

## **Revision History**

<b><u>Rev. No.</u></b>	<b><u>History</u></b>	<b><u>Issue Date</u></b>
1.0	New issue	Apr. 06,2016
2.0	Modify $I_{CC2} = 1.2\text{mA}(\text{Max})$ Modify Current Source =250 $\mu\text{A}(\text{Min})$	May. 10,2016

## High Power Factor & Accuracy Constant Current LED Driver

### General Description

The CS8906 is a non-isolation LED buck controller and integrated. It provides a simple circuit to get higher power factor, higher efficiency and meet the accuracy average LED current, reduce the cost of LED power supply.

The CS8906 has a 45kHz fixed frequency oscillator, an internal 200mV precision reference, and a PWM comparator with latching logic. To protect the external power MOSFET from being damaged by supply over voltage, the CS8906 OUT pin voltage is clamped to about 15V.

The accurate output LED current is achieved by an averaging current feedback loop and the LED current dimming can be easily controlled via the DIM pin.

The COMP pin controls the duty by connected an RC compensation network to ground and forming the closed loop feedback control.

The CS8906 also has multiple features to protect the controller and system from fault conditions, including: Under Voltage Lockout(UVLO), Over Current Protection (OCP), Over Voltage Protection(OVP) and internal over temperature protection(OTP).

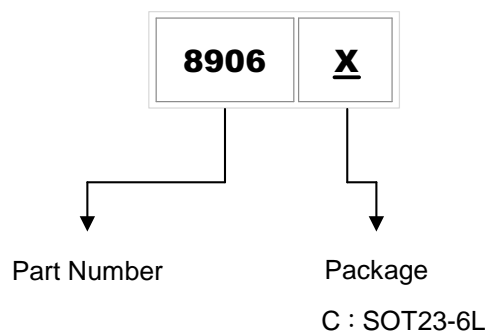
### Applications

- ◆ E26/27, T5/T8 LED Lamp
- ◆ Others LED Lighting Applications

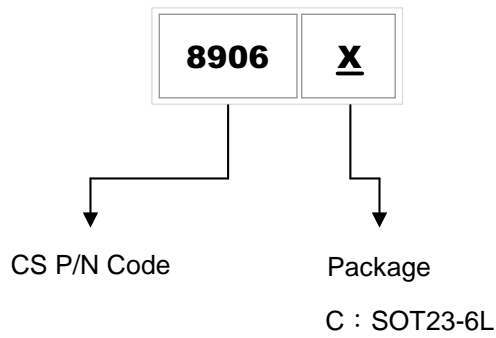
### Features

- ◆ Low BOM Cost
- ◆ Linear Dimming on DIM Pin
- ◆ High Power Factor, Low THD
- ◆ Accuracy Constant Current
- ◆ 300mA Driving Capability for OUT Pin
- ◆ Internal OTP Protection
- ◆ LED Open Protection (OVP)
- ◆ LED Short Protection (SCP)
- ◆ Over Current Protection (OCP)
- ◆ Output Voltage Clamp
- ◆ Average Current / 45kHz of fixed Frequency Control
- ◆ Available in the 6-Pin Pb-Free SOT-23-6L

