Constant Current LED Lighting Driver

With PWM Dimming Control

General Description

The EMD2081 was designed with high efficiency step up DC/DC converter with constant current source for driving lighting LEDs. Wide input voltage range makes the application more flexible. LED dimming can be achieved with pulse width modulation dimming on DIM pin. The EMD2081 switches at 1.2MHz and allows using small inductor and both of input/output capacitors. An internal compensation can reduce external component.

The EMD2081 include current limit, over voltage and thermal shutdown protection. The EMD2081 is available in MSOP-10 package.

Features

- Supply Voltage: 5.2V ~ 30V
- Driving Current:
  - Up to 500mA @VIN=12V, VOUT=23V
- Over Voltage Protection: 36.5V
- Shutdown Current < 3μA
- Reference Voltage 0.245V
- Internal Soft Start and Compensation
- 1.4A Internal power MOSFET Switch
- Thermal Shutdown Protection

Applications

- Mood and Accent Lighting
- Automotive Lighting
- Ambient Lighting
- RGB LED Driver

Typical Application

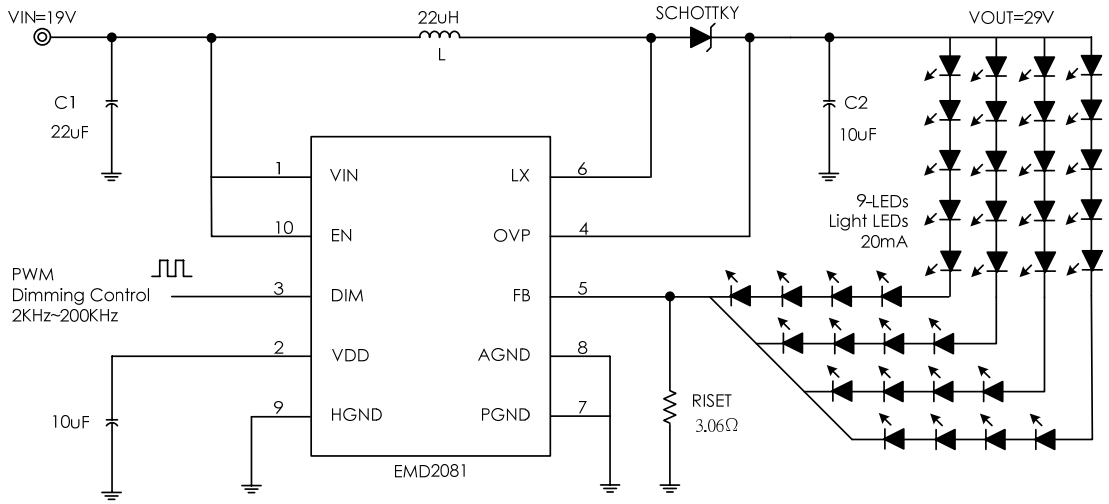
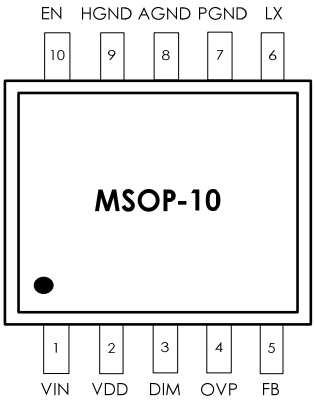


Fig. 1

Connection Diagram

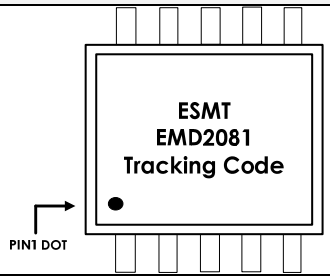


Order Information

EMD2081-00MH10NRR

00	Option Code
MH10	MSOP-10 Package
NRR	RoHS & Halogen free package
	Rating: -40 to 85°C
	Package in Tape & Reel

Order, Mark & Packing Information

Package	Vout	Product ID	Marking	Packing
MSOP-10	Adjustable	EMD2081-00MH10NRR		Tape & Reel 3Kpcs

Pin Functions

Pin Name	Pin #	Function
VIN	1	Power Supply Voltage Pin.
VDD	2	Regulated 5V.
DIM	3	PWM dimming control pin by applying 2KHZ – 200KHZ PWM signal. Active pin when dimming is not used.
OVP	4	Over voltage protection.
FB	5	Feedback sense pin. Reference voltage is 0.245V.
LX	6	Switch pin.
PGND	7	Power ground of the IC.
AGND	8	Analog ground of the IC.
HGND	9	Analog ground of the IC.
EN	10	The enable pin. With internal pull high resistor.

