

# AP8800EV2 USER GUIDE

## DESCRIPTION

The AP8800EV2, Figure 1, is a PCB constructed using an FR4 base for evaluating the AP8800 LED driver with internal switch in MSOP-8L 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 operating voltage for the evaluation board ranges from 8V to 28V maximum. Higher voltage means lower supply current.

The nominal current for the evaluation board is set at 300mA with a 0R33 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 300mA output, the connected LED will be hot and very bright

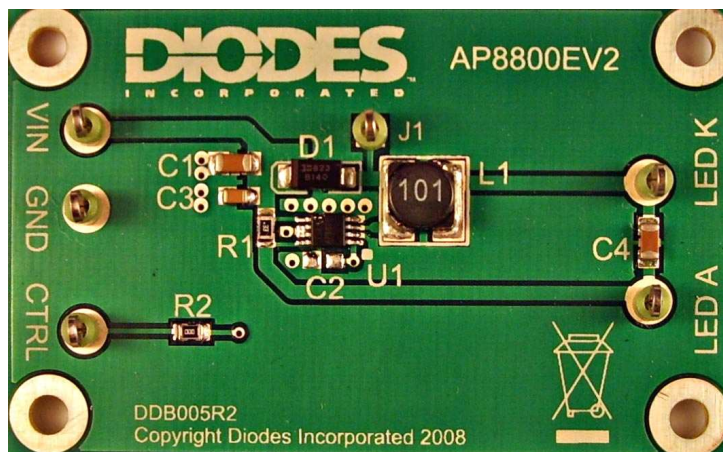


Figure 1: AP8800EV2 Evaluation Board

## AP8800 DEVICE DESCRIPTION

The AP8800 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 28V. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminates the need for ballast resistors. The AP8800 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 AP8800 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 300mA.

**AP8800 DEVICE FEATURES**

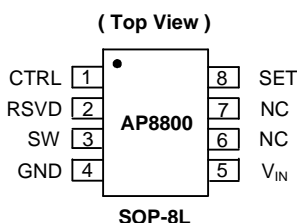
- LED driving current up to 350mA
- Input voltage from 8V to 28V
- High efficiency up to 92%
- High switching frequency up to 500KHz minimum
- PWM/DC input for dimming control
- Built-in soft-start function
- Built-in output open-circuit protection
- SOP-8L, MSOP-8L and DFN3030-10 are available in “Green” Molding Compound (No Br, Sb)
- Lead Free Finish/RoHS Compliant (Note 1)

**DEVICE APPLICATIONS**

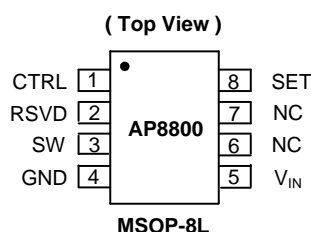
- Commercial & industrial lighting
- Small LCD panel backlighting
- Appliance interior lighting
- Architecture detail lighting

**AP8800 Device Packages, Pin and Definitions**

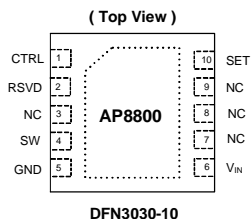
**(1) SOP-8L**



**(2) MSOP-8L**



**(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 200k, and if the pin is left open $V_{CTRL} = V_{REF}$
V <sub>IN</sub>	Input Supply Pin. Must be locally bypassed with a capacitor.
NC	No connection

**ORDERING INFORMATION**

EVALBOARD ORDER NUMBER
AP8800EV2

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

DEVICE ORDER NUMBER		
Device	Package	Tape & Reel
AP8800	S (SOP8L)	-13
	M8 (MSOP-8L)	-13
	FN(DFN3030-10)	-7

## AP8800EV2 EVALUATION BOARD REFERENCE DESIGN

The AP8800EV2 is an evaluation board configured to be used with the AP8800 in MSOP-8L package. The target application is a driver for one or more series-connected LEDs for luminaires in both commercial and automotive applications.

The maximum operating voltage for the evaluation board is 28V, and a 0R33 sense resistor R1 sets the nominal current at 300mA.

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, 100mV represents 0.3 Amp when using a 0R33 sense resistor.

The CTRL pin connects to a low pass filter within the AP8800 chip to provide some decoupling, but the external capacitor C2 (100nF) can be 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 can be used to set the soft start time. The amount of soft start time achievable is approximately 0.5ms/nF.

For other reference designs or further applications information, please refer to the AP8800 datasheet.

