340KHz, 36V/3A Step-down Converter With Soft-Start

General Description

The LP6483S contains an independent 340KHz constant frequency, current mode, PWM step-down converters. The converter integrates a main switch and a synchronous rectifier for high efficiency without an external Schottky diode. The converter can supply 3000mA of load current from a 4.5V to 36V input voltage. The output voltage can be regulated as low as 0.923V. The LP6483S can also run at 90% duty cycle for low dropout applications.

The LP6483S is available in a ESOP8 package and is rated over the -40℃ to 85℃ temperature range.

Order Information

LP6483S □ □ □

- F: Pb-Free
- Package Type SP:ESOP-8

Applications

- ✧ Portable Media Players
- ✧ Cellular and Smart mobile phone
- ✧ PDA/DSC
- ✧ GPS Applications

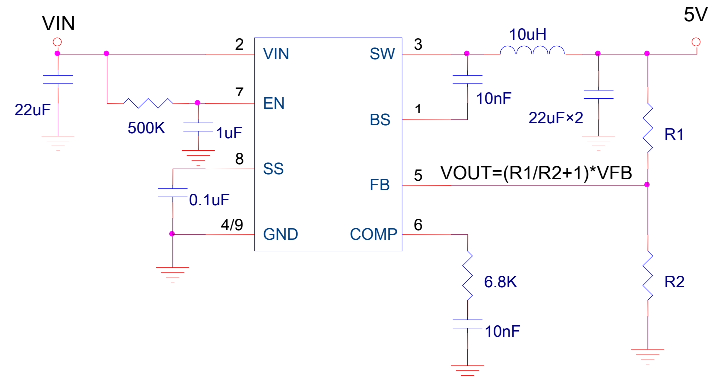
Features

- ◆ Input Voltage Range: 4.5V to 36V
- ◆ Output Voltage Range: 0.923V to 12V
- ◆ 3000mA Load Current on Channel
- ◆ Up to 95% Efficiency
- ◆ 90% Duty Cycle in Dropout
- ◆ <1uA Shutdown Current
- ◆ 340KHz Switching Frequency
- ◆ Soft star Function
- ◆ Short Circuit Protection
- ◆ Current Mode Operation
- ◆ Thermal Fault Protection
- ◆ ESOP-8 Package
- ◆ RoHS Compliant and 100% Lead (Pb)-Free

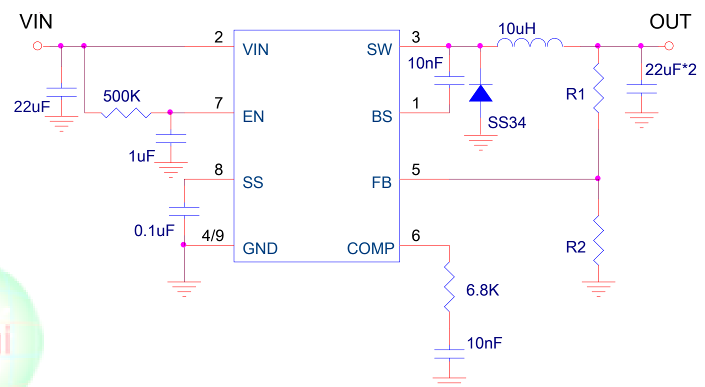
Marking Information

Device	Marking	Package	Shipping
LP6483S	LPS LP6483S XXXX	SP:ESOP-8	2.5K/REEL
Y: Year code. W: Week code. X: Batch numbers.			

