

## 6V~140V输入，3A实地异步降压变换器

### 140V Input, 3A, A-Synchronous Buck Converter

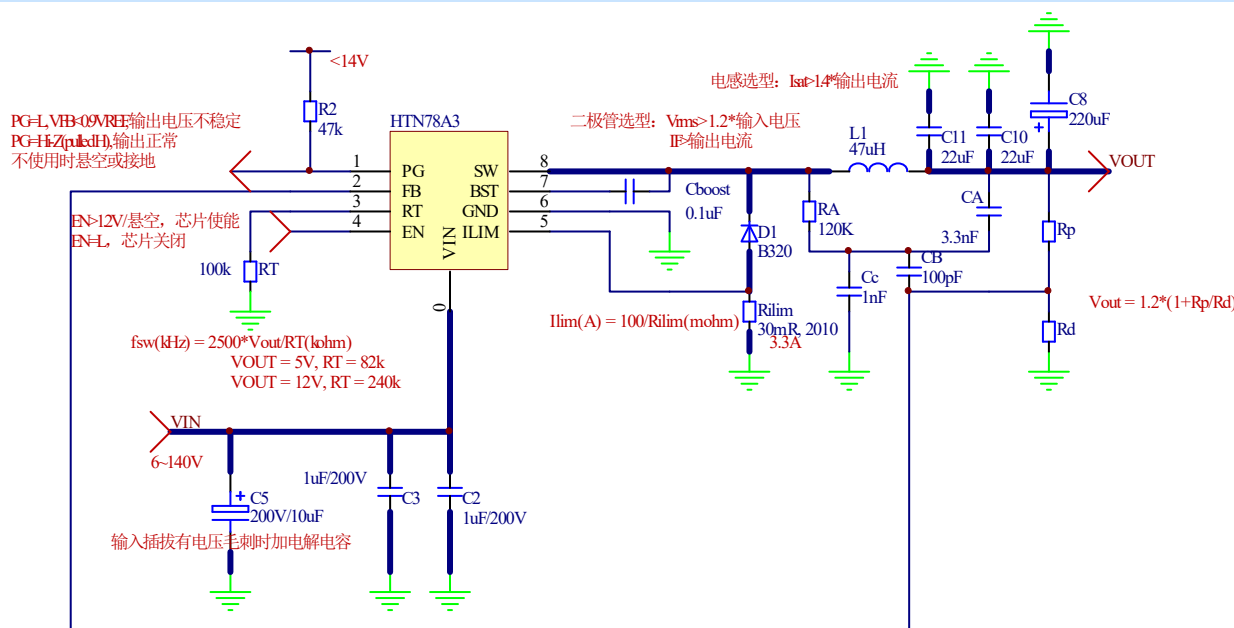
#### FEATURES

- 3A converter with 250mΩ HS FET
- Input voltage range: 6V~140V
- Pulse Skipping Mode (PSM) in light load
- Up to 1MHz Programmable Switching Frequency
- COT ripple-base voltage mode control
- Over-voltage, Over-current and Over-Temperature Protection
- Packages: Pb-free Packages, ESOP8
- 3A降压，内置250mΩ高侧功率管
- 输入电压范围：6V~140V
- 脉冲跳跃模式使得轻载下高效率
- 最高1MHz可编程开关频率
- COT纹波电压控制架构
- 欠压保护、过流保护和过热关断保护
- 无铅封装，ESOP8

#### APPLICATIONS

- E-bike
- Solar Energy System
- HV battery
- Industrial Power Supplies
- Automotive System
- 二轮电瓶车
- 太阳能系统
- 高压电池组
- 工业电源
- 汽车系统

#### TYPICAL APPLICATION



1.  $f_{sw}(kHz) = \frac{2500 * V_{OUT}(V)}{RT(k\Omega)}$  ;
2.  $V_{OUT} = 1.2 * (1 + \frac{R_p}{R_t})$ ;
3.  $I_{lim}(A) = \frac{100}{R_{lim}(m\Omega)}$ , 典型  $R_{lim}=30m\Omega$ ,  $I_{lim} = 3.3A$ ;  $R_{lim}$  需大尺寸封装, 承受功率建议  $>I_{outmax}^2 * R_{lim}$ , 建议使用 1812 或更大封装 ( $\geq 0.5W$ );
4. 相关推荐参数设置:

