NEW PRODUCT

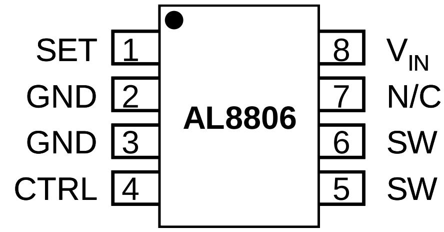
Description

The AL8806 is a step-down DC/DC converter designed to drive LEDs with a constant current. The device can drive up to 8 LEDs, depending on the forward voltage of the LEDs, in series from a voltage source of 6V to 30V. The AL8806 switches at frequency up to 1MHz. This allows the use of small size external components, hence minimizing the PCB area needed.

Maximum output current of AL8806 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 0.4V or lower at CTRL switches off the output MOSFET simplifying PWM dimming.

Pin Assignments

MSOP-8EP



Features

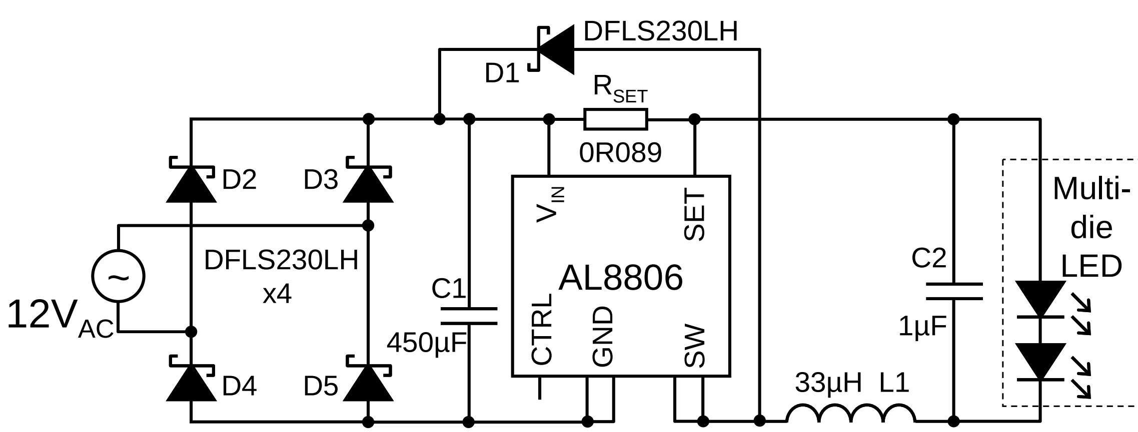
- LED driving current up to 1.5A
- Better than 5% accuracy
- High efficiency up to 98%
- Operating input voltage from 6V to 30V
- High switching frequency up to 1MHz
- PWM/DC input for dimming control
- Built-in output open-circuit protection
- SOT25 MSOP8-EP: Available in "Green" Molding Compound (No Br, Sb) with lead Free Finish/RoHS Compliant (Note 1)

Applications

- High power MR16 lamps
- General illumination lamps
- Multi-die LED driver

Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at: http://www.diodes.com/products/lead_free.html

Typical Application Circuit



Pin Descriptions

Pin Name	Pin Number MSOP-8EP	Descriptions
SW	5, 6	Switch Pin. Connect inductor/freewheeling diode here, minimizing track length at this pin to reduce EMI.
GND	2, 3	GND Pin
CTRL	4	Dimming and On/Off Control Input. • Leave floating for normal operation. (V_{CTRL} = V_{REF} = 2.5V giving nominal average output current I_{OUTnom} = 0.1/R_S) • Drive to voltage below 0.4V to turn off output current • Drive with DC voltage (0.5V < V_{CTRL} < 2.5V) to adjust output current from 20% to 100% of I_{OUTnom} • A PWM signal (low level ≤ 0.4V and high level > 2.6; transition times less than 1us) allows the output current to be adjusted below the level set by the resistor connected to SET input pin.
SET	1	Set Nominal Output Current Pin. Configure the output current of the device.
V_{IN}	8	Input Supply Pin. Must be locally decoupled to GND with $\geq$ 2.2µF X7R ceramic capacitor – see applications section for more information.
EP	EP	Exposed pad/TAB connect to GND and thermal mass for enhanced thermal impedance
N/C	7	no connection

Absolute Maximum Ratings (T_A = 25°C)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	2.5	kV
ESD MM	Machine Model ESD Protection	200	V
V_{IN}	Continuous V_{IN} pin voltage relative to GND	-0.3~36	V
V_{SW}	SW voltage relative to GND	-0.3~36	V
V_{CTRL}	CTRL pin input voltage	-0.3 ~ 6	V
I_{SW-RMS}	DC or RMS switch current	1.65	A
I_{SW-PK}	Peak switch current (<10%)	3	A
T_J	Junction Temperature	150	°C
T_{LEAD}	Lead Temperature Soldering	300	°C
T_{ST}	Storage Temperature Range	-65 to +150	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any condition.
Semiconductor devices are ESD sensitive and may 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)

Symbol	Parameter	Min	Max	Unit
V_{IN}	Operating Input Voltage relative to GND	6.0	30	V
V_{CTRLH}	Voltage High for PWM dimming relative to GND	2.6	5.5	V
V_{CTRLDC}	Voltage range for 20% to 100% DC dimming relative to GND	0.5	2.5	V
V_{CTRLL}	Voltage Low for PWM dimming relative to GND	0	0.4	V
I_{SW}	DC or RMS switch current		1.5	A
f_{OSC}	Switching Frequency		1	MHz
T_J	Junction Temperature Range	-40	125	°C

