

High Precision Non-Isolated Buck LED Driver SIC9552A/9553A/9554A/9555A/9556A

General Description

The SIC9552A/9553A/9554A/9555A/9556A are high precision buck LED drivers. The chips are suitable for 85~265Vac universal input LED lighting applications.

The SIC9552A/9553A/9554A/9555A/9556A integrate high-precision sampling and compensation circuit, the constant current of circuit can achieve accuracy under $\pm 3\%$. It can also achieve the adaptive demand between both output inductor current and output voltage, so as to achieve good linear regulation and load regulation.

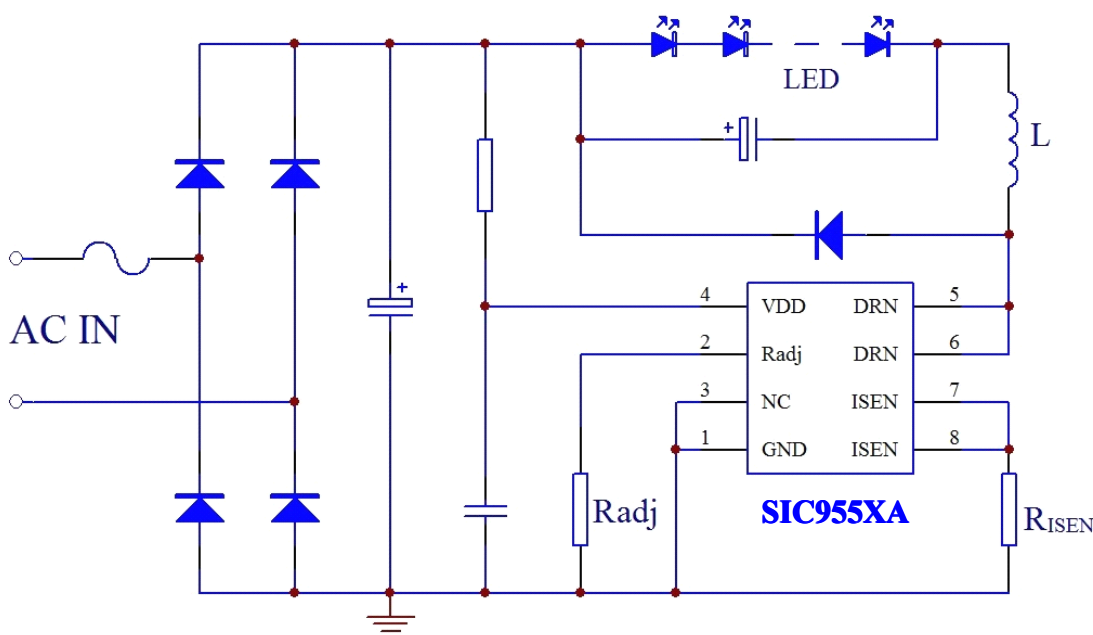
The SIC9552A/9553A/9554A/9555A/9556A integrate 500V power MOSFET. The simple peripheral structure of the system can be benefit from its precise and stable adaptive technology. It is able to work without secondary feedback circuitry or compensation circuitry. The SIC9552A/9553A/9554A/9555A/9556A can achieve precision constant current control under a small number of peripheral devices and loosen parameter conditions. Such features can greatly save both cost and size of the system. At the same time, it can ensure the consistency of parameters when making mass production of LED lighting devices.

The SIC9552A/9553A/9554A/9555A/9556A have extensive protection features, including LED open protection, LED short protection, current sampling resistor short protection, V_{DD} under-voltage protection, over-temperature protection.

Features

- Internal 500V Power MOSFET
- Ultra Low Operating Current
- No Auxiliary Winding
- $\pm 3\%$ LED Output Current Accuracy
- Inductor Current Critical Continuous Mode
- Excellent Line and Load Regulation
- Cycle-by-Cycle Current Limit
- LED Open Protection
- LED Short Protection
- Current Sampling Resistor Short Protection
- V_{DD} Under-Voltage Protection
- Over Temperature Protection

