100V Input, 1.5A Current Limit, Non-synchronous Step-down Converter

General Description

The ET8A10AXKP is a high voltage, non-synchronous step-down converter operates over a wide range input voltage 9V to 100V. The ET8A10AXKP integrates a 100V 400mΩ high-side MOSFET.

The ET8A10AXKP delivers 1A continuous load current with up to 92% efficiency, it operates with fixed frequency peak current control with built-in compensation eliminates the need for external components. Cycle-by-cycle current limit in high-side MOSFET protects the converter in an overload condition. Hiccup mode protection is triggered if the over-current condition has persisted for longer than the present time.

The ET8A10AXKP exhibits protection features that protect the load from faults like under-voltage,over-current and over-temperature.

Features

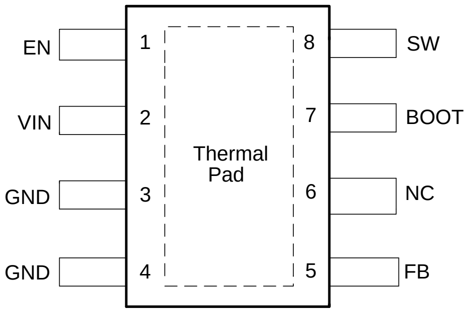
- 9V to 100V input voltage range
- 1A continuous load current , 1.5A current limit
- 92% Peak Efficiency
- 400μA operating quiescent current
- 9μA shutdown current
- 100V 400mΩ high-side MOSFET
- Peak Current mode control
- 300 kHz fixed frequency
- Internal compensation for ease of use
- Up to 92% duty cycle
- 0.8V voltage reference
- 150ms Hiccup mode short circuit protection function
- Thermal shutdown function
- Package:

Part No.	SW	Package	Body Size
ET8A10A1KP	150KHz	ESOP8	4.9mm × 3.9mm
ET8A10A3KP	300KHz	ESOP8	4.9mm × 3.9mm

