20V,15A全集成同步升压转换器

20V,15A Fully-Integrated Synchronous Boost Converter

■ FEATURES

- Input voltage range V_{IN}: 2.7V to 20V
- Output voltage range V_{OUT}: 4.5V to 20V
- Programmable switch peak current limit: up to 15A
- High Efficiency
  93% (V_{IN} = 7.4V, V_{OUT}=15.5V, I_{OUT} =1.5A)
- 2 modulation mode available: PFM or FPWM mode at light load
- Two modes of with fast or slow tr/tf for EMI solution
- 1.0μA current consumption during shutdown
- Adjustable switching frequency: 200k to 1.0MHz
- Programmable soft start
- Output overvoltage protection (at 22V), cycle-by-cycle overcurrent protection, thermal shutdown protection
- Pb-free Packages,QFN20L, 3.5*4.5mmmm

- 输入电压范围V_{IN}：2.7V-20V
- 输出电压范围V_{OUT}：4.5V-20V
- 可编程峰值电流：15A
- 高转换效率：
  93% (V_{IN} = 7.4V, V_{OUT}=15.5V, I_{OUT} =1.5A)
- 轻载条件下两种调制方式：脉频调制（PFM）和强制脉宽调试（FPWM）
- 支持两种tr/tf模式，应对EMI挑战
- 低关断功耗，关断电流1uA
- 可调节的开关频率：200k-1.0M
- 可编程软启动
- 输出过压 (22V)、逐周期过流、热关断等保护
- QFN20L， 3.5mm *4.5mm 无铅超薄封装

■ APPLICATIONS

- Wireless/ Speakers
- Portable Speakers
- Quick Charge Power Bank
- E-Cigarette
- Power Interface (USB Type-C, Thunderbolt)
- POS Terminal
- Tablet PC/Note Book

- 无线音箱
- 便携式音箱
- 快充移动电源
- 电子烟
- USB TYPE-C 电源传输
- 拉杆音箱
- 平板电脑，笔记本电脑
- POS机终端

■ DESCRIPTION

The HT71782 is a high-power density, fully integrated synchronous boost converter with a 16mΩ power switch and a 18mΩ rectifier switch to provide a high efficiency and small size solution in portable systems. The HT71782 has wide input voltage range from 2.7 V to 20V to support applications with single cell and two cell Lithium batteries. The device has 15A switch current capability and can provide an output voltage up to 20V.

The HT71782 uses adaptive constant off-time peak current control topology to regulate the output voltage. In moderate to heavy load condition, it works in the PWM mode. In light load condition, the device has two operation modes selected by the MODE pin. One is PFM mode to improve the efficiency and another one is the forced PWM mode to avoid application problems caused by low switching frequency. The switching frequency in the PWM mode is adjustable ranging from 200kHz to 1.0MHz by an external resistor.

HT71782 integrates two modes with different tr/tf to balance EMI and efficiency in different applications.

The HT71782 also implements a programmable soft-start function and an adjustable switching peak current limit function. In addition, the device provides 22V output overvoltage protection, cycle-by-cycle overcurrent protection, and thermal shutdown protection.

HT71782是一款高功率、全集成升压转换器，集成16mΩ功率开关管和18mΩ同步整流管，为便携式系统提供高效的小尺寸解决方案。

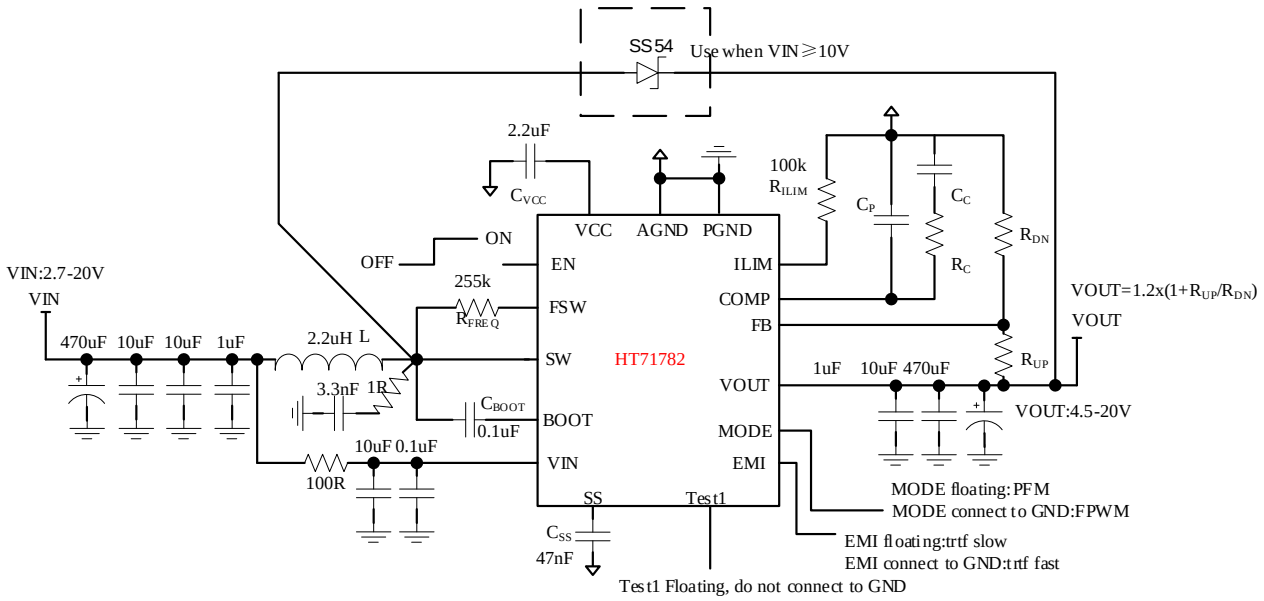
HT71782具有2.7V至20V宽输入电压范围，可为采用单节或两节锂电池的应用提供支持。该器件具备15A开关电流能力，并且能够提供20V的输出电压。

