450KHz, 24V, 3A Synchronous Step-Down Converter

Features

- Input Voltage Range: 4V to 24V
- Output Constant Current: 3A
- Up to 95% efficiency Current Mode Control
- Fixed 450KHz Switching Frequency
- High efficiency at light load
- Internal Soft-start
- 70mΩ/38mΩ $R_{DS(ON)}$ Internal Power MOSFETs
- Input under voltage lockout
- Current run-away protection
- Output short protection
- Thermal Shutdown
- Available in an TSOT23-8 package
- RoHS Compliant and Halogen-Free

Applications

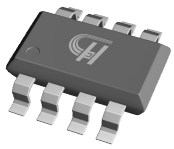
- Notebook Systems and I/O Power
- Digital Set-top Boxes
- LCD Monitors and TVs
- Distributed Power Systems

General Description

The HCR3226J is a monolithic buck switching regulator based on I2 architecture for fast transient response. Operating with an input range of 4V~24V, the HCR3226J 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 HCR3226J guarantees robustness with output short protection, thermal protection, current run-away protection, input under voltage lockout.

The HCR3226J is available in TSOT23-8 packages, which provide a compact solution with minimal external components. Its operating temperature range from -40'C to +85'C'



TSOT23-8

Figure 1. Package Type of HCR3226J

450KHz, 24V, 3A Synchronous Step-Down Converter

Pin Configuration

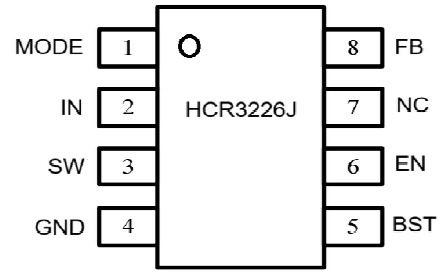
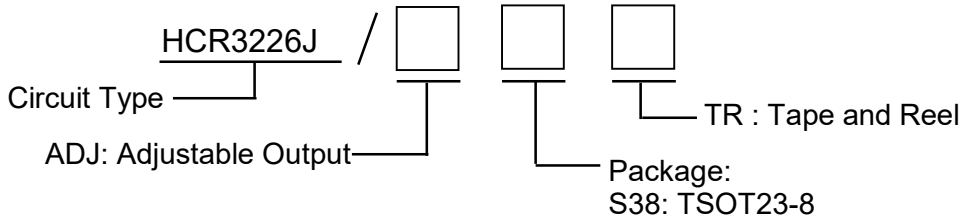


Figure 2. Pin Configuration of HCR3226J (Top View)

Pin Function Table

Pin Number	Pin Name	Function
1	MODE	Pull MODE pin low to GND to achieve PFM operation. Pull MODE up to VIN or floating to achieve FCC operation.
2	IN	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.
3	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
4	GND	System Ground. This pin is the reference ground of the regulated output voltage, and PCB layout requires special care. For best results, connect to GND with copper traces and vias.
5	BST	Connect a 0.1uF capacitor between BST and SW pin to supply current for the top switch driver.
6	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
7	NC	-
8	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 0.8V. Connect a resistive divider at FB.

Ordering Information



Ordering Code

Part Number	Marking ID note2	Temperature Range	Package	Quantity per Reel
HCR3226J/ADJS38TR	J6xxxx	-40'C to +85'C	TSOT23-8	3000pcs /tape&Reel

Note 2: "J6" is device code and "xxxx" is Inside code.

