100 V, 1 A, 450 kHz Asynchronous Step-Down Converter

Features

- 4.5 V to 100 V operating input range
- 1.0 A continuous output current
- 450 kHz switching frequency
- Hiccup-mode short-circuit protection
- Built-in overcurrent limiting
- Low noise and low EMI
- Internal soft-start
- 500 mΩ high-side MOSFET on-resistance
- Output voltage adjustable from 0.78 V
- 98% maximum duty cycle
- Thermal shutdown
- Current-mode control
- Discontinuous conduction mode (DCM)
- MSL 3 package

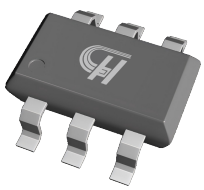
Applications

- Automotive entertainment
- Wireless and DSL modems
- Computer entertainment
- Internet of Things (IoT) applications
- Digital still and video cameras
- GPS, electric bicycles and electric motors

General Description

The HCR3453H is a low-EMI, asynchronous step-down switching converter with an integrated power MOSFET. It delivers 1.0 A of continuous output current across a wide input voltage range. Controlled switching edges reduce EMI, and the converter provides tight line and load regulation.

The converter uses constant-on-time control and incorporates programmable-output overvoltage protection and thermal shutdown. It requires few external components and is available in a six-lead SOT23-6L package.



SOT23-6L

Figure 1. Package Type of HCR3453H

Pin Configuration

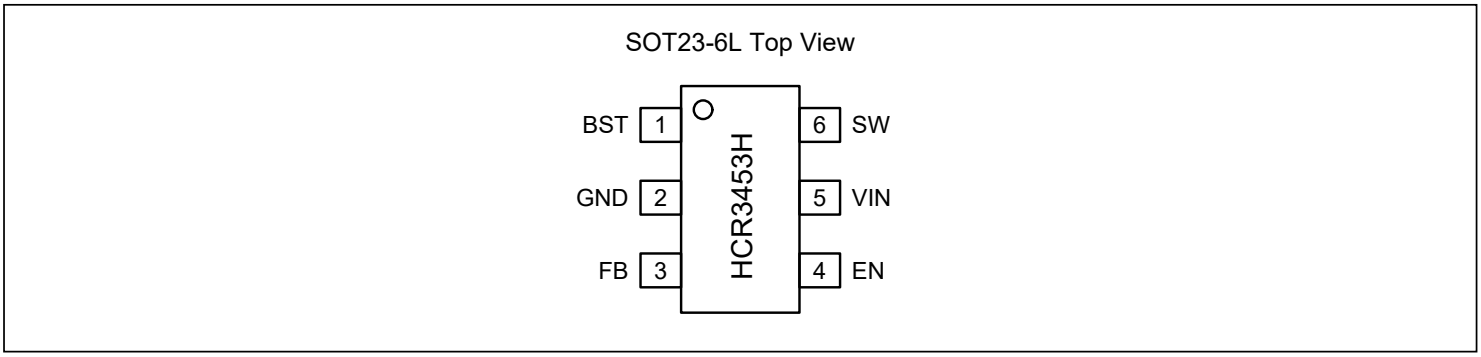
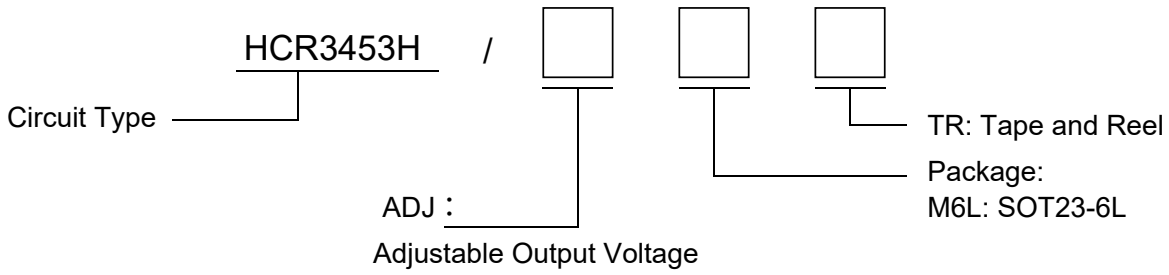


Figure 2. Pin Configuration of HCR3453H (Top View)

Pin Function Table

Pin No.	Pin Name	Function
1	BST	Bootstrap supply. Connect a capacitor between BST and SW to supply the floating high-side switch driver.
2	GND	Ground.
3	FB	Feedback input. Connect FB to the midpoint of the external output-voltage divider.
4	EN	Enable input. Drive high to enable the converter. Drive low to enter micropower shutdown.
5	VIN	Input power supply.
6	SW	Switching node.

