

Parameters Subject to Change Without Notice

DESCRIPTION

The HM3413D is a current mode monolithic buck switching regulator. Operating with an input range of 2.5V-6V, the HM3413D delivers 3A of continuous output current with integrated P-Channel and N-Channel MOSFETs. The internal synchronous power switches provide high efficiency. At light loads, the regulator operate in low frequency to maintain high efficiency and low output ripples. Current mode control provides tight load transient response and cycle-by-cycle current limit.

The HM3413D guarantees robustness with hiccup output short-circuit protection, FB short-circuit protection, start-up current run-away protection, input under voltage lockout protection, hot-plug in protection, and thermal protection.

The HM3413D provides output power good indication.

The HM3413D is available in 8-pin DFN2X2-8 package, which provides a compact solution with minimal external components.

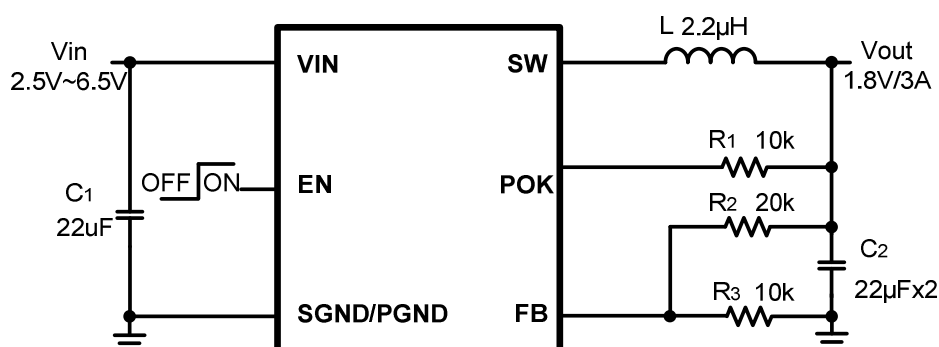
FEATURES

- 2.5V to 6V operating input range
- Up to 3A output current
- Up to 95% peak efficiency
- High efficiency at light load
- Internal Soft-Start
- 1MHz switching frequency
- Input under voltage lockout
- Short circuit protection
- Thermal protection
- Hot-plug in protection
- Output POK indication
- Available in DFN2X2-8 package

APPLICATIONS

- 5V or 3.3V Point of Load Conversion
- Set Top Boxes
- Telecom/Networking Systems
- Storage Equipment
- GPU/DDR Power Supply

TYPICAL APPLICATION



ORDER INFORMATION

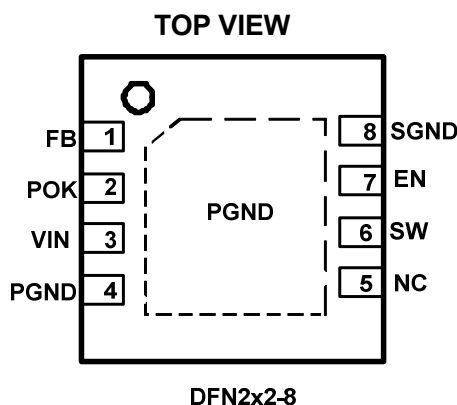
LEAD FREE FINISH	TAPE AND REEL ¹⁾	BULK	TRAY	PACKAGE	TOP MARKING ²⁾
HM3413D	JW5213ADFND#TRPBF	-	-	DFN2X2-8	JWF6 XXXX

Notes:

1) JW□□#TRPBF
 Part No. Package Code PB Free
 Tape and Reel (If "TR" is not shown, it means tube)

2) Line 1 of top marking means Part No., and the line 2 of top marking means Date Code.

PIN CONFIGURATION



ABSOLUTE MAXIMUM RATING¹⁾

EN, FB, POK Pins	-0.3V to 7.0 V
Vin, SW Pins	-0.3V(-1.7V for 20ns) to 7.0V(7.5V for 70ns)
Junction Temperature. ^{2) 3)}	150°C
Lead Temperature	260°C
Storage Temperature	-65°C to +150°C
ESD Susceptibility (Human Body Model)	2kV

RECOMMENDED OPERATING CONDITIONS

Input Voltage VIN	2.5V to 6V
Output Voltage Vout	0.6V to VIN
Operating Junction Temperature	-40°C to 125°C

THERMAL PERFORMANCE⁴⁾

θ_{JA} θ_{JC}

DFN2x2-8	120....34°C/W
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Note:

- 1) Exceeding these ratings may damage the device.
- 2) The HM3413D guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
- 3) The HM3413D includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
- 4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

