Lead-free Green

Description

The AL9910/A high-voltage PWM LED driver-controller provides an efficient solution for offline high brightness LED lamps from rectified line voltages ranging from 85V$_{AC}$ up to 277V$_{AC}$. The AL9910/A drives external MOSFETs at switching frequencies up to 300kHz, with the switching frequency determined by a single resistor. The AL9910/A topology creates a constant current through the LEDs providing constant light output. The output current is programmed by one external resistor and is ultimately determined by the external MOSFET chosen and therefore allows many low current LEDs to be driven as well as a few high current LEDs.

The LED brightness can be varied by both linear and PWM dimming using the AL9910/A's LD and PWM_D pins respectively. The PWM_D input operates with duty ratio of 0 to 100% and frequency of up to several kHz.

The AL9910/A can withstand input voltages up to 500V, which makes it very resilient to transients at standard mains voltages. As well as standard SO-8 package, the AL9910/A is available in the thermally enhanced SO-8EP package.
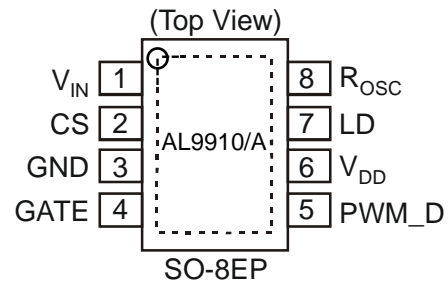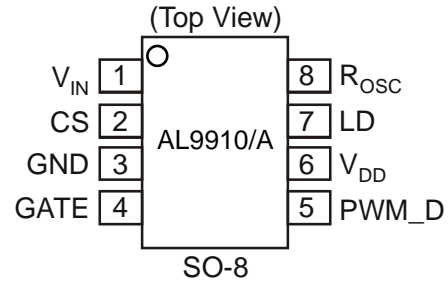
Pin Assignments

(Top View)

V$_{IN}$	1		8	R$_{OSC}$
CS	2		7	LD
GND	3	AL9910/A	6	V$_{DD}$
GATE	4		5	PWM_D

SO-8

(Top View)

V$_{IN}$	1		8	R$_{OSC}$
CS	2		7	LD
GND	3	AL9910/A	6	V$_{DD}$
GATE	4		5	PWM_D

SO-8EP

Features

- > 90% Efficiency
- Universal Rectified 85 to 277V$_{AC}$ Input Range
- Input Voltage Up to 500V
- Internal Voltage Regulator Removes Startup Resistor
  - 7.5V MOSFET Drive – AL9910
  - 10V MOSFET Drive – AL9910A
- Tighter Current-Sense Tolerance: 5% AL9910-5, AL9910A-5 and 6% AL9910-6
- Drives LED Lamps with Both High and Low Current LEDs
- LED Brightness Control with Linear and PWM Dimming
- Internal Thermal Protection (OTP)
- Available in the SO-8 and SO-8EP Packages
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.**
  https://www.diodes.com/quality/product-definitions/

Applications

- LED offline lamps
- High-voltage DC-DC LED drivers
- Signage and decorative LED lighting
- Back lighting of flat panel displays
- General-purpose constant current sources

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
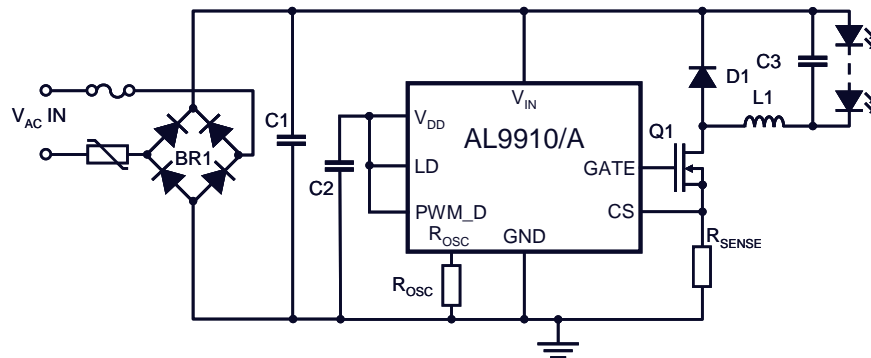
AL9910/A
Document number: DS35103 Rev. 11 - 2

1 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Typical Applications Circuit

Pin Descriptions

Pin Name	Pin Number		Function
	SO-8	SO-8EP	
V_{IN}	1	1	Input Voltage
CS	2	2	Senses LED string and external MOSFET switch current
GND	3	3	Device Ground
GATE	4	4	Drives the gate of the external MOSFET switch.
PWM_D	5	5	Low Frequency PWM Dimming pin, also Enable input. Internal 200kΩ pulldown to GND.
V_{DD}	6	6	Internally regulated supply voltage. ▪ 7.5V nominal for AL9910 and AL9910-5 ▪ 10V nominal for AL9910A. Can supply up to 1mA for external circuitry. A sufficient storage capacitor is used to provide storage when the rectified AC input is near the zero crossing.
LD	7	7	Linear Dimming Input. Changes the current limit threshold at current-sense comparator and changes the average LED current.
R_{OSC}	8	8	Oscillator Control. A resistor connected between this pin and ground sets the PWM frequency. The devices can be switched into constant off time (PFM) mode by connecting the external oscillator resistor between R_{OSC} pin and the gate of the external MOSFET.
EP PAD	N/A	EP	Exposed Pad (bottom). Connect to GND directly underneath the package.

Functional Block Diagram

AL9910/A
Document number: DS35103 Rev. 11 - 2

2 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.
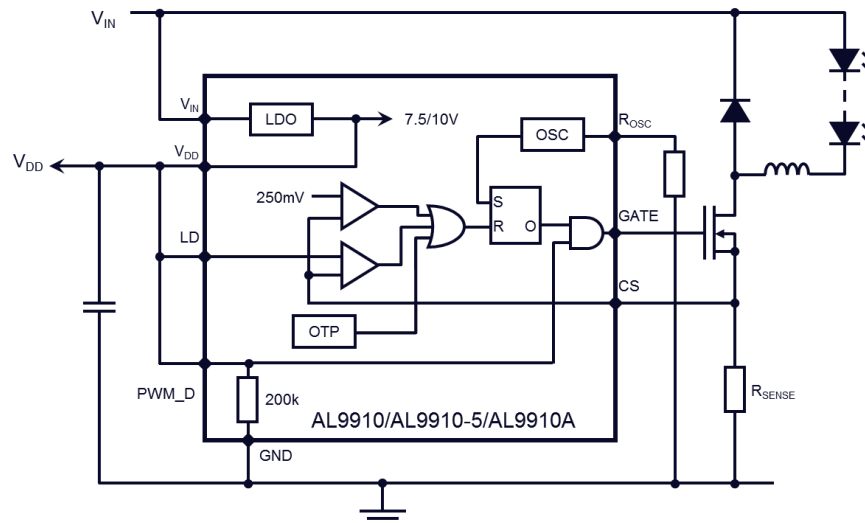
Absolute Maximum Ratings (Note 4) (@T$_A$ = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
V$_{IN(MAX)}$	Maximum Input Voltage, V$_{IN}$, to GND	-0.5 to +520	V
V$_{CS}$	Maximum CS Input Pin Voltage Relative to GND	-0.3 to +0.45	V
V$_{LD}$	Maximum LD Input Pin Voltage Relative to GND	-0.3 to (V$_{DD}$ +0.3)	V
V$_{PWM\_D}$	Maximum PWM_D Input Pin Voltage Relative to GND	-0.3 to (V$_{DD}$ +0.3)	V
V$_{GATE}$	Maximum GATE Pin Voltage Relative to GND	-0.3 to (V$_{DD}$ +0.3)	V
V$_{DD(MAX)}$	Maximum V$_{DD}$ Pin Voltage Relative to GND	12	V
—	Continuous Power Dissipation (T$_A$ = +25°C)	—	—
—	SO-8 (Derate 6.3mW/°C Above +25°C)	630	mW
—	SO-8EP (Derate at 22mW/°C Above +25°C)	2200	mW
T$_J$	Junction Temperature Range	+150	°C
T$_{ST}$	Storage Temperature Range	-65 to +150	°C
ESD HBM	Human Body Model ESD Protection (Note 5)	1500	V
ESD MM	Machine Model ESD Protection (Note 5)	300	V

