LM25XX DATASHEET

Specification Revision History:

Version	Date	Description
V1.0	2019/03	New
V1.1	2021/08	Modify Ordering Information
V1.2	2025/02	Modify Ordering Information
V1.3	2025/03	Add application precautions and overall typesetting.

General Description

The LM25XX series of regulators are monolithic integrated circuit that provides all the active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. The LM25XX available in fixed output voltages of 3.3V, 5V, 12Vand 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 LM25XX 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. A standard of inductors optimized for use withthe LM25XX are 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 ±15% on the oscillator frequency. External shutdown is included, featuring 50μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

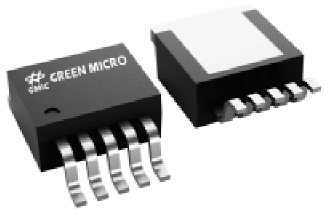
Features

- 3.3V, 5V, 12V and adjustable output versions
- High efficiency and guaranteed 3A output current
- Requires only 4 external components
- 150 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- Uses readily available standard inductors
- Thermal shutdown and current limit protection
- Adjustable version output voltage range, 1.23V to 37V ±4% max over line and load conditions

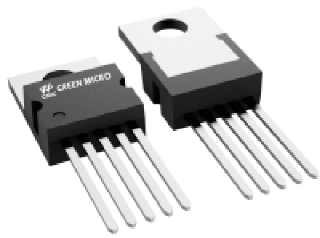
Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

The appearance of the product



TO263-5

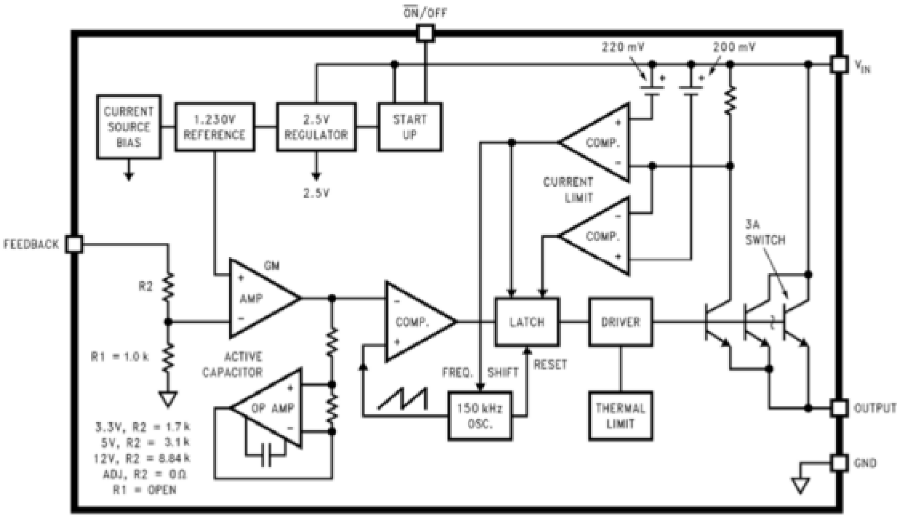


TO220-5

Ordering Information

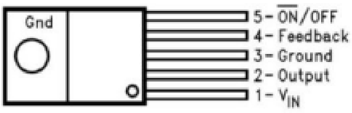
Product Model	Package Type	Marking	Packing	Packing Qty
LM2576S-ADJ(GMIC)	TO-263-5	LM2576-ADJ 264	REEL	500PCS/REEL
LM2576S-3.3(GMIC)		LM2576-3.3 205	REEL	500PCS/REEL
LM2576S-5.0(GMIC)		LM2576-5.0 274	REEL	500PCS/REEL
LM2576S-12(GMIC)		LM2576-12 304	REEL	500PCS/REEL
LM2576T-ADJ(GMIC)	TO-220-5	LM2576-ADJ 264	TUBE	1000PCS/BOX
LM2576T-3.3(GMIC)		LM2576-3.3 205	TUBE	1000PCS/BOX
LM2576T-5.0(GMIC)		LM2576-5.0 274	TUBE	1000PCS/BOX
LM2576T-12(GMIC)		LM2576-12 304	TUBE	1000PCS/BOX
2576S-ADJ(GMIC)	TO-263-5	LM2576-ADJ GM	REEL	1000PCS/REEL
2576S-3.3(GMIC)		LM2576-3.3 GM	REEL	1000PCS/REEL
2576S-5.0(GMIC)		LM2576-5.0 GM	REEL	1000PCS/REEL
2576S-12(GMIC)		LM2576-12 GM	REEL	1000PCS/REEL
2576T-ADJ(GMIC)	TO-220-5	LM2576-ADJ GM	TUBE	1000PCS/BOX
2576T-3.3(GMIC)		LM2576-3.3 GM	TUBE	1000PCS/BOX
2576T-5.0(GMIC)		LM2576-5.0 GM	TUBE	1000PCS/BOX
2576T-12(GMIC)		LM2576-12 GM	TUBE	1000PCS/BOX