Electrical Characteristics

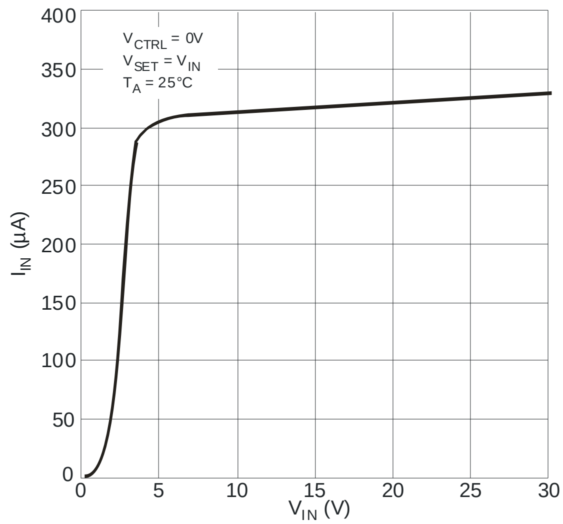
V_{IN} =12V, T_A=25°C, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
V_{INSU}	Internal regulator start up threshold	V_{IN} rising			5.9	V
V_{INSH}	Internal regulator hysteresis threshold	V_{IN} falling	100		300	mV
I_Q	Quiescent current	Output not switching (Note 2)			350	µA
I_S	Input supply Current	CTRL pin floating f = 250kHz		1.8	5	mA
V_{TH}	Set current Threshold Voltage	V_{CTRL} ≥ 2.6V or floating.	95	100	105	mV
$V_{TH\text{-}H}$	Set threshold hysteresis			±20		mV
I_{SET}	SET pin input current	V_{SET} = V_{IN}-0.1		16	22	µA
R_{CTRL}	CTRL pin input resistance	Referred to internal reference		50		kΩ
V_{REF}	Internal Reference Voltage			2.5		V
$R_{DS(on)}$	On Resistance of SW MOSFET	I_{SW} = 1A		0.18	0.35	Ω
$I_{SW\_Leakage}$	Switch leakage current	V_{IN} =30V			0.5	µA
θ_{JA}	Thermal Resistance Junction-to-Ambient (Note 4)	MSOP-8EP (Note 3)		69		°C/W

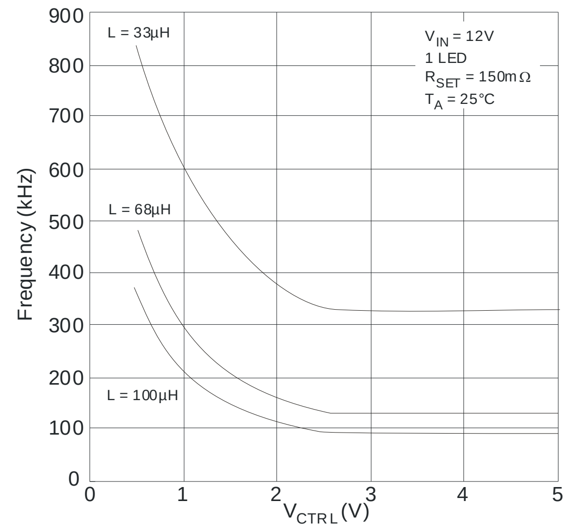
Notes:
2. AL8806 does not have a low power standby mode but current consumption is reduced when output switch is inhibited: V_{SENSE} = 0V. Parameter is tested with V_{CTRL} ≤ 2.5V
3. Measured on an FR4 51x51mm PCB with 2oz copper standing in still air. Refer to figure 5 for the device derating curve.
4. Test condition: 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

NEW PRODUCT

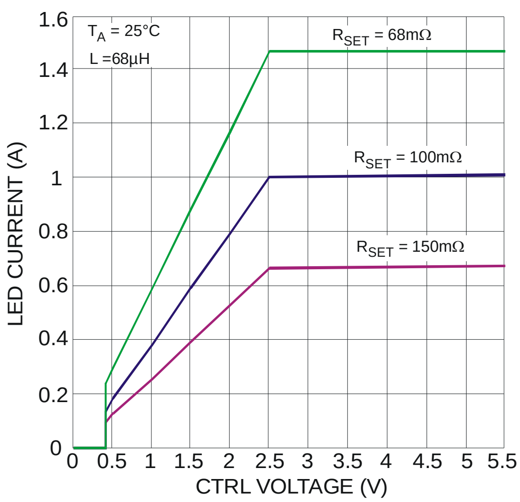
Typical Performance Characteristics (T_A = 25°C unless otherwise stated)



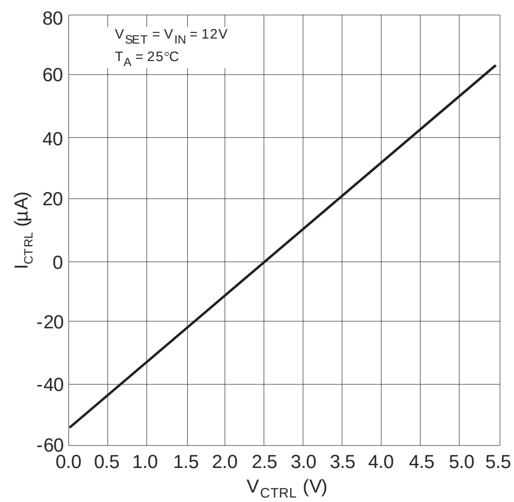
Supply Current (not switching) vs. Input Current



