600KHz 18V, 3A Synchronous Step-Down Converter

Features

- High Efficiency: Up to 95%
- 600KHz Switch Frequency
- Up to 3A Output Current
- PFM at light load
- Wide Input Voltage Range: 4.5V to 18V
- 0.6V Reference Voltage
- Internal Soft-start
- Input under-voltage lockout
- Current run-away protection
- Output Short Protection
- Thermal Shutdown
- Available in SOT23-6L Package

General Description

The HCR3146M is a fully integrated, high efficiency 3.0A synchronous rectified step-down converter.

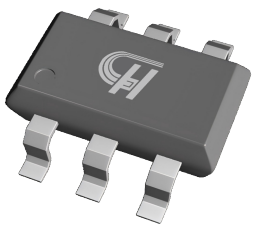
The HCR3146M operates at high efficiency over a wide output current load range.

This device offers two operation modes, PWM control and PFM Mode switching control, which allows a high efficiency over the wider range of the load.

The HCR3146M requires a minimum number of readily available standard external components and is available in a SOT23-6L ROHS compliant package.

Applications

- Distributed Power Systems
- Networking Systems
- FPGA, DSP, ASIC Power Supplies
- Green Electronics Appliances
- Notebook Computer



SOT23-6L

Figure 1. Package Type of HCR3146M

600KHz 18V, 3A Synchronous Step-Down Converter

Pin Configuration

SOT23-6L Top View

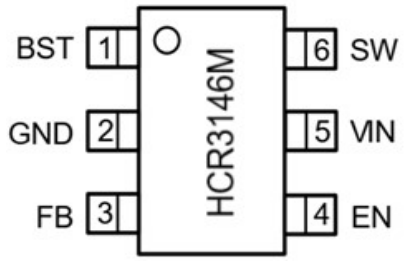
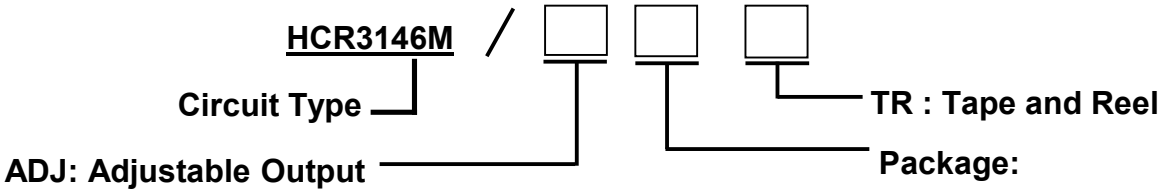


Figure 2. Pin Configuration of HCR3146M (Top View)

Pin Function Table

Pin Number	Pin Name	Function
1	BST	Connect a 0.1uF capacitor between BST and SW pin to supply voltage for the top switch driver.
2	GND	Ground Pin
3	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.
4	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
5	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.5V to 18V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
6	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.

Ordering Information



Ordering Code

Part Number	Marking ID note2	Temperature Range	Package	Quantity per Reel
HCR3146M/ADJM6LTR	** PXX	-40'C to +125'C	SOT23-6L	3000pcs/TR

Note 2: "**P" is device code of JWP and "XX" is Inside code.

Absolute Maximum Ratings Note 1

Parameter	Symbol	Value	Unit
Input Supply Voltage Range	V_{IN}	-0.3 to +20.0	V
SW Voltage Range	V_{SW}	-0.3 to +20.0	V
EN Voltage Range	V_{EN}	-0.3 to +20.0	V
BST Voltage Range	V_{BST}	-0.6 to +25.0	V
All other Pins	V*	-0.3 to +4.0	V
Power Dissipation	P_O	920	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100	'C/W
Thermal Resistance Junction to Case	$R_{\theta JC}$	25	'C/W
Storage Temperature Range	T_{STG}	-65 to 150	'C
Operating Junction Temperature	T_J	-40 to +125	'C
Lead Temperature (Soldering, 10s)	T_{LEAD}	260	'C

Note 1: Stresses beyond those listed under"Absolute maximum Ratings" may damage the device.

2: The device is not guaranteed to function outside the recommended operating conditions.

Recommended Operating Conditions

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input Voltage Range	V_{IN}		4.5	-	18	V
Output Voltage	V_{OUT}		0.6	-	V_{IN}*Dmax	V
Operating Junction Temperature Range	T_J		-40	-	125	'C

Electrical Characteristics

(VIN=VEN=12V, VOUT=5V, TA=25'C, unless otherwise noted.)

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input voltage lockout Threshold	V_{IN_MIN}		-	4.2	-	V
Input voltage lockout Hysteresis	$V_{IN\_MIN\_HYST}$		-	350	-	mV
Quiescent Current	I_Q	V_{EN}=5.0V, V_{FB}=1V	-	150	-	uA
Shutdown Current	I_{SHDN}	V_{EN}=0V	-	1	-	uA
Regulated Feedback Voltage Accuracy	V_{REF}	T_A=25'C, 4.5V<V_{IN}<18V	-	0.600	-	V
FB Leakage Current	I_{FB}	V_{FB}=0.85V	-	-	100	uA
High-Side Switch On Resistance	$R_{DS(ON)1}$		-	80	-	mΩ
Low-Side Switch On Resistance	$R_{DS(ON)2}$		-	45	-	mΩ
High-Side Switch Leakage Current	I_{SW_LC}	V_{EN}=0V, V_{LX}=0V	-	-	1.0	uA
Upper Switch Current Limit	I_{LIM}	Minimum Duty Cycle	-	3.5	-	A
Oscillation Frequency	FOSC	V_{FB}=0.6V	-	600	-	KHz
Maximum Duty Cycle	η	V_{FB}=0.6V	-	95	-	%
EN High Level Input Voltage	V_{EN-H}	V_{EN} rising	-	1.2	-	V
EN Low Level Input Voltage	V_{EN-L}	V_{EN} falling	-	1.05	-	V
EN Leakage Current	I_{EN_LC}		-	-	2.0	uA
Minimum On-Time	TON		-	120	-	nS
Minimum Off-Time	Toff	V_{FB}=0.4V	-	150	-	nS
Soft Start	Tstart		-	1	-	mS
Thermal Shutdown note3	TSHDN		-	160	-	'C
Thermal Hysteresis note3	THYTS		-	20	-	'C

Note 3. Thermal shutdown threshold and hysteresis are guaranteed by design.

