MT7890

TRIAC Dimmable Constant Current LED Driver

DESCRIPTION

MT7890 is a high precision LED constant current controller. It operates in critical conduction mode (CRM) with zero current switched-on and peak current switched-off. It's mainly targeted for BUCK, Fly-back LED power systems. MT7890 supports high power factor application. The Power Factor (PF) can reach 0.8 or higher.

CRM ensures that the MT7890 turns on the internal power MOSFET when the inductor current reaches zero, reducing the power MOSFET switching loss. With critical conduction mode, and line compensation, MT7890 outputs high accuracy LED current, and further achieves excellent line regulation and load regulation.

The external MOSFET that can be chosen depend on output power, it can achieve simplified peripheral circuits and low BOM cost.

MT7890 provides various protection features to improve the system reliability, including over current protection (OCP), short circuit protection (SCP), adjustable over voltage protection (OVP) and over temperature LED current foldback, etc. With a wide dimmer compatibility, the dimming curve meets the NEMA SSL6 standard.

FEATURES

- Supports high PF application (PF>0.8)
- Wide range of dimmer compatibility
- Deep dimming level (<1%)
- Highly accurate constant LED current
- Cycle-by-cycle current limiting
- LED short circuit protection
- Adjustable LED over voltage protection
- Under-voltage lockout (UVLO) protection
- Over temperature LED current foldback
- Available in SOP8 package

APPLICATIONS

- LED bulb, panel light
- Filament bulb
- General purpose constant current source

Typical Application Circuit
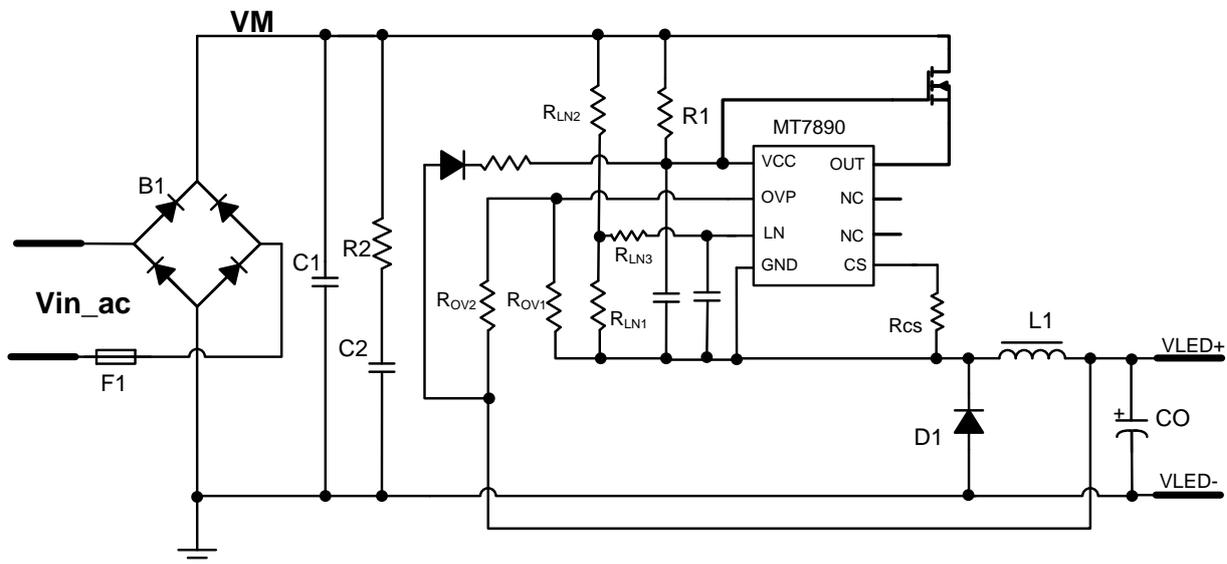
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ABSOLUTE MAXIMUM RATINGS

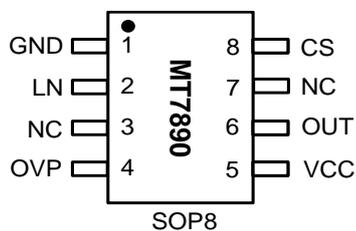|	
VCC maximum sink current	5mA
OVP (over voltage protection pin voltage)	-0.3 ~ 6V
LN (line compensation pin voltage)	-0.3 ~ 6V
OUT (Gate driver pin voltage)	-0.3V ~ 40V
CS (current sense pin input voltage)	-0.3V ~ 6V
P_{DMAX} (maximum power consumption)	0.8W
Storage Temperature	-55°C ~ 150°C
Junction Temperature (Tj)	150°C

