

General Description

The SIC9866/SIC9867 are high precision primary-side regulation isolated flyback controller with single-stage Active PFC, specially designed for offline constant current LED lighting. The controller with on-chip PFC circuit operates in CCM (Critical Conduction Mode) to achieve high power factor and reduce the power MOSFET switching loss. The controller precisely control the LED current without secondary side sense and feedback circuit including opto-coupler. It uses source driver architecture and pending internal charging circuit for low primary side switching loss, ultra fast V_{DD} start up and LED turn on.

The SIC9866/SIC9867 use compensation method to achieve excellent line regulation, and it still can be tuned externally for flexibility. The controller also has outstanding load regulation for driving wide range of LED numbers. 700V power MOSFET is integrated, which can significantly simplify the design of LED lighting system.

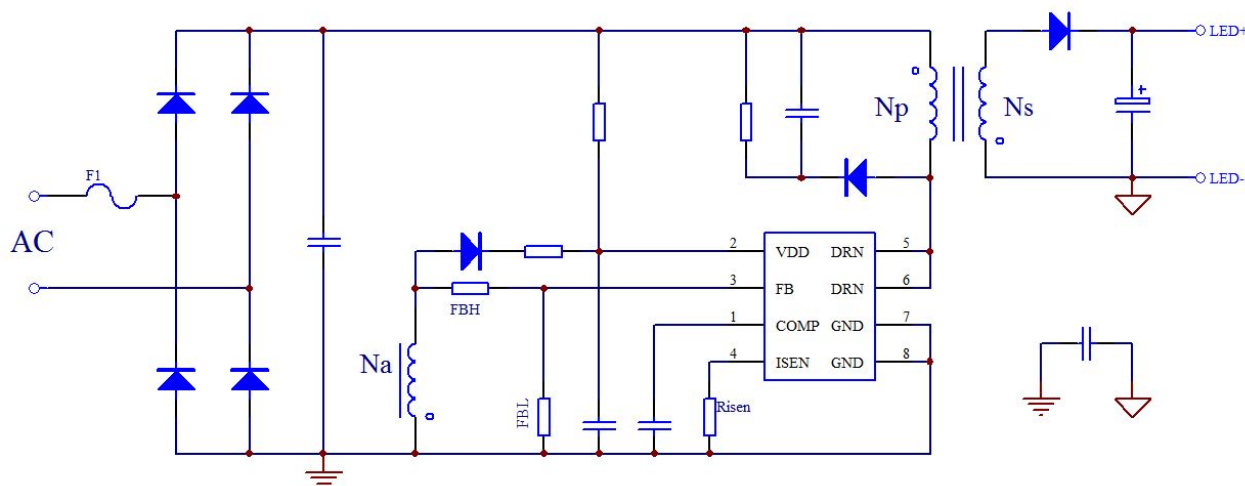
The SIC9866/SIC9867 offer rich protection functions to improve the system reliability, including LED short circuit protection, LED open circuit protection, V_{DD} over voltage protection, V_{DD} under voltage protection, ISEN resistor short circuit protection, ISEN resistor open circuit protection, cycle-by-cycle current limit and die over-temperature protection. All the protection features are auto-recovery.

The SIC9866/SIC9867 are available in SOP-8 & DIP-7 package.

Features

- Single-Stage Active PFC for High Power Factor and Low THD
- No Opto-Coupler Required
- $\pm 3\%$ LED Current Accuracy
- Critical Conduction Mode Operation
- High Resistance Feedback Resistor for Improved Efficiency
- Ultra-Low Operating Current
- ISEN Resistor Short and Open Circuit Protection
- Cycle-by-Cycle Current Limit
- Auto Recovery
- Primary Side Control Constant Current Operation
- Built-in 700V Power MOSFET
- Excellent Line and Load Regulation
- Gate Driver Structure for Improved Efficiency
- Ultra-Low Start up Current
- LED Short and Open Circuit Protection
- Transformer Saturation Protection
- VDD Over-voltage and Under-voltage Protection
- Over Temperature Protection

