# 70mΩ,3A Smart Universal Power Switch with Flag

## ■ General Description

The LN9703 is a low voltage, high performance single N-MOSFET power switch, designed for power rail on/off control with low $R_{DS(ON)}$≈70mΩ and full protection functions. The LN9703 equipped with a charge pump circuitry to drive the internal MOSFET switch and a flag output is available to indicate fault conditions against large di/dt which may cause the supply to fall out of regulation. In order to fit different application, an ISET pin is offered for current limit point setting, a resistor from ISET to ground sets the current limit for the switch.

Additional features include soft-start to limit inrush current during plug-in, thermal shutdown to prevent catastrophic switch failure from high-current loads, Output anti back irrigation Protection whether CE pin is connected GND or VIN,under-voltage lockout (UVLO) to ensure that the device remains off unless there is a valid input voltage present, a precision resistor-programmable output current limit up to 3.5A. Besides, the lower quiescent current as 40μA making this device ideal for portable battery-operated equipment.

## ■ Applications

- USB 3G/4G/5G Datacard
- USB Dongle
- MiniPCI Accessories
- LCD Monitor, LCD-TV
- USB Power Module for ADSL
- Information Appliance and Set-Top Box
- Battery-Powered Equipment
- Hot-Plug Power Supplies
- ACPI Power Distribution
- PCI Bus Power Switching
- Motherboard & Notebook PCs
- PC Card Hot Swap Application

## ■ Features

- Adjustable Current Limiting up to 3.5A
- Built-In (Typically 70mΩ) N-MOSFET
- Reverse Current Flow Blocking (no body diode) Output Can Be Forced Higher than Input (Off or On State)
- Low Supply Current :

  --------40μA Typical at Switch on State

  --------Less than 1μA Typical at Switch Off State
- Guaranteed Continuous Load Current

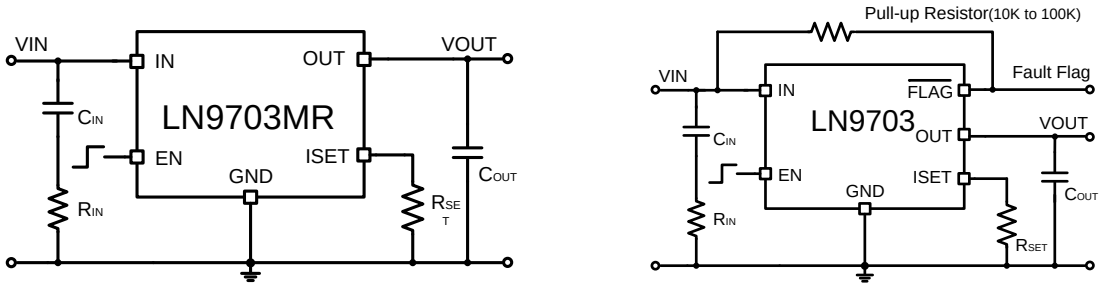
  --------LN9703MR、LN9703NR（SOT23）：3A

  --------LN9703TMR、LN9703TNR（TSOT23）：3A

  --------LN9703DR（DFN2x2）：3A

  --------LN9703SR（SOP8）：3.5A
- Wide Input Voltage Ranges : 2V to 5.5V
- Open-Drain Fault Flag Output
- Hot Plug-In Application (Soft-Start)
- 1.7V Typical Under-Voltage Lockout (UVLO)
- Reverse-Voltage Protection
- Thermal Shutdown Protection
- RoHS Compliant and 100% Lead (Pb)-Free

## ■ Typical Application Circuit




Basic Application Circuit

Note：Current limit：$I_{LIMSET}(A)=\frac{2.7x10^5}{R_{SET}(\Omega)}$

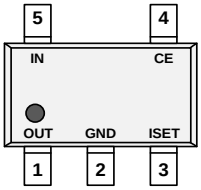
## ■ Ordering Information

**LN9703①②-③**

| Parameter | Symbol | Description |
|---|---|---|
| ① | TM | TSOT23-5L Package (No Fault Flag Output Pin) |
| | M | SOT23-5L Package (No Fault Flag Output Pin) |
| | TN | TSOT23-6L |
| | N | SOT23-6L |
| | D | DFN2x2-6L |
| | TD | TDFN2x2-6L |
| | S | SOP8 |
| ② | R | Embossed Tape: Standard Feed |
| | L | Embossed Tape: Reverse Feed |
| ③ | G | Green epoxy molding compound |

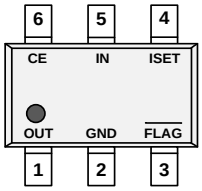
## ■ Pin Configurations And Marking Rule