Applications

- Charger in vehicle
- Battery Chargers
- Power adapter

Pin Configuration

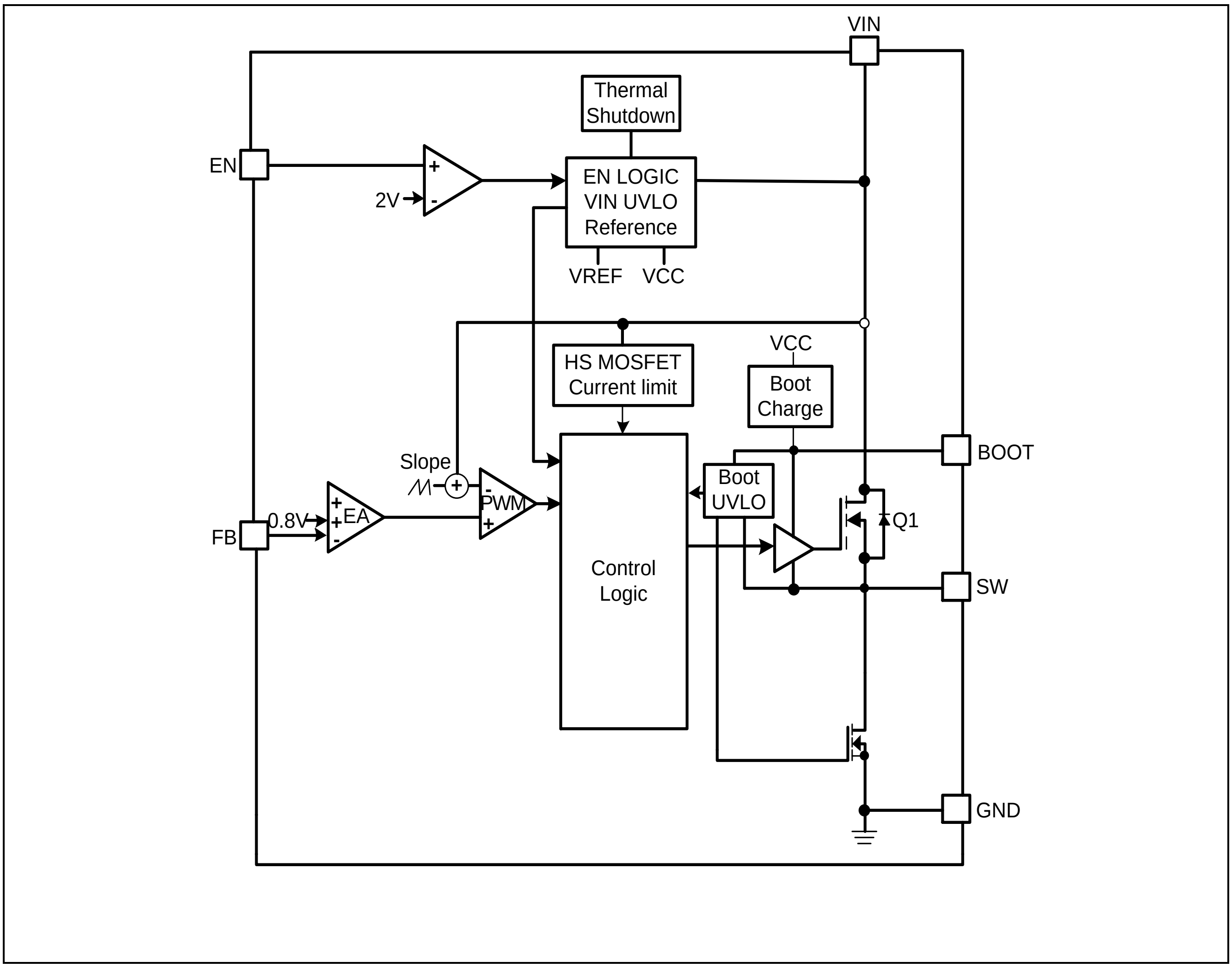


TOP VIEW

Pin Function

Pin No.	Pin Name	Pin Function
1	EN	**Enable input**. Pull EN below the specified threshold to shut down . Pull EN above the specified threshold to enable device .
2	VIN	**Input supply**. Connect a local bypass capacitor from VIN pin to GND pin. Path from VIN pin to high frequency bypass capacitor and GND must be as short as possible.
3 , 4	GND	**Ground**. GND should be placed as close to the output capacitor as possible to avoid the high-current switch paths. Connect the exposed pad to GND plane for optimal thermal performance.
5	FB	**Feedback**.Inverting input of the trans-conductance error amplifier. The tap of external feedback resistor divider from the output to GND sets the output voltage. The device regulates FB voltage to the internal reference value of 0.8V typical.
6	NC	**No Connection**
7	BOOT	**Bootstrap**. Power supply bias for high-side power MOSFET gate driver. Connect a 0.1uF capacitor from BOOT pin to SW pin. Bootstrap capacitor is charged when SW voltage is low.
8	SW	**Switch node**. SW is the output from the high-side switch. A low forward voltage schottky rectifier to ground is required. The rectifier must be placed close to SW to reduce switching spikes.
9	Thermal Pad	**Heat dissipation pad**. Electrically connection to GND pin. Must be connected to ground plane on PCB for proper operation and optimized thermal performance.

Block Diagram



Absolute Maximum Ratings

Item	Description	Range	Unit
V_{SW}, V_{EN}, V_{IN}	SW，EN，VIN Voltage	-0.3 ~ +110	V
V_{FB}	FB Voltage	-0.3 ~ +7	V
V_{BOOT}	BOOT to GND	-0.3 ~ +110.5	V
	BOOT to SW	-0.3 ~ +5.5	
T_{STG}	Storage Junction Temperature	-65 ~ 150	°C
T_J	Operating Junction Temperature	-40 to 150	°C
T_L	Lead Temperature (Soldering 10 sec.)	260	°C
V_{ESD}	HBM	±2000	V
	CDM	±200	V

Note: exceeding the range specified by the rated parameters will cause damage to the chip, and the working state of the chip beyond the range of rated parameters cannot be guaranteed. Exposure outside the rated parameter range will affect the reliability of the chip.

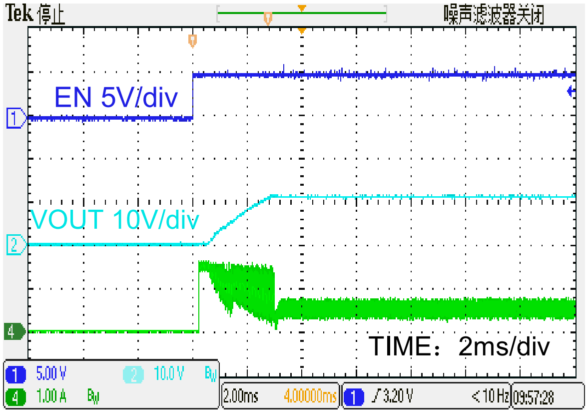
Electrical Characteristics

(V_{IN}=48V, V_{OUT}=5V, Typical values are at. T_A=25°C unless otherwise noted)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VCC SUPPLY VOLTAGE						
Input Voltage	V_{IN}		9		100	V
UVLO	V_{STRAT}	V_{IN} rising		8		V
UVLO Hysteresis	V_{UVLO1}			0.3		V
Shutdown Supply Current	I_{SHUT}	EN=0V,no load		9		uA
Input Quiescent Current	I_Q	EN floating, no load, non-switching		400		uA
ENABLE						
Enable Threshold Voltage	V_{EN}			2.2		V
Enable Threshold Voltage Hysteresis	V_{EN_HYS}			0.2		V
Enable Max Voltage	V_{EN_MAX}		100			V
FEEDBACK						
FB Reference Threshold	V_{FB}			0.8		V
Feedback Short Voltage	$V_{FB(short)}$			0.35		V
Feedback Short Voltage Hysteresis	V_{FB2}			0.1		V
OSCILLATOR						
Switching Frequency(A1)	F	I_{OUT}=500mA		150		kHz
Switching Frequency(A3)		I_{OUT}=500mA		300		
Maximum Duty Cycle	D_{MAX}	V_{IN}=12V		92		%
HIGH-SIDE MOSFET						
On-resistance	R_{DSON}	V_{IN}=18V		400		mΩ
CURRENT LIMIT						
Current Limit Threshold	I_{PEAK}			1.5		A
THERMAL SHUTDOWN						
Thermal shutdown Temp	T_{SD}			150		ºC
Thermal shutdown Temp Hysteresis	T_{SH}			30		ºC

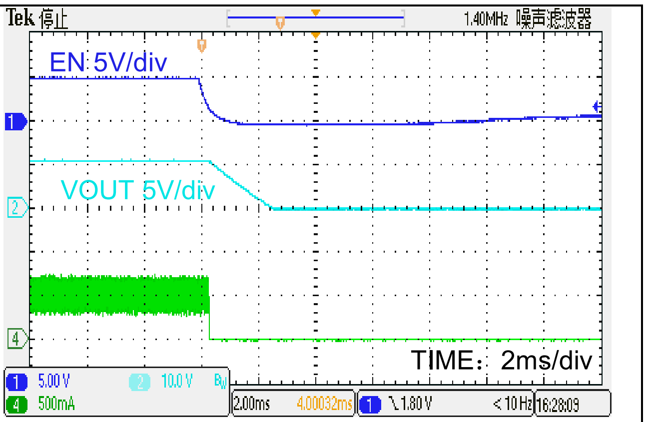
Typical Characteristics

(At T_A=25ºC, V_{IN}=48V, V_{OUT}=12V, Unless Otherwise Noted)