Notes: 4. Stresses above those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods can affect device reliability. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.

5. Semiconductor devices are ESD sensitive and can be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

Recommended Operating Conditions (@T$_A$ = +25°C, unless otherwise specified.)

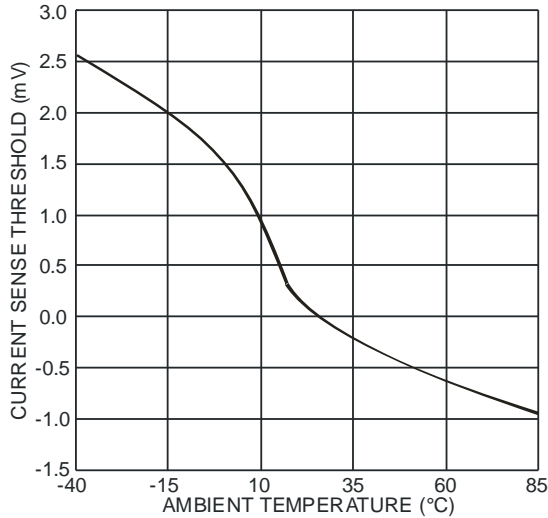| Symbol	Parameter		Min	Max	Unit
V$_{INDC}$	Input DC Supply Voltage Range	AL9910 AL9910-5 AL9910-6	15.0	500	V
		AL9910A AI9910A-5	20.0	500	
T$_A$	Ambient Temperature Range (Note 6)	AL9910_S	-40	+85	°C
		AL9910_SP	-40	+105	
V$_{DD}$	Maximum Recommended Voltage Applied to V$_{DD}$ Pin (Note 7)	AL9910 AL9910-5 AL9910-6	—	10	V
		AL9910A AL9910A-5	—	12	
V$_{EN(LO)}$	Pin PWM_D Input Low Voltage		0	1	V
V$_{EN(HI)}$	Pin PWM_D Input High Voltage		2.4	V$_{DD}$	

Notes: 6. Maximum ambient temperature range is limited by allowable power dissipation. The exposed pad SO-8EP with its lower thermal impedance allows the variants using this package to extend the allowable maximum ambient temperature range.

7. When using the AL9910 in isolated LED lamps an auxiliary winding might be used.

AL9910/A
Document number: DS35103 Rev. 11 - 2

3 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Electrical Characteristics ($@T_A$ = +25°C, unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{INSD}	Shutdown Mode Supply Current	Pin PWM_D to GND, V_{IN} = $V_{IN(MIN)}$ (Note 6)	AL9910 AL9910-5	—	0.50	1	mA
			AL9910A	—	0.65	1.2	
V_{DD}	Internally Regulated Voltage	V_{IN} = $V_{IN(MIN)}$ to 500V, (Note 8) $I_{DD(ext)}$ = 0, Gate pin open	AL9910 AL9910-5	7.0	7.5	8.0	V
			AL9910-6	7.0	—	8.2	
			AL9910A	9	10	11	
$I_{DD(ext)}$	V_{DD} Current Available for External Circuitry	V_{IN} = $V_{IN(MIN)}$ to 100V (Notes 8 & 9)		—	—	1.0	mA
UVLO	V_{DD} Undervoltage Lockout Threshold	V_{DD} rising	AL9910 AL9910-5	6.4	6.7	7	V
			AL9910-6	6.4	—	7.4	
			AL9910A	8	9	10	
ΔUVLO	V_{DD} Undervoltage Lockout Hysteresis	V_{DD} falling	AL9910 AL9910-5 AL9910-6	—	500	—	mV
			AL9910A	—	750	—	
R_{PWM_D}	PWM_D Pulldown Resistance	V_{PWM_D} = 5V		150	200	250	kΩ
$V_{CS(HI)}$	Current-Sense Threshold Voltage	Full ambient temperature range (Note 10)	AL9910	225	250	275	mV
			AL9910A	230	255	280	
			AL9910A-5	242	255	267	
			AL9910-5	237.5	250	262.5	
			AL9910-6	249	265	281	
$V_{GATE(HI)}$	GATE High Output Voltage	I_{OUT} = 10mA		V_{DD} -0.3	—	V_{DD}	V
$V_{GATE(LO)}$	GATE Low Output Voltage	I_{OUT} = -10mA		0	—	0.3	V
f_{OSC}	Oscillator Frequency	R_{OSC} = 1MΩ		20	25	30	kHz
		R_{OSC} = 226kΩ		80	100	120	
D_{MAXhf}	Maximum Oscillator PWM Duty Cycle	f_{PWMhf} = 25kHz, at GATE, CS to GND.		—	—	100	%
V_{LD}	Linear Dimming Pin Voltage Range	Full ambient temperature range (Note 10), V_{IN} = 20V		0	—	250	mV
t_{BLANK}	Current-Sense Blanking Interval	V_{CS} = 0.45V, V_{LD} = V_{DD}		160	250	440	ns
t_{DELAY}	Delay From CS Trip to GATE lo	V_{IN} = 20V, V_{LD} = 0.15V, V_{CS} = 0 to 0.22V after t_{BLANK}		—	—	300	ns
t_{RISE}	GATE Output Rise Time	C_{GATE} = 500pF		—	30	50	ns
t_{FALL}	GATE Output Fall Time	C_{GATE} = 500pF		—	30	50	ns
T_{SD}	Thermal Shut Down	—		—	+150	—	°C
T_{SDH}	Thermal Shut Down Hysteresis	—		—	+50	—	
$θ_{JA}$	Thermal Resistance Junction-to-Ambient	SO-8 (Note 11)		—	110	—	°C/W
		SO-8EP (Note 12)		—	66	—	
$θ_{JC}$	Thermal Resistance Junction-to-Case	SO-8 (Note 11)		—	22	—	°C/W
		SO-8EP (Note 12)		—	9	—	

