# HT7L4811 Non-isolation Buck LED Lighting Driver with Active PFC

## Features

- Tiny package SOT23-6
- Non-isolation buck topology
- Low BOM Cost
- Wide AC input range – from 85$V_{AC}$ to 265$V_{AC}$
- High Power Factor of >0.9 without additional circuitry
- Accurate constant current (< ±3%)
- Low start-up current which reduces power dissipation
- Full protection functions for enhanced safety
    - Gate driver output voltage clamp
    - VCC over voltage protection (VCC OVP)
    - VCC under-voltage lockout with hysteresis (VCC UVLO)
    - Output LED string over current protection
    - Output LED string short protection
    - Output LED string open protection
    - On-chip over temperature protection (OTP)

## Applications

- General illumination
- E26/27, T5/T8 LED Lamp
- Other LED Lighting Applications

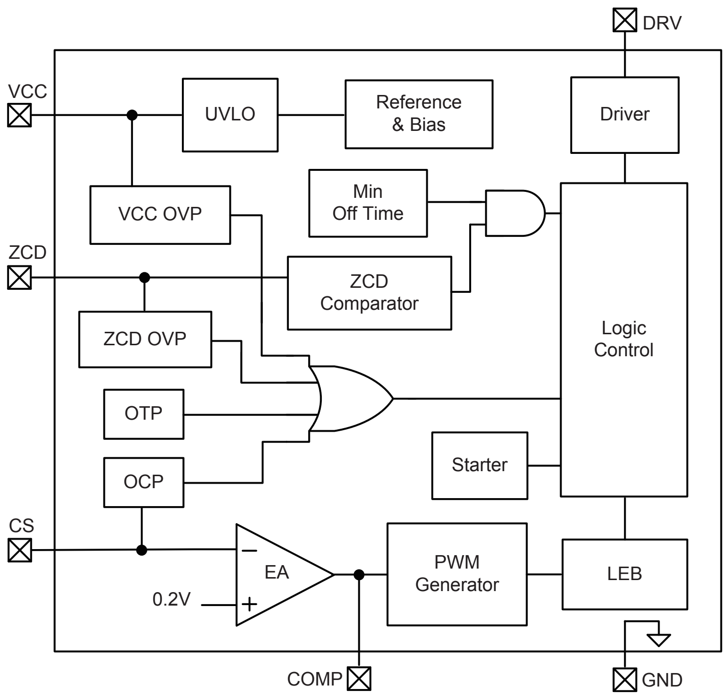
## General Description

The HT7L4811 is a non-isolation buck PWM controller for LED lighting applications. The device has a fully integrated PFC circuit which operates in a boundary conduction mode (BCM) to achieve high power factor values. With good control over external MOSFETs, the device can easily meet exacting LED current and high power factor requirements.

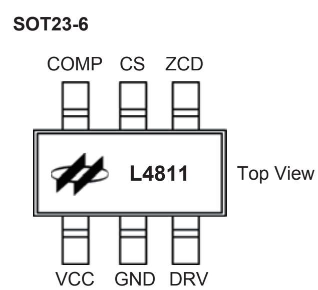
The HT7L4811 provides several protection functions, which include VCC Under Voltage Lockout (UVLO), Over Current Protection (OCP), Output LED String Open Protection, Output LED String Short Protection, VCC Over Voltage Protection (OVP) and Leading-Edge Blanking (LEB) for current sensing. Additionally and to ensure system reliability, the device includes a fully integrated thermal protection function. To protect the external power MOSFET from being damaged by a supply over voltage, the device DRV pin voltage is clamped to about 17V.

The high level of functional integration minimises the external component count giving major advantages in terms of cost and circuit board area. The device is supplied in a SOT23-6 package.

