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

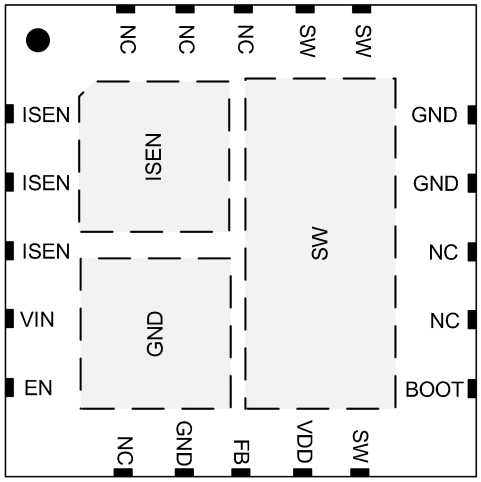
- 9V to 100V input voltage range
- 5A continuous output current
- 96% Peak Efficiency
- 500μA operating quiescent current
- Peak Current mode control
- 100V 20-mΩ high-side and low-side MOSFET
- 150 kHz Fixed Frequency
- Internal compensation for ease of use
- Up to 91% duty cycle
- 0.8V voltage reference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

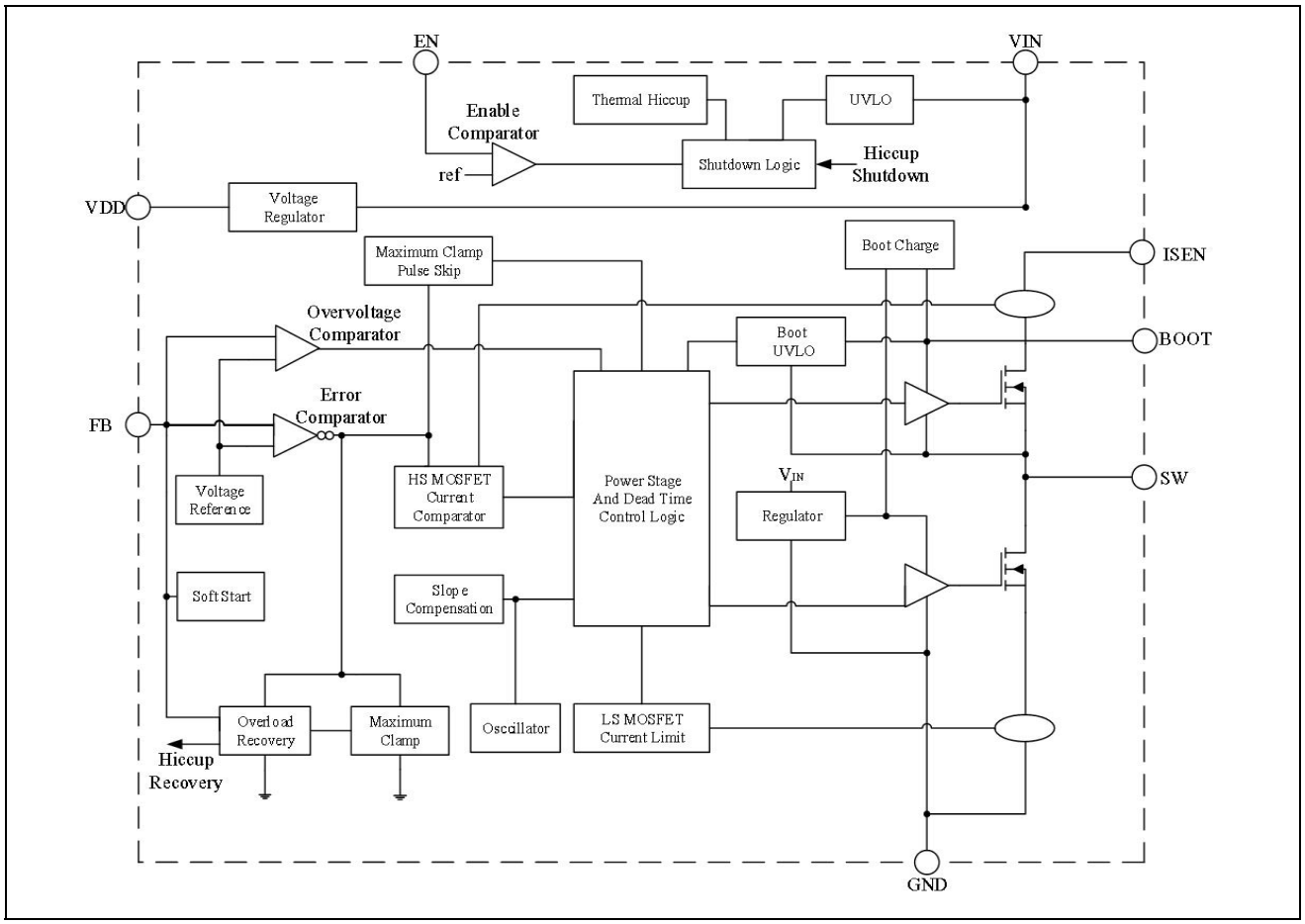


TOP VIEW

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
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.

