# 100V Input, 5A Output, Synchronous Step-down Converter

## General Description

The ET8A50QA is a high voltage, synchronous step-down controller operates over a wide range input voltage 9V to 100V. The ET8A50QA delivers 5A continuous load current with up to 96% efficiency.

The ET8A50QA 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 ET8A50QA exhibits protection features that protect the load from faults like under-voltage,over-current and over-temperature.

The ET8A50QA is available in an QFN20.

## Features

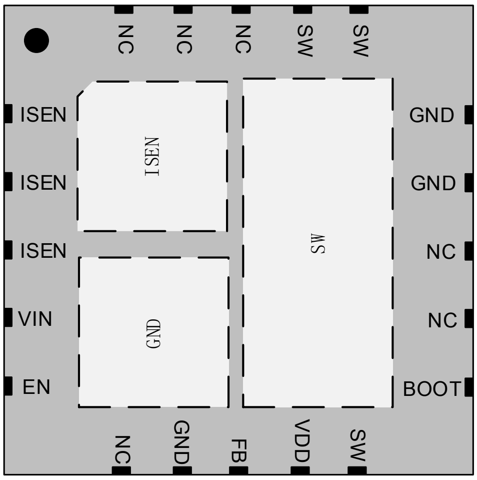
- 9V to 100V input voltage range
- 5A continuous output current
- 96% Peak Efficiency
- 500μA operating quiescent current
- Peak Current mode control
- 100V 20-mΩ high-side and low-side MOSFET
- 150 kHz Fixed Frequency
- Internal compensation for ease of use
- Up to 91% duty cycle
- 0.8V voltage reference
- 9μA shutdown current
- 150ms Hiccup mode short circuit protection
- Thermal shutdown Function
- Package:

| Part No. | Package | Body Size | Reel |
|---|---|---|---|
| ET8A50QA | QFN20 | 5.0mm × 5.0mm | 2500pcs/reel |

