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

Features

- High Efficiency: Up to 95%@5V
- 600KHz Frequency Operation
- 3.0A Output Current
- No Schottky Diode Required
- 3.5V to 18V Input Voltage Range
- 0.8V Reference
- Slop Compensated Current Mode Control for Excellent Line and Load Transient Response
- Integrated internal compensation
- Stable with Low ESR Ceramic Output Capacitors
- Over Current Protection With Hiccup-Mode
- Input over voltage protection(OVP)
- Thermal Shutdown
- Inrush Current Limit and Soft Start

Applications

- Vehicle USB Power Chargers
- Distributed Power Systems
- Digital Set Top Boxes
- Flat Panel Televicion and Monitors
- Notebook Computer
- Wireless and DSL Modems

General Description

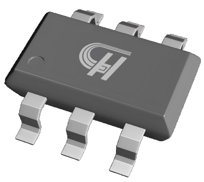
The HCR3143 is a fully integrated, high efficiency 3.0A synchronous rectified step -down converter. The HCR3143 operates at high efficiency over a wide output current load range.

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

The HCR3143 requires a minimum number of readily available standard external components and is available in a TSOP-6 (SOT23-6L) ROHS compliant package.

Pacakage

- TSOP-6 (SOT23-6L)



TSOP-6 (SOT23-6L)

Figure 1. Package Type of HCR3143

Pin Configuration

TSOP-6 (SOT23-6L) Top View

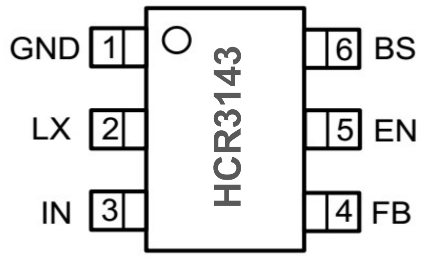
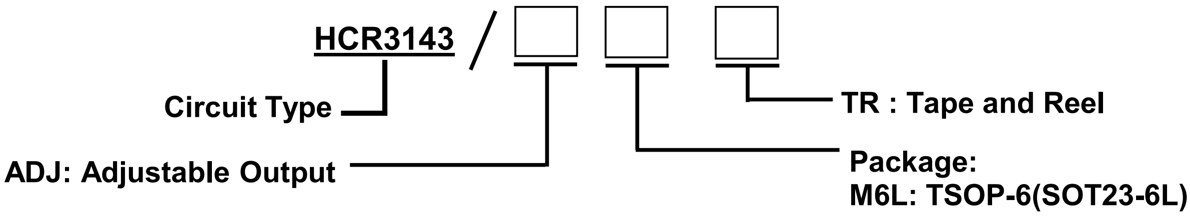


Figure 2. Pin Configuration of HCR3143 (Top View)

Pin Function Table

Pin Number	Pin Name	Function
1	GND	Ground Pin
2	LX	Power Switch Output. It is the switch node connection to inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
3	VIN	Power Supply input pin.
4	FB	Output Voltage Feedback Pin. Connect FB to the center point of the external resistor divider.
5	EN	Chip Enable Pin. Drive EN pin to a logic-high to enable the IC. Drive EN pin to a logic-Low to disable the IC and enter micro-power shutdown mode. Don't floating this pin.
6	BS	Bootstrap. A capacitor connected between LX and BS pins is required to form a floating supply across the high-side switch driver.

Ordering Information



Ordering Code

Part Number	Marking ID note2	Temperature Range	Package	Quantity per Reel
HCR3143/ADJM6LTR	S43BXXX	-40'C to +85'C	TSOP-6 (SOT23-6L)	3000pcs/TR

Note 2: "S43B" is device code and "XXX" is Inside code.

Absolute Maximum Ratings Note 1

Parameter	Symbol	Value	Unit
Input Supply Voltage Range	V_{IN}	-0.3 to +20.0	V
LX Voltage Range	V_{LX}	-0.3 to +20.0	V
EN Voltage Range	V_{EN}	-0.3 to +20.0	V
FB Voltage Range	V_{FB}	-0.3 to +6.0	V
BS Voltage Range	V_{BS}	-0.6 to +25.0	V
Power Dissipation	P_O	1000	mW
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	118.0	'C/W
Thermal Resistance Junction to Case	$R_{\theta JC}$	11.2	'C/W
Storage Temperature Range	T_{STG}	-65 to 150	'C
Operating Junction Temperature	T_J	-40 to +85	'C
Lead Temperature (Soldering, 10s)	T_{LEAD}	260	'C
Human Body Model for all pins	V_{ESD_HBM}	±2000	V
Charge Device Model for all pins	V_{ESD_CDM}	±400	V

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

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

Recommended Operating Conditions

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input Voltage Range	V_{IN}		3.5	-	18	V
Operating Junction Temperature Range	T_J		-40	-	125	'C