Ordering Information



Ordering Code

Part Number	Marking ID[2]	Ambient Temp.	Package	Quantity per Reel
HCR3453H/ADJM6LTR	xxYLL	−40 to +85°C	SOT23-6L	3000 pcs

Note [2]. The "xx" is device code anf the "Y" is inside code, and the "LL" is Lot code.

Functional Block Diagram

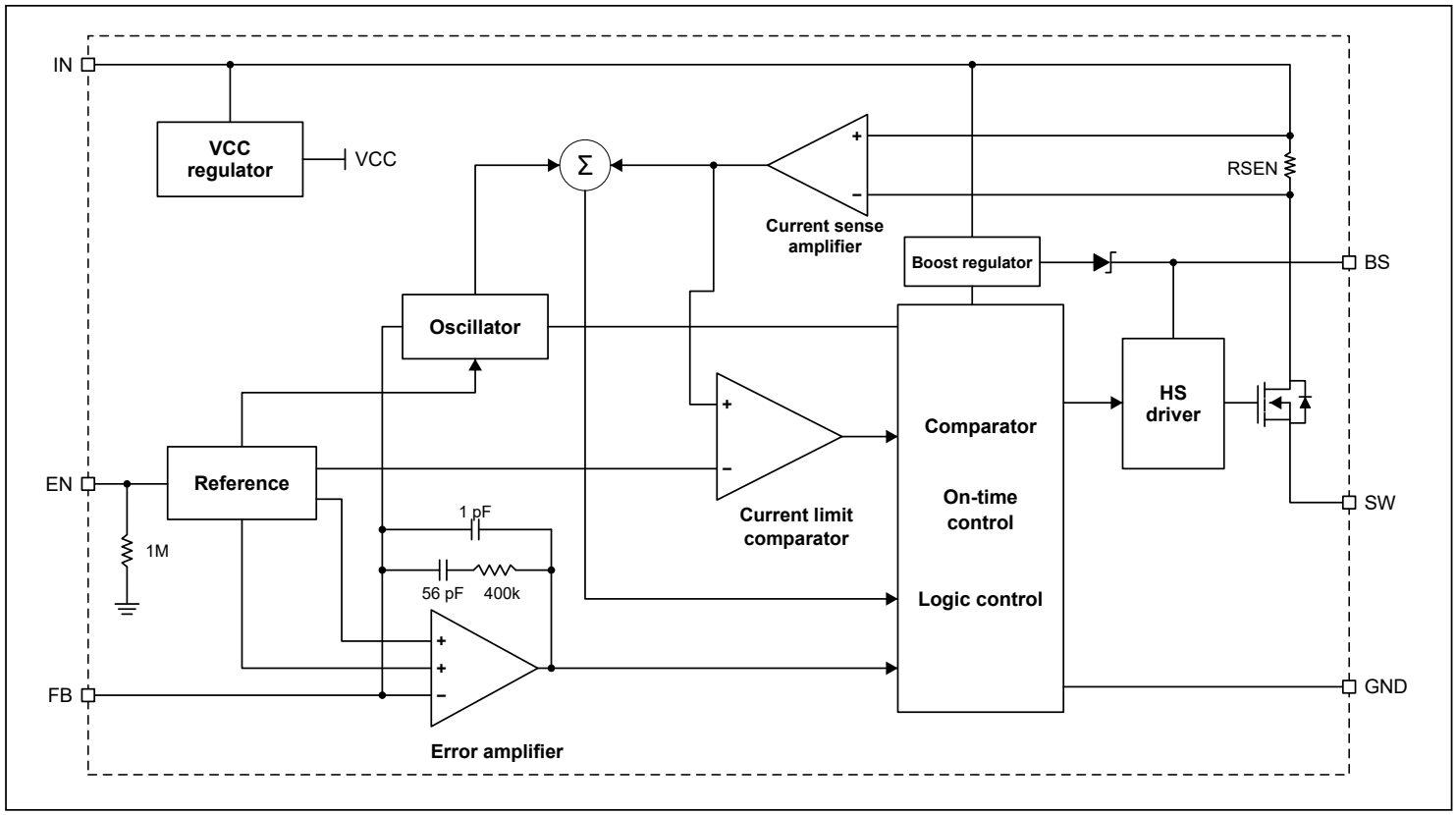


Figure 3. Functional Block Diagram of HCR3453H

Typical Application Circuit

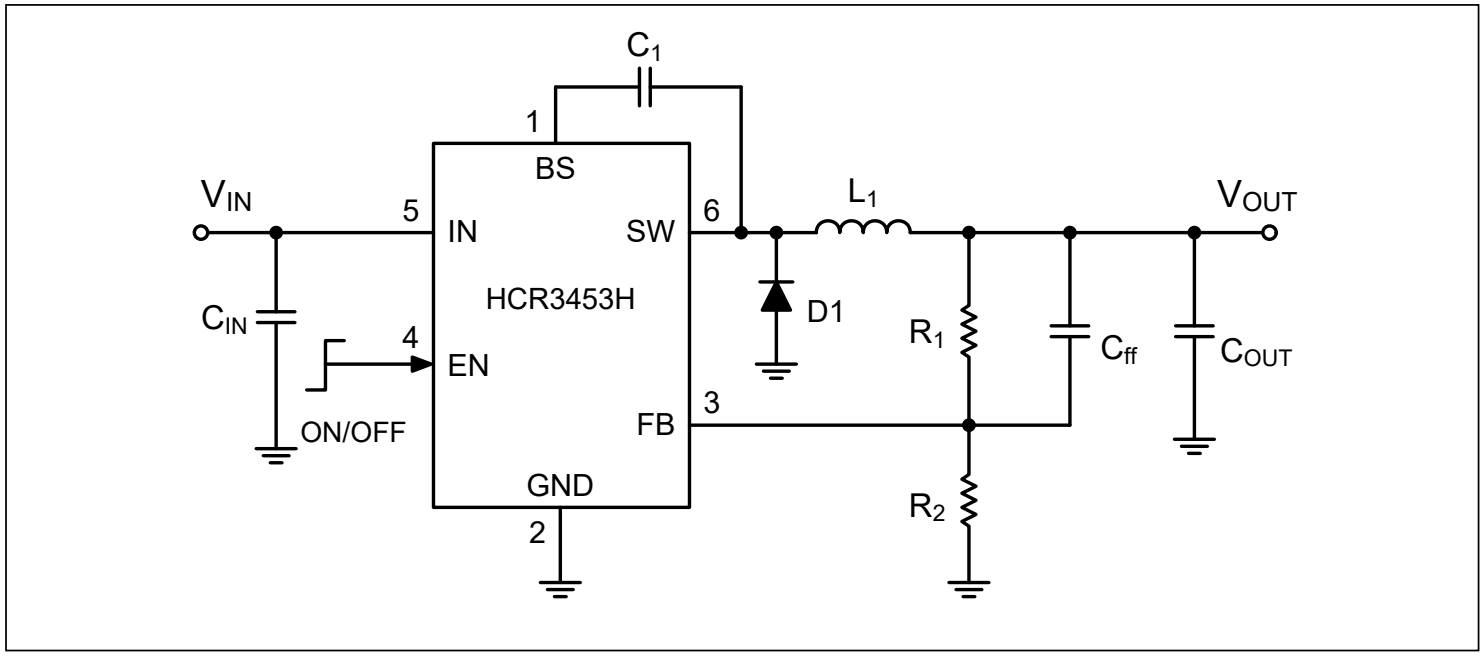


Figure 4. Basic Application Circuit

Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VIN voltage	−0.3	110	V
EN voltage	−0.3	6.5	V
SW voltage	−0.3 (−5 V for < 10 ns)	V_{IN} + 0.5 V (+115 V for < 10 ns)	V
BST voltage	-	V_{SW} + 5	V
FB voltage	−0.3	6.5	V
Power dissipation	-	0.75	W
Operating junction temperature, T_J	−40	150	°C
Storage temperature, T_{stg}	−65	150	°C
Lead temperature (soldering, 10 s)	-	260	°C

Exceeding these ratings may damage the device.
Device operation outside the specified operating conditions is not guaranteed.

