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

Features

- Input Voltage Range: 4.5V to 24V
- Output Constant Current: 3A
- Up to 95% efficiency Current Mode Control
- Fixed 500KHz Switching Frequency
- Fixed Synchronizes from a 200KHz to 1MHz External Clock
- 80mΩ/30mΩ Low $R_{DS(ON)}$ Internal Power MOSFETs
- Power Saving Mode at Light Load
- Internal Soft-start
- Power Good Indicator
- Over Current Protection and Hiccup
- Thermal Shutdown
- Input Under Voltage Lockout
- Available in an TSOT23-8 package
- RoHS Compliant and Halogen-Free

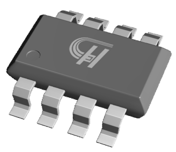
Applications

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

General Description

The HCR32900B is a high frequency synchronous rectified step-down current mode converter with built-in power MOSFETs. It offers a very compact solution to achieve a 3A continuous output current with excellent load and line regulation over a wide input supply range from 4.5V to 24V. The HCR32900B has synchronous mode operation for higher efficiency over the output current load range. Current-mode operation provides fast transient response and eases loop stabilization. Full protection features include input under voltage lockout, input over voltage protection, output under voltage protection, over-current protection and thermal shutdown.

The HCR32900B requires a minimal number of readily available standard external components, and is available in a space-saving TSOT23-8 package.
Its operating temperature range from -40'C to +85'C'



TSOT23-8

Figure 1. Package Type of HCR32900B

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

Pin Configuration

TSOT23-8 Top View

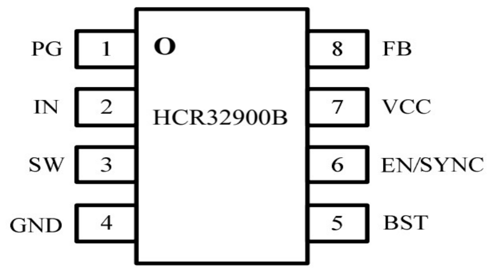
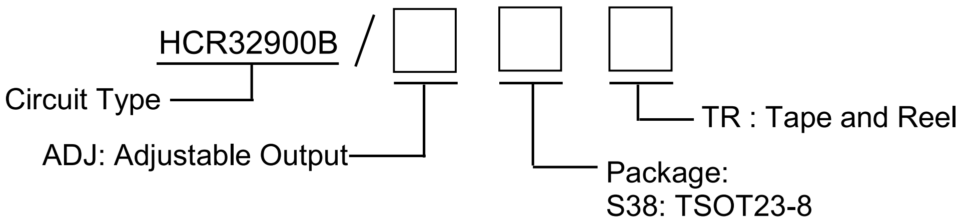


Figure 2. Pin Configuration of HCR32900B (Top View)

Pin Function Table

Pin Number	Pin Name	Function
1	PG	Power Good. The output of this pin is an open drain and goes high if the output voltage exceeds 90% of the nominal voltage.
2	IN	Supply Voltage Input. The HCR32900B operates from a 4.5V to 24V input rail. Requires C1 to decouple the input rail. Connect using a wide PCB trace.
3	SW	Switch Output. Connect with a wide PCB trace.
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	Bootstrap. Requires a capacitor connected between SW and BST pins to form a floating supply across the high-side switch driver.
6	EN/SYNC	Enable/Synchronize. EN/SYNC high to enable the HCR32900B. Apply an external clock to the EN/SYNC pin to change the switching frequency. For automatic startup, directly connect EN/SYNC to IN (or through a resistor).
7	VCC	Internal 5V LDO output. Connect a minimum of 0.1μF capacitor to ground.
8	FB	Feedback. Connect to an external resistor divider to set the output voltage.

Ordering Information



Ordering Code

Part Number	Marking ID note2	Temperature Range	Package	Quantity per Reel
HCR32900B/ADJS38TR	B900xxxx	-40'C to +85'C	TSOT23-8	3000pcs /tape&Reel

Note 2: "B900" is device code and "xxxx" is Inside code.