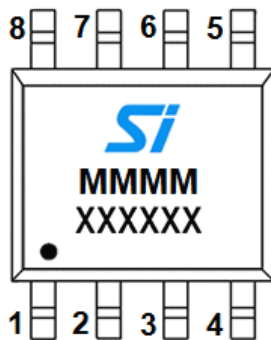
Typical Application



Ordering Information

Part Number	Package	Package Method	Marking
SIC9552A (SOP-8)	SOP-8	Tape 3,000pcs/Roll	Si 9552A XXXXXX
SIC9553A (SOP-8)	SOP-8	Tape 3,000pcs/Roll	Si 9553A XXXXXX
SIC9553A (DIP-7)	DIP-7	Tube 50pcs/Tube	Si SIC9553A XXXXXX
SIC9554A (SOP-8)	SOP-8	Tape 3,000pcs/Roll	Si 9554A XXXXXX
SIC9554A (DIP-7)	DIP-7	Tube 50pcs/Tube	Si SIC9554A XXXXXX
SIC9555A (DIP-7)	DIP-7	Tube 50pcs/Tube	Si SIC9555A XXXXXX
SIC9556A (DIP-7)	DIP-7	Tube 50pcs/Tube	Si SIC9556A XXXXXX

Pin Assignment

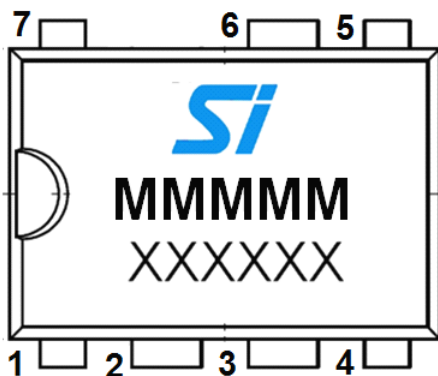


SOP-8 Products

“Si”-Logo of SI Semiconductors

MMMM--Part Number

XXXXXX--Date Code



DIP-7 Products

“Si”-Logo of SI Semiconductors

MMMMM--Part Number

XXXXXX--Date Code

Pin Description for SOP-8

Pin	Pin Name	Description
1	GND	Ground.
2	RADJ	Over voltage protection Pin. The pin is used for output current control.
3	NC	No Connection. Suggest connected to GND.
4	VDD	Power Supply Pin. This pin supplies current to the internal start-up circuit. This pin must be bypassed with a capacitor nearby.
5	DRN	DRAIN of the MOSFET.
6		
7	ISEN	Output Current Sense Pin. The pin is used for output current control.
8		

Pin Description for DIP-7

Pin	Pin Name	Description
1	GND	Ground.
2	RADJ	Over voltage protection Pin. The pin is used for output current control.
3	NC	No Connection. Suggest connected to GND.
4	VDD	Power Supply Pin. This pin supplies current to the internal start-up circuit. This pin must be bypassed with a capacitor nearby.
5	DRN	DRAIN of the MOSFET.
6	DRN	
7	ISEN	Output Current Sense Pin. The pin is used for output current control.

Recommended Operation Conditions

Products	Symbol	Range	Unit	Products
SIC9552A	I _{LED1}	V _{in} 220V±20%	155@V _{OUT} =80V	mA
	I _{LED2}	V _{in} 220V±20%	255@V _{OUT} =36V	
SIC9553A	I _{LED1}	V _{in} 220V±20%	225@V _{OUT} =80V	mA
	I _{LED2}	V _{in} 220V±20%	330@V _{OUT} =36V	
SIC9554A	I _{LED1}	V _{in} 220V±20%	360@V _{OUT} =80V	mA
	I _{LED2}	V _{in} 220V±20%	400@V _{OUT} =36V	
SIC9555A	I _{LED1}	V _{in} 220V±20%	400@V _{OUT} =80V	mA
	I _{LED2}	V _{in} 220V±20%	490@V _{OUT} =36V	
SIC9556A	I _{LED1}	V _{in} 220V±20%	500@V _{OUT} =80V	mA
	I _{LED2}	V _{in} 220V±20%	550@V _{OUT} =36V	
V _{LED} min.	V _{MIN}	>15		V

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Absolute Maximum Ratings

Parameter	Symbol	Parameter Range	Unit
Voltage On Pin V _{DD}	V _{DD}	-0.3-20	V
Voltage On Pin V _{DRN}	V _{DRN}	-0.3-500	V
Voltage On Pin V _{ISEN}	V _{ISEN}	-0.3-6	V
Maximum Operation Current	I _{DDMAX}	5	mA
Voltage On Pin V _{RADJ}	V _{RADJ}	-0.3-6	V
Maximum Power Dissipation (T _a =25°C)	P _{tot}	0.45@SOP-8	W
		0.90@DIP-7	
Thermal Resistance Junction-ambient	R _{thj-a}	145@SOP-8	°C/W
		80@DIP-7	
Operating Junction Temperature	T _J	-40-150	°C
Storage Temperature Range	T _{STG}	-55-150	°C
ESD		2,000	V

