



## DESCRIPTION

The PT6989 is a high precision buck LED Driver IC intended for PWM dimming products. The IC has a wide range input range which is 85V~265V and the default dimming state is three Level.

The PT6989 integrates high precision current detection and constant current circuit which can realize high precision LED constant current and excellent line voltage regulation. The PT6989 works in CRM mode, the LED current is constant with inductance and LED output voltage change, good load regulation.

The PT6989 integrates a 500V power MOSFET, uses the source driver architecture, with a low operating current, so the PT6989 doesn't need the auxiliary winding for sensing the output current and supplying the chip. It has a few external components, saves the cost of volume system.

The multi-protection features of PT6989 greatly enhance the system reliability and safety. The PT6989 provides CS resistance short-circuit protection, short LED protection, open LED protection, VIN under voltage protection, temperature intelligent control, etc.

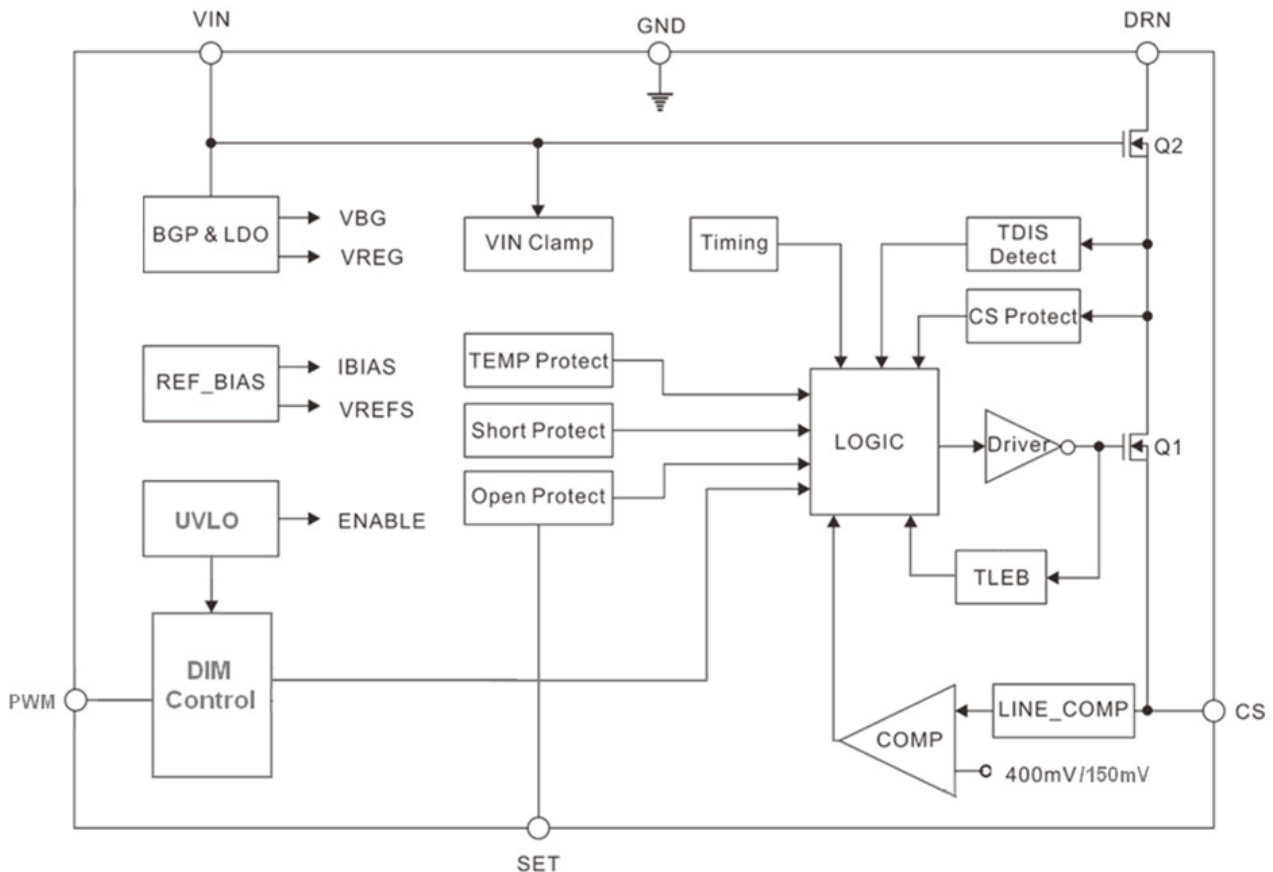
## FEATURES

- Integrates 500V Power MOSFET
- PWM Dimming Function
- CRM Mode(rated light)
- No Auxiliary Winding for Sensing and Supplying
- Low Operating Current
- $\pm 5\%$  Output Current Accuracy
- LED Open/Short Circuit Protection
- CS Resistor Short Circuit Protection
- VIN Under Voltage Protection
- Temperature Intelligent Control
- System Auto-Restart Function
- SOP-8 Package

