High Efficiency 1.2MHz Step Up Regulator TD8213

General Description

The TD8213 is the high power and high efficiency boost converter with an integrated 30V FET ideal for LCD panel backlighting applications. 30V output voltage allows for 8 high-power LEDs in series, and 3.5A inductor current limit allows for more LED strings connected in parallel. The low 0.5V feedback voltage offers higher efficiency in WLED driver applications. The wide input range from 2.7V to 21V made TD8213 a perfect solution for various applications such as LCD monitor and portable devices. The OVP pin monitors the output voltage to protect IC during open load and FB pin short circuit operations. The TD8213 provides the ALS pin to simplify the interface to an ambient light sensor for automatic dimming. The TD8213 is available in the thermally enhanced DFN-10 lead 3mmx3mm package.

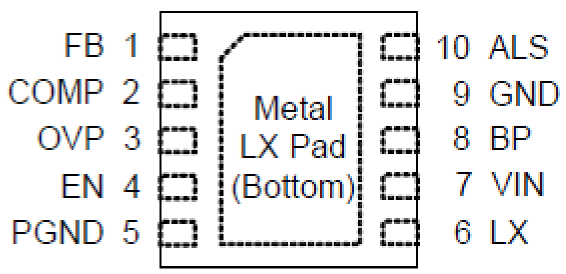
Features

- Wide Input Voltage Range from 2.7V to 21V
- High Current-Limit up to 3.5A
- 0.5V Reference Voltage with ±3% System Accuracy
- 50mΩ Integrated N-FET
- Fixed 1.2MHz Switching Frequency
- High Efficiency up to 95%
- Open-LED Protection
- Under-Voltage Lockout Protection
- ALS Control Input Pin
- Over-Temperature Protection
- Low Shutdown Current: <1mA
- 3mmx3mm DFN-10 Package
- Lead Free and Green Devices Available

Applications

- Display Backlighting
- Automotive
- LCD Monitors
- Notebook Displays
- Portable Displays

Pin Assignments

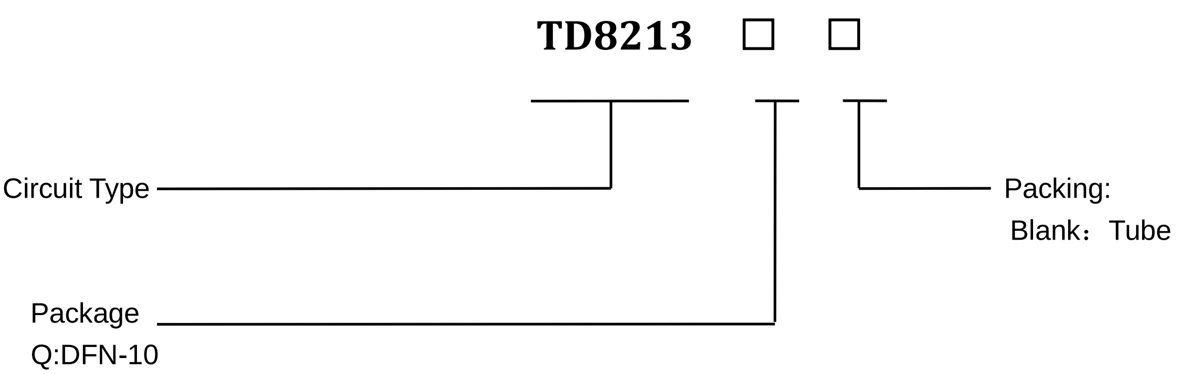


DFN3x3-10
(Top View)

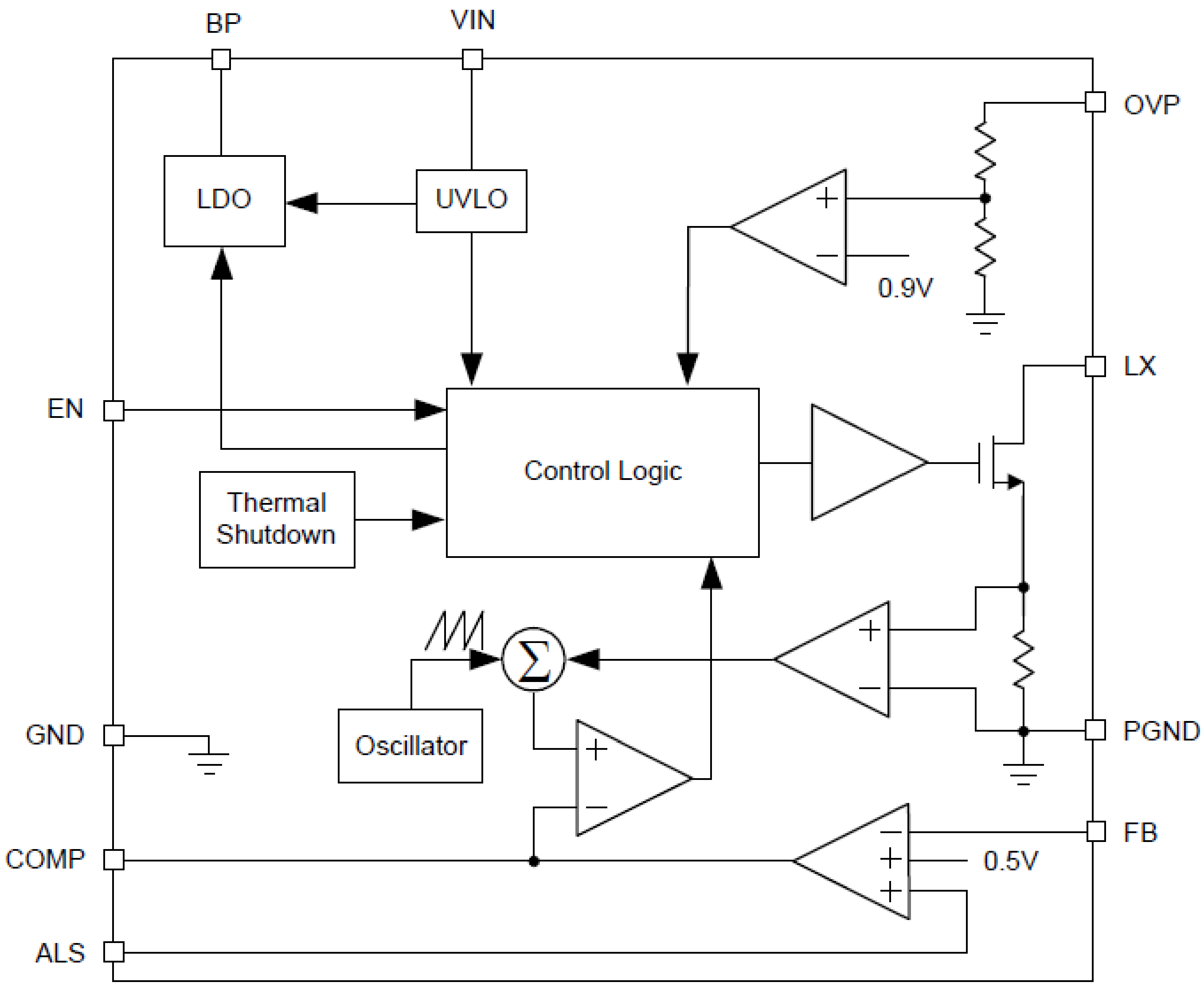
Pin Description

PIN		FUNCTION
NO.	NAME	
1	FB	Regulator Feedback Pin. Connect a current sense resistor to GND to set the LED current.
2	COMP	Error Amplifier Output. Connect a 0.22μF capacitor for compensation and soft-start. When EN is pulled low, an internal switch will discharge the COMP voltage to 0V.
3	OVP	Output Over Voltage Monitor Pin. Tie to VOUT for OVP function.
4	EN	Enable Input Pin. Pull EN above 2.4V to enable the device; pull EN below 0.4V to disable the device. The EN pin cannot be left floating.
5	PGND	Power Ground. Source of the internal N-channel power MOSFET.
6	LX	Internal Power MOSFET Drain.
7	VIN	Supply Voltage Input.
8	BP	Output of The Internal 5V Regulator. Connect a 1μF bypass capacitor to GND. Do not apply an external load to BP.
9	GND	Signal Ground.
10	ALS	Ambient Light Sensor Input. Allow the light sensor to control the FB voltage for LED dimming. If the ALS function is not used, tie the ALS pin to BP pin.

Ordering Information



Functional Block Diagram



Functional Block Diagram of TD8213

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
VIN	VIN pin to GND	-0.3 to 30	V
VLX	LX pin to PGND	-0.3 to 30	V
VOVP	OVP pin to GND	-0.3 to 30	V
VBP	BP pin to GND	-0.3 to 6	V
VEN	EN pin to GND	-0.3 to 30	V
VALS	ALS pin to GND	-0.3 to 6	V
	PGND to GND	-0.3 to 0.3	V
TJ	Maximum Junction Temperature	150	℃
TSTG	Storage Temperature Range	-65 to 150	℃
TL	Maximum Lead Soldering Temperature, 10 Seconds	260	℃

Recommended Operating Conditions

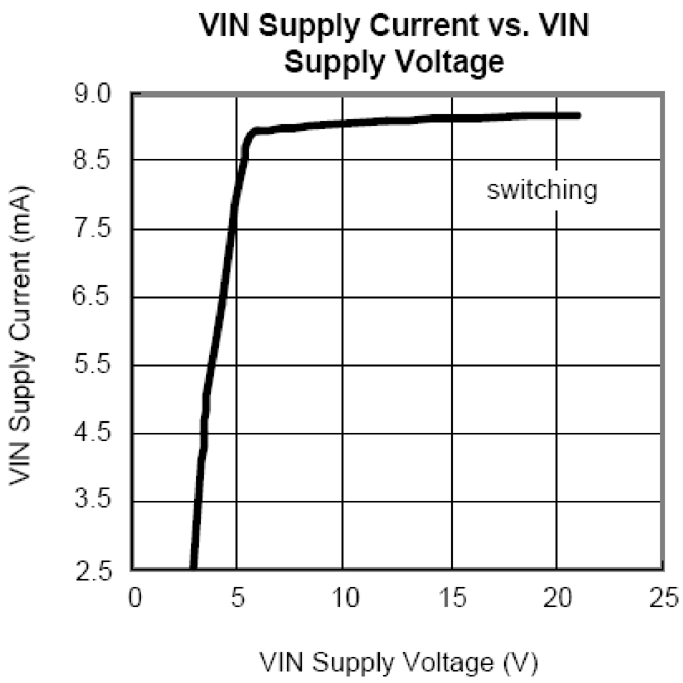
Symbol	Parameter	Typical Value	Unit
VIN	VIN Supply Voltage, (VIN=BP)	2.7 to 5.5	V
	VIN Supply Voltage, (BP is open)	3.7 to 21V	V
VOUT	Output Voltage	up to 30	V
TJ	Operating Ambient Temperature	-40 to 85	℃
TA	Operating Junction Temperature	-40 to 125	℃

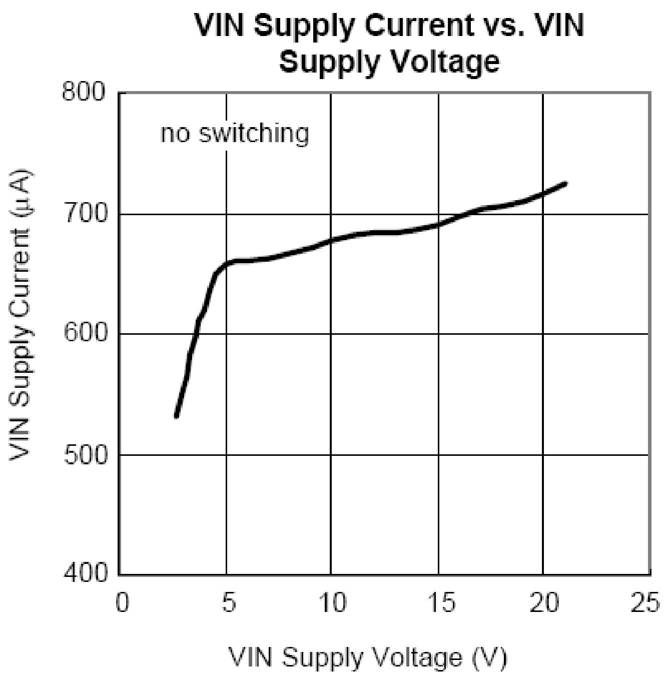
Electrical Characteristics

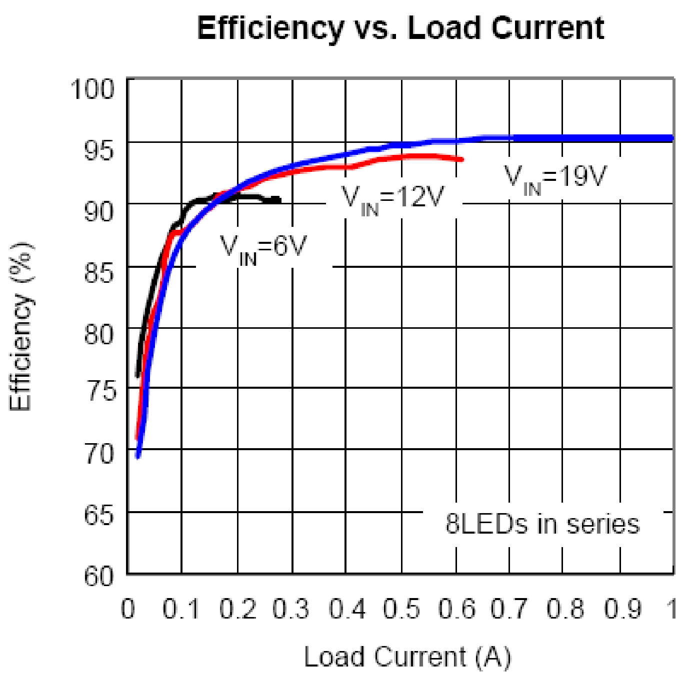
The following specifications apply for V_{IN} =6V T_A=25°C, unless specified otherwise.