Electrical Characteristics

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

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input Voltage Range	V_{IN}		3.5	-	18	V
Input OVP Threshold	V_{OVP}		-	19	-	V
UVLO Threshold	V_{UVLO}		3.0	-	-	V
Quiescent Current	I_Q	V_{EN}=2.0V, I_{OUT}=0, No Load	-	400	600	uA
Shutdown Current	I_{SHDN}	V_{EN}=0V	-	2	-	uA
Regulated Feedback Voltage Accuracy	V_{REF}	T_A=25'C, 3.5V<V_{IN}<18V	0.784	0.800	0.816	V
High-Side Switch On Resistance	$R_{DS(ON)1}$		-	120	-	mΩ
Low-Side Switch On Resistance	$R_{DS(ON)2}$		-	70	-	mΩ
High-Side Switch Leakage Current	I_{LX_LC}	V_{EN}=0V, V_{LX}=0V	-	0.01	10	uA
Upper Switch Current Limit	I_{LIM}	Minimum Duty Cycle	-	3.3	-	A
Oscillation Frequency	F_{OSC}	V_{FB}=0.8V	-	600	-	KHz
Maximum Duty Cycle	η	V_{FB}=0.8V	-	95	-	%
EN High Level Input Voltage	V_{EN-H}		1.5	-	-	V
EN Low Level Input Voltage	V_{EN-L}		-	-	0.3	V
EN Leakage Current	I_{EN_LC}		-	-	2.0	uA
Minimum On-Time	T_{ON}		-	100	-	nS
Minimum Off-Time	T_{off}		-	160	-	nS
Soft Start	T_{start}		-	800	-	uS
Thermal Shutdown [note3]	T_{SHDN}		-	160	-	'C
Thermal Hysteresis[note3]	T_{HYTS}		-	30	-	'C

