LS9100

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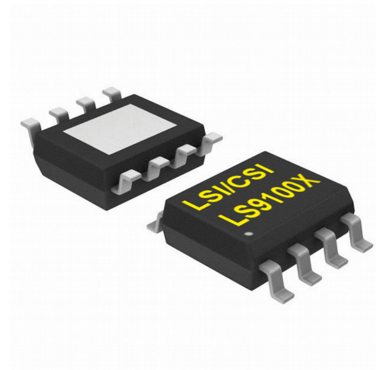
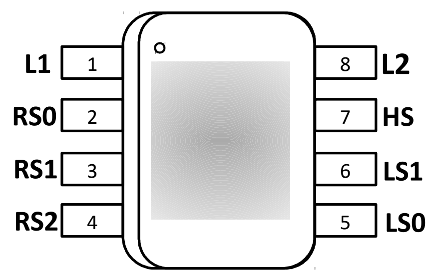
Dimmable High Voltage LED Direct AC Driver

Archimedes Series



Features

- Integrated Bridge Rectifier and MOSFET Driver
- Wide AC input range up to 310 Vac 50/60Hz
- 50mA DC output current
- Ultra simple circuit solution. Requires Only One R passive component
- Thermal Turndown Protections
- Voltage Shutdown Protections
- Thermal Enhanced SOP-8 and Heat Sink PAD package
- TRIAC Dimmable (Leading/Trailing Edge)
- Programmable LED Current with an external sense resistor



Applications

- LED Driver
- Current Source limiter
- General Illumination
- Commercial and Industrial Lighting

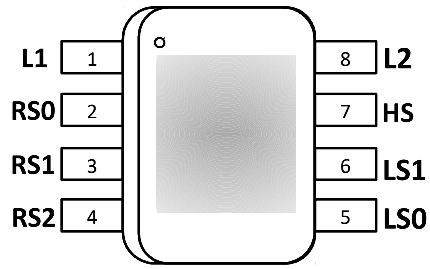
Description

The **LS9100** is a High Voltage full-bridge rectifier combined with a current limiter source circuit and protection circuit. Its rugged design is optimized for driving LED banks directly from the main utility line eliminating external components by merging them into a monolithic package, drastically reducing the board space and cost. The thermal turndown located in the center of the IC protects itself from operating in atypical conditions. The voltage shutdown protection circuit safeguards the IC and the system's LEDs from voltage surges that can overstress the system.

Ordering Information

Part Number	**Description**
LS9100X-S	
LS9100X-STR	SOP-8: Tape and Reel (1000/Reel)

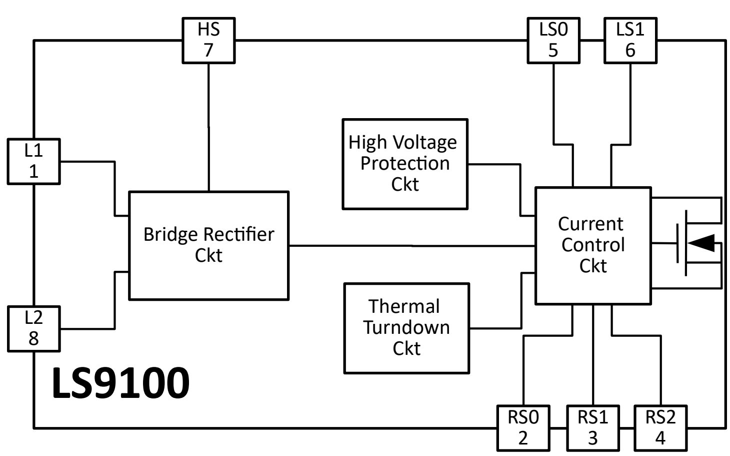
PIN Configuration



Top View

PIN #	Name	Description
1	L1	Input 1 AC
2	RS0	Current sense resistor input 0
3	RS1	Current sense resistor input 1
4	RS2	Current sense resistor input 2
5	LS0	Low Side input 0
6	LS1	Low Side input 1
7	HS	High side output
8	L2	Input 2 AC
PAD	xPAD	Current sense resistor input 0

Block Diagram



Maximum Rating And Electrical Characteristics

Rating at 25°C ambient temperature unless otherwise specified (Note).

