FEATURES

- 3.3 V, 5.0 V, 12 V, and Adjustable Output Versions
- Adjustable version output voltage range, 1.23V
- to 57V ± 4% max over line and load conditions
- Output load current: 3A
- Input voltage range up to 60V
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Thermal shutdown and current limit protection
- Built-in switching transistor on chip
- 5-lead T0-220 package

APPLICATIONS

- Simple High-Efficiency Step-Down (Buck) Regulator
- Efficient Pre-Regulator for Linear Regulators
- On-Ca「d Switching Regulators
- Positive to Negative Converter (Buck-Boost)
- Negative Step-Up Converters
- Power Supply for Battery Chargers

GENERAL DESCRIPTION

The CBM2576HVSseries of regulators are monolithic integrated circuits that provide all the 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 voltages of 3.3V, 5.0V, 12V, and 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 CBM2576HVSseries offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required. A standard series of inductors optimized for use with the CBM2576HVSare available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed±4% tolerance on output voltage within specified input voltages and output load conditions, and ± 10% on the oscillator frequency. The external shutdown function can be controlled by logic level and then come into standby mode. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

The CBM2576HVSseries a「e available in a standard 5-lead T0-220 package.

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Block diagram

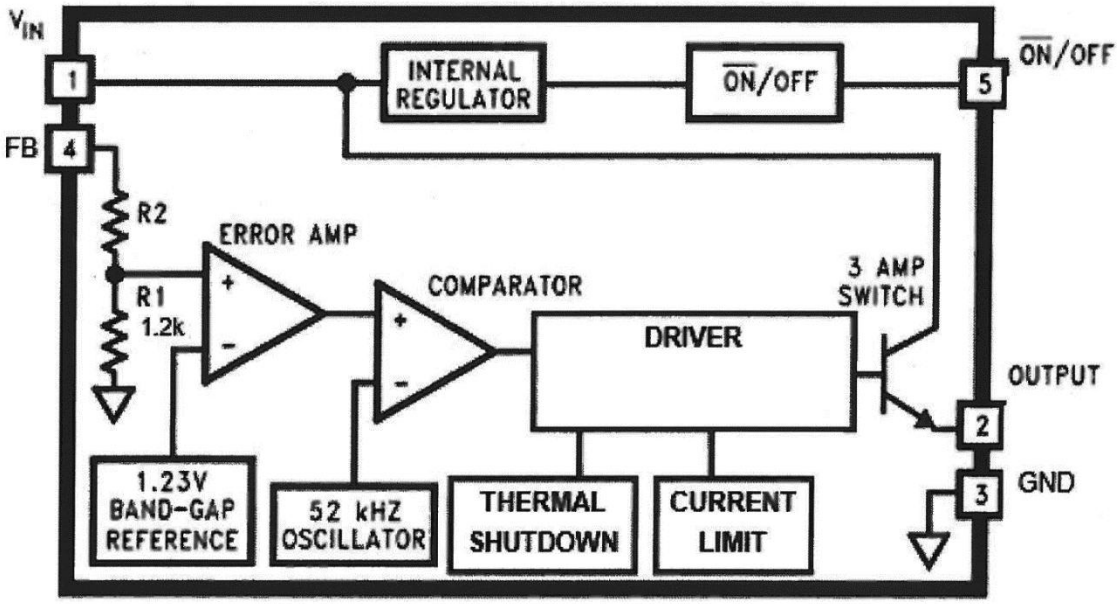


Figure 1.

3.3V R2 = 2.02k

5.0V, R2 = 3.69k

12V, R2 = 10.56k

For adjustable version

R1 = Open, R2 = on

Typical Electrical Parameters

Parameter, unit		Symbol	Typ. value	Test condition
Efficiency,%	CBM2576HVS-ADJ		77	V_{IN} = 12V, I_{LOAD} = 3A, V_{OUT} = 5V
	CBM2576HVS-3.3		75	V_{IN} = 12V, I_{LOAD} = 3A
	CBM2576HVS-5.0		77	
	CBM2576HVS-12		88	V_{IN} = 15V, I_{LOAD} = 3A
Max. Duty Cycle {ON), %		DC_{max}	98	V_{FB} = 0V

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Typical Application (Fixed Output voltage versions)

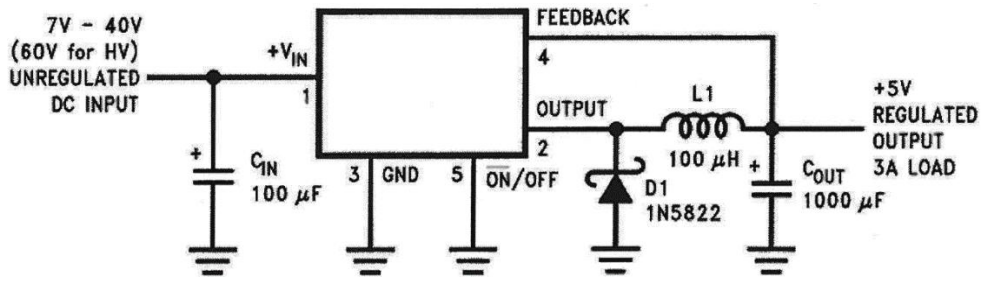


Figure 2.