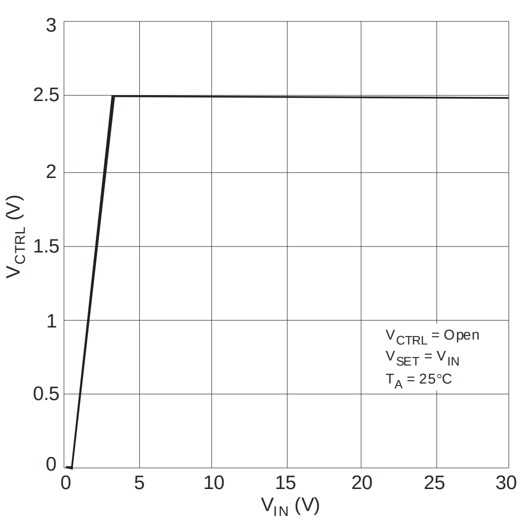
Switching Frequency vs. V_{CTRL}



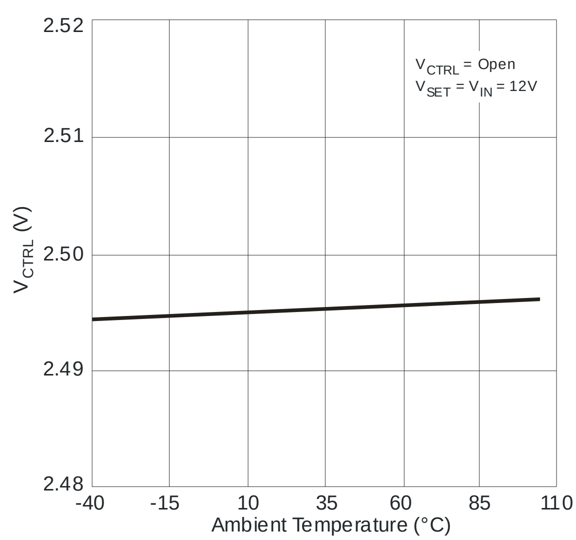
LED Current vs. V_{CTRL}



I_{CTRL} vs V_{CTRL}



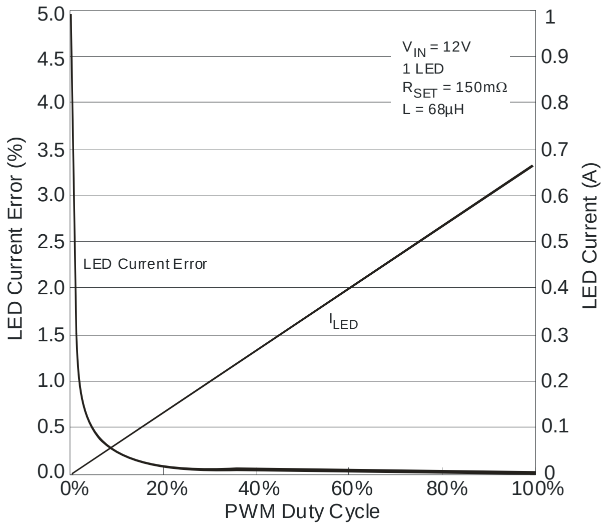
V_{CTRL} vs. Input Voltage
(CTRL pin open circuit)



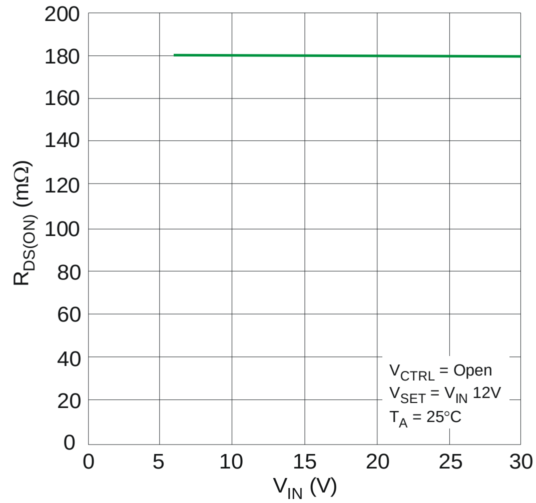
V_{CTRL} vs. Temperature

NEW PRODUCT

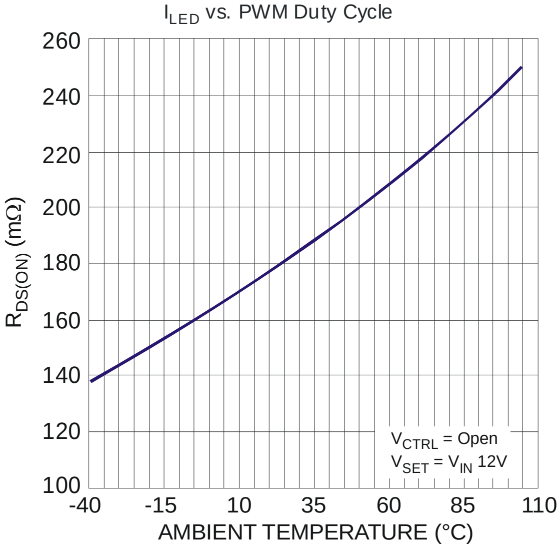
Typical Performance Characteristics Continued (T_A = 25°C unless otherwise stated)



