Battery Output Current Sense Protection IC

General Description

The RT9554A is designed for over-current detection. The current sense amplifier amplifies the voltage across resistor which is connected between CSP and CSN by 200. The amplified voltage is compared with the voltage of BAT_REF and check whether over-current happens or not. The RT9554A also provides a comparator with two input pins, AC_REAL and AC_REF for users. There is an output pin $\overline{\text{FLAG}}$ as an indicator which is a N-MOSFET in open-drain configuration. Users can connect one resistor between the $\overline{\text{FLAG}}$ pin and supply voltage. Either over-current condition occurs or the AC_REAL voltage is larger than the AC_REF voltage, the $\overline{\text{FLAG}}$ is pulled low. The RT9554A is a available in the WDFN-8L 2x2 package.

Ordering Information

RT9554A □□

- Package Type
  QW : WDFN-8L 2x2 (W-Type)
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Features

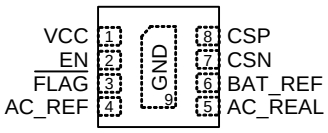
- **Common Mode Input Range up to 24V**
- **VCC Operating Current : 200μA**
- **VCC Shutdown Current : 5μA (under S3/S4/S5)**
- **Programmable Over-Current Level**
- **$\overline{\text{FLAG}}$ Signal goes Low when OCP**
- **RoHS Compliant and Halogen Free**

Applications

- Notebooks

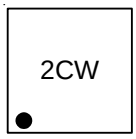
Pin Configurations

(TOP VIEW)



WDFN-8L 2x2

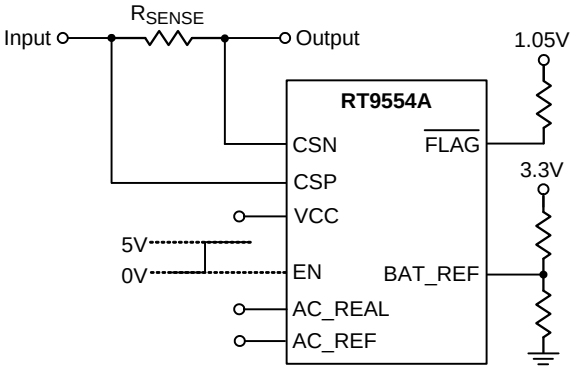
Marking Information



2C : Product Code

W : Date Code

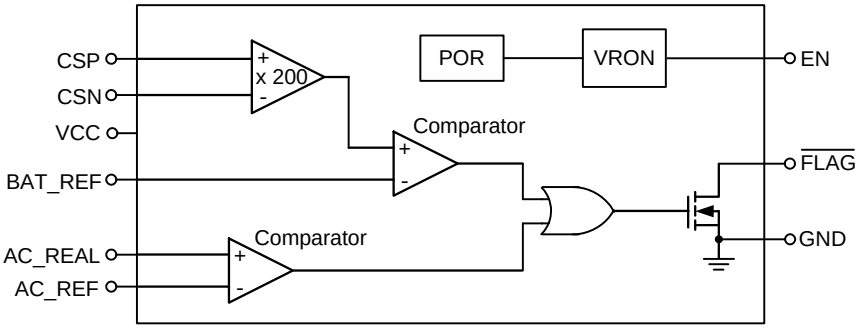
Simplified Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	VCC	Power Supply Input. Connect this pin to 5V and place a minimum 0.1μF decoupling capacitor .The decoupling capacitor should be placed to this pin as close as possible.
2	EN	Enable Control Input.
3	$\overline{\text{FLAG}}$	Open-Drain Output. Connected to an external resistor. When over-current occurs, this pin will be pulled low.
4	AC_REF	Comparator Inverting Input.
5	AC_REAL	Comparator Non-Inverting Input.
6	BAT_REF	Over-Current Threshold Setting. It is used to set over-current threshold from 0.4V to 2V.
7	CSN	Negative Current Sense Input.
8	CSP	Positive Current Sense Input.
9 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation

Function Block Diagram



Operation

The RT9554A consists of one current sensing amplifier and one comparator, and it provides the following functions : over-current protection and voltage comparison between AC_REAL and AC_REF. Users can connect one resistor between the $\overline{\text{FLAG}}$ pin and supply voltage. Either over-current condition or the occurs AC_REAL voltage is larger than AC_REF, the $\overline{\text{FLAG}}$ pin is pulled low.