C1—aluminum electrolytic capacitor(100uF, 75V);

C2—aluminum electrolytic capacitor(1000uF, 25V);

L1—inductor (100uH);

D1—Schottky diode

Adjustable Output Voltage Versions

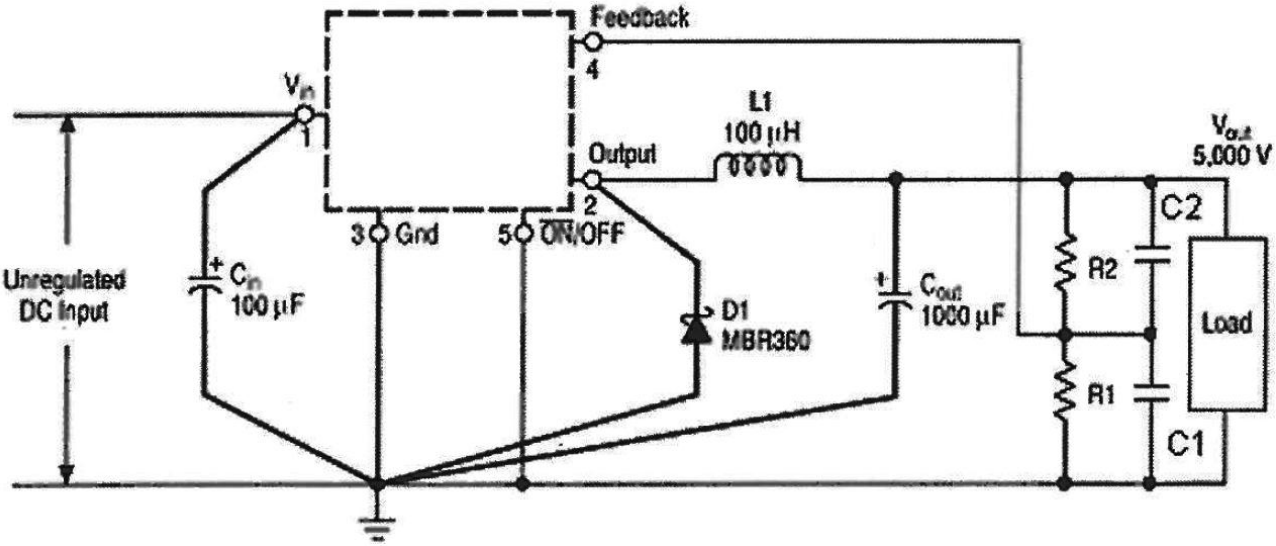


Figure 3.

$$V_{out} = V_{ref}\left(1.0 + \frac{R_2}{R_1}\right), \quad R_2 = R_1\left(\frac{V_{out}}{V_{ref}} - 1.0\right)$$

Where Vref = 1.23 V, R1 between 1.0 k and 5.0 k

C1 = 10 nF

C2 = 1 nF

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ABSOLUTE MAXIMUM RATINGS

(Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.)

Rating	Symbol	Value	Unit
Maximum Supply Voltaqe	Vin	63	V
ON/OFF Pin Input Voltage		-0.3V ≤ V ≤ +25	V
Output Voltaoe to Ground (Steadv-State)		-0.1	V
Power Dissipation			
TO-220,5-Lead	P_D	Internally Limited	W
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	65	℃/W
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	5.0	℃/W
T0-263, 5-Lead (D2PAK)	P_D	Internally Limited	W
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	70	℃/W
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	5.0	℃/W
Storage Temperature Range	Tstg		℃
Minimum ESD Rating (Human Body Model: C=100pF,R=1.5kΩ)		2.0	kV
Lead Temperature (Soldering, 10 seconds)		260	℃
Maximum Junction Temperature	T_J	150	℃

* Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.

Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

OPERATING RATINGS

(Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	-40 to +125	℃
Supply Voltage	V_{IN}	60	V

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ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, Vin = 12V for the 3.3V, 5.0V, and Adjustable version, Vin = 25V for the 12V version, and Vin = 30V for the 15V version. I_{Load} = 500mA, T_J = 25℃, for min/max values T_J is the operating junction temperature range that applies unless otherwise noted)