**LN9703MR**
**LN9703TMR**
**(Top View)**



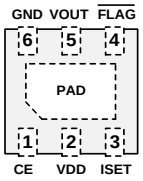

**SOT23-5L/TSOT23-5L**

**LN9703NR**
**LN9703TNR**
**(Top View)**



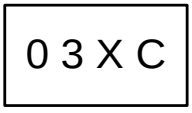

**SOT23-6L/TSOT23-6L**

**LN9703DR**
**(Top View)**



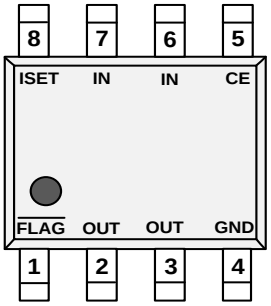

**DFN2020-6L**

**MARKING Rule**




**03----LN9703**
**X----die code**
**C----process code**

**LN9703SR(Top View)**




**SOP8**

**Marking Rule**

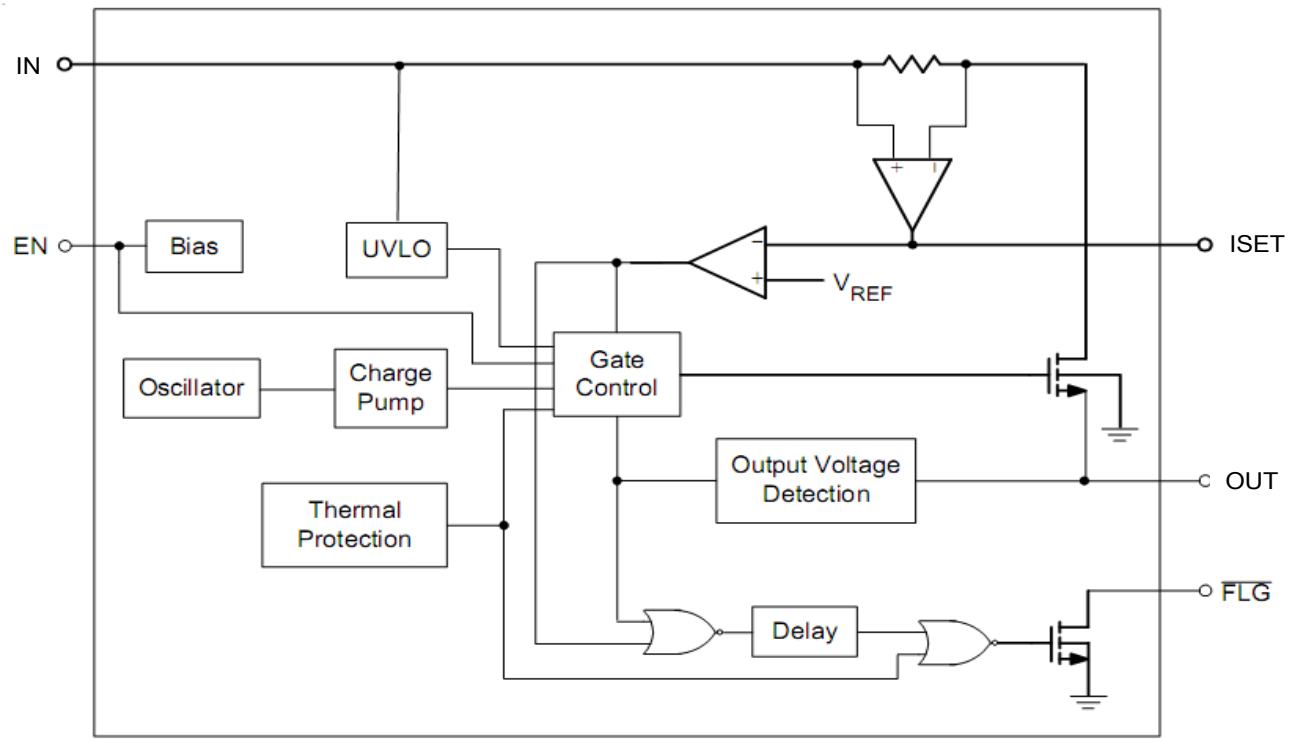



**LN9703----LN9703SR**
**XXXX----process code**
**YYYYYY----lot code**

## ■ Functional Pin Description

| Pin Name | Pin Function | Pin Name | Pin Function |
|---|---|---|---|
| IN | Power Input Voltage. | CE | Chip Enable (Active High). |
| OUT | Output Voltage. | ISET | Current Limit Programming Input. |
| GND | Ground. | $\overline{\text{FLAG}}$ | Open-Drain Fault Flag Output.(Active Low) |

## ■ Function Block Diagram




## ■ Absolute Maximum Ratings

- Supply Voltage ----------6.5V
- Chip Enable Input Voltage ----------−0.3V to 6.5V
- Flag Voltage----------6.5V
- Power Dissipation, PD @ TA = 25°C
  - SOT23-5L/6L----------0.6W
  - TSOT23-5L/6L----------0.62W
  - DFN2x2-6L----------0.70W
  - TDFN2x2-6L----------0.72W
  - SOP8 ----------0.95W
- Package Thermal Resistance
  - SOT23,$\theta_{JC}$ ----------60°C/W
  - SOT23,$\theta_{JA}$ ----------203°C/W
  - TSOT23,$\theta_{JA}$ ----------195°C/W
  - DFN2x2,$\theta_{JA}$ ----------140°C/W
  - TDFN2x2,$\theta_{JA}$ ----------140°C/W
  - SOP8, $\theta_{JA}$ ----------104°C/W
- Junction Temperature ----------125℃
- Lead Temperature (Soldering, 10 sec.) ----------260℃
- Storage Temperature Range ----------−65℃ to 150℃
- ESD Susceptibility (Note 2)
  - HBM (Human Body Mode) ----------5KV
  - MM (Machine Mode) ----------500V

## ■ Electrical Characteristics

Typical values are referenced to $V_{IN}$ = 5V and $T_A$ = +25℃ (Others be noted).

