WS4694C

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28-V, Over-Voltage and Over-Current Protection Load Switch with Adjustable Current-Limit Control

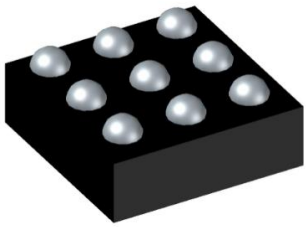

Figure 1 CSP-9L

Descriptions

The WS4694C is a small, low RON, single channel load switch with controlled slew rate. The device operates over an input voltage range of 2.6 V to 5.5 V. The device supports current limit from 0.05 A to 2 A.

The controlled rising time of the device greatly reduces inrush current caused by large bulk load capacitance, thereby reducing or eliminating power supply drop. The WS4694C has a True Reverse-Current Blocking (TRCB) function that obstructs unwanted reverse current from VOUT to VIN during ON and OFF states. The small size and low R_{ON} device is designed for space constrained battery powered applications. The wide input voltage range of the switch makes it a versatile solution for many different voltage rails.

The WS4694C are available in a CSP-9L package. Standard products are Pb-free and Halogen-free.

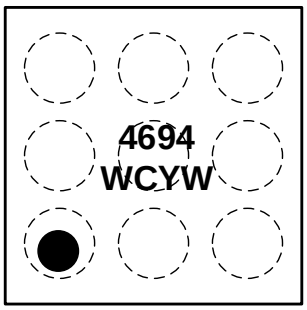

Figure 2 Marking (Top View)

4694 = Device Code
WC = Special Code
Y = Year Code
W = Week Code

Features

- Input Voltage Range: 2.6 V ~ 5.5 V
- Absolute Rating at V_{OUT}: 28 V
- Maximum Output current: 2.0 A
- Adjustable Current Limit: 0.05 A ~ 2.0 A
  1 A ~2.0 A with 15% Accuracy
- True Reverse-Current Blocking (TRCB)
- Under-Voltage Lockout and Thermal Shutdown
- CSP-9L

Applications

- Smart Phones, Tablet PCs
- Storage, DSLRs, and other portable devices

Order Information

Table 1

Device	Package	Shipping
WS4694C-9/TR	CSP-9L	3000/Reel&Tape

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Pin Information

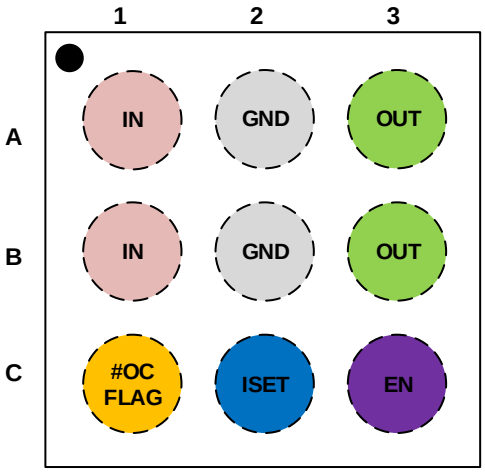

Figure 3 Pin Information (Top View)

Table 2

Pin	Symbol	Description
A3, B3	OUT	Output pin
A1, B1	IN	Input pin
A2, B2	GND	Ground
C3	EN	ON/OFF Control Input: Active HIGH
C2	ISET	Current Limit Set Input: A resistor from ISET to ground sets the current limit for the switch.
C1	#OCFLAG	Fault Output: Active LOW, open-drain output that indicates an input over current. An external pull-up resistor to VDD is required.