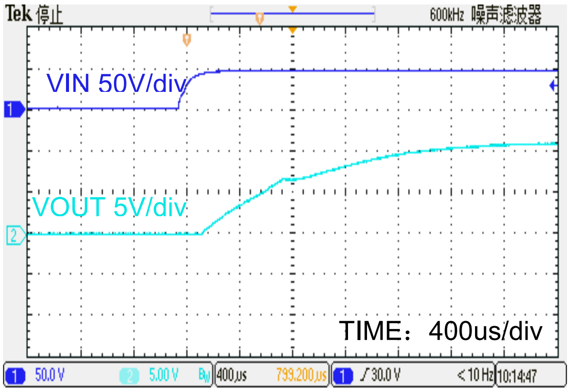
V_{IN}=48V EN=5V

Figure1 EN Start up



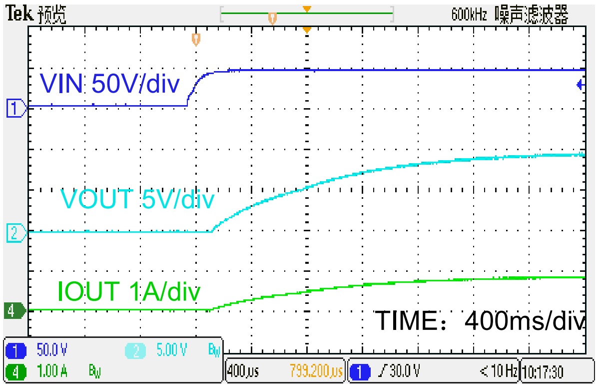
V_{IN}=48V EN=5V

Figure2 EN Turn off



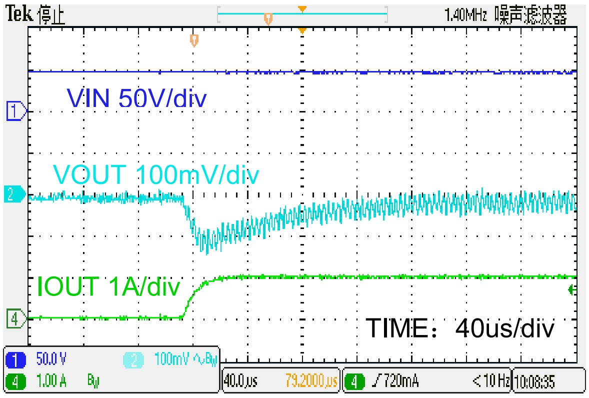
V_{IN}=48V I_{OUT}=0A

Figure3 Start up



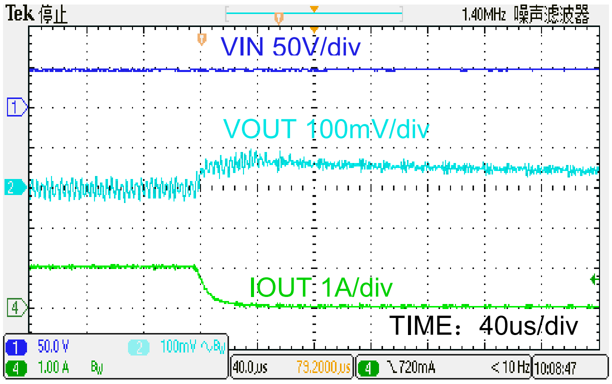
V_{IN}=48V I_{OUT}=700mA

Figure4 Start up



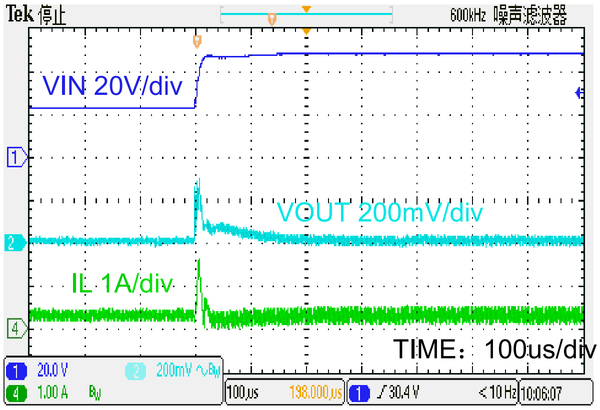
I_{OUT}=10mA~1A V_{IN}=48V

Figure5 Load Transient



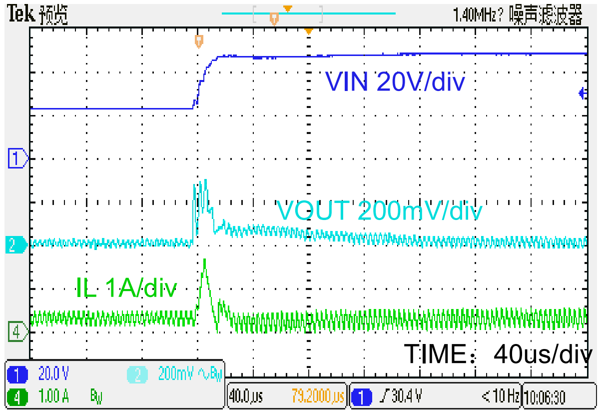
I_{OUT}=1A~10mA V_{IN}=48V

Figure6 Load Transient



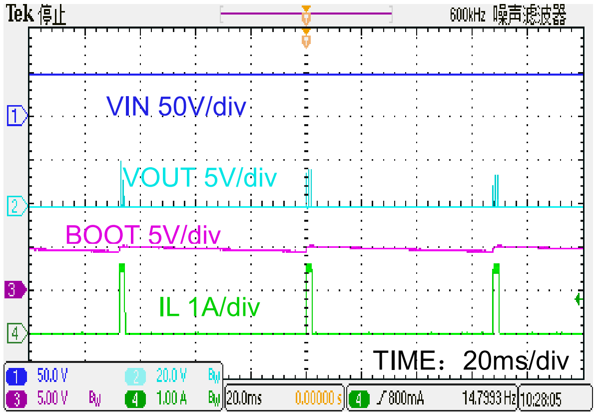
I_{OUT}=300mA V_{IN}=24V~48V

Figure7 Line Transient



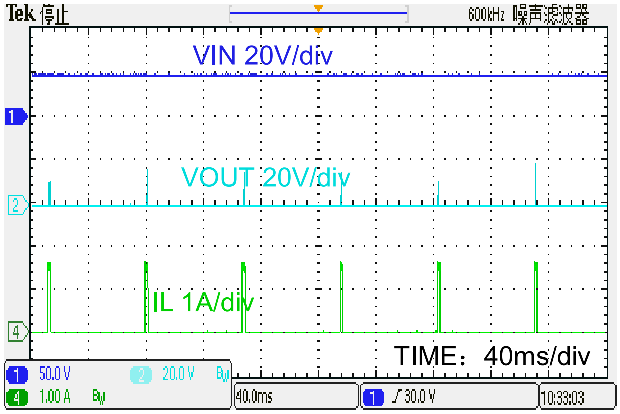
I_{OUT}=300mA V_{IN}=24V~48V

Figure8 Line Transient