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **POWER SWITCH** | | | | | | |
| Vin | Input Power range | -45℃≤TA≤+125℃ | 2 | | 5.5 | V |
| $R_{DS(ON)}$ | Switch On Resistance | $V_{IN}$=5V,$I_{OUT}$ = 1A | - | 65 | 75 | mΩ |
| $T_R$ | Output Rise time | $V_{IN}$=5V,$C_{IN}$=10uA, $C_L$=1μF, $R_L$=33Ω | - | 0.2 | 2 | ms |
| $T_F$ | Output Fall time | (See **Figure 1**) | - | 0.1 | 0.5 | ms |
| **CURRENT LIMIT** | | | | | | |
| $I_{OCP}$ | Current-limit Threshold (Maximum DC output current Iout Delivered to Load) | $V_{IN}$=5V, $R_{SET}$=270kΩ | 0.8 | 1 | 1.2 | A |
| | | $V_{IN}$=5V, $R_{SET}$=135kΩ | 1.6 | 2 | 2.4 | A |
| | | $V_{IN}$=5V, $R_{SET}$=90kΩ | 2.4 | 3 | 3.6 | A |
| $\Delta I_{LIMSET}$ | Current Limit Setting Accuracy | $I_{LIMSET}$ = 1A to 2A | -20 | - | +20 | % |
| $T_{OCP}$ | Overcurrent Protection Time | $V_{IN}$=5V | 20 | 35 | 40 | ms |
| $T_{DET}$ | Response Time to Short Circuit | | 20 | 35 | 40 | ms |
| $T_{REG}$ | Regulation Time | | 1.8 | 3 | 4 | ms |
| **ENABLE INPUT CE** | | | | | | |
| $V_{CEH}$ | CE Threshold Logic-High Voltage | Switch On with no load | - | 0.75 | - | v |
| | | Switch On with $I_{out}$=10mA | - | 1.15 | - | v |
| $V_{CEL}$ | CE Threshold Logic-Low Voltage | Switch Off no load | - | 0.7 | - | v |
| | | Switch Off $I_{out}$=10mA | - | 1.1 | - | v |
| $I_{CE}$ | CE Input Current | $V_{CE}$ = 0V to 5.5V | - | 10 | - | pA |
| $T_{on}$ | Turn on time | $V_{IN}$=5V,$C_{IN}$=10uA, $C_L$=1μF, $R_L$=33Ω | - | - | 3 | ms |
| $T_{off}$ | Turn off time | (See **Figure 1)** | - | - | 3 | ms |
| **REVERSE-VOLTAGE PROTECTION** | | | | | | |
| $V_{REV}$ | $V_{OUT}$ – $V_{IN}$ | | 80 | 135 | 175 | mv |
| $T_{REV}$ | Time from reverse-voltage condition to MOSFET turn off | $V_{IN}$=5.0V, | 4 | 6 | 9 | ms |
| $T_{RREV}$ | Re-arming Time | | 7 | 10 | 15 | ms |
| **SUPPLY CURRENT** | | | | | | |
| $I_{IN_off}$ | Supply current, low-level output | $V_{IN}$ = 5 V,$V_{CE}$=0V， No load on OUT | - | 0.1 | 1 | μA |
| $I_{IN_on}$ | Supply current, high-level output | $V_{IN}$=$V_{CE}$=5V No load on OUT | - | 45 | 80 | μA |
| $I_{REV}$ | Reverse leakage current | $V_{OUT}$ =5 V, $V_{IN}$ = $V_{CE}$ =0 V | - | 0.5 | 1 | μA |
| **FLAG PIN** | | | | | | |
| $V_{OL}$ | FLAG Output Low Voltage | $I_{FLAG}$ = 1 mA | - | - | 400 | mV |
| $I_{LEAK}$ | Off-state Leakage | $V_{FLAG}$ = 5 V | - | 10 | | nA |
| $R_{FLG}$ | FLAG Output Resistance | $I_{SINK}$ = 1mA | - | 14 | 400 | Ω |
| $T_{FLG}$ | FLAG Deglitch | FLAG De-assertion Time due to Overcurrent or Reverse Voltage Condition | 1 | 2.3 | 5 | ms |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **THERMAL SHUTDOWN** | | | | | | |
| $T_{SD}$ | Thermal Shutdown Threshold | | - | 140 | - | ℃ |
| $T_{SDOCP}$ | Thermal Regulation Threshold | | - | 125 | | ℃ |
| $T_{RSD}$ | Thermal Shutdown Rearming Threshold | | - | 115 | - | ℃ |
| **UNDERVOLTAGE LOCKOUT** | | | | | | |
| $V_{UVLO}$ | IN Pin Low-level Input Voltage | $V_{IN}$ Rising,$V_{CE}$=5.0V | 1.75 | 1.8 | 2.0 | V |
| $V_{HYST}$ | IN Pin Hysteresis | | - | 100 | - | mV |
| $T_{RUVLO}$ | Re-arming Time | | 20 | 35 | 40 | ms |

## ■ PARAMETER MEASUREMENT INFORMATION

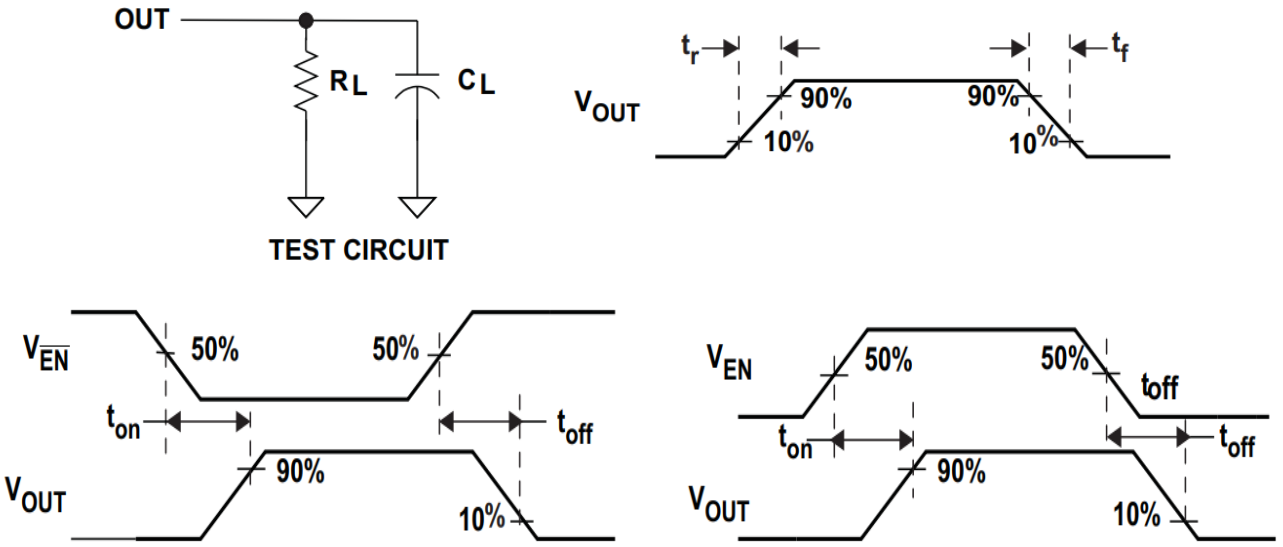
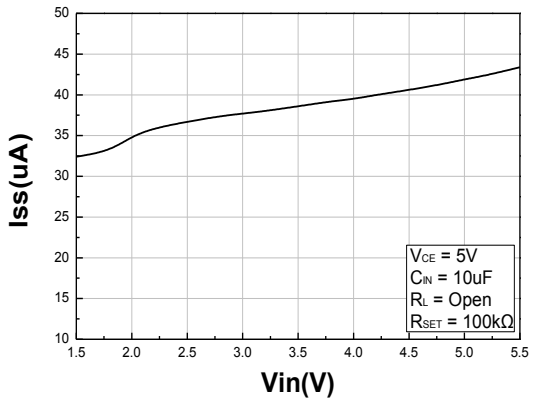