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Block Diagram

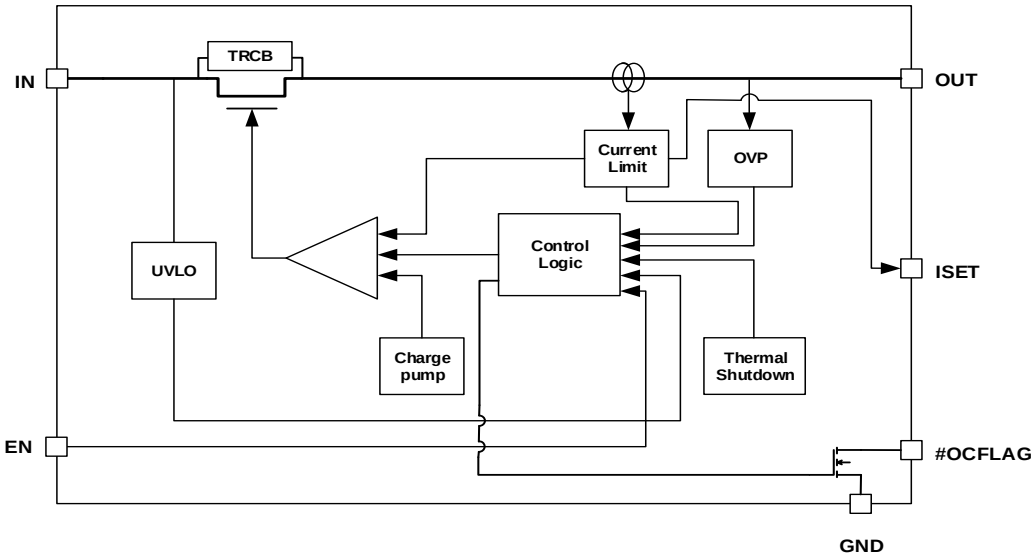

Figure 4 Block Diagram

Typical Application

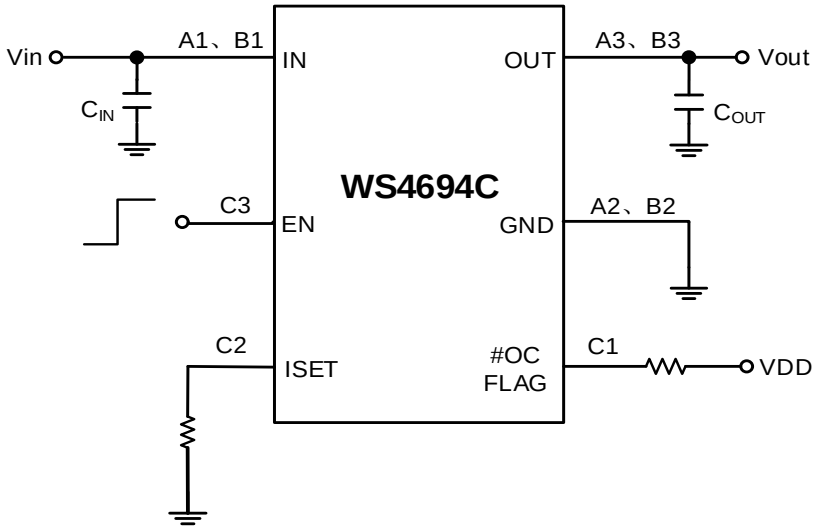

Figure 5 Typical Application

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Absolute Maximum Ratings

These are stress ratings only. Stresses exceeding the range specified in Table 3 might cause substantial damage to the device. Functional operation of the device at other conditions beyond those listed in the specification is not implied. Prolonged exposure to extreme conditions might affect device reliability.

Table 3

Parameter	Symbol	Min.	Max.	Unit
V_{OUT} to GND, V_{OUT} to VIN	OUT	-0.3	28	V
Other Pins to GND	IN, EN, ISET, #OCFLAG	-0.3	6	V
Maximum Continuous Switch Current (1)	I_{SW}	2.3		A
Operating Junction Temperature	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C
Lead Temperature	T_L	260		°C
ESD Ratings	HBM	5		kV
	CDM	2		kV
	Air Discharge (V_{IN}, V_{OUT} to GND)	15		kV
	Contact Discharge (V_{IN}, V_{OUT} to GND)	8		kV

(1) Maximum Junction Temperature = 85°C

Recommend Operation Ratings

The following table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications.

Table 4

Parameter	Symbol	Min.	Max.	Unit
Supply Voltage	VIN	2.6	5.5	V
Other Pins	EN, ISET, #OCFLAG	2.5	5.5	V
Operating Ambient Temperature	T_A	-40	85	°C
Thermal Resistance, $R_{\theta JA}$ (CSP-9L) (2)	$R_{\theta JA}$	110		°C/W

(2) Surface mounted on FR-4 Board using 2 oz, 1 square inch Cu area, PCB board size 1.5*1.5 square inches.