Functional Block Diagram

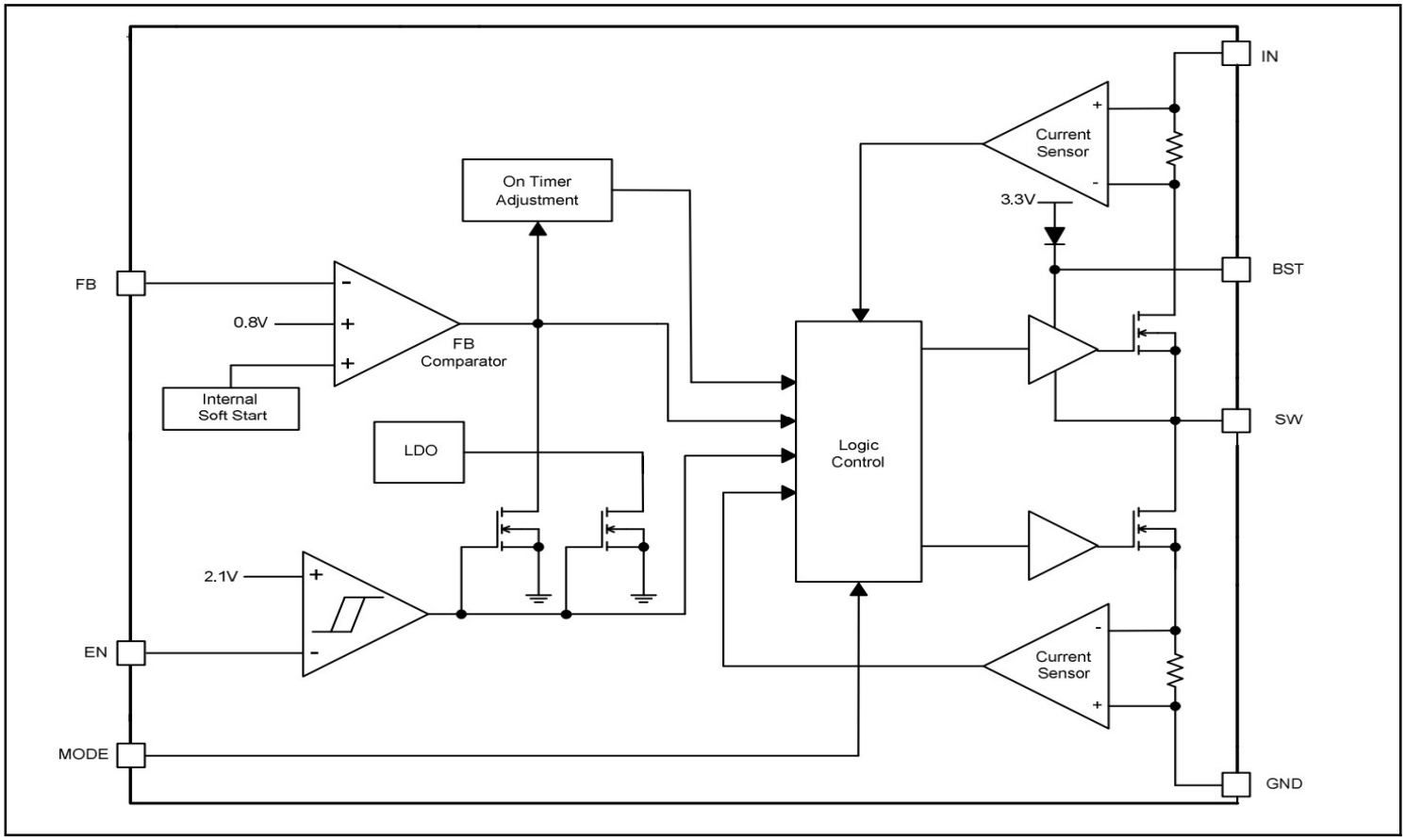


Figure 3. Functional Block Diagram of HCR3226J

Typical Application Circuit

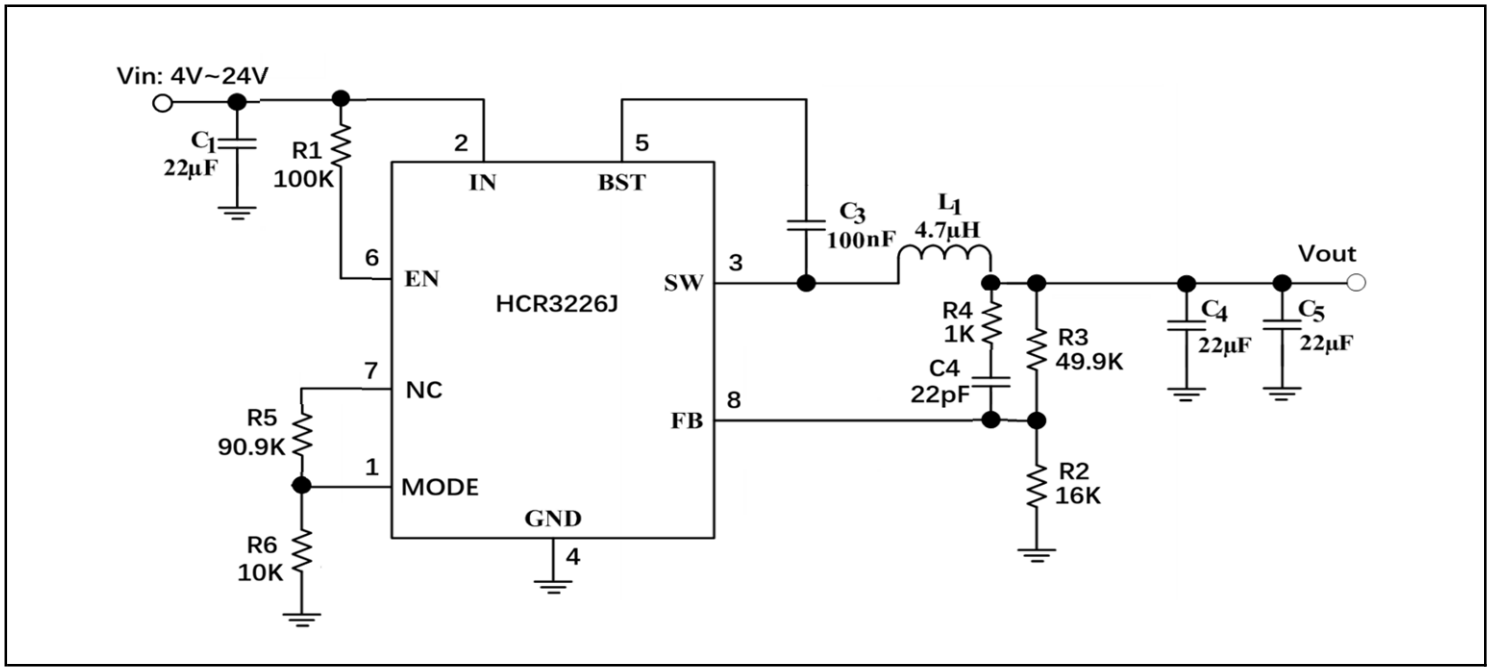


Figure 4. Typical Application Circuit of HCR3226J

Absolute Maximum Ratings Note 1

Parameter	Symbol	Value	Unit
Input Supply Voltage Range	V_{IN}	-0.3 to +24.0	V
Switch Voltage Range	V_{SW}	-0.3 to +24.0	V
Enable Voltage Range	V_{EN}	-0.3 to +24.0	V
Booststrap Voltage Range	V_{BST}	V_{SW}-0.3 to V_{SW}+5.0	V
All other Pins	V*	-0.3 to +6.0	V
Power Dissipation	P_O	920	mW
Thermal Resistance Junction to Ambient note4	θ_{JA}	110	'C/W
Thermal Resistance Junction to Case note4	θ_{JC}	55	'C/W
Storage Temperature Range	T_{STG}	-65 to 150	'C
Junction Temperature note2,3	T_J	+150	'C
Lead Temperature (Soldering, 10s)	T_{LEAD}	+260	'C
ESD Susceptibility(Human Body Model)	HBM	2	KV

Note 1: Exceeding these ratings may damage the device.