Notes: 6. Maximum ambient temperature range is limited by allowable power dissipation. The exposed pad SO-8EP with its lower thermal impedance allows the variants using this package to extend the allowable maximum ambient temperature range.
8. $V_{IN(MIN)}$ for the AL9910 is 15V and for the AL9910A it is 20V.
9. Also limited by package power dissipation limit, whichever is lower.
10. Full ambient temperature range for AL9910-5S, AL9910AS and AL9910S is -40 to +85°C; for AL9910-5SP, AL9910ASP and AL9910SP is -40°C to +105°C.
11. Device mounted on FR-4 PCB (25mm x 25mm 1oz copper, minimum recommended pad layout on top. For better thermal performance, larger copper pad for heat-sink is needed.
12. Device mounted on FR-4 PCB (51mm x 51mm 2oz copper, minimum recommended pad layout on top layer and thermal vias to bottom layer ground plane. For better thermal performance, larger copper pad for heat-sink is needed.
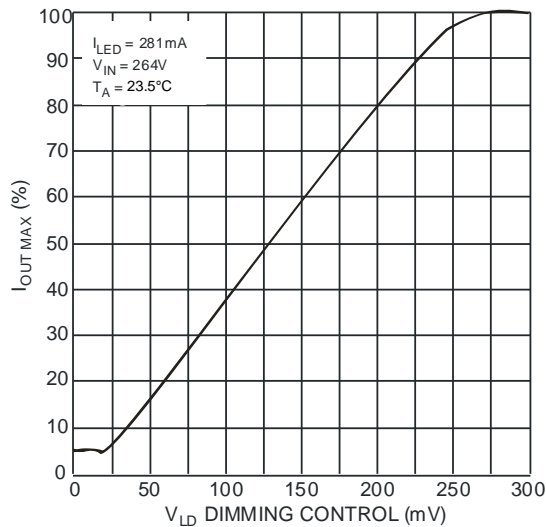
AL9910/A
Document number: DS35103 Rev. 11 - 2
4 of 15
www.diodes.com
September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.
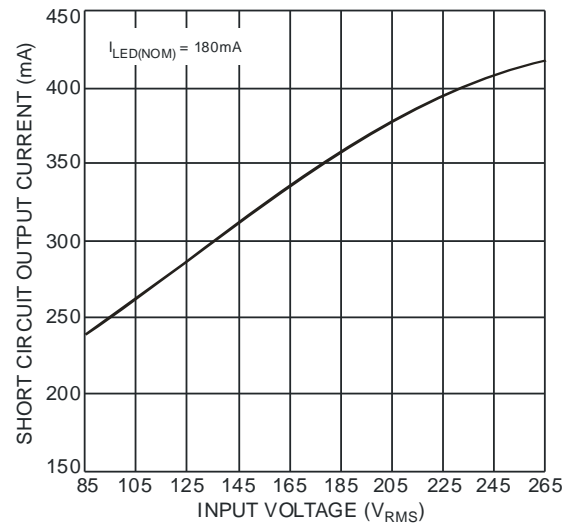
Typical Characteristics

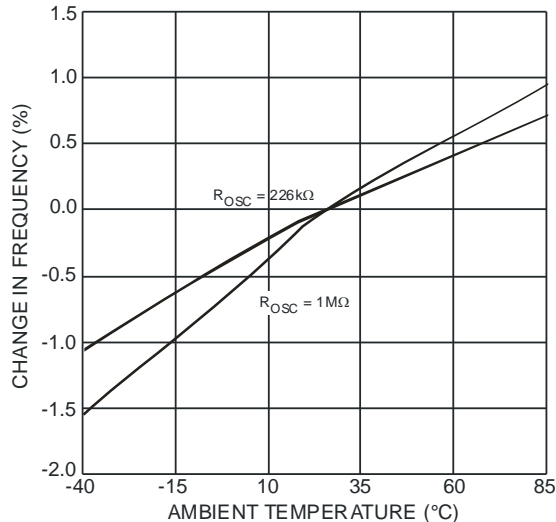Change in Current Sense Threshold vs. Ambient Temperature
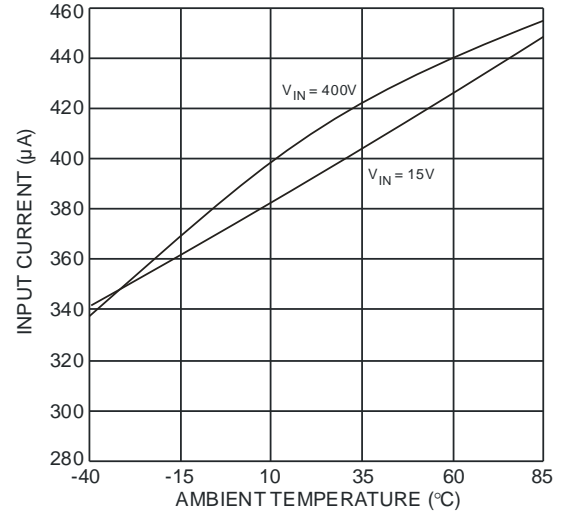
Input Current vs. Ambient Temperature