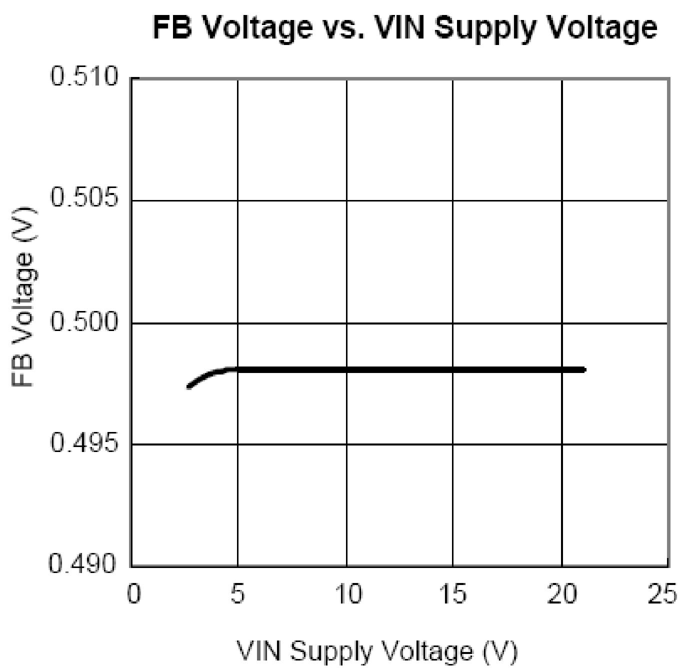
Symbol	Parameter	Test Conditions	TD8213			Unit
			Min.	Typ.	Max.	
INPUT SUPPLY CURRENT AND UVLO						
	BP Under Voltage Lockout Threshold	V_{IN} rising	2.4	2.5	2.6	V
	UVLO Hysteresis		-	100	-	mV
I_{VIN}	VIN Supply Current	EN=5V, switching	-	9	15	mA
		EN=0V	-	-	1	uA
ERROR AMPLIFIER						
gm	Error Amplifier Transconductance		-	350	-	uA/V
I_{COMP}	COMP Output Current	sourcing and sinking, V_{COMP}=1.5V	-	50	-	uA
V_{FB}	FB Voltage		485	500	515	mV
	Minimum FB Voltage	V_{ALS}=0.3V	188	200	212	mV
I_{FB}	FB Input Bias Current		-	-	1	uA
	FB Line Regulation	V_{IN}=2.7V to 21V	-	0.02	0.04	%/V
INTERNAL POWER SWITCH						
	Power Switch Current-Limit		2.5	3.5	4.5	A
$R_{DS(ON)}$	Power Switch On Resistance		-	50	100	mΩ
	LX Leakage Current	V_{LX}=30V	-	-	1	uA
F_{SW}	Switching Frequency		0.9	1.2	1.5	MHz
D_{MAX}	LX Maximum Duty Cycle		92	95	98	%
ALS						
	ALS Ratio	V_{ALS}=1V, V_{ALS}/V_{FB}	2.9	3	3.1	V/V
	ALS Pin Leakage	V_{ALS}=5V	-	-	1	uA
OUTPUT OVER-VOLTAGE PROTECTION						
	Over-Voltage Threshold		30	32	34	V
	OVP Hysteresis		2	3	4	V
	OVP Leakage Current		-	-	30	uA
CONTROL LOGIC PIN						
	EN High-Level Input Voltage		2.4	-	-	V
	EN Low-Level Input Voltage		-	-	0.4	V
	EN Leakage Current	V_{EN}=21V	-	-	1	uA
THERMAL SHUTDOWN						
	Thermal Shutdown Threshold		-	150	-	℃
	Thermal Shutdown Hysteresis		-	50	-	℃

Typical Operating Characteristics









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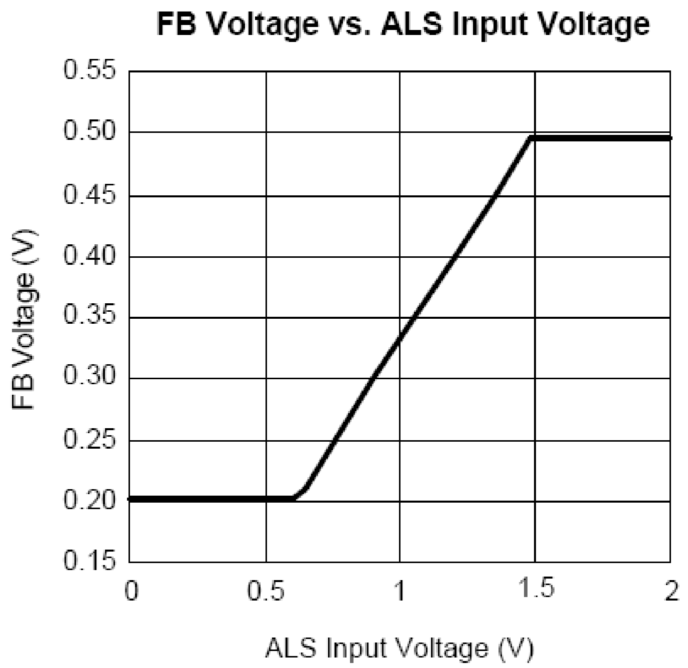
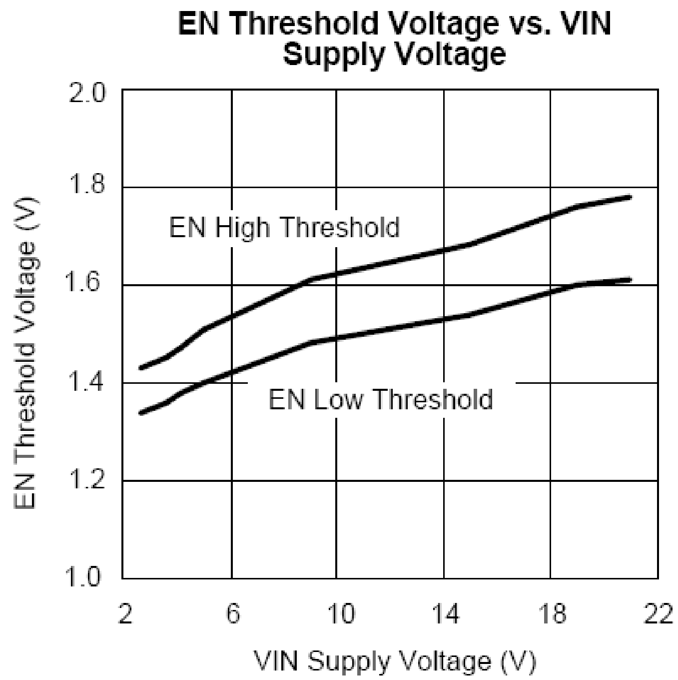
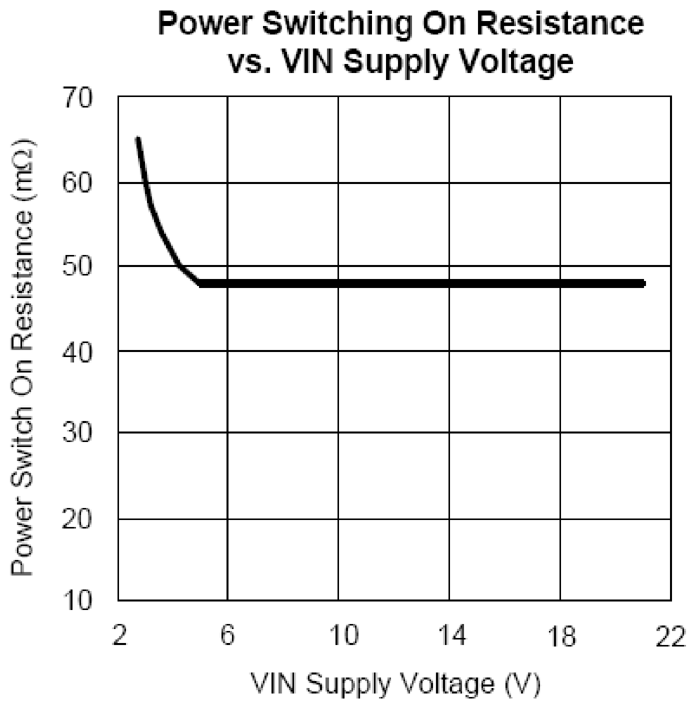
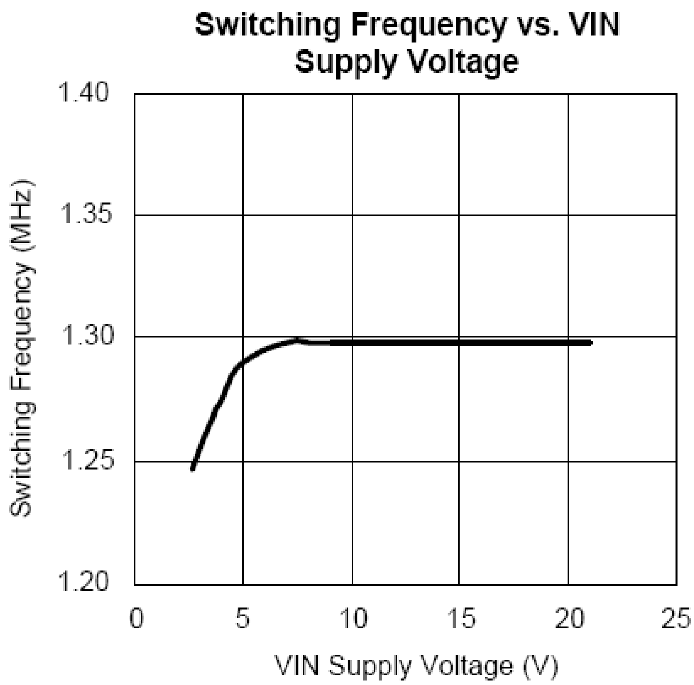
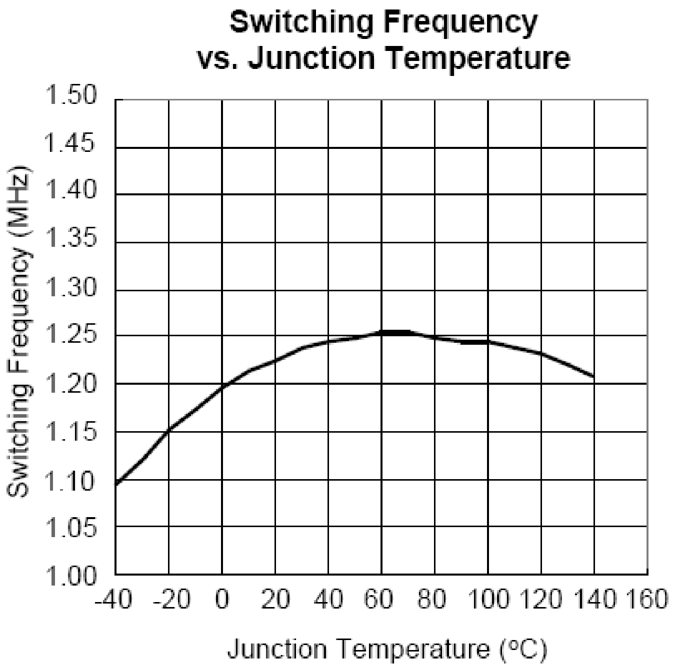


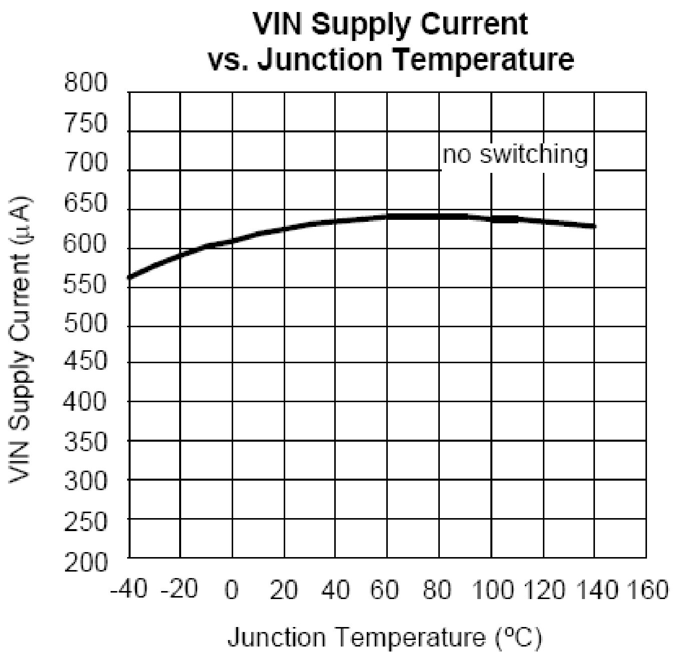


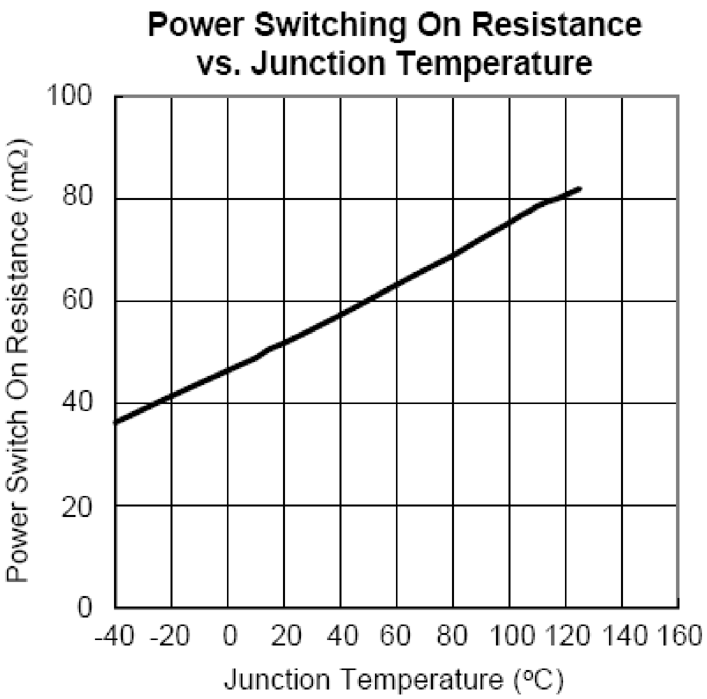


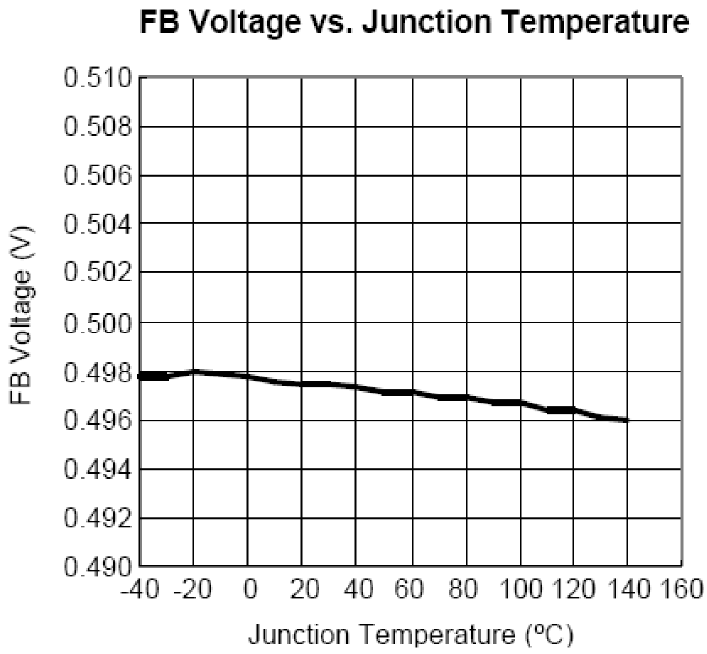


Typical Operating Characteristics(Cont.)



