3通道，2.5~5.5V输入，2A同步降压变换器

3-Channel, 2.5~5.5V Input, 2A, Synchronous Buck Converter

■ FEATURES

- 2A converter with 150mΩ and 100mΩ FETs
- Input voltage range: 2.5V~5.5V
- Output voltage range: 0.6 V~VIN
- Power save mode to keep high efficiency in light load
- 100% duty cycle for low dropout
- 30*3uA Quiescent Current
- 1.5MHz typical switching frequency
- Shutdown current: <=1 μA (typical)
- Soft start and start delay
- Over current limit protection
- Non-latching Undervoltage protection and Thermal Shutdown protection
- Enable pin
- Packages: Pb-free Packages, QFN3*3-20L

- 2A降压，内置150mΩ和100mΩ功率管
- 输入电压范围：2.5V~5.5V
- 输出电压范围：0.6V~VIN
- 轻载下具有节能高效率
- 支持100%占空比低压降
- 30*3uA静态电流
- 1.5MHz典型开关频率
- 关断电流<=1uA (典型值)
- 软起动，启动延迟
- 过流检测限制保护
- 欠压保护、过热关断保护，不锁定可自动恢复
- 具有使能pin
- 无铅封装，QFN3*3-20L

■ APPLICATIONS

- 5V power rail applications
- Set top box
- Consumer electronics
- Industrial power supplies

- 5V电源轨
- 机顶盒
- 消费电子
- 工业电子

■ DESCRIPTION

The HTN1302 is a 3-channel, 2A, synchronous buck converter with minimum external components and low shutdown current.

The device operates in PWM mode with typical 1.5MHz switching frequency at medium to heavy loads. At light load, the device operates in power save mode to keep high efficiency.

The output voltage is adjustable through external resistor.

The HTN1302 is available in QFN3*3-20L packages.

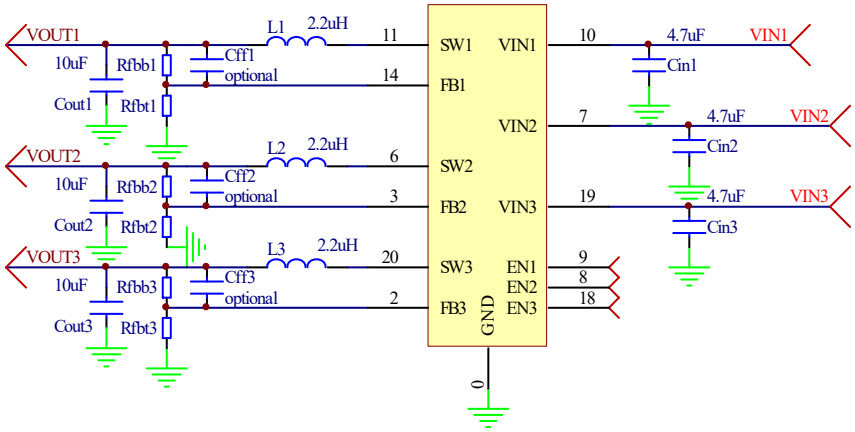
HTN1302 是一款3通道、2A同步降压转换器，具有最少的外部元件和低关断电流。