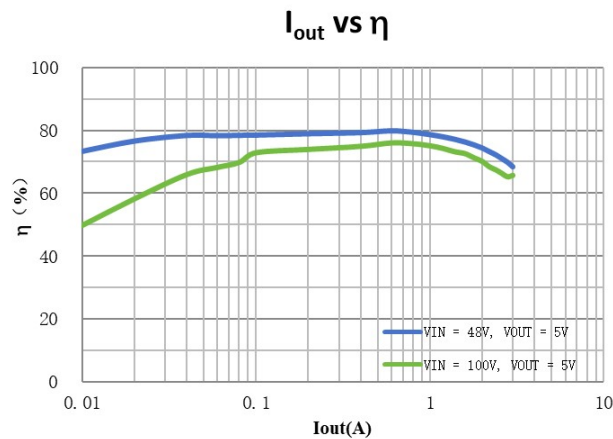
	R <sub>p</sub>	R <sub>d</sub>	R <sub>A</sub>	C <sub>A</sub>	C <sub>B</sub>	C <sub>C</sub>	R <sub>T</sub>
V <sub>OUT</sub> = 5V	47k	15k	120k	3.3nF	100pF	1nF	82k (f <sub>sw</sub> ≈150kHz)
V <sub>OUT</sub> = 12V	200k	22k	330k	1nF	100pF	3.3nF	200k (f <sub>sw</sub> ≈150kHz)

5. 输出电容: 220uF(电解)//47uF(陶瓷), 额定耐压大于V<sub>OUT</sub> 2倍以上;
6. 底部VIN需大面积铺铜以提高散热。

### DESCRIPTION

The HTN78A3 is 3A buck converters with wide input voltage, ranging from 6V to 140V, which integrates an 250mΩ high-side MOSFET. The HTN78A3, adopting the ripple-base voltage mode control, supports the Pulse Skipping Modulation (PSM) which assists the converter on achieving high efficiency at light load. The HTN78A3 features programmable switching frequency from 100kHz to 1MHz with an external resistor. The HTN78A3 allows power conversion from high input voltage to low output voltage with a minimum 120ns on-time of switch MOS. The device offers fixed 3ms soft start to prevent inrush current during the startup. The HTN78A3 features external loop compensation to provide the flexibility to optimize either loop stability or loop response. The HTN78A3 provides valley current limit, thermal shutdown protection, output over-voltage protection, output over load protection and input voltage under-voltage protection. The device is available in an ESOP8 package.

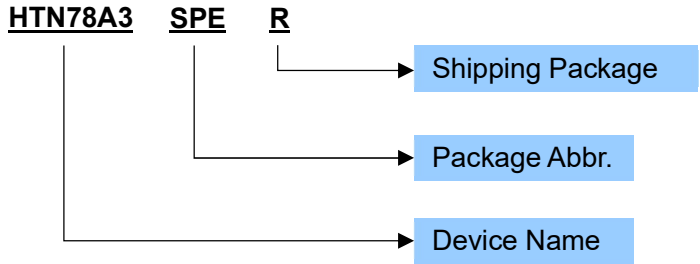
HTN78A3是3A降压转换器，具有从6V到140V的宽输入电压，集成了250mΩ高侧MOSFET。HTN78A3采用基于纹波电压模式控制，支持跳周期调制（PSM），有助于转换器在轻负载下实现高效率。HTN78A3具有100kHz至1MHz的可编程开关频率，外部电阻可调。HTN78A3允许从高输入电压到低输出电压的功率转换，开关MOS的最小导通时间为120ns。该器件提供3ms的固定软启动，以防止启动过程中的涌入电流。HTN78A3具有外部环路补偿功能，可灵活优化环路稳定性或环路响应。HTN78A3提供谷值电流限制、热关断保护、输出过压保护、输出过载保护和输入电压欠压保护。该器件采用ESOP8封装。



