ZHEJIANG UNIU-NE Technology CO.,LTD

浙 江 宇 力 微 新 能 源 科 技 有 限 公 司

U3504E Data Sheet

V 1.1

150V Input, Switching Current Limit Step-Down Converter

General Description

The U3504E is a high voltage, step-down, switching regulator built-in MOSFET. It integrates a high-side, high-voltage, power MOSFET with a current limit of 10A(I_{PK}) typically. The input ranges accommodates a variety of step-down applications, making it ideal for automotive, industry, and lighting applications. Hysteretic voltage-mode control is employed for very fast response. UNIU's proprietary feedback control scheme minimizes the number of required external components.

The switching frequency is 150KHz, allowing for small component size. Thermal shutdown and short-circuit protection (SCP) provide reliable and fault-tolerant operations. Low quiescent current allows the U3504E to be used in battery-powered applications.

The U3504E is available in a ESOP-8 package with an exposed pad.

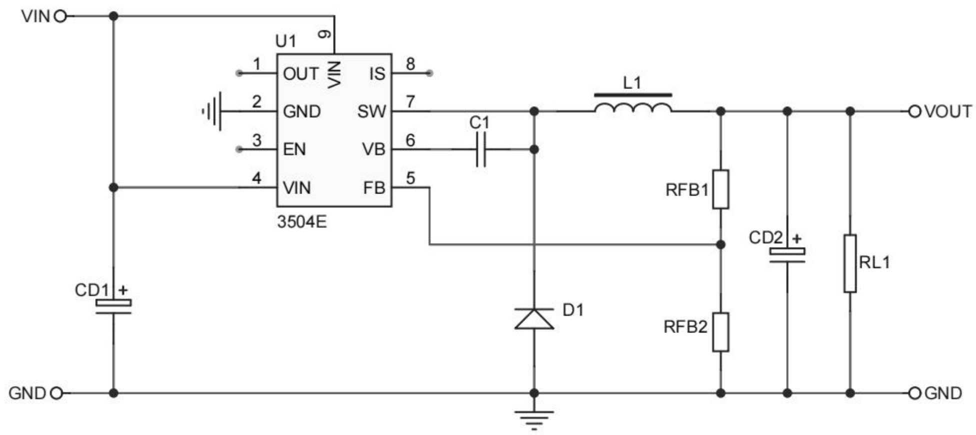
Key Features

- Integrated high voltage start circuit
- Default 5V output（Type）
- Built-In 150V/98mΩ MOSFET
- Built-in Bootstrap Diode
- Hysteretic Control: No Compensation
- 150KHz Switching Frequency
- PWM Dimming Control Input for step-down Application
- Short-Circuit Protection (SCP) with Integrated High-Side MOSFET
- Low Quiescent Current
- Thermal Shutdown
- Available in a ESOP-8 Package with an Exposed Pad

Applications

- Scooters, E-Bike Control Power Supplies
- Solar Energy Systems
- Automotive System Power
- Industrial Power Supplies
- High-Power LED Drivers
- USB

Simplified Application

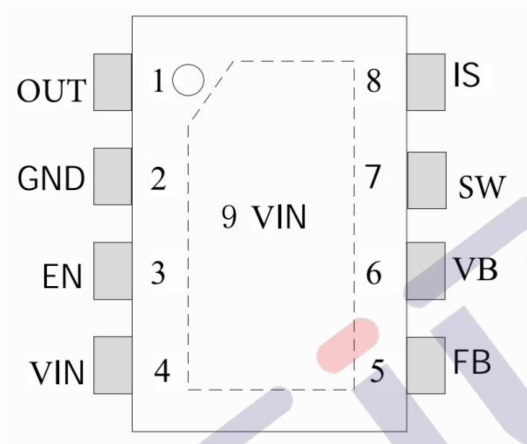


Ordering Information

Part Number	Package	Vo	VIN MAX	I_{PK}	Description
U3504E	ESOP-8	＞2V	150V	10A	4000Pcs/Reel