该器件在中到重载时，工作在典型开关频率为1.5MHz的PWM模式；在轻载时，器件工作在高效节能模式。

输出电压可通过外部电阻调节。

HTN1302 采用QFN3*3-20L封装。

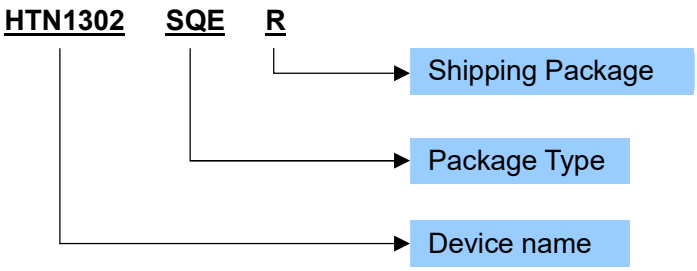
■ TYPICAL APPLICATION



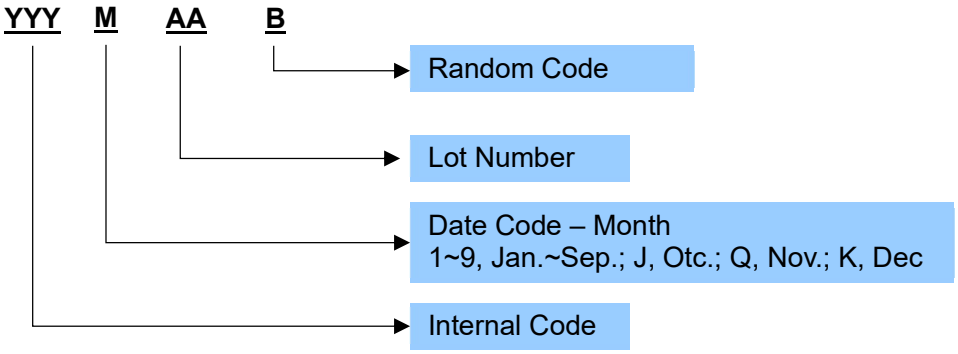
■ ORDERING INFORMATION

Part Number	Package Type	Package Abbr.	Eco Plan	MSL Level	Marking	Shipping Package / MOQ
HTN1302SQER	QFN3×3-20L	SQE	RoHS	MSL3	HTN1302 YYYMAAB[1]	Tape and Reel (R) / 5000pcs

Part Number

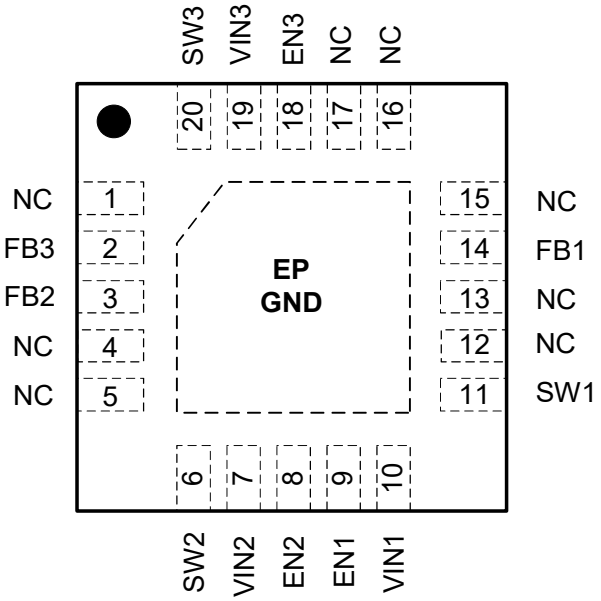


Production Tracking Code



[1] YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION



Top View

■ TERMINAL FUNCTION

Terminal No.	Name	Description
1, 4, 5, 12, 13, 15, 16, 17	NC	No internal connection, connect to GND for better thermal performance. 无内部连接，外部连接到地以加强散热
2	FB3	Feedback for CH3. Connect resistor divider to output voltage. 通道3的反馈端。接分压电阻到输出电压。
3	FB2	Feedback for CH2. Connect resistor divider to output voltage. 通道2的反馈端。接分压电阻到输出电压。
6	SW2	Switch node for CH2. 通道2的开关端口。
7	VIN2	Input supply for CH2. VIN supplies power to all of the internal control circuitries. A decoupling capacitor to ground must be placed close to VIN to minimize switching spikes. 通道2的输入电源。VIN为所有内部控制电路供电。接地滤波电容必须放置在VIN附近，以减少开关尖峰。
8	EN2	Enable input for CH2. Pull EN below the specified threshold to shut down the device. Pull EN above the specified threshold to enable the device. Don't leave EN floating. EN can be connected to VIN. 通道2的使能脚。将EN拉到阈值以下以关闭。将EN拉至阈值以上启用。EN脚不能悬空，可以接到VIN脚。
9	EN1	Enable input for CH1. Pull EN below the specified threshold to shut down the device. Pull EN above the specified threshold to enable the device. Don't leave EN floating. EN can be connected to VIN. 通道1的使能脚。将EN拉到阈值以下以关闭。将EN拉至阈值以上启用。EN脚不能悬空，可以接到VIN脚。
10	VIN1	Input supply for CH1. VIN supplies power to all of the internal control circuitries. A decoupling capacitor to ground must be placed close to VIN to minimize switching spikes. 通道1的输入电源。VIN为所有内部控制电路供电。接地滤波电容必须放置在VIN附近，以减少开关尖峰。
11	SW1	Switch node for CH1. 通道1的开关端口。
14	FB1	Feedback for CH1. Connect resistor divider to output voltage. 通道1的反馈端。接分压电阻到输出电压。
18	EN3	Enable input for CH3. Pull EN below the specified threshold to shut down the device. Pull EN above the specified threshold to enable the device. Don't leave EN floating. EN can be connected to VIN.

