2A, 60V, 200KHz Asynchronous Step-Down Converter

Features

- 2A output Current
- 4.5V to 60V Input Operating Range
- High efficiency at light load
- Adjustable Switching Frequency
- Fixed 200KHz Frequency
- Internal soft-start
- Input under voltage lockout
- Current run-away protection
- Short circuit protection
- Thermal Protection
- RoHS Compliant and 100% Lead(pb)-Free Halogen-Free

Applications

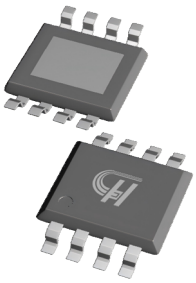
- Distributed Power Systems
- Automotive Systems
- High Voltage Power Conversion
- Industrial Power Systems
- Battery Powered Systems

General Description

The HCR3422 is a current mode monolithic buck switching regulator. Operating with an input voltage range of 4.5V to 60V, The HCR3422 delives 2A of continuous output current with an integrated high side N-Channel MOSFET. At light loads, the regulator operates in low frequency to maintain high efficiency and low output ripple. Current mode control provides tight load transient mode control provides tight load transient response and cycle-by-cycle current limit.

The HCR3422 guarantees robustness with short-circuit protection, thermal protection, current run-away protection, and input under voltage lockout.

The HCR3422 is available in SOP-8(EP) package, which provides a compact solution with minimal external components.



SOP-8(EP)

Figure 1. Package Type of HCR3422

Pin Configuration

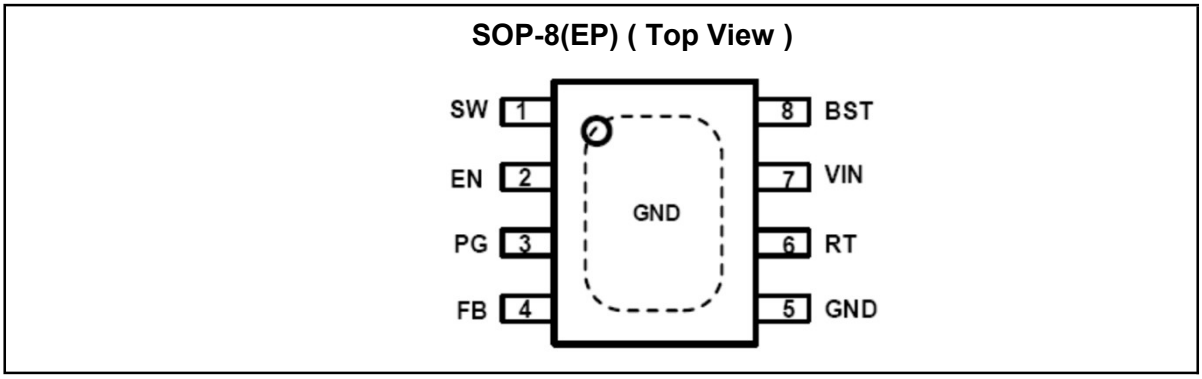
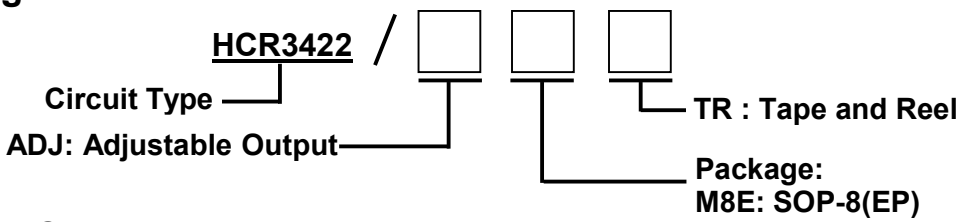


Figure 2. Pin Configuration of HCR3422 (Top View)

Pin Function Table

Pin Number	Pin Name	Function
1	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
2	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
3	PG	Open drain output for power-good flag. Use a 100KΩ pull-up resistor to logic rail or other DC voltage no higher than 20V.
4	FB	Output Feedback pin. FB senses the output voltage and is regulated by the control loop to 800mV. Connect a resistive divider at FB.
5	GND	Ground. GND Pin should be connected to the exposed thermal pad for proper operation.
6	RT	Switching Frequency Program Input. Connect a resistor from this pin to ground to set the switching frequency.
7	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.5V to 60V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
8	BST	Boosttrap pin for top switch.
-	GND	EP(Exposed Pad) This power thermal pad should be connected to PCB ground plane using multiple vias for good thermal performance.

Ordering Information



Ordering Code

Part Number	Marking [a]	Temperature Range	Package	Quantity per Reel
HCR3422/ADJM8ETR	HCR3422 XX	-40'C to +125'C	SOP-8(EP)	4000pcs/TR