RECOMMENDEDE OPERATING CONDITIONS

Operating Temperature range	-40°C ~ 105°C
Output Power	<50W @ V_{OUT}=36V

Thermal resistance

Junction to ambient ($R_{\theta JA}$)	128°C/W
Junction to Case ($R_{\theta JC}$)	90°C/W

PIN CONFIGURATIONS

```
       ┌─────────┐
GND ─┤1  ●      8├─ CS
 LN ─┤2         7├─ NC
 NC ─┤3  MT7890 6├─ OUT
OVP ─┤4         5├─ VCC
       └─────────┘
          SOP8
```

Chip Mark

MT7890
YY WW xx
— Manufacture code
— Week code
— Year code

PIN DESCRIPTION

Name	Pin No.	Description
GND	1	Chip ground
LN	2	Line compensation pin. Tie to GND to disable line compensation function
NC	3	No Connection
OVP	4	Adjustable over voltage protection pin
VCC	5	Power supply, internal clamped at 19V
OUT	6	Gate driver pin, connect this pin to the gate of external power MOSFET
NC	7	No Connection
CS	8	Current sense pin, connect a sense resistor to ground

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ELECTRICAL CHARACTERISTICS

(Test condition: VCC=12V, TA=25°C unless otherwise stated.)

Symbol	Parameter		Min	Typ	Max	Unit
Start-up and supply voltage (VCC Pin)						
I_{START}	Start up current	$V_{CC} < V_{CC\_UV}$		160	200	µA
V_{CC_UV}	Lower threshold voltage of V_{CC} (UVLO)	V_{CC} Pin ramp down		7		V
V_{START}	Start-up voltage	V_{CC} Pin ramp up		14		V
$V_{CC\text{-}CLAMP}$	V_{CC} Clamping voltage	$I_{DD} < 5mA$		19		V
I_{op}	Operating current			0.3		mA
Current sense (CS Pin)						
$V_{CS\text{-}TH}$	Threshold voltage for peak current limit		390	400	410	mV
LEB	Leading edge blanking time for current sense			500		ns
V_{LN}	Threshold voltage for line compensation			2.7		V
Over voltage protection						
V_{TH_OVP}	Threshold voltage for OVP			1		V
Thermal Protection						
T_{ADJ}	Temperature threshold for LED current foldback			150		℃
Driver Circuit						
T_{OFF_MIN}	Minimum OFF time			2		us
T_{OFF_MAX}	Maximum OFF time			200		us
T_{ON_MAX}	Maximum ON time			10		us
Internal Power MOSFET						
R_{DSON}	Static drain-source on-resistance			1		Ω

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BLOCK DIAGRAM
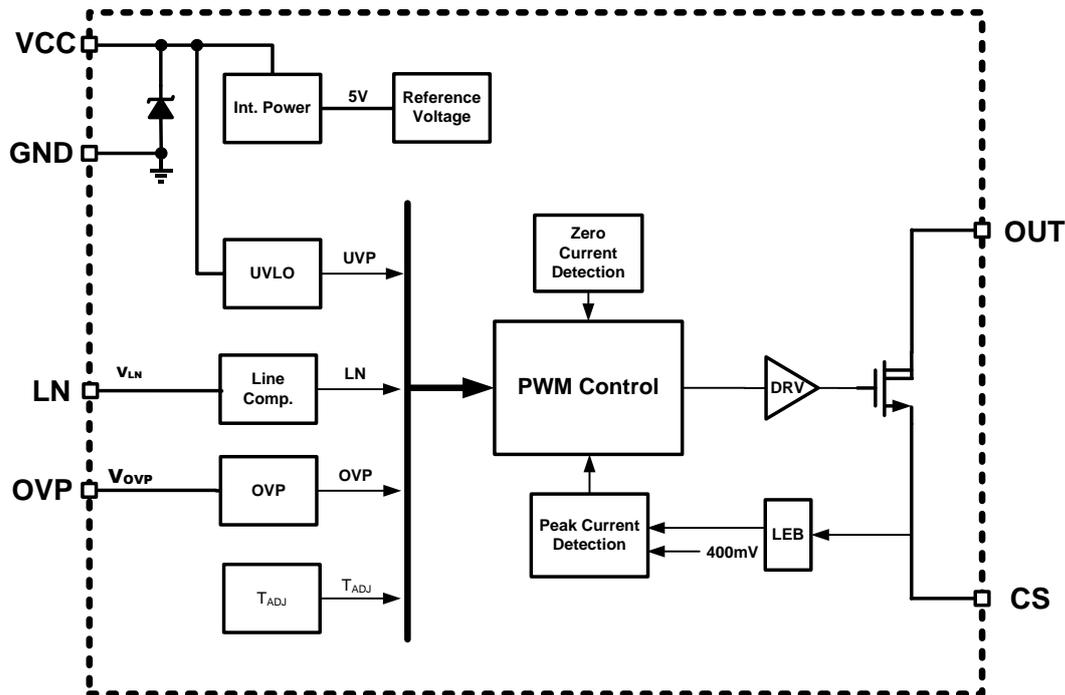
APPLICATION INFORMATION