Recommended Operating Conditions

Parameter	Min.	Max.	Unit
Operating junction temperature	−40	125	°C
Operating temperature range	−40	85	°C
Input voltage	4.5	100	V
Output voltage	0.8	30	V
Output current (12 V)	0	1.0	A
Output current (5 V)	0	1.0	A
Output current (peak, < 100 ms)	0	1.5	A

All limits are specified at room temperature (T_A = 25 °C) unless otherwise specified. All room-temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Thermal Information

Symbol	Description	SOT23-6L	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	170	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	130	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	46	°C/W

Package thermal impedance is calculated in accordance with JESD 51-7.
Thermal resistances were simulated on a four-layer JEDEC board.

Electrical Characteristics

V_{IN} = 48 V, T_A = 25 °C, unless otherwise specified.

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Input voltage range	-	4.5	-	100	V
Quiescent current into VIN pin	V_{EN} = 5.0 V, V_{IN} = 48 V	-	180	300	μA
Shutdown current into VIN pin	V_{EN} = 0 V, V_{IN} = 48 V	-	-	3	μA
Regulated feedback voltage	V_{IN} = 48 V, T_A = 25 °C	765	780	795	mV
Output voltage line regulation	V_{IN} = 4.5 V to 100 V, V_{OUT} = 5.0 V	-	-	1	%
Output voltage load regulation	V_{IN} = 48 V, V_{OUT} = 5.0 V, ΔV_{LOAD} (0 to 1.5 A)	-	-	1	%
Oscillation frequency	V_{IN} = 48 V, V_{OUT} = 5 V, I_{LOAD} = 1 A	300	450	650	kHz
High-side switch on-resistance	I_{SW} = 1000 mA	-	500	-	mΩ
High-side switch current limit	V_{IN} = 48 V, FB = 90%	-	2.0	-	A
VIN undervoltage lockout threshold	-	-	4.0	-	V
VIN undervoltage lockout threshold hysteresis	-	-	300	-	mV
EN rising threshold	-	1.5	-	-	V
EN falling threshold	-	-	-	0.4	V
EN threshold hysteresis	-	-	200	-	mV
EN leakage current	-	-	-	5.0	μA
SW leakage current	V_{EN} = 0 V, V_{IN} = V_{SW} = 48 V	-	-	2.0	μA
Soft start	-	1	1.8	3	ms
Thermal shutdown	-	-	160	-	°C
Thermal recovery temperature	-	-	30	-	°C

MOSFET on-resistance specifications are guaranteed by correlation to wafer-level measurements.

Thermal shutdown specifications are guaranteed by correlation to the design and characteristics analysis.

Detailed Description

Internal Regulator

The HCR3453H uses constant-on-time (COT) control to provide fast transient response without external loop compensation. An integrated, low-resistance, high-voltage power MOSFET and a 450 kHz switching frequency support a compact, efficient design with good AC and DC performance.

Error Amplifier

The error amplifier compares the FB voltage with the internal feedback reference and generates a current proportional to the difference. This current charges or discharges the internal compensation network, which controls the power MOSFET current. Internal compensation simplifies loop design and reduces the number of external components.

Undervoltage Lockout (UVLO)

UVLO monitors the internal regulator voltage to prevent operation with an insufficient supply. The device shuts down when the voltage falls below the UVLO threshold and is enabled again when the voltage rises above it.

Thermal Shutdown

Thermal protection shuts down the converter when the die temperature reaches 160°C (typical). Operation resumes when the die cools to the recovery temperature of 30°C (typical).

Internal Soft-Start

Soft-start limits output-voltage overshoot at startup. The internal soft-start voltage (SS) ramps from 0 V to 0.78 V. While SS is below the internal reference (REF), the error amplifier uses SS as its reference. When SS exceeds REF, the amplifier returns to the internal reference. The maximum soft-start time is 3.0 ms.

Startup and Shutdown

The chip starts when both V_{IN} and EN exceed their respective thresholds. The reference block starts first, generating stable reference voltages and currents. The internal regulator then supplies the remaining circuitry.