note a. the HCR3422 is product type and the XX is date code

2A, 60V, 200KHz Asynchronous Step-Down Converter

Functional Block Diagram

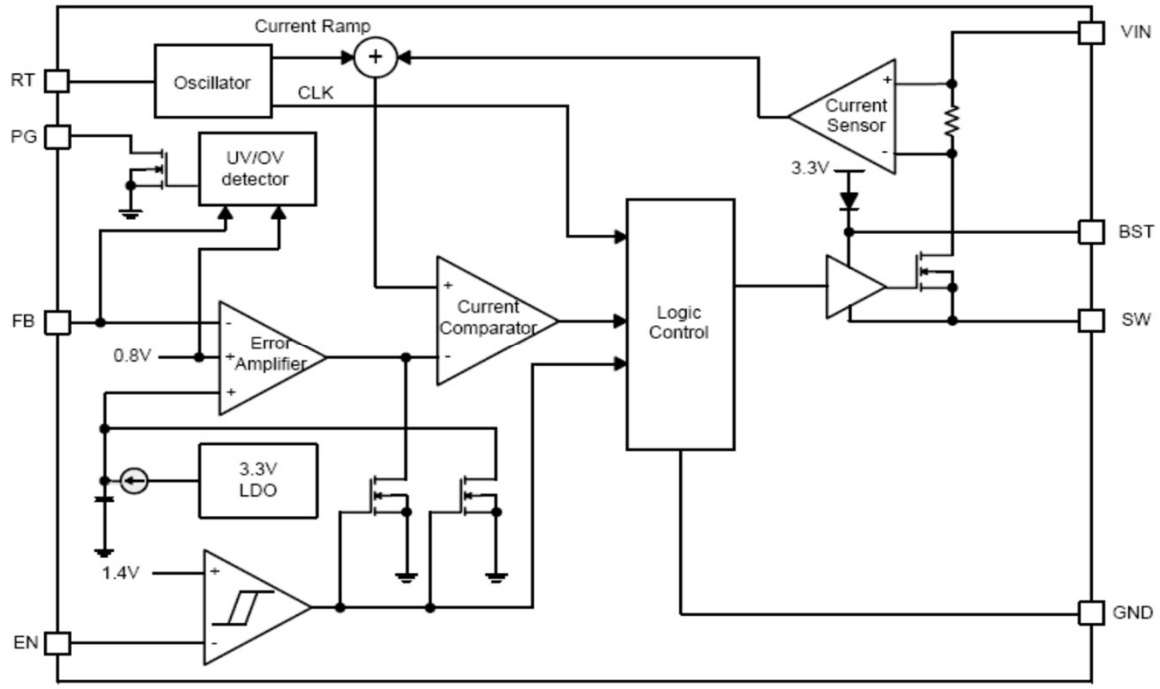


Figure 3. Functional Block Diagram of HCR3422

Absolute Maximum Ratings Note 1

Parameter	Symbol	Value	Unit
VIN and Enable Supply Voltage	V_{IN}, V_{EN}	-0.3 to +66	V
Switch Voltage	V_{SW}	-0.3(-5V for 10ns) to +66	V
Boot Voltage	V_{BST}	VSW-0.3 to V_{SW} +5	V
PG Voltage	V_{PG}	-0.3 to +22	V
All Other Pins	-	-0.3 to +6	V
Maximum Power Dissipation	PD	2.083	W
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	50	'C/W
Thermal Resistance Junction to Case	$R_{\theta JC}$	10	'C/W
Storage Temperature Range	T_{STG}	-65 to 150	'C
Operating Junction Temperature	T_J	-40 to 150	'C
Lead Temperature (Soldering, 10s)	T_{LEAD}	260	'C

Recommend Operating Conditions note2

Parameter	Symbol	Value	Unit
Input Voltage	V_{IN}	4.5 to 60	V
Output Voltage	V_{OUT}	0.8 to Dmax X V_{IN}	V
Ambient Operting Temp	T_A	-40 to +125	'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.

Electrical Characteristics

The specifications which apply over the full operating temperature range, otherwise specification are VIN=12V, (Ta=25'C; unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
VIN Under Voltage Lockout Threshold	V_{IN_MIN}	V_{IN} Rising	3.4	3.6	3.85	V
VIN Under Voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$	-	-	200	-	mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V	-	1	4	uA
Quiescent Supply Current	I_q	V_{EN}=5V, V_{FB}=1V	-	130	160	uA
Feedback Voltage	VFB	4.5V<V_{IN}<60V	0.788	0.800	0.812	V
Power Switch Resistance	$R_{DS(ON)}$	-	250	280	310	mΩ
Power Switch Leakage Current	I_{LEAK}	V_{IN}=60V, V_{EN}=0V, V_{SW}=0V	-	-	1.0	uA
Power Switch Current Limit	I_{LIM}	Minimum Duty Cycle	3	3.5	4	A
Switch Frequency	fSW	R_{RT}=220K	160	200	240	KHz
Switch Frequency Range	fSW		100	-	2000	KHz
Minimum On Time	T_{on_MIN}		96	100	115	ns
Minimum Off Time	T_{off_MIN}	V_{FB}=0V	-	100	-	ns
Soft-start Time	Tss	SOP-8(EP)	-	0.8	-	ms
Soft-start Charge Current	Iss		-	10	-	uA
Power Good Lower Threshold	PGLTH	FB falling	84	87	90	%
Power Good Upper Threshold	PGDTH	FB rising	109	112	115	%
Power Good Sink Current	IPG	VPG=0.4V	1	-	-	mA
Power Good Delay	PGDLY	PG from low to high	-	240	-	us
EN Shut Down Threshold Voltage	V_{EN_H}	EN rising	-	1.4	1.52	V
	V_{EN_L}	EN falling	1.0	1.2	-	
EN Shut Down Hysteresis	V_{EN_HYST}	-	-	200	-	mV
Thermal Shutdown note3	T_{TSD}		-	150	-	'C
Thermal Shutdown Hysteresis note3	T_{TSD_HYST}		-	15	-	'C

note3. Guaranteed by design.

Typical Performance Characteristics

(VIN=12V, Vout=5V, Fs=500KHz, L=10uH, Cout=44uF, TA=25'C, Unless Otherwise Noted)

Iout=2A

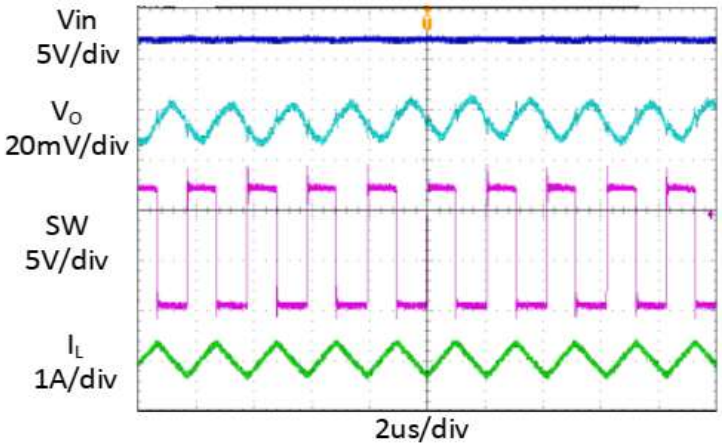


Figure 4. Steady State Test

Iout=2A(Resistive load)

