

SM6380

Primary-side current control IC with High PFC for LED Lighting



FEATURES

- Primary-side feedback control without the opto-coupler
- Low input current THD
- Built-in Active Power Factor Correction Technique
- Quasi-resonant switching mode
- Excellent Line voltage and load Regulation
- +/- 3% LED output current accuracy
- Low start-up current
- Over-Voltage Protection on VCC pin
- Short-LED Protection
- Cycle by Cycle Over current Protection on CS pin
- Over-Temperature Protection
- Gate Driving Voltage Clamping
- SOT23-6L Package

APPLICATIONS

- LED lighting
- Down light
- Tubelight
- PAR lamp
- Bulb

DESCRIPTION

SM6380 is a primary-side Fly-back control IC with single-stage active power factor correction function for LED lighting systems.

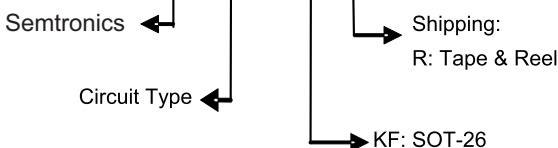
The IC achieves high power factor and low THD operation by quasi-resonant switch-mode in zero-current state conduction. This effectively reduces the switching losses of power MOSFET to improve system efficiency, but also improves the EMI characteristics of the system. The line and load regulation of LED current is about $\pm 3\%$ because of this particular control method.

SM6380 can achieve high precision LED constant current output, does not need an opto coupler, secondary feedback circuitry. This save the cost and size of the system, simplifying the design of LED lighting systems. SM6380 also provides gate driving voltage clamping, VCC over-voltage protection and system output open/short circuit protection to increase IC performance.

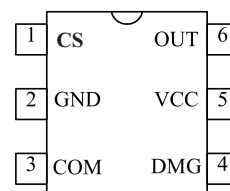
ORDER INFORMATION

PIN CONFIGURATIONS (TOP VIEW)

SM 6380- KF R



SOT-26



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PIN DESCRIPTIONS

Pin Name	Pin Description
COM	Output pin of error amplifier.
GND	Ground return for all internal circuitry.
CS	Input current sense pin.
OUT	Power MOS output pin.
VCC	Power supply pin for all internal circuit.
DMG	Zero current demagnetization sensing.

