500KHz, 24V, 3A Synchronous Step-Down Converter

Features

- Input Voltage Range: 4.0V to 24V
- Output Constant Current: 3A
- Up to 95% efficiency
- High Efficiency (>85%) at light load
- 500KHz Switching Frequency
- Internal Soft-start
- Input under-voltage lockout
- Current run-away protection
- Output Short Protection
- Thermal Shutdown
- Available in SOT23-6L

Applications

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

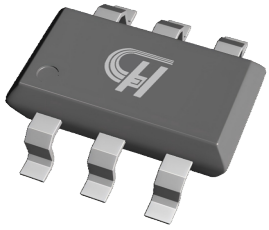
General Description

The HCR3227 is a monolithic buck switching regulator based on I2 architecture for fast transient response. Operating with an input range of 4V~24V.

the HCR3227 delivers 3A of continuous output current with two integrated N-Channel MOSFETs. The internal synchronous power switches provide high efficiency without the use of an external Schottky diode. At light loads, the regulator operates in low frequency to maintain high efficiency and low output ripples.

The HCR3227 guarantees robustness with output short protection, thermal protection, current run-away protection, input under voltage lockout.

The HCR3227 is available in SOT23-6L packages, which provide a compact solution with minimal external components.



SOT23-6L

Figure a. Package Type of HCR3227

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Pin Configuration

SOT23-6L Top View

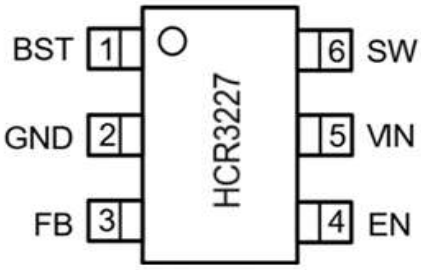
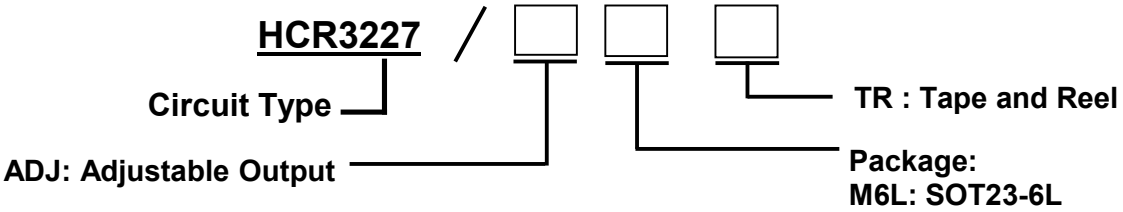


Figure b. Pin Configuration of HCR3227 (Top View)

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 4V to 24V 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
HCR3227/ADJM6LTR	*W67XX	-40'C to +125'C	SOT23-6L	3000pcs /tape&Reel

Note 2: The "XX" is Inside code.