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

Functional Block Diagram

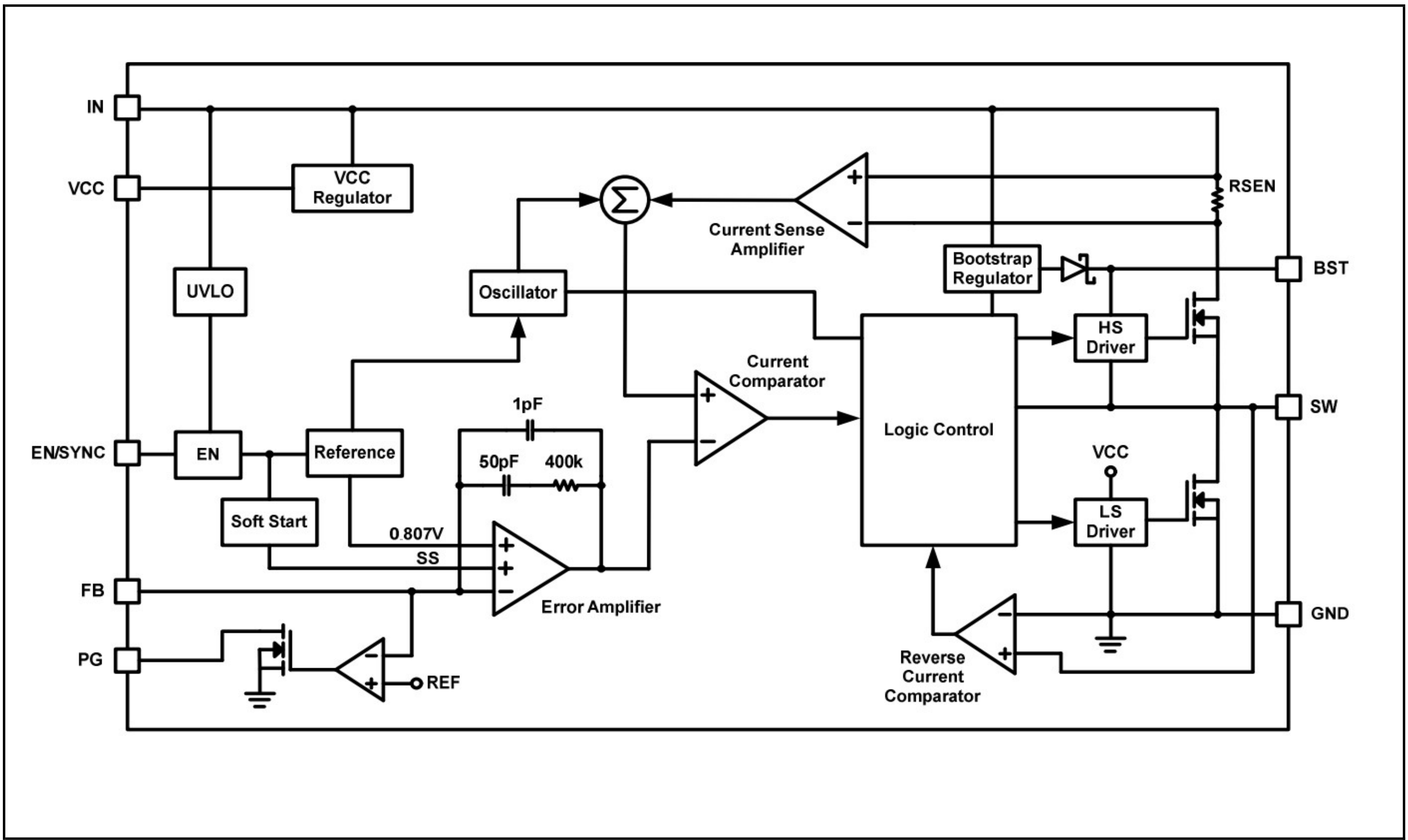


Figure 3. Functional Block Diagram of HCR32900B

Typical Application Circuit

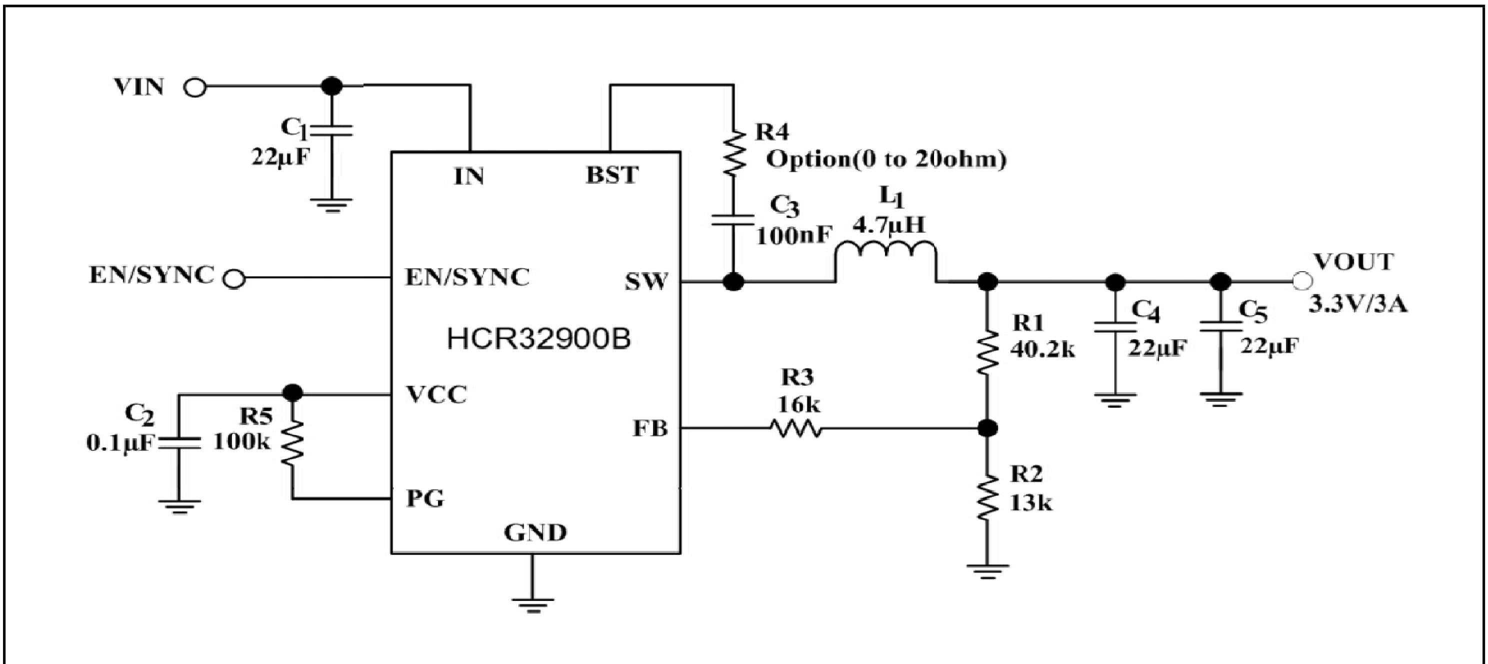


Figure 4. Typical Application Circuit of HCR32900B

Absolute Maximum Ratings [Note 1]

Parameter	Symbol	Value	Unit
Input Supply Voltage Range	V_{IN}	-0.3 to +26.0	V
Switch Voltage Range	V_{SW}	-0.3 to +26.0	V
Enable Voltage Range	V_{EN}	-0.3 to +26.0	V
Booststrap Voltage Range	V_{BST}	V_{SW}-0.3 to V_{SW}+6.0	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}	100	'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 HCR32900B 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 HCR32900B 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}		4.5	-	24	V
Operating Temperature Range	T_J		-40	-	+85	'C

Electrical Characteristics

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

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input voltage Range	VIN		4.5	-	24	V
VIN UVLO Rising Threshold	VUVLO_R	VIN Rising	3.6	3.8	4.0	V
VIN UVLO Falling Threshold	VUVLO_F	VIN falling	3.2	3.4	3.6	V
VIN UVLO Threshold Hysteresis	VUVLO_HYS	-	-	400	-	mV
Quiescent Current	IQ	VEN=2.0V, VFB=1V	-	140	200	uA
Shutdown Current	ISD	VEN=0V	-	4	10	uA
Switch Leakage Current	ILKG_SW	VEN=0V, VSW=12V	-	-	1.0	uA
VCC Regulator	VCC	-	-	4.9	-	V
Regulated Feedback Voltage Accuracy	VFB	TA=25'C, 4.5V<VIN<24V	0.791	0.807	0.823	V
FB Leakage Current	IFB	VFB=0.6V	-	-	120	uA
Oscillator Frequency	fSW	VFB=0.75V	430	500	570	KHz
Fold-Back Frequency	fFB	VFB<0.4V	-	125	-	KHz
Maximum Duty Cycle	DMAX	VFB=0.7V, 500kHz	90	95	-	%
Minimum On-Time[note5]	tON_MIN	-	-	150	-	nS
Synchronous Frequency Range	fSYNC	-	0.2	-	1	MHz
Enable Threshold	VEN-H	EN Rising Threshold	1.2	1.42	1.6	V
	VEN-L	EN Falling Threshold	1.1	1.22	1.4	
High Side MOS on Resistance	RON_HS		-	80	-	mΩ
Low Side MOS on Resistance	RON_LS		-	30	-	mΩ
PG Rising Threshold	PGVTH_R	As percentage of VFB	-	90	-	%
PG Falling Threshold	PGVTH_F	As percentage of VFB	-	84	-	%
PG Threshold Hysteresis	PGVTH_HYS	As percentage of VFB	-	6	-	%
PG Sink Current Capability	VPG	Sink 4mA	-	0.1	0.4	V
Soft Start time[note5]	Tss		-	1.2	-	mS
Current Limit	ILIMIT	Under 40% Duty Cycle	4.2	5	-	A
Thermal Shutdown Threshold [note5]	TSD		-	160	-	'C
Thermal Shutdown Hysteresis[note5]	TSD_HYS		-	40	-	'C