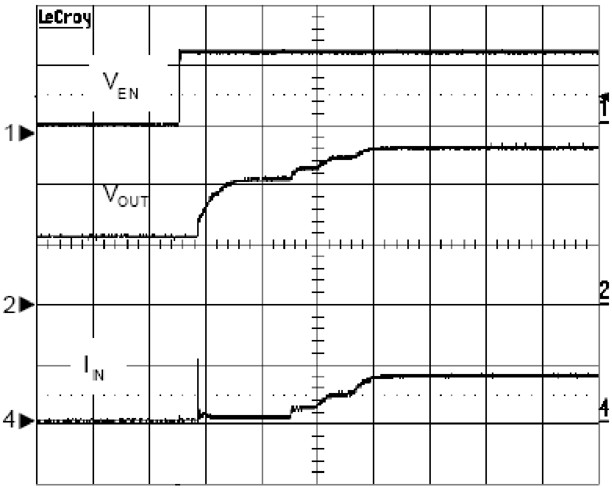






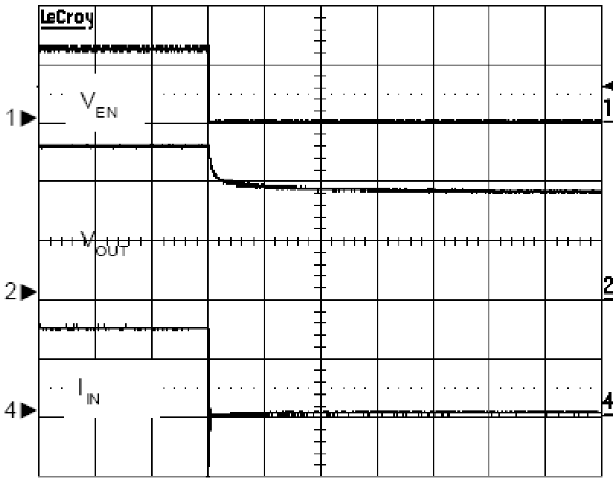
Operating Waveforms

Start-up



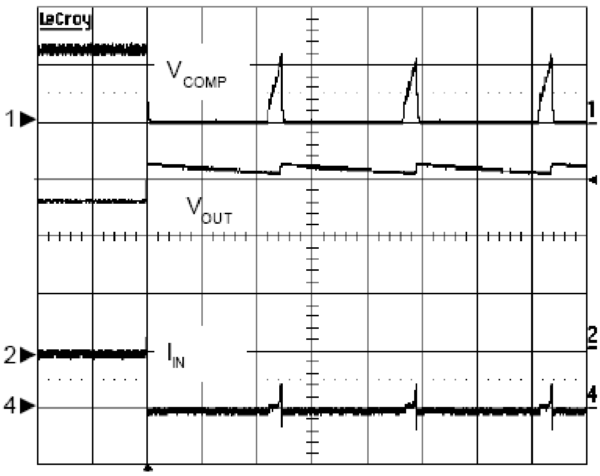
V_{IN}=12V, L=10µH, C_{COMP}=0.22µF
CH1: V_{EN}, 10V/div, DC
CH2: V_{OUT}, 10V/div, DC
CH4: I_{IN}, 500mA/div, DC
TIME: 1ms/div

Shutdown



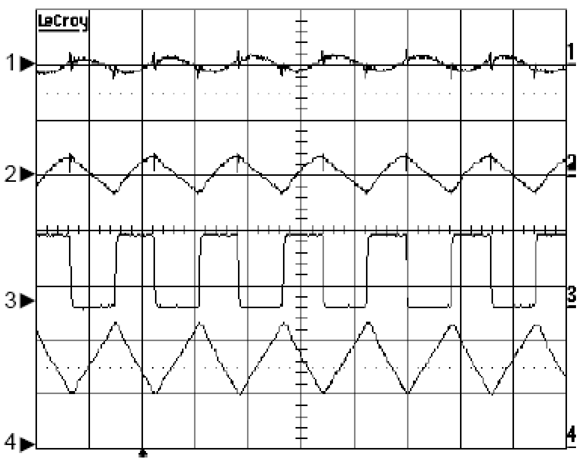
V_{IN}=12V, L=10µH, C_{COMP}=0.22µF
CH1: V_{EN}, 10V/div, DC
CH2: V_{OUT}, 10V/div, DC
CH4: I_{IN}, 500mA/div, DC
TIME: 10ms/div

Over-Voltage Protection



Output is open
CH1: V_{COMP}, 0.5V/div, DC
CH2: V_{OUT}, 10V/div, DC
CH4: I_{IN}, 100mA/div, DC
TIME: 10ms/div

Switching Waveforms



V_{IN}=12V, L=10µH, C_{COMP}=160mA
CH1: V_{IN}, 50mV/div, AC
CH2: V_{OUT}, 200mV/div, AC
CH3: V_{LX}, 20V/div, DC
CH4: I_L, 200mA/div, DC
TIME: 0.5µs/div

Typical Application Circuit

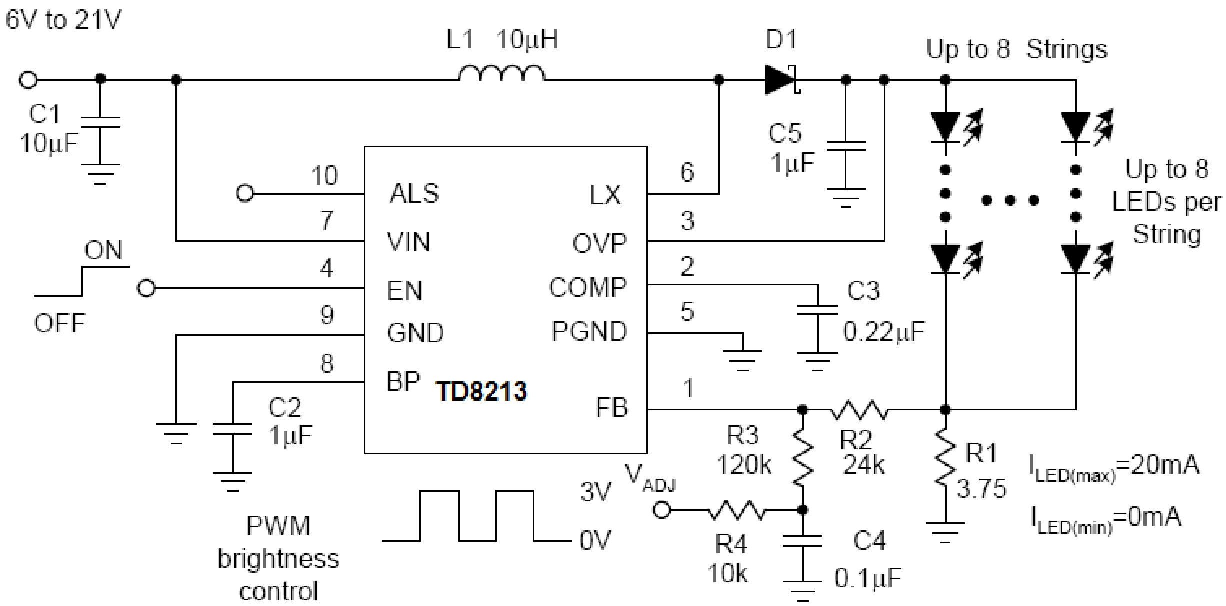


Figure1. Analog Dimming with PWM Voltage

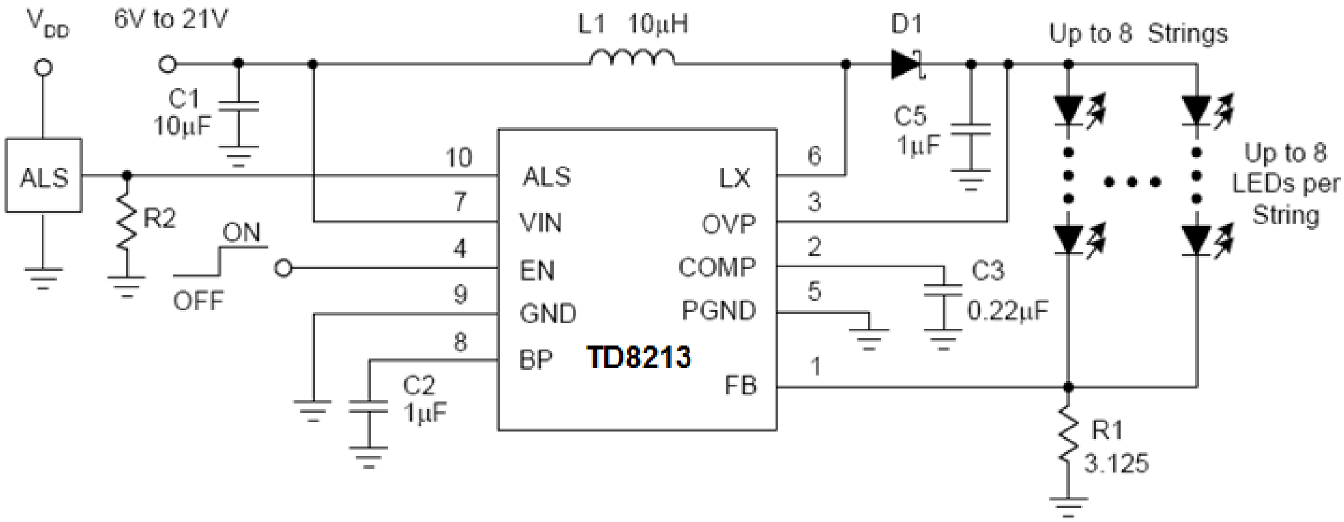


Figure2. Analog Dimming with External ALS Voltage

Typical Application Circuit(Cont.)

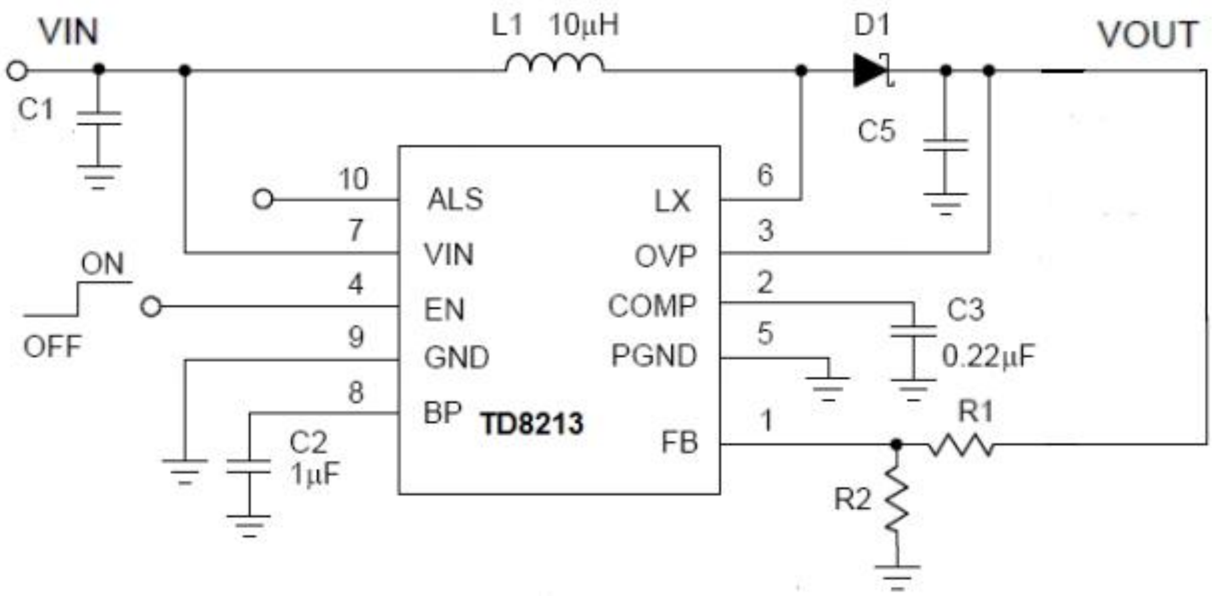


Figure 3 General Boost Converter Application

Designation	Supplier	Part Number	Specification	Wedsite
L1	GOTREND	GTSD53	10uH, 1.33A	www.gotrend.com.tw
C1	Murata	GRM31CR61E106K	X5R, 25V, 10uF	www.murata.com
C2	Murata	GRM155R61A105K	X5R, 10V, 1u F	www.murata.com
C3	Murata	GRM155R60J224KE01	X5R, 6.3V. 0.22uF	www.murata.com
C5	Murata	GRM21BR71H105KA12	X7R, 50V, 1u F	www.murata.com
D1	Zowie	MSCD104	1.0A, 40V	www.zowie.com.tw

Function Description

Output Over-Voltage Protection

If the FB pin is shortened to the ground or an LED fails open circuit, output voltage in BOOST mode can increase to potentially damaging voltages. An optional over-voltage protection circuit can be enabled by connection of the OVP pin to the output voltage. The device will stop switching if the output voltage exceeds OVP high threshold and re-start when the output voltage falls below OVP low threshold. During sustained OVP fault conditions, V_{OUT} will saw-tooth between the upper and lower threshold voltages at a frequency determined by the magnitude of current available to discharge the output capacitor. Note that the OVP pin must be connected to output voltage for OVP function.

Ambient Light Sensor Interface

The TD8213 provides the ALS pin to simplify the interface to an ambient light sensor. The ambient light sensor detects the ambient light and yields a current which is related to the illuminance. Connect a load resistor from the current output of ambient light sensor to ground to provide an output voltage to ALS pin. The ALS voltage will be divided by an internal divider circuit, and the divided ALS voltage will replace the internal reference voltage.The LED current can be calculated by the following equation:

$$I_{LED} = \frac{1}{3} \times \frac{V_{ALS}}{R1}$$

Note that the maximum FB voltage is set to 0.5V, and minimum FB voltage is set to 0.2V. If the divided ALS voltage is over 0.5V or less 0.2V, the LED current is limited at:

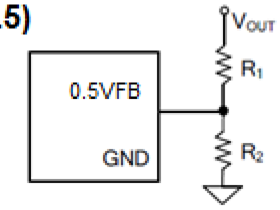
$$I_{LED(MAX)} = \frac{0.5V}{R1} \qquad I_{LED(MIN)} = \frac{0.2V}{R1}$$

where R1 is the resistor from FB to GND.

Feedback resistor dividers R1 and R2:

Choose R1 and R2 to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R1 and R2. A value of between 10k and 1M is recommended for both resistors. If R1=200k is chosen, then R2 can be calculated to be:

$$R2=R1*0.5/(Vout-0.5)$$



Enable/Disable

Pull the EN above 2V to enable the device and pull EN pin below 0.4V to disable the device. In shutdown mode, the internal control circuits are turned off, the quiescent current is below 1μA.

Thermal Shutdown

When the junction temperature exceeds 150°C, the internal thermal sensor circuit will disable the device and allow the device to cool down. When the device's junction temperature cools by 50°C, the internal thermal sense circuit will enable the device, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the IC in the event of over temperature conditions. For normal operation, the junction temperature cannot exceed T_J=+125 °C.

Internal 5V LDO

The TD8213 provides an internal 5V LDO for the control circuitry, and the output of the internal LDO is BP pin. In normal operation, connect a 1μF or greater capacitor to GND is recommended. The internal LDO cannot supply any more current than is required to operate the TD8213. Therefore, do not apply any external load to BP pin. In applications, where the V_{IN} is less than 5.5V, BP should be tied to VIN through a 10Ω resistor.

Application Information

Connecting More LED Strings

The TD8213 can drive 8 LED strings in parallel and up to 8 LEDs per string (V_F<3.5V). Each string must have the same number of LEDs. In the applications that have the same total number of LEDs, more strings and less LEDs in series are more efficiency than less strings and more LEDs in series.

Brightness Control

The method for dimming the LEDs is to apply a PWM voltage through an RC filter into the FB pin.

