100V, 2A Step-Down Converter with 3.5A Switch Current Limit

Features

- Wide 5V to 100V input range
- 3.5A typical peak switching current limit
- Hysteretic control: no compensation
- Up to 1MHz switching frequency
- PWM dimming control input for LED applications
- Short-circuit protection (SCP) with integrated high-side MOSFET
- 200μA quiescent current
- Thermal shutdown
- Pb-free SOP-8(EP) package

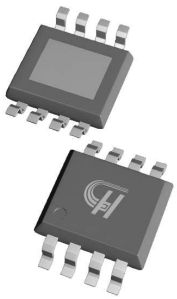
Applications

- Scooters and E-bike control power supplies
- Solar energy systems
- Automotive system power
- Industrial power supplies
- High-power LED drivers

General Description

The HCR3457H is a high-voltage, step-down, switching regulator that delivers up to 2A of continuous current to the load. It integrates a high-side, high-voltage, power MOSFET with a current limit of 3.5A, typically. The wide 5V to 100V input range accommodates a variety of step-down applications, making it ideal for automotive, industry, and lighting applications. Hysteretic voltage-mode control is employed for very fast response.

The switching frequency can be up to 1MHz, allowing for small component size. Thermal shutdown and short-circuit protection (SCP) provide reliable and fault-tolerant operations. A 200μA quiescent current allows the HCR3457H to be used in battery-powered applications. The HCR3457H is available in a SOP-8(EP) package.



SOP-8(EP)

Figure 1. Package Type of HCR3457H

Pin Configuration

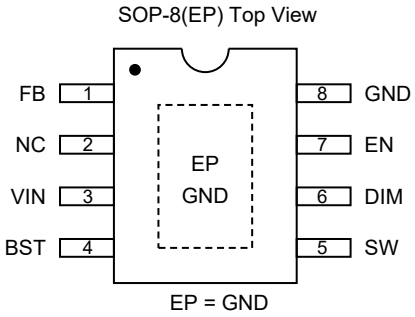
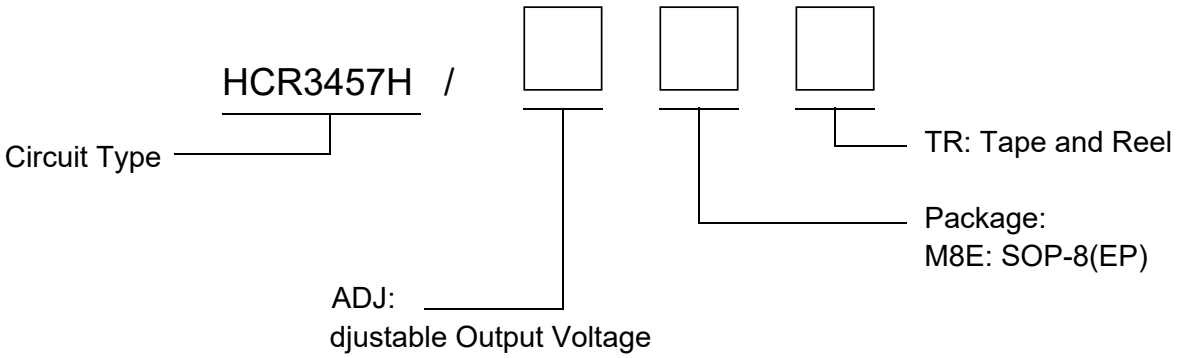


Figure 2. Pin Configuration (Top View)

Pin No.	Name	Description
1	FB	Feedback. FB is the input to the voltage hysteretic comparators. The average FB voltage is maintained at 200mV by loop regulation.
2	NC	No connection.
3	V_{IN}	Input supply. V_{IN} supplies power to all of the internal control circuitries, both BST regulators, and the high-side switch. A decoupling capacitor to ground must be placed close to V_{IN} to minimize switching spikes.
4	BST	Bootstrap. BST is the positive power supply for the internal, floating, high-side MOSFET driver. Connect a bypass capacitor between BST and SW.
5	SW	Switch node. SW is the output from the high-side switch. A low forward voltage Schottky rectifier to ground is required. The rectifier must be placed close to SW to reduce switching spikes.
6	DIM	PWM dimming input. DIM is useful in LED driver applications. Pull DIM below the specified threshold for dimming off. Pull DIM above the specified threshold for dimming on. If the dimming function is not needed, such as in common buck applications, then connect DIM and EN together.
7	EN	Enable input. Pull EN below the specified threshold to shut down the HCR3457H. Pull EN above the specified threshold or leave EN floating to enable the HCR3457H.
8	GND	Ground. GND should be placed as close to the output capacitor as possible to avoid the high-current switch paths. Connect the exposed pad to GND plane for optimal thermal performance.
EP	GND	Provides both electrical and thermal connection from the device to the board. A matching ground pad must be provided on the PCB and the device connected to it via solder. For proper electrical operation, this ground pad must be connected to the system ground.