Absolute Maximum Ratings

Devices are subjected to failure if they stay above absolute maximum ratings

VIN Voltage	36V	Storage Temperature	–65°C to 150°C
LX, OVP Voltages	39V	Junction Temperature	150°C
EN Voltage	36V	Lead Temperature (Soldering, 10 sec)	260°C
VDD Voltage	6.0V		
DIM Voltage	< pin of VDD		
FB Voltage	6.0V		

Operating Ratings

VIN, EN Voltages	5.2V to 30V	Thermal Resistance (θ_{JA})	
VDD, DIM Voltages	3.0V to 5.5V	MSOP-10 (Single layer PCB)	200°C/W
Operating junction Temperature	-40°C to 125°C	MSOP-10 (4-layer PCB)	120°C/W

Electrical Characteristics

(VIN = 12V, T_A = 25°C, unless otherwise specified.)

PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Voltage VIN		5.2		30	V
Supply Current	Continuously Switching			1	mA
Quiescent Current	No Switching, VFB = 1V		100		μA
Shutdown Current	EN,DIM= " L "			3	uA
Operation Frequency		0.9	1.2	1.5	MHz
Maximum Duty Cycle		93	95		%
Feedback Voltage		0.2205	0.245	0.2695	V
Thermal Shutdown Protection			160		℃
Thermal Shutdown Hysteresis			20		℃
BOOST internal NMOS Ron	Isw = 200mA		0.5	0.8	ohm
Current Limit			1.4		A
Shutdown Voltage Low	EN			0.4	V
	DIM			0.4	
Enable Voltage High	EN	1.2			V
	DIM	1.2			
EN Leakage Current	EN		1.3		μA
Maximum Output Voltage			36		V
OVP		34	36.5	39	V
OVP Hysteresis			1	3	V