## APPLICATIONS

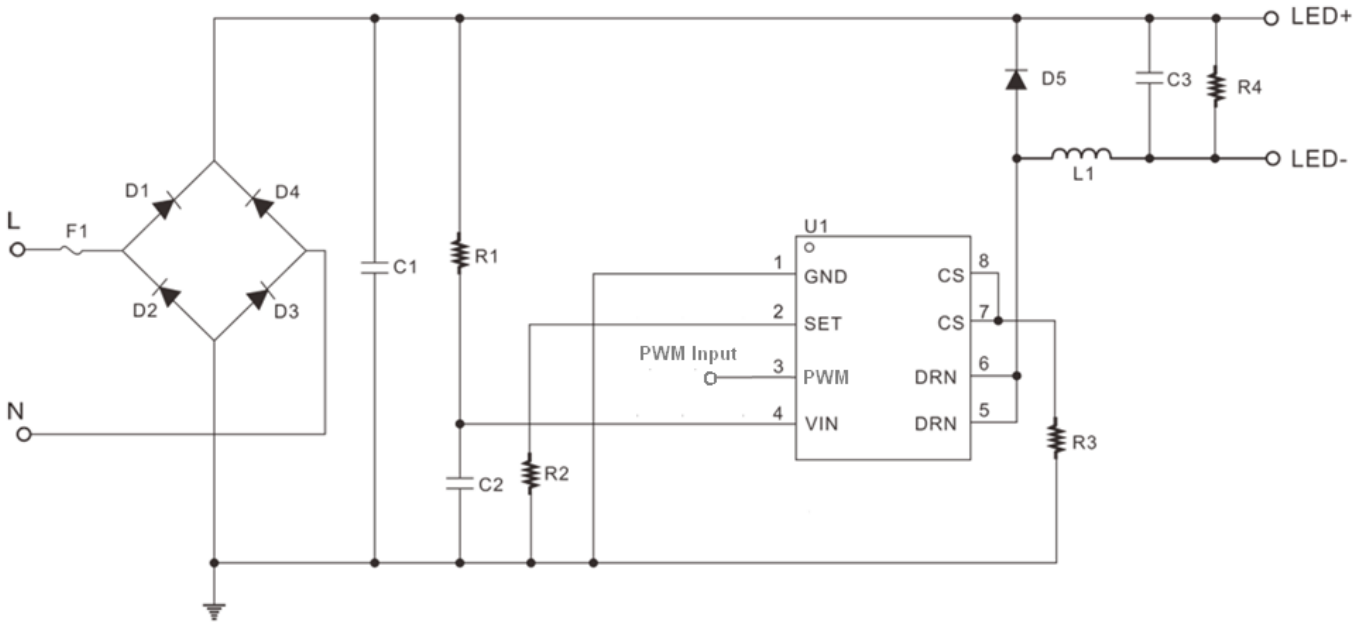
- LED Bulb lamp · LED PAR lamp
- LED Tube lamp
- Other LED lighting

## BLOCK DIAGRAM





## TYPICAL APPLICATION

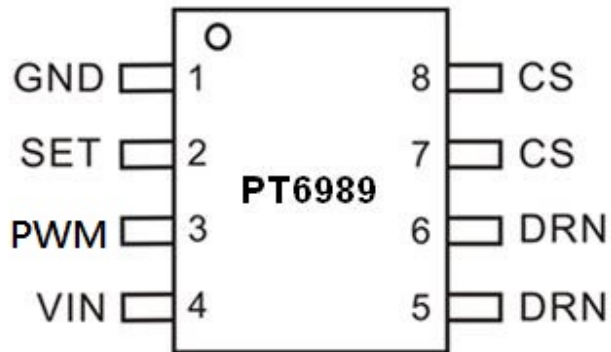




## ORDER INFORMATION

Valid Part Number	Package Type	Top Code
PT6989-S	SOP8	PT6989-S

## PIN CONFIGURATION



## PIN DESCRIPTION

Pin Name	Description	Pin No.
GND	Ground	1
SET	LED open-circuit voltage protection Settings, by connecting the resistance to the ground	2
PWM	PWM input PIN	3
VIN	Power supply pin	4
DRN	Power MOSFET Drain	5, 6
CS	Current sense pin, sense the inductor current while the switch is on-stage.	7, 8



## FUNCTION DESCRIPTION

### OPERATION

Under the rated situation of current output (100% light), PT6989 is designed to work in CRM mode and is especially suitable for non-isolated buck LED lighting applications. It is designed to work in CRM mode, can achieve high precision LED constant current without any closed loop control. PT6989 integrates a 500V power MOSFET, and doesn't need the auxiliary winding for sensing the output current and supplying the chip. System only needs a few peripheral devices can achieve excellent line regulation and load regulation.

