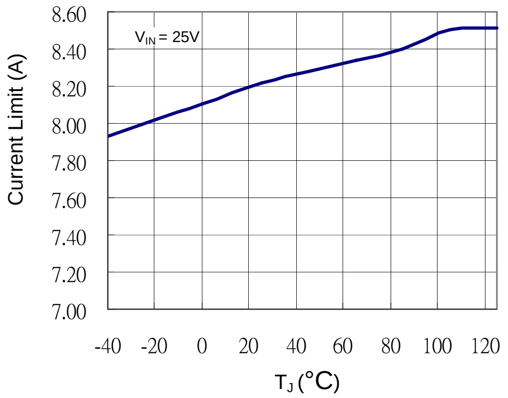
### Output voltage vs. temperature



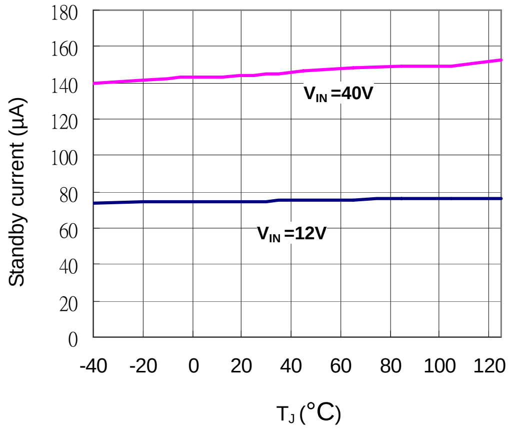

### Line regulation



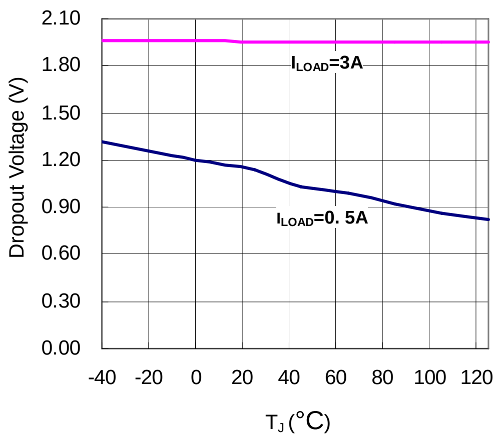

### Current limit vs. temperature



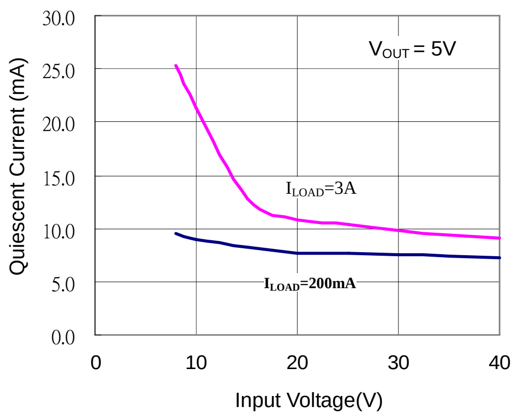

### Standby current vs. temperature




### Dropout voltage vs. temperature



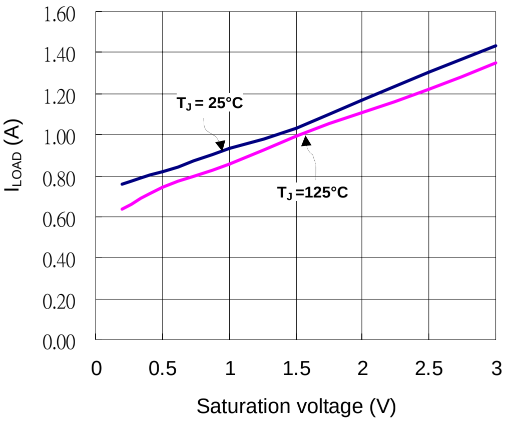

### Quiescent current vs. input voltage



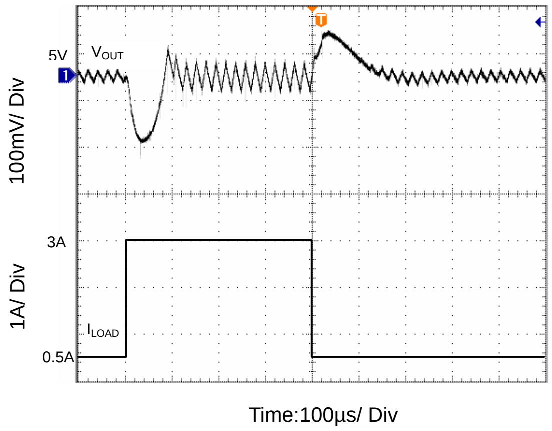
## CHARACTERIZATION CURVES (continued)

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

Saturation voltage vs. load current




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 application, 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 GP2576 and design short PC board traces as possible. 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 ($\Delta I_{IND}$).

$$\text{Output Ripple Voltage} = (\Delta I_{IND}) \times (\text{ESR of } C_{OUT})$$

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 GP2576 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.