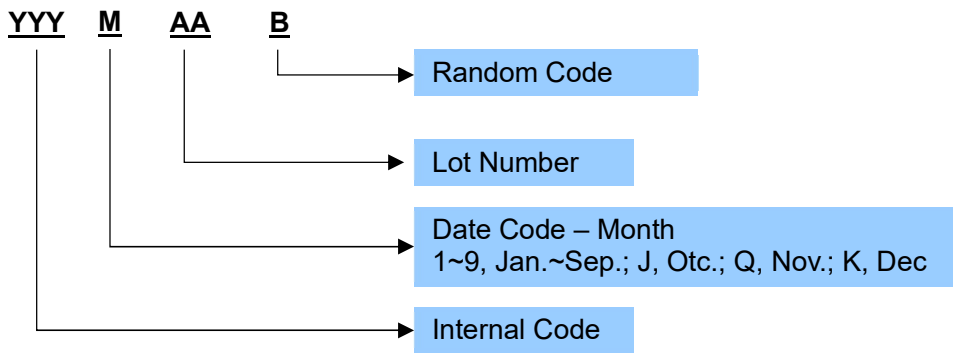
**ORDERING INFORMATION**

Part Number	Package Type	Package Abbr.	Eco Plan	MSL Level	Marking	Shipping Package / MOQ
HTN78A3SPER	ESOP8	SPE	RoHS	MSL3	HTN78A3 YYYMAAB <sup>1</sup>	Tape and Reel (R) / 2500pcs

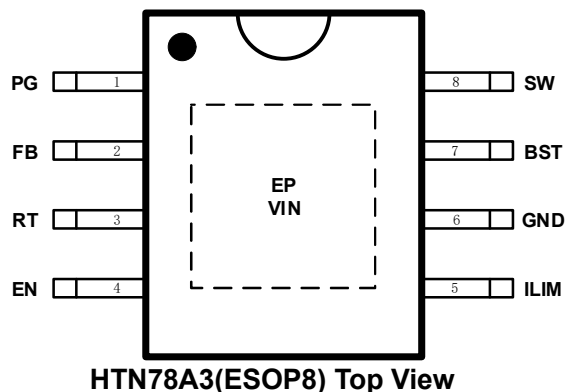
**Part Number**



**Production Tracking Code**



<sup>1</sup> YYYMAAB is production tracking code  
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**■ TERMINAL CONFIGURATION**

**HTN78A3(ESOP8) Top View**
**■ TERMINAL FUNCTION**

Terminal No.	Name	Description
1	PG	Power good. 输出电源信号建立标志。
2	FB	Feedback. Connect resistor divider to output voltage. 反馈。接分压电阻到输出电压。
3	RT	Set the internal oscillator clock frequency. Connect a resistor from this pin to ground to set switching frequency. 设置内部振荡器时钟频率。将一个电阻器从该引脚连接到地，以设置开关频率。
4	EN	Enable pin to the regulator with internal pull-up current source. Pull low to disable the converter. Float or connect to HIGH to enable the converter. 稳压器使能引脚，带内部上拉电流源。将端口拉低以禁用转换器。悬空或连接到逻辑高电平可以启动转换器。
5	ILIM	Valley Current limit setting terminal, $I_{LIM} = 100\text{mV}/R_{ilim}$ 电感谷值限流设置，限流公式 $I_{LIM}=100\text{mV}/R_{ilim}$
6	GND	Analog Ground 芯片模拟地
7	BST	Bootstrap. Power supply for the high-side MOSFET driver. Connect a bypass capacitor between BST and SW. BST是内部高端MOSFET驱动器的正电源。在BST和SW之间连接一个旁路电容器。
8	SW	Switch node, Connect SW to an external power inductor. 开关端口，连接外部功率电感。
EP	VIN	Voltage input terminal, also provides thermal connection from the device to the board. 芯片电源输入，同时也是散热路径。

**SPECIFICATIONS<sup>1</sup>**
**Absolute Maximum Ratings<sup>2</sup>**

PARAMETER	Symbol	MIN	TYP	MAX	UNIT
VIN supply voltage	VIN	-0.3		150	V
BST voltage	BST	-0.3		155	V
BST voltage (10ns transient)	BST	-0.3		157.5	V
Voltage between BST and SW	BST to SW	-0.3		6	V
FB voltage	FB	-0.3		5.5	V
EN voltage	EN	-0.3		VIN+0.3	V
SW voltage	SW	-2		150	V
SW voltage (10ns transient)	SW	-3.5		152	V
Moisture Sensitivity Level (MSL)			MSL3		
Junction Temperature	TJ	-40		150	°C
Storage Temperature	TSTG	-55		150	°C
ESD, Human-body model (HBM)	HBM		±2000		V
ESD, Charged-device model (CDM)	CDM		±500		V

**Recommended Operating Conditions**

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VIN supply voltage	VIN		6		140	V
BST voltage	BST		-0.1		145.5	V
Voltage between BST and SW	BST to SW		-0.1		5.5	V
FB voltage	FB		-0.1		4.5	V
EN voltage	EN		-0.1		VIN	V
SW voltage	SW		-1.8		140	V
Junction Temperature	TJ		-40		125	°C

**Electrical Characteristics**

VIN = 12V, TA = +25°C, Riim=30mΩ, unless otherwise noted.

