

# AP8802EV3 USER GUIDE

## DESCRIPTION

The AP8802EV3, Figure 1, is a PCB constructed using an FR4 base for evaluating the AP8802 LED driver with internal switch in DFN3030-10 package. The evaluation board can be used to drive an external choice of LEDs; the total forward voltage across the LEDs depending on the number and type connected. [1]

The suggested operating voltage for the evaluation board ranges from 8V to 45V maximum. Higher voltage means lower supply current.

The nominal current for the evaluation board is set at 1A with a 0R2 sense resistor, R1.

Test point CTRL provides a connection point for DC or PWM dimming and shutdown.

**Note:** The evaluation board does not have reverse polarity protection

Warning: with 1A output, the connected LED will be hot and very bright

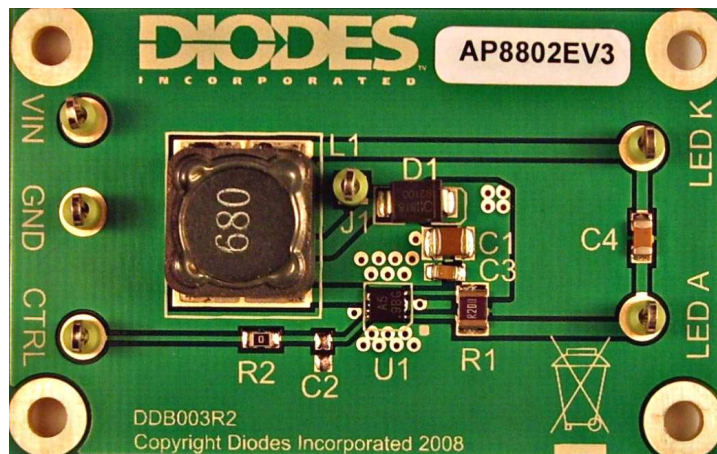


Figure 1: AP8802EV3 evaluation board

## AP8802 DEVICE DESCRIPTION

The AP8802 is a step-down DC/DC converter designed to drive LEDs with a constant current. The device can drive up to thirteen LEDs, depending largely on the forward voltage of the LEDs, in series from a voltage source of 8V to 60V. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminates the need for ballast resistors. The AP8802 switches at frequencies up to 500kHz. This allows the use of small size external components, hence minimizing the PCB area needed.

Maximum output current of AP8802 is set via an external resistor connected between the  $V_{IN}$  and SET input pins. Dimming is achieved by applying either a DC voltage or a PWM signal at the CTRL input pin. An input voltage of 0.2V or lower at CTRL shuts down the output at SW and puts the device into a low-current standby state.

The device includes the output switch and a current sense circuit, which requires an external sense resistor to set the nominal current up to 1A.

## AP8802 DEVICE FEATURES

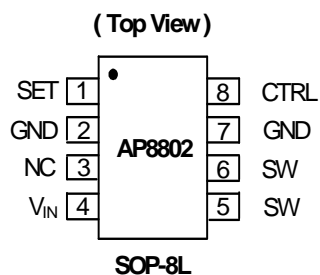
- LED driving current up to 1A
- Input voltage from 8V to 60V
- High efficiency up to 92%
- High switching frequency up to 500KHz minimum
- PWM/DC input for dimming control
- Built-in soft-start function
- Built-in output open-circuit protection
- SOP-8L, MSOP-8L, DFN3030-10 are available in "Green" Molding Compound (No Br, Sb)
- Lead Free Finish/RoHS Compliant (Note 1)

## DEVICE APPLICATIONS

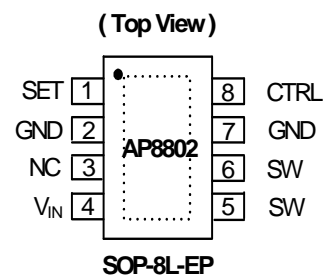
- Commercial & industrial lighting
- Small LCD panel backlighting
- Appliance interior lighting
- Architecture detail lighting

## AP8802 Device Packages, Pin and Definitions

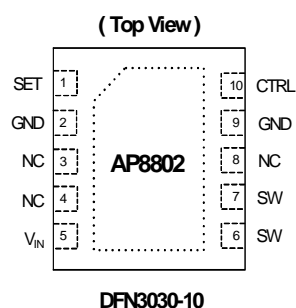
## (1) SOP-8L



## (2) SOP-8L-EP



## (3) DFN3030-10



## PIN DESCRIPTION

| Name     | Description   |
|----------|---|
| SW       | Switch Pin. Connect inductor/freewheeling diode here. Minimize trace area at this pin to reduce EMI.  |
| GND      | GND pin   |
| SET      | Set Nominal Output Current Pin. Configure the output current of the device.   |
| CTRL     | Dimming and On/Off Control Input. Input voltage of 0.2V or lower forces the device into low current standby mode and shut off the output. A PWM signal allows the output current to be adjusted above or below the level set by the resistor connected to SET input pin. The input impedance is about 50k, and if the pin is left open $V_{CTRL} = V_{REF}$ |
| $V_{IN}$ | Input Supply Pin. Must be locally bypassed with a capacitor.  |
| NC       | No connection   |

