



ZHEJIANG UNIU-NE Technology CO., LTD

浙江宇力微新能源科技有限公司



## U3500D Data Sheet

V 1.3

版权归浙江宇力微新能源科技有限公司

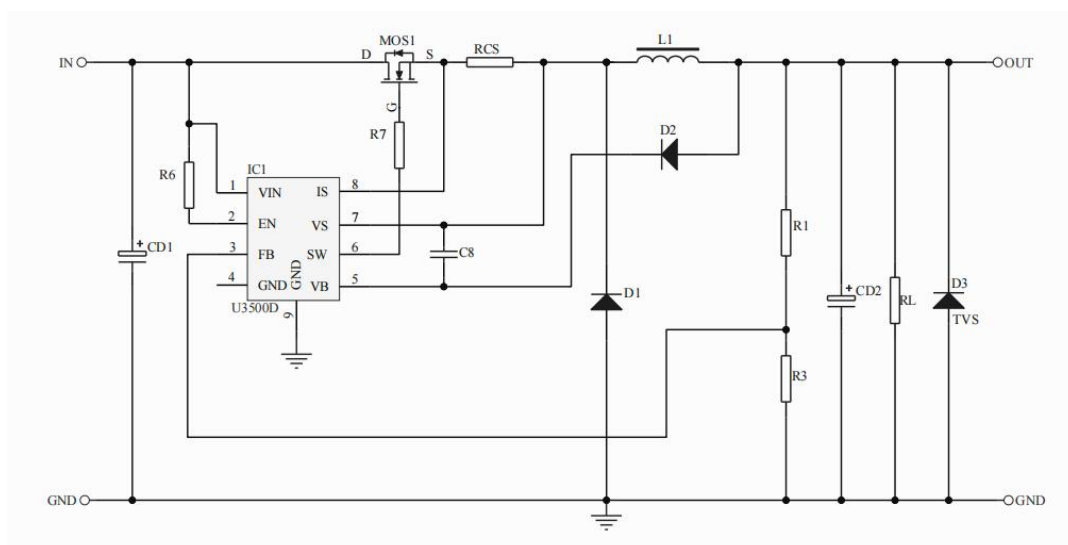
## Switching Current Limit Step-Down Converter

### General Description

The U3500D is a high-voltage, step-down, switching regulator that drives External power MOSFET. The input range 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. UNI's proprietary feedback control scheme minimizes the number of required external components.

The switching frequency is 140KHz, allowing for small component size. Thermal shutdown and short-circuit shutdown (SCS) provide reliable and fault-tolerant operations. Low quiescent current allows the U3500D to be used in battery-powered applications.

### Typical Application



### Key Features

- Internal integrated bootstrap power supply circuit
- DC-DC 12V Typical Switching Current Application
- Hysteretic Control: No Compensation
- 140KHz Switching Frequency
- PWM Control Input for step-down Application
- 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

## Operation

### Hysteresis Current Control with Adaptive Threshold Adjustment

The U3500D 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 FB-on and remains on until  $V_{FB}$  rises to FB-off. The power MOSFET is turned off when  $V_{FB}$  drops to FB-off and remains off until  $V_{FB}$  falls to FB-on. The two thresholds of FB-on and FB-off are adjusted adaptively to compensate for all the circuit delays, so the output voltage is regulated with an average 1.3V 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 U3500D is very flexible, it is recommended to use the U3500D 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.

## 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  $1k\Omega$  to  $50k\Omega$ .  $R1$  can then be determined with Equation (1):

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

Where  $V_{FB}$  is 1.3V, 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  $0.1\mu F$ , the suggested ESR range of the output capacitor is  $100m\Omega$  to  $250m\Omega$ . 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):

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

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.

### Peak current regulation

Current estimation formula(4)

$$I_{PK} = \frac{V_{IPK}}{R_{CS}} = \frac{0.25V}{R_{CS}} \quad (4)$$

Note: The voltage calculation will be affected by the freewheeling diode, and the actual debugging shall prevail

### 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 (5):

$$I_{IN\_AC} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \quad (5)$$

With low ESR capacitors, the input voltage ripple can be estimated with Equation (6):

$$\Delta V_{IN} = \frac{I_{OUT} \times V_{OUT}}{F_{SW} \times C_{IN} \times V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (6)$$

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.: 0.1  $\mu$ 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). An external VB diode is recommended from the VB supply to VB in the following cases:

- There is a 12V rail available in the system
- IO is greater than 1A

This diode is also recommended for high duty cycle operations (when  $V_{OUT} / V_{IN} > 65\%$ ) and very high frequency applications.

The bootstrap diode can be a low-cost one, such as FR107.