Parameter	Symbol	Min	Typ	Max	Unit
Repetitive peak reverse voltage (Input L1-L2)	Vrrm			500	V
DC Blocking voltage (Input L1-L2)	Vdc			500	V
RMS Voltage (Input L1-L2)	Vrms			310	V
Instantaneous forward voltage (L1-2/HV)	Vf		0.75		V
Average forward current (L1-2/HV)	Iav			50	mA
Peak Forward surge current (Note 2)	Ifsm			80	mA
DC reverse current @TA=25°C @TA=100°C	Ir			.5 1.00	uA
Low Side peak voltage (Input LS0-1)	Vls		100	350	V
Low Side Voltage Shutdown Protection (Input LS0-1)	Vshdw	115	130	145	V
Total Low Side Current (Input LS0-1)			50	140	mA
Package Power Dissipation (Note 3)	PDpkd			2500	mW
Typical Thermal resistance (Note 3)	Rθja			45	°C/W
Typical Junction capacitance (PIN 1,8)	Cj		45		pF
Operating Junction Temperature	Tj	-40		+125	°C
Current Thermal turndown	Itdw		-0.32		%A/°C
Storage temperature	Tstrg	-55		+125	°C
Junction Temperature	Tjmax			+150	°C
Lead Temperature (10 second soldering)	Tsld			+300	°C

Notes:

1. Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability.
2. 1msec half sine wave superimposed on rated load
3. Power dissipated from junction to lead PCB mounted on suggested PAD Layout. Derate 20mW/°C when the ambient temperature is above 25 °C. Special care of the thermal dissipation in the PCB design must be taken.
4. ESD protection. HBM : 1kV at all Pins.

Electrostatic Discharge Sensitivity

This integrated circuit can be damaged by ESD. LSI/CSI recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Typical Application

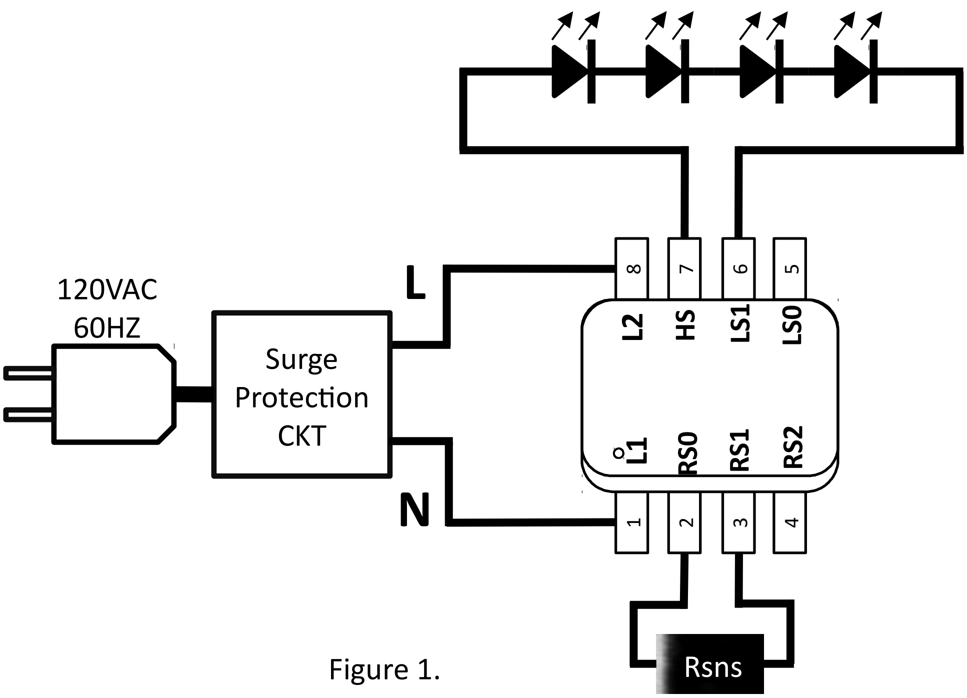


Figure 1.