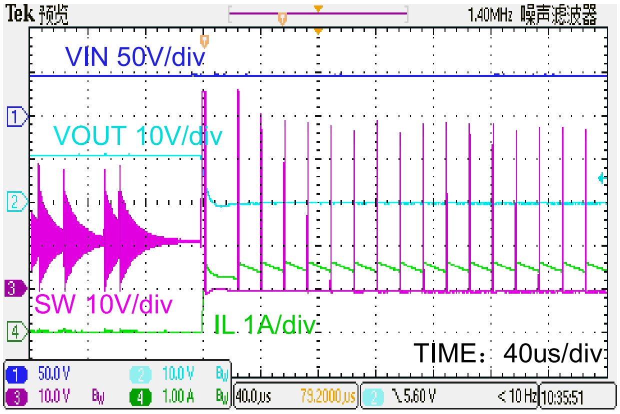
V_{IN}=24V I_{OUT}=0A

Figure9 Continuous Short Circuit



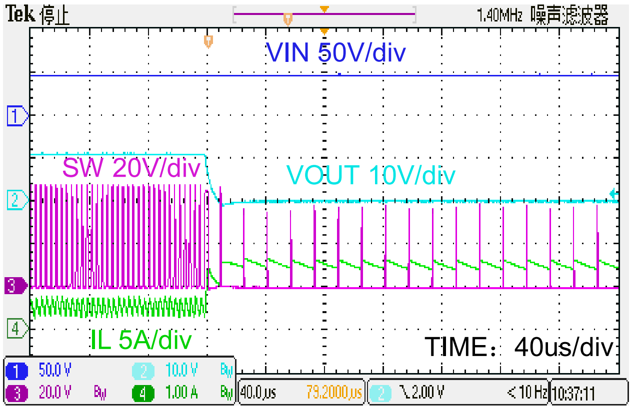
V_{IN}=48V

Figure10 Continuous Short Circuit



V_{IN}=48V I_{OUT}=0A

Figure11 Power On Short Circuit



V_{IN}=48V I_{OUT}=1A

Figure12 Power On Short Circuit

Efficiency

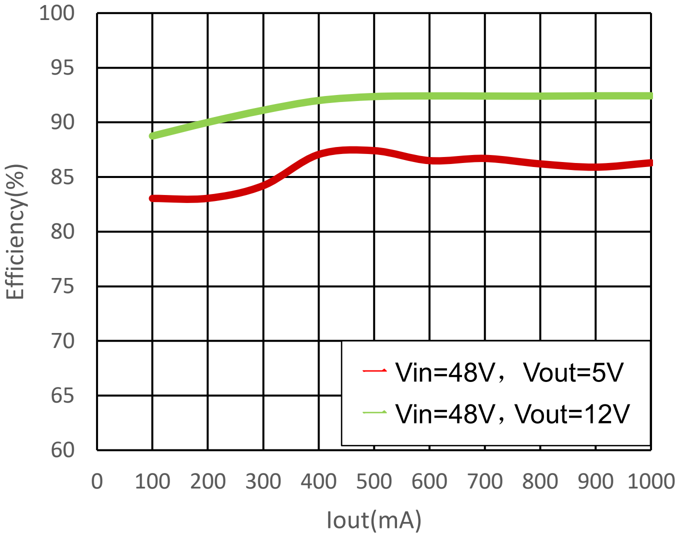


Figure 13. Efficiency

Application Circuits

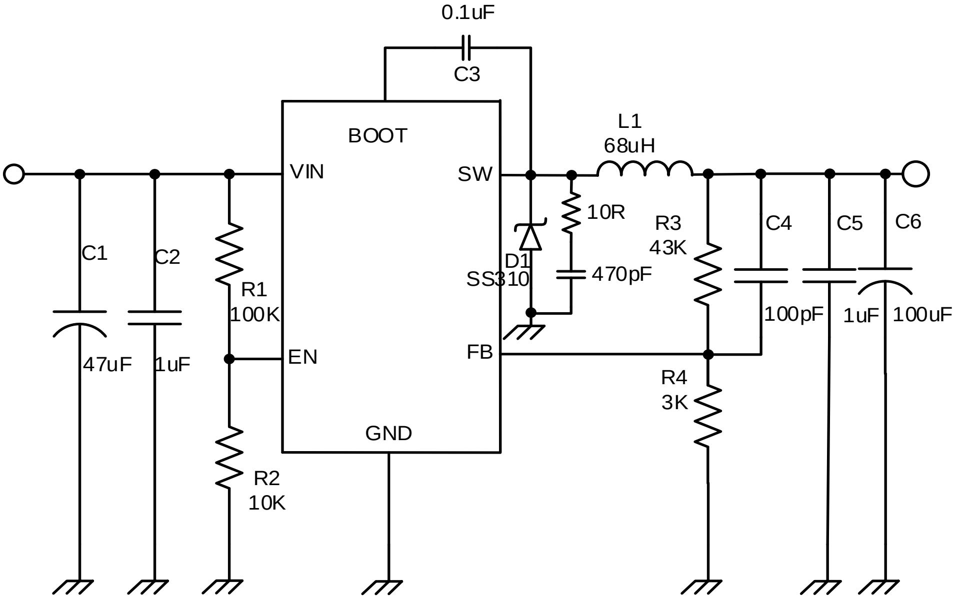


Figure14. Application Circuit 1

12V Output with Programmable UVLO

Design Parameters	Example Value
Input Voltage	48V
Output Voltage	12V
Maximum Output Current	2A
Switching Frequency	150K/300KHz
Start Input Voltage (rising VIN)	24V
Stop Input Voltage (falling VIN)	22V

