60V/1A Buck Converter For LED Applications : Built-in 60V MOSFET Constant-off Time Frequency Mode with Analog and PWM Dimming

Features：

- Operate at DC voltage 8V~60V
- Integrated 60V MOSFET with low Rsd_on
- Support constant current up to 1A
- Constant-off time operation frequency mode in 25KHz~300KHz
- Adjustable constant-off time mode frequencymode by external resistor
- Built-in current limit circuit setting by external resistor
- Tolerance of CS pin voltage is <4%
- Supports PWM dimming through PWM_D pin
- Support Linear dimming through LD pin
- Support Over Temperature Limit (OTL) by NTC through LD pin
- Built in Over Temperature Protection (OTP)
- ESOP-8 package

Description

The SMD804 is a Buck Converter integrated with MOSFET for output current up to 1A in DC input from 8V to 60V.

The SMD804 works in constant frequency mode or constant-off time frequency mode by external resistor connection.

The well design and placement between SMD804 PWM circuit and internal MOSFET switching stage reduce the heat interference, so that the over temperature protection will operate accurately.

SMD804 supports two kinds of dimming methods. The digital dimming by input PWM waveform with duty ration from 0% to 100%. The multi-chip SMD804 design can be programmed by MCU for RGBW color harmonious illumination application. The analog dimming by input linear voltage level to change the current sense threshold voltge.

Applications

- Stage Illumination
- DC power LED Lighting
- Car Front light, Working light, Light bar

Frequency Mode Circuit