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

Typical Performance Characteristics

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

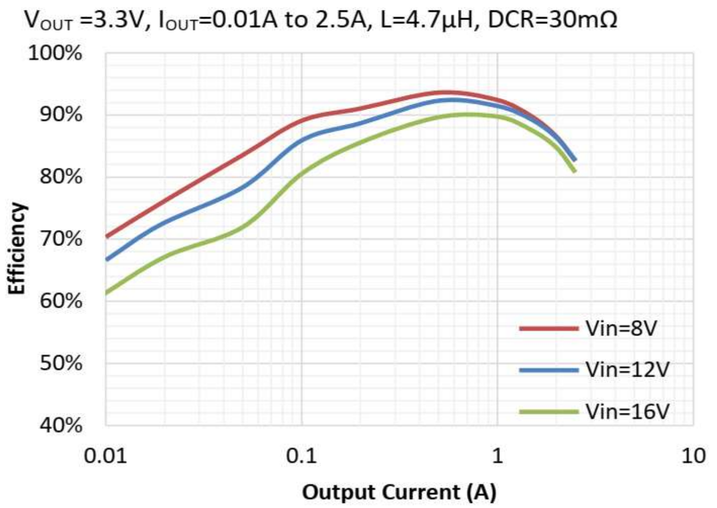


Figure 3. Efficiency

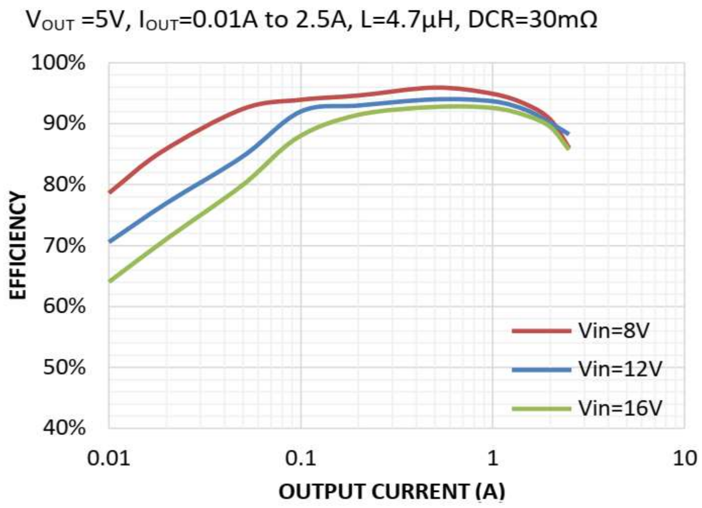


Figure 4. Efficiency

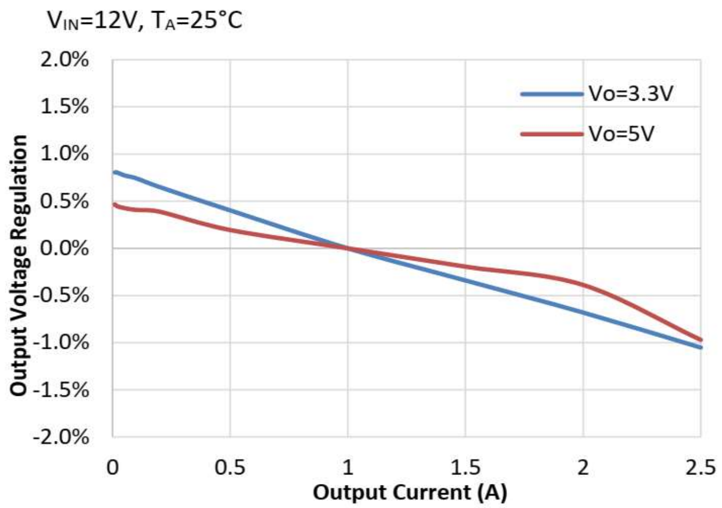


Figure 5. Load Regulation

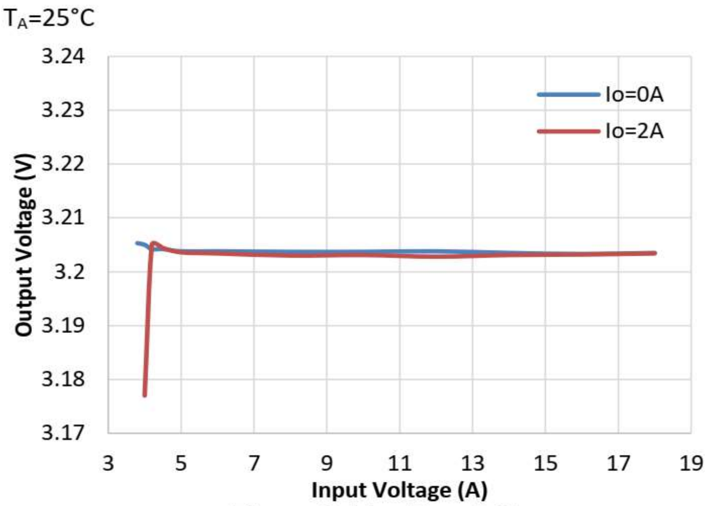


Figure 6. Line Regulation

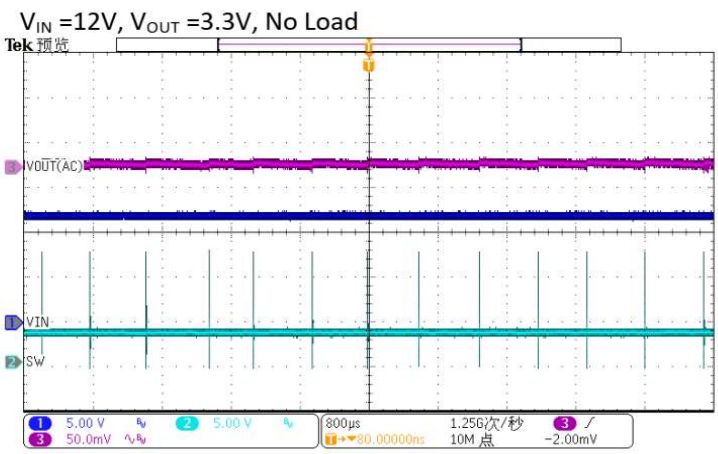


Figure 7 . Steady State Operation

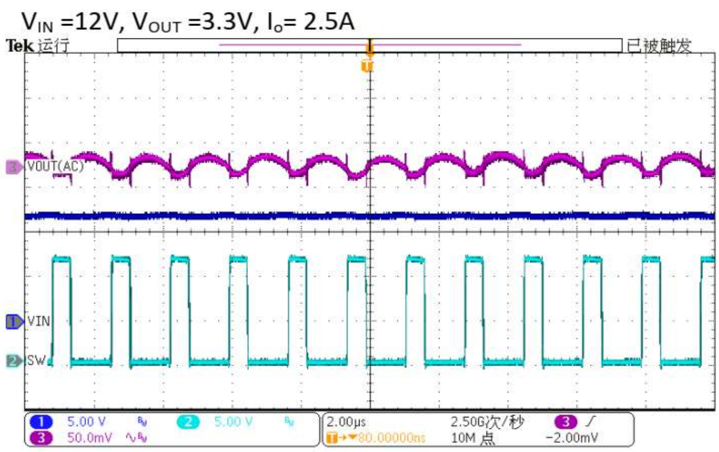


Figure 8. Steady State Operation

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

Typical Performance Characteristics(Con.)