## ORDERING INFORMATION

| EVALBOARD ORDER NUMBER |
|------------------------|
| AP8802EV3              |

**Please note: Evaluation boards are subject to availability and qualified leads.**

| DEVICE ORDER NUMBER |                 |             |
|---------------------|-----------------|-------------|
| Device              | Package         | Tape & Reel |
| AP8802              | S (SOP8L)       | -13         |
|                     | SP (SOP-8L-EP)  | -13         |
|                     | FN (DFN3030-10) | -7          |

### AP8802EV3 EVALUATION BOARD REFERENCE DESIGN

The AP8802EV3 is an evaluation board configured to be used with the AP8802 in DFN3030-10 package. The target application is a driver for one or more series-connected LEDs for luminaires in both commercial and automotive applications.

The suggested maximum operating voltage for the evaluation board is 45V, and a 0R2 sense resistor R1 sets the nominal current at 1A.

An accurate way of determining the current, avoiding the need to insert an ammeter in the current path, is to measure the voltage on the sense resistor. A 10k resistor and a 1uF capacitor can be used to form a low pass filter and the voltage across the capacitor represents a more stable dc reading of current. Using this method, 200mV represents 1 Amp when using a 0R2 sense resistor.

The CTRL pin connects to a low pass filter within the AP8802 chip to provide some decoupling, but the external capacitor C2 (100nF) is used to provide additional decoupling to reduce any high frequency noise as well as providing soft start function.

Both DC and PWM dimming can be achieved by driving the CTRL pin. For DC dimming, the CTRL pin may be driven between 0.3V and 1.25V. Driving the CTRL pin below 0.2V will shut down the output current. For PWM dimming, an external open-collector NPN transistor or open-drain N-channel MOSFET can be used to drive the CTRL pin. The PWM frequency can be around 100Hz to 1 kHz. For better resolution, PWM capacitor C2 should be removed on the evaluation board, to give a more accurate duty cycle.

Shorting R2 will connect the test pin CTRL to device pin CTRL if needed. The external capacitor C2 on the CTRL pin sets the soft start time. The amount of soft start time achievable is approximately 0.2ms/nF.

For other reference designs or further applications information, please refer to the AP8802 datasheet.

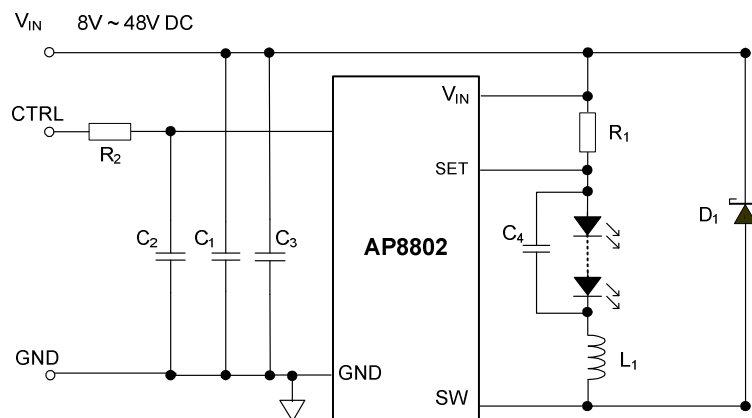


Figure 2: Schematic of the Evaluation Board

## AP8802 OPERATION

In normal operation, when voltage is applied at  $V_{IN}$ , the AP8802's internal NDMOS switch is turned on. Current starts to flow through sense resistor  $R_1$ , inductor  $L_1$ , and the LED(s). The current ramps up linearly. The ramp rate is determined by the input voltage  $V_{IN}$  and inductor  $L_1$ . This rising current produces a voltage ramp across  $R_1$ . The internal circuit of the AP8802 senses this voltage and applies a proportional voltage to the input of the internal comparator. When this voltage reaches an internally set upper threshold, the NDMOS switch is turned off. The inductor current continues to flow through  $R_1$ ,  $L_1$ , LED(s), Schottky diode  $D_1$ , and back to the supply rail. The current decays, with the rate of decay determined by the forward voltage drop of the LEDs and the Schottky diode. This decaying current produces a falling voltage at  $R_1$  which is sensed by the AP8802. A voltage proportional to the sense voltage across  $R_1$  is applied at the input of the internal comparator. When this voltage falls to the internally set lower threshold, the NDMOS switch is turned on again. This switch-on-and-off cycle continues to provide an average current (set by the sense resistor  $R_1$ ) to the LEDs. Please refer to the datasheet for the threshold limits, AP8802 internal circuits, electrical characteristics and parameters.