Pin Description

TOP VIEW



ESOP-8

Pin Functions

ESOP-8 Pin #	Name	Description
1	OUT	Default 5V output（Type）
2	GND	Ground. GND
3	EN	En input.Default suspension, built-in resistance
4	VIN	Input supply. VIN supplies power to all of the internal control circuitries.
5	FB	Feedback. FB is the input to the voltage hysteretic comparators.
6	VB	VB is the positive power supply for the internal, floating, high-side MOSFET driver. Connect a bypass capacitor between VB and SW.
7	SW	Switch node.
8	IS	Current detection. Current Sensing Input.
9	VIN	Input supply. VIN supplies power toallofthe internal control circuitries

Block Diagram

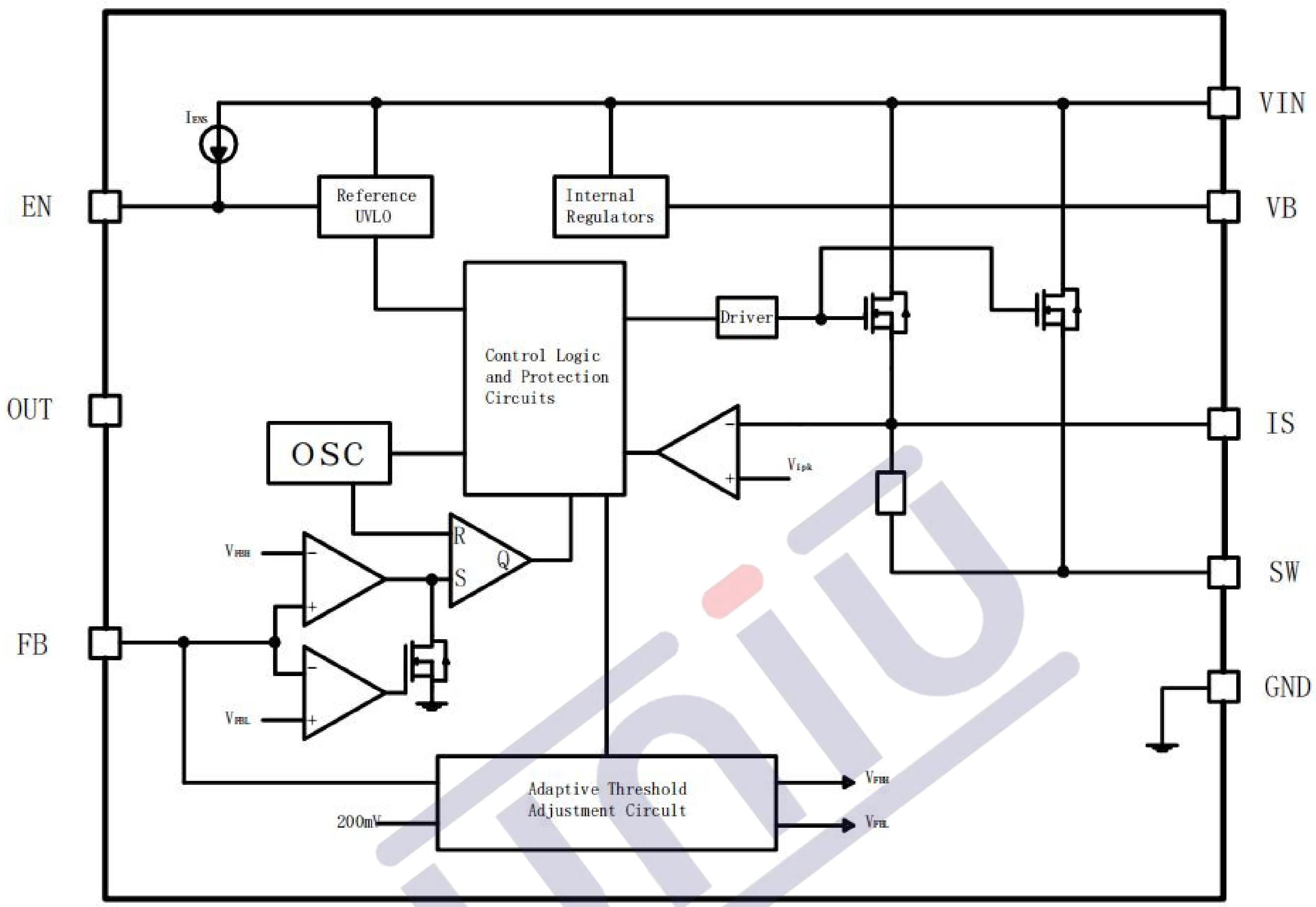


Figure 1:Function Block Diagram

Absolute Maximum Ratings (Note 1)