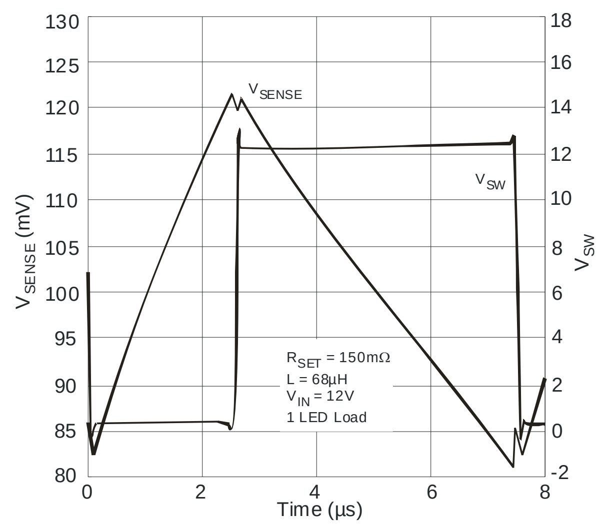
I_{LED} vs. PWM Duty Cycle



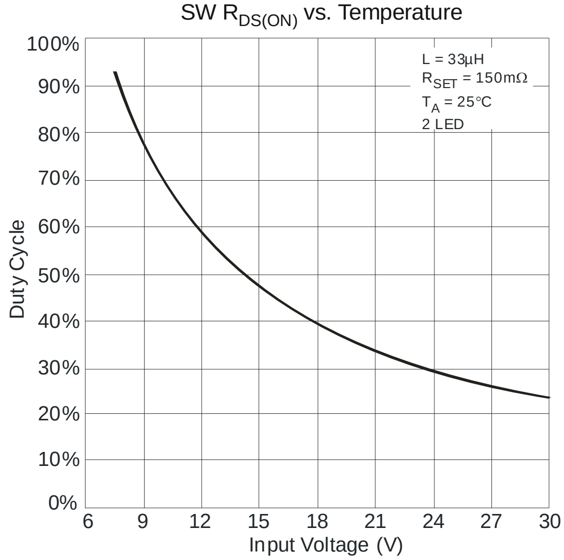
$R_{DS(ON)}$ vs. Input Voltage



SW $R_{DS(ON)}$ vs. Temperature



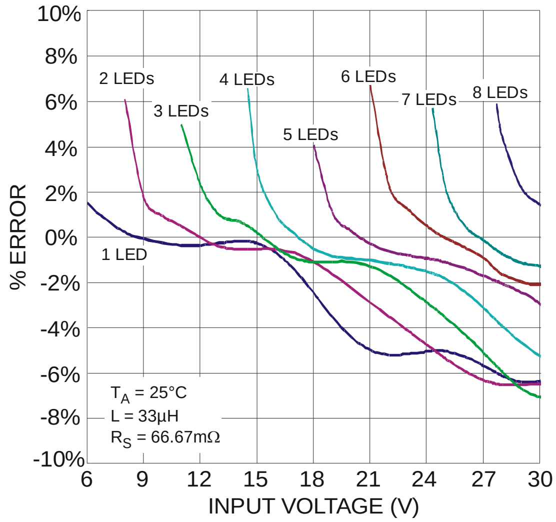
SW Output Switching Characteristics



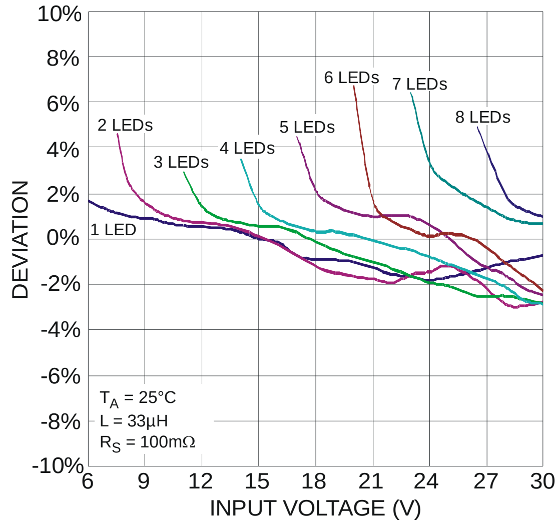
Duty Cycle vs. Input Voltage

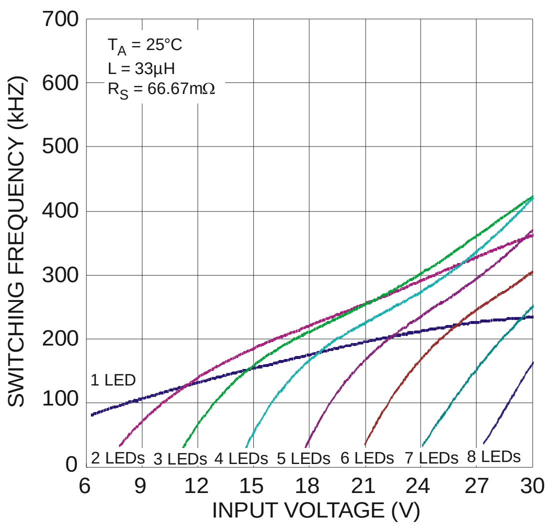
Typical Operating Performance Characteristics (T_A = 25°C unless otherwise stated)

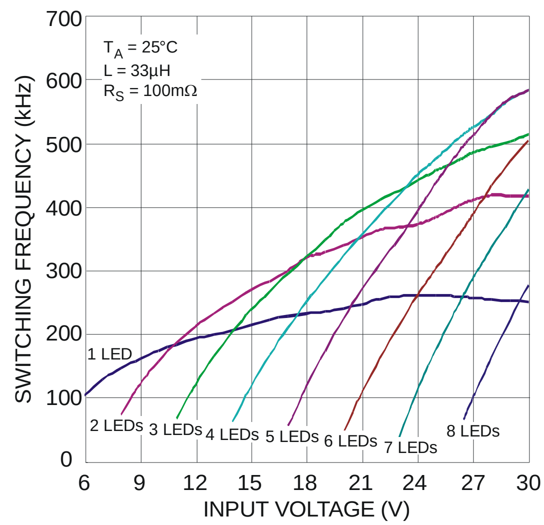
1.5A nominal LED current

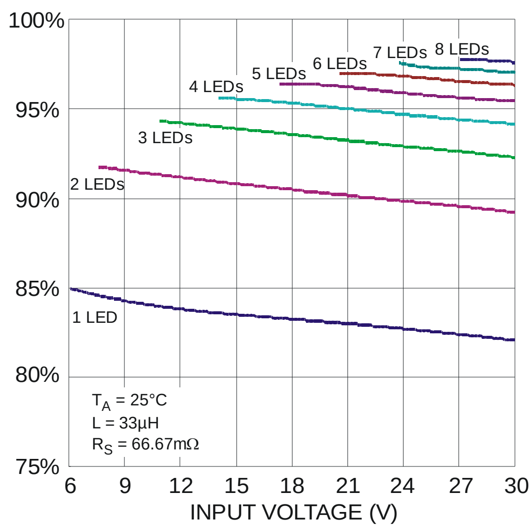


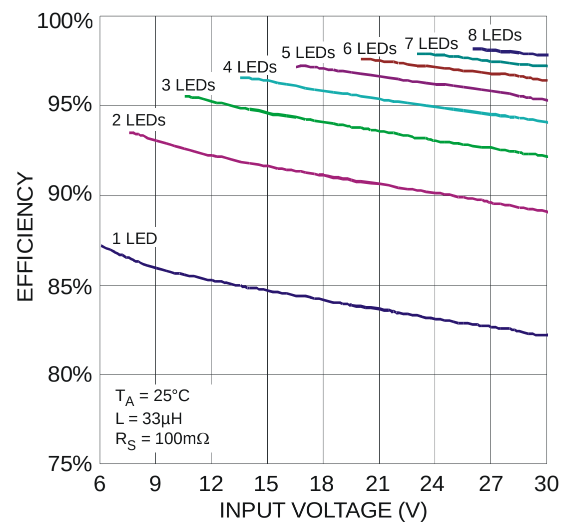
1.0A nominal LED current











Application Information

AL8806 Operation

In normal operation, when voltage is applied at V_{IN}, the AL8806 internal switch is turned on. Current starts to flow through sense resistor R_{SET}, inductor L1, and the LEDs. The current ramps up linearly, and the ramp rate is determined by the input voltage V_{IN} and the inductor L1.