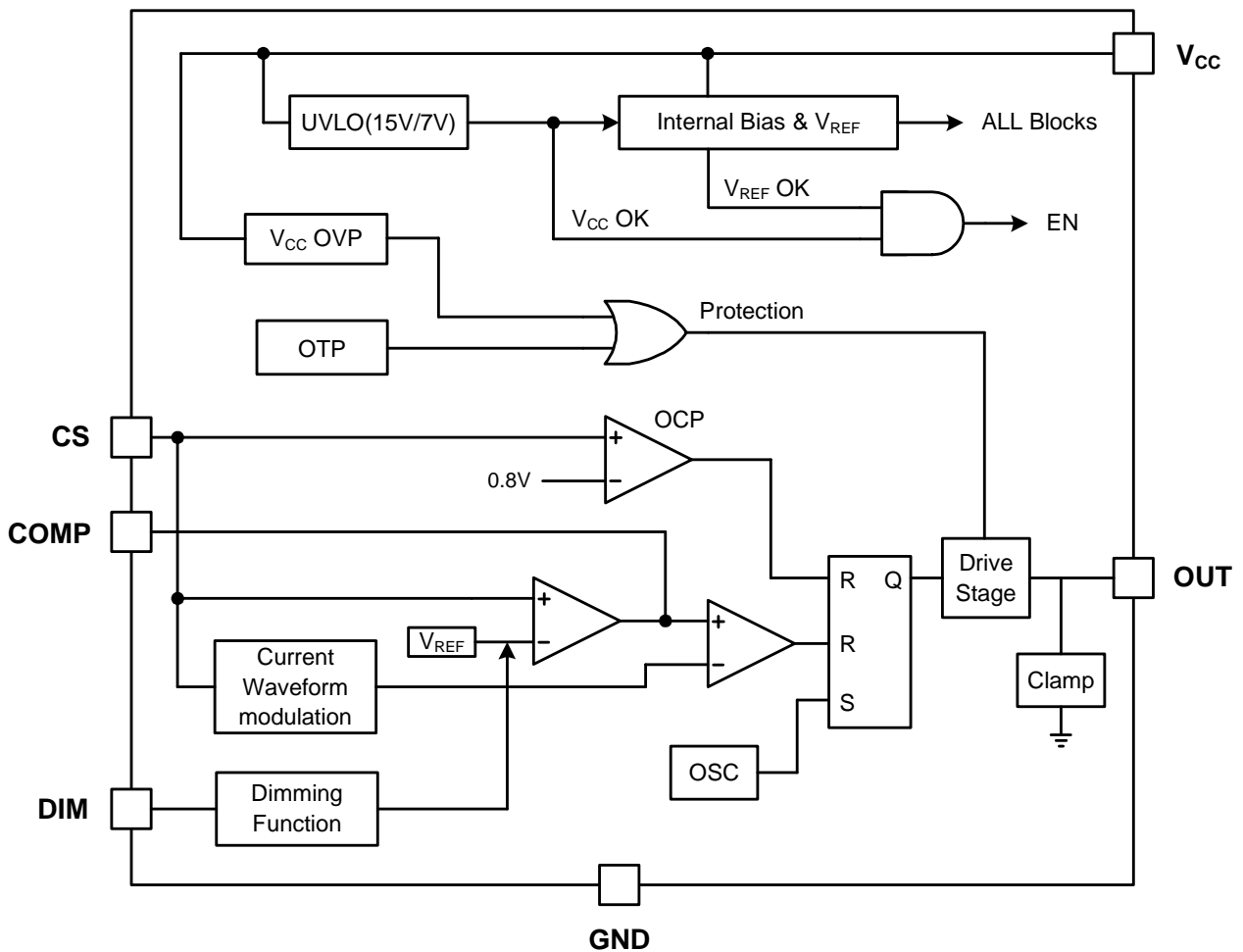
### Ordering Information



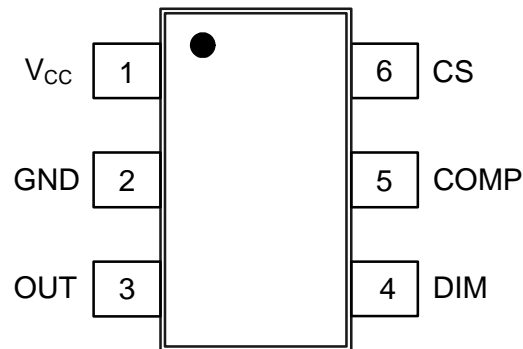
## Marking Information



## Functional Block Diagram



## Pin Configuration



## Pin Description

Pin NO.	Name	Function
1	VCC	Power Supply Pin
2	GND	Ground Pin
3	OUT	The Output Driver for Driving The External MOSFET
4	DIM	Dimming Control Pin by Input a DC Voltage
5	COMP	Feedback Compensation Network
6	CS	Current Sense Pin, Connect to Sense The MOSFET Current