2: The HCR3226J 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 HCR3226J 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	V_{IN}		4.0	-	24	V
Output Voltage Range	Vout		0.8	-	VIN-3	V
Operating Temperature Range	Ta		-40	-	+85	'C

Electrical Characteristics

(VIN=12V, TA=+25°C, unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input voltage Range	V_{IN}		4.0	-	24	V
VIN Under Voltage Lock-out Threshold	V_{IN_MIN}	V_{IN} Rising	3.5	3.7	3.9	V
VIN UVLO Threshold Hysteresis	$V_{IN\_MIN\_HYS}$	-	-	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, 4.0V<V_{IN}<24V	0.776	0.80	0.824	V
FB Leakage Current	I_{FB}	V_{FB}=0.8V	-	-	50	uA
Oscillator Frequency	f_{SW}	-	420	450	480	KHz
Maximum Duty Cycle	D_{MAX}	V_{FB}=0.8V, 450kHz	-	95	-	%
Enable Threshold	V_{EN-H}	EN Rising Threshold	2.2	-	-	V
	V_{EN-L}	EN Falling Threshold	-	-	0.4	
Top Switch Resistance	$R_{DS(ON)T}$		-	70	-	mΩ
Bottom Switch Resistance	$R_{DS(ON)B}$		-	38	-	mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=24V, V_{EN}=0V, V_{SW}=0V	-	1	-	uA
Bottom Switch Leakage Current	I_{LEAK_BOT}	V_{IN}=24V, V_{EN}=0V, V_{SW}=24V	-	1	-	uA
Top Switch Current Limit	I_{LIM_TOP}	-	5	6	7	A
Minimum On Time	T_{ON_MIN}	-	-	120	-	ns
Minimum Off Time	T_{Off_MIN}	V_{FB}=0.4V	-	100	-	ns
Soft Start time[note5]	t_{ss}		-	1.6	-	mS
Thermal Shutdown Threshold [note5]	T_{TSD}		-	140	-	'C
Thermal Shutdown Hysteresis[note5]	T_{TSD_HYS}		-	15	-	'C

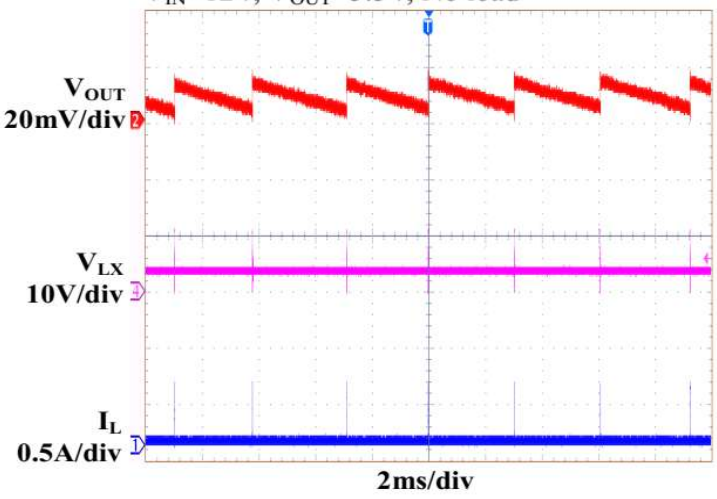
Note 5. Guaranteed by design.

Typical Performance Characteristics

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=450kHz, unless otherwise specified.)