The RC filter is used to convert the PWM voltage into an analog voltage. The values of the R and C depend upon the frequency of the PWM voltage and the amount of allowable ripple voltage on FB pin. The LED current is proportional to the PWM duty cycle. 0 % duty delivers maximum LED current and 100% duty delivers minimum LED current. The values of R1 and R2 are calculated by the following equations:

$$R2 = \frac{V_{FB} \times (I_{LED(max)} \times R3 + V_{ADJ(low)} - I_{LED(min)} \times R3 - V_{ADJ(high)})}{V_{ADJ(high)} \times I_{LED(max)} + V_{FB} \times I_{LED(min)} - V_{ADJ(low)} \times I_{LED(min)} - V_{FB} \times I_{LED(max)}}$$

$$R1 = \frac{V_{FB} \times (1 + \frac{R2}{R3}) - \frac{R2}{R3} \times V_{ADJ(low)}}{I_{LED(max)}}$$

where:

$I_{LED(max)}$ is the maximum LED current

$I_{LED(min)}$ is the minimum LED current

$V_{ADJ(high)}$ is the maximum PWM voltage level

$V_{ADJ(low)}$ is the minimum PWM voltage level

V_{FB} is the FB pin Voltage

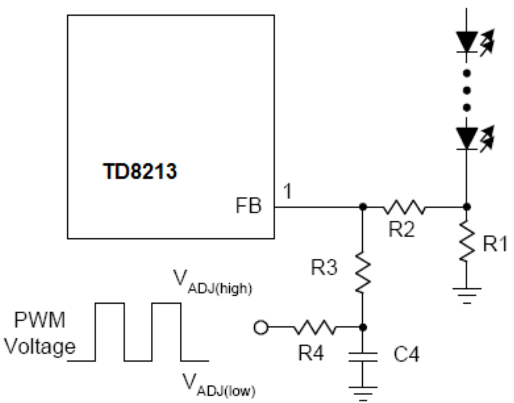


Figure 3. Dimming with the PWM Voltage

Inductor Selection

A larger value of inductor will reduce the peak inductor current, resulting in smaller input ripple current, higher efficiency and reducing stress on the internal MOSFET. However, the larger value of inductor has a large dimension, lower saturation current, and higher series resistance.

A good rule for determining the inductance is to allow the peak-to-peak ripple current to be approximately 30% to 50% of the maximum input current. Calculate the required inductance value by the equation:

$$L = \frac{(V_{OUT} - V_{IN}) \times V_{IN}}{\Delta I_L \times F_{SW} \times V_{OUT}}$$

$$\Delta I_L = (30\% - 50\%) \times I_{IN}$$

$$I_{IN} = \frac{V_{OUT} \times I_{LOAD}}{V_{IN} \times \eta}$$

It is necessary to choose an inductor that ensures the inductor saturation current rating to exceed the peak inductor current for the application.

To make sure that the peak inductor current is below the current-limit 2.5A. Calculating the peak inductor current by the following equation:

$$I_{PEAK} = I_{IN} + 0.5 \times \Delta I_L$$

$$I_{PEAK} = \frac{V_{OUT} \times I_{LOAD}}{V_{IN} \times \eta} + \frac{(V_{OUT} - V_{IN}) \times V_{IN}}{2 \times L \times F_{SW} \times V_{OUT}}$$

where

η is the efficiency

Schottky Diode Selection

A fast recovery time and low forward voltage Schottky diode is necessary for optimum efficiency. Ensure that the diode's average and peak current rating exceed the average output current and peak inductor current. In addition, the diode's reverse voltage must exceed output voltage.

Capacitor Selection

An input capacitor is required to supply the ripple current to the inductor and stabilize the input voltage. Larger input capacitor values and lower ESR provide smaller input voltage ripple and noise. The typical value for input capacitor is 2.2µF to 10µF.

Application Information(Cont.)

Capacitor Selection (Cont.)

The output capacitor with typical value 1μF to 10μF is required to maintain the output voltage. The COMP capacitor with typical value 0.22μF to 1μF stabilizes the converter and controls the soft-start.

To ensure the voltage rating of input and output capacitors is greater than the maximum input and output voltage. It is recommended using the ceramic capacitors with X5R, X7R, or better dielectrics for stable operation over the entire operating temperature range.

Layout Consideration

The correct PCB layout is important for all switching converters. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems. Figure. 4 illustrates the layout guidelines; the bold lines indicate these traces that must be short and wide. The capacitors, the diode, and the inductor should be as close to the IC as possible. Keep traces short, direct, and wide. Keep the LX node away from FB and COMP pins. The trace from diode to the LEDs may be longer. The ground return of input capacitor and output capacitor should be tied close to PGND. Use the different ground planes for signal ground and power ground to minimize the effects of ground noise. Connect these ground nodes at any place close to one of the ground pins of the IC. The resistor from FB to GND should be close to the FB pin as possible. The metal plate of the bottom must be soldered to the PCB and connected to LX node and the LX plane on the backside through several thermal vias to improve heat dissipation.

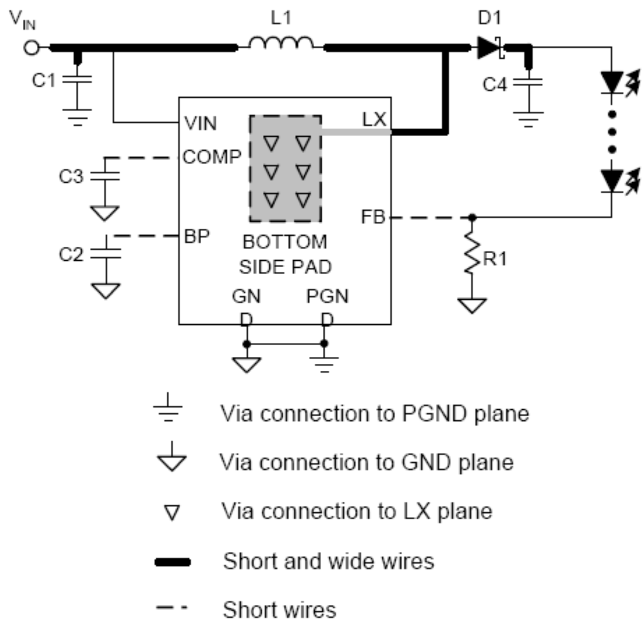
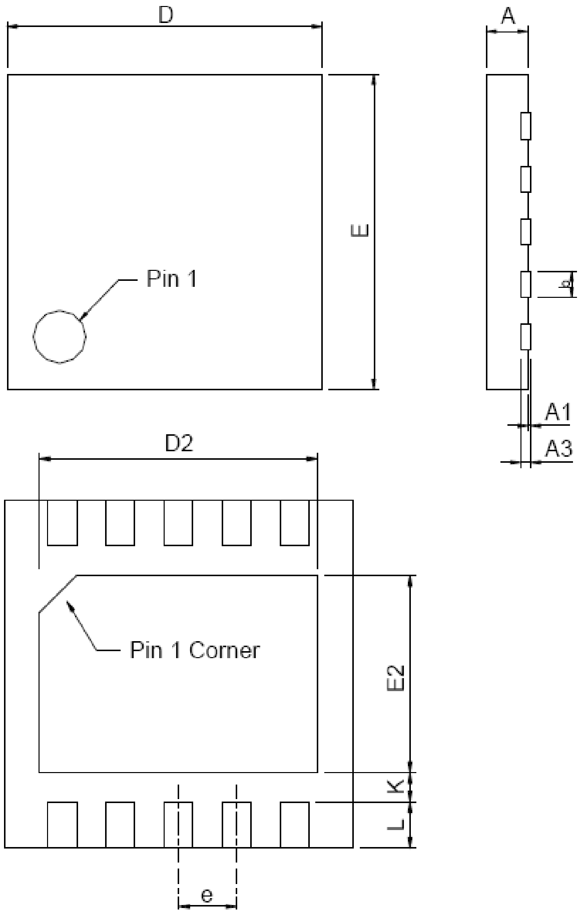


Figure 4. Layouy Guidelines

Package Information

DFN3x3-10



SYMBOL	DFN3x3-10			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.80	1.00	0.031	0.039
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	2.90	3.10	0.114	0.122
D2	2.20	2.70	0.087	0.106
E	2.90	3.10	0.114	0.122
E2	1.40	1.75	0.055	0.069
e	0.50 BSC		0.020 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	

Note : 1. Followed from JEDEC MO-229 VEED-5.

Design Notes

High Efficiency 1MHz, 2A Step Up Regulator   TD8228

General Description

TD8228 is a high efficiency, current-mode control Boost DC to DC regulator with an integrated 120mΩ $R_{DS(ON)}$ N-channel MOSFET. The fixed 1MHz switching frequency and internal compensation reduce external component count and save the PCB space. The build-in internal soft start circuitry minimizes the inrush current at start-up.

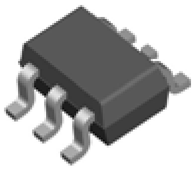
Features

- Wide input range:2.5-6V
- 1MHz switching frequency
- Minimum on time: 100ns typical
- Minimum off time: 100ns typical
- Max output voltage: 6V
- Low $R_{DS(ON)}$: 120mΩ
- Adjustable Over Current Protection:0.5~4.5A
- RoHS Compliant and Halogen Free
- Compact package: SOT23-6

Applications

- Cell Phone and Smart Phone
- PDA, PMP, MP3
- Digital Camera

Package Types



SOT23-6

Figure 1. Package Types of TD8228

Pin Configurations

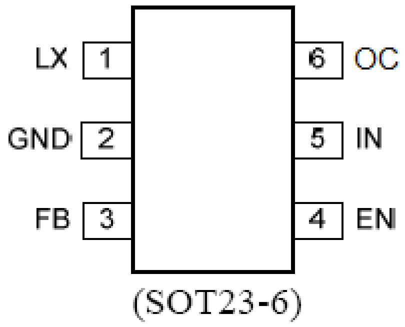
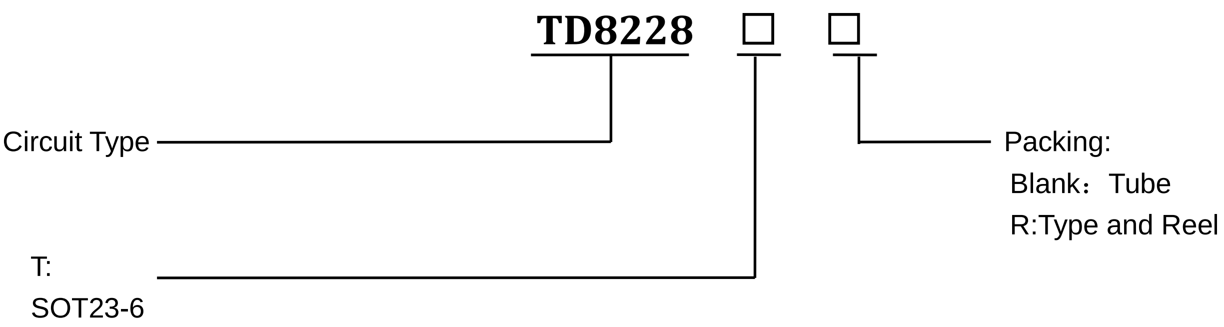


Figure 2 Pin Configuration of TD8228(Top View)

Pin Description

Pin Number	Pin Name	Description
1	LX	Inductor node. Connect an inductor between IN pin and LX pin.
2	GDN	GND
3	FB	Feedback pin. Connect a resistor R1 between V_{OUT} and FB, and a resistor R2 between FB and GND to program the output voltage: V_{OUT}=0.6V*(R1/R2+1)
4	EN	Enable control. High to turn on the part. Don't leave it floated.
5	IN	Power Input pin.
6	OC	Adjustable Over Current Protection I_{OC}=120000/R

Ordering Information



Function Block

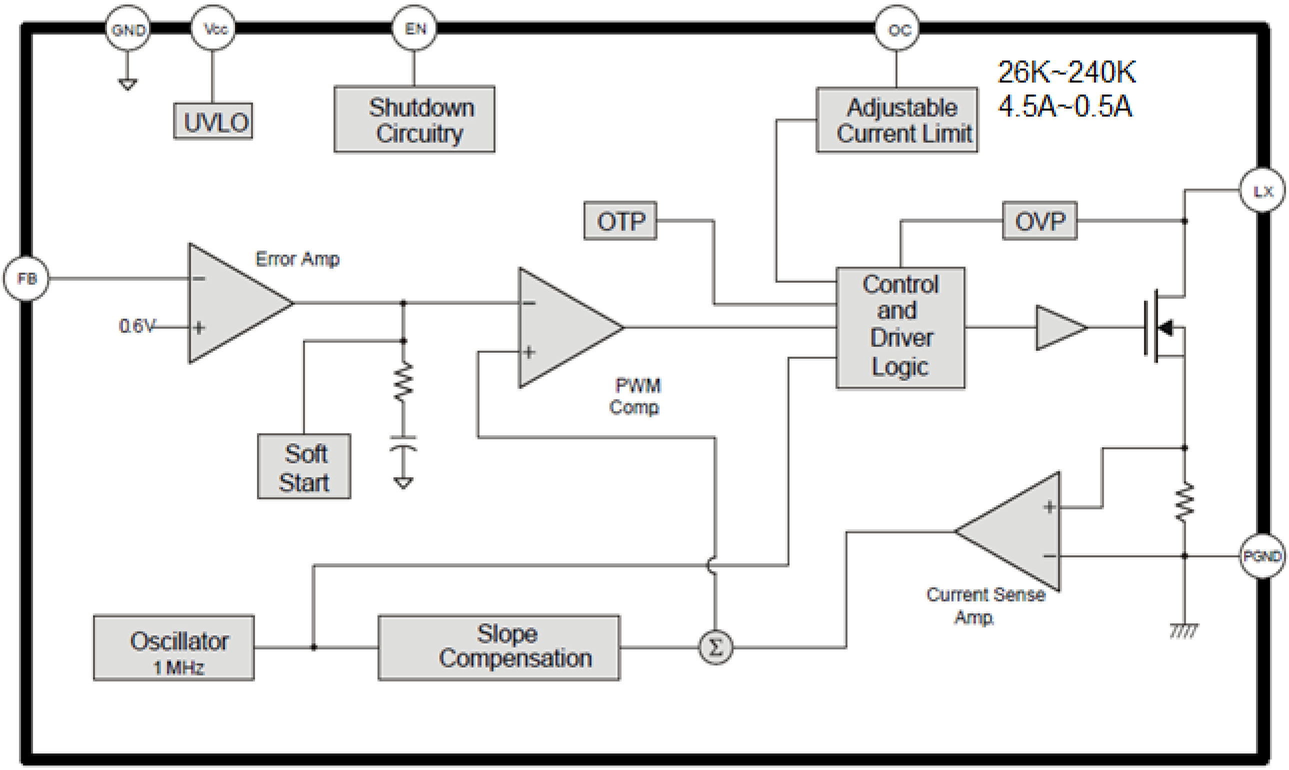


Figure 3 Function Block Diagram of TD8228

Absolute Maximum Ratings

EN, VDD, LX--7V
FB------------------------- ---3.6V
Power Dissipation, P_D @ T_A = 25°C, SOT23-6 --- 0.6W
Package Thermal Resistance (Note 2)
SOT23-6, θ_{JA} -- 200°C/W
SOT23-6, θ_{JC} -- 130°C/W
Junction Temperature Range --- 125°C
Lead Temperature (Soldering, 10 sec.) --- 260°C
Storage Temperature Range -- -65°C to 150°C

Recommended Operating Conditions

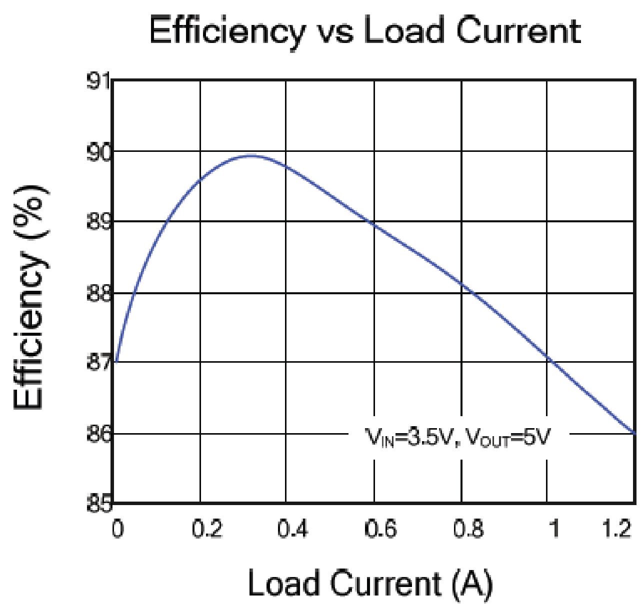
VDD pin------------------------- -- 2.5V to 6V
FB--- -- 0V to 1V
Junction Temperature Range -- -40°C to 125°C
Ambient Temperature Range -- -40°C to 85°C