<i>V_{IN}=5V, T_A=25 °C, unless otherwise stated.</i>						
Item	Symbol	Condition	Min.	Typ.	Max.	Units
V _{IN} Under Voltage Lockout Threshold	V _{IN_UVLO}	V _{IN} rising	2.3	2.4	2.5	V
V _{IN} Under Voltage Lockout Hysteresis	V _{IN_UVLO_HYST}	V _{IN} falling		200		mV
V _{IN} Over Voltage Protection Threshold	V _{IN_OVP}	V _{IN} rising	6.6	6.8	7	V
V _{IN} Over Voltage Protection Hysteresis	V _{IN_OVP_HYST}	V _{IN} falling		400		mV
Shutdown Current	I _{SHDN}	V _{EN} =0V		0.1	1	μA
Quiescent Current	I _Q	V _{EN} =2V, V _{FB} =V _{REF} *105%		50		μA
Regulated Feedback Voltage	V _{FB}	2.5V<V _{IN} <6V	0.588	0.6	0.612	V
PFET On Resistance ⁵⁾	R _{DSON_P}	V _{IN} =3.6V, I _{SW} =200mA		110		mΩ
NFET On Resistance ⁵⁾	R _{DSON_N}	V _{IN} =3.6V, I _{SW} =-200mA		90		mΩ
PFET Leakage Current	I _{LEAK_P}	V _{IN} =5.5V, V _{EN} =0V, V _{SW} =0V			1	uA
NFET Leakage Current	I _{LEAK_N}	V _{IN} =5.5V, V _{EN} =0V, V _{SW} =5.5V			1	uA
PFET Current Limit ⁵⁾	I _{LIM_TOP}	Duty Cycle=100%	3.5	4.8		A
Switch Frequency	F _{SW}	I _{OUT} =1A	0.8	1	1.2	MHz
Minimum On Time ⁵⁾	T _{ON_MIN}			80		ns
Maximum Duty Cycle	D _{MAX}			95		%
EN Rising Threshold	V _{EN_TH}	V _{EN} rising, FB=0.4V	1.5			V
EN Falling Threshold	V _{EN_HYST}	V _{EN} falling, FB=0.4V			0.4	V
Short Circuit Protection Threshold	V _{SCP}			240		mV
POK Low Threshold	V _{POKL}	V _{FB} falling	520	540	560	mV
POK High Threshold	V _{POKH}	V _{FB} rising	690	720	750	mV
Over-voltage Protection Threshold	V _{OVP}	V _{FB} rising	690	720	750	mV
Over-voltage Deglitch Time	T _{OVP}		20	30	40	us
SW Discharge Resistance ⁵⁾	R _{DISC}			50		Ω
Thermal Shutdown Threshold ⁵⁾	T _{SHDN}			150		°C
Temperature Hysteresis ⁵⁾	T _{HYS}			15		°C