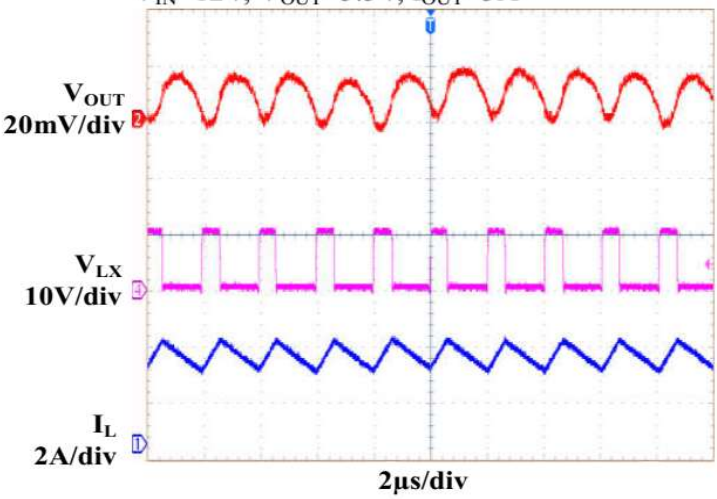
Steady State

V_{IN}=12V, V_{OUT}=3.3V, No load



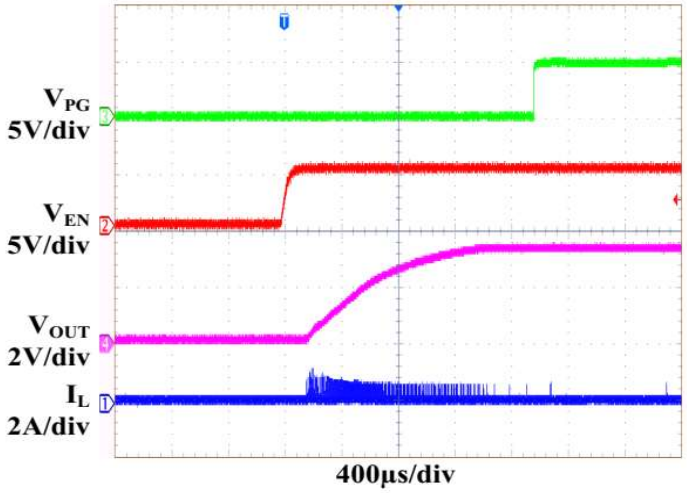
Steady State

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=3A



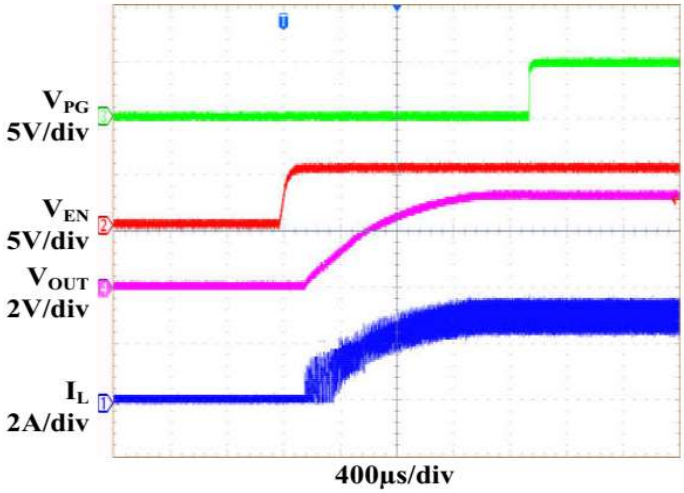
Startup through Enable

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0A



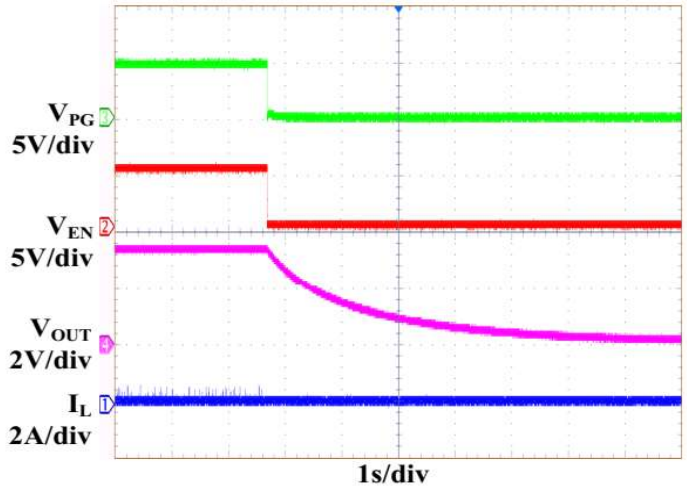
Startup through Enable

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=3A



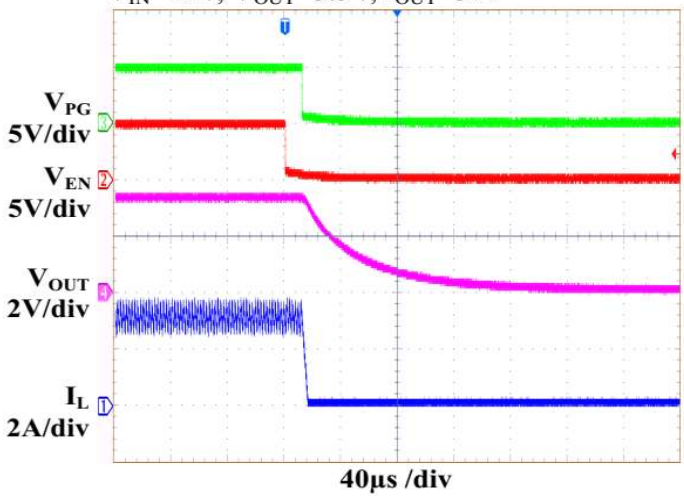
Shutdown through Enable

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0A



Shutdown through Enable

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=3A

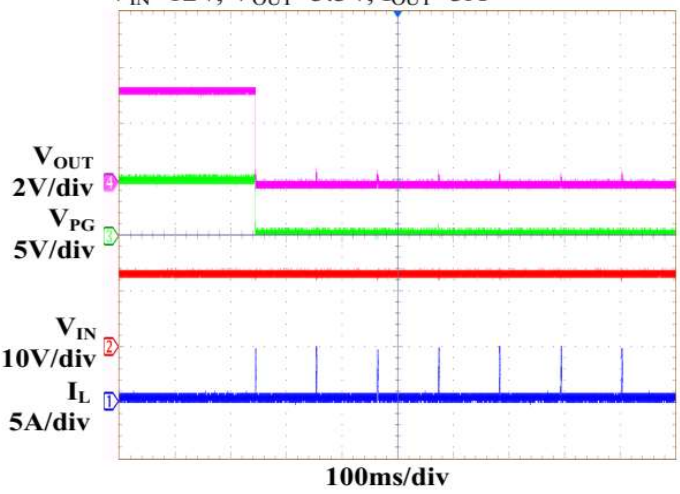


Typical Performance Characteristics(Con.)

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=450kHz, unless otherwise specified.)