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Ordering Information



Ordering Code

Part Number	Marking ID	Temperature Range	Package	Quantity per Reel
HCR3457H/ADJM8ETR	HCR3457Hxx	−40 to +125°C	SOP-8(EP)	2500 pcs/TR

xx indicates the date code and trace code.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage for V_{IN}	V_{IN}	−0.3	-	100	V
Power supply voltage for V_{IN}, transient <100ns		−0.3	-	120	V
Switch voltage	SW	−0.5 (−7V for 10ns)	-	V_{IN} + 0.5	V
BST to SW	-	−0.3	-	6	V
All other pins	-	−0.3	-	6	V
Moisture sensitivity level (MSL)	-	-	MSL3	-	-
Ambient operating temperature	T_A	−40	-	125	°C
Junction temperature	T_J	−40	-	150	°C
Storage temperature	T_{STG}	−65	-	150	°C

Depending on parts and PCB layout, characteristics may be changed.

Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Power supply voltage for V_{IN}	V_{IN}	-	5	-	95	V
EN and DIM voltages	-	-	0	-	5	V
Maximum switching frequency	f_{sw}	-	-	-	1M	Hz
Ambient operating temperature	T_a	-	−40	-	125	°C

Electrical Characteristics

V_{IN} = 60V, T_A = +25°C, unless otherwise noted. Specifications over temperature are guaranteed by design and characterization.

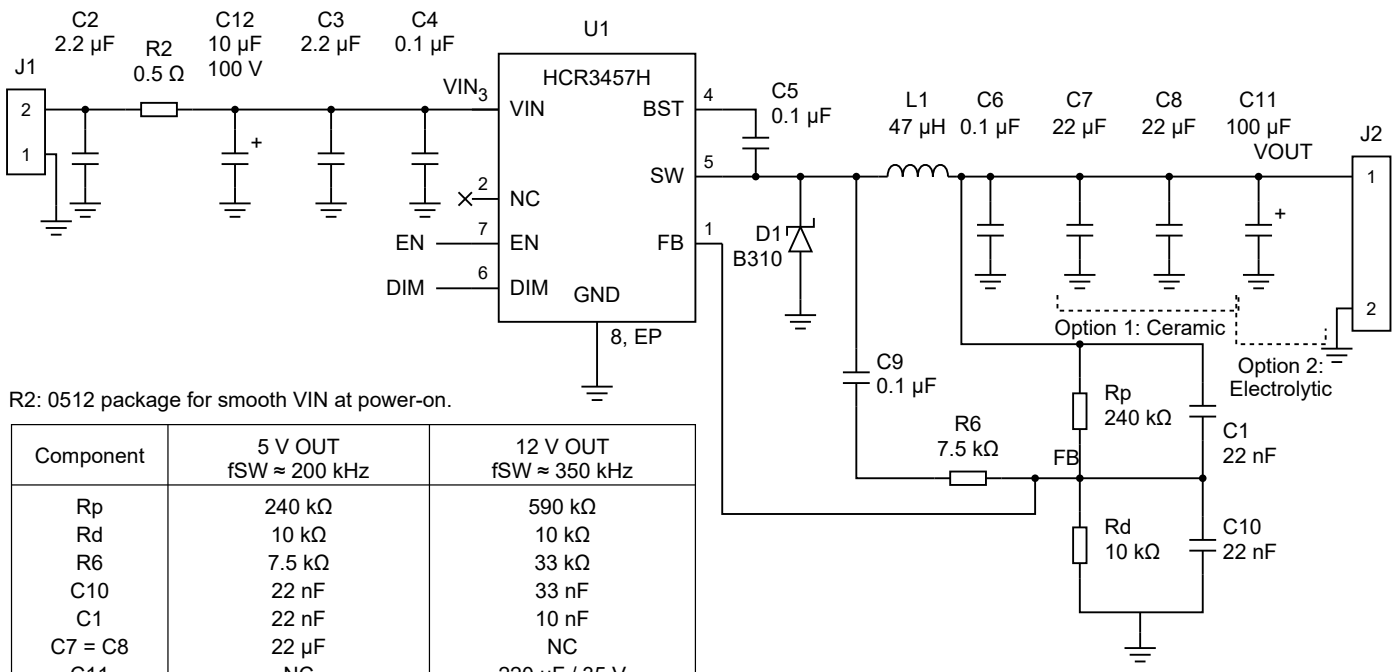
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
V_{IN} UVLO threshold	V_{UVLO}	-	-	4.7	-	V
V_{IN} UVLO hysteresis	V_{hys}	-	-	0.3	-	V
Shutdown supply current	I_{SD}	V_{EN} = 0V	-	5	-	μA
Quiescent supply current	I_Q	No load, DIM = low, V_{FB} = 250mV	-	200	-	μA
Upper switch on resistance	$R_{DS(ON)}$	$V_{BST} - V_{SW}$ = 5V	-	380	-	mΩ
Upper switch leakage current	I_{SWLK}	V_{EN} = 0V, V_{SW} = 0V	-	0.01	-	μA
Current limit	I_{PK}	V_{FB} = 150mV, HCR3457H	-	3.5	-	A
EN up threshold	V_{ENH}	-	-	1.8	-	V
EN threshold hysteresis	V_{ENHY}	-	-	400	-	mV
EN input current	I_{ENI}	V_{EN} = 5V	-	0.01	-	μA
EN pull-up current	I_{ENS}	EN = 2V	-	2	-	μA
DIM up threshold	V_{DIMH}	-	-	1.1	-	V
DIM threshold hysteresis	V_{DIMHY}	-	-	200	-	mV