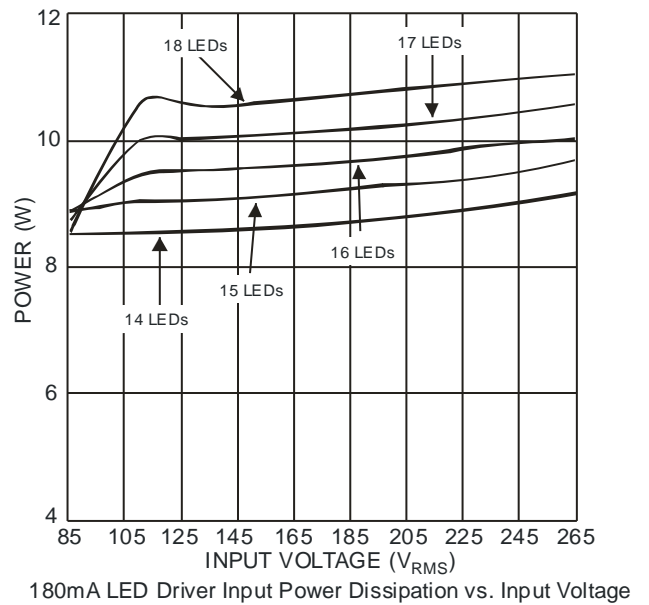$I_{OUT\,MAX}$ vs. V_{LD} Dimming Control
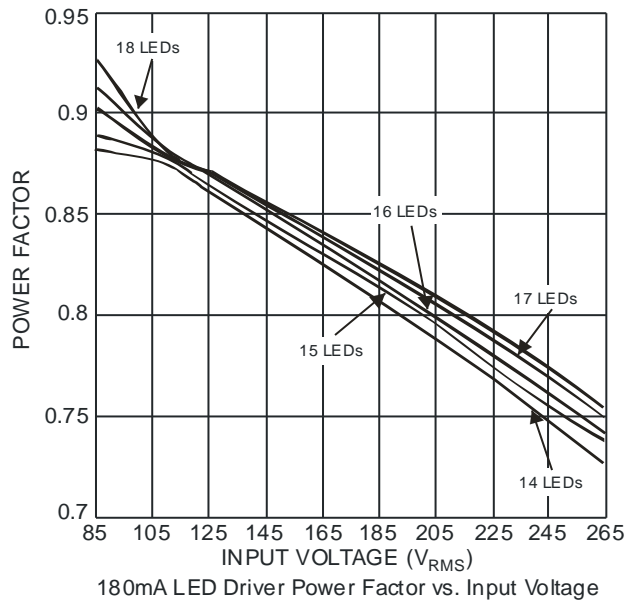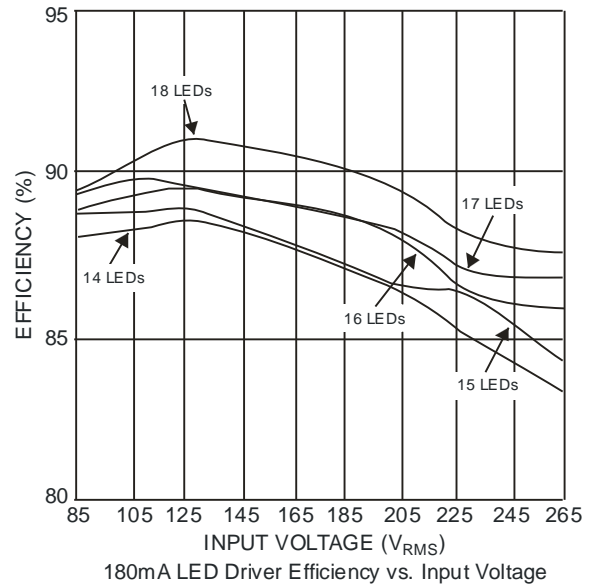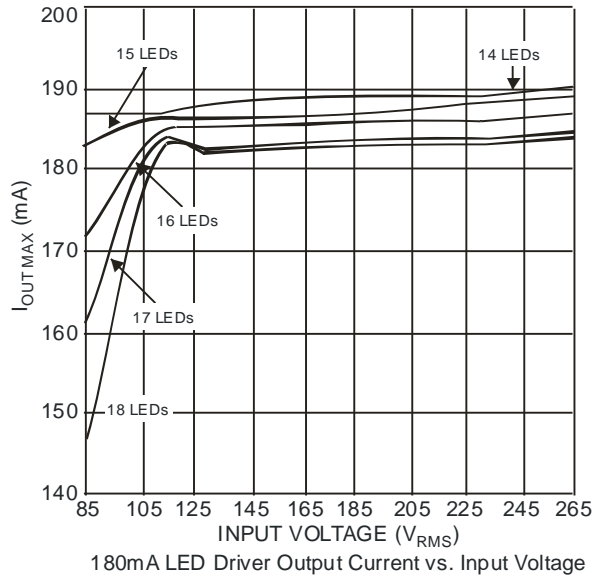

180mA LED Driver Short Circuit Output Current vs. Input Voltage

Change in Oscillation Frequency vs. Ambient Temperature

AL9910/A
Document number: DS35103 Rev. 11 - 2

5 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Typical Characteristics (continued) measured using AL9910EV4

180mA LED Driver Output Current vs. Input Voltage

180mA LED Driver Efficiency vs. Input Voltage

180mA LED Driver Power Factor vs. Input Voltage

180mA LED Driver Input Power Dissipation vs. Input Voltage

AL9910/A
Document number: DS35103 Rev. 11 - 2

6 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Application Information

The AL9910/A is very versatile and is capable of operating in isolated or non-isolated topologies. It can also be made to operate in continuous- as well as discontinuous-conduction mode.
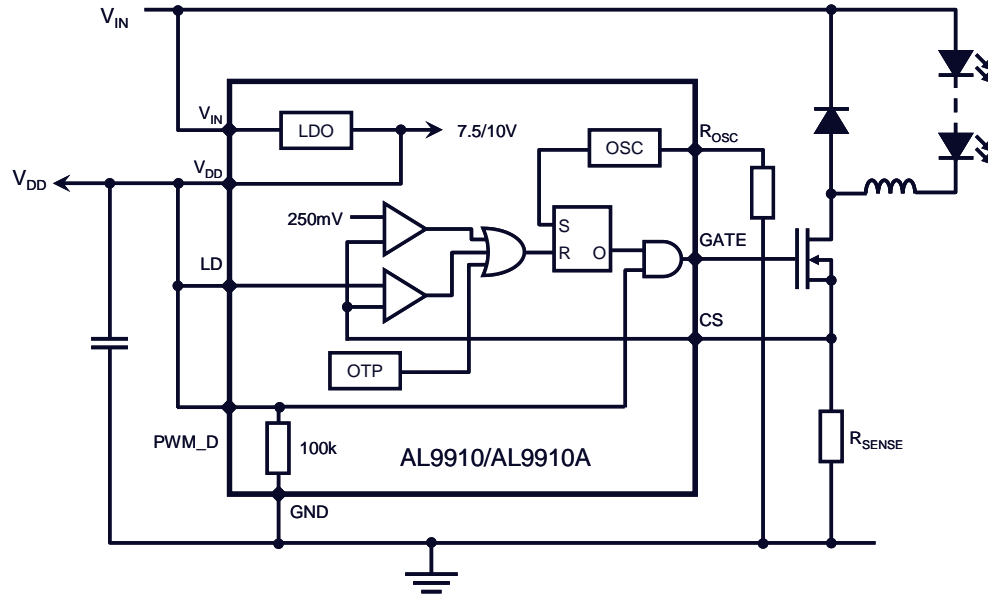

Figure 1. Functional Block Diagram

The AL9910/A contains a high-voltage LDO (see Figure 1). The output of the LDO provides a power rail to the internal circuitry including the gate driver. A UVLO on the output of the LDO prevents incorrect operation at low input voltage to the V_{IN} pin.

In a non-isolated buck LED driver when the gate pin goes high, the external power MOSFET Q1 is turned on causing current to flow through the LEDs, inductor (L1) and current-sense resistor (R_{SENSE}). When the voltage across R_{SENSE} exceeds the current-sense pin threshold, the external MOSFET Q1 is turned off. The stored energy in the inductor causes the current to continue to flow through the LEDs via diode D1.

The AL9910/A's LDO provides all power to the rest of the IC including gate drive. This removes the need for large high-power startup resistors. This means that operate correctly it requires around 0.5mA from the high-voltage power rail. The LDO can also be used to supply up to 1mA to external circuits.

The AL9910/A operates and regulates by limiting the peak current of the external MOSFET; the peak current-sense threshold is nominally set at 250mV.

The same basic operation is true for isolated topologies. However, in these the energy stored in the transformer delivers energy to LEDs during the off-cycle of the external MOSFET.

Design Parameters
Setting the LED Current

In the non-isolated buck converter topology, figure 1, the average LED current is not the peak current divided by 2 - however, there is a certain error due to the difference between the peak and the average current in the inductor. The following equation accounts for this error:

$$R_{SENSE} = \frac{250mV}{\left(I_{LED} + (0.5 * I_{RIPPLE})\right)}$$

AL9910/A
Document number: DS35103 Rev. 11 - 2

7 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Applications Information (continued)

Setting Operating Frequency

The AL9910/A is capable of operating over a 25 and 300kHz switching frequency range. The switching frequency is programmed by connecting an external resistor between R_{OSC} pin and ground. The corresponding oscillator period is:

$$t_{OSC} = \frac{R_{osc} + 22}{25} \text{ μs} \qquad \text{with } R_{OSC} \text{ in k}\Omega$$

The switching frequency is the reciprocal of the oscillator period. Typical values for R_{OSC} vary from 75kΩ to 1MΩ

When driving smaller numbers of LEDs, care should be taken to ensure that $t_{ON} > t_{BLANK}$. The simplest way to do this is to reduce/limit the switching frequency by increasing the R_{OSC} value. Reducing the switching frequency will also improve the efficiency.