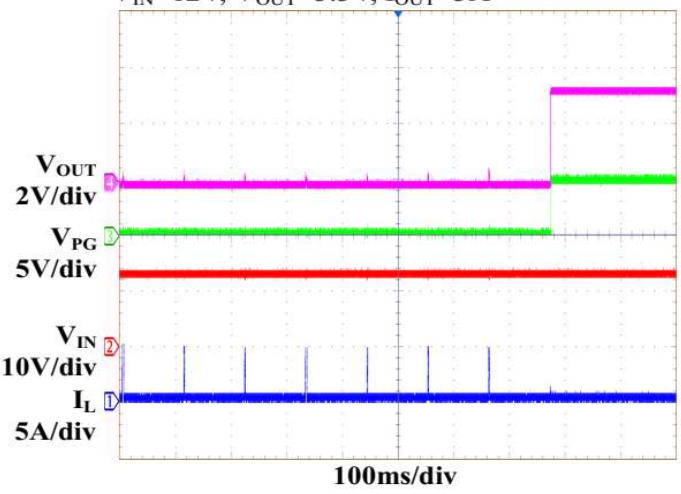
Short Circuit

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=3A



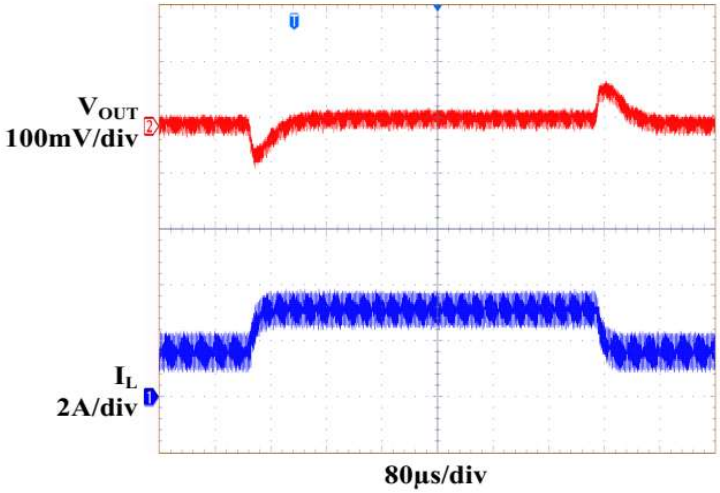
Short Circuit Recovery

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=3A



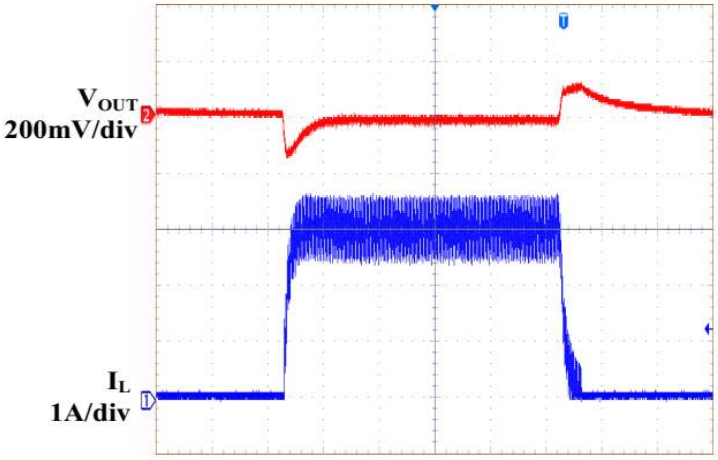
Load Transient Response

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=1.5A to 3A

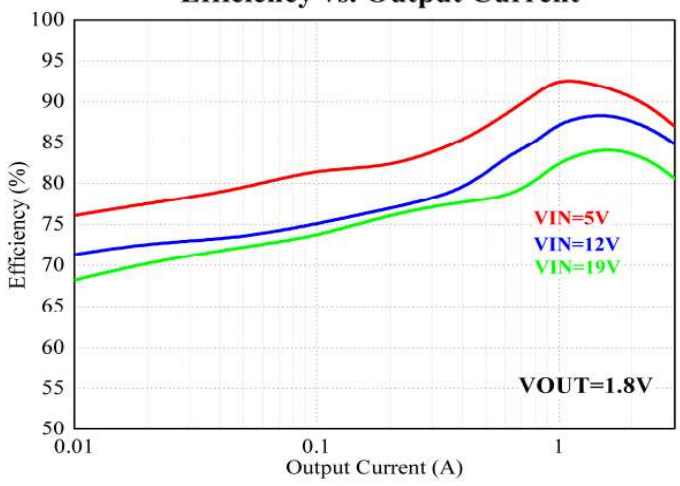


Load Transient Response

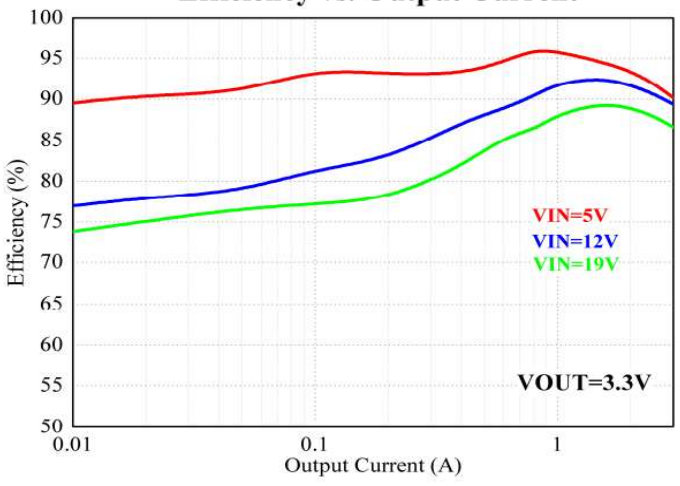
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0A to 3A



Efficiency vs. Output Current



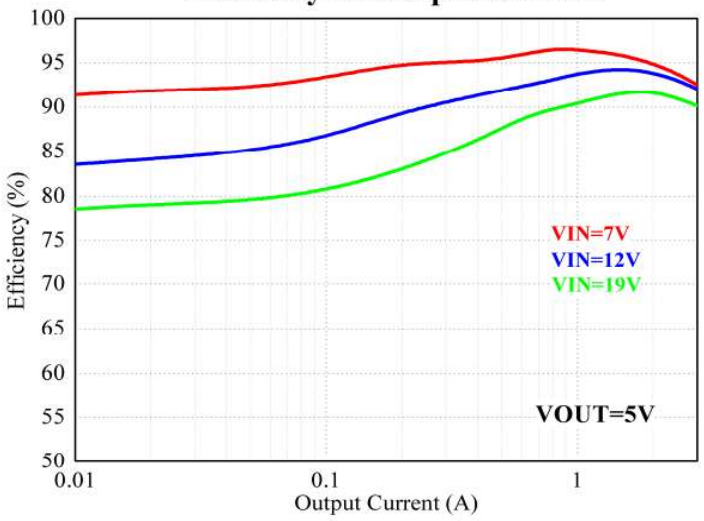
Efficiency vs. Output Current



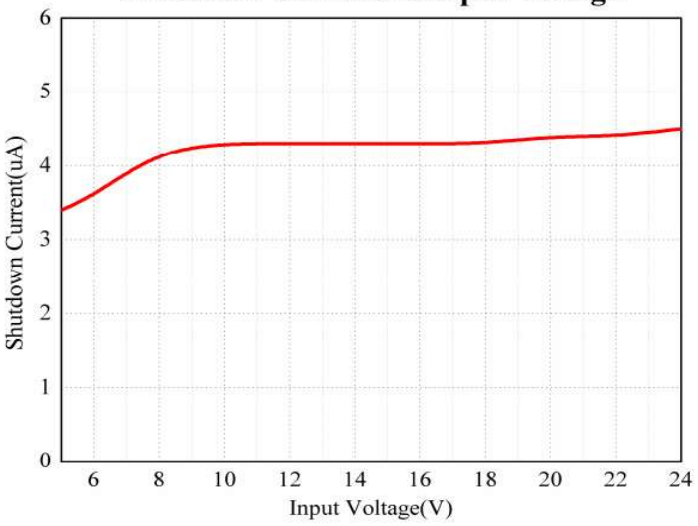
Typical Performance Characteristics(Con.)