MT7890 is a constant current LED driver and is suitable for TRIAC dimmable LED system. The critical conduction mode and line compensation ensures that MT7890 outputs high accuracy LED current, and further achieves excellent line regulation and load regulation. With very few peripheral components, the system cost and size are greatly reduced.

Start up

VCC is charged by the startup resistor (or other startup circuit) once the system is powered on. As the VCC reaches 14V, the control logic starts to work, and internal switch starts toggling. When the VCC rises up to 19V, it will be clamped. MT7890 shuts down as VCC falls below 7V.

CRM and Output Current Setup

The peak current of the internal power MOSFET is cycle–by–cycle detected by monitoring the voltage on the CS pin. When the voltage reaches

400mV (internal reference voltage without line compensation function), the internal power MOSFET is turned off, when the inductor current drops to zero, it will be turned on again.

The peak inductor current without line compensation function is given by:

$$I_{LPK} = \frac{400}{R_{CS}} (mA) \qquad (1)$$

Where, R_{CS} is the current sense resistor in ohm. The CS comparator also includes a 500ns leading edge blanking time to block the transient noise as the power switch just turned on.
The current at LED can be calculated as:

$$I_{LED} = k \times \frac{I_{LPK}}{2} = k \times \frac{400\,mV}{2 \times Rcs} (mA) \qquad (2)$$

Where, I_{LPK} is the peak current of the inductor;
k is the compensation factor, and is less than 1. Shown in the equation (2), the output current is determined by the R_{CS} and the 400mV reference

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voltage, insensitive to the inductance. Please utilize the design tool that Maxic provided to calculate the initial value of R_{CS}.
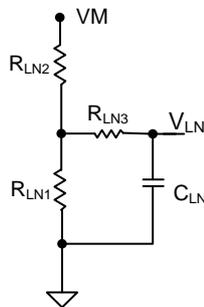
Line Compensation

MT7890 integrates the line compensation function. Once the voltage on LN pin (V_{LN}) exceeds 2.7V, the threshold for peak current limit decreases, thus, the input voltage compensation is achieved.

The relationship between V_{CS_PEAK} and V_{LN} as shown below:
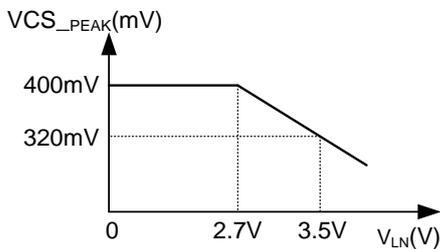
Where, V_{LN} is proportional to the average value of the rectified input voltage, which is obtained by sampling and filtering the input voltage as shown below:

Where, R_{LN1} is about 10kohm; R_{LN3} is about 200kohm; C_{LN} is about 1uF.

The passive filter R_{LN3} and C_{LN} converts the input line voltage VM to the DC-like line compensation voltage V_{LN}. Adjusting the ratio of R_{LN2} and R_{LN1} achieves optimized line compensation effect.

If the line compensation function is not needed, tie LN pin to ground.

Maxic provides design tool of MT7890 to help customer to design appropriate R_{LN1} and R_{LN2} ratio.

Switching Frequency

MT7890 operates in critical conduction mode. When the inductor current is zero, the system turns on the internal power MOSFET, the inductor current rises up from the ground. The on time of the power MOSFET is calculated by the equation:

$$T_{ON} = \frac{L \times I_{LPK}}{V_{IN} - V_{LED}} \qquad (3)$$

Where, L is the inductance of the inductor;
I_{LPK} is the peak current through the inductor;
V_{IN} is the DC voltage of the rectified input voltage.