Parameter	Value	Unit
VIN,SW,IS Pin Voltage Range	-0.3 to 150	V
VB Supply Voltage	150+20	V
FB, EN Voltage Range	-0.3 to 7	V
Package Thermal Resistance ---Junction to Ambient (ESOP-8)	165	°C/W
Maximum Junction Temperature	160	°C
Storage Temperature Range	-65 to 150	°C
Lead Temperature (Soldering, 10sec.)	260	°C
ESD Capability, HBM (Human Body Model)	2	kV
ESD Capability, MM (Machine Model)	200	V

Note: For electrostatic sensitive devices, pay attention to ESD prevention measures when operating them.

Electrical Characteristics

V_{IN} = 60V, T_A = +25°C, unless otherwise noted. Specifications over temperature are guaranteed by design and characterization.

Parameter	Symbol	Condition	Min	Typ	Max	Units
OUT	V_{OUT}	VIN=60V	—	5	—	V
Shutdown supply current		V_{EN} = 0V	—	4	—	μA
Quiescent supply current		No load, DIM = low, V_{FB} = 1.4V	—	0.7	—	mA
Upper switch on resistance	$R_{DS(ON)}$	V_{VB} - V_{SW}= 12V	—	98	120	mΩ
Upper switch leakage current	I_{SWLK}	V_{EN} = 0V, V_{SW} = 0V	—	0.02	1.5	μA
Current limit	I_{PK}	V_{FB} = 1.3V	—	7	—	A
Working frequency	F_{SW}		—	150	—	KHz
EN -on	V_{ENH}		—	2.4	7	V
EN -off	V_{ENL}		—	—	1	V
EN threshold hysteresis	V_{ENHY}		—	500	—	mV
Feedback voltage threshold	V_{FBH}		1.25	1.30	—	V
Peak current threshold	V_{IPK}		215	230	245	mV
FB to ground resistance	R_{FB}		—	50K	—	Ω
Thermal shutdown		Trigger thermal shutdown	—	150	—	°C
		Hysteresis	—	20	—	

NOTES:

Note1. Stresses listed as the above "Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. 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 maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note2. The device is not guaranteed to function outside its operating conditions.

Note3. Guaranteed by design.

Operation

Hysteresis Current Control with Adaptive Threshold Adjustment

The U3504E operates in a hysteretic voltage-control mode to regulate the output voltage. FB is connected to the tap of a resistor divider, which determines the output voltage. The power MOSFET is turned on when the FB voltage (V_{FB}) rises to FBon and remains on until V_{FB} rises to FBoff. The power MOSFET is turned off when V_{FB} drops to FBoff and remains off until V_{FB} falls to FBon. The two thresholds of FBon and FBoff are adjusted adaptively to compensate for all the circuit delays, so the output voltage is regulated with an average 1.30V value at FB.

Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor.

The bootstrap capacitor is charged and regulated to about 12V by the dedicated internal bootstrap regulator.

If the internal circuit does not have sufficient voltage, and the bootstrap capacitor is not sufficiently charged, extra external circuitry can be used to ensure that the bootstrap voltage is in the normal operating region. Refer to the External Bootstrap Diode section for more details.

Fast charging Function for USB Applications

Because the FB reference of the U3504E is very flexible, it is recommended to use the U3504E for USB Fast charging Applications by connecting the current sense resistor between FB and GND.

Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from operating at exceedingly high temperatures. When the silicon die temperature is higher than its upper threshold, the entire chip shuts down. When the temperature is lower than its lower threshold, the chip is enabled again.

Output Short Protection

The output voltage is well-regulated when VFB is around 1.30V. If the output is pulled low in over- current protection (OCP) or is shorted to GND directly, V_{FB} is low, even though the power MOSFET is turned on. The U3504E regards the low V_{FB} as a failure. The power MOSFET shuts off if the failure time is longer than 10μs. The U3504E attempts operation again after a delay of about 300μs.

The power MOSFET current is also accurately sensed via a current sense MOSFET. If the current is over the current limit, the IC is shut down. This offers extra protection under output- short conditions.