A low EN voltage, a low V_{IN} voltage, or thermal shutdown can turn off the device. During shutdown the signal path is blocked first to prevent false triggering. The compensation voltage and internal supply rail are then pulled down. The floating driver is unaffected by this shutdown command.

Application Information

Setting the Output Voltage

An input capacitor, an output capacitor and an inductor are required for proper operation. The device is internally compensated. An external resistor divider sets the output voltage as shown in Figure 4.

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

R_1 connects V_{OUT} to FB. R_2 connects FB to ground. The table below lists the component values for 5 V and 12 V outputs.

Selecting the Inductor

Select an inductor that will not saturate under any expected operating condition. Check the peak load current and ripple current. Manufacturers may specify saturation current differently and usually rate it at 25°C. Verify the rating at the highest ambient temperature of the application.

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

Choose an inductor ripple current (ΔI_L) of approximately 30% of maximum load current. The maximum inductor current is:

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

At light loads below 100 mA, a larger inductance is recommended to improve efficiency.

Recommended Component Values

V_{OUT}	R_1	R_2	L1	D1	C_{IN}	C_{OUT}	C_{FF}
12 V	144 kΩ 1%	10 kΩ 1%	33 µH 2 A	SS310	2 × 2.2 µF 100 V	22 µF + 22 µF	10 pF
5 V	54 kΩ 1%	10 kΩ 1%	33 µH 2 A	SS310	2 × 2.2 µF 100 V	22 µF + 22 µF	47 pF

Application Information (Continued)

Selecting the Output Capacitor

DC bias can reduce effective ceramic capacitance below the minimum recommended for the design. Capacitance also changes with temperature. X7R capacitors vary by no more than ±15% over −55°C to +125°C. X5R capacitors offer a similar tolerance over −55°C to +85°C.

Many ceramic capacitors above 1 µF use Z5U or Y5V dielectrics. Their capacitance can drop by more than 50% as the temperature rises from 25°C to 85°C. Use X5R or X7R when the ambient temperature can vary significantly above or below 25°C.

For equal capacitance and voltage ratings in the 0.47 µF to 44 µF range, tantalum capacitors are generally more expensive than ceramic capacitors. Their equivalent series resistance (ESR) is also higher for a given size. Meeting the stable ESR range may therefore require a higher-capacitance, larger, and more costly tantalum capacitor.

Allow margin for temperature effects: the ESR of a typical tantalum capacitor approximately doubles as its temperature falls from 25°C to −40°C.

PCB Layout Guidelines

PCB layout is important for high-frequency switching converters. Poor layout can impair line or load regulation and cause instability.

1. Keep the high-current GND, V_{IN} and SW paths close to the device. Use short, direct, wide traces.

2. Place the input capacitor as close to V_{IN} and GND as possible.

3. Place the VCC bypass capacitor as close to VCC as possible.

4. Route the SW node away from the output-voltage sensing network.

5. Place an array of thermal vias under the exposed pad to improve heat conduction.

Recommended Application Circuits

12 V Output at 1.0 A

Input: 30 V to 100 V DC. With EN floating: 12 V to 100 V.

