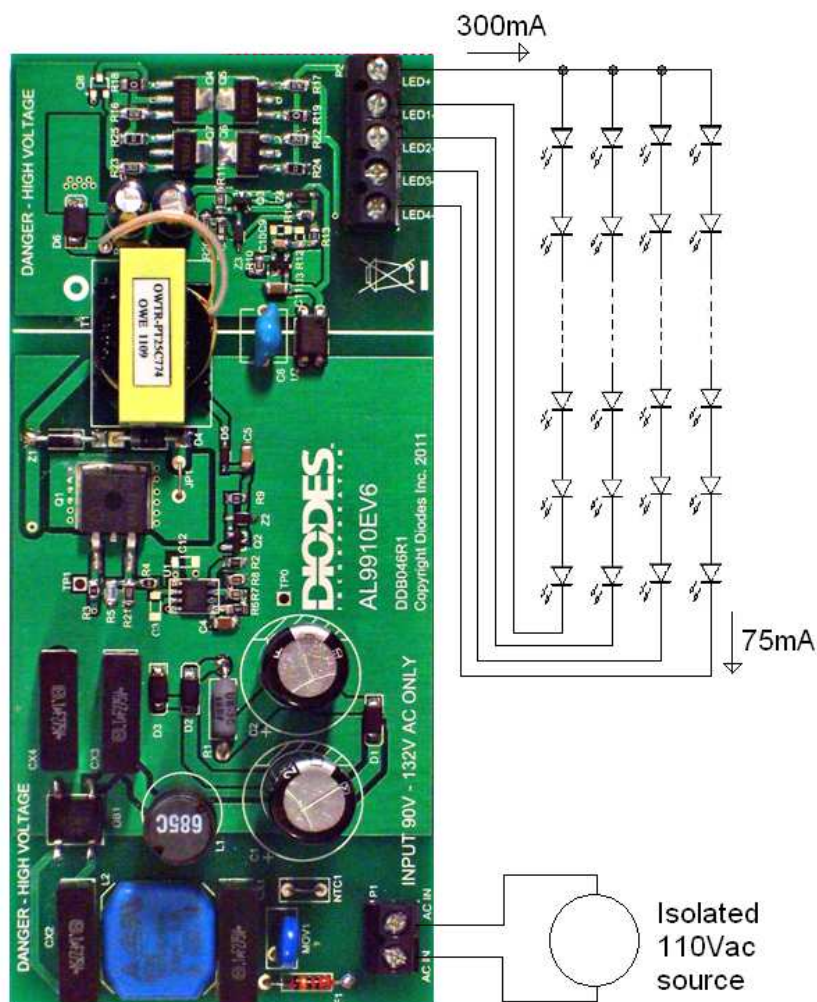


# AL9910EV6 ISOLATED LED DRIVER USER GUIDE



**WARNING: DANGER – HIGH VOLTAGES ARE PRESENT ON THIS EVALUATION BOARD**

Fig. 1 AL9910EV6 evaluation board connection diagram

## **DESCRIPTION**

The AL9910EV6 is an offline isolated LED driver evaluation board designed to work on 110V AC line voltage. It provides four constant LED current outputs which drive four separate strings of between 8 and 14 LEDs, with a LED current of 75mA per string.

It will provide a total LED power ranging from 8W to 15W.

## **AL9910EV6 SETUP AND TESTING PROCEDURE**

### **Prerequisite**

1. AL9910EV6 evaluation board.
2. Four sets of LEDs strings with 8 to 14 series-connected LEDs. Please note that the number of LEDs in each string must be equal. The LEDs should be mounted on a heatsink capable of a power dissipation of 8 to 15W.
3. For safety reasons during testing, please use an isolated 110V AC source from the output of an isolation transformer. For public demonstration, the evaluation board and LEDs should be fitted into a transparent case with sufficient insulation to meet the local safety requirements.

