

## 内置MOS, 9V, 9A高效率升压转换器

### ■ 特点

- 输入电压范围 $V_{IN}$ : 2.5V-8.5V
- 输出电压范围 $V_{OUT}$ :  $V_{IN}$ -9V
- 内置固定开关频率: 600kHz
- 内置60m $\Omega$ , 9A功率开关管
- 高转换效率:  
88% ( $V_{IN} = 3.7V$ ,  $V_{OUT} = 7.5V$ ,  $I_{OUT} = 1A$ )
- 限流保护功能, 外部可调节
- 输出过压 (9.3V)、热关断等保护
- SOP8L-PP, 无铅封装

### ■ 应用

- 智能音箱
- 便携式音箱
- 移动电源
- 无线音箱
- 电子烟
- 拉杆音箱

### ■ 典型应用图

### ■ 概述

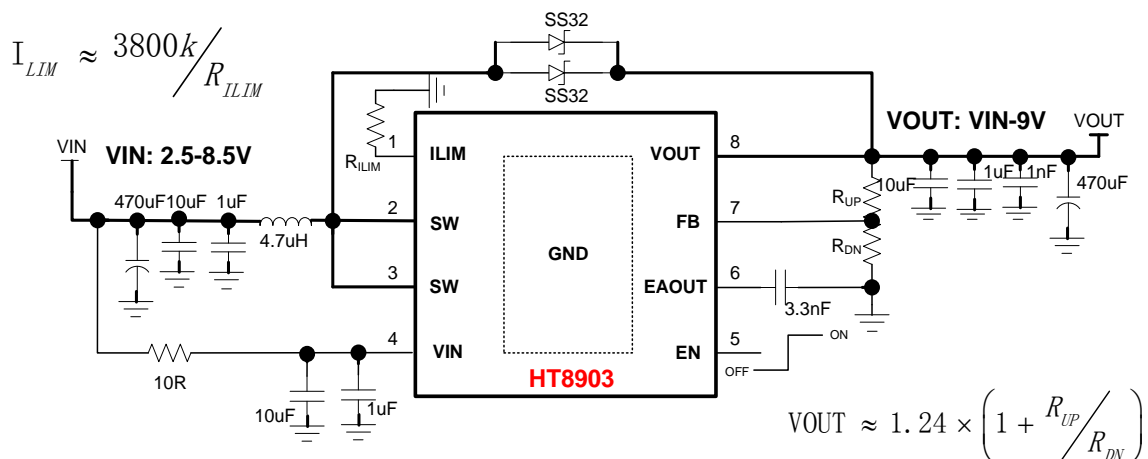
HT8903是一款采用CMOS工艺的升压转换器, 内部集成了60m $\Omega$ , 9A功率开关管。

HT8903具有2.5V至8.5V的输入电压范围, 可为采用单节或两节锂电池的应用提供支持。该器件具备9A开关电流能力, 并且能够提供最高9V的输出电压。

HT8903具有可外部调节的限流保护功能, 不仅可保护芯片过流, 亦可有效防止电池被拉死。

HT8903外围精简, 采用SOP8L-PP封装, 使用和测试简单, 为便携式系统提供了高效的小尺寸解决方案。

HT8903内置了9.3V的过压保护和过热关断保护功能。



## 9V,9A Non-Synchronous Boost Converter

### FEATURES

- Input voltage range  $V_{IN}$ : 2.5V to 8.5V
- Output voltage range  $V_{OUT}$ :  $V_{IN}$  to 9V
- Internal Fixed PWM Frequency: 600kHz
- Internal 60m $\Omega$ , 9A power MOSFET
- High Efficiency  
88% ( $V_{IN} = 3.7V$ ,  $V_{OUT}=7.5V$ ,  $I_{OUT} = 1A$ )
- Adjustable Current Limitation
- Output overvoltage protection (at 9.3V), thermal shutdown protection
- Pb-free Packages, SOP8L-PP

### APPLICATIONS

- Wireless Speakers    • Portable Speakers
- Quick Charge Power Bank    • E-Cigarette
- Power bank                      • POS Terminal

### DESCRIPTION

The HT8903 is a non-synchronous boost converter integrated with a 60m $\Omega$  power switch to provide a high efficiency and small size solution in portable systems.