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VIN UVLO threshold	VUVLO	Rising		5		V
		Falling		4.6		V
VIN UVLO hysteresis	Vhys			0.4		V
Quiescent supply current	IQ	VEN = 12V, VFB = 1.0 V, no switching		260		uA
Shutdown supply current	ISD	VEN = 0V		6		μA
High-side switch on resistance	RDS(ON)_H	VBST - VSW = 5.5V		250		mΩ
Valley Current limit	ILIM_valley	Rilim = 30mohm		3.3		A
EN threshold	VENH	No voltage hysteresis, rising and falling		1.2		V
EN source current	ISource	EN = GND		1		uA
Feedback voltage	VFBH			1.2		V
FB input current	IFB	VFB = 1.2V	-100		100	nA
Minimum on time	tON_MIN			120		ns
Soft-start time	tSS			3		ms
Switching frequency range	fsw		100		1000	kHz
		RT = 82KΩ, VOUT = 5V		150		kHz
Thermal shutdown		Trigger thermal shutdown		160		°C
		Hysteresis		25		°C

## APPLICATION INFORMATION

### 1 Description

The HTN78A3 is 3A buck converters with wide input voltage, ranging from 6V to 140V, which integrates an 250mΩ high-side MOSFET. The HTN78A3, adopting the ripple-base voltage mode control, supports the Pulse Skipping Modulation (PSM) which assists the converter on achieving high efficiency at light load. The HTN78A3 features programmable switching frequency from 100kHz to 1MHz with an external resistor. The HTN78A3 allows power conversion from high input voltage to low output voltage with a minimum 120ns on-time of switch MOS. The device offers typical 3ms soft start to prevent inrush current during the startup. The HTN78A3 features external loop compensation to provide the flexibility to optimize either loop stability or loop response. The HTN78A3 provides valley current limit, thermal shutdown protection, output over-voltage protection, output over load protection and input voltage under-voltage protection. The device is available in an ESOP8 package.

### 2 Enable (EN) Control

The HTN78A3 is enabled when the VIN pin voltage rises above 5V and the EN pin voltage exceeds the enable threshold. The HTN78A3 is disabled when the VIN pin voltage falls below 4.4V or when the EN pin voltage is low. The EN pin has an internal pull-up current source of 1 μA that enables operation of the HTN78A3 when the EN pin floats.

### 3 Soft Start and Start Delay with Pre-biased Output Voltage

The HTN78A3 employs an internal 3ms soft start to ramp up the FB voltage from 0V to 1.2V linearly once EN pulled high.

### 4 Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) is implemented to protect the chip from operating at an insufficient supply voltage. The UVLO rising threshold is about 5V, while its falling threshold is about 4.6V.

### 5 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.

HTN78A3 是 3A 降压转换器, 具有从 6V 到 140V 的宽输入电压, 集成了 250mΩ 高侧 MOSFET。HTN78A3 采用基于纹波电压模式控制, 支持跳周期调制 (PSM), 有助于转换器在轻负载下实现高效率。HTN78A3 具有 100kHz 至 1MHz 的可编程开关频率, 外部电阻可调。HTN78A3 允许从高输入电压到低输出电压的功率转换, 开关 MOS 的最小导通时间为 120ns。该器件提供 3ms 的固定软启动, 以防止启动过程中的涌入电流。HTN78A3 具有外部环路补偿功能, 可灵活优化环路稳定性或环路响应。HTN78A3 提供谷值电流限制、热关断保护、输出过压保护、输出过载保护和输入电压欠压保护。该器件采用 ESOP8 封装。

当 VIN 引脚电压升至 5V 以上且 EN 引脚电压超过启用阈值时, HTN78A3 启用。当 VIN 引脚的电压降至 4.6V 以下或 EN 引脚的电压低于阈值时, HTN78A3 禁用。EN 引脚有一个 1μA 的内部上拉电流源, 当 EN 引脚浮空时, 它可以使 HTN78A3 工作。