Application Circuits(Continued)

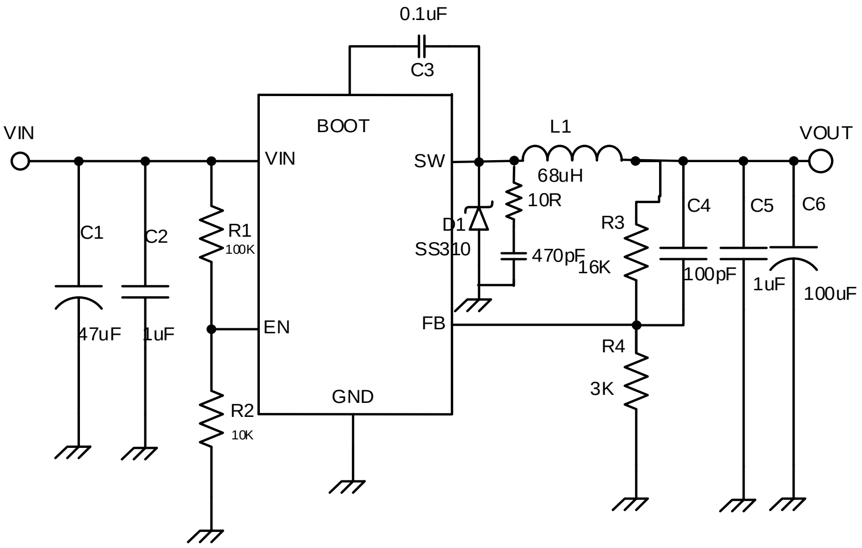


Figure15. Application Circuit 2

5V Output with Programmable UVLO

Design Parameters	Example Value
Input Voltage	48V
Output Voltage	5V
Maximum Output Current	2A
Switching Frequency	150K/300KHz
Start Input Voltage (rising VIN)	24V
Stop Input Voltage (falling VIN)	22V

Output Voltage

The output voltage is set by an external resistor divider R3 and R4 in typical application schematic.

Recommended R4 resistance is 10KΩ. Use equation 1 to calculate R3.

$$R_3 = \left(\frac{V_{OUT}}{V_{REF}} - 1\right) * R_4 \qquad (1)$$

Under Voltage Lock-Out

An external voltage divider network of R1 from the input to EN pin and R2 from EN pin to the ground can set the input voltage's Under Voltage Lock-Out (UVLO) threshold.

$$R_1 = \left(\frac{V_{UVLO}}{V_{EN}} - 1\right) * R_2 \qquad (2)$$

Inductor Selection

There are several factors should be considered in selecting inductor such as inductance, saturation current,RMS current and DC resistance(DCR). Larger inductance results in less inductor current ripple and lower output voltage ripple. However, the larger value inductor always corresponds to a bigger physical size,higher series resistance, and lower saturation current. A good rule for determining the inductance to use is to allow inductor peak-to-peak ripple current to be approximately 20%~40% of the maximum output current.The peak-to-peak ripple current in the inductor ILPP can be calculated as in Equation 3.

$$I_{LPP} = \frac{V_{OUT}*(V_{IN}-V_{OUT})}{V_{IN}*L*f_{SW}} \qquad (3)$$

- I_{LPP} is the inductor peak-to-peak current
- L is the inductance of inductor
- f_{SW} is the switching frequency
- V_{OUT} is the output voltage
- V_{IN} is the input voltage

Since the inductor-current ripple increases with the input voltage, so the maximum input voltage is always used to calculate the minimum inductance required. Use Equation 4 to calculate the inductance value

$$L_{MIN} = \frac{V_{OUT}}{f_{SW}*LIR*I_{OUT(max)}} * \left(1 - \frac{V_{OUT}}{V_{IN(max)}}\right) \qquad (4)$$

- L_{MIN} is the minimum inductance required
- fsw is the switching frequency
- V_{OUT} is the output voltage
- $V_{IN(max)}$ is the maximum input voltage
- $I_{OUT(max)}$ is the maximum DC load current
- LIR is coefficient of I_{LPP} to I_{OUT}

The total current flowing through the inductor is the inductor ripple current plus the output current. When selecting inductor, choose its rated current especially the saturation current larger than peak current and RMS current also not be exceeded. Therefore, the peak switching current of inductor, ILPEAK

and ILRMS can be calculated as in equation 5 and equation 6.

$$I_{LPEAK} = I_{OUT} + \frac{I_{LPP}}{2} \quad (5)$$

$$I_{LRMS} = \sqrt{(I_{OUT})^2 + \frac{1}{12} * (I_{LPP})^2} \quad (6)$$

- I_{LPEAK} is the inductor peak current
- I_{OUT} is the DC load current
- I_{LPP} is the inductor peak-to-peak current
- I_{LRMS} is the inductor RMS current

In overloading or load transient conditions, the inductor peak current can increase up to the switch current limit of device which is typically 1.5A. The most conservative approach is to choose an inductor with saturation current greater than 1.5A. Because of the maximum ILPEAK limited by device, maximum output current that can deliver depends on inductor current ripple. Thus, maximum desired output current affects the selection of inductance. The smaller inductor results in larger inductor current ripple leading to lower maximum output current.

Diode Selection

requires an external catch diode between the SW pin and GND. The selected diode must have areverse voltage ra-ting equal to or greater than VIN(max). The peak current rating of the diode must be greater than the maximum inductor current. Schottky diodes are typically a good choice for the catch diode due to low forward voltage. The lower the forward voltage of the diode, the higher the efficiency of the regulator.

Typically, diodes with higher voltage and current ratings have higher forward voltages. A diode with a minimum of100V reverse voltage is preferred to allow input voltage transients up to the rated voltage

For the example design, the SS310 Schottky diode is selected for its lower forward voltage and good thermal

characteristics compared to smaller devices. The typical forward voltage of the SS310 is 0.65 volts at 3 A.