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

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

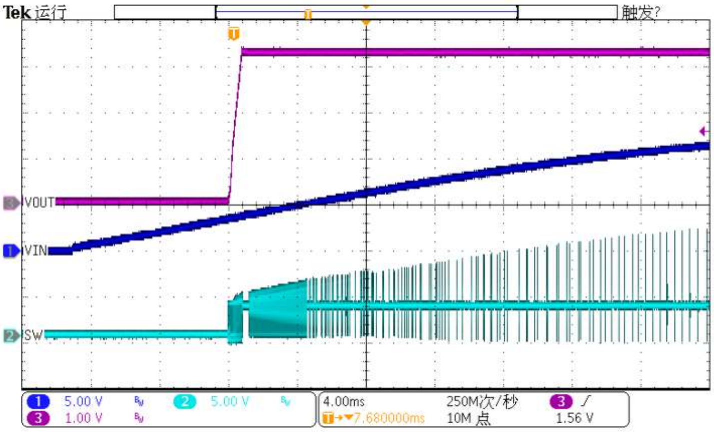


Figure 9. Input Power On

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

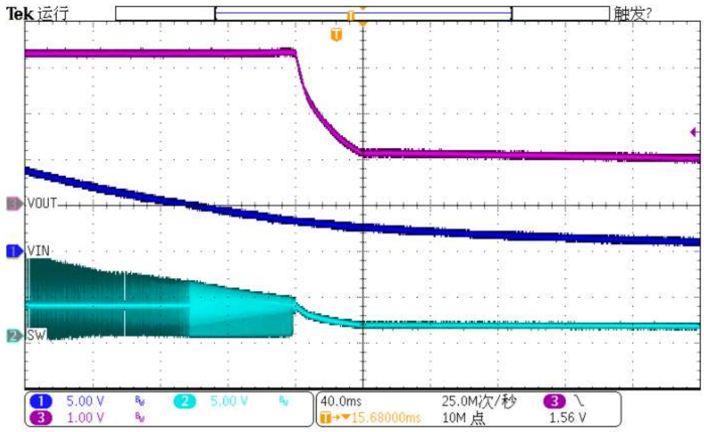


Figure 10. Input Power Down

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

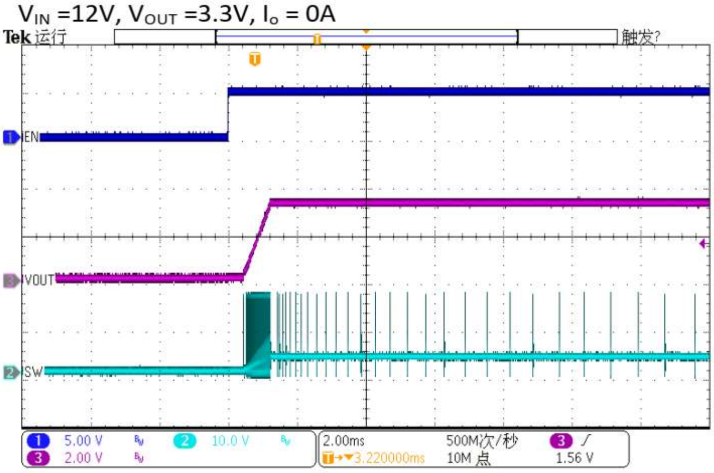


Figure 11. EN Enable

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

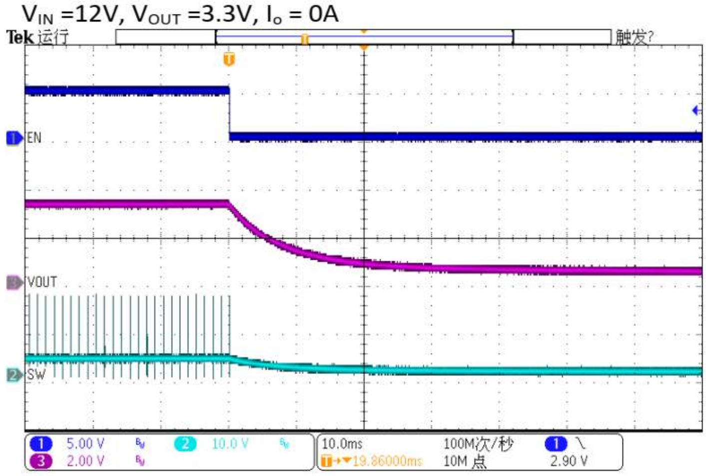


Figure 12. EN Disable

V_{IN} =12V, V_{OUT} =3.3V, I_o = 2A

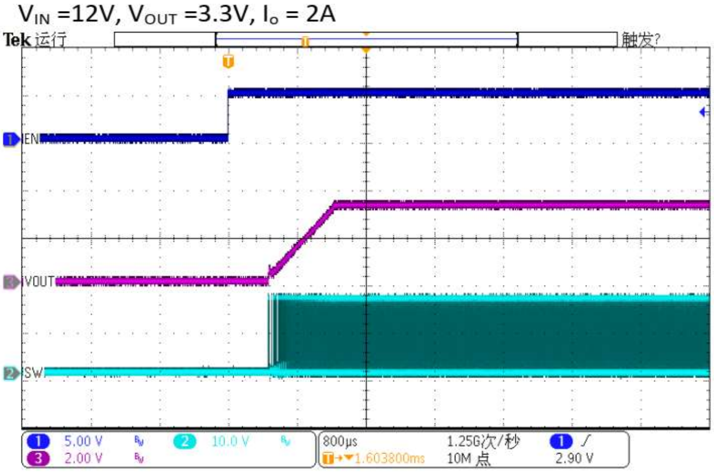


Figure 13. EN Enable

V_{IN} =12V, V_{OUT} =3.3V, I_o = 2A

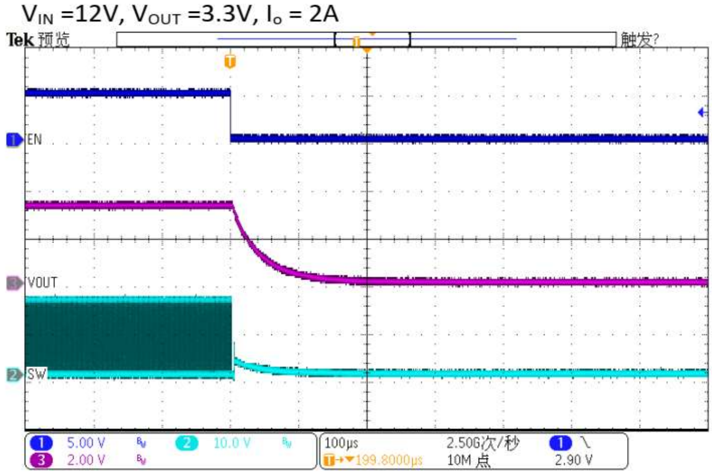


Figure 14. EN Disable

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

Typical Performance Characteristics(Con.)