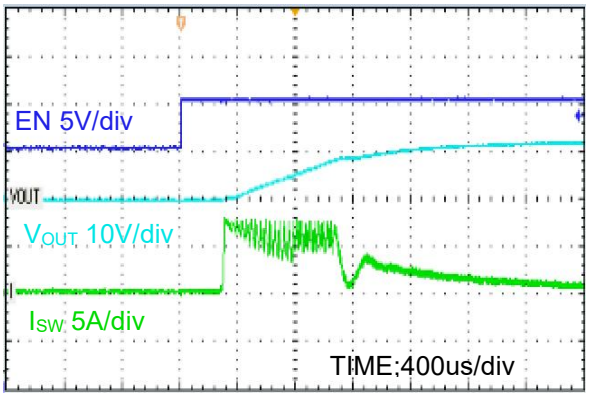
Electrical Characteristics

(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		500		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	$V_{FB(short)}$			0.1		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}			125		mV
THERMAL SHUTDOWN						
Thermal shutdown Temp	T_{SD}			130		ºC
Thermal shutdown Temp Hysteresis	T_{SH}			20		ºC

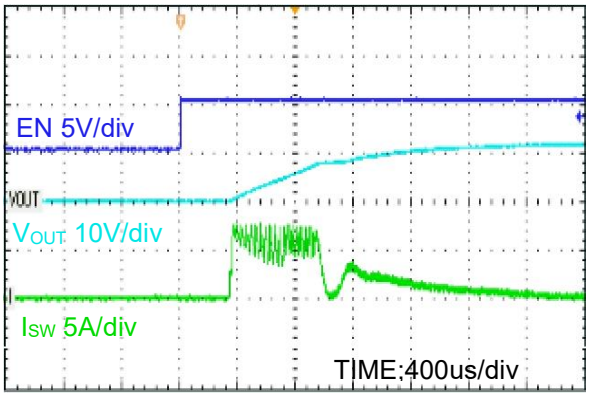
Typical Characteristics

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



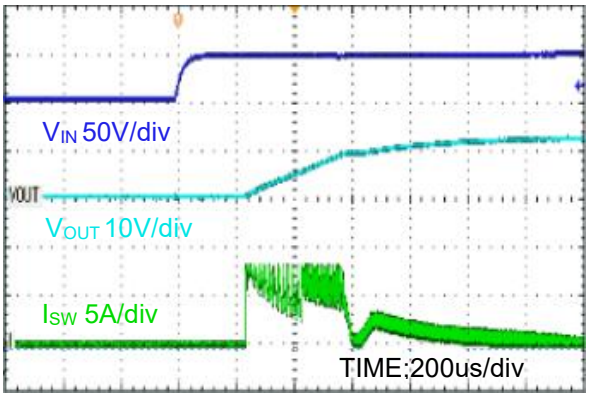
V_{IN}=48V EN=5V I_{OUT}=1A

Figure1 EN Start up



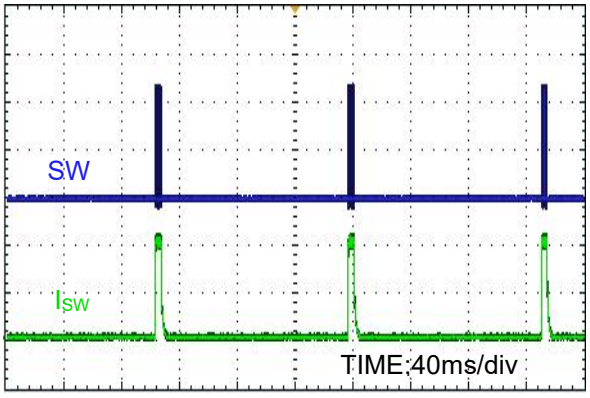
V_{IN}=48V EN=5V I_{OUT}=0A

Figure2 EN Turn off



