DESCRIPTION

MT7967 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 600V power switch and adjustable LED open-circuit protection (OVP) function simplifies the system design and improves the reliablity.

With Maxic's proprietary current regulation technique, the MT7967 achieves ±3% accuracy of LED current along with excellent line regulation and load regulation.

MT7967 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.

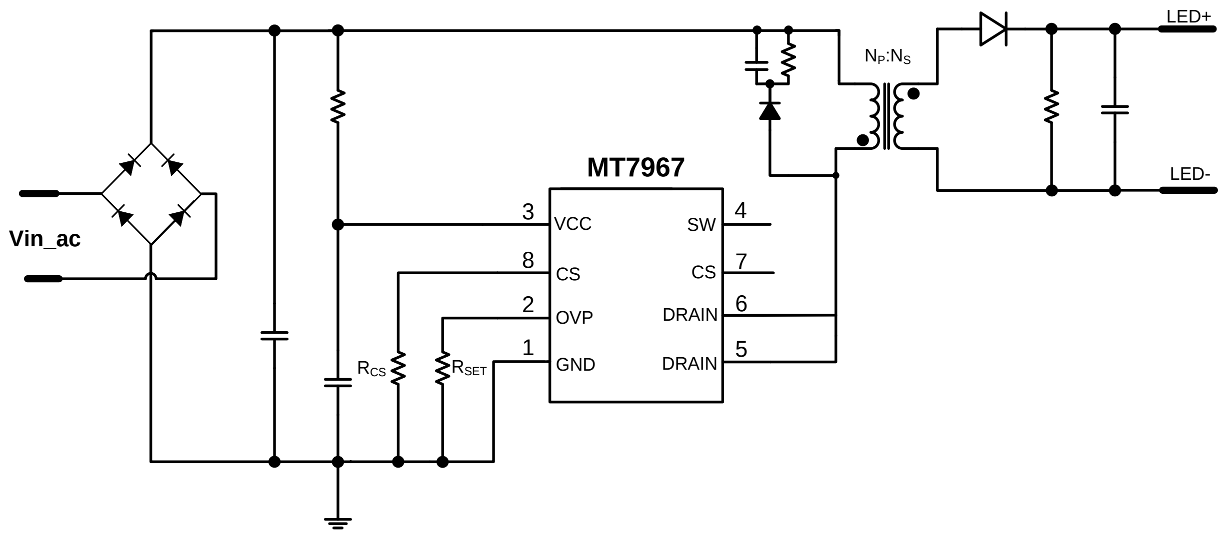
FEATURES

- Build in 600V power MOSFET
- No auxiliary winding needed
- Supporting 85V to265V AC line voltage range
- Primary side sensing and regulation, no need of secondary side feedback
- High precision constant LED current (+/-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 DIP8 package

APPLICATION

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

Typical Application Circuit



ABSOLUTE MAXIMUM RATINGS

DRAIN	-0.3V to 600V
VCC	-0.3V to 40V
VCC maximum sink current	5mA
OVP, CS	-0.3V to 6V
P_{DMAX}（Maximum Power）	1.2W
Storage Temperature	-55°C to 150°C
Junction Temperature (Tj)	150°C

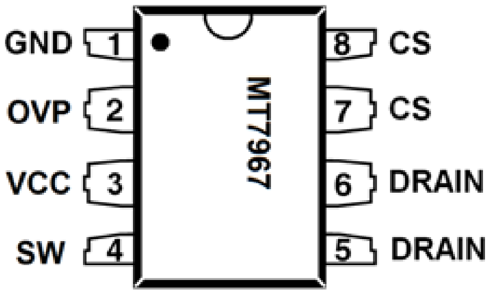
Recommended operating conditions

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

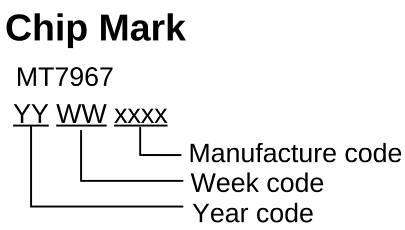
Thermal resistance

Case to ambient ($R_{\theta CA}$)	70°C/W

PIN CONFIGURATIONS



(DIP8)



