DESCRIPTION

The MT7900 is a hysteresis current mode control LED driver IC. The MT7900 operates in constant off-time mode. It allows efficient operation of High Brightness (HB) LEDs from voltage sources ranging from 14V_{DC} up to 450V_{DC} or 85V_{AC} ~ 265V_{AC}. The MT7900 is ideally suited for buck LED drivers. Since the MT7900 operates in hysteresis current mode control, the controller achieves good output current regulation without the need for any loop compensation. Further, with Maxic proprietary control technology (patent pending), MT7900 achieves precision output current accuracy from 85VAC ~ 265VAC.
Frequency jittering is used to reduce the EMI.

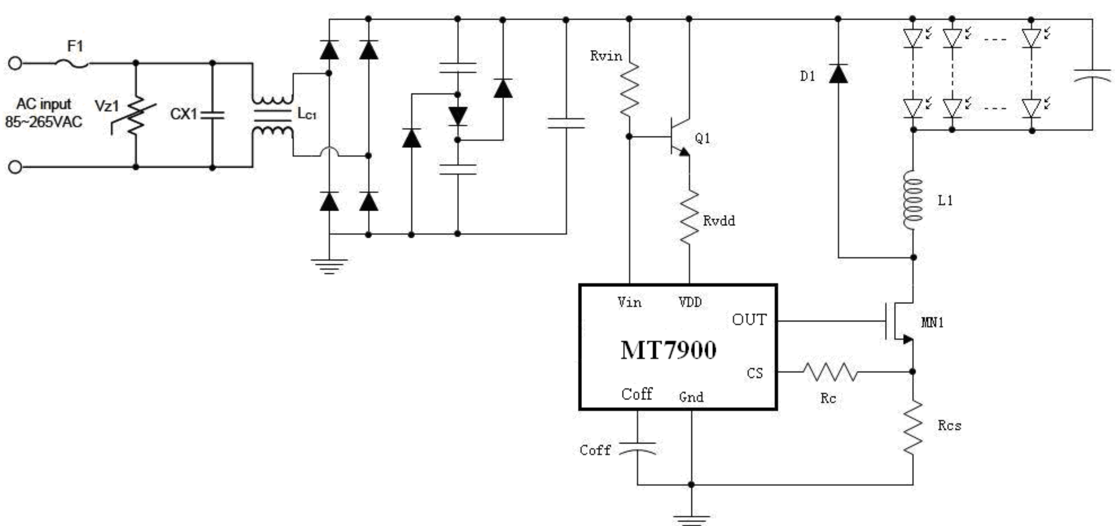
FEATURES

- Proprietary constant-current control. Great LED current accuracy.
- Wide input range from 14VDC to 450VDC or 85VAC to 265VAC
- Application from a few mA to more than 1A output
- Up to 92% efficiency
- Up to hundreds of LEDs
- Requires few external components for operation
- Embedded Over-temperature, LED open circuit, LED short-circuit protection
- SOT23-6 package

APPLICATION

- DC/DC or AC/DC LED driver applications
- RGB backlighting LED driver
- General purpose constant current source
- Signal and decorative LED lighting
- E14/E27/PAR30/PAR38/GU10 LED lamp

TYPICAL APPLICATION CIRCUIT



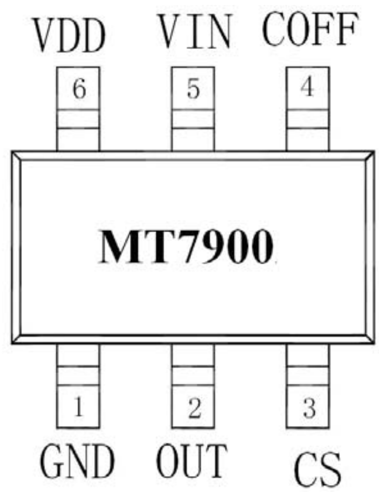
ABSOLUTE MAXIMUM RATINGS

VIN / VDD / OUT Pin	-0.3V to +16V
All other pins	-0.3V to +6V
ESD (HBM)	±4000V
Storage Temperature	-55°C to 150°C

THERMAL RESISTANCE

Junction to ambient (RθJA)	128°C/W

PIN CONFIGURATIONS



PIN DESCRIPTION

Name	Pin No.	Description
GND	1	Ground return for all internal circuitry. This pin must be electrically connected to the ground of the power train.
OUT	2	This pin is the output GATE driver for an external N-channel power MOSFET.
CS	3	This pin is the current sense pin used to sense the FET current by means of an external sense resistor. When this pin exceeds the internal 250mV, the gate output (OUT pin) goes low.
COFF	4	This pin adjusts the off time of the power MOSFET by tie a capacitor between this pin and GND.
VIN	5	This pin is the input of an 14V – 450V voltage supply through a resistor, internally clamped at 12V. It also used to sense the line voltage for output current compensation.
VDD	6	Internal circuits power supply. Internally clamped at 10V. It must bypass to GND with a capacitor as close as possible.