### **Connections and Power up**

1. Preset the isolated AC source to either 110VAC.
2. **ENSURE THAT THE AC SOURCE IS SWITCHED OFF OR DISCONNECTED.**
3. Solder the anode wires of all LED strings to the LED+ terminal.
4. Solder the cathode wires of the four LED strings individually to the LED1-, LED2-, LED3- and LED4- terminals. Connect ammeters in series with the cathode wires if LED current measurements are required.
5. Connect the two AC line wires to the AC1 and AC2 terminals which are located at the bottom left hand corner of the evaluation board.
6. Ensure that the area around the board is clear and safe, and preferably that the board and LEDs are enclosed in a transparent safety cover.
7. Turn on the mains switch. LED string should light up. **DO NOT TOUCH THE BOARD, LEDs OR BARE WIRING.**

**Caution: The input terminals carry high voltage during operation!**

## **OPERATION**

The AL9910A device is a PWM high-efficiency LED driver control IC. It allows efficient operation of High Brightness (HB) LEDs from voltage sources ranging from 85VAC up to 265VAC. The AL9910A can be configured to work in either fixed frequency or constant OFF-time mode. In fixed frequency mode, the AL9910A controls an external MOSFET at a fixed switching frequency up to 300kHz, which can be programmed using a single resistor. The LED string is driven at a constant current rather than at a constant voltage, thus providing constant light output and enhanced reliability. The output current can be programmed between a few milliamps and more than 1.0A.

### **Input filter and Rectifier section**

In order to meet the EMI requirement, CX1, CX2, CX3, CX4, L1 and L2 are used to provide sufficient filtering for both differential-mode and common-mode noise generated from the switching converter circuit after the bridge rectifier.

The rectified line voltage from the bridge rectifier DB1 is fed into a valley-filled passive power factor correction stage to provide a high power factor for the AC line input. The passive PFC stage comprises of C1, C2, D1, D2, D3 and R1. This design gives power factors of greater than 0.9.

### **Constant Current Flyback Converter section**

The isolated Flyback converter section consists of LED controller AL9910A (U1), ultra-fast free-wheeling rectifier ES2G (D6), transformer (T8) and a high voltage MOSFET switch (Q1). On this evaluation board, the AL9910A is configured to operate in the constant frequency mode to provide the best LED current regulation. The switching frequency of the AL9910A is set to 100kHz using resistor R2. Please refer to the product datasheet for more details on how to configure the constant frequency mode.

The Flyback converter have been designed to provide an total output current of 300mA. The LED current is regulated with an isolated secondary side feedback, consisting of an opto coupler (U2), sense resistors (R1, R2) and voltage reference (U3). The LED current level is set by resistors R1 and R2.

The voltage regulator network consisting of Q2, R9 and Z2 provides stable voltage to the AL9910A from the transformer auxillary winding. Zener diode Z4 and resistor R13 provides protection to the power stage under open LED condition.

### **Multi-channel LED Current Balancing section**

In this section of the evaluation board, bipolar transistors Q4-Q7 are connected as current mirror to provide an effective LED current balancing function to drive up to 4 strings of LEDs with minimal losses. The transistors are mounted as close to one another on the PCB to achieve the best possible thermal coupling. R16, R17, R22 and R23 are the transistor's emitter resistors added to improve the LED current balancing.