HT71782采用自适应恒定关断时间峰值电流控制拓扑结构来调节输出电压。在中等到重负载条件下，HT71782工作在PWM 模式。在轻负载条件下，该器件可通过MODE引脚选择下列两种工作模式之一。一种是可提高效率的PFM模式；另一种是可避免因开关频率较低而引发应用问题的强制PWM模式。PWM模式下，HT71782的开关频率可通过外部电阻调节，支持200kHz至1.0MHz的范围。

HT71782还支持可编程的软启动，以及可调节的开关峰值电流限制。另外，HT71782支持两种不同的tr/tf，以适应不同的EMI和效率需求。

此外，该器件还提供有22V输出过压保护、逐周期过流保护和热关断保护。

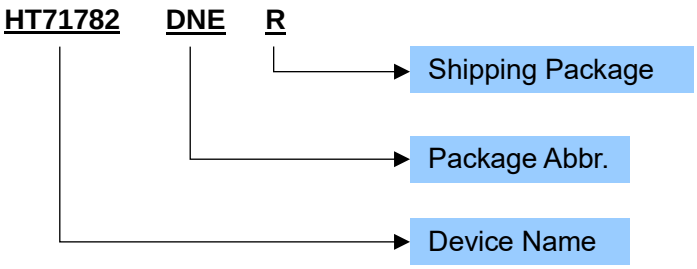
■ TYPICAL APPLICATION



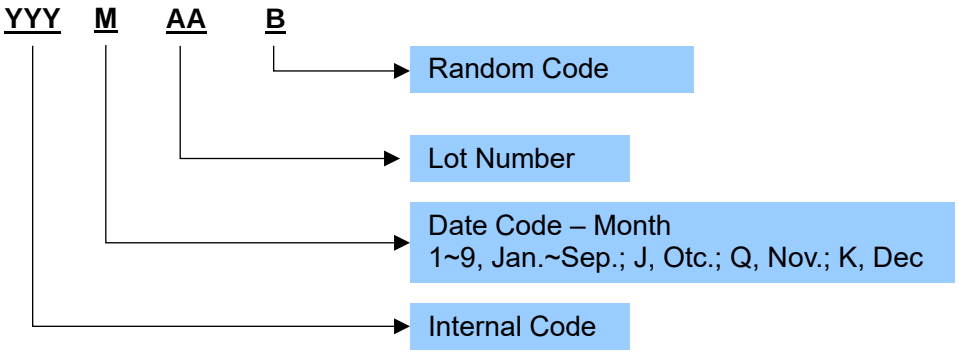
■ ORDERING INFORMATION

Part Number	Package Type	Package Abbr.	Marking	Shipping Package / MOQ
HT71782DNER	QFN3.5×4.5-20L	DNE	HT71782 YYYMAAB[1]	TBD

Part Number

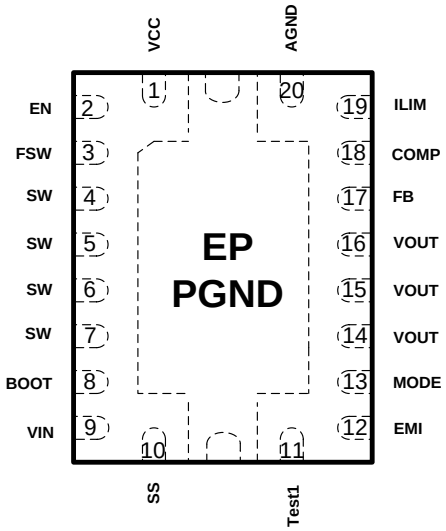


Production Tracking Code



[1] YYYMAAB is production tracking code

■ TERMINAL CONFIGURATION



Top View

■ TERMINAL FUNCTION

Terminal No.	Name	I/O[1]	Description
1	VCC	O	Output of the internal regulator. A ceramic capacitor of 2.2uF is required between this pin and ground. 接2.2uF到地。
2	EN	I	Enable logic input. Logic high level enables the device. Logic low level disables the device and turns it into shutdown mode. 使能输入，接高电平使能，低电平关断
3	FSW	I	The switching frequency is programmed by a resister between this pin and the SW pin. 接电阻到SW脚，调节PWM开关频率
4,5,6,7	SW	P	The switching node pin of the converter. 升压开关节点
8	BOOT	O	Power supply for high-side MOSTFET gate driver. A ceramic capacitor of 0.1μF must be connected between this pin and the SW pin. 接0.1uF电容到SW
9	VIN	P	IC power supply input. 电源输入脚
10	SS	O	Soft-start programming pin. An external capacitor connected to ground sets the ramp rate of the internal error amplifier's reference voltage during soft-start. 接电容到地，设置软起动时间。
11	Test1	I	For internal test, must be float, do not pull up or down. 内部测试用，必须悬空，不能上拉或下拉。
12	EMI	O	Selection for fast or slow tr/tf. Tr/tf模式选择
13	MODE	I	Operation mode selection pin for the device in light load condition. When this pin is connected to ground, the device works in PWM mode. When this pin is left floating, the device works in PFM mode.接地选择强制PWM模式，悬空选择PFM模式
14,15,16	VOUT	P	Boost converter output. 升压输出
17	FB	I	Voltage feedback. 电压反馈
18	COMP	O	Output of the internal error amplifier, the loop compensation network should be connected between this pin and the AGND pin. 接阻容补偿网络到地。
19	ILIM	O	Adjustable switch peak current limit. An external resister should be connected between this pin and the AGND pin. 接电阻到地，调节开关峰值限制电流
20	AGND	G	Signal ground of the IC. 器件信号地
EP	PGND	G	Provides both electrical and thermal connection from the device to the board. A matching ground pad must be provided on the PCB and the device connected to it via solder. For proper electrical operation, this ground pad must be connected to the system ground. 既是地，又是散热PAD

