

1. Features

- 3A Continuous Output Current
- Wide 4.5V to 30V Operating Input Range
- Integrated Power MOSFET Switches
- Output Adjustable from 0.9V to 0.9*Vin
- Up to 95% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 300KHz Switching Frequency
- Cycle-by-Cycle Current Limiting
- Input Under-Voltage Lockout
- Input Over-Voltage Protection
- Output Over-Voltage Protection
- Over-Temperature Protection
- Thermally Enhanced ESOP-8 Package

2. Applications

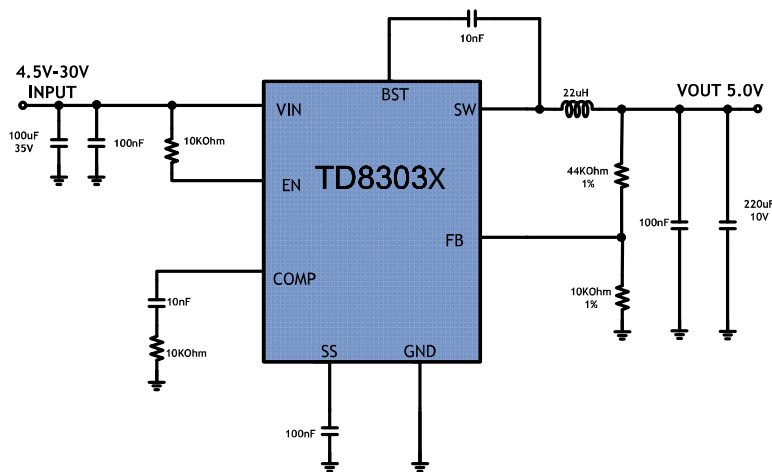
- Car charger
- Automotive Applications
- LCD TV and Displays
- STB (Set-Top-Box)
- Desktop and Laptop Computers
- Networking Systems

3. Description

The TD8303X is a monolithic synchronous buck regulator. The device integrates low Rds(on) MOSFETS that provide 3A of continuous load current over a wide operating input voltage of 4.5V to 30V. Current Mode Control provides fast transient responses and cycle-by-cycle current limiting. An adjustable soft-start prevents inrush current at turn-on, and the supply current drops below 3μA in shutdown mode. It integrates Input Under-Voltage Protection, Over-Voltage Protection, Output Over-Voltage Protection and a 160C Thermal Protection Threshold with 15C hysteresis.

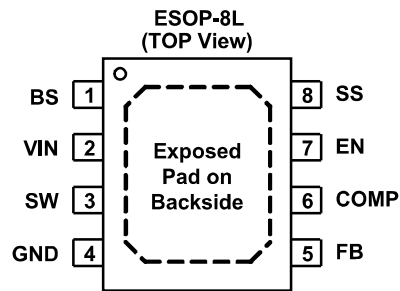
This device, available in ESOP-8 package, provides a very compact system solution with a minimal number of external components

4. Typical Application Schematic



4.5V-30V Input Voltage, 5V Output Voltage Step-Down Converter

5. Pin Configuration and Functions



Pin-Functions

Pin #	Name	Description
1	BST	High-Side Gate Drive Boost Input. BST supplies the drive for the high-side N-Channel MOSFET switch. Connect a 0.01 μ F or greater capacitor from SW to BST to power the high side switch.
2	VIN	Power Input. VIN supplies the power to the IC, as well as the Buck converter. Supply VIN with a 4.5V to 30V power source. Bypass VIN to GND with a large capacitor and at least another 0.1 μ F ceramic capacitor to eliminate noise on the input to the IC.
3	SW	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BST to power the high-side switch.
4	GND	Ground
5	FB	Feedback Input. FB senses the output voltage. Connect FB with a resistor divider connected from the output and ground. FB is a sensitive node. Keep FB away from SW, VIN and BST pin.
6	COMP	Current sense for line compensation and current limitation
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator; low to turn it off. Attach to VIN with a 100k Ω pull up resistor for automatic soft-startup.
8	SS	Soft-start adjustment. Connect a cap to program soft-start time. The default soft-start time will be 1ms if this pin is floating.

