SR2366X(A/B/D/F/G)J

Constant Current Regulated Buck Controller with Active Power Factor Correction

Features

- High Voltage (800V) JFET Technology for Direct Power Supply of IC with No MLCC Buffer
- Constant On Time Control for Active PFC for High Power Factor and Low THD
- Optimized Design for Subharmonics Restraining
- Capacitance Amplifier Technology is Applied for Loop Compensation of Control with No MLCC
- Maximum Switching Frequency Clamping for System Reliability and High Efficiency
- Real Time Compensating Technology for High Precision (±3%) LED Current Control, Excellent Line and Load Regulation
- Soft Driving and Critical Conduction Mode Operation for Low EMI Optimization with Both Conduction and Radiation
- Pin-to-Pin Replacement forSR2366XJSerious with Integrated MOSFET
- SOP7 Package

Protection

- Built-In Soft Start
- Thermal Regulation
- LED Open and Short Protection
- Cycle by Cycle Current Limit
- Leading Edge Blanking for Current Sensing
- Leading Edge Blanking for Zero Crossing Detection
- VCC Under Voltage Lock Out (UVLO) and Clamping

Application

- Non-isolated APFC BUCK LED Driver
- Recommended Operation Conditions With Input Voltage 90-264Vac

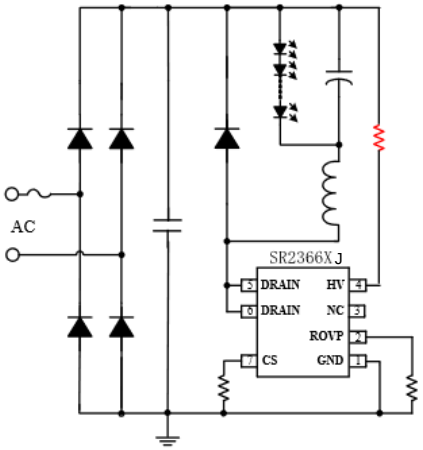


图1 SR2366XJ示意图

Part No.	MOSFET	Output Spec.
SR2366AJ	500V15ohm	72$V_{dc,}$ 70 mA, Bulb
SR2366BJ	500V9.0ohm	72$V_{dc,}$ 100 mA, Bulb
SR2366DJ	500V5.0ohm	72$V_{dc,}$ 120 mA, Bulb
SR2366FJ	500V3.0ohm	72$V_{dc,}$ 220 mA, Tube
SR2366GJ	500V2.3ohm	72$V_{dc,}$ 270 mA, Tube

Note 1： SR2366XJ where “X” can be “A”, “B”, “D”, “F”, “G” to distinguish the built-in MOSFET.

Package and Ordering Information

Part No.	Material Type	Package	Operating Temperature	Built-in MOSFET	Packing Method
SR2366A	Green	SOP7	-40℃ to 105℃	500V15ohm	Tape 4000 pcs/Reel
SR2366B	Green	SOP7	-40℃ to 105℃	500V9.0ohm	Tape 4000 pcs/Reel
SR2366D	Green	SOP7	-40℃ to 105℃	500V5.0ohm	Tape 4000 pcs/Reel
SR2366F	Green	SOP7	-40℃ to 105℃	500V3.0ohm	Tape 4000 pcs/Reel
SR2366G	Green	SOP7	-40℃ to 105℃	500V2.3ohm	Tape 4000 pcs/Reel

Pin Configuration

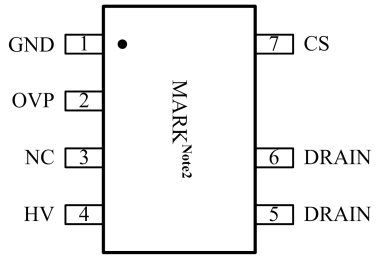


Fig. 2. Pin configuration

Note 2：Marking Rule". SR2366A/B/D/F/G

Pin Definition

Pin No.	Name	Description
1	GND	Ground.
2	OVP	Over Voltage Protection. With "No Connection", "Connect Directly to GND", "Connect A 68kohm Resistor to GND" and "Connect A 510kohm Resistor to GND", OVP Voltage of 115V, 90V, 230V and 175V Can be Obtained.
3	NC	No Connection.
4	HV	High Voltage Power Supply. No MLCC Buffer is Needed. **A 15kohm Resistor with 1206 Packaging is Suggested for Surge Application.**
5、6	DRAIN	Internal HV MOSFET Drain.
7	CS	Current Sense. Connect A Resistor to GND to Sense the Inductor Current.