Typical Application Circuit

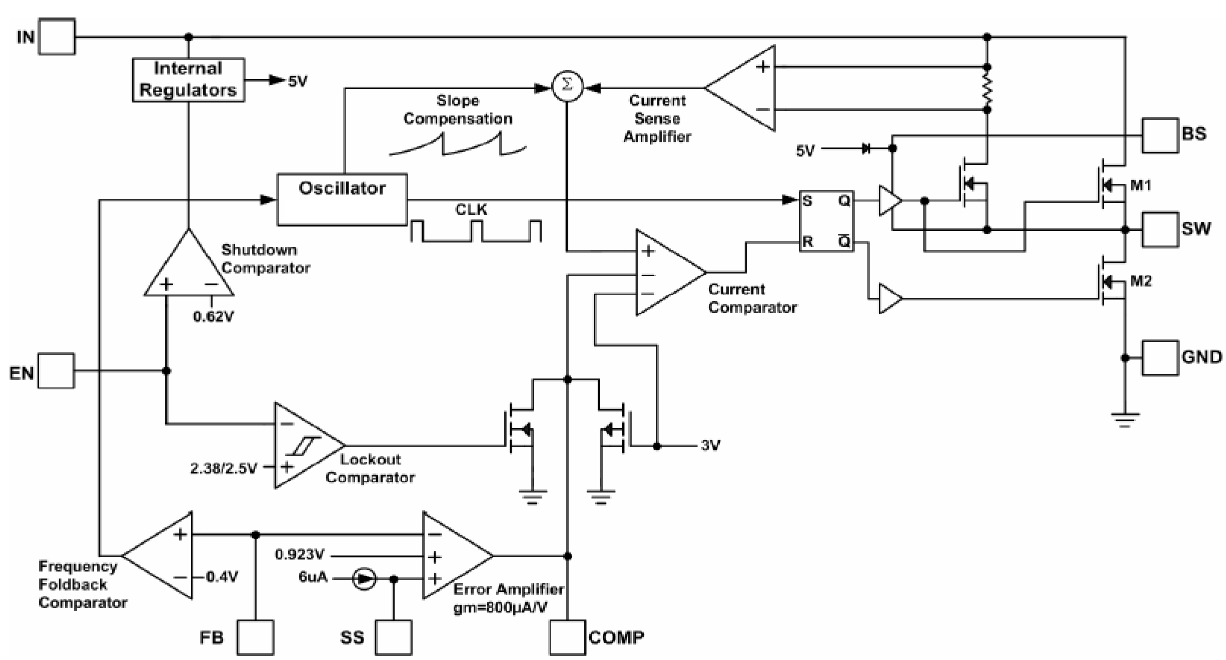


LP6483S application circuit with small output current

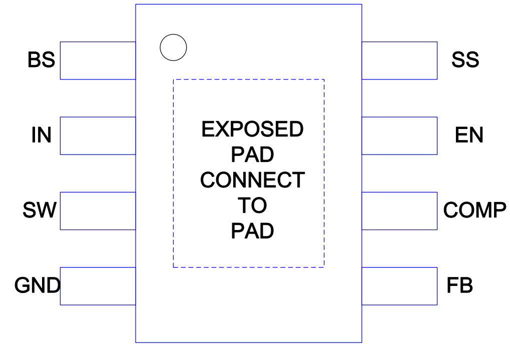


LP6483S application circuit with large output current

Function Block Diagram



Functional Pin Description

Package Type	Pin Configurations
ESOP-8	

Pin Description

Pin	Name	Description
1	BS	High-Side Gate Drive Boost Input. Connect a 0.01uF or greater capacitor from SW to BS to power the high side switch.
2	Vin	Supply Input.
3	SW	Switch Mode Connection to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
4	GND	Ground.
5	FB	Feedback Input. Connect FB to the center point of the external resistor divider. Normal voltage for this pin is 0.923V.
6	COMP	Loop compensation input. Connect a series RC network from COMP to GND to Compensate the regulation control loop.
7	EN	Enable Control Input. Drive EN between 2.5V and 6.0V to turn on the Channel. Drive EN below 0.4V to turn it off (shutdown current < 0.1μA).
8	SS	Soft-start control input. Connect an external capacitor to program the soft-start. If unused, leave it open, which means internal soft-start function.
9	E-Pad	Exposed Pad. The pin connect to GND.

Absolute Maximum Ratings [Note 1]

- ✧ Input Voltage to GND -- 36V
- ✧ SW to GND (VSW) -- - 0.3V to VIN +0.3V
- ✧ FB to GND (VFB) -- -0.3V to 6V
- ✧ EN to GND (VEN) -- -0.3V to 6V
- ✧ BS to GND (VBS) -- -0.3V to 40V
- ✧ COMP to GND (VCOMP) -- -0.3V to 6V
- ✧ SS to GND (VSS) -- -0.3V to 6V
- ✧ Maximum Junction Temperature -- 150℃
- ✧ Operating Ambient Temperature Range (T_A) -- -40℃ to 85℃
- ✧ Storage Temperature -- -65℃ to 165℃
- ✧ Maximum Soldering Temperature (at leads, 10 sec) -- 260℃

Note 1. 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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information

- ✧ Maximum Power Dissipation (ESOP-8, P_D,T_A=25℃) -- 2W
- ✧ Thermal Resistance (ESOP-8, θ_{JA}) -- 50℃/W