Application Information

Setting the Output Voltage

The output voltage (V_{OUT}) is set by a resistor divider (R1 and R2) (see the Typical Application on page 1). To achieve good noise immunity and low power loss, R2 is recommended to be in the range of 1kΩ to 50kΩ. R1 can then be determined with Equation (1):

$$R1 = \frac{V_{OUT} - V_{FB}}{V_{FB}} \times R2 \quad (1)$$

Where V_{FB} is 1.30V, typically.

FB has 50K resistance inside, and the calculation is in parallel with R2

Output Capacitor and Frequency Setting

The output capacitor (C_{OUT}) is necessary for achieving a smooth output voltage. The ESR of the capacitor should be sufficiently large compared to the capacitance; otherwise, the system may behave in an unexpected way, and the current ripple may be very high.V_{FB} changes from 1.25V to 1.35V when the power MOSFET switches on. To charge the capacitor and generate 1.35V at FB, the system needs ESR and some inductor current. For example, for a 5V V_{OUT}, if the forward capacitor is 0.1μF, the suggested ESR range of the output capacitor is 100mΩ to 250mΩ. Tantalum or aluminum electrolytic capacitors with a small ceramic capacitor are recommended.

A forward capacitor across R1 is recommended when the output capacitor is tantalum or aluminum electrolytic, which can set the desired frequency if the output capacitor and ESR cannot be changed. The forward capacitor can reduce the output voltage ripple.

In some application, simply a forward capacitor may not get proper frequency, then we can add a forward resistor in series with the forward capacitor or even more add a ceramic on the output.

Selecting the Inductor

The inductor (L) is required to convert the switching voltage to a smooth current to the load. Although the output current is low, it is recommended that the inductor current be continuous in each switching period to prevent reaching the current limit. Calculate the inductor value with Equation (2):

$$L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{F_{SW} \times I_{OUT} \times V_{IN} \times K} \quad (2)$$

Where K is a coefficient of about 0. 15 ~ 0.85

Output Rectifier Diode

The output rectifier diode supplies current to the inductor when the high-side switch is off. To reduce losses due to the diode forward voltage and recovery times, use a Schottky diode. The average current through the diode can be approximated with Equation (3):

$$I_D = I_{OUT} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (3)$$

Choose a diode with a maximum reverse voltage rating greater than the maximum input voltage and a current rating is greater than the average diode current.

Input Capacitor (C_{IN})

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance, especially under high switching frequency applications.

The RMS current through the input capacitor can be calculated with Equation (4):

$$I_{IN\_AC} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}})} \quad (4)$$

With low ESR capacitors, the input voltage ripple can be estimated with Equation (5):

$$\Delta V_{IN} = \frac{I_{OUT} \times V_{OUT}}{F_{SW} \times C_{IN} \times V_{IN}} \times (1 - \frac{V_{OUT}}{V_{IN}}) \quad (5)$$

Choose an input capacitor with enough RMS current rating and enough capacitance for small input voltage ripples.

When electrolytic or tantalum capacitors are applied, a small, high-quality ceramic capacitor (i.e.: 0. 1μ F) should be placed as close to the IC as possible.

External Bootstrap Diode

An external bootstrap diode may enhance the efficiency of the converter (see Figure 2).

The bootstrap diode can be a low-cost one, Optimize circuit structure, save cost, and reduce error rate for peripheral circuit configuration.