## Block Diagram




## Pin Assignment




## Pin Description

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | VCC | Power supply pin |
| 2 | GND | Ground pin |
| 3 | DRV | Gate drive output for driving external power MOSFETs |
| 4 | ZCD | Zero-current detect pin |
| 5 | CS | Current sense pin. A resistor is connected to sense the MOSFET current. |
| 6 | COMP | Loop compensation pin. A capacitor is placed between COMP and GND. |

## Absolute Maximum Ratings

VCC supply voltage ................................ -0.3V to 33V
Input voltage to CS pin ............................. -0.3V to 6V
Output voltage at COMP pin .................... -0.3V to 6V
Maximum current at ZCD pin................3mA (source), 3mA (sink)
Maximum operating junction temperature......... 150°C
Storage temperature range .................. -55°C to 150°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

## Recommended Operating Ranges

VCC supply voltage...................................17V to 25V
Operating junction temperature ..........−40°C to 125°C

## Electrical Characteristics

$V_{CC}$=18V, Ta=25°C

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Power Supply (VCC Pin)** | | | | | | |
| $VCC_{ON}$ | $UVLO_{ON}$ | — | — | 18 | — | V |
| $VCC_{OFF}$ | $UVLO_{OFF}$ | — | — | 10 | — | V |
| $VCC_{HYS}$ | UVLO Hysteresis | — | 7 | — | — | V |
| $V_{OVP}$ | VCC OVP Trip Point | — | 26 | 29 | 32 | V |
| $I_{START}$ | Start-up Current | Before turn-on, @ $V_{CC}$ = $UVLO_{ON}$ - 1V | — | 10 | 20 | μA |
| $I_Q$ | Quiescent Current | No switching | — | 0.6 | 1 | mA |
| $I_{CC}$ | Operating Current | @ 70kHz, Co=1nF | — | 1.8 | 2.5 | mA |
| **Error Amplifier** | | | | | | |
| $V_{FB}$ | Feedback Reference Voltage | Ta = 25°C | 194 | 200 | 206 | mV |
| **Current Sense Comparator** | | | | | | |
| $t_{LEB}$ | Leading Edge Blanking Time | — | — | 400 | — | ns |
| $V_{CL}$ | Current Limit Threshold | — | — | 1.3 | — | V |
| $V_{OCP}$ | Over Current Trip Point | — | — | 0.9 | — | V |
| | Over Current Release Point | — | — | 0.2 | — | V |
| **Zero Current Detector** | | | | | | |
| $V_{ZCDH}$ | Upper Clamp Voltage | $I_{ZCD}$ = 300μA | — | 3 | — | V |
| $V_{ZCDL}$ | Lower Clamp Voltage | $I_{ZCD}$ = -2.5mA | — | -0.2 | — | V |
| $V_{ZCDA}$ | Positive-Going Edge | — | — | 1.5 | — | V |
| $V_{ZCDT}$ | Negative-Going Edge | — | — | 1 | — | V |
| $I_{OVP}$ | OVP Current on ZCD pin | — | 270 | 300 | 330 | μA |
| $t_{B\_OVP}$ | Blanking Time for OVP Detection | — | — | 1 | — | μs |
| **Starter** | | | | | | |
| $t_{START}$ | Start Timer Period | — | — | 40 | — | μs |
| $t_{OFF}$ | Minimum Off Time | — | — | 4 | — | μs |
| **Over Temperature Protection** | | | | | | |
| OTP | Over Temperature Trip Point | — | — | 150 | — | °C |

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Gate Driver** | | | | | | |
| $t_R$ | Rising Time | $C_{LOAD}$=1nF, 10%~90% | — | 85 | — | ns |
| $t_F$ | Falling Time | $C_{LOAD}$=1nF, 10%~90% | — | 50 | — | ns |
| $I_{Source}$ | Source Current | — | — | 220 | — | mA |
| $I_{Sink}$ | Sink Current | — | — | 250 | — | mA |
| $V_{G\_CLAMP}$ | Gate Clamp Voltage | @ $V_{CC}$ = 25V | — | 16 | 19.5 | V |