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

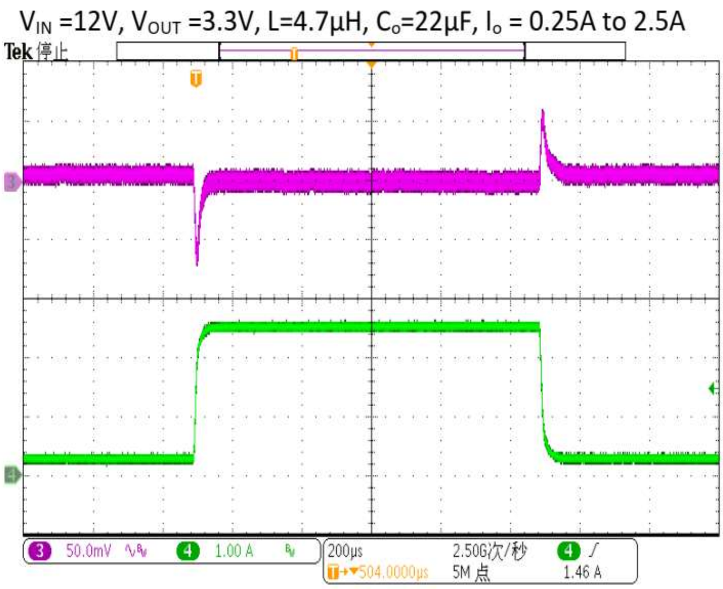


Figure 15. Load Transient

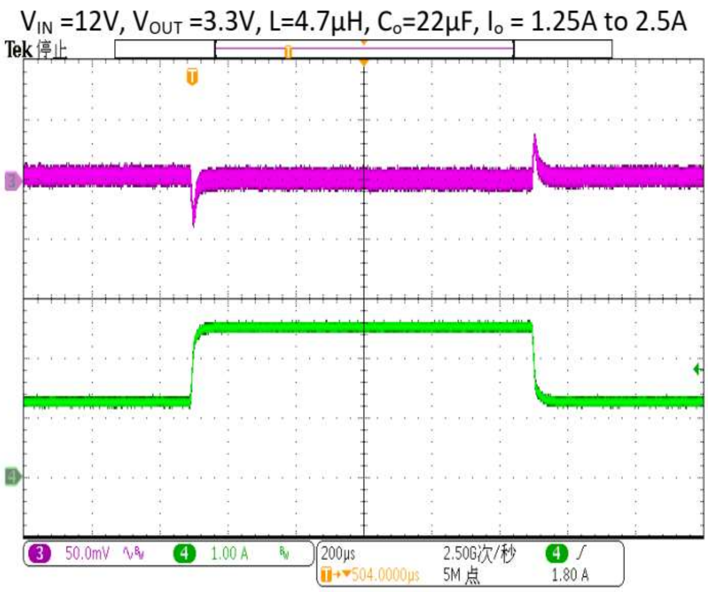


Figure 16. Load Transient

Functional Block Diagram

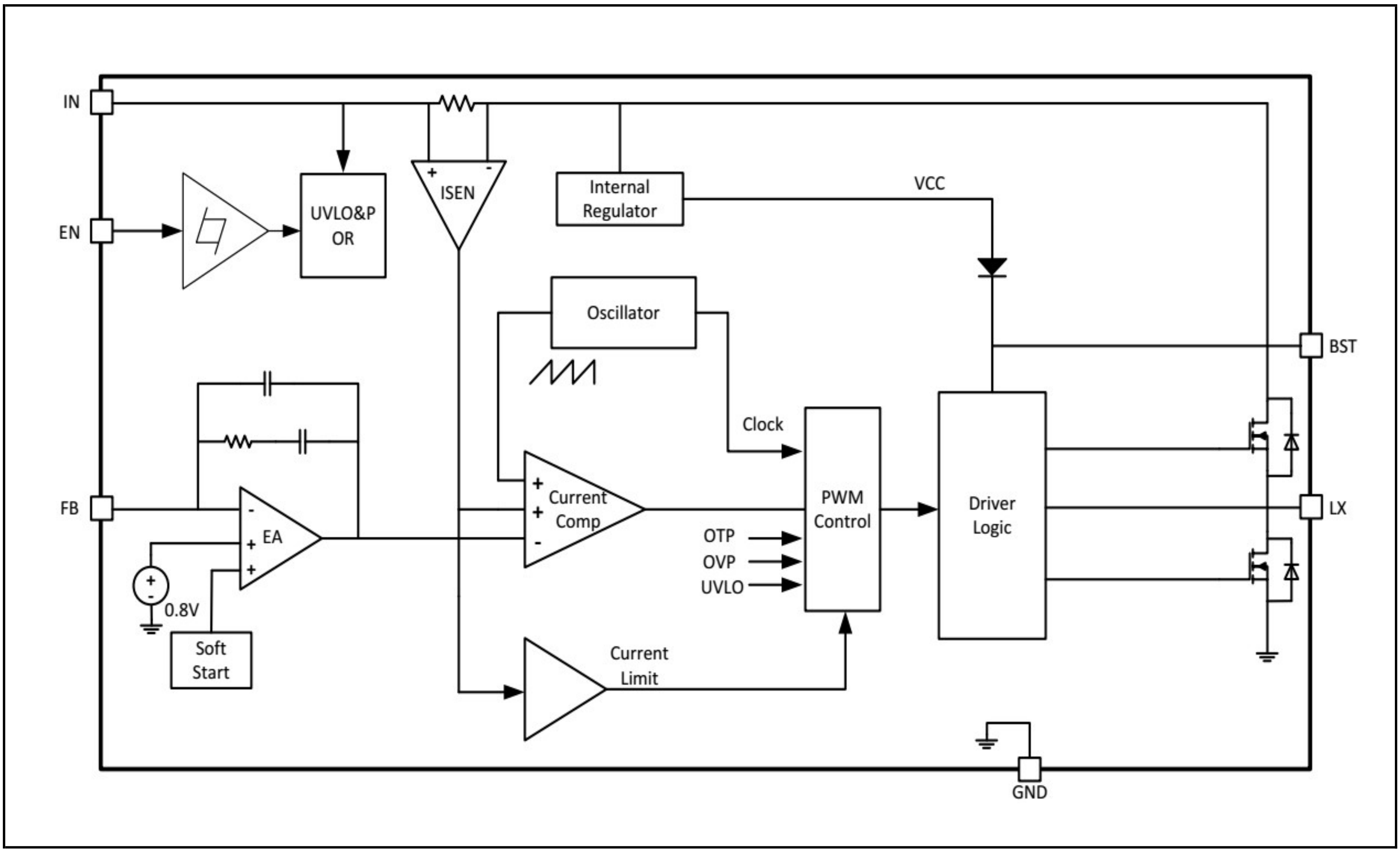


Figure 17. Functional Block Diagram of HCR3143

Operation Description

Internal Regulator

The HCR3143 is a current mode step down DC/DC converter that provides excellent transient response with no extra external compensation components.This device contains an internal/low resistance/high voltage power MOSFET&operates at a high 600KHz operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

Error Amplifier

The error amplifier compares the FB pin voltage with the internal FB reference (VFB) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network to form the COMP voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

Error Amplifier