IC	Parameter, unit	Symbol	Limit		Test condition	T_A,℃
			min	max		
CBM2576 HVS-ADJ	Feedback bias current, nA	IB	-	100 500	VFB = 1,3V; VIN= 12V	25±10 125* -40
	Oscillator frequency, kHz	fOSC	47 42	58 63	VIN= 12V	
	Saturation voltage, V	VSAT	-	1.8 2,0	VFB = OV; VIN= 12V; IOUT = 3A no external circuit	
	Current limit, A	ICL	4.2 3.5	6.9 7.5	VFB = OV; VIN= 12V; 3A ≤ IOUT ≤ 8A no external circuit	
	Output leakage current, mA	IL(O)		2	VFB = 12V; VIN= 60V; VOUT = OV no external circuit	25±10
		IL(-1)		30	VFB = 12V; VIN= 60V; VOUT =-1V no external circuit	
	Quiescent current, mA	IQ		10	VFB = 12V; VIN= 12V	
	Standby quiescent current, uA	ISTBY		200	VFB = OV; VIN= 60V; VON/OFF =5V	
	ON/OFF pin low level input voltage (switch on), V	VIL	1.0 0.8		FB = 0V; N = 12V	25±10 125* -40
	ON/OFF pin high level input voltage (switch off), V	VIH		2.2 2.4		
	ON/OFF pin high level input current (switch off}, uA	IIH		30	VFB = 0V; VIN= 12V; VON/OFF = 5V	25±10
	ON/OFF pin low level input current (switch on), uA	IIL		10	VFB = 0V; VIN= 12V; VON/OFF= 0V	
	Feedback voltage, V	VFB	1.217	1.243	VIN=12V;ILOAD=0.5A; VOUT = 5V	
			1.193 1.180	1.273 1.286	8V ≤ VIN ≤ 60V; 0.5A ≤ ILOAD ≤ 3A; VOUT = 5V	25±10 125* -40

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IC	Parameter, unit	Symbol	Limit		Test condition	T_A,℃
			min	max		
CBM2576 HVS-3.3	Oscillator frequency, kHz	f_{OSC}	47 42	58 63	V_{IN} = 12V	25±10 125* -40
	Saturation voltage, V	V_{SAT}		1.8 2.0	V_{FB} = 0V; V_{IN} = 12V; I_{OUT} = 3A no external circuit	
	Current limit, A	ICL	4.2 3.5	6.9 7.5	V_{FB} = 0V; V_{IN} = 12V; 3A ≤ I_{OUT} ≤ 8A; no external circuit	
	Output leakage current, mA	$I_{L(0)}$		2	V_{FB} = 12V; V_{IN} = 60V; 3A ≤ I_{OUT} ≤ 8A no external circuit	25±10
		$I_{L(-1)}$		30	V_{FB} = 12V; V_{IN} = 60V; V_{OUT} = -1V; no external circuit	
	Quiescent current, mA	I_Q		10	V_{FB} = 12V; V_{IN} = 12V	
	Standby quiescent current, uA	I_{STBY}		200	V_{FB} = 0V; V_{IN} = 60V; $V_{ON/OFF}$ = 5V	
	ON/OFF pin low level input voltage (switch on), V	V_{IL}	1.0 0.8		V_{FB} = 0V; V_{IN} = 12V	25±10 125* -40
	ON/OFF pin high level input voltage (switch off), V	V_{IH}		2.2 2.4		
	ON/OFF pin high level input current (switch off), uA	I_{IH}		30	V_{FB} = 0V; V_{IN} = 12V; $V_{ON/OFF}$ = 5V	25±10
	ON/OFF pin low level input current (switch on), uA	I_{IL}	-	10	V_{FB} = 0V; V_{IN} = 12V; $V_{ON/OFF}$ = 0V	
	Output voltage, V	V_{OUT}	3.234	3.366	V_{IN} = 12V; V_{LOAD}=0.5A	
			3.168 3.135	3.450 3.682	6V ≤ V_{IN} ≤ 60V; 0.5A ≤ I_{LOAD} ≤ 3A	25±10 125* -40

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IC	Parameter, unit	Symbol	Limit		Test condition	T_A,℃
			min	max		
CBM2576 HVS-5.0	Oscillator frequency, kHz	f_{SOC}	47 42	58 63	V_{IN} = 12V	25±10 125* -40
	Saturation voltage, V	V_{SAT}		1.8 2.0	V_{FB} = 0V; V_{IN} = 12V; I_{OUT} = 3A no external circuit	
	Current limit, A	I_{CL}	4.2 3.5	6.9 7.5	V_{FB} = 0V; V_{IN} = 12V; 3A ≤ I_{OUT} ≤ 8A no external circuit	
	Output leakage current, mA	$I_{L(0)}$		2	V_{FB} = 12V; V_{IN} = 60V; V_{OUT} = 0A no external circuit	25±10
		$I_{L(-1)}$		30	V_{FB} = 12V; V_{IN} = 60V; V_{OUT} = -1A no external circuit	
	Quiescent current, mA	I_Q		10	V_{FB} = 12V; V_{IN} = 12V	
	Standby quiescent current, uA	I_{STBY}		200	V_{FB} = 0V; V_{IN} = 60V; $V_{ON/OFF}$ = 5V	
	ON/OFF pin low level input voltage (switch on), V	V_{IL}	1.0 0.8		V_{FB} = 0V; V_{IN} = 12V	25±10 125* -40
	ON/OFF pin high level input voltage (switch off), V	V_{IH}		2.2 2.4		
	ON/OFF pin high level input current (switch off), uA	I_{IH}		30	V_{FB} = 0V; V_{IN} = 12V; $V_{ON/OFF}$ = 5V	25±10
	ON/OFF pin low level input current (switch on), uA	I_{IL}		10	V_{FB} = 0V; V_{IN} = 12V; $V_{ON/OFF}$ = 0V	
	Output voltage, V	V_{OUT}	4.90	5.10	V_{IN} = 12V; I_{LOAD} = 0.5A	
			4.800 4.750	5.225 5.275	8V ≤ V_{IN} ≤ 60V; 0.5A ≤ I_{LOAD} ≤ 3A	25±10 125* -40