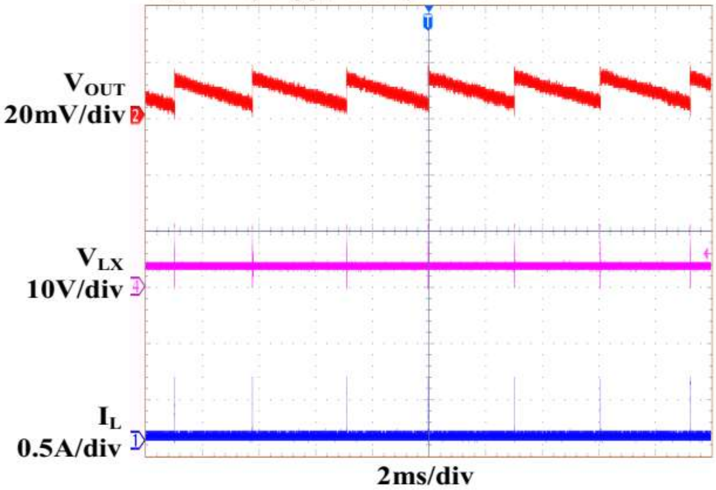
Note 5. Guaranteed by design.

Typical Performance Characteristics

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=500kHz, unless otherwise specified.)