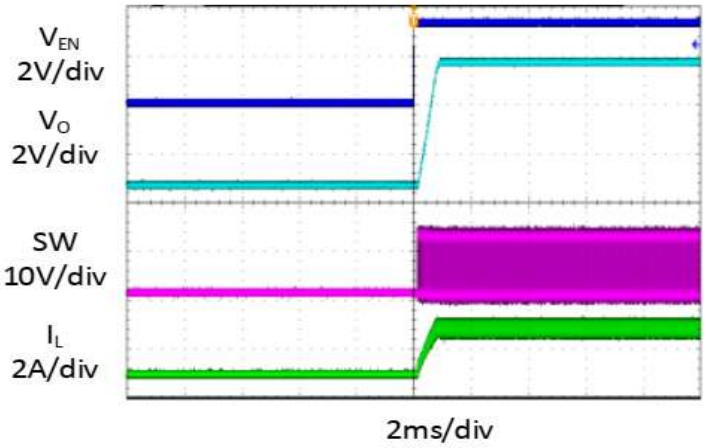


Figure 5. Startup Through Enable

Iout=2A(Resistive load)

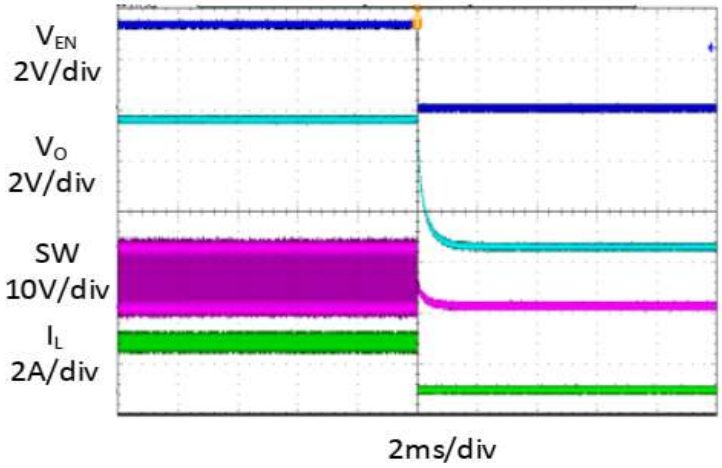


Figure 6. Shutdown Through Enable

2A LOAD

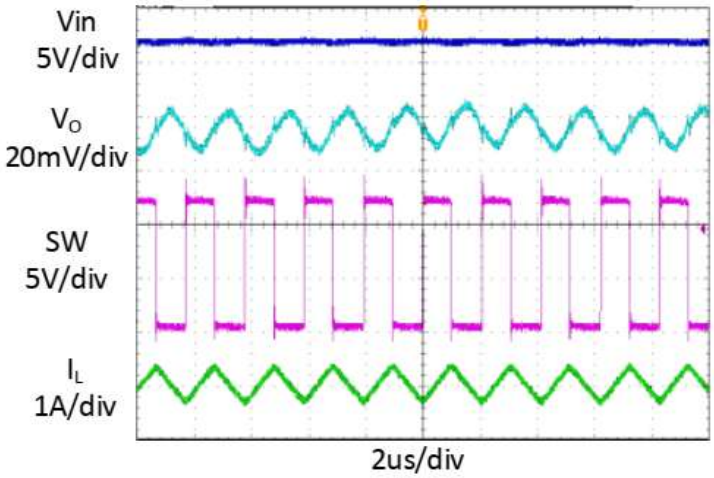


Figure 7. Heavy Load Operation

1.1A LOAD

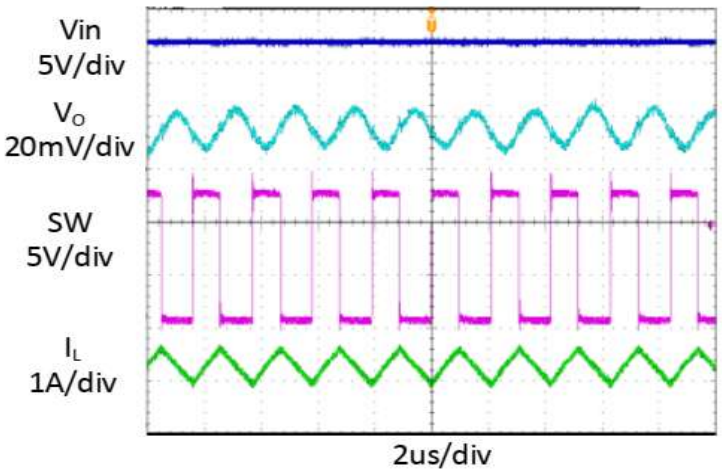


Figure 8. Medium Load Operation

0A LOAD

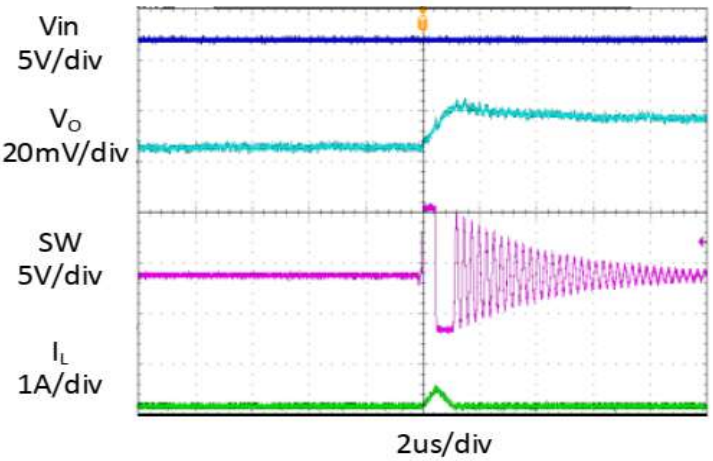


Figure 9. Light Load Operation

Typical Performance Characteristics(Con.)

(VIN=12V, Vout=5V, Fs=500KHz, L=10uH, Cout=44uF, TA=25'C, Unless Otherwise Noted)