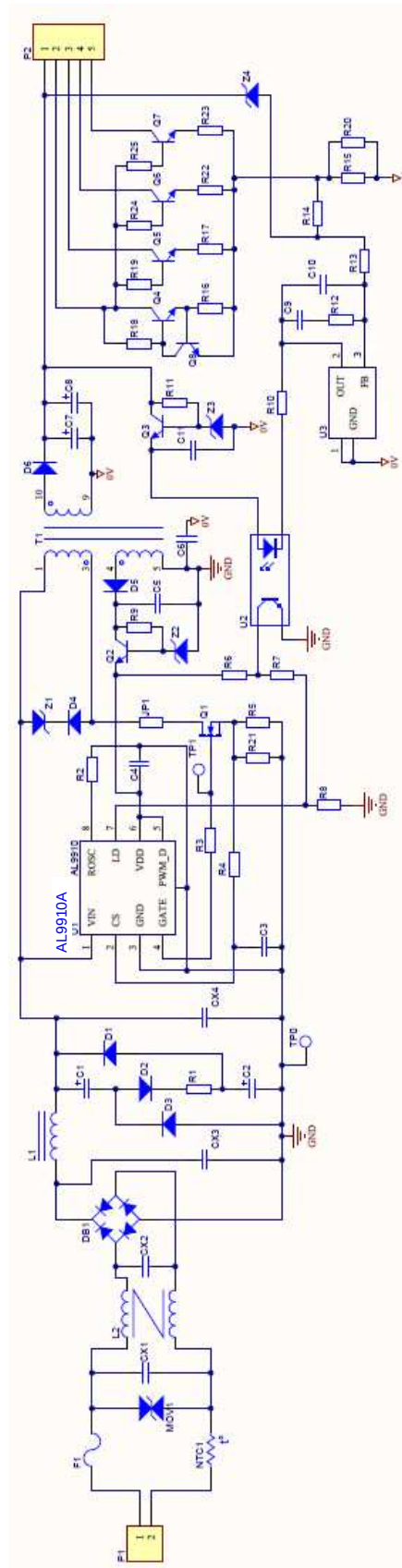
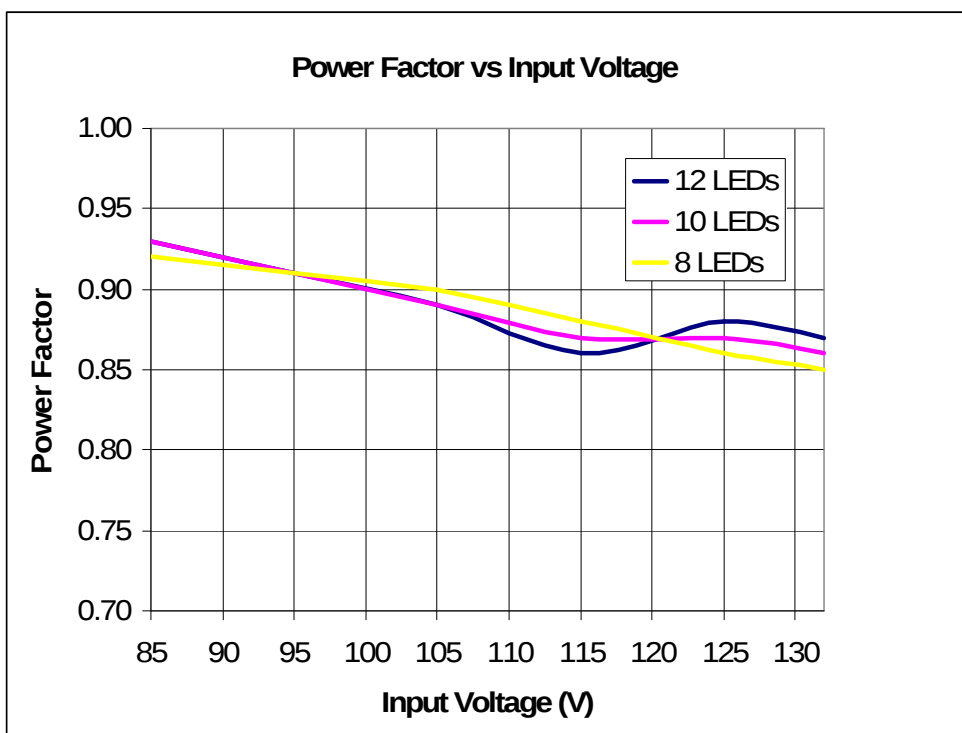