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Functional Block Diagram

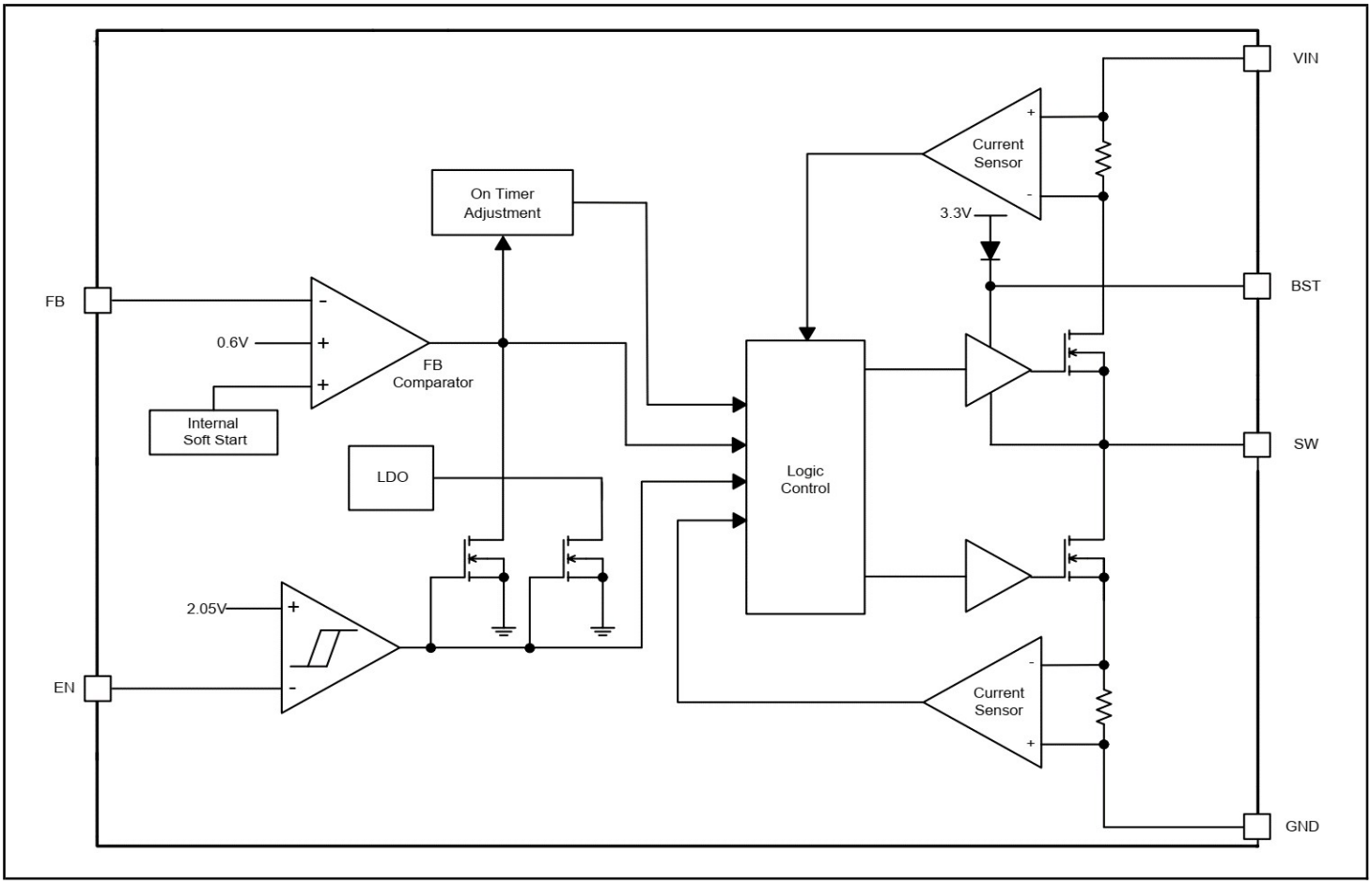


Figure c. Functional Block Diagram of HCR3227

Typical Application Circuit

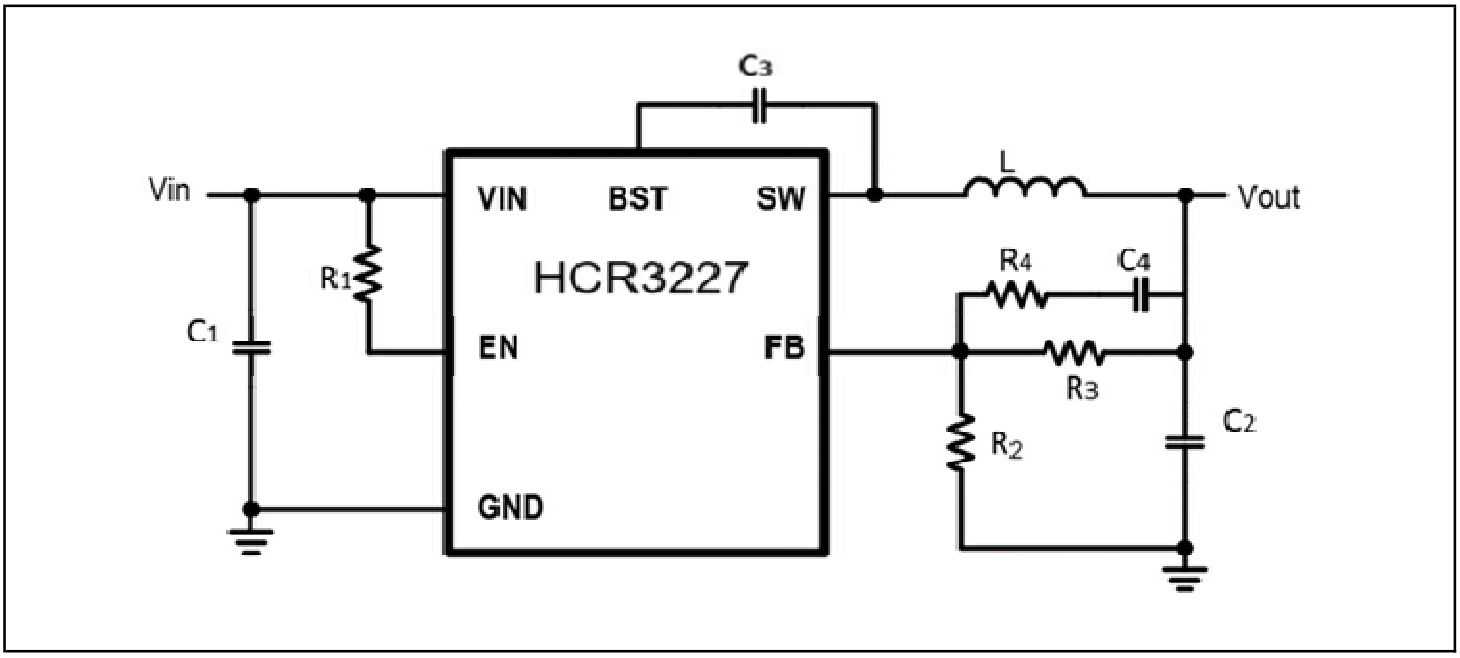


Figure d. Typical Application Circuit of HCR3227

Absolute Maximum Ratings Note 1

Parameter	Symbol	Value	Unit
Input Supply Voltage Range	VIN	-0.3 to +25.0	V
SW Voltage Range	VSW	-0.3 to +25.0	V
EN Voltage Range	VEN	-0.3 to +25.0	V
BST Voltage Range	VBST	SW-0.3 to SW+5.0	V
All other Pins	V*	-0.3 to +6.0	V
Power Dissipation	PO	920	mW
Thermal Resistance Junction to Ambient note4	RθJA	110	'C/W
Thermal Resistance Junction to Case note4	RθJC	55	'C/W
Storage Temperature Range	TSTG	-65 to 150	'C
Junction Temperature note2,3	TJ	150	'C
Lead Temperature (Soldering, 10s)	TLEAD	260	'C
ESD Susceptibility(Human Body Model)	HBM	2	KV

Note 1: Exceeding these ratings may damage the device.

2: The HCR3227 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 HCR3227 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

Recommended Operating Conditions

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input Voltage Range	VIN		4.0	-	24	V
Output Voltage	VOUT		0.6	-	VIN-3	V
Operating Junction Temperature Range	TJ		-40	-	125	'C

Electrical Characteristics

(VIN=12V, TA=25'C, unless otherwise stated.)