The soft-start is implemented to prevent the converter output voltage from overshooting during startup.When the chip starts, the internal circuitry generates a soft-start voltage(SS) ramping up from 0V to 0.8V. When it is lower than the internal refernce(VREF), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than REF, REF regains control. The SS time is internally fixed to 0.8ms.

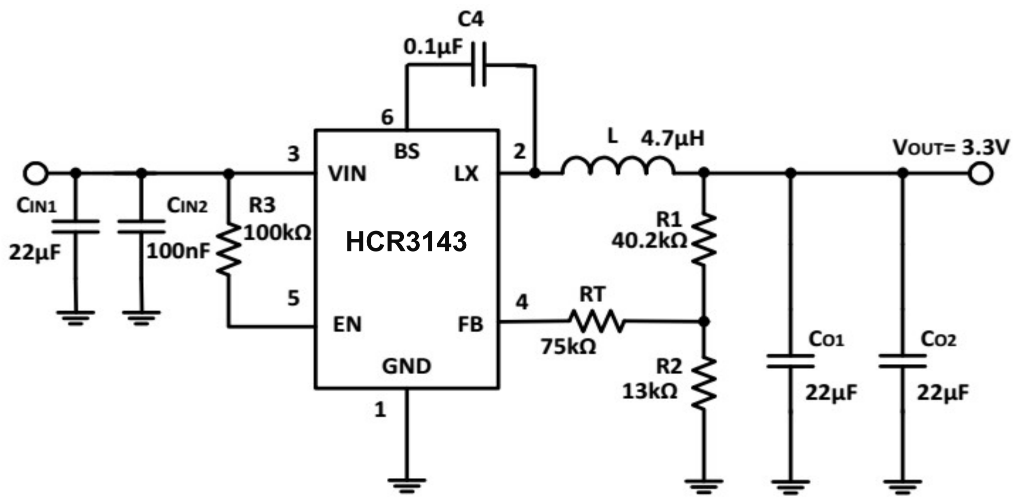
Over-Current-Protection and Hiccup

The HCR3143 has cycle-by-cycle over current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, output voltage starts to drop until FB is below the Under-voltage(UV) threshold, typically 55% below the reference. Once a UV is triggered,the HCR3143 enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-short to ground. The average short circuit current is greatly reduced to alleviate the thermal issue and to protect the regulator. The HCR3143 exits the hiccup mode once the over current condition is removed.