Functional Block Diagram

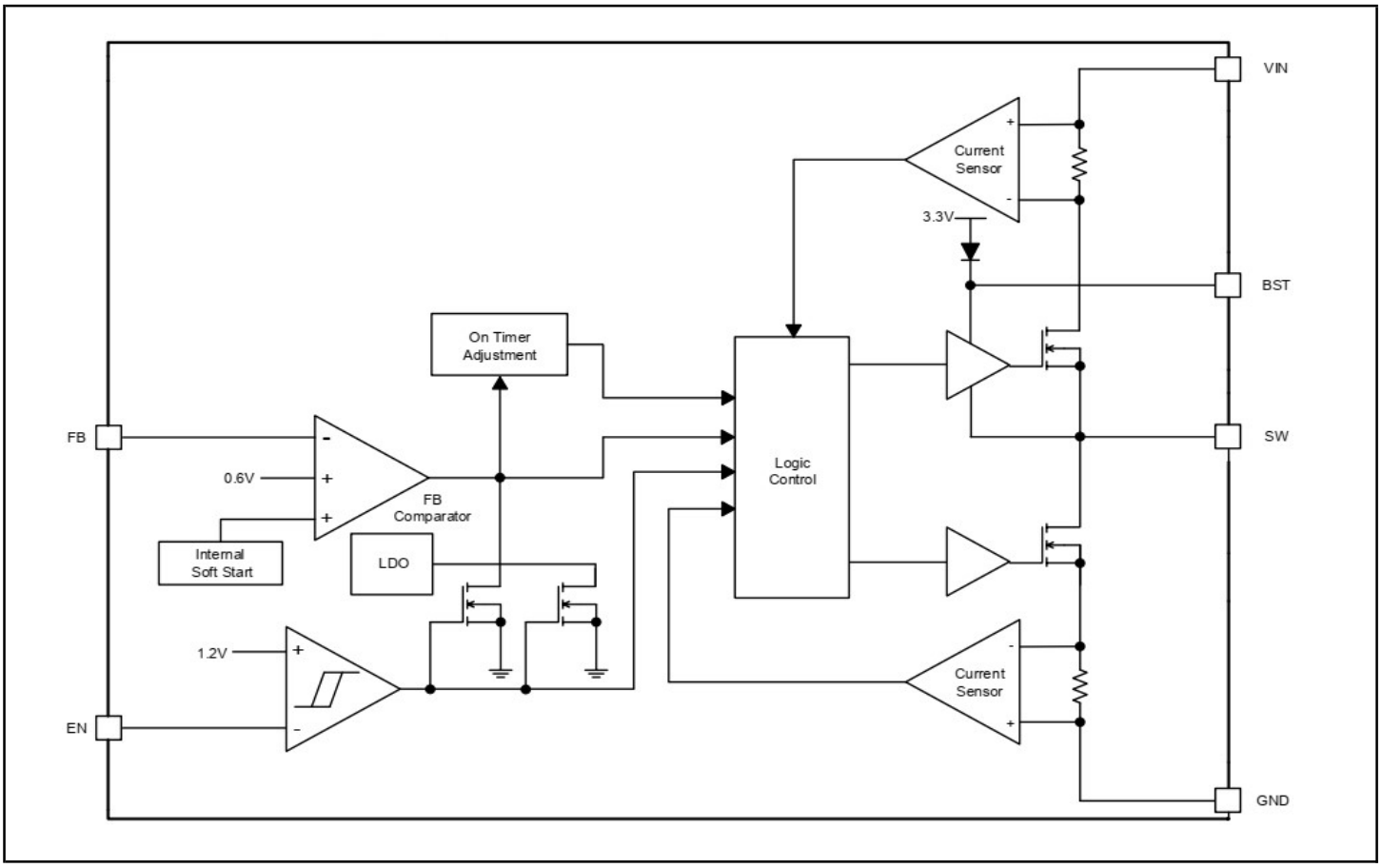


Figure 3. Functional Block Diagram of HCR3146M

Typical Application Circuit

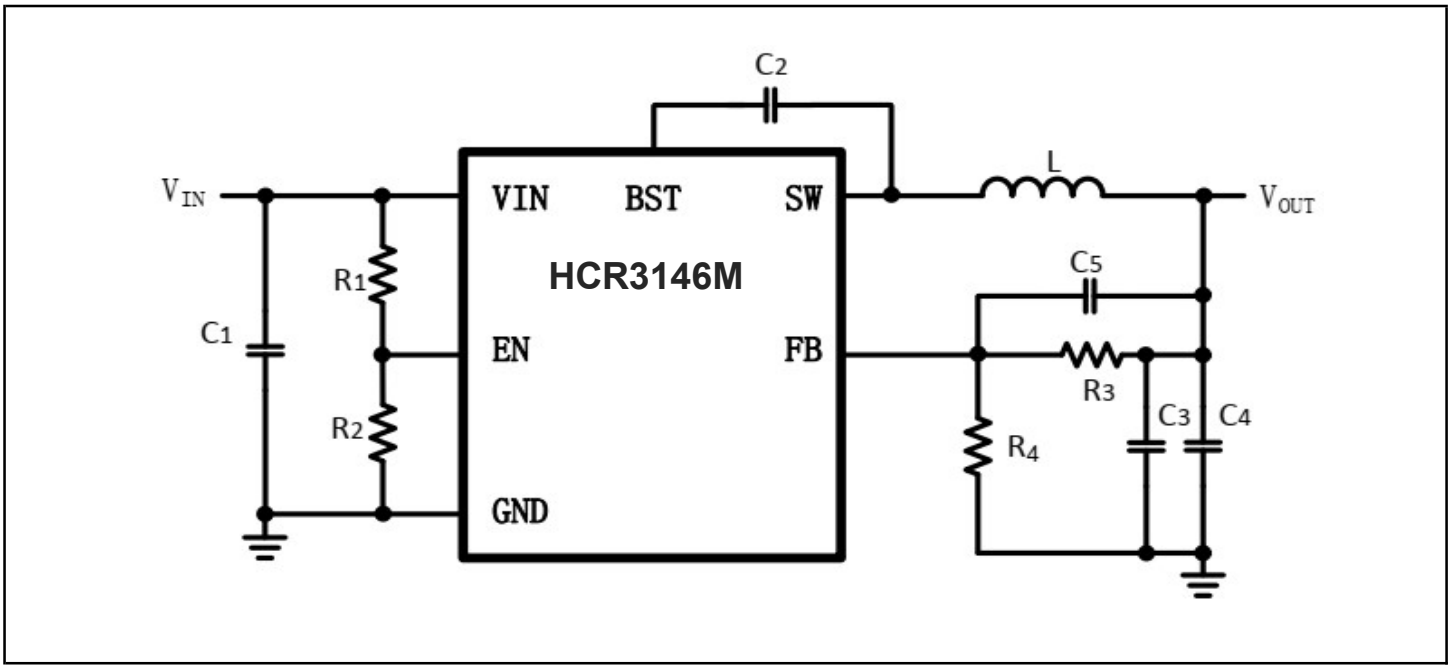


Figure 4. Typical Application Circuit of HCR3146M

600KHz 18V, 3A Synchronous Step-Down Converter

Typical Performance Characteristics

(Test condition: VIN=12V, VOUT=3.3V, L=3.3uH, TA=25'C, unless otherwise noted.)