Electrical Characteristics (Continued)

V_{IN} = 60V, T_A = +25°C, unless otherwise noted. Specifications over temperature are guaranteed by design and characterization.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
DIM input current	I_{DIM}	V_{DIM} = 5V or 0V	-	0.01	-	μA
DIM on propagation delay	T_{DIMDH}	V_{FB} = 0V, V_{DIM} rising edge to V_{SW} rising edge	-	50	-	ns
DIM off propagation delay	T_{DIMDL}	V_{FB} = 0V, V_{DIM} falling edge to V_{SW} falling edge	-	50	-	ns
Feedback voltage threshold high	V_{FBH}	4.5V < V_{IN} < 95V, V_{FB} rising from 0V until V_{SW} < 30V	-	215	-	mV
Feedback voltage threshold low	V_{FBL}	4.5V < V_{IN} < 95V, V_{FB} falling from 0.25V until V_{SW} > 30V	-	185	-	mV
FB input current	I_{FB}	V_{FB} = 5V or 0V	−300	-	300	nA
FB propagation delay to output high	T_{FBDH}	Falling edge of V_{FB} from 0.25V to 0V to V_{SW} rising edge	-	100	-	ns
FB propagation delay to output low	T_{FBDL}	Rising edge of V_{FB} from 0V to 0.25V to V_{SW} falling edge	-	100	-	ns
Thermal shutdown	-	Trigger thermal shutdown	-	150	-	°C
Thermal shutdown	-	Hysteresis	-	20	-	°C

Typical Application Circuit



R2: 0512 package for smooth VIN at power-on.

Component	5 V OUT fSW ≈ 200 kHz	12 V OUT fSW ≈ 350 kHz
Rp	240 kΩ	590 kΩ
Rd	10 kΩ	10 kΩ
R6	7.5 kΩ	33 kΩ
C10	22 nF	33 nF
C1	22 nF	10 nF
C7 = C8	22 µF	NC
C11	NC	220 µF / 35 V