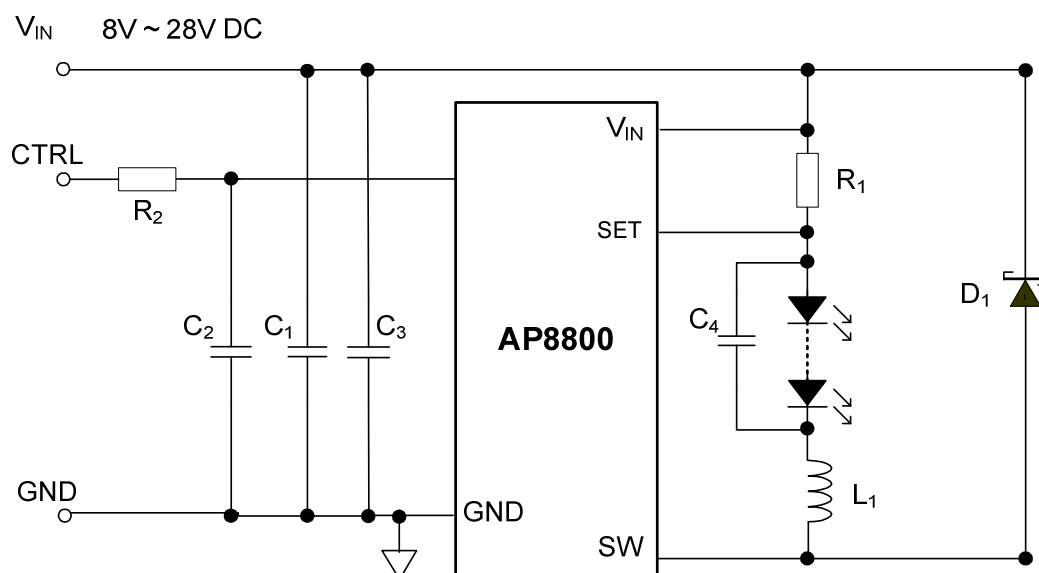


Figure 2: Schematic of the Evaluation Board

## AP8800 Operation

In normal operation, when voltage is applied at  $V_{IN}$ , the AP8800's internal NDMOS switch is turned on. Current starts to flow through sense resistor R1, inductor L1, and the LED(s). The current ramps up linearly. The ramp rate is determined by the input voltage  $V_{IN}$  and inductor L1. This rising current produces a voltage ramp across R1. The internal circuit of the AP8800 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 R1, L1, LED(s), Schottky diode D1, 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 R1 which is sensed by the AP8800. A voltage proportional to the sense voltage across R1 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 R1) to the LEDs. Please refer to the datasheet for the threshold limits, AP8800 internal circuits, electrical characteristics and parameters.

## AP8800EV2 Evaluation Board - BOM

Ref	Value	Package	Part Number	Manufacturer	Notes
U1	AP8800	MSOP-8L	AP8800M8G	DIODES inc	DC-DC converter
D1	40V, 1A	SMA	B140	DIODES inc	Schottky diode
R1	0R33	0805	NCST10FR330FTRF Generic	NIC	1%
R2	0R0	0805	Generic	-	-
C1,C4	1uF 50V	1206	NMC1206X7R105K50F	NIC	10%
C2	-	-	Not Fitted	-	-
C3	100nF, 100V	0805	C0805C104K1RAC NMC0805X7R104K100	Kemet NIC	10%
L1	100uH	-	MSS6132 100uH NPIS53D101MTRF	Coilcraft NIC	100uH

The FR4 PCB design, with adequate copper top and bottom and plated through vias for thermal coupling, guarantees a good thermal dissipation for the AP8800 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 28V operation with 300mA output, the board temperature rises by around 50C from ambient after 30 minutes of operation.**

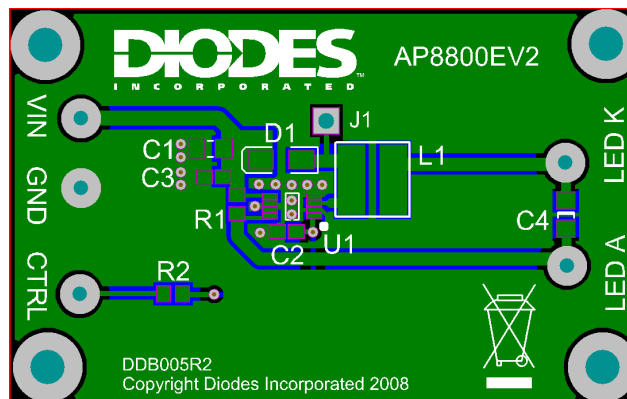


Figure 3: Component layout and circuit board view

AP8800EV2 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

### AP8800EV2 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 7 x 3.2V LEDs can be connected using a 28V 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 8V and 28V)
4. Turn on the PSU. The external LEDs will illuminate and the current should be approximately 300mA
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 0.5ms/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. Remove R1
2. 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 :

$$R1 = 0.1V / I_{LED} \quad \text{where } I_{LED} = \text{the LED current.}$$

R1 = the sense resistors value in ohms.  
0.1V 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 28V supply and 7 LEDs, the switching frequency is typically 320 kHz 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] AP8800 Datasheet – [www.diodes.com](http://www.diodes.com)

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