TYPICAL APPLICATION CIRCUITS

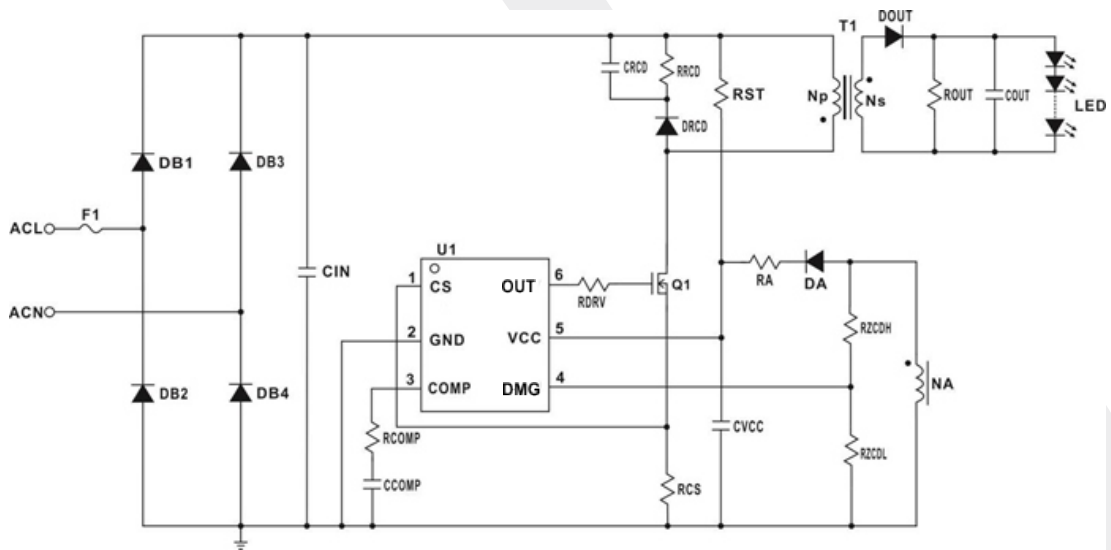


Figure 1

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Symbol	Range	Unit
Power supply pin	V_{CC}	25	V
DMG voltage to GND	V_{DMG}	-0.3 to 25	V
OUT voltage to GND	V_{OUT}	-0.3 to 25	V
CS voltage to GND	V_{CS}	-0.3 to 6	V
COM voltage to GND	V_{COM}	-0.3 to V_{CC}	V
Junction Temperature Range	T_j	-40 to +150	°C
Storage Temperature Range	T_{STG}	-65 to +150	°C
Lead Temperature (Soldering 10 sec)	T_{LEAD}	260	°C
Power Dissipation @ $T_A=25\text{ °C}$	P_D	0.5	W
Thermal Resistance Junction to Ambient (Note 2)	θ_{JA}	220	°C/W
Thermal Resistance Junction to Case	θ_{JC}	106.6	°C/W
ESD Rating (Human body mode) (Note 3)	V_{ESD}	2	kV

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: Thermal Resistance is specified with the component mounted on a low effective thermal conductivity test board in free air at $T_A=25\text{ °C}$.

Note 3: Devices are ESD sensitive. Handling precaution recommended.

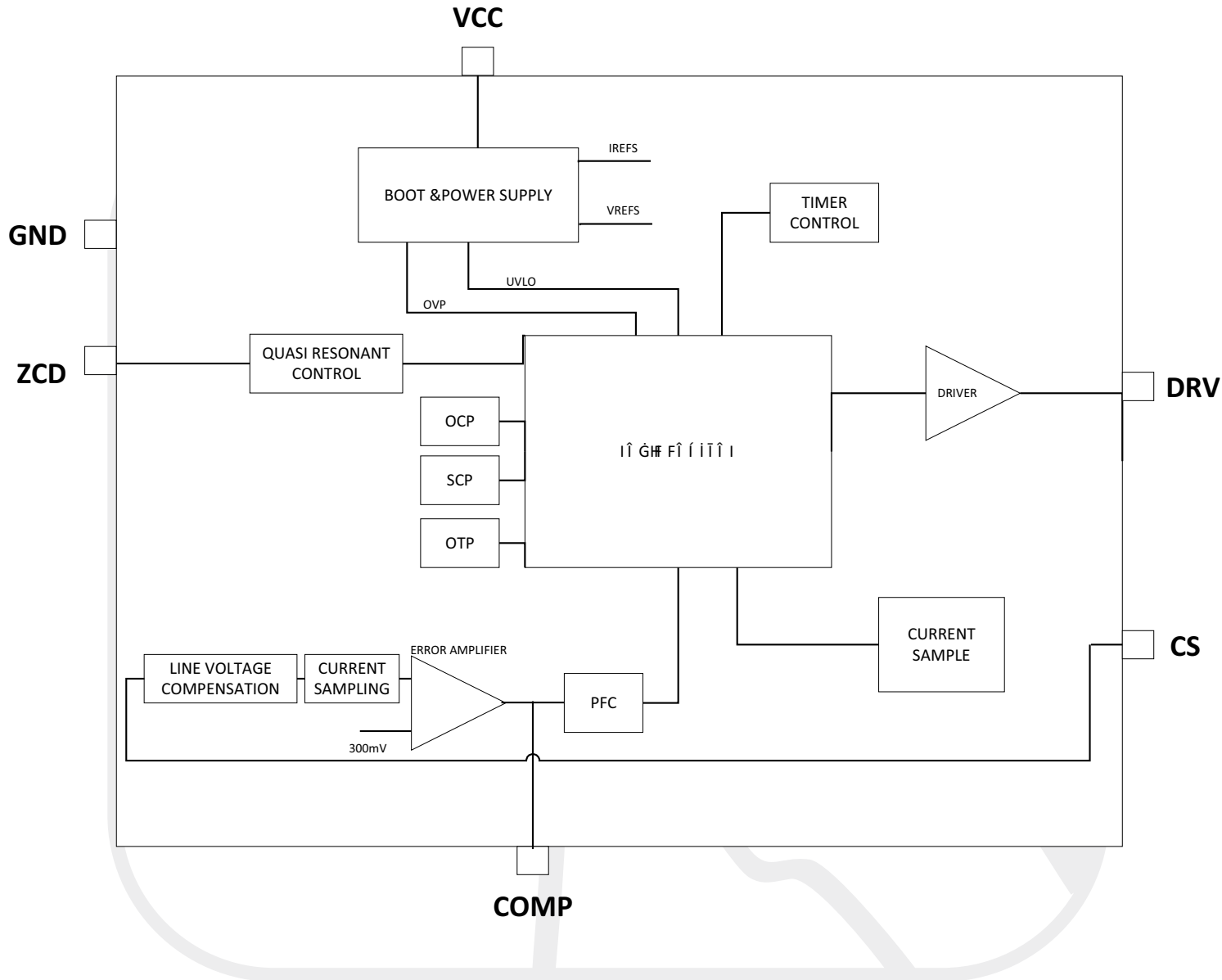
Note 4: The device is not guaranteed to function outside its operating conditions.