## Absolute Maximum Ratings (Note 1)

- Supply Voltage ( $V_{CC}$ ): \_\_\_\_\_ 【30V】
- DIM, COMP, CS : \_\_\_\_\_ 【-0.3V to 7V】
- OUT : \_\_\_\_\_ 【15V】
- Storage Temperature Range ( $T_{STG}$ ): \_\_\_\_\_ 【-65°C to +150°C】
- Maximum Junction Temperature ( $T_J$ ): \_\_\_\_\_ 【150°C】

## Thermal Information

- Thermal Resistance: (Note 2)
  - Junction to Ambient ( $\theta_{JA}$ ):
  - SOT-23-6L : \_\_\_\_\_ 【330°C/W】
  - Junction to Case ( $\theta_{JC}$ ):
  - SOT-23-6L : \_\_\_\_\_ 【100°C/W】
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ\text{C}$  (Note 3)
  - SOT-23-6L : \_\_\_\_\_ 【300mW】

## Recommended Operation Conditions (Note 4)

- Operating Ambient Temperature Range ( $T_{OPA}$ ): \_\_\_\_\_ 【-20°C to +85°C】
- Supply Voltage ( $V_{CC}$ ): \_\_\_\_\_ 【+12 to +25V】
- DIM, COMP, CS : \_\_\_\_\_ 【-0.3V to 6V】

Note 1: Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device.

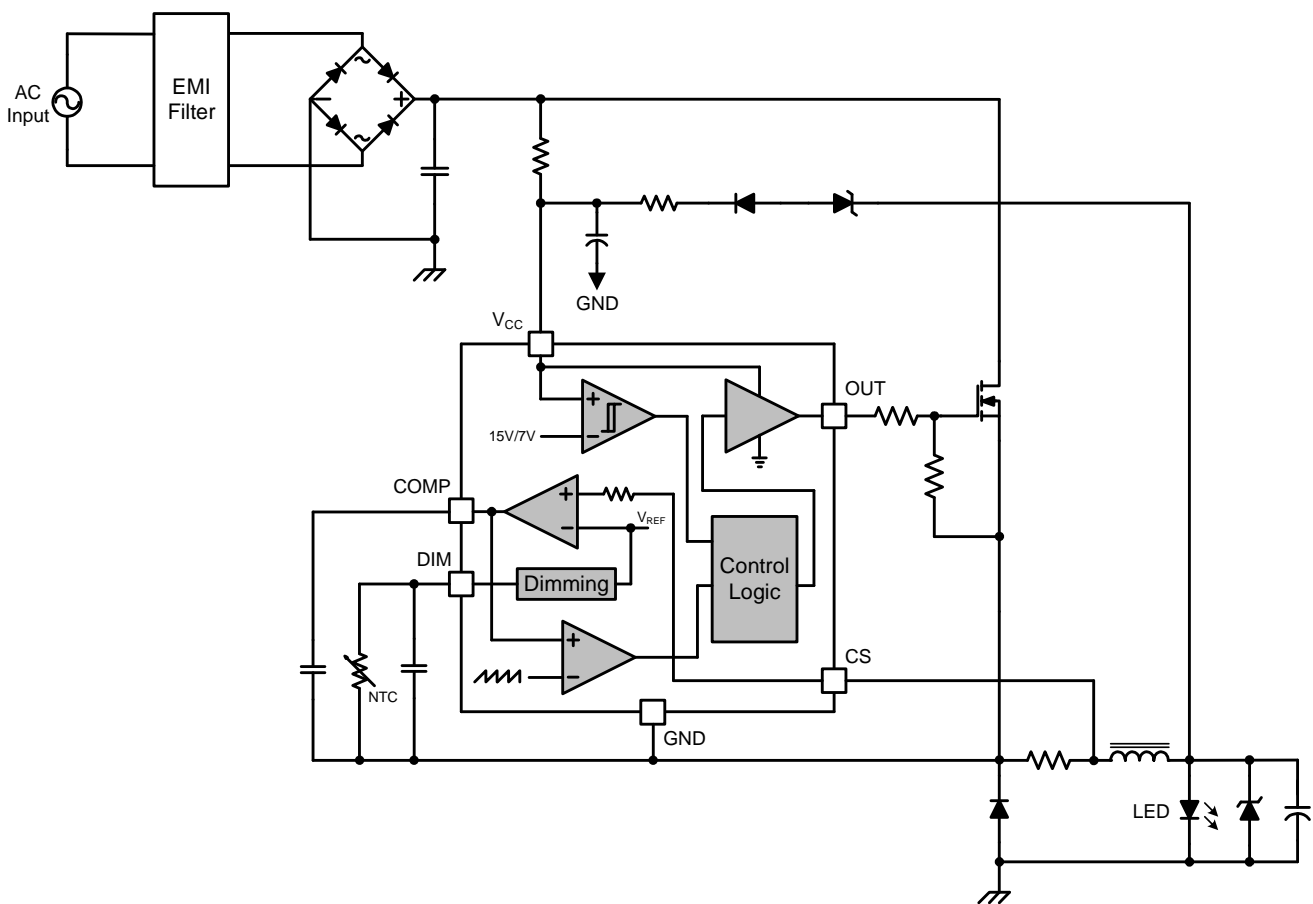
These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