Typical Application



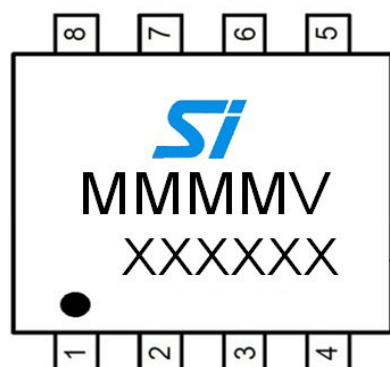
Recommended Operation Conditions

Symbol	Products	Range	Unit
V _{DD}	Power Voltage	8.5-18	V
Pout@ SIC9866(SOP-8)	Vin=220±20%	<8	W
	Vin=85-264V	<5	
Pout@ SIC9866(DIP-7)	Vin=220±20%	<18	W
	Vin=85-264V	<12	
Pout@ SIC9867(DIP-7)	Vin=220±20%	<24	W
	Vin=85-264V	<18	

Ordering Information

Part Number	Package	Package Method	Marking
SIC9866	SOP-8	Tape 3,000pcs/Roll	Si 9866 XXXXXX
SIC9866	DIP-7	Tube 50pcs/Tube	Si SIC9866 XXXXXX
SIC9867	DIP-7	Tube 50pcs/Tube	Si SIC9867 XXXXXX

Pin Assignment



SOP-8 Products

“Si”-Logo of SI Semiconductors

MMMM--Part Number (4 digits) ; V : Version(1 digit, optional)

XXXXXX--Date Code (6 digits)



DIP-7 Products

“Si”-Logo of SI Semiconductors

MMMM--Part Number (4 digits) ; V : Version(1 digit, optional)

XXXXXX--Date Code (6 digits)

Pin Description

Pin	Pin Name	Description
1	COMP	Loop Compensation Node. This pin connects a capacitor to GND for stabilization the control loop, achieve accurate LED current, high Power Factor and low THD.
2	V _{DD}	Power Supply pin.
3	FB	Feedback Voltage Input pin. This pin detects the output information through the auxiliary winding. It is also used for line regulation compensation.
4	ISEN	Current Sense pin. This pin connects a resistor to GND to sense the transformer primary side current.
5、6	DRAIN	DRAIN of the MOSFET.
7、8	GND	Ground.

Absolute Maximum Ratings

Parameter	Symbol	Parameter Range	Parameter
Voltage on PIN VDD	V _{DD}	-0.3~25	V
Maximum Clamping Current for PIN VDD	I _{CC_MAX}	5	mA
Voltage on PIN COMP	V _{COMP}	-0.3~6	V
Voltage on PIN FB	V _{FB}	-0.3~6	V
Voltage on PIN ISEN	V _{ISEN}	-0.3~6	V
Voltage for Built-in MOSFET Drain and Source	V _{MOS-DS}	-0.3~700	V
Maximum Power Dissipation(Ta=25℃)	P _{tot}	0.45@ SOP-8	W
		0.90@ DIP-7	
Thermal Resistance Junction-ambient	R _{thj-a}	145@ SOP-8	℃/W
		80@ DIP-7	
Operating Junction Temperature	T _J	-40~150	℃
Storage Temperature Range	T _{STG}	-55~150	℃
ESD		2,000	V

Note: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Electronic Characteristics