DANGER!: THE READER IS WARNED THAT CAUTION MUST BE USED IN THE CONSTRUCTION, TESTING AND USE OF THIS CIRCUIT. LETHAL HIGH VOLTAGE POTENTIALS ARE PRESENT IN THIS CIRCUIT. EXTREME CAUTION MUST BE USED IN WORKING WITH, AND MAKING CONNECTIONS TO, THIS CIRCUIT. USE CAUTION.

Typical Characteristics

At Tamb = + 25, unless otherwise noted.

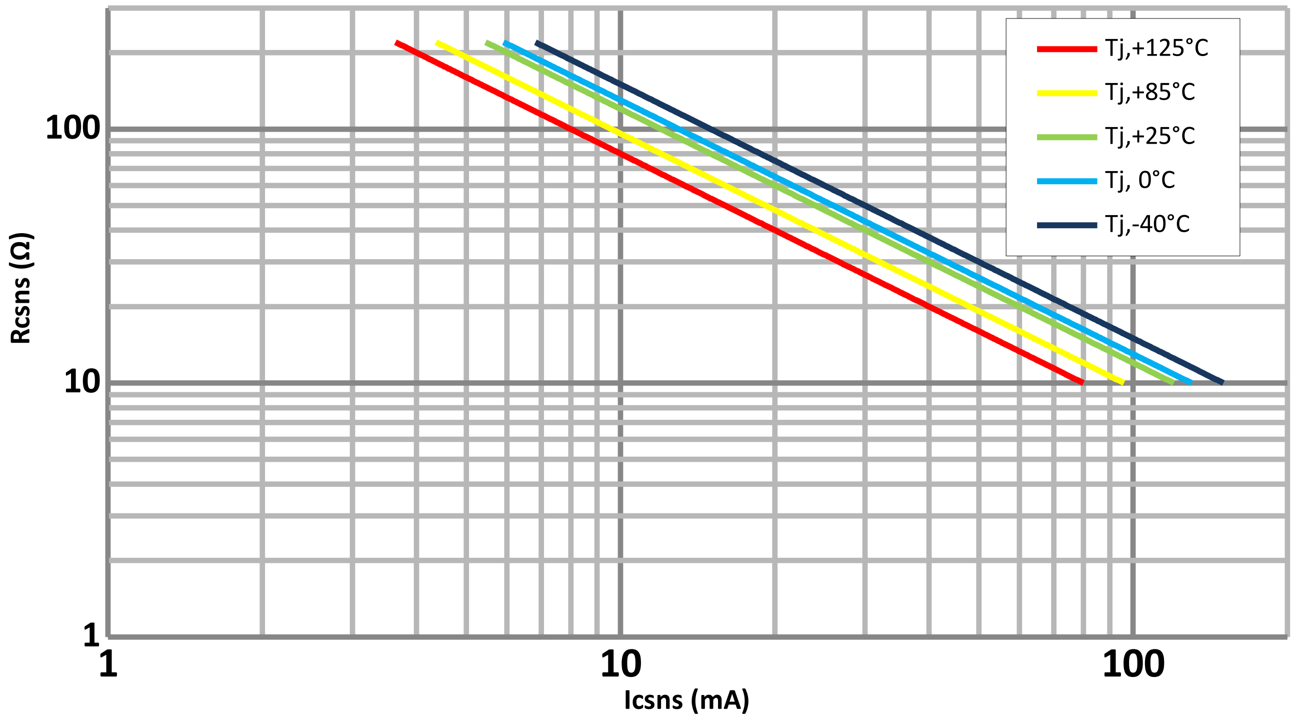


Figure 2. Output Current (Icsns) vs. External Resistor (Rcsns)