HTN78A3 采用内部 3ms 软启动, 一旦 EN 拉高, FB 电压就会线性上升至 1.2V。

欠压锁定 (UVLO) 功能可避免芯片工作在电源电压不足的条件。UVLO 上升阈值约为 5V, 下降阈值为 4.6V。

过热关断保护是为了防止芯片在极高的温度下工作。当芯片温度高于其上限阈值时, 整个芯片关闭。当温度低于其下限阈值时, 芯片再次启用。

## 6 COT Mode Control

The HTN78A3 step-down switching converter employs a constant on-time (COT) control scheme. The COT control scheme sets a fixed on time,  $t_{ON}$ , of the high-side FET using a timing resistor ( $R_T$ ).  $t_{ON}$  is adjusted as  $V_{IN}$  changes and is inversely proportional to the input voltage to maintain a fixed frequency when in continuous conduction mode (CCM). After expiration of  $t_{ON}$ , the high-side MOSFET remains off until the feedback pin is equal or below the reference voltage of 1.2 V. To maintain stability, the feedback comparator requires a minimal ripple voltage that is in-phase with the inductor current during the off time. Furthermore, this change in feedback voltage during the off time must be large enough to dominate any noise present at the feedback node. The minimum recommended ripple voltage is 20 mV. During a rapid start-up or a positive load step, the regulator operates with minimum off times until regulation is achieved. This feature enables extremely fast load transient response with minimum output voltage undershoot. When regulating the output in steady-state operation, the off time automatically adjusts itself to produce the SW pin duty cycle required for output voltage regulation to maintain a fixed switching frequency. In CCM, the switching frequency  $f_{SW}$  is programmed by the  $R_T$  resistor. Use formula 1 to calculate the switching frequency.

$$f_{sw}(kHz) = \frac{2500 * V_{OUT}(V)}{R_T(k\Omega)} \quad (\text{公式 1})$$

## 7 Bootstrap Voltage Regulator

The HTN78A3 contains an internal linear regulator that is powered from  $V_{IN}$  with a nominal output of 5 V, eliminating the need for an external capacitor to stabilize the linear regulator. The internal VCC regulator supplies current to internal circuit blocks. The input pin ( $V_{IN}$ ) can be connected directly to line voltages up to 140 V.

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own undervoltage lockout (UVLO) protection. The UVLO rising threshold is 2.9V with a hysteresis of 200mV. The bootstrap capacitor is charged and regulated to about 5V by the dedicated internal bootstrap regulator.

HTN78A3 降压开关转换器采用恒定导通时间 (COT) 控制方案。该方案使用定时电阻  $R_T$  设置高侧 MOSFET 的固定导通时间  $t_{ON}$ 。 $t_{ON}$  被调整为随  $V_{IN}$  变化, 与输入电压成反比, 以在连续工作时 (CCM) 保持频率固定。 $t_{ON}$  后, 高侧 MOSFET 将保持关断状态, 直到 FB 等于或等于低于 1.2V 的参考电压。为了保持稳定性, 需要一个在关断期间与电感电流同相的最小纹波电压信号注入到 FB 节点。这个关断期间的反馈信号电压必须足够大, 以免被噪声干扰。建议的最小纹波电压为 20 mV。确保在整个输入电压范围内的稳定性。

在快速启动或大负载阶段, 调节器以最小的关闭时间运行, 直到达到调节。此功能能够以最小的输出电压下冲实现极快的负载瞬态响应。在稳态操作中调节输出时, 关断时间会自动调整, 以产生输出电压调节所需的 SW 引脚占空比, 从而保持固定的开关频率。工作在 CCM 时, 开关频率  $f_{SW}$  由  $R_T$  电阻器编程。使用公式 1 计算开关频率。

HTN78A3 包含一个内部线性稳压器, 该稳压器由  $V_{IN}$  供电, 输出为 5V, 消除了对外部电容器来稳定线性调节器的需要。内部 VCC 调节器为内部电路提供电流。输入引脚 ( $V_{IN}$ ) 可以直接连接到高达 140V 的线电压。