The internal power MOSFET is turned off, while the voltage on the CS pin increases to 400mV. The inductor current will discharge the LED through the free-wheeling diode. The internal power MOSFET won't be turned on until the current in the inductor drops to zero. The off time of the power MOSFET is calculated by the equation:

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

Operating frequency of the system is:

$$F = \frac{1}{T_{ON} + T_{OFF}} = \frac{V_{LED} \times (1 - \frac{V_{LED}}{V_{IN}})}{L \times I_{LPK}} \qquad (5)$$

From the equation, it's showing that MT7890 operating frequency is determined by the input voltage V_{IN}, the LED forward voltage drop V_{LED} and the inductance L. The higher input voltage V_{IN} makes the operating frequency to be higher. For both EMI and efficiency consideration, it's recommended to set the operating frequency between 30kHz ~ 120kHz. The appropriate inductance should be determined at minimum input voltage condition to meet the requirement. MT7890 sets the minimum off time T_{OFF_MIN}=2us. Shown in T_{OFF} equation, if the inductance is too

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small, the T_{OFF} may be shorter than T_{OFF_MIN}, the system will operate in discontinuous conduction mode. The actual LED current will be smaller than the target value.

MT7890 determines the line valley automatically. The valley detection circuit is integrated in the MT7890. It senses when the input voltage reaches its lowest level (valley) automatically. MT7890 sets the maximum off time T_{OFF_MAX}=2.5us when the valley is detected in order to limit the operating efficiency. In application, the inductance should not be too big, it may cause the real current may not exactly match the design value by longer demagnetization time during valley.

Maxic provides design tool of this chip, it helps customer to come out proper solution and to choose the right inductance.

Over-current Protection

MT7890 immediately turns off the internal power MOSFET once the voltage on CS pin exceeds 400mV. This cycle-by-cycle current limitation scheme prevents the relevant components, such as power MOSFET, transformer, etc. suffers from damage.

LED Over voltage protection

The LED over voltage condition can be detected by OVP pin. The OVP threshold voltage is 1V. MT7890 shuts down and the VCC restarts as V_{OVP} exceeds 1V. MT7890 will resume when the over voltage condition has been removed.

The V_{OVP} is programmed by adjusting the pull up resistor R_{OVP2} and the pull down resistor R_{OVP1}:

$$V_{OVP} = 1V \times (1 + \frac{R_{OVP2}}{R_{OVP1}}) \qquad (6)$$

Where, R_{OVP1} is about 4.7k.

PCB Layout Consideration

1) The VCC de-couple capacitor (typically 1uF ~ 4.7uF ceramic capacitor) should be kept as close to the VCC pin as possible (no more than 5mm). This can greatly improve the system noise immunity.

2) The OVP (pin4) connection wire should be as short as possible. The connection wire and the related resistor terminals must be placed far away from the high voltage components (>3mm), such as the VCC pad.

3) The RC filter of LN pin (pin2) should be kept as close to the LN pin as possible, and the divider terminals must be placed far away from the high voltage components and other noise sources, such as the VCC pad, OUT pad, etc..

4) The area of main current loop should be as small as possible to reduce EMI radiation, such as the related pathways area of the inductor current.

5) The ground path should be short and wide, and it should be as close as possible to the IC ground, such as the ground path of VCC capacitor, OVP, and the resistors of LN.
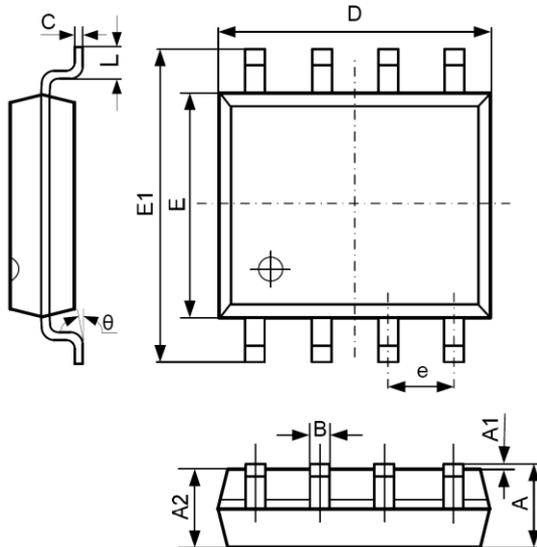
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PACKAGE INFORMATION

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
θ	0°	8°	0°	8°

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