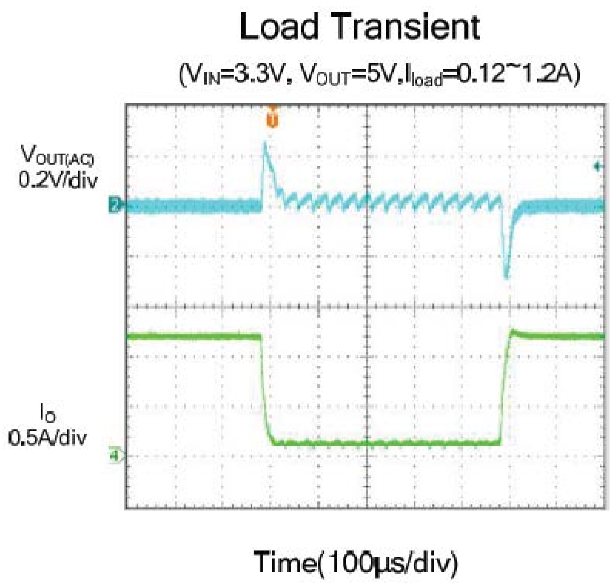
Electrical Characteristics

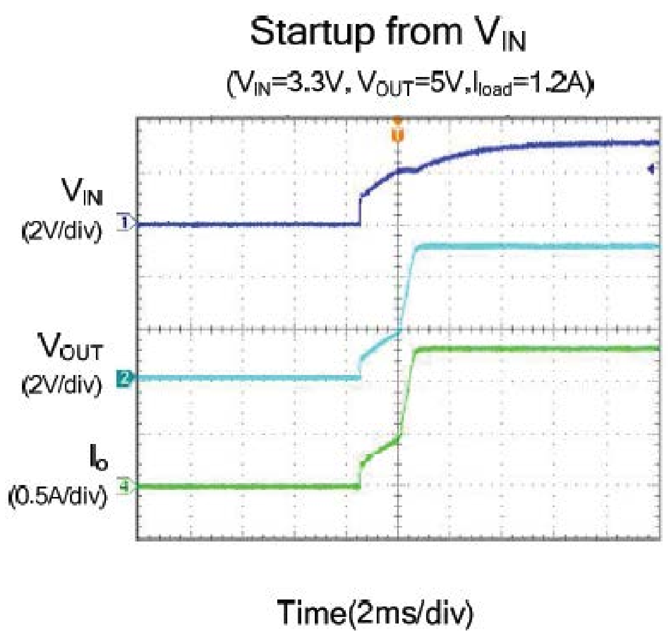
(V_{IN} = 3.3V, V_{OUT}=5V, I_{OUT}=100mA, T_A = 25°C unless otherwise specified)

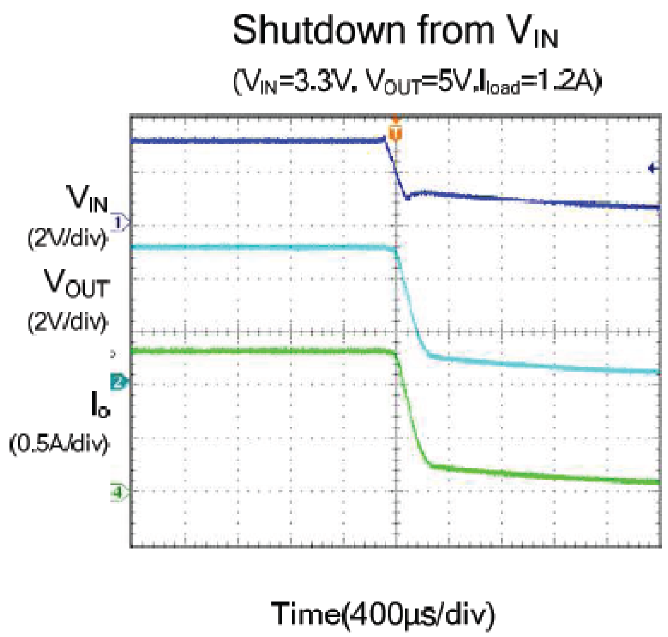
Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input Voltage Range	V_{IN}		2.5		6	V
Quiescent Current	I_Q	V_{FB}=0.66V		200		μA
Low Side Main FET	Rds(on)			120		mΩ
Main FET Current	I_{LIM1}		3			A
Switching Frequency	Fsw		0.8	1	1.2	MHz
Feedback Reference	V_{REF}		0.588	0.6	0.612	V
IN UVLO Rising	$V_{IN,UVLO}$				1.9	V
OCP Current	Iocp			4.5		A
Adjustable OCP Current	Iocp	With External Resistor:26K~240K	0.5		4.5	A
Thermal Shutdown	T_{SD}			150		°C

Typical Performance Characteristics



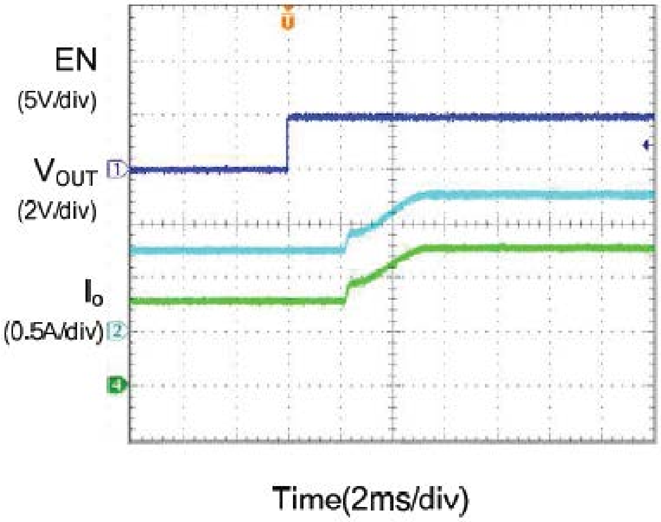






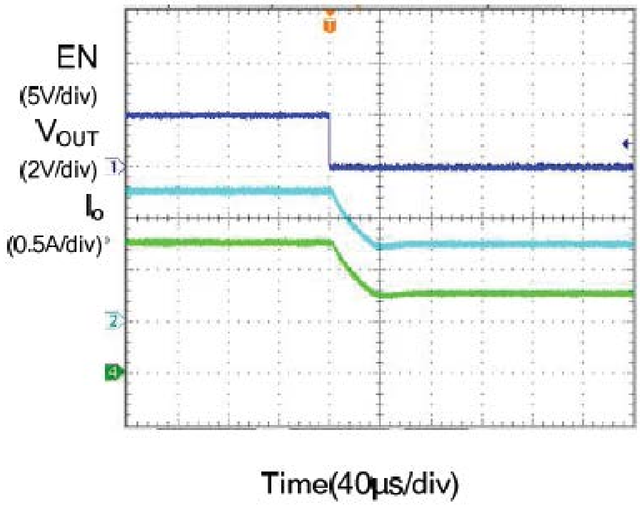
Startup from Enable

$(V_{IN}=3.3V, V_{OUT}=5V, I_{load}=1.2A)$



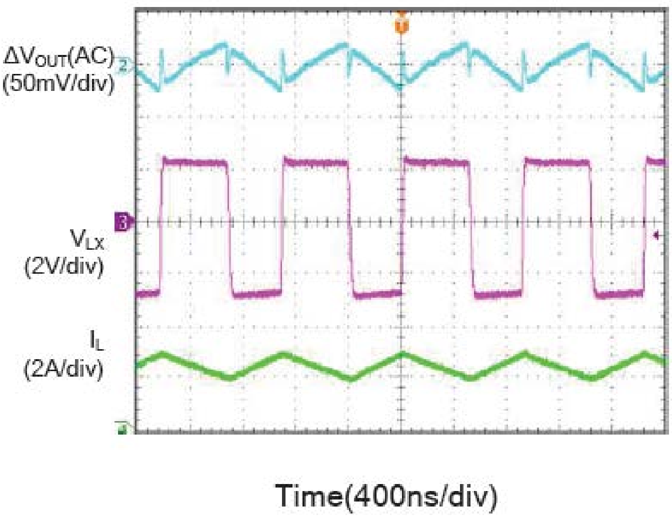
Shutdown from Enable

$(V_{IN}=3.3V, V_{OUT}=5V, I_{load}=1.2A)$



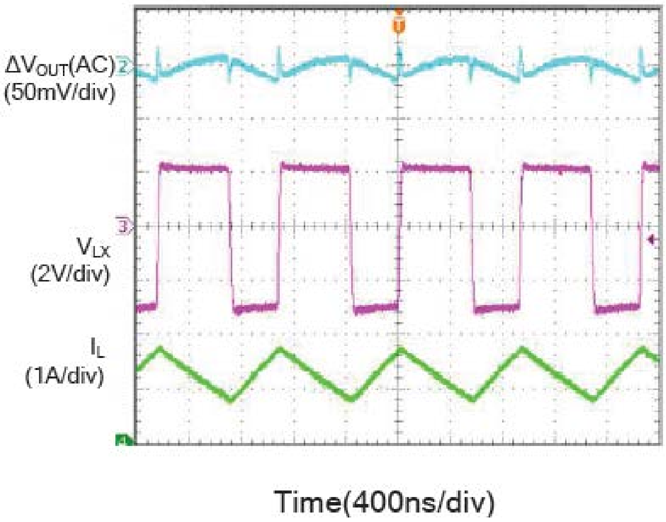
Output Ripple

$(V_{IN}=3.3V, V_{OUT}=5V, I_O=1.2A)$

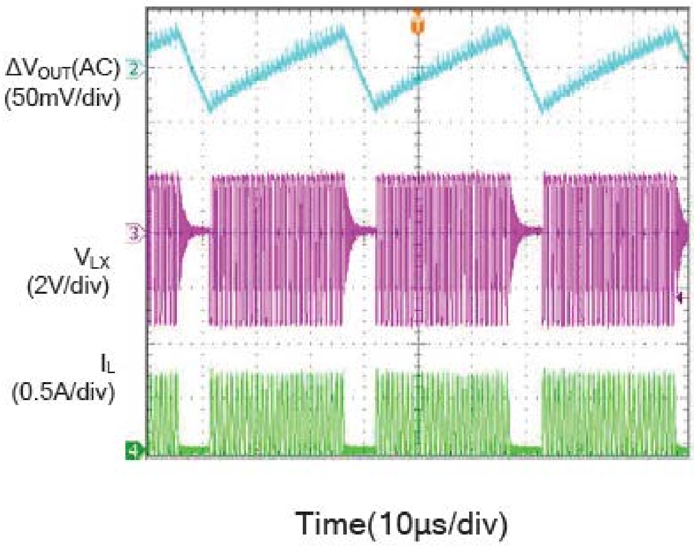


Output Ripple

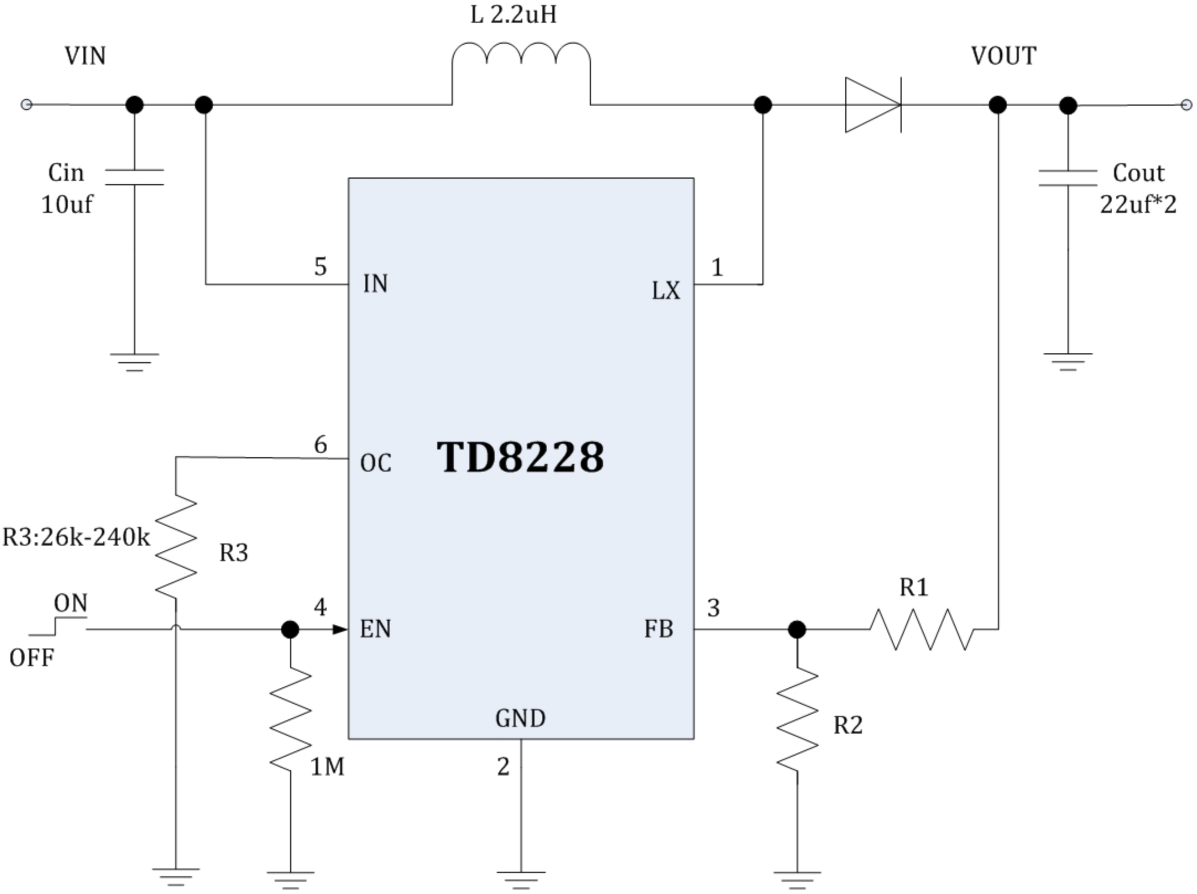
$(V_{IN}=3.3V, V_{OUT}=5V, I_O=0.6A)$



Output Ripple
(V_{IN}=3.3V, V_{OUT}=5V,I_O=0.12A)



Typical Application Circuit



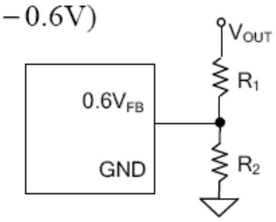
Function Description

Because of the high integration in the TD8228 IC, the application circuit based on this regulator IC is rather simple. Only input capacitor C_{IN}, output capacitor C_{OUT}, inductor L and feedback resistors (R_1 and R_2) need to be selected for the targeted applications specifications.

Feedback resistor dividers R_1 and R_2:

Choose R_1 and R_2 to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R_1 and R_2. A value of between 10k and 1M is recommended for both resistors. If R_1=200k is chosen, then R_2 can be calculated to be:

$$R_2 = (R_1 \times 0.6V)/(V_{OUT} - 0.6V)$$



Output capacitor C_{OUT}:

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, it is recommended to use X5R or better grade ceramic capacitor with 25V rating and more than two pcs 10uF capacitor.