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Electrical Characteristics

T_A = -40 to +85°C, V_{IN} = 2.6 to 5.5 V, Typical values are at V_{IN} = 5 V and T_A = 25°C, unless otherwise noted.

Table 5

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Basic Operation						
Input Voltage	V_{IN}		2.6		5.5	V
Quiescent Current	I_Q	V_{IN}= V_{EN}, V_{OUT}=Open, T_A=25°C		80	150	μA
Shutdown Current	I_{SD}	V_{IN}=5.5 V, V_{OUT}=0 V, V_{EN}=GND		0.1		μA
Off Supply Current	$I_{Q(OFF)}$	V_{EN}=GND, V_{OUT}=Open		1		μA
On Resistance	R_{ON}	V_{IN}=V_{EN}=5 V, I_{OUT}=1 A, T_A=25°C		75	100	mΩ
		V_{IN}=V_{EN}=3.7 V, I_{OUT}=1 A, T_A=25°C		85	105	
EN Logic High Voltage	V_{IH}	V_{IN}=5 V, I_{OUT}=0.1 A	1.1			V
EN Logic Low Voltage	V_{IL}	V_{IN}=5 V, I_{OUT}=0.1 A			0.4	V
#OCFLAG Output Logic Low Voltage	V_{IL_FLAG}	V_{IN}=5 V, I_{SINK}=10 mA		0.1	0.2	V
		V_{IN}=2.6 V, I_{SINK}=10 mA		0.15	0.3	V
#OCFLAG Output Logic High Leakage Current	I_{FLAG_LK}	V_{IN}=5 V, Switch on		0.1	1	μA
EN Input Leakage	I_{ON}	V_{EN}=0 V to V_{IN}			1	μA
Pull-Down Resistance at EN Pin	R_{EN_PD}	V_{IN}=2.6~5.5 V, V_{EN}=High TA= -40 to 85°C		14		MΩ
Over-Voltage Protection						
Output OVP Lockout	V_{OV_TRIP}	V_{OUT} Rising Threshold	5.5	5.8	6	V
		V_{OUT} Falling Threshold		5.5		
Output OVP Hysteresis	OUT_{HYS}			0.3		V
OVP Response Time(3)	t_{OVP}	I_{OUT}=0.5 A, C_L=1 μF, T_A=25°C, V_{OUT} from 5.5 V to 6.0 V	1		4	μs
Over-Current Protection						
Current Limit	I_{LIM}	V_{IN}=V_{EN}=5 V, R_{SET}=1000 Ω	850	1000	1150	mA
		V_{IN}=V_{EN}=5 V, R_{SET}=500 Ω	1700	2000	2300	
Under-Voltage Lockout	V_{UVLO}	V_{IN} Increasing		2.4		V
		V_{IN} Decreasing		2.2		
UVLO Hysteresis	V_{UVLO_HYS}			200		mV
RCB Protection Trip Point	V_{T_RCB}	V_{OUT} - V_{IN}		50		mV

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Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
RCB Protection Release Trip Point	V_{R_RCB}	V_{IN} - V_{OUT}		50		mV
RCB Hysteresis	V_{RCB_HYS}			100		mV
Default RCB Response Time(3)	t_{RCB}	V_{IN}=5 V, V_{EN}=High/Low		2		µs
RCB Current	I_{RCB}	V_{EN}=0 V, V_{OUT}=5.5 V		7		µA
Hard Over-Current Response Time(3)	t_{HOCP}	Moderate Over-Current Condition, $I_{OUT} \geq I_{LIM}$, V_{OUT}=0 V		2		µs
Over-Current Response Time(3)	t_{OCP}	Moderate Over-Current Condition, $I_{OUT} \geq I_{LIM}$, $V_{OUT} \leq V_{IN}$		25		µs
Over-Current Flag Response Time	t_{OC_FLAG}	When Over-Current Occurs to Flag Pulling LOW		8		ms
Thermal Shutdown	TSD	Shutdown Threshold		150		°C
		Return from Shutdown		130		
		Hysteresis		20		
Turn-On Delay	T_{DON}	V_{IN}=5 V, R_L=100 Ω, C_L=1 uF R_{SET}=2000 Ω, T_A=25°C		0.8		ms
V_{OUT} Rise Time	T_R			0.3		
Turn-On Time	T_{ON}			1.1		
Turn-Off Delay	T_{DOFF}			10		µs
V_{OUT} Fall Time	T_F			270		
Turn-Off Time	T_{OFF}			280		
Turn-On Delay	T_{DON}	V_{IN}=5 V, R_L=3.8 Ω, C_L=10 uF R_{SET}=600 Ω, T_A=-40 to 85°C		0.8		ms
V_{OUT} Rise Time	T_R			0.5		
Turn-On Time	T_{ON}			1.3		
Turn-Off Delay	T_{DOFF}			10		µs
V_{OUT} Fall Time	T_F			230		
Turn-Off Time	T_{OFF}			240		