Iout=2A-Short

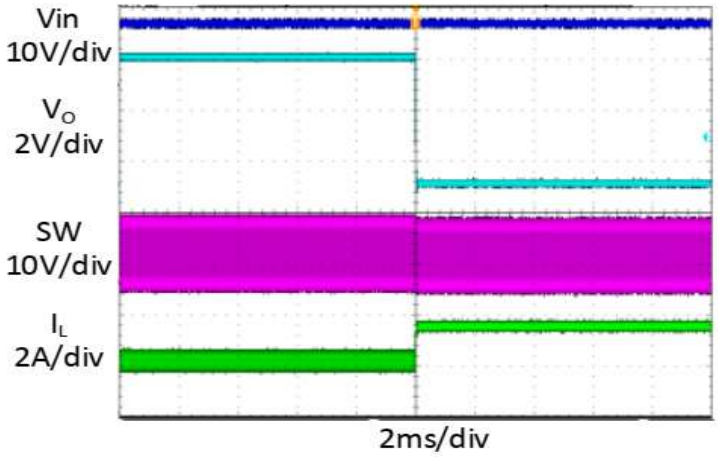


Figure 10. Short Circuit Protection

Iout=Short-2A

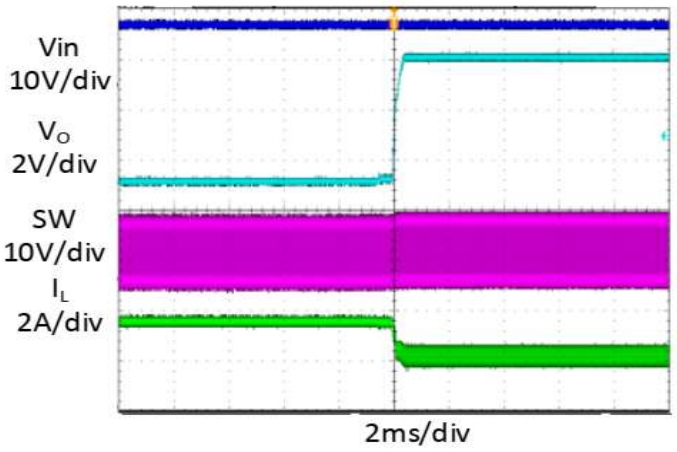


Figure 11. Short Circuit Protection

0.5A LOAD->2A LOAD->0.5 LOAD

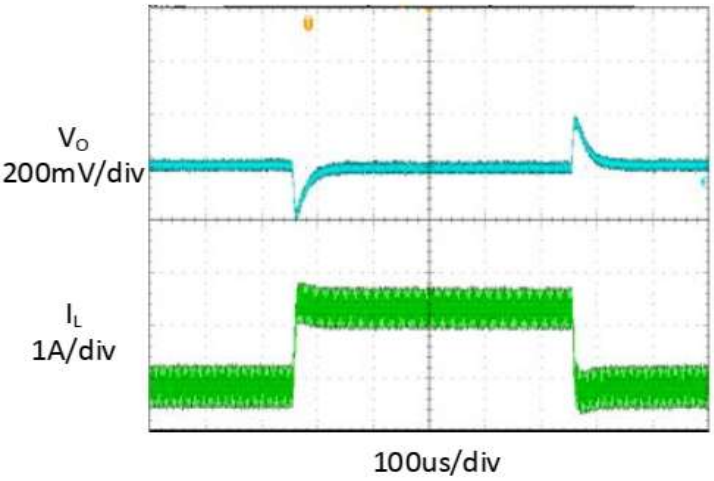


Figure 12. Load Transient

VIN=5V~60V, VEN=3V, VFB=1V

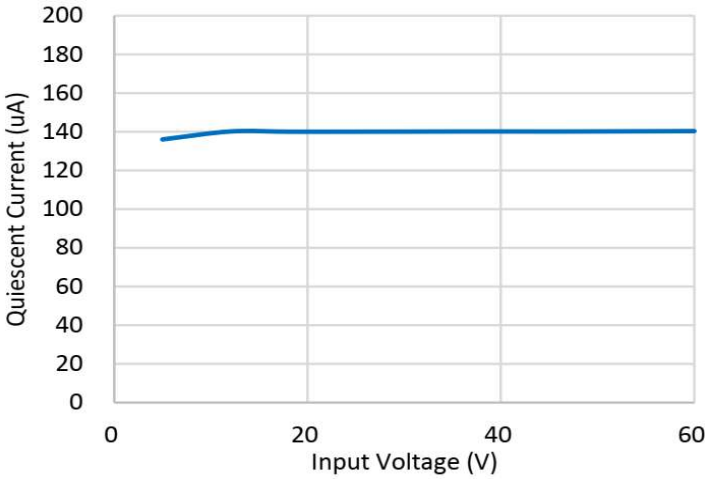


Figure 13. Quiescent Current Vs. Input Voltage

VIN=5V~60V, VEN=0V, VFB=0.3V

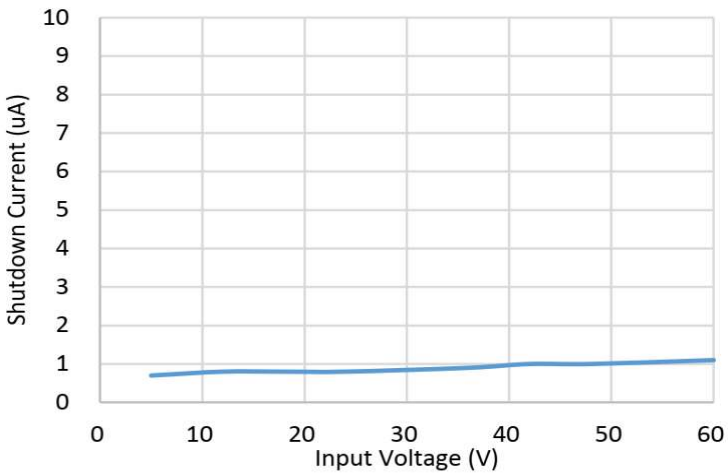


Figure 14. Shutdown Current Vs. Input Voltage

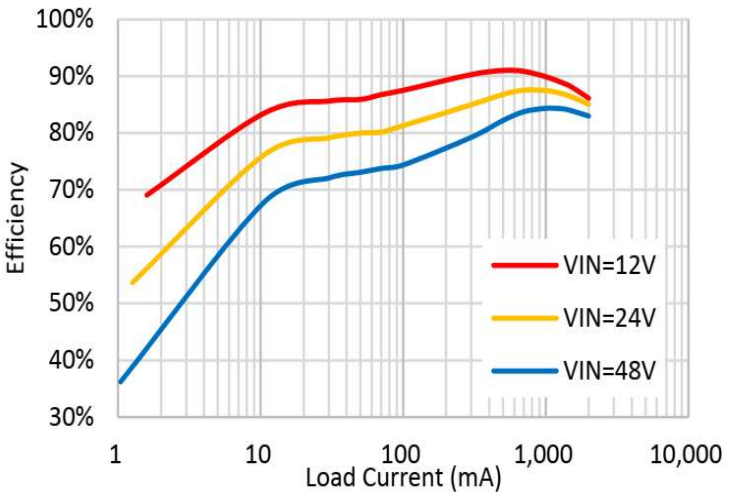


Figure 15. Efficiency@300KHz

Typical Performance Characteristics(Con.)