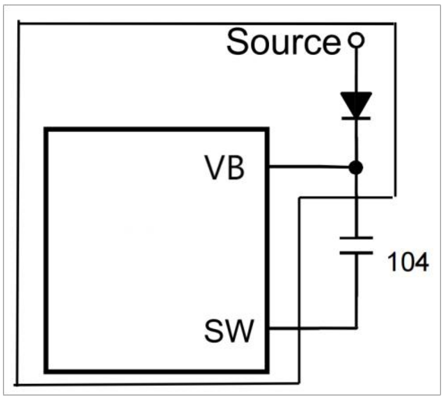


Figure 2: External Bootstrap Diode

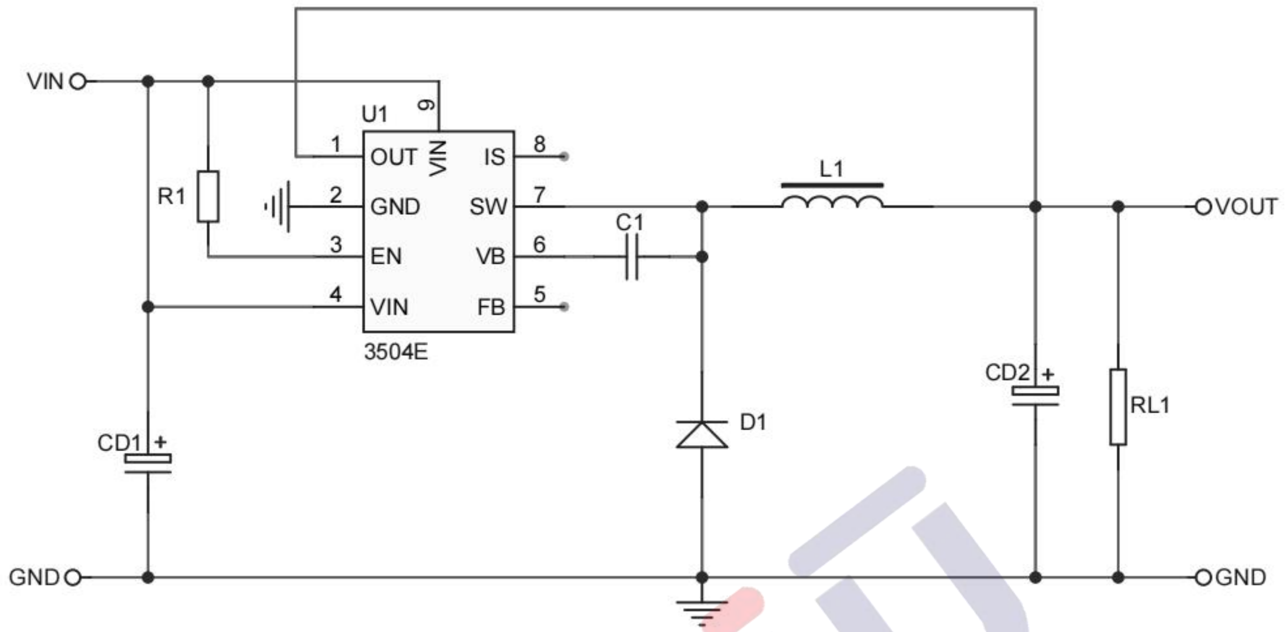
PCB Layout Guidelines

Efficient PCB layout is critical for stable operation. For best results, refer to Figure 3 and follow the guidelines below.

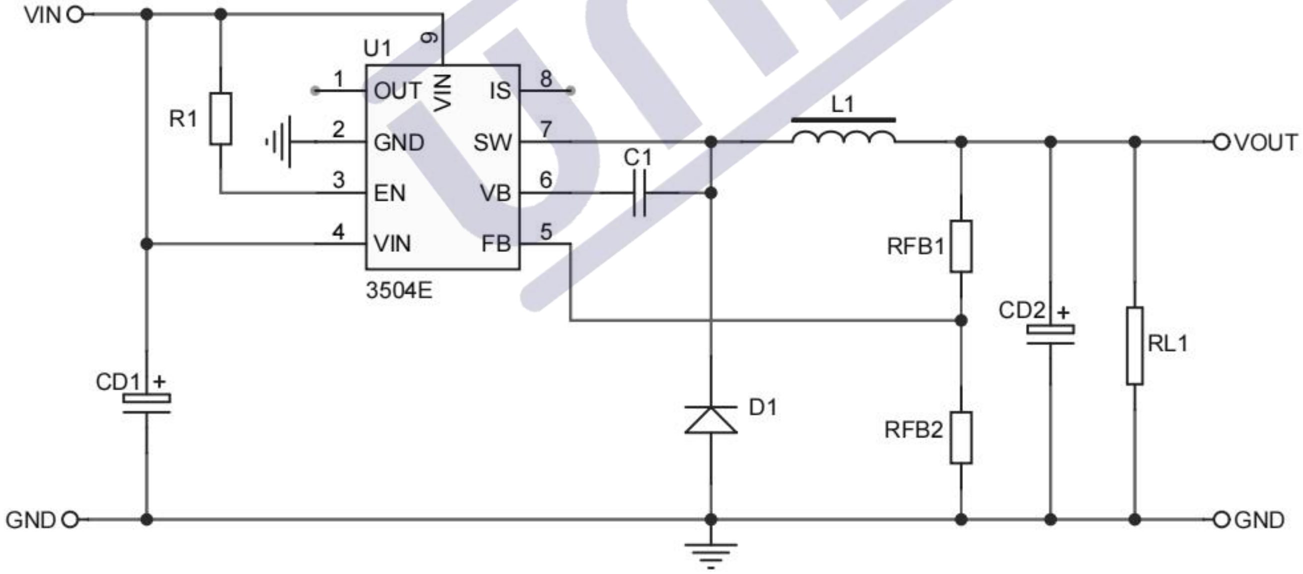
1. Place the input decoupling capacitor, catch diode, and the U3504E (VIN, SW, and PGND) as close to each other as possible.
2. Keep the power traces very short and fairly wide, especially for the SW node.This can help greatly reduce voltage spikes on the SW node and lower the EMI noise level.
3. Run the feedback trace as far from the inductor and noisy power traces (like the SW node) as possible.
4. Place thermal vias with 15mil barrel diameter and 40mil pitch (distance between the centers) under the exposed pad

