TS2576

3A Step Down Switching Voltage Regulator

TO-220-5L



TO-263-5L



Pin assignment:
1. Input
2. Output
3. Ground
4. Feedback
5. Enable

52KHz Oscillating Frequency
Output Current up to 3A
Enable Input Control

General Description

The TS2576 Series are step-down switching regulators with all required active functions. It is capable of driving 3A load with excellent line and load regulations. These devices are available in fixed output voltages of 3.3V, 5V, and an adjustable output version.

The TS2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. Also it requires a minimum number of external components. It substantially not only reduces the area of board size but also the size of heat sink, and in some cases no heat sink is required. The ±4% tolerance on output voltage within specified input voltages and output load conditions is guaranteed. Also, the oscillator frequency accuracy is within ±10%. External shutdown is included. Featuring 70μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

This series are offered in 5-pin TO-263, TO-220 package.

Features

- ✧ Guaranteed 3A output current
- ✧ 3.3V, 5V, and adjustable versions
- ✧ Wide input voltage range, up to 40V
- ✧ Internal oscillator of 52KHz fixed frequency
- ✧ Wide adjust version output voltage range, from 1.23V to 37V ±4% max. at over line and load conditions.
- ✧ Low standby current, typ. 70μA, at shutdown mode
- ✧ Requires only 4 external components
- ✧ Thermal shutdown and current limit protection
- ✧ P+ product enhancement tested

Ordering Information

Part No.	Operating Temp. (Ambient)	Package
TS2576CZ5-**xx**	-20 ~ +85 °C	TO-220-5L
TS2576CZ5		
TS2576CM5-**xx**		TO-263-5L
TS2576CM5		

Note: Where **xx** denotes voltage option, available are 12V, 5V and 3.3V. Leave blank for adjustable version. Contact factory for additional voltage options.

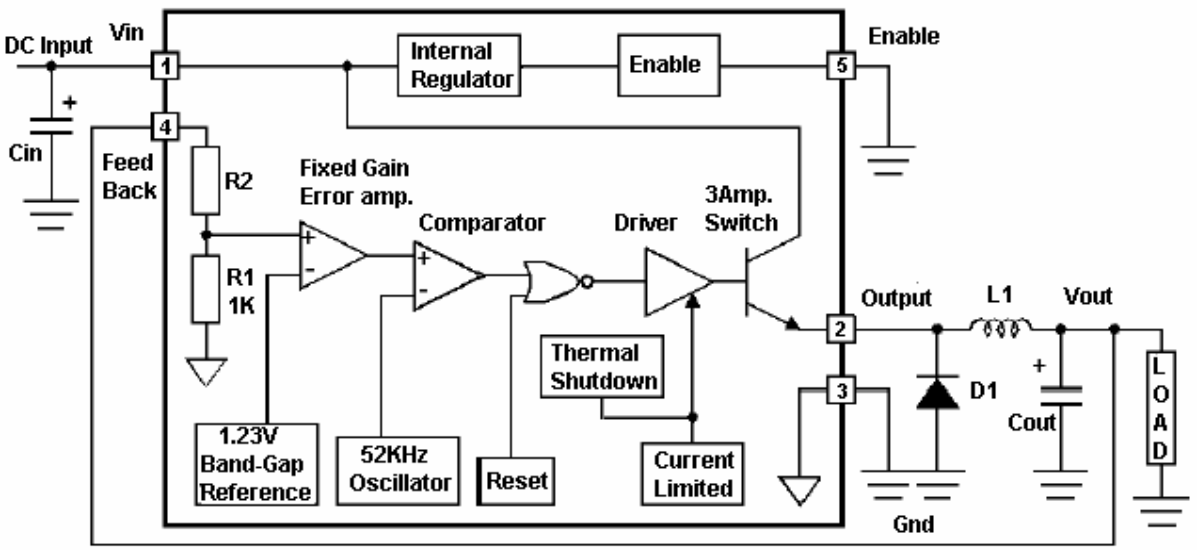
Applications

- ✧ LCD Monitors
- ✧ ADD-ON Cards Switching Regulators
- ✧ High Efficiency Step-Down Regulators
- ✧ Efficient Pre-regulator for Linear Regulators
- ✧ Positive to Negative converter (Buck-Boost)

Absolute Maximum Rating

Input Voltage	Vin	+45	V
ENABLE Pin Input Voltage	Vin (operate)	-0.3V ≤ V ≤ Vin	V
Power Dissipation	P_D	Internal Limited	W
Operating Junction Temperature Range	T_J	-0 ~ +150	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C
Lead Soldering Temperature (260 °C) TO-220-5L / TO-263-5L Package		5	S