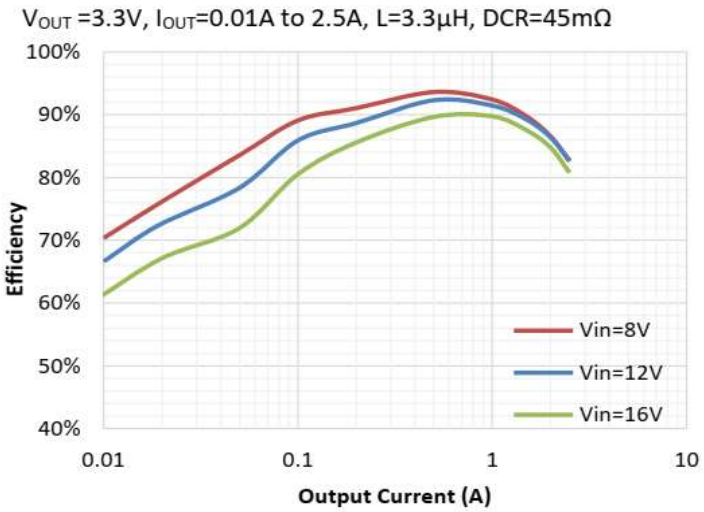


Figure 5. Efficiency

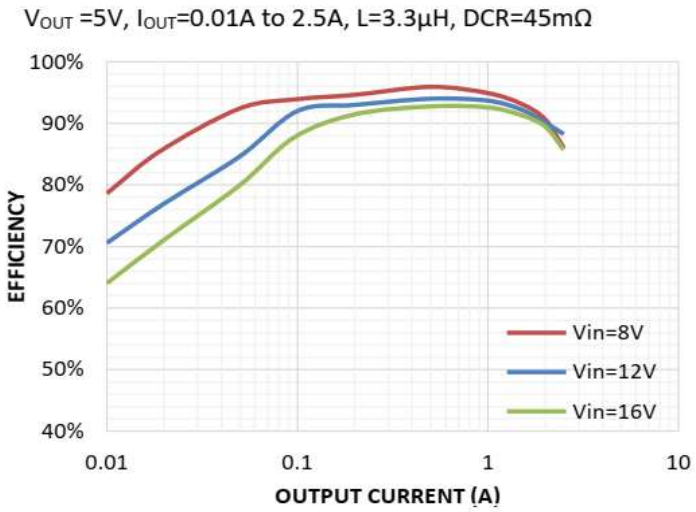


Figure 6. Efficiency

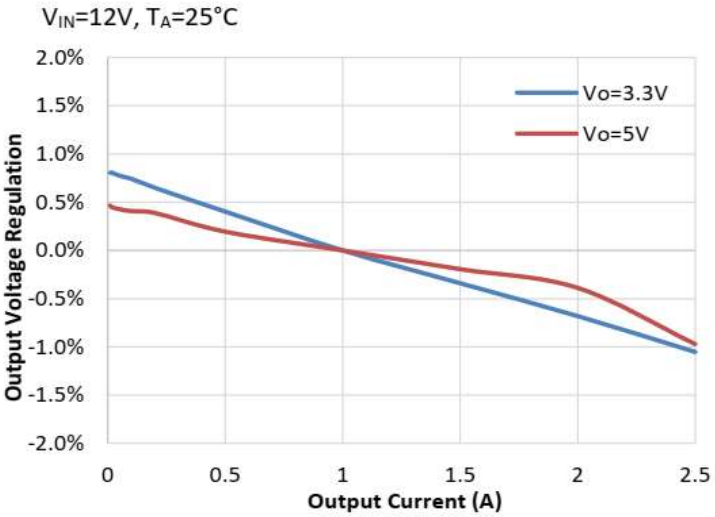


Figure 7. Load Regulation

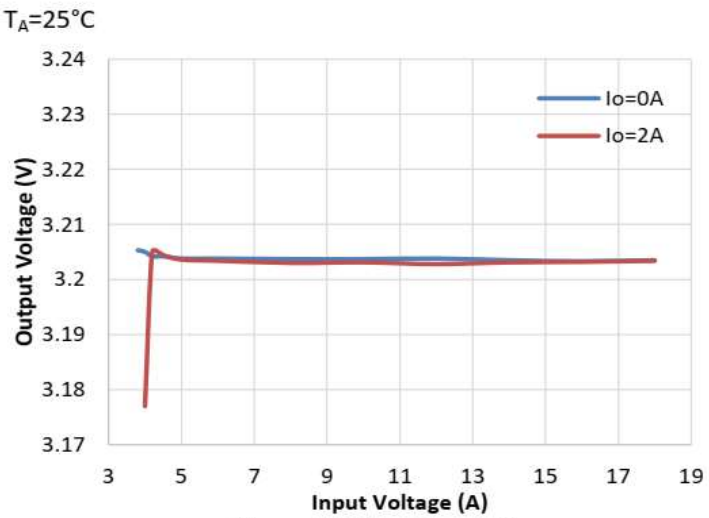


Figure 8. Line Regulation

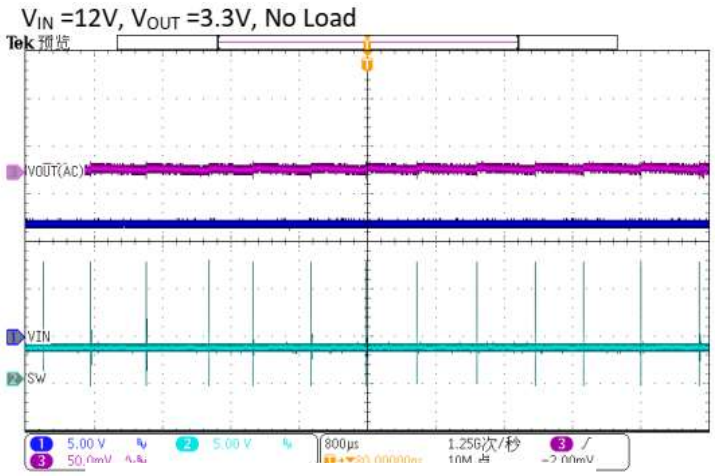


Figure 9. Steady State Operation

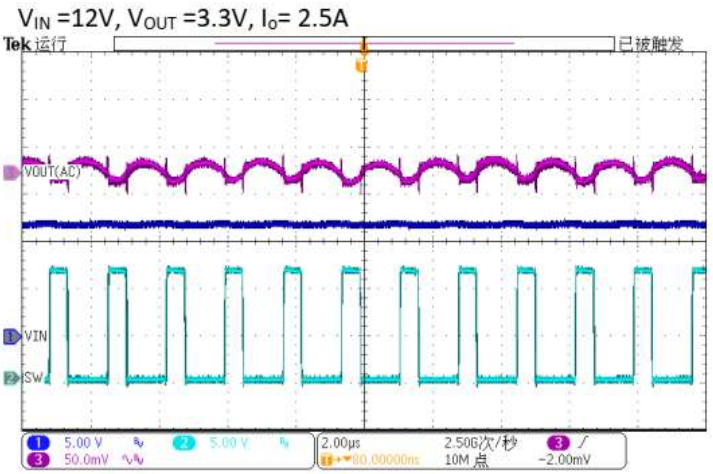


Figure 10. Steady State Operation

600KHz 18V, 3A Synchronous Step-Down Converter

Typical Performance Characteristics(Con.)

(Test condition: VIN=12V, VOUT=3.3V, L=3.3uH, TA=25'C, unless otherwise noted.)