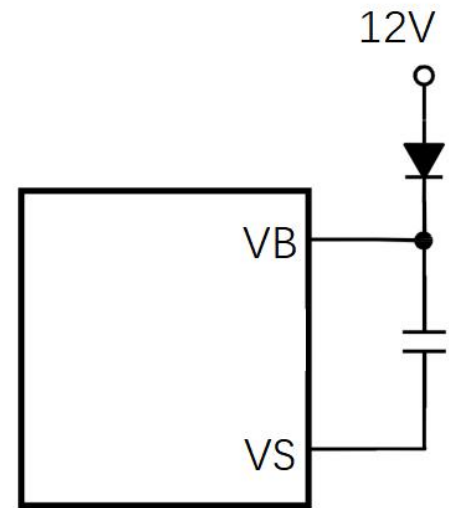


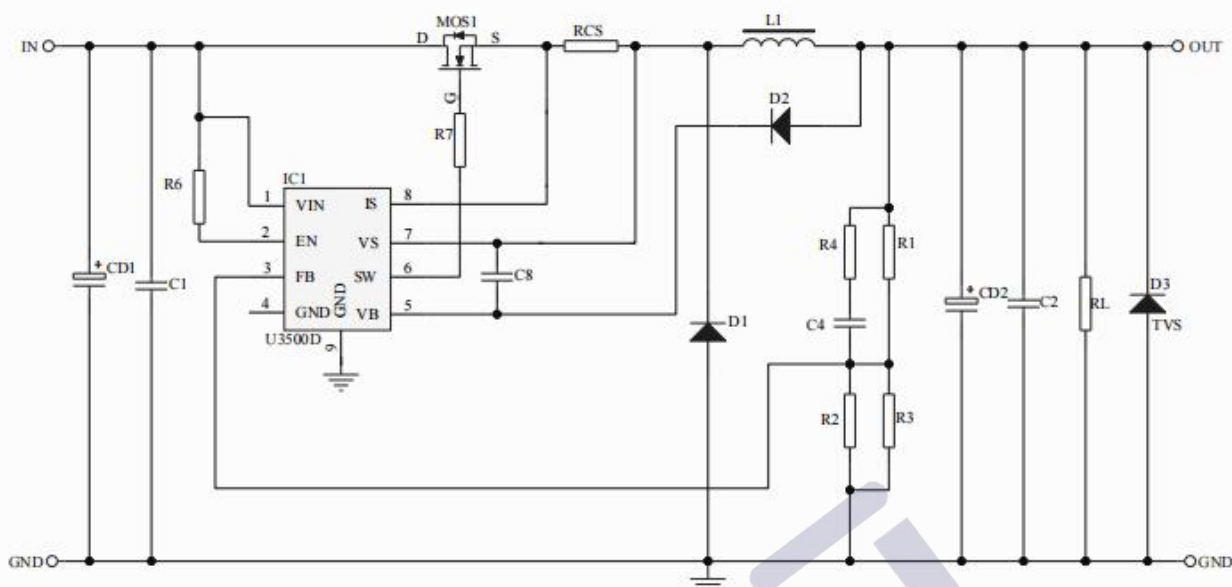
Figure 2: External Bootstrap Diode

### PCB Layout Guidelines

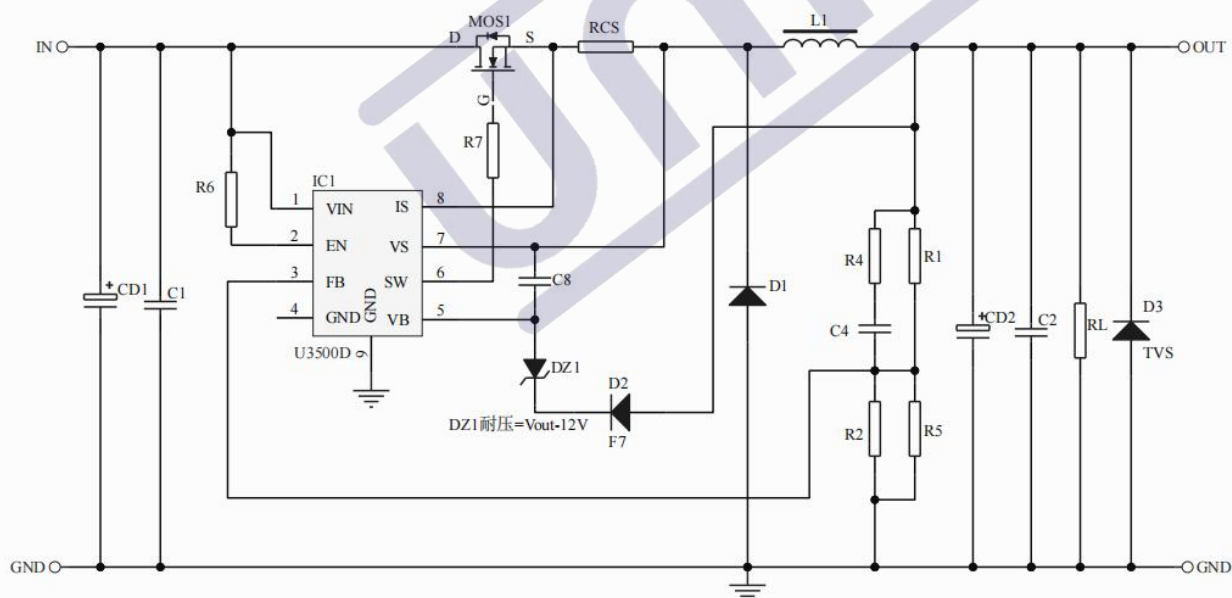
Efficient PCB layout is critical for stable operation. For best results, follow the guidelines below.