Over Current Protection

With 1mΩ order of resistor shunts between CSP and CSN, the current sensing amplifier amplifies the voltage between CSP and CSN by 200 and compares the result with the BAT_REF voltage. If the output voltage of current sensing amplifier is larger than the BAT_REF voltage, the $\overline{\text{FLAG}}$ pin is pulled low.

AC_REAL & AC_REF Comparison

A comparator is designed for the voltage comparison between AC_REAL and AC_REF. If the voltage of AC_REAL is larger than AC_REF, the $\overline{\text{FLAG}}$ pin is pulled low.

Absolute Maximum Ratings (Note 1)

- CSP/CSN to GND ---------- –0.3V to 26V
- VCC, BAT_REF, EN, AC_REAL, AC_REF, $\overline{FLAG}$ to GND ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  WDFN-8L 2x2 ---------- 2.19W
- Package Thermal Resistance (Note 2)
  WDFN-8L 2x2, θ_{JA} ---------- 45.5°C/W
  WDFN-8L 2x2, θ_{JC} ---------- 11.5°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 2kV
  MM (Machine Model) ---------- 200V

Recommended Operating Conditions (Note 4)

- High-Side Voltage, VCSP/VCSN ---------- 4.5V to 24V
- Supply Voltage, VCC ---------- 4.5V to 5.5V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{CC} = 5V, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
CSN CSP Input							
Input Voltage Range		V_{CSP}, V_{CSN}		5	--	24	V
I_{CSN} + I_{CSP}			EN = High	--	50	--	μA
			EN = Low	--	--	5	μA
VCC Input							
VCC Operating Current		I_{VCC}	V_{CC} > POR, EN = High	--	200	--	μA
VCC Shutdown Current		I_{VCC_shd}	V_{CC} > POR, EN = Low	--	2	5	μA
VCC POR Rising Voltage		V_{IN_POR}	Rising	2.8	--	3.7	V
			Hysteresis	--	400	--	mV
Enable							
Enable Input Voltage	Logic-High	V_{IH}		0.7	--	--	V
	Logic-Low	V_{IL}		--	--	0.3	V
Current Sense Circuit							
System Response Time		OC_{delay}	OCP triggered	--	50	--	μs
OP Gain		A_V	V_{CSP} = V_{CSN} = 12V	--	200	--	V/V

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
$\overline{\text{FLAG}}$ Pull Low Voltage		I_{SINK} = 10mA	--	--	0.1	V
Input Current Sensing Accuracy	CS_{acc}	V_{BAT_REF} = 0.4V	--	--	15	%
		V_{BAT_REF} = 0.8V	--	--	10	%
		V_{BAT_REF} = 2V	--	--	5	%
$\overline{\text{FLAG}}$ Leakage Current	$I_{leak\_\overline{FLAG}}$	EN Low	--	--	5	μA
OCSET Comparator						
BAT_REF Leakage Current	$I_{leak\_BAT\_REF}$	EN Low	--	--	5	μA
BAT_REF Input Range	V_{BAT_REF}		0.4	--	2	V
AC_REAL & AC_REF Comparator						
Comparator Offset	$V_{OS\_AL\_CMP}$	V_{AC_REAL} = 0.3V to 2V	--	--	10	mV
AC_REAL Input Range	V_{AC_REAL}		0.3	--	2	V
AC_REF Input Range	V_{AC_REF}		0.3	--	2	V
Comparator Response Time		$V_{AC\_REAL} > V_{AC\_REF}$ $\overline{\text{FLAG}}$ go low	--	--	200	ns