		通道3的使能脚。将EN拉到阈值以下以关闭。将EN拉至阈值以上启用。EN脚不能悬空，可以接到VIN脚。
19	VIN3	Input supply for CH3. VIN supplies power to all of the internal control circuitries. A decoupling capacitor to ground must be placed close to VIN to minimize switching spikes. 通道3的输入电源。VIN为所有内部控制电路供电。接地滤波电容必须放置在VIN附近，以减少开关尖峰。
20	SW3	Switch node for CH3. 通道3的开关端口。
EP	GND	Ground. GND should be placed as close to the output capacitor as possible to avoid the high-current switch paths. 地。GND应尽可能靠近输出电容，以避免高电流开关路径。

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings [2]

PARAMETER	Symbol	MIN	TYP	MAX	UNIT
VINx, ENx	VIN	-0.3		6	V
FBx voltage	FB	-0.3		5.5	V
SWx voltage (DC)	SW	-2		VIN+0.3	V
SWx voltage (10ns transient)	SW	-3.5		9	V
Moisture Sensitivity Level (MSL)			MSL3		
Junction Temperature	T_J	-40		150	℃
Storage Temperature	T_{STG}	-55		150	℃
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
VINx supply voltage	V_{IN}		2.5		5.5	V
Output voltage	V_{OUT}		0.6		VIN	V
Output current	I_{OUT}		0		2	A
Operation Temperature	T_A		-40		85	℃

● Electrical Characteristics

VIN = 5V, T_A = +25°C, unless otherwise noted.

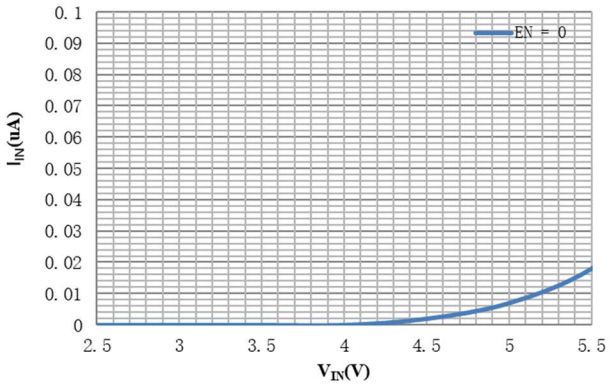
PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
VINx UVLO threshold	V_{UVLO}	Rising		2.40		V
		Falling		2.30		V
VINx UVLO hysteresis	V_{hys}			0.06		V
Quiescent supply current	I_Q	EN=H, V_{FB} = 1.0 V, no switching		30*3		uA
Shutdown supply current	I_{SD}	V_{EN} = 0V		0.015		μA
High-side switch on resistance	$R_{DS(ON)\_H}$	V_{BST} - V_{SW} = 5.5V		150		mΩ
Low-side switch on resistance	$R_{DS(ON)\_L}$			100		mΩ
Current limit (high-side switch)	I_{LIM}			3		A
Zero cross current detection	I_{ZC}			0		A
ENx up threshold	V_{ENH}			1.1	1.3	V
ENx low threshold	V_{ENL}		0.4	0.95		V
Feedback voltage	V_{FBH}			600		mV
Soft-start time	t_{SS}			800		us
Switching frequency	f_{sw}	V_{OUT} = 1.8V		1.5		MHz
Thermal shutdown		Trigger thermal shutdown		150		℃
		Hysteresis		20		℃

[1] Depending on parts and PCB layout, characteristics may be changed.
[2] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

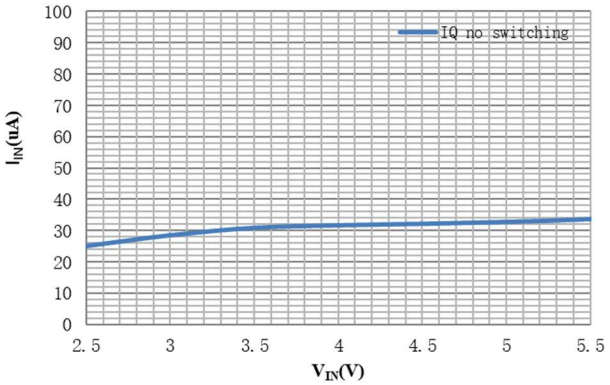
■ TYPICAL OPERATING CHARACTERISTICS

Characteristics of one channel.