1. Place the input decoupling capacitor, catch diode, and the U3500D (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 to improve thermal conduction.

VOUT12V



## Typical application



u ni u

[illegible]

The diagram illustrates a buck converter circuit. The input voltage is connected to the VIN pin (pin 1) of the U3500D IC. A resistor R2 is connected between the input and ground. The EN pin (pin 2) is connected to the input. The FB pin (pin 3) is connected to the feedback network, which consists of two resistors, RFB1 and RFB2, connected in a voltage divider configuration across the output. The GND pin (pin 4) is connected to ground. The SW pin (pin 6) is connected to the gate of the MOSFET Q1. The VS pin (pin 7) is connected to the source of the MOSFET. The VB pin (pin 5) is connected to ground. The IC is powered by a 5V regulator (U3500D) which has its input connected to the input voltage and its output connected to the SW pin. The MOSFET Q1 is connected to the input voltage through an inductor L1. The drain of the MOSFET is connected to the output voltage through an inductor L2. The output voltage is also connected to a load resistor RL. A capacitor C1 is connected between the input and the MOSFET gate. A capacitor C2 is connected between the VS pin and ground. A diode D1 is connected in parallel with the load resistor RL, with its cathode to the output and its anode to ground. The output voltage is also connected to a capacitor CD2 and a load resistor RL.

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.



## 1、版本记录

DATE	REV.	DESCRIPTION
2023/7/25	1.0	首次发布
2023/10/10	1.1	增加小功率电路
2023/11/08	1.2	增加使能输入的应用电路
2024/03/27	1.3	增加IPK计算公式和升降压应用电路

## 2、联系我们

浙江宇力微新能源科技有限公司

总部地址：绍兴市越城区斗门街道袍渎路25号中节能科创园45幢4/5楼

电话：0575-85087896（研发部）

传真：0575-88125157

E-mail:htw@uni-semic.com

无锡地址：江苏省无锡市锡山区先锋中路6号中国电子（无锡）数字芯城1#综合楼503室

电话:0510-85297939

E-mail:zh@uni-semic.com

深圳地址：深圳市宝安区西乡街道南昌社区宝源路泳辉国际商务大厦410

电话：0755-84510976

E-mail:htw@uni-semic.com



**重要注意事项：**

- 1、绍兴宇力半导体有限公司和浙江宇力微新能源科技有限公司，简称“宇力”，宇力保留说明书、应用指导书等的更改权，不另行通知。客户在采购时应获取我司最新版本资料，并验证相关信息是否最新和完整。产品使用前请仔细阅读本说明书、应用指导书等相关资料和其中的注意事项。
- 2、本产品属于消费类电子产品，宇力对宇力产品的任何特定用途的适用性不做任何保证。产品也不得应用在被任何适用法律或法规禁止制造、使用或销售的任何设备或系统中。如果宇力的产品被用禁止产品或系统中，此类应用产品的全部风险由客户自行承担，宇力对此不承担任何责任。
- 3、本文件和产品的应用指导书等相关资料所描述的产品的应用仅用于说明参考，本文件提供的参数在不同应用中可能而且确实会有所不同，实际性能可能会随之变化。使用时需要进一步评估、测试和验证。宇力对产品应用或客户产品设计等方面的任何协助不承担责任。
- 4、客户须在产品的有效存储期内使用完毕，客户如对宇力产品的有效存储期有任何疑问的，请即时联系宇力对接销售人员或宇力客户服务支持，对于超过存储期使用的，宇力不承担任何责任。
- 5、未经宇力事先书面同意，不得对文件和产品进行拆解、更改、修改或者复制。
- 6、购买产品时请认清宇力商标和物料名称，如有疑问请联系宇力。第三方购买请注意是否为宇力授权的资质，同时在采购之前联系我司，以确认产品为宇力原厂正品。
- 7、客户在应用和使用产品时请务必遵守相关法规，包括但不限于贸易管制法规等。本产品为民用电子产品，请勿应用于非民用领域。
- 8、产品提升永无止境，我公司将竭诚为客户提供更优秀的产品！