Functional Block Diagram

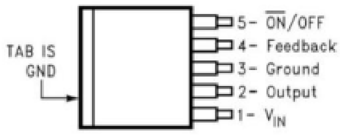


Pin Configuration

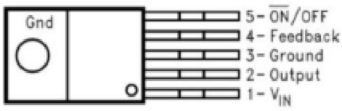
TO-220 (T)
Top View



TO-263 (S)
Top View

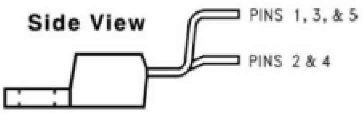


TO-220 (B)
Top View



Side View

Side View



Pin Description

Pin Number	Pin Name	Function Description
1	VIN	This is the positive input supply for the IC switching regulator
2	OUTPUT	Circuit ground
3	GROUND	Internal switch, the voltage at this pin switches between (+V_{IN} V_{SAT}) and approximately -0.5V
4	FEEDBACK	Senses the regulated output voltage to complete the feedback loop
5	$\overline{ON}/OFF$	Allows the switching regulator circuit to be shut down using logic level signals

Absolute Maximum Ratings

Parameter Name	Symbol	Value	Unit
Maximum Supply Voltage	V_{IN}	45	V
$\overline{ON}/OFF$ Pin Input Voltage	$\overline{ON}/OFF$	-0.3V≤V≤+V_{IN}	V
Output Voltage to Ground (steady state)	V_{OUT}	-1	V
Power Dissipation	P_{DMAX}	Internally Limited	
Storage Temperature Range	Tstg	-65~+150	℃
Maximum Junction Temperature	T_{JA}	150	℃
ESD Susceptibility (Human Body Model)	ESD	2	kV

Recommended Operating Conditions

Parameter Name	Symbol	Value	Unit
Supply Voltage	V_{IN}	8~40	V
Operating temperature range	Topr	-40~+125	℃

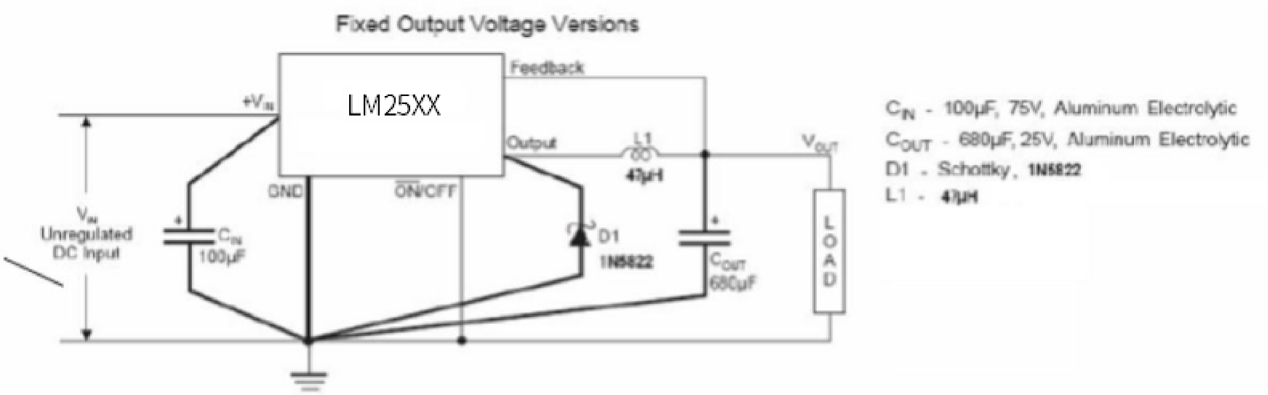
Electrical Characteristics (Unless otherwise specified: T_J = 25°C)