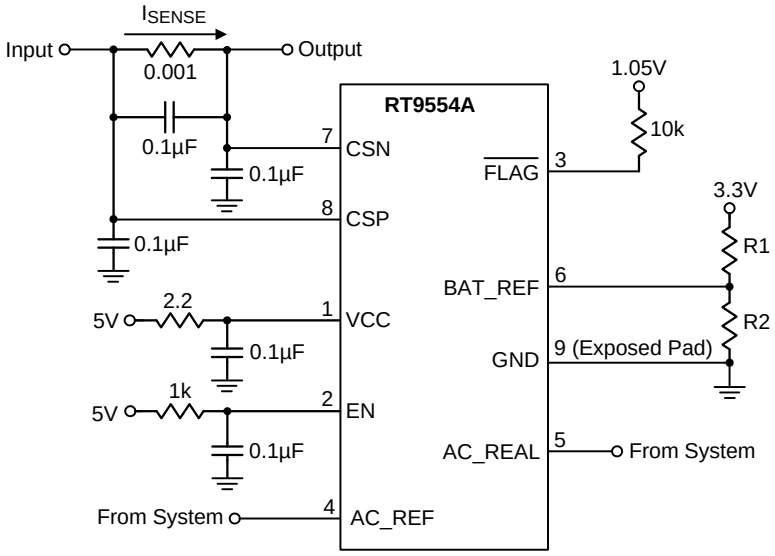
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

Note 3. Devices are ESD sensitive. Handling precaution is recommended.

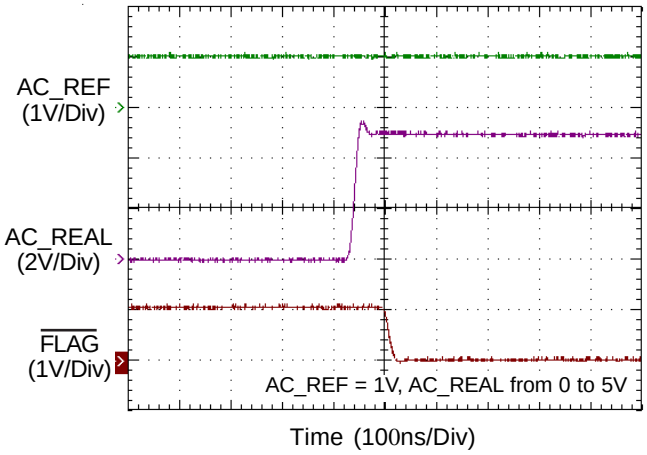
Note 4. The device is not guaranteed to function outside its operating conditions.