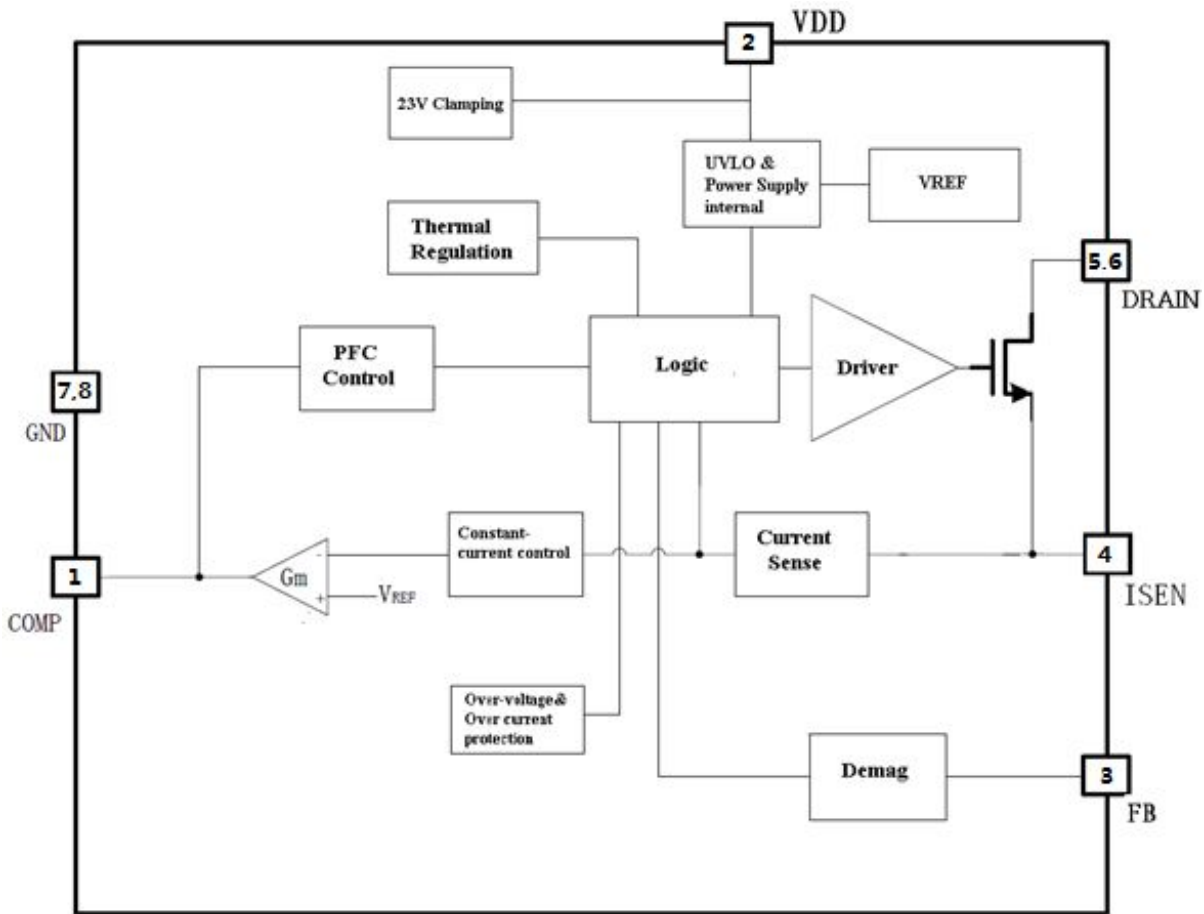
T _a =25℃, V _{DD} =15V, unless otherwise specified						
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VDD Turn On Threshold Voltage	V _{DD_ON}	VDD Rising		16.7		V
VDD Turn Off Threshold Voltage	V _{DD_UVLO}	VDD Falling		7.5		V
VDD Start Up Current	I _{ST}	VDD= V _{DD_ON} -1V		33	50	uA
VDD Operating Current	I _{OP}	F =10KHZ		1	2	mA
VDD Clamp Voltage	V _{DD_CLAMP}	1mA		23		V
FB Falling Edge Threshold Voltage	V _{FB_FALL}	FB Falling		0.1		V

High Precision PSR APFC Isolated LED Driver

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
FB Hysteresis Voltage		V_{FB_HYS}	FB Rising		0.08		V
FB Over Voltage Protection Threshold		V_{FB_OVP}			1.6		V
Minimum Degaussing time		T_{OFF_MIN}			4.5		us
Maximum Degaussing time		T_{OFF_MAX}			100		us
Maximum On time		T_{ON_MAX}			25		us
ISEN Peak Voltage Limitation		V_{ISEN_LIMIT}			1		V
Leading Edge Blanking Time for Current Sense		T_{LEB}			350		ns
Switch off Delay Time		T_{DELAY}			200		ns
Internal Reference Voltage		V_{REF}		194	200	206	mV
COMP Low Clamp Voltage		V_{COMP_LO}			1.5		
COMP Linear Operating Voltage Range		V_{COMP}		1.5		3.5	V
COMP High Clamp Voltage		V_{COMP_OVP}			3.6		V
Maximum Sourcing Current for PIN Gate		I_{SOURCE_MAX}			200		mA
Maximum Sinking Current for PIN Gate		I_{SINK_MAX}			600		mA
SIC9866	MOSFET	$R_{DS(ON)}$	$V_{GS}=15V/ I_{DS}=0.5A$		2.80	3.20	Ω
SIC9867	$R_{DS(ON)}$				1.90	2.80	
Breakdown Voltage		BV_{DSS}	$V_{GS}=0/ I_{DS}=250\mu A$	700			V
Drain Leakage Current		I_{DSS}	$V_{GS}=0/ V_{DS}=700V$			1	uA
Over-temperature Protection		T_{REG}			150		°C