Figure 3. Typical Application Circuit

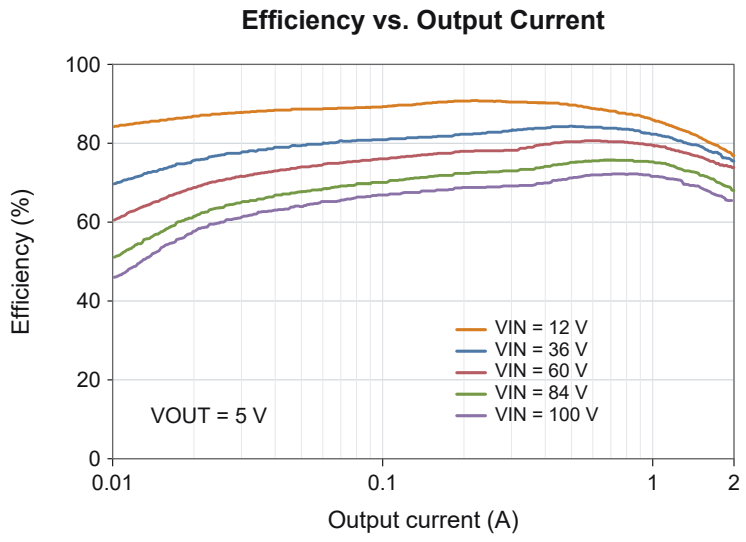


Figure 4. Efficiency vs. Output Current

Typical Operating Characteristics

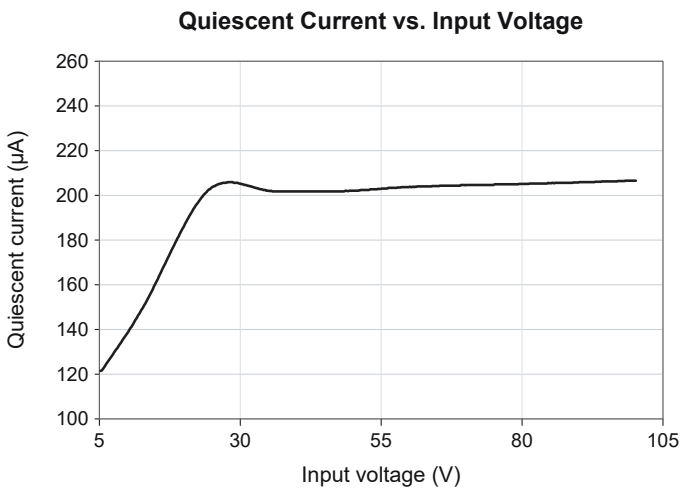


Figure 5. Quiescent Current vs. Input Voltage

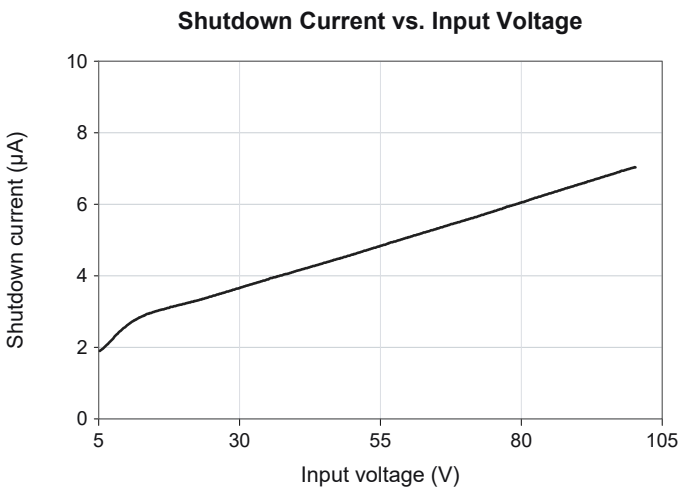


Figure 6. Shutdown Current vs. Input Voltage

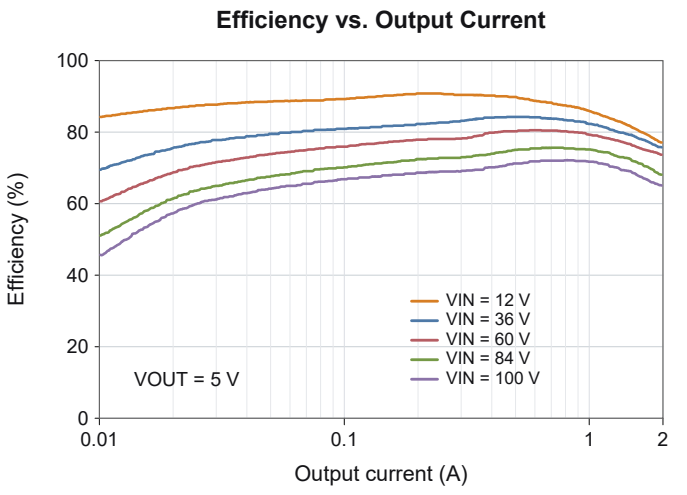


Figure 7. Efficiency vs. Output Current

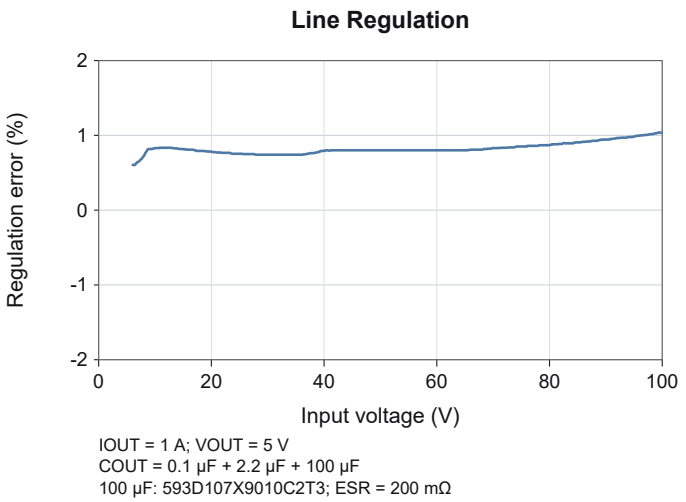


Figure 8. Line Regulation

Application Notes

The output capacitor (C_{OUT}) of the HCR3457H is necessary for achieving a smooth output voltage and has strict ESR requirements. As described in this specification, the output capacitor ESR should be sufficiently large; otherwise, the system may operate unexpectedly and the current ripple may be very high. An output capacitor ESR of 100mΩ to 250mΩ is generally recommended over the full operating conditions and operating temperature range. Specific choices are described below.

1. Ceramic or Electrolytic Capacitors (Recommended)

When using ceramic or electrolytic capacitors, change the feed-forward capacitor and resistor (C_9 and R_6) to connect FB to SW, as shown in the typical application circuit. Adjusting R_6 and C_{10} changes the SW frequency:

$$f_{SW} \propto \frac{1}{R_6 C_{10}}$$

Increasing R_6 or C_{10} reduces f_{sw}. A switching frequency of approximately 200kHz to 300kHz is recommended.