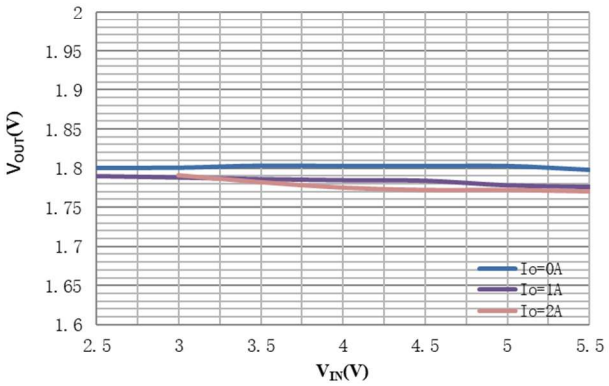
V_{IN} vs I_{IN}



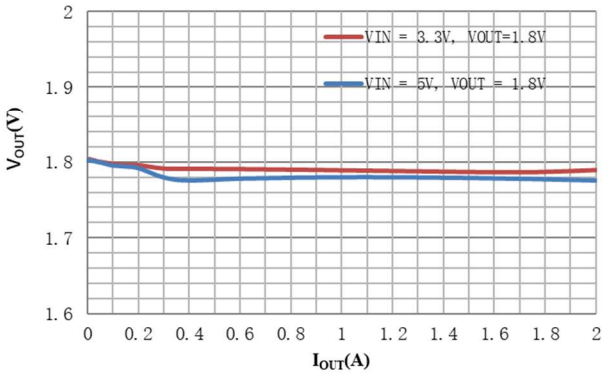
V_{IN} vs I_{IN}



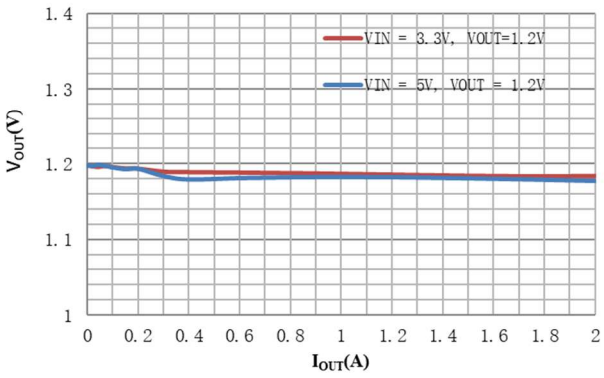
V_{IN} vs V_{OUT}

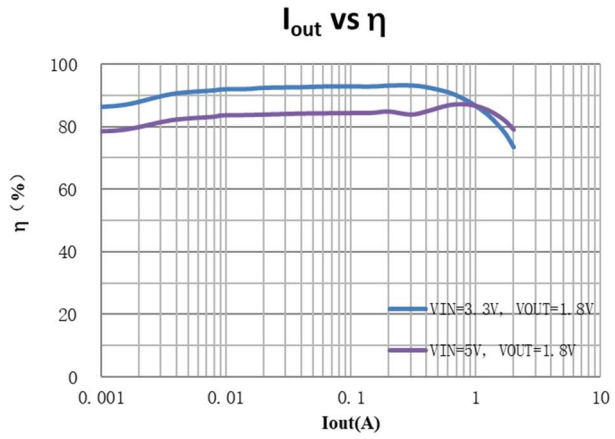


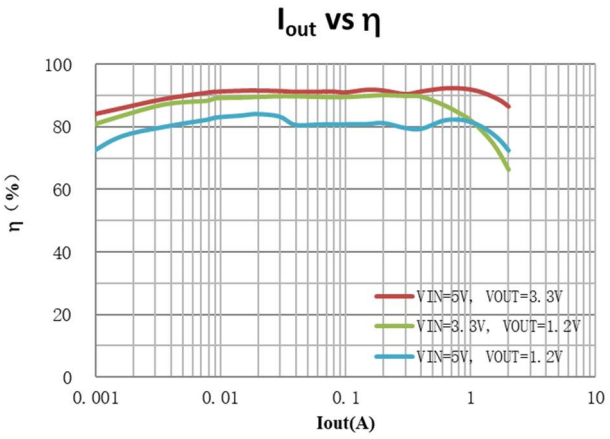
I_{OUT} vs V_{OUT}

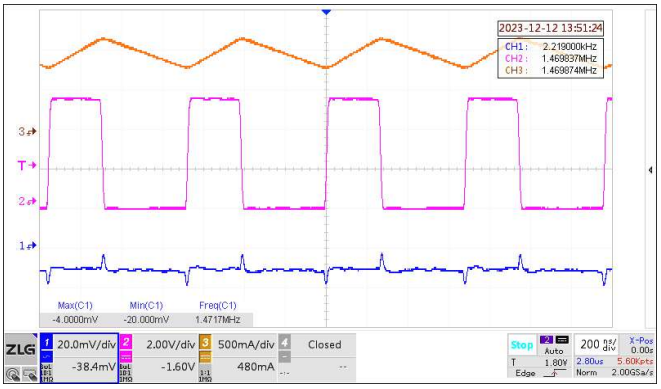


I_{OUT} vs V_{OUT}

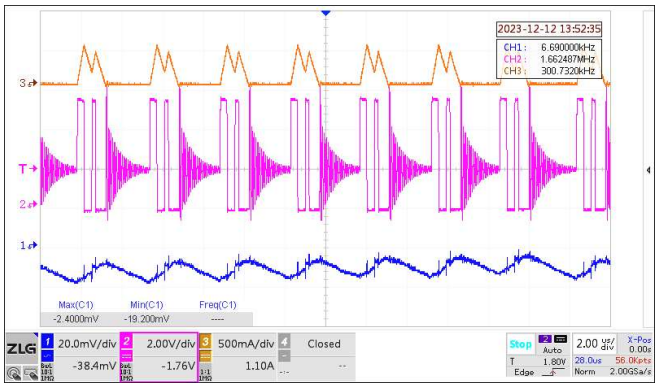






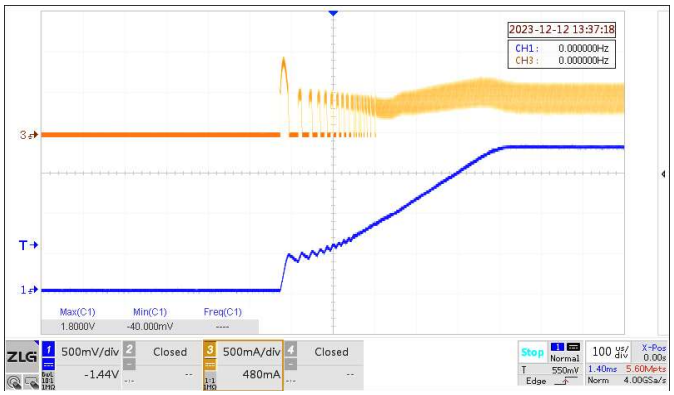


V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 1A

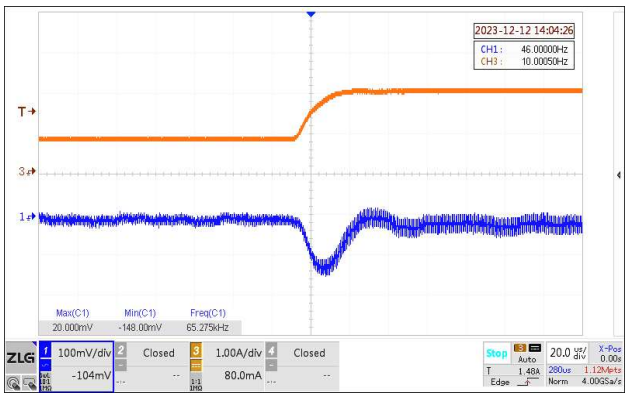


V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 0.1A

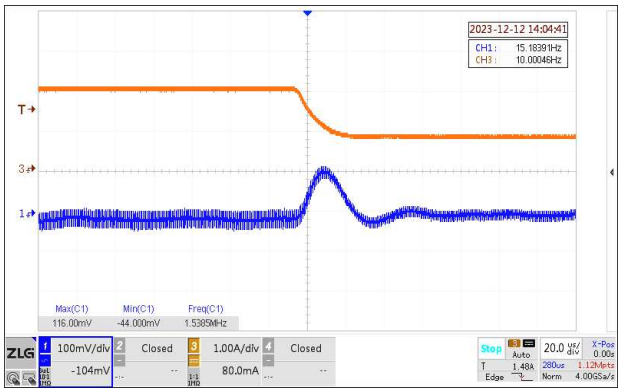
CH1->V_{OUT}; CH2->V_{SW}, CH3->I_{SW}



I_{Load} = 4R, Startup Sequence, CH1->V_{OUT} , CH3->I_{SW}

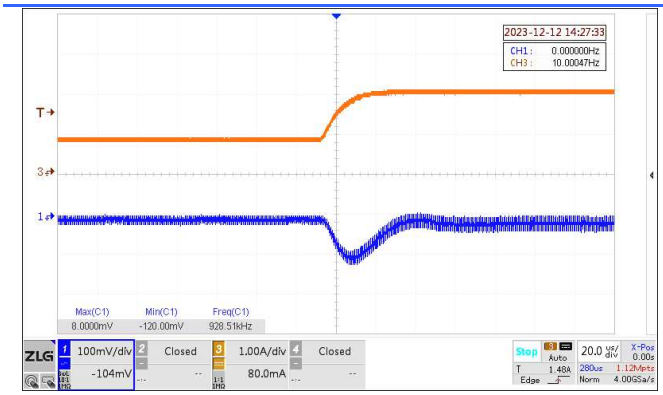


V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 0.8A->2A

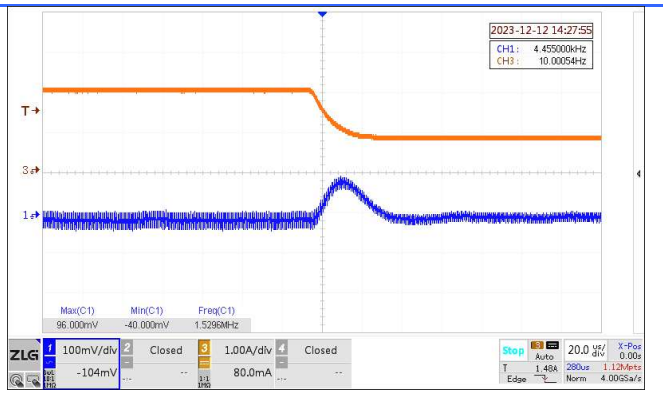


V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 2A->0.8A

CH1->V_{OUT}; CH3->I_{OUT}



V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 0.8A->2A, C_{FF}=22pF



V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 2A->0.8A, C_{FF}=22pF

CH1->V_{OUT}; CH3->I_{OUT}

■ APPLICATION INFORMATION

1 Description

The HTN1302 is a 3-channel, 2A, synchronous buck converter with minimum external components and low shutdown current. Each channel operates a sync buck converter with identical performance and independent operation.

The device operates in PWM mode with typical 1.5MHz switching frequency at medium to heavy loads. At light load, the device operates in power save mode to keep high efficiency.