(3) This parameter is guaranteed by design.

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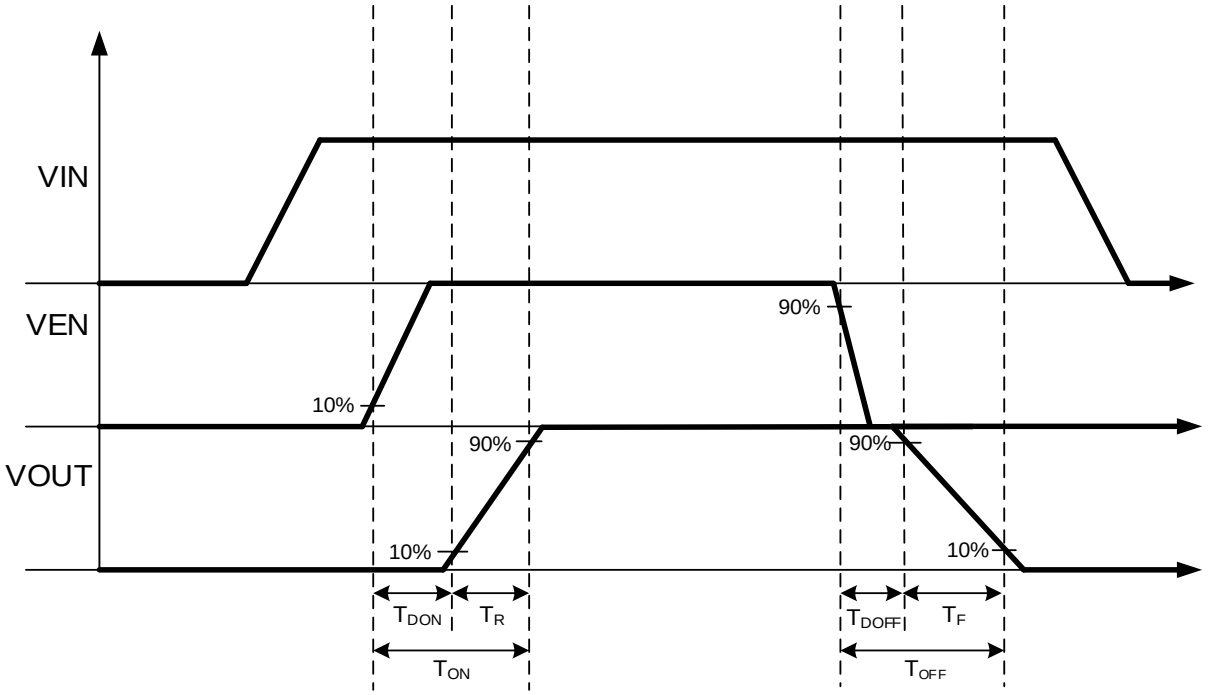
Timing Diagram



Note: $T_{ON}=T_{DON}+T_R$, $T_{OFF}=T_{DOFF}+T_F$.