Input capacitor C_{IN}:

The ripple current through input capacitor is calculated as:

$$I_{CIN\_RMS} = \frac{V_{IN} \cdot (V_{OUT} - V_{IN})}{2\sqrt{3} \cdot L \cdot F_{SW} \cdot V_{OUT}} (A)$$

To minimize the potential noise problem, place a typical X5R or better grade ceramic capacitor really close to the VDD and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and VDD/GND pins. In this case a 22uF low ESR ceramic capacitor is recommended.

Boost inductor L:

There are several considerations in choosing this inductor.

1) Choose the inductance to provide the desired ripple current. It is suggested to choose the ripple current to be about 40% of the maximum average input current. The inductance is calculated as:

$$L = \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \frac{(V_{OUT} - V_{IN})}{F_{SW} \times I_{OUT,MAX} \times 40\%}$$

where F_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current.

The TD8228 regulator IC is quite tolerant of different ripple current amplitude. Consequently, the final choice of inductance can be slightly off the calculation value without significantly impacting the performance.

2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

$$I_{SAT,MIN} > \left(\frac{V_{OUT}}{V_{IN}}\right) \times I_{OUT\_MAX} + \frac{V_{IN}(V_{OUT} - V_{IN})}{2 \times F_{SW} \times L \times V_{OUT}}$$

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with DCR<50mohm to achieve a good overall efficiency.

Enable Operation

Pulling the EN pin low (<0.4V) will shut down the device. During the shut down mode, the TD8228 shut down current drops to lower than 1uA, Driving the EN pin high (>2.0V) will turn on the IC again.

Diode Selection

Schottky diode is a good choice for high efficiency operation because of its low forward voltage drop and fast reverse recovery. The current rating of the diode must meet following:

$$I_D(RMS) \approx \sqrt{(I_{OUT} \times I_{PEAK})}$$

The schottky diode reverse breakdown voltage should be larger than the output voltage

Current Limit Program:

A resistor between OC and GND pin programs peak switch current.The resistor value should be between 26K and 240K.The current limit will be set from 0.5A to 4.5A.Keep traces at this pin as short as possible.Do not put capacitance at this pin. To set the over current trip point according to the following equation:

Iocp=120000/R

.

Layout Design:

The layout design of TD8228 regulator is relatively simple. For the best efficiency and minimum noise problems, we should place the following components close to the IC: C_{IN}, L, R_1 and R_2.

1) It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.

2) C_{IN} must be close to Pins IN and GND. The loop area formed by C_{IN} and GND must be minimized.

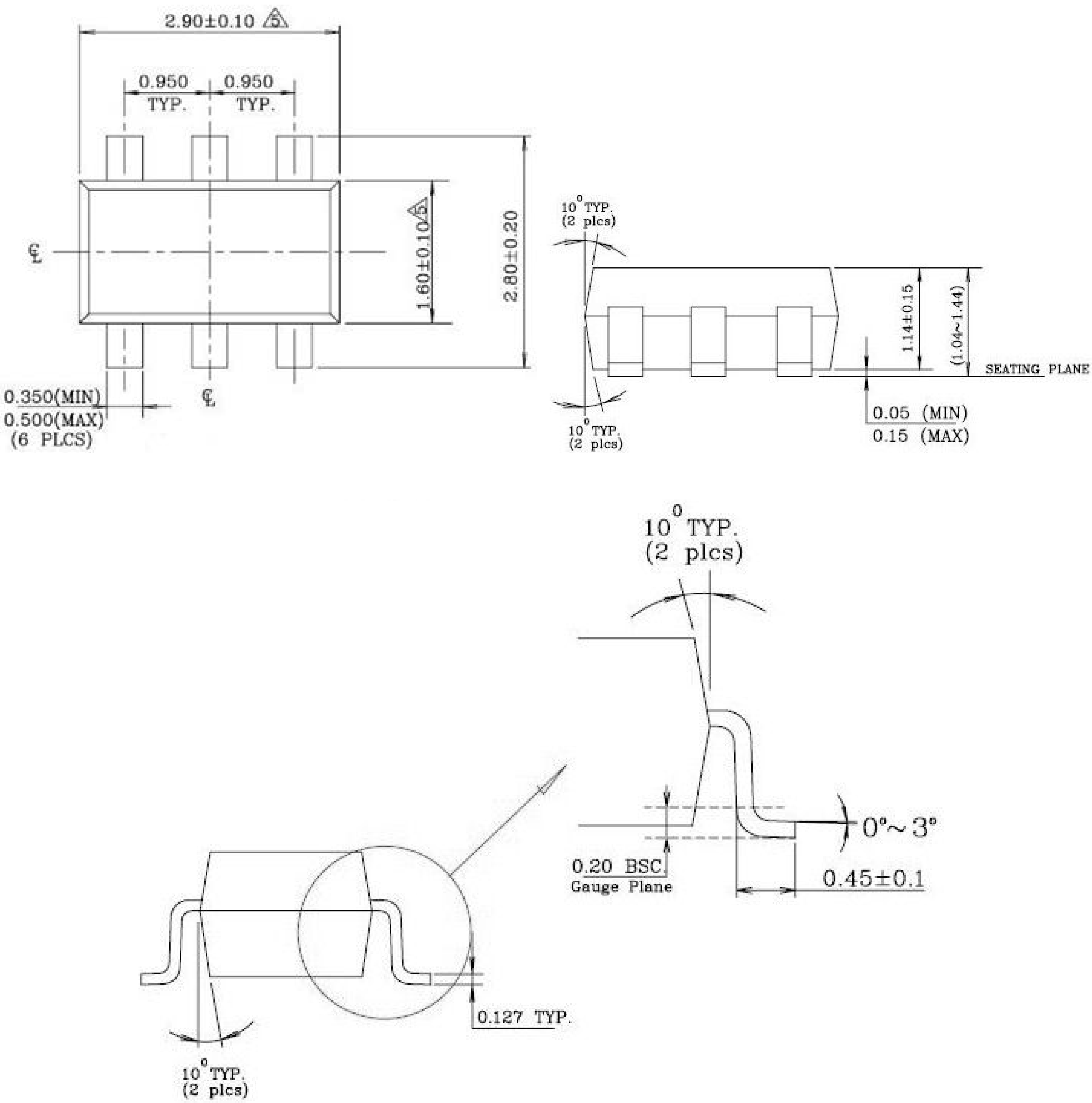
3) The PCB copper area associated with LX pin must be minimized to avoid the potential noise problem.

4) The components R_1 and R_2, and the trace connecting to the FB pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.

5) If the system chip interfacing with the EN pin has a high impedance state at shutdown mode and the IN pin is connected directly to a power source such as a Li-Ion battery, it is desirable to add a pull down 1Mohm resistor between the EN and GND pins to prevent the noise from falsely turning on the regulator at shutdown mode.

Package Information

SOT23-6 Package Outline Dimensions



Design Notes

Techcode® DATASHEET

5V 2.1A 1.2MHz Synchronous Boost Converter TD8587

General Description

The TD8587 is a synchronous rectifier, fixed switching frequency (1.2MHz typical), and current-mode step-up regulator. The device allows use of small inductors and output capacitors for USB devices. The current-mode control scheme provides fast transient response and good output voltage accuracy.

At light loads, the TD8587 will automatically enter in Pulse Frequency Modulation (PFM) operation to reduce the dominant switching losses. During PFM operation,the IC consumes very low quiescent current and maintains high efficiency over the complete load range.The TD8587 also includes current-limit and overtemperature shutdown to prevent damage in the event of an output overload.

The TD8587 is available in ESOP-8 packages.

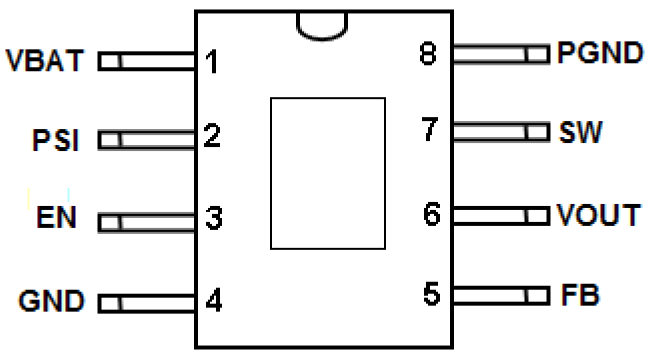
Features

- 92%EffiicencySynchronousBoostConverter With 1000-mA Output Current From 1.8V Input
- Stable with Low ESR Output Capacitors
- Fixed 1.2MHz Oscillator Frequency
- Low EMI Converter (Integrated Anti-Ringing Function)
- Low Battery Output
- Integrated Power SaveModeOperation to Improve Light Load Efficiency
- Load Disconnected During Shutdown
- Output Current-Limit Protection
- Over Temperature Protection
- Under Voltage Protection
- Enable/ShutdownFunction
- Available in ESOP-8 Packages
- Lead Free and Green Devices Available(RoHS Compliant)

Applications

- Power Bank
- Tablet
- Portable Equiment

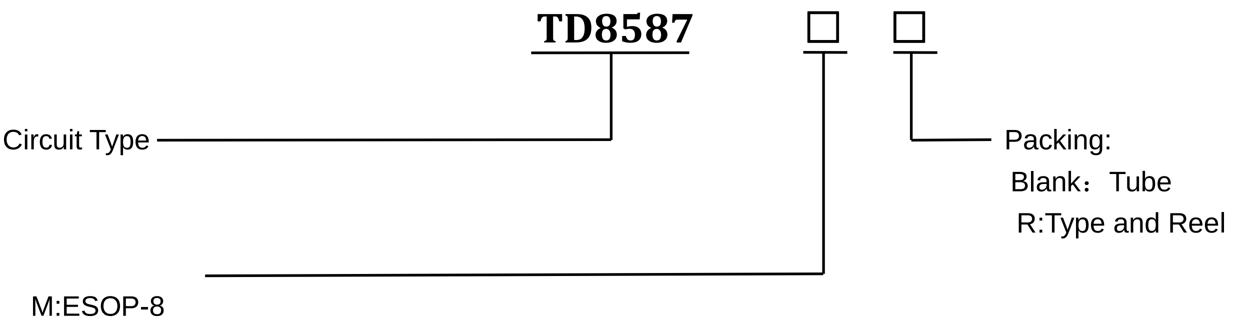
Pin Configurations



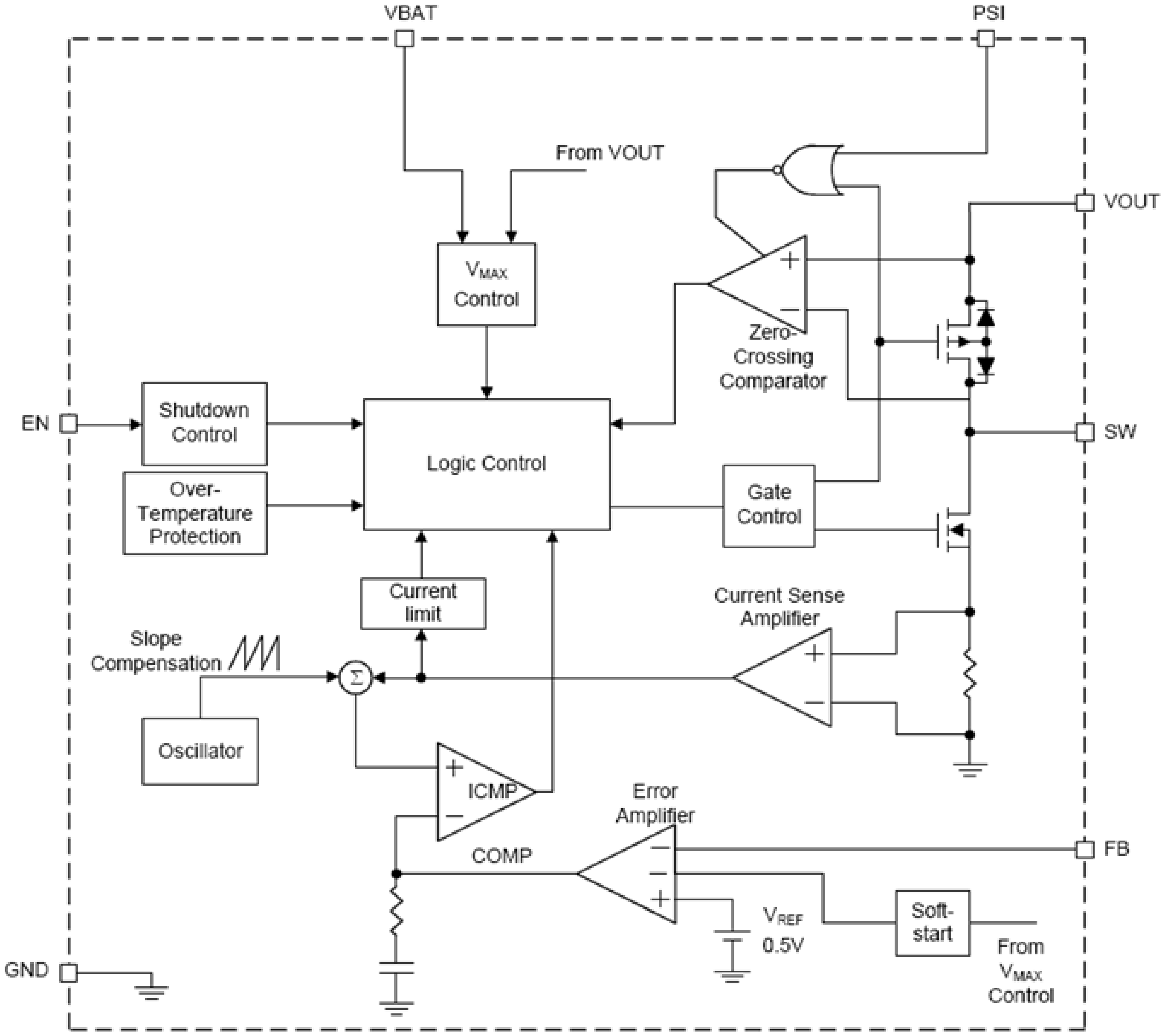
Pin Description

NO.	NAME	FUNCTION
1	VBAT	Converter Supply Voltage.
2	PSI	Power Saving Input. Force V_{PSI} exceed 1V enter PFM. Left V_{PSI} below 0.4V enter PWM mode
3	EN	Device Enable Control Input. Force V_{EN} exceed 1V enable the device. Left V_{EN} below 0.4V to shutdown.
4	GND	Signal Ground. Connect this pin to PGND.
5	FB	Converter Feedback Input.
6	VOUT	Converter Output and IC Supply Voltage
7	SW	Converter Switch Pin. Connect inductor here.
8	PGND	Power Ground. Connect these pins to GND.