Function block

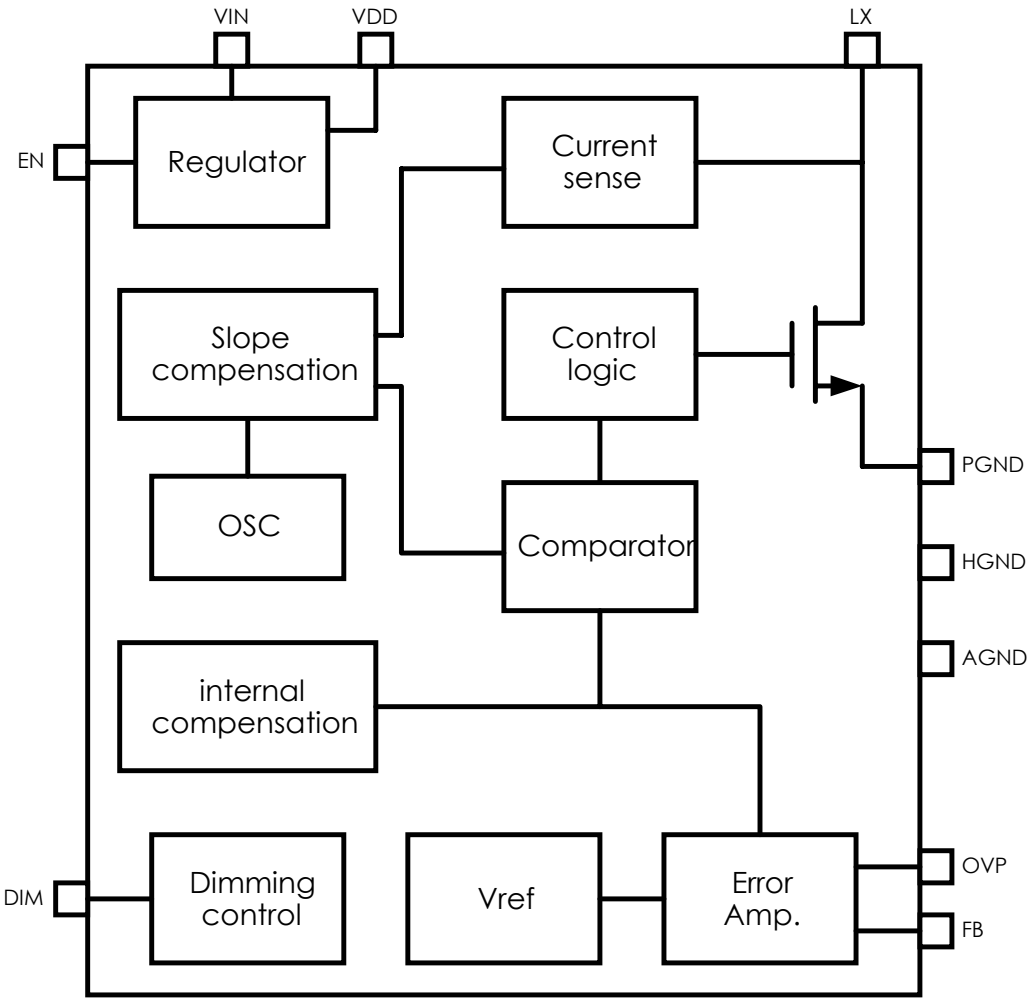
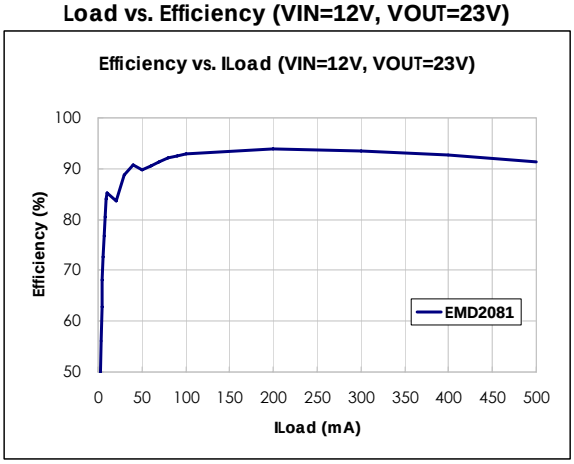


Fig. 2

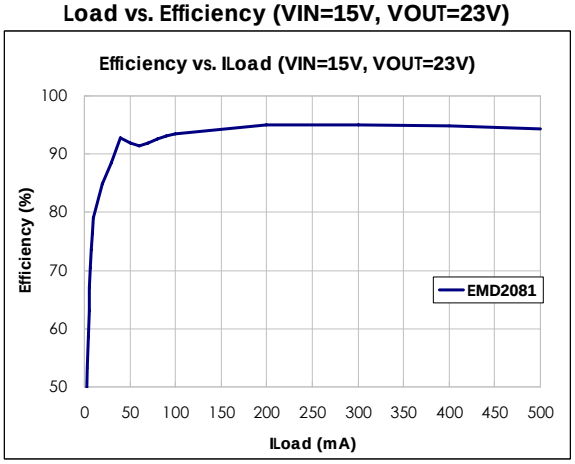
Typical Performance Characteristics

VIN = 12V, T_A = 25°C, unless otherwise specified.