When operating in buck mode, the designer must keep in mind that the input voltage must be maintained higher than 2 times the forward voltage drop across the LEDs. This limitation is related to the output current instability that may develop when the AL9910/A operates at a duty cycle greater than 0.5. This instability reveals itself as an oscillation of the output current at a sub-harmonic (SBO) of the switching frequency.

The best solution is to adopt the so-called constant off-time operation as shown in Figure 2. The resistor (R_{OSC}) is, connected to ground by default, to set operating frequency. To force the AL9910/A to enter constant OFF time mode, R_{OSC} is connected to the gate of the external MOSFET. This will decrease the duty cycle from 50% by increasing the total period, $t_{OFF} + t_{ON}$.
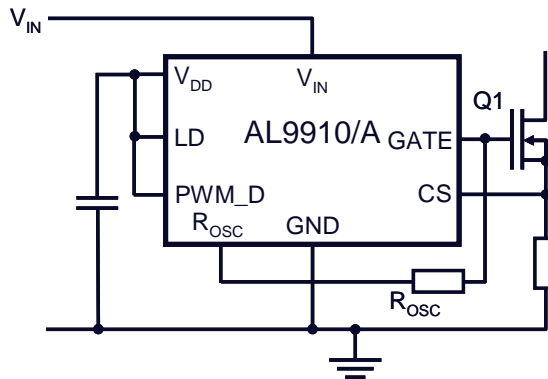

Figure 2. Constant Off-Time Configuration

The oscillator period equation above now defines the AL9910/A off time, t_{OFF}.
When using this mode the nominal switching frequency is chosen and from the nominal input and output voltages the off-time can be calculated:

$$t_{OFF} = \left(1 - \frac{V_{OUT(nom)}}{V_{IN(nom)}}\right) * \frac{1}{f_{OSC}}$$

From this the timing resistor, R_{OSC}, can be calculated: $R_{OSC} = \left(t_{OFF}(\text{μs}) * 25\right) - 22(\text{k}\Omega)$

Inductor Selection

The non-isolated buck circuit, Figure 1, is usually selected and it has two operation modes: continuous- and discontinuous-conduction modes. A buck power stage can be designed to operate in continuous mode for load current above a certain level usually 15% to 30% of full load. Usually, the input voltage range, the output voltage and load current are defined by the power stage specification. This leaves the inductor value as the only design parameter to maintain continuous-conduction mode. The minimum value of inductor to maintain continuous-conduction mode can be determined by the following example.

The required inductor value is determined from the desired peak-to-peak LED ripple current in the inductor; typically around 30% of the nominal LED current.

$$L = \frac{(V_{IN} - V_{LEDs}) \times D}{(0.3 \times I_{LED}) \times f_{OSC}} \qquad \text{Where D is duty cycle}$$

The next step is determining the total voltage drop across the LED string. For example, when the string consists of 10 high-brightness LEDs and each diode has a forward voltage drop of 3.0V at its nominal current; the total LED voltage V_{LEDS} is 30V.

AL9910/A
Document number: DS35103 Rev. 11 - 2

8 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Applications Information (continued)

Dimming

The LED brightness can be dimmed either linearly (using the LD pin) or via pulse width modulation (using the PWM-D pin); or a combination of both - depending on the application. Pulling the PWM_D pin to ground will turn off the AL9910/A. When disabled, the AL9910's quiescent current is typically 0.5mA (0.65mA for AL9910A). Reducing the LD voltage will reduce the LED current but it will not entirely turn off the external power transistor and hence the LED current – this is due to the finite blanking period. Only the PWM_D pin will turn off the power transistor.

Linear dimming is accomplished by applying a 45mV to 250mV analog signal to the LD pin. This overrides the default 250mV threshold level of the CS pin and reduces the output current. If an input voltage greater than 250mV is applied to the LD, then the output current will not change.

The LD pin also provides a simple cost-effective solution to soft-start; by connecting a capacitor to the LD pin down to ground at initial power up the LD pin will be held low causing the sense threshold to be low. As the capacitor charges up, the current-sense threshold will increase thereby causing the average LED current to increase.

PWM dimming is achieved by applying an external PWM signal to the PWM_D pin. The LED current is proportional to the PWM duty cycle and the light output can be adjusted between zero and 100%. The PWM signal enables and disables the AL9910/A - modulating the LED current. The ultimate accuracy of the PWM dimming method is limited only by the minimum gate pulse width, which is a fraction of a percentage of the low frequency duty cycle. PWM dimming of the LED light can be achieved by turning on and off the converter with low frequency 50Hz to 1000Hz TTL logic level signal.

With both modes of dimming it is not possible to achieve average brightness levels higher than the one set by the current-sense threshold level of the AL9910/A. If a greater LED current is required, then a smaller sense resistor should be used.

Output Open Circuit Protection

The non-isolated buck LED driver topology provides inherent protection against an open circuit condition in the LED string due to the LEDs being connected in series with the inductor. Should the LED string become open circuit, then no switching occurs and the circuit can be permanently left in this state with damage to the rest of the circuit.

AC/DC Off-Line LED Driver

The AL9910/A is a cost-effective off-line buck LED driver-controller specifically designed for driving LED strings. It is suitable for being used with either rectified AC line or any DC voltage between 15V to 500V. See Figure 3 for typical circuit.
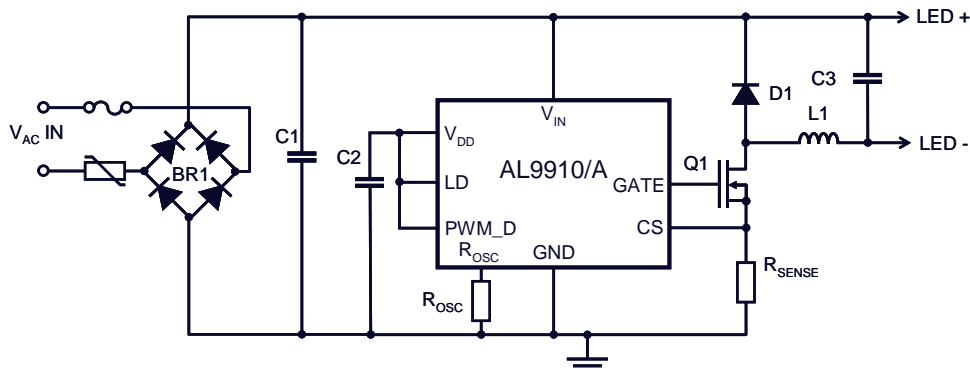

Figure 3. Typical Application Circuit (Without PFC)

Buck Design Equations:

$$D = \frac{V_{LEDs}}{V_{IN}}$$

$$t_{ON} = \frac{D}{f_{OSC}}$$

$$L \geq \frac{(V_{IN} - V_{LEDs}) \times t_{ON}}{0.3 \times I_{LED}}$$

$$R_{SENSE} = \frac{0.25}{I_{LED} + (0.5 \times (I_{LED} \times 0.3))} \quad \text{where } I_{LED} \times 0.3 = I_{RIPPLE}$$