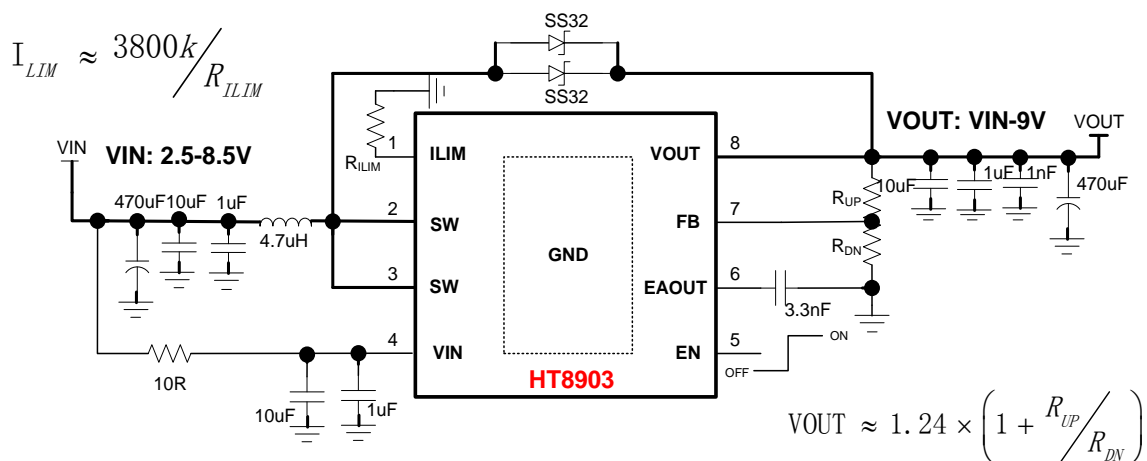
The HT8903 has an input voltage range from 2.5 V to 9V to support applications with single cell and two cell Lithium batteries. The device has 9A switch current capability and can provide an output voltage up to 9V.

A function of adjustable Current limitation is available to protect HT8903 from over current during operation, and to prevent the battery from being over-pulled caused by an overload.

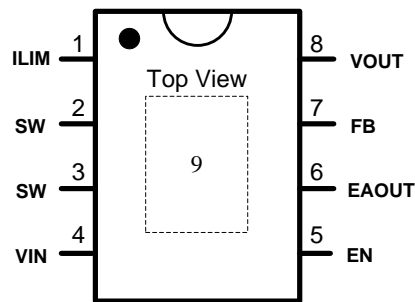
The HT8903 is available in SOP8L-PP, with very limited external components, so that it provides space-saving PCB for various applications.

The HT8903 provides 9.3V output overvoltage protection, and thermal shutdown protection.

### TYPICAL APPLICATION



**■ TERMINAL CONFIGURATION**



**■ TERMINAL FUNCTION**

Terminal No.	NAME	I/O <sup>*1</sup>	Description
1	ILIM	O	Adjustable switch peak current limit. An external resistor should be connected between this pin and the GND pin.
2,3	SW	PWR	The switching node pin of the converter.
4	VIN	I	IC power supply input.
5	EN	I	Enable logic input. Logic high level enables the device. Logic low level disables the device and turns it into shutdown mode.
6	EAOUT	O	Error amplifier output. Connect a 3.3nF capacity to GND.
7	FB	I	Voltage feedback.
8	VOUT	PWR	Boost converter output.
9	GND	PWR	Power ground of the IC.