Figure 6 Timing Diagram

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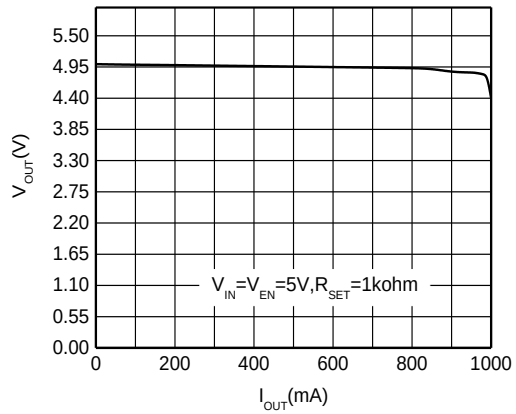
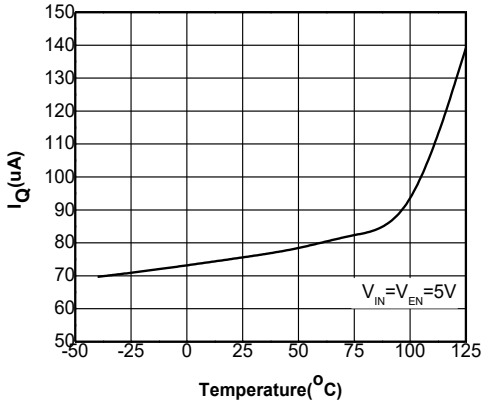
Typical characteristics

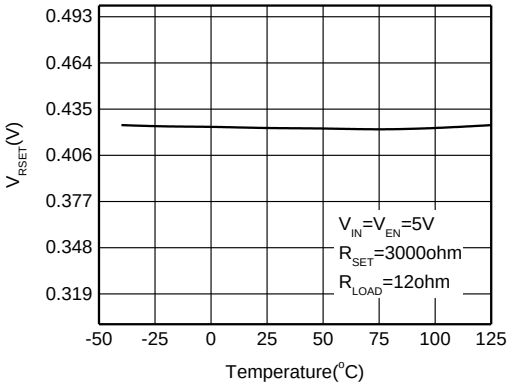
T_A = 25ºC, V_{IN} = V_{EN} = 5 V, C_{IN} = 1 µF, C_{OUT} = 1 µF, unless otherwise noted.