## AP8802EV3 EVALUATION BOARD - BILL OF MATERIALS

| Ref | Value       | Package | Part Number  | Manufacturer            | Notes               |
|-----|-------------|---------|--|-------------------------|---------------------|
| U1  | AP8802      | DFN3030 | AP8802FNG  | DIODES inc              | DC-DC converter     |
| D1  | 100V, 2A    | SMB     | B2100  | DIODES inc              | Schottky diode      |
| R1  | 0R2         | 1206    | SR732ETTDR200F                                     | KOA                     | +/-1%,<br>+/-100ppm |
| R2  | 0R0         | 0805    | Generic  | -                       | +/-1%               |
| C1  | 4.7uF 50V   | 1210    | C1210X475K5RAC<br>GRM32ER71H475KA88L               | KEMET Murata            | X7R +/-10%          |
| C2  | -           | -       | Not Fitted   | -                       | -                   |
| C3  | 100nF, 100V | 0805    | Generic  | -                       | X7R +/-20%          |
| C4  | 100nF 100V  | 1206    | Generic  | -                       | X7R +/-20%          |
| L1  | 68uH        | -       | MSS1038-683ML<br>NPIS104F680MTRF<br>NPIS24H680MTRF | Coilcraft<br>NIC<br>NIC | 68uH                |

The FR4 PCB design, with adequate copper top and bottom and plated through vias for thermal coupling, guarantees a good thermal dissipation for the AP8802 device. Other sources of heat are the Schottky diode, the inductor and the sense resistor, therefore care must be taken in their placement.

**Warning: At 45V operation with 1A output, the board temperature rises by around 60C from ambient after 30 minutes of operation.**

| AP8802EV3 Connection Point Definition |  |
|---------------------------------------|--|
| Name                                  | Description  |
| VIN                                   | Positive supply voltage.   |
| GND                                   | Supply Ground (0V).  |
| CTRL                                  | Internal voltage ref. pin (1.25V). This pin can be used to achieve dimming and soft-start, and for switching the output current off. <ul style="list-style-type: none"> <li>• Leave floating for normal operation.</li> <li>• See 'Circuit Features' section to achieve dimming, soft-start and for switching the output current off.</li> </ul> |
| LED A                                 | LED A connects to the external LED anode   |
| LED K                                 | LED K connects to the external LED cathode   |

### AP8802EV3 BASIC OPERATION AT FULL VOLTAGE

1. Connect external LEDs across test pins 'LED A' (anode) and 'LED K' (cathode). The number of external LEDs that can be connected depends on their operating power and forward voltage drop, but typically 12 x 3.2V LEDs can be connected using a 45V rail. For an external load other than LEDs, the positive terminal of the load should be connected to the anode and the negative to the cathode.

2. Connect VIN and GND.

Warning: The board does not have reverse battery/supply protection.

3. Set the PSU to the desired input voltage (usually between 12V and 45V)
4. Turn on the PSU. The external LEDs will illuminate and the current should be approximately 1A
5. The switching waveform on the SW pin can be acquired using the test point J1

Warning: Do not stare at the LEDs directly.

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## CIRCUIT FEATURES

### N.B. Remove power whilst changing components!

#### Soft-start

1. The AP8802 has a in-built soft start function. A capacitor, C2 may be fitted to the evaluation board to increase the soft start time by slowing the rise time of the adjust pin at start-up at the rate of 0.2ms/nF. The board is supplied with a zero-ohm resistor in position R2. Please see the data sheet for further details.

#### PWM

1. Remove the soft start capacitor C2
2. Refer to the datasheet for instructions on how to perform PWM

#### Switching off the output current

3. Shorting the CTRL pin to GND will cause the LED current to go to zero. Releasing this pin will switch on the system (creating a soft-start power up sequence if the C2 capacitor is used).

#### Changing the LED current

1. refer to the datasheet for the derating curve and the power dissipation capability of the package
2. Remove R1
3. Calculate and fit a new sense resistor, R1, the value of which is based on the required LED current without dimming. R1 can be calculated using following equation :

$$R1 = 0.2V / I_{LED} \quad \text{where } I_{LED} = \text{the LED current.}$$

R1 = the sense resistors value in ohms.  
0.2V is the nominal sense voltage with CTRL open circuit or set to 1.25V.

## PERFORMANCE

The system efficiency depends on the sense resistor, supply voltage, switching inductor, and the number of LEDs.

With a 45V supply and 12 LEDs, the switching frequency is typically 200kHz and efficiency levels >90% are achievable.

Visit our website [www.diodes.com](http://www.diodes.com) to find useful tools for circuit design and simulation.

## REFERENCE

[1] AP8802 Datasheet – [www.diodes.com](http://www.diodes.com)

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