Note 3: Thermal Resistance is specified with the component mounted on a low effective thermal conductivity test board in free air at  $T_A=25^\circ\text{C}$ .

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

## Typical Applications



 **Electrical Characteristics** (Unless otherwise specified  $V_{CC}=15V$ ,  $T_A=25^\circ C$ )

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>SUPPLY INPUT VOLTAGE</b>						
I <sub>STR</sub>	Startup Current	$V_{CC}=UVLO_{ON} - 1V$		8	15	μA
I <sub>CC1</sub>	Operating Current	with 1nF load on OUT pin, $V_{COMP}= 2.5V$		2	3	mA
I <sub>CC2</sub>	Operating Current	with 1nF load on OUT pin, Protection Tripped (OCP, OVP, SCP, OTP)		0.7	1.2	mA
V <sub>CC(OFF)</sub>	Turn-off Threshold Voltage		6	7	8	V
V <sub>TH(ON)</sub>	Turn-on Threshold Voltage		14	15	16	V
V <sub>OVP</sub>	OVP Level on V <sub>CC</sub> Pin		29.5	31.5	33.5	V
T <sub>D-OVP</sub>	OVP De-Bounce Time			40		μs
<b>VOLTAGE FEEDBACK</b>						
V <sub>REF</sub>	Feedback Reference Voltage		0.194	0.2	0.206	V
gm	Tran-Conductance			120		μS
I <sub>SINK</sub>	Output Sink Current			12		μA
I <sub>SOURCE</sub>	Output Source Current			12		μA
<b>CURRENT SENSING</b>						
V <sub>OCP</sub>	Over Current Protection Threshold			0.8		V
V <sub>CS_OPEN</sub>	Open Loop Voltage, CS Pin Open			5		V
T <sub>LEB</sub>	Leading-Edge Blanking Time			410		nS
T <sub>D_OCP</sub>	Delay to Output			100	220	nS
<b>SWITCHING FREQUENCY</b>						
f <sub>OSC</sub>	Switching Frequency		42	45	48	KHz
D <sub>MAX</sub>	Maximum Duty		90			%
Δf/freq	Frequency Jitter Range			+/-4		%
F <sub>DT</sub>	Frequency Variation vs. Temperature Deviation	$T_A = -40^\circ C \sim 125^\circ C$			6	%
F <sub>DV</sub>	Frequency Variation vs. V <sub>CC</sub> Deviation	$V_{CC} = 11V \sim 25V$			1	%