When the VIN pin voltage is higher than chip's starting-threshold, PT6989 begins to work, when the switch of PT6989 is turned on, the inductor current sensed by the CS resistor rises up linearly at a rate. When the CS pin voltage rises up to the internal reference voltage, the switch will be turned off. During the switch is off-level, the inductor current falls down linearly at a rate. When the inductor current drop to zero, the switch will be turned on again. This switching process will be repeated to realize the constant current control.

### START-UP

The PT6989 provides VIN under voltage protection. Under the UVLO mode, closed switch of MOSFET, so the PT6989 has a low start-up current (180μA Typical). When VIN voltage is greater than 16V, PT6989 begins to work. The PT6989 has a low operating current (125μA Typical) which means the current could be provided by the resistor R1 connected between DC-BUS and VIN pin. So, the PT6989 doesn't need the auxiliary winding for supplying the chip. The PT6989 integrates a power-supply clamped circuit to realize the over voltage protection, the clamped voltage is 16.8V typically.

### CONSTANT CURRENT CONTROL

The PT6989 output current is controlled by the inductance peak current. The inductance peak current sensed by the resistor R<sub>CS</sub>. When the CS voltage rises up to the internal reference voltage, the switch is turned off. The inductor peak current is given by the following equation:

$$I_{PEAK} = \frac{V_{CS}}{R_{CS}} \quad (1)$$

Where, R<sub>CS</sub> is the current sense resistor which connects CS pin and GND. V<sub>CS</sub> is reference voltage sense peak current.

Under the rated situation of current output (100% light), PT6989 works in CRM mode, the LED output current is half the peak inductor current. The output current is given by the following equation:

$$I_{LED} = \frac{I_{PEAK}}{2} = \frac{1}{2} * \frac{0.4V}{2} \quad (2)$$

### INDUCTANCE CALCULATION

The PT6989 is a buck controller for LED lighting, and it works in CRM mode. The switch on-time is given by the following equation:

$$T_{ON} = \frac{L \times I_{PEAK}}{V_{BUS} - V_{LED}} \quad (3)$$

The switch off-time is given by the following equation:

$$T_{OFF} = \frac{L \times I_{PEAK}}{V_{LED}} \quad (4)$$

The L is the value of the inductance. The I<sub>PEAK</sub> is the inductor peak current. The V<sub>BUS</sub> is the DC-BUS voltage after rectification. The V<sub>LED</sub> is the LED output voltage.

The value of the inductances given by the following equation:

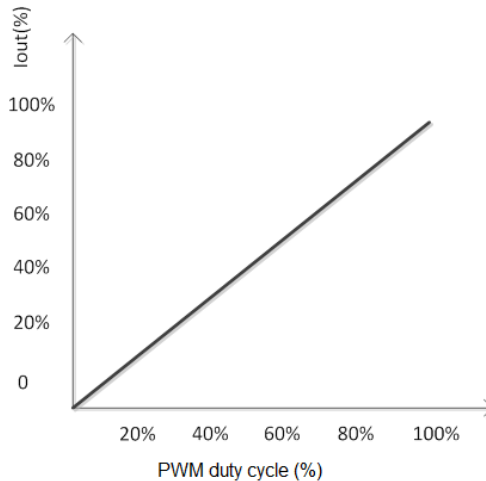
$$L = \frac{V_{LED} \times (V_{BUS} - V_{LED})}{f_{osc} \times I_{PEAK} \times V_{BUS}} \quad (5)$$



Where,  $f_{osc}$  is the operating frequency. When the inductance L is selected, the system operating frequency rises with the DC-BUS voltage rising. To define the inductance L, the parameters should be set with the minimum input voltage ( $V_{BUSMIN}$ ), the minimum LED output voltage ( $V_{LEDMIN}$ ) and the minimum operating frequency ( $f_{oscmin}$ )

## PWM DIMMING CONTROL

PT6989 has PWM dimming Function. We can realize PWM dimming function by supplying PWM signal through PWM PIN (PIN3) and the LED current is direct proportional to the duty cycle of the input PWM signal. PT6989 has a perfect dimming linearity, and can realize 1%-100% dimming range at 200Hz PWM signal.