## Applications

- Charger in vehicle
- Battery Chargers
- Power adapter

## Pin Configuration

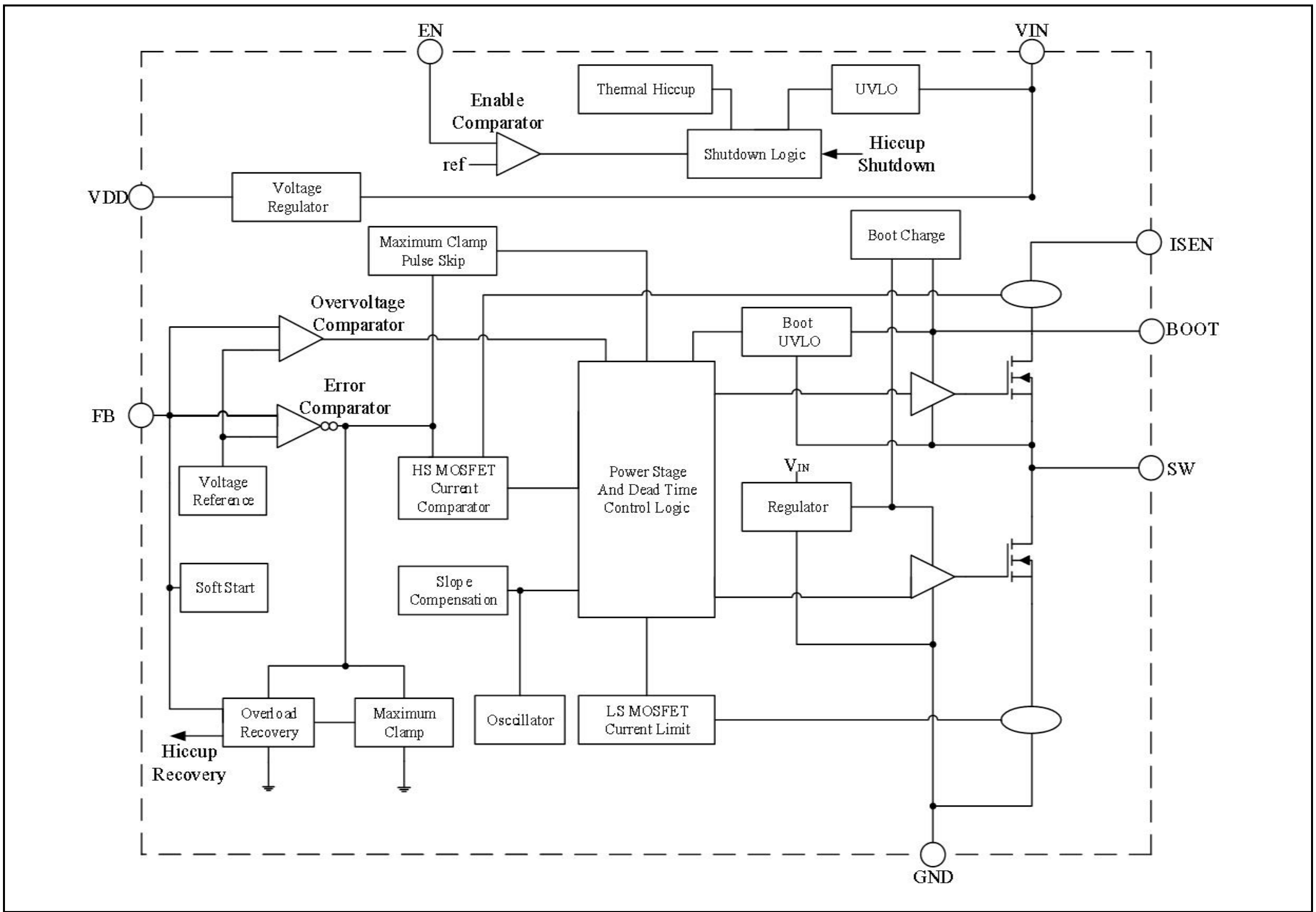



TOP VIEW

## Pin Function

| Pin No. | Pin Name | Pin Function |
|---|---|---|
| 1,2.3 | ISEN | Connecting a resistance from ISEN to VIN sets the output short circuit detection threshold. |
| 4 | VIN | Input supply. VIN supplies power to all of the internal control circuitries, both BOOT regulators, and the high-side switch. |
| 5 | EN | Enable input. Pull EN below the specified threshold to shut down the ET8A50QA. Pull EN above the specified threshold or leave EN floating to enable the ET8A50QA. |
| 6,12,13,18, 19,20 | NC | No Connection |
| 7,14,15 | 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. |
| 8 | FB | Feedback. FB is the input to the voltage hysteretic comparators. The average FB voltage is maintained at 800mV by loop regulation. |
| 9 | VDD | Power input to the controller. |
| 10,16,17 | 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. |
| 11 | BOOT | Bootstrap. BOOT is the positive power supply for the internal, floating, high-side MOSFET driver. Connect a bypass capacitor between BOOT and SW. |

## Block Diagram




## Absolute Maximum Ratings

| Item | Description | Range | Unit |
|---|---|---|---|
| $V_{EN}$, $V_{IN}$,$V_{ISEN}$,$V_{SW}$ | $V_{EN}$, $V_{IN}$,$V_{ISEN}$,$V_{SW}$ Voltage | -0.3 ~ +110 | V |
| $V_{FB}$,$V_{DD}$ | $V_{FB}$,$V_{DD}$ Voltage | -0.3 ~ +7 | V |
| $V_{BOOT}$ | BOOT to GND | -0.3 ~ +110 | 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 |
| 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.