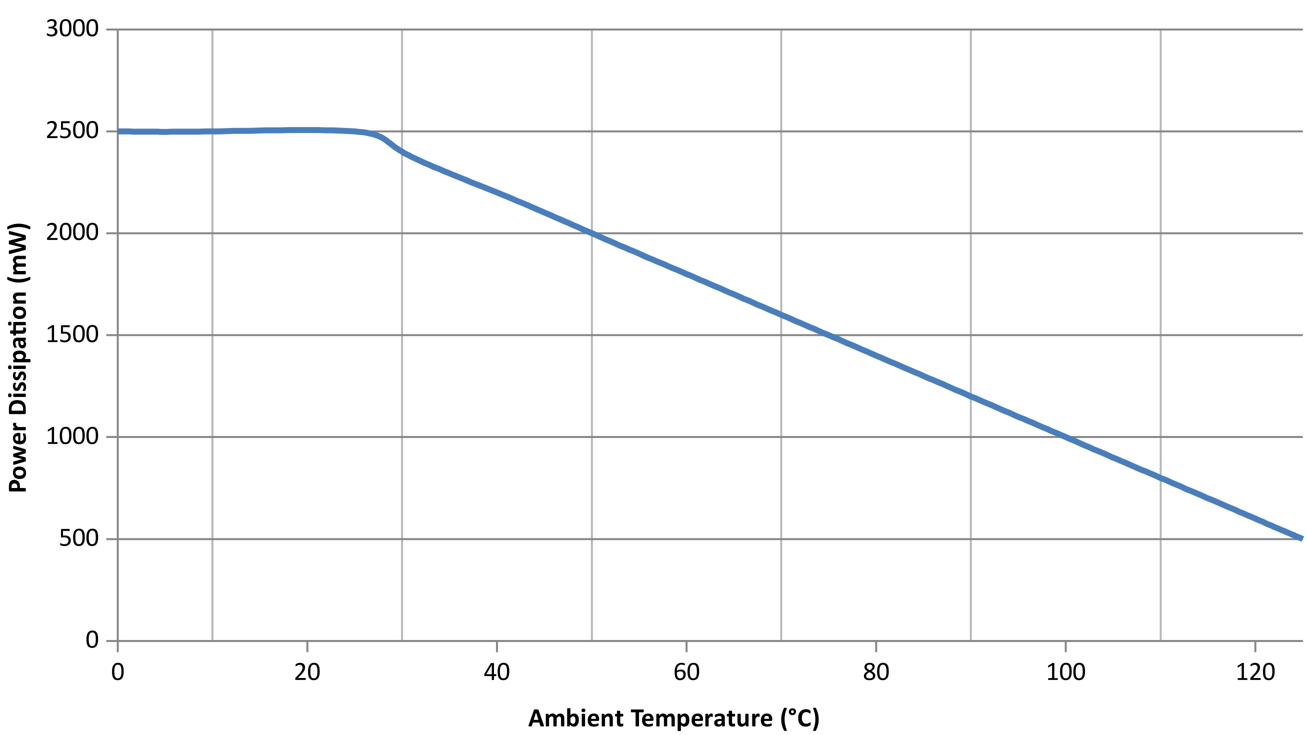
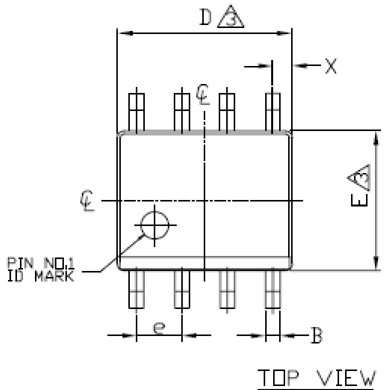
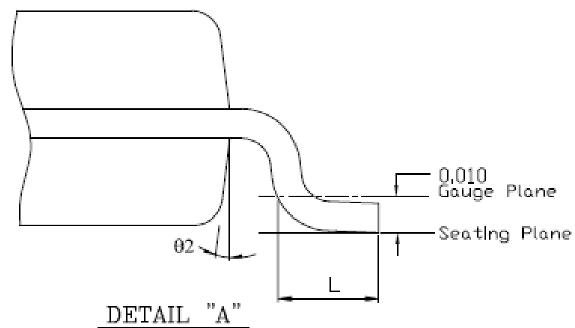
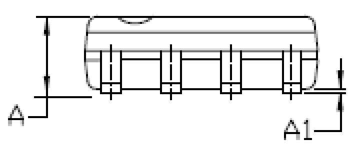