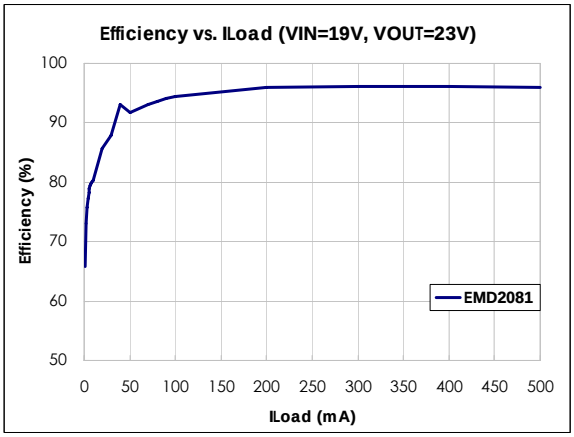
Load vs. Efficiency (VIN=12V, VOUT=23V)



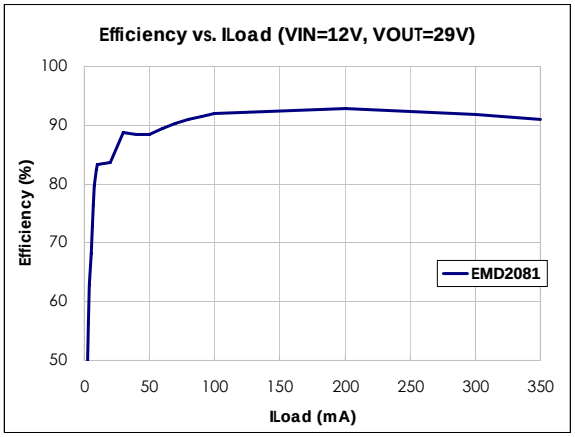
Load vs. Efficiency (VIN=15V, VOUT=23V)



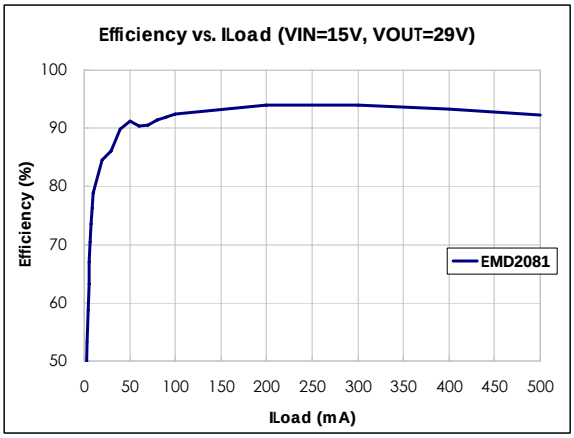
Load vs. Efficiency (VIN=19V, VOUT=23V)



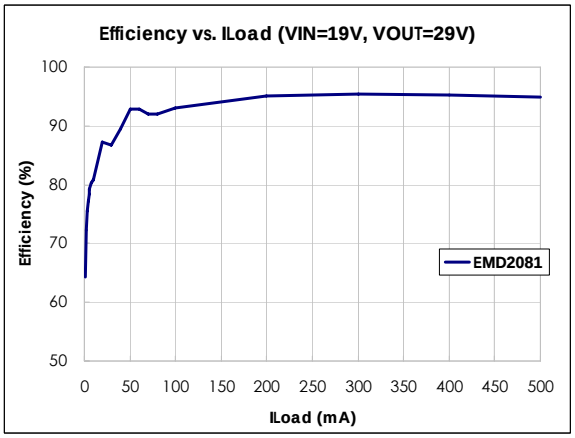
Load vs. Efficiency (VIN=12V, VOUT=29V)



Load vs. Efficiency (VIN=15V, VOUT=29V)



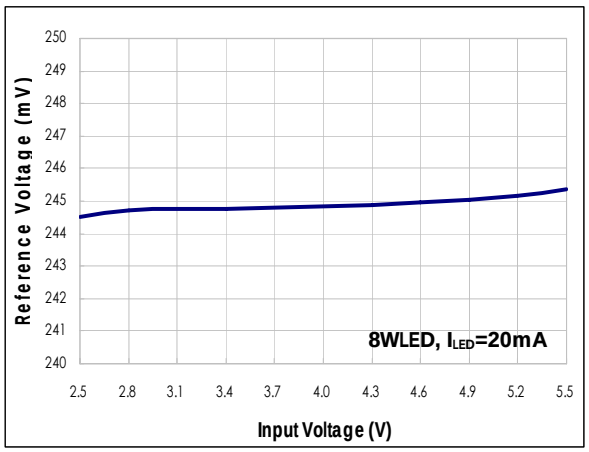
Load vs. Efficiency (VIN=19V, VOUT=29V)