## Typical Performance Characteristics

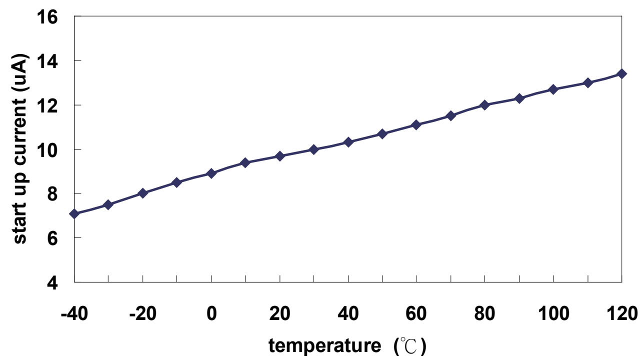



**Figure 1. Start-Up Current vs. Temperature**

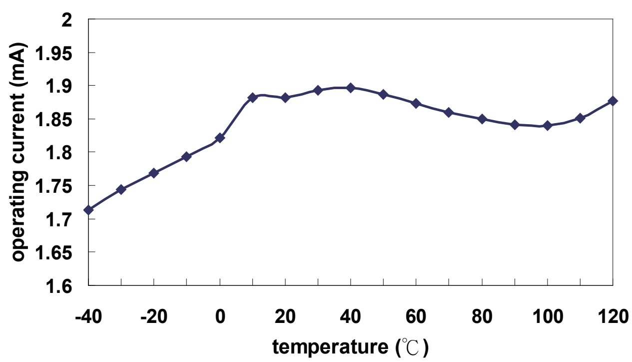



**Figure 2. Operation Current vs. Temperature**

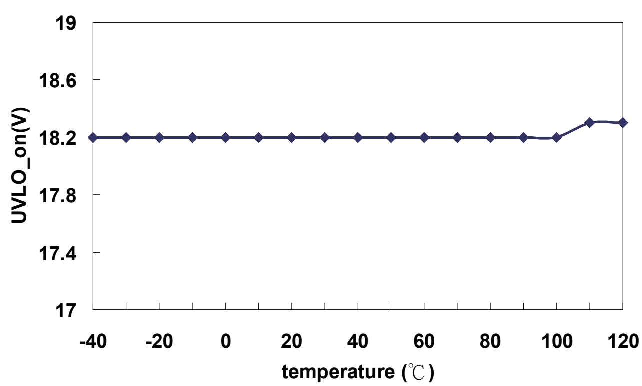



**Figure 3. UVLO_on vs. Temperature**

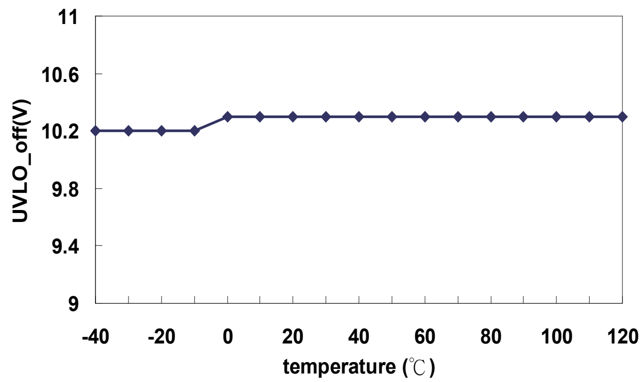



**Figure 4. UVLO_off vs. Temperature**

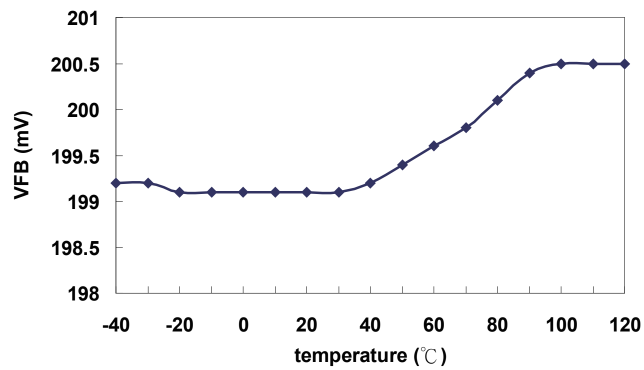



**Figure 5. VFB vs. Temperature**

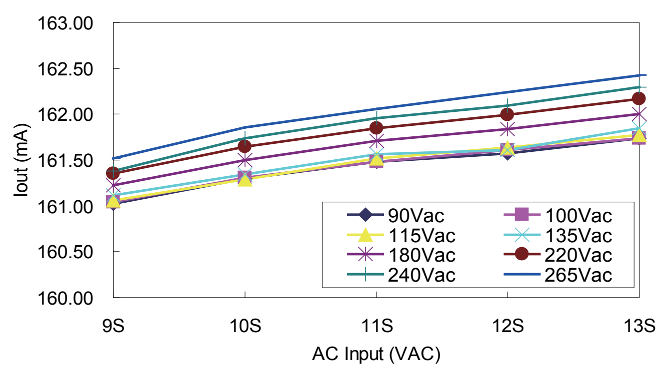