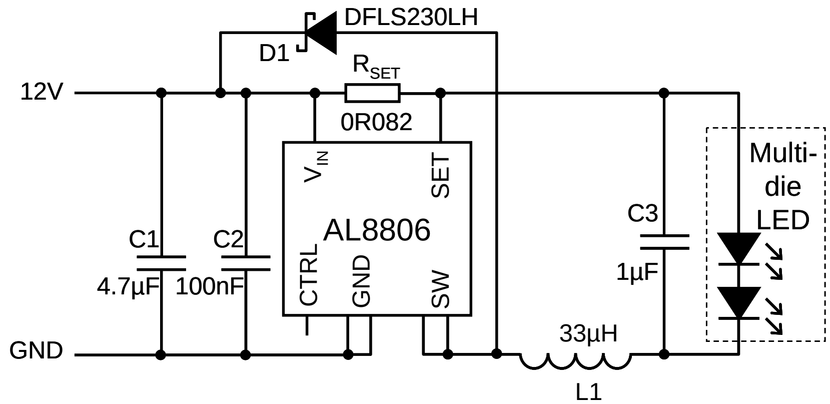


Figure 1: Typical Application Circuit

This rising current produces a voltage ramp across R_{SET}. The internal circuit of the AL8806 senses the voltage across R_{SET} and applies a proportional voltage to the input of the internal comparator.

When this voltage reaches an internally set upper threshold, the internal switch is turned off. The inductor current continues to flow through R_{SET}, L1, the LEDs and the schottky diode D1, and back to the supply rail, but it 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 AL8806. A voltage proportional to the sense voltage across R_{SET} is applied at the input of the internal comparator. When this voltage falls to the internally set lower threshold, the internal switch is turned on again. This switch-on-and-off cycle continues to provide the average LED current set by the sense resistor R_{SET}.

LED Current Control

The LED current is controlled by the resistor R_{SET} in Figure 1.

Connected between V_{IN} and SET the nominal average output current in the LED(s) is defined as:

$$I_{LED} = \frac{V_{THD}}{R_{SET}}$$

If the CTRL pin is driven by an external voltage (higher than 0.4V and lower than 2.5V), the average LED current is:

$$I_{LED} = \frac{V_{CTRL}}{V_{REF}} \frac{V_{THD}}{R_{SET}}$$

For example for a desired LED current of 1.33A and a default voltage V_{CTRL}=2.5V the resulting resistor is:

$$R_{SET} = \frac{V_{THD}}{I_{LED}} \frac{V_{CTRL}}{V_{REF}} = \frac{0.1}{1.33} \frac{2.5}{2.5} \approx 75m\Omega$$

DC Dimming

The CTRL pin can be driven by an external DC voltage (V_{CTRL}), to adjust the output current to a value below the nominal average value defined by R_{SET}. The LED current decreases linearly with the CTRL voltage when $0.5V \le V_{CTRL} \le 2.5V$, as shown on page 4 for 4 different current levels.

Note that 100% brightness setting corresponds to $V_{CTRL} = V_{REF}$, nominally 2.5V. For any voltage applied on the CTRL pin that is higher than V_{REF}, the device will not overdrive the LED current and will still set the current according to the equation $V_{CTRL} = V_{REF}$.

When the CTRL voltage falls below the threshold, 0.4V, the output switch is turned off which allows PWM dimming.

Applications Information (continued)

PWM Dimming

LED current can be adjusted digitally, by applying a low frequency Pulse Width Modulated (PWM) logic signal to the CTRL pin to turn the device on and off. This will produce an average output current proportional to the duty cycle of the control signal. In particular, a PWM signal with a max resolution of 10bit can be applied to the CTRL pin to change the output current to a value below the nominal average value set by resistor R_{SET}. To achieve this resolution the PWM frequency has to be lower than 500Hz, however higher dimming frequencies can be used - at the expense of dimming dynamic range and accuracy.

Typically, for a PWM frequency of 500Hz the accuracy is better than 1% for PWM ranging from 1% to 100%.