HTN1302 是一款 3 通道、2A 同步降压转换器，具有最少的外部元件和低关断电流。每个通道性能一致、工作相互独立。

该器件在中到重载时，工作在典型开关频率为 1.5MHz 的 PWM 模式；在轻载时，器件工作在高效节能模式。

1.1 Power Save Mode

At light load, each channel operates in power save mode, the switching frequency and current is reduced.

在轻载时，该通道工作在高效节能模式，频率降低，电流减小。

1.2 100% Duty Cycle for Low Dropout

HTN1302 offers an output voltage close to the input voltage as it supports 100% duty cycle, where the high-side switch FET is constantly turned on and the low-side switch FET is turned off.

HTN1302 是一款 3 通道、2A 同步降压转换器，具有最少的外部元件和低关断电流。

每个通道在中到重载时，工作在典型开关频率为 1.5MHz 的 PWM 模式；在轻载时，则工作在高效节能模式。

2 Enable (EN) Control

Each channel has a dedicated enable control pin (EN) with positive logic. Its falling threshold is 0.4V, and its rising threshold is 1.3V.

When ENx is below the threshold, each channel is in shutdown mode where the switching regulator turns off.

每个通道的 EN 脚高电平有效，控制芯片使能。其下降阈值为 0.4V，上升阈值为 1.3V。 当 EN 低于 0.4V，器件进入关断模式。

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

Each channel employs an internal 500us soft start to ramp up the FB voltage from 0V to 0.6V linearly once EN pulled high.

每个通道采用内部 500ums 软启动，一旦 EN 拉高，FB 电压就会线性上升至 0.6V。

4 Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) is implemented to protect each channel from operating at an insufficient supply voltage. The UVLO rising threshold is about 2.36V, while its falling threshold is about 2.3V.

欠压锁定（UVLO）功能可避免每个通道工作在电源电压不足的条件。UVLO 上升阈值约为 2.36V，下降阈值为 2.3V。

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.