Ordering Information



Functional Block Diagram



Absolute Maximum Ratings

Symbol	Parameter		Rating	Unit
VOUT	Output and IC Supply Voltage (V_{OUT} to GND)		-0.3 ~ 7	V
VBAT	Converter Supply Voltage (V_{BAT} to GND)		-0.3 ~ 7	V
VSW	SW to GND Voltage	>30ns	-0.3 ~ 7	V
		<30ns	-0.3 ~ 9	V
	EN and FB to GND Voltage		-0.3 ~ 7	V
	PGND to GND		-0.3 ~+0.3	V
T_J	Maximum Junction Temperature		150	°C
T_{STG}	Storage Temperature		-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)		260	°C

Note1: 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 rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	50	°C/W
θ_{JC}	Junction-to-Case Resistance	20	°C/W

Note 2 : θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note 3)

Symbol	Parameter		Rating	Unit
VOUT	Output and IC Supply Voltage (V_{OUT} to GND)		2.7 ~5.5	V
VBAT	Converter Supply Voltage (V_{BAT} to GND)		1.8 ~ V_{OUT}	V
VSW	SW to GND Voltage	>30ns	-0.3 ~ V_{OUT}+0.3	V
		<30ns	-3 ~ V_{OUT}+3	V
	LBI, SYNC, EN, LBO and FB to GND Voltage		0 ~ V_{OUT}	V
T_J	Junction Temperature		-40 ~ 125	°C
T_A	Ambient Temperature		-40 ~ 85	°C

Note 3 : Refer to the typical application circuit

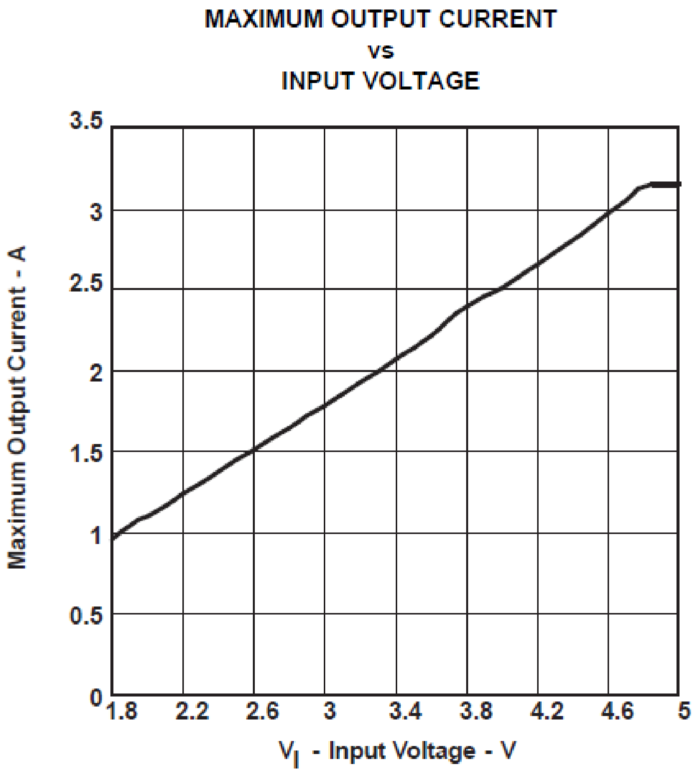
Electrical Characteristics

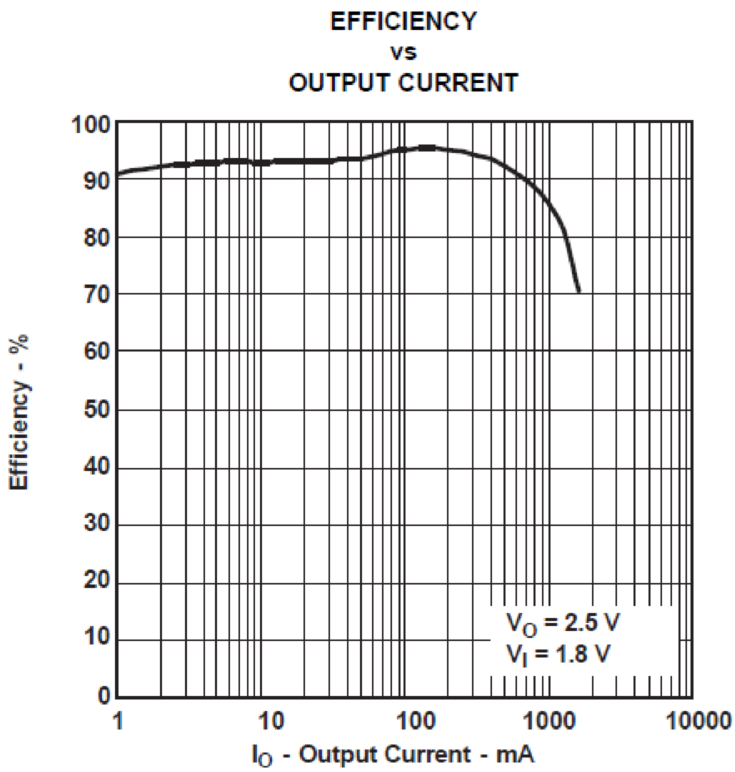
Unless otherwise specified, these specifications apply over V_{BAT}=3.3V, V_{OUT}=5V and T_A= 25 °C.

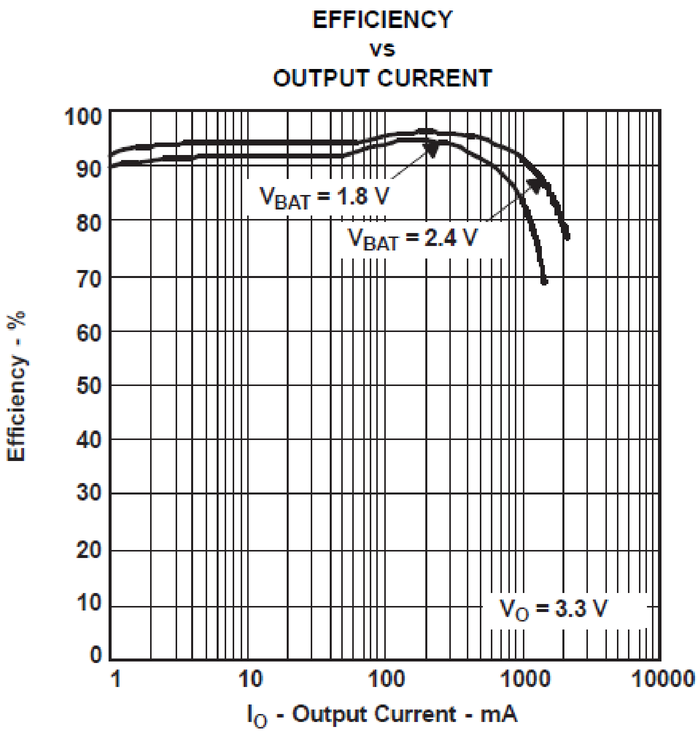
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{BAT}	Converter Supply Voltage Range		1.8	-	5.5	V
V_{OUT}	Converter Output and IC Supply Voltage		3.0	-	5.5	V
I_{DD1}	No Switching Quiescent Current	Measured from VOUT, V_{FB}=0.6V, V_{OUT}=3.3V	-	40	60	uA
I_{VBAT}	V_{BAT} Quiescent Current	Measured from VBAT, V_{BAT}=3.3V, EN=H	-	0.5	1	uA
$I_{VBAT-SD}$	V_{BAT} Quiescent Current	V_{EN}=GND, V_{BAT}=3.3V (Isolate VBAT & VOUT)	-	0.1	1	uA
V_{UVLO}	V_{BAT} Under Voltage Lockout Threshold		1.6	1.7	1.8	V
V_{REF}	Regulated Feedback Voltage		490	500	510	mV
I_{FB}	FB Input Leakage Current		-100	-	100	nA
	Over Temperature Protection Hysteresis(note 4)	T_J Falling	-	30	-	°C
F_{OSC}	Switching Frequency	FB=GND	900	1200	1500	MHz
R_{N-FET}	N-FET Switch On Resistance	V_{OUT}=5V	-	55	-	mΩ
R_{P-FET}	P-FET Switch On Resistance	V_{OUT}=5V	-	55	-	mΩ
	N-FET Current Limit	V_{OUT}=5V	4.5	5.0	5.5	A
	Dead-time (note 4)	V_{OUT}=3.3V~5V	-	10	-	ns
D_{MAX}	SW Maximum Duty Cycle		80	85	90	%
	PFM Current Limit		-	700	-	mA
EN	EN Input Low Threshold		-	-	0.4	V
	EN Input High Threshold		1	-	-	V
	Internal Pull Low		-	500	-	kΩ
PSI	PSI Input Low Threshold		-	-	0.4	V
	PSI Input High Threshold		1	-	-	V
I_{EN}	EN Input Leakage Current	V_{EN}=1.5V	-	3	5	uA
I_{PSI}	PSI Input Leakage Current	V_{PSI}=1.5V	-	0.4	1	uA
V_{ZC}	P-FET Zero Current Detect		-	+100	-	mA
	V_{FB} Under Voltage Protection		70	75	80	%V_{REF}
	UVP Debounce	(Option)	-	2	-	us
T_{OTP}	Over Temperature Protection (note 4)	T_J Rising	-	150	-	°C
	Over Temperature Protection Hysteresis(note 4)	T_J Falling	-	30	-	°C

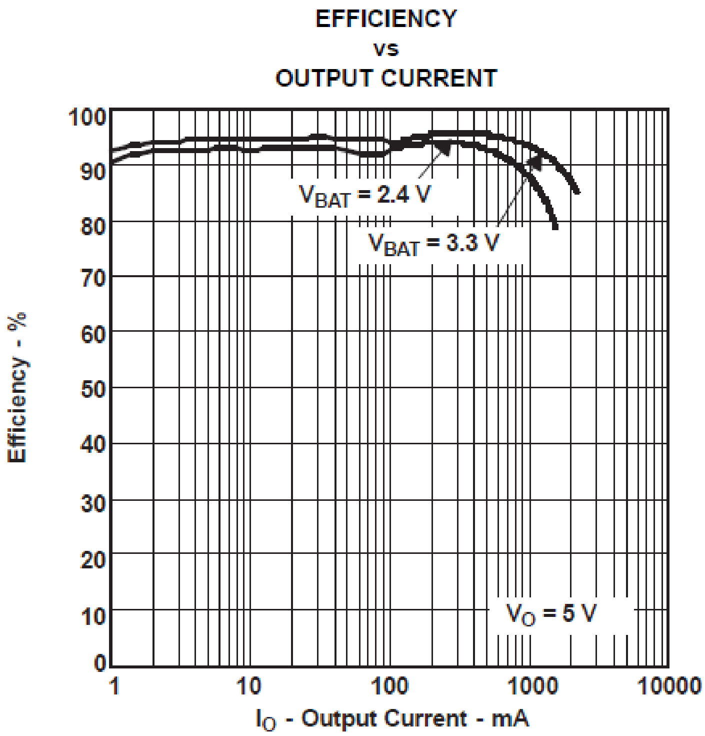
Note 4: Guaranteed by design, not production tested.

Typical Operating Characteristics

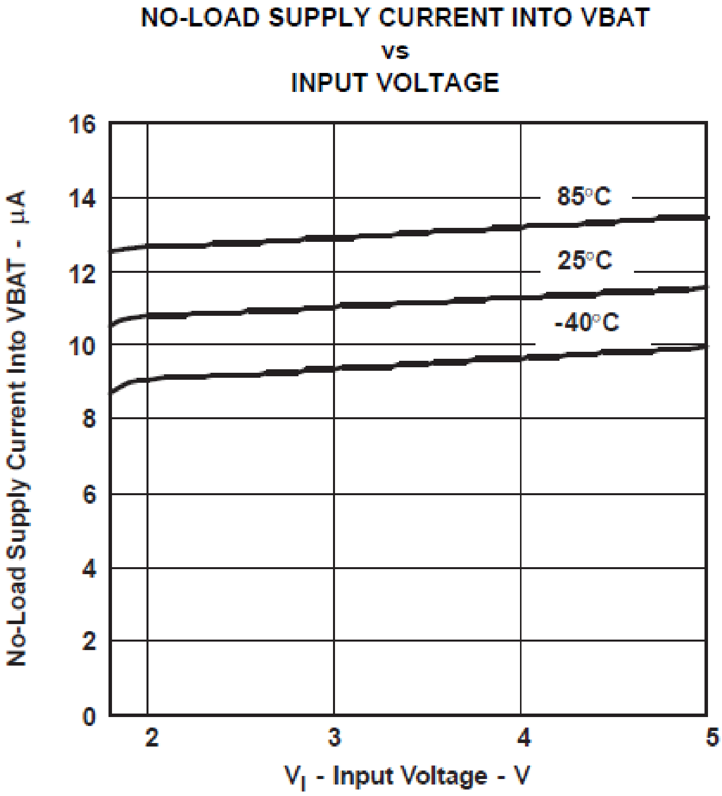


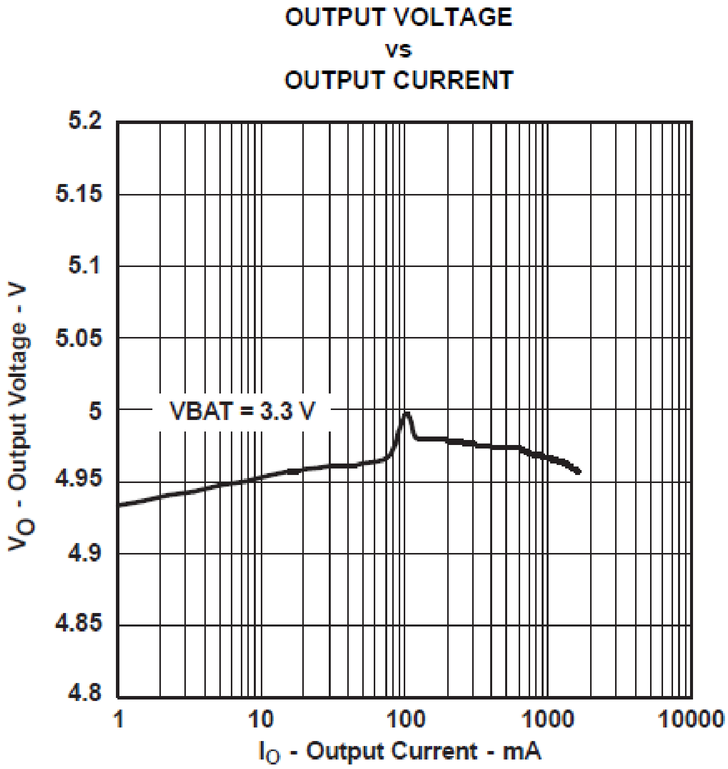


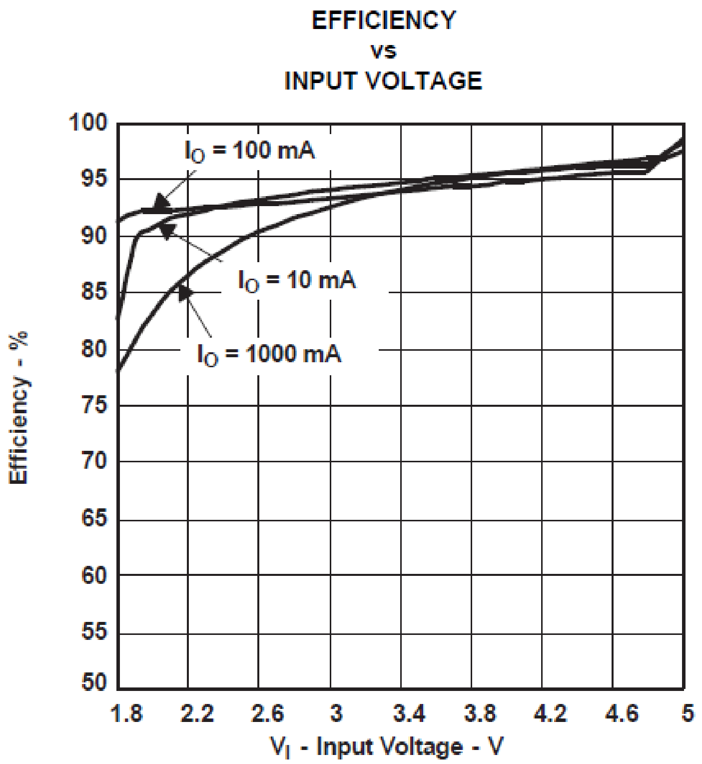


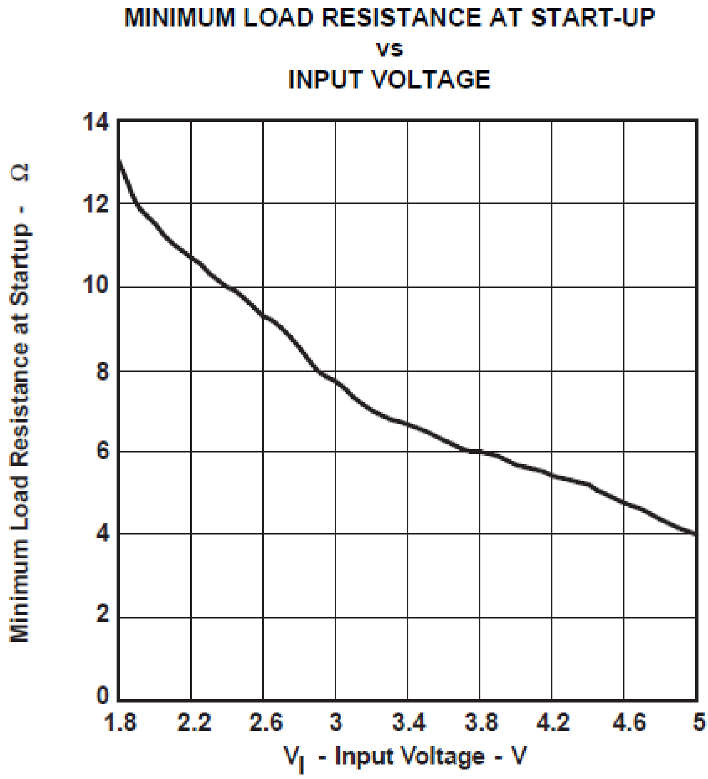


Typical Operating Characteristics(Cont.)