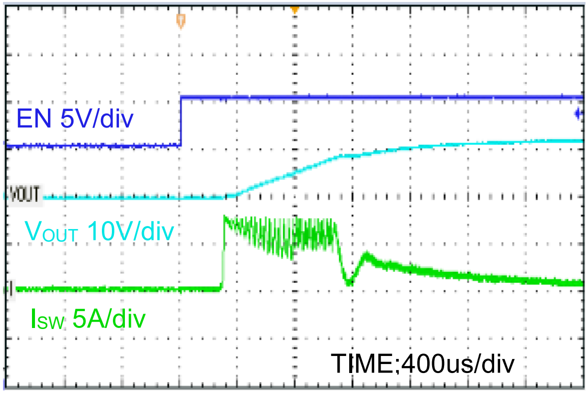
## Electrical Characteristics

($V_{IN}$=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 | - | 500 | - | uA |
| **ENABLE** | | | | | | |
| Enable Threshold Voltage | $V_{EN}$ | | 2.2 | | 100 | V |
| Enable Threshold Voltage Hysteresis | $V_{UVLO2}$ | | - | 0.2 | - | V |
| **FEEDBACK** | | | | | | |
| FB Reference Threshold | $V_{FB}$ | | - | 0.8 | - | V |
| Feedback Short Voltage | $V_{FB(short)}$ | | - | 0.1 | - | V |
| Feedback Short Voltage Hysteresis | $V_{FB2}$ | | - | 0.12 | - | V |
| **OSCILLATOR** | | | | | | |
| Switching Frequency | F | $I_{OUT}$=500mA | - | 150 | - | kHz |
| Maximum Duty Cycle | $D_{MAX}$ | $V_{IN}$=12V | - | 91 | - | % |
| **VDD** | | | | | | |
| VDD Voltage | $V_{DD}$ | | - | 5.4 | - | V |
| **SENSE VOLTAGE** | | | | | | |
| Cycle-by-cycle Sense Voltage | $V_{SEN}$ | | - | 150 | - | mV |
| **THERMAL SHUTDOWN** | | | | | | |
| Thermal shutdown Temp | $T_{SD}$ | | - | 130 | - | ºC |
| Thermal shutdown Temp Hysteresis | $T_{SH}$ | | - | 20 | - | ºC |