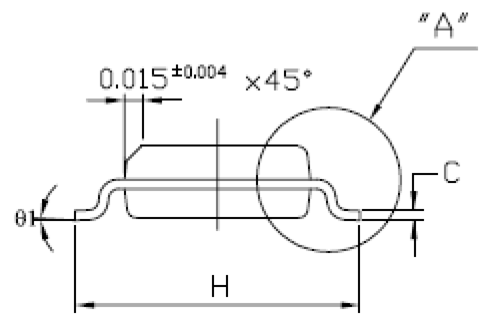
Figure 3. Total Power Dissipation (mW) vs. Ambient Temperature (Ta)

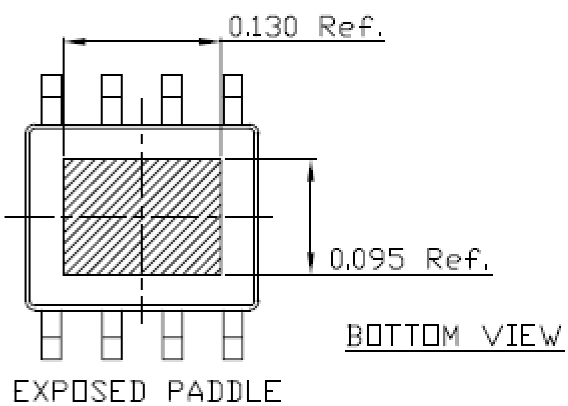
Package Information 8-Lead SOP Exposed Pad Plastic Package











SYMBOL	8 SOIC	
	MIN	MAX
A	0.054	0.068
A1	0.001	0.004
B	0.014	0.019
D	0.189	0.196
E	0.150	0.157
H	0.229	0.244
e	0.050 BSC	
C	0.0075	0.0098
L	0.020	0.040
X	0.0215 REF	
θ1	0°	8°
θ2	7° BSC	

Notes:

A. All linear dimension are in inches.

B. The thermal pad is design to be solder on the PCB.

C. This drawing is subject to change without notice.

Package Mounting

The figure below provides the minimum recommended PCB layout for the LS9100 device. For lowest overall thermal resistance, it is best to solder the heat sink Pad directly to the circuit board. Adding more area to the heat sink improves heat dissipation.

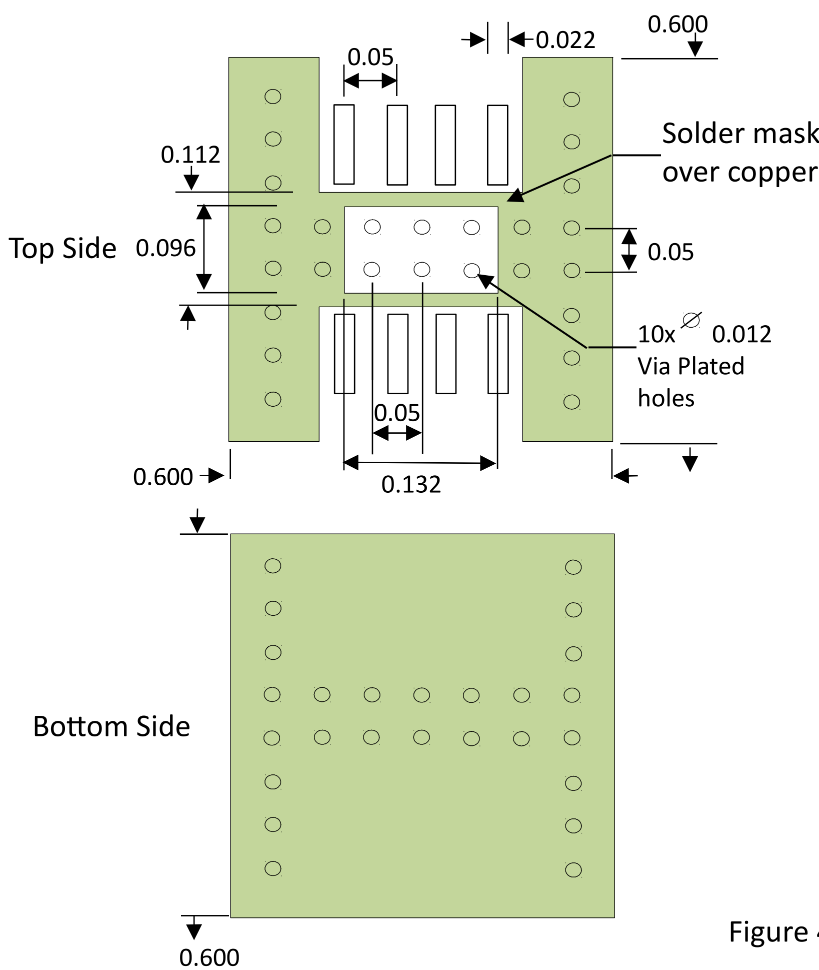


Figure 4.