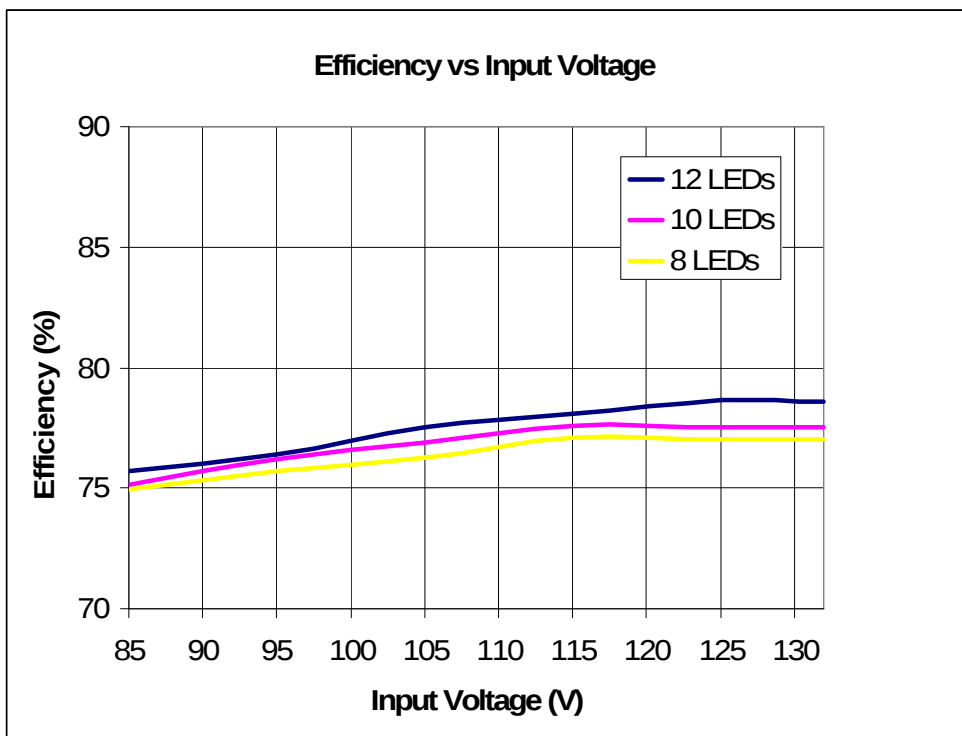