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input voltage lockout Threshold	V_{IN_MIN}		3.3	3.6	3.8	V
Input voltage lockout Hysteresis	$V_{IN\_MIN\_HYST}$		-	200	-	mV
Quiescent Current	I_Q	V_{EN}=5.0V, V_{FB}=1.2V	-	220	-	uA
Shutdown Current	I_{SD}	V_{EN}=0V	-	-	1	uA
Regulated Feedback Voltage Accuracy	V_{FB}	T_A=25'C, 4V<V_{IN}<24V	588	600	612	mV
FB Leakage Current	I_{FB}	V_{FB}=0.6V	-	-	120	uA
Top Switch On Resistance note5	$R_{DS(ON)T}$		-	70	-	mΩ
Bottom Switch On Resistance note5	$R_{DS(ON)B}$		-	38	-	mΩ
Top Switch Leakage Current note5	I_{LEAK_TOP}	V_{IN}=24V, V_{EN}=0V, V_{SW}=0V	-	-	1.0	uA
Bottom Switch Leakage Current note5	I_{LEAK_BOT}	V_{IN}=24V, V_{EN}=0V, V_{SW}=24V	-	-	1.0	uA
Top Switch Current Limit note5	I_{LIM_TOP}	Minimum Duty Cycle	5	6	7	A
Bottom Switch Current Limit note5	I_{LIM_BOT}	Minimum Duty Cycle	2.8	3.4	4.1	A
Oscillation Frequency	F_{OSC}	V_{FB}=0.6V	-	500	-	KHz
Maximum Duty Cycle	η	V_{FB}=0.6V	-	95	-	%
EN Rising Threshold note5	V_{EN-H}	V_{EN} rising	1.9	2.05	2.2	V
EN Hysteresis note5	V_{EN-HYS}	V_{EN} Hysteresis	-	150	-	mV
Minimum On-Time note5	T_{ON}		-	120	-	nS
Minimum Off-Time note5	Toff	V_{FB}=0.4V	-	100	-	nS
Soft Start time note5	Tss		-	1.6	-	mS
Thermal Shutdown note5	T_{TSD}		-	140	-	'C
Thermal Shutdown Hysteresis note5	T_{TSD_HYST}		-	15	-	'C

Note 5. Guaranteed by design.

500KHz, 24V, 3A Synchronous Step-Down Converter

Typical Performance Characteristics

(Test condition: VIN=12V, VOUT=3.3V, L=4.7uH, Cout=22uF, TA=25'C, unless otherwise noted.)