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 Over Current Limit Protection

Each channel is protected from over current by current limitation the peak of the inductor current. The high side power MOSFET current is accurately sensed via a current sense MOSFET. When the high-side MOSFET current reaches to the limitation, the high-side MOSFET is turned off and the low-side MOSFET is turned on to ramp down the inductor current with an adaptive off-time.

每个通道通过对电感电流峰值的电流限制来防止过流。高侧功率管的电流被实时监测。当高侧功率管达到限流值，高侧功率管关断，低测功率管在一个自适应的时间内导通，释放电感电流。

7 Setting the Output Voltage

The output voltage (V_{OUT}) of each channel is set by a resistor divider (R_{FBT} and R_{FBB}). The resistors can be determined with following Equation.

Where V_{FB} is 0.6V, typically.

每个通道的输出电压（V_{OUT}）由电阻分压器（R_{FBT} 和 R_{FBB}）设置。 电阻可以通过以下公式确定。

其中，V_{FB} =0.6V。

$$VOUT = V_{FB} \times \left(1 + \frac{R_{FBT}}{R_{FBB}}\right) \quad (2)$$

8 Selecting the Inductor and Output Capacitor

Use the inductor and output capacitor as following.

推荐电感和输出电容如下表。

OUTPUT VOLTAGE (V)	R_{FBT} (kΩ)	R_{FBB}(kΩ)	C_{FF} (pF) (optional)	L (uH)			C_{OUT}(uF)
				MIN	TYP	MAX	
1.2	100	100	22	1	2.2	2.2	22~44
1.5	150	100	22	1	2.2	2.2	22~44
1.8	200	100	22	1	2.2	2.2	10~44
2.5	150	47	22	1	2.2	2.2	10~44
3.3	120	26.7	22	1	2.2	2.2	10~44

The inductor peak-to-peak ripple current I_{L_PP}, peak current I_{L_PK} and RMS current I_{L_RMS} are calculated as following. The inductor saturation current rating must be greater than the I_{L_PK} and the RMS or heating current rating must be greater than I_{L_RMS}.