2. Tantalum Capacitors

For the output capacitor, use the parallel combination 0.1μF + 2.2μF + 100μF (tantalum). The tantalum capacitor may be 593D107X9010C2T3 or a similar device with a nominal ESR of 200mΩ.

3. Ceramic Capacitors with a Parallel Resistor

Because tantalum capacitors are expensive, more customers prefer low-cost electrolytic or ceramic capacitors. Electrolytic capacitors are generally not recommended because of their poor temperature characteristics.

Ceramic capacitors have a low ESR that is insufficient for stable operation of the HCR3457H. A resistor R_s (100mΩ to 250mΩ) must therefore be connected in series with the ceramic capacitors, with no additional capacitance at the subsequent stage, because additional capacitance also affects the ESR, as shown below.

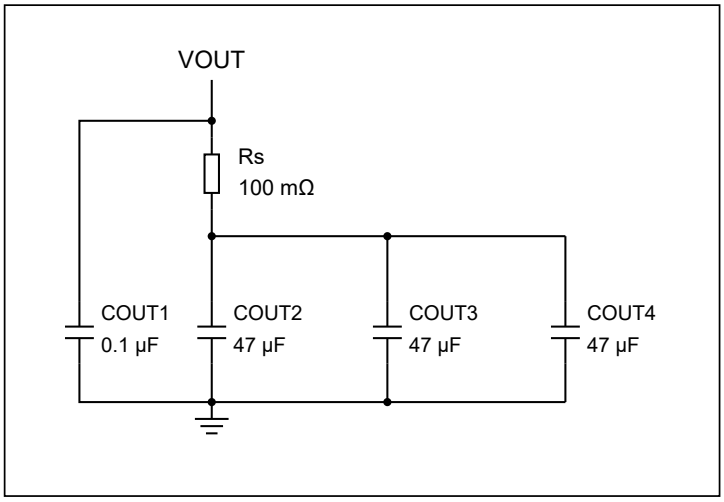


Figure 9. Ceramic Output Capacitors with Series ESR Resistor

HCR3457H Layout Recommendations

(1) Place the input capacitor, diode, and HCR3457H (V_{IN}, SW, and PGND) as close to each other as possible.

(2) At least one electrolytic input capacitor is recommended (at least 10μF, with a voltage rating ≥ 1.5 times the maximum input voltage).

(3) Keep the power traces very short and fairly wide, especially for the SW node. This greatly reduces voltage spikes on SW and lowers EMI noise.

(4) Run the FB trace as far from the inductor and power traces (such as SW) as possible.

(5) Place thermal vias with a 15mil diameter and 40mil pitch (center-to-center) under the exposed pad to improve thermal conduction.

Application Information

1. Hysteresis Current Control with Adaptive Threshold Adjustment

The HCR3457H operates in a hysteretic voltage-control mode to regulate the output voltage. FB is connected to the tap of a resistor divider, which determines the output voltage. The power MOSFET is turned on when the FB voltage (V_{FB}) drops to 185mV and remains on until V_{FB} rises to 215mV. The power MOSFET is turned off when V_{FB} rises to 215mV and remains off until V_{FB} falls to 185mV. The two thresholds of 215mV and 185mV are adjusted adaptively to compensate for all the circuit delays, so the output voltage is regulated with an average 200mV value at FB.

2. Enable (EN) Control

The HCR3457H has a dedicated enable control pin (EN) with positive logic. Its falling threshold is 1.3V, and its rising threshold is 1.7V. When floating, EN is pulled up to about 2.5V by an internal 2μA current source, so it is enabled. A current over 2μA is needed to pull EN down.

3. Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own under-voltage lockout (UVLO) protection. The UVLO rising threshold is 2.2V with a hysteresis of 150mV. The bootstrap capacitor is charged and regulated to about 5V by the dedicated internal bootstrap regulator.

4. Undervoltage Lockout (UVLO)

Under-voltage lockout (UVLO) is implemented to protect the chip from operating at an insufficient supply voltage. The UVLO rising threshold is about 4.7V, while its falling threshold is a consistent 4.4V.

5. Dimming Function for LED

Because the FB reference of the HCR3457H is very low, it is recommended to use the HCR3457H for LED drivers by connecting the LED current sense resistor between FB and GND. In such applications, the HCR3457H uses DIM for dimming. To achieve dimming, apply a pulse on DIM. The high level of the pulse should be >1.5V, and the low level should be <0.5V. The frequency can be as high as 20kHz.

6. Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from operating at exceedingly high temperatures. When the silicon die temperature is higher than its upper threshold, the entire chip shuts down. When the temperature is lower than its lower threshold, the chip is enabled again.