ESD Susceptibility

- ✧ HBM(Human Body Mode) -- 2KV
- ✧ MM(Machine Mode) -- 200V

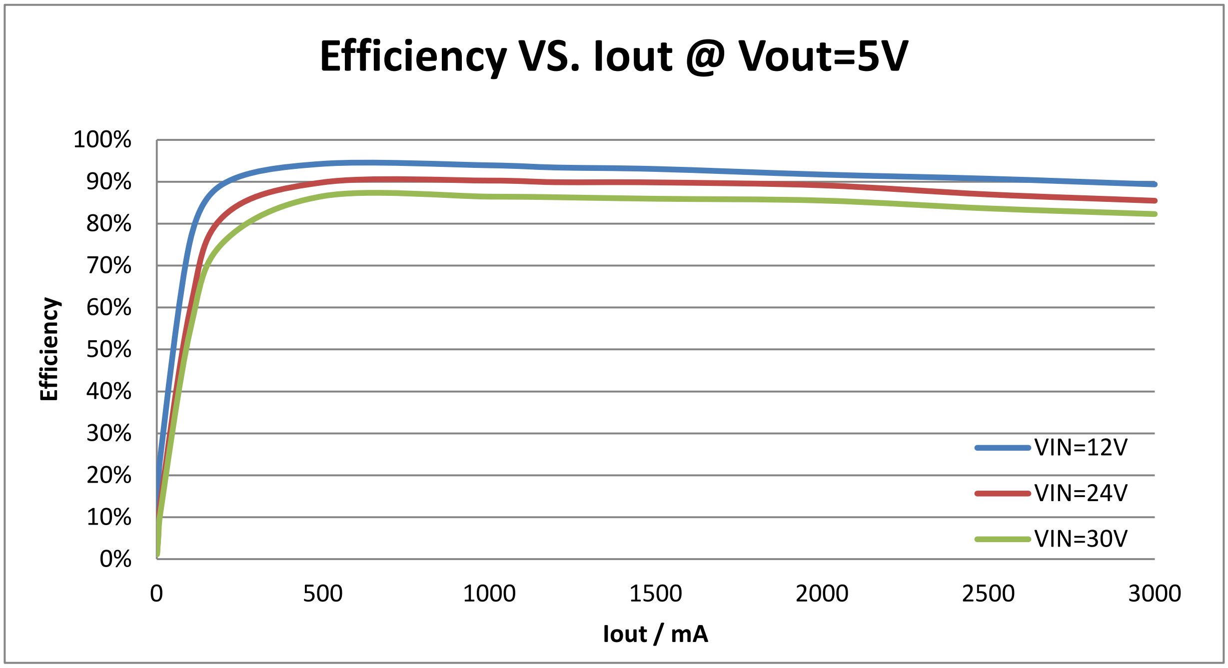
Electrical Characteristics

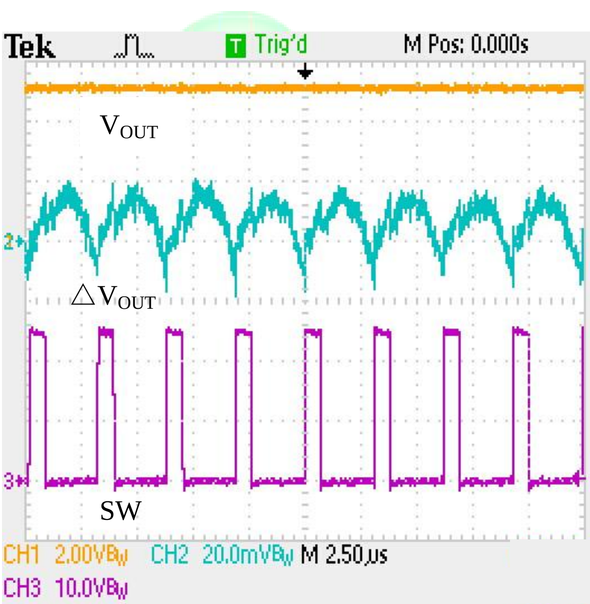
(V_{IN}=12V, V_{EN}=5V, L=10uH, C_{IN}=22uF, C_{OUT}=22uF+22uF+22uF typical values are T_A=25℃)