电感峰峰值电流 I_{L_PP}、峰值电流 I_{L_PK} 和 RMS 电流 I_{L_RMS} 计算如下。电感额定饱和电流必须大于 I_{L_PK}，RMS 或热电流额定值必须大于 I_{L_RMS}。

$$I_{L_{PP}} = \frac{V_{OUT}}{V_{IN_{MAX}}} \times \frac{V_{IN_{MAX}} - V_{OUT}}{L \times f_{SW}} \quad (3)$$

$$I_{L_{PK}} = I_{OUT} + \frac{I_{L_{PP}}}{2} \quad (4)$$

$$I_{L_{RMS}} = \sqrt{{I_{OUT}}^2 + \frac{1}{12} \times {I_{L_{PP}}}^2} \quad (5)$$

The output capacitor should be used with ceramic or other low ESR capacitors. The required RMS current rating for the output capacitor is as follow.

输出电容应使用陶瓷电容或其他低 ESR 电容。输出电容要求的额定 RMS 电流如下。

$$I_{C_{RMS}} = \frac{\left(V_{IN_{MAX}} - V_{OUT}\right) \times V_{OUT}}{\sqrt{12} \times F_{SW} \times V_{IN_{MAX}} \times L} \quad (6)$$

9 Input Capacitor (C_{IN})

An input decoupling capacitor (0.1uF) and a bulk capacitor (Over 10uF) is needed for each channel. The voltage rating should be higher than the maximum input voltage.

每个通道的输入端推荐一个滤波电容（0.1uF）和一个储能电容（超过 10uF）。额定电压应高于最大输入电压。

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 of each channel 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.

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）将每个通道的输入电容、输出电容尽可能靠近芯片。

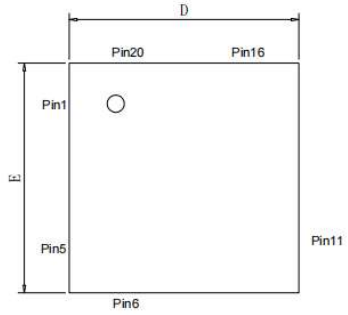
（2）保持电源轨迹非常短且相当宽，特别是对于 SW 节点。

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。

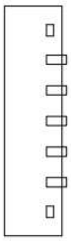
（3）FB 走线尽可能远离电感和功率走线（如 SW 节点）。

■ PACKAGE OUTLINE

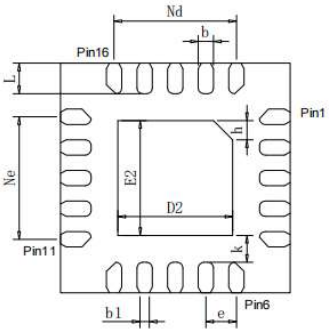
QFN3*3-20L



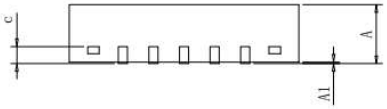
Top View



Side View



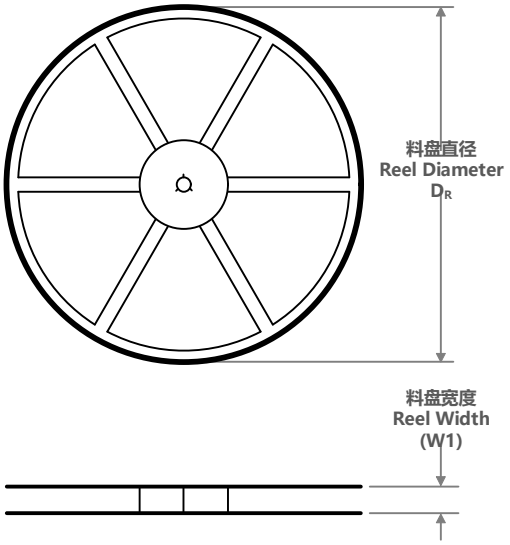
Bottom View

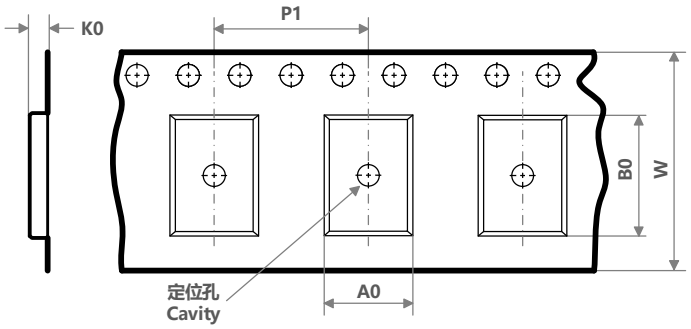


Side View

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	—	0.02	0.05
b	0.15	0.20	0.25
b1	0.07	0.12	0.17
c	0.203 REF		
D	2.90	3.00	3.10
D2	1.40	1.50	1.60
Nd	1.60 BSC		
e	0.40 BSC		
E	2.90	3.00	3.10
E2	1.40	1.50	1.60
Ne	1.60 BSC		
h	0.20	0.25	0.30
k	0.30	0.35	0.40
L	0.35	0.40	0.45