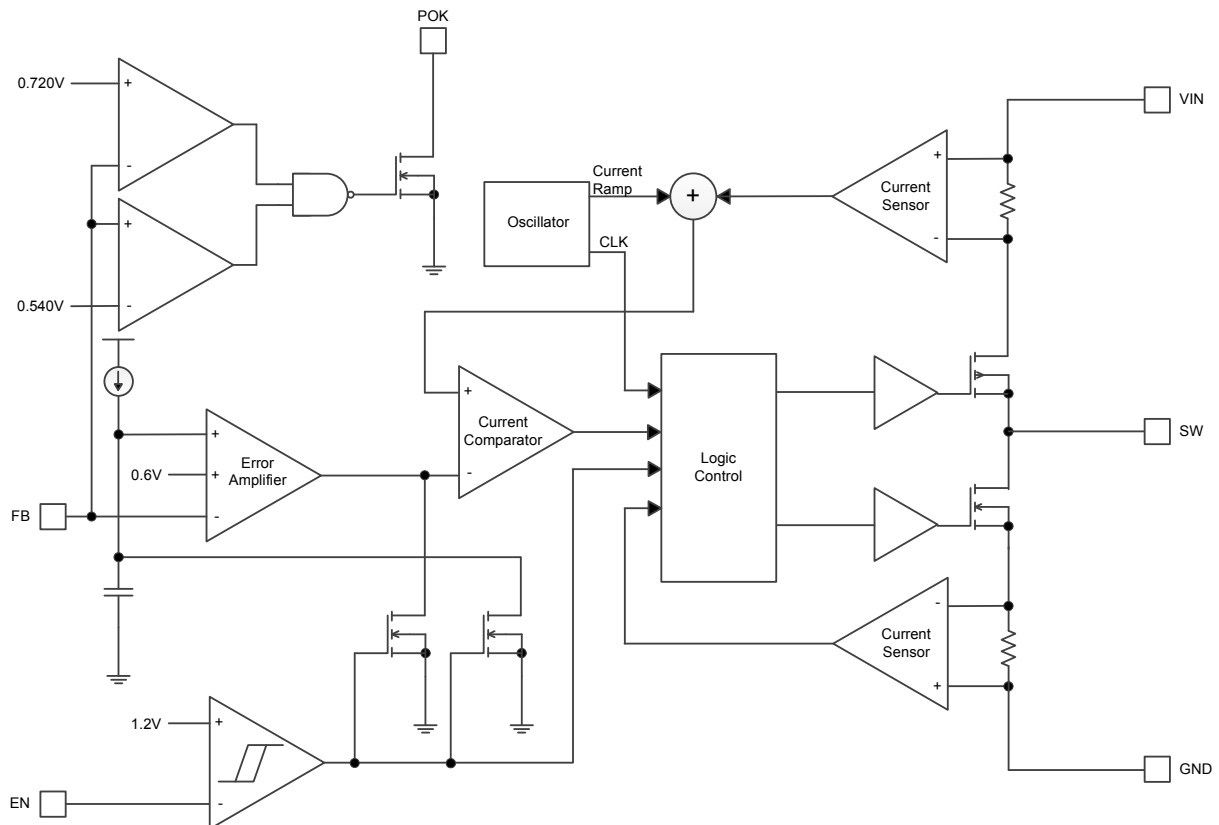
Note:

5) Guaranteed by design.

PIN DESCRIPTION

DFN2X2-8	Name	Description
1	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.6V. Connect a resistive divider at FB.
2	POK	Open drain output. Connect a 10KΩ resistor from POK to output. POK is high when V_{FB} is within >90% and <120% of V_{REF} .
3	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 2.5V to 6V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
4	PGND	Power ground pin.
5	NC	No connection.
6	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
7	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
8	SGND	Signal ground pin.
Exposed Pad	PGND	Power ground pin.

BLOCK DIAGRAM



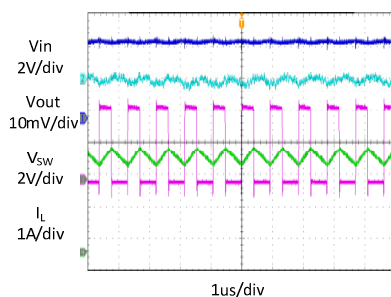
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{in} = 5V$, $V_{out} = 1.8V$, $L = 2.2\mu H$, $C_{out} = 22\mu F \times 2$, $T_A = +25^\circ C$, unless otherwise noted

Steady State Test

$V_{in}=5V$, $V_{out}=1.8V$

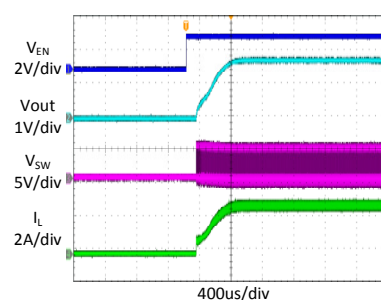
$I_{out}=3A$



Startup through Enable

$V_{in}=5V$, $V_{out}=1.8V$

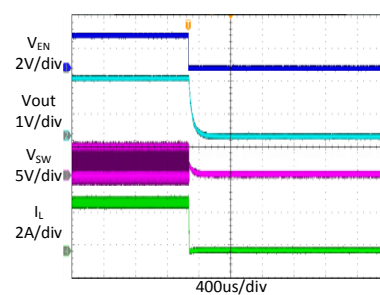
$I_{out}=3A$ (Resistive load)



Shutdown through Enable

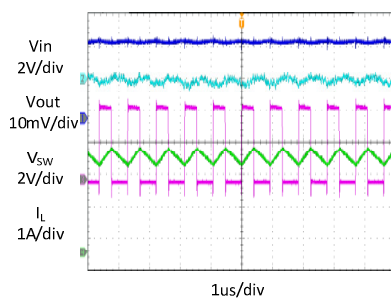
$V_{in}=5V$, $V_{out}=1.8V$

$I_{out}=3A$ (Resistive load)