Typical Application Circuit

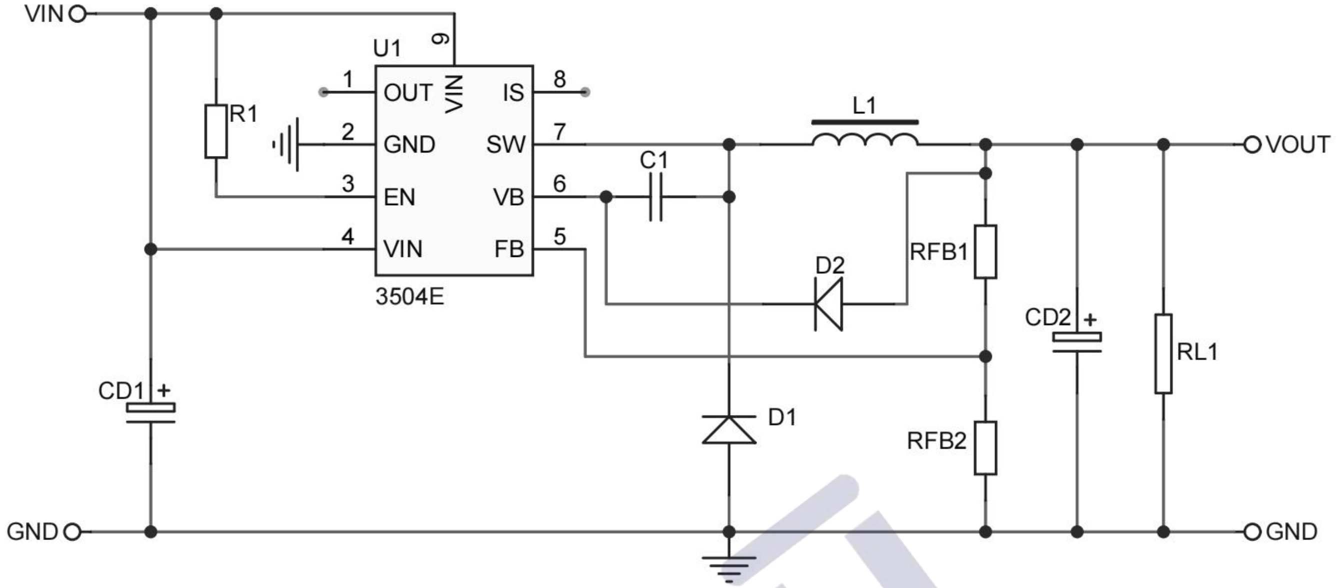
APP1: V_{OUT} =5V



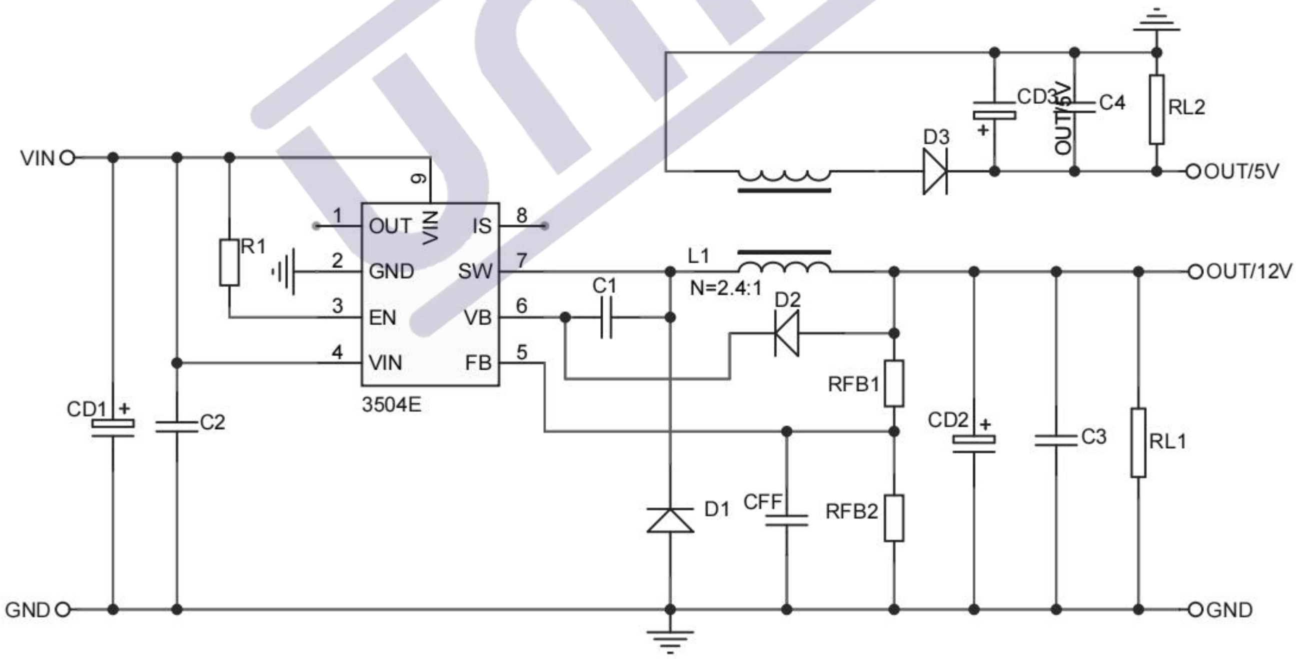
APP2: V_{OUT} <10V



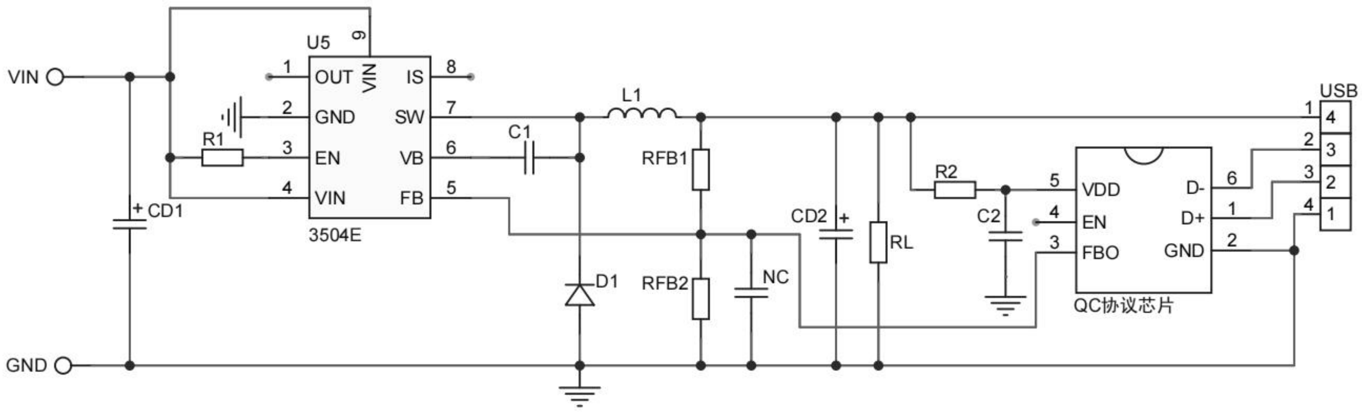
APP3:VOUT=10~15V



APP4:VOUT12V/VOUT5V



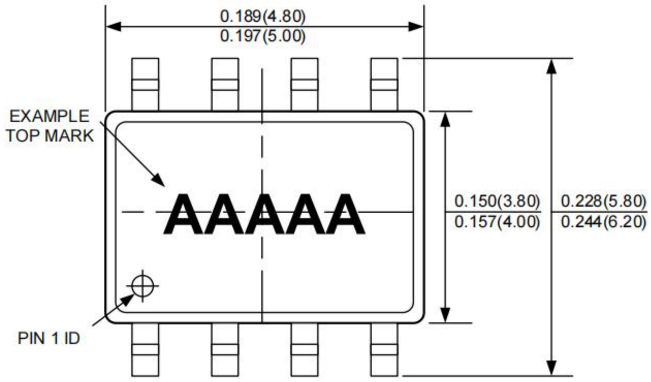
APP5:QC2.0/QC3.0



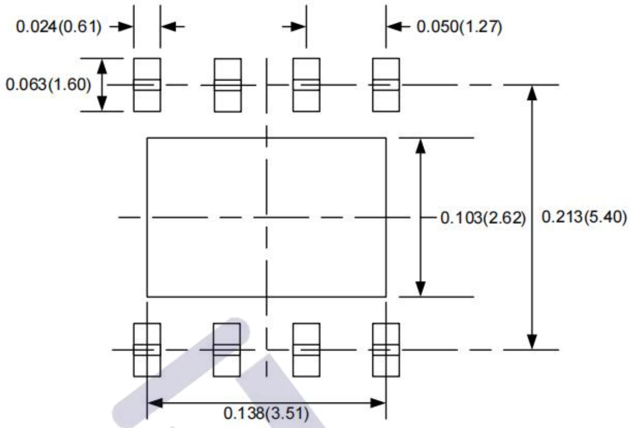
1. Typical application circuit and parameters for reference, the actual application circuit parameters please set on the basis of measurement, mass