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IC	Parameter, unit	Symbol	Limit		Test condition	T_A,℃
			min	max		
CBM2576 HVS-12	Oscillator frequency, kHz	F_{OSC}	47 42	58 63	V_{IN} = 25V	25±10 125* -40
	Saturation voltage, V	V_{SAT}		1.8 2.0	V_{FB} = 0V; V_{IN} = 25V; I_{OUT} = 3A no external circuit	
	Current limit, A	I_{CL}	4.2 3.5	6.9 7.5	V_{FB} = 0V; V_{IN} = 25V; 3A ≤ I_{OUT} ≤ 8A no external circuit	
	Output leakage current, mA	$I_{L(0)}$		2	V_{FB} = 25V; V_{IN} = 60V; V_{OUT} = 0V no external circuit	25±10
		$I_{L(-1)}$		30	V_{FB} = 25V; V_{IN} = 60V; V_{OUT} = -1V no external circuit	
	Quiescent current, mA	I_Q		10	V_{FB} = 25V; V_{IN} = 25V	
	Standby quiescent current, uA	I_{STBY}		200	V_{FB} = 0V; V_{IN} = 60V; $V_{ON/OFF}$ = 5V	
	ON/OFF pin low level input voltage (switch on), V	V_{IL}	1.0 0.8		V_{FB} = 0V; V_{IN} = 25V	25±10 125* -40
	ON/OFF pin high level input voltage (switch off), V	V_{IH}		2.2 2.4		
	ON/OFF pin high level input current (switch off), uA	I_{IH}		30	V_{FB} = 0V; V_{IN} = 25V; $V_{ON/OFF}$ = 5V	25±10
	ON/OFF pin low level input current (switch on), uA	I_{IL}		10	V_{FB} = 0V; V_{IN} = 25V; $V_{ON/OFF}$ = 0V	
	Output voltage, V	V_{OUT}	11.76	12.24	V_{IN} = 25V; I_{LOAD} = 0.5A	
			11.52 11.40	12.54 12.66	15V ≤ V_{IN} ≤ 60V; 0.5A ≤ I_{LOAD} ≤ 3A	25±10 125* -40

* Junction temperature. Junction temperature is equal to ambient because of measurements of electric parameters are executed in pulse mode.

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Application Information

INVERTING REGULATOR

Figure 4 shows a CBM2576-12 in a buck-boost configuration to generate a negative 12V output from a positive input voltage. This circuit bootstraps the regulator's ground pin to the negative output voltage, then by grounding the feedback pin, the regulator senses the inverted output voltage and regulates it to -12V.

For an input voltage of 12V or more, the maximum available output current in this configuration is approximately 700 mA. At lighter loads, the minimum input voltage required drops to approximately 4.7V.

The switch currents in this buck-boost configuration are higher than in the standard buck-mode design, thus lowering the available output current. Also, the start-up input current of the buck-boost converter is higher than the standard buck-mode regulator, and this may overload an input power source with a current limit less than 5A. Using a delayed turn-on or an undervoltage lockout circuit (described in the next section) would allow the input voltage to rise to a high enough level before the switcher would be allowed to turn on.

Because of the structural differences between the buck and the buck-boost regulator topologies, the buck regulator design procedure section can not be used to to select the inductor or the output capacitor. The recommended range of inductor values for the buck-boost design is between 68μH and 220μH, and the output capacitor values must be larger than what is normally required for buck designs. Low input voltages or high output currents require a large value output capacitor (in the thousands of micro Farads).

The peak inductor current, which is the same as the peak switch current, can be calculated from the following formula:

$$I_p \approx \frac{I_{LOAD}(V_{IN} + |V_O|)}{V_{IN}} + \frac{V_{IN}|V_O|}{V_{IN} + |V_O|} \times \frac{1}{2L_1F_{OSC}}$$

Where f_{OSC} = 52 kHz. Under normal continuous inductor current operating conditions, the minimum V_{IN} represents the worst case. Select an inductor that is rated for the peak current anticipated.