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{IN}	Input Voltage		4.5		36	V
ΔV_{OUT}	Output Voltage Line Regulation	I_{LOAD}=1mA to 2000mA		0.25	0.6	%/V
ΔV_{FB}	Reference Voltage Line Regulation	V_{IN}=5V to 30V, V_{EN}=5V		0.25	0.4	%/V
V_{OUT}	Output Voltage Range		0.923		12	V
V_{SW}	SW Voltage Range	V_{IN} and EN floating	0		0.3	V
I_Q	Quiescent Current	V_{IN}=12V			15	mA
I_{SHDN}	Shutdown Current	EN=GND			1	μA
I_{LIM}	P-Channel Current Limit		4			A
$R_{DS(ON)\_H}$	High-Side Switch On Resistance			80		mΩ
$R_{DS(ON)\_L}$	Low-Side Switch On Resistance			75		mΩ
I_{LX_LEAK}	LX Leakage Current	V_{EN}=0V, V_{SW}=0 or 5V, V_{IN}=5V		1		μA
V_{FB}	Feedback Threshold Voltage Accuracy	V_{IN}=12V	0.895	0.923	0.951	V
I_{FB}	FB Leakage Current	V_{OUT}=5.0V			30	nA
f_{OSC}	Oscillator Frequency			340		KHz
t_S	Startup Time	From Enable to Output Regulation		120		μs
T_{SD}	Over-Temperature Shutdown Threshold			150		℃
T_{HYS}	Over-Temperature Shutdown Hysteresis			20		℃
$V_{EN(L)}$	Enable Threshold Low				0.4	V
$V_{EN(H)}$	Enable Threshold High		2.5		6	V
I_{EN}	Input Low Current	V_{IN}=12V, V_{EN}=5V	-1		1	μA

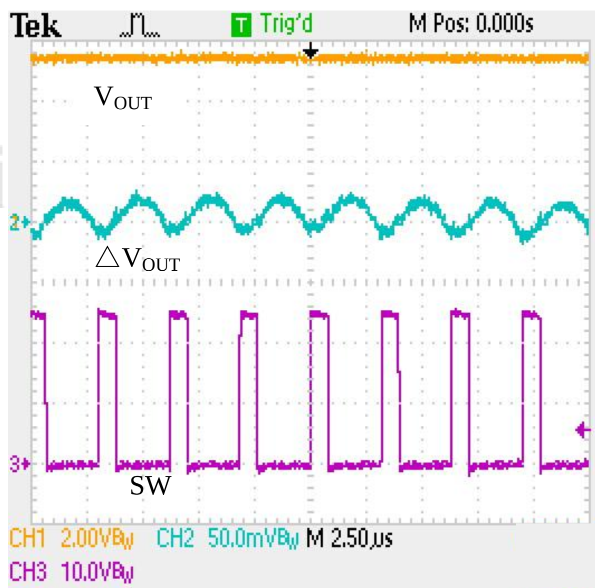
Note: Output Voltage: $V_{OUT} = V_{FB} \times (1 + R_1 / R_2)$ Volts;

Typical Operating Characteristics





V_{IN}=24V, V_{OUT}=5V, I_{OUT}=2.5A



V_{IN}=24V, V_{OUT}=5V, I_{OUT}=3.2A

Operation Information

Functional Description

The LP6483S is a high output current monolithic switch-mode step-down DC-DC converter. The device operates at a fixed 340KHz switching frequency, and uses a slope compensated current mode architecture. This step-down DC-DC converter can supply up to 3A output current at V_{OUT}=3.3V and has an input voltage range from 4.5V to 36V. It minimizes external component size and optimizes efficiency at the heavy load range. The integrated slope compensation allows the device to remain stable over a wider range of inductor values so that smaller values (6.8μH to 33μH) with lower DCR can be used to achieve higher efficiency. The device can be programmed with external feedback to any voltage, ranging from 0.923V to 12V. It uses internal MOSFETs to achieve high efficiency and can generate very low output voltages by using an internal reference of 0.923V. At dropout, the converter duty cycle increases to 90% and the output voltage tracks the input voltage minus the low $R_{DS(ON)}$ drop of the P-channel high-side MOSFET and the inductor DCR. The internal error amplifier and compensation provides excellent transient response, load and line regulation.

Enable The Chip

The enable pin is active high(2.5V to 6.0V). When pulled low, the enable input (EN) forces the LP6483S into a low-power, non-switching state. The total input current during shutdown is less than 1μA. When apply LP6483S to a circuit, there should be a 500KΩ resistance between EN and GND.