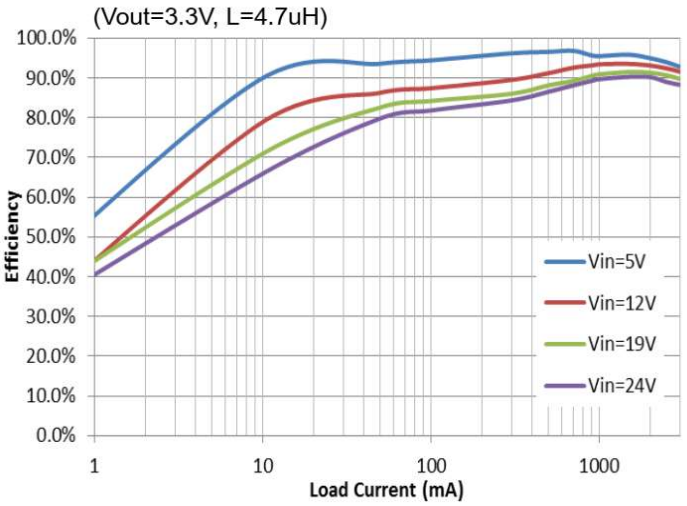


Figure 1. Efficiency vs Load Current

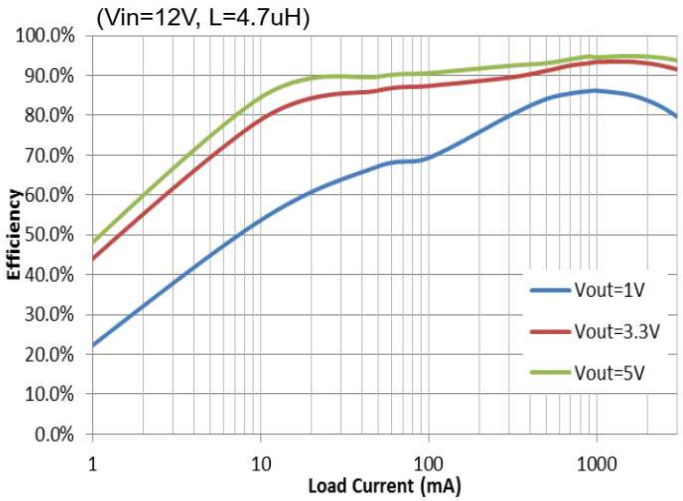


Figure 2. Efficiency vs Load Current

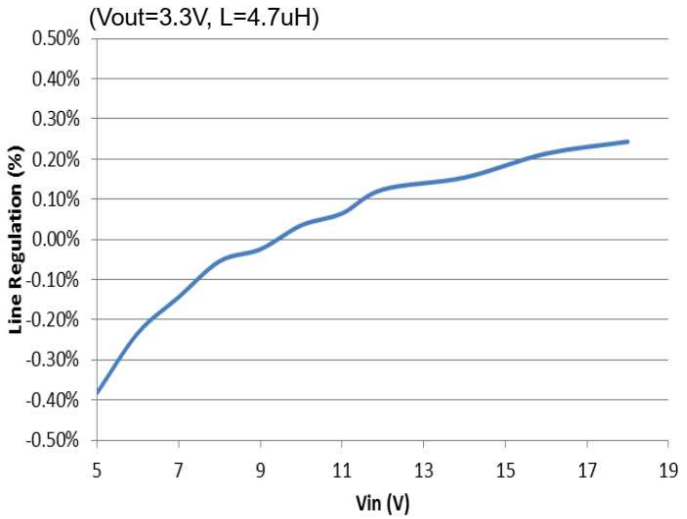


Figure 3. Line Regulation vs Vin

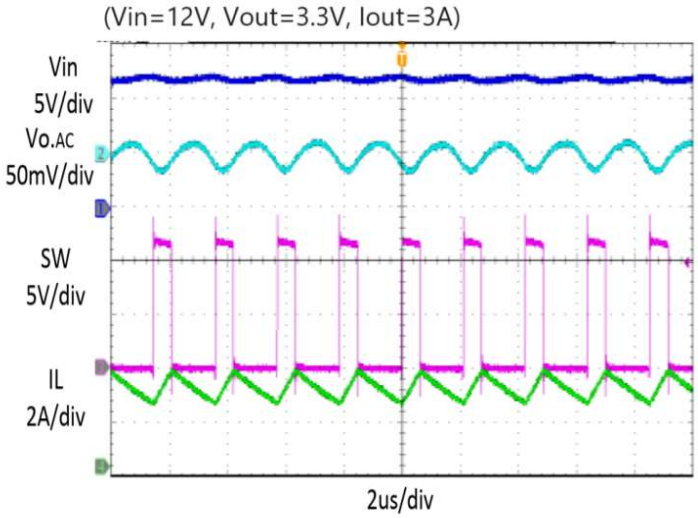


Figure 4. Steady State Test

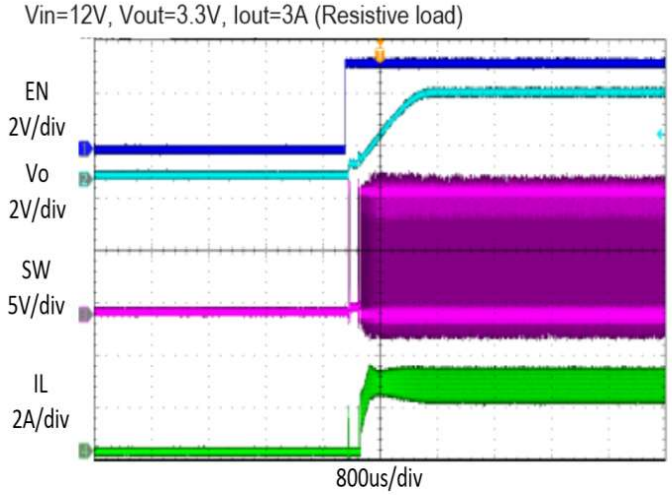


Figure 5. Startup through Enable

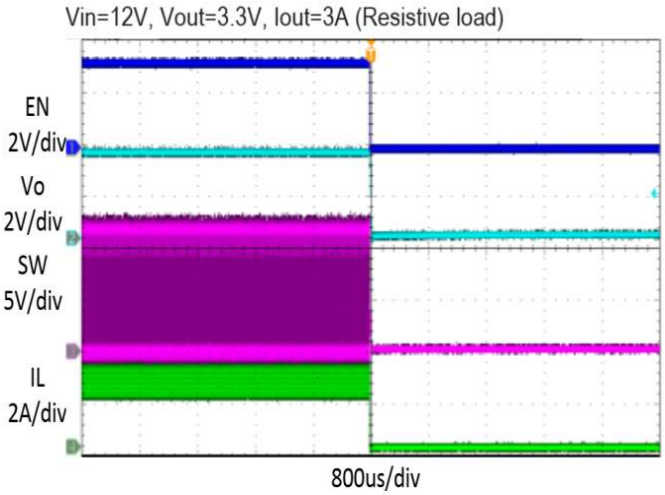


Figure 6. Shutdown through Enable

500KHz, 24V, 3A Synchronous Step-Down Converter

Typical Performance Characteristics(Con.)

(Test condition: VIN=12V, VOUT=3.3V, L=4.7uH, Cout=22uF, TA=25'C, unless otherwise noted.)