Applications Information (continued)

Design Example

For an AC line voltage of 120V the nominal rectified input voltage V_{IN} = 120V*1.41 = 169V. From this and the LED chain voltage the duty cycle can be determined:

$$D = V_{LEDs} / V_{IN} = 30/169 = 0.177$$

From the switching frequency, for example f_{OSC} = 50kHz, the required on-time of the external MOSFET can be calculated:

$$t_{ON} = D/f_{OSC} = 3.5\mu s$$

The value of the inductor for an LED current of 350mA is determined as follows:

$$L = (V_{IN} - V_{LEDs}) * t_{ON} /(0.3 * I_{LED}) = 4.6mH$$

Input Bulk Capacitor

For offline lamps, an input bulk capacitor is required to ensure that the rectified AC voltage is held above twice the LED string voltage throughout the AC line cycle. The value can be calculated from:

$$C_{IN} \geq \frac{P_{IN} \times (1 - D_{CH})}{\sqrt{2} \times V_{LINE\_MIN} \times 2f_L \times \Delta V_{DC\_MAX}}$$

Where

D_{ch} : Capacity charge work period, generally about 0.2 to 0.25

f_L : Input frequency for full range (85 to 265V_{RMS})

ΔV_{DC_MAX} should be set 10 to15% of $\sqrt{2} V_{LINE\_MIN}$

If the capacitor has a 15% voltage ripple, then a simplified formula for the minimum value of the bulk input capacitor approximates to:

$$C_{MIN} = \frac{I_{LED} \times V_{LEDs} \times 0.06}{V_{IN}^2}$$

Power Factor Correction

If power factor improvement is required, then for the input power less than 25W, a simple passive power factor correction circuit can be added to the AL9910/A typical application circuit. Figure 4 shows that passive PFC circuitry (3 current steering diodes and 2 identical capacitors) does not significantly affect the rest of the circuit. Simple passive PFC improves the line current harmonic distortion and achieves a power factor greater than 0.85.
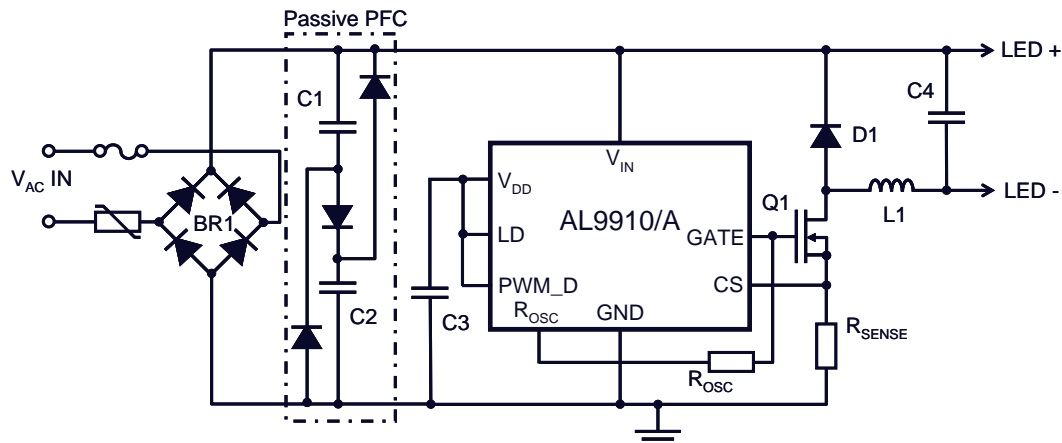

Figure 4. Typical Application Circuit With Passive PFC

Each of these identical capacitors should be rated for half of the input voltage and have twice as much capacitance as the calculated C_{MIN} of the buck converter circuit without passive PFC (see above section on bulk capacitor calculation).

For further design information please see AN75 from Diodes Incorporated's website.

AL9910/A
Document number: DS35103 Rev. 11 - 2

10 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Applications Information (continued)

DC-DC Buck LED Driver

The design procedure for an ac input buck LED driver outlined in the previous chapters equally applies DC input LED drivers.

When driving long LED chains, care should be taken not to induce SBO – maximum LED chain voltage should be less half of V_{IN}. So either maximum duty cycle should be kept below 50% or use of constant off-time removes this issue.

DC-DC Boost LED Driver

Due to the topology of the AL9910/A LED driver-controller, it is capable of being used in boost configurations – at reduced accuracy. The accuracy can be improved by measuring the LED current with an op amp and use the op amp's output to drive the LD pin.

A boost LED driver is used when the forward voltage drop of the LED string is higher than the input supply voltage. For example, the boost topology can be appropriate when input voltage is supplied by a 48V power supply and the LED string consists of twenty HB LEDs, as the case may be for a street light.
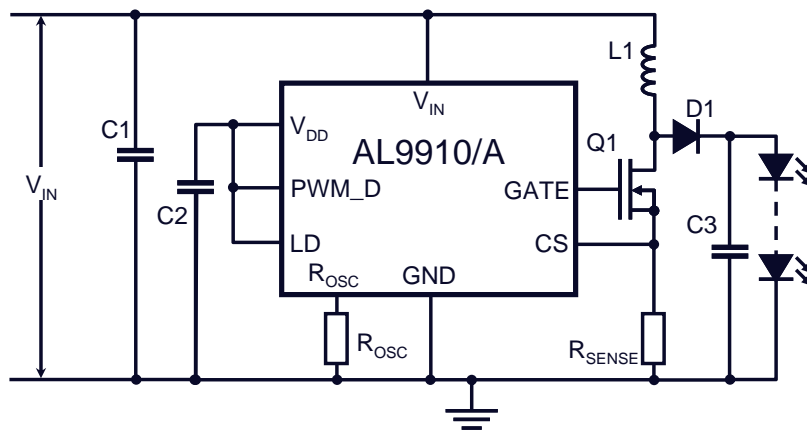

Figure 5. Boost LED Driver

In a boost converter, when the external MOSFET is ON, the energy is stored in the inductor which is then delivered to the output when the external MOSFET switches OFF. If the energy stored in the inductor is not fully depleted by the next switching cycle (continuous-conduction mode) the DC conversion between input and output voltage is given by:

$$V_{OUT} = \frac{V_{IN}}{1-D} \quad \blacktriangleright \quad D = \frac{V_{OUT} - V_{IN}}{V_{OUT}}$$

From the switching frequency, f_{OSC}, the on-time of the MOSFET can be calculated:

$$t_{ON} = \frac{D}{f_{OSC}}$$

From this the required inductor value can be determined by:

$$L = \frac{V_{IN} * t_{ON}}{0.3 * I_{LED}}$$

The boost topology LED driver requires an output capacitor to deliver current to the LED string during the time that the external MOSFET is on.