Typical Application Circuit

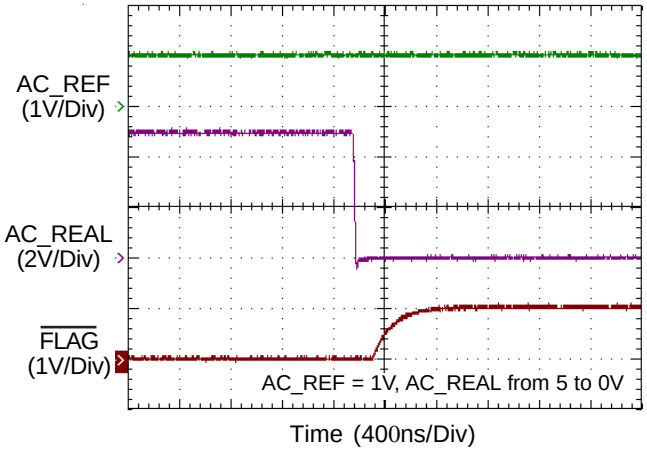


Typical Operating Characteristics

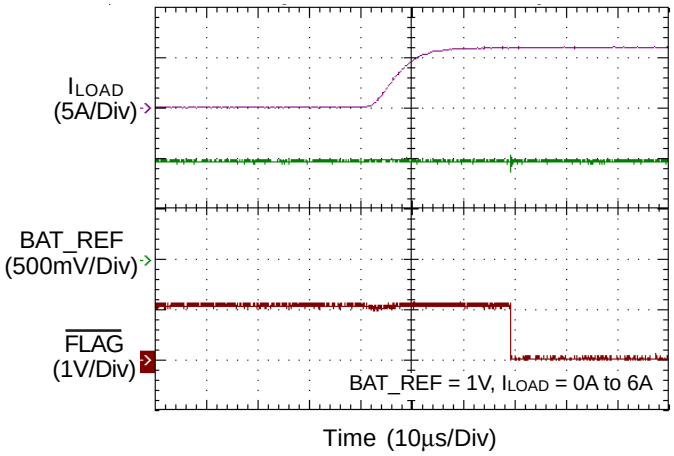
$\overline{FLAG}$ Behavior



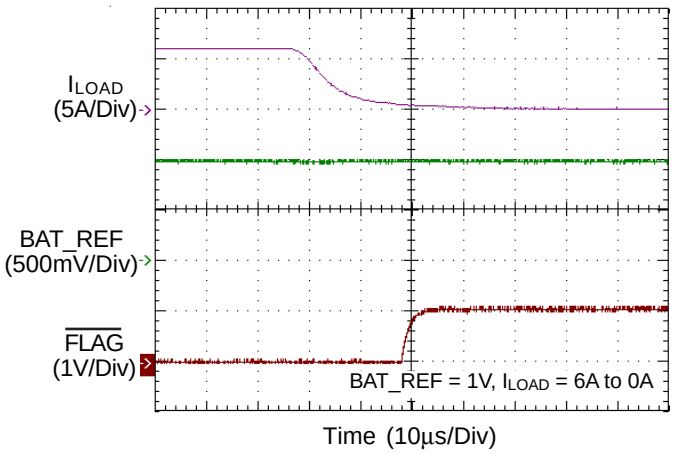
$\overline{FLAG}$ Behavior



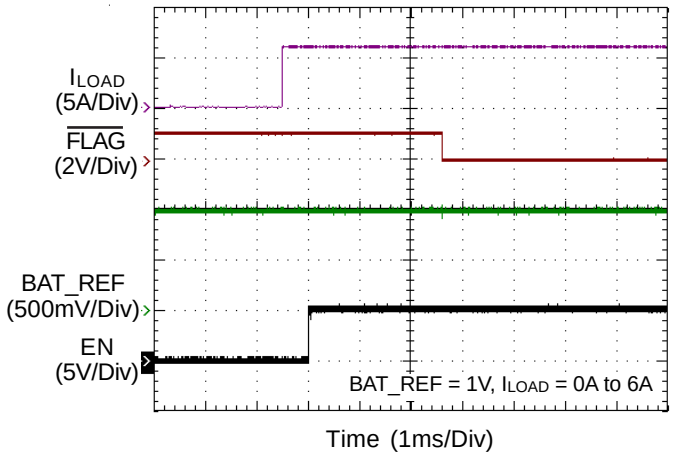
$\overline{FLAG}$ Behavior



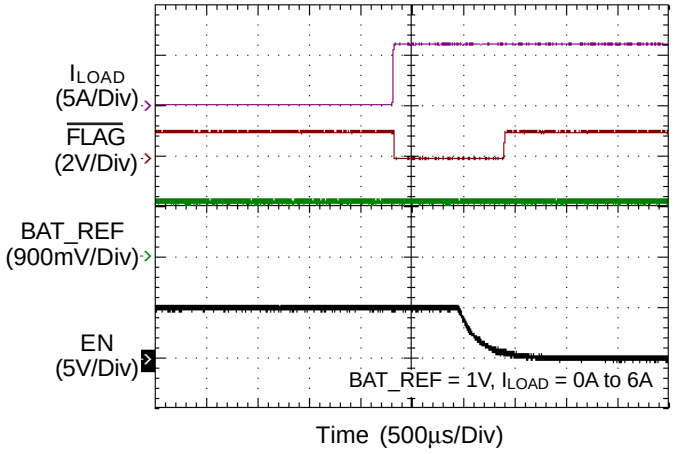
$\overline{FLAG}$ Behavior

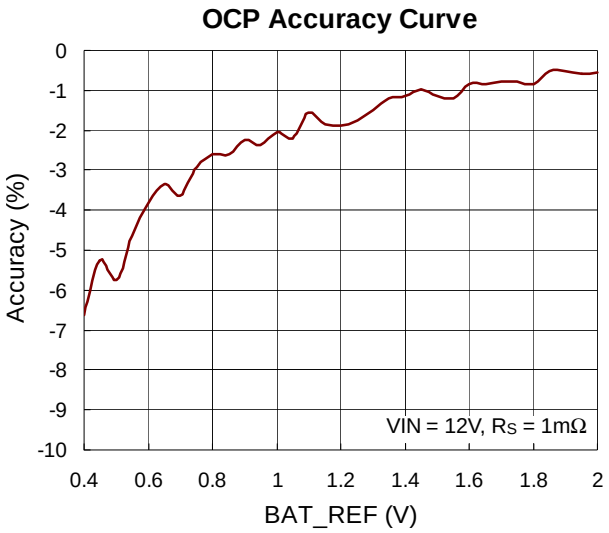


Power On Mask Time



Power Off from EN





Application Information

The RT9554A provides battery OCP protection functions with $\overline{FLAG}$ indicator to informs system. It can operate with minimized external components of switching power supply systems to achieve OCP protection. The over-current is detected by monitoring the differential voltage of input current sense resistor. The RT9554A provides a 50μs system response time for $\overline{FLAG}$ and there is a 3ms mask time after EN rising edge. Also, the RT9554A provides a comparator with two pins, AC_REAL and AC_REF for users.

$\overline{FLAG}$