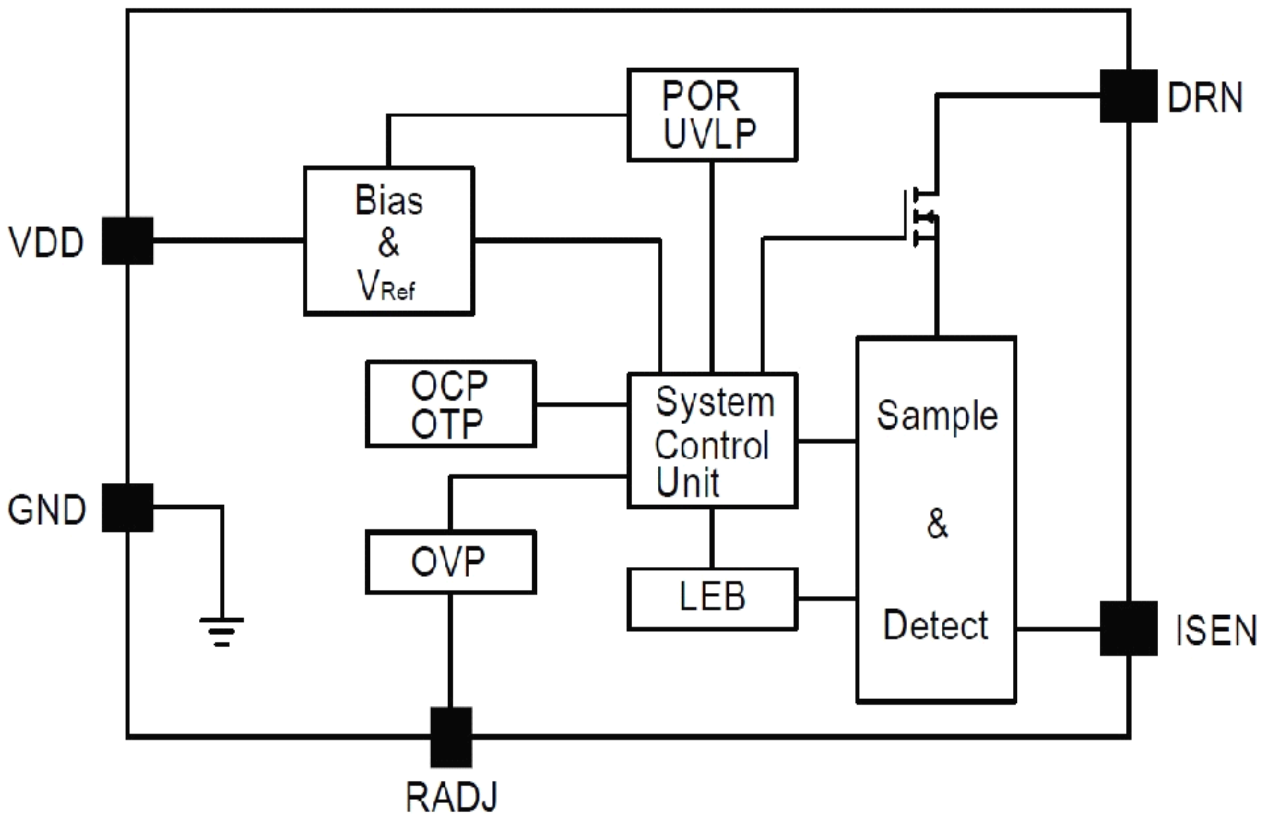
Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Electronic Characteristics

V_{DD} = 15V & T_C = 25°C, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
V _{DD} Clamp Voltage	V _{DD_CLP}	0.8mA	15.8		17.2	V
Operating Current	I _{DD}	F _{sys} =65KHz			135	μA
V _{DD} Start-up Threshold	V _{ST}	V _{DD} Rising	12.8		14.2	V
Start-up Current	I _{ST}	V _{DD} =V _{ST} - 1V			195	μA
V _{DD} Turn Off Threshold	V _{UVLO}	V _{DD} Falling	8.1		9.1	V
Internal Reference Voltage	V _{ISEN}		392	400	408	mV
Threshold for peak current limit while Output short	V _{ISEN_SHT}	Output Short		198		mV
Leading Edge Blanking Time for Current Sense	T _{LEB}			500		ns
Switch Off Delay time	T _{DELAY}			150		ns
Breakdown Voltage	BV _{DSS}	V _{GS} =0V/ I _{DS} =250uA	500	530		V
SIC9552A	MOSFET R _{DS(ON)}	R _{DS(ON)} V _{GS} =15V/ I _{DS} =0.5A		14.0	16.0	Ω
SIC9553A				9.0	10.0	
SIC9554A				5.5	6.0	
SIC9555A				2.8	3.5	
SIC9556A				1.7	2.2	
Drain Leakage Current	I _{DSS}	V _{GS} =0V/ V _{DS} =500V			0.5	μA
Voltage for Pin RADJ	V _{RADJ}			0.55		V
Maximum On time	T _{ON_MAX}			45		μs
Maximum Degaussing time	T _{OFF_MAX}			255		μs
Minimum Degaussing time	T _{OFF_MIN}			5		μs
Over-temperature Protection	T _{REG}			155		°C