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BLOCK DIAGRAM



ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
POWER START						
Turn-on voltage	V _{CC_ON}			17		V
Turn-off voltage	V _{CC_OFF}			9.5		V
Over-voltage Threshold	V _{CC_OVP}			24		V
Turn-on Current	I _{CC_ON}	V _{CC} =V _{CC_ON} -1V		16		uA
Working Current	I _{OP}	F _{OSC} =70kHz; C _L =100pF		1		mA
Over-voltage discharge current on V _{CC}	I _{OVP}	V _{CC_ON} > V _{CC_OVP}		4.5		mA
VOLTAGE REFERENCE						
Output average current reference threshold voltage	V _{REF}		291	300	309	mA
CS by cycle current limit threshold	V _{CB_LIMIT}			1.5		V
ZCD over voltage protection threshold voltage	V _{ZCD_OVP}			2		V
TIMING CONTROL						
Current detection leading edge blanking time	T _{LEB}			400		ns
Maximum on-time	T _{ON_MAX}			35		us
Minimum off-time	T _{OFF_MIN}			2		us
Maximum off-time	T _{OFF_MAX}			100		us
Maximum operating frequency	F _{OSC_MAX}			140		kHz
DRIVER						
High voltage gate drive	V _{DRVH}			V _{CC}		V
Pull on maximum driving current	I _{SOURCE}			250		mA
Pull on maximum driving current	I _{SINK}			500		mA
OVER-TEMPERATURE PROTECTION						
Over temperature protection	T _{SD}			150		°C
OTP hysteresis	T _{HYS}			125		°C

APPLICATION INFORMATION

SM6380 is a primary-side Fly-back control IC with high power factor primary feedback. With integrated single-stage power factor correction circuit, can achieve high power factor and low input current total harmonic distortion, particularly suitable for 85VAC ~ 275VAC full input voltage range of high performance isolated LED lighting systems. SM6380 work under the primary side feedback and a quasi-resonant switching mode, low power MOSFET switching loss can be achieved with high accuracy LED constant current output.

Boot process

After the system bus voltage capacitor charging through startup resistor to VCC, when the VCC voltage reaches the turn-on threshold of the chip, SM6380 internal control circuit work. In this case, the chip first COMP RC network is pre-charged, so COMP voltage quickly rose to 1.55V. After COMP pre-charge is completed, the power transistor switch starts, the LED output voltage rises gradually increased. When the LED output voltage is established, the transformer secondary winding start to VCC power supply, chip startup is completed. COMP precharge time is adjusted by RCOMP, larger RCOMP can obtain a large loop phase margin.

Output current setting

When the power transistor starts conducting current transformer primary winding ramps up from scratch, while the voltage CS pin also ramp up. After a constant on-time, the power transistor is turned off. Transformer primary winding peak current can be expressed as:

$$I_{P_PK} = \frac{V_{CSP}}{R_{CS}}$$

Wherein, VCSP is the peak voltage CS pin; RCS for the transformer primary winding current sense resistor value.

During the power MOSFET is turned off, the stored energy is transferred from the transformer primary winding to the secondary winding, when the peak current in the primary winding and the secondary winding has the following relationship:

$$I_{S_PK} = I_{P_PK} \times \frac{N_P}{N_S}$$

Which, NP is the transformer primary winding turns; Ns is the transformer secondary winding turns.

