

DESCRIPTION

MT7938 is a single-stage, primary side control AC-DC LED driver with active power factor correction. MT7938 integrates on-chip PFC circuit operates in critical conduction mode (CRM) to achieve high power factor and reduce the power MOSFET switching loss. With innovative control technique, precision LED current is achieved without secondary side sense and feedback circuit including opto-coupler.

MT7938 provides various protections, such as over current protection (OCP), output over voltage protection (OVP), short circuit protection (SCP) and over temperature regulation (OTR), etc., to improve system reliability. Moreover, MT7938 is designed with thermal regulation setting pin TADJ, which allows flexible setting of the thermal regulation threshold by connecting an external resistor to ground.

APPLICATIONS

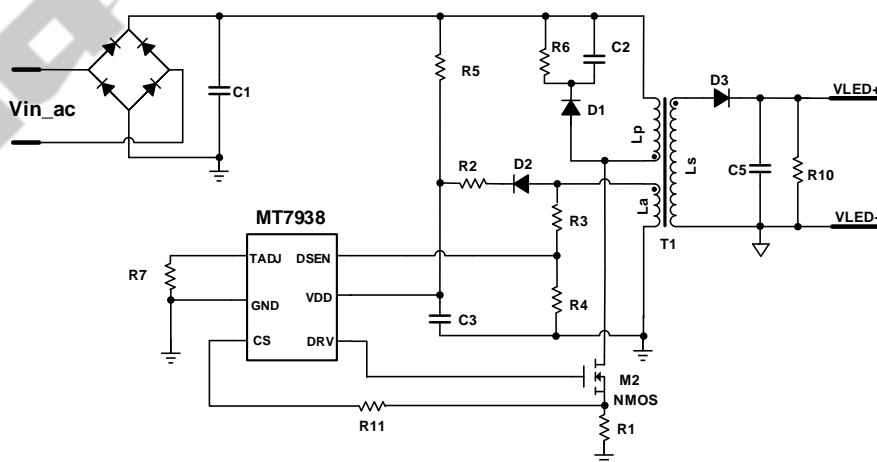
- AC/DC LED driver applications
- Signal, decorative LED lighting and street light
- E27/PAR30/PAR38/GU10 etc.LED lamp

- LED fluorescent lamp

FEATURES

- Single-stage Active PFC for high power factor
- Internal integrator (no external COMP capacitor)
- Internal THD compensation circuit
- Internal line regulation
- Primary side control saving opto-coupler
- High precision LED current ($\pm 5\%$)
- Critical Conduction Mode operation
- Cycle-by-cycle current limiting
 - Over current protection
 - Output over-voltage/open-circuit protection
 - Short circuit protection
- Flexibly set thermal regulation threshold through TADJ
- Power on soft-start
- Available in SOT23-6 packages

Typical Application Circuit



ABSOLUTE MAXIMUM RATINGS

VDD Voltage	-0.3V to VDD Clamp
DRV Pin Voltage	-0.3V to 24V
TADJ/CS/DSEN Pins Voltage	-0.3V to 5V
Power Dissipation (TA=25°C)	1W
Lead Temperature (soldering, 10 sec.)	260°C
Storage Temperature (T _{STG})	-55°C to 150°C
Operating Junction Temperature (T _j)	-40°C to 150°C

Recommended operating conditions

Supply voltage	7.2V to 18V
Operating Temperature	-40°C to 125°C

Thermal resistance^①

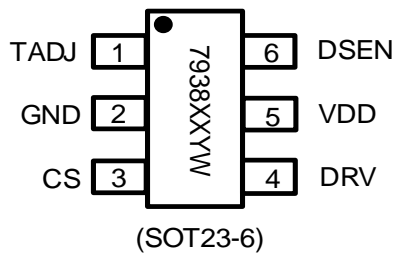
Junction to ambient (R _{θJA})	145°C/W
Junction to Case (R _{θJC})	80°C/W

Note:

- ① R_{θJA}, R_{θJC} are measured in the natural convection at TA = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2" X 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

ORDERING INFORMATION

Part Number	Package	Packing Method	Chip Mark
MT7938	SOT23-6	Tape 3,000 Pcs/Reel	.7938XXYW

PIN CONFIGURATIONS

Chip Mark
.7938XXYW

Week Code

Year Code

Manufacture Code

PIN DESCRIPTION

Name	Pin No.	Description
TADJ	1	Thermal regulation setting pin, to set thermal regulation threshold through connecting an external resistor to ground.
GND	2	Ground.
CS	3	Current Sensing pin.
DRV	4	Gate drive output for primary MOSFET.
VDD	5	Power Supply.
DSEN	6	The voltage feedback from auxiliary winding. Connected to a resistor divider from auxiliary winding to sense output voltage.