Notes:

A. All linear dimension are in inches (not to scale).
B. This drawing is subject to change without notice.
C. This package mounting is a guideline example and does not cover all applications.
D. Conformal Coating material must be applied to act as protection against moisture and harsh environments.

Application Information

AC Lines' Voltage Surge and
Voltage Low Side Shutdown Protection Circuit

Because of the possible direct connection to the utility line, it is recommended to add an external surge protection circuitry (MOV) to the final application to limit any potential over voltage conditions (see Maximum Rating and Electrical Characteristics section) . The low side voltage shutdown protection circuitry is employed to turn off the driver's current (I_{led}) when the voltage exceeds the predefined value (Vshdw). This feature limits the power dissipated on the system preventing damage during system voltage surges below maximum ratings.

Adjustable Peak Output Current

The LS9100's output current is externally adjustable providing an accurate means of controlling the peak current flowing to the load (LEDs). The output current can be set over a range of at least 50mA to 0.1mA using the external shunt current sense resistor (Rsns). The regulation target current is calculated at Tj=25°C as follows:

$$I_{led} = \frac{1.2V}{Rsns}$$

Examples.

1) R_{sns} = 24 ohms

$$I_{led} = \frac{1.2V}{24} = 50.0\text{ mA}$$

2) R_{sns} = 50 ohms

$$I_{led} = \frac{1.2V}{50} = 24.0\text{ mA}$$

Operating Region and Power Dissipation

The LS9100 power dissipation depends on the AC line voltage and load configuration. The driver current starts to flow when the HS voltage reaches the forward voltage across the total LED series circuit. The power dissipation (Ppkd) is primarily equal to the product of the LS pin's **time average** voltage and current values. The above product should not exceed the rated power (see Maximum Rating and Electrical Characteristic section).

Power dissipation capability is limited by the maximum junction temperature . However, it is designed to release heat efficiently when mounted on the PCB. Therefore, the heat dissipation value will vary depending on copper pattern, the material, the rate of surrounding airflow , etc. of the PCB on which the package is mounted (see package mounting section).

The maximum power dissipation can be calculated by the following formula:

$$Pd(max) = \frac{(Tj(max) - Ta)}{\Theta JA}$$

Where the Tj(Max) is maximum operation junction temperature 125°C, TA is the ambient temperature and the ϴJA is the junction to ambient thermal resistance. The junction to ambient thermal resistance of the LS9100 thermal enhanced SOP-8 and Heat Sink PAD package is 45 °C/W, on standard JEDEC 51-7 thermal test board. The maximum power dissipation at Ta = 25°C is equal:

$$Pd(max) = \frac{(125\,°C - 25\,°C)}{45\,°C/W} = 2.22\text{W}$$

Thermal Turdown Protection

The power dissipated in the LS9100 causes its internal junction temperature to increase reaching an equilibrium point that strictly depends on the overall system's physical characteristics and ambient temperature. The internal circuitry is adjusting the current by tuning it down -0.32 A/°C. Use the Output Current (Isns) vs. External Resistor (Rsns) plot (figure 2 page 5) to graphically retrieve the current variation over junction temperatures Tj (-40 °C to +125°C).

Application Information (2)

Design Guide Lines for Vin = 120 Vac at 60Hz

1. Target LED's current:

I_{led} = 25 mA

2. AC Input voltage:

V_{in} = 120 Vac at 60Hz

3. LEDs' characteristics (from supplier's datasheet)

V_{led} = 2.8 V; I_{ledMax} = 40mA

4. Calculate Current Sense Resistor (R_{sns}). The current conduction take place only when the input voltage magnitude is greater than the overall series forward LED's voltages. Consequently, the final R_{sns} calculation is only dependent on the current conduction time and its peak value.