<sup>1</sup> I: input O: output PWR: power

**ORDERING INFORMATION**

Part Number	Package Type	Marking	Operating Temperature Range	Shipping Package / MOQ
HT8903SPET	SOP8L-PP	HT8903SP	-40°C~85°C	Tube / 100PCS

**ELECTRICAL CHARACTERISTIC**

● **Absolute Maximum Ratings<sup>\*2</sup>**

PARAMETER	Symbol	MIN	MAX	UNIT
Voltage range	SW	-0.3	11	V
	V <sub>IN</sub> , V <sub>OUT</sub>	-0.3	9.3	
Operating temperature range	T <sub>A</sub>	-40	85	°C
Operating junction temperature range	T <sub>J</sub>	-40	150	°C
Storage temperature range	T <sub>STG</sub>	-50	150	°C

● **Recommended Operating Conditions**

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
IC power supply voltage range	V <sub>IN</sub>		2.5		9	V
Output voltage range	V <sub>OUT</sub>		2.5		9	V
Inductance, effective value	L		2.2	4.7	10	μH
Input capacitance, effective value	C <sub>i</sub>			470		μF
Output capacitance, effective value	C <sub>o</sub>			470		μF
Operating temperature	T <sub>a</sub>		-40	25	85	°C
Operating junction temperature	T <sub>J</sub>		-40		125	°C

<sup>2</sup> Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

● **Electrical Characteristics<sup>3</sup>**

Condition:  $T_a = 25^\circ\text{C}$ ,  $V_{IN} = 2.7\text{V}-8.5\text{V}$ ,  $V_{OUT}=4.5-9\text{V}$ , unless otherwise specified.

**Power Supply**

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Input power voltage range	$V_{PIN}$		2.7		8.5	V
Under-voltage lockout (UVLO) threshold	$V_{IN\_UVLO}$	VIN rising	2.4			V
		VIN falling	2.1			V
VIN UVLO hysteresis	$V_{IN\_HYS}$			300		mV
Quiescent current	$I_Q$	$V_{IN} = 3.7\text{V}$ , $V_{OUT} = 7.5\text{V}$		20		$\mu\text{A}$
Shutdown current	$I_{SD}$	IC disabled, $V_{IN} = 3.7\text{V}$ , without current consumed by FB resistors.		1		$\mu\text{A}$

**Input and Output**

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
EN high threshold voltage	$V_{ENH}$		1.5			V
EN low threshold voltage	$V_{ENL}$				0.4	V
EN internal pull-down resistance	$R_{EN}$			300		k $\Omega$
EN delay time	$T_{delay}$			4.5		ms
Output voltage range	$V_{OUT}$		$V_{IN}$		9	V
Output overvoltage protection	$V_{OVP}$			9.3		V
Reference voltage at the FB pin	$V_{REF}$			1.24		V

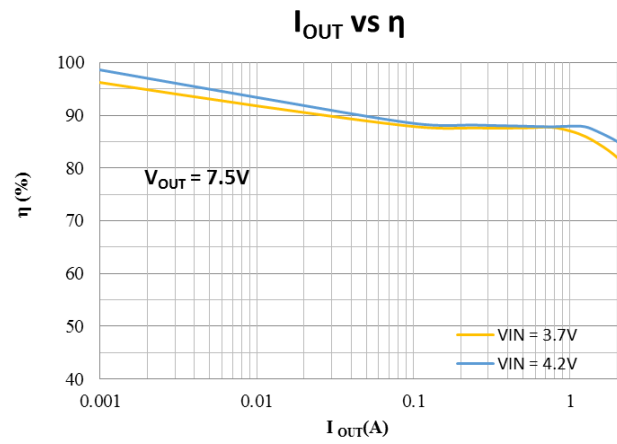
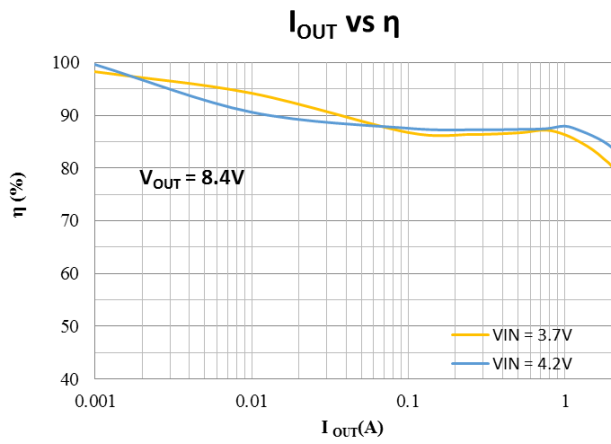
**Other characteristics**