ELECTRICAL CHARACTERISTICS

 (Test conditions: $V_{DD}=15V$, $T_A=25^{\circ}C$, unless otherwise stated.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Start-up (VDD Pin)						
I_{START}	Startup current			50		μA
UVLO	Under-voltage lock-out threshold	V_{DD} pin ramp down		7.2		V
V_{START}	Startup voltage	V_{DD} pin ramp up		18		V
Supply Current						
I_q	Quiescent current			0.5		mA
I_{VDD_CLAMP}	VDD clamp current	$V_{DD}>18V$		10		mA
Control Loop						
V_{FB}	Primary current sense reference voltage		392	400	408	mV
V_{DDCLM}	VDD clamp			18		V
OVP1	Over Voltage Protection threshold at VDD pin			29		V
OVP2	Over Voltage Protection threshold at DSEN pin			3.6		V
T_{OFF_LEB}	Leading Edge Blanking (LEB) at OFF state			2.1		μs
T_{ON_MAX}	Maximum ON time			25		μs
T_{OFF_MAX}	Maximum OFF time			250		μs
MinT	Minimum switching period			10		μs
Current Sense (CS Pin)						
T_{CS_LEB}	Leading Edge Blanking of CS			240		ns
V_{CS_OCP}	Over Current Protection threshold at CS pin			1.8		V
Thermal Regulation (TADJ Pin)						
T_{OTR_MAX}	Maximum temperature regulation threshold	TADJ pin floating		135		$^{\circ}C$
T_{OTR_MIN}	Minimum temperature regulation threshold	Connecting an external resistor at TADJ to ground		80		$^{\circ}C$
Drive Stage (DRV Pin)						
I_{SINK}	Sinking Capability	DRV=4V		0.2		A
I_{SOURCE}	Sourcing Capability	DRV=4V		0.2		A

APPLICATION INFORMATION

MT7938 is a single-stage, primary-side controller for AC-DC LED driver. The LED current can be accurately regulated through sensing the primary side information. MT7938 integrates power factor correction function and THD compensation to eliminate noise to the AC line and works in CRM (Critical Conduction Mode) and Quasi-resonant mode (QRM) reducing the power MOSFET switching loss and increasing the system efficiency.

Current Control

MT7938 accurately regulate LED current through sensing the primary side information. The LED current can be easily set as following (refer to the typical application circuit on page 1):

$$I_{LED} = \frac{1}{2} \cdot \frac{N_P}{N_S} \frac{V_{FB}}{R1}$$

Where N_P is primary winding, N_S is secondary winding; V_{FB} (=400mV) is the internal voltage reference and $R1$ is an external current sensing resistor.

Start Up

During start-up process, VDD is charged through a start-up resistor. As VDD reaches 18V, the system senses the resistance of R9 at TADJ pin during quiescent state, sets the thermal regulation threshold, and then the internal control system starts.

The internal integrator builds the algorithm immediately to make the system reach a stable state promptly and avoid generating the current spikes at ON time to realize soft-start.

The power supply is taken over by the auxiliary winding once the voltage of this winding is high enough.

The PWM signal is shut down after VDD goes

below 7.2V (UVLO threshold voltage).

Power Factor Correction

The primary side current increases linearly from zero to peak value, as sensed by the current sensing pin CS, during the power MOSFET on-time. When the primary current reaches the threshold, MT7938 turns off the power MOSFET immediately. MT7938 turns on the power MOSFET again after the drain of the power MOSFET damps to its valley or nearby. Through internal THD compensation circuit, system corrects the current waveform distortion. As a result, the average input current is sinusoidal-shaped, high power factor and extremely low THD is therefore achieved in this way.

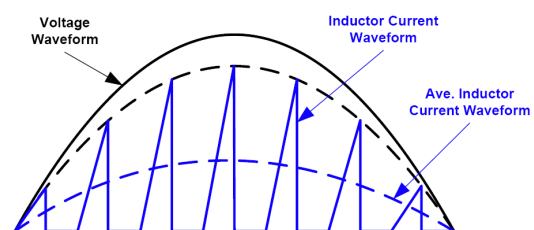


Fig.1 Power Factor Correction

Auxiliary Sensing

The turning-on of power MOSFET is determined by sensing the end of demagnetization. The demagnetization sensing is controlled by sensing DSEN's waveform, which is sampled from auxiliary windings by the resistor-divider. As DSEN's waveform goes below 0V at OFF time, which indicates the drain of power MOSFET damps to its valley or nearby the power MOSFET will be turned on. Besides, minimum OFF time control provides noise immunity.

Furthermore, MT7938 features open-circuit protection. The protection is triggered by sensing

the auxiliary winding waveform information, as the auxiliary winding voltage is proportional to the output voltage (secondary winding voltage) during the OFF time period. The auxiliary winding voltage is sampled by DSEN pin, one LEB (Leading Edge Blanking) time right after DRV signal is turned off.

Auxiliary sensing function is shown in Fig.2.