Internal Block Diagram

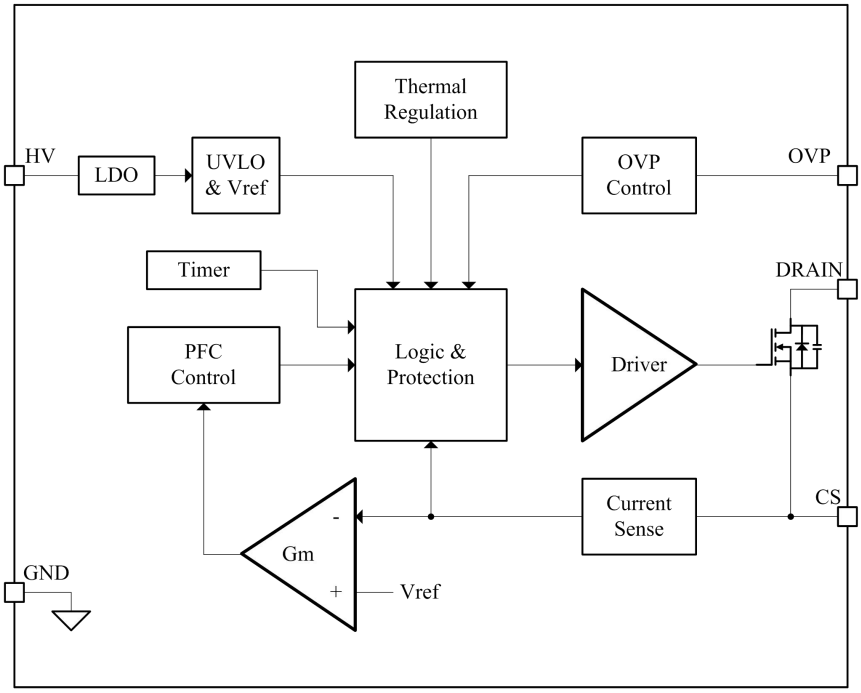


Fig. 3 Internal block diagram

Absolute Maximum Ratings[Note3]

Parameters	Symbol	Range	Units
"HV" voltage range	V_{HV}	-0.3 ~ 800	V
"CS" and "OVP" voltage range	V_{CS}, V_{OVP}	-0.3 ~ 6	V
Guaranteed minimum "DRAIN" voltage[Note4]	V_{DS_min}	500	V
ESD Human mode[Note5]	ESD_{hbm}	3000	V
Operating junction temperature range	T_j	-40 ~ 150	℃
Ambient temperature range	T_a	-40 ~ 105	℃
Storage Temperature Range	T_{stg}	-40 ~ 150	℃
Welding temperature (< 20 *s* welding)	T_{lead}	260	℃
SOP, junction to ambient thermal resistance	θ_{thja_SOP}	145	℃/W

Note3：Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

Note4：Depending on the different built-in MOSFET SPEC, see the corresponding relationship between the model and the built-in MOSFET.

Note5：Electrical components and circuit boards will be aware of the situation in the discharge is not easy. Although this product has a special electrostatic protection circuit, but in the case of high-energy electrostatic discharge, the chip may have damage and loss of function or performance degradation. Therefore, users still need to take appropriate preventive measures ESD.

Electrical Characteristics[Note6] (Unless otherwise specified, T_a = 25 ℃)

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
HV						
HV Turn On Threshold	V_{HV_ON}	V_{HV} Rising	12			V
HV Quiescent Current	I_{HV_Q}			180		μA
PWM						
Minimum On Time	T_{on_min}			1		μs
Maximum On Time	T_{on_max}			20		μs
Minimum Off Time	T_{off_min}			0.9		μs
Maximum Off Time	T_{off_max}			440		μs
Switching Period At Line Valley	T_{LV}			60		μs
CS						
Internal Reference Voltage	V_{REF}		0.194	0.200	0.206	V
Minimum CS Voltage	V_{CS_LMT}			0.315		V
CS Sampling Clamp Voltage	V_{CS_LMT}			1.2		V
CS Leading Edge Blanking Time	T_{LEB_CS}			350		ns
Switch off Delay Time	T_{DELAY}			200		ns
OVP						
OVP Voltage With No Connection	V_{OVP_OPEN}	V_{OVP} > 4.2 V		115		V
OVP Voltage With R_{OVP} = 510 kohm	V_{OVP_RES1}	V_{OVP} = [1.1, 3.4] V		175		V
OVP Voltage With R_{OVP} = 68 kohm	V_{OVP_RES2}	V_{OVP} = [0.12, 0.95] V		230		V
OVP Voltage With GND Short	V_{OVP_SC}	V_{OVP} < 0.12 V		90		V
MOSFET						
Drain-Source Breakdown Voltage	BV_{DSS_2366XJ}		500			V
Drain-Source On Resistance	$R_{DS\_ON\_SR2366AJ}$			15		ohm
	$R_{DS\_ON\_SR2366BJ}$			9		
	$R_{DS\_ON\_SR2366DJ}$			5.0		
	$R_{DS\_ON\_SR2366FJ}$			3.0		
	$R_{DS\_ON\_SR2366GJ}$			2		
OTR						
OTR Threshold	T_{OTR_TH}			150		℃