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>GATE DRIVER OUTPUT</b>						
$t_R$	Rising Time	Load Capacitance = 1nF		160	320	nS
$t_F$	Falling Time	Load Capacitance = 1nF		80	160	nS
$V_{CLAMP}$	GATE Pin Voltage Clamp	$V_{CC} = 25V$		13.5	15	V
<b>DIM INPUT SECTION</b>						
$V_{H\_TH}$	Saturation Threshold Voltage		3			V
$V_{LD}$	Linear Dimming Range		0.3		3	V
$V_{L\_TH}$	Output Minimum Pulse Threshold Voltage				0.3	V
$I_{DS}$	Current Source		250	300	330	$\mu A$
<b>OTP SECTION</b>						
$T_{OTP}$	OTP Trip Point			170		$^{\circ}C$
$T_{OTP\_RE}$	OTP Release Point			140		$^{\circ}C$
$T_{OTP\_HY}$	OTP Hysteresis			30		$^{\circ}C$
$T_{DE}$	OTP De-Bounce Time			80		$\mu S$

## Application Information

### Start-up Current

The V<sub>CC</sub> pin of CS8906 is connected to the line input through a resistor. The typical start-up current is around 8μA. A large value startup resistor can be used to minimize the power loss in application because the start current of CS8906 is very low.

A hysteresis UVLO comparator is implemented in CS8906, then the turn-on and turn-off thresholds level are fixed at 15V and 7V respectively, shown in Fig 1.

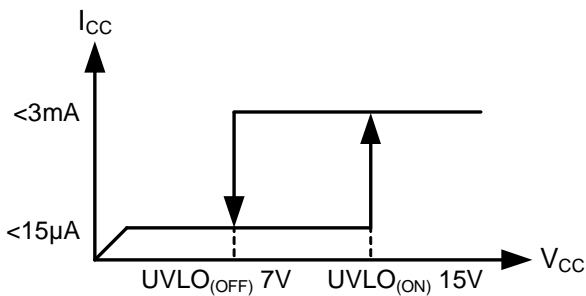


Fig 1. Start-up Function

### Oscillator

The operating frequency of CS8906 is fixed at 45kHz and the maximum duty-cycle is up to 90% for driving high LED voltage string. It has a wide output voltage range for LED lighting application.

### Gate Clamp/Soft Driving

Driver output voltage is clamped to 15V by an internal clamping circuit to protect the power circuit. Those damages usually come from undesired over-voltage OUT signals.

In order to reduce EMI interference, CS8906 is built in soft driving function. It helps designer save EMI components and cost.

### LEB (Leading-Edge Blanking)

Cycle-by-cycle current limiting is offered in CS8906. The switch current is detected by a sense resistor into the CS pin. When the power switch is turned on, a turn-on spike will occur on this resistor. A 410ns leading-edge blanking (LEB) is built in to avoid false-termination of the switching pulse so that the external RC filtering is no longer needed. The current limit comparator is disabled and cannot turn off the external MOSFET during the blanking period.

### Over Current Protection

The CS8906 has an over current protection function on CS pin. The switch current is detected by a sense resistor into the sense pin, when the current is larger than a OCP level, the output pin will keep on low level. Then V<sub>CC</sub> is lower than UVLO off level, the controller resets again.

### Over Voltage Protection

The CS8906 is implemented an OVP function on V<sub>CC</sub> Pin to protect LED power system. When the V<sub>CC</sub> voltage is higher than the OVP threshold voltage 31.5V, the output gate driver circuit will be shut down immediately to stop the switching of power MOSFET, until the V<sub>CC</sub> voltage drops below the UVLO threshold, then start again. The CS8906 is working in an auto-recovery mode as shown in Fig 2.