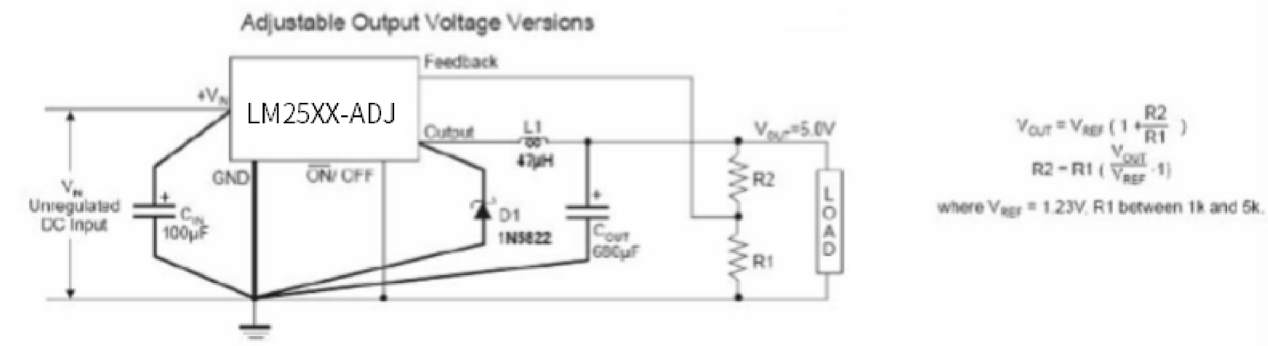
Parameter Name	Symbol	Test Conditions	Min	Typ	Max	Units
Device Parameters						
Feedback Bias Current	Ib	Adjustable version only, V_{OUT}=5V		50	100	nA
Oscillator Frequency	fo		127	150	173	kHz
VSAT Saturation Voltage	V_{SAT}	I_{OUT}=3A		1.4	1.8	V
Max. Duty Cycle(ON)	DC		93	98		%
Current Limit	I_{CL}		4.2	5.8	6.9	A
Output Leakage Current	I_L	Output=0V			2	mA
		Output=-1V		7.5	30	mA
Quiescent Current	I_Q			5	10	mA
Standby Quiescent Current	I_{STBY}	$\overline{ON}$/ OFF pin=5V(OFF)		50	200	µA
$\overline{ON}$/ OFF Control						
$\overline{ON}$/ OFF Pin Logic Input Level	V_{IH}	V_{OUT}=0V	2.0			V
	V_{IL}	V_{OUT}=nominal output voltage			0.8	V
$\overline{ON}$/ OFF Pin Input Current	I_{IH}	$\overline{ON}$/ OFF pin=5V(OFF)		12	30	µA
	I_{IL}	$\overline{ON}$/ OFF pin=0V(ON)		0	10	µA

Parameter Name	Symbol	Test Conditions	Min	Typ	Max	Units
LM25XX 3.3V						
Output Voltage	V_{OUT}	V_{IN}=12V, I_O=500mA	3.234	3.3	3.366	V
		8V≤V_{IN}≤40V 0.5A≤I_{LOAD}≤3A	3.168	3.3	3.450	V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A		75		%
LM25XX 5.0V						
Output Voltage	V_{OUT}	V_{IN}=12V, I_O=500mA	4.900	5.000	5.100	V
		8V≤V_{IN}≤40V 0.5A≤I_{LOAD}≤3A	4.800	5.000	5.200	V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A		77		%
LM25XX 12V						
Output Voltage	V_{OUT}	V_{IN}=18V, I_O=500mA	11.760	12.000	12.240	V
		15V≤V_{IN}≤40V 0.5A≤I_{LOAD}≤3A	11.520	12.000	12.480	V
Efficiency	η	V_{IN}=18V, I_{LOAD}=3A		88		%

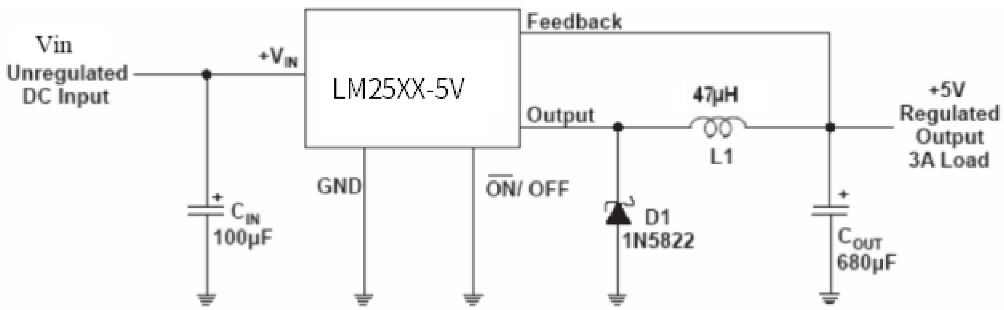
Parameter Name	Symbol	Test Conditions	Min	Typ	Max	Units
LM25XX ADJ						
Output Voltage	V_{OUT}	V_{IN}=12V,I_O=500mA, V_{OUT}=5V	1.217	1.230	1.243	V
		8V≤V_{IN}≤40V 0.5A≤I_{LOAD}≤3A	1.193	1.230	1.267	V
Efficiency	η	V_{IN}=12V,I_{LOAD}=3A		77		%