Note6： The max and minimum parameters specified are guaranteed by test, the typical value are guaranteed by design, characterization and statistical analysis.

Application Suggestion

SR2366XJ is a high precision active PFC driver integrating 800V JFET, specially designed for non-isolated buck offline constant current LED lighting. Operating in critical conduction mode, the driver achieves high power factor, low THD and high efficiency.

Start Up And Supply

When AC line is applied, main bus voltage can be built, then the JFET of the IC supply the inner operation. When the voltage of inner VCC reaches V_{HV_ON}, PWM is enabled; If the voltage of inner VCC drops below the V_{HV_UVLO}, PWM is disabled and restart is necessary.

HV Resistor

To enhance the surge capability, a 15 *kohm* resistor with 1206 packaging is recommended in series with HV. Larger HV resistor means better surge capability but too large HV resistor may decrease the drive current, then the maximum HV resistance is limited by formula (1)

$$\frac{V_O - 15V}{R_{HV}} > 3mA \quad (1)$$

Obviously, R_{HV} should be reduced with the reduction of V_O, especially in low output voltage and high output current applications with high Q_g MOSFET.

However, a minimum value of 5.1 *kohm* for R_{HV} should be guaranteed.

Principle of The Active Power Factor Correction (APFC)

Constant on time (T_{on}) control with boundary conduction mode (BCM) operation is the key principle to achieve active power factor correction, thereby high power factor and low THD can be expected.

The power inductor is charged during the fixed T_{on} of the MOSFET, i_L increase linearly to the peak (i_{pk}) from zero; when MOSFET tuned off, the freewheeling diode release the inductor current, i_L decrease linearly from i_{pk} to zero and next switching cycle is triggered.

Fig. 4 shows the Key waveforms of the CC controlled buck with APFC.

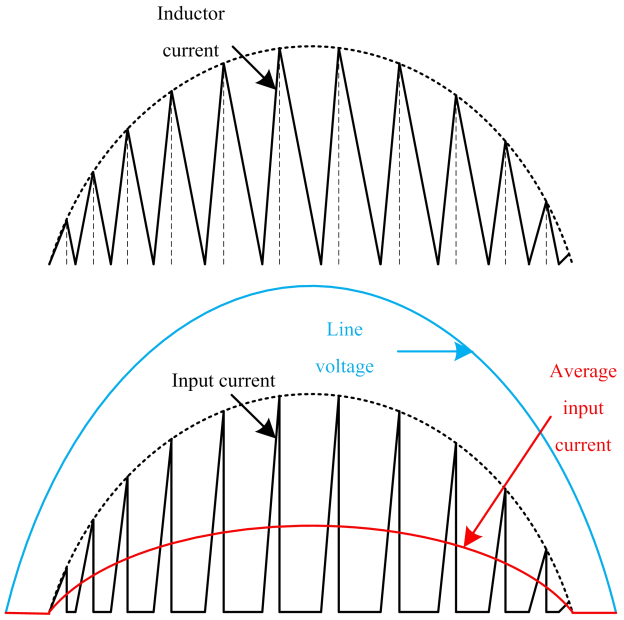


Fig. 4 Key waveforms of the CC controlled buck with APFC

Constant Current Control

In order to achieve high precision (±3%) output current control, excellent line and load regulation, YT218X operates in BCM and makes the real time sensing to the inductor current. I_o can be calculated with formula (2)

$$I_o = \frac{V_{ref}}{R_{cs}} \quad (2)$$

Where V_{ref} is the reference voltage， R_{cs} is the current sensing resistance.

Zero Current Detection (ZCD) and Valley Switching Technique

Dedicated zero crossing detection of the inductor current is designed for PWM turn-on signal, thereby the valley turn-on of the MOSFET and BCM operation of the inductor current can be achieved.

Maximum Off Time

Maximum off time (T_{off_max}) is set to avoid the condition that ZCD block missing the zero crossing event of the inductor current.