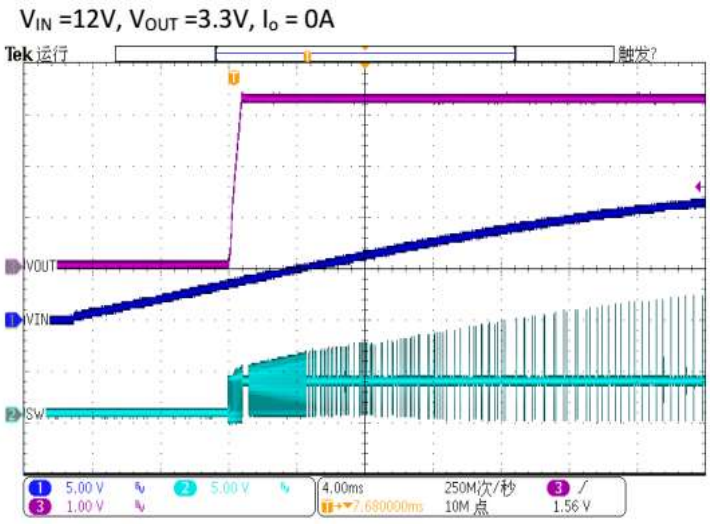


Figure 11. Input Power On

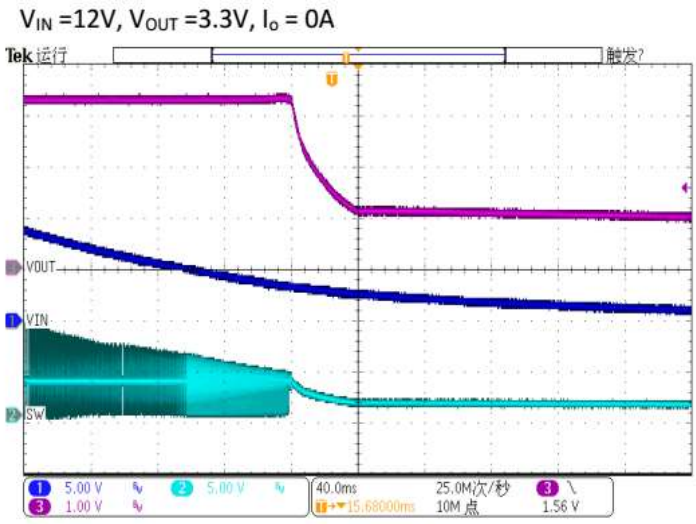


Figure 12. Input Power Down

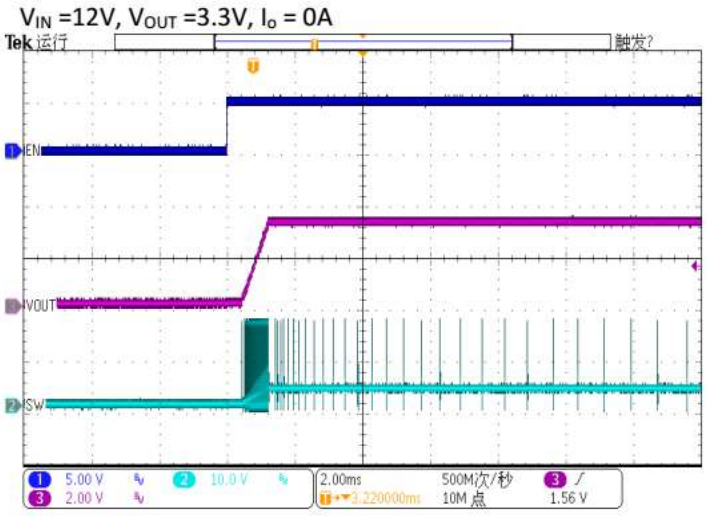


Figure 13. EN Enable

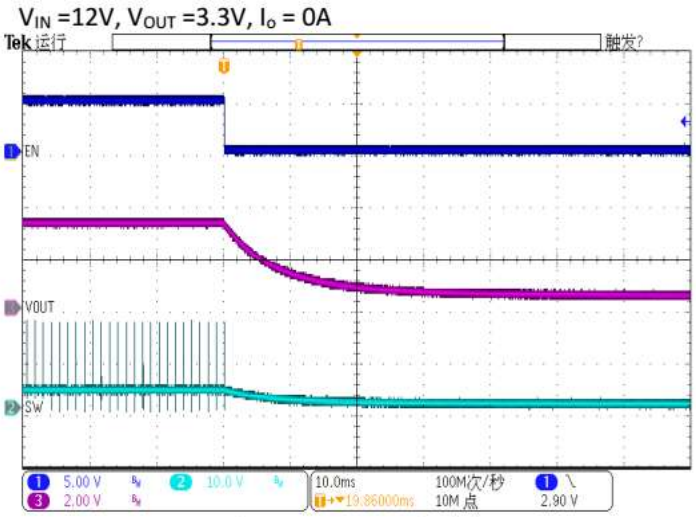


Figure 14. EN Disable

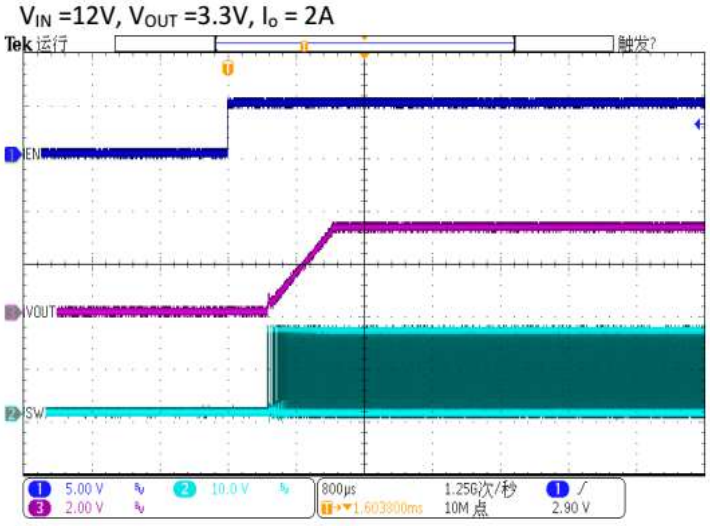


Figure 15. EN Enable

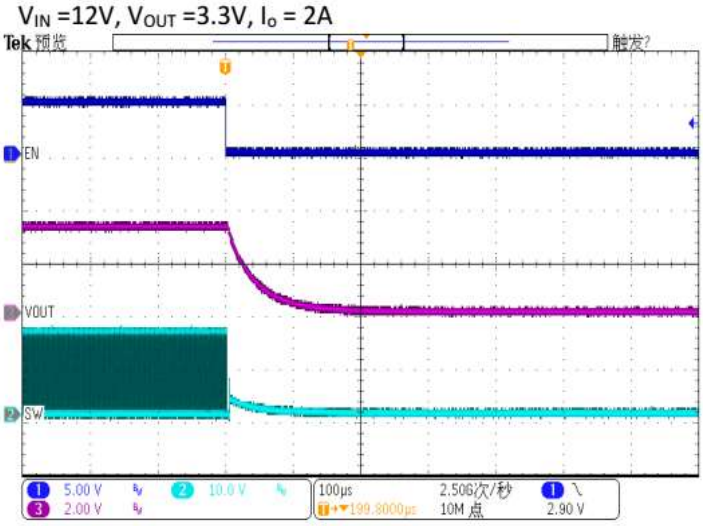


Figure 16. EN Disable

Typical Performance Characteristics(Con.)

(Test condition: VIN=12V, VOUT=3.3V, L=3.3uH, TA=25'C, unless otherwise noted.)