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
<b>POWER SWITCH</b>						
MOSFET on-resistance	$R_{DS(on)}$			60		m $\Omega$
<b>CURRENT LIMIT</b>						
Peak switch current limit	$I_{LIM}$	$R_{ILIM} = 510\text{ k}\Omega$ ,		7.5		A
Boost converter start-up limit				2.8		A
Reference voltage at the ILIM pin	$V_{ILIM}$			1.24		V
<b>SWITCHING FREQUENCY</b>						
Switching frequency	$f_{sw}$			600		kHz
<b>Protection</b>						
Thermal shutdown threshold	$T_{SD}$			150		$^\circ\text{C}$
Thermal shutdown hysteresis	$T_{SD\_HYS}$			20		$^\circ\text{C}$

<sup>3</sup> Depending on parts and pattern layout, characteristics may be changed

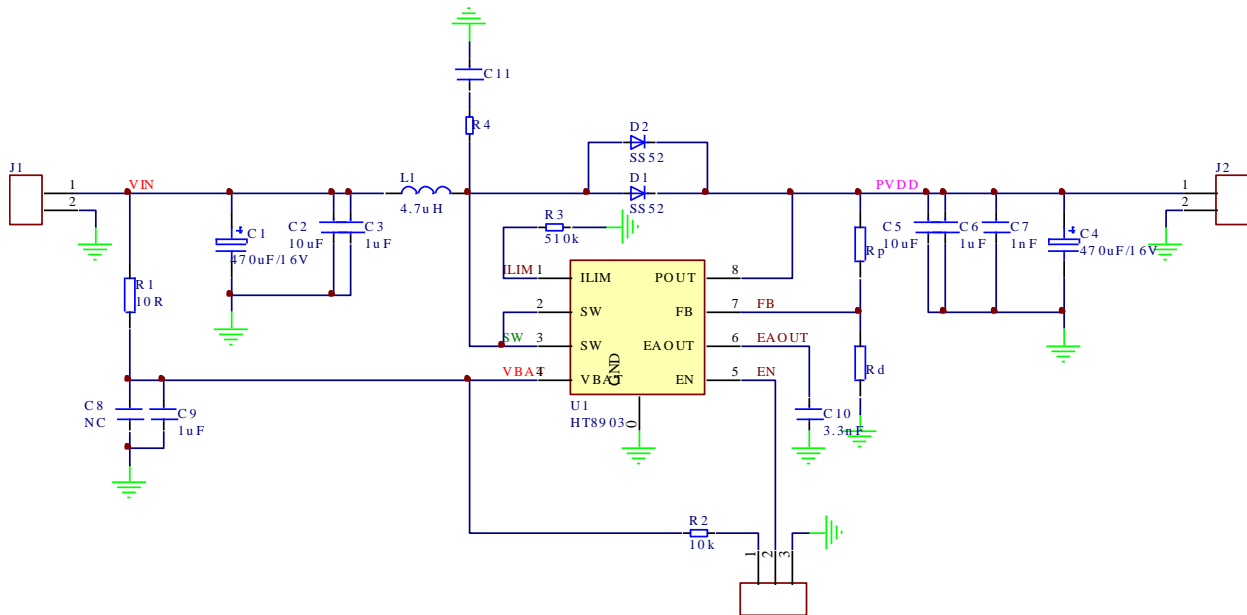
## TYPICAL OPERATING CHARACTERISTICS

Condition:  $L = 4.7\mu\text{H}$ ,  $R_{\text{LIM}} = 510\text{k}$ ,  $C_{\text{EAOUT}} = 3.3\text{nF}$ , Input Capacitor = Output Capacitor =  $1\mu\text{F}/10\mu\text{F}/470\mu\text{F}$ , otherwise specified.