Current Limit and Over-Temperature Protection

For overload conditions, the peak input current is limited to 3A. To minimize power dissipation and stresses under current limit and short-circuit conditions, switching is terminated after entering current limit condition. The termination lasts for seven consecutive clock cycles after a current limit has been sensed during a series of four consecutive periods of oscillations. Thermal protection completely disables switching when internal dissipation becomes excessive. The junction over-temperature threshold is 150℃ with 20℃ of hysteresis. Once an over-temperature or over-current fault conditions is removed, the output voltage automatically recovers.

Dropout Operation

When input voltage decreases near the value of the output voltage, the LP6483S allows the main switch to remain on for more than one switching cycle and increases the duty cycle until it reaches 90%. The duty cycle D of a step-down converter is defined as:

$$\mathbf{D} = \mathbf{t_{ON}} \times \mathbf{f_{OSC}} \times \mathbf{100\%} = \frac{\mathbf{V_{OUT}}}{\mathbf{V_{IN}}} \times \mathbf{100\%}$$

Where t_{ON} is the main switch on time and f_{OSC} is the oscillator frequency.

Setting the Output Voltage

The LP6483S can be externally programmed. Feedback resistors R1 and R2 program the output to regulate at a voltage higher than 0.923V. To limit the bias current required for the external feedback resistor string while maintaining good noise immunity, the minimum suggested value for R2 is 33kΩ. Although a larger value will further reduce quiescent current, it will also increase the impedance of the feedback node, making it more sensitive to external noise and interference. The LP6483S, combined with an external feed forward capacitor, delivers enhanced transient response for extreme pulsed load applications. The addition of the feed forward capacitor typically requires a larger output capacitor C2 for stability. The external resistor sets the output voltage according to the following equation:

$$\mathbf{V_{OUT} = 0.923V \times (1 + \frac{R_1}{R_2})}$$

$$\mathbf{R_1 = (\frac{V_{OUT}}{0.923V} - 1) \times R_2}$$

Inductor Selection

For most designs, the LP6483S operates with inductor values of 6.8μH to 33μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

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

Where ΔIL is inductor ripple current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 60% of the maximum load current 3A, or

$$\Delta I_L = 1800mA$$

Manufacturer's specifications list both the inductor DC current rating, which is a thermal limitation, and the peak current rating, which is determined by the saturation characteristics. The inductor should not show any appreciable saturation under normal load conditions. Some inductors may meet the peak and average current ratings yet result in excessive losses due to a high DCR.

Always consider the losses associated with the DCR and its effect on the total converter efficiency when selecting an inductor. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 20mΩ to 100mΩ range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (3A + 900mA).

Output Capacitor Selection

The function of output capacitance is to store energy to attempt to maintain a constant voltage. The energy is stored in the capacitor's electric field due to the voltage applied. The value of output capacitance is generally selected to limit output voltage ripple to the level required by the specification. Since the ripple current in the output inductor is usually determined by L, V_{OUT} and V_{IN}, the series impedance of the capacitor primarily determines the out-put voltage ripple. The three elements of the capacitor that contribute to its impedance (and output voltage ripple) are equivalent series resistance (ESR), equivalent series inductance (ESL), and capacitance (C). The output voltage droop due to a load transient is dominated by the capacitance of the ceramic output capacitor. During a step increase in load current, the ceramic output capacitor alone supplies the load current until the loop responds. Within three switching cycles, the loop responds and the inductor current increases to match the load current demand. The relationship of the output voltage droop during the three switching cycles to the output capacitance can be estimated by:

$$C_{OUT} = \frac{3 \times \Delta I_{LOAD}}{V_{DROP} \times f_S}$$

In many practical designs, to get the required ESR, a capacitor with much more capacitance than is needed must be selected. For continuous or discontinuous inductor current mode operation, the ESR of the C_{OUT} needed to limit the ripple to ΔVo, V peak-to-peak is:

$$ESR \le \frac{\Delta V_{OUT}}{\Delta I_L}$$

Ripple current flowing through a capacitor's ESR causes power dissipation in the capacitor. This power dissipation causes a temperature increase internal to the capacitor. Excessive temperature can seriously shorten the expected life of a capacitor. Capacitors have ripple current ratings that are dependent on ambient temperature and should not be exceeded. The output capacitor ripple cur-rent is the inductor current, IL, minus the output current, Io.

Thermal Calculations

There are three types of losses associated with the LP6483S step-down converter: switching losses, conduction losses, and quiescent current losses. Conduction losses are associated with the $R_{DS(ON)}$ characteristics of the power output switching devices. Switching losses are dominated by the gate charge of the power output switching devices.