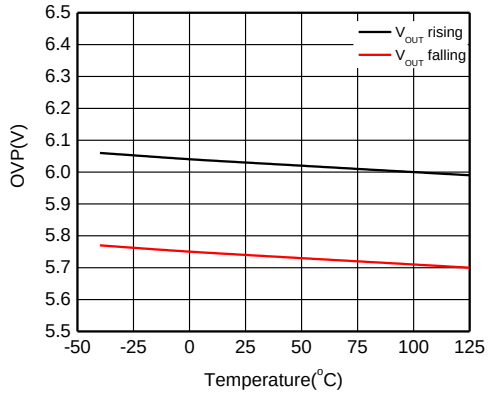
V_{OUT} VS. I_{OUT}



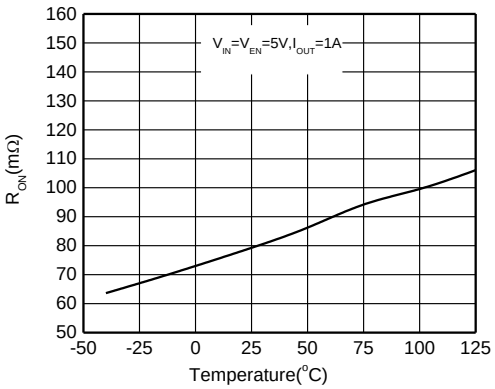
I_Q VS. Temperature



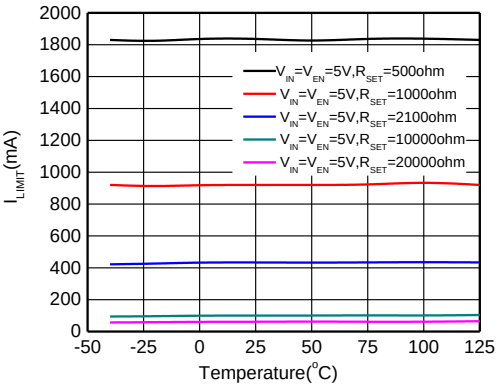
V_{RSET} VS. Temperature



OVP VS. Temperature



R_{ON} VS. Temperature



I_{LIMIT} VS. Temperature

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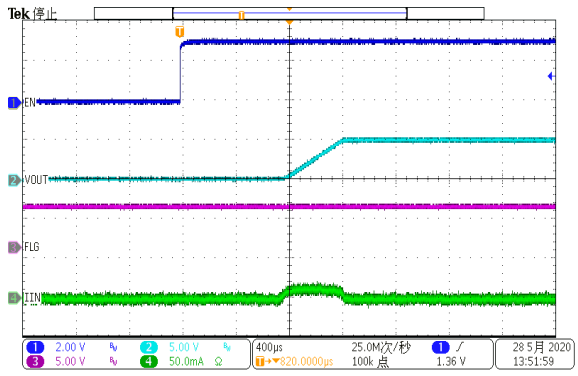
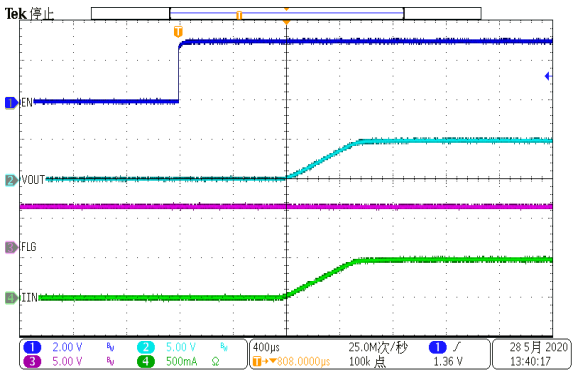
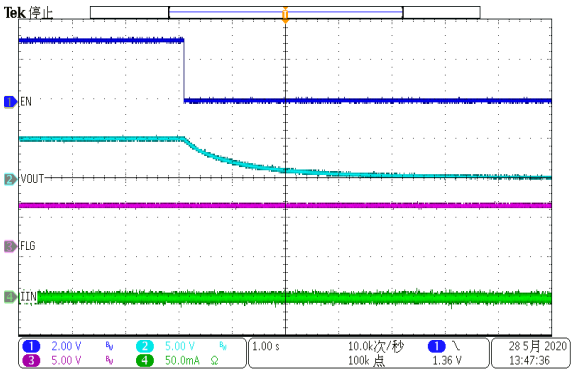


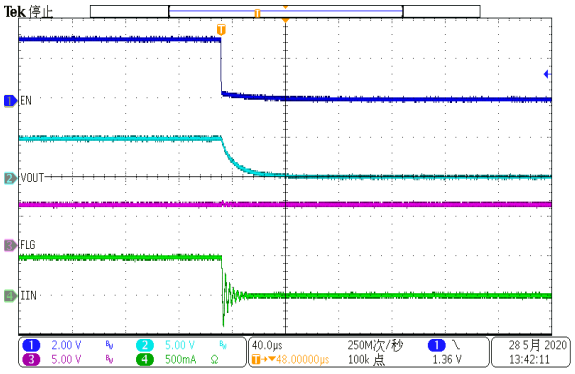
Start up by EN, C_{IN}=C_{OUT}=1 uF, V_{IN}=V_{EN}=5 V, R_{SET}=1 K, I_{OUT}=0 mA



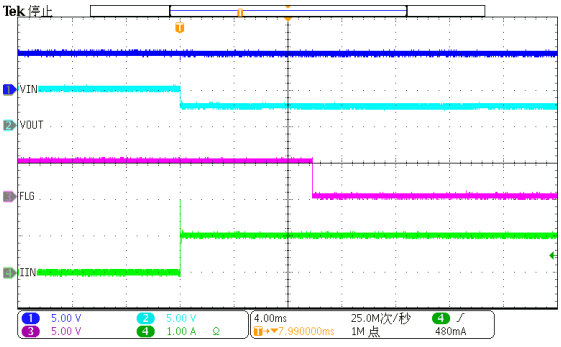
Start up by EN, C_{IN}=C_{OUT}=1 uF, V_{IN}=V_{EN}=5 V, R_{SET}=1 K, I_{OUT}=500 mA



Shut down by EN, C_{IN}=C_{OUT}=1 uF, V_{IN}=V_{EN}=5 V, R_{SET}=1 K, I_{OUT}=0 mA



Shut down by EN, C_{IN}=C_{OUT}=1 uF, V_{IN}=V_{EN}=5 V, R_{SET}=1 K, I_{OUT}=500 mA



Current limit, C_{IN}=C_{OUT}=1 uF, V_{IN}=V_{EN}=5 V, R_{SET}=1 K, R_{LOAD}=2.5 Ω

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Application Information

Input Capacitor

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch turns on, a capacitor needs to be placed between the VIN and the GND. Higher values of CIN can be used to further reduce the voltage drop in high-current applications.