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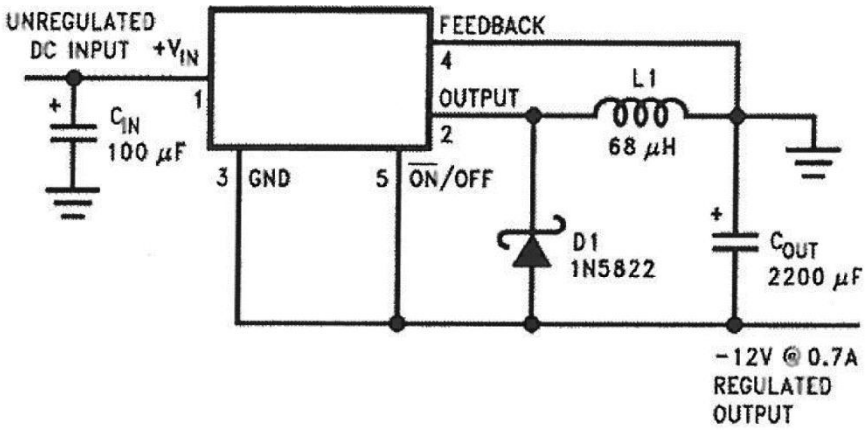
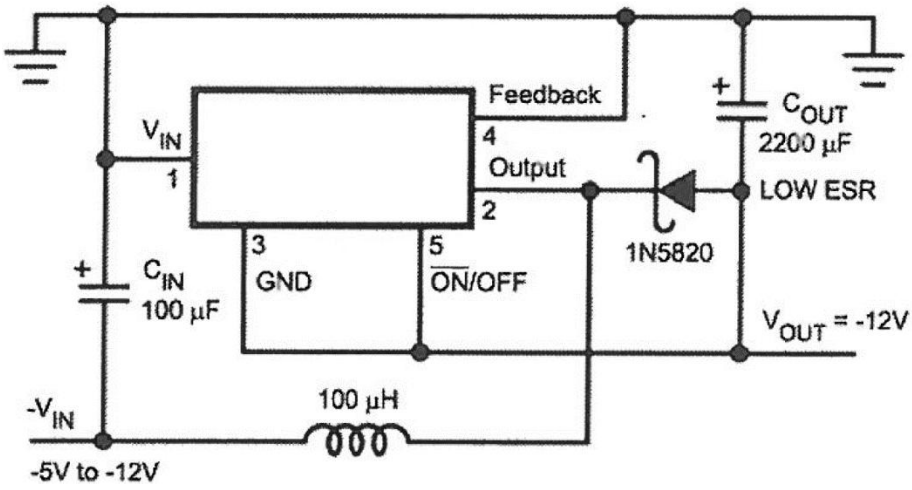


FIGURE 4. Inverting Buck-Boost Develops -12V

Also, the maximum voltage appearing across the regulator is the absolute sum of the input and output voltage. For a -12V output, the maximum input voltage for the IL2576 is +28V.

NEGATIVE BOOST REGULATOR

Another variation on the buck-boost topology is the negative boost configuration. The circuit in Figure 5 accepts an input voltage ranging from -SV to -12V and provides a regulated -12V output. Input voltages greater than-12V will cause the output to rise above -12V, but will not damage the regulator



Typical Load Current

400 mA for V_{IN}= -5.2V

750 mA for V_{IN} = -7V

Note: Heat sink may be required

FIGURE 5. Negative Boost

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Because of the boosting function of this type of regulator, the switch current is relatively high, especially at low input voltages.

Output load current limitations are a result of the maximum current rating of the switch. Also, boost regulators can not provide current limiting load protection in the event of a shorted load, so some other means (such as a fuse) may be necessary.

UNDERVOLTAGE LOCKOUT

In some applications it is desirable to keep the regulator off until the input voltage reaches a certain threshold. An undervoltage lockout circuit which accomplishes this task is shown in Figure 6 while Figure 7 shows the same circuit applied to a buck-boost configuration. These circuits keep the regulator off until the input voltage reaches a predetermined level.