4.1 Calculate Conduction Time:

Number of LEDs in series = 32

$$Conduction\ Angle\ \theta = 180 - 2 \times \arcsin\left(\frac{V_{led} \times Leds}{V_{in} \times \sqrt{2}}\right)$$

$$\theta = 180 - 2 \times \arcsin\left(\frac{2.8\,V \times 32}{120 \times \sqrt{2}}\right) = 116.263^{\circ}$$

$$Conduction\ Time = \left(\frac{\theta}{180}\right) * \frac{1}{(2 \times V_{in}\ Frequency)}$$

$$Cond.\ Time = \left(\frac{116.263}{180}\right) * \frac{1}{(2 \times 60\ Hz)} = 5.382\ msec$$

4.2 Calculate the LEDs' peak current I_{peak} required for I_{avg} = 25mA. In order to simplify the calculations it is assumed that the final LEDs' current is equal to a square wave:

$$I_{avg} = I_{peak} \times Duty\ Cycle$$

$$Duty\ Cycle\,(DC) = Cond.\ Time \times 2 \times 60\ Hz \times 100\,\%$$

$$\%DC = 5.382\ msec \times 2 \times 60\ Hz \times 100\,\% = 64.58\,\%$$

,then follow the equations below and verify that the value is within specifications:

$$I_{avg} = I_{peak} \times Duty\ Cycle$$

$$I_{peak} = \frac{25\ mA}{0.6458} = 38.7\ mA$$

4.3 Calculate the Rsns at Tj=25°C:

$$R_{sns} = \frac{1.2\ V}{I_{peak}}$$

$$R_{sns} = \frac{1.2\ V}{38.87\ mA} = 31 \approx 30\ ohms$$

5. Calculate Total Power dissipation on the LS9100 driver:

$$P_{tot} = (V_{mosfet} + 1.6\ V) \times I_{avg} + P_{ctrlMax}$$

$$P_{ctrlMax} = max\ device's\ control\ ckt\ power\ diss. = 0.080\ W$$

$$V_{mosfet} = V_{in} - V_{leds} - 2.8\ V$$

$$V_{mosfet} = 120\ V - (2.8\ V \times 32) - 2.8\ V = 27.6$$

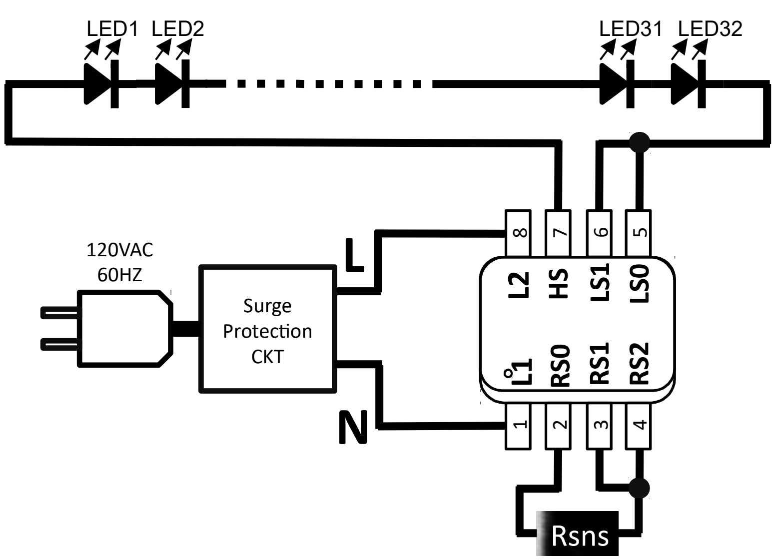
$$P_{tot} = (27.6\ V + 1.6\ V) \times 25\ mA + 0.080\ W = 0.810\ W$$

6. If P_{tot} is greater then 2.5W at Tj =< 25°C or derated value (power dissipation plot figure 3 on page 5), then:

a. Increase total number of LEDs to reduce V_{mosfet}

b. Reduce I_{leds} by increasing R_{sns}

c. Parallel devices (up to 6 devices) to obtain requested value



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