[1] I: Input; O: Output; G: Ground; P: Power; BST: BOOT Strap; OD: Open drain

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings*2

PARAMETER		Symbol	MIN	MAX	UNIT
Voltage range	BOOT	/	-0.3	SW+7	V
	EN, SW, FSW, V_{OUT}, V_{IN}		-0.3	22	
	VCC, SS, COMP, MODE，EMI		-0.3	7	
	ILIM, FB		-0.3	3.6	
Operating temperature range		T_A	-40	85	℃
Operating junction temperature range		T_J	-40	150	℃
Storage temperature range		T_{STG}	-50	150	℃

● Recommended Operating Conditions

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
IC power supply voltage range	V_{IN}		2.7		20	V
Output voltage range	V_{OUT}		4.5		20	V
Inductance, effective value	L		0.47	2.2	10	μH
Input capacitance, effective value	C_I		10			μF
Output capacitance, effective value	C_O		6.8	47	1000	μF
Operating temperature	T_a		-40	25	85	℃
Operating junction temperature	T_J		-40		125	℃

[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.

Electrical Characteristics[*1]

Condition: Ta = 25ºC, V_{IN} = 2.7V-20V, V_{OUT}=4.5-20V, unless otherwise specified.

Power Supply

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
IC power supply voltage range	V_{IN}		2.7		20	V
Under-voltage lockout (UVLO) threshold	V_{IN_UVLO}	VIN rising		2.5		V
		VIN falling		2.3		V
VIN UVLO hysteresis	V_{IN_HYS}			200		mV
VCC UVLO threshold	V_{CC_UVLO}			2.1		V
Operating quiescent current from V_{IN}	I_Q	IC enabled, no load, V_{FB} = 1.3V, V_{OUT} = 12V		1		uA
Operating quiescent current from V_{OUT}				150		
Shutdown current into V_{IN}	I_{SD}	IC disabled, no load, no feedback resistor divider		1		uA
VCC regulation	V_{CC}	V_{IN} = 4.0V, V_{OUT} = 12V, light load		5.249		V
		V_{IN} = 4.0V, V_{OUT} = 12V, I_{LOAD} = 1A		5.008		V

EN, Mode and EMI Input

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
EN high threshold voltage	V_{ENH}				1.5	V
EN low threshold voltage	V_{ENL}		0.3			V
EN internal pull-down resistance	R_{EN}			1300		kΩ
MODE high threshold voltage	V_{MODEH}				3.5	V
MODE low threshold voltage	V_{MODEL}		0.3			V
MODE internal pull-up resistance				800		kΩ
EMI high threshold voltage	V_{EMIH}				3.5	V
EMI low threshold voltage	V_{EMIL}		0.3			V
EMI internal pull-up resistance				800		kΩ

OUTPUT

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Output voltage range	V_{OUT}		4.5		20	V
Output overvoltage protection	V_{OVP}			22		V
Reference voltage at the FB pin	V_{REF}		1.17	1.204	1.23	V
Soft-start charging current	I_{SS}			5		uA

[1] Depending on parts and pattern layout, characteristics may be changed

ERROR AMPLIFIER

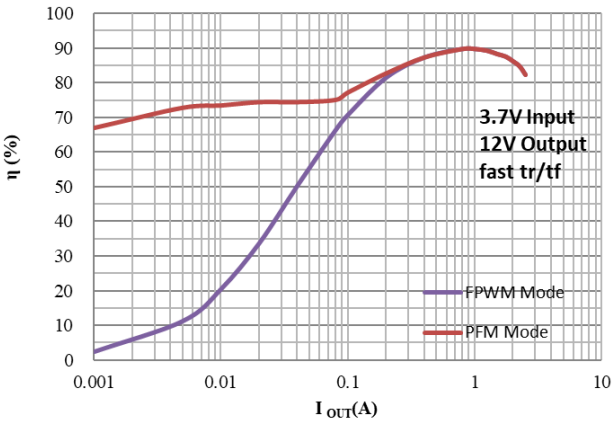
PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
COMP pin sink current	I_{SINK}	V_{FB} = V_{REF} +200 mV, V_{COMP} = 1.5 V		20		uA
COMP pin source current	I_{SOURCE}	V_{FB} = V_{REF} –200 mV, V_{COMP} = 1.5 V		20		uA
High clamp voltage at the COMP pin	V_{CC_LPH}	V_{FB} = 1 V, R_{ILIM} = 100 kΩ		2.1		V
Low clamp voltage at the COMP pin	V_{CC_LPL}	V_{FB} = 1.4 V, R_{ILIM} = 100 kΩ,		0.95		V
Error amplifier transconductance	G_{EA}	V_{COMP} = 1.5 V		204		uA/V