Start up and Shutdown

If both VIN and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuits. Three events can shutdown the chip: EN low. VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault trigger--ing. The COMP voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

Basic Application Circuit



Note: if RT=0Ω, R1 should be selected from 56KΩ to 200KΩ

Figure 18. Basic Application Circuit of HCR3143

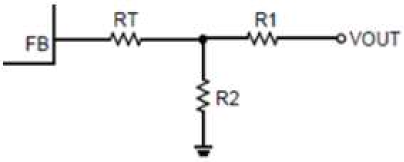
Application Information

Setting the Output Voltage

The external resistor divider is used to set the output voltage(see Figure 18).The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor. Choose R1 to be around 10KΩ for optimal transient response. R2 is then given by:

$$R_2 = \frac{R_1}{V_{out} / V_{FB} - 1}$$

Use a T-type network for when VOUT is low.



VOUT	R1(KΩ)	R2(KΩ)	RT(KΩ)
5V	40.2	7.68	75
3.3V	40.2	13	75
2.5V	40.2	19.1	100
1.8V	40.2	32.4	120
1.2V	20.5	41.2	249
1.05V	10	32.4	300

Inductor Selection

A DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. Inductance value is related to inductor ripple current value, input voltage, output voltage setting and switching frequency. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor ripple current. Large value inductors result in lower ripple current & small value inductors result in high ripple current, So inductor value has effect on output voltage ripple value. DC resistance of inductor which has impact on efficiency of DC/DC converter should be taken into account when selecting the inductor.

The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency.

Output Capacitor Selection

The output capacitor (Co1 and Co2) is required to maintain the DC output voltage. Ceramic, tantalum,or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times \left[R_{ESR} + \frac{1}{8 \times f_S \times C_2}\right]$$

where L is the inductor value and RESR is the equivalent series resistance(ESR) value of the output capacitor. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance.

the output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^2 \times L \times C_2} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right]$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The HCR3143 can be optimized for a wide range of capacitance and ESR values.

Layout Consideration

when laying out the printed circuit board, the following checking should be used to ensure proper operation of the HCR3143. Check the following in your layout:

1.1) Keep the path of switching current short and minimize the loop area formed by input capacitor, high-side MOSFET and low-side MOSFET.

1.2) Bypass ceramic capacitors are suggested to be put close to the IN Pin.

1.3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation as close to the chip as possible.

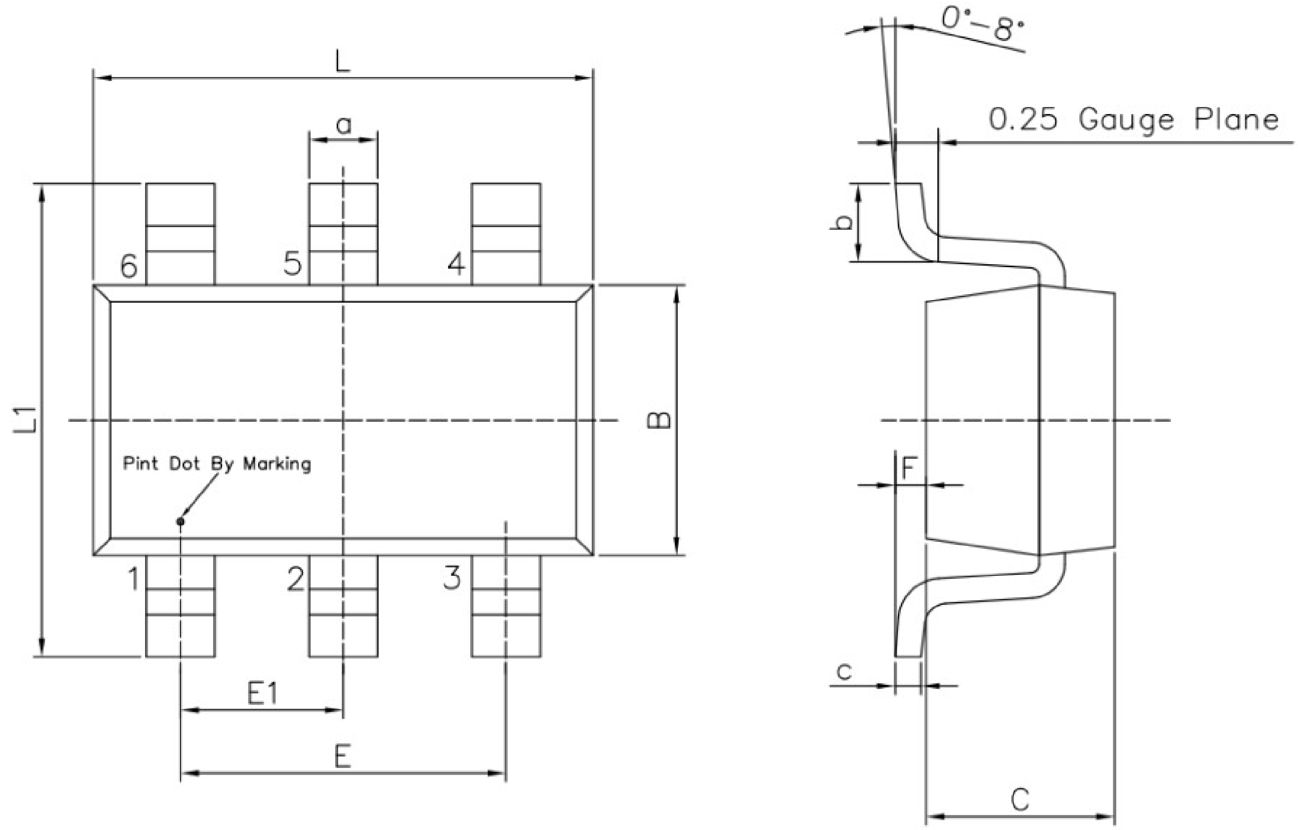
1.4) VOUT, LX away from sensitive analog areas as FB.