In boost LED driver topologies if the LEDs should become open circuit damage may occur to the power switch and so some form of detection should be present to provide overvoltage detection/protection.
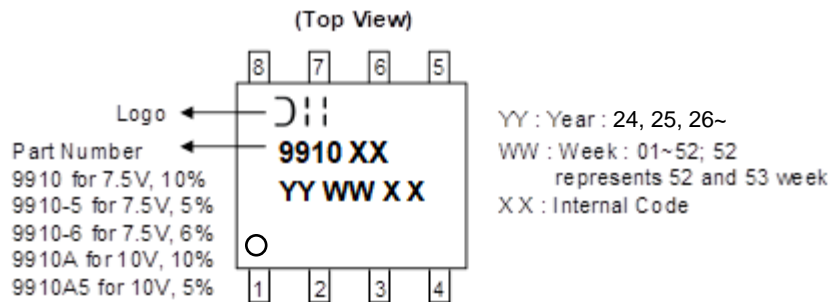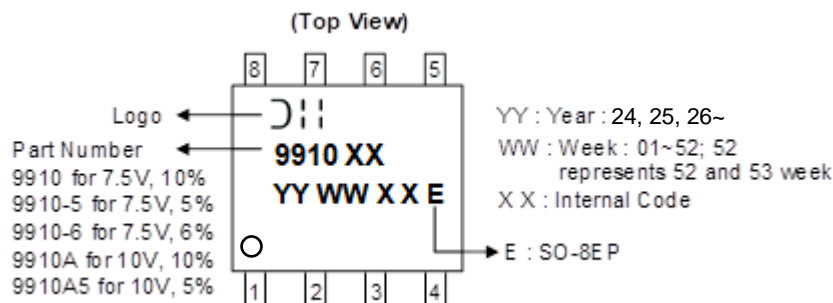
Ordering Information

```
AL9910 X XX XX - 13
```

Variant	V_CS Tolerance	Package	Packing

Blank : 7.5V V_{DD}
A : 10V V_{DD}

Blank : 10%
-5 : 5%
-6 : 6%

S : SO-8
SP : SO-8EP

13 : 13" Tape & Reel
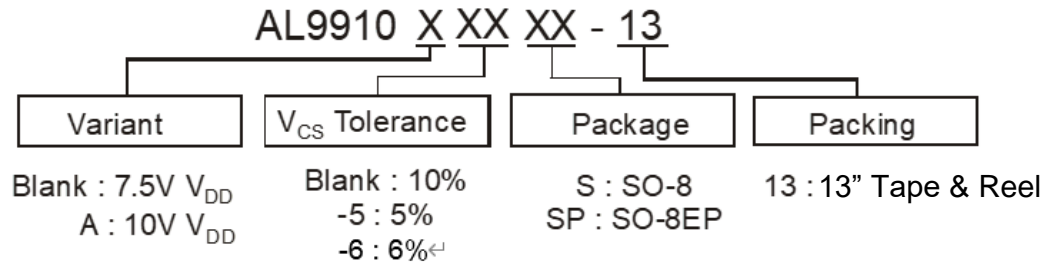
Orderable Part Number	V_CS Tolerance	Package Code	Package	Packing	
				Qty.	Carrier
AL9910-5S-13	±5%	S	SO-8	2500	13" Tape and Reel
AL9910-5SP-13	±5%	SP	SO-8EP	2500	13" Tape and Reel
AL9910-6S-13	±6%	S	SO-8	2500	13" Tape and Reel
AL9910-6SP-13	±6%	SP	SO-8EP	2500	13" Tape and Reel
AL9910A-5S-13	±5%	S	SO-8	2500	13" Tape and Reel
AL9910A-5SP-13	±5%	SP	SO-8EP	2500	13" Tape and Reel
AL9910AS-13	±10%	S	SO-8	2500	13" Tape and Reel
AL9910ASP-13	±10%	SP	SO-8EP	2500	13" Tape and Reel
AL9910S-13	±10%	S	SO-8	2500	13" Tape and Reel
AL9910SP-13	±10%	SP	SO-8EP	2500	13" Tape and Reel

Marking Information

(1) SO-8

(Top View)

Logo

Part Number
9910 for 7.5V, 10%
9910-5 for 7.5V, 5%
9910-6 for 7.5V, 6%
9910A for 10V, 10%
9910A5 for 10V, 5%

9910 XX
YY WW X X

YY : Year : 24, 25, 26~
WW : Week : 01~52; 52
        represents 52 and 53 week
X X : Internal Code

(2) SO8-EP

(Top View)

Logo

Part Number
9910 for 7.5V, 10%
9910-5 for 7.5V, 5%
9910-6 for 7.5V, 6%
9910A for 10V, 10%
9910A5 for 10V, 5%

9910 XX
YY WW X X E

YY : Year : 24, 25, 26~
WW : Week : 01~52; 52
        represents 52 and 53 week
X X : Internal Code
E : SO-8EP

AL9910/A
Document number: DS35103 Rev. 11 - 2

12 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SO-8
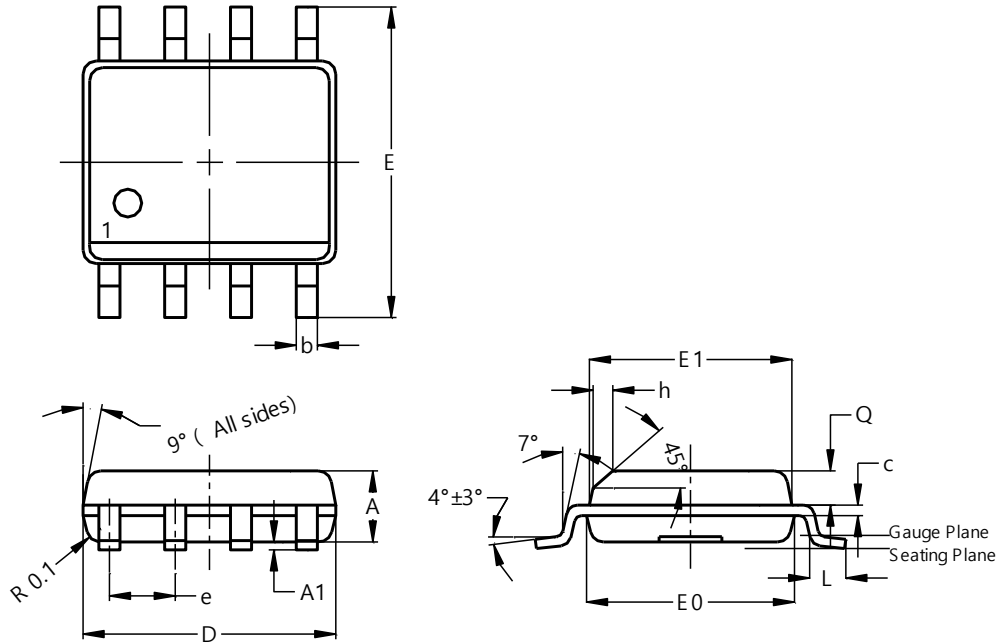
SO-8			
Dim	Min	Max	Typ
A	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
c	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
e	--	--	1.27
h	-	--	0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All Dimensions in mm			