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=450kHz, unless otherwise specified.)

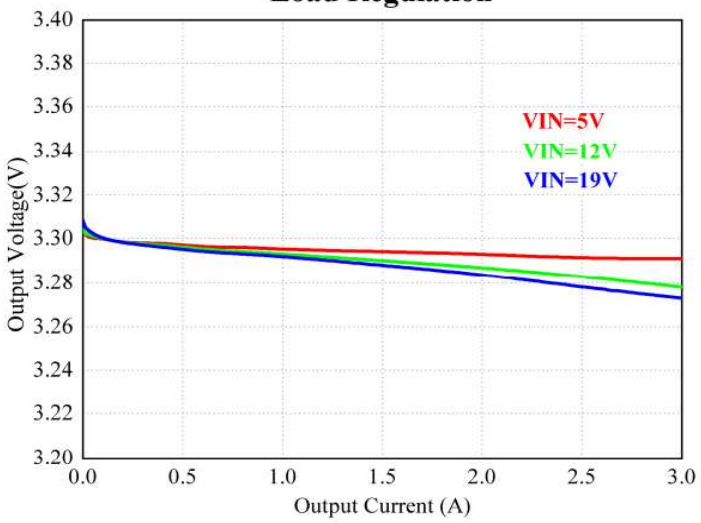
Efficiency vs. Output Current



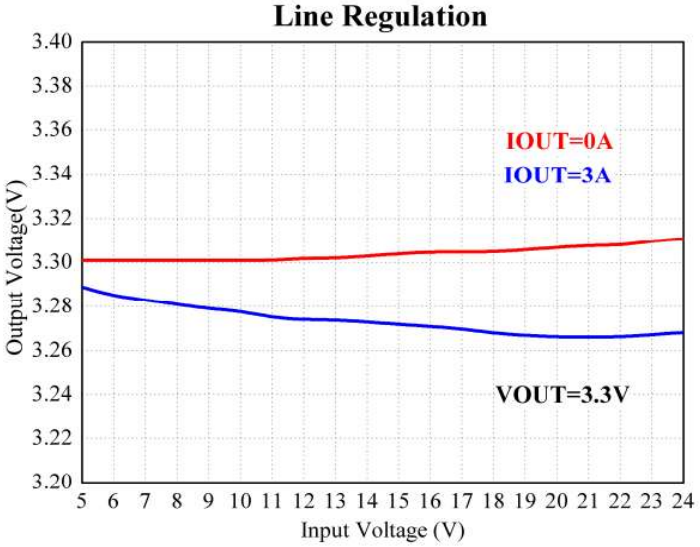
Shutdown Current vs Input Voltage



Load Regulation



Line Regulation



Functional Description

The HCR3226J 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 0.8V, and is capable of supplying up to 3A of load current.

Shut-Down Mode

The HCR3226J shuts down when voltage at EN pin is driven below 0.3V. The entire regulator is off and the supply current consumed by the HCR3226J drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the HCR3226J 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 2V 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 HCR3226J 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 HCR3226J rises above 140°C, t is forced into thermal shut-down. Only when core temperature drops below 125°C can the regulator becomes active again.

Application Information

Setting the Output Voltage

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 15kΩ, and then R3 can be calculated by:

$$R_3 = R_2 \cdot \left(\frac{V_{OUT}}{0.8V} - 1 \right)$$

Too large resistance and the following table lists the recommended values.

VOUT(V)	R2 (KΩ)	R3 (KΩ)
2.5	22.1	47
3.3	16	49.9
5	20	105

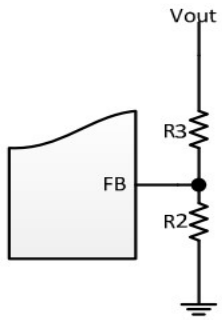


Figure 5. FB circuit diagram

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.

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

Input Capacitor(con.)

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

where C1 is the input capacitance value, fs is the switching frequency, △VIN is the input ripple voltage. The input capacitor can be electrolytic, tantalum or ceramic. To minimizing the potential noise, a small X5R or X7R ceramic capacitor, i.e. 0.1uF, should be placed as close to the IC as possible when using electrolytic capacitors.

A 22uF 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, which lower ESR capacitors get lower output ripple voltage. The output capacitors also affect the system stability and transient response, and a 22uF~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

Application Information(con.)

Inductor(con.)

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 △IL 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 connected to 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 100pF.

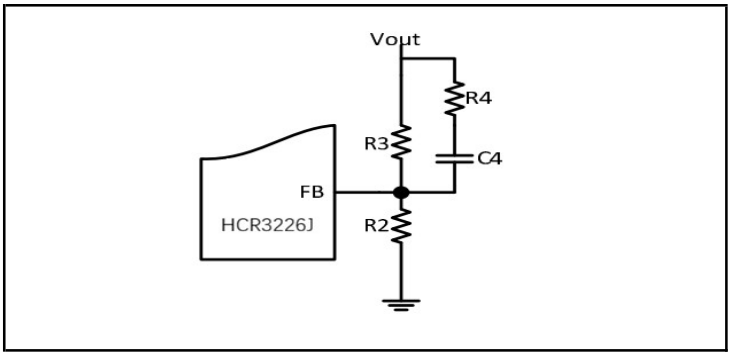


Figure 6. FB circuit diagram

Start up through EN

If the HCR3226J start up through EN, a 10nF or larger capacitor should be connected between EN pin and GND to eliminate noise.