**Figure 6. Iout vs. LED(s) Regulation in E27 Bulb**

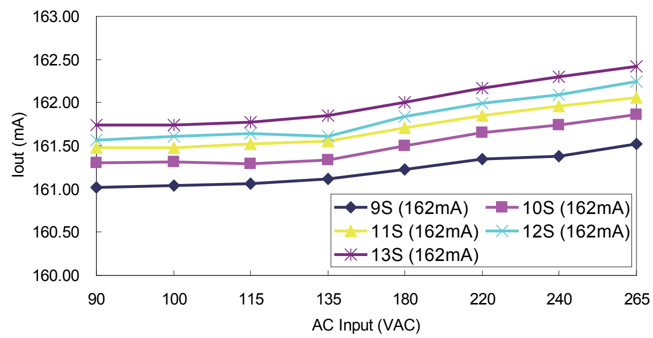



Figure 7. Iout vs. Wide AC Voltage in E27(8W, 13S / 162mA) Bulb

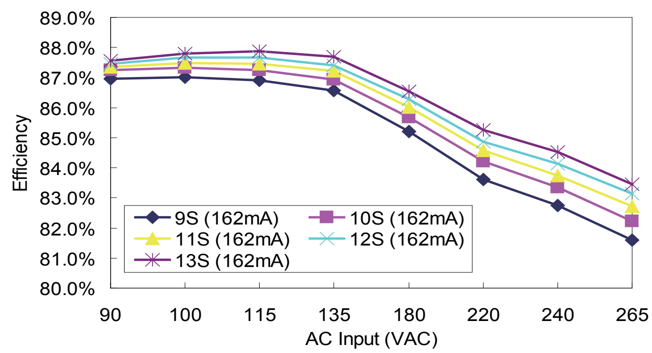



Figure 8. Efficiency vs. Wide AC Voltage in E27(8W, 13S / 162mA) Bulb

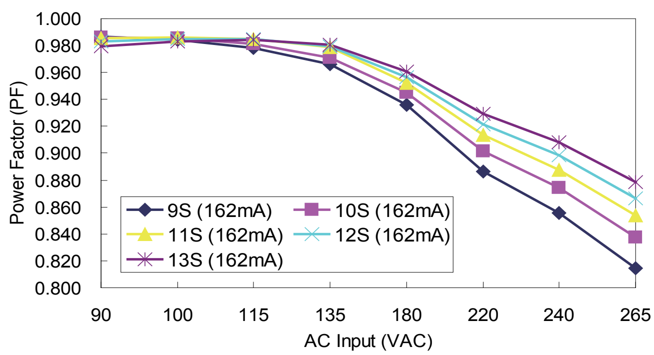



Figure 9. Power Factor (PF) vs. Wide AC Voltage in E27(8W, 13S / 162mA) Bulb

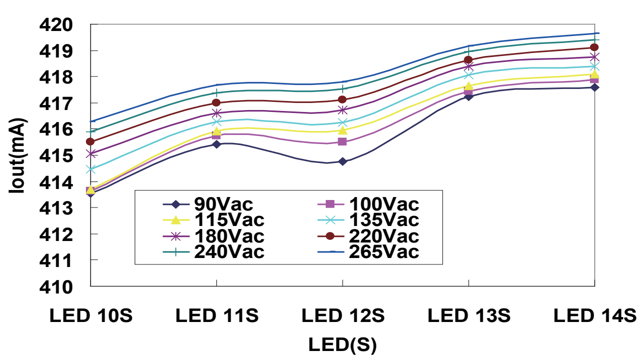