production please communicate with the original factory, other unknown please contact our engineers.
2. Input electrolytic capacitor (CE1) and continuous current diode (D1) according to the actual use of voltage, current to adjust.
3. Continuous current diode recommended to use Schottky.

Package Information

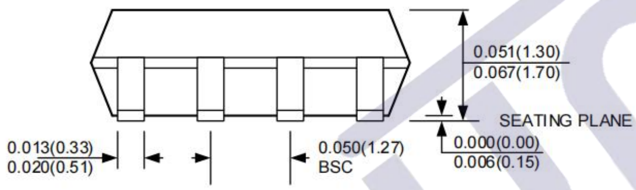
ESOP8 (EXPOSED PAD)



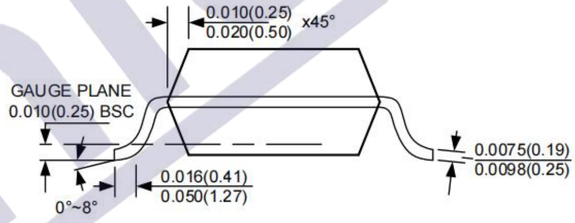
TOP VIEW



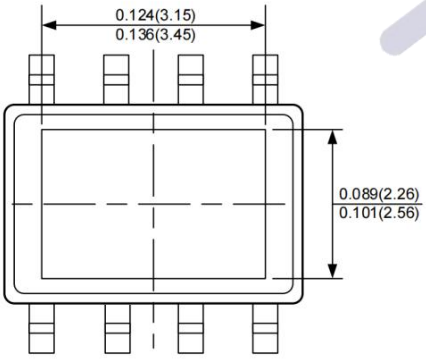
RECOMMENDED PAD LAYOUT



FRONT VIEW



SIDE VIEW



BOTTOM VIEW

NOTE:

1.CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.

2.PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.

3.PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.

4.LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.

5.DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.

6.DRAWING IS NOT TO SCALE

1、版本记录

DATE	REV.	DESCRIPTION
2023/2/25	1.0	首次发布
2023/7/12	1.1	优化参数

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