

## DESCRIPTION

MT7965 is a PWM controller for AC-DC LED lighting. With primary side sensing and regulation technology, no secondary side feedback circuit is needed. Further, the loop compensation components are also eliminated while maintaining system stability. Integrated with 650V power switch and adjustable LED open-circuit protection (OVP) function simplifies the system design and improves the reliability.

With Maxic's proprietary current regulation technique, the MT7965 achieves  $\pm 3\%$  accuracy of LED current along with excellent line regulation and load regulation.

MT7965 provides plenty of protections, such as over current protection(OCP), short circuit protection (SCP), over voltage protection (OVP) and over temperature protection(OTP),etc, to enhance system reliability.

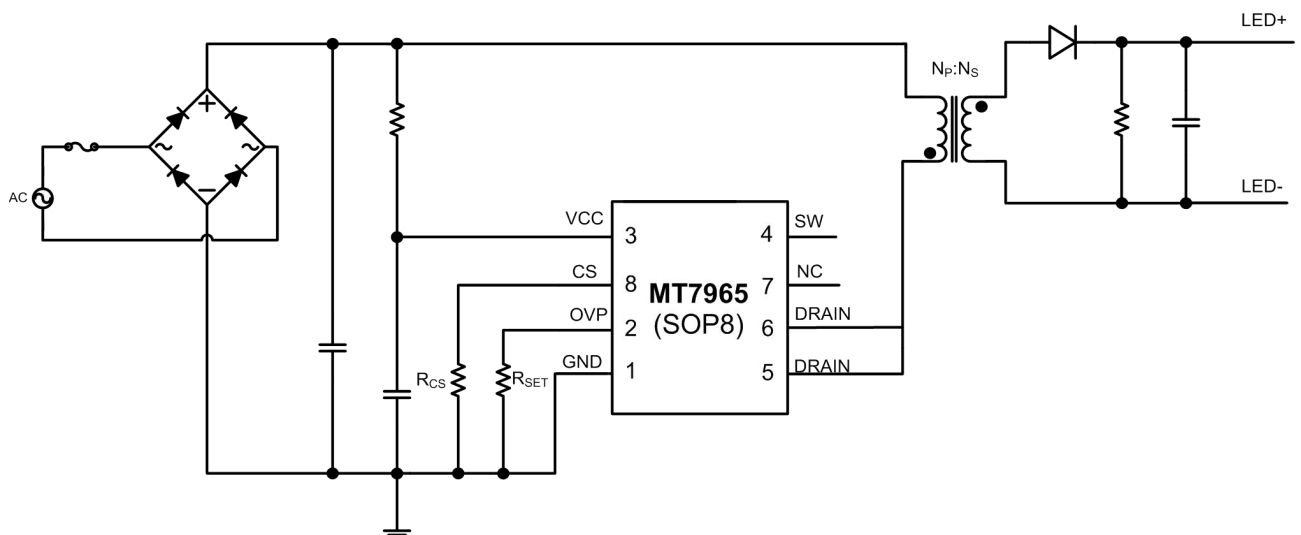
## FEATURES

- Build in 650V power MOSFET
- No auxiliary winding needed
- Supporting 85V to 265V AC line voltage range
- Primary side sensing and regulation, no need of secondary side feedback
- High precision constant LED current ( $\pm 3\%$ )
- Adjustable LED open-circuit voltage protection threshold
- LED short circuit protection
- Cycle-by-cycle peak current control
- VDD under voltage lock-out protection
- Over temperature protection
- Available in SOP8 package

## APPLICATION

- LED bulb, Spotlight
- LED lighting application
- General purpose constant current source

## Typical Application Circuit



### ABSOLUTE MAXIMUM RATINGS

DRAIN	-0.3V to 650V
VCC	-0.3V to 40V
VCC maximum sink current	5mA
OVP, CS	-0.3V to 6V
P <sub>DMAX</sub> (Maximum Power)	0.45W
Storage Temperature	-55°C to 150°C
Junction Temperature (T <sub>j</sub> )	150°C