功率 MOSFET 驱动由外部自举电容器供电。该功率管有其自身的欠压锁定 (UVLO) 保护。UVLO 上升阈值为 2.9V, 磁滞 200mV。

内部自举调节器通过外部自举电容充电调节至约 5V。

## 8 Over Current Limit and Hiccup Mode

The inductor current is monitored during high-side MOSFET off. The HTN78A3 implements over current protection with cycle-by-cycle limiting inductor valley current to avoid inductor current running away during unexpected overload or output hard short condition. When overload or hard short happens, the high-side MOSFET remains off until the inductor current drops below this foldback valley current limit, after which the next on-pulse is initiated. This method folds back the switching frequency to prevent overheating and limits the average output current. The inductor current is clamped at over current limitation. Thus, the output voltage drops below regulated voltage with FB voltage less than internal reference voltage continuously. An internal counter starts to count when FB voltage is below 0.8V, for 64 cycles, the converter stops switching. After remaining OFF for about 65mS, the device restarts from soft starting phase. If overload or hard short condition still exists during soft-start for 64 cycles, the device enters into turning-off mode again. When overload or hard short condition is removed, the device automatically recovers to enter normal regulating operation. The hiccup protection mode above makes the average short circuit current to alleviate thermal issues and protect the regulator.

## 9 Power Good (PGOOD)

The HTN78A3 provides a PGOOD flag pin to indicate when the output voltage is within the regulation level. Use the PGOOD signal for start-up sequencing of downstream converters or for fault protection and output monitoring. PGOOD is an open-drain output that requires a pullup resistor to a DC supply not greater than 14 V. The typical range of pullup resistance is 10 k $\Omega$  to 100 k $\Omega$ . If necessary, use a resistor divider to decrease the voltage from a higher voltage pullup rail. When the FB voltage exceeds 95% of the internal reference VREF, the internal PGOOD switch turns off and PGOOD can be pulled high by the external pullup. If the FB voltage falls below 90% of VREF, an internal 7- $\Omega$  PGOOD switch turns on and PGOOD is pulled low to indicate that the output voltage is out of regulation. The rising edge of PGOOD has a built-in deglitch delay of 5  $\mu$ s.

在高压侧 MOSFET 关断期间监测电感器电流。HTN78A3 通过逐周期限制电感器谷值电流来实现过电流保护,以避免电感器电流在过载或输出短路情况下失控。当发生过载或短路时,高侧 MOSFET 保持关断状态,直到电感器电流降至折返谷值电流限制以下,之后启动下一个导通脉冲。这种方法折叠降低了开关频率以防止过热并限制平均输出电流。电感器电流被箝位在过电流限制下。因此,输出电压持续下降到低于调节电压,FB 电压低于内部参考电压。当 FB 电压低于 0.8V 时,内部计数器开始计数,持续 64 个周期后,转换器停止切换。在保持关闭状态约 65mS 后,器件从软启动阶段重新启动。如果软启动期间过载或短路情况仍然存在,并持续 64 个周期,则器件再次进入关闭模式。当过载或短路条件消除时,器件会自动恢复,进入正常调节操作。上述打嗝保护模式使平均短路电流减轻热问题并保护调节器。

HTN78A3 提供 PGOOD 标志引脚,以指示输出电压何时在调节水平内。使用 PGOOD 信号对下游转换器进行启动排序或进行故障保护和输出监测。PGOOD 是一种开漏输出,需要一个上拉电阻连接到不大于 14 V 的直流电源。上拉电阻的典型范围为 10 k $\Omega$  至 100 k $\Omega$ 。如有必要,使用分压器从更高电压的上拉轨降低电压。当 FB 电压超过内部参考 VREF 的 95% 时,内部 PGOOD 开关关断,PGOOD 可以通过外部上拉被拉高。如果 FB 电压降至 VREF 的 90% 以下,则内部 7- $\Omega$  PGOOD 开关打开,PGOOD 被拉低,表示输出电压不稳定。PGOOD 的上升沿具有 5 $\mu$ s 的内置延迟。



## 10 PCB Layout Guidelines

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

(1) Place the input capacitor and output capacitor as close to the device 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) A whole VIN pad must be provided on the PCB and the device connected to it via solder for better thermal performance.