Ordering Information

TD8303X-X X X

Output Voltage :
Blank : ADJ

Package :
F : ESOP-8L

Packing :
A : Tape & Reel

Device	Package Code	Package	Tape & Reel	
			Quantity	Part Number Suffix
TD8303X-FA	F	ESOP-8L	2500	A

6. Specifications

6.1 Absolute Maximum Ratings^(Note2)

Symbol	Description	Rating	Unit
V _{IN}	Supply Voltage	-0.3 to +36	V
V _{SW}	Switch Voltage	-1 to V _{IN} + 0.3	V
V _{BST}	Boost Voltage	V _{sw} - 0.3 to V _{sw} + 6	V
	All Other Pins	-0.3 to +6	V
T _{ST}	Storage Temperature	-65 to +150	°C
T _J	Junction Temperature	+150	°C
T _L	Lead Temperature	+260	°C
ESD	HBM	2	kV
	CDM	500	V

6.2 Operating Ratings^(Note 3)

Symbol	Description	Rating	Unit
V _{IN}	Supply Voltage	4.5 to 30	V
T _A	Operating Ambient Temperature Range	-40 to +85	°C
V _{OUT}	Output Voltage	0.8 to 20	V

6.3 Thermal Resistance ^(Note 4)

Symbol	Description	ESOP-8	Unit
θ _{JA}	Junction to Ambient	90	°C/W
θ _{JC}	Junction to Case	45	°C/W

Notes:

- 2) Exceeding these ratings may damage the device.
- 3) The device function is not guaranteed outside of the recommended operating conditions.
- 4) Measured on approximately 1" square of 1 oz copper.

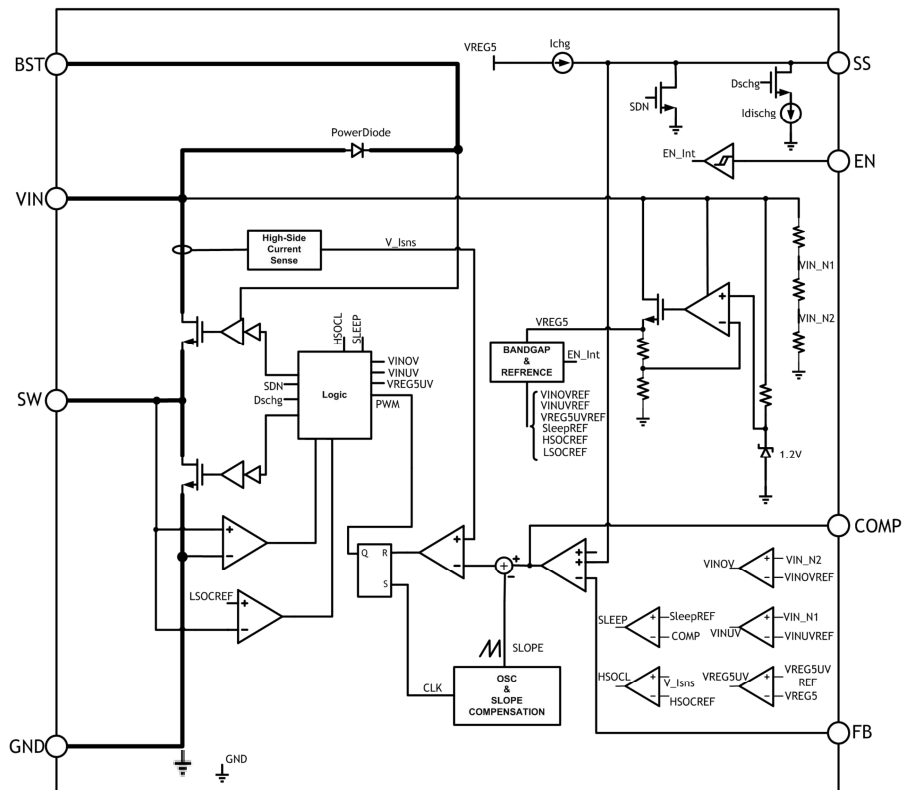
6.4 Electrical Characteristics(At $V_{in}=5$ to $12V$ and $T_j=-40$ to $125C$, Typical at $12V$, $T_j=25C$)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_{q_sdn}	Shutdown Supply Current	$V_{EN} = 0V$		2.6	10	μA
I_q	Quiescent Supply Current	$V_{EN} = 2.0V$, $V_{FB} = 1.0V$		1.0		mA
V_{fb}	Feedback Voltage	$4.5V \leq V_{IN} \leq 30V$		0.9		V
V_{ovp}	Feedback Over-voltage Threshold			0.99		V
R_{dson_hs}	High-Side Switch On-Resistance (5)			88		m Ω
R_{dson_ls}	Low-Side Switch On-Resistance (5)			68		m Ω
I_{leak_sw}	High-Side Switch Leakage Current	$V_{EN} = 0V$, $V_{LX} = 0V$		0	10	μA
I_{oc_hs}	Upper Switch Current Limit	Minimum Duty Cycle		5.9		A
I_{oc_ls}	Lower Switch Current Limit	From Drain to Source		5.5		A
G_{m_PS}	COMP to Current Sense Transconductance			7		A/V
I_{cmp_src}	Comp Source Current	$V_{FB}=1.0V$		6.9		μA
I_{cmp_snk}	Comp Sink Current	$V_{FB}=0.8V$		3.6		μA
f_{osc}	Oscillation Frequency	Normal operation		300		KHz
D_{max}	Maximum Duty Cycle	$V_{FB} = 1.0V$		93		%
$T_{on,min}$	Minimum On Time (5)			100		ns
V_{IH}	EN High Voltage		1.2			V
V_{IL}	EN Low Voltage				1	V
I_{EN}	EN Input Current			2.6		μA
V_{IN_uvlo}	Input Under Voltage Lockout (UVLO) Threshold	VIN Rising		4.31		V
V_{IN_hys}	UVLO Threshold Hysteresis			0.267		mV
I_{chg_ss}	Soft-Start Charge Current			3.9		μA
$V_{boot,refresh}$	Bootstrap refresh voltage			2.8		V
T_{sd}	Thermal Shutdown (5)			160		$^{\circ}C$
T_{sd_hys}	Thermal Shutdown Hysteresis (5)			15		$^{\circ}C$