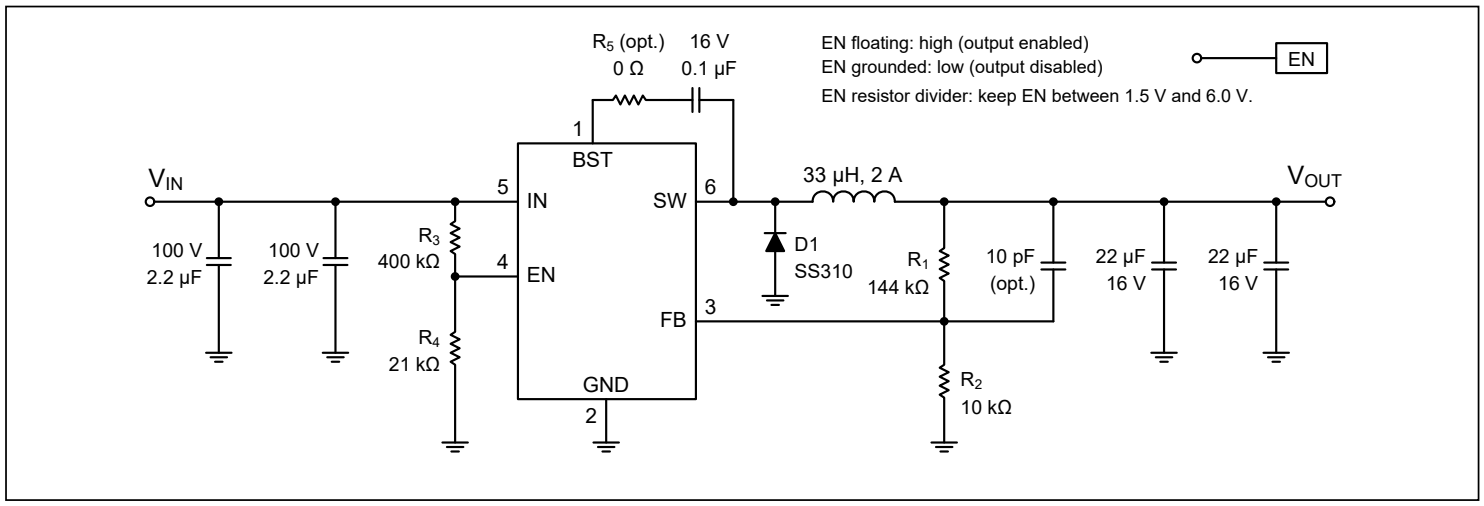


Figure 5. 12 V Output Application Circuit

5 V Output at 1.0 A

Input: 30 V to 100 V DC. With EN floating: 5.5 V to 100 V.

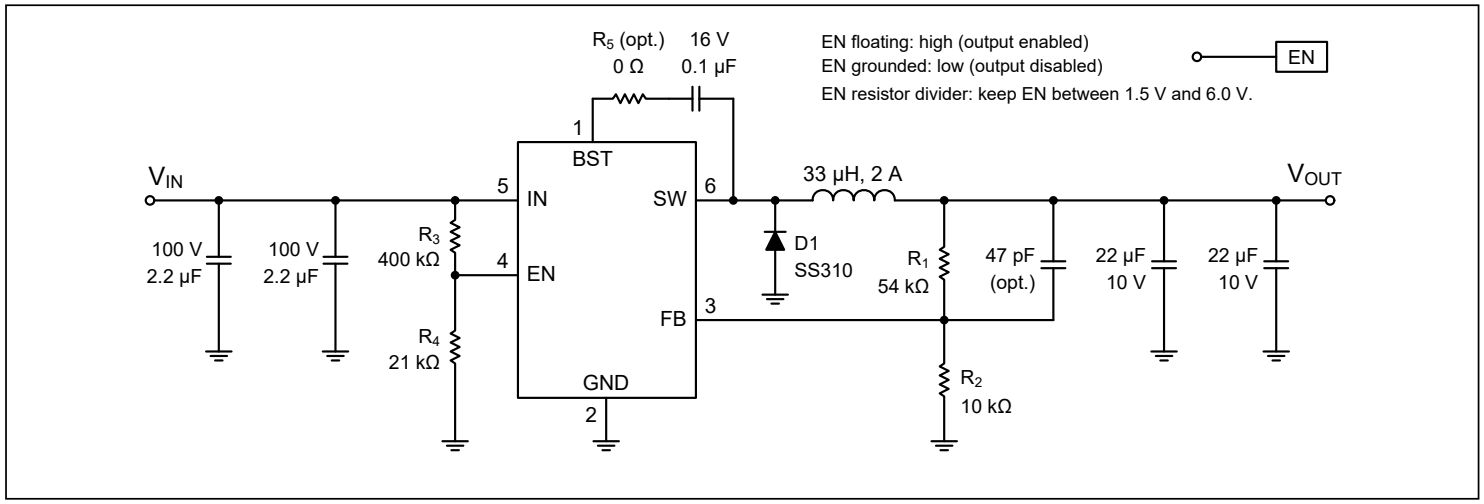


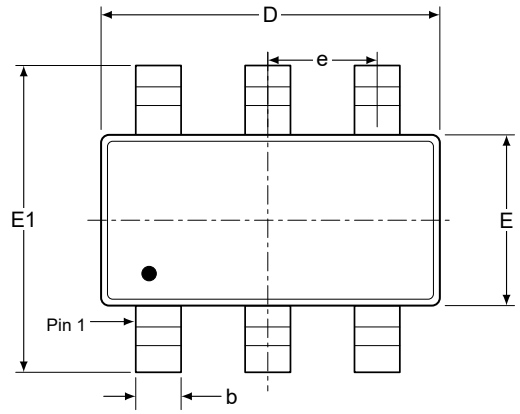
Figure 6. 5 V Output Application Circuit