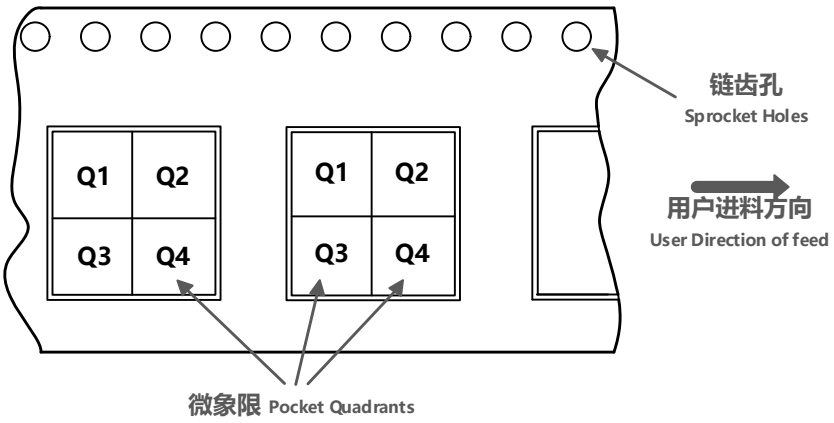
■ TAPE AND REEL INFORMATION





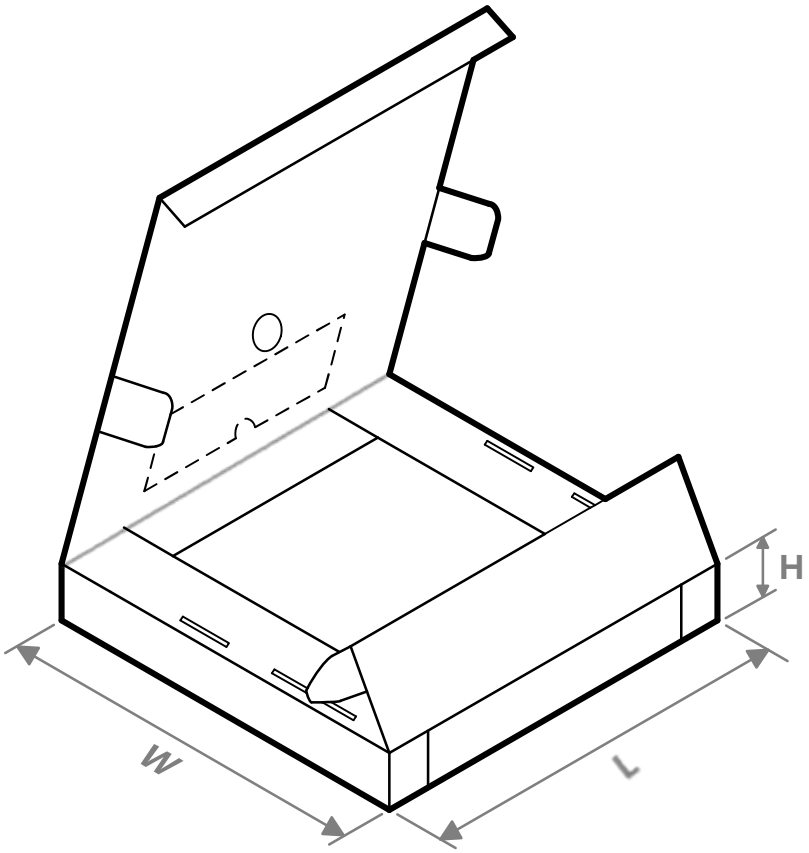
A0	Dimension designed to accommodate the component width; 料槽宽度
B0	Dimension designed to accommodate the component length; 料槽长度
K0	Dimension designed to accommodate the component thickness; 料槽厚度
W	Overall width of the carrier tape; 载带整体宽度
P1	Pitch between successive cavity centers; 相邻槽中心间距

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 Code	引脚数 Pins	SPQ	料盘直径 D_R(mm)	料盘宽度 W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 象限 Quadrant
HTN1302SQER	**QFN3*3**	SQE	20	5000	330	12	3.3	3.3	1.05	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 Code	引脚数 Pins	SPQ	长度 Length (mm)	宽度 Width (mm)	高度 Height (mm)
HTN1302SQER	QFN3*3	SQE	20	10000	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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