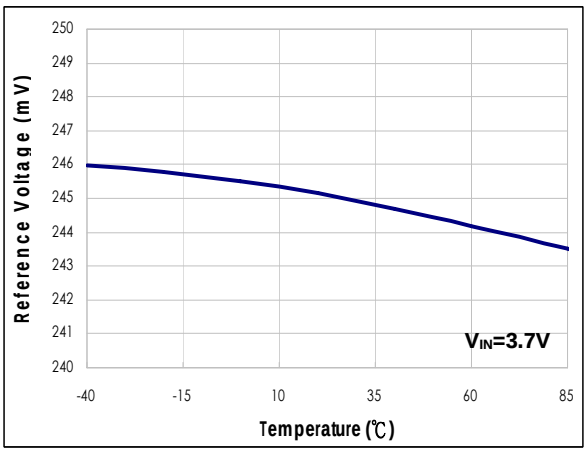
Typical Performance Characteristics

V_{IN} = 3.7V, C_{IN}=4.7uF, C_{OUT}=1uF, I_{OUT}=20mA, L=22uH, T_A = 25°C, unless otherwise specified.

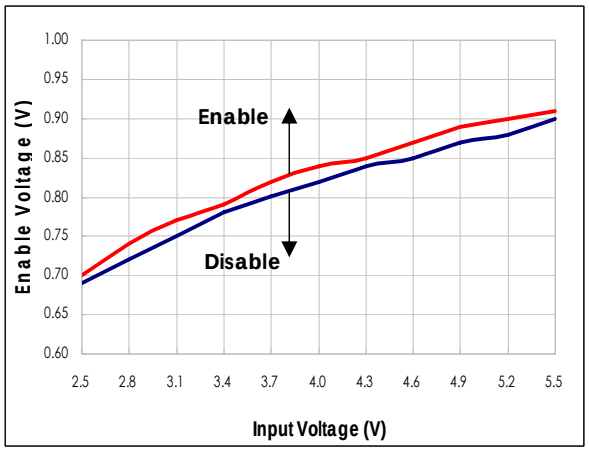
Reference Voltage vs. Input Voltage



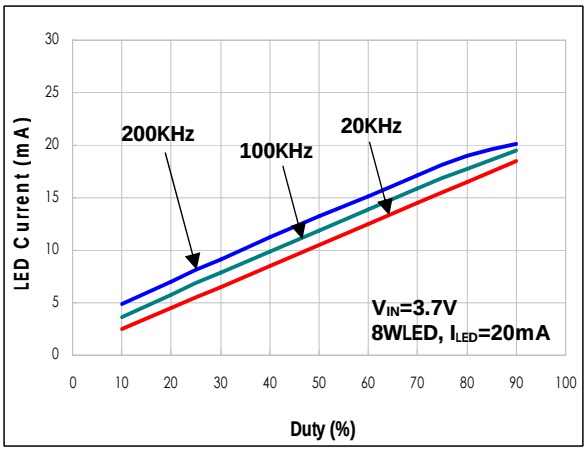
Reference Voltage vs. Temperature



Enable Threshold vs. Input Voltage



LED Current vs. Duty



Application Information

Detailed Description

The EMD2081 is a constant frequency current-mode boost converter with constant current source and is designed for WLEDs driver. This device provides the same output current through each WLED that get even illumination. The fast operation frequency allows for small inductor and input/output capacitors.

During normal operation, the internal oscillators send a pulse signal to set latch and turn on internal MOSFET each duty circle. A current sense voltage sums MOSFET current and slope signal connected to the negative terminal of the PWM comparator. When this signal voltage exceeds output voltage of error amplifier, the PWM comparator will send a signal to reset latch and turn off internal MOSFET. The output voltage of error amplifier is magnified from the difference between reference voltage and feedback voltage. If reference voltage is higher than feedback voltage, more current is delivered to the output, the other way, less current is delivered.