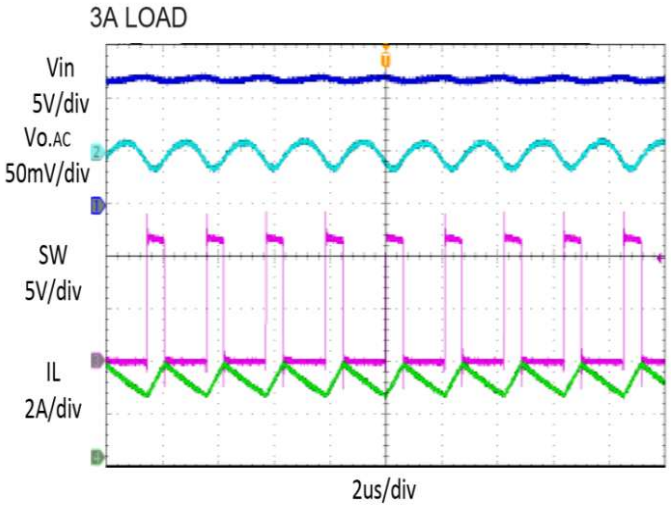


Figure 7. Heavy Load Operation

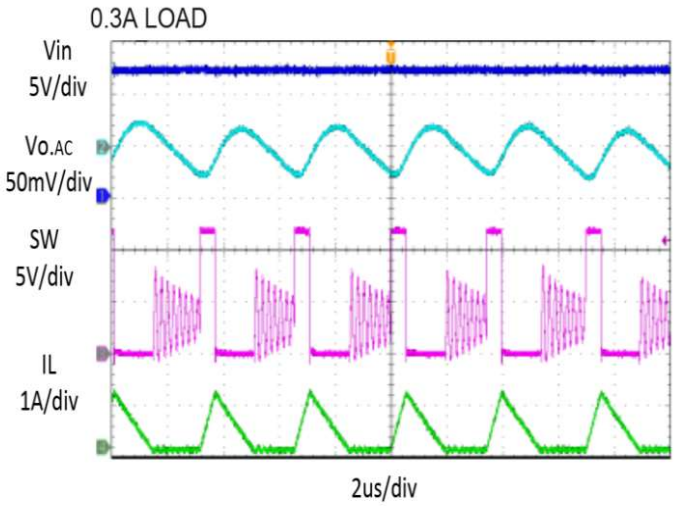


Figure 8. Medium Load Operation

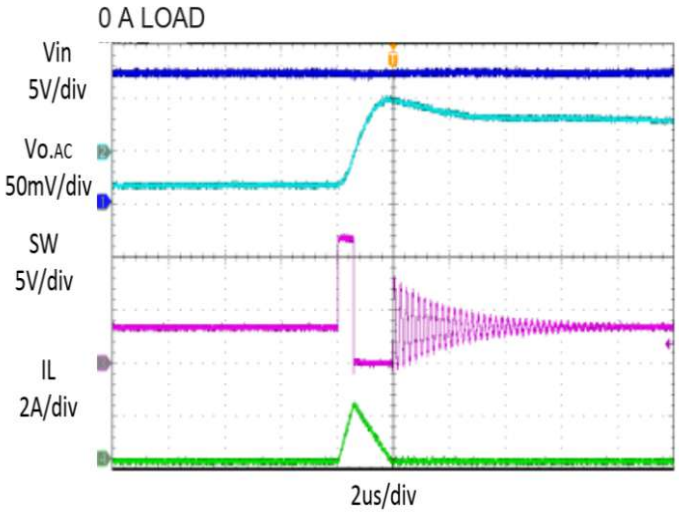


Figure 9. Light Load Operation

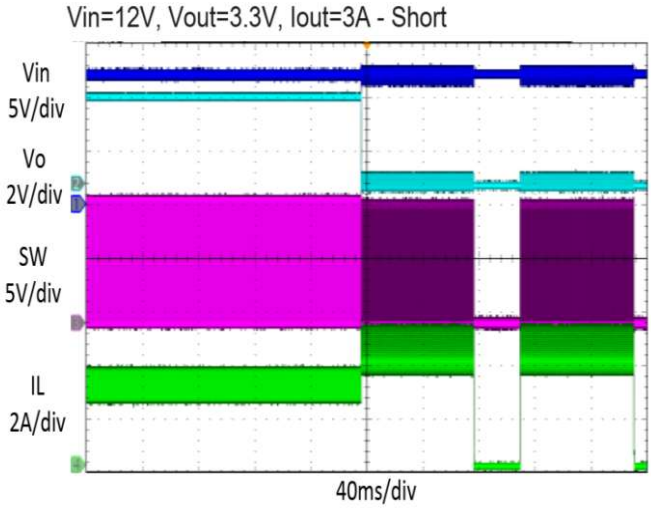


Figure 10. Short Circuit Protection

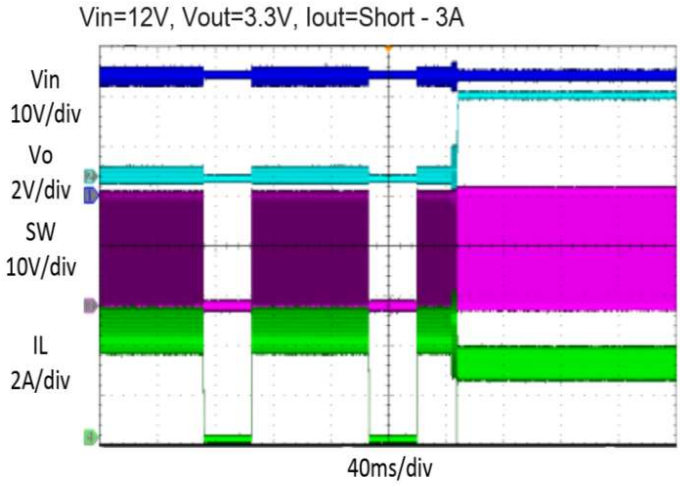


Figure 11. Short Circuit Recovery

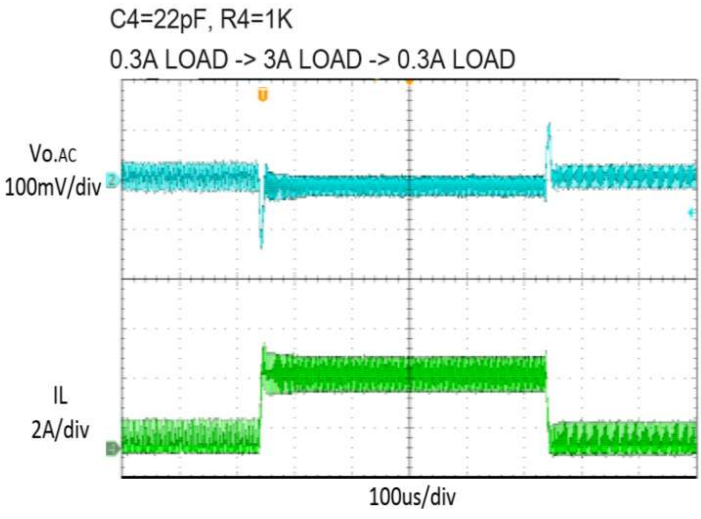


Figure 12. Load Transient

FUNCTIONAL DESCRIPTION

The HCR3227 is a synchronous step-down regulator based on I2 control architecture. It regulates input voltages from 4V to 24V down to an output voltage as low as 0.6V, and is capable of supplying up to 3A of load current.

Shut-Down Mode

HCR3227 shuts down when voltage at EN pin is driven below 0.3V. The entire regulator is off and the supply current consumed by HCR3227 drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the HCR3227 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 connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 3.7V 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 1.9V 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 start-up output current. A valley current limit is designed in the HCR3227 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 1024 cycles. If the short condition is cleared within this period, then the regulator resumes normal operation. If the short condition is still present after 1024 switching cycles, then no switching is allowed and the regulator enters hiccup mode for 2048 cycles. After the 2048 hiccup cycles, the regulator will try to start-up again. If the short condition still exists after 1024 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 HCR3227 rises above 140°C, it is forced into thermal shut-down. Only when core temperature drops below 125°C can the regulator becomes 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:

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

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

Choose R2 around 10kΩ~15kΩ, and then R3 can be calculated by:

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

The following table lists the recommended values.

Output Voltage Set (Con.)