The $\overline{FLAG}$ is an open-drain output and requires a pull-up resistor. When over-current is detected, $\overline{FLAG}$ is pulled low within 50μs and maintain until OCP status releases.

Over Current Protection(OCP)

As an industry standard, high accuracy current sense amplifier is used to monitor the input current that flow through current sense resistor, The RT9554A detects CSP-CSN differential voltage across the current sense resistor to monitor input current from battery. The OCP trigger point equation is shown as below :

$$BAT\_REF = 3.3V \times \frac{R2}{R1+R2}$$

$$(I_{SENSE} \times 0.001) \times 200 = BAT\_REF$$

200 is the internal error amp AV.

We suggest R1+ R2 = 100kΩ to avoid power consumption.

Isense is over-current protection trigger point.

For the overall timing sequence, please refer to Figure 1.

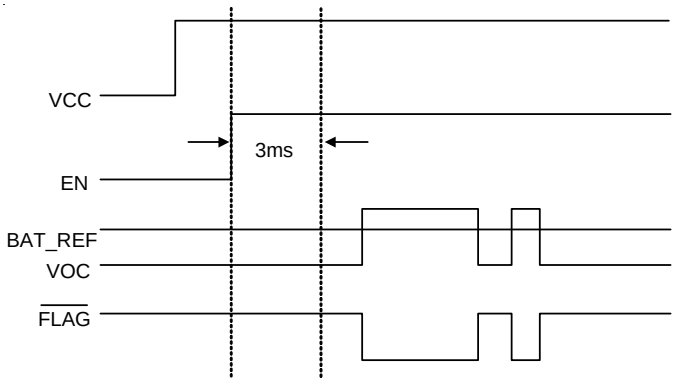


Figure 1. Timing Sequence

Filter capacitor

A 0.1μF capacitor between CSP and CSN for differential mode filtering is recommended. A 0.1μF capacitor between CSN and ground is for common mode filtering, and an optional 0.1μF capacitor between CSP and ground is for common mode filtering.