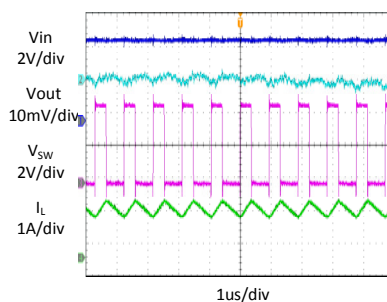
Heavy Load Operation

3A LOAD



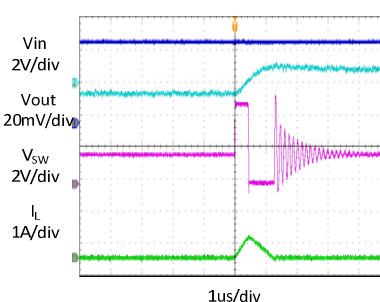
Medium Load Operation

1.5A LOAD



Light Load Operation

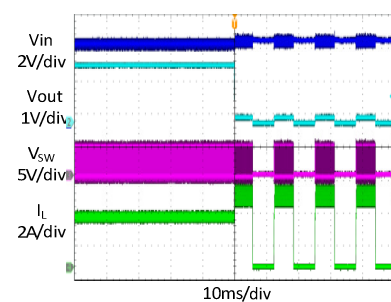
0 A LOAD



Short Circuit Protection

$V_{in}=5V$, $V_{out}=1.8V$

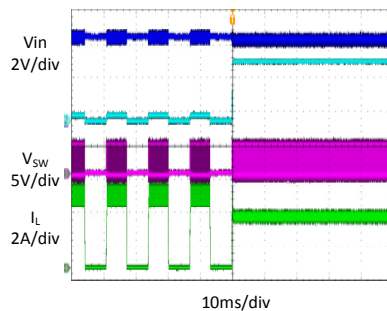
$I_{out}=3A$ - Short



Short Circuit Protection

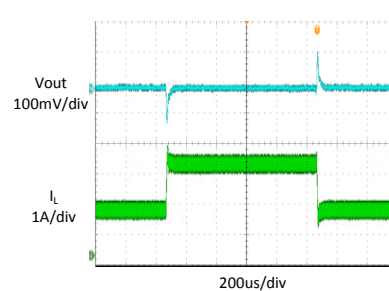
$V_{in}=5V$, $V_{out}=1.8V$

I_{out} = Short -3A



Load Transient

1.5A LOAD $\rightarrow$ 3A LOAD
 $\rightarrow$ 1.5A LOAD

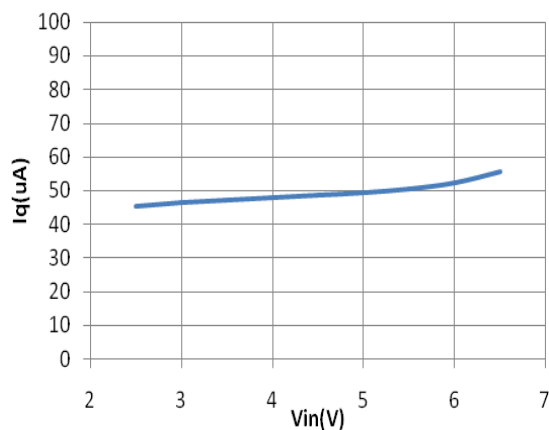


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$V_{in} = 5V$, $V_{out} = 1.8V$, $L = 2.2\mu H$, $C_{out} = 44\mu F$, $T_A = +25^\circ C$, unless otherwise noted