## PROTECTION FEATURES

To greatly enhance the system reliability and safety, the PT6989 provides multi-protection functions such as VIN under voltage protection, LED open circuit protection, LED short circuit protection, CS resistor short circuit protection, temperature intelligent control, etc.

When the LED short circuit happens, the system works at a low frequency, which is 4kHz typically, and the internal reference voltage  $V_{REF}$  will be changed to 150mV.

When the LED open circuit happens, protection logic is active. PT6989 enters a stage of HIPCUP mode. So VIN voltage began to decline, the system restart when VIN drops to the UVLO threshold. When the LED open circuit happens, the output capacitance has been charging, output voltage is slowly rising. So to set the maximum output voltage, prevent to damage output capacitance when the LED open circuit happens. PT6989 provides LED open-circuit voltage protection which set by connecting the resistance to the ground to set the maximum output voltage. The SET resistance formula is equation (6), Where  $V_{cs}$  is the internal reference voltage (400mV),  $V_{OVP}$  the maximum output voltage, When the LED open circuit happens, the system will goes into the auto-restart mode, therefore need a resistor paralleled in the output capacitance to discharge energy produced during the restart system.

$$R_{SET} \approx 15 \times \frac{V_{CS} \times L}{R_{CS} \times V_{OVP}} \times 10^6 (k\Omega) \quad (6)$$

When the CS resistance short circuit protection happens, protection logic is active. PT6989 enters a stage of HIPCUP.

The temperature intelligent control function is built in the PT6989 to protect the chip and system. when the temperature of PT6989 rises up to 145°C typically, the output current is reduced gradually with the temperature rises; when the temperature of PT6989 rises up to 165°C typically, the output current decreases to zero. To control the output power and temperature, The PT6989 temperature changes smoothly. This can not only protect the chip, and can avoid the traditional way of chip overheat shut off as a result of the LED flashing phenomenon, in order to improve the reliability of the system.



## ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Input Voltage	$V_{IN}$	18	V
Maximum VIN Input Current	$I_{VIN}$	5	mA
DRN to GND	$V_{DRN}$	-0.3~500V	V
SET to GND	$V_{SET}$	-0.3~6	V
CS to GND	$V_{CS}$	-0.3~6	V
PWM to GND	$V_{PWM}$	-0.3~6	V
Power Loss	$P_{Total}$	0.45	W
Operating Temperature	$T_{OP}$	-40~150	°C
Storage Temperature	$T_{ST}$	-40~150	°C
ESD	ESD	2	KV

## RECOMMENDED OPERATING CONDITIONS

Parameter	Conditions	Rating	Unit
$I_{LED}$	Input AC Voltage: 176V~265V, Output Voltage 80V	PT6989-S	300
	Input AC Voltage: 176V~265V, Output Voltage 40V	PT6989-S	360
	Input AC Voltage: 90V~265V, Output Voltage 40V	PT6989-S	300
$V_{LEDMIN}$	Minimum LED Output Voltage	PT6989-S	>12



## ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, Ta=25°C, V<sub>IN</sub>=15V)

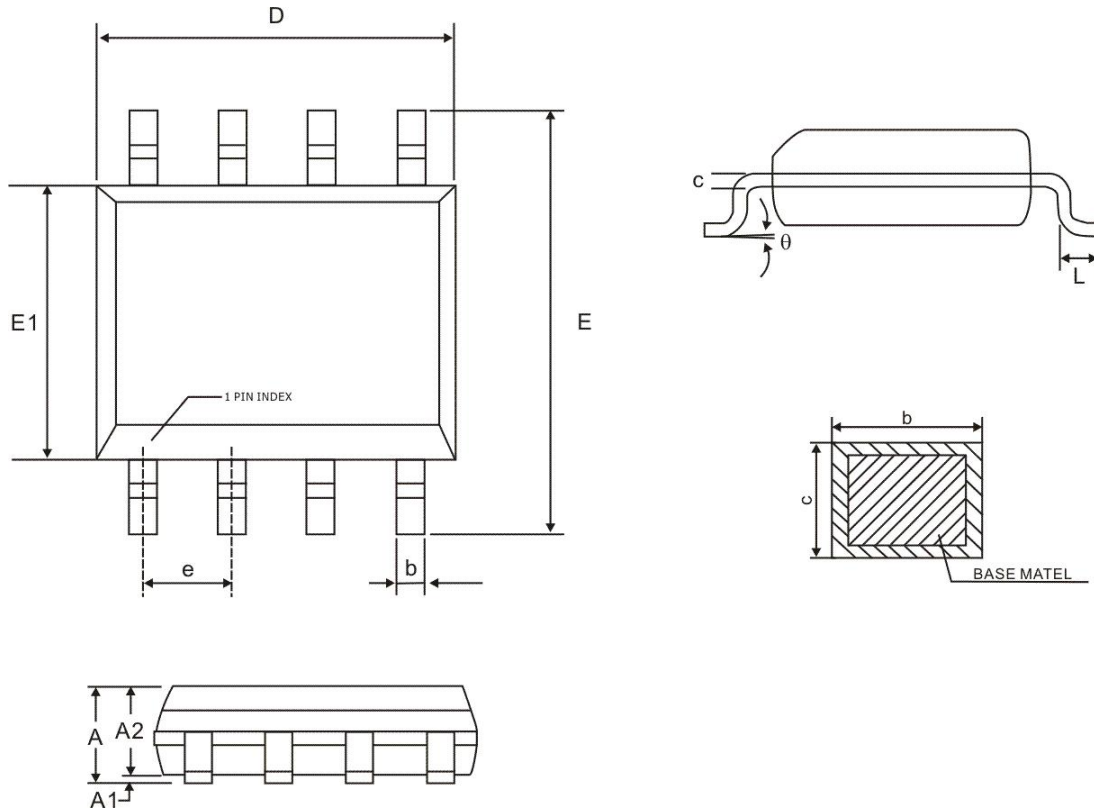
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
<b>Supply Characteristics</b>						
VIN Start-up Voltage	V <sub>ST</sub>	V <sub>VIN</sub> rising		16		V
VIN Shutdown Voltage	V <sub>SD</sub>	V <sub>VIN</sub> falling		9		V
VIN Clamp Voltage	V <sub>CLAMP</sub>	I <sub>VIN</sub> =1mA		16.8		V
IC Start-up Current	I <sub>ST</sub>	V <sub>VIN</sub> = V <sub>ST</sub> -1V		175		μA
IC Operating Current	I <sub>OP</sub>	F <sub>OSC</sub> =70KHZ		125		μA
<b>Current Sense Section</b>						
Internal Reference Voltage	V <sub>CS</sub>		388	400	412	mV
Internal Reference Voltage at LED Short Status	V <sub>CS_SHORT</sub>	LED short		150		mV
Leading Edge Blanking Time	T <sub>LEB</sub>			350		ns
Switch-off Delay Time	T <sub>DELAY</sub>			200		ns
<b>Switching Section</b>						
Max OFF Time	T <sub>DIS_MAX</sub>			130		μs
Min OFF Time	T <sub>DIS_BLK</sub>			5		μs
Max ON Time	T <sub>ON_MAX</sub>			55		μs
<b>Power MOSFET Section</b>						
Drain-Source On-Resistance(PT6989)	R <sub>ON</sub>	V <sub>GS</sub> =15V/I <sub>DS</sub> =1.0A		3		Ω
Drain-Source Leakage Current	I <sub>LEAK</sub>	V <sub>GS</sub> =0V/ V <sub>DS</sub> =500V			1	μA
Drain-Source Breakdown Voltage	BV <sub>DSS</sub>	V <sub>GS</sub> =0V/I <sub>DS</sub> =0.5A	500			V
<b>PWM Dimming Control</b>						
Pull up resister	R <sub>PWM</sub>			200		KΩ
PWM Start-up threshold voltage	V <sub>PWM_ON</sub>			1.5		V
PWM Shut-down threshold voltage	V <sub>PWM_OFF</sub>			0.7		V
<b>Protection Features</b>						
SET Reference Voltage	V <sub>SET</sub>			1.5		V
Thermal Shutdown Starting Temperature	T <sub>STR</sub>			145		°C
Thermal Shutdown Cutoff temperature	T <sub>Z</sub>			165		°C

Note: The VIN voltage first rise up over the V<sub>ST</sub> voltage, and then fall down to 15V.



# PACKAGE INFORMATION

## SOP8, 150MIL



Symbol	Dimensions(mm)		
	Min.	Nom.	Min.
A	1.35	1.60	1.77
A1	0.08	0.15	0.28
A2	1.20	1.40	1.65
b	0.33	-	0.51
c	0.17	-	0.26
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC.		
L	0.38	0.60	1.27
$\theta$	0°	-	8°

Notes:

1. Refer to JEDEC MS-012AA
2. All dimensions are in millimeter



## **IMPORTANT NOTICE**

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