(VIN=12V, Vout=5V, Fs=500KHz, L=10uH, Cout=44uF, TA=25'C, Unless Otherwise Noted)

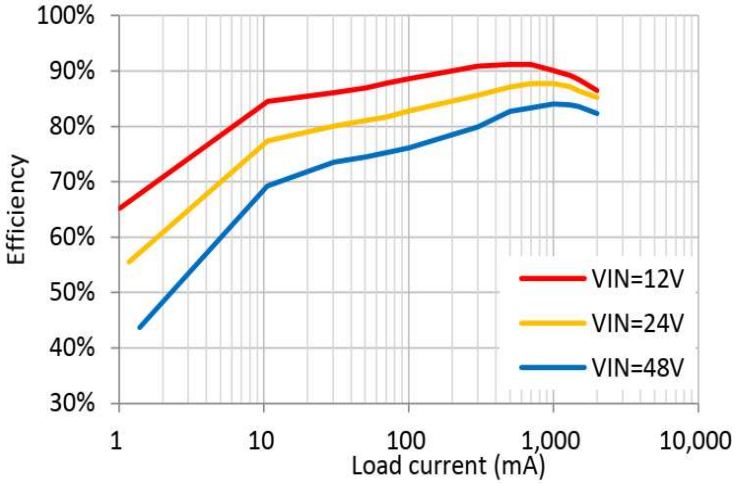


Figure 16. Efficiency@500KHz

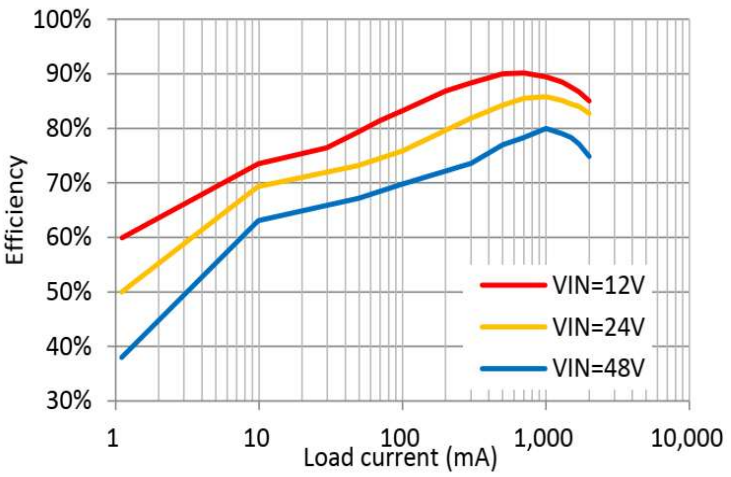


Figure 17. Efficiency@1MHz

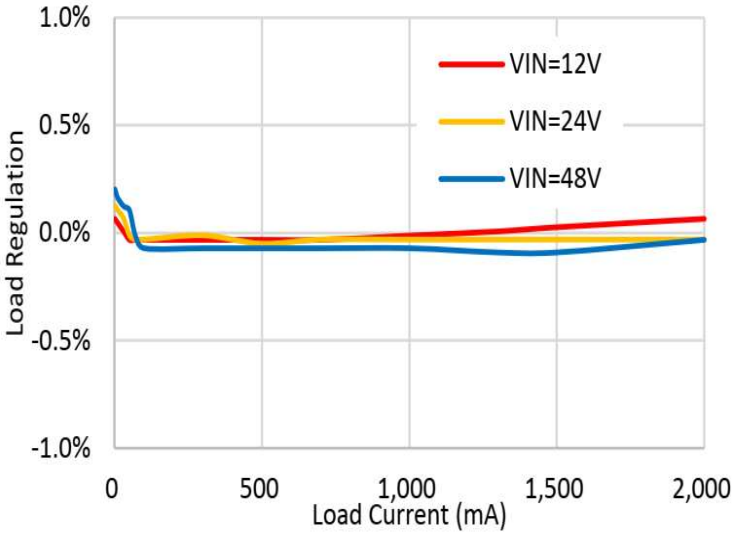


Figure 18. Load Regulation@300KHz

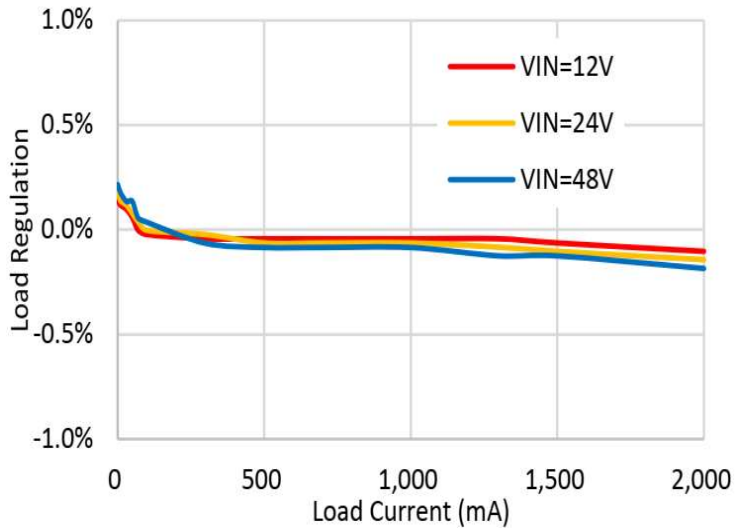


Figure 19. Load Regulation@500KHz

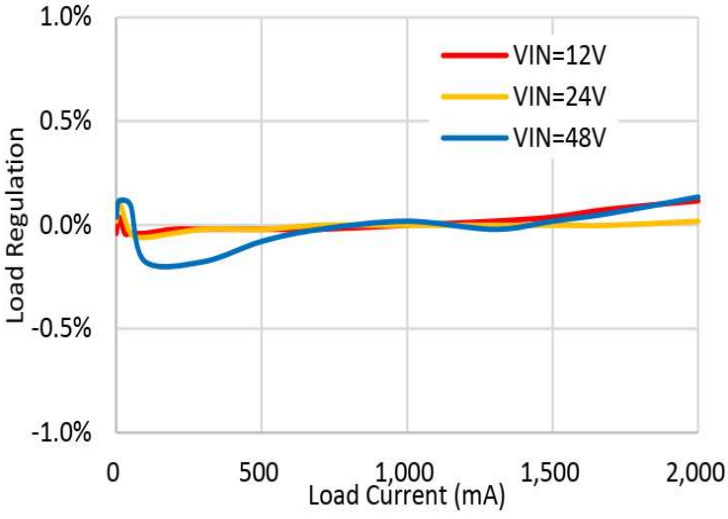


Figure 20. Load Regulation@1MHz

Function Description

The HCR3422 is an asynchronous, current-mode, step-down regulator. It regulates input voltages from 4.5V to 60V down to an output voltage as low as 0.8V, and is capable of supplying up to 2A of load current.