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
POWER SWITCH						
MOSFET on-resistance	$R_{DS(on)}$	High-side MOSFET		18		mΩ
		Low-side MOSFET		16		mΩ
CURRENT LIMIT						
Peak switch current limit	I_{LIM}	R_{ILIM} = 120 kΩ		12.3		A
		R_{ILIM} = 100 kΩ		14.8		
Reference voltage at the ILIM pin	V_{ILIM}			1.204		V
SWITCHING FREQUENCY						
Switching frequency	f_{SW}	R_{FREQ} = 200 kΩ, V_{IN} = 3.7V, V_{OUT} = 12V		520		kHz
Minimum on-time	t_{ON_min}	R_{FREQ} = 200 kΩ, V_{IN} = 3.7V, V_{OUT} = 12V		230		ns
THERMAL SHUTDOWN						
Thermal shutdown threshold	T_{SD}			160		℃
Thermal shutdown hysteresis	T_{SD_HYS}			20		℃

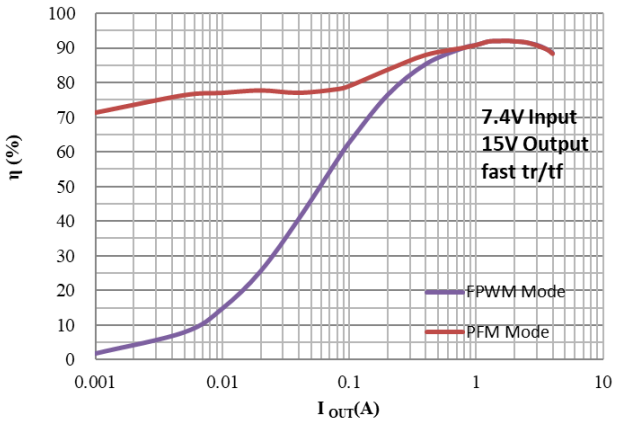
■ TYPICAL OPERATING CHARACTERISTICS

Condition: L = 2.2uH, R_{ILIM} = 100k， R_{FREQ} = 240k, RC (1Ω+3.3nF) from SW to GND, otherwise specified.

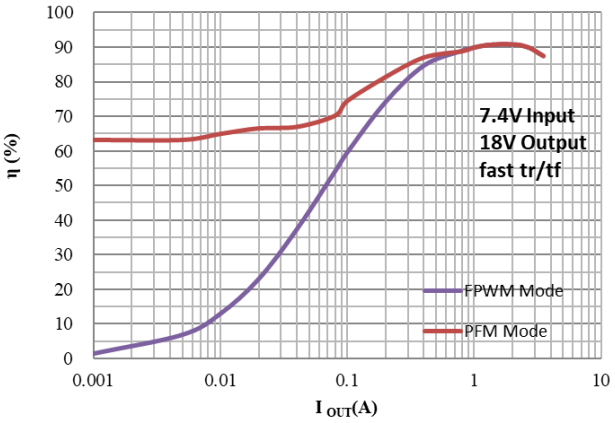
I_{OUT} vs η



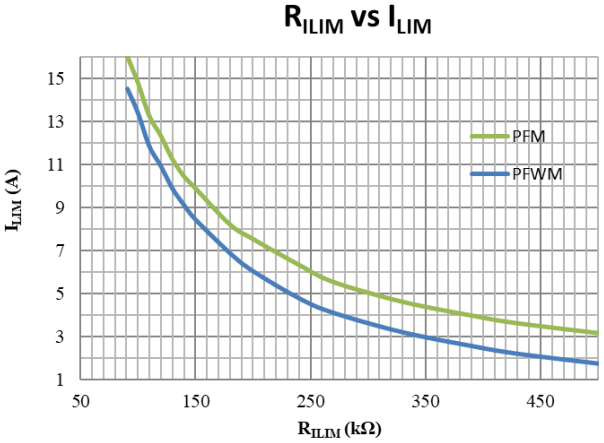
I_{OUT} vs η



I_{OUT} vs η



R_{ILIM} vs I_{LIM}



■ APPLICATION INFORMATION

1 Operation Mode (MODE pin and EMI pin)

The synchronous boost converter HT71782 operates at a quasi-constant frequency pulse width modulation (PWM) in moderate to heavy load condition. In light load condition, the HT71782 implements two operation modes, PFM mode and forced PWM mode, to meet different application requirements. The operation mode is set by the status of the MODE pin. When the MODE pin is connected to ground, the device works in the forced PWM mode. When the MODE pin is left floating, the device works in the PFM mode, which is the recommended mode.

HT71782 integrates two modes with different tr/tf. When the EMI pin is connected to ground, the mode with steep tr/tf will be selected, HT71782 operates with a higher efficiency and poorer EMI performance. However, if the EMI pin is left floating, the mode with flatter tr/tf is selected, HT71782 operates with a lower efficiency and better EMI performance.

同步升压芯片 HT71782 在重载时，工作在类似固定频率的 PWM 调制。在轻载时，其具有两种工作模式，PFM 模式和强制 PWM 模式，以适应不用应用。当 MODE 脚接地，HT71782 工作在强制 PWM 模式；当 MODE 脚悬空，其工作在 PFM 模式，这是推荐的工作模式。

HT71782 具有两种不同 tr/tf 时间的模式。当 EMI 引脚接地时，tr/tf 更陡，此时 HT71782 的效率更高，但 EMI 表现更差；当 EMI 引脚悬空时，tr/tf 更缓，此时 HT71782 的效率更低，但 EMI 表现更好。

2 Enable and Startup (EN and SS pin)

The HT71782 has an adjustable soft start function to prevent high inrush current during start-up. To minimize the inrush current during start-up, an external capacitor, connected to the SS pin and charged with a constant current, is used to slowly ramp up the internal positive input of the error amplifier. The larger the capacitance at the SS pin, the slower the ramp of the output voltage and the longer the soft-start time. A 47-nF capacitor is usually sufficient for most applications.