The diode must also be selected with an appropriate power rating. The diode conducts the output current during off-time of the internal power switch.

Input Capacitor Selection

The input current to the step-down DCDC converter is discontinuous, therefore it requires a capacitor to supply AC current to the step-down DCDC converter while maintaining the DC input voltage. Use capacitors with low ESR better performance. Ceramic capacitors with X5R or X7R dielectrics are usually suggested low ESR and small temperature coefficients, and it is strongly recommended to use another lower value capacitor (e.g.1uF) with small package size (0805) to filter high frequency switching noise. Place the small size cap to VIN and GND pins as possible.

For this example, four 4.7uF, X7R ceramic capacitors rated for 100 V in parallel are used. And a 0.1uF for High frequency filtering capacitor is placed as close as possible to the device pins.

Bootstrap Capacitor Selection

A 0.1F ceramic capacitor must be connected between BOOT pin and SW pin for proper operation. capacitor with X5R or better grade dielectric is recommended. The capacitor should have a 10V or higher voltage.

Output Capacitor Selection

The selection of output capacitor will affect output voltage ripple in steady state and load transient performance.The output ripple is essentially composed of two parts. One is caused by the inductor current ripple going through

Equivalent Series Resistance ESR of the output capacitors and the other is caused by the inductor current ripplecharging and discharging the output capacitors. To achieve small output voltage ripple, choose a low-ESR outputcapacitor like ceramic capacitor. For ceramic capacitors, the capacitance dominates the output ripple. For simplification, the output voltage ripple can be estimated by Equation 7 desired.

$$\Delta V_{OUT} = \frac{V_{OUT} * (V_{IN} - V_{OUT})}{8 * f_{SW}{}^{2} * L * C_{OUT} * V_{IN}} \qquad (7)$$

- ΔV_{OUT} is the output voltage ripple
- F_{SW} is the switching frequency
- L is the inductance of inductor
- C_{OUT} is the output capacitance
- V_{OUT} is the output voltage
- V_{IN} is the input voltage

Typically, four 47F ceramic output capacitors work for most applications.

Applications Information

Over-current Protection

The ET8A10AXKP implements current-mode control which uses the internal COMP voltage to control the turn on and the turnoff of the high-side MOSFET on a cycle-by-cycle basis.

During each cycle,the switch current and the current reference generated by the internal COMP voltage are compared. When the peak switch current intersects the current reference the high-side switch turns off.

Furthermore,if an output overload condition occurs for more than the hiccup wait time,which is programmed for 512 switching cycles,the device shuts down and restarts after the hiccup time of 16384 cycles. The hiccup mode helps to reduce the device power dissipation under severe over-current conditions.

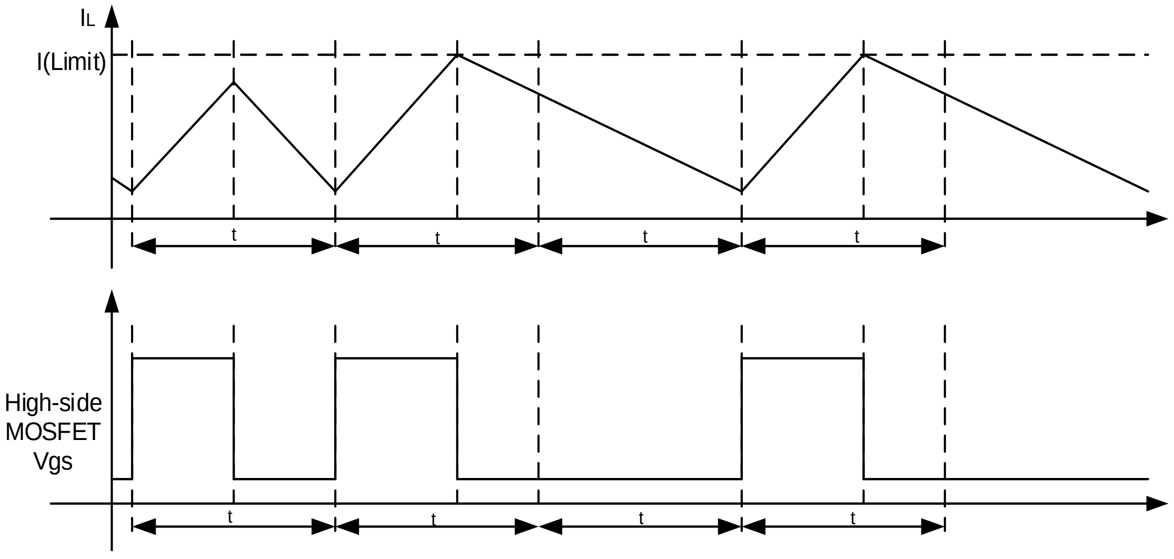


Figure16. Over-current Protection

Hiccup mode

If an output overload condition occurs for more than the hiccup wait time,which is programmed for 512 switching cycles(T1),the device shuts down and restarts after the hiccup time of 16384 cycles(T2). The hiccup mode helps to reduce the device power dissipation under severe over-current conditions.