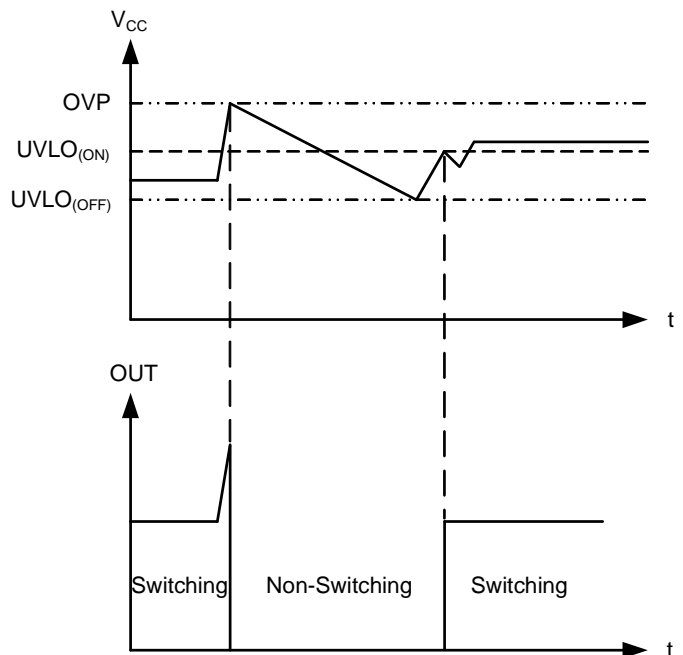


Fig 2. OVP Function



**Over Temperature Protection/Dimming Function**

The typical application for DIM pin is shown in Fig 3. The NTC thermistor is setting as an external OTP protection. In this DIM pin, there is one comparator for Output Minimum Pulse mode protection.

The application of DIM pin is as below:

1. Output Minimum Pulse mode protection is less than 0.3V.
2. The linear Dimming is between 0.3V and 3V.
3. The normal operating area is higher than 3V.
4. User can open this Dimming Pin when the Output Minimum Pulse mode and the linear Dimming are not required.