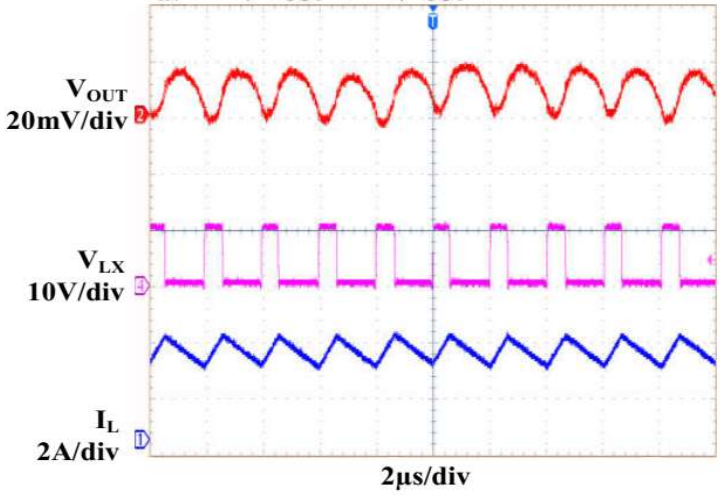
Steady State

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



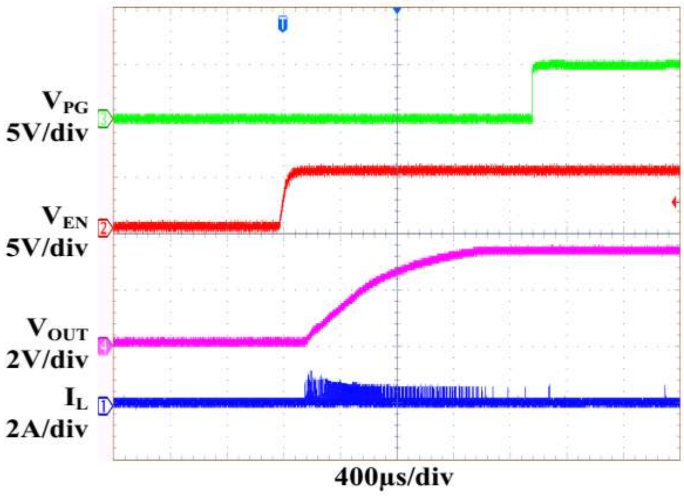
Steady State

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



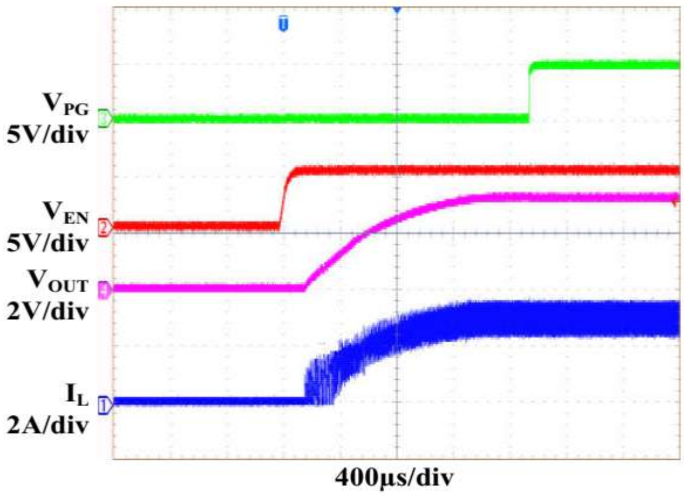
Startup through Enable

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



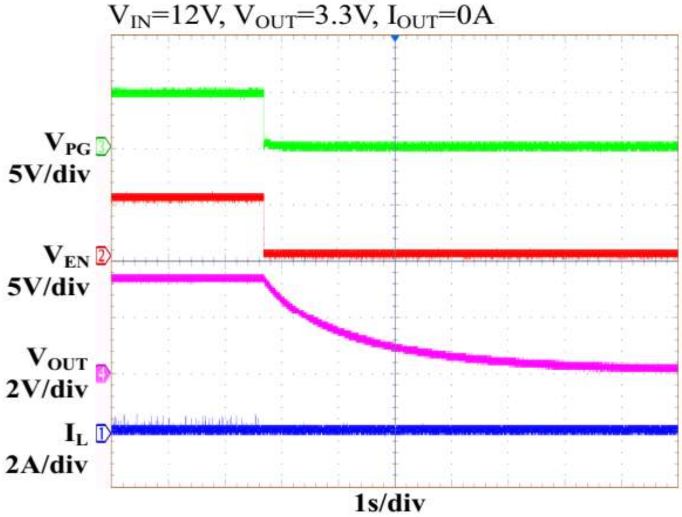
Startup through Enable

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



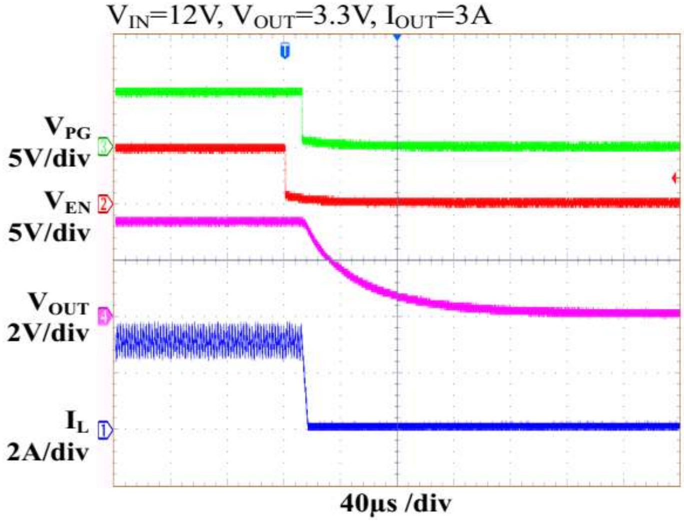
Shutdown through Enable

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



Shutdown through Enable

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

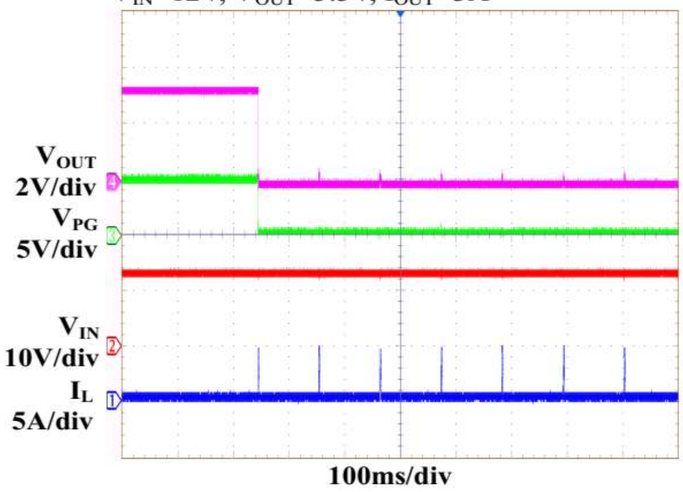


Typical Performance Characteristics(Con.)

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=500kHz, unless otherwise specified.)