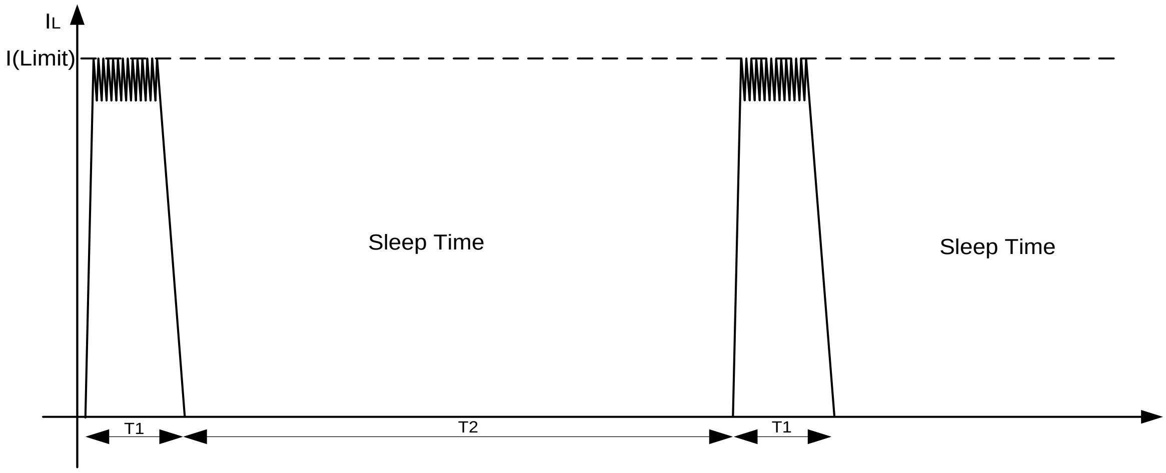


Figure17. Hiccup Mode

Layout

Proper PCB layout is a critical for MST8A10KP's stable and efficient operation. The traces conducting fast switching currents or voltages are easy to interact with stray inductance and parasitic capacitance to generate noise and degrade performance. For better results, follow these guidelines as below:

1. Power grounding scheme is very critical because of carrying power, thermal, and glitch/bouncing noise associated with clock frequency. The thumb of rule is to make ground trace lowest impendence and power are distributed evenly on PCB. Sufficiently placing ground area will optimize thermal and not causing over heat area.

2. Place a low ESR ceramic capacitor as close to VIN pin and the ground as possible to reduce parasitic effect.

3.Freewheeling diode should be place as close to SW pin and the ground as possible to reduce parasitic effect.

4.For operation at full rated load, the top side ground area must provide adequate heat dissipating area. Make sure top switching loop with power have lower impendence of grounding.

5. The bottom layer is a large ground plane connected to the ground plane on top layer by vias. The power pad should be connected to bottom PCB ground planes using multiple vias directly under the IC. The center thermal pad should always be soldered to the board for mechanical strength and reliability, using multiple thermal vias underneath the thermal pad. Improper soldering thermal pad to ground plate on PCB will cause SW higher ringing and overshoot besides downgrading thermal performance. it is recommended 8mil diameter drill holes of thermal vias, but a smaller via offers less risk of solder volume loss. On applications where solder volume loss thru the vias is of concern, plugging or tenting can be used to achieve a repeatable process.

6. Output inductor and freewheeling diode should be placed close to the SW pin. The switching area of the PCB conductor minimized to prevent excessive cap active coupling.

7. Route BOOT capacitor trace on the other layer than top layer to provide wide path for topside ground.

Layout Example

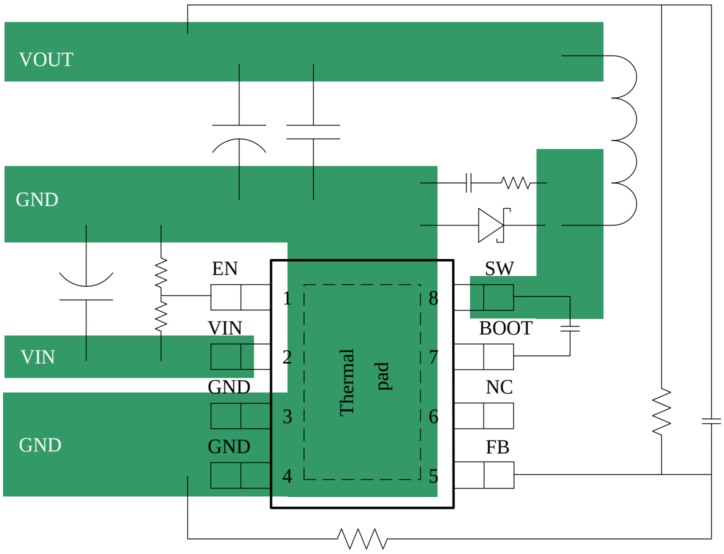


Figure18. PCB LAYOUT

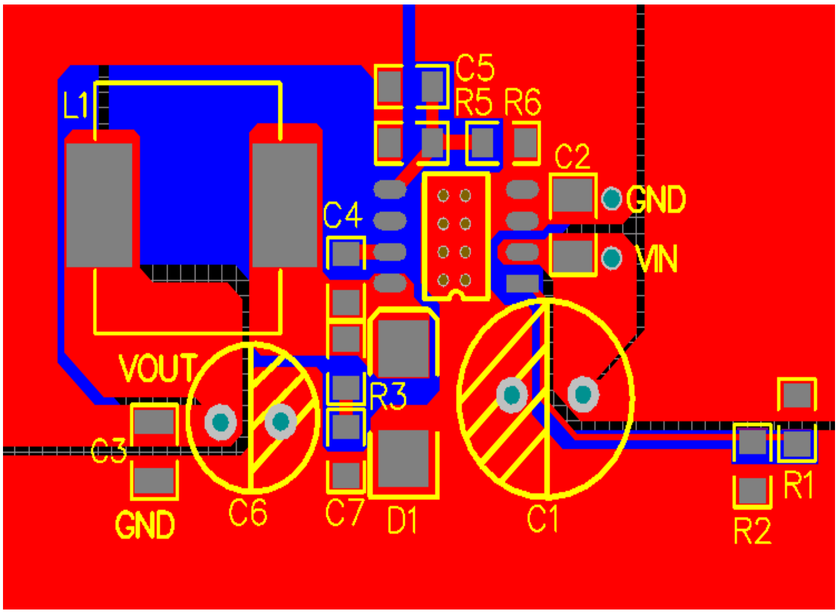
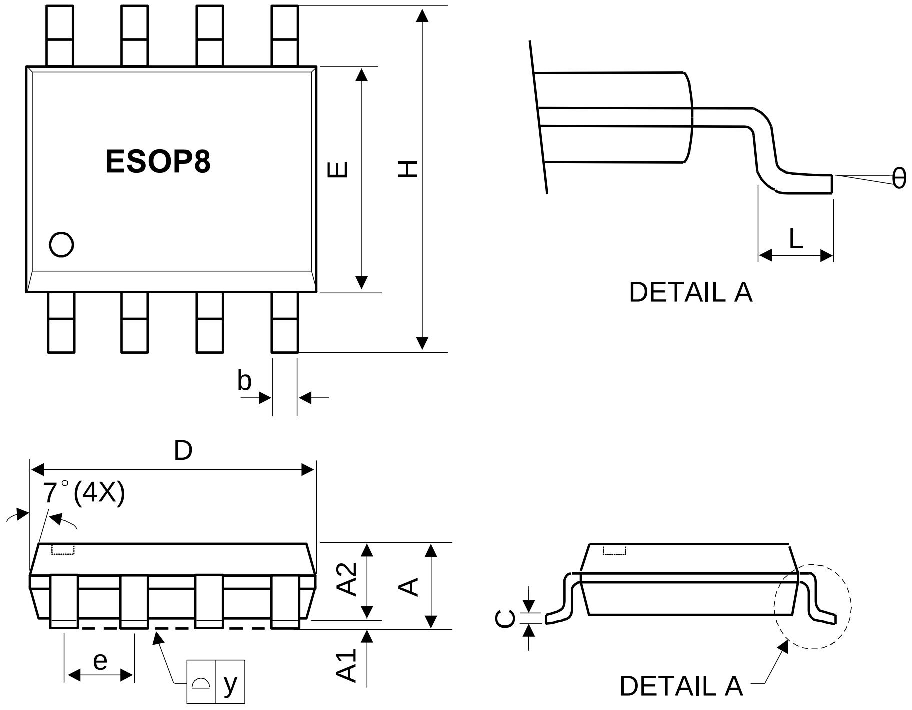