When the EN pin is pulled into logic low, the HT71782 goes into the shutdown mode and stops switching. Only when EN pin is pulled into logic high, the HT71782 works.

HT71782 具有软起动功能，防止启动时的高浪涌电流。SS 脚需外界电容到地，一般 47nF，SS 使用恒定电流对该电容充电，电容越大，充电时间越长，即软起动时间越长。

EN 为芯片使能脚，EN 拉低，芯片进入关断模式，停止开关；EN 拉高，芯片进入工作状态。

3 Adjustable Switching Frequency (FSW pin)

This device features a wide adjustable switching frequency ranging from 200 kHz to 1.0MHz. The switching frequency is set by a resistor (R_{FREQ}) connected between the FSW pin and the SW pin of the HT71782. The switching frequency can be calculated by:

$$R_{FREQ} = \frac{4\times(\frac{1}{f_{SW}} - t_{DELAY}\times\frac{V_{OUT}}{V_{IN}})}{C_{FREQ}} \qquad \text{Equation 1}$$

where

- R_{FREQ} is the resistance connected between the FSW pin and the SW pin.
- C_{FREQ} = 25.1pF.
- f_{SW} is the desired switching frequency.
- t_{DELAY} = 201.8ns.
- V_{IN} is the input voltage.
- V_{OUT} is the output voltage.

HT71782 的开关频率可通过 FSW 与 SW 之间的电阻 R_{FREQ} 调节，范围 200 kHz 到 1.0MHz。

其中：

- R_{FREQ}即SW和FSW间电阻；
- C_{FREQ} = 25.1pF.
- f_{SW}即开关频率.
- t_{DELAY} = 201.8ns.
- V_{IN} 是输入电压.
- V_{OUT} 是输出电压。

4 Adjustable Peak Current Limit (ILIM pin)

To avoid an accidental large peak current, an internal cycle-by-cycle current limit is adopted. The low-side switch is turned off immediately as soon as the switch current touches the limit. The peak switch current limit can be set by a resistor (RILIM) at the ILIM pin to ground. The relationship between the current limit and the resistance is as follows:

芯片采用逐周期电流限制，避免意外的大峰值电流。当开关电流达到设置的限流值，低侧开关管立即断开。峰值开关电流限制（限流值 ILIM）可以通过 ILIM 引脚对地接 R_{ILIM} 进行设置。限制值 ILIM 和电阻 R_{ILIM} 之间的关系如下：

$$I_{LIM} = \frac{1500000}{R_{ILIM}}$$ Equation 2

5 Output Voltage Setting (FB pin)

The output voltage is set by an external resistor divider (R_{UP}, R_{DN} in the Typical Application Circuit):

输出电压由外部电阻分压器（R_{UP}，典型应用电路中的 R_{DN}）设置：

$$V_{OUT} = V_{REF} \times (1 + \frac{R_{UP}}{R_{DN}})$$ Equation 3

Where V_{REF} = 1.204V.

其中 V_{REF} = 1.204V。

Some typical output voltages can be set as the following parameters.

部分典型电压可参考如下：

Table 1 Typical Output Voltage Settings

V_{OUT}(V)	R_{UP}(Ω)	R_{DN}(Ω)
7.3	510k	100k
9.4	510k	75k
12.2	510k	56k
15.5	510k	43k
18.3	510k	36k
19.5	510k	33k

6 Inductor Selection (SW pin)

The inductor is the most important component in switching power regulator design. Three most important specifications to the performance of the inductor are the inductor value, DC resistance, and saturation current.

To be simplified, the inductor value can be set as 2.2uH which can be used in most cases.

The rated current, especially the saturation current should be larger than the peak current during the whole operation. The peak current can be calculated as follows.

电感是该芯片的关键器件，影响性能的主要是其电感值，直流阻抗，饱和电流。

对于电感值，使用 2.2uH 的电感可以满足大部分应用。

对于额定电流，特别是饱和电流，必须大于所有工作条件下的最大峰值电流，最大峰值电流计算如下：

$$I_{Lpeak} = I_{DC} + \frac{I_{PP}}{2}$$ Equation 4

$$I_{DC} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta}$$ Equation 5

$$I_{PP} = \frac{1}{L\times(\frac{1}{V_{OUT}-V_{IN}}+\frac{1}{V_{IN}})\times f_{SW}}$$ Equation 6

Boost converter efficiency is affected significantly by the inductor's DC resistance (DCR), equivalent series resistance (ESR) at the switching frequency, and the core loss. An inductor with lower DCR and ESR would increase the efficiency significantly.

升压效率受电感的直流阻抗、开关频率下的等效 ESR、磁心损耗等影响。选择小的 DCR 和 ESR 可提升效率。

The inductor should be placed as close as possible to the SW pin. For a lower EMI radiation, connecting a resistor and a capacitor in series to the ground would be helpful. 1ohm resistor and 3.3nF capacitor would be recommended in most cases.