Current-Mode Control

The HCR3422 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. The voltage feedback loop is compensated by an internal RC network.

Output of the error amplifier VCOMP is compared with the switch current measured internally to control the output current.

PFM Mode

The HCR3422 operates in PFM mode at light load. In PFM mode, 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 HCR3422 shuts down when voltage at EN pin is below 1V. The entire regulator is off and the supply current consumed by the HCR3422 drops below 1uA.

Power Switch

N-Channel MOSFET switches are integrated on the HCR3422 to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage greater 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 3.3V 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 1.2V to trigger input under voltage lockout protection.

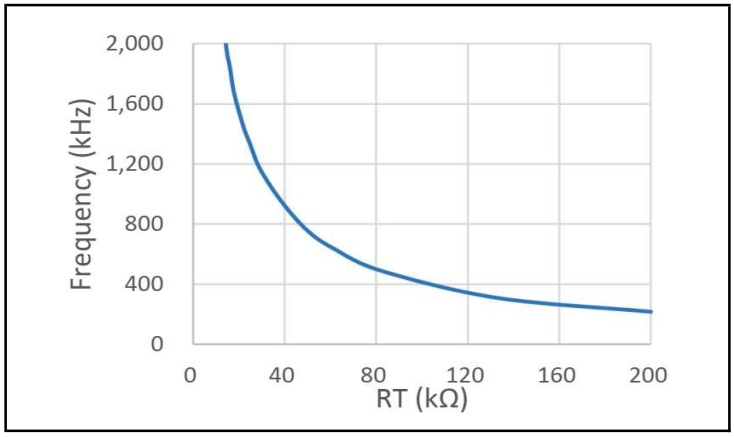
Soft-Start

Soft-start is designed in the HCR3422 to prevent the converter output voltage from overshooting during startup and short-circuit recovery. When the chip starts,the internal circuit generates a soft-start voltage (SS) ramping up from 0V to 1.2V. When it is less than the VREF, SS overrides VREF and the error amplifier uses SS as the reference. When SS exceeds VREF, VREF regains control.

Switching Frequency

The switching frequency of HCR3422 can be programmed by the resistor RT from the RT pin and GND pin over a wide range from 100 kHz to 2000KHz. The RT pin voltage is typically 1.2V and must have a resistor to ground to set the switching frequency.The RT resistance can be calculated by the following equation for a given switching frequency fSW.

$$R_T(\Omega) = \frac{\frac{1}{f_{SW}(Hz)} - 175 * 10^{-9}}{2.31 * 10^{-11}}$$



To reduce the solution size one would typically set the switching frequency as high as possible, but tradeoffs of the conversion efficiency, maximum input voltage and minimum controllable on time should be considered. The minimum controllable on time is typically 120 ns which limit the maximum operating frequency in applications with high input to output step down ratios.

Over Current / Output Short Protection

To protect the converter in overload conditions at higher switching frequencies and input voltages,

Function Description(Con.)

Over Current / Output Short Protection(Con.)

the HCR3422 implements a frequency fold-back. The oscillator frequency is divided by 2^X(X=0, 1, 2…7) if the power FET current rises above the current limit by 0.5A in a minimum detection time (typ. 60ns). The fold-back frequency depends on the number of consecutive triggers. Once the power FET is turned off by the current limit instead of minimum on time, the frequency exist fold-back state.

During short-circuit events, the inductor current may exceed the peak current limit because of the high input voltage and the minimum controllable on time. When the output voltage is forced low by the shorted load, the inductor current decreases slowly during the switch off time. The frequency fold-back effectively increases the off time by increasing the period of the switching cycle providing more time for the inductor current to ramp down. With a maximum frequency fold-back ratio of 128, there is a maximum frequency at which the inductor current can be controlled by frequency fold-back protection.

Power Good

The HCR3422 has power-good(PG) output. The PG pin is the open drain of a MOSFET. Connect to a voltage source (such as Vout) through a resistor. When the output voltage becomes within ±12% of the target value, internal comparators detect power good state and the power good signal becomes high.If the feedback voltage goes under or higher 12% of the target value, the power good signal becomes low.

RT Short Protection

If the RT pin is detected to be short to ground, the HCR3422 is not allowed to switch to prevent abnormal operation state. The regulator can be reactivated again when the short condition at the RT pin is removed.

Thermal Protection

When the temperature of the HCR3422 rises above 150°C, it is forced into thermal shut-down.

Only when core temperature drops below 135°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:

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

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

Choose R2 around 20kΩ, and then R3 can be calculated by:

$$R_3 = \frac{R_2}{\frac{V_{OUT}}{0.8} - 1}$$

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

VOUT(V)	R2(KΩ)	R3(KΩ)
3.3	20	6.4
5.0	20	3.8
12.0	20	1.4

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 (Con.)

input capacitor can be calculated by:

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

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.

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

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 4.7~10uF ceramic capacitor is recommended in typical application.

APPLICATION INFORMATION(Con.)

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:

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

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.

A 22~66uF 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:

$$\mathrm{L} = \frac{V_{OUT}}{f_S * \Delta I_L} * (1 - \frac{V_{OUT}}{V_{IN}})$$

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.

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 HCR3422 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.