PIN DESCRIPTION

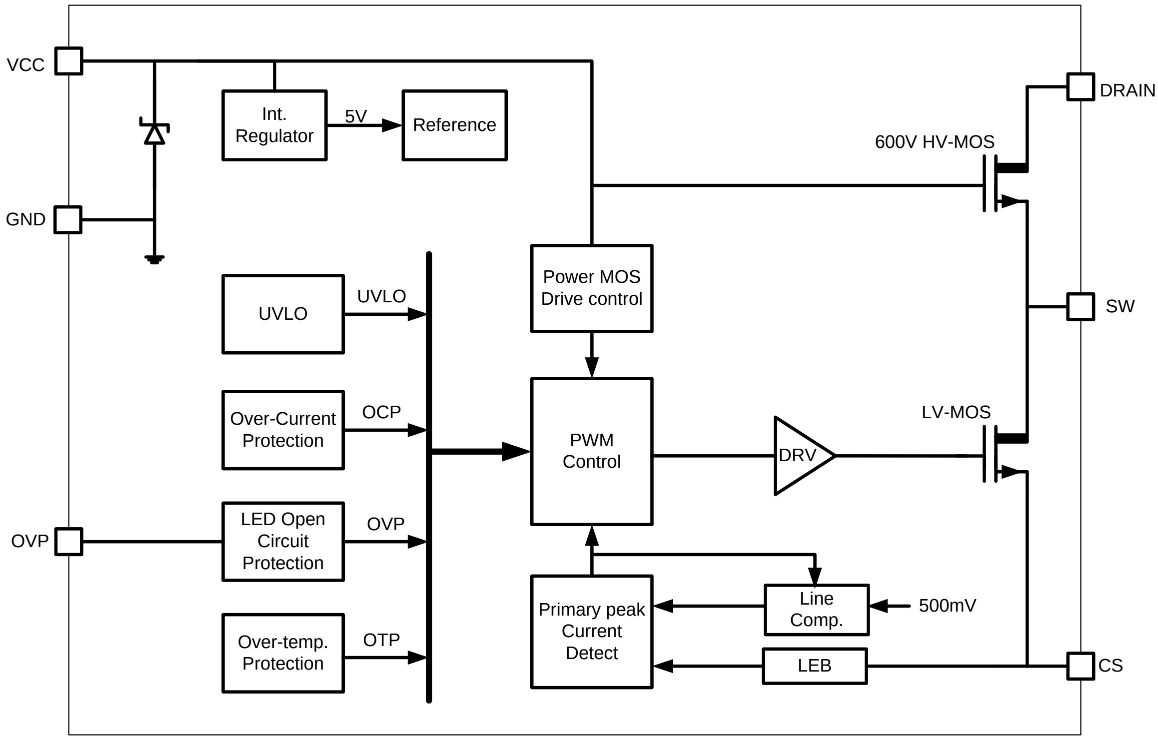
Name	Pin No.	Description
GND	1	Ground
OVP	2	LED open-circuit voltage protection setup. Refer to *LED Open Circuit Protection* section.
VCC	3	Power supply
SW	4	Internal power MOS source
DRAIN	5	Internal power MOS drain
	6	
CS	7	Current sense input, sense resistor connected between CS and GND
	8	

ELECTRICAL CHARACTERISTICS

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Start-up & Power supply (VCC Pin)						
I_{START}	Start-up Current			35	60	μA
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
$V_{CC\text{-}CLAMP}$	VCC clamp voltage	I_{DD}=5mA		15.5		V
Operation Current						
I_Q	Operation current			0.3		mA
Current Sense (CS Pin)						
$V_{CS\text{-}TH}$	Threshold Voltage of Peak Current Protection		487	500	513	mV
LEB1	Leading Edge Blanking at CS Pin			500		nS
Driver Circuit						
T_{OFF_MIN}	Minimum OFF time			2		us
T_{OFF_MAX}	Maximum OFF time			240		us
T_{ON_MIN}	Minimum ON time			1		us
T_{ON_MAX}	Maximum ON time			24		us
D_{UTY_MAX}	Maximum Duty cycle			42		%
Over Temperature Protection						
OTP	Over temperature protection threshold			155		℃
	Over temperature protection release thysteresis			20		℃
Power MOSFET (DRAIN Pin)						
R_{DSON}	Drain-source turn on resistance	VGS=10V/I_{DS}=0.5A		7		Ω
BV_{DSS}	Drain-source breakdown voltage	VGS=0V/I_{DS}=250uA	600			V
I_{DSS}	Drain-source leakage current	VGS=0V/V_{DS}=600V			10	uA

BLOCK DIAGRAM



APPLICATION INFORMATION

MT7967 is a high performance power switch specially designed for LED lighting. MT7967 works in Discontinuous Conduction Mode (DCM). With Maxic's proprietary constant current regulation and compensation technique, MT7967 achieves accurate LED current output without auxiliary winding and secondary side feedback circuit. It integrates 600V 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.

MT7967 will shut down if VCC goes below 7V (UVLO threshold voltage).

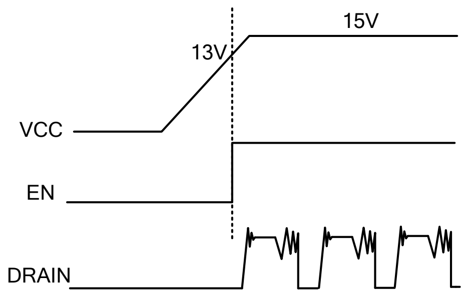


Fig.1 Start up sequence

Constant Current Control and Output Current Setup

Cycle-by-cycle current sense is offered in MT7967. 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

MT7967 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, Lp 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, MT7967 implements LED open circuit protection function.