VOUT(V)	R3(KΩ)	R2(KΩ)
2.5	47	15
3.3	49.9	11
5.0	110	15

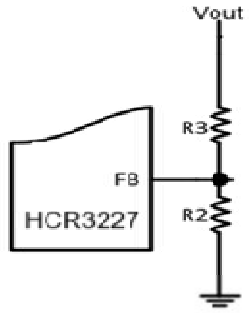


Figure e-1. Output Voltage Set

APPLICATION INFORMATION(Con.)

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 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:

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

where C2 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.

The output capacitors also affect the system stability and transient response, and a 47uF 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

Inductor(Con.)

which affect the efficiency and the output voltage ripple The ripple current is 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.

Feedforward Capacitor

In order to minimize the ripple of output voltage at light load, a feedforward capacitor in series with a resistor should be in parallel to the upper divider resistor. Choose R4 around 1kΩ and C4 around 22pF.

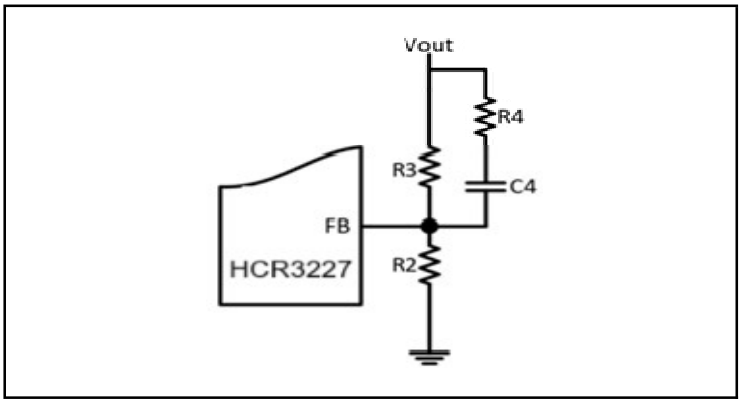


Figure e-2. Feedforward Capacitor

Start up through EN

If HCR3227 start up through EN, a 10nF or larger capacitor should be connected between EN pin and GND to eliminate noise.

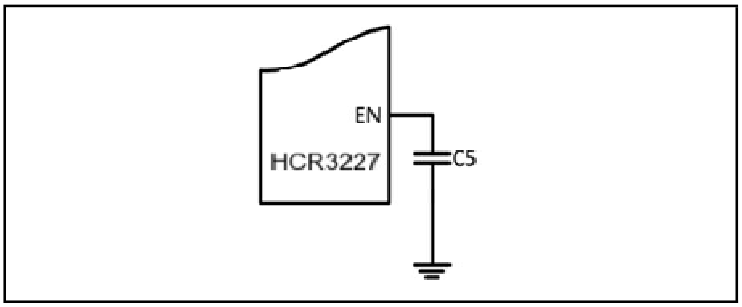


Figure e-3. Start up through EN

APPLICATION INFORMATION(Con.)

External Components Suggestion:

VOUT	R2	R3	R4	C4	L	Cout
(V)	(KΩ)	(KΩ)	(KΩ)	(pF)	(uH)	(uF)
1.0	13.3	9	1	180	4.7	54~66
1.2	28	28	1	180	4.7	54~66
1.5	16	24	1	180	4.7	54~66
2.5	15	47	1	22	4.7	22~66
3.3	11	49.9	1	22	4.7	22~66
5.0	15	110	1	22	4.7	22~66

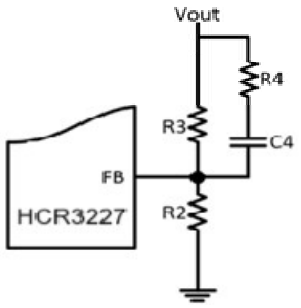


Figure e-4. External Components Suggestion

PCB Layout Note

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

a-1. Place the input decoupling capacitor as close to the HCR3227 (VIN pin and PGND) as possible to eliminate noise at the input pin.

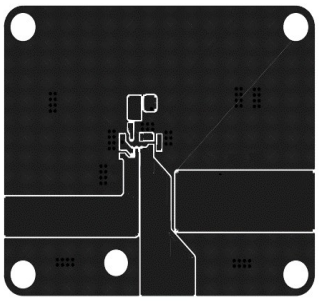
The loop area formed by input capacitor and GND must be minimized.

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

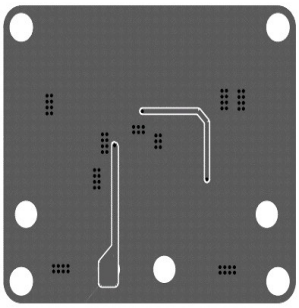
a-3. The ground plane on the PCB should be as large as possible for better heat dissipation.

PCB Layout Note(Refer to Layout Diagram)