ELECTRICAL CHARACTERISTICS

(Test conditions: TA=25°C unless otherwise stated.)

Symbol	Description	Conditions	Min	Typ	Max	Unit
VDC	Input DC supply voltage range	Connect an appropriate resistor from DC supply voltage to VIN pin and VDD pin	14		450	
VDD	Internal regulated voltage	Get power from DC power rail through a resistor or transistor		10		V
VIN	Internal regulated voltage for line compensation	Connect to DC power rail through a resistor		12		V
Iin	Operating current	Gate floating		0.5		mA
Under Voltage lockout						
UVLO	Under voltage lockout	VDD rising.		8		V
ΔUVLO	UVLO hysteresis	VDD falling		2		V
Current sense stage						
Vcs	Current sense pull-in threshold voltage			250		mV
Tblank	Current sense blank time			430		ns
Toff	Off time	COFF Pin floating		200		ns
Ioff	Off time current			20		uA
Driver stage						
trise	Gate output rise time	Cgate=500pF		42		ns
tfall	Gate output fall time	Cgate=500pF		30		ns
Over Temperature Protection						
OTP	Thermal protection threshold			160		°C
	OTP hysteresis			30		°C

APPLICATION INFORMATION

MT7900 is a low-cost off-line buck, boost or buck-boost converter control IC specifically designed for driving multi-LED strings or arrays. It can be operated from either universal AC line or any DC voltage between 14-450V. Optionally, a passive power factor correction circuit can be used in order to pass the AC harmonic limits set by EN 61000-3-2 Class C for lighting equipment having input power less than 25W. The MT7900 can drive up to hundreds of High-Brightness (HB) LEDs or multiple strings of HB LEDs. The LED arrays can be configured as a series or series/parallel connection.

The MT7900 regulates constant current by using hysteresis current mode that ensures controlled brightness and spectrum of the LEDs, and extends their lifetime. This control method provides fairly accurate LED current control without the need for a high side current sensing or the design of any additional loop compensation. The IC uses very few external components.

A capacitor connected to the COFF (Pin4) pin programs the off-time of the oscillator inside. The oscillator produces pulses at regular intervals. These pulses set the SR flip-flop in the MT7900 which causes the GATE driver to turn on (OUT pin goes high). When the MOSFET turns on, the current through the inductor starts ramping up. This current flows through the external sense resistor R_{CS} and produces a ramp voltage at the CS pin. The comparator is constantly comparing the CS pin voltage to the internal 250mV. Once the blanking time is complete, the output of the comparator is allowed to reset the flip-flop. When the output of the comparator goes high, the flip-flop is reset and the OUT pin goes low to shut off the external MOSFET.

Assuming a 70% ripple in the inductor, the current sense resistor R_{CS} can be set using:

$$R_{CS} = \frac{250mV}{(1+70\%/2)\bullet I_{LED}(A)} = \frac{250mV}{1.35\bullet I_{LED}(A)}$$

Input Voltage Regulator

When a voltage is applied through a suitable input resistor or transistor to the VDD pin (Pin6), the MT7900 maintains a constant 10V (typ.) at the VDD pin. This voltage is used to power the IC. The VDD pin must be bypassed by a low ESR capacitor to provide a low impedance path for the high frequency current of the output GATE driver. The input current drawn from VDD pin is a sum of the 0.5mA(typ.) current drawn by the internal circuit and the dynamic current drawn by the GATE driver (which in turn depends on th switching frequency and the GATE charge of the external MOSFET).

$$I_{VDD} \approx 0.5mA + Q_G \bullet f_S$$

Where f_S is the switching frequency and Q_G is the GATE charge of the external MOSFET (which can be obtained from the datasheet of the MOSFET).

Input voltage further applied through a suitable resistor to VIN pin (Pin5), MT7900 clamped VIN pin at 12V. This regulated voltage can be used to bias the base or gate of the NPN or NMOS transistor, which provides power to the VDD pin. Further more, MT7900 detects the line voltage VDC through VIN pin and compensates the line voltage variation. Combined with the peak current at CS pin control scheme, the accuracy of the LED current is greatly improved and almost insensitive to input voltage variation.