Note:

5) Guaranteed by design, not tested in production.

7. Block Diagram



TD8303X Diagram

8. Detailed Description

The TD8303X is a single channel, constant frequency, current mode step-down switching regulator for 30V, 3A application. It regulates 4.5V to 30V down an output voltage as low as 0.8V, and supplies up to 3A of load current.

The TD8303 uses current-mode control to regulate the output voltage. the output voltage is measured at FB through a resistive voltage divider and amplified through the internal error amplifier. The voltage at COMP pin is compared to the high-side switch current measured internally to control the output voltage.

The converter uses internal N-channel MOSFET switches to step-down the input voltage to the regulated output voltage. Since the high-side MOSFET requires a gate voltage greater than the input voltage, a boost capacitor is connected between SW and BST, charged by internal boost regulator during the period when low-side MOSFET is on.

When FB voltage exceeds 0.9V , the over-voltage comparator will generate a signal to shut High-side MOSFET to prevent FB voltage running away.

The TD8303X device has a fixed 300KHZ switching frequency. The device adjusts the soft-start time with the SS pin.

8.1. Peak Current Mode Control

The TD8303 uses a fixed 300kHz frequency, peak current mode control. The output voltage is sensed by an external feedback resistor string on FB pin to an internal error amplifier. The output of error amplifier (COMP) will compare with the sensed signal of current flowing through high side switch by internal PWM comparator. PWM comparator will generate a shut signal to high side driver, which will make high side switch off. The COMP voltage increases and decreases as the output current increases and decreases. The TD8303X has a current limit feature inside to help maintain load current in a safe region.

8.2. Sleep Operation for light load efficiency

The TD8303X has an internal feature to help improve light load efficiency. when COMP voltage is less than 1.25V, The TD8303X will judge and IC will go into sleep mode. Under sleep mode, typically, The peak current of high side switch will be about 400mA. when load current is smaller than this value, IC will switch in a very long period controlled by COMP voltage. With this work mode, The TD8303X will reach a very high efficiency under light load condition.