Test Circuit





Typical Application



Application Information

Input Capacitor (C_{IN})

To maintain stability, the regulator input pin must be bypassed with at least a 100 µF electrolytic capacitor. The capacitor's leads must be kept short, and located near the regulator. If the operating temperature range includes temperatures below -25°C, the input capacitor value may need to be larger. With most electrolytic capacitors, the capacitance value 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. For maximum capacitor operating lifetime, the capacitor's RMS ripple current rating should be greater than

$$1.2 \times \left(\frac{t_{ON}}{T}\right) \times I_{LOAD}$$

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

and $\frac{t_{ON}}{T} = \frac{|V_{OUT}|}{|V_{OUT}| + V_{IN}}$ for a buck-boost regulator.

Inductor Selection

All switching regulators have two basic modes of operation: continuous and discontinuous. The difference between the two types relates to the inductor current, whether it is flowing continuously, or if it drops to zero for a period of time in the normal switching cycle. Each mode has distinctively different operating characteristics, which can affect the regulator performance and requirements.

The LM25XX can be used for both continuous and discontinuous modes of operation.

When using inductor values shown in the inductor selection guide, the peak-to-peak inductor ripple current will be approximately 20% to 30% of the maximum DC current. 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). This discontinuous mode of operation is perfectly acceptable. 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. The selection guide chooses inductor values suitable for continuous mode operation, but if the inductor value chosen is prohibitively high, the designer should investigate the possibility of discontinuous operation.

Inductors are available in different styles such as pot core, toriod, 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, 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 voltages in the scope probe.

The inductors listed in the selection chart include ferrite pot core construction for AIE, powdered iron toroid for Pulse Engineering, and ferrite bobbin core for Renco.

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 kept in mind when selecting an inductor.

The inductor manufacturer's data sheets include current and energy limits to avoid inductor saturation.

Inductor Ripple Current

When the switcher is operating in the continuous mode, the inductor current waveform ranges from a triangular to a sawtooth type of waveform (depending on the input voltage).For a given input voltage and output voltage, the peak-to-peak amplitude of this inductor current waveform remains constant. As the load current rises or falls, the entire sawtooth current waveform also rises or falls. The average DC value of this waveform is equal to the DC load current (in the buck regulator configuration). If the load current drops to a low enough level, the bottom of the sawtooth current waveform will reach zero, and the switcher will change to a discontinuous mode of operation. This is a perfectly acceptable mode of operation. Any buck switching regulator (no matter how large the inductor value is) will be forced to run discontinuous if the load current is light enough.

Catch Diode

Buck regulators require a diode to provide a return path for the inductor current when the switch is off. This diode should be located close to the LM25XX using short leads and short printed circuit traces. Because of their fast switching speed and low forward voltage drop, Schottky diodes provide the best efficiency, especially in low output voltage switching regulators (less than 5V). 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 a better choice. Standard 60 Hz diodes (e.g., 1N4001 or1N5400, etc.) are also not suitable.

Output Capacitor

An output capacitor is required to filter the output voltage and is needed for loop stability. The capacitor should be located near the LM25XX using short pc board traces. Standard aluminum electrolytics are usually adequate, but low ESR types are recommended for low output ripple voltage and good stability. The ESR of a capacitor depends on many factors, some which are: the value, the voltage rating, physical size and the type of construction. In general, low value or low voltage (less than 12V) electrolytic capacitors usually have higher ESR numbers.

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}). See the section on inductor ripple current in Application Hints. The lower capacitor values (220µF~1000µF) will allow typically 50mV to 150mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately20 mV to 50mV.Output Ripple Voltage=(ΔI_{IND}) (ESR of C_{OUT}). To further reduce the output ripple voltage, several standard electrolytic capacitors may be paralleled, or a higher-grade capacitor may be used. Such capacitors are often called "high-frequency" "low-inductance" or "low-ESR" These will reduce the output ripple to 10mV or 20mV.

However, when operating in the continuous mode, reducing the ESR below 0.03Ω can cause instability in the regulator. Tantalum capacitors can have a very low ESR, and should be carefully evaluated if it is the only output capacitor. Because of their good low temperature characteristics, a tantalum can be used in parallel with aluminum electrolytics, with the tantalum making up 10% or 20% of the total capacitance. The capacitor's ripple current rating at 150kHz should be at least 50% higher than the peak-to-peak inductor ripple current.