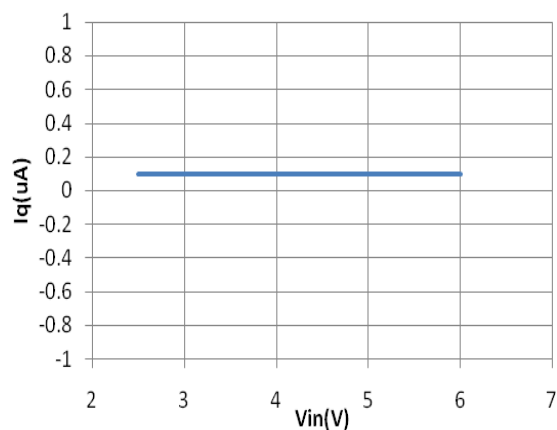
Quiescent Current Vs. Input Voltage

$V_{IN}=3V \sim 6.5V$, $V_{EN}=3V$, $V_{FB}=0.8V$

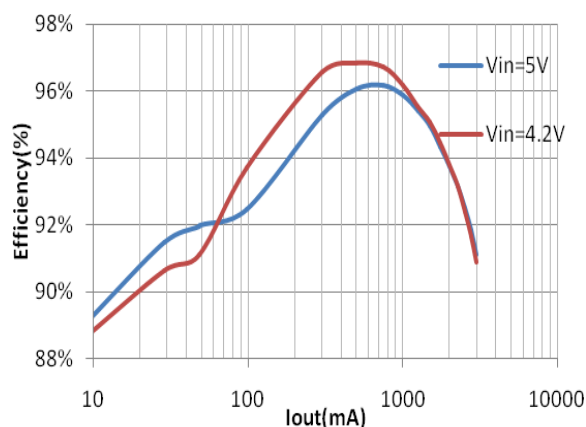


Shutdown Current Vs. Input Voltage

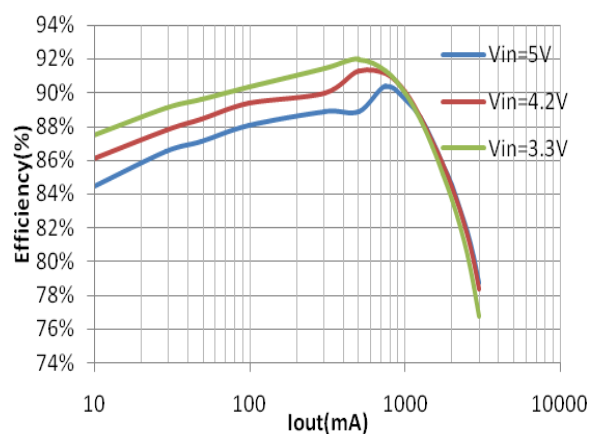
$V_{IN}=3V \sim 6.5V$, $V_{EN}=0V$, $V_{FB}=0.3V$



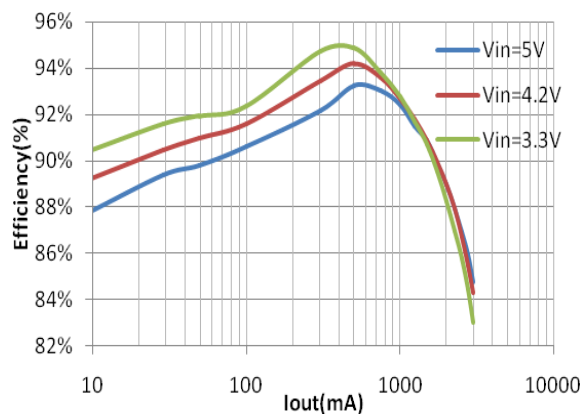
Efficiency @ $V_{out}=3.3V$



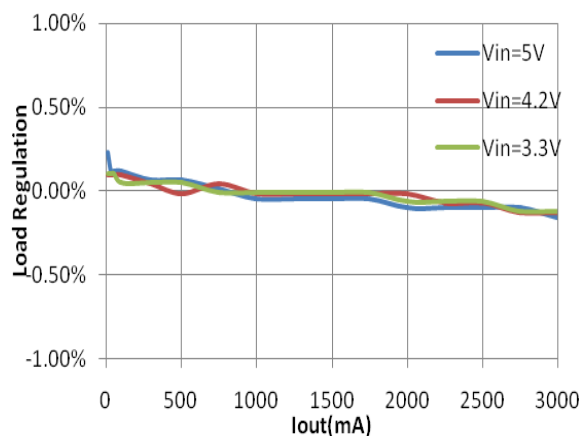
Efficiency @ $V_{out}=1.2V$



Efficiency @ $V_{out}=1.8V$



Load regulation @ $V_{out}=1.8V$



FUNCTIONAL DESCRIPTION

The HM3413D is a synchronous, current-mode, step-down regulator. It regulates input voltages from 2.5V~6V down to an output voltage as low as 0.6V, and is capable of supplying up to 3A of load current.

Current-Mode Control

The HM3413D utilizes current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal transconductance error amplifier. Output of the internal error amplifier is compared with the switch current measured internally to control the output current limit.

PFM Mode

The HM3413D operates in PFM mode at light load. In PFM mode, switch frequency is continuously controlled in proportion to the load current, i.e. switch frequency decreases when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency increases when load current rises, minimizing output voltage ripples.

Shut-Down Mode

The HM3413D operates in shut-down mode when voltage at EN pin is driven below 0.4V. In shut-down mode, the entire regulator is off and the supply current consumed by the HM3413D drops below 1uA.

Power Switches

P-channel and N-channel MOSFET switches are integrated on the HM3413D to down convert

the input voltage to the regulated output voltage.