有效的 PCB 布局对于稳定运行至关重要。要获得最佳结果，请参考下图并遵循以下指南。

(1) 将输入电容、输出电容尽可能靠近芯片。

(2) 保持电源轨迹非常短且相当宽，特别是对于 SW 节点。

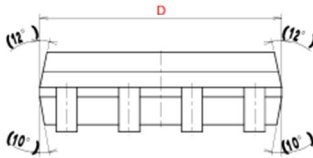
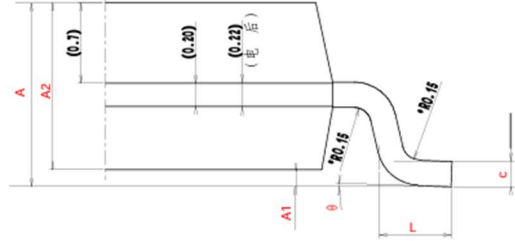
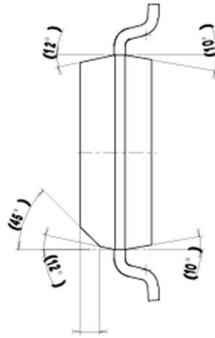
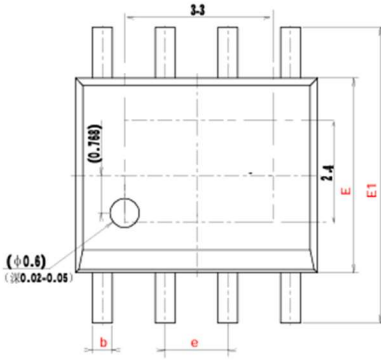
这有助于大大降低 SW 节点上的电压尖峰，并降低 EMI 噪声水平。