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

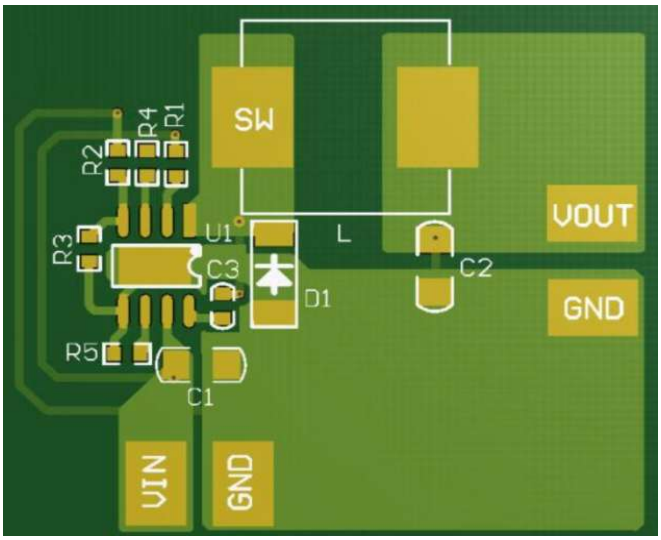


Figure 21. PCB Layout Recommendation

2A, 60V, 200KHz Asynchronous Step-Down Converter

REFERENCE DESIGN

Reference-1:

Vin: 7V to 60V, Vout: 5V, IOUT: 0~2A

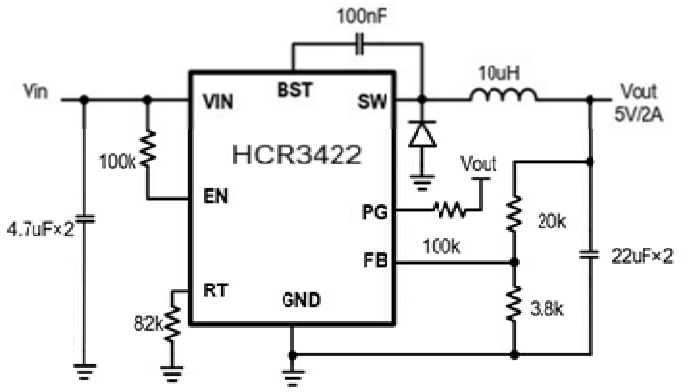


Figure 22. Typical Application-1

Reference-2:

Vin: 5V to 60V, Vout: 3.3V, IOUT: 0~2A

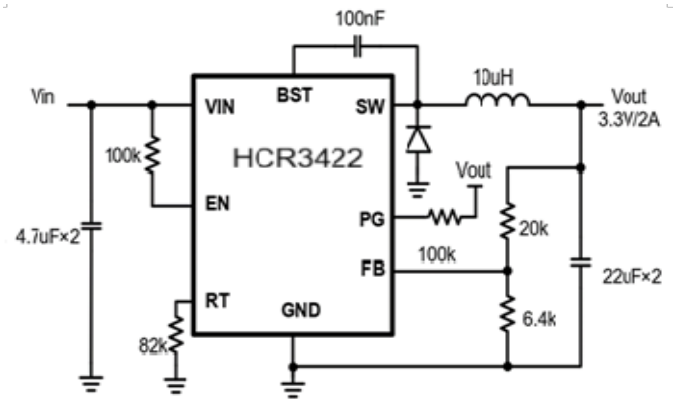


Figure 23. Typical Application-2

Reference-3:

Vin: 14V to 60V, Vout: 12V, IOUT: 0~2A

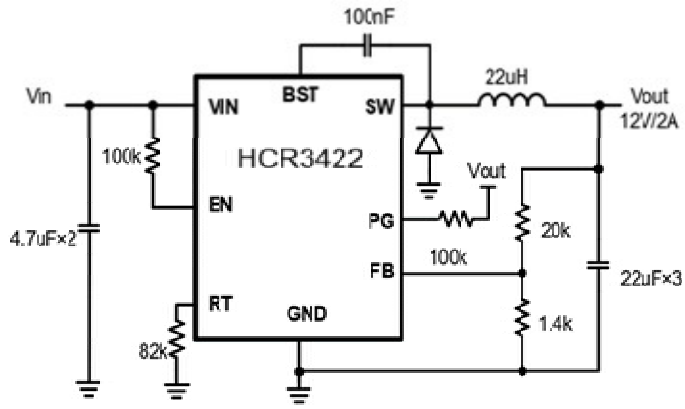


Figure 24. Typical Application-3

Reference-4:

Vin: 8V to 25V, Vout: 5V, IOUT: 0~2A

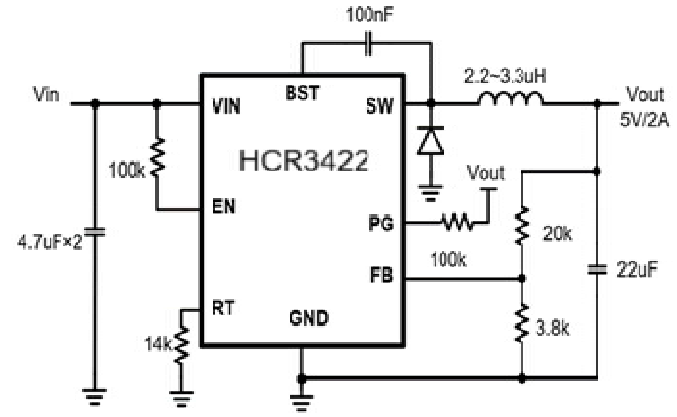
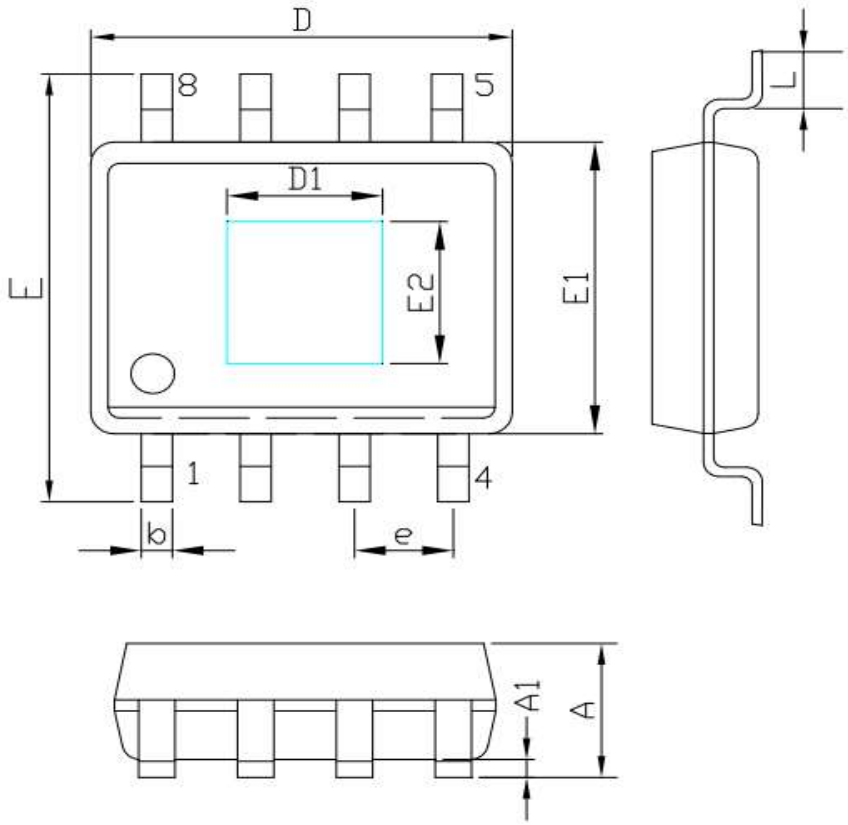