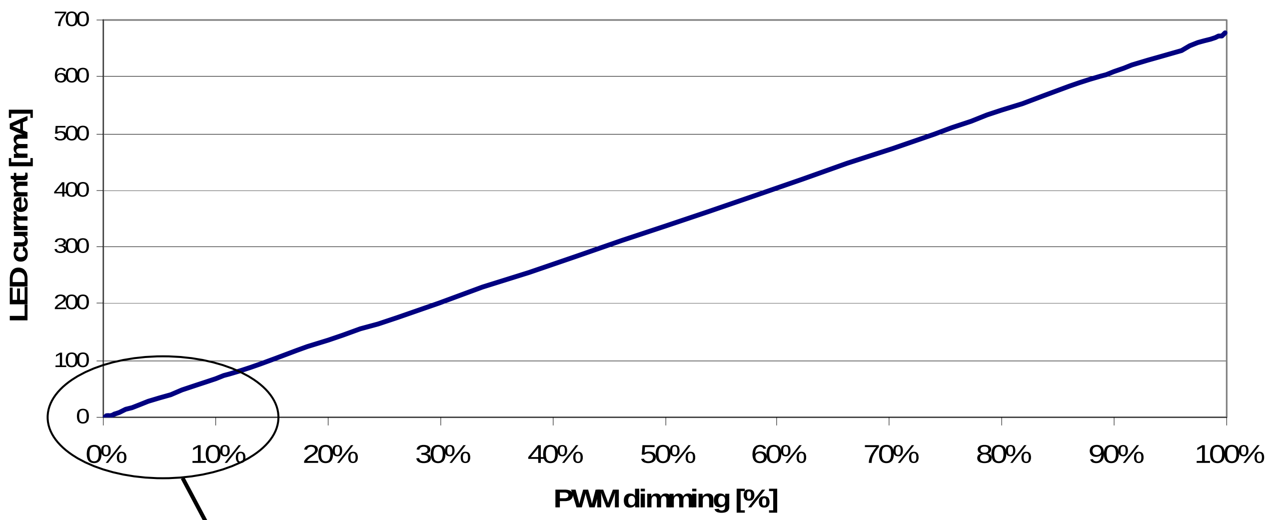


Figure 2. PWM Dimming at 500Hz

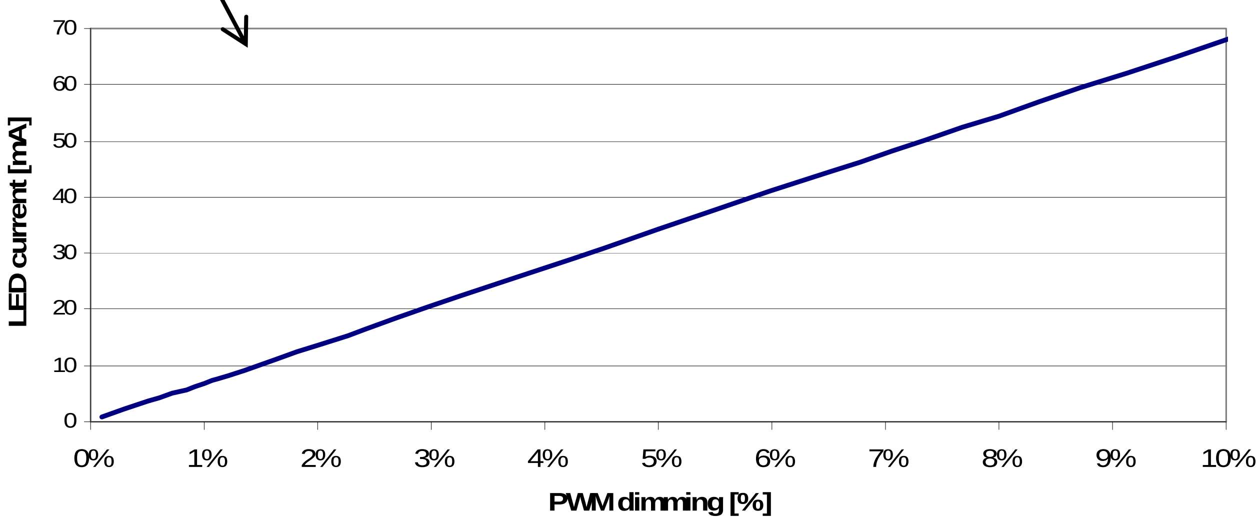


Figure 3. Low duty cycle PWM Dimming at 500Hz

The PWM pin is designed to be driven by both 3.3V and 5V logic levels directly from a logic output with either an open drain output or push-pull output stage.

Applications Information (continued)

Soft Start

The AL8806 does not have in-built soft-start action – this provides very fast turn off of the output the stage improving PWM dimming accuracy; nonetheless, adding an external capacitor from the CTRL pin to ground will provide a soft-start delay. This is achieved by increasing the time taken for the CTRL voltage to rise to the turn-on threshold and by slowing down the rate of rise of the control voltage at the input of the comparator. Adding a capacitor increases the time taken for the output to reach 90% of its final value, this delay is 0.1ms/nF, but will impact on the PWM dimming accuracy depending on the delay introduced.