Enable / Disable

The EMD2081 enters shutdown mode when EN and DIM pins voltage are less 0.4V. When in shutdown mode, all internal circuits of the EMD2081 are turn off and quiescent current is reduced to less than 3uA. When EN and DIM pins voltage are higher than 1.2V, start-up begins.

DIM pin can be used for dimming control, the PWM frequency range is from 2KHz to 200kHz. The average LED current is proportional to the PWM duty cycle, while 0% duty cycle triggers zero WLEDs current and 100% duty cycle triggers full WLEDs current set by RISET (Eq.1).

OVP

When WLEDs are open, the boost control loop just like open loop operation, it may causes over voltage damage on LX pin. In order to prevent this damage, the EMD2081 provides OVP function to protect it from damage. The protection threshold is set at 36.5V.

OTP

The internal thermal sensor turn off power MOSFET when junction temperature is exceeded 160℃, the OTP is designed with a 20℃ hysteresis.

LED Current Setting

Referring to Figure 1 of the typical application, adjusting the output current changes the brightness of WLEDs, the EMD2081 regulates output current by sense resistor (RISET). The output current is given by:

LED current (mA) = 245 mV / R_{SET} (Ω) Eq. 1

LED Dimming Control

0) Using a PWM signal to EN pin

With the PWM signal applied to the EN pin, the EMD2081 is correspondingly controlled ON or OFF by PWM signal. The LEDs alternate between zero and full programmed current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle PWM signal will turn off the EMD2081 and corresponds to zero LED current. A 100% duty cycle PWM signal turns on the LEDs continuously at full current. The minimum dimming frequency limit is due to error amplifier offset which will cause the larger LED current variation and the maximum dimming frequency limit is due to the boost converter startup time. In low PWM duty dimming signal, the filtered reference voltage is low and the error amplifier offset can cause bigger variation of the output current, that's not recommended to dimming it by the EN pin. The typical frequency range of the PWM signal is 2kHz to 200kHz.

V_{FB} = Duty x 0.245V

Where

Duty = duty cycle of the PWM dimming signal

0.245V = internal reference voltage

b) Using a DC voltage to FB pin

Using a variable DC voltage to adjust the brightness is a popular method in some application. The dimming control using a DC voltage circuit is shown in figure 3. As the DC voltage increases, the current flows through R1 increasingly and the voltage drop on R1 increase, it causes LED current decrease. The LED current can be calculated by the following equation.

$$I_{LED} = \frac{V_{FB} - \frac{R1 \times (V_{DC} - V_{FB})}{R2}}{R_{SET}}$$

Where

VFB = 0.245 internal reference voltage

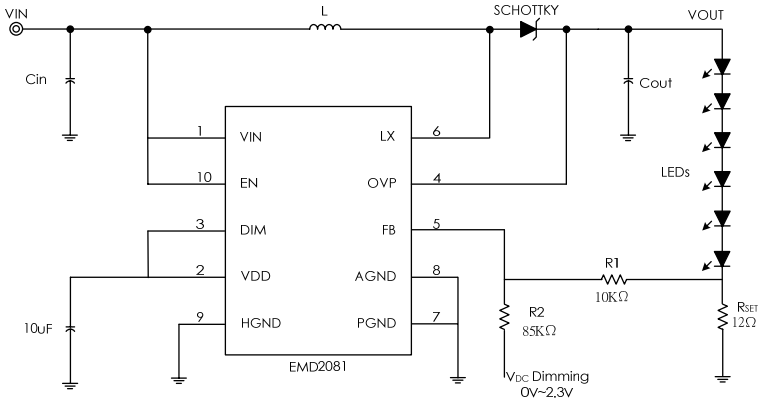


Fig. 3 Dimming control using a DC voltage

c) Using a filtered PWM signal to FB pin

Another common application is using a filtered PWM signal as an adjustable DC voltage for LED dimming control. A filtered PWM signal acts as the DC voltage to regulate the output current. The recommended application circuit is shown as figure 4. To fix the frequency of PWM signal and change the duty cycle of PWM signal can get different output current. This method can be used for higher frequency PWM dimming signals compared to method (a) using a PWM signal to EN pin. The lower limit of the PWM dimming frequency is controlled by the RC filter, PWM dimming frequency should be higher than the cutoff frequency of the RC filter (The recommended frequency of 2.8V PWM signal should be above 2kHz). The LED current can be calculated by the following equation.