7. Output Short Protection

The output voltage is well-regulated when V_{FB} is around 200mV. If the output is pulled low in over-current protection (OCP) or is shorted to GND directly, V_{FB} is low, even though the power MOSFET is turned on. The HCR3457H regards the low V_{FB} as a failure. The power MOSFET shuts off if the failure time is longer than 10μs. The HCR3457H attempts operation again after a delay of about 300μs. The power MOSFET current is also accurately sensed via a current sense MOSFET. If the current is over the current limit, the IC is shut down. This offers extra protection under output-short conditions.

8. Setting the Output Voltage

The output voltage (V_{OUT}) is set by a resistor divider (R_1 and R_2) (see the Typical Application Circuit, Figure 3). The resistor divider can be determined with the following equation.

$$R_1 = \frac{V_{OUT} - V_{FB}}{V_{FB}} \times R_2$$

Where V_{FB} is 0.2V, typically.

9. Output Capacitor and Frequency Setting

The output capacitor (C_{OUT}) is necessary for achieving a smooth output voltage. The ESR of the capacitor should be sufficiently large compared to the capacitance; otherwise, the system may behave in an unexpected way, and the current ripple may be very high. V_{FB} changes from 185mV to 215mV when the power MOSFET switches on. To charge the capacitor and generate 215mV at FB, the system needs ESR and some inductor current. For example, for a 5V

Application Information (Continued)

V_{OUT}, if the forward capacitor is 0.1μF, the suggested ESR range of the output capacitor is 100mΩ to 250mΩ. Tantalum or aluminum electrolytic capacitors with a small ceramic capacitor are recommended. A forward capacitor across R_1 is recommended when the output capacitor is tantalum or aluminum electrolytic, which can set the desired frequency if the output capacitor and ESR cannot be changed. The forward capacitor can reduce the output voltage ripple. In some application, simply a forward capacitor may not get proper frequency, then we can add a forward resistor in series with the forward capacitor or even more add a ceramic on the output.

10. Selecting the Inductor

The inductor (L) is required to convert the switching voltage to a smooth current to the load. Although the output current is low, it is recommended that the inductor current be continuous in each switching period to prevent reaching the current limit.

Calculate the inductor value with the following equation.

$$L = \frac{(V_{IN} - V_{OUT}) \times V_{OUT}}{F_{SW} \times I_{OUT} \times V_{IN} \times K}$$

Where K is a coefficient of about 0.15 to 0.85.

11. Output Rectifier Diode

The output rectifier diode supplies current to the inductor when the high-side switch is off. To reduce losses due to the diode forward voltage and recovery times, use a Schottky diode.

The average current through the diode can be approximated with the following equation:

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

Choose a diode with a maximum reverse voltage rating greater than the maximum input voltage and a current rating greater than the average diode current.

12. Input Capacitor (C_{IN})

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance, especially under high switching frequency applications.

The RMS current through the input capacitor can be calculated with the following equation:

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

With low ESR capacitors, the input voltage ripple can be estimated with the following equation.

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

Choose an input capacitor with enough RMS current rating and enough capacitance for small input voltage ripples. When electrolytic or tantalum capacitors are applied, a small, high-quality ceramic capacitor (i.e., 0.1μF) should be placed as close to the IC as possible.