电感应尽可能靠近 SW 引脚放置，并靠近 SW 引脚放置 1ohm 串联 3.3nF 到地。

7 Input Capacitor Selection (VIN, VCC pin)

For good input voltage filtering and small voltage ripple, we recommend low-ESR capacitors of 1uF//10uF//10uF//220uF ("//" represents paralleled) be placed as close as possible to the inductor.

为了良好的储能和滤波以及减小电压波动，建议电源输入端使用 1uF//10uF//10uF//220uF 组合，放置在靠近电感的大电流路径上。

The VIN pin is the power supply for the HT71782, a 1uF paralleled with 10uF ceramic capacitor should be placed as close as possible to the VIN pin. A resistor of 100R is recommended between input power supply and VIN pin so that the power supply of HT71782 would be more stable. An extensive power supply such as the logic power supply connecting to VIN would be another choice.

VIN 脚是 HT71782 的电源供电端，1uF 并联 10uF 对地电容放置在靠近 VIN 脚。输入电源和 VIN 脚之间可以串联 1 个 100R 电阻，已稳定 VIN 电压。VIN 还可以有系统中的逻辑电源供电。

The VCC pin is the output of internal LDO. A ceramic capacitor of 2.2uF is required at the VCC pin to get a stable operation of LDO.

VCC 是内部 LDO 输出，接 2.2uF 电容到地。

8 Output Capacitor Selection (VOUT pin)

To be simplified, we recommend low-ESR capacitors of 1uF//10uF//10uF//470uF ("//" represents paralleled) be placed as close as possible to VOUT pin for small output voltage ripple.

简单来说，升压输出到地滤波电容建议使用 1uF//10uF//10uF//470uF 的组合，尽量靠近 Vout 引脚放置。

In detail, for the require output voltage ripple, use the following equations to calculate the minimum required effective capacitance C_{OUT}

具体的，可以根据需要的输出电压纹波，得到需要的输出电容值：

$$V_{ripple\_dis} = \frac{(V_{OUT}-V_{IN_{MIN}})\times I_{OUT}}{V_{OUT}\times f_{SW}\times C_{OUT}}$$ Equation 7

$$V_{ripple\_ESR} = I_{Lpeak} \times R_{C\_ESR}$$ Equation 8

Where

- f_{SW} is the converter switching frequency.
- R_{C_ESR} is the ESR of the output capacitors.
- Vripple_dis is output voltage ripple caused by charging and discharging of the output capacitor.
- Vripple_ESR is output voltage ripple caused by ESR of the output capacitor.
- V_{IN_MIN} is the minimum input voltage of boost converter..
- V_{OUT} is the output voltage..
- I_{OUT} is the output current.
- I_{Lpeak} is the peak current of the inductor.

其中：

- V_{ripple_dis} 是对电容充放电引起的输出电压纹波.
- V_{ripple_ESR} 是输出电容ESR引起的输出电压纹波.
- V_{IN_MIN} 是最小输入电压.
- V_{OUT} 是输出电压.
- I_{OUT} 是输出电流.
- I_{Lpeak} 是电感峰值电流.
- f_{SW} 是开关频率.
- R_{C_ESR} 是输出电容 ESR.

9 Loop Stability (COMP pin)

The HT71782 requires external compensation, which allows the loop response to be optimized for each application. The COMP pin is the output of the internal error amplifier. An external compensation network comprised of resister R_C, ceramic capacitors C_C and C_P is connected to the COMP pin.

To be simplified, R_C is 56kΩ, C_C is 3.3nF, and C_P can be floating. But notice that this setting can only be adopted in most cases. In detail, the compensation network parameters can be calculated as follows.

(1) Set the cross over frequency, f_c

The first step is to set the loop crossover frequency, f_C. The higher crossover frequency, the faster the loop response is. It is generally accepted that the loop gain cross over no higher than the lower of either 1/10 of the switching frequency, f_{SW}, or 1/5 of the RHPZ frequency, f_{RHPZ}. It's proper to use a fixed parameter of 10kHz for f_C.

$$f_{RHPZ} = \frac{R_O \times (1-D)^2}{2\pi \times L} \quad \text{Equation 9}$$

(2) Set the compensation resistor, R_C.

$$R_C = \frac{2\pi \times V_{OUT} \times R_{sense} \times f_C \times C_O}{(1-D) \times V_{REF} \times G_{EA}} \quad \text{Equation 10}$$

(3) Set the compensation resistor, C_C.

$$C_C = \frac{R_O \times C_O}{2 \times R_C} \quad \text{Equation 11}$$

(4) Set the compensation resistor, C_P.

$$C_P = \frac{R_{ESR} \times C_O}{R_C} \quad \text{Equation 12}$$

HT71782 需要外部补偿，在 COMP 引脚外接 Rc, Cc, Cp。简单来说，R_C=56kΩ, C_C=3.3nF，C_P 悬空可以满足大部分应用。以下是补偿网络的计算过程：

(1) 设置交叉频率 fc

Fc 越大，响应越快。一般其设置为开关频率的 1/10 或 1/5 的 f_{RHPZ}，或直接为 10kHz.

(2) 设置补偿网络 Rc

(3) 设置补偿网络 Cc

(4) 设置补偿网络 Cp

If the C_P is less than 10pF, it can be left open.

- R_O is the output load resistance.
- D is the switching duty cycle. 1 - D = V_{IN} / V_{OUT}
- R_{sense} is the equivalent internal current sense resistor, which is 0.091 Ω.
- C_O is output capacitor.
- V_{REF} is the reference voltage at the FB pin, which is 1.204V.
- G_{EA} is the amplifier's transconductance, which is 204uA/V.
- R_{ESR} is the equivalent series resistance of the output capacitor.