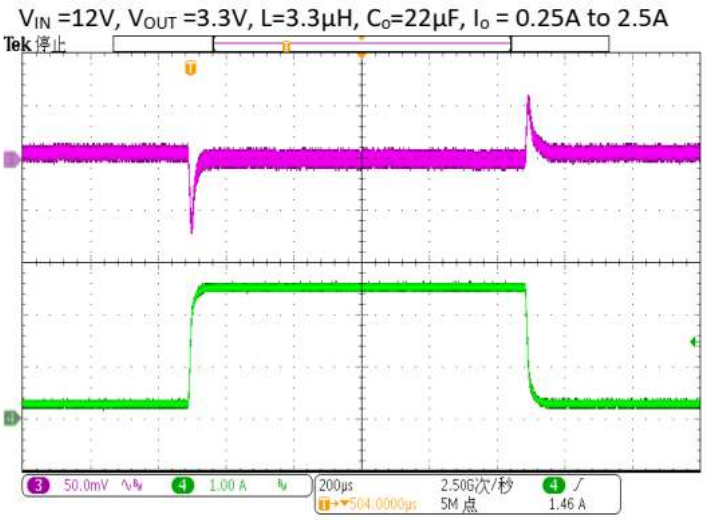


Figure 17. Load Transient

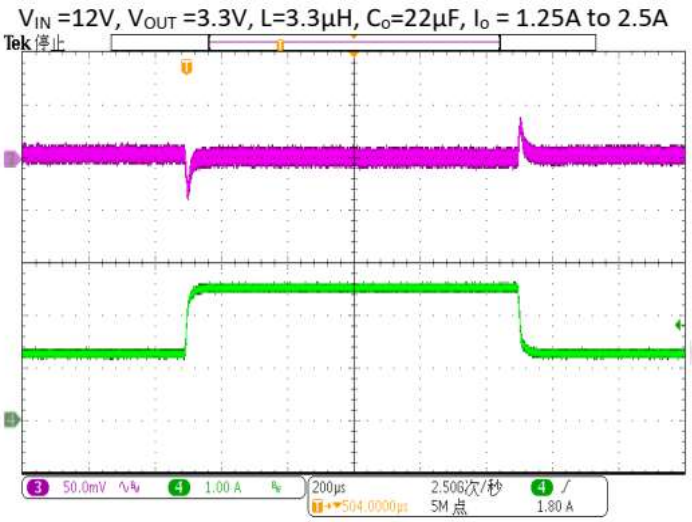


Figure 18. Load Transient

Typical Application Circuit-2

VIN: 4.5V ~ 18V, VOUT=3.3V, ILOAD: 0 - 3A

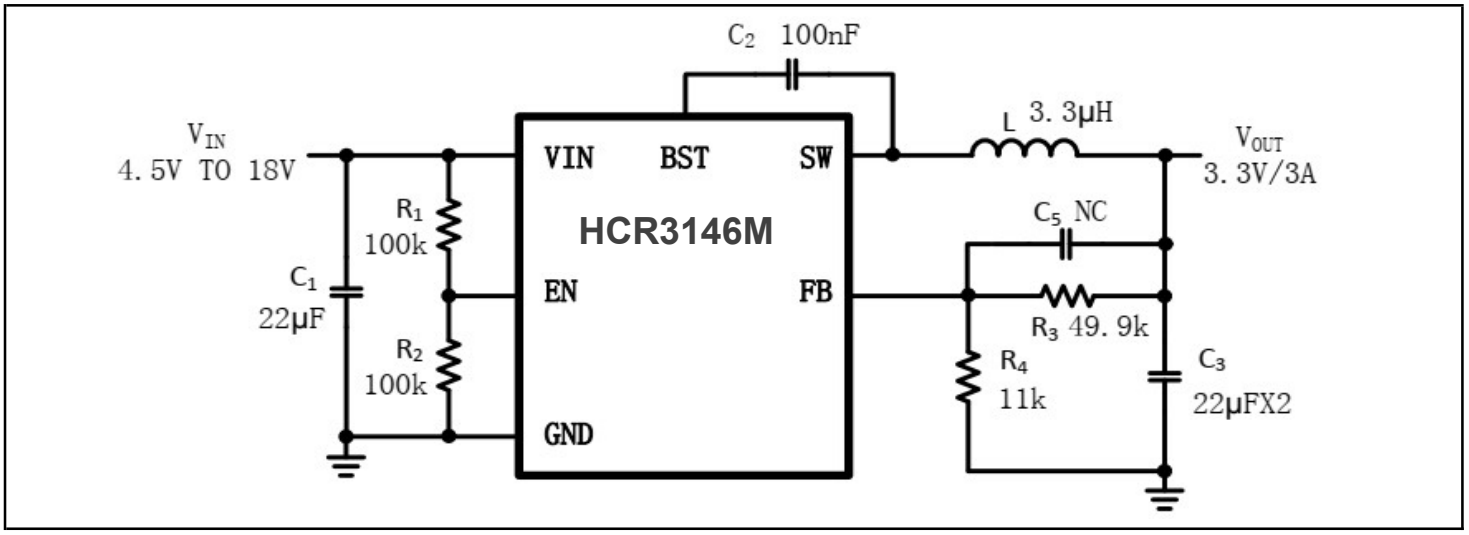


Figure 19. Typical Application Circuit of HCR3146M

External Components Suggestion(VIN=12V):

VOUT(V)	R4 (kΩ)	R3 (kΩ)	C5 (pF)	L (μH)	C3 (μF)
0.8	11	3.6	NC	1	66
1	11	7.3	NC	1.5	66
1.2	11	11	NC	1.5	66
1.8	11	22	NC	2.2	44
2.5	11	34.8	NC	2.2	44
3.3	11	49.9	NC	3.3	44
5	11	80.6	NC	4.7	44

Note: In order to improve dynamic performance, a feedforward capacitor(C5) can be considered to be in parallel with R3.

Operation Description

The HCR3146M is synchronous step-down regulator based on 12 control arachitecture. It regulates input voltages from 4.5V to 18V down to an output voltage as low as 0.6V, and is capable of supplying up to 3A of load current.

Shut-Down Mode

The regulator shuts down voltage at EN pin is driven below 0.4V. The entire regulator is off and the supply current consumed by the regulator drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the HCR3146M to down convert the input voltage to the regulated output voltage.Since the top MOSFET needs a gate voltage great than the input voltage, a boost capacitor connnect between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 3.3V rail when SW is LOW.

VIN Under-Voltage Protection

A resistive divider can be connected between VIN and ground, with the central tap connected to EN, So that when VIN drops to the pre-set value, EN drops below 1.05V to trigger input under voltage lockout protection.

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 inductor can be easily built up,resulting in a large strt-up output current. A valley current limit is designed in the HCR3146M so that only when output current drops below the valley current limit can the top power switch be turned on. By such control mechanism, the output current at start-up is well controlled.