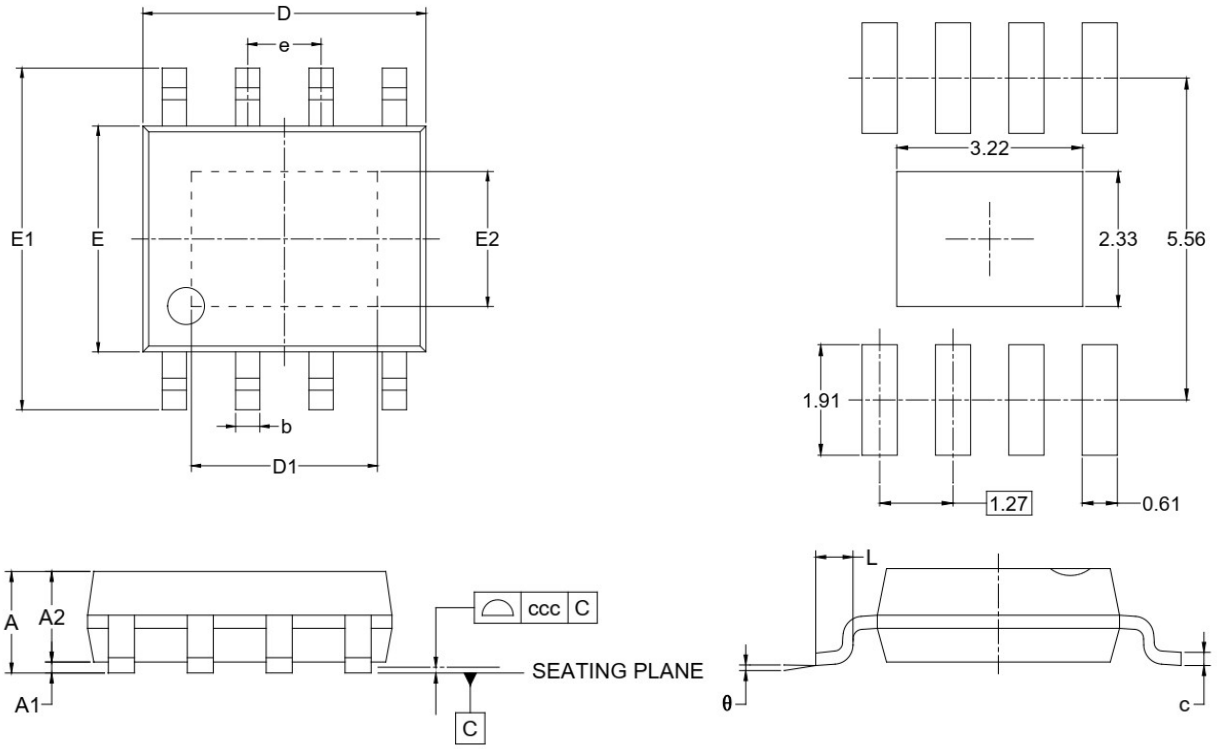
13. PCB Layout Guidelines

Efficient PCB layout is critical for stable operation. For best results, refer to Figure 3 and follow the guidelines below. (1) Place the input decoupling capacitor, output rectifier diode, and the HCR3457H (V_{IN}, SW, and PGND) as close to each other as possible. (2) Keep the power traces very short and fairly wide, especially for the SW node. This can help greatly reduce voltage spikes on the SW node and lower the EMI noise level. (3) Run the feedback trace as far from the inductor and noisy power traces (like the SW node) as possible. (4) Place thermal vias with 15mil barrel diameter and 40mil pitch (distance between the centers) under the exposed pad to improve thermal conduction.

Mechanical Dimensions

M8E PKG: SOP-8(EP)