Functional Block Diagram



APPLICATION INFORMATION

Function Description:

The SIC9552A/9553A/9554A/9555A/9556A are constant current driver chips dedicated for LED Lighting applications. The chips integrate 500V power MOSFET which work under CRM mode. The chips are able to fit in all working voltage range with excellent linear adjustment rate, load regulation and constant-current characteristics. With very few external components, the converter achieves excellent constant current control. It does not need auxiliary winding for powering the IC or voltage sensing, hence the system size and cost is greatly reduced.

Start Up

The starting current of the chips is very low, after the system is powered on, V_{DD} starting resistance start charge the capacitance. When the V_{DD} reach the open threshold range, the circuit begins to work. When the chips are under normal operation condition, the internal circuit of the electric current can be as low as $135\mu A$, and internal system can offer an unique power mechanism. Thus, power supply can run normally without auxiliary winding supply.

Sampling resistance and constant current control

The chips work under the CRM mode, and it has a reference voltage of 400mv inside. The reference voltage and inductance in the system compares the original edge peak current calculation. Through the adjustment of the

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sampling resistance, it is able to achieve the current control of LED driver:

$$I_{LED} = \frac{400}{2R_{ISEN}} \text{mA}$$

Note: I_{LED} is the LED drive current
 R_{ISEN} is the Sample resistance

Inductor Selection

The chips work under CRM mode, when the circuit electrical pulse output is on control. Internal MOSFET will continue to work in conduction/closed. When the internal MOSFET starts, inductance will begin to conduct, energy also starts storage. Until reaching the peak current, internal MOSFET stopped and the inductance of the conduction time goes to:

$$I_P = \frac{400}{R_{ISEN}} \text{mA}; \quad T_{ON} = \frac{L \times I_P}{V_{IN} - V_{LED}}$$

Note: I_P is the inductor current peak
 L is the inductance
 V_{IN} is the DC value of the rectified AC input
 V_{LED} is the LED load of positive pressure drop

When the internal MOSFET turned off, inductor current will gradually decrease from the peak value, after it reduced to zero, the internal MOSFET will start to work again. The inductance of the closing time goes to:

$$T_{OFF} = \frac{L \times I_P}{V_{LED}}$$

In summary, the inductance can be calculated as below:

$$L = \frac{V_{LED} \times (V_{IN} - V_{LED})}{V_{IN} \times I_P \times F}$$

The working frequency of the system is F. When designing the system, the first value should be determined is I_{LED} , and then goes to R_{ISEN} , I_P , and other values are identified accordingly. From this formula, the system frequency is proportional to the input voltage, and is inversely proportional to the inductance L: when the input voltage value is the minimum or inductance value is high, the system frequency is low; when the input voltage is the highest or inductance value is low, the system frequency is higher. Thus, if the input voltage range of the system is determined, inductance values can have directly effect to the system frequency range and also the characteristics of constant current. Having considered that the system frequency can not be too low (e.g., over with the audio range), or too high (resulting in too much loss of the power MOSFET and against EMI effect), the chips also set a minimum and maximum off time. Therefore, when designing the system, the recommended frequency is recommended to set among the range of 50 KHZ to 100 KHZ.

Over Voltage Protection

In the system, when the LED circuits are open, since there is no load connection, the output voltage will gradually rise, leads to the decrease of demagnetization time. Therefore the corresponding demagnetization time can be controlled by R_{ADJ} external resistor, and then the open circuit voltage protection become easy to realize.

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According to the internal circuit, the relation between R_{ADJ} and V_{OVP} can be draw as below:

$$R_{ADJ} \approx \frac{V_{ISEN} \times L \times 15}{R_{ISEN} \times V_{OVP}} \times 10^6 (\text{Kohm})$$

Note: V_{ISEN} is ISEN turn off threshold

L is inductance value

R_{ISEN} is Sample resistance

V_{OVP} is over voltage protection value

Protection Function

The chips have a variety of protective functions such as the LED to open/short circuit protection, I_{SEN} resistance short-circuit protection, V_{DD} over-voltage/under-voltage, Over heat temperature adjustment and etc.