Output capacitor

An output capacitor needs to be placed between the VOUT and the GND pin. The capacitor prevents parasitic board inductance from forcing VOUT below GND when the switch is on. The capacitor also prevents reverse inrush current from a voltage spike that could damage the device in the case of a VOUT short.

Fault Reporting

Upon the detection of an over-current, #OC_FLAG signals the fault by activating LOW.

Current Limiting

The current limit ensures that the current through the switch does not exceed the maximum set value, while not limiting the minimum value. The current at which the part's limit is adjustable through the selection of the external resistor connected to the ISET pin. Information for selecting the resistor is found in the section below. The device acts as a constant-current source when the load draws more than the maximum value set by the device until thermal shutdown occurs. The device recovers if the die temperature drops below the threshold.

Under-Voltage Lockout

The Under-Voltage Lockout (UVLO) turns off the switch if the input voltage drops below the lockout threshold. With the EN pin activated, the input voltage rising above the UVLO threshold releases the lockout and enables the switch.

True Reverse-Current Blocking

The true reverse-current blocking feature protects the input source against current flow from output to input regardless of whether the load switch is on or not.

Thermal Shutdown

The thermal shutdown protects the die from internally or externally generated excessive temperature. During an over-temperature condition, the switch is turned off. The switch automatically turns on again if the temperature of the die drops below the threshold temperature.

Setting Current Limit

The current limit is set with an external resistor connected between the ISET and GND pins.
The current limit is calculated as the following:

$$I_{LIMIT}(A) = \frac{1000}{Rset(\Omega)}$$

The resistor tolerance of 1% or less is recommended.

Table 6 Current Limit Settings by R_{SET}

$R_{SET}\Omega$	Min. Current Limit (mA)	Typ. Current Limit (mA)	Max. Current Limit (mA)
500	1700	2000	2300
571	1490	1750	2010
667	1275	1500	1725
800	1065	1250	1435
1000	850	1000	1150
1111	750	900	1050
1250	650	800	950
1429	550	700	850
1667	450	600	750
2000	350	500	650

Note: Table values are based on 1% tolerance resistors.

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Layout Guide

For best performance, all traces need to be as short as possible. To be the most effective, the input and output capacitors need to be placed close to the device to minimize the effect that parasitic trace inductance might have on normal and short-circuit operation. Using wide traces for VIN, VOUT, GND helps minimize parasitic electrical effects along with the case-to-ambient thermal impedance.

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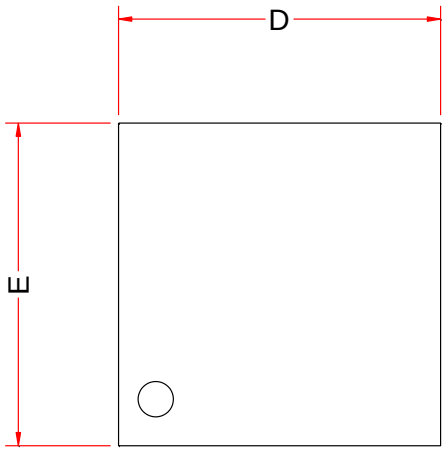
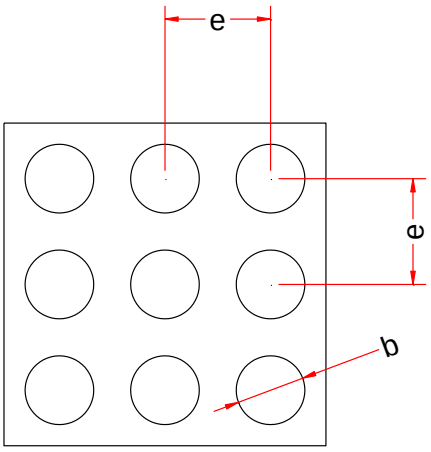
Package Outline Dimensions