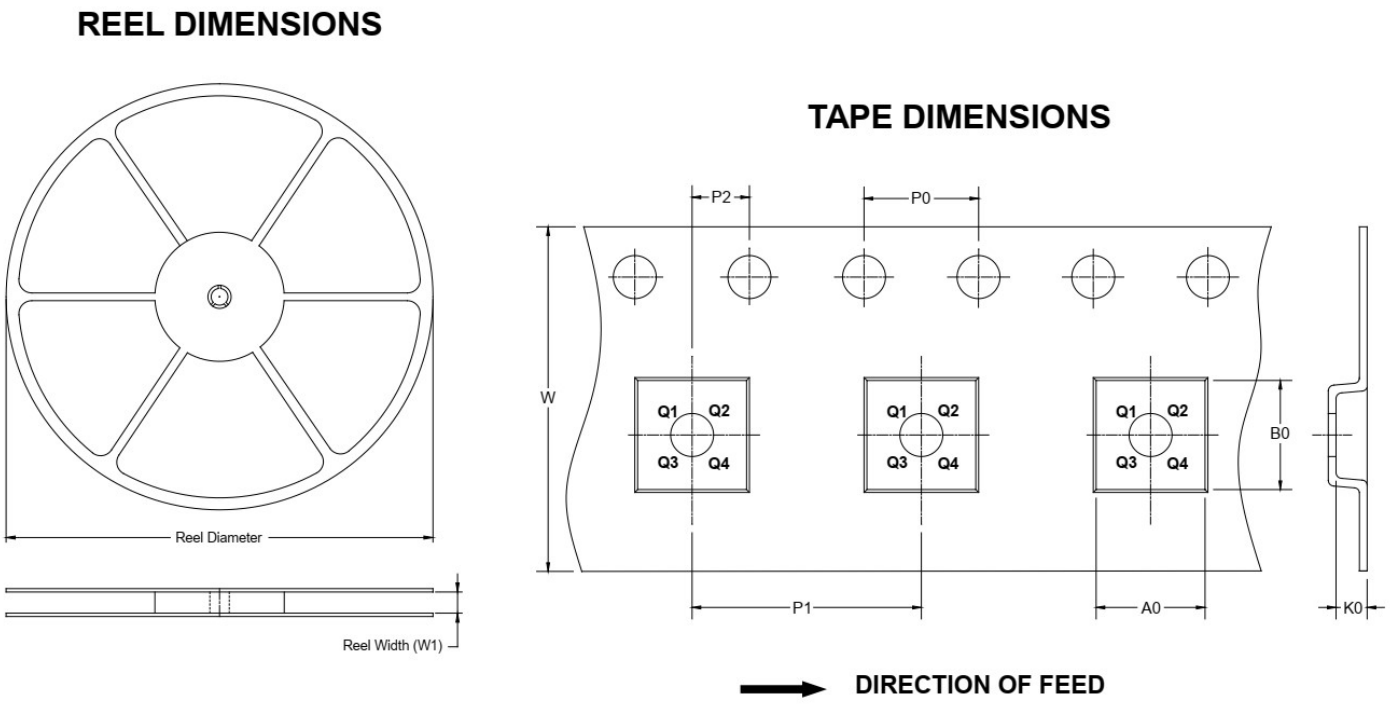
Unit: mm



Symbol	Dimensions in Millimeters		
	MIN	MOD	MAX
A	-	-	1.700
A1	0.000	-	0.150
A2	1.250	-	1.650
b	0.330	-	0.510
c	0.170	-	0.250
D	4.700	-	5.100
D1	3.020	-	3.420
E	3.800	-	4.000
E1	5.800	-	6.200
E2	2.130	-	2.530
e	1.27 BSC		
L	0.400	-	1.270
θ	0°	-	8°
ccc	0.100		

1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MS-012.

Tape and Reel Information



The picture is for reference only. The actual product shall be the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	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

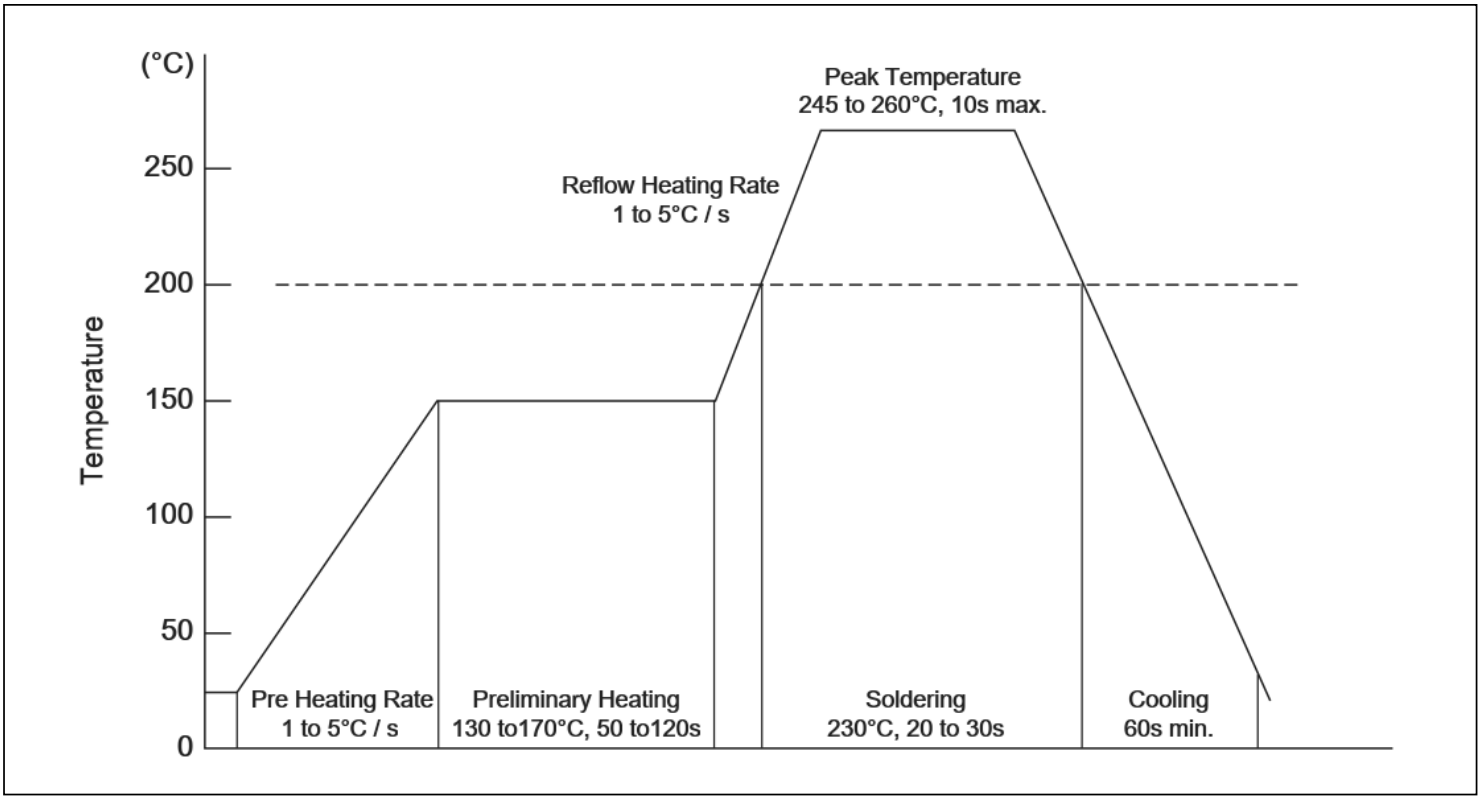
Part Number: HCR3457H/ADJM8ETR

Packing Type: Tape and Reel

Quantity per Reel: 2500 pcs

Conditions 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