Output Short Protection

When the output is shorted to ground, the regulator is allowed to switch for 2048 cycles. If the short condition is cleared within this period,then the regulator resumes normal operation. If the short condition is still present after 2048 switching cycles, then no switching is allowed and the regulator enters hiccup mode for 6144 cycles. After the 6144 hiccup cycles, the regulator will try to start-up again. If the short condition still exists after 2048 cycles of switching, the regulator enters hiccup mode. This process of start-up and hiccup iterate itself until the short condition is removed.

Thermal Protection

When the temperature of the regulator rises above 160'C, it is forced into thermal shut-down. Only when core temperature drops below 140'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:

$$V_{FB} = V_{OUT} \cdot \frac{R_4}{R_4 + R_3}$$

Where VFB is the feedback voltage and VOUT is the output voltage.

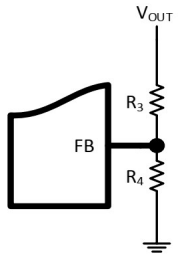
Choose R4 around 11KΩ, and then R3 can be calculated by:

$$R_3 = R_4 \cdot \left(\frac{V_{OUT}}{0.6} - 1 \right)$$

The following table lists the recommended values.

Output Voltage Set (Con.)

refer to schmatic diagram



VOUT(V)	R4(KΩ)	R3(KΩ)
0.8	11	3.6
1.0	11	7.3
1.2	11	11
1.8	11	22
2.5	11	34.8
3.3	11	49.9
5.0	11	80.6

Application Information(Con.)

Feedforward Capacitor

In order to improve dynamic performance, a feed-forward capacitor(C5) can be considered to be in parallel with R3.

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintain the DC input voltage. Estimate the RMS current in the input capacitor with:

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

where ILOAD is the load current, VOUT is the output voltage, VIN is the input voltage.

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 C1 is the input capacitance value, fs is the switching frequency, ΔVIN is the input ripple voltage. The input capacitor can be electrolytic, tantalum or ceramic. To minimize the potential noise, a small X5R or X7R ceramic capacitor, e.g 0.1uF, should be placed as close to the IC as possible when using electroly capacitors. A 22uF/25V 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:

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

where COUT is the output capacitance value and RESR is the equivalent series resistance value of the output capacitor.

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

Output Capacitor(Con.)

The output capacitors also affect the system stability and transient response, and a 44uF~66uF 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 40% 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 VIN is the input voltage, VOUT is the output voltage fs is the switching frequency, and ΔIL is the peak-to-peak inductor ripple current.

External Bootstrap Capacitor

A bootstrap capacitor is required to supply voltage to the top switch driver. A 0.1uF low ESR ceramic capacitor is recommended to be connected between the BST pin and SW pin.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to follow the guidelines as below.

a.1 place the input decoupling capacitor as close to the HCR3146M(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.

a.2 Put the feedback trace as far away from the inductor and noisy power traces as possible.

a.3 The ground plane on the PCB should be as large as possible for better heat dissipation.

a.4 Keep the switching node SW short to prevent excessive capacitive coupling.

a.5 Make VIN, VOUT and ground bus connections as wide as possible. This reduces any voltage drops on the input or output paths of the converter and maximizes efficiency.