$V_{TH} = V_{Z1} + 2VB_{E(}Q1)$

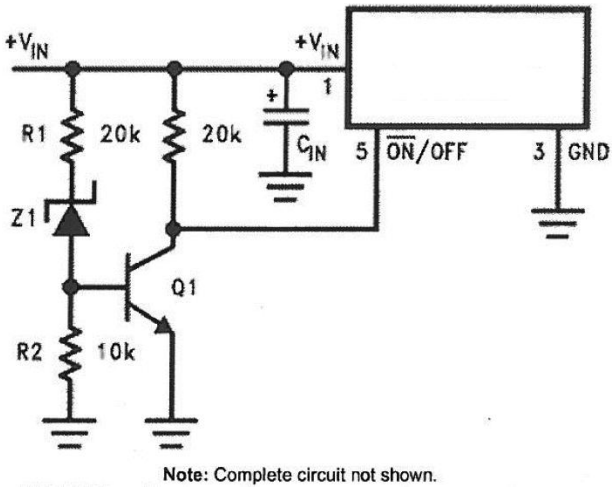


FIGURE 6. Undervoltage Lockout for Buck Circuit

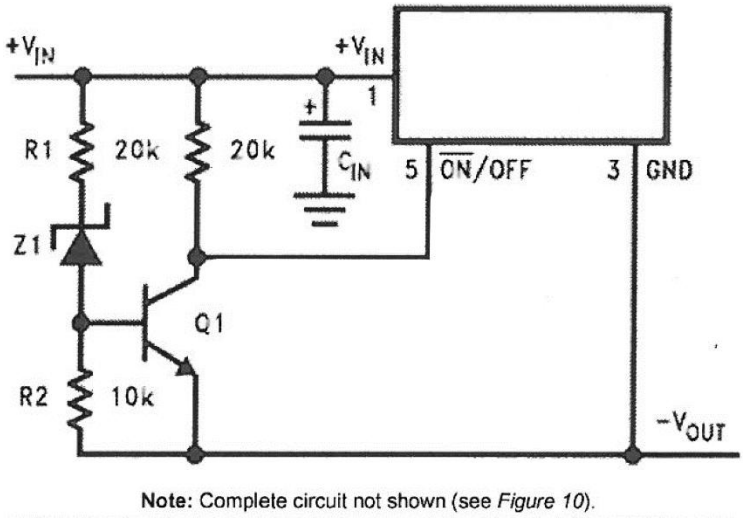


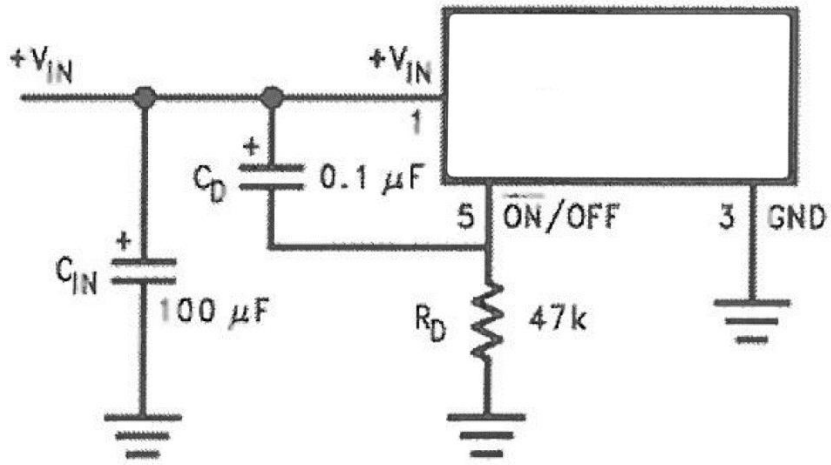
FIGURE 7. Undervoltage Lockout for Buck-Boost Circuit

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DELAYED STARTUP

The ON /OFF pin can be used to provide a delayed startup feature as shown in Figure 8. With an input voltage of 20V and for the part values shown, the circuit provides approximately 10 ms of delay time before the circuit begins switching

Increasing the RC time constant can provide longer delay times. But excessively large RC time constants can cause problems with input voltages that are high in 60Hz or 120Hz ripple, by coupling the ripple into the ON /OFF pin.



Note: Complete circuit not shown.

FIGURE 8. Delayed Startup

ADJUSTABLE OUTPUT, LOW-RIPPLE POWER SUPPLY

A 3A power supply that features an adjustable output voltage is shown in Figure 9. An additional L-C filter that reduces the output ripple by a factor of 10 or more is included in this circuit.

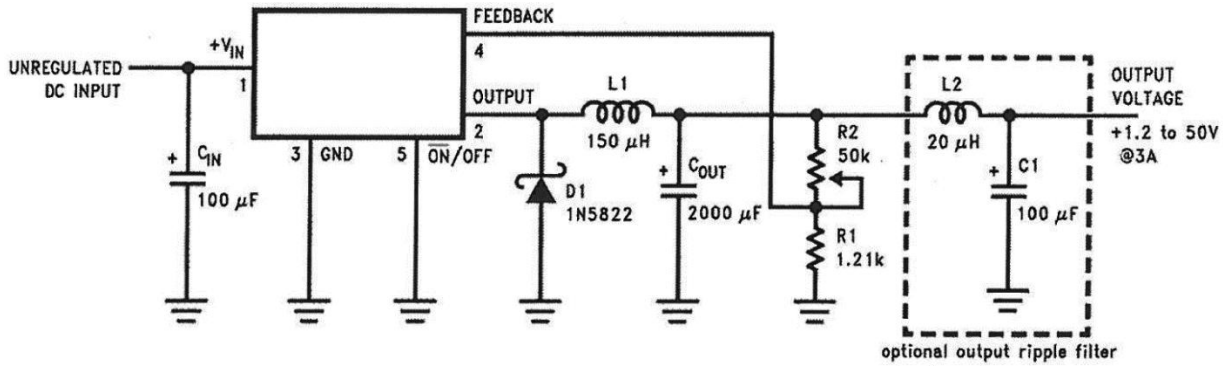


FIGURE 9. Adjustable 3A Power Supply with Low Output Ripple

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Definition of Terms

BUCK REGULATOR

A switching regulator topology in which a higher voltage is converted to a lower voltage. Also known as a step-down switching regulator.