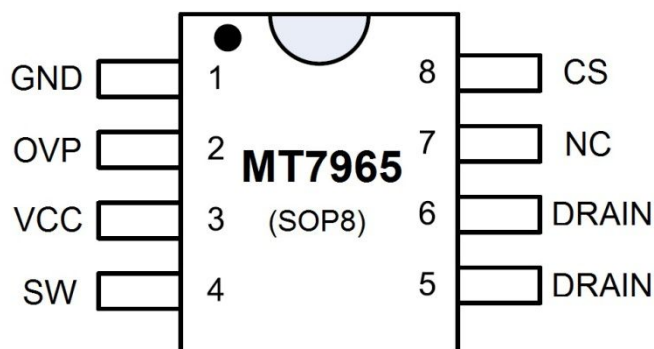
### Recommended operating conditions

Supply voltage	8V to 15V
Operating Temperature (Environment)	-40°C to 105°C

### Thermal resistance

Case to ambient (R <sub>θCA</sub> )	128°C/W
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### PIN CONFIGURATIONS



### PIN DESCRIPTION

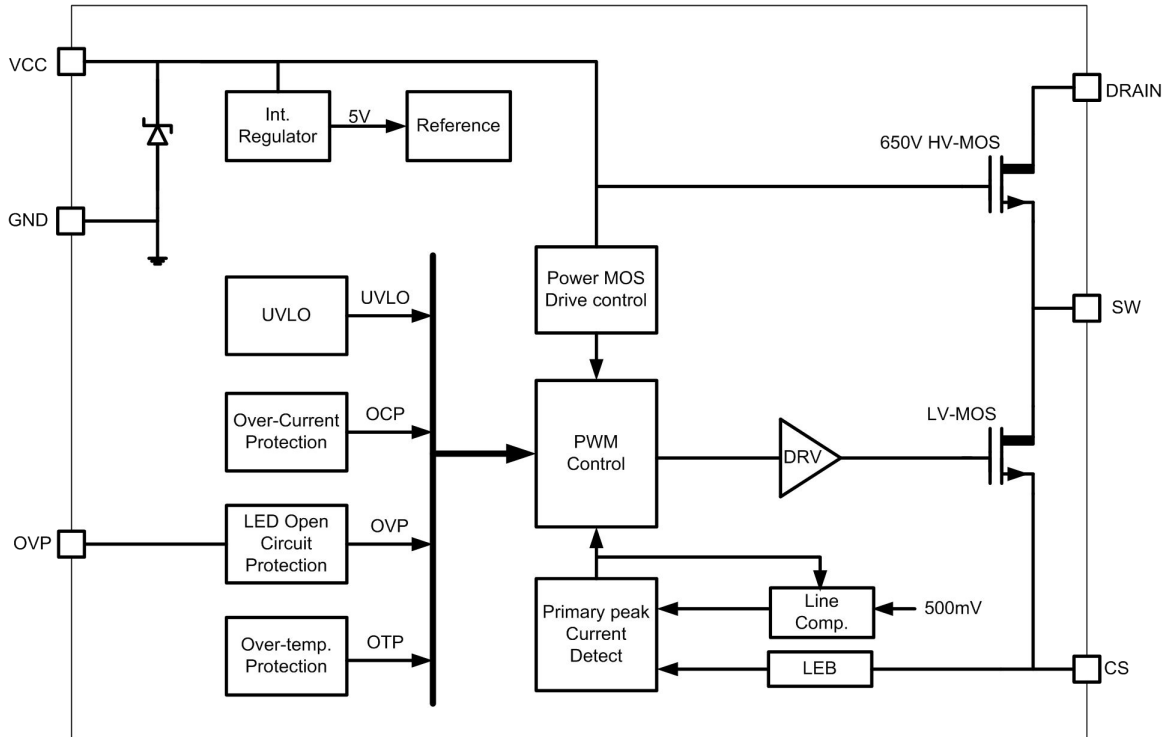
Name	Pin No.	Description
GND	1	Ground
OVP	2	LED open-circuit voltage protection setup. Refer to <i>LED Open Circuit Protection</i> section.
VCC	3	Power supply
SW	4	Internal power MOS source
DRAIN	5	Internal power MOS drain
	6	
NC	7	No connection. This pin must be floating.
CS	8	Current sense input, sense resistor connected between CS and GND