Output Voltage Ripple and Transients

The output voltage of a switching power supply will contain a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and may also contain short voltage spikes at the peaks of the sawtooth waveform. The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor. The voltage spikes are present because of the fast switching action of the output switch, and the parasitic inductance of the output filter capacitor. To minimize these voltage spikes, special low inductance capacitors can be used, and their lead lengths must be kept short. Wiring inductance, stray capacitance, as well as the scope probe used to evaluate these transients, all contribute to the amplitude of these spikes. An additional small LC filter (20µH & 100µF) can be added to the output to further reduce the amount of output ripple and transients. A 10 x reduction in output ripple voltage and transients is possible with this filter.

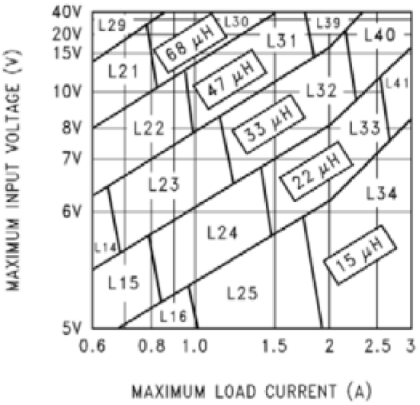
Feedback Connection

The LM25XX (fixed voltage versions) feedback pin must be wired to the output voltage point of the switching power supply. When using the adjustable version, physically locate both output voltage programming resistors near the LM25XX to avoid picking up unwanted noise. Avoid using resistors greater than 100k Ω because of the increased chance of noise pickup.

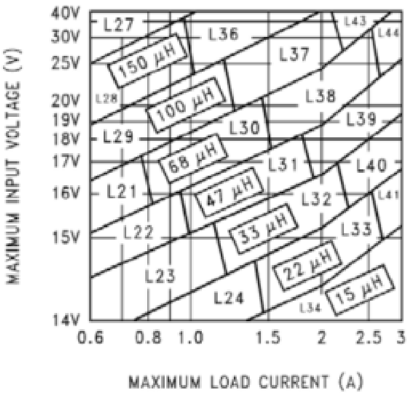
$\overline{\text{ON}}$ / OFF Input

For normal operation, the $\overline{\text{ON}}$ / OFF pin should be grounded or driven with a low-level TTL voltage (typically below 1.6V). To put the regulator into standby mode, drive this pin with a high-level TTL or CMOS signal. The $\overline{\text{ON}}$ / OFF pin can be safely pulled up to +VIN without a resistor in series with it. The ON / $\overline{\text{OFF}}$ pin should not be left open.

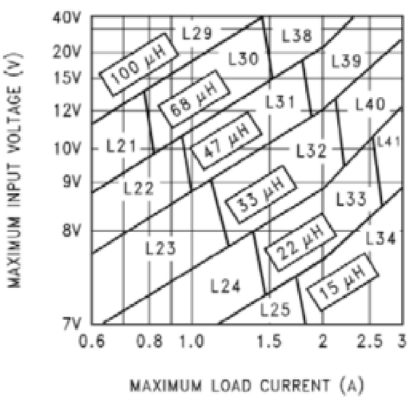
Inductor Value Selection Guides (For Continuous Mode Operation)