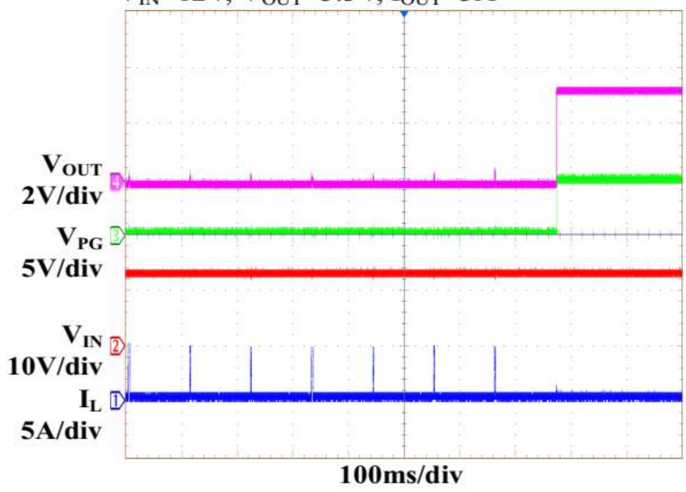
Short Circuit

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



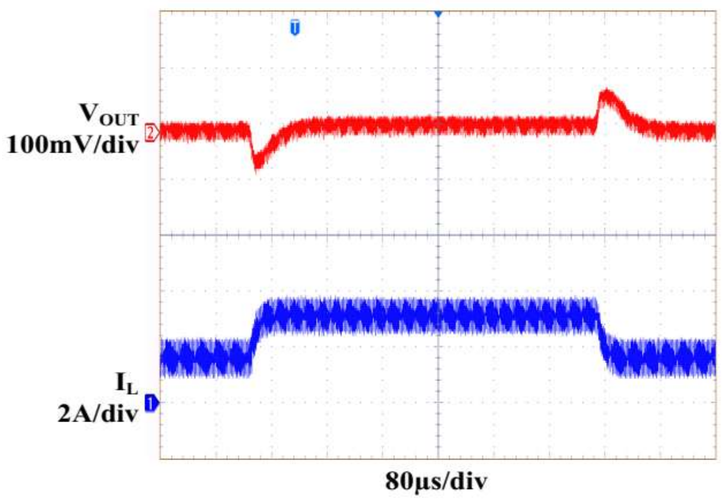
Short Circuit Recovery

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



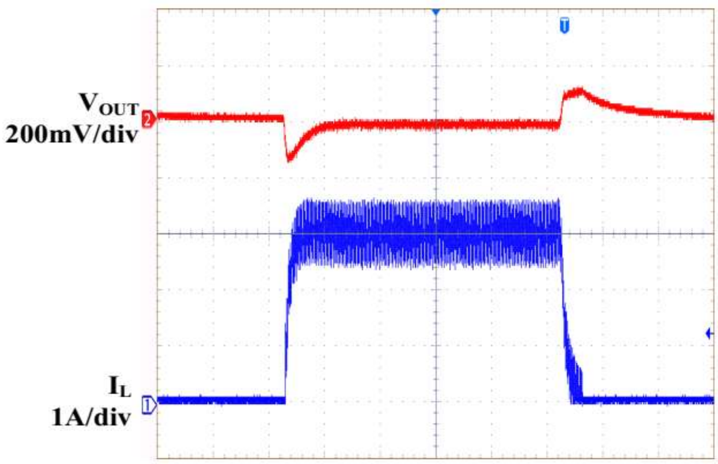
Load Transient Response

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

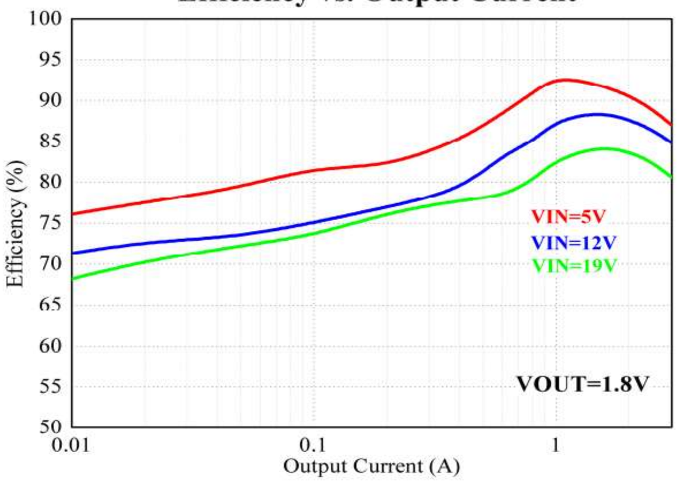


Load Transient Response

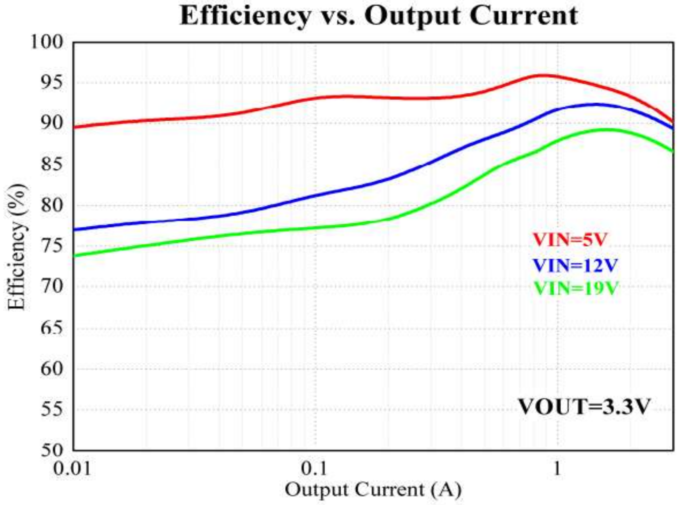
V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0A to 3A



Efficiency vs. Output Current



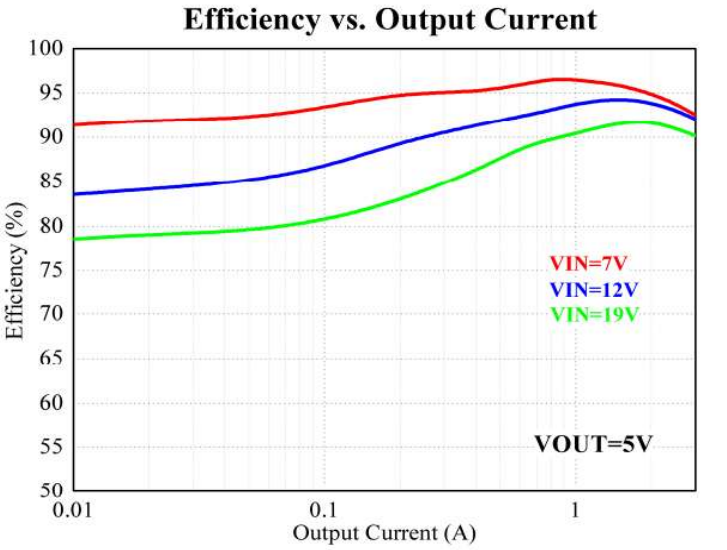
Efficiency vs. Output Current

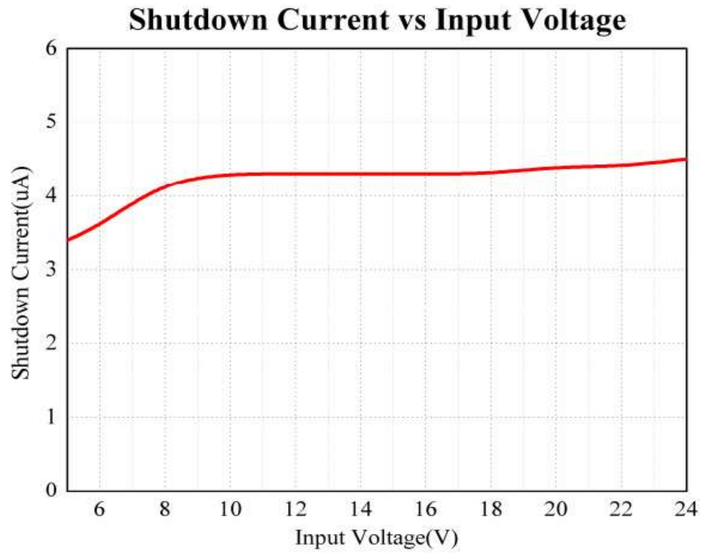


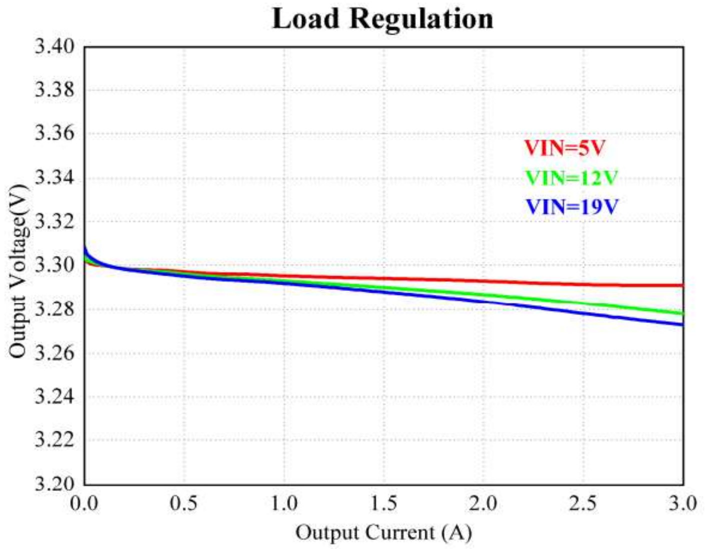
500KHz, 24V, 3A Synchronous Step-Down Converter