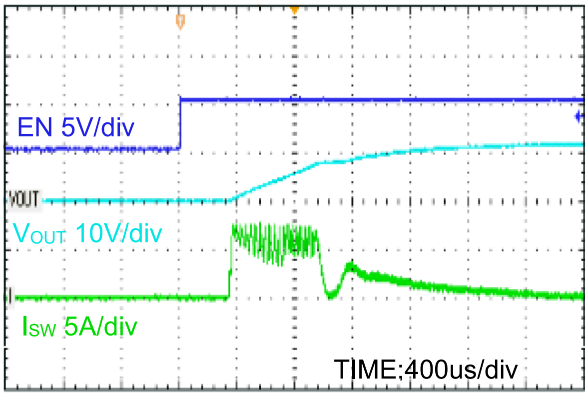
## Typical Characteristics

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



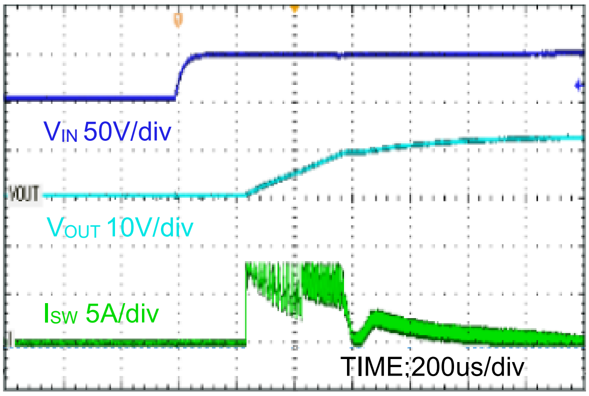

$V_{IN}$=48V EN=5V $I_{OUT}$=1A

Figure1 EN Start up



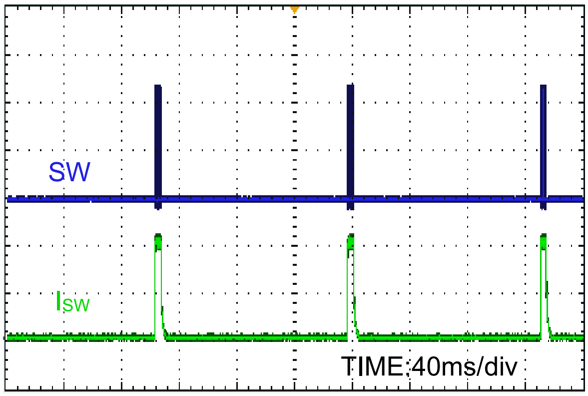

$V_{IN}$=48V EN=5V $I_{OUT}$=0A

Figure2 EN Turn off



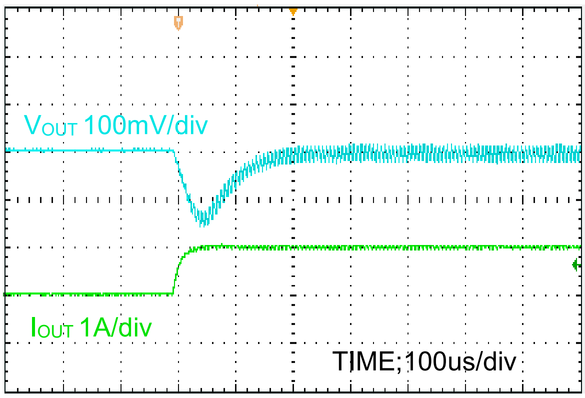

$V_{IN}$=48V $I_{OUT}$=0A

Figure3 Start up



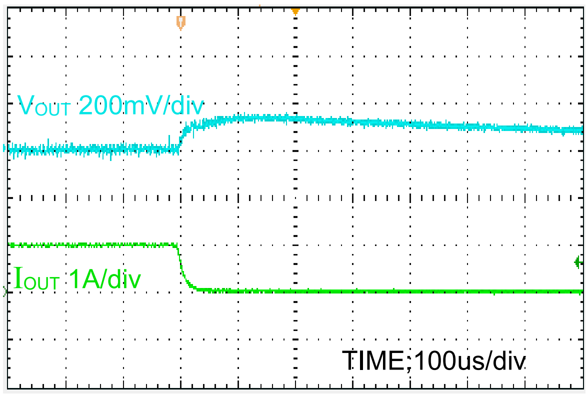

$V_{IN}$=48V

Figure4 Short




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

Figure5 Load Transient




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