8.3. Voltage Reference

The voltage reference system produces a precise $\pm 2\%$ voltage reference over temperature supported by the TD8303

8.4. Setting Output Voltage

The output voltage is set with a resistor divider from the output node to the FB pin. The 1% resistance accuracy of this resistor divider is preferred. The output voltage value is set as equation 1 below (R1 is the lower resistor, R2 is the upper resistor) :

$$V_{out} = V_{ref} \times \frac{R_1}{R_1 + R_2} \quad (1)$$

8.5. Setting Enable Threshold

The TD8303X has a internal comparator to judge enable threshold at EN pin. When the EN pin voltage exceeds the threshold voltage, The TD8303 begins to work. When keeping EN low (below threshold), The TD8303X will stop working. The quiescent current of TD8303 is very low to maintain a good shut down operation for system.

The TD8303X has an internal pull up resistor to make sure IC work when EN is float. if an application requires control of EN pin, use open drain or open collector output logic to interface with this EN pin.

When system need a higher VIN UVLO threshold from the TD8303X then the EN pin can be configured as shown in Figure 5 below.

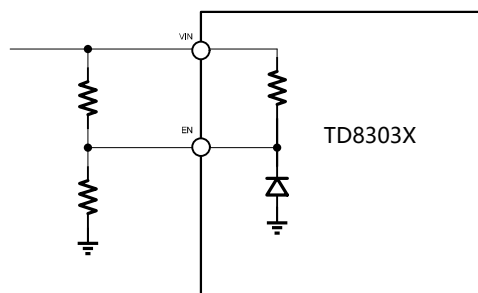


Figure.5 Adjustable VIN Undervoltage Lockout

8.6. Error Amplifier

The TD8303X has a transconductance amplifier as the error amplifier. The error amplifier compares FB voltage with lower one between 0.8-V reference voltage and a Soft-start voltage appear at SS pin. The transconductance of the error amplifier is 1.155 $\mu\text{A/V}$. the frequency compensation components are placed between the COMP pin and ground.

8.7. Slope Compensation

The TD8303X adds a slope compensation ramp to the signal of COMP pin. this slope compensation will make sure IC not go into subharmonic oscillations as duty cycle increases.

8.8. Bootstrap Voltage provided by internal LDO

The TD8303X has an internal LDO to provide energy consumed by high side switch. At BST pin, The TD8303X needs a small ceramic capacitor between BST and SW pin to provide gate-drive voltage for high side switch. The bootstrap capacitor is charged when high side is off. When IC works under CCM mode, the bootstrap capacitor will be charged when low side is on. The bootstrap capacitor will be maintained at about 5.3V. When IC works under sleep mode, what value the bootstrap capacitor is charged depends on the difference of V_{in} and output voltage. However, when the voltage on the bootstrap capacitor is below bootstrap refresh voltage, The TD8303X will force low side on to charge bootstrap capacitor.

8.9. Soft-Start & Hiccup

The TD8303X needs a capacitor at SS pin to support soft-start function. system can adjust soft-start time by setting difference soft-start capacitor at SS pin. Inside TD8303 there is one 4 μA current to charge SS pin when IC starts to work.

The TD8303X also uses SS pin to configure its hiccup rest time. when the output voltage is lower than 0.4V and high side peak current reaches current limit threshold, the TD8303X will stop working and discharge SS capacitor in an internal 1 μA current.

When the voltage at SS pin is lower than 0.1V, IC will starts to work again and charge SS capacitor till SS voltage reaches 1.2V. if still, the output voltage is lower than 0.4V and high side peak current reaches current limit threshold, the TD8303 will stop working and discharge SS capacitor again.

8.10. Output Overvoltage Protection

The TD8303X provides a overvoltage protection by detecting FB pin. when FB voltage is larger than 1V, IC will shut high-side switch till FB is back to normal.

8.11. High Side Over Current Protection

The device implements current mode control which uses the COMP pin voltage to control the turn off of the high side MOSFET and the turn on of the low-side MOSFET on a cycle-by-cycle basis. During each cycle, the voltage of COMP and the voltage generated by high side current are compared. When the voltage generated by high side current reaches COMP voltage, high-side turns off.