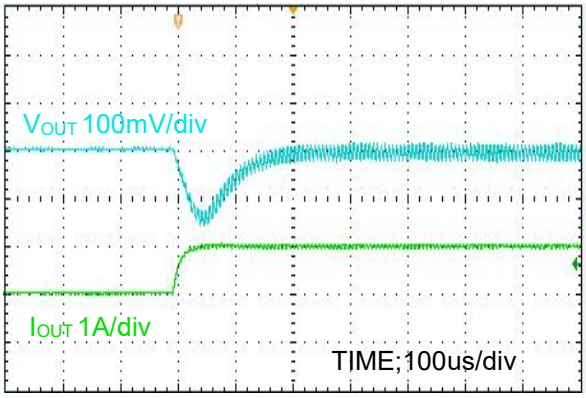
V_{IN}=48V I_{OUT}=0A

Figure3 Start up



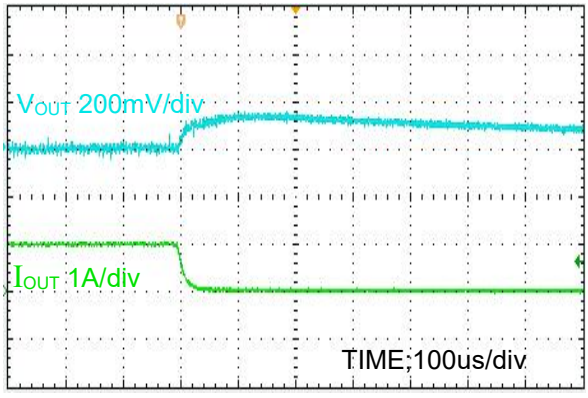
V_{IN}=48V

Figure4 Short



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

Figure5 Load Transient



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

Figure6 Load Transient

Efficiency

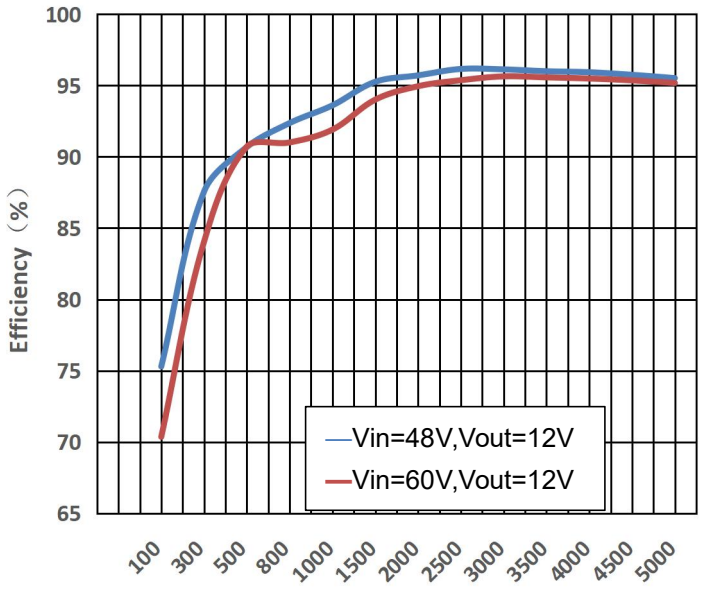


Figure7. Efficiency

Application Circuits

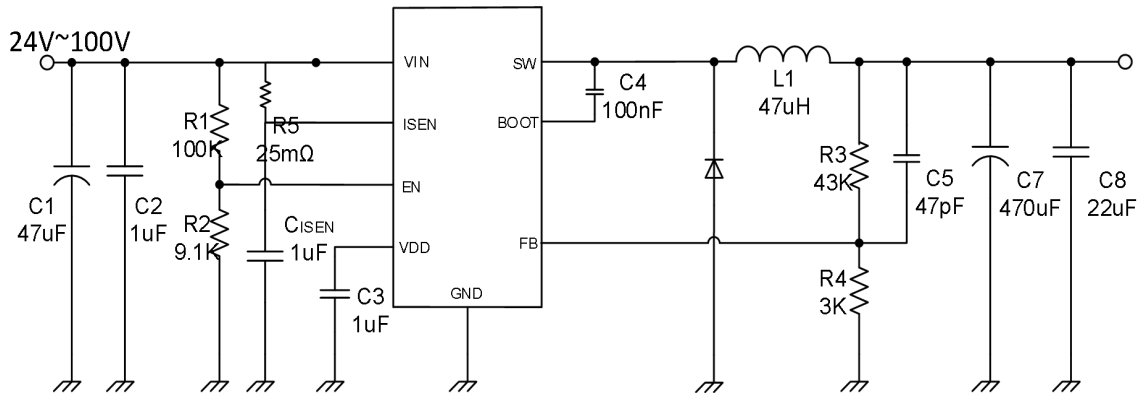


Figure8. Application Circuit

12V Output with Programmable UVLO

Design Parameters	Example Value
Input Voltage	24V-100V
Output Voltage	12V
Maximum Output Current	5A
Switching Frequency	150Khz
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.