Figure19. Top Layer

Package Dimension

ESOP8



<table>
<tr><th rowspan="2">Symbol</th><th colspan="3">Millimetre</th><th colspan="3">Inch</th></tr>
<tr><th>Min</th><th>Typ</th><th>Max</th><th>Min</th><th>Typ</th><th>Max</th></tr>
<tr><td>A</td><td>-</td><td>-</td><td>1.75</td><td>-</td><td>-</td><td>0.069</td></tr>
<tr><td>A1</td><td>0.1</td><td>-</td><td>0.25</td><td>0.04</td><td>-</td><td>0.1</td></tr>
<tr><td>A2</td><td>1.25</td><td>-</td><td>-</td><td>0.049</td><td>-</td><td>-</td></tr>
<tr><td>C</td><td>0.1</td><td>0.2</td><td>0.25</td><td>0.0075</td><td>0.008</td><td>0.01</td></tr>
<tr><td>D</td><td>4.7</td><td>4.9</td><td>5.1</td><td>0.185</td><td>0.193</td><td>0.2</td></tr>
<tr><td>E</td><td>3.7</td><td>3.9</td><td>4.1</td><td>0.146</td><td>0.154</td><td>0.161</td></tr>
<tr><td>H</td><td>5.8</td><td>6</td><td>6.2</td><td>0.228</td><td>0.236</td><td>0.244</td></tr>
<tr><td>L</td><td>0.4</td><td>-</td><td>1.27</td><td>0.015</td><td>-</td><td>0.05</td></tr>
<tr><td>b</td><td>0.31</td><td>0.41</td><td>0.51</td><td>0.012</td><td>0.016</td><td>0.02</td></tr>
<tr><td>e</td><td colspan="3">1.27 BSC</td><td colspan="3">0.050 BSC</td></tr>
<tr><td>y</td><td>-</td><td>-</td><td>0.1</td><td>-</td><td>-</td><td>0.004</td></tr>
<tr><td>θ</td><td>0°</td><td>-</td><td>8°</td><td>0°</td><td>-</td><td>8°</td></tr>
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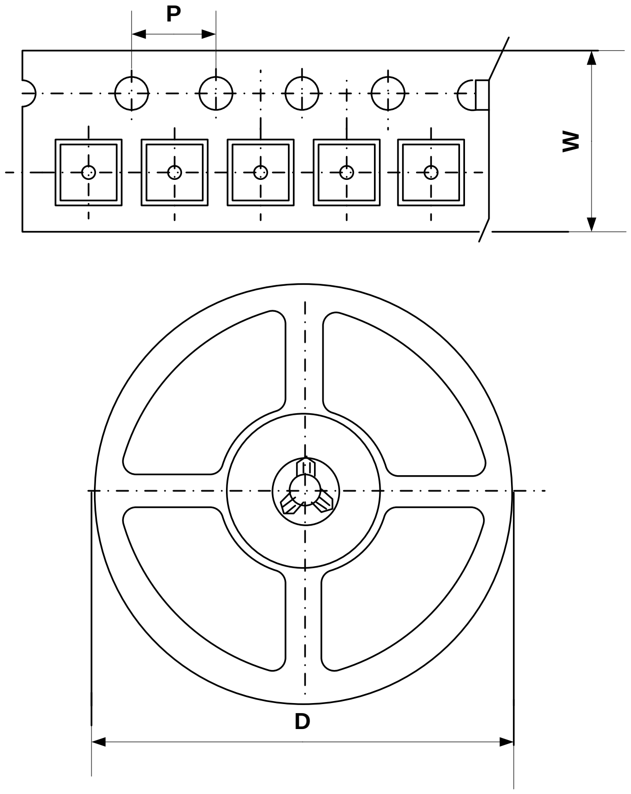
Packing Information



Type	W(mm)	P(mm)	D(mm)	Qty (pcs)
ESOP8	12.0±0.1 mm	8.0±0.1 mm	330±1 mm	2500pcs

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2022-9-20	Offed Version	Shibo	Shibo	Zhujl
1.1	2023-2-17		Shibo	Xingxiaolin	Xingxiaolin
1.2	2023-2-22	Update form	Shibo	Xingxiaolin	Xingxiaolin