8.12. Low Side Over Current Protection

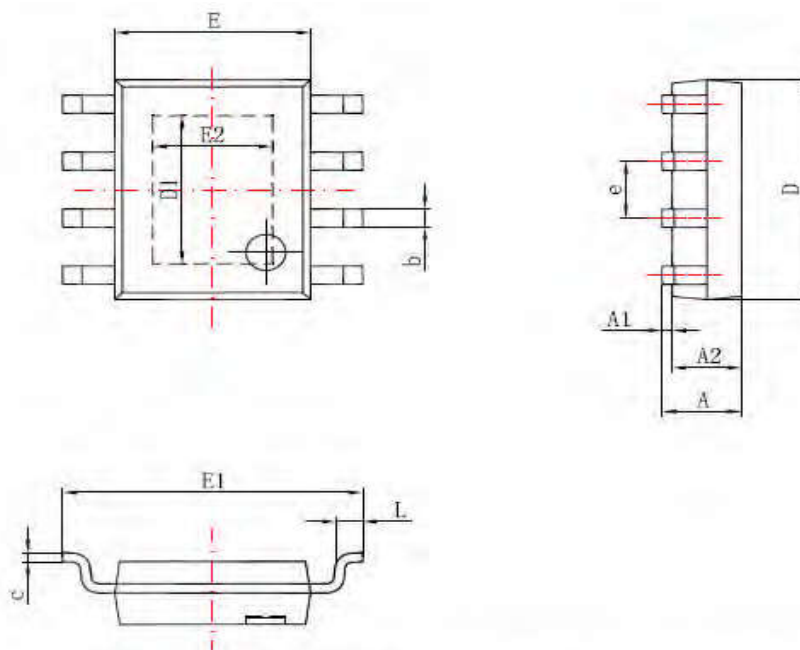
While the low-side MOSFET is turned on, the conduction current is monitored by the internal circuitry. During normal operation the low-side MOSFET sources current to the load. At the end of every clock cycle, the SW voltage is sensed to generate a internal signal to compare with GND voltage. when GND voltage is larger than this internal signal, it means low side current limit reached. As long as inductor current is larger than low side current limit, high side switch won't be turned on.

The TD8303X provides zero current detection too. When the source current of low side switch reaches zero, low side switch will be immediately turned off.

8.13. Thermal Shutdown

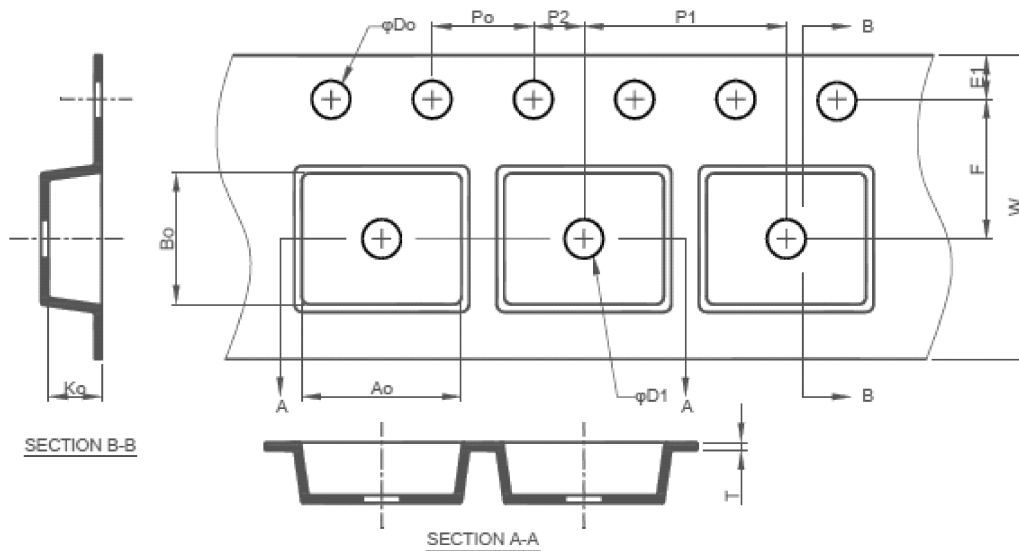
The internal thermal-shutdown circuitry forces the device to stop switching if the junction temperature exceeds 160°C typically. When the junction temperature drops below 155°C typically, IC will starts to work again.