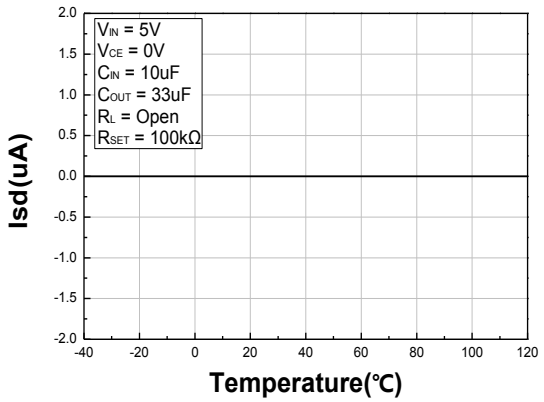

Figure 1. Test Circuit and Voltage Waveforms

## ■ Typical Performance Characteristics

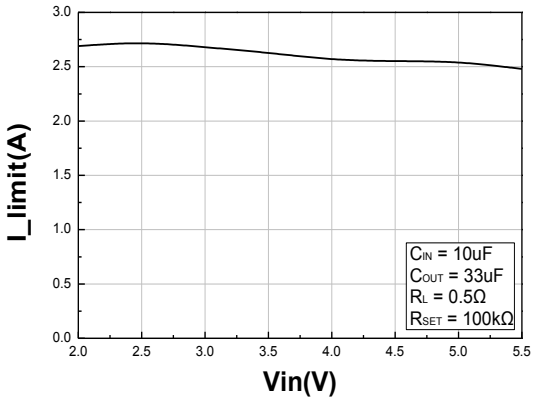
**1、 On-State Supply Current VS Input Voltage**