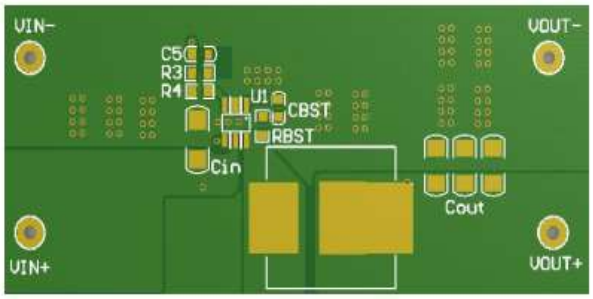


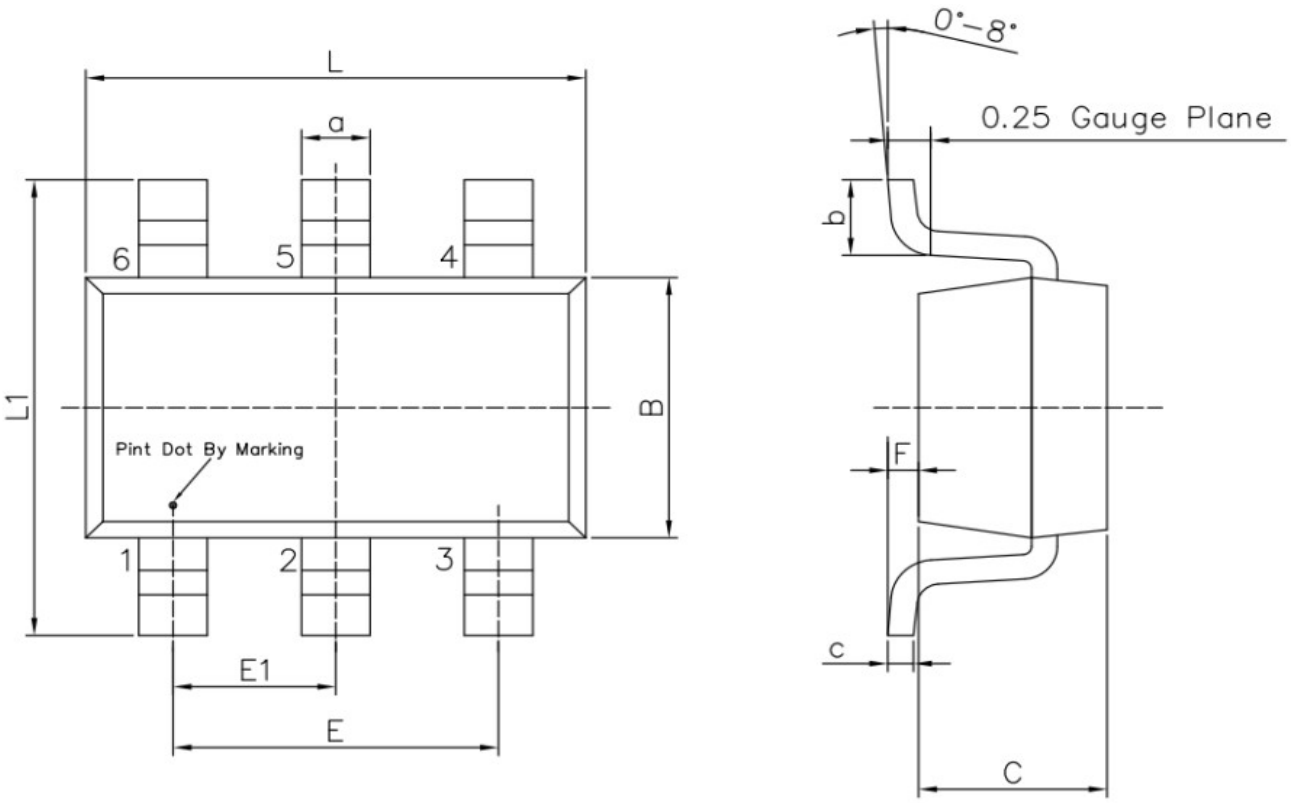
Figure 20. PCB Layout Recommendation

600KHz 18V, 3A Synchronous Step-Down Converter

Mechanical Dimensions

M6L PKG: SOT23-6L

Unit: mm



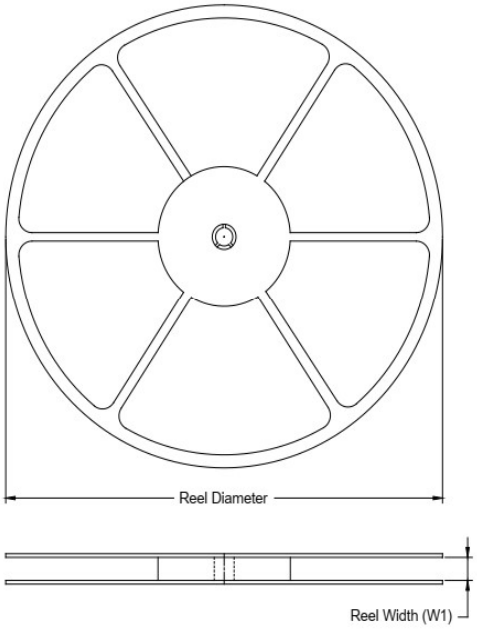
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.82	3.02	E1	0.85	1.05
B	1.50	1.70	a	0.35	0.50
C	0.90	1.30	c	0.10	0.20
L1	2.60	3.00	b	0.35	0.55