BUCK-BOOST REGULATOR

A switching regulator topology in which a positive voltage is converted to a negative voltage without a transformer.

DUTY CYCLE (D)

Ratio of the output switch's on-time to the oscillator period.

for buck regulator $D = \frac{t_{ON}}{T} = \frac{V_{OUT}}{V_{IN}}$

for buck-boost regulator $D = \frac{t_{ON}}{T} = \frac{|V_O|}{|V_O|+V_{IN}}$

CATCH DIODE OR CURRENT STEERING DIODE

The diode which provides a return path for the load current when the IL2576 switch is OFF.

EFFICIENCY (η)

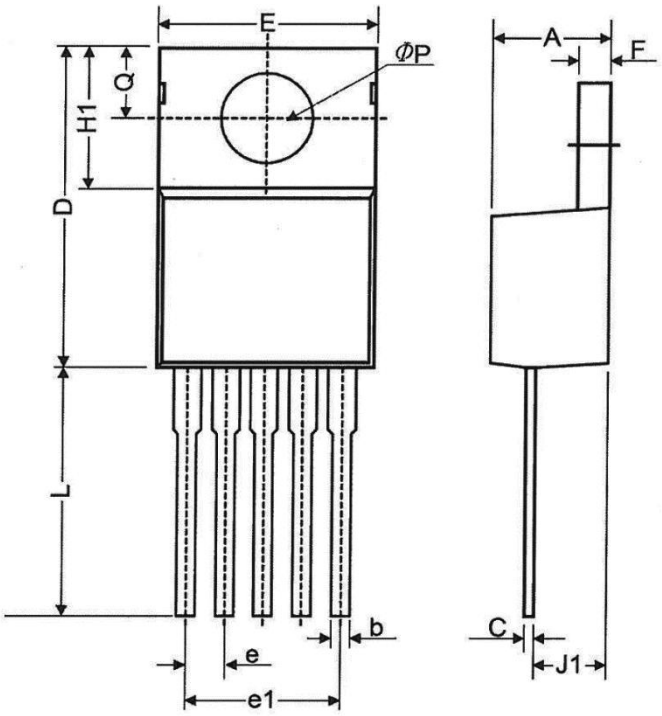
The proportion of input power actually delivered to the load.

$$\eta = \frac{P_{OUT}}{P_{IN}} \approx \frac{P_{OUT}}{P_{OUT} + P_{LOSS}}$$

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PACKAGE INFORMATION

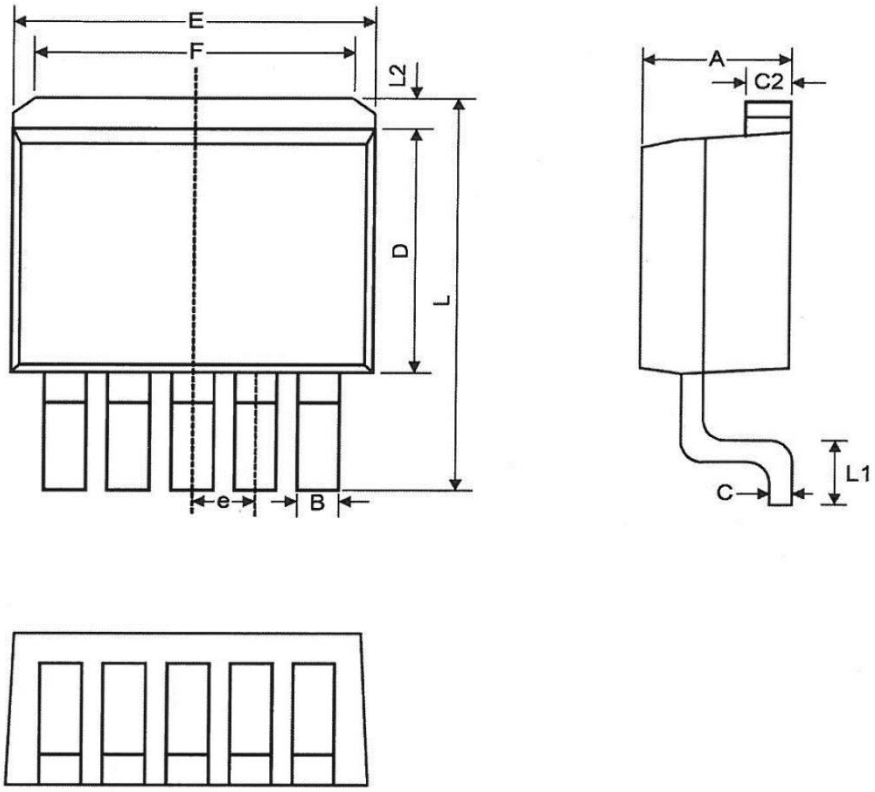
TO-220-5L



SYMBOL	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	4.07	4.45	4.82	0.160	0.175	0.190
b	0.76	0.89	1.02	0.030	0.035	0.040
C	0.36	0.50	0.64	0.014	0.020	0.025
D	14.22	14.86	15.50	0.560	0.585	0.610
E	9.78	10.16	10.54	0..385	0.400	0.415
e	1.57	1.71	1.85	0.062	0.067	0.073
e1	6.68	6.81	6.93	0.263	0.268	0.273
F	1.14	1.27	1.40	0.045	0.050	0.055
H1	5.46	6.16	6.86	0.215	0.243	0.270
J1	2.29	2.74	3.18	0.090	0.108	0.125
L	13.21	13.97	14.73	0.520	0.550	0.580
øp	3.68	3.81	3.94	0.145	0..150	0.155
Q	2.54	2.73	2.92	0.100	0.107	0.115