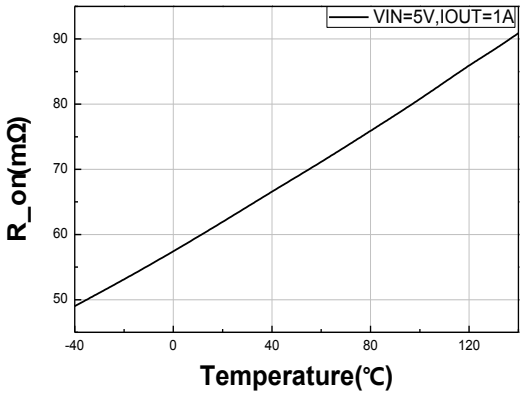

**2、Off-State Supply Current VS Temperature**



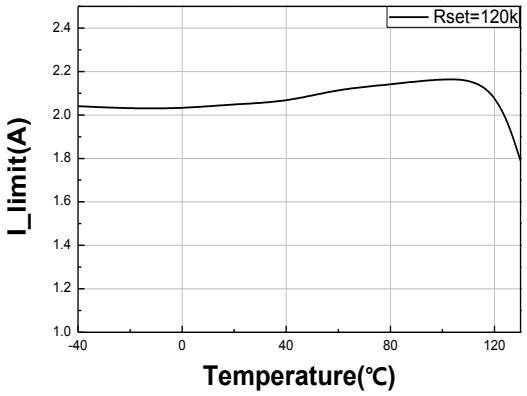
### 3、 Current Limit VS Input Voltage



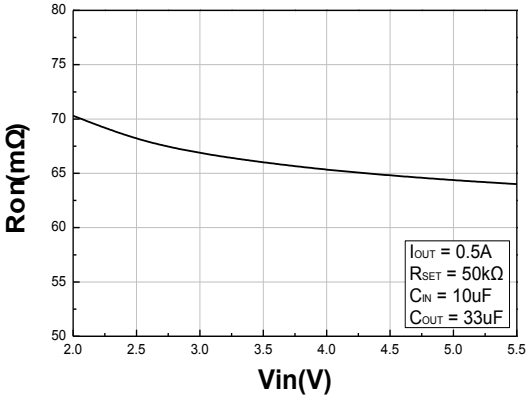

### 4、Ron(mΩ) VS Temperature



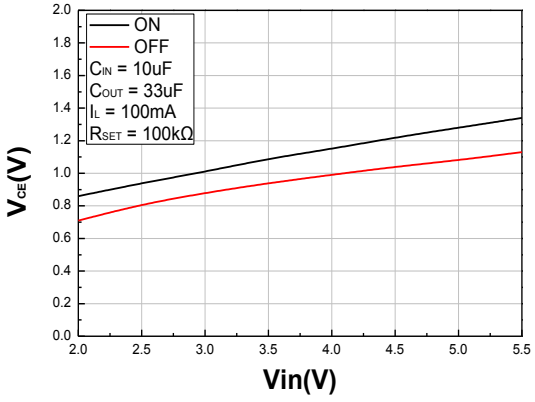

### 5、Output Current Limit VS Temperature



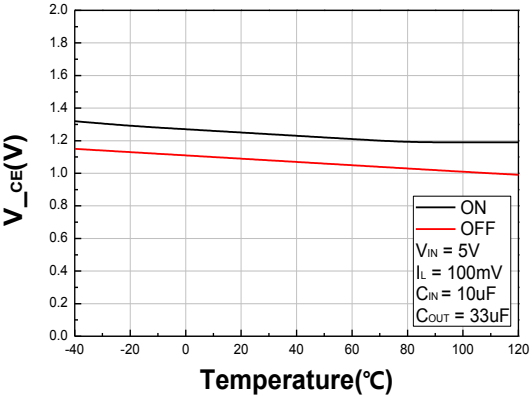

### 6、On-Resistance VS Input Voltage



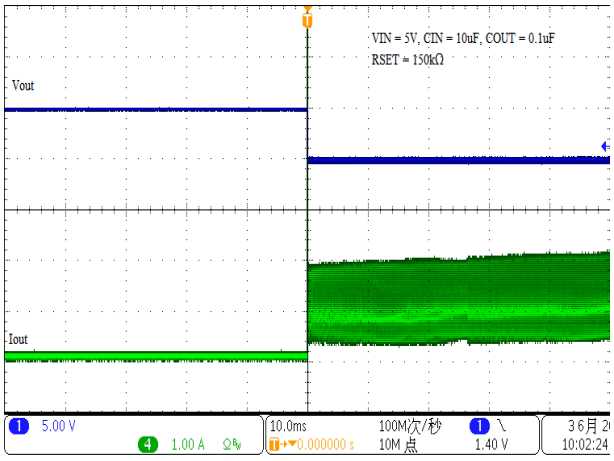

### 7、CE Threshold Voltage VS Input Voltage



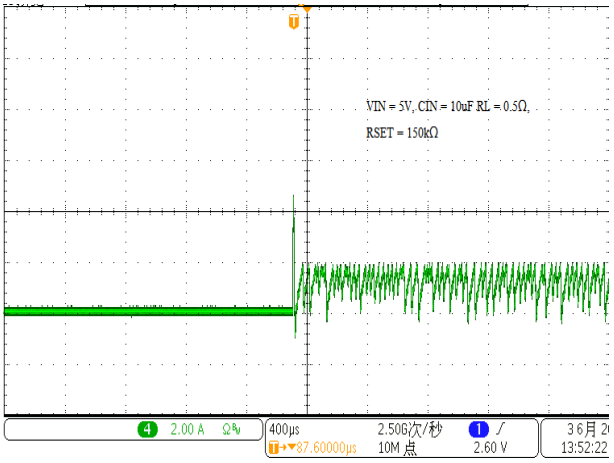

### 8、CE Threshold Voltage VS Temperature



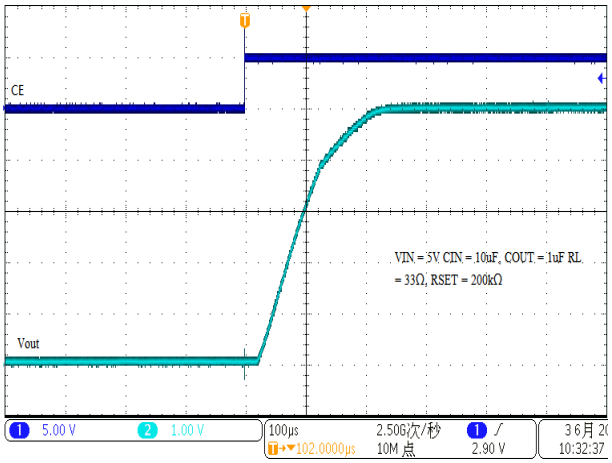
### 9、Short Circuit Current Response



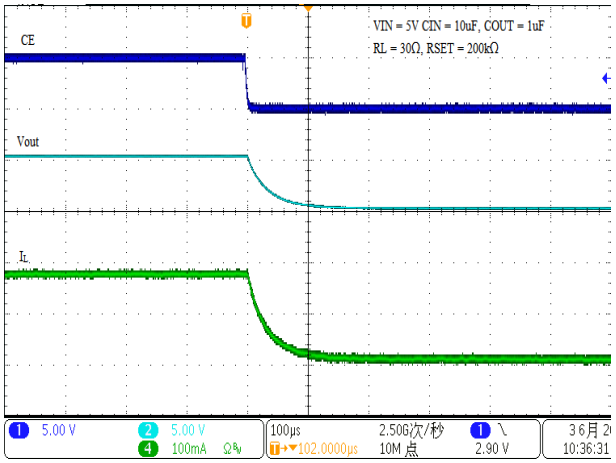

### 10、Inrush Current Response



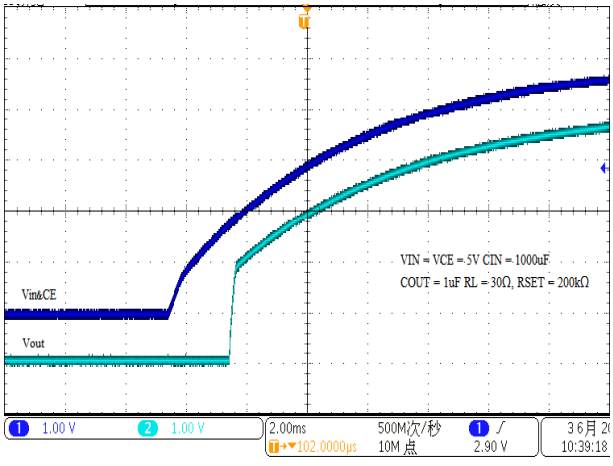

### 11、Turn-On Response



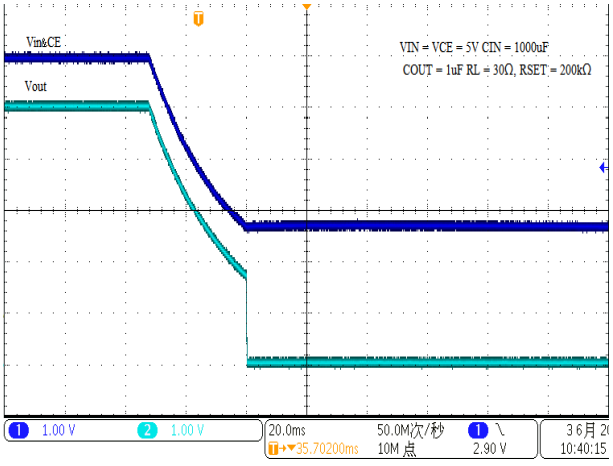

### 12、Turn-Off Response



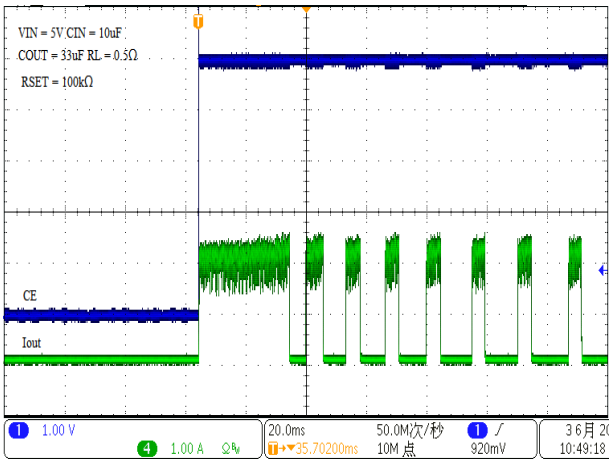

### 13、UVLO at Rising



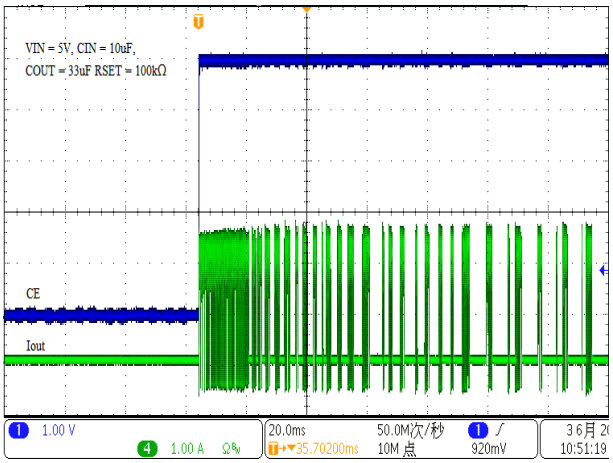

### 14、UVLO at Falling



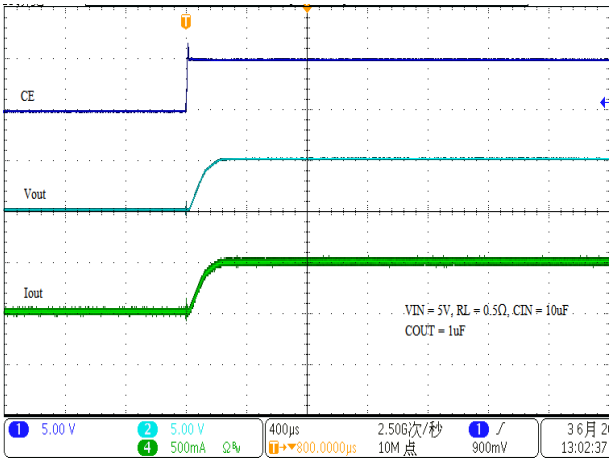
### 15、Current Limit with Thermal Shutdown



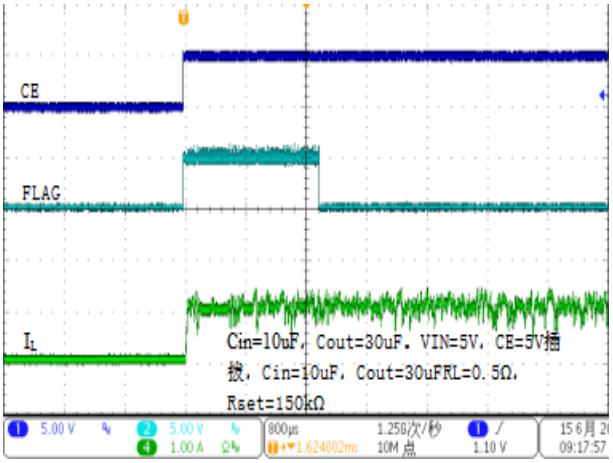

### 16、Short- Circuit with Thermal Shutdown



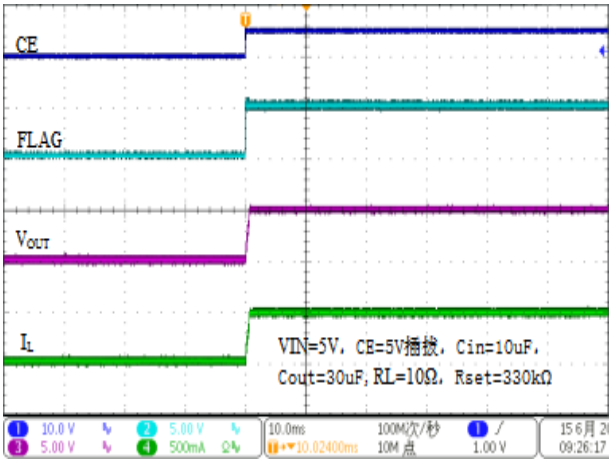

### 17、Soft-Start Response




### 18、FLAG Response (Enable into Current Limit)




### 19、FLAG Response at Chip Enable



## ■ Applications Information

The LN9703 is a high-side, N-Channel, power switch available with active-high enable input. Low $R_{DS(ON)}$≈70mΩ and full protection functions make it optimized to replace complex discrete on/off control circuitry.

- **Chip Enable Input**

The switch will be disabled when the CE pin is in a logic low condition. During this condition, the internal circuitry and MOSFET are turned off, reducing the supply current to 0.1μA typically. The maximum guaranteed voltage for a logic low at the CE pin is 0.8V. A minimum guaranteed voltage of 2V at the CE pin will turn the LN9703 back on. Floating the input may cause unpredictable operation. CE should not be allowed to go negative with respect to GND. The CE pin may be directly tied to VIN to keep the part on.

- **Soft-Start for Hot Plug-In Applications**