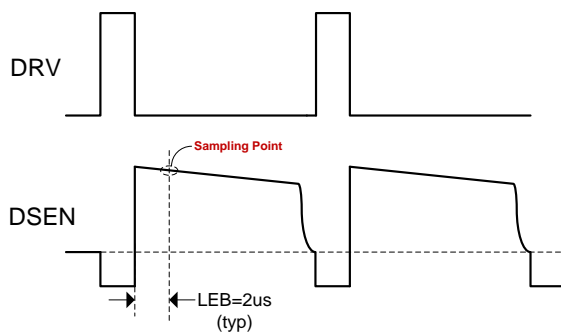


Fig.2 Auxiliary Signal Sensing

Line Regulation

MT7938 is designed with internal line regulation circuit. The compensation value can be adjust through the resistance of R3 at DSEN pin and the R11 at CS pin (refer to typical application circuit on page 1), to adjust the ratio of line regulation.

If the output current I_o becomes larger as input voltage ramps up, it indicates that the line compensation capacity is too weak. Increase R11 but can't exceed $1k\Omega$ to check whether the requirement can be met. If can't, decrease R3 until meet the requirement.

If the output current I_o becomes smaller as input voltage ramps up, it means that current line voltage compensation is too much. Decrease R11 to 0Ω at least to check whether the requirement can be met. If can't, increase R3 until meet the requirement.

In order to keep the output over voltage threshold unchanged, the R4 resistance should

be adjusted correspondingly.

THD Compensation Circuit

MT7938 integrates an adaptive THD compensation circuit. The compensation value will be automatically adjusted according to the system operating mode, without any external compensation circuit. It is insensitive to inductance and the inductance can be selected arbitrarily in a wide range.

Output Over Voltage Protection

MT7938 is implemented with two levels output over voltage protection schemes:

(1) If DSEN pin's voltage is detected above 3.6V for three times, (refer to **Auxiliary Sensing** section), MT7938 turns off the PWM switching signal, and VDD voltage gradually drops to UVLO threshold, and the system will be re-started. The threshold voltage of output over-voltage protection V_{OUT_OV} , can be easily defined as (refer to the application circuit in page 1):

$$V_{OUT_OV} = 3.6 * (1 + \frac{R3}{R4}) * \frac{N_s}{N_a} + V_{D3}$$

Where N_s is the secondary winding, N_a is auxiliary winding, V_{D3} is the forward bias of the secondary side rectifier diode.

(2) If VDD pin's voltage exceeds 29V for three consecutive switching periods, MT7938 turns off the PWM switching signal, and VDD gradually drops to UVLO threshold, and then the system restarts. It is highly recommended to set up the VDD voltage between 12V and 18V by designed a proper N_a to N_s ratio of the transformer. The gate drive switching will be turned off as the output over voltage protection is triggered. After 300ms, VDD is discharged by system or is naturally discharged to UVLO and the system restarts.

Output Short-Circuit Protection

The short-circuit protection is triggered if the system cannot detect the falling edge of DSEN at T_{OFF_MAX} for a continuous time of 10 to 20ms. The gate drive switching will be turned off, after 300ms, VDD is discharged by system or is naturally discharged to UVLO and the system restarts.

This re-start process will repeat if the short-circuit condition continues to exist.

Over-Current Protection

MT7938 immediately turns off the power MOSFET once the voltage at CS pin exceeds 1.8V. This cycle by cycle current limitation scheme prevents the relevant components, such as power MOSFET, transformer, etc. from damage.

When the output shorts, if T_{OFF_MAX} is triggered in the previous cycle, the over current protection threshold for the next cycle will be reduced to 0.8V to prevent excessive current during short-circuit sensing period.

Thermal Regulation Threshold Setting

TADJ pin connects R7 to ground (See Fig.3). Set

the thermal regulation threshold (T_{OTR}) through adjusting the ratios of R7 and R_{DSEN} . See the following table.

R7/ R_{DSEN} ratios	T_{OTR} °C
0	79.4
1.5	86.5
2.5	93.8
3.5	101.4
4.5	109.3
5.5	117.6
6.5	126.2
∞	135.2

Where, the R_{DSEN} is the total equivalent resistance on DSEN pin, so it is the parallel value of R3 and R4. Since R3 is much larger than R4, R_{DSEN} is approximately equal to R4.

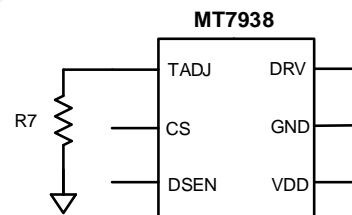
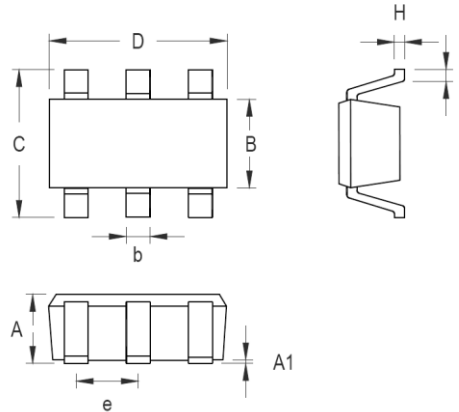


Fig.3 Thermal Regulation Threshold Setting with TADJ

PACKAGE INFORMATION
SOT23-6


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

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