APPLICATION INFORMATION

1. Typical Application



2. Feature Description

2.1. Operation

The non-synchronous boost converter HT8903 operates at a quasi-constant frequency pulse width modulation (PWM) in moderate to heavy load condition. The switching frequency is around 600kHz. It is optimized for single Li-Ion and Li-polymer battery powered products, in a wide range of wireless speakers, power bank and other portable devices. The converter integrates 60-mΩ /60-mΩ power switches and is capable of delivering up to 3-A output current for 3.7-V to 7.5-V conversion.

2.2. Current Limit Program

A resistor between ILIM and GND pin determines the peak switch current. The resistor value should be not larger than 510kohm, so that the current limit will be set below 7.5A.

2.3. Enable (EN pin)

When the EN pin is pulled into logic low (below 0.4V), the HT8903 goes into the shutdown mode and stops switching. Only when EN pin is pulled into logic high (above 1.5V), the HT8903 works.

2.4. Output Voltage Setting (FB pin)

The output voltage is set by an external resistor divider (R<sub>UP</sub>, R<sub>DN</sub> in the Typical Application Circuit). To get the output voltage V<sub>OUT</sub>, the Value of R<sub>UP</sub> and R<sub>DN</sub> can be calculated as:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_{UP}}{R_{DN}}\right)$$

Where V<sub>REF</sub> ≈ 1.24V.

Some typical output voltages can be set as the following parameters.

V <sub>OUT</sub> (V)	R <sub>UP</sub> (Ω)	R <sub>DN</sub> (Ω)
8.38	120k	22k
7.96	120k	23.2k
7.74	120k	24k
7.48	120k	24.9k

## 2.5. Inductor Selection (SW pin)

Because the selection of the inductor affects the power supply's steady state operation, transient behavior, loop stability, and boost converter efficiency, the inductor is the most important component in switching power regulator design. Three most important specifications to the performance of the inductor are the inductor value, DC resistance, and saturation current.

To be simplified, the inductor value can be set as 4.7μH which can be used in most cases.

The rated current, especially the saturation current should be larger than the peak current during the whole operation. The peak current can be calculated as follows.

$$I_{Lpeak} = I_{DC} + \frac{I_{PP}}{2}$$

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

$$I_{PP} = \frac{1}{L \times \left( \frac{1}{V_{OUT} - V_{IN}} + \frac{1}{V_{IN}} \right) \times f_{SW}}$$

Boost converter efficiency is affected significantly by the inductor's DC resistance (DCR), equivalent series resistance (ESR) at the switching frequency, and the core loss. An inductor with lower DCR and ESR would increase the efficiency significantly.

The inductor should be placed as close as possible to the SW pin.

## 2.6. Input Capacitor Selection

For good input voltage filtering and small voltage ripple (less than 100mV is required), we recommend low-ESR capacitors of 1μF//10μF//470μF ("//" represents paralleled) be placed as close as possible to the inductor.

The V<sub>IN</sub> pin is the power supply for the HT8903, a 1μF ceramic capacitor should be placed as close as possible to the V<sub>IN</sub> pin.

## 2.7. Output Capacitor Selection (V<sub>OUT</sub> pin)

To be simplified, we recommend low-ESR capacitors of 1μF//10μF//470μF ("//" represents paralleled) be placed as close as possible to V<sub>OUT</sub> pin for small output voltage ripple.

Capacitors can lose most of their capacitance at rated voltage. Therefore, leave margin on the voltage rating to ensure adequate effective capacitance.

## 2.8. Diode Selection

Schottky diode with fast recovery times and low forward voltages are recommended. Ensure the diode average and peak current rating exceed the average output current and peak inductor current. In addition, the diode's reverse breakdown voltage must exceed the output voltage.