Figure 2 shows the transformer primary and secondary current waveform while MT7967 is working:

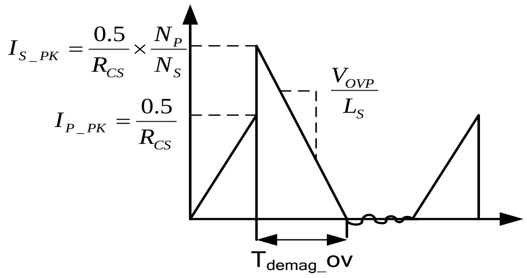


Fig.2 Transformer primary and secondary current waveform

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

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

where, N_P is the turns of the primary winding, N_S is the turns of the secondary winding, Ls 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:

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

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

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

R_{SET} units is kΩ.

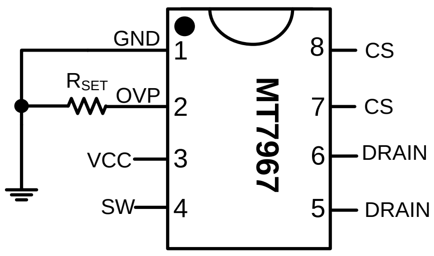


Fig.3 OVP pin schematic

The OVP voltage is:

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

Where L_S units is uH, R_{CS} units is Ω, R_{SET} units is kΩ. Since the minimum T_{OFF} time is 2us, so the resistance of R_{SET} can't be less than 20kΩ.

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

MT7967 immediately turns off the power MOSFET once the voltage at CS pin exceeds 500mV. 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 MT7967 PCB layout:

Bypass Capacitor

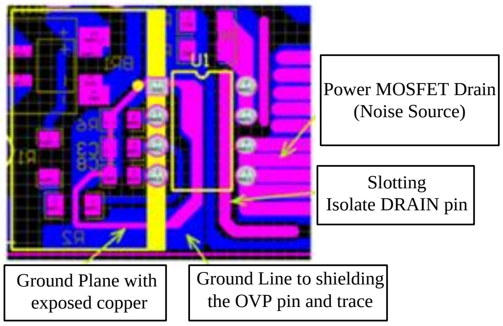
The bypass capacitor on VCC pin should be as close as possible to the pin.

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 (R6 in the following PCB Layout example) 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. As the package is DIP8, must be slotted under the chip to isolate the DRAIN pins. 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

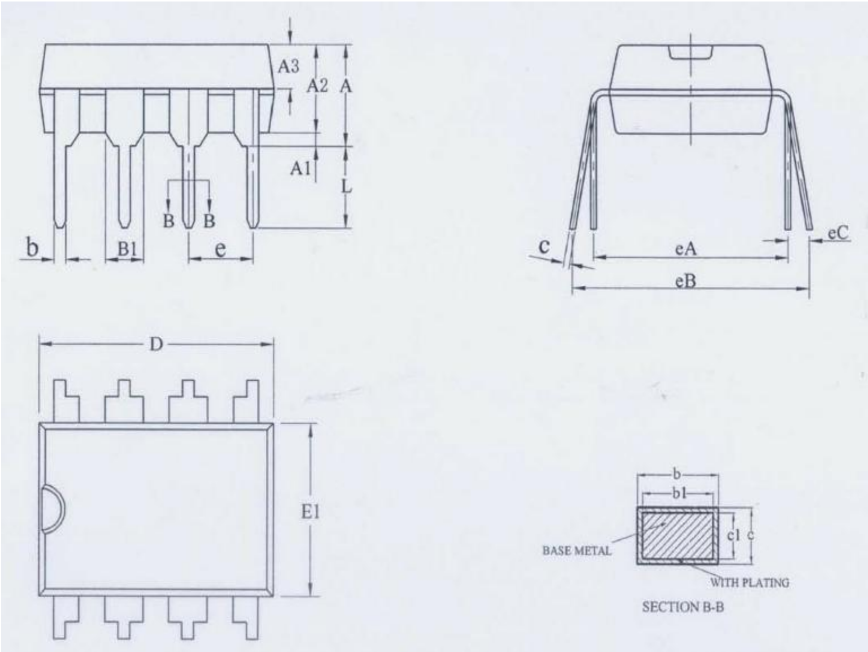
Increase the copper area of the drain terminal for thermal consideration. But Drain terminal is the major noise source of the system. Should be trade-off with thermal dissipation and noise reduction.

NC pin

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

PACKAGE INFORMATION

DIP-8 (8-Lead Dual In-Line)



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	3.60	3.80	4.00
A1	0.51	—	—
A2	3.00	3.30	3.40
A3	1.55	1.60	1.65
b	0.44	—	0.53
b1	0.43	0.46	0.48
B1	1.52BSC		
c	0.24	—	0.32
c1	0.23	0.25	0.27
D	9.05	9.25	9.45
E1	6.15	6.35	6.55
e	2.54BSC		
eA	7.62BSC		
eB	7.62	—	9.30
eC	0	—	0.84
L	3.00	—	—
L/F载体尺寸 (mil)	80*80		

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