At full load, assuming continuous conduction mode (CCM), a simplified form of the losses is given by:

$$P_{TOTAL} = \frac{I_{OUT}^2 (R_{DSON(HS)} \times V_{OUT} + R_{DSON(LS)} \times (V_{IN} - V_{OUT}))}{V_{IN}} + (t_{SW} \times f \times I_{OUT} + I_Q) \times V_{IN}$$

I_Q is the step-down converter quiescent current. The term t_{SW} is used to estimate the full load step-down converter switching losses. For the condition where the step-down converter is in dropout at 90% duty cycle, the total device dissipation reduces to:

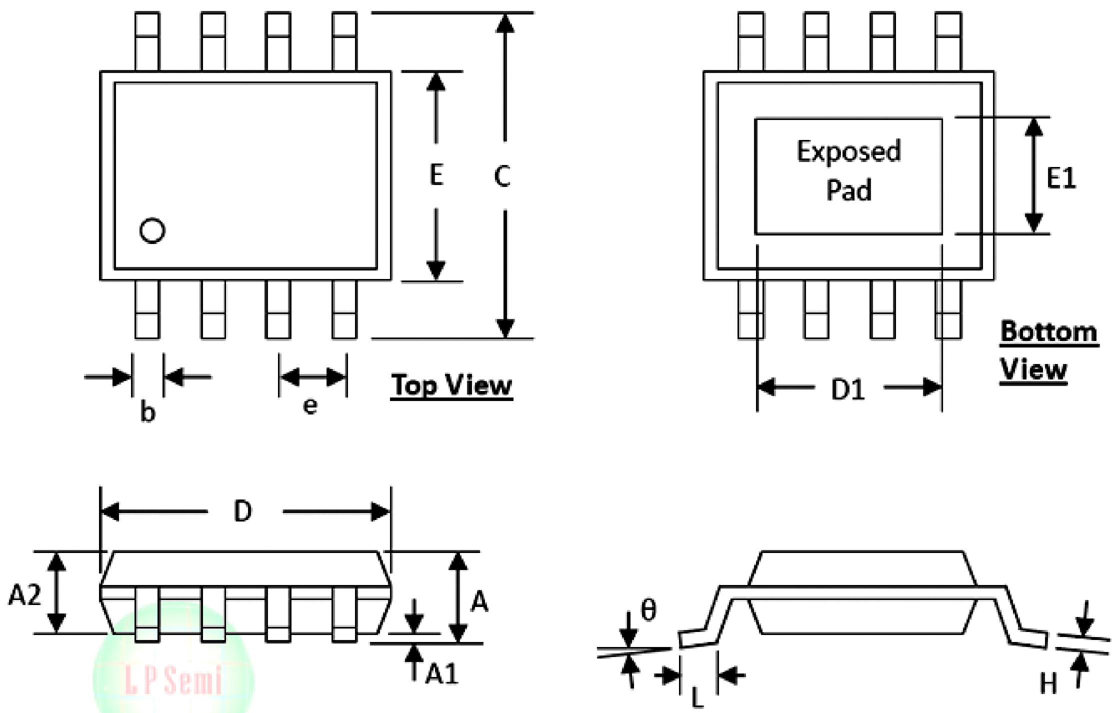
$$P_{TOTAL} = I_{OUT}^2 \times R_{DSON(HS)} + I_Q \times V_{IN}$$

Since $R_{DS(ON)}$, quiescent current, and switching losses all vary with input voltage, the total losses should be investigated over the complete input voltage range. Given the total losses, the maximum junction temperature can be derived from the θ_{JA} for the ESOP8 package which is 67°C/W.

$$T_{J(MAX)} = P_{TOTAL} \times \theta_{JA} + T_{AMB}$$

Packaging Information

ESOP8



SYMBOLS	DIMENSION (MM)		DIMENSION (INCH)	
	MIN	MAX	MIN	MAX
A	1.30	1.70	0.051	0.067
A1	0.00	0.15	0.000	0.006
A2	1.25	1.52	0.049	0.060
b	0.33	0.51	0.013	0.020
C	5.80	6.20	0.228	0.244
D	4.80	5.00	0.189	0.197
D1	3.15	3.45	0.124	0.136
E	3.80	4.00	0.150	0.157
E1	2.26	2.56	0.089	0.101
e	1.27 BSC		0.050 BSC	
H	0.19	0.25	0.0075	0.0098
L	0.41	1.27	0.016	0.050
θ	0°	8°	0°	8°