## ELECTRICAL CHARACTERISTICS

(Test conditions:  $V_{CC}=12V$ ,  $T_A=25^{\circ}C$  unless otherwise stated.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Start-up &amp; Power supply (VCC Pin)</b>						
$I_{START}$	Start-up Current			35	60	$\mu A$
UVLO	Under-voltage Lockup (Lower Threshold Voltage of $V_{CC}$ )	$V_{CC}$ Pin ramp down		7		V
$V_{START}$	Start-up Voltage	$V_{CC}$ Pin ramp up		13		V
$V_{CC-CLAMP}$	VCC clamp voltage	$I_{DD}=5mA$		15.5		V
<b>Operation Current</b>						
$I_Q$	Operation current			0.2		mA
<b>Current Sense (CS Pin)</b>						
$V_{CS-TH}$	Threshold Voltage of Peak Current Protection		487	500	513	mV
LEB1	Leading Edge Blanking at CS Pin			500		nS
<b>Driver Circuit</b>						
$T_{OFF\_MIN}$	Minimum OFF time			2		$\mu s$
$T_{OFF\_MAX}$	Maximum OFF time			240		$\mu s$
$T_{ON\_MIN}$	Minimum ON time			1		$\mu s$
$T_{ON\_MAX}$	Maximum ON time			24		$\mu s$
$DUTY\_MAX$	Maximum Duty cycle			42		%
<b>Over Temperature Protection</b>						
OTP	Over temperature protection threshold			155		$^{\circ}C$
	Over temperature protection release thysteresis			20		$^{\circ}C$
<b>Power MOSFET (DRAIN Pin)</b>						
$R_{DS(on)}$	Drain-source turn on resistance	$V_{GS}=10V/I_{DS}=0.4A$		13		$\Omega$
$BV_{DSS}$	Drain-source breakdown voltage	$V_{GS}=0V/I_{DS}=250\mu A$	650			V
$I_{DSS}$	Drain-source leakage current	$V_{GS}=0V/V_{DS}=650V$			10	$\mu A$

**BLOCK DIAGRAM**

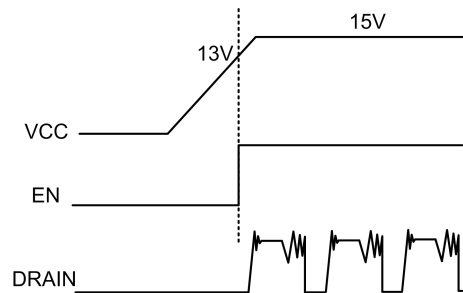


**APPLICATION INFORMATION**

MT7965 is a high performance power switch specially designed for LED lighting. MT7965 works in Discontinuous Conduction Mode (DCM). With Maxic’s proprietary constant current regulation and compensation technique, MT7965 achieves accurate LED current output without auxiliary winding and secondary side feedback circuit. It integrates 650V power MOSFET, minimizes the external component count, lower the total BOM cost.

**Start Up**

During start-up, VCC is charged through a start-up resistor. As VCC reaches 13V, the control logic starts to work, and the power MOSFET begins to switch, as show in Fig.1. MT7965 will shut down if VCC goes below 7V (UVLO threshold voltage).



**Fig.1 Start up sequence**

**Constant Current Control and Output Current Setup**

Cycle-by-cycle current sense is offered in MT7965. The CS pin is connected to the current sense comparator, and the voltage on CS pin is compared with the internal 500mV reference voltage. The MOSFET is turned off when the voltage on the CS pin reaches the threshold. The comparator also includes a 500nS leading edge blanking time to block the transient noise as the power switch just turned on.