1.5) Connect IN, LX, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

Mechanical Dimensions

M6L PKG: TSOP-6 (SOT23-6L)

Unit: mm



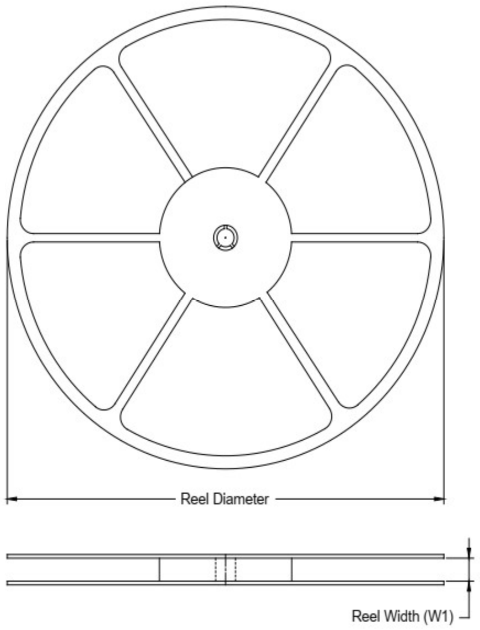
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
L	2.82	3.02	E1	0.85	1.05
B	1.50	1.70	a	0.35	0.50
C	0.90	1.30	c	0.10	0.20
L1	2.60	3.00	b	0.35	0.55
E	1.80	2.00	F	0	0.15

Note:

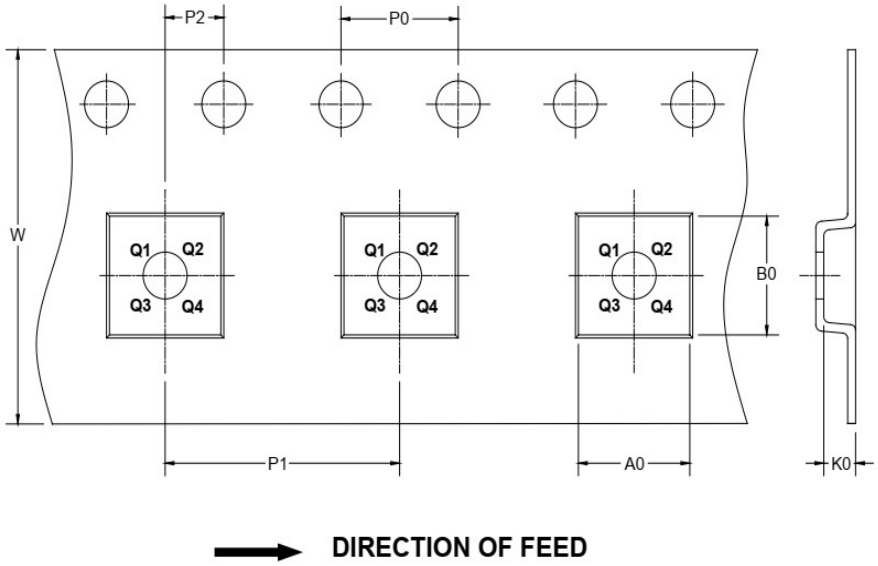
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top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

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

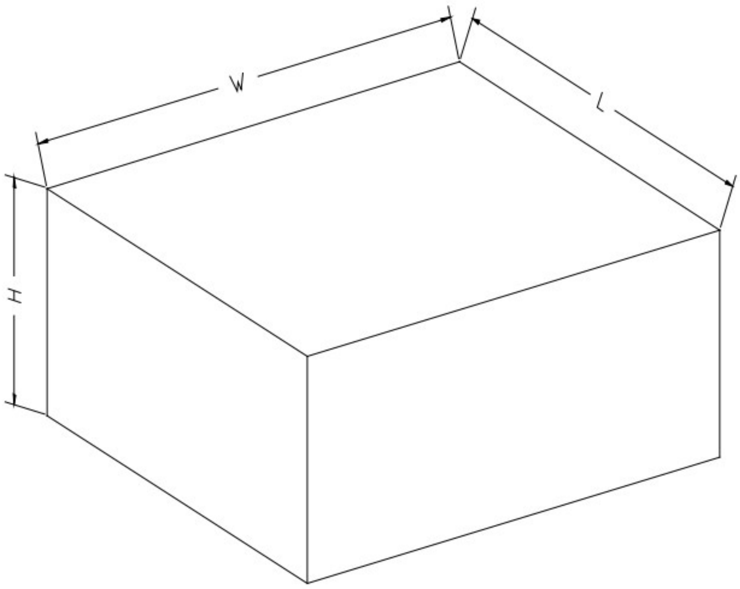


NOTE: The picture is only for reference. Please make the object as the standard.

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
TSOP-6 (SOT23-6L)	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

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