## 2.9. EAOUT pin

The HT8903 requires external compensation for the stability of boost converter. The EAOUT pin is the output of the internal error amplifier. An external ceramic capacitors C<sub>C</sub> is connected from the EAOUT pin to





GND. To be simplified,  $C_C$  is 3.3nF which can be adopted in most cases.

## 2.10. Protection Function

### Under-voltage Lockout (UVLO)

The UVLO circuit prevents the device from malfunctioning at low input voltage and the battery from excessive discharge. It disables the device from switching when the falling voltage at the  $V_{IN}$  pin trips the UVLO threshold  $V_{IN\_UVLO}$ , which is typically 2.4V. The device starts operating when the rising voltage at the  $V_{IN}$  pin is 300mV above the  $V_{IN\_UVLO}$ .

### Over-voltage Protection

If the output voltage at the  $V_{OUT}$  pin is detected above 9.3 V (typical value), the HT8903 stops switching immediately until the voltage at the  $V_{OUT}$  pin drops the hysteresis value lower than the output overvoltage protection threshold. This function prevents overvoltage on the output and secures the circuits connected to the output from excessive overvoltage.

### Thermal Shutdown

A thermal shutdown is implemented to prevent damages due to excessive heat and power dissipation. Typically, the thermal shutdown happens at a junction temperature of 150°C. When the thermal shutdown is triggered, the device stops switching until the junction temperature falls below typically 130°C, then the device starts switching again.





### 3. Application Notes

#### 3.1. Radiated EMI Reduction

##### (1) Minimize High di/dt Path Loop Area

EMI Starts off from high di/dt loops. The high di/dt critical path locates as the red circle showed in the following figure. The output capacitor should be placed as close to the VOUT pin as possible resulting in minimum area of the high di/dt loop.

##### (2) PCB Trace and Ground Plane

High trace inductance leads to poor radiation EMI. The inductance of a PCB trace is a function of its length and width. So, increase the trace width and decrease the trace length will significantly decrease the radiation EMI.

Meanwhile, good designed ground planes will help decrease the radiation EMI too:

- Placing a solid ground plane with minimum distance to the critical trace;
- Wider and bigger ground plane result in smaller signal trace inductance;
- Thinner insulation thickness between the ground plane and the signal traces also results in smaller inductance;

##### (3) RC Snubber

Adding an RC snubber across the SW pin and the power ground can help reduce the radiation EMI levels. The RC snubber should be placed as close as possible to the switching node and the power ground.

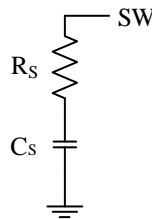


Figure 1 Placement of RC Snubber

The aim of the snubber resistor  $R_S$  is to add sufficient damping to the parasitic resonant circuit. The value of  $R_S$  depends on the desired damping factor and the parasitic inductor  $L_P$  and parasitic capacitor  $C_P$  of the circuit:

$$R_S = \frac{1}{\xi} \times \sqrt{\frac{L_P}{C_P}}$$

Where  $\xi$  is the damping factor, normally can range from 0.5 to 1.

The value of  $L_P$  and  $C_P$  can be measured by:

- Measure the original ringing frequency  $f_{RING}$ ;
- Add some small capacitance from switch node to ground. Keep increasing capacitance until the ringing frequency is 50% of the original ringing frequency  $f_{RING}$ , and the capacitance is  $C_S$ ,  $C_P = 1/(3C_S)$ ;
- $L_P = \frac{1}{C_P \times (2\pi \times f_{RING})^2}$

To be simplified, a resistor of 1ohm ( $R_S$ ) and a capacitor of 2.2nF ( $C_S$ ) can be used. However, notice that larger  $C_S$  results in higher power loss.

##### (4) Radiation from Cables

A longer input or output cables result in poor radiation EMI. So, make the length of input cable and output cable very close to the real application.

##### (5) Ferrite Bead

Ferrite Bead is used in series with the power line. Before using a ferrite bead, you need to consider about the specifications of the bead as follows:

- The frequency characteristics

Make sure that the resistive impedance of the bead is much higher than the reactive impedance in the noise frequency range.

