High Current and Performance White LED Driver

Features

- Input range from 2.6V~5.5V
- Built-in Power MOSFET
- Can drive up to 39 White LEDs with a 5V input
- Low standby current: 0.1μA (typ.) with V_{EN} low
- Integrated Over-voltage, Over-temperature and Over-current protection circuits
- Under voltage lock-out protection
- 1.2MHz fixed switching frequency
- High efficiency - up to 90%
- 6-pin SOT23-6 package

Applications

- Display Backlighting
  - Automatic
  - DVD player
  - Digital photo frame
  - Handheld computer
- LED lighting

General Description

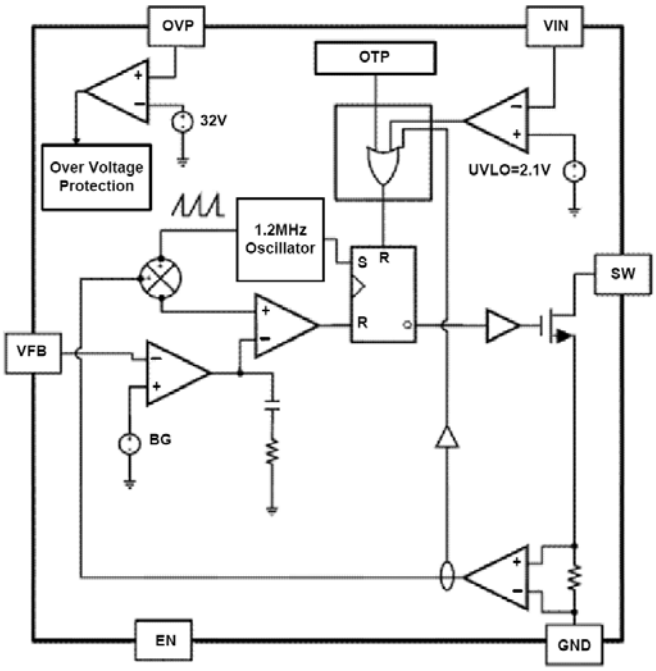
The HT7939 is a high efficiency boost converter for driving White LEDs using current mode operation. The device is designed to drive up to 39 White LEDs from a 5V power supply. The White LED current is setup using an external current setting resistor, which has a low feedback voltage of 0.2V to minimise power losses in the resistor which improves efficiency. The Over-voltage function prevents damage to the IC by turning off the converter when the LED load is open circuit.

The device includes over current protection, over temperature protection and under voltage protection preventing damage to the device when the output is overloaded.

Selection Table

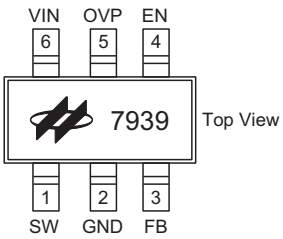
Part No.	Package	Marking
HT7939	SOT23-6	7939

Block Diagram



Pin Assignment

SOT23-6



Pin Description

Pin No.	Pin Name	Description
1	SW	Switching pin. Internal power MOSFET drain. Connected to inductor and diode.
2	GND	Signal Ground.
3	FB	Feedback pin. Reference voltage. The HT7939 feedback voltage is 200mV. Connect the sense resistor from FB to GND to set the LED current. Calculate resistor value according to $R_{FB} = \frac{200mV}{I_{LED}}$.
4	EN	Shutdown & Dimming control input. Don't allow this pin to float.
5	OVP	Over voltage protection pin which is connected to the output.
6	VIN	Input supply pin. The input supply pin for the IC. Connect VIN to a supply voltage between 2.6V~5.5V.

Absolute Maximum Ratings

Input Voltage.....6.0V
FB Voltage.....6.0V
OVP Voltage.....38V
Storage Temperature Range .....–55°C to +150°C
SW Voltage.....38V
EN 6.0V
Operating Temperature Range .....–40°C to +85°C
Maximum Junction Temperature.....+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.

Electrical Characteristics

V_{IN}=5V, L=10μH, C1=C2=2.2μF, Ta=25°C (unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Input Voltage	—	2.6	—	5.5	V
UVLO	Under Voltage Lockout	—	1.8	2.1	2.4	V
I_{IN}	Supply Current	Switching	—	1.0	2.5	mA
		V_{EN}= 0V	—	0.1	1.0	μA
Error Amplifier						
V_{FB}	Feedback Voltage	—	190	200	210	mV
Power Switch						
f_{OSC}	Switching Frequency	Measurement at SW pin	0.8	1.2	1.6	MHz
DC	Maximum Duty Cycle		85	90	—	%
$R_{DS(ON)}$	SW On Resistance	—	—	0.5	—	Ω
$I_{SW(OFF)}$	Switch Leakage Current	—	—	0.1	1.0	μA
EN Pin						
V_{IH}	EN Voltage High	V_{IN}=2.6V~5.5V	2.0	—	—	V
V_{IL}	EN Voltage Low	V_{IN}=2.6V~5.5V	—	—	0.8	V
OVP and OCP						
V_{OVP}	OVP Threshold	No load	29	32	35	V
I_{OCP}	N-channel MOSFET Current Limit	—	1000	1200	—	mA
Thermal Shutdown						
T_{SHUT}	Thermal Shutdown Threshold	—	—	150	—	°C
	Thermal shutdown Hysteresis	—	—	25	—	°C

Function Description

VIN Under-Voltage Lockout – UVLO

The device contains an Input Under Voltage Lockout (UVLO) circuit. The purpose of the UVLO circuit is to ensure that the input voltage is high enough for reliable operation. When the input voltage falls below the under voltage threshold, the internal FET switch is turned off. If the input voltage rises by the under voltage lockout hysteresis, the device will restart. The UVLO threshold is set below the minimum input voltage of 2.6V to avoid any transient VIN drops under the UVLO threshold and causing the converter to turn off.

Current Limit Protection

The device has a cycle-by-cycle current limit to protect the internal power MOSFET. If the inductor current reaches the current limit threshold, the MOSFET will be turned off. It is import to note that this current limit will not protect the output from excessive current during an output short circuit. If an output short circuit has occurred, excessive current can damage both the inductor and diode.

Over-Voltage Protection – OVP

The device provides an over-voltage protection function. If the FB pin is shorted to ground or an LED is disconnected from the circuit, the FB pin voltage will fall to zero and the internal power MOSFET will switch with its full duty cycle. This may cause the output voltage to exceed its maximum voltage rating, possibly damaging the IC and external components. Internal over-voltage protection circuitry turns off the power MOSFET and shuts down the IC as soon as the output voltage exceeds the V_{OVP} threshold. As a result, the output voltage falls to the level of the input supply voltage. The device remains in shutdown mode until the power is recycled.

Over-Temperature protection – OTP

A thermal shutdown is implemented to prevent damages due to excessive heat and power dissipation. Typically the thermal shutdown threshold is 150°C. When the thermal shutdown is triggered the device stops switching until the temperature falls below typically 125°C. Then the device starts switching again.

Application Information

- Inductor Selection
  The selection of the inductor affects steady state operation as well as transient behavior and loop stability. There are three important electrical parameters which need to be considered when choosing an inductor: the value of inductor, DCR (copper wire resistance) and the saturation current.

  Choose an inductor that can handle the necessary peak current without saturating, and ensure that the inductor has a low DCR to minimise power losses. A 10μH/22μH inductor should be a good choice for most HT7939 applications. However, a more exact inductance value can be calculated. A good rule for choosing an inductor value is to allow the peak-to-peak ripple current to be approximately 30~50% of the maximum input current. Calculate the required inductance value using the following equation:

$$L = \frac{V_{IN} \times (V_{OUT} - V_{IN})}{V_{OUT} \times F_{SW} \times \Delta I_L}$$

$$I_{IN(MAX)} = \frac{V_{OUT} \times I_{OUT(MAX)}}{V_{IN} \times \eta}$$

$$\Delta I_L = (30\% \sim 50\%) \times I_{IN(MAX)}$$

$$I_{L(PEAK)} = I_{IN(MAX)} + \frac{1}{2}\Delta I_L$$

  In the equation above, $I_{OUT(MAX)}$ is the maximum load current, ΔI_L is the peak-to-peak inductor ripple current, η is the converter efficiency, F_{SW} is the switching frequency and $I_{L(PEAK)}$ is the peak inductor current.

- Output Capacitor Selection
  The output capacitor determines the steady state output voltage ripple. The voltage ripple is related to the capacitor's capacitance and its ESR (Equivalent Series Resistance). A ceramic capacitor with a low ESR value will provide the lowest voltage ripple and are therefore recommended. Due to its low ESR, the capacitance value can be calculated by the equation:

$$C_{out} = \frac{(V_O - V_{IN}) \times I_{OUT}}{V_{OUT} \times F_{SW} \times V_{ripple}}$$

  In the equation above, V_{ripple} =peak to peak output ripple, F_{SW} is the switching frequency.
  A 1μF~10μF ceramic capacitor is suitable for most application.

- Input Capacitor Selection
  An input capacitor is required to supply the ripple current to the inductor, while limiting noise at the input source. A low ESR ceramic capacitors is required to keep the noise at the IC to a minimum.
  A 4.7μF~10μF ceramic capacitor is suitable for most application. This capacitor must be connected very close to the VIN pin and inductor, with short traces for good noise performance.

- Schottky Diode Selection

  The output rectifier diode conducts during the internal MOSFET is turn off. The average and peak current rating must be greater than the maximum output current and peak inductor current. The reverse breakdown voltage must be greater than the maximum output voltage. It is recommended to use a schottky diode with low forward voltage to minimize the power dissipation and therefore to maximize the efficiency of the converter. A 1N5819 type diode is recommended for HT7939 applications.

- LED Current Selection

  The LED current is controlled by the current sense feedback resistor R_{fb}, The current sense feedback reference voltage is 200mV. In order to have accurate LED currents, precision resistors are the preferred type with a 1% tolerance. The LED current can be calculated from the following formula.

$$I_{LED} = \frac{V_{FB}}{R_{fb}} = \frac{200mV}{R_{fb}}$$

  Where I_{LED} is the total output LED current, V_{FB}=feedback voltage, R_{fb}=current sense resistor.

- Digital and Analog Dimming Control

  The LED illumination level can be controlled using both digital and analog methods.

  The digital method uses a PWM signal applied to the EN pin. This is shown in figure 13. The average LED current increases proportionally with the PWM signal duty cycle. A 0% duty cycle corresponds to zero LED current. A 100% duty cycle corresponds to full LED current. The PWM signal frequency should be set below 1kHz due to the delay time of device startup.

  There are two methods of analog LED brightness control. The first method uses a DC voltage to control the feedback voltage. If the DC voltage range is from 0V to 3.3V, the selection of resistors control the LED current from 20mA to 0mA as shown in figure14. The other way is to use a filtered PWM signal, as shown in figure15. The filtered PWM signal application acts in the same way as the DC voltage dimming control.

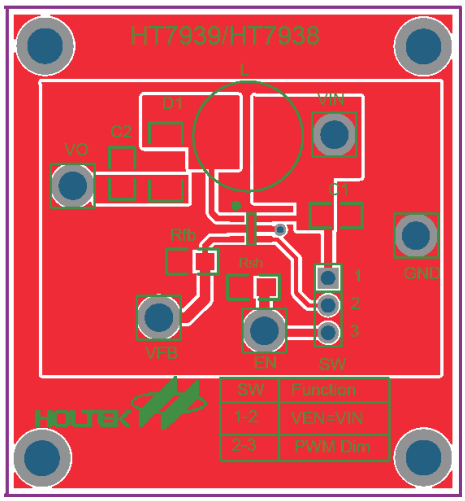
Layout Considerations

Circuit board layout is a very important consideration for switching regulators if they are to function properly. Poor circuit layout may result in related noise problems.

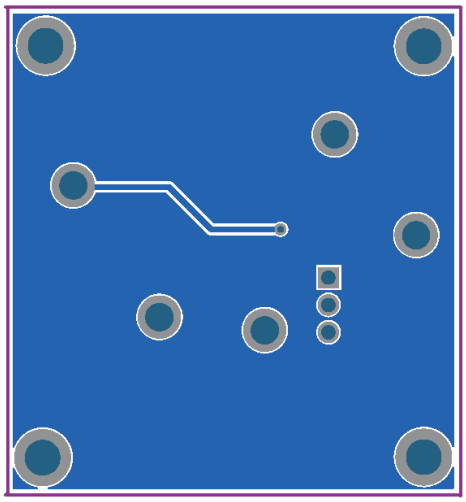
In order to minimize EMI and switching noise, please follow the guidelines below:

- All tracks should be as wide as possible.
- The input and output capacitors, C1 and C2, should be placed close to the VIN, VO and GND pins.
- The Schottky diode, D1, and inductor, L, must be placed close to the SW pin.
- Feedback resistor, Rfb, must be placed close to the FB and GND pins.
- A full ground plane is always helpful for better EMI performance.

A recommended PCB layout with component locations is shown below.



Top Layer



Bottom Layer

Typical Performance Characteristics

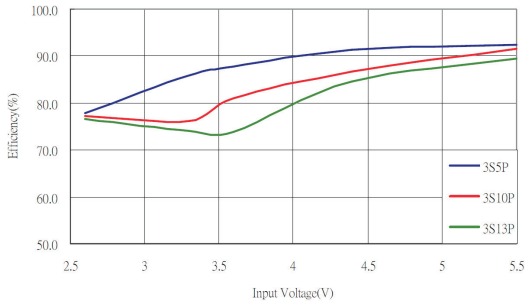


Fig.1 Efficiency VS Input Voltage

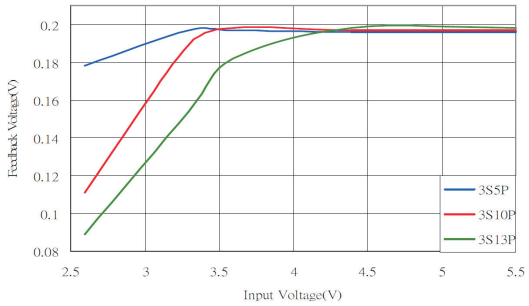


Fig.5 Feedback Voltage VS Input Voltage

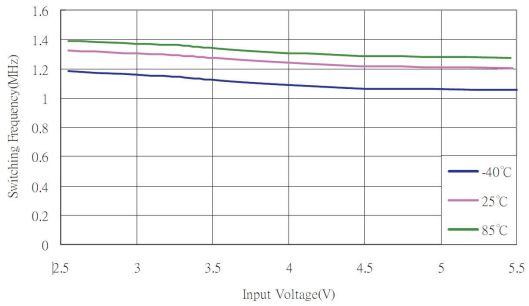


Fig.2 Switching Frequency VS Input Voltage

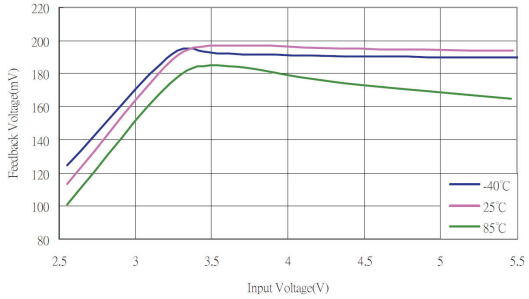


Fig.6 Feedback Voltage VS Input Voltage

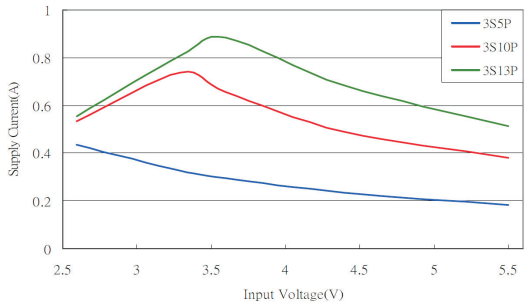


Fig.3 Supply Current VS Input Voltage

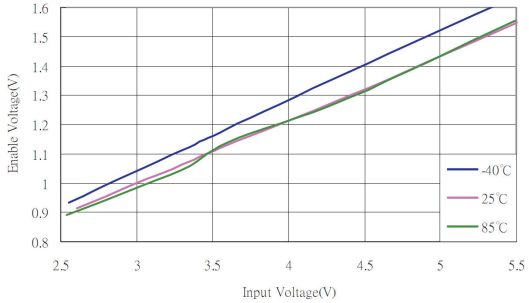


Fig.7 Enable Voltage VS Input Voltage

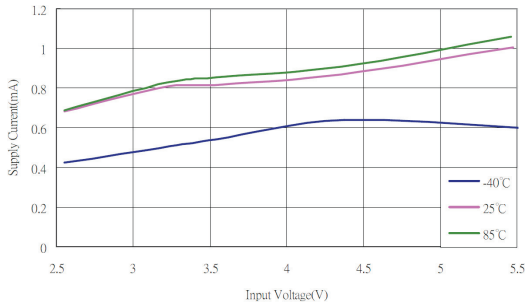


Fig.4 Supply Current VS Input Voltage

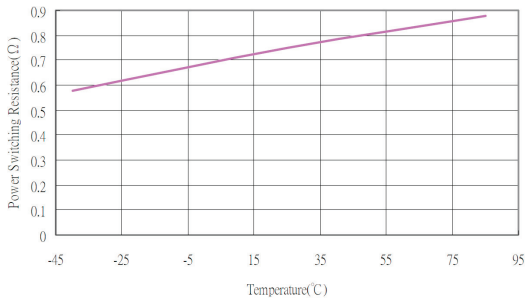


Fig.8 $R_{DS(ON)}$ VS Temperature

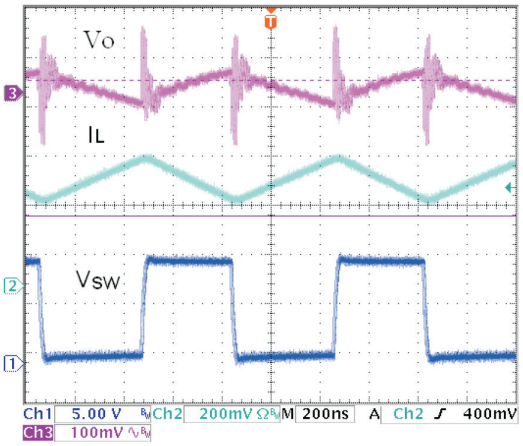


Fig.9 Switching Waveform

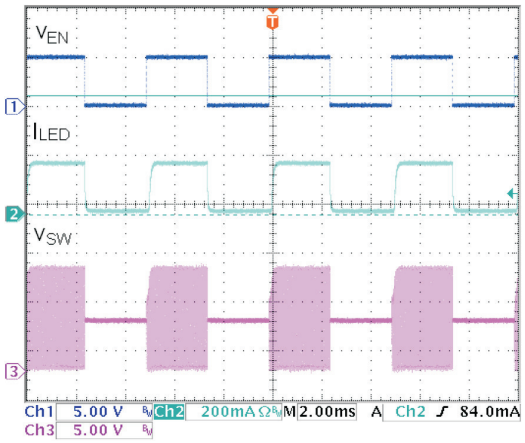


Fig.11 200Hz PWM Dimming Waveform

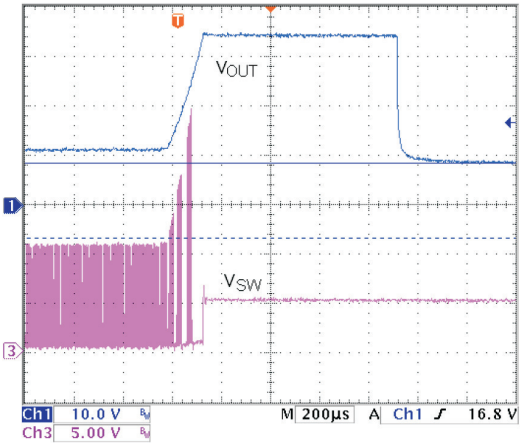


Fig.10 Open LED Protection

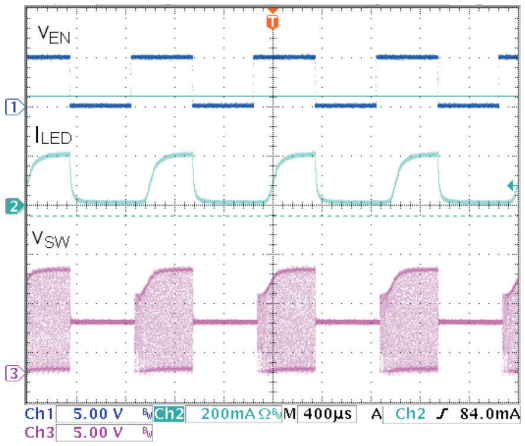
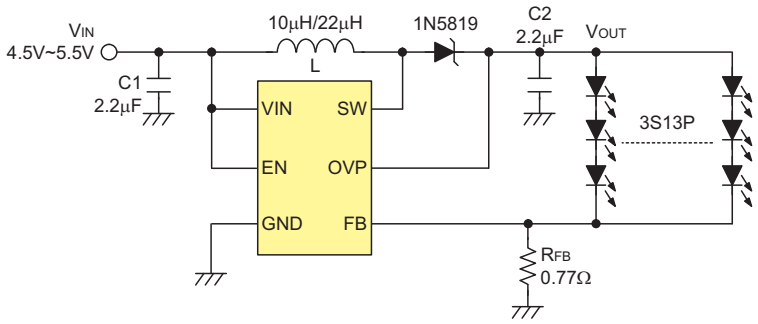


Fig. 12 1kHz PWM Dimming Waveform

Application Circuits



L: GS54-100K (GANG SONG)
C1: GRM21BR61E475KA12L(MURATA)
C2: GRM21BR71E225KA73L (MURATA)

Fig.12 Application Circuits for Driving 39 WLEDs

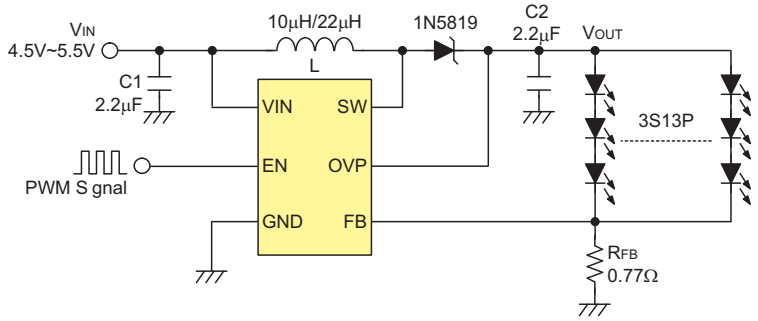


Fig.13 Application Circuit for Dimming Control Using a PWM Logic Signal

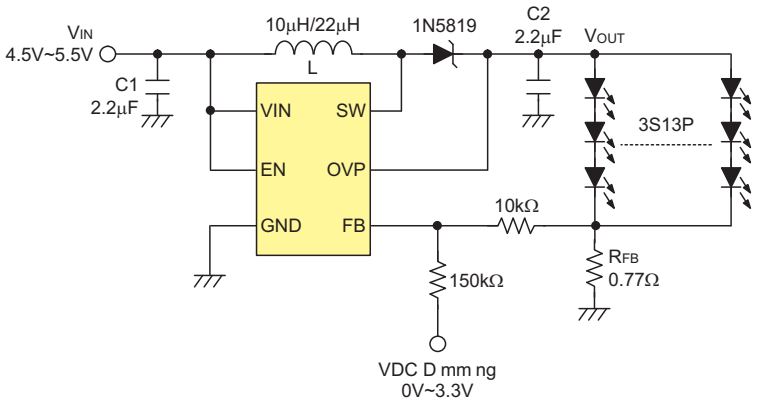


Fig.14 Application Circuit for Dimming Control Using a DC Voltage

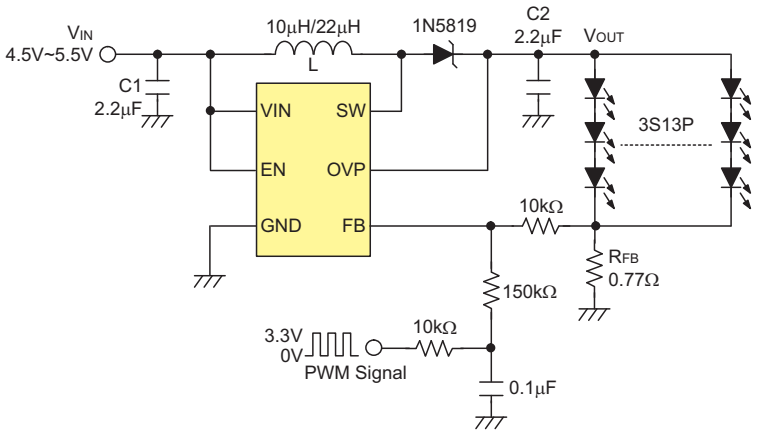


Fig.15 Application Circuit for Dimming Control Using a Filtered PWM Signal

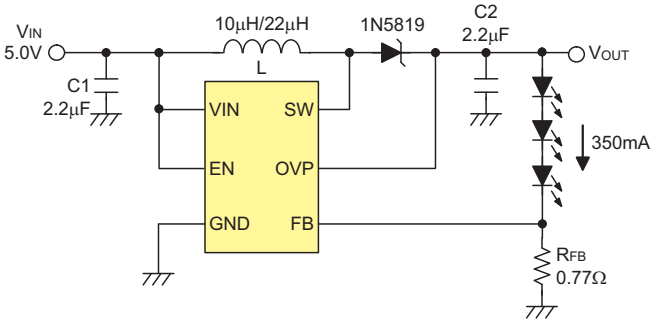


Fig.16 Application Circuit for Drive 3 High Brightness LEDs

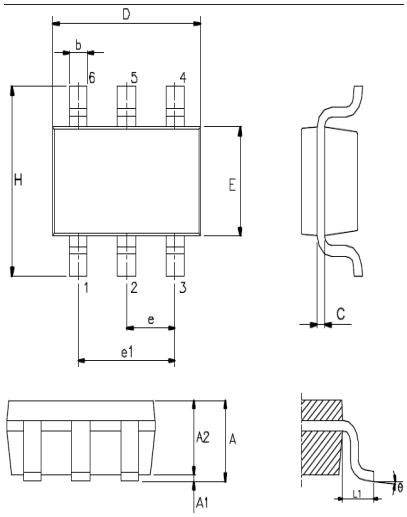
Package Information

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.

- Further Package Information (include Outline Dimensions, Product Tape and Reel Specifications)
- Packing Meterials Information
- 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°

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