$$I_{LED} = \frac{V_{FB} - \frac{R1 \times (V_{PWM} \times Duty - V_{FB})}{R2 + R3}}{R_{SET}}$$

Where

VFB = 0.245 internal reference voltage

Duty = duty cycle of the PWM dimming signal from FB pin

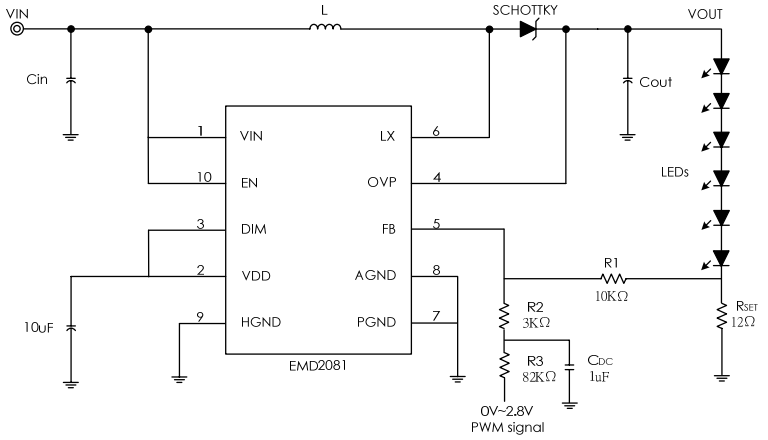
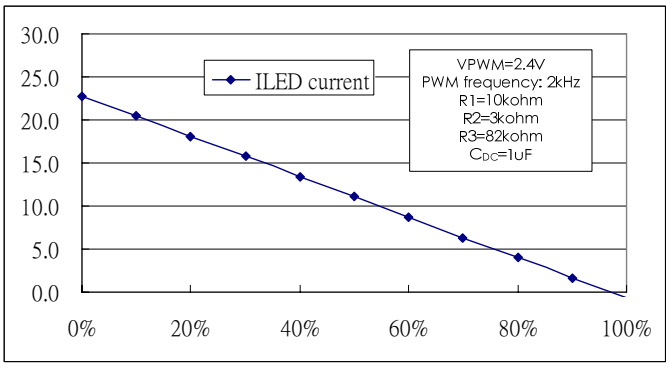


Fig. 4 Dimming control using a filtered PWM signal



Cin and Cout Selection

It is recommended to use the X5R or X7R which have best temperature and voltage characteristics of all the ceramics for a give value and size. A minimum input capacitance of 10μF is required for the EMD2081, the capacitor value may be increased without limit. The typical output capacitor value is 10μF, higher capacitance can be used to reduce voltage ripple.

Inductor Selection

The inductor values range from 10μH to 33μH. The typical inductor value is 22μH. The low DCR inductor is preferred. In addition, the limit saturation current of inductor must exceed current limit of the EMD2081.

Diode Selection

Referring to Figure 1 of the typical application, the EMD2081 is high switching control devise which demands a high speed rectification diode for optimum efficiency. The schottky diode is preferred, for high efficiency, schottky diode provide fast recovery time and low forward voltage that reduce power loss. The breakdown voltage of schottky diode must exceed output voltage.