8.14. Package Information ESOP-8



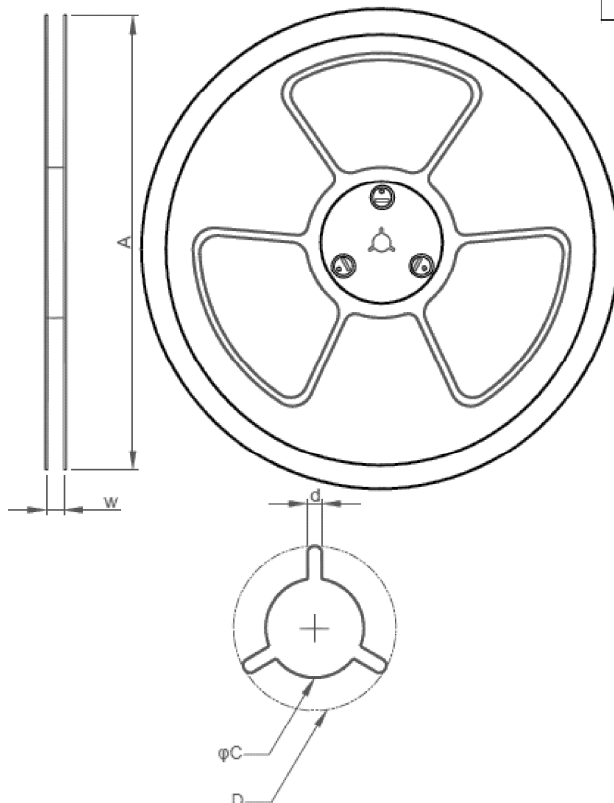
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A		1.700		0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
c	0.170	0.250	0.007	0.010
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
L	0.400	1.270	0.016	0.050
b	0.330	0.510	0.013	0.020
D	4.700	5.100	0.185	0.201
D1	3.202	3.402	0.126	0.134
e	1.270 BASIC		0.050 BASIC	
θ	0°	8°	0°	8°

Tape/Reel



- Note: 1. Refer to EIA-481-B
 2. 10 sprocket hole pitch cumulative tolerance ± 0.2
 3. Material: conductive polystyrene
 4. A_0 and B_0 measured on a plane 0.3mm above the bottom of the pocket
 5. K_0 measured from a plane on the inside bottom of the pocket to the top surface of the carrier

SYMBOL	A0	B0	K0	T	D0	D1
SPEC	6.400 \pm 0.100	5.350 \pm 0.100	2.000 \pm 0.100	0.250 \pm 0.020	1.550 \pm 0.050	1.550 \pm 0.100
SYMBOL	P0	P1	P2	E1	F	W
SPEC	4.000 \pm 0.100	8.000 \pm 0.100	2.000 \pm 0.050	1.750 \pm 0.100	5.500 \pm 0.050	12.000 \pm 0.30



Package Type	A	W	C	d	D
TO-252-3L	330 \pm 2	16.4 $\begin{smallmatrix} +2.0 \\ -0.0 \end{smallmatrix}$	13.0 $\begin{smallmatrix} +0.5 \\ -0.2 \end{smallmatrix}$	1.5 MIN.	20.2 MIN.
SOP-8 SOT-223	330 \pm 2	12.4 $\begin{smallmatrix} +2.0 \\ -0.0 \end{smallmatrix}$	13.0 $\begin{smallmatrix} +0.5 \\ -0.2 \end{smallmatrix}$	1.5 MIN.	20.2 MIN.
SOT-89-3L	178 \pm 2	12.4 $\begin{smallmatrix} +2.0 \\ -0.0 \end{smallmatrix}$	13.0 $\begin{smallmatrix} +0.5 \\ -0.2 \end{smallmatrix}$	1.5 MIN.	20.2 MIN.

Note: Refer to EIA-481-B

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