Figure 25. Typical Application-4

Mechanical Dimensions

M8E PKG: SOP-8(EP)

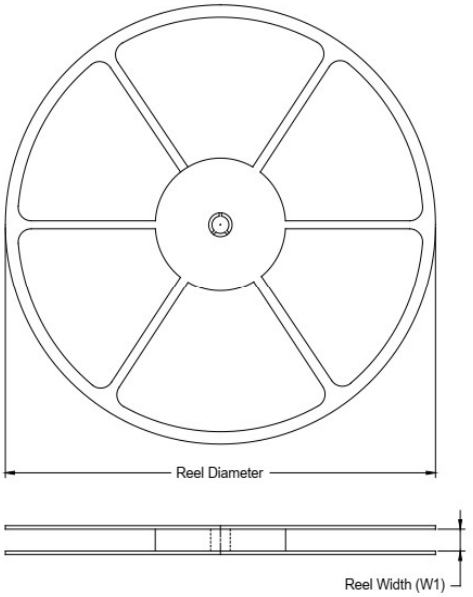
Unit: mm(inch)



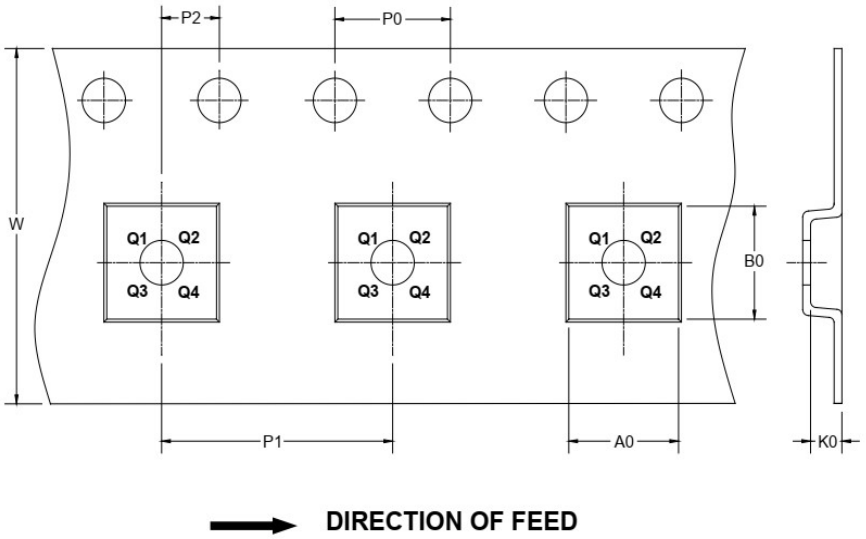
SYMBOLS	MILLIMETERS			INCHES		
	MIN.	Normal	MAX.	MIN.	Normal	MAX.
A	1.35	-	1.75	0.053	-	0.069
A1	0.00	-	0.25	0.000	-	0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
E1	3.70	3.90	4.00	0.146	0.154	0.157
D1	2.67	2.97	3.50	0.105	0.117	0.138
E2	1.78	2.18	2.60	0.070	0.086	0.102
E	5.80	6.00	6.20	0.228	0.236	0.244
L	0.40	-	1.27	0.016	-	0.050
b	0.31	-	0.51	0.012	-	0.020
e	1.27 REF			0.050 REF		

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

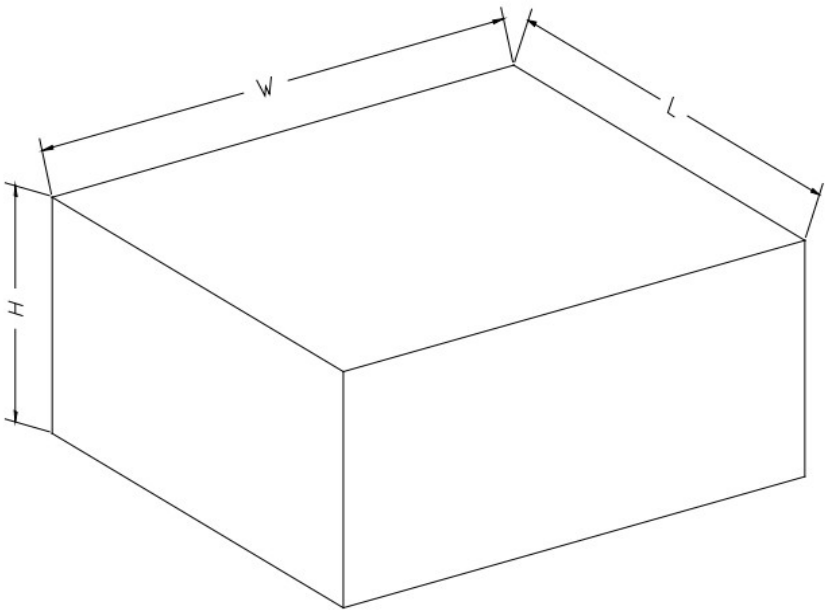


NOTE: The picture is only for reference. Please make the object as the standard.

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
SOP-8(EP)	13"	12.4	6.40	5.40	2.10	4.0	8.0	2.0	12.0	Q1

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
13″	386	280	370	5