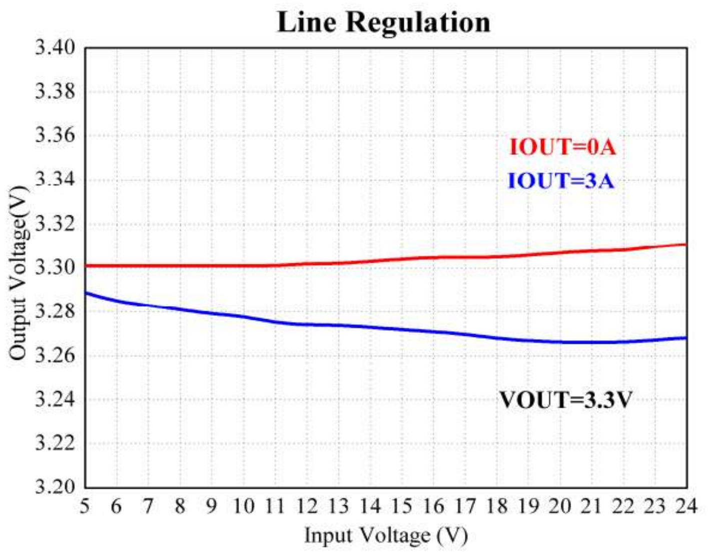
Typical Performance Characteristics(Con.)

(TA=25°C, VIN=12V, VOUT=3.3V, FSW=500kHz, unless otherwise specified.)









Functional Description

The HCR32900B is a high-frequency synchronous rectified step-down current mode converter with 4.5V to 24V input power supply. The device can provide up to 3A continuous current to the output.

Internal Regulator

The internal regulator generates 5V power and drives internal circuit. When VIN exceeds 5V, the output of the regulator is in full regulation. When VIN is less than 5V, the output decreases. A minimum 0.1μF ceramic capacitor is required between VCC and GND.

Enable/SYNC Control

The EN pin is the chip enable input. Pulling the EN pin low (<0.5V) will shutdown the output voltage. During shutdown mode, the HCR32900B's shutdown current drops to about 4μA. Driving the EN pin high (>1.6V) will turn on the device.

The internal oscillator runs at 500 kHz (typ.) when the EN/SYNC pin is at logic-high level (>1.6V). If the EN pin is pulled to low-level over 13μs, the IC will shut down. The HCR32900B can be synchronized with an external clock ranging from 200 kHz to 1MHz applied to the EN/SYNC pin.

Soft-Start

The HCR32900B has internal soft start feature to minimize the inrush supply current and the output overshoot at initial startup. When the HCR32900B starts up, the internal reference voltage which is compared with VFB ramps up gradually, so the output voltage ramps up as well. The typical soft-start time is 1.2ms.

Over Current Protection and Hiccup

The HCR32900B features cycle-by-cycle current limit protection and prevents the device from the damage in output short circuit or over current. The HCR32900B

Over Current Protection and Hiccup(con.)

enters hiccup mode to periodically restart the part when VFB below 0.42V (tpy.). This protection greatly reduces the average short-circuit current to alleviate thermal issues and protect the regulator. The HCR32900B exits the hiccup mode once the over current condition is removed.

Under Voltage Lockout (UVLO)

The HCR32900B includes an input Under Voltage Lockout Protection (UVLO). If the input voltage exceeds the UVLO rising threshold voltage (3.8V), the converter will power up. If the input voltage falls below the UVLO falling threshold voltage (3.4V) during normal operation, the device stops switching. The UVLO rising and falling threshold voltage includes a hysteresis to prevent noise caused reset.

Power Good Indicator

The HCR32900B features an open-drain power-good output(PG) to monitor the output voltage status.Connect PG to VCC with a resistor. The power-good function is activated after soft-start is finished and is controlled by a comparator connected to the feedback signal VFB. If VFB rises above typically 90% of the reference voltage, the PG pin will be in high impedance. When VFB goes below typically 84% of the reference voltage, the PG pin will be pulled low.

Bootstrap Voltage Regulator

An external bootstrap capacitor and an option resistor between BOOT pin and SW pin powers the floating gate driver to high-side power MOSFET. The bootstrap capacitor voltage is charged from an integrated voltage regulator when high-side MOSFET is off and the low-side MOSFET turns on. The recommended value of the BOOT capacitor is 0.1μF, resistor is 0~20Ω.

Functional Description(con.)

Thermal Shutdown

The HCR32900B stops switching when its junction temperature exceeds 160°C and r esumes when the temperature has dropped by 40°C to protect the device.

Application Information

Setting the Output Voltage

The output voltage is set through a resistive voltage divider and can be expressed by the equation as follows

$$V_{OUT} = 0.807 \times \frac{R1 + R2}{R2}$$

The T-type network is highly recommended when VOUT is low.

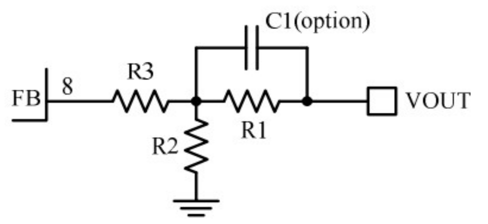


Figure5. Output Voltage Setting

Table 1 lists the recommended resistors value for common output voltages.

Table1. Recommended Resistors Value

VOUT (V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	L1 (uH)
1.0	20.5	84.5	82	2.2
1.8	40.2	32.4	33	3.3
2.5	40.2	19.1	33	3.3
3.3	40.2	13.0	16	4.7
5.0	40.2	7.68	16	4.7

Inductor

The inductor is required to supply constant current to the load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will in turn result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and lower saturation current. A good rule for determining inductance is to allow the peak-to-peak ripple current to be approximately 30% of the maximum switch current limit. So, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = \frac{V_{OUT}}{F_{SW} \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where VOUT is the output voltage, VIN is the input voltage, FSW is the switching frequency, and ΔIL is the peak-to-peak inductor ripple current.Choose an inductor that will not saturate under the maximum inductor peak current, calculated by:

$$I_{LP} = I_{LOAD} + \frac{V_{OUT}}{2 \times F_{SW} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where ILOAD is the load current, the choice of which style inductor to use mainly depends on the price vs size requirements and any EMI constraints. In overloading or load transient conditions, the inductor peak current can increase up to the switch current limit of the device which is typically 5A. The most conservative approach is to choose an inductor with a saturation current rating greater than 5A. Because of the maximum ILP limited by device,the maximum output current that the HCR32900B can deliver also depends on the inductor current ripple. Thus, the maximum desired output current also affects the selection of inductance. The smaller inductor results in larger inductor current ripple leading to a lower maximum output current.