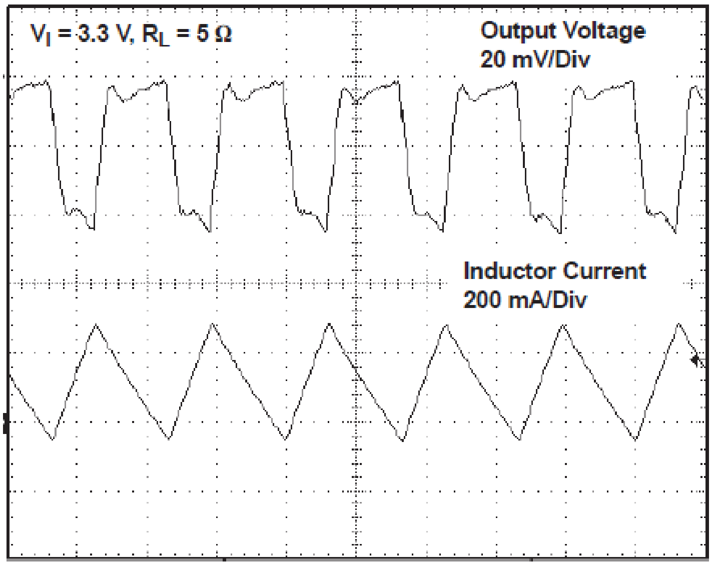






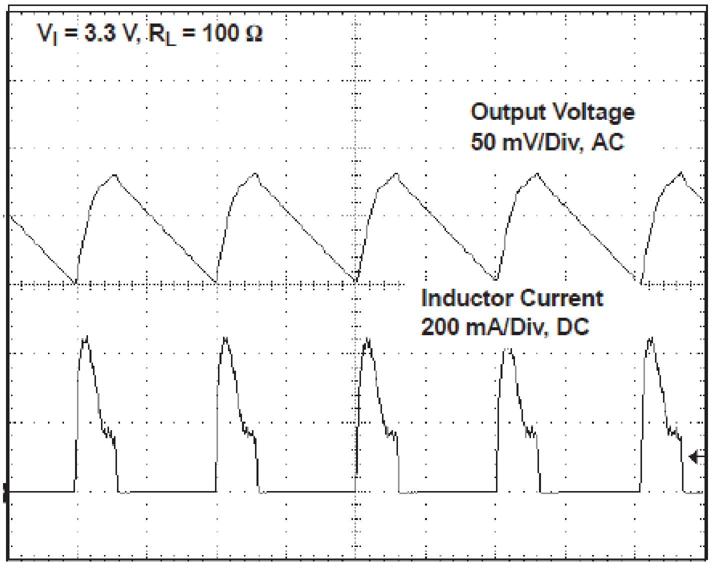
Typical Operating Characteristics(Cont.)

OUTPUT VOLTAGE IN CONTINUOUS MODE



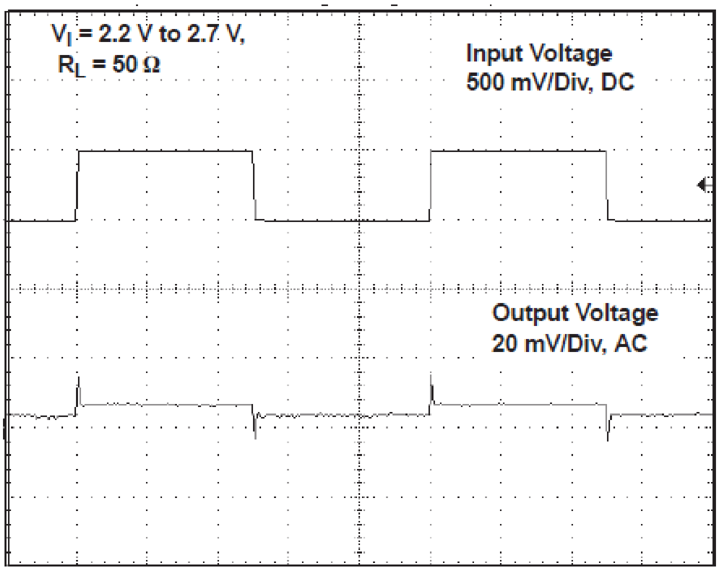
Timebase - 1 µs/Div

OUTPUT VOLTAGE IN POWER SAVE MODE



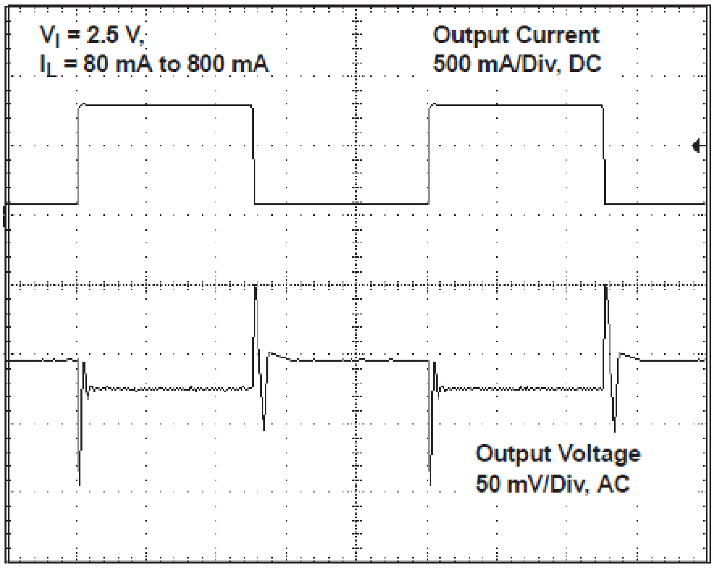
Timebase - 200 µs/Div

LINE TRANSIENT RESPONSE



Timebase - 2 ms/Div

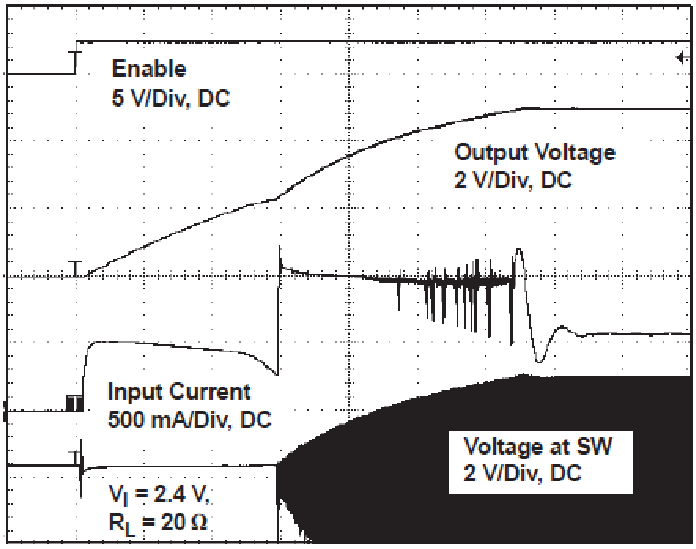
LOAD TRANSIENT RESPONSE



Timebase - 2 ms/Div

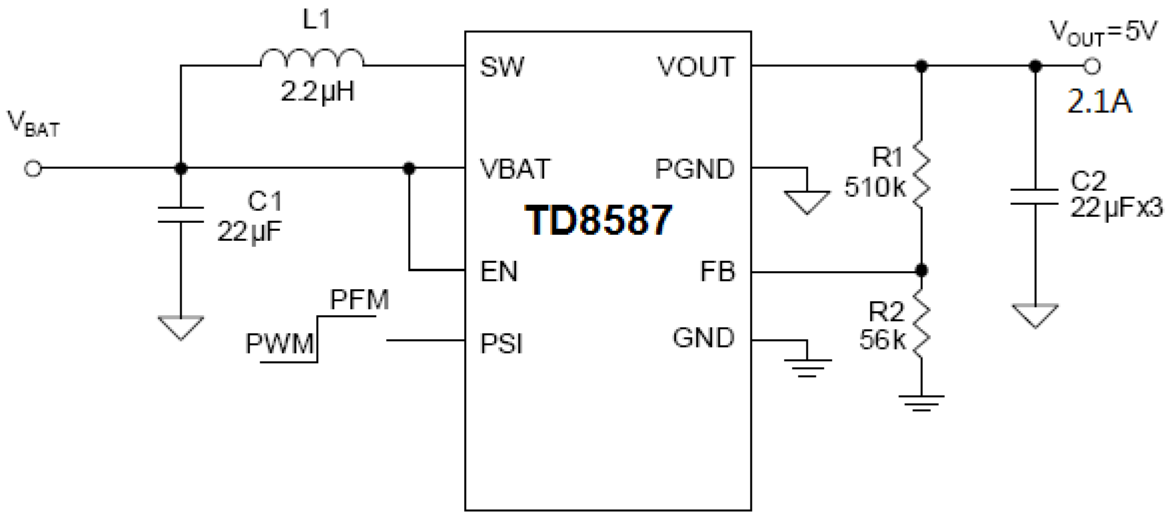
Typical Operating Characteristics(Cont.)

DC/DC CONVERTER START-UP AFTER ENABLE



Timebase - 400 µs/Div

Type Application Circuit



Function Description

Main Control Loop

The TD8587 is a constant frequency, synchronous rectifier, and current-mode switching regulator. In normal operation, the internal N-channel power MOSFET is turned on each cycle when the oscillator sets an internal RS latch and turned off when an internal comparator (ICMP) resets the latch. The peak inductor current which ICMP resets the RS latch is controlled by the voltage on the COMP node, which is the output of the error amplifier (EAMP). An external resistive divider connected between V_{OUT} and ground allows the EAMP to receive an output feedback voltage V_{FB} at FB pin. When the load current increases, it causes a slightly decrease in V_{FB} relative to the 0.5V reference, which in turn causes the COMP voltage to increase until the average inductor current matches the new load current.

Start-up

A start-up oscillator circuit is integrated in the TD8587. When the device enables, the circuit pumps the output voltage high. Once the output voltage reaches 1.6V (typ), the main DC-DC circuitry turns on and boosts the output voltage to the final regulation voltage.

Automatic PFM/PWM mode Switch

The TD8587 is a fixed frequency PWM peak current modulation control step-up converter. At light loads, the TD8587 will automatically enter in pulse frequency modulation operation to reduce the dominant switching losses. In PFM operation, the inductor current may reach zero or reverse on each pulse. A zero current comparator turns off the P-channel synchronous MOSFET, forcing DCM(Discontinuous Current Mode) operation at light load. These controls get very low quiescent current, help to maintain high efficiency over the complete load range.

Synchronous Rectification

The internal synchronous rectifier eliminates the need for an external Schottky diode, thus reducing cost and board space. During the cycle off-time, the P-FET turns on and shunts the FET body diode. As a result, the synchronous rectifier significantly improves efficiency without the addition of an external component. Conversion efficiency can be as high as 92%.

Load Disconnect

Driving EN to ground places the TD8587 in shutdown mode. When in shutdown, the internal power MOSFET turns off, all internal circuitry shuts down and the quiescent supply current reduces to 1µA maximum.

A special circuit is applied to disconnect the load from the input during shutdown the converter. In conventional synchronous rectifier circuits, the back-gate diode of the highside P-FET is forward biased in shutdown and allows current flowing from the battery to the output. However, this device uses a special circuit, which takes the cathode of the back-gate diode of the high-side P-FET and disconnects it from the source when the regulator is shutdown. The benefit of this feature for the system design engineer is that the battery is not depleted during shutdown of the converter. No additional components must be added to the design to make sure that the battery is disconnected from the output of the converter.

Current-Limit Protection

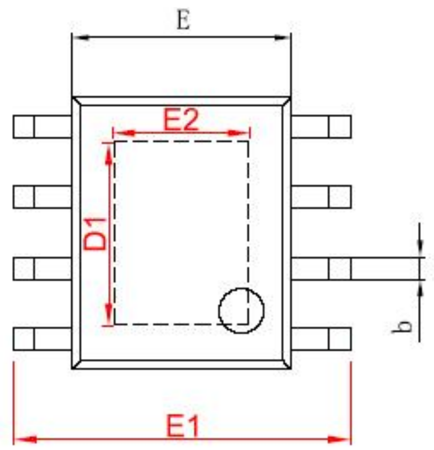
The TD8587 monitors the inductor current, flowing through the N-FET, and limits the current peak at currentlimit level to prevent loads and the TD8587 from damages during overload conditions.

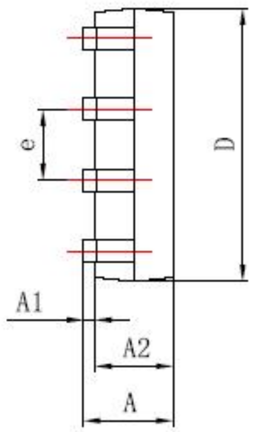
Over-Temperature Protection (OTP)

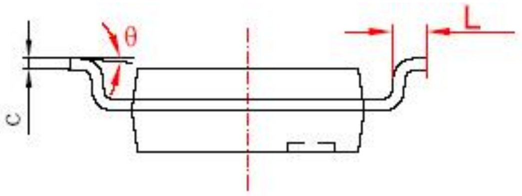
The over-temperature circuit limits the junction temperature of the TD8587. When the junction temperature exceeds 150°C, a thermal sensor turns off the both N-FET and P-FET, allowing the devices to cool. The thermal sensor allows the converters to start a soft-start process and regulate the output voltage again after the junction temperature cools by 30°C. The OTP is designed with a 30°C hysteresis to lower the average Junction Temperature (T_J) during continuous thermal overload conditions, increasing the lifetime of the device.

Package Information

ESOP-8







	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
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
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Design Notes