Application Circuit

- **Application circuit for 9S4P (S: Series ; P: Parallel)**

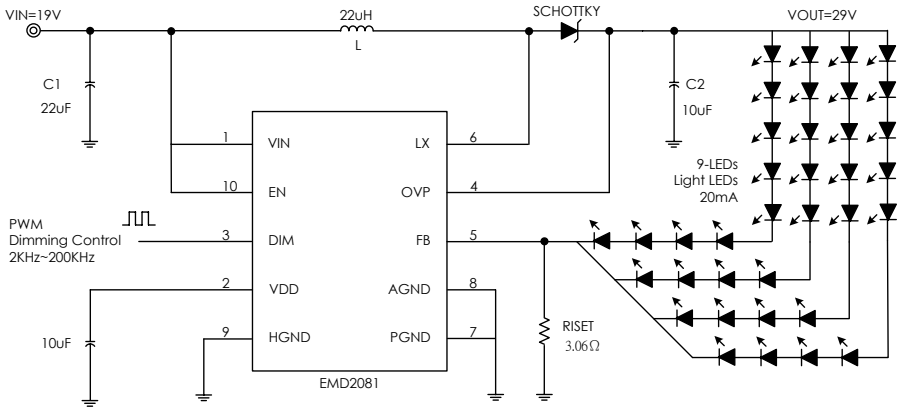
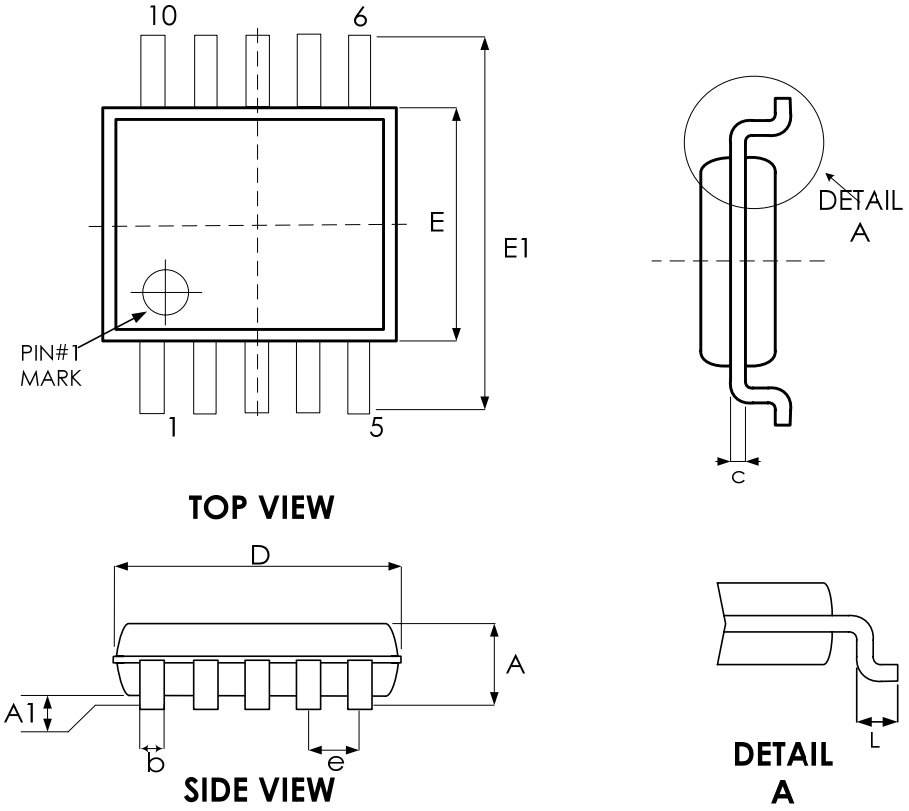


Fig. 5

Package Outline Drawing
MSOP-10 (118 mil)



Symbol	Dimension in mm	
	Min	Max
A	0.81	1.10
A1	0.00	0.15
b	0.17	0.33
c	0.08	0.23
D	2.90	3.10
E	2.90	3.10
E1	4.80	5.00
e	0.50 BSC	
L	0.40	0.80

Revision History

Revision	Date	Description
0.1	2015.02.10	Initial version.
1.0	2015.07.02	Modify version to 1.0
1.1	2015.07.29	Updated recommend operation of OVP maximum output voltage and minimum Vin.
1.2	2015.11.10	Shout down current update from '<1uA' change to '<3uA' (page1, 3, 7)

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