Current Sense

The current sense input of the MT7900 goes to the noninverting input of the comparator. The inverting terminal of the comparator is tied to an internal 250mV reference. The output is fed into the reset pin of the flip-flop. Thus, when the current sense pin CS voltage higher than 250mV, the GATE output is turned off.

The output of the comparator also includes a typical 430ns blanking time which prevents spurious turn-offs of the external MOSFET due to the turn-on spike normally present in peak current mode control. In rare cases, this internal blanking time might not be enough to filter out the turn-on spike. In this case, an external RC filter needs to be added between the external sense resistor (R_{CS}) and the CS pin.

Please note that the comparator is relatively fast with a typical 80ns response time. A proper layout minimizing external inductances will prevent false triggering of the comparator.

Oscillator

Reference to Fig.1, the oscillator in the MT7900 is controlled by the capacitor connected at COFF pin and series resistor connected to CS pin.

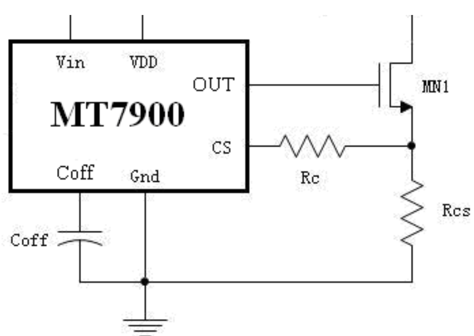


Fig.1 Setup Toff time

First the charge current is determined by R_C and R_{CS}, calculated as:

$$I_{off} = \frac{185mV}{(R_C + R_{CS})} \approx \frac{185mV}{R_C}$$

Where, normally $R_{CS} << R_C$. Typically, R_C=10KΩ, Ioff = 18.5uA.

Then, Toff time of the oscillator is given by:

$$T_{off} = \frac{C_{off} \bullet 2V}{I_{off}} \approx \frac{C_{off} \bullet R_C \bullet 2V}{185mV} = 10.8 \bullet C_{off}$$

where Coff is in pF and Toff is in us.

As equation shows, the Toff time is determined by external RC value. So the constant-off time is accurately controlled and consistency.

Power Factor Correction

When the input power to the LED driver does not exceed 25W, a simple passive power factor correction circuit consisting of 3 diodes and 2 capacitors can be added across the rectified AC line input to improve the line current harmonic distortion and achieve a power factor greater than 0.85. Reference to MT7900 typical application circuit (Fig.2, Fig.3).

LEDs Open Circuit Protection

When the buck topology is used, the LEDs is connected in series with the inductor, there is no need for any protection against an open circuit condition in the LED string. Open LED connection means no switching and the output current will ceased automatically.

Special note should be mentioned here, in LED open condition, V_O will reach V_{INDC_max}, so the capacitor C_O parallel with LED will tolerance V_{INDC_max} voltage instead of V_O.

LEDs Short-Circuit Protection

In buck topology, the LED string is short circuited, the output current will become bigger and bigger. When the output current reach MT7900 internal Over-current/Short-circuit protection threshold, MT7900 will stop switching, output current will drop to zero.

Short-circuit protection can only be cleared by power down.

DESIGN EXAMPLE

AC input voltage range: 85VAC ~ 265VAC
Output LED String: V_O = 48V (15 LEDs in series, 3.2V each)
I_O = 360mA (18 parallel LEDs, 20mA each branch)

Input Circuits

AC voltage through the full-bridge rectifier and capacitor, becomes approximately DC voltage, $V_{DC\_MAX} = \sqrt{2} \bullet V_{AC} = 120V \sim 375V$, further through the passive PFC circuit (3 diodes, 2 capacitors), the voltage valley is about half. So, the final DC voltage to the MT7900 system is:

$$V_{INDC} = 60V \sim 375V$$

As current draw from VDD pin is about

$I_{VDD} \approx 0.5mA + Q_G \bullet f_S$, assume 1mA

Refer to Fig.2 application circuit,

$$R_{vdd} = \frac{V_{INDC\_\min} - VDD}{I_{VDD}}$$
$$= \frac{60V - 10V}{1mA} = 50k\Omega$$

When VINDC becomes maximum,

$$I_{VDD\_\max} = \frac{V_{INDC\_\max} - VDD}{R_{vdd}}$$
$$= \frac{375V - 10V}{50k} = 7.3mA$$

Even MT7900 only need 1mA, but the 6.3mA extra current is wasted. The power burn on R_{vdd} resistor is

$$(V_{INDC\_\max} - VDD) \times I_{VDD\_\max}$$
$$= (375V - 10V) \times 7.3mA = 2.66W$$

This is a huge power being wasted and will lower the system efficiency. So, application circuit shown in Fig.2 only suits for relatively low input voltage and low cost application, such as 110VAC input application.