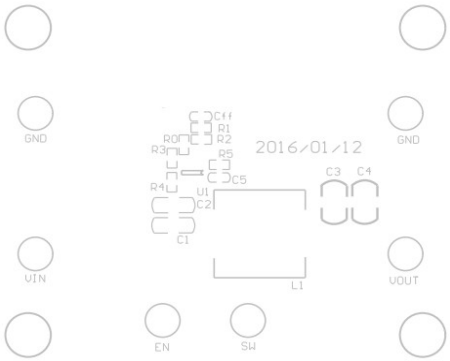
Top Layer



Bottom Layer



Silk Layer



500KHz, 24V, 3A Synchronous Step-Down Converter

Refer to Design

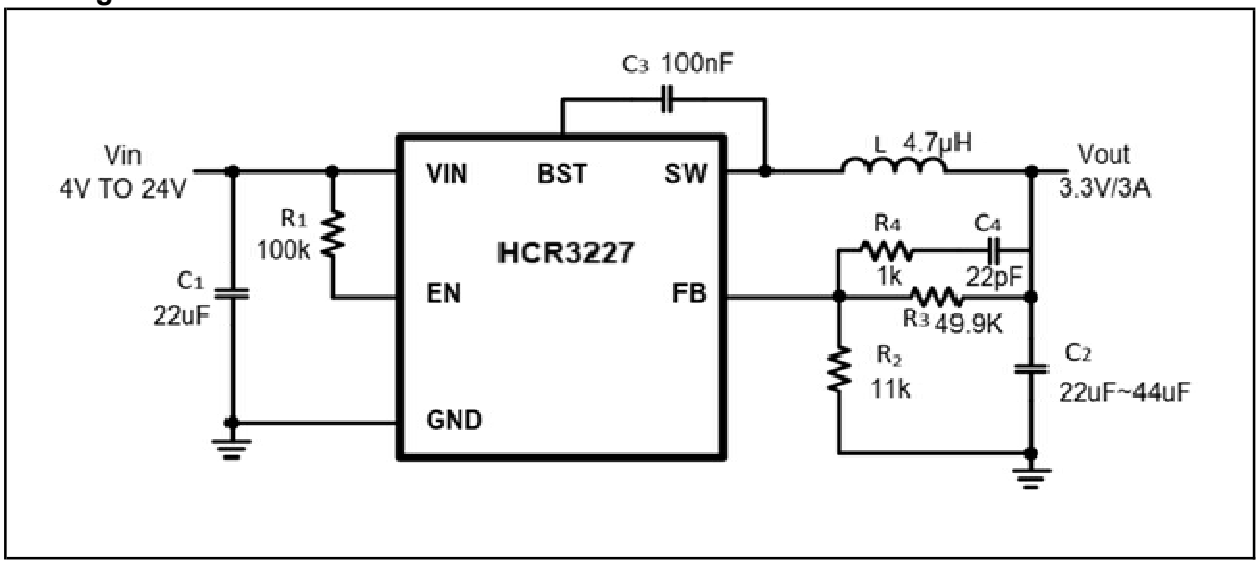
Reference-1

Vin : 4V ~ 24V

Vout : 3.3V

Iout : 0 ~ 3A

Package: SOT23-6L



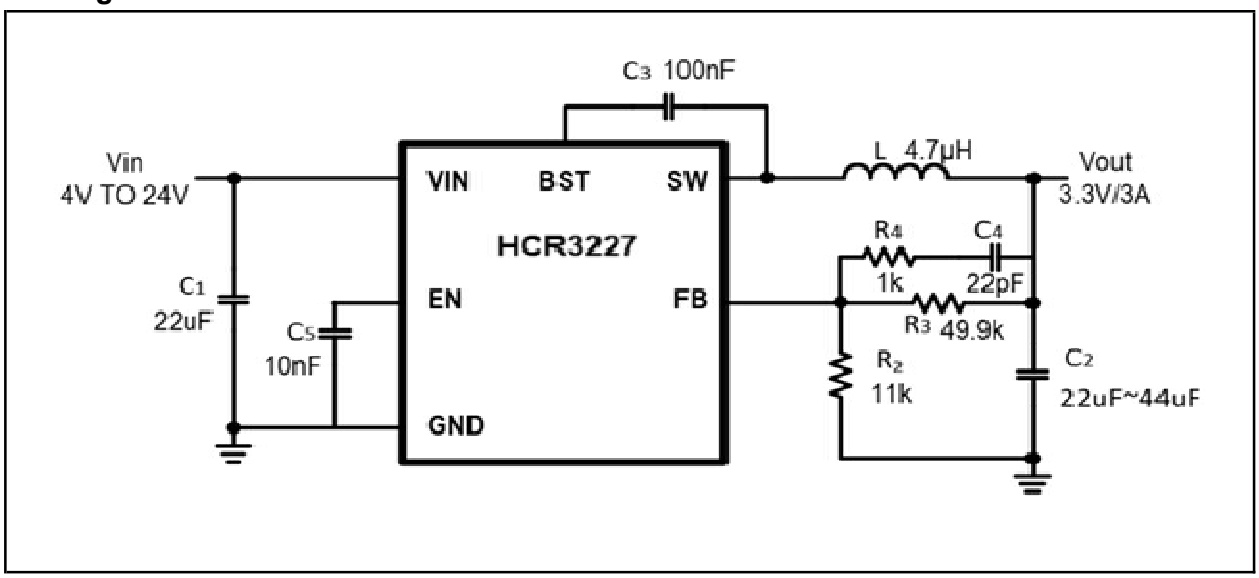
Start up Through EN

Vin : 4V ~ 24V

Vout : 3.3V

Iout : 0 ~ 3A

Package: SOT23-6L

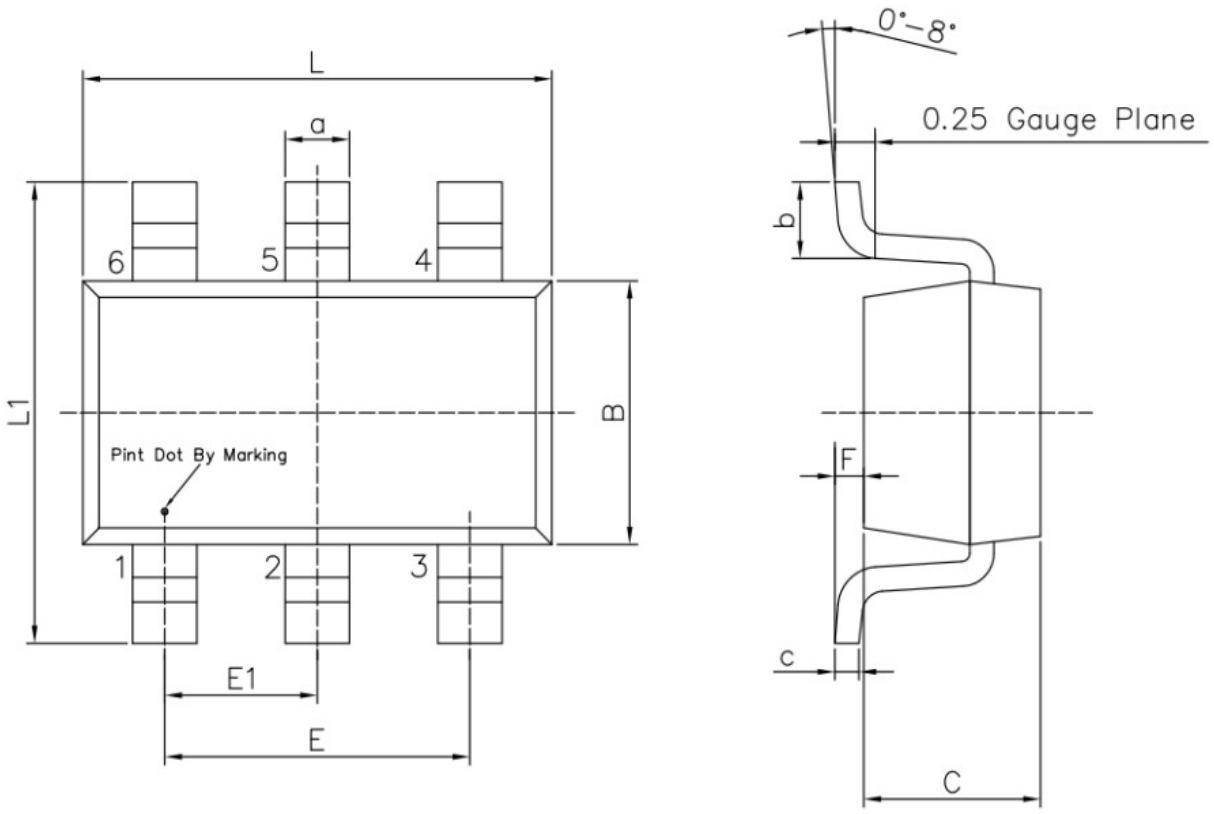


500KHz, 24V, 3A Synchronous Step-Down Converter

Mechanical Dimensions

M6L PKG: SOT23-6L

Unit: mm



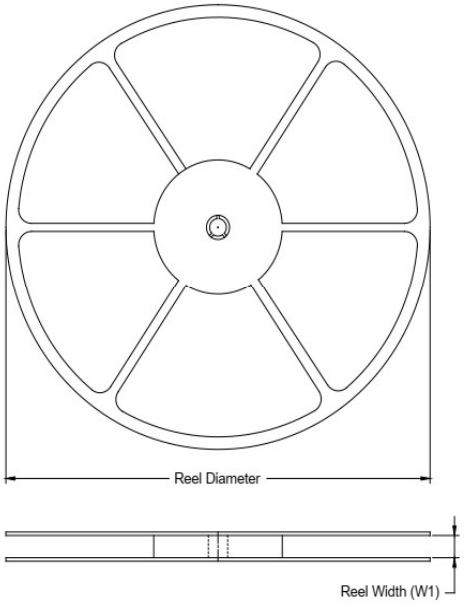