The primary side peak current is given by:

$$I_{P\_PK} = \frac{500}{R_{CS}} (mA)$$

where  $R_{CS}$  is the peak current sensing resistor (refer to the *Typical Application Circuit*),  
The LED current can be calculated by the following equation:

$$I_{LED} = \frac{I_{P\_PK}}{4} \times \frac{N_P}{N_S} = \frac{500}{4 \times R_{CS}} \times \frac{N_P}{N_S} (mA)$$

where  $N_P$  is the turns of the primary winding,  $N_S$  is the turns of the secondary winding,  $I_{P\_PK}$  is the primary side peak current. Shown in the above equation, the output current is determined by the turns ratio of the transformer and the current sense resistor value, insensitive to the inductance of the transformer.

### Switching Frequency

MT7965 is designed to operating in discontinuous conduction mode and no external loop compensation is needed for stability. The maximum duty cycle is limited to 42%. It's highly recommended to limit the maximum switching frequency less than 100KHz and the minimum switching frequency more than 20KHz.

The switching frequency can be set by formula:

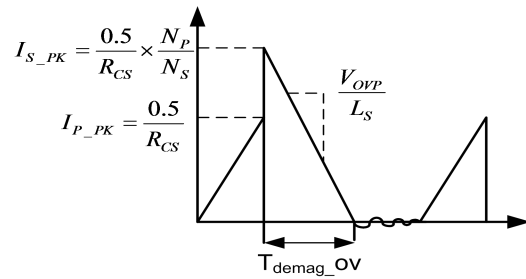
$$f_{SW} = \frac{N_P^2 \times V_{LED}}{8 \times N_S^2 \times L_p \times I_{LED}}$$

where,  $N_P$  is the turns of the primary winding,  $N_S$  is the turns of the secondary winding,  $L_p$  is the transformer primary winding inductance. Designing the switching frequency between 40KHz to 80KHz by properly set the transformer parameters.

### LED open circuit protection (OVP)

By detecting the secondary inductor demagnetization time, MT7965 implements LED open circuit protection function.

Figure 2 shows the transformer primary and secondary current waveform while MT7965 is working:



**Fig.2 Transformer primary and secondary current waveform**

Refer to Fig 2, when LED is open-circuited, the secondary inductor demagnetization time is:

$$T_{demag\_OV} = \frac{I_{S\_PK}}{V_{OVP}/L_S} = \frac{L_S \times \frac{0.5}{R_{CS}} \times \frac{N_P}{N_S}}{V_{OVP}} (us)$$

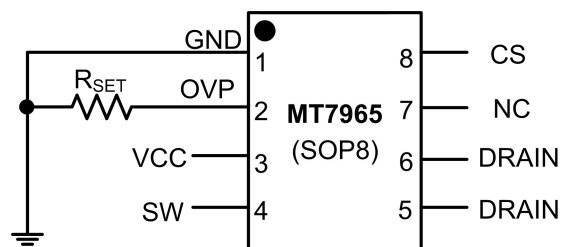
where,  $N_P$  is the turns of the primary winding,  $N_S$  is the turns of the secondary winding,  $L_S$  is the secondary inductance in uH, 0.5 is voltage threshold for  $V_{CS}$  detection in unit volt. From the above formula, secondary inductor demagnetization time contains  $V_{OVP}$  voltage information. By detecting secondary inductor demagnetization time when LED is open-circuited, OVP protection is achieved:

$$V_{OVP} = \frac{L_S \times \frac{0.5}{R_{CS}} \times \frac{N_P}{N_S}}{T_{demag\_OV}} (V)$$

A resistor  $R_{SET}$  at OVP pin (see Figure 3) sets the demagnetization time when LED is open-circuited :

$$T_{demag\_OV} = 0.09 \times R_{SET} (us)$$

$R_{SET}$  units is K $\Omega$ .