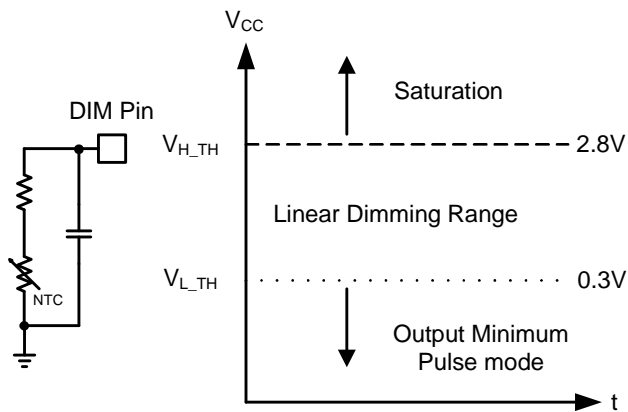
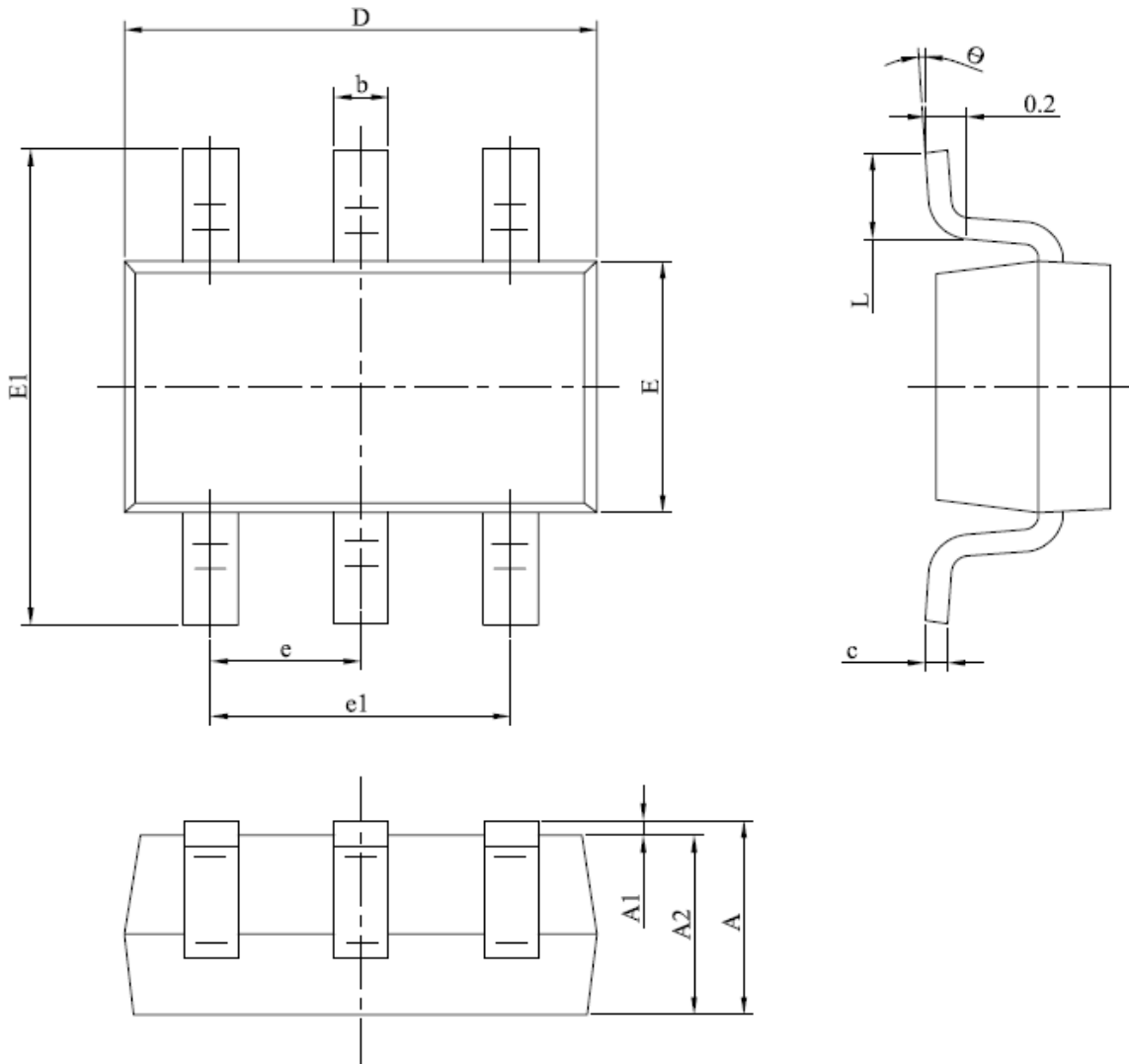


Fig 3. OTP&DIM Function

# SOT-23-6L



SYMBOL		A	A1	A2	b	c	D	E	E1	e	e1	L	$\theta$	
UNIT														
mm	Min.	1.050	0.000	1.050	0.300	0.100	2.820	1.500	2.650	0.950 (BSC)	1.800	0.300	0°	
	Nom.	-	-	-	-	-	-	-	-		-	-	-	-
	Max.	1.250	0.100	1.150	0.500	0.200	3.020	1.700	2.950		2.000	0.600	8°	
inch	Min.	0.041	0.000	0.041	0.012	0.004	0.111	0.059	0.104	0.037 (BSC)	0.071	0.012	0°	
	Nom.	-	-	-	-	-	-	-	-		-	-	-	-
	Max.	0.049	0.004	0.045	0.020	0.008	0.119	0.067	0.116		0.079	0.024	8°	