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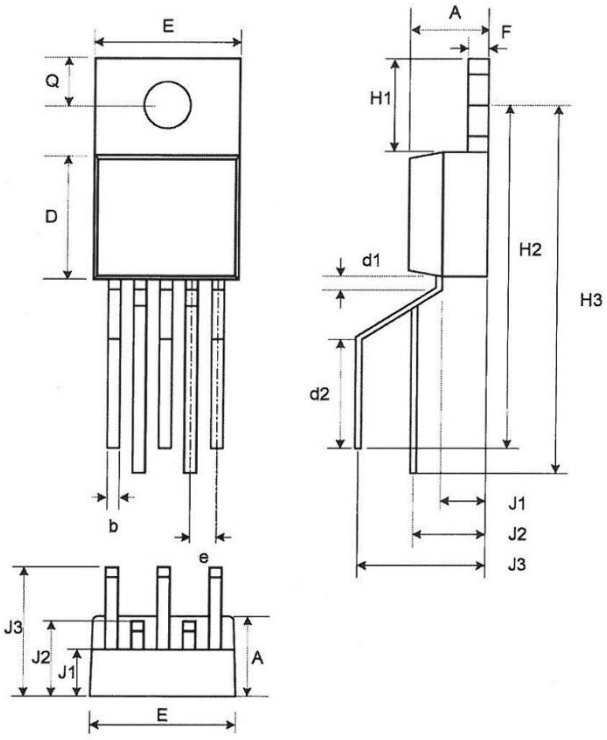
TO-263-5L



SYMBOL	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	4.07	4.46	4.85	0.160	0.176	0.191
B	0.66	0.84	1.02	0.026	0.033	0.040
C	0.36	0.50	0.64	0.014	0.020	0.025
C2	1.14	1.27	1.40	0.045	0.050	0.055
D	8.65	9.15	9.65	0.341	0.360	0.380
E	9.78	10.16	10.54	0.385	0.400	0.415
e	1.57	1.71	1.85	0.062	0.068	0.073
F	6.60	6.86	7.11	0.260	0.270	0.280
L	14.61	15.24	15.88	0.575	0.600	0.625
L1	2.29	2.54	2.79	0.090	0.100	0.110
L2			2.92			0.115

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TO-220-5L(Bent Staggered)



SYMBOL	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	4.4	4.6	4.7	0.175	0.180	0.185
b	0.7	0.8	0.9	0.027	0.032	0.037
D	8.4	8.7	8.9	0.330	0.340	0.350
d1		1.0			0.039	
d2		6.3			0.248	
E	9.91	10.16	10.41	0.390	0.400	0.410
e	1.6	1.7	1.8	0.062	0.067	0.072
F	1.2	1.25	1.3	0.048	0.050	0.052
H1		6.4			0.250	
H2	20.8	21.6	22.4	0.820	0.850	0.880
H3	23.9	24.7	25.5	0.942	0.972	1.002
J1		2.7			0.105	
J2	3.7	4..5	5.3	0.147	0.177	0.207
J3		8.4			0.331	
Q	2.5	2.8	3.0	0.100	0.110	0.120

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PACKAGE/ORDERING INFORMATION

PRODUCT	ORDERING NUMBER	TEMPRANGE	PACKAGE	PAKEAGE MARKING	TRANSPOT MEDIA,QUANTILY
CBM2576	CBM2576HVT-ADJ	-40℃~125℃	TO-220	2576HVT-ADJ	Tape and Reel,46
	CBM2576HVS-ADJ	-40℃~125℃	TO-263-5	2576HVS-ADJ	Tape and Reel,500
CBM2576-3.3	CBM72576HVT-3.3	-40℃~125℃	TO-220	2576HVT-3.3	Tape and Reel,46
	CBM2576HVS-3.3	-40℃~125℃	TO-263-5	2576HVS-3.3	Tape and Reel,500
CBM2576-5	CBM2576HVT-5.0	-40℃~125℃	TO-220	2576HVT-5.0	Tape and Reel,46
	CBM2576HVS-5.0	-40℃~125℃	TO-263-5	2576HVS-5.0	Tape and Reel,500
CBM2576-12	CBM2576HVT-12	-40℃~125℃	TO-220	2576HVT-12	Tape and Reel,46
	CBM2576HVS-12	-40℃~125℃	TO-263-5	2576HVS-12	Tape and Reel,500

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