Figure6 Load Transient

### Efficiency

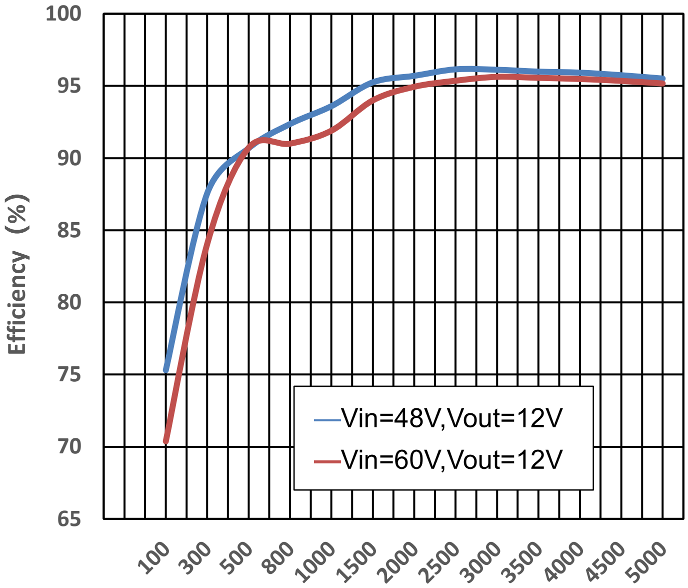



Figure7. Efficiency

## Application Circuits

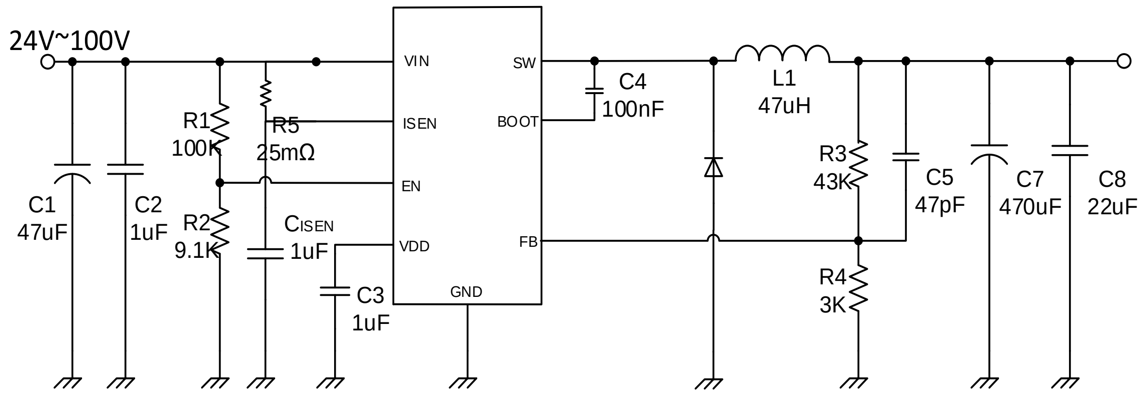



Figure8. Application Circuit

**12V Output with Programmable UVLO**

| Design Parameters | Example Value |
|---|---|
| Input Voltage | 24V-100V |
| Output Voltage | 12V |
| Maximum Output Current | 5A |
| Switching Frequency | 150Khz |
| Output voltage ripple (peak to peak) | 150mV |
| Transient Response 0.5A to 1A load step | 500mV |
| Start Input Voltage (rising VIN) | 24V |
| Stop Input Voltage (falling VIN) | 22V |