Input Capacitor

The input current to the step-down converter is discontinuous,therefore a capacitor is required to supply the AC current while maintaining the DC input voltage. Use low ESR capacitors for the best performance.

Application Information(con.)

Input Capacitor(con.)

Ceramic capacitors are preferred, but tantalum or low -ESR electrolytic capacitors will also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors. Since the input capacitor (CIN) absorbs the input switching current, it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

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

The worst-case condition occurs at VIN = 2VOUT, where ICIN = ILOAD/2. For simplification, use an input capacitor with a RMS current rating greater than half of the maximum load current. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{C_{IN} \times F_{SW}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where CIN is the input capacitance. For this example design, a ceramic capacitor with at least a 25V voltage rating is required to support the maximum input voltage.

Output Capacitor

The selection of output capacitor will affect output voltage ripple in steady state and load transient performance.The output ripple is essentially composed of two parts. One is caused by the inductor current ripple going through the ESR of the output capacitors and the other is caused by the inductor current ripple charging and discharging the output capacitors. To achieve small output voltage ripple, choose a low-ESR output capacitor like ceramic capacitor. For ceramic capacitors, the capacitance dominates the output ripple. For simplification, the output voltage ripple can be estimated by equation below:

Output Capacitor(con.)

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times F_{SW}^2 \times L \times C_{OUT}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where COUT is the output capacitance value and FSW is the switching frequency. Due to capacitor’s degrading under DC bias, the bias voltage can significantly reduce capacitance. Ceramic capacitors can lose most of their capacitance at rated voltage. Therefore, leave margin on the voltage rating to ensure adequate effective capacitance.

Layout Considerations

For all switching power supplies, the layout is an important step in the design especially at high peak currents and switching frequencies. There are several signal paths that conduct fast changing currents or voltages that can interact with stray inductance or parasitic capacitance to generate noise or degrade performance. When laying out the printed circuit board, the following guidelines should be used to ensure proper operation of the HCR32900B.

1.1 Place a low ESR ceramic capacitor as close to VIN pin and the ground as possible to reduce parasitic effect.

1.2. The power traces, consisting of the GND trace, the SW trace and the VIN trace should be kept short, direct and wide.

1.3. For operation at full rated load, the top side ground area must provide adequate heat dissipating area. Make sure top switching loop with power have lower impendence of grounding.

1.4. The feedback components must be connected as close as possible between the FB and GND.

1.5. Keep the switching node, SW, away from the sensitive FB node.

1.6. Output inductor should be placed close to the SW pin. The switching area of the PCB conductor minimized to prevent excessive capacitive coupling.

Application Information(con.)

Layout Considerations(con.)

1.7. PG resistors and feedback components should connect to small signal ground which must return to the GND pin without any interleaving with power ground.

1.8. Route BST capacitor trace on the other layer than top layer to provide wide path for topside ground.

An example of PCB layout guide is shown in the figure 6 below for reference.

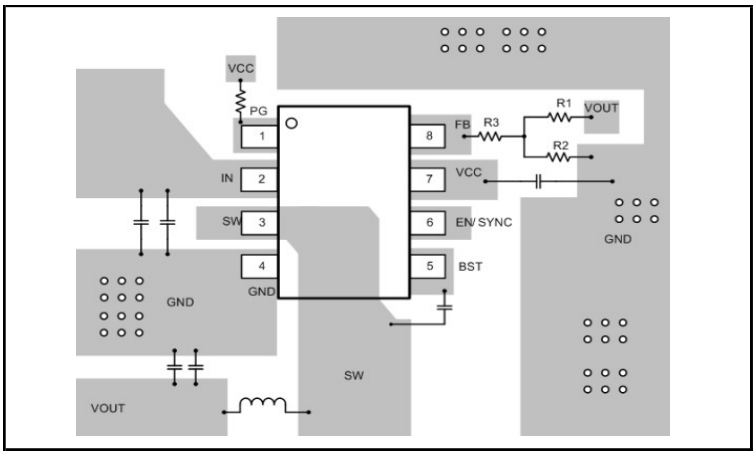
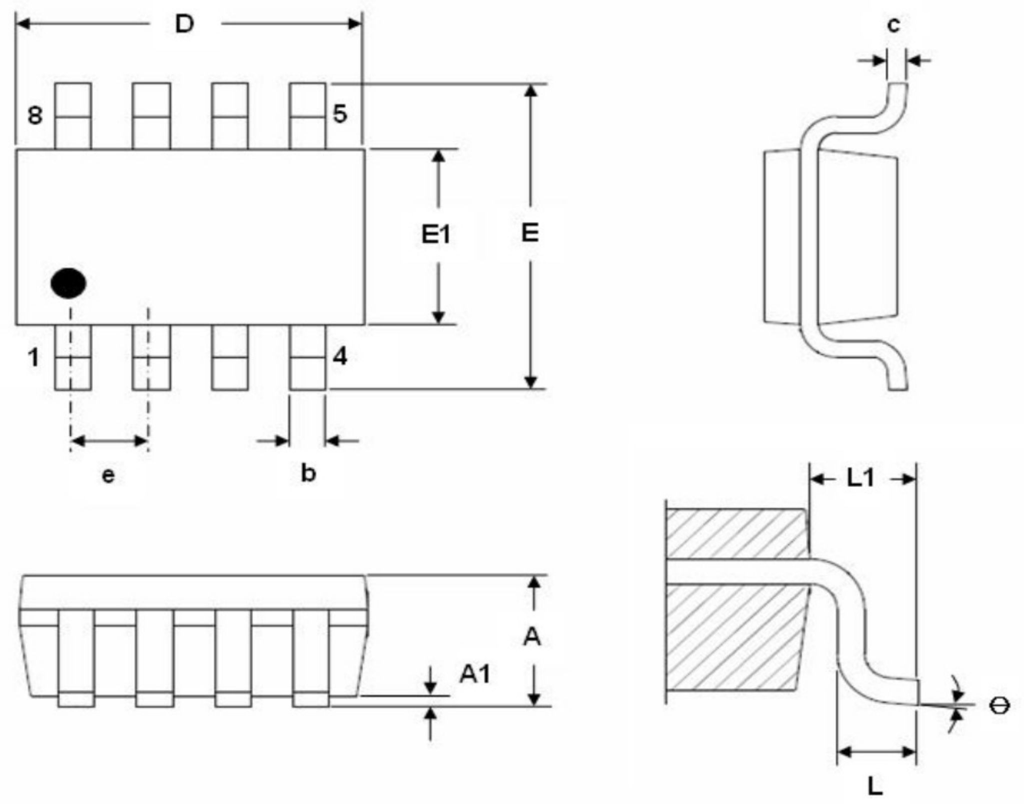