Block Diagram



Electrical Characteristics

Vin = 12V, I_L = 500mA, Ta = 25 °C unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Unit
TS2576-3.3V					
Output Voltage (Note 1)	Vin=12V, I_L=0.5A (Figure 1)	0.98|Vo|	3.3	1.02|Vo|	V
Output Voltage (Note 1)	0.5A ≤ I_L ≤ 3A, 6V ≤ Vin ≤ 40V (Figure 1)	0.96|Vo|		1.04|Vo|	
Efficiency	Vin=12V, I_L=3A	--	75	--	%
TS2576-5V					
Output Voltage (Note 1)	Vin=12V, I_L=0.5A(Figure 1)	0.98|Vo|	5.0	1.02|Vo|	V
Output Voltage (Note 1)	0.5A ≤ I_L ≤ 3A, 8V ≤ Vin ≤ 40V (Figure 1)	0.96|Vo|		1.04|Vo|	
Efficiency	Vin=12V, I_L=3A	--	77	--	%
TS2576-12V					
Output Voltage (Note 1)	Vin=25V, I_L=0.5A (Figure 1)	0.98|Vo|	12	1.02|Vo|	V
Output Voltage(Note 1)	0.5A ≤ I_L ≤ 3A, 15V ≤ Vin ≤ 40V (Figure 1)	0.96|Vo|		1.04|Vo|	
Efficiency	Vin=15V, I_L=3A	--	88	--	%
TS2576					
Feedback Voltage (Note 1)	Vin=12V, Vout=5V,I_L=0.5A (Figure 2)	0.98|Vo|	1.23	1.02|Vo|	V
Feedback Voltage (Note 1)	0.5A ≤ I_L ≤ 3A, 8V ≤ Vin ≤ 40V, Vout=5V (Figure 2)	0.96|Vo|		1.04|Vo|	
Efficiency	Vin=12V, Vout=5V, I_L=3A	--	77	--	%

All Output Voltage Version (Vin=12V for 5V, 3.3V and Adjustable version, Vin=25V for 12V version, I_L = 500mA)					
Oscillator Frequency (Note 2)		47	52	58	kHz
Quiescent Current (Note 3)		--	5	10	mA
Standby Current	ENABLE =5V	--	70	200	uA
Saturation Voltage (Note 4)	I_{LOAD}=3A	--	1.4	1.8	V
Feedback Bias Current	V_{OUT}=5V (Adj. Version only)	--	50	100	nA
Duty Cycle (Note 5)	Operating (ON)	93	98	--	%
Current Limit (Note 2)(Note 4)		4.2	7.0	8.8	A
Output Leakage Current (Note 3)	V_{OUT}=0V	--	0.3	2	mA
	V_{OUT}=-1V	--	7.5	30	
ENABLE Threshold Voltage	V_{IH} (V_{OUT}=0V)	2.2	1.4	--	V
	V_{IL}(V_{OUT}=Normal Output Voltage)	--	1.2	1.0	
ENABLE Input Current	I_{IH} (ENABLE =5V)	--	12	30	uA
	I_{IH} (ENABLE =0V)	--	0	10	

Note 1: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. Refer to Application information for details.

Note 2: The oscillator frequency reduces to approximately 11KHz in the event of fault conditions, such as output short or overload. 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 connected to V_{OUT}.