In order to support full input voltage range, 85VAC~265VAC, application circuit in Fig. 3 will be considered.

MT7900 VDD power is supplied by an NPN transistor.

As VIN = 12V, VDD = 10V,

$$R_{vdd} = \frac{VIN - VDD - V_{be\_Q1}}{I_{VDD}}$$
$$= \frac{12V - 10V - 0.6V}{1mA} = 1.4k\Omega$$

Rin is around 500K to 800K, fine tune for line compensation to improve the output LED current accuracy.

C_{vin} and C_{vdd} can chose 2.2uF/40V ~ 10uF/40V capacitor.

Toff Time Regulation Capacitor

For higher output voltage, lower output current application, we need to shorter Toff Time to obtain the application inductor smaller. For high output current application, it is suggested that the frequency is set no more than 50KHz (typical 25~30KHz). In MT7900, set Rc=10K, Ioff = 18.5uA,

$$T_{off} = \frac{C_{off} \bullet 2V}{I_{off}} \approx \frac{C_{off} \bullet R_C \bullet 2V}{185mV} = 10.8 \bullet C_{off}$$

where Coff is in pF, Toff is in us. For this application, chose Coff = 120pF, Toff = 12.96us.

The inductor (L1)

The inductor value depends on the ripple current in the LEDs. Normally, ripple current is about 30%~100% of the average current. Set ripple current as 60% of the output average current,

$$I_{ripple} = 60\% \times I_O = 60\% \times 360mA = 216mA$$

$$L = \frac{V_O \times T_{off}}{I_{ripple}} = \frac{48 \times 12.96us}{216mA} = 2.88mH$$

The inductor chosen should have a saturation current higher than the peak output current and a continuous current rating above the required mean output current.

The DC resistance (DCR) of the inductor is also essential when choosing an inductor. Bigger DCR will leader to more heat. The value of the inductor will reduce as its temperature rises, leading to higher current ripple, which, in turn, reduces the average output current.

Current Sense Resistor (R_{CS})

Designing for low current ripple will improve current accuracy, but it also requires a large value of inductor. High current ripple allows a lower cost inductor. So we need to consider these two factors when selecting an inductor. A capacitor C_O placed in parallel with the array of LEDs can be used to reduce the LED current ripple while keeping the same average current. A typical value is 1uF.

Since the output average current I_O = 360mA, Iripple = 216mA as above section calculated, then

$$I_{O\_Peak} = 0.5 \times I_{ripple} + I_O$$
$$= 0.5 \times 216 + 360 = 468mA$$

$$R_{CS} = \frac{250mV}{I_{O\_Peak}} = \frac{250mV}{468mA} = 0.534\Omega$$

MOSFET (MN1) and Diode (D1)

The peak voltage seen by the MOSFET is equal to the maximum input voltage. Using a 50% safety margin,

$$V_{FET} = 1.5 \times V_{INDC\_\max} = 1.5 \times 375 = 563V$$

The maximum RMS current through the MOSFET depends on the maximum current. Hence, the current rating of the MOSFET is:

$$I_{FET} = 1.5 \times I_{O\_Peak} = 1.5 \times 468mA = 702mA$$

For the application, choose a MOSFET 600V, 1A to 2A. 2N60 is a good choice.

The peak voltage rating of the diode is the same as the MOSFET. The current range of the diode is:

$$I_{diode} = 1.5 \times I_{O\_Peak} = 1.5 \times 468mA = 702mA$$

For this application, 600V/1A fast recovery diode is recommended.