The CSP and CSN pins are used to sense Rsense with default value of 1mΩ. However, resistors of other values can also be used. Using a larger sense resistor, can have higher regulation accuracy, but, it comes with higher conduction loss.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For WDFN-8L 2x2 package, the thermal resistance, θ_{JA}, is 45.5°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C – 25°C) / (45.5°C/W) = 2.19W for WDFN-8L 2x2 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure 2 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

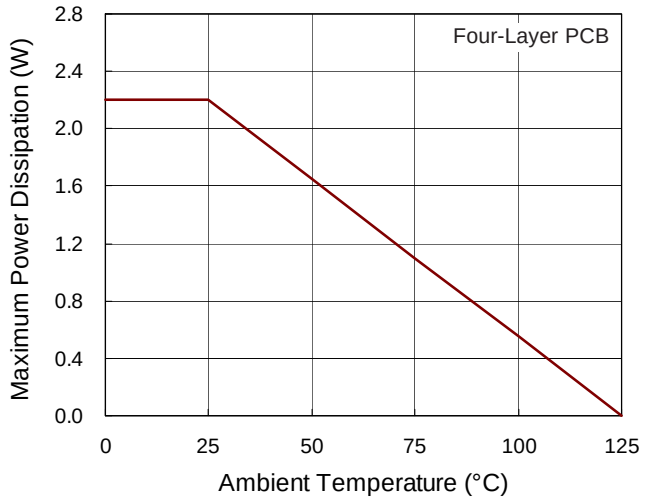


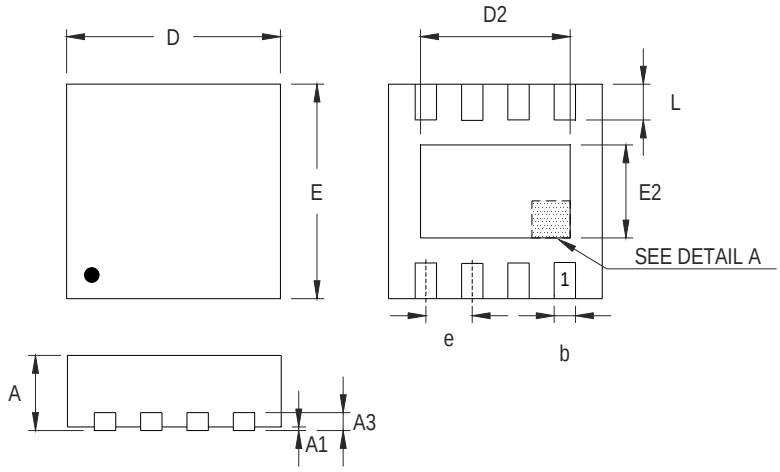
Figure 2. Derating Curve of Maximum Power Dissipation

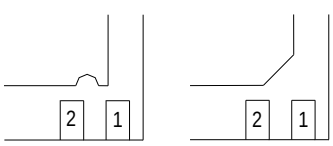
Layout Considerations

Layout is very important for the RT9554A. If designed improperly, the PCB may radiate excessive noise. Certain points must be considered before starting a layout for the RT9554A.

- Connect an RC low pass filter to VCC, 0.1μF, and 2.2Ω are recommended Connect a RC low pass filter to EN, 0.1μF, and 1kΩ are recommended. Place the filter capacitor close to the IC.
- Current sense connections must always be made using Kelvin connections to ensure an accurate signal with the current limit resistor located at the device.
- All sensitive analog traces and components such as CSP, CSN, VCC, EN and $\overline{\text{FLAG}}$, should be placed away form high voltage switching nodes to avoid coupling.

Outline Dimension





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.200	0.300	0.008	0.012
D	1.950	2.050	0.077	0.081
D2	1.000	1.250	0.039	0.049
E	1.950	2.050	0.077	0.081
E2	0.400	0.650	0.016	0.026
e	0.500		0.020	
L	0.300	0.400	0.012	0.016

W-Type 8L DFN 2x2 Package

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