During the power MOSFET turns off, the transformer secondary winding start demagnetization, when the secondary winding current begins to decrease at a constant slope from the peak. When the secondary current drops to zero, the power transistor is turned on to restart. LED output average current and the secondary winding peak current relationship as follows:

$$I_{LED} = \frac{1}{2} \times I_{S_PK} \times \frac{T_{DIS}}{T_S}$$

Among them, the demagnetization time TDIS for the transformer secondary winding; TS is a power tube switching cycles. Thus, LED output average current can be expressed as:

$$I_{LED} = \frac{1}{2} \times \frac{1}{R_{CS}} \times \frac{N_P}{N_S} \times V_{CSP} \times \frac{T_{DIS}}{T_S}$$

SM6380 house sampling and constant current control, such that:

$$V_{CSP} \times \frac{T_{DIS}}{T_S} = V_{REF}$$

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Wherein, VREF is the output average current reference voltage is typically 300mV. And locked, the system immediately stops working. By setting the ratio of the voltage dividing resistors transformer auxiliary winding open circuit voltage LED output can be set to open when:

Thus, LED output average current can be expressed as:

$$I_{LED} = \frac{1}{2} \times \frac{V_{REF}}{R_{CS}} \times \frac{N_P}{N_S}$$

From the above equation, LED output average current by the transformer turns ratio, CS resistors and chip internal reference voltage 300mV decision on the inductance of the transformer is not sensitive.

Active Power factor correction

SM6380 power tube in a constant on-time mode, you can achieve high power factor. Peak current transformer primary winding by the following public

Represented by the formula:

$$I_{P_PK} = \frac{V_{IN}}{L_P} \times T_{ON}$$

Where, VIN is the input line voltage is a sine waveform; TON of power MOSFET time; LP transformer primary winding inductance. Since the TON and LP constant value, the peak current of the transformer primary winding follow the input line voltage changes, also presented as a sine wave. At the same time, average input current is rendered as a quasi-sine wave, so the system can achieve high power factor and low input current total harmonic distortion.

SM6380 through constant on-time error amplifier chip and chip COMP pin external capacitor to achieve. In order to achieve high power factor and a stable loop system, CCOMP capacitor is recommended to be set to 2.2uF ~ 4.7uF.

$$V_{LED_OVP} = V_{ZCD_OVP} \times \frac{R_{ZCDL} + R_{ZCDH}}{R_{ZCDL}} \times \frac{N_S}{N_A}$$
$$V_{LED_OVP} \leq V_{VCC_OVP} \times \frac{N_S}{N_A}$$

Wherein, NA is the transformer secondary winding turns; VVCC_OVP to VCC OVP voltage; up and down RZCDH, RZCDL transformer auxiliary winding voltage divider resistors; VZCD_OVP overvoltage protection for the ZCD voltage threshold. RZCDH adjust the resistance on the line voltage compensation can be fine-tuning the system. When the LED output current with the input voltage increases, decreases

RZCDH resistance; on the contrary, increase RZCDH resistance. It takes a value RZCDH advice to 100kΩ ~ 1MΩ.

By-cycle current limit

When LED short circuit or other abnormal transformer saturation occurs, the transformer primary winding will face a lot of peak current. In order to protect the power tube, transformer and output diode from damage, SM6380 transformer primary winding by-cycle current limit. When the CS-by-cycle current limit voltage exceeds the threshold voltage, power management immediately shut off until the next switching cycle was re-turned.

In the COMP pin parallel with a 10pF ~ 100pF capacitor can effectively inhibit the COMP pin high frequency noise.

Quasi-resonant switching

SM6380 work in quasi-resonant switch-mode power tube in the bottom zero current turn-on, you can achieve low switching losses. Drain voltage power tube sampling through the transformer auxiliary winding and ZCD pin is detected via the resistor divider to. During the power is off, the current transformer secondary winding from the peak

Protection

SM6380 integrates several protection features to ensure stable and reliable system. Including the VCC supply voltage protection, VCC supply voltage protection, LED open circuit, short circuit protection, over temperature protection and transformer primary winding current by-cycle current limit and so on.