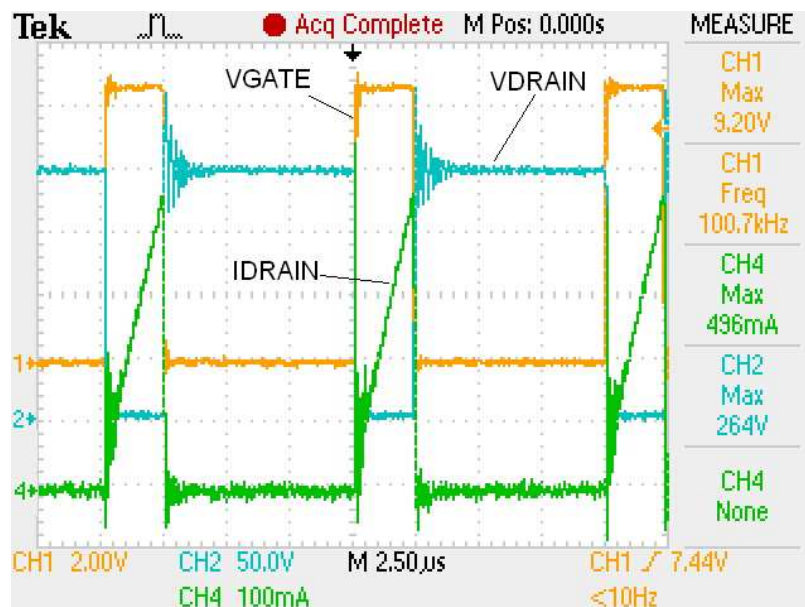
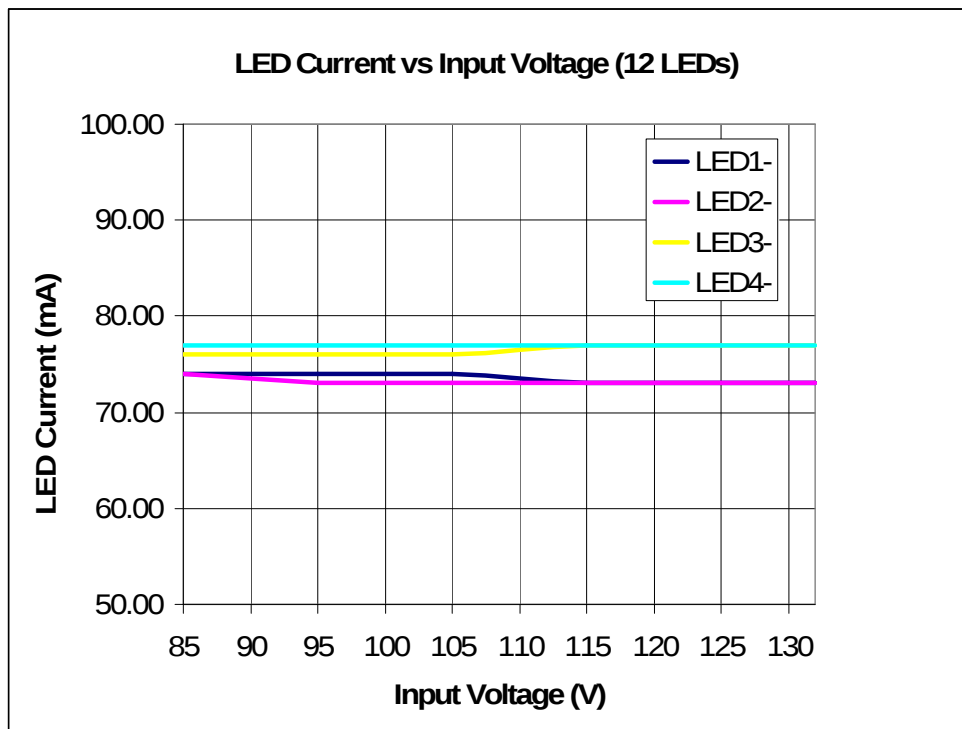
Fig. 2 AL9910EV6 Schematic Diagram