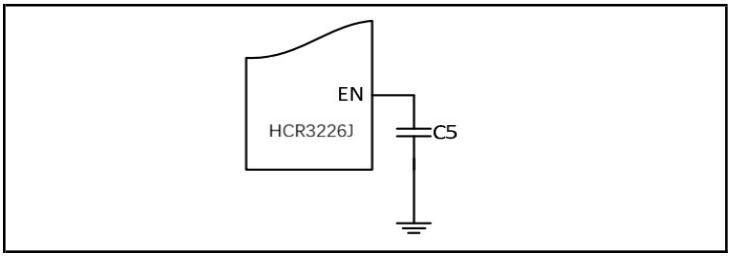


Figure 7. EN circuit diagram

PCB Layout Note

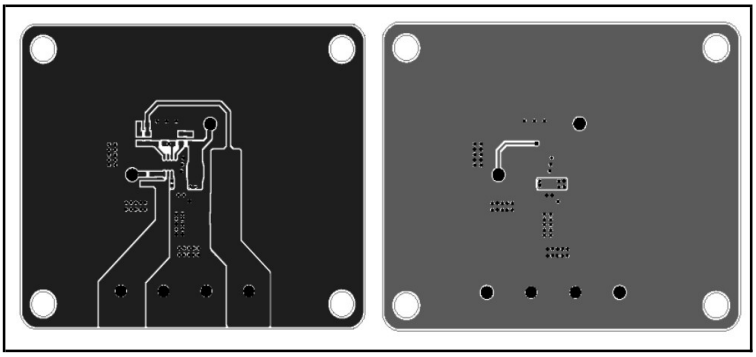
For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1.1 Place the input decoupling capacitor as close to the HCR3226J (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.

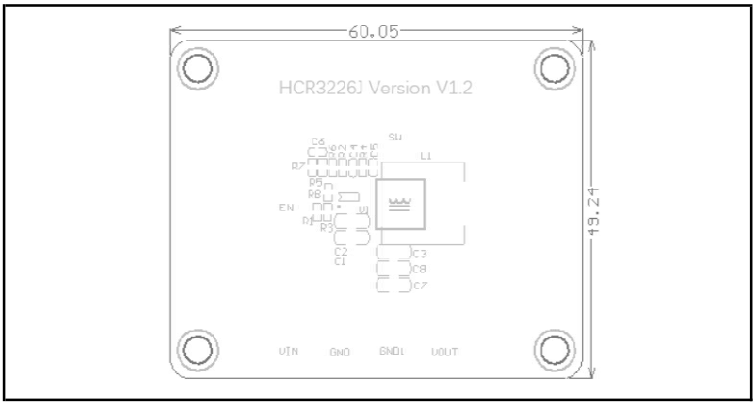
1.2 Put the feedback trace as far away from the inductor and noisy power traces as possible.

1,3 The ground plane on the PCB should be as large as possible for better heat dissipation.

TSOT23-8:



Top Layer Bottom Layer

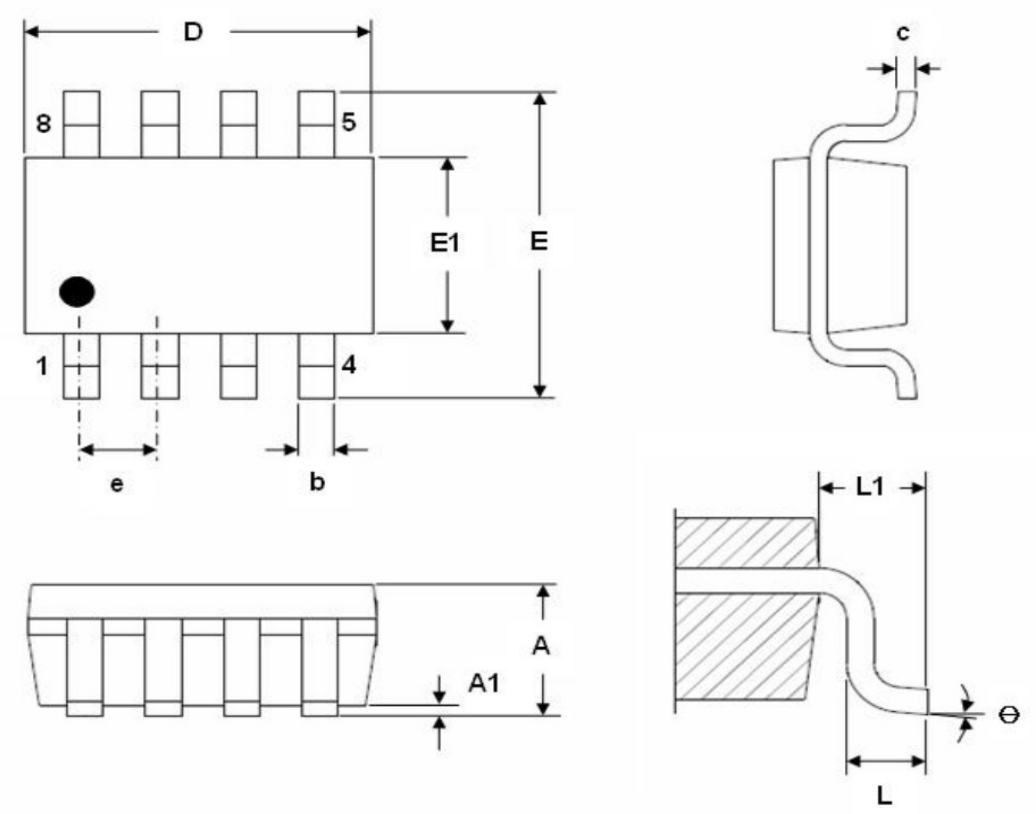


Top Silk Layer

Mechanical Dimensions

S38 PKG: TSOT23-8

Unit: mm



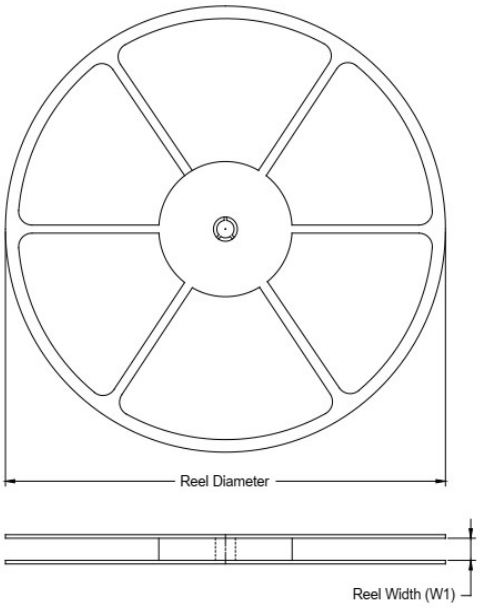
SYMBOLS	MILLIMETERS			INCHES		
	MIN.	Normal	MAX.	MIN.	Normal	MAX.
A	0.70	-	1.00	0.028	-	0.039
A1	0.00	-	0.10	0.000	-	0.004
b	0.20	-	0.50	0.008	-	0.020
c	0.09	-	0.20	0.004	-	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.65 REF			0.026 REF		
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.60 REF			0.024 REF		
Θ	0°	4°	8°	0°	4°	8°