In order to eliminate the upstream voltage droop caused by the large inrush current during hot-plug events, the "soft-start" feature effectively isolates the power source from extremely large capacitive loads.

- **Fault Flag**

The LN9703 provides a FLAG signal pin which is an N-Channel open drain MOSFET output. This open drain output goes low when VOUT < VIN -1V, current limit or the die temperature exceeds 150°C approximately. The FLAG output is capable of sinking a 10mA load to typically 150mV above ground. The FLAG pin requires a pull-up resistor, this resistor should be large in value to reduce energy drain. A 10kΩ to 100kΩ pull-up resistor works well for most applications. In the case of an over-current condition, FLAG will be asserted only after the flag response delay time, $t_D$, has elapsed. This ensures that FLAG is asserted only upon valid over-current conditions and that erroneous error reporting is eliminated.

For example, false over-current conditions may occur during hot-plug events when a highly large capacitive load is connected and causes a high transient inrush current that exceeds the current limit threshold. The FLAG response delay time $t_D$ is typically 2.3ms.

- **Reverse-Voltage Protection**

The reverse-voltage protection feature turns off the N-channel MOSFET whenever the output voltage exceeds the input voltage by 140 mV . A reverse current of $(V_{OUT}-V_{IN})/R_{DS(on)}$ will be present when this occurs. This prevents damage to devices on the input side of the LN9703 by preventing significant current from sinking into the input capacitance. The LN9703 devices allow the N-channel MOSFET to turn on once the output voltage goes below the input voltage for the same 2.3ms deglitch time. The reverse-voltage comparator also asserts the FLAG after 2.3ms.

- **Under-Voltage Lockout**

Under-Voltage lockout (UVLO) prevents the MOSFET switch from turning on until input voltage exceeds approximately 1.7V. If input voltage drops below approximately 1.3V, UVLO turns off the MOSFET switch, FLAG will be asserted accordingly. Under- Voltage detection functions only when the chip enable input is enabled.