## PARTS LIST

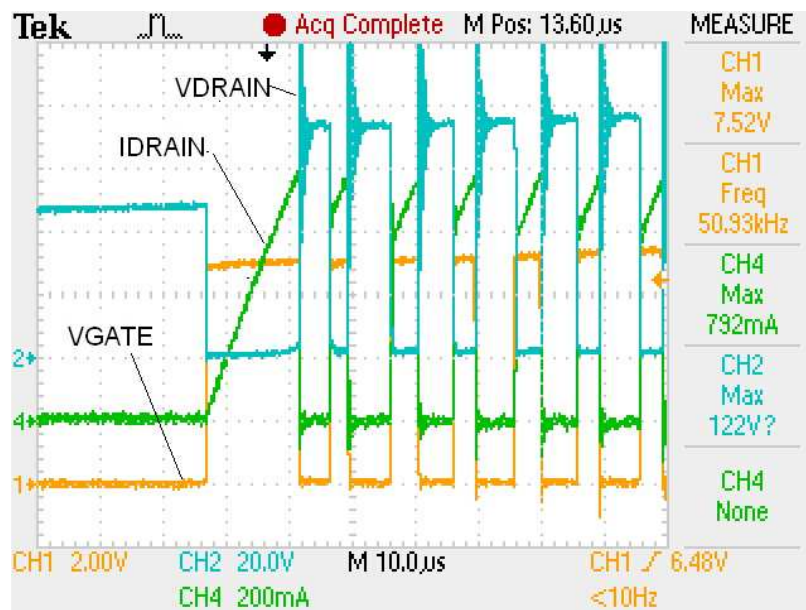
| Ref                   | Description                                         | P/N             | Package    | Manufacturer |
|-----------------------|-----------------------------------------------------|-----------------|------------|--------------|
| U1                    | Universal high brightness LED driver                | AL9910A         | SO8        | Diodes Inc   |
| U2                    | Opto coupler CTR 80-160%                            | FOD817A300      |            | Fairchild    |
| U3                    | Shunt regulator                                     | ZTLV431         | SOT23      | Diodes Inc   |
| Q1                    | N-ch 600V MOSFET 3.2A, $Q_{G(max)} = 16nC$          | SPB03N60S5      | TO252      | Infineon     |
| Q2                    | NPN Transistor                                      | MMBT2222A       | SOT23      | Diodes Inc   |
| Q3                    | 60V NPN Transistor                                  | MMBTA06         | SOT23      | Diodes Inc   |
| Q4, Q5,<br>Q6, Q7     | 60V NPN Transistor                                  | FZT853          | SOT223     | Diodes Inc   |
| D1, D2,<br>D3         | 1A 1KV diode $t_{RR}=1.8\mu s$                      | S1M-13-F        | SMA        | Diodes Inc   |
| D4                    | 400V 1A ultrafast recovery diode                    | MUR140          | DO-41      | Diodes Inc   |
| D5                    | 150V 400mA switching diode                          | BAV20W-7        | SOD123     | Diodes Inc   |
| D6                    | 400V 2A ultrafast recovery diode                    | ES2G            | SMB        | Diodes Inc   |
| DB1                   | 1A, 600V bridge rectifier                           | DF06S           |            | Diodes Inc   |
| Z1                    | 100V 1W Zener                                       | 1N4764ADO41     | DO-41      | Diodes Inc   |
| Z2                    | 9.1V 50mW Zener                                     | BZT52C9V1-7     | SOD123     | Diodes Inc   |
| Z3                    | 16V 500mW Zener                                     | DDZ9703         | SOD123     | Diodes Inc   |
| Z4                    | 56V 500mW Zener                                     | MMSZ5263B       | SOD123     | Diodes Inc   |
| R1                    | 10R 3W resistor, +/-50ppm/C, +/-1% generic          |                 | Wire wound |              |
| R2                    | 226K 0.125W +/-1% generic                           |                 | 0805       |              |
| R3,R4                 | 0R 0.125W +/-5% generic                             |                 | 0805       |              |
| R5                    | 0R5 0.25W +/-1% generic                             |                 | 1206       |              |
| R6                    | 5K6 0.125W +/-5% generic                            |                 | 0805       |              |
| R7                    | 100K 0.125W +/-5% generic                           |                 | 0805       |              |
| R8, R10               | 5K1 0.125W +/-5% generic                            |                 | 0805       |              |
| R9                    | 1K 0.125W +/-5% generic                             |                 | 0805       |              |
| R11                   | 10K 0.25W +/-5% generic                             |                 | 1206       |              |
| R13                   | 20K 0.125W +/-5% generic                            |                 | 0805       |              |
| R14                   | 470R 0.125W +/-5% generic                           |                 | 0805       |              |
| R15, R20              | 8R2 0.33W +/-1% generic                             |                 | 1206       |              |
| R16, R17,<br>R22, R23 | 2R2 0.25W +/-1% generic                             |                 | 1206       |              |
| R18, R19,<br>R24, R25 | 0R 0.25W +/-1% generic                              |                 | 1206       |              |
| R21                   | 1R 0.25W +/-1% generic                              |                 | 1206       |              |
| F1                    | 10R 1W fusible resistor +/-200ppm generic           |                 |            |              |
| C1,C2                 | 33 $\mu$ F 450V electrolytic capacitor              | EEUED2E330      |            | Panasonic    |
| C4,C11                | 4.7 $\mu$ F 25V X7R                                 |                 | 1206       |              |
| C5                    | 1 $\mu$ F 50V X7R                                   |                 | 1206       |              |
| C7,C8                 | 33 $\mu$ F 63V                                      |                 |            |              |
| C10                   | 100nF 16V X7R                                       |                 | 0805       |              |
| CX1,CX2,<br>CX3, CX4  | 100nF 275VAC, Film, X2, 20%                         | ECQU2A104ML     |            | Panasonic    |
| MOV1                  | 275V Varistor, 21J                                  | B72207S0271K101 | 5mm pitch  | Epcos        |
| L1                    | 6.8mH 290mA                                         | 19R685C         |            | Murata       |
| L2                    | 30mH 300mA common mode choke                        | B82791G2301N001 |            | Epcos        |
| T1                    | 800 $\mu$ H Flyback transformer turn ratio = 1.76:1 | OWTR-PT25C774   | EER25      | Olewoff      |

## PERFORMANCE





Operating waveforms during normal operation (Orange: AL9910A's gate output voltage; Green: Q1's Drain current; Blue: Q1's Drain voltage)



Operating waveforms during start up condition (Orange: AL9910A's gate output voltage; Green: Q1's Drain current; Blue: Q1's Drain voltage)

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