Figure 6. PCB Layout Example

Mechanical Dimensions

S38 PKG: TSOT23-8

Unit: mm

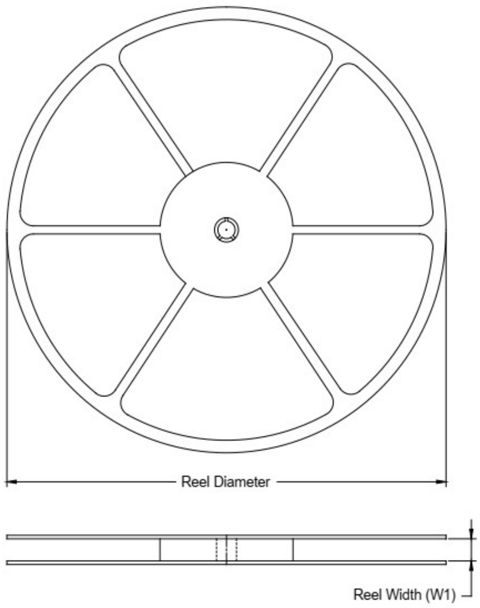


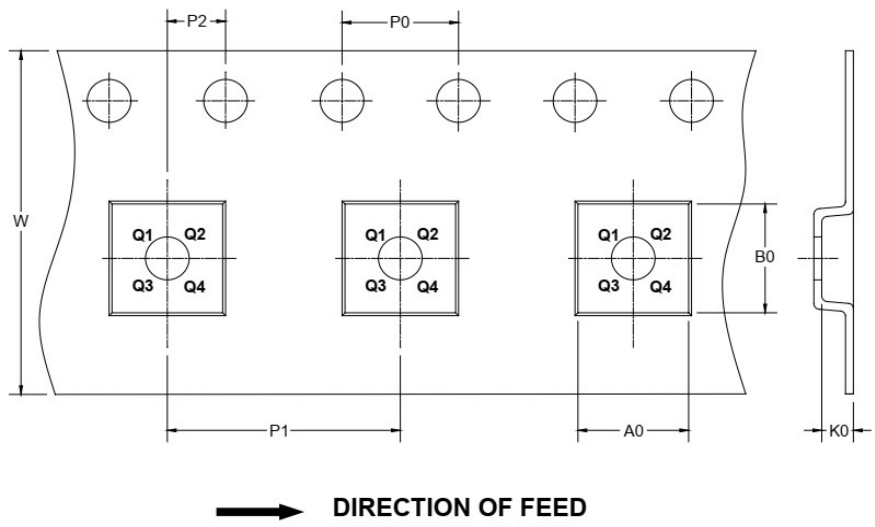
SYMBOLS	MILLIMETERS			INCHES		
	MIN.	Normal	MAX.	MIN.	Normal	MAX.
A	0.70	-	1.00	0.028	-	0.039
A1	0.00	-	0.10	0.000	-	0.004
b	0.20	-	0.50	0.008	-	0.020
c	0.09	-	0.20	0.004	-	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.65 REF			0.026 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





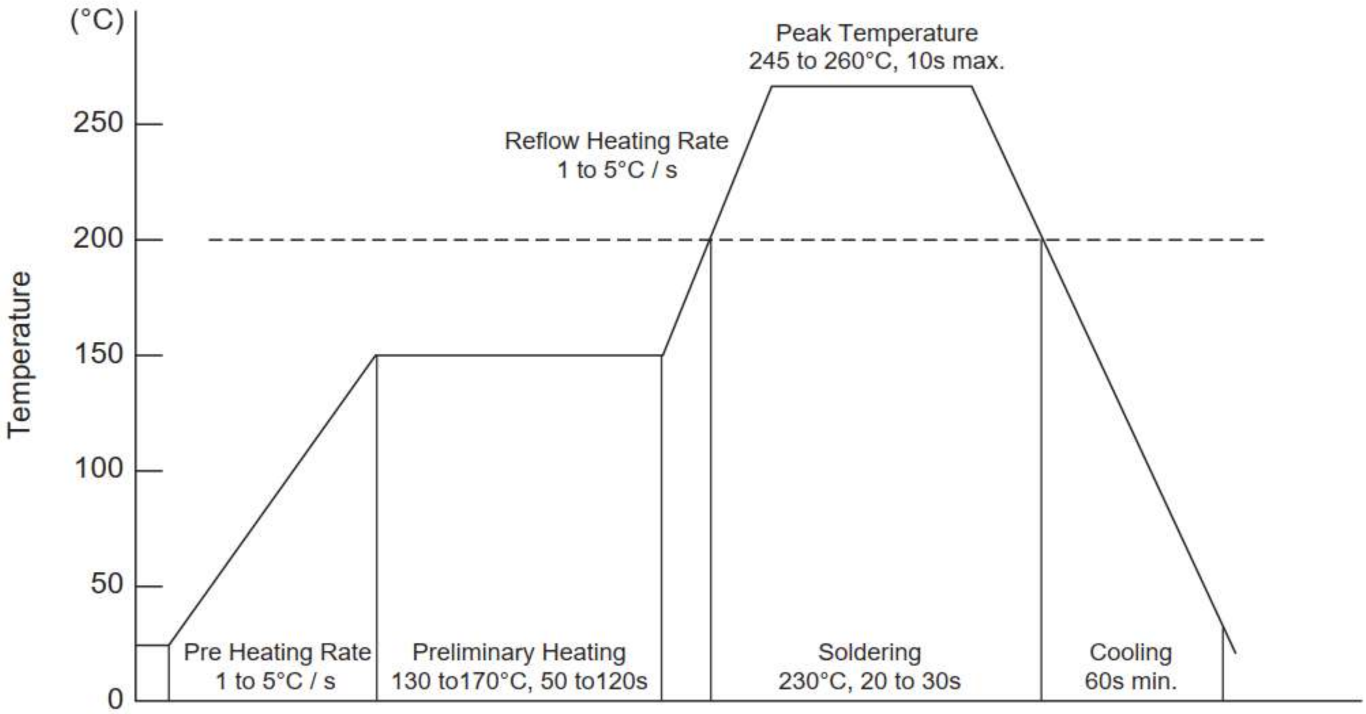
NOTE: The picture is only for reference. Please make the object as the standard.

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
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