Over-temperature protection

SM6380 has overtemperature protection function which can prevent damage to the chip temperature. When the chip's junction temperature reaches 150 °C, the system will immediately stop working and remains off until the junction temperature drops to 125 °C. Once the system enters the locked state, the system will go into auto-restart mode. In the system automatically restart after completion, if abnormal situation persists, the system will work in hiccup mode until anomalies lifted.

Began to decline. When the current secondary winding down to zero, the drain voltage of the power tube started quasi-resonant, when the drain voltage resonance to the bottom, power management resume conducting. Therefore, the drain-source voltage of the power MOSFET when the smallest and the drain-source current is zero, it can achieve low switching losses.

Open LED Protection

When LED open circuit occurs, the system will still be charged for the output capacitor, the output voltage will gradually rise, this time transformer auxiliary winding voltage, VCC voltage and ZCD pin voltage follower rise. When the VCC voltage rises to VCC OVP voltage ZCD voltage threshold or minimum off time after rising to ZCD voltage threshold Overvoltage protection of logic chips are triggered

PCB Layout

SM6380 during PCB layout, we recommend the following rules:

Traces

1. The auxiliary winding to be connected to VCC capacitor ground, then connect the chip ground.
2. ZCD, COMP and other signals connected with the chip, traces as short as possible.
3. The chip resistor is connected with the CS and then connected to the input capacitor ground, and go The shorter the line, the better.
4. ZCD weak signal, ZCD ZCD foot resistance should be as close as possible, and away from interference sources.
5. The power tube leak extremely important source of interference, traces as short as possible.
6. VCC capacitor should be as close to the chip's VCC pin and GND pin.

Power loop area

Power loop area should be as small as possible, such as a transformer primary winding, power management, CS resistors, capacitors input current loop area and a secondary winding, output diode and output capacitors current loop area. In this way we can improve the EMI characteristics of the system.

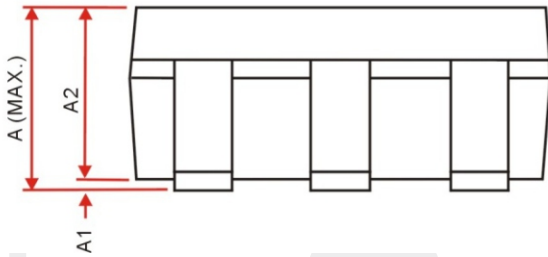
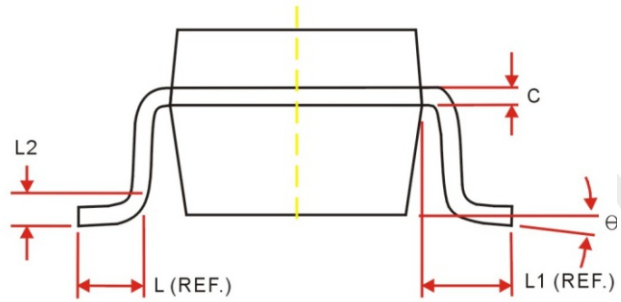
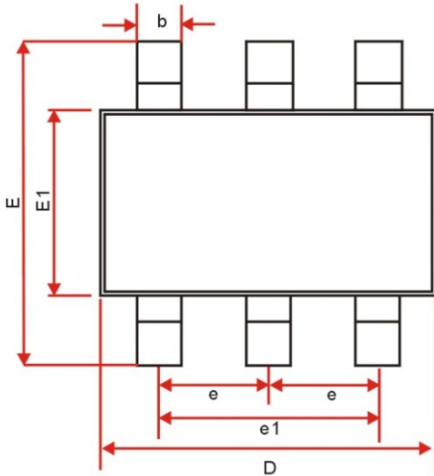
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PACKAGE OUTLINE DIMENSIONS

SOT-26 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters	
	Min	Max
A		1.45 MAX.
A1	0	0.15
A2	0.90	1.30
C	0.08	0.22
D	2.90 REF.	
E	2.80 REF.	
E1	1.60 REF.	
L	0.30	0.60
L1	0.60 REF.	
L2	0.25 REF.	
θ	0°	10°
b	0.30	0.50
e	0.95 REF.	
e1	1.90 REF.	