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.82	3.02	E1	0.85	1.05
B	1.50	1.70	a	0.35	0.50
C	0.90	1.30	c	0.10	0.20
L1	2.60	3.00	b	0.35	0.55
E	1.80	2.00	F	0	0.15

Note:

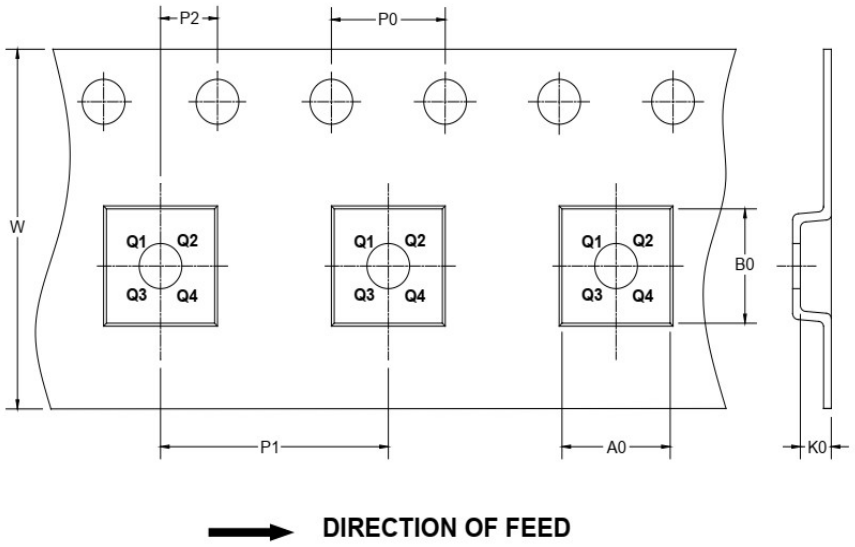
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top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

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

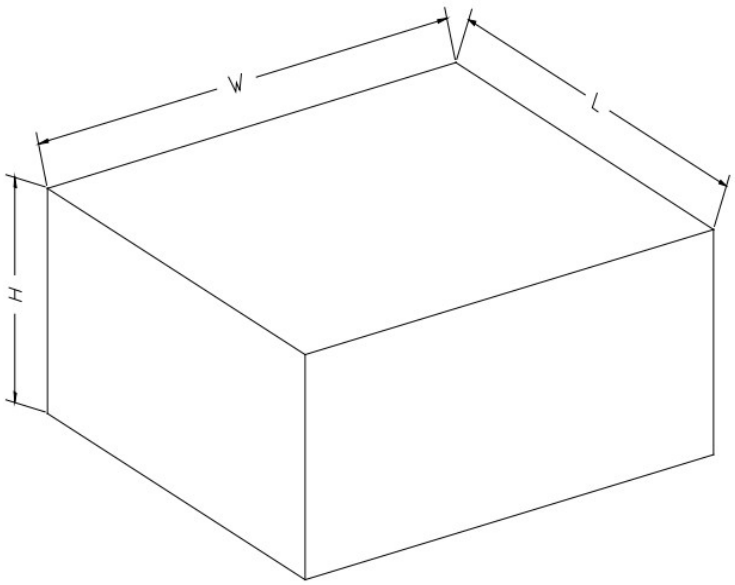


NOTE: The picture is only for reference. Please make the object as the standard.

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
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