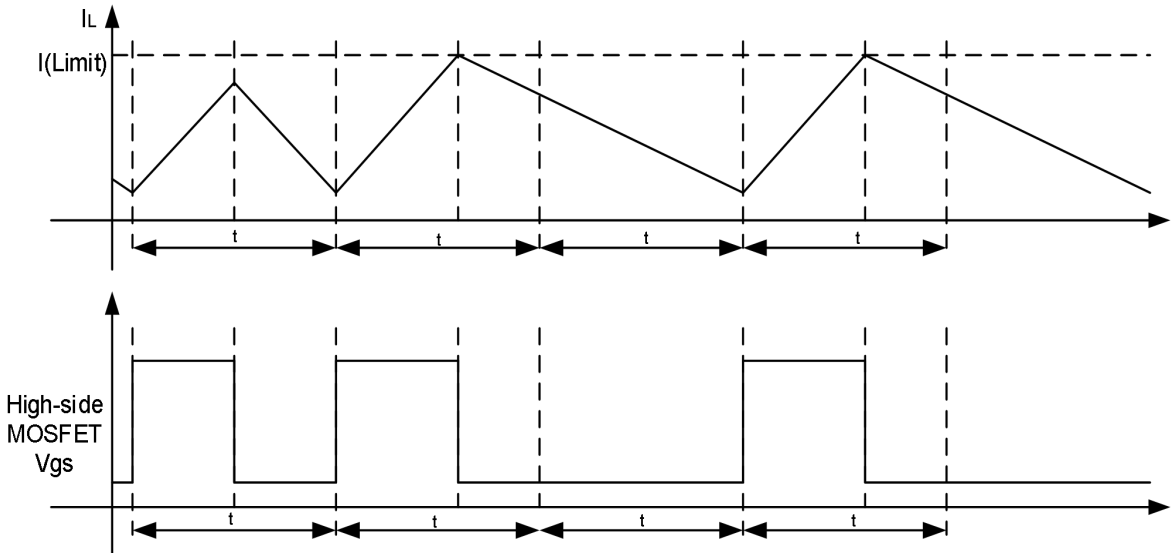


Figure9. Over-current Protection

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.

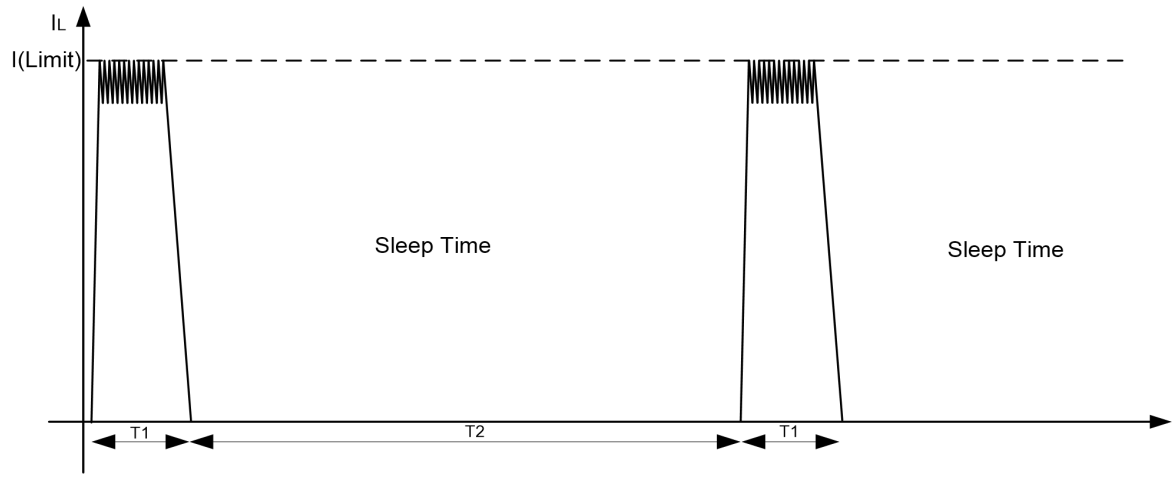


Figure10. Hiccup Mode

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 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

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

- 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.