## Overview

The ET8A50QA is a high voltage, synchronous step-down controller operates over a wide range input voltage 9V to 100V. The ET8A50QA delivers 5A continuous load current with up to 96% efficiency.The ET8A50QA 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 ET8A50QA exhibits protection features that protect the load from faults like under-voltage,over-current and over-temperature.

## Applications Information

### Over-current Protection

The ET8A50QA 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.

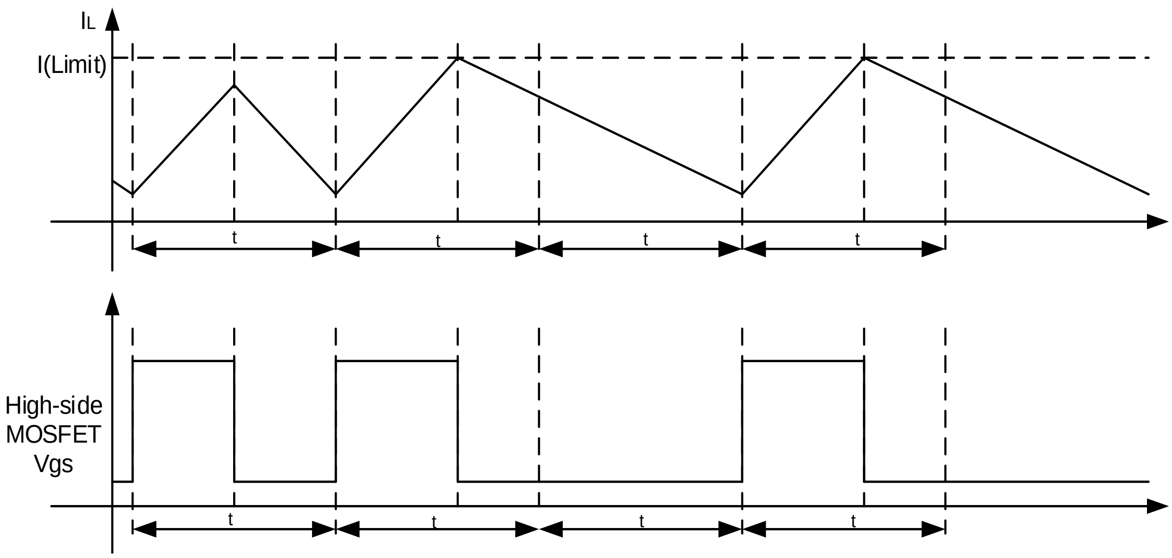



Figure9. Over-current Protection

### 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.

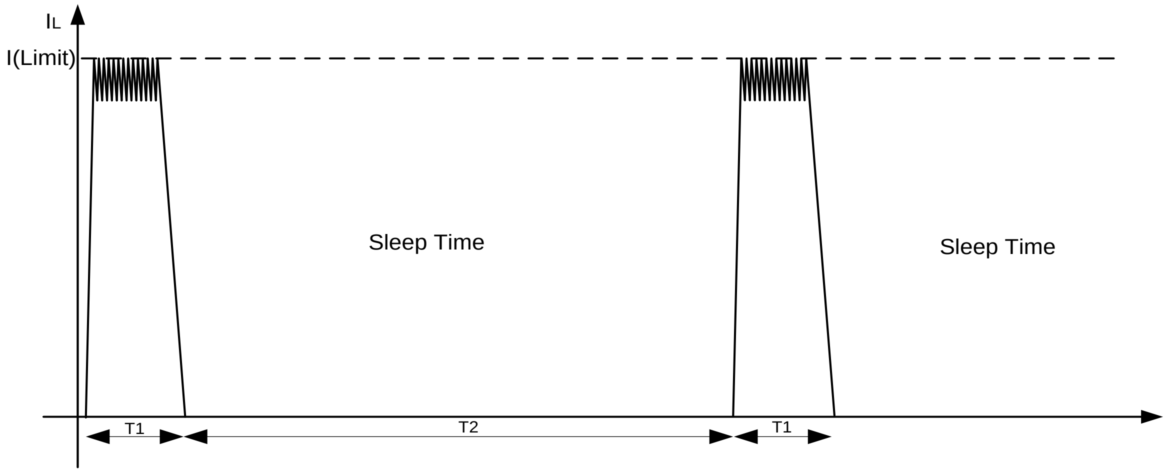



Figure10. Hiccup Mode

**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 s et 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 physi cal size,higher series resistance, and lower saturation current. A good rule for determining the inductance t o 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

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

- $L_{MIN}$ 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 sel ecting 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 li mit of device which is typically 5A. The most conservative approach is to choose an inductor with saturation c urrent greater than 5A. Because of the maximum $I_{LPEAK}$ 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 low er maximum output current.

**Diode Selection**

requires an external catch diode between the SW pin and GND. The selected diode must have areverse v oltage 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 minimu m 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 duri ngthe 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 sup ply 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 capacito r (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.

The voltage rating of the input capacitor must be greater than the maximum input voltage.And the capacitor must have a ripple current rating greater than the maximum input current ripple.The RMS current in the input.

$$I_{CINRMS} = I_{OUT} * \sqrt{\frac{V_{OUT}}{V_{IN}} * (1 - \frac{V_{OUT}}{V_{IN}})} \qquad (7)$$

The worst case condition occurs at VIN=2*VOUT, where:

$$I_{CINRMS} = 0.5 * I_{OUT} \qquad (8)$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the ma ximum load current.

When selecting ceramic capacitors, it needs to consider the effective value of a capacitor decreasing a s the DC bias voltage across a capacitor increasing.

The input capacitance value determines the input ripple voltage of the regulator. The input voltage ripple can be calculated using Equation 9 and the maximum input voltage ripple occurs at 50% duty cycle.

$$\Delta V_{IN} = \frac{I_{OUT}}{f_{SW} * C_{IN}} * \frac{V_{OUT}}{V_{IN}} * (1 - \frac{V_{OUT}}{V_{IN}}) \qquad (9)$$

For this example, four 4.7uF, X7R ceramic capacitors rated for 100 V in parallel are used. And a 0.1uF for hi gh-requency 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.c apacitor with X5R or better grade dielectric is recommended. The capacitor should have a 10V or higher volt age.

**Output Capacitor Selection**

The selection of output capacitor will affect output voltage ripple in steady state and load transient performan ce.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 ri pplecharging and discharging the output capacitors. To achieve small output voltage ripple, choose a low-ES R outputcapacitor like ceramic capacitor. For ceramic capacitors, the capacitance dominates the output ripple. For simplification, the output voltage ripple can be estimated by Equation 10 desired.