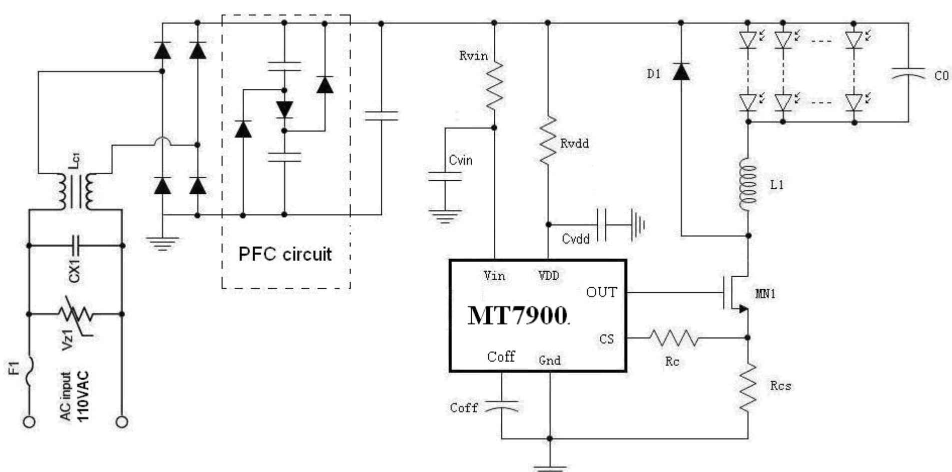


Fig.2 MT7900 Application Circuit (Low Cost)

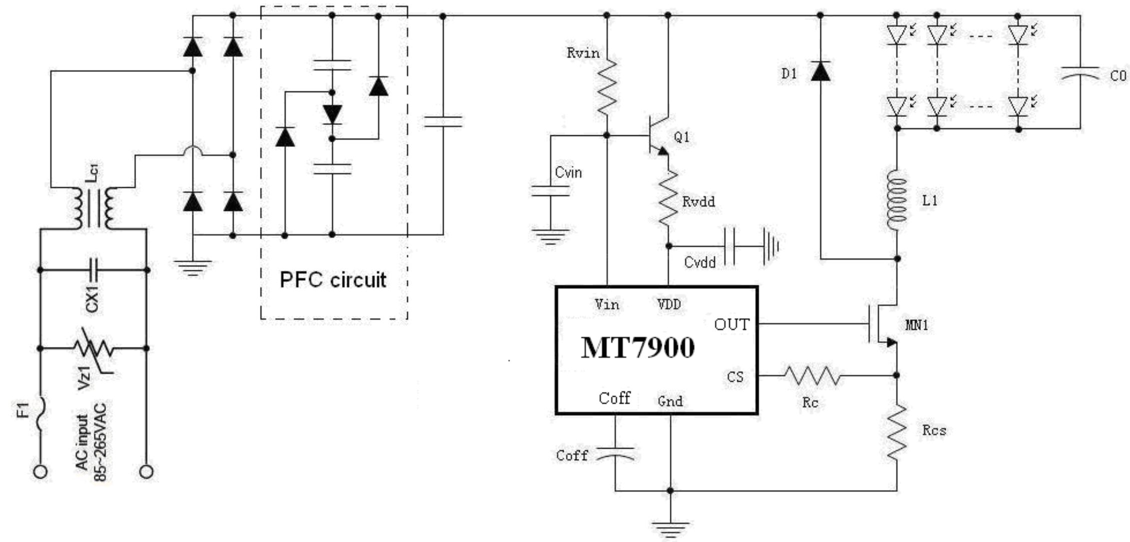
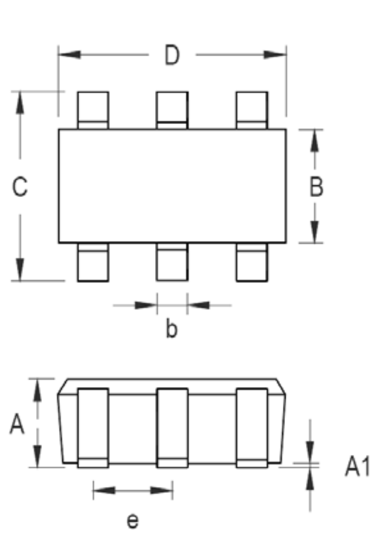


Fig.3 MT7900 Application Circuit (High Efficient)

PACKAGE INFORMATION



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.559	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

For detail products information and sample requests, please contact:

Maxic Technology Corporation (Beijing Office)
Room 911, Building 3, Zi Jin Digital Garden, Hai Dian District, Beijing, China, 100190
Tel: 86-10-62662828
Fax: 86-10-62662951

Maxic Technology Coporation (Shenzhen office)
7K, Block B, Fortune Plaza, Futian District, Shenzhen 518040
Tel: 86-0755-83021778
Fax: 86-0755-83021336

Maxic Technology Corporation(Hong Kong office)
Rm D1, 7th floor, JianAn Commercial Building,
No. 49-51, Suhong Str., Sheung Wan, Hong Kong

Web: www.maxictech.com
E-mail: **sales@maxictech.com**, **info@maxictech.com**