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

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

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

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.

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

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 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 10 desired.

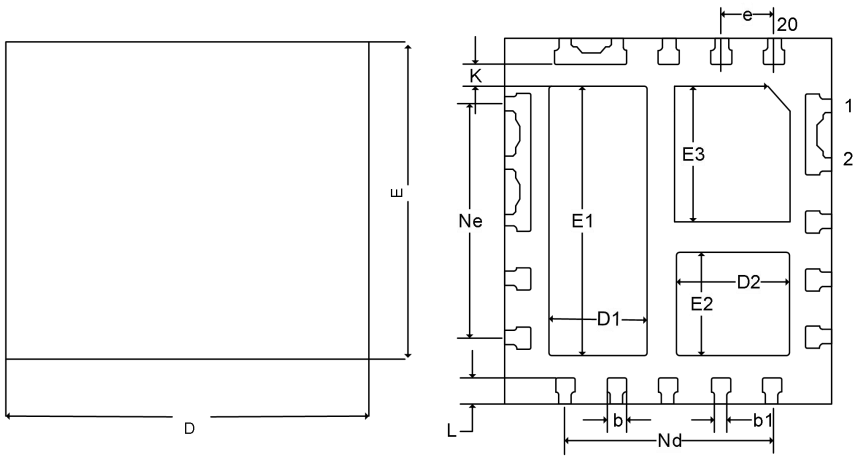
$$\Delta V_{OUT} = \frac{V_{OUT} * (V_{IN} - V_{OUT})}{8 * f_{SW}^{2} * L * C_{OUT} * V_{IN}} \quad (10)$$

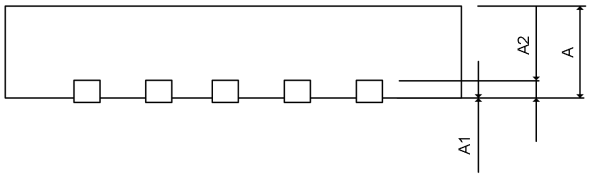
- ΔV_{OUT} is the output voltage ripple
- F_{SW} is the switching frequency
- L is the inductance of inductor
- C_{OUT} is the output capacitance
- V_{OUT} is the output voltage
- V_{IN} is the input voltage

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

Package Dimension

QFN20



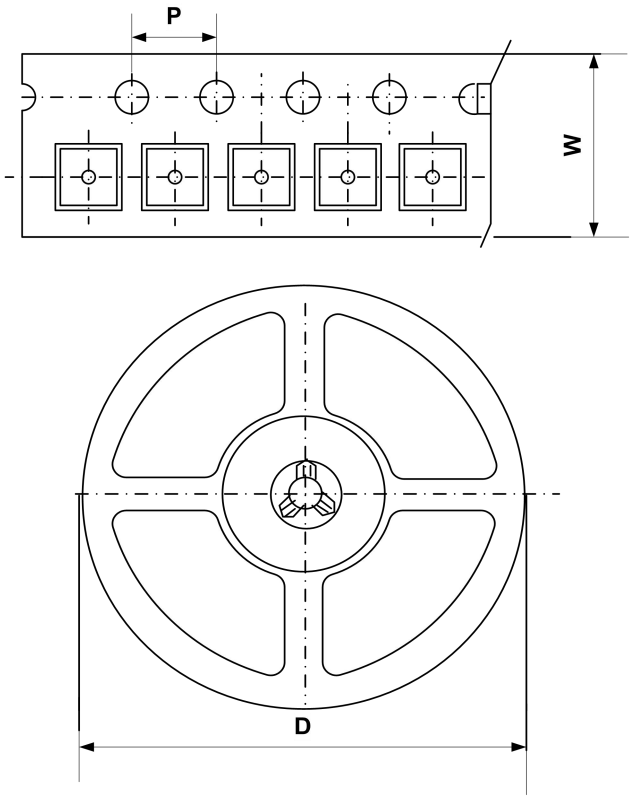


COMMON DIMENSIONS

(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	-	0.05
A2	0.19	0.20	0.21
b	0.25	0.30	0.35
D	4.95	5.00	5.05
D1	1.40	1.50	1.60
D2	1.65	1.75	1.85
E	4.95	5.00	5.05
E1	3.60	3.70	3.80
E2	1.30	1.40	1.50
E3	1.75	1.85	1.95
e	-	0.8	-
L	0.25	0.35	0.45
K	0.25	0.30	0.35
Nd	-	3.20	-
Ne	-	3.20	-

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