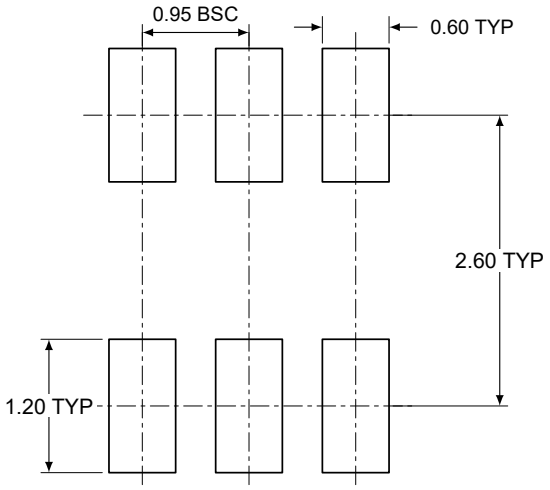
For hot-plug applications, use an SMCJ-series input TVS diode rated above 1000 W to protect the IC from surge voltage.

Mechanical Dimensions

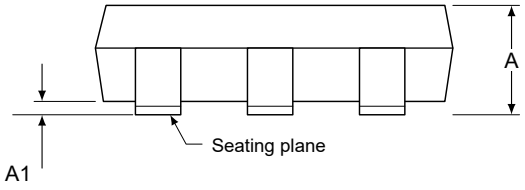
M6L PKG: TSOP-6 (SOT23-6L)