(3) FB 走线尽可能远离电感和功率走线（如 SW 节点）。

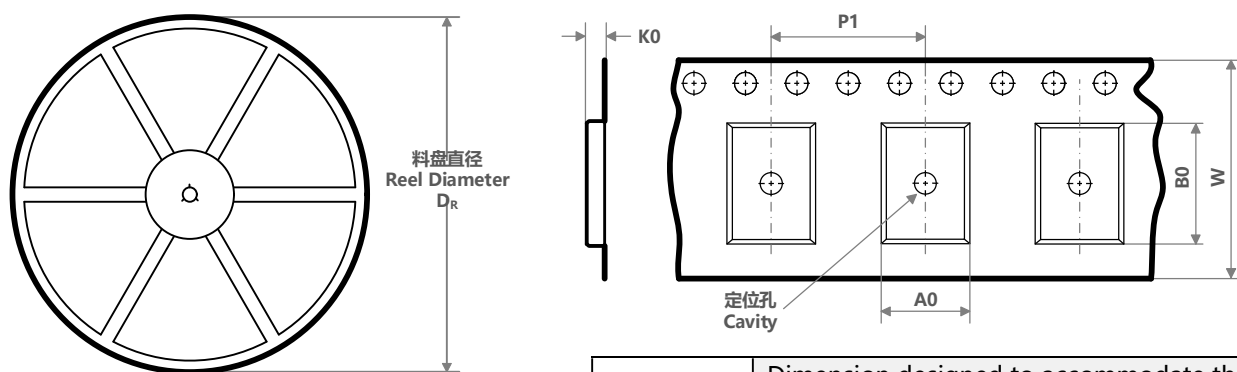
(4) 底部 VIN 大面积铺铜以提高散热。

■ PACKAGE OUTLINE

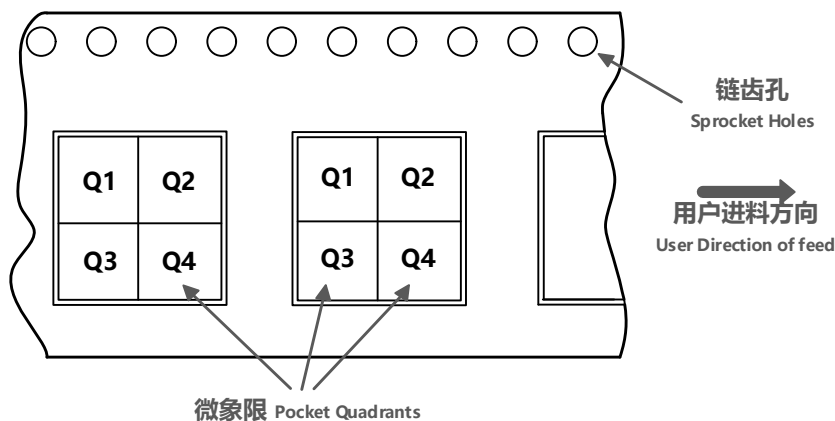
ESOP8



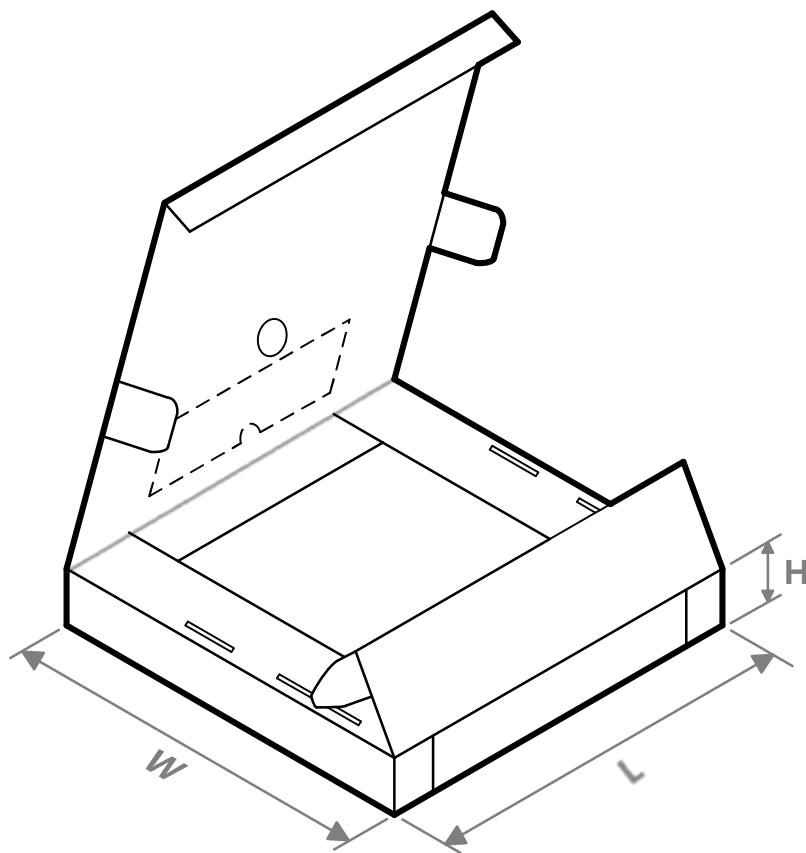
字符	Dimension millimeters		
	Min	Standard	Max
A	1.350	1.500	1.700
A1	0	0.050	0.100
A2	1.350	1.450	1.550
b	0.360	0.400	0.440
c	0.215	0.220	0.235
D	4.800	4.900	5.000
E	3.840	3.940	4.040
E1	5.900	6.000	6.100
e	1.27BSC		
L	0.400	0.550	0.700
⊙	0°		8°

**TAPE AND REEL INFORMATION**


<b>A0</b>	Dimension designed to accommodate the component width; 料槽宽度
<b>B0</b>	Dimension designed to accommodate the component length; 料槽长度
<b>K0</b>	Dimension designed to accommodate the component thickness; 料槽厚度
<b>W</b>	Overall width of the carrier tape; 载带整体宽度
<b>P1</b>	Pitch between successive cavity centers; 相邻槽中心间距

**编带 PIN1 方位象限分配**  
**Quadrant Assignments for Pin1 Orientation in Tape**


器件料号 Part No.	封装类型 Package Type	封装标识 Package Abbr.	引脚数 Pins	SPQ	料盘直径 Dr(mm)	料盘宽度 W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 象限 Quadrant
HTN78A3SPER	ESOP	SPE	8	2500	330	12	6.55	5.55	1.95	8	12	Q1

**TAPE AND REEL BOX INFORMATION**


器件料号 Part No.	封装类型 Package Type	封装标识 Package Abbr.	引脚数 Pins	SPQ	长度 Length (mm)	宽度 Width (mm)	高度 Height (mm)
HT78A3SPER	ESOP	SPE	8	5000	360	345	65

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**禾润电子科技（嘉兴）股份有限公司****Heroic Electronic Technology (Jiaxing) Co., Ltd.**

地址：浙江省嘉兴市南湖区亚太路906号科创CBD园区21号楼11层

Add: 11th floor, Building 21, No. 906, Yatai Road, Jiaxing, Zhejiang Province

Sales: 0573-82586608, sales@heroic.com.cn

Support: 0573-82586151, support@heroic.com.cn

Website: www.heroic.com.cn; wap.heroic.com.cn

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