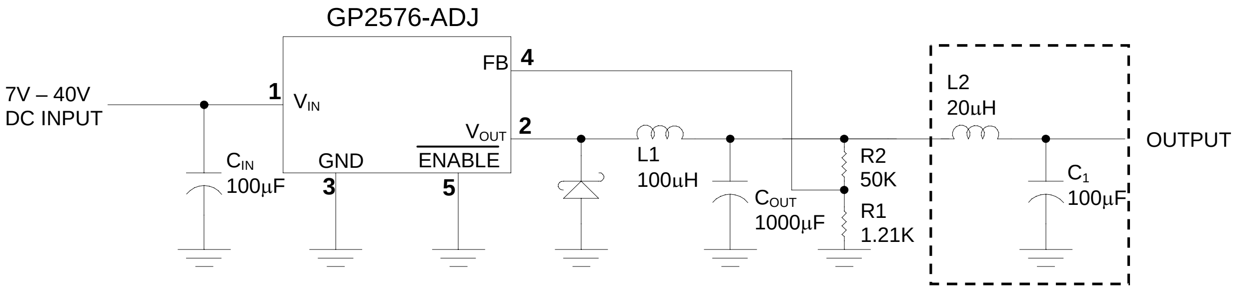



**Figure 3. LC Filter for Low Output Ripple**

### Inductor Selection

The GP2576 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 be forced 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 versions, the FB (feedback) pin must be connected to $V_{OUT}$ directly. 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 GP2576 requires only a small heat sink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances $\theta_{JA}$ and $\theta_{JC}$, 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:

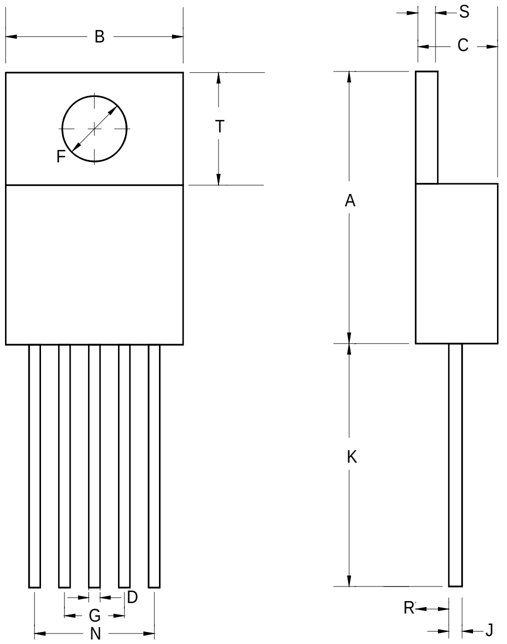
$$T_J = \Delta T_J + T_A ;$$

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 rise will be reduced by the following equation:

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

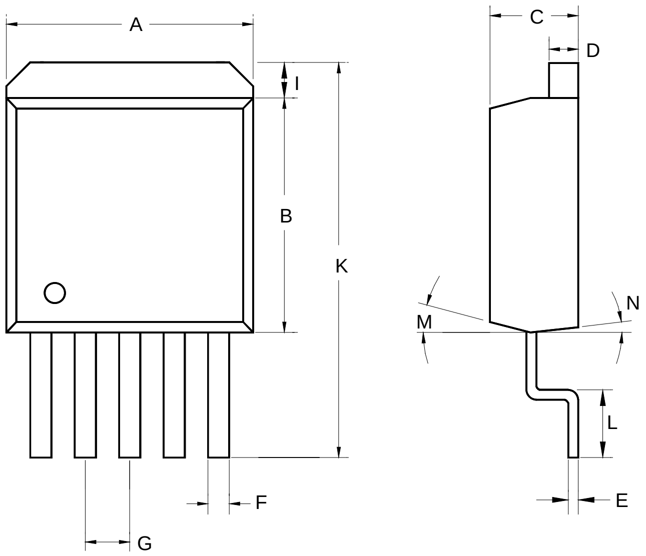
From the above equation, it is important to choose a heat sink with adequate size and thermal resistance, so that to maintain the regulator's junction temperature below the maximum operating temperature.

## 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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