Functional Block Diagram



Applications Information

Functional Description:

The SIC9866/SIC9867 are high precision primary-side regulation isolated flyback controller with single-stage Active PFC, specially designed for offline constant current LED lighting, can achieve high power factor, low THD and high efficiency.

Start-up:

After system powered up, the V_{DD} pin capacitor is charged up by the start up resistor. When the V_{DD} pin voltage reaches the turn on threshold, the internal circuits start working. The COMP pin voltage is pulled up to 1.5V quickly, then the SIC9866/SIC9867 starts the MOSFET driver. The system works at 10kHz frequency at the beginning, the COMP voltage rises up gradually, and the transformer primary peak current also rises up. The LED current hence achieves a soft start without overshoot. After the output voltage is built up, the V_{DD} power is supplied by the auxiliary winding.

Constant Current Control:

The SIC9866/SIC9867 uses compensation method to achieve excellent line regulation, and it still can be tuned externally for flexibility. Output current is given by:



$$I_{OUT} \approx \frac{V_{REF}}{2 \times R_{ISEN}} \times \frac{N_P}{N_S}$$

Where,

N_P is turns of transformer primary winding;

N_S is turns of transformer secondary winding;

V_{REF} is the internal reference voltage, typical is 200mV;

R_{ISEN} is current detection resistor.

Feedback Network:

The SIC9866/SIC9867 detect the output zero current through feedback network, the FB sense down threshold is set at 0.1V, Hysteresis voltage is 0.08V. The FB sense is also used to detect output OVP, threshold is 1.6V.

The ratio of FB upper resistor to lower resistor can be set :

$$\frac{R_{FBL}}{R_{FBL} + R_{FBH}} = \frac{1.6V}{V_{OVP_FB}} \times \frac{N_S}{N_A}$$

Where,

R_{FBL} : the lower resistor of the feedback network;

R_{FBH} : the upper resistor of the feedback network;

V_{OVP} : output over voltage setting point;

N_S is turns of transformer secondary winding

The FB upper resistor can be set to around 300K Ω to improve the system efficiency. It is also used for fine tuning the LED current line compensation.

LED Over Temperature Protection

The output current will be decrease when SIC9866/SIC9867's temperature are over setting. The output power and thermal dissipation are also reduced. The system temperature is regulated and the system reliability is improved. The thermal regulation temperature is set to 150 $^{\circ}\text{C}$ internally.

LED Open Protection

The output voltage can be detected by the FB pin. When the FB voltage is higher than 1.6V, the LED open protection is triggered and the power MOSFET gate driver stops switching. After several seconds, the gate driver starts switching again.

LED Short Protection

The SIC9866/SIC9867 judges LED short from the FB voltage. During a shorted LED condition, SIC9866/SIC9867 reduces the internal command current to a very low level and slows down the switching frequency to 10 kHz to decrease the output current. Meanwhile, the output voltage is low and the V_{DD} pin cannot be charged up by the output voltage, so the V_{DD} pin voltage will gradually decrease and finally reaches the U_{VLO} threshold. After the system enters into fault condition, the V_{DD} voltage will decrease until it reaches U_{VLO} threshold. Then the system will re-start again. If the fault condition is removed, the system will resume normal operation.



PCB Layout Guidelines:

Bypass Capacitor: The bypass capacitor on V_{DD} pin should be as close as possible to the V_{DD} and GND pins.