(2) SO-8EP
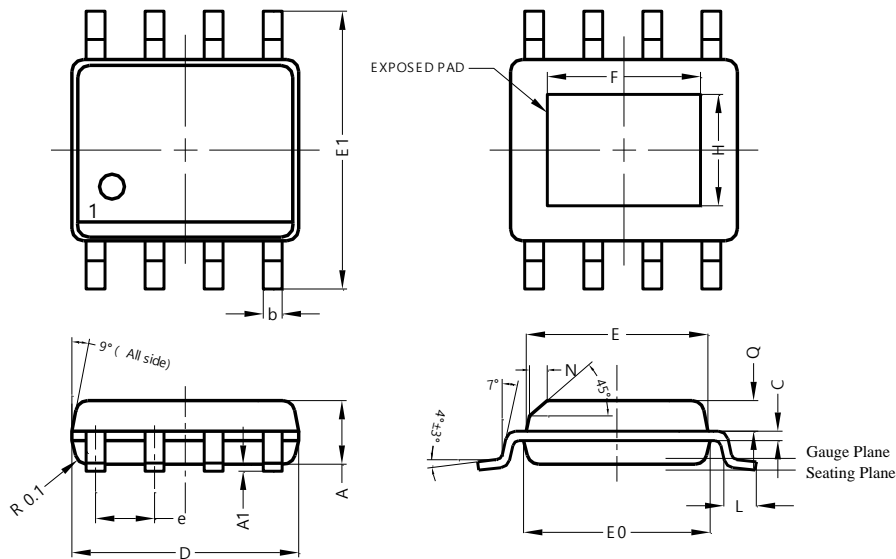
SO-8EP			
Dim	Min	Max	Typ
A	1.40	1.50	1.45
A1	0.00	0.13	-
b	0.30	0.50	0.40
C	0.15	0.25	0.20
D	4.85	4.95	4.90
E	3.80	3.90	3.85
E0	3.85	3.95	3.90
E1	5.90	6.10	6.00
e	-	-	1.27
F	2.75	3.35	3.05
H	2.11	2.71	2.41
L	0.62	0.82	0.72
N	-	-	0.35
Q	0.60	0.70	0.65
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1)   SO-8
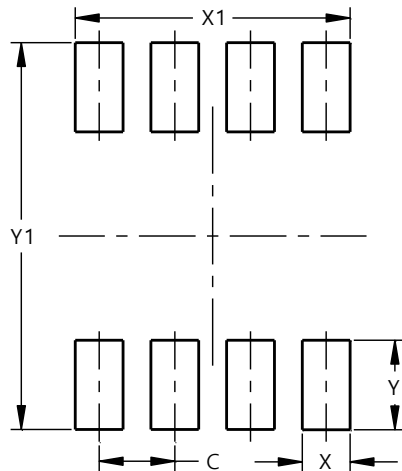
Dimensions	Value (in mm)
C	1.27
X	0.802
X1	4.612
Y	1.505
Y1	6.50

(2)   SO-8EP
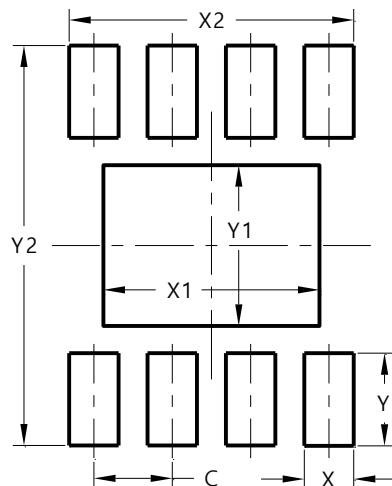
Dimensions	Value (in mm)
C	1.270
X	0.802
X1	3.502
X2	4.612
Y	1.505
Y1	2.613
Y2	6.500

Mechanical Data

- Moisture Sensitivity: Level 1 per JESD22-A113
- Terminals: Finish - Matte Tin Plated Leads, Solderable per M2003 JESD22-B102 e3
- Weight:
  - SO-8: 0.076 grams (Approximate)
  - SO-8EP: 0.081 grams (Approximate)

AL9910/A
Document number: DS35103 Rev. 11 - 2

14 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

IMPORTANT NOTICE

1. DIODES INCORPORATED (Diodes) AND ITS SUBSIDIARIES MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO ANY INFORMATION CONTAINED IN THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

2. The Information contained herein is for informational purpose only and is provided only to illustrate the operation of Diodes' products described herein and application examples. Diodes does not assume any liability arising out of the application or use of this document or any product described herein. This document is intended for skilled and technically trained engineering customers and users who design with Diodes' products. Diodes' products may be used to facilitate safety-related applications; however, in all instances customers and users are responsible for (a) selecting the appropriate Diodes products for their applications, (b) evaluating the suitability of Diodes' products for their intended applications, (c) ensuring their applications, which incorporate Diodes' products, comply the applicable legal and regulatory requirements as well as safety and functional-safety related standards, and (d) ensuring they design with appropriate safeguards (including testing, validation, quality control techniques, redundancy, malfunction prevention, and appropriate treatment for aging degradation) to minimize the risks associated with their applications.

3. Diodes assumes no liability for any application-related information, support, assistance or feedback that may be provided by Diodes from time to time. Any customer or user of this document or products described herein will assume all risks and liabilities associated with such use, and will hold Diodes and all companies whose products are represented herein or on Diodes' websites, harmless against all damages and liabilities.

4. Products described herein may be covered by one or more United States, international or foreign patents and pending patent applications. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks and trademark applications. Diodes does not convey any license under any of its intellectual property rights or the rights of any third parties (including third parties whose products and services may be described in this document or on Diodes' website) under this document.

5. Diodes' products are provided subject to Diodes' Standard Terms and Conditions of Sale (https://www.diodes.com/about/company/terms-and-conditions/terms-and-conditions-of-sales/) or other applicable terms. This document does not alter or expand the applicable warranties provided by Diodes. Diodes does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.

6. Diodes' products and technology may not be used for or incorporated into any products or systems whose manufacture, use or sale is prohibited under any applicable laws and regulations. Should customers or users use Diodes' products in contravention of any applicable laws or regulations, or for any unintended or unauthorized application, customers and users will (a) be solely responsible for any damages, losses or penalties arising in connection therewith or as a result thereof, and (b) indemnify and hold Diodes and its representatives and agents harmless against any and all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim relating to any noncompliance with the applicable laws and regulations, as well as any unintended or unauthorized application.

7. While efforts have been made to ensure the information contained in this document is accurate, complete and current, it may contain technical inaccuracies, omissions and typographical errors. Diodes does not warrant that information contained in this document is error-free and Diodes is under no obligation to update or otherwise correct this information. Notwithstanding the foregoing, Diodes reserves the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes.

8. Any unauthorized copying, modification, distribution, transmission, display or other use of this document (or any portion hereof) is prohibited. Diodes assumes no responsibility for any losses incurred by the customers or users or any third parties arising from any such unauthorized use.

9. This Notice may be periodically updated with the most recent version available at https://www.diodes.com/about/company/terms-and-conditions/important-notice

The Diodes logo is a registered trademark of Diodes Incorporated in the United States and other countries.
All other trademarks are the property of their respective owners.
© 2024 Diodes Incorporated. All Rights Reserved.

www.diodes.com

AL9910/A
Document number: DS35103 Rev. 11 - 2

15 of 15
www.diodes.com

September 2024
© 2024 Copyright Diodes Incorporated. All Rights Reserved.

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Diodes Incorporated](#):

AL9910-5SP-13 AL9910S-13 AL9910AS-13 AL9910SP-13 AL9910ASP-13 AL9910-5S-13 AL9910A-5S-13
AL9910A-5SP-13