- The rated current

Make sure that the rated current of the bead should be at least 30% higher than the expected maximum current.

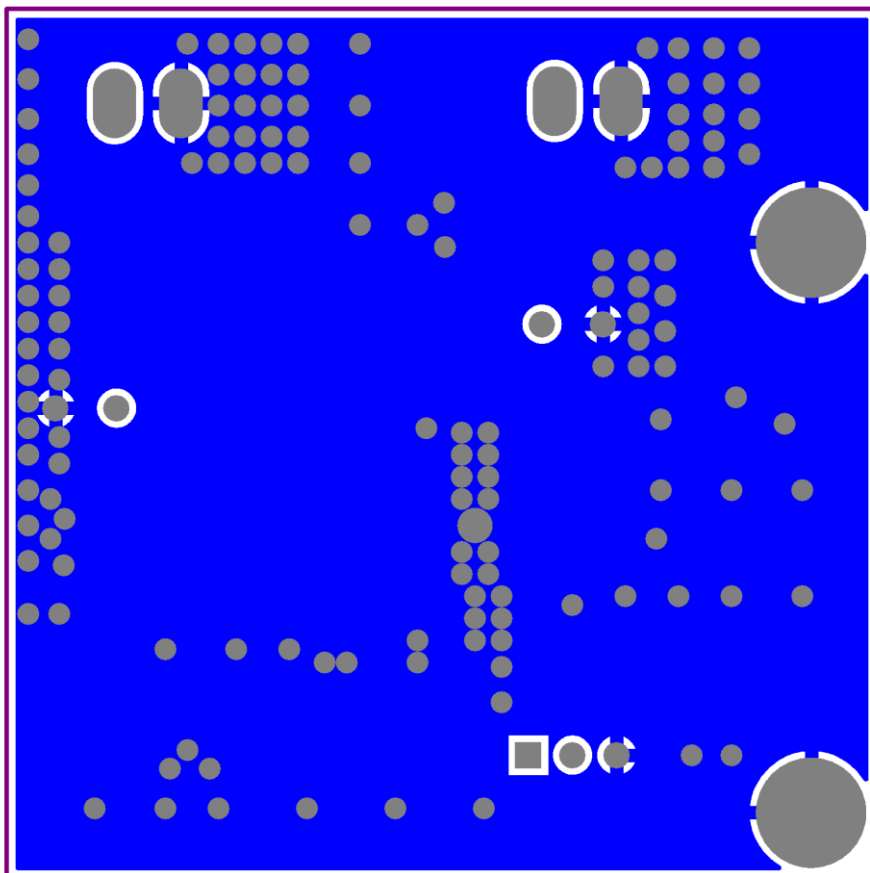
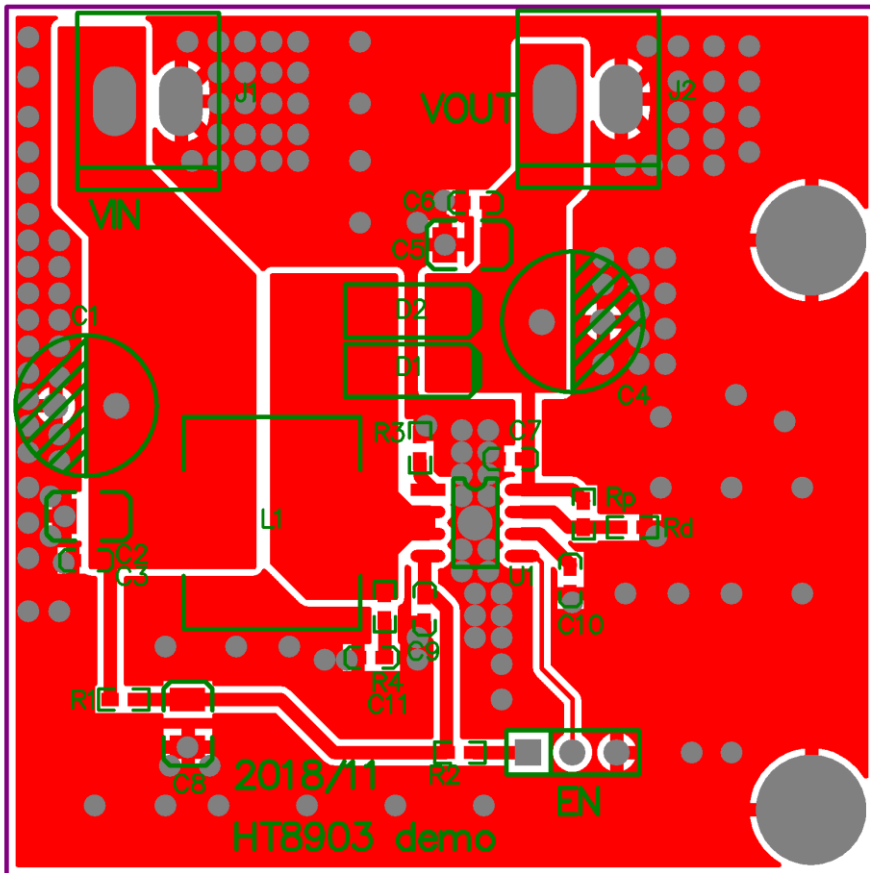
- The DC resistance