Note:

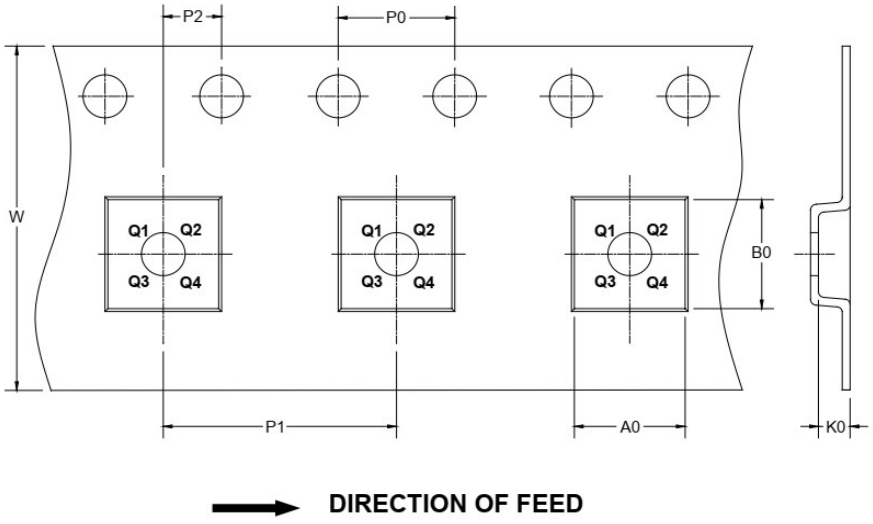
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top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

Tape and Reel Information

REEL DIMENSIONS



TAPE DIMENSIONS



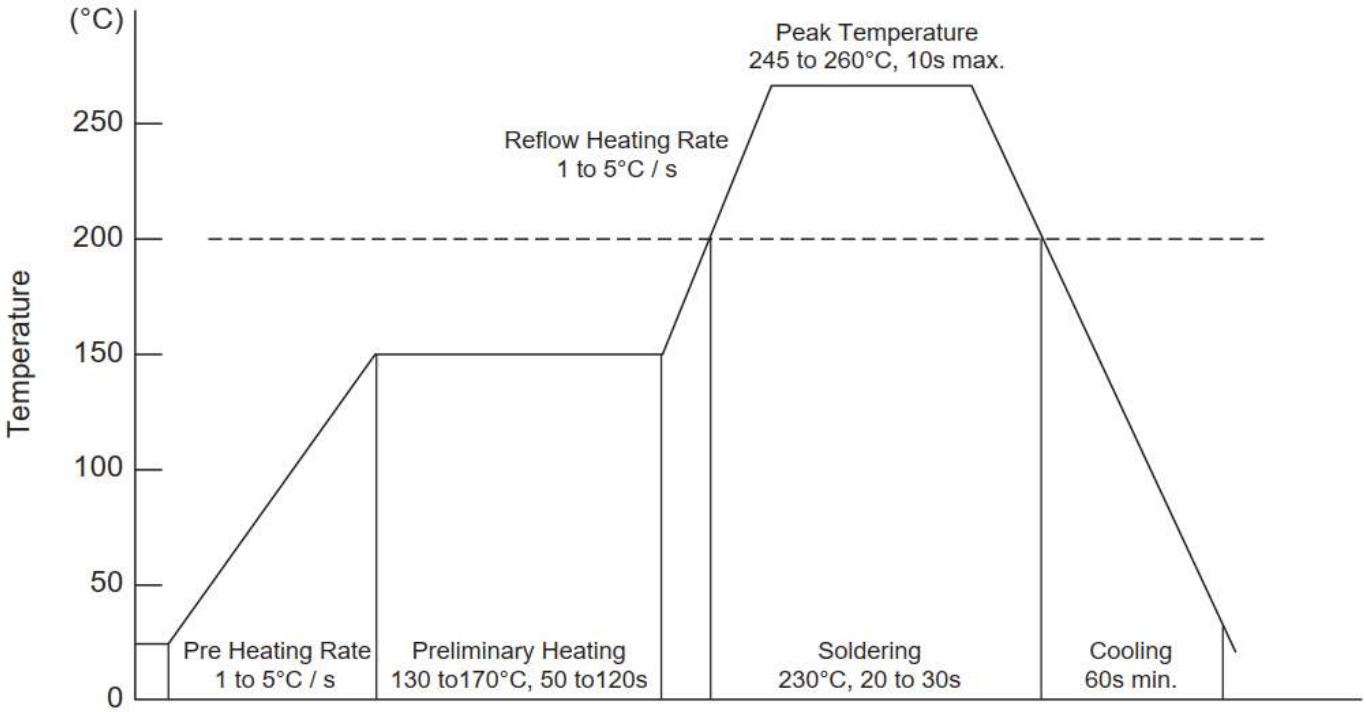
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1	A0	B0	K0	P0	P1	P2	W	Pin1
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	Quadrant
TSOT23-8	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

Conditins of Soldering and Storage

* Recommended condition of reflow soldering



Recommended peak temperature is over 245'C, if peak temperature is below 245'C, you may adjust the following parameters:

* Time length of peak temperature (longer)
* Time length of soldering (longer)
* Thickness of solder paste (thicker)

* Conditions of hand soldering
  * Temperature : 300'C
  * Time : 3s max
  * Times : one time

* Storage conditions
  * Temperature
    5 to 40'C
  * Humidity
    30 to 80% RH
  * Recommended period
    One year after manufacturing