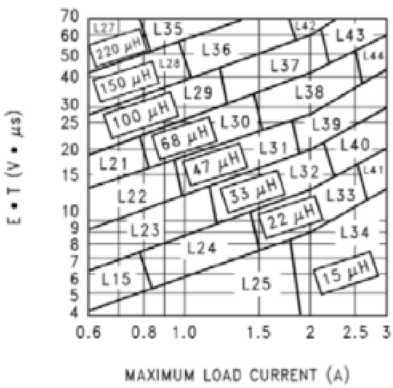
LM25XX-3.3



LM25XX-12



LM25XX-5.0



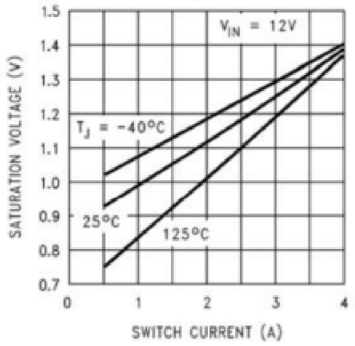
LM25XX-ADJ

	Inductance (pH)	Current (A)	Schott		Renco		Pulse Engineering		Coilcraft
			Through Hole	Surface Mount	Through Hole	Surface Mount	Through Hole	Surface Mount	Surface Mount
L15	22	0.99	67148350	67148460	RL-1284-22-43	RL1500-22	PE-53815	PE-53815-S	DO3308-223
L21	68	0.99	67144070	67144450	RL-5471-5	RL1500-68	PE-53821	PE-53821-S	DO3316-683
L22	47	1.17	67144080	67144460	RL-5471-6	—	PE-53822	PE-53822-S	DO3316-473
L23	33	1.40	67144090	67144470	RL-5471-7	—	PE-53823	PE-53823-S	DO3316-333
L24	22	1.70	67148370	67148480	RL-1283-22-43	—	PE-53824	PE-53825-S	DO3316-223
L25	15	2.10	67148380	67148490	RL-1283-15-43	—	PE-53825	PE-53824-S	DO3316-153
L26	330	0.80	67144100	67144480	RL-5471-1	—	PE-53826	PE-53826-S	DO5022P-334
L27	220	1.00	67144110	67144490	RL-5471-2	—	PE-53827	PE-53827-S	DO5022P-224
L28	150	1.20	67144120	67144500	RL-5471-3	—	PE-53828	PE-53828-S	DO5022P-154
L29	100	1.47	67144130	67144510	RL-5471-4	—	PE-53829	PE-53829-S	DO5022P-104
L30	68	1.78	67144140	67144520	RL-5471-5	—	PE-53830	PE-53830-S	DO5022P-683
L31	47	2.20	67144150	67144530	RL-5471-6	—	PE-53831	PE-53831-S	DO5022P-473
L32	33	2.50	67144160	67144540	RL-5471-7	—	PE-53932	PE-53932-S	DO5022P-333
L33	22	3.10	67148390	67148500	RL-1283-22-43	—	PE-53933	PE-53933-S	DO5022P-223
L34	15	3.40	67148400	67148790	RL-1283-15-43	—	PE-53934	PE-53934-S	DO5022P-153
L35	220	1.70	67144170	—	RL-5473-1	—	PE-53935	PE-53935-S	—
L36	150	2.10	67144180	—	RL-5473-4	—	PE-54036	PE-54036-S	—
L37	100	2.50	67144190	—	RL-5472-1	—	PE-54037	PE-54037-S	—
L38	68	3.10	67144200	—	RL-5472-2	—	PE-54038	PE-54038-S	—
L39	47	3.50	67144210	—	RL-5472-3	—	PE-54039	PE-54039-S	—
L40	33	3.50	67144220	67148290	RL-5472-4	—	PE-54040	PE-54040-S	—
L41	22	3.50	67144230	67148300	RL-5472-5	—	PE-54041	PE-54041-S	—
L42	150	2.70	67148410	—	RL-5473-4	—	PE-54042	PE-54042-S	—
L43	100	3.40	67144240	—	RL-5473-2	—	PE-54043		—
L44	68	3.40	67144250	—	RL-5473-3	—	PE-54044		—

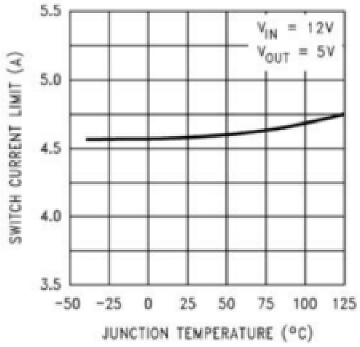
V_R	Schottky		Fast Recovery	
	3A	4A-6A	3A	4A-6A
20V	1N5820、MBR320P、SR302	1N5823	The following diodes are all rated to 100V 31DF1、HER302	The following diodes are all rated to 100V 50WF10、MUR410、HER602
30V	1N5821、MBR330、31DQ03、SR303	50WQ03、1N5824		
40V	1N5822、MBR340、31DQ04、SR304	MBR340、50WQ04、1N5825		
50V	MBR350、31DQ05、SR305	50WQ05		
60V	MBR360、DQ06、SR306	50WR06、50SQ060		