- **Current Limiting**

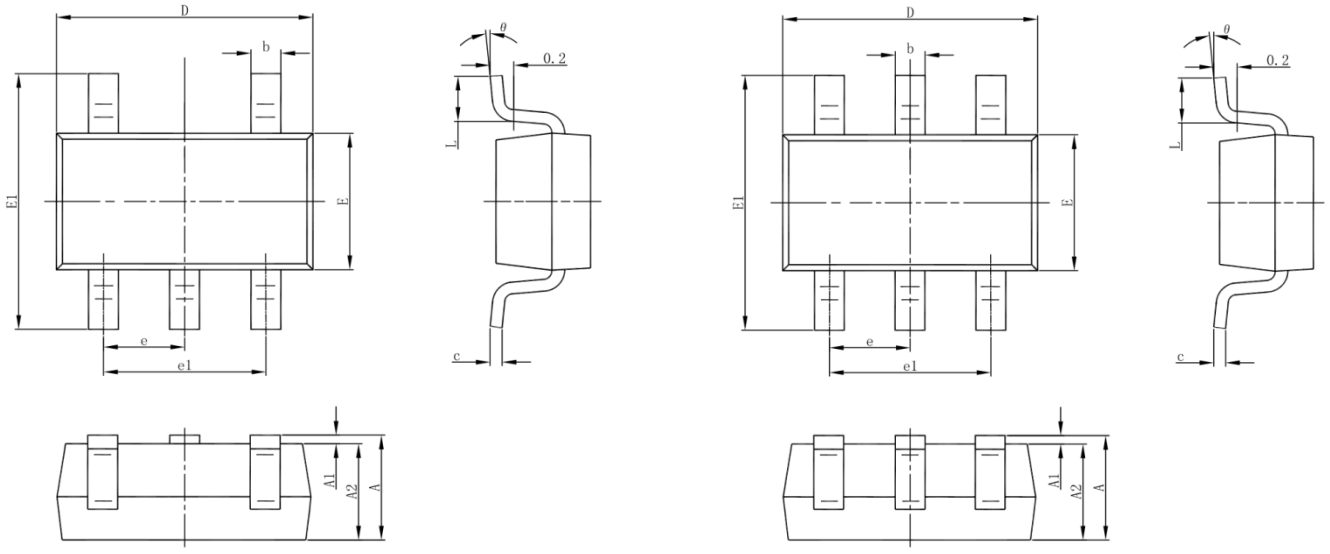
The current limit circuitry prevents damage to the MOSFET switch and external load. It is user adjust- able with an external set resistor, RSET, ILIMIT = 270k/RSET in the range of 600mA to 3.5A. The accuracy of current limit set point may vary with operating temperature and supply voltage. See "Typical Performance Characteristics" graph for further details.

- **Thermal Shutdown**

Thermal shutdown is employed to protect the device from damage if the die temperature exceeds approxi- mately 150°C. If enabled, the switch automatically restarts when the die temperature falls 30°C. The output and FLAG signal will continue to cycle on and off until the device is disabled or the fault is remove.

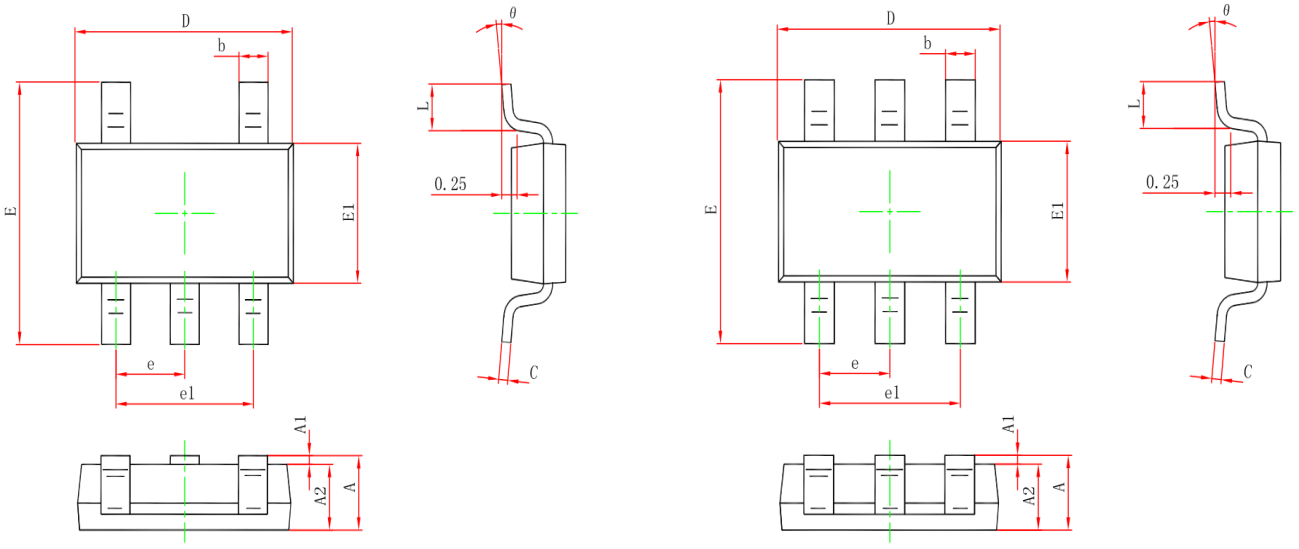
## ■ Package Information

- **SOT23-5L**
- **SOT23-6L**



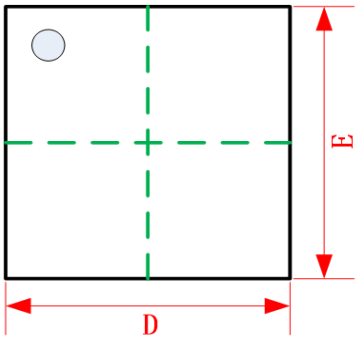

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950(BSC) | | 0.037(BSC) | |
| e1 | 1.800 | 2.000 | 0.071 | 0.079 |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

- **TSOT23-5L**
- **TSOT23-6L**

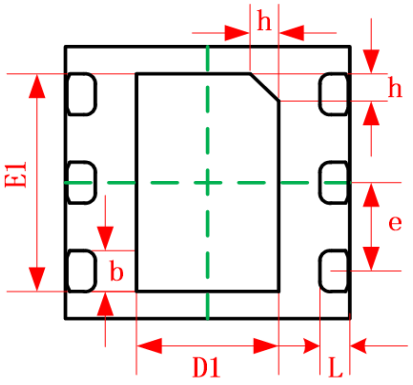



| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | - - - | 0.900 | - - - | 0.035 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 0.700 | 0.800 | 0.028 | 0.031 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950(BSC) | | 0.037(BSC) | |
| e1 | 1.800 | 2.000 | 0.071 | 0.079 |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