如果 Cp 小于 10pF，可以悬空。

其中 Ro 是输出负载；

D 是占空比，1 - D = V_{IN} / V_{OUT}

R_{sense} 是内部等效电流感应电阻，0.076 Ω

Co 是输出电容

VREF 是 FB 电压，1.204V

G_{EA} 是跨导，204uA/V

R_{ESR} 是输出电容的等效串联电阻。

10 Selecting the Bootstrap Capacitor (BOOT pin)

The bootstrap capacitor (C_{BST}) between the BOOT and SW pin supplies the gate current to charge the high-side FET device gate during each cycle's turn-on and supplies charge for the bootstrap capacitor. The recommended value of the bootstrap capacitor is 0.1μF to 1μF. C_{BST} should be a good quality, low ESR, ceramic capacitor located at the pins of the device to minimize potentially damaging voltage transients caused by trace inductance. A value of 0.1μF can be used in most cases.

BOOT 和 SW 之间需放置一个 C_{BST} 电容，用于高端管开启时的栅极驱动。一般使用 0.1uF~1uF，大部分情况下可使用 0.1uF 电容。

11 Protection Function

11.1 Under-voltage Lockout (UVLO)

The UVLO circuit prevents the device from malfunctioning at low input voltage and the battery from excessive discharge. The HT71782 has both VIN UVLO function and VCC UVLO function. It disables the device from switching when the falling voltage at the VIN pin trips the UVLO threshold V_{IN_UVLO}, which is typically 2.3V. The device starts operating when the rising voltage at the VIN pin is 200mV above the V_{IN_UVLO}. It also disables the device when the falling voltage at the VCC pin trips the UVLO threshold V_{CC_UVLO}, which is typically 2.1V.

HT71782 具有 VIN 和 VCC 欠压保护。当 VIN 小于 V_{IN_UVLO}（典型 2.3V）时，器件停止开关，直至 VIN 大于 V_{IN_UVLO}（典型 2.5V）,器件重新工作。当 VCC 小于 V_{CC_UVLO}（典型 2.1V）时，器件同样停止工作。

11.2 Over-voltage Protection

If the output voltage at the VOUT pin is detected above 22 V (typical value), the HT71782 stops switching immediately until the voltage at the VOUT pin drops the hysteresis value lower than the output overvoltage protection threshold. This function prevents overvoltage on the output and secures the circuits connected to the output from excessive overvoltage.

当 VOUT 电压高于 22V (典型值)，HT71782 停止工作，直到 VOUT 低于 21.5V （典型值）。

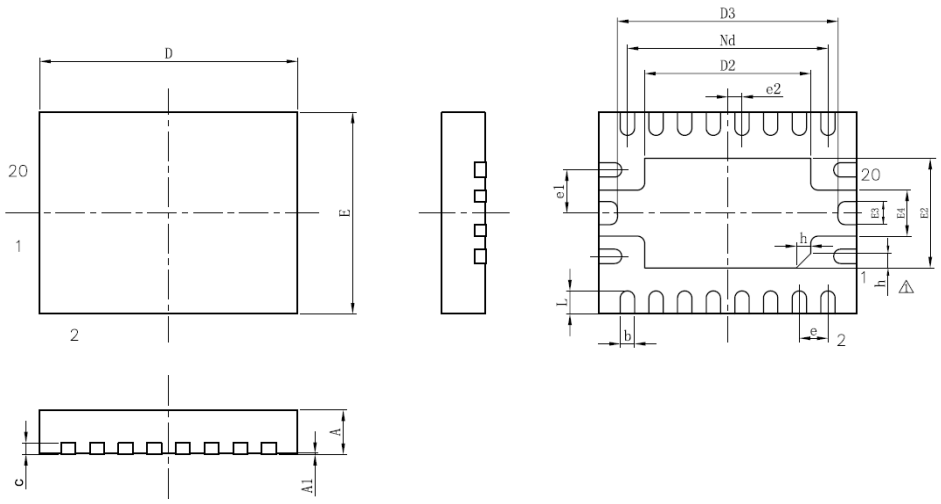
11.3 Thermal Shutdown

A thermal shutdown is implemented to prevent damages due to excessive heat and power dissipation. Typically, the thermal shutdown happens at a junction temperature of 160°C. When the thermal shutdown is triggered, the device stops switching until the junction temperature falls below typically 140°C, then the device starts switching again.