**Fig.3 OVP pin schematic**

The OVP voltage is:

$$V_{OVP} = 5.5 \times \frac{L_S}{R_{CS} \times R_{SET}} \times \frac{N_P}{N_S} \quad (\text{V})$$

Where  $L_S$  units is  $\mu\text{H}$ ,  $R_{CS}$  units is  $\Omega$ ,  $R_{SET}$  units is  $\text{K}\Omega$ . Since the minimum  $T_{OFF}$  time is  $2\mu\text{s}$ , so the resistance of  $R_{SET}$  can't be less than  $20\text{K}\Omega$ .

The inductor's inductance variation affects the accuracy of OVP threshold. System design should take this into consideration. Remain certain margin for OVP threshold is needed. Highly recommended to set the OVP threshold at least 1.3 times higher than the LED string voltage.

### Over-Current Protection

MT7965 immediately turns off the power MOSFET once the voltage at CS pin exceeds  $500\text{mV}$ . This cycle by cycle current limitation scheme prevents the relevant components, such as power MOSFET, transformer, etc. from damage.

### PCB Layout

The following rules should be followed in MT7965 PCB layout:

#### Bypass Capacitor

The bypass capacitor on VCC pin should be as close as possible to the pin.

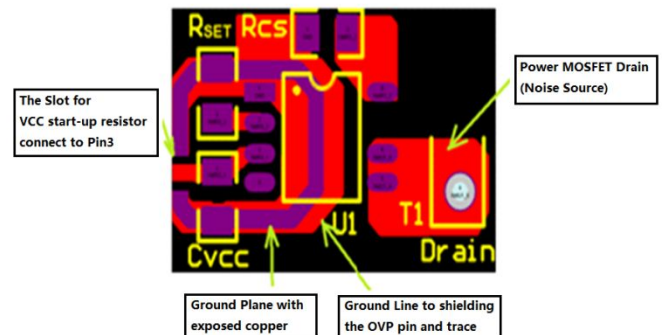
#### Ground Path

The power ground path for current sense should be short, and the power ground path should separate from other small signal ground path. Power ground path and signal ground path

Kevin contact together at the bulk capacitor negative terminal.

#### OVP Pin and Its Trace

Keep the OVP pin trace as short as possible.  $R_{SET}$  resistor should be close to the OVP pin. OVP pin trace can't close to the DRAIN and SW pin and related traces. Using ground line to shield the OVP pin and traces. This shielding ground should expose the copper. Refer to the following PCB Layout example.



#### The Area of Power Loop

The area of main current loop should be as small as possible to reduce EMI radiation, such as the primary current loop, the snubber circuit and the secondary rectifying loop.

#### DRAIN pin

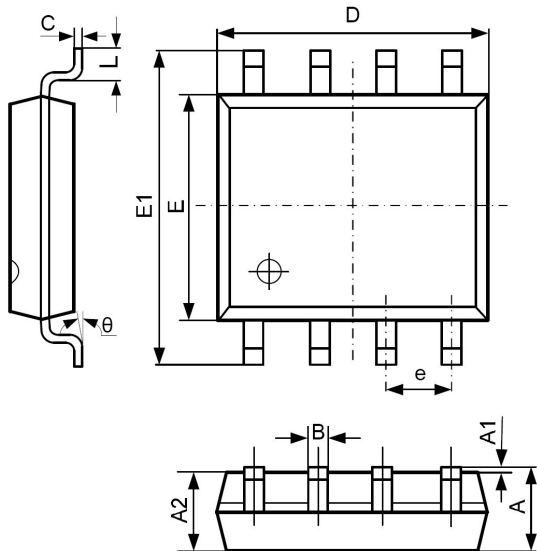
Increase the copper area of the drain terminal for thermal consideration. But Drain terminal is the major noise source of the system. Should be trade-off with thermal dissipation and noise reduction.

#### NC pin

NC pin must left floating to reserve enough space for creepage distance.

## PACKAGE INFORMATION

### SOP-8 PACKAGE OUTLINE AND DIMENSIONS



SYMBOL	DIMENSION IN MILLIMETERS		DIMENSION IN INCHES	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270 TYP		0.050 TYP	
L	0.400	1.270	0.016	0.050
theta	0°	8°	0°	8°

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