Figure 10. Iout vs. LED(s) Regulation in T8 Tube

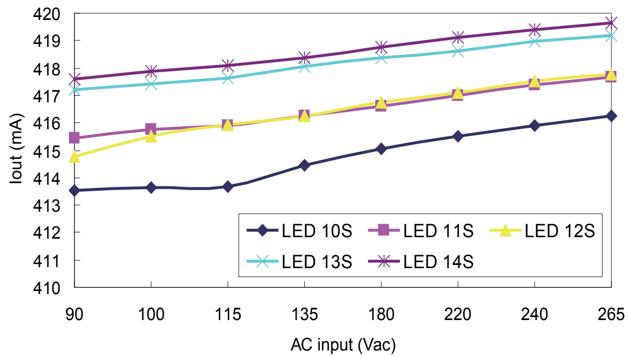



**Figure 11. Iout vs. Wide AC Voltage in T8 (18W, 12S / 425mA*) Tube**

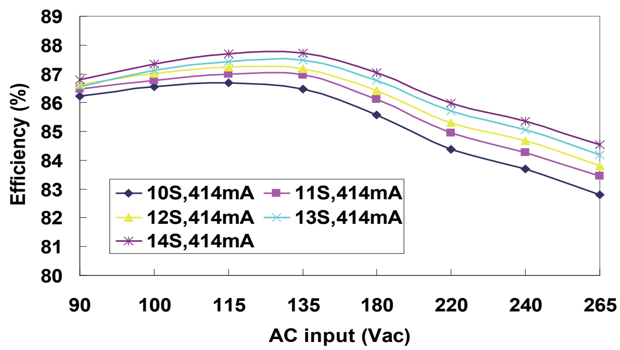



**Figure 12. Efficiency vs. Wide AC Voltage in T8(18W, 12S / 425mA) Tube**

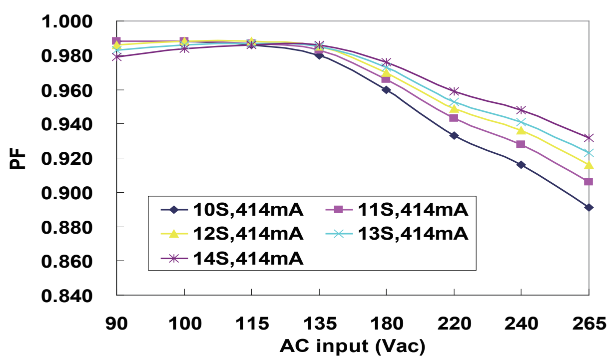



**Figure 13. Power Factor (PF) vs. Wide AC Voltage in T8(18W, 12S / 425mA) Tube**

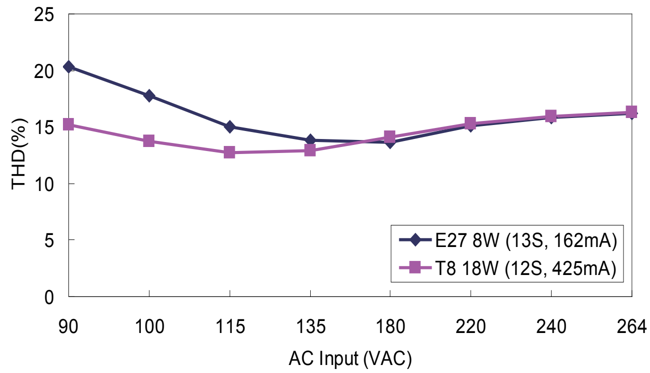
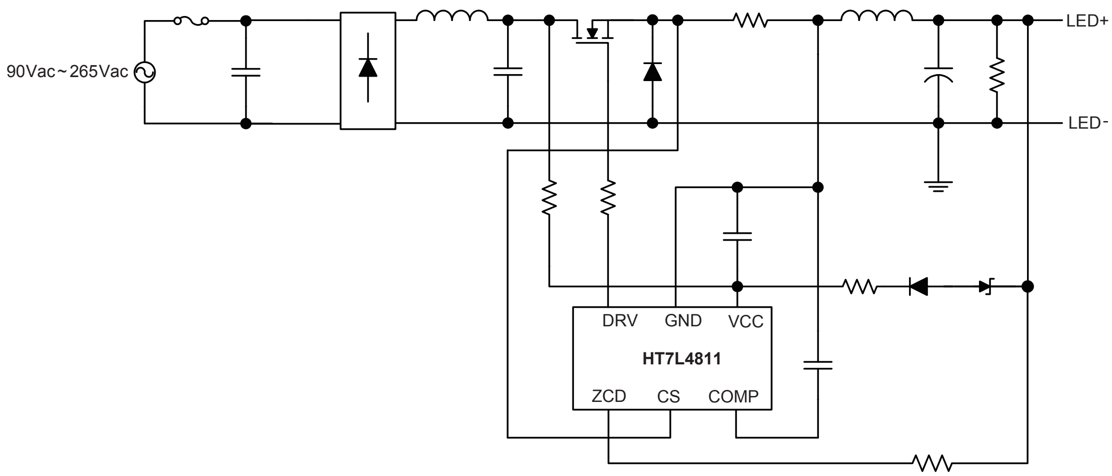



**Figure 14. E27/T8 THD vs. Wide AC Voltage**

Note: * 425mA is typical current limit. Actual LED current will be variable due to sense resistor tolerance.

## Typical Application Circuit




## Application Information

The HT7L4811 is a universal AC/DC LED driver designed for LED lighting applications. The device can achieve high Power Factor values without resorting to additional circuits and can also generate high accuracy LED drive currents with very few external components. Separate grounds are provided; one is a floating ground for the HT7L4811 while the other one is the earth. Users should be aware that the two grounds cannot be directly connected together to avoid IC damage and system malfunction.

### Start-up Current

A very low start-up current, ISTART, allows the users to select a larger value of start-up resistor which reduces power dissipation.

### VCC Under Voltage Lockout – UVLO

The device includes a UVLO feature which has 8V hysteresis. The PWM controller turns on when VCC is higher than 18V and turns off when VCC is lower than 10V. The hysteresis characteristics guarantee that the device can be powered by an input capacitor during start-up. When the output voltage increases to a certain value after start-up, VCC will be charged by an output through an auxiliary winding or a Zener Diode. $V_Z$=$V_{LED}$ - $V_{CC}$.

## Boundary Conduction Mode – BCM

The power MOSFET is turned on by inductor current zero-crossing detection. The current zero-crossing can be detected by a ZCD voltage. When the inductor current is at the zero crossing point, the voltage on the ZCD pin will drop rapidly. The HT7L4811 then detects the falling edge and turns on the Power MOSFET. The boundary conduction mode provides low turn-on switching losses and high conversion efficiency.

## Zero Current Detection – ZCD

The ZCD voltage is designed to operate between 0V and 3V for normal operation. If the voltage on the ZCD pin goes higher than 1.5V, the ZCD comparator waits until the voltage goes below 1V. When the inductor current is at the zero crossing point, the voltage on the ZCD pin will drop rapidly. The device will then detect the 1V falling edge and turn on the Power MOSFET. The 0.5V hysteresis avoids any false triggering actions due to noise.

## Constant Current Control

The HT7L4811 will sense the overall inductor current and form a closed-loop with an internal error amplifier to obtain high constant current accuracy. The CS voltage and the 0.2V reference voltage are the inputs of a Gm amplifier whose output is integrated via an external COMP capacitor. The ON time of the MOSFET is controlled by the COMP voltage to adjust the output current.

## LEB on CS – Leading-Edge Blanking

Each time the external power MOSFET is switched on, a turn-on spike will inevitably occur at the sense resistor. To avoid faulty triggering, a 400ns leading-edge blank time is generated. As this function is provided conventional RC filtering is therefore unnecessary. During this blanking period, the current-limit comparator is disabled and can therefore not switch off the gate driver.

## Gate Driver Clamp

The DRV pin is connected to the gate of external MOSFET to control its ON/OFF function. To protect the external power MOSFET from being over-stressed, the gate driver output is clamped to 17V.

## OVP on VCC – Over Voltage Protection

In order to prevent PWM controller damage, the device includes an OVP function on VCC. Should the VCC voltage be higher than the OVP threshold voltage of 29V, the PWM controller will stop operating immediately. When the VCC voltage decreases below the UVLO off level, the controller will reset.

## LED Open Protection – ZCD OVP

The LED voltage is reflected on the ZCD pin through a resistor RZCD. When the current on the resistor RZCD is higher than 300μA, then ZCD OVP protection will take place. Here the PWM controller will stop operating immediately. When the VCC voltage decreases below the UVLO off level, the controller will reset.

$V_{OVP\text{-}ZCD}$ can be set using the following equation:

$$V_{OVP-ZCD} = V_{ZCDH} + I_{OVP} \times R_{ZCD}$$

The $V_{ZCDH}$ is the upper clamp voltage 3V on the ZCD pin. The $I_{OVP}$ represents the OVP current level on the ZCD pin which is 300μA. The $R_{ZCD}$ stands for the resistor connected between the ZCD pin and the LED positive terminal.

## OCP – Over Current Protection

The HT7L4811 includes an over current protection function on the CS pin. An internal circuit detects the current level and when the current is larger than the over current protection threshold level, $V_{OCP}/R_{CS}$, the gate output will remain at a low level.

## LED Short Protection – SCP

The output voltage drops when a number of LEDs in a string are shorted resulting in a voltage drop at VCC. Once the VCC drops below 10V, the device will stop operating. Under such situations, the start-up operation will recharge the VCC pin through the start-up resistor and the device will enter the UVLO hiccup mode.

## Thermal Protection

A thermal protection feature is included to protect the device from excessive heat damage. When the junction temperature exceeds a threshold of 150°C, the thermal protection function will turn off the DRV terminal immediately. When the VCC decreases below the UVLO off level, the controller will reset.

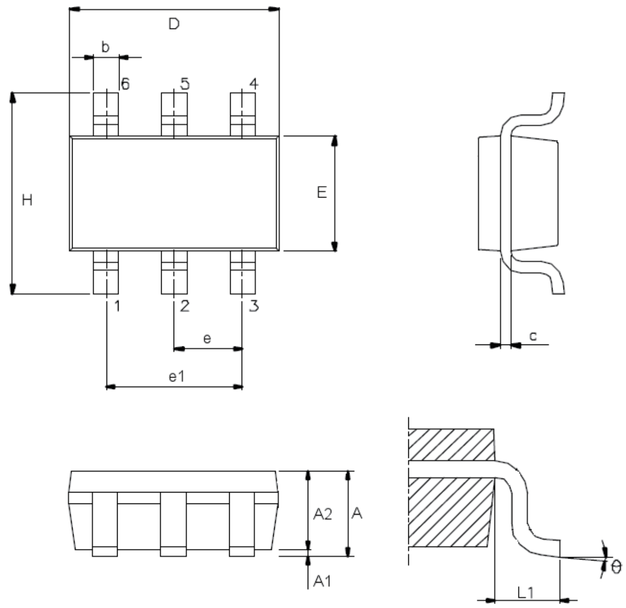
## Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the Holtek website for the latest version of the Package/ Carton Information.

Additional supplementary information with regard to packaging is listed below. Click on the relevant section to be transferred to the relevant website page.

- Package Information (include Outline Dimensions, Product Tape and Reel Specifications)
- The Operation Instruction of Packing Materials
- Carton information

## 6-pin SOT23-6 Outline Dimensions




| Symbol | Dimensions in inch | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | — | — | 0.057 |
| A1 | — | — | 0.006 |
| A2 | 0.035 | 0.045 | 0.051 |
| b | 0.012 | — | 0.020 |
| C | 0.003 | — | 0.009 |
| D | — | 0.114 BSC | — |
| E | — | 0.063 BSC | — |
| e | — | 0.037 BSC | — |
| e1 | — | 0.075 BSC | — |
| H | — | 0.110 BSC | — |
| L1 | — | 0.024 BSC | — |
| θ | 0° | — | 8° |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | — | — | 1.45 |
| A1 | — | — | 0.15 |
| A2 | 0.90 | 1.15 | 1.30 |
| b | 0.30 | — | 0.50 |
| C | 0.08 | — | 0.22 |
| D | — | 2.90 BSC | — |
| E | — | 1.60 BSC | — |
| e | — | 0.95 BSC | — |
| e1 | — | 1.90 BSC | — |
| H | — | 2.80 BSC | — |
| L1 | — | 0.60 BSC | — |
| θ | 0° | — | 8° |