芯片具有过温关断保护功能。当结温大于 160°C（典型值），芯片关断；当结温低于 140°C（典型值），芯片恢复工作。

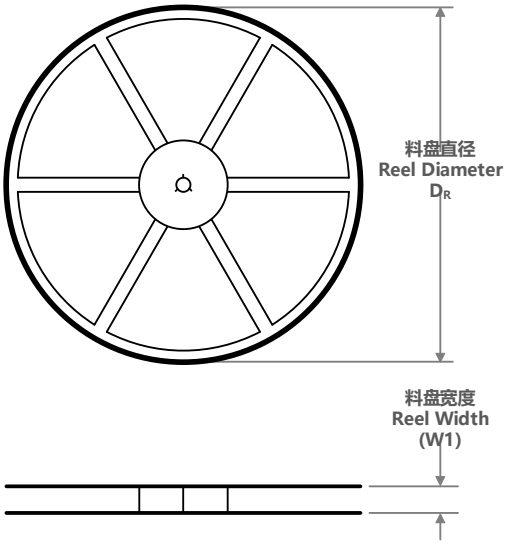
■ PACKAGE OUTLINE

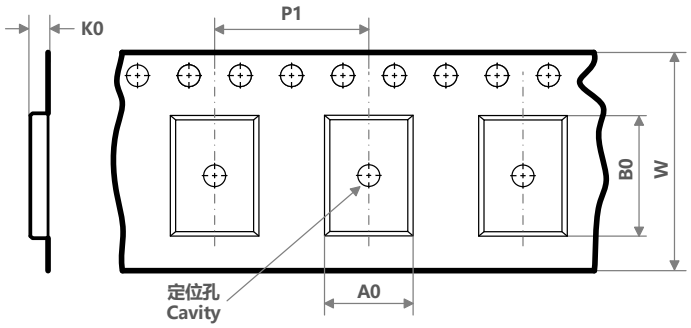
DNE (QFN3.5×4.5-20L)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0. 70	0.75	0. 80
A1	—	0.01	0. 05
b	0. 18	0.25	0. 30
c	0. 18	0.20	0. 25
D	4. 40	4. 50	4. 60
D2	3. 10	3. 20	3. 30
D3	3. 85REF		
e	0. 50BSC		
e1	0. 75BSC		
e2	0. 25BSC		
Nd	3. 50BSC		
E	3. 40	3. 50	3. 60
E2	2. 10	2. 20	2. 30
E3	0. 35REF		
E4	0. 75REF		
L	0. 35	0.40	0. 45
h	0. 20	0.25	0. 30
载体尺寸 (mil)	134*94		

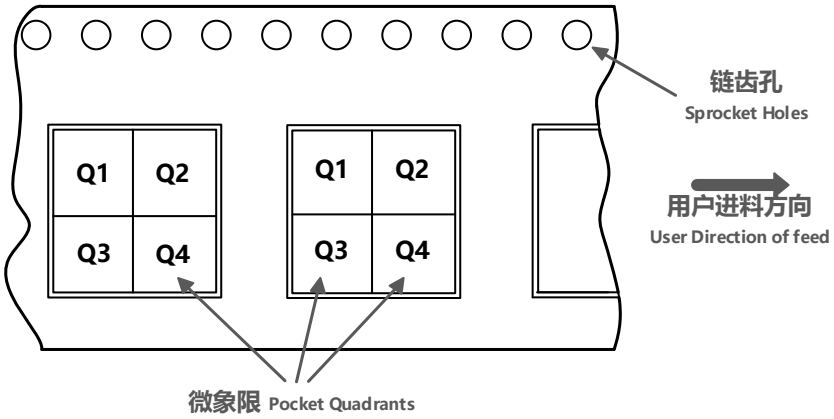
■ TAPE AND REEL INFORMATION





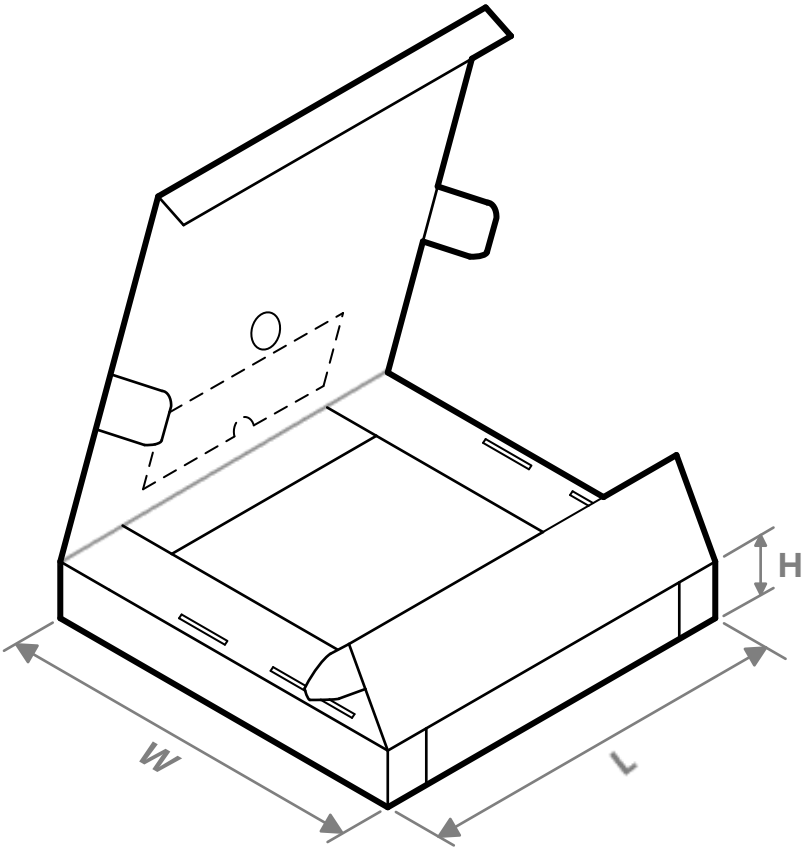
A0	Dimension designed to accommodate the component width; 料槽宽度
B0	Dimension designed to accommodate the component length; 料槽长度
K0	Dimension designed to accommodate the component thickness; 料槽厚度
W	Overall width of the carrier tape; 载带整体宽度
P1	Pitch between successive cavity centers; 相邻槽中心间距

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
HT71782DNER	QFN3.5 ×4.5	DNE	20	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

■ 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)
HT71782DNER	QFN3.5×4.5	DNE	20	TBD	TBD	TBD	TBD

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