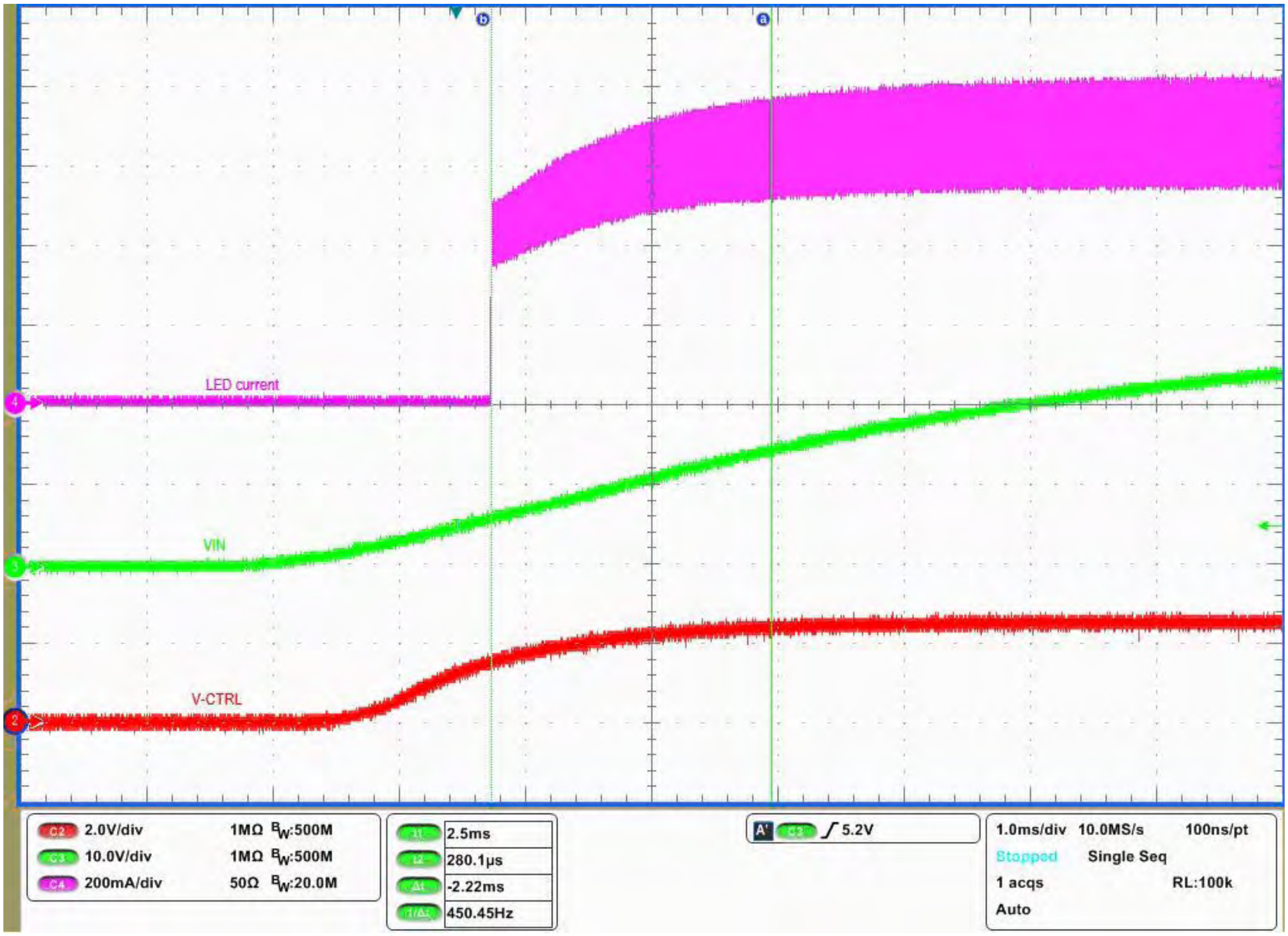


Figure 4. Soft start with 22nF capacitor on CTRL pin (V_{IN} = 30V, I_{LED} = 667mA, 1 LED)

Applications Information (continued)

Reducing output ripple

Peak to peak ripple current in the LED(s) can be reduced, if required, by shunting a capacitor C2 across the LED(s) as shown already in the circuit schematic.

A value of 1µF will reduce the supply ripple current by a factor three (approx.). Proportionally lower ripple can be achieved with higher capacitor values. Note that the capacitor will not affect operating frequency or efficiency, but it will increase start-up delay, by reducing the rate of rise of LED voltage. By adding this capacitor the current waveform through the LED(s) changes from a triangular ramp to a more sinusoidal version without altering the mean current value.

Capacitor Selection

The small size of ceramic capacitors makes them ideal for AL8806 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Z5U.
A 2.2µF input capacitor is sufficient for most intended applications of AL8806; however a 4.7µF input capacitor is suggested for input voltages approaching 30V.

Diode Selection

For maximum efficiency and performance, the rectifier (D1) should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature. The Schottky diode also provides better efficiency than silicon PN diodes, due to a combination of lower forward voltage and reduced recovery time.
It is important to select parts with a peak current rating above the peak coil current and a continuous current rating higher than the maximum output load current. In particular, it is recommended to have a diode voltage rating at least 15% higher than the operating voltage to ensure safe operation during the switching and a current rating at least 10% higher than the average diode current. The power rating is verified by calculating the power loss through the diode.

Schottky diodes, e.g. B240 or B140, with their low forward voltage drop and fast reverse recovery, are the ideal choice for AL8806 applications.

Thermal and layout considerations

For continuous conduction mode of operation, the absolute maximum junction temperature must not be exceeded. The maximum power dissipation depends on several factors: the thermal resistance of the IC package θ_{JA}, PCB layout, airflow surrounding the IC, and difference between junction and ambient temperature.

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

$$P_{D(MAX)} = \frac{(125°C - 25°C)}{69°C/W} = 1.45W$$

where $T_{J(MAX)}$ is the maximum operating junction temperature,

T_A is the ambient temperature, and
θ_{JA} is the junction to ambient thermal resistance.

The recommended maximum operating junction temperature, T_J, is 125°C and so maximum ambient temperature is determined by the AL8806's junction to ambient thermal resistance, θ_{JA}. To support high LED drive at higher ambient temperatures the AL8806 has been packaged in thermally enhanced MSOP-8EP package.

θ_{JA}, is layout dependent and the AL8806 in MSOP-8EP's θ_{JA} on a 51 x 51mm single layer PCB with 2oz copper standing in still air is approximately 69°C/W.

Therefore the maximum power dissipation at T_A = 25°C is:

$$P_{D(MAX)} = \frac{(125°C - 25°C)}{69°C/W} = 1.45W$$

Figure 5, shows the power derating of the AL8806 on an FR4 51x51mm PCB with 2oz copper standing in still air.

As the ambient temperature increases and/or the PCB area reduces the maximum power dissipated by the AL8806 will decrease.

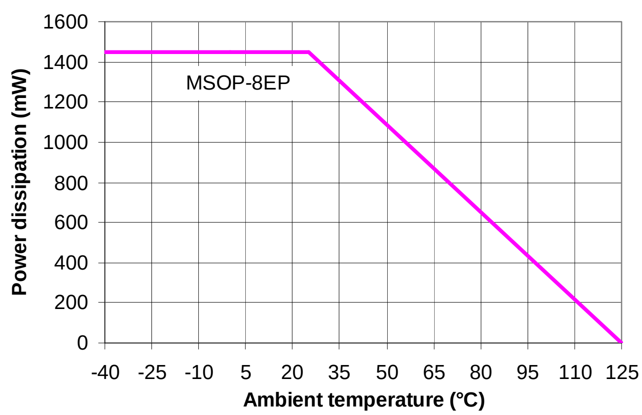


Figure 5. Derating Curve

NEW PRODUCT

Applications Information (continued)

PCB Layout

When laying out the PCB for the AL8806 the following should be observed:

1. The decoupling capacitor C1 has to be placed as close as possible to V_{IN}
2. The sense resistor, R_{SET}, has to be placed as close as possible to V_{IN} and SET
3. The anode of the freewheel diode (D1), the SW pin and the inductor have to be placed as close as possible to each other to avoid ringing.

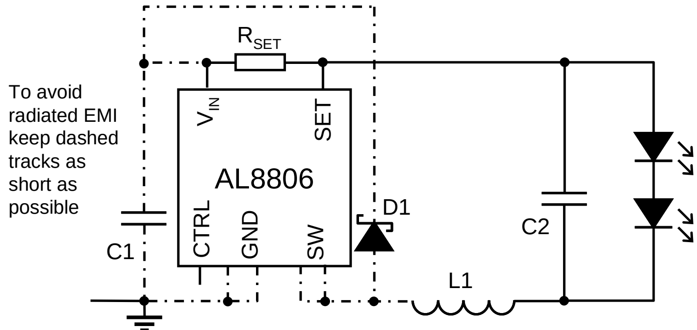


Figure 6. PCB Layout

The AL8806 has two evaluation boards available on request. Information can be found on the Diodes website and from a Diodes' sales representative.