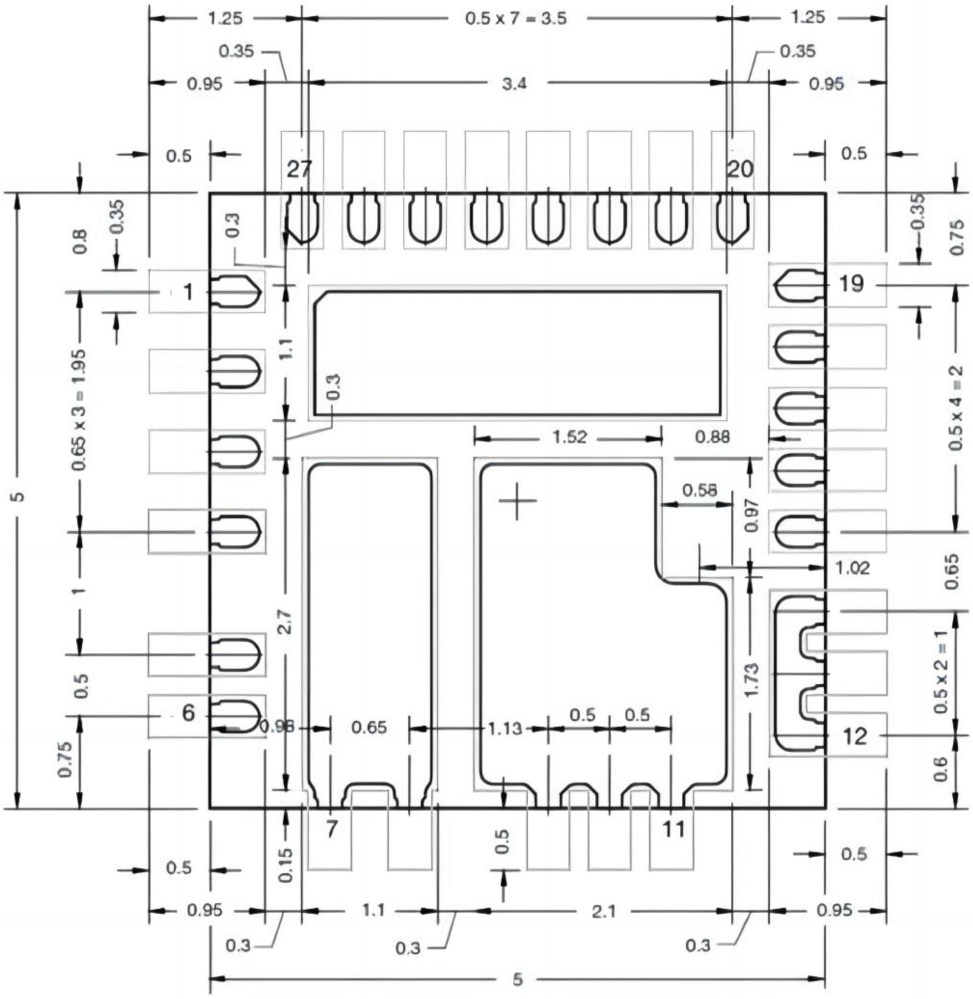
$$\Delta V_{OUT} = \frac{V_{OUT}*(V_{IN}-V_{OUT})}{8*f_{SW}{}^{2}*L*C_{OUT}*V_{IN}} \quad (10)$$

- $\Delta V_{OUT}$ 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

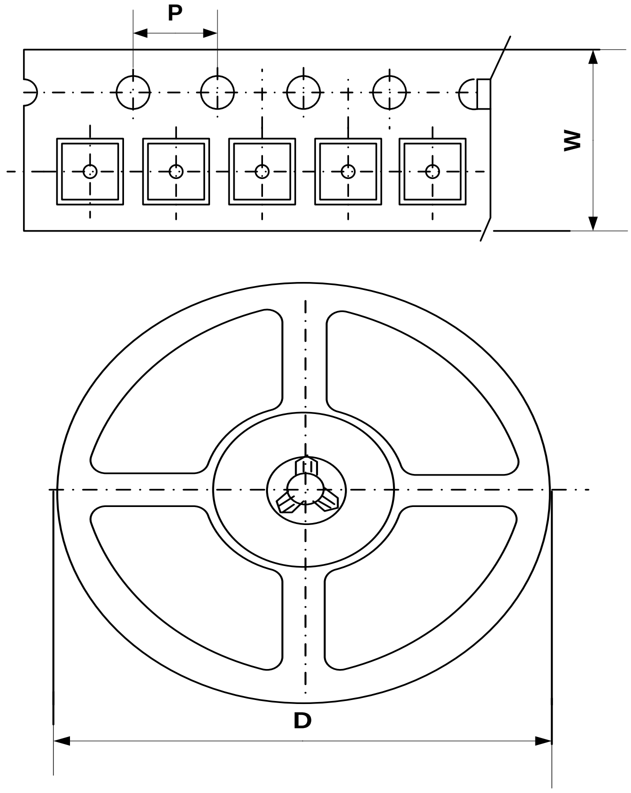
Typically, four 47F ceramic output capacitors work for most applications.

## Package Dimension

ESOP8



## Packing Information




| Type | W(mm) | P(mm) | D(mm) | Qty (pcs) |
|---|---|---|---|---|
| QFN20 | 6.5±0.1 mm | 6.5±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 | 2023-2-22 | Offed Version | Shibo | Shibo | Zhujl |
| 1.1 | 2023-3-02 | | Shibo | Xingxiaolin | Xingxiaolin |
| | | | | | |