Hot-Plug In Protection

If the Vin voltage exceeds 6.85V, IC will turn off power switch, entering over-voltage protection. It will remain in this state until Vin voltage is less than 6V.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductance can be easily built up, resulting in a large start-up output current. A valley current limit is designed in the HM3413D so that only when output current drops below the valley current limit can the bottom power switch be turned off. By such control mechanism, the output current at start-up is well controlled.

Short Circuit Protection

When output falls below 40% of the regulation, the switching frequency is reduced to prevent the inductor current from increasing beyond PFET current limit. If short circuit condition holds for more than 1024 cycles, both PFET and NFET are forced off and can be enabled again after 8ms. This procedure is repeated as long as short circuit condition is not removed.

Thermal Protection

When the temperature of the HM3413D rises above 150°C, it is forced into thermal shut-down.

Only when core temperature drops below 135°C can the regulator become active again.

APPLICATION INFORMATION

Output Voltage Set

The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

$$V_{FB} = V_{OUT} \cdot \frac{R_3}{R_2 + R_3}$$

where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

Choose R_3 around 10K ω , and then R_2 can be calculated by:

$$R_2 = R_3 \cdot \left(\frac{V_{OUT}}{0.6V} - 1 \right)$$

The following table lists the recommended values.

Vout(V)	R2(K ω)	R3(K ω)
1.2	10	10
1.8	20	10
2.5	31.6	10.2
3.3	46.4	10.2

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintaining the DC input voltage. The ripple current through the input capacitor can be calculated by:

$$I_{C1} = I_{LOAD} \cdot \sqrt{\frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)}$$

where I_{LOAD} is the load current, V_{OUT} is the output voltage, V_{IN} is the input voltage.

Thus the input capacitor can be calculated by the following equation when the input ripple voltage is determined.

$$C_1 = \frac{I_{LOAD}}{f_s \cdot \Delta V_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)$$

where C_1 is the input capacitance value, f_s is the switching frequency, ΔV_{IN} is the input ripple current.

The input capacitor can be electrolytic, tantalum or ceramic. To minimizing the potential noise, a small X5R or X7R ceramic capacitor, i.e. 0.1 μ F, should be placed as close to the IC as possible when using electrolytic capacitors.

A 10 μ F ceramic capacitor is recommended in typical application.

Output Capacitor

The output capacitor is required to maintain the DC output voltage, and the capacitance value determines the output ripple voltage. The output voltage ripple can be calculated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \cdot L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \cdot \left(R_{ESR} + \frac{1}{8 \cdot f_s \cdot C_2} \right)$$

where C_2 is the output capacitance value and R_{ESR} is the equivalent series resistance value of the output capacitor.

The output capacitor can be low ESR electrolytic, tantalum or ceramic, which lower ESR capacitors get lower output ripple voltage.

The output capacitors also affect the system stability and transient response, and a 22 μ F ceramic capacitor is recommended in typical application.

Inductor

The inductor is used to supply constant current to the output load, and the value determines the ripple current which affect the efficiency and the output voltage ripple. The ripple current is typically allowed to be 30% of the maximum

switch current limit, thus the inductance value can be calculated by:

$$L = \frac{V_{OUT}}{f_s \cdot \Delta I_L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)$$

where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_s is the switching frequency, and ΔI_L is the peak-to-peak inductor ripple current.

PCB Layout Note

For minimum noise problem and best operating

performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to HM3413D (VIN pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation.

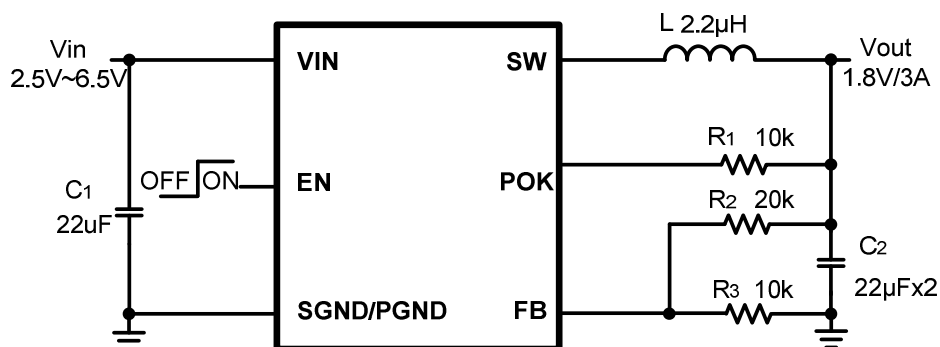
REFERENCE DESIGN

Reference 1:

V_{IN} : 2.5V ~ 6V

V_{OUT} : 1.8V

I_{OUT} : 0~3A

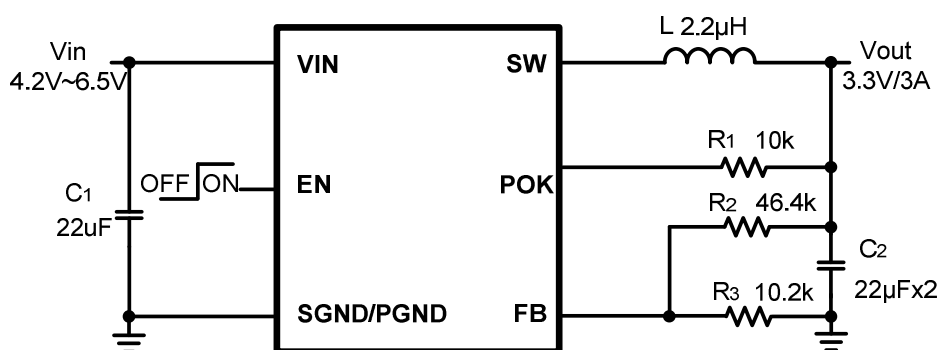


Reference 2:

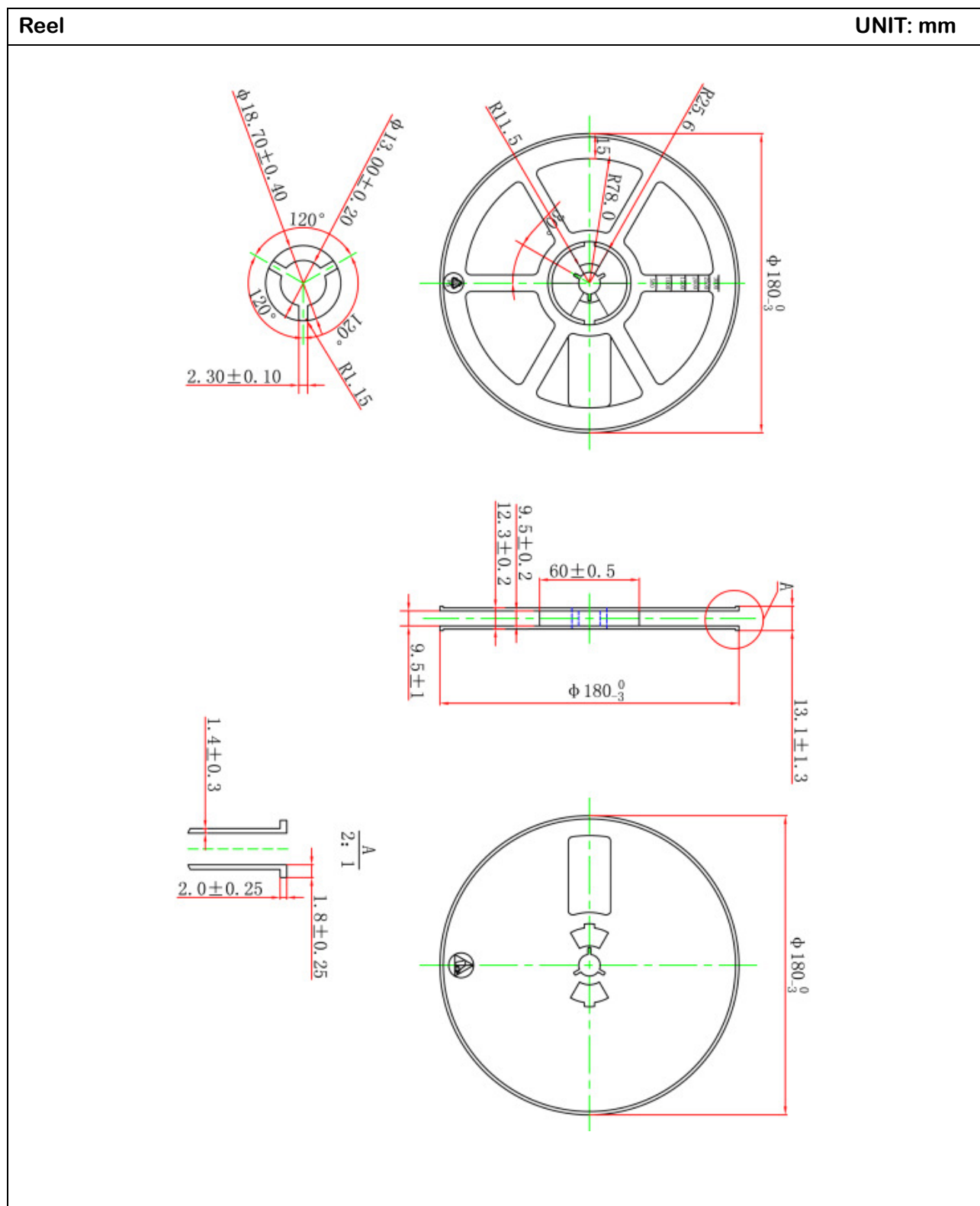
V_{IN} : 4.2V ~ 6 V

V_{OUT} : 3.3V

I_{OUT} : 0~3A

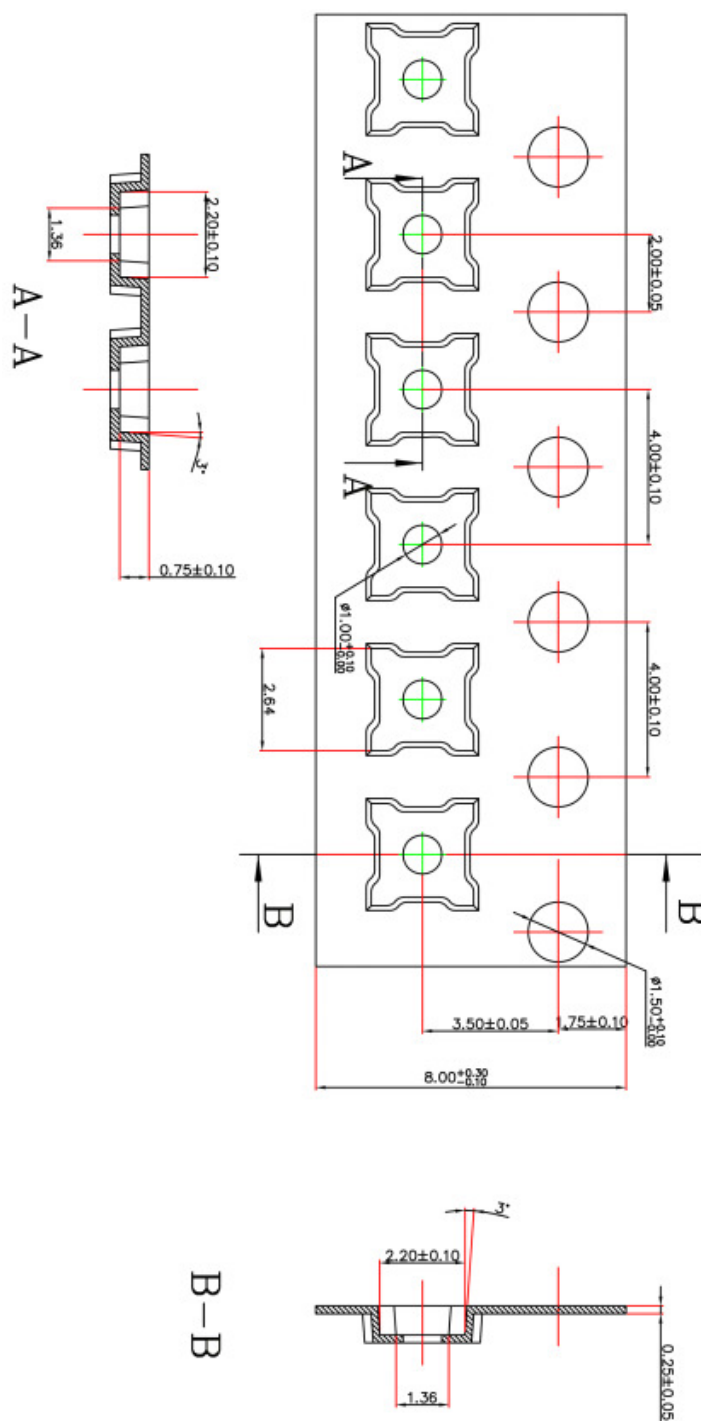


TAPE AND REEL INFORMATION



Carrier Tape

UNIT: mm



Notes:

- 1) COVER TAPE WIDTH: 5.50+0.10.
- 2) COVER TAPE COLOR: TRANSPARENT.
- 3) 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ± 0.20 MAX.
- 4) CAMBER NOT TO EXCEED 1MM IN 100 MM.

PACKAGE OUTLINE