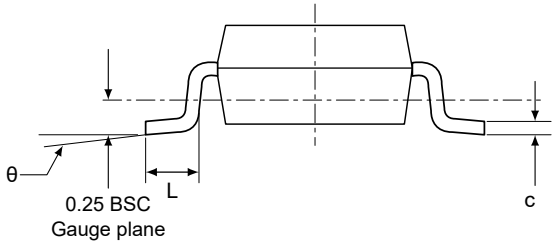
Unit: mm





RECOMMENDED LAND PATTERN

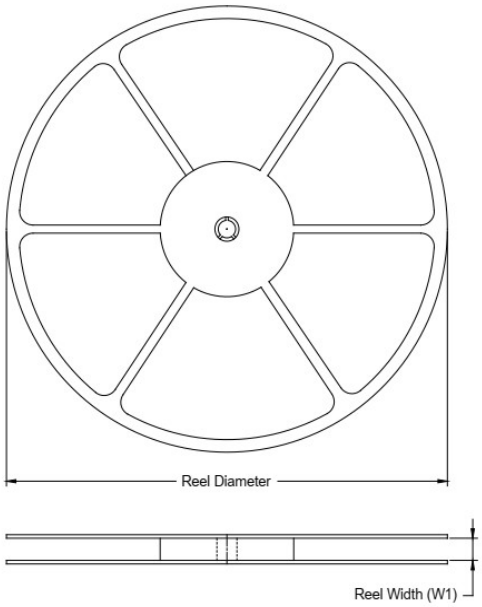




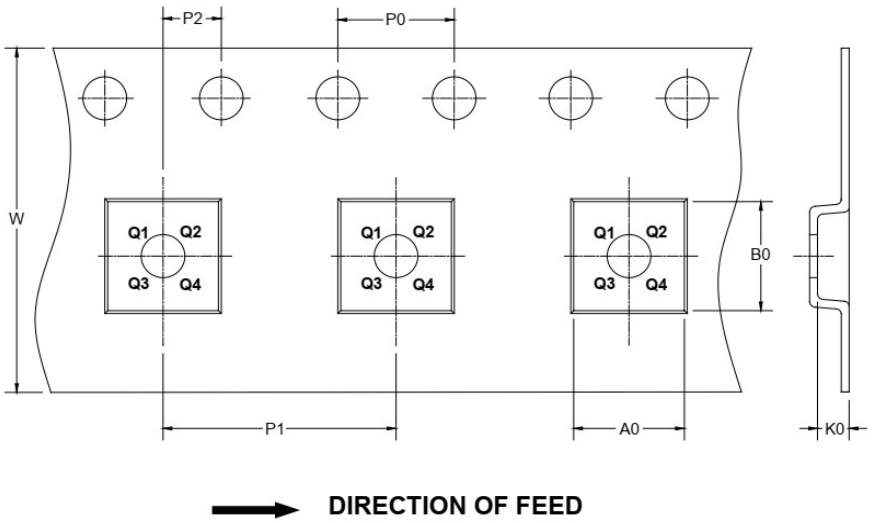
Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	-	-	1.45
A1	0.00	-	0.15
b	0.25	-	0.50
c	0.09	-	0.20
D	2.80	-	3.00
E	1.50	-	1.70
E1	2.60	-	3.10
e	0.95 BSC		
L	0.30	-	0.55
θ	0°	-	8°

Tape and Reel Information

REEL DIMENSIONS



TAPE DIMENSIONS



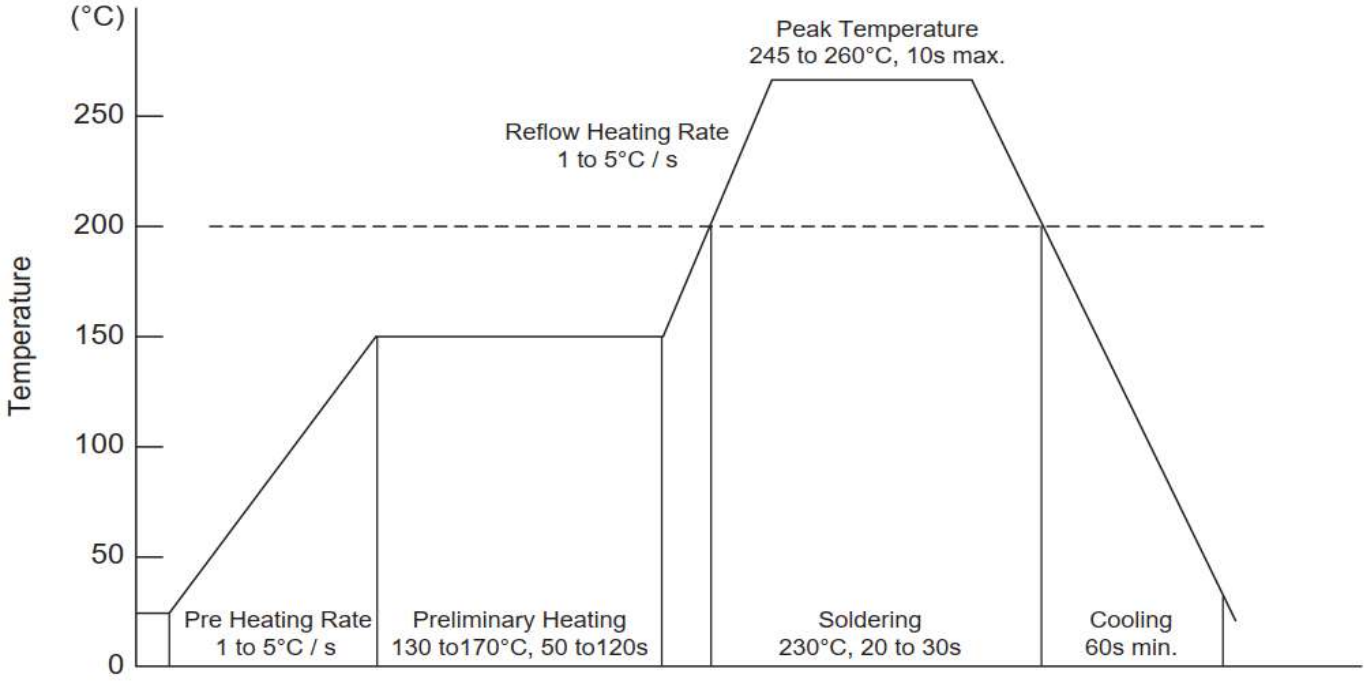
NOTE: The picture is only for reference. Please make the object as the standard.

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

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
    Two year after manufacturing