Ground Path: The power ground path for current sense resistor should be short and wide, and it should be as close as possible to the IC ground (pin7&8 for SOP-8 package and pin7 for DIP-7 package), otherwise the LED output current accuracy maybe affected. The IC signal ground for COMP and FB components should be connected to the IC GND pin with short traces and should be away from the power ground path.

The Area of Power Loop: The area of main current loop should be as small as possible to reduce EMI radiation.

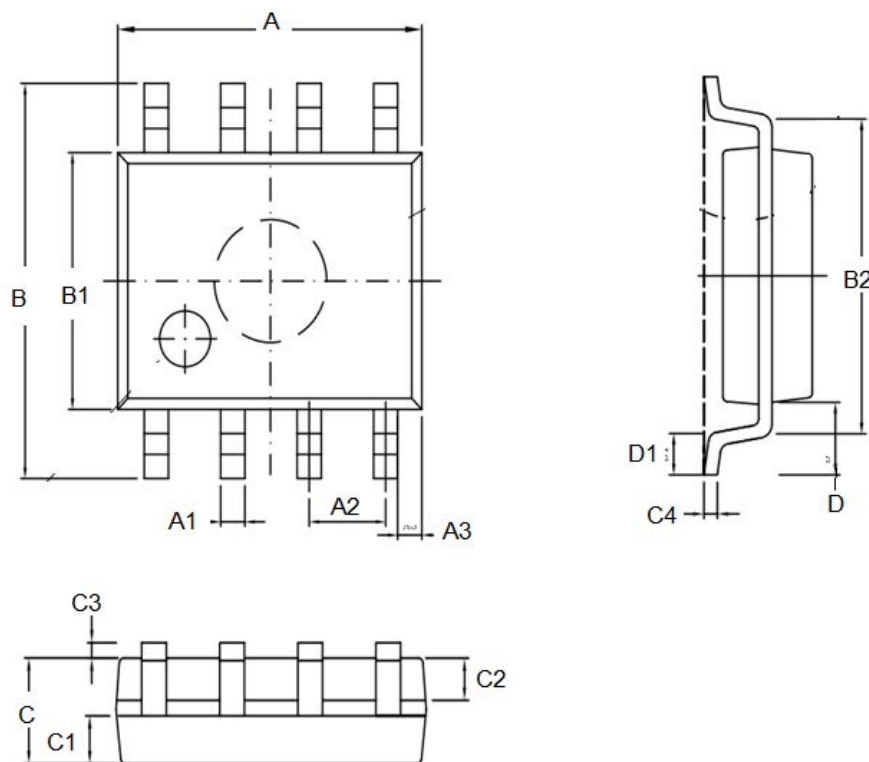
FB Pin: The feedback resistor divider should be as close as possible to the FB pin, and the trace must keeps away from dynamic node of the inductor, otherwise the FB pin OVP function might have risk to be mis-triggered by the system noise.

SOP-8 封装机械尺寸

SOP-8 MECHANICAL DATA

单位:毫米/UNIT: mm

符号 SYMBOL	最小值 min	典型值 nom	最大值 max	符号 SYMBOL	最小值 min	典型值 nom	最大值 max
A	4.80		5.00	C	1.30		1.50
A1	0.37		0.47	C1	0.55		0.75
A2		1.27 TYP		C2	0.55		0.65
A3		0.41 TYP		C3	0.05		0.20
B	5.80		6.20	C4	0.19	0.20TYP	0.23
B1	3.80		4.00	D		1.05TYP	
B2		5.0TYP		D1	0.40		0.62



DIP-7 封装机械尺寸

DIP-7 MECHANICAL DATA

单位:毫米/UNIT: mm

符号 SYMBOL	最小值 min	典型值 nom	最大值 max	符号 SYMBOL	最小值 min	典型值 nom	最大值 max
A	9.00		9.20	C2		0.50TYP	
A1	1.474		1.574	C3	3.20		3.40
A2	0.41		0.51	C4	1.47		1.57
A3	2.44		2.64	D	8.20		8.80
A4		0.51TYP		D1	0.244		0.264
A5		0.99TYP		D2	7.62		7.87
B	6.10		6.30	θ1		17°TYP4	
C	3.20		3.40	θ2		10°TYP4	
C1	7.10		7.30	θ3		8°TYP	