The DC resistance of the ferrite bead should be as low as possible.

### **3.2. Layout Guidelines**

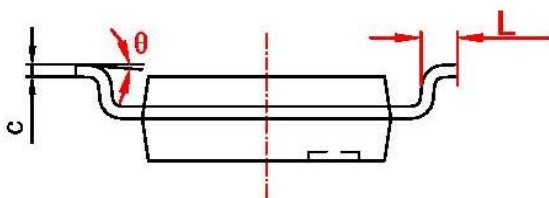
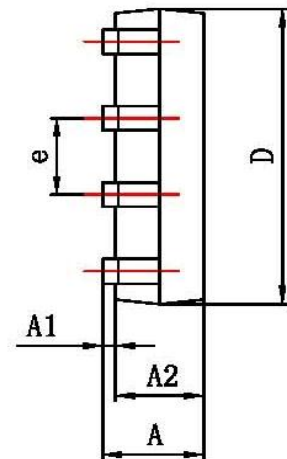
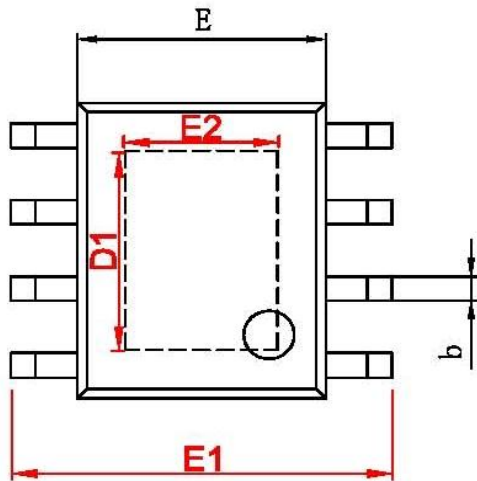
1. Minimize the length and area of all traces connected to the SW pin, and always use a ground plane under the switching regulator to minimize interplane coupling.
  2. The input capacitor needs to be close to inductor L, and GND pin in order to reduce the input supply ripple. The output capacitor needs to be close to VOUT pin and GND pin in order to reduce the output supply ripple.
  3. The layout should also be done with well consideration of the thermal as this is a high-power density device. A thermal pad that improves the thermal capabilities of the package should be soldered to the large ground plate, using thermal vias underneath the thermal pad.
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3.3. Layout Examples



■ PACKAGE OUTLINE

SOP8-PP(EXP PAD) PACKAGE OUTLINE DIMENSIONS



字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.002	0.006
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	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°