When the chips working, it is able to monitoring the various working status automatically. When the load turns to open, the circuit will enter a state of over-voltage protection, immediately shut off the internal MOSFET and the system runs into interval detection at the same time. After the recovery of the failure, circuit will automatically return to normal working state; if Load circuit runs into short situation, the system will work at around 5 KHZ state of low frequency, low power consumption, constantly monitoring the system at the same time. After the load circuit is back to normal condition, the circuit will also resume back to normal working status; In the situation of I_{SEN} resistance short-circuit, or other failure such as inductor saturation, fast protection mechanism circuit will immediately stop the MOSFET switching action. Working circuit power supply will also be declined, at this point, when U_{VLO} circuit is triggered, the system will also restart. In summary, such design can realize the protection function of trigger and restart working mechanism.

The chips integrate Over temperature regulation function. When the system is over temperature, the output current is gradually reduced; 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 155°C internally.

PCB Layout

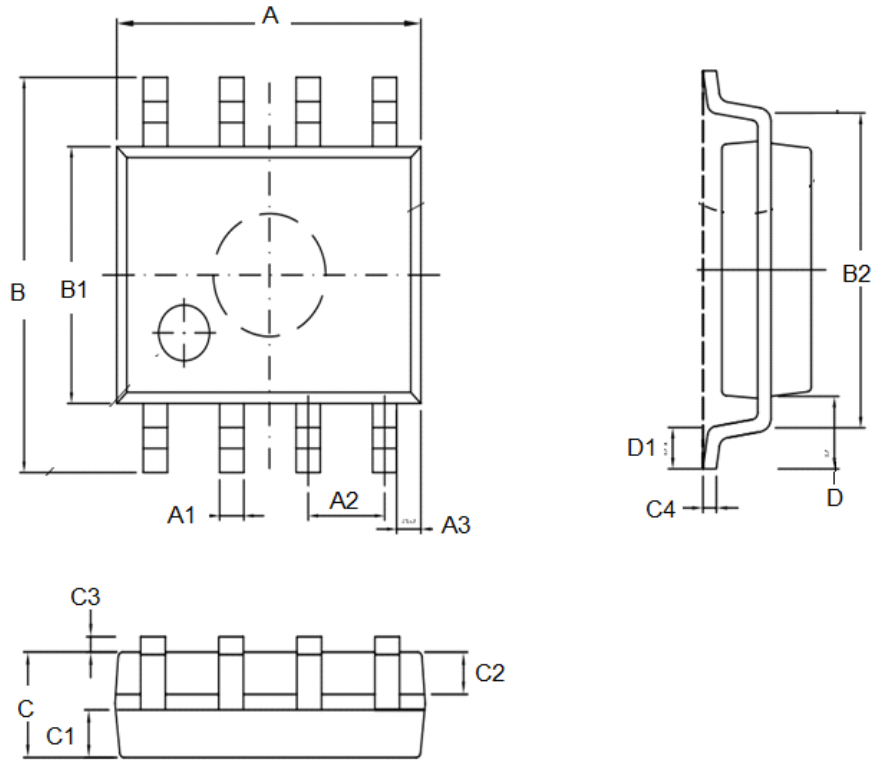
Please followed the following rules in the SIC9552A/9553A/9554A/9555A/9556A PCB layout:

1. It's very critical for V_{DD} bypass capacitor, should be as close as possible to V_{DD} and GND pin.
2. The area of main current loop should be as small as possible to reduce EMI radiation, such as the inductor, the output diode and the bus capacitor loop.
3. The power ground path should be separated from small signal ground path and shorten the distance with the capacitance.
4. R_{ADJ} external resistance should be as close as possible to R_{ADJ} pin, and connected to the ground.
5. The NC pin (Pin3) should be connected to GND (Pin1), and the R_{ADJ} external resistance should be surrounded by the GND if possible.
6. DRN pin (PIN5, PIN6) apply copper area should be as large as possible for better thermal dissipation. However too large copper area may compromise EMI performance.

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





DIP7 封装机械尺寸 DIP7 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	9.10		9.50	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	8.00		8.80
A4		0.51TYP		D1	0.244		0.264
A5		0.99TYP		D2	7.45		7.87
B	6.10		6.40	∅1		17°TYP4	
C	3.20		3.40	∅2		10°TYP4	
C1	6.80		7.40	∅3		8°TYP	