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

Typical Application Circuit

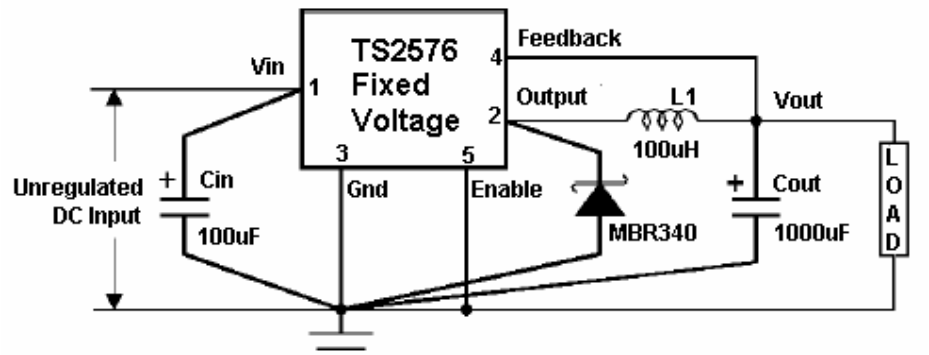


Figure 1 Fixed Voltage Version

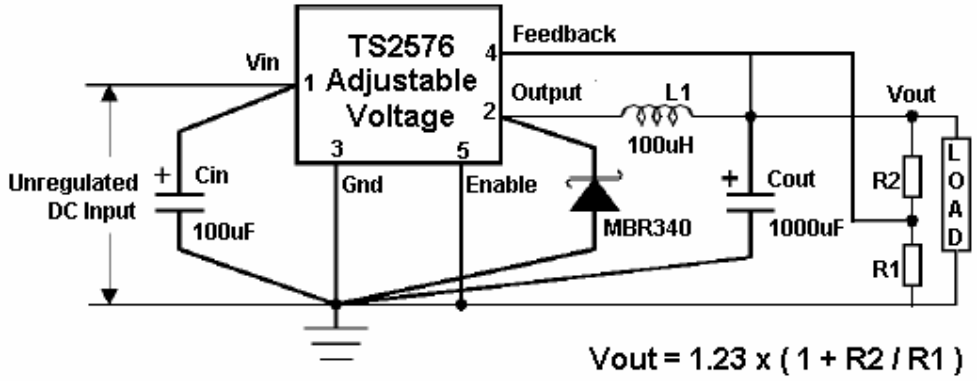


Figure 2: Adjustable Voltage Version

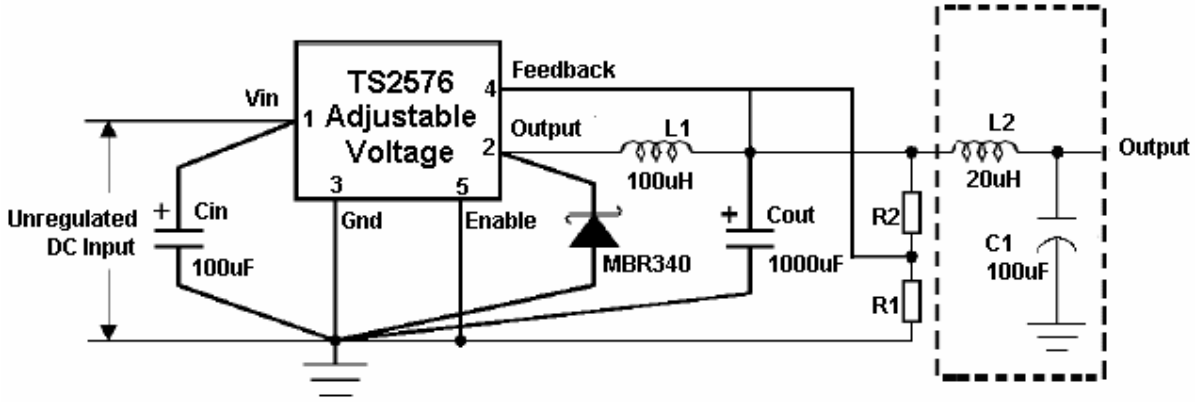


Figure 3: LC filter for Low Output Ripple

Application Information

It is required that VIN must be bypassed with at least a 100μF electrolytic capacitor for stability. Also, it is strongly recommended the capacitor's leads must be dept short, and located near the regulator as possible.

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

Output Capacitor

An output capacitor is also required to filter the output voltage and is needed for loop stability. The capacitor should be located near the TS2576 using 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 example, the lower capacitor values (220μF - 1000μF) will yield typically 50mV to 150mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20mV to 50mV.

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}) x (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 10mV or 20mV. However, very low ESR capacitors, such as tantalum capacitors, should be carefully evaluated.

Catch Diode

This diode is required to return path for the inductor current when the switch is off. It should be located close to the TS2576 using short leads and short printed circuit traces as possible.

To satisfy the need to 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). Beside, 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 is better choice.

Inductor Selection

The TS2576 can be used for either continuous or discontinuous modes of operation. Each mode has distinctively 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 force to the discontinuous mode (inductor current falls to zero for a period of time). For light loads (less than approximately 300mA) it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode.

Indictors are available in different styles such as pot core, toroid, E-frame, bobbin core, et., 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, but since the magnetic flux is not completely contained within the core, it generates more electromagnetic interference (EMI). This EMI can cause problems in sensitive circuits, or can give incorrect scope readings because of induced voltage 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 as inductor.

Feedback Connection

For 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 near TS2576 as possible in order to minimize the noise introduction.

Enable Input

It is required that the 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 $+_{VIN}$ 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 rather connection may be used.

Thermal Characteristics

The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor. The output ripple voltage of a switching power supply will contain a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltages, and may also contain short voltage spokes of the sawtooth waveform.