Characteristic Curves

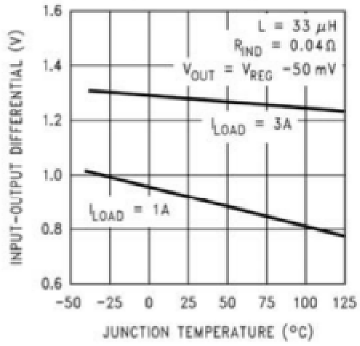
Switch Saturation Voltage



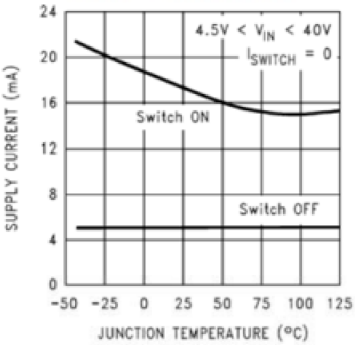
Switch Current Limit



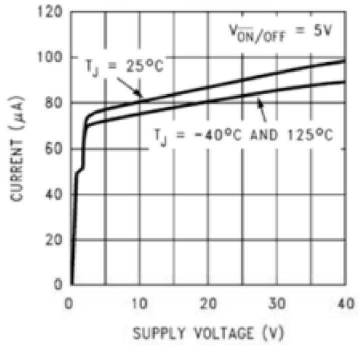
Dropout Voltage



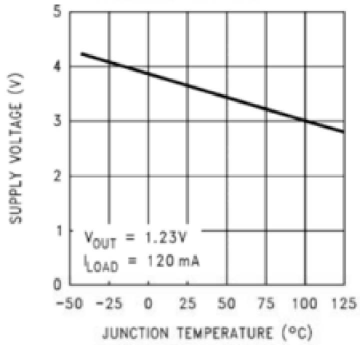
Operating Quiescent Current



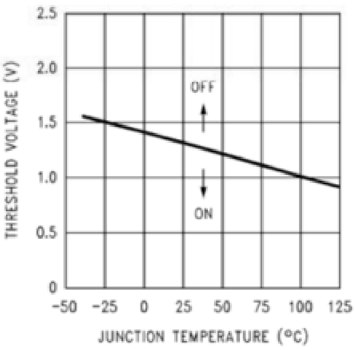
Shutdown Quiescent Current



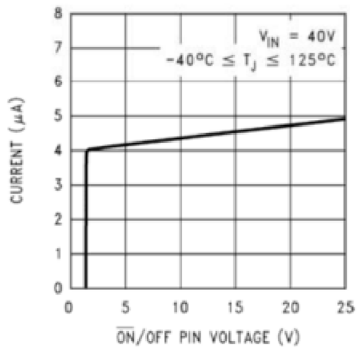
Minimum Operating Supply Voltage



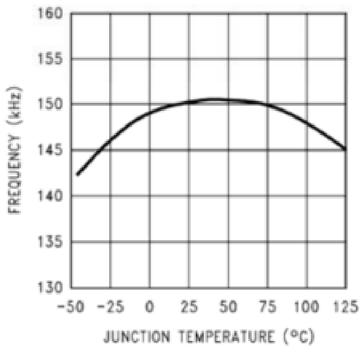
$\overline{ON}$ /OFF Threshold Voltage



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

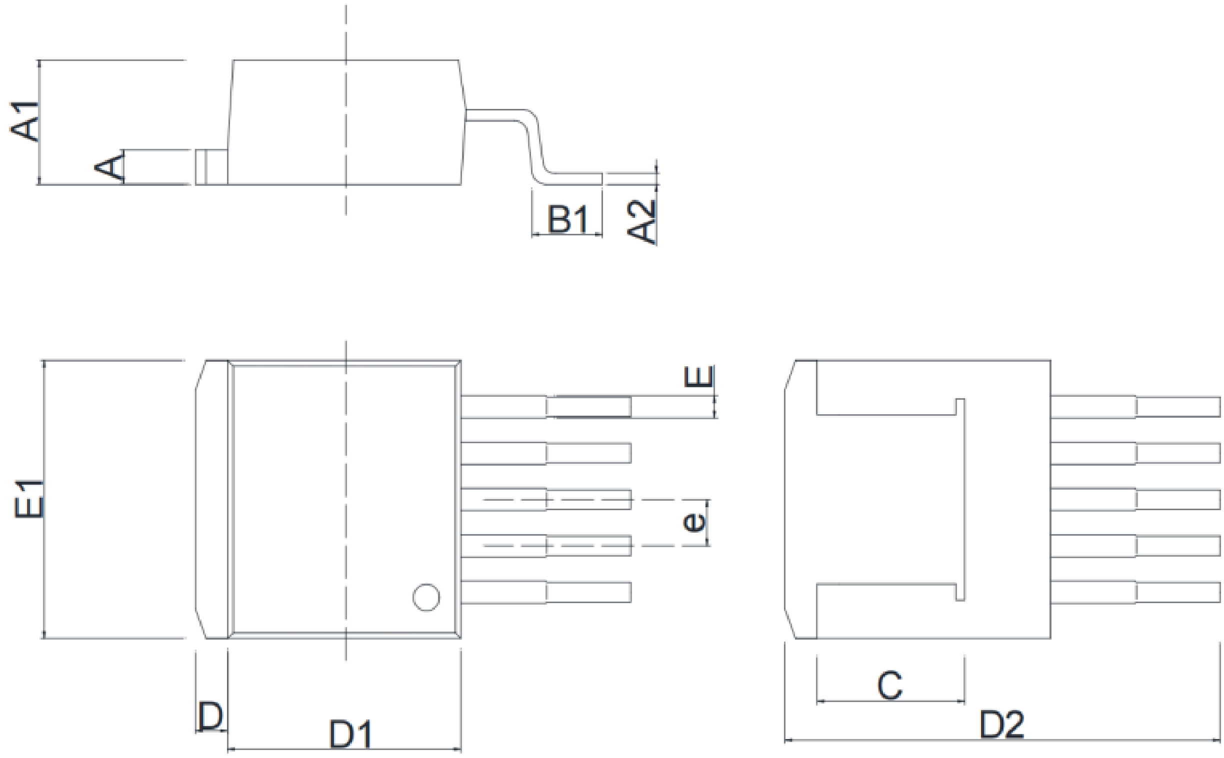


Switching Frequency



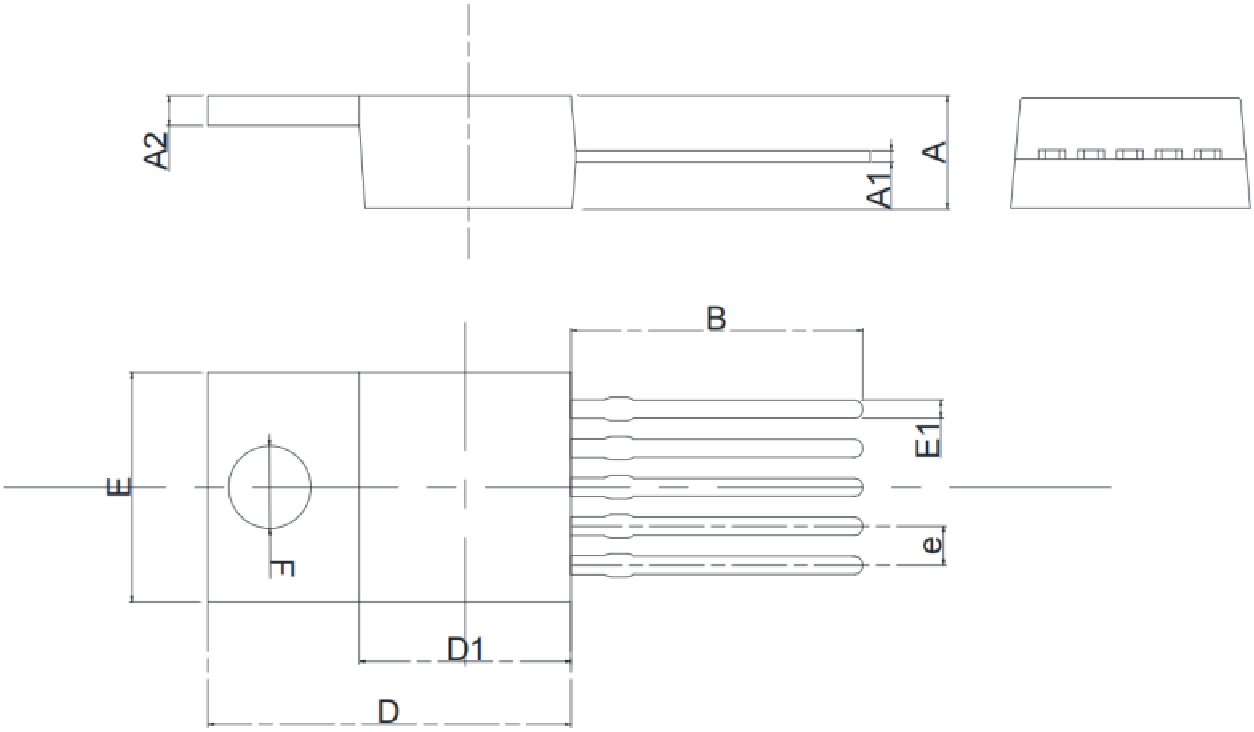
Outline Dimensions

TO-263-5 **Unit : mm**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.170	1.370	0.046	0.054
A1	4.470	4.670	0.176	0.184
A2	0.310	0.530	0.012	0.021
B1	2.340	2.740	0.092	0.108
C	5.080 REF		0.200 REF	
D	1.170	1.370	0.046	0.054
D1	8.500	8.900	0.335	0.350
D1	14.550	15.550	0.572	0.612
E	0.660	0.860	0.025	0.034
E1	10.010	10.310	0.394	0.406
e	1.700 (BSC)		0.067 (BSC)	

TO-220-5 Unit : mm



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.300	4.700	0.169	0.185
A1	0.450	0.600	0.017	0.023
A2	1.250	1.400	0.049	0.055
B	12.880	13.380	0.507	0.527
D	15.500	15.900	0.610	0.626
D1	9.000	9.400	0.354	0.370
E	9.700	10.100	0.381	0.398
E1	0.660	0.914	0.025	0.036
e	1.702 (BSC)		0.670 (BSC)	
F	Φ3.500	Φ3.700	Φ0.137	Φ0.146

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