E	1.80	2.00	F	0	0.15

Note:

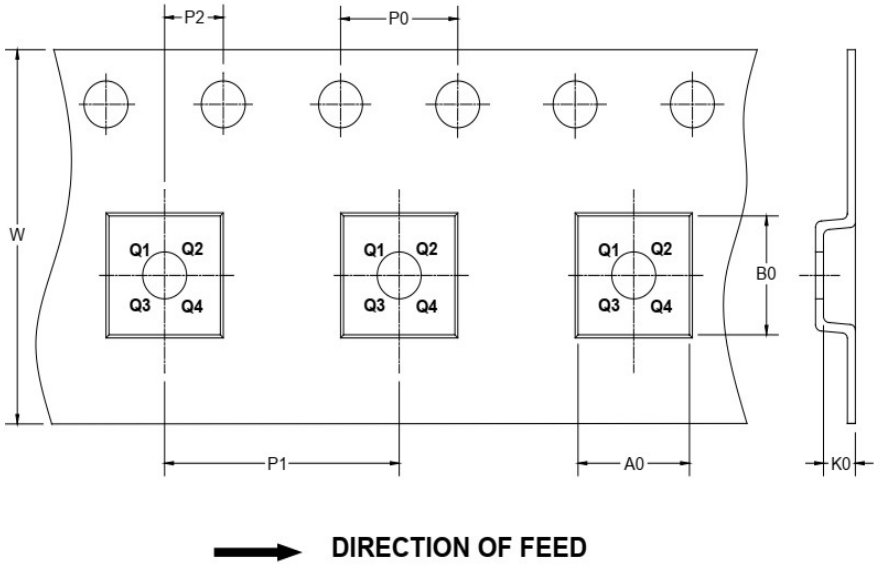
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top mark from left to right.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



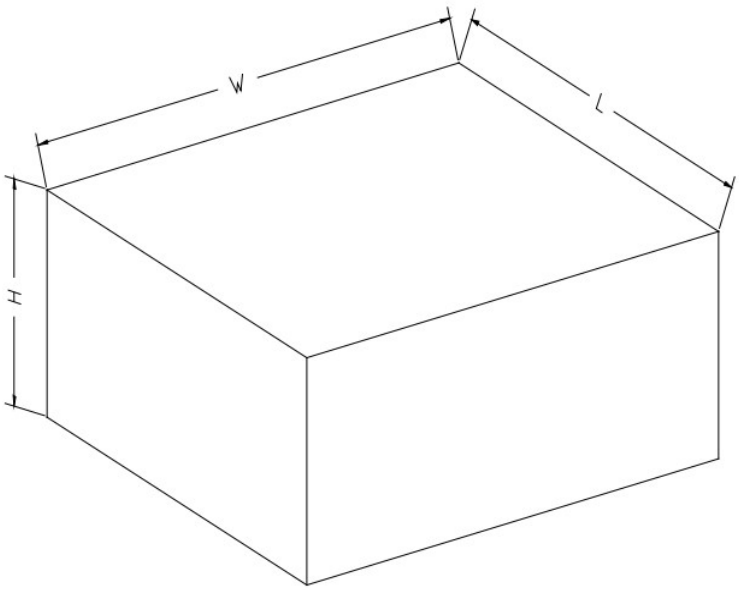
DIRECTION OF FEED

NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TSOP-6 (SOT23-6L)	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″	442	410	224	18