Application Example

A typical application example for the AL8806 is the MR16 lamp; which normally operate from $12V_{DC}$ or $12V_{AC}$ supplies, using conventional electromagnetic transformers or electronic transformers.

As a replacement for MR16 halogen lamp LED lamps offer a more energy efficient solution - radiating no heat and no Ultra Violet light. The low thermal impedance of the AL8806 and its 1.5A switch capability allows it drive some of the latest multi-die LEDs; which increases the lamp's luminance.

This application example is intended to fit into the base connector space of an MR16 style LED lamp. The design has been optimized for part count and thermal performance for a multi-die LED in the Lens section.

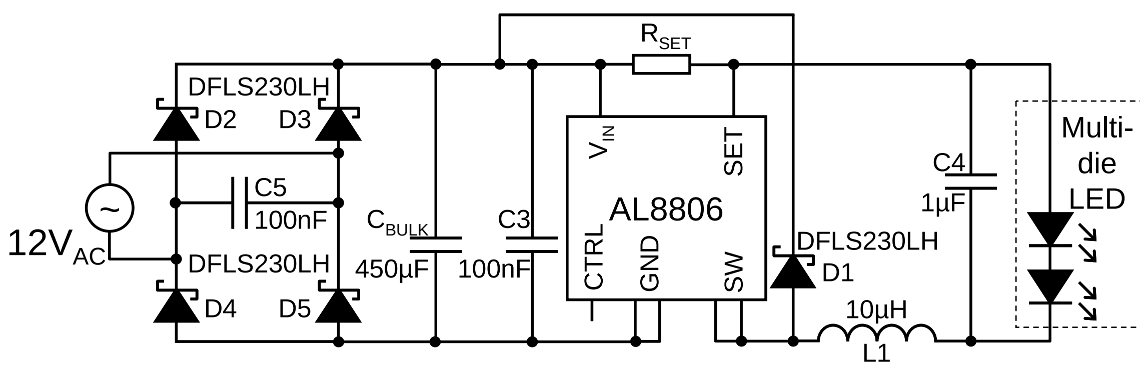


Figure 7. MR16 Schematic

The output of the 12V transformer is fed into the bridge rectifier, comprising of D2, D3, D4 and D5. C1 offers an optional EMI filtering at the input.

Capacitor, C_{BULK}, (capacitors C1, C2, C6 and C7 on the PCB and BOM are multiple components to reduce size) forms the bulk reservoir capacitance - used to sustain operation of the device during the low part of the rectified AC wave. In the case of a system driving two LEDs at 1.1A, three 150µF capacitors are required.

C3 provides local decoupling for the AL8806. It is important that C3 is as close as possible to the AL8806, as reflected in the layout shown below in figures 8 and 9.

NEW PRODUCT

Applications Information (continued)

The LED current is determined by the total resistance between the V_{IN} and SET pins (R_{SET} in schematic but named R1 and R2 in the PCB and BOM).

C4 decouples the LED connections, again to minimize EMI, as well as smoothing the current.

D1 operates as the freewheeling diode, providing a current path for the LED current when the power switch at SW pin is off.

Figure 8. AL8806EV3 evaluation board (Top)

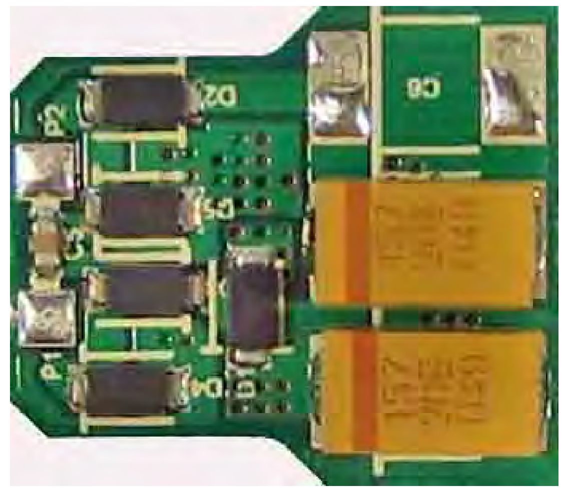


Figure 9. AL8806EV3 evaluation board (Bottom)

AL8806EV3 BOM

QUANTITY	PCB IDENT	VALUE	DESCRIPTION
1	U1	AL8806MP8-13	Diodes LED Driver IC
5	D1, D2, D3, D4, D5	DFLS230LH	Diodes freewheeling diode and bridge
1	R1	0R15	Resistor, 0805, +/-1% <+/-300ppm Generic KOA SR732ATTDR150F
1	R2	0R22	Resistor, 0805, +/-1% <+/-300pp Generic
3	C1, C2, C7	150µF 20V	SMD tantalum Kemet D case, T491X157K020AT
1	C3	100nF ≥ 25V	X7R 0805 Generic Kemet C0805C104K5RAC (50v) NIC NMC0805X7R104K50TRPF (50V)
1	C4	100nF ≥ 25V	X7R 1206 Generic
1	C5	100nF ≥ 25V	X7R 0603 Generic
0	C6	150µF 20V	SMD tantalum Kemet D case, T491X157K020AT
1	L1	10µH	MSS7341– 103ML

The AL8806 guarantees high level of performance both with $12V_{AC}$ and $12V_{DC}$ power supply.

Ordering Information

AL8806 XXX - XX

Package	Packing
MP8 : MSOP-8EP	13 : 13" Tape & Reel

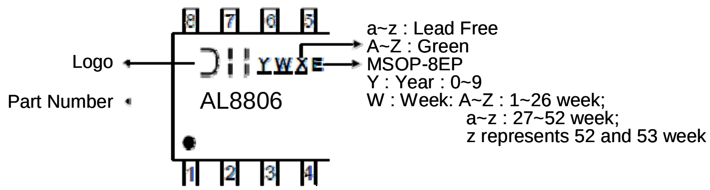
Device	Package Code	Packaging (Note 5)	Tape and Reel	
			Quantity	Part Number Suffix
AL8806MP8-13	MP8	MSOP-8EP	2500/Tape & Reel	-13

Notes: 5. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Marking Information

MSOP-8EP

(Top View)



Part Number	Package
AL8806MP8-13	MSOP-8EP

Package Information

MSOP-8EP