Due to the fast switching action, and the parasitic inductance of the output filter capacitor, there is voltage spikes presenting at the peaks of the sawtooth waveform. Cautions must be taken for stray capacitance. Wiring inductance, and even the scope probes used for transients evaluation. To minimize these voltage spikes, shortening the lead length and PCB traces is always the first thought. Further more, an additional small LC filter (30μH & 100μF) (as shown in Figure 3) will possibly provide a 10X reduction in output ripple voltage and transients.

Heatsink and Thermal Consideration

Although the TS2576 requires only a small heatsink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances Θja and Θjc, total power dissipation can be estimated as follows:

$PD = (Vin \times Iq) + (Vout / Vin)(Iout \times Vsat)$;

When no heatsink is used, the junction temperature rise can be determined by the following:

$\Delta T_J = PD \times \Theta ja$

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

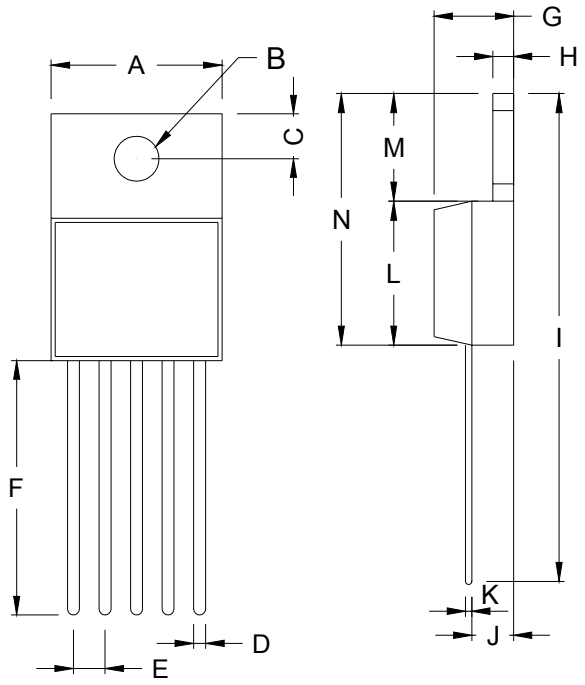
$Tj = \Delta Tj + Ta$

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

$\Delta Tj = PD \times (\Theta jc + \Theta \text{ interface} + \Theta \text{ heatsink})$;

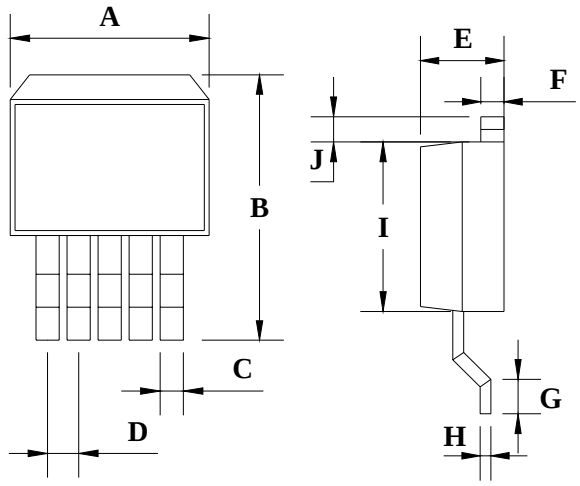
Also one can see from the above, it is important to choose an heatsink with adequate size and thermal resistance, such that to maintain the regulator's junction temperature below the maximum operating temperature.

TO-220-5L Mechanical Drawing



TO-220 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.00	10.50	0.394	0.413
B	3.240	4.440	0.128	0.175
C	2.440	2.940	0.096	0.116
D	0.260	1.020	0.010	0.040
E	1.570	1.830	0.062	0.072
F	13.31	14.13	0.524	0.556
G	4.475	5.225	0.176	0.206
H	1.170	1.370	0.046	0.054
I	27.60	29.44	1.087	1.159
J	2.175	2.925	0.086	0.115
K	0.297	0.477	0.012	0.019
L	8.280	8.800	0.326	0.346
M	6.010	6.510	0.237	0.256
N	14.29	15.31	0.563	0.603

TO-263-5L Mechanical Drawing



TO-263 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.220	10.260	0.402	0.404
B	14.600	15.870	0.575	0.625
C	0.750	0.770	0.030	0.030
D	1.573	1.827	0.062	0.072
E	4.560	4.570	0.179	0.180
F	1.240	1.270	0.049	0.050
G	2.280	2.790	0.090	0.110
H	0.280	0.320	0.011	0.013
I	8.240	8.280	0.324	0.326
J	1.540	1.800	0.060	0.071