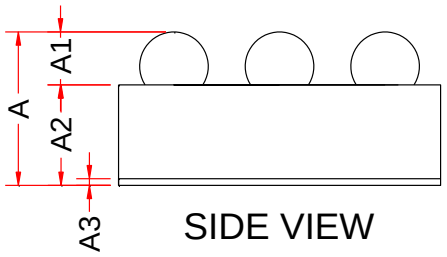
CSP-9L



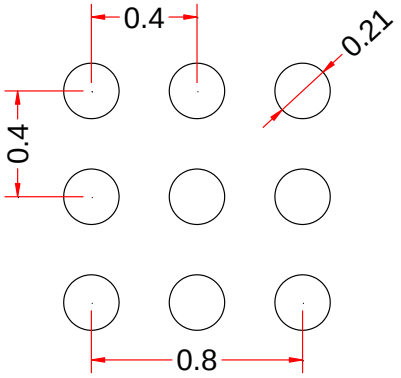
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN(unit:mm)

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.54	0.58	0.63
A1	0.18	0.20	0.22
A2	0.36	0.38	0.41
A3	0.025 Ref.		
D	1.19	1.22	1.25
E	1.19	1.22	1.25
b	0.24	0.26	0.28
e	0.40 BSC		

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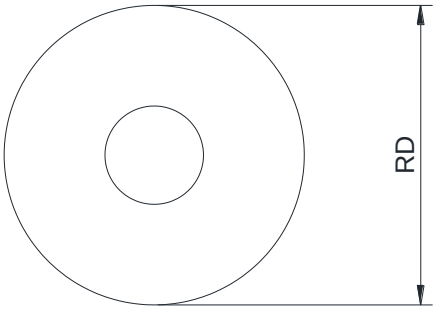
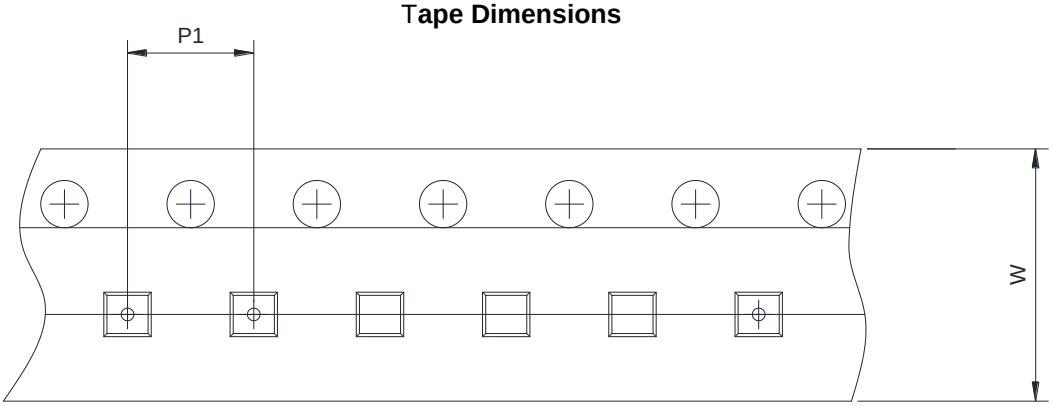
Tape And Reel Information

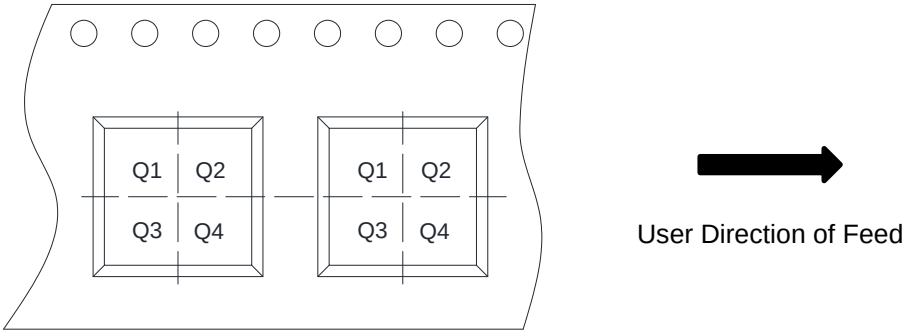
Reel Dimensions



Tape Dimensions



Quadrant Assignments for PIN1 Orientation in the Tape



RD	Reel dimension	☑ 7inch	☐ 13inch		
W	Overall width of the carrier tape	☑ 8mm	☐ 12mm		
P1	Pitch between successive cavity centers	☐ 2mm	☑ 4mm	☐ 8mm	
Pin1	Pin1 quadrant	☑ Q1	☐ Q2	☐ Q3	☐ Q4

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