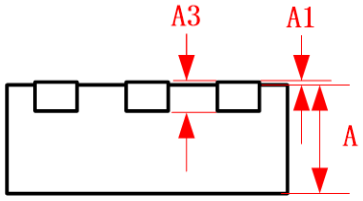
- **DFN2x2-6L**




Top View
【顶视图】



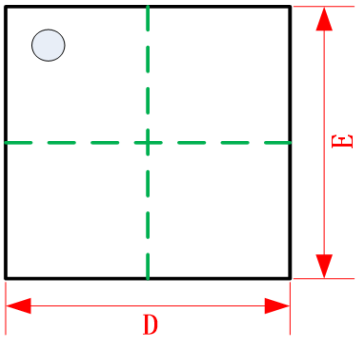

Bottom View
【背视图】



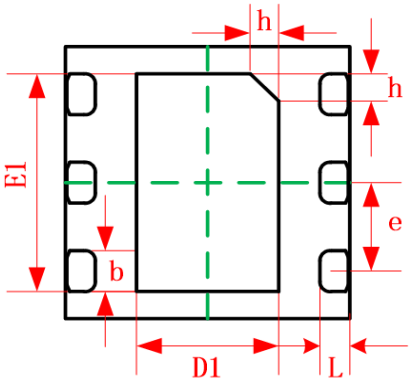

Side View
【侧视图】

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.700 | 0.800 | 0.027 | 0.032 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A3 | 0.203Ref | | 0.008 | |
| D | 1.900 | 2.100 | 0.074 | 0.083 |
| E | 1.900 | 2.100 | 0.074 | 0.083 |
| D1 | 0.950 | 1.050 | 0.037 | 0.041 |
| E1 | 1.550 | 1.650 | 0.061 | 0.065 |
| b | 0.250 | 0.350 | 0.010 | 0.014 |
| e | 0.650(TYP) | | 0.026 | |
| h | 0.200 | | 0.008 | |
| L | 0.200 | 0.300 | 0.008 | 0.012 |

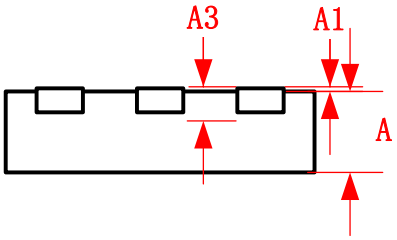
- **TDFN2x2-6L**




Top View
【顶视图】



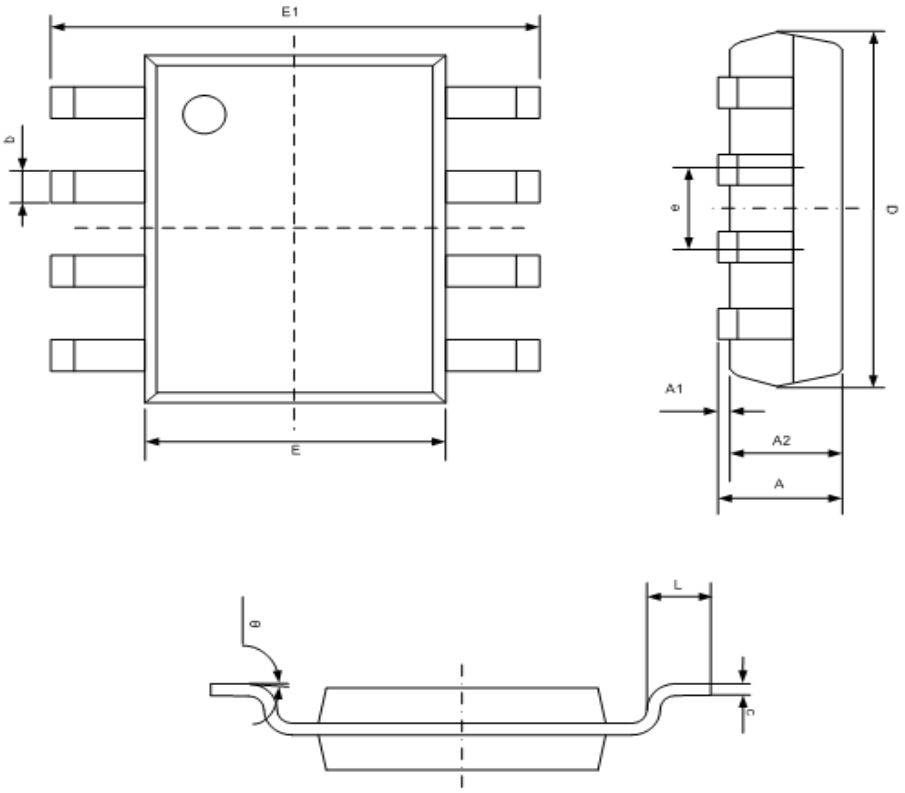

Bottom View
【背视图】




Side View
【侧视图】

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.500 | 0.600 | 0.020 | 0.024 |
| A1 | 0.000 | 0.050 | 0.000 | 0.002 |
| A3 | 0.152Ref | | 0.006 | |
| D | 1.900 | 2.100 | 0.074 | 0.083 |
| E | 1.900 | 2.100 | 0.074 | 0.083 |
| D1 | 0.950 | 1.050 | 0.037 | 0.041 |
| E1 | 1.550 | 1.650 | 0.061 | 0.065 |
| b | 0.250 | 0.350 | 0.010 | 0.014 |
| e | 0.650(TYP) | | 0.026 | |
| h | 0.200 | | 0.008 | |
| L | 0.200 | 0.300 | 0.008 | 0.012 |

- **SOP8**




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.350 | 1.750 | 0.053 | 0.069 |
| A1 | 0.100 | 0.250 | 0.004 | 0.010 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| c | 0.170 | 0.250 | 0.007 | 0.010 |
| D | 4.700 | 5.100 | 0.185 | 0.200 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| E1 | 5.800 | 6.200 | 0.228 | 0.244 |
| e | 1.270(BSC) | | 0.050(BSC) | |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |