Non-isolated Buck High Precision Three-stage Dimming LED Driver

Features

- Three-stage switcher dimming: 100%-40%-15%
- Compatible PCB with WS3442
- Internal 500V Power MOSFET
- Critical Conduction Mode Operation
- ±3% LED Current Accuracy
- without Auxiliary Winding for power supplying
- Efficiency up to 93%
- LED Open and Short Circuit Protection
- Thermal Regulation Function to avoid lights flicking under high temperature.

Typical Applictions

- T5/T8 LED Strings
- Ceiling Lamps
- Bulbs
- Other LED Lightings

Description

The WS9822B is a three-stage dimming constant current LED driver with high precision and is applied to non-isolated buck LED power system. The WS9822B integrates a switch dimming circuit and can change the output current through switch shifting.

The device operates in critical conduction mode and is suitable for universal input offline LED lighting to dim with three-stage by switcher.

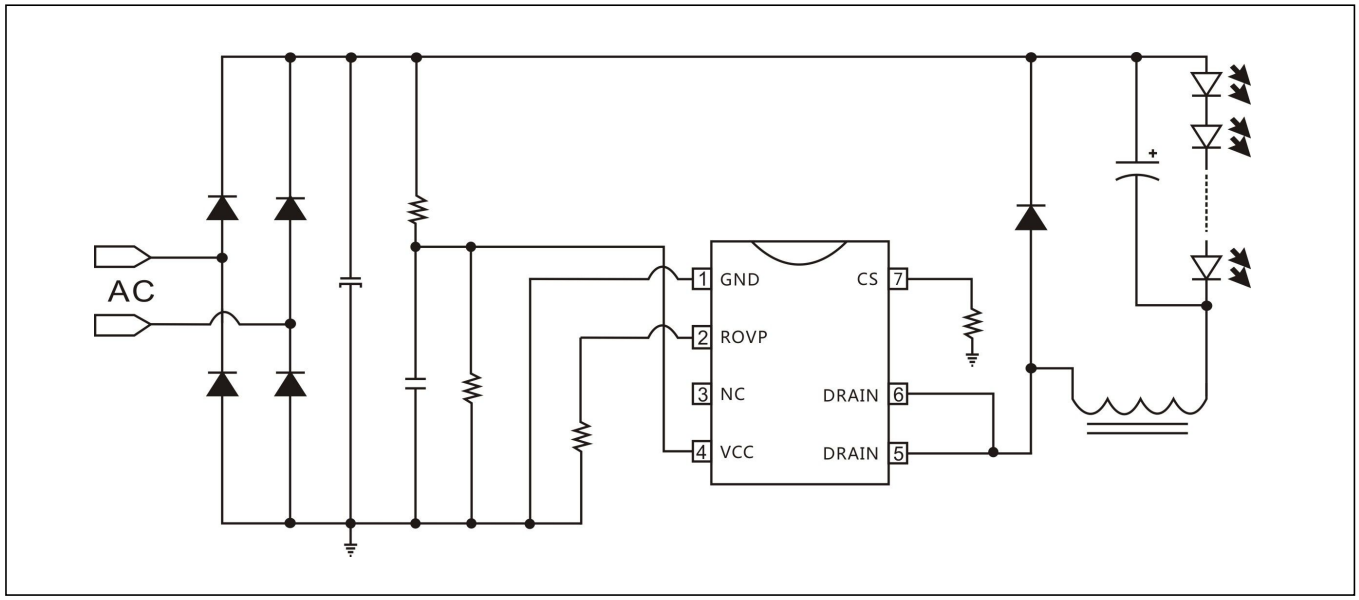
The WS9822B utilizes proprietary current control method. It can achieve precise LED output current and excellent line regulation.

The operating current of the IC is as low as 120uA. So it doesn't need the auxiliary winding for supplying the chip, which brings more simplified designs and lower cost.

The WS9822B adopts intelligent temperature control and thoroughly solves the problem of LED flickering under high temperature.

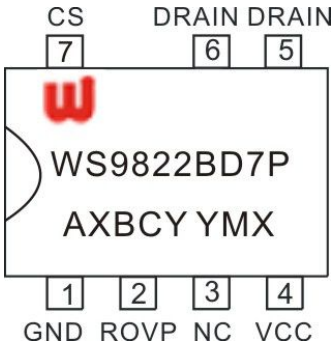
The WS9822B offers multiple protection functions to improve the system reliability, including LED open circuit protection, LED short circuit protection, and VCC under voltage protection.

Typical Application Circuit

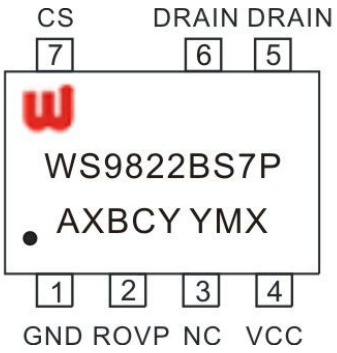


Pin Definition and Device Marking

WS9822B is available in DIP-7 and SOP-7 packages:



WS9822BD7P：Product Code
A：Product Code
X：Internal Code
BCY：Internal QC Code
YMX：D/C

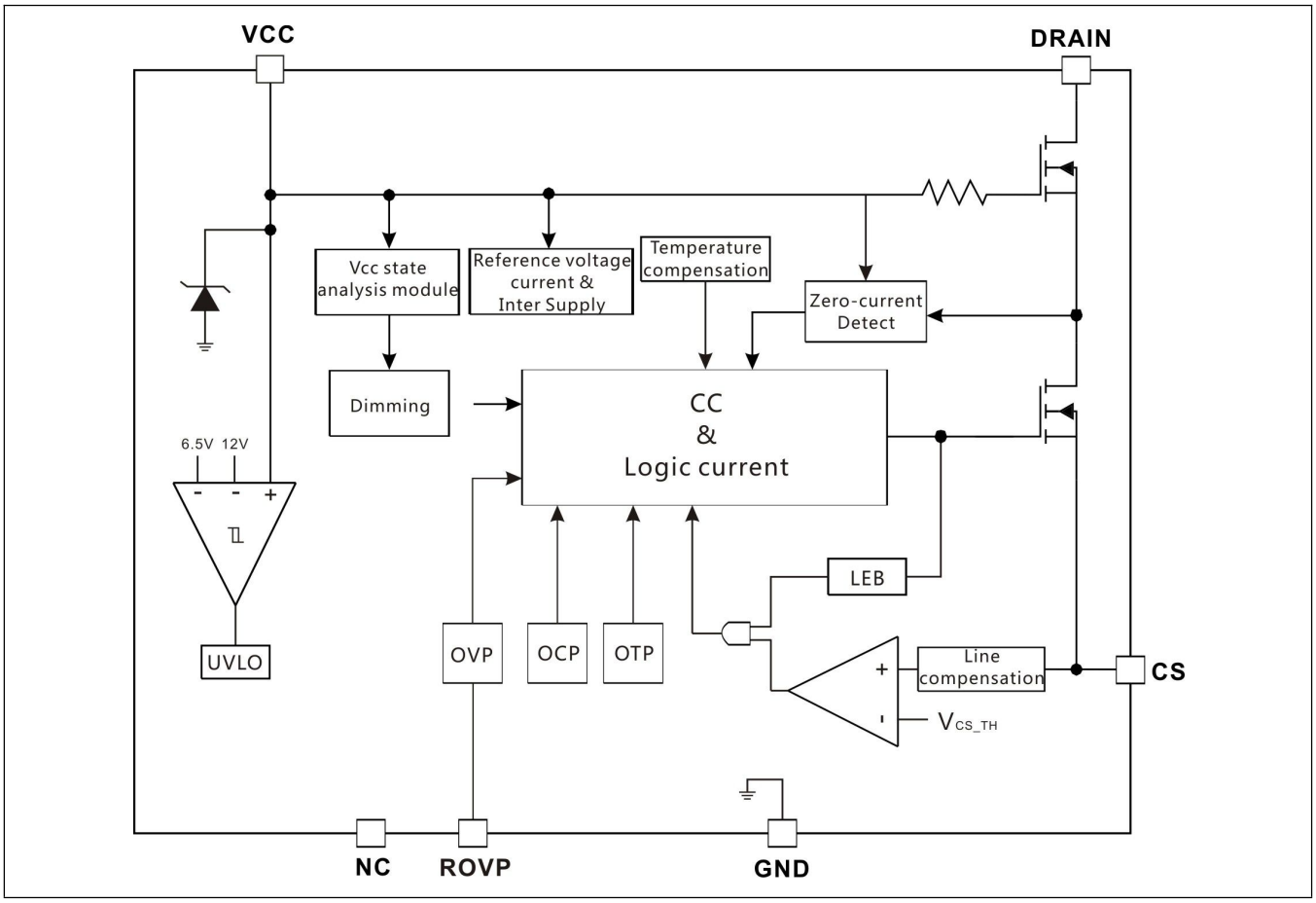


WS9822BS7P：Product Code
A：Product Code
X：Internal Code
BCY：Internal QC Code
YMX：D/C

Package Pin Definition

Pin name	Pin No.	Desciption
1	GND	Ground
2	ROVP	Over Voltage Protection Setting Pin. Connect a resistor to GND.
3	NC	No connection, must be floated.
4	VCC	Power Supply Pin
5/6	Drain	Internal HV Power MOSFET Drain.
7	CS	Current Sense Pin. Connect a sensing resistor between this pin and GND pin.

Internal Block Diagram



Ordering Information

Package	Marking	Part Number
7-Pin DIP-7, Pb-free	WS9822BD7P	WS9822BD7P
7-Pin SOP-7, Pb-free	WS9822BS7P	WS9822BS7P

Recommended Operation Conditions

Part Number	Package	Input voltage	Maximum output power
WS9822B	DIP7	175VAC-264VAC	28W
	SOP7	175VAC-264VAC	24W

Absolute Maximum Ratings

Symbol	Parameter	Limit	Unit
V_D	Internal HV MOSFET drain voltage	-0.3~500	V
I_{CC_MAX}	Maximum sink current	20	mA
V_{ROVP}	LED open circuit protection voltage regulation	-0.3~7	V
V_{CS}	Current sense pin input voltage	-0.3~7	V
P_{DMAX}	Power dissipation (note 2)	0.9	W
T_J	Maximum operating junction temperature	165	℃
T_{STG}	Minimum/Maximum Storage temperature	-55~165	℃

Note 1：Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

Note 2：The value of power dissipation is closely related to the heat emission conditions. The values in the table above are measured on the test board without heat sink and case, and Ta<40℃.

Electrical Characteristics

Conditions: T_A=25℃, VCC=14V（Unless otherwise specified）

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
Power Supply Section						
VCC_CLAMP	VCC Clamp Voltage	IVCC=1mA		16		V
ICC_CLAMP	VCC Clamp Current			5	20	mA
UVLO_OFF	Chip Startup Voltage	VCC Rising		15.8		V
UVLO_ON _HYS	Under voltage Protection Hysteresis	VCC Falling		3.5		V
IST	Startup Current	VCC=UVLO_off-0.5V	65	130	195	uA
IOP	Operating Current			120		uA
Current Detection Section						
VCS_TH	Threshold Voltage for Peak Current Limitation			400		mV
VCS_DIM	Threshold Value for Dimming Test			114		mV
TLEB	Leading Edge Blanking Time for Current Sense			350		ns
TDELAY	Switch Off Delay Time			200		ns
Switching Frequency Section						
TOFF_MIN	Minimum OFF Time			3		us
TOFF_MAX	Maximum OFF Time			240		us
TON_MAX	Maximum On Time			40		us
VROVP	ROVP PIN Voltage			0.5		V
DIM Dimming Section						
TRESET	Shutdown Reset Time			5		S
MOSFET Section						
IDSS	Power MOSFET Drain Leakage Current	VGS=0V,VDS=500V			10	uA
BVDSS	Drain-Source Breakdown Voltage		500			V
RDS_ON	Static Drain-source On-state resistance			4.8	6	Ω
Thermal section						
TREG	Thermal Regulation Temperature			150		℃

Function Description

The WS9822B is a three-stage dimming constant current LED driver with high precision and is applied to non-isolated buck LED power system. The WS9822B integrates a switcher dimming circuit and can change the output current through shifting external switcher ON/OFF to perform the dimming function.

The WS9822B is compatible the PCB board with mainstream non-dimming products in the markets, such as WS3442, thus it can achieve the seamless upgrades from non-dimming to ON/OFF dimming.

Switcher Dimming Control

The switcher is opened first and closed again when the dimming is required, and the output current changes in accordance with the presetted current. The switching time should be more than 500mS. The dimming current cyclically varies in the sequence of 100% to 40% to15%. The reset time is 5S. So it is a normal dimming if the time interval of the switch from turn-off to turn-on is less than 5s; otherwise it will be considered as a reset signal. The output current reaches up to 100% after the switch is on again whatever the output stage of the preceding current is.

Start Up

The VCC capacitor will be charged through the start-up resistor when the system is powered on. When the VCC pin voltage reaches the turn on threshold, the internal circuits start operating. The WS9822B integrates the 16V ZENER for clamping the VCC.

The typical value of the start-up current is 130uA (the maximum value is 195 uA). For the application of 176VAC—264VAC, the start-up resistor can be calculated by the equation（1）:

$$R_{st} < \frac{V_{in\_\min} \times 1.414}{I_{st\_\max}} \approx \frac{176V \times 1.414}{195uA} = 1.27\text{M}\Omega \quad (1)$$

The start-up resistor can be chosen from 720KΩ to 1.2MΩ. Two resistors in 1206 size SMD or 1/4W metal film resistors can be used in series.

Due to the ultra-low operating current, the auxiliary winding is not needed to supply the IC.

VCC Capacitor Selection

The Vcc capacitor is used to bypass noise to IC, so that to assure its stable operation, and should be as close as possible to the chip.

A 4.7uF/25V electrolytic capacitor can be used to Vcc Pin. If selecting MLCC, the material of X7R will be used to satisfy the stability of the capacity under high temperature. Due to external damage resulted from small volume and brittle texture of MLCC, it is easy to cause Vcc currents leakage, which will make the WS9822B unable to start. Strict control measures are taken in the layout and productive process.

In order to avoid the return flickering and the disorder time, the Vcc capacitor should be in parallel with discharge resistor, which value should be chosen from 150KΩ to 240KΩ.

Constant Current Control

Utilizing proprietary current control method, the WS9822B can achieve precise LED output current with a few external components. Cycle by Cycle current sense is adopted in WS9822B, the CS pin is connected to the current sense comparator, and the voltage on CS pin is compared with the internal 400mV reference voltage. The MOSFET will be switched off when the voltage on CS pin reaches the threshold. The CS comparator includes a 350ns leading edge blanking time.

The peak inductor current is calculated by the equation（2）:

$$I_{PK} = \frac{0.4}{R_{cs}}(mA) \quad (2)$$

Where, RCS is the current sense resistor value.

The current in LED can be calculated by the equation（3）:

$$I_{LED} = \frac{I_{PK}}{2}(mA) \quad (3)$$

Where, IPK is the peak current of the inductor.

Freewheeling Diode

The diode will bear the reverse voltage equal to the input voltage when the MOSFET is on. A 600V diode was

suggested to use. Besides, the operating frequency of freewheeling diode is from 20K to 120 KHz, such ultra fast recovery diodes as ES and ER whose Trr is less than 50ns are good choice.

Input Buck Electrolytic Capacitor

Input voltage should be considered in to the capacitor pressure, and the common value is 400V.

In general, the capacitor design can be calculated by the following empirical equations:

90Vac~264Vac: 1W output uses1uF intput electrolytic capacitor;

176Vac~264Vac: 1W output uses 0.5uF intput electrolytic capacitor.

Output Capacitor

Electrolytic capacitor is recommended to be used. Its stable capacitance can improve the efficiency of power supply, the LED ripple current and luminous efficiency.

Vovp voltage should be considered in output capacitor pressure.

Inductor Selection

The WS9822B works under inductor current critical conduction mode. When the power MOFET is switched on, the current in the inductor rises up from zero. The on time of the MOSFET can be calculated by the equation (4):

$$t_{on} = \frac{L \times I_{PK}}{V_{IN} - V_{LED}} \qquad (4)$$

Where,

L is the inductance value,

I_{PK} is the peak current of the inductor,

V_{IN} is the DC bus voltage after the rectifier bridge,

V_{LED} is the voltage on the LED.

After the power MOSFET is switched off and the current in the inductor decreases. When the inductor current reaches zero, the power MOSFET is turned on again by IC internal logic. The off time of the MOSFET is given by the equation （5）:

$$t_{off} = \frac{L \times I_{PK}}{V_{LED}} \qquad (5)$$

The inductance can be calculated by the equation（6）:

$$L = \frac{V_{LED} \times (V_{IN} - V_{LED})}{f \times I_{PK} \times V_{IN}} \qquad (6)$$

Where, f is the maximum system switching frequency, which is proportional to the input voltage. So the minimum switching frequency is set at lowest input voltage, and the maximum switching frequency is set at highest input voltage.

The minimum and maximum off time of WS9822B is set at 3us and 240us respectively. Referring to the equation of Toff calculation, if the inductance is too small, the Toff may be smaller than the minimum off time, the system will operate in discontinuous conduction mode and the output current will be smaller than the designed value. If the inductance is too large, the Toff may be larger than the maximum off time, the system will operate in continuous conduction mode and the output current will be higher than the designed value. So it is important to choose a proper inductance.

In addition, the OVP voltage changes with the Inductance value. Due to open magnetic flux of DR core, the Inductance value changes easily under the influence of temperature and external environment. Therefore, please don't use them along with the product in order to prevent from false triggering of OVP.

Over Voltage Protection

The over voltage protection of the WS9822B can be programmed by the ROVP pin resistor. The voltage of ROVP pin is 0.5V.

When the LED is open circuit, the period of the output voltage increases gradually, the demagnetization time gets shorter. The demagnetization time at OVP---- Tovp can be calculated by the open circuit protection voltage by the equation （7）:

$$T_{OVP} = \frac{L \times V_{CS}}{R_{CS} \times V_{OVP}} \qquad (7)$$

Where，

Vcs is the CS pin turn off threshold (400mV);

Vovp is the open circuit protection voltage.

And then the Rovp resistor value can be calculated by the equation （8）:

$$R_{OVP} = 5 \times T_{OVP} \times 10^6 \quad (K\Omega) \quad （8）$$

In normal application, the value of Tovp cannot be lower than 4us, or in other words, the value of Rovp cannot be lower than 20K, with its recommended range from 20K to 50K. The resistance of Rovp with 1% accuracy should be used to assure the accuracy of OVP.

Line Voltage Compensation

The WS9822B integrates line voltage compensation function, which makes LED current remain unchanged in the range of full voltage, thus has good line regulation and current accuracy.

Thermal Regulation

The WS9822B integrates thermal regulation function. When the system is under higher temperature, the output current is gradually reduced; the output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved. The thermal regulation temperature is set at 150℃ internally.

Protection Function

The WS9822B offers full protection functions to improve the system reliability, including LED open/short protection, CS resistor short protection, VCC under voltage protection, thermal regulation. When the LED is open circuit, the system will trigger the over voltage protection and stop switching. When the LED short circuit is detected, the system works at lowest frequency. So the system power consumption is very low.

At some abnormal fault condition, such as CS resistor shorted or inductor saturation, the internal fast fault detection circuit will be triggered, the system stops switching immediately.

After the system enters into faulty condition, the VCC voltage will decrease until it reaches the UVLO threshold, then the system will restart again. If the fault condition is removed, the system will recover to normal operation.

PCB Layout

The following rules should be followed in WS9822B PCB layout:

VCC Capacitor: The VCC capacitor should be as close as possible to the VCC Pin and GND pin.

Ground Path: The power ground path for current sense resistor should be as short as possible, and the power ground path should be separated from small signal ground path before connecting to the negative node of the bulk capacitor.

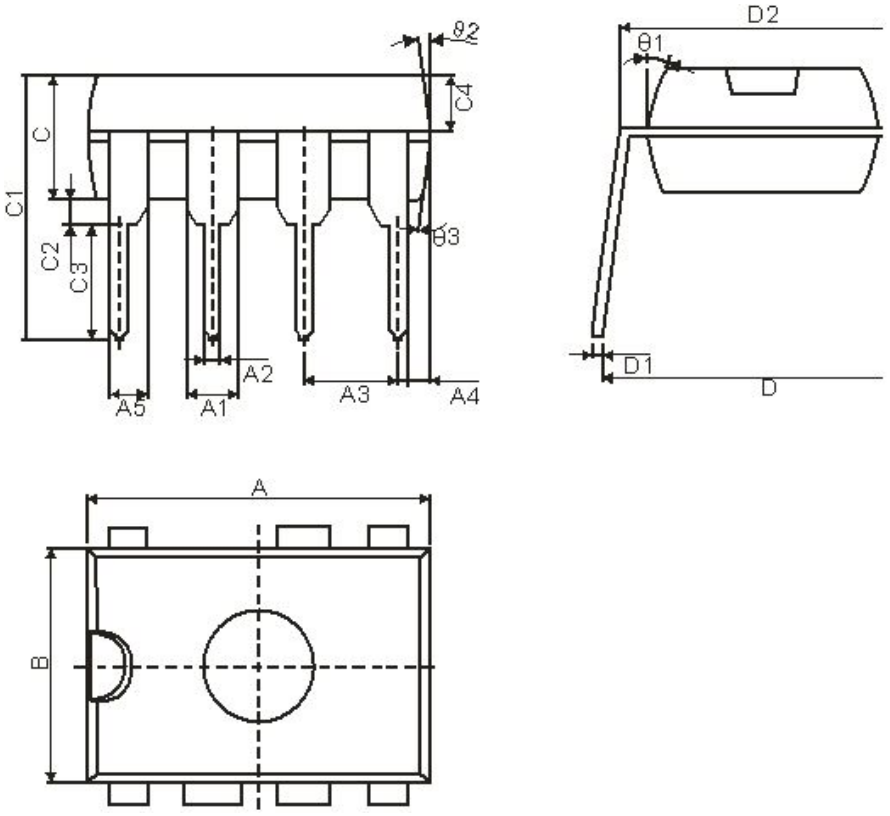
The Area of Power Loop: The area of main current loop should be as small as possible to reduce EMI radiation, and it should be away from diodes and other heating components.

DRAIN PIN: The copper area of DRAIN pin can be increased for better thermal dissipation. And it should be away from CS / VCC and ROVP Pin.

ROVP PIN: The ROVP resistor should be as close as possible to the ROVP Pin to prevent from the interference.

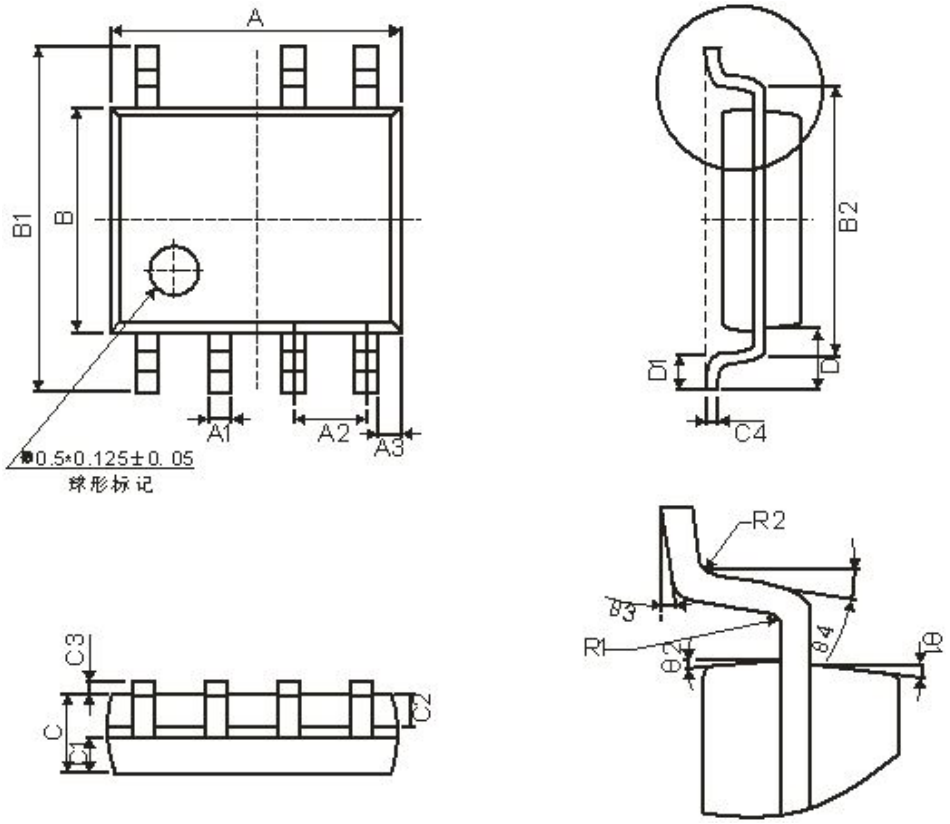
The material of PCB: Avoid choosing the material that is easy to absorb the moisture, just like paper copper-clad laminates.

DIP7 Package Dimension



Winsemi				
Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	9.00	9.50	0.354	0.374
B	6.10	6.60	0.240	0.260
C	3.0	3.4	0.118	0.134
A1	1.474	1.574	0.058	0.062
A2	0.41	0.53	0.016	0.021
A3	2.44	2.64	0.096	0.104
A4	0.51TYP		0.02TYP	
A5	0.99TYP		0.04TYP	
C1	6.6	7.30	0.260	0.287
C2	0.50TYP		0.02TYP	
C3	3.00	3.40	0.118	0.134
C4	1.47	1.65	0.058	0.065
D	7.62	9.3	0.300	0.366
D1	0.24	0.32	0.009	0.013
D2	7.62TYP		0.3TYP	

SOP7 Package Dimension



Symbol	Winsemi			
	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	4.70	5.10	0.185	0.201
B	3.70	4.10	0.146	0.161
C	1.30	1.50	0.051	0.059
A1	0.35	0.48	0.014	0.019
A2	1.27TYP		0.05TYP	
A3	0.345TYP		0.014TYP	
B1	5.80	6.20	0.228	0.244
B2	5.00TYP		0.197TYP	
C1	0.55	0.70	0.022	0.028
C2	0.55	0.70	0.022	0.028
C3	0.05	0.225	0.002	0.009
C4	0.203TYP		0.008TYP	
D	1.05TYP		0.041TYP	
D1	0.40	0.80	0.016	0.031

NOTE:

1.We strongly recommend customers check carefully on the trademark when buying our product, if there is any question, please don't be hesitate to contact us.

2.Please do not exceed the absolute maximum ratings of the device when circuit designing.

3.Winsemi Microelectronics Co., Ltd reserved the right to make changes in this specification sheet and is subject to change without prior notice.

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