Minimum Off Time

Minimum off time (T_{off_min}) is set to limit the maximum switching frequency (f_{sw_max}), then the switching loss and EMC performance can be guaranteed. As shown in Fig. 5, PWM is triggered at the first valley after T_{off_min}.

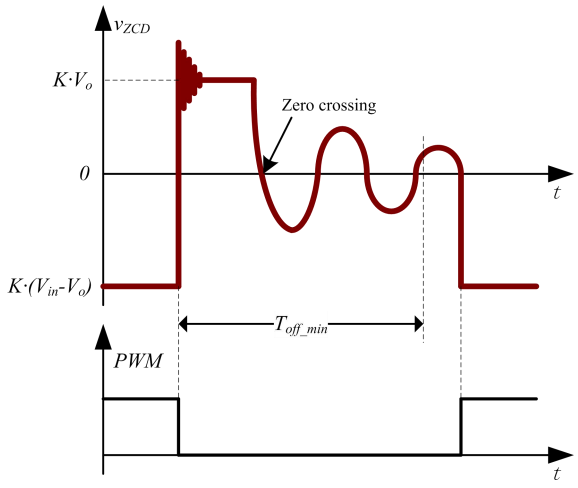


Fig. 5 Minimum off time

ZCD Blanking

Fig. 6 shows ZCD blanking time (T_{LEB_ZCD}) is set to avoid the fault trigger by the oscillation after the turn off.

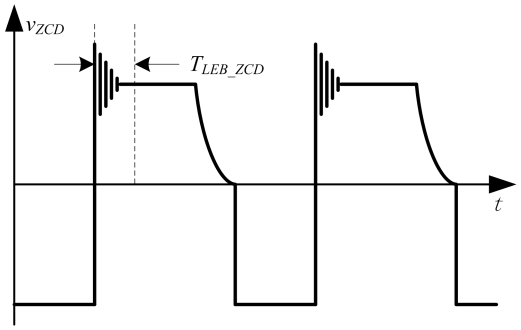


Fig. 6 ZCD blanking

CS Blanking

Fig. 7 shows CS blanking time (T_{LEB_CS}) is set to avoid the fault trigger by the oscillation after the turn on.

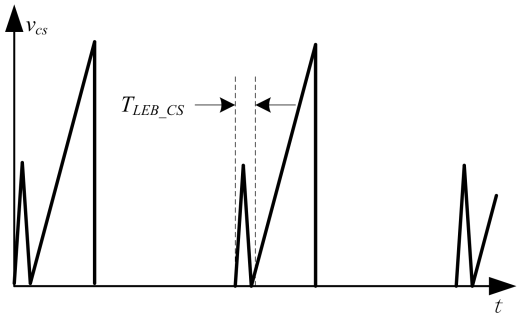


Fig. 7 CS blanking

Cycle by Cycle Current Limiting

When LED short or inductor saturation happens, CS pin voltage (V_{CS}) goes higher than regulation. However, CS voltage limit (V_{CS_LMT}) can help to stop PWM cycle by cycle to protect the MOSFET and the other power devices.

Over Temperature Regulation (OTR)

When the junction temperature goes higher than the threshold of the over temperature regulation (T_{OTR_TH}), chip will reduce the output current (I_o) by reducing the internal reference (V_{ref}). This is helpful to regulation the system temperature, guarantees the stability of both the driver and LED chip, and improves the reliability of the LED lighting system. Fig. 8 shows the principle of the over temperature regulation, where I_{o1} is the output current before OTR triggered; I_{o2} is the output current during OTR triggering and the junction temperature is T_{j2} for I_{o2}.

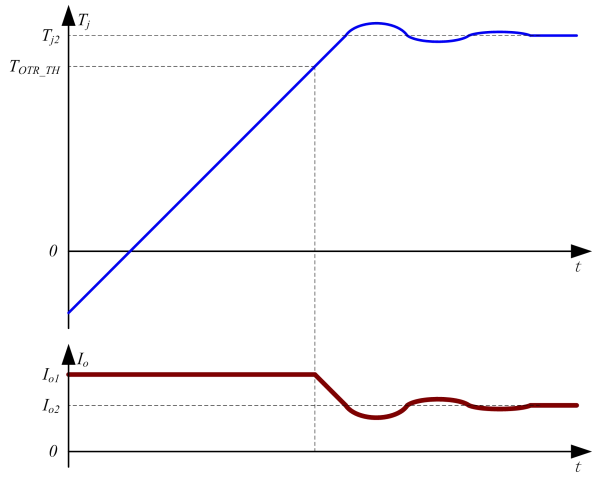


Fig. 8 Principle of the over temperature regulation

Over Voltage Protection for Output

Output OVP threshold can be programmed by connecting resistor with different values to the the OVP pin, and the relationship between the resistor value and the output OVP threshold is shown in the electrical characteristics table. However, HV resistor has the affection to OVP voltage. Higher OVP voltage can be obtained by slightly increasing the HV resistance.

PCB Design Guide

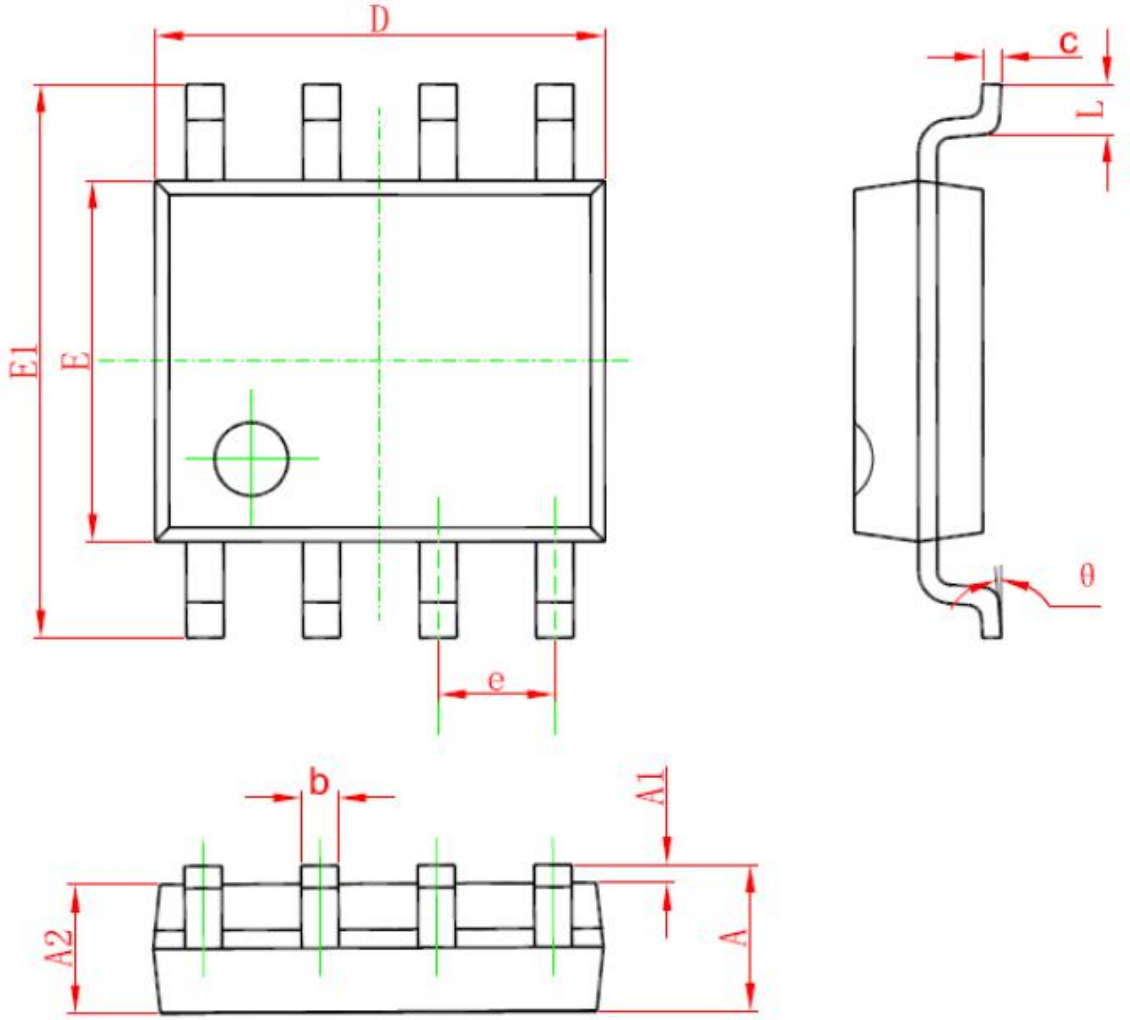
1. Current sensing resistor (R_{cs}) shall be placed very close to the chip, minimize the loop from CS pin to R_{cs} and GND pin.

2. Separate the power ground and the signal ground. Please use star connection method to connect power ground, signal ground to GND pin.

3. Minimize the loop from input capacitor (C_{in}) to MOSFET and the freewheeling diode to improve the system stability and EMC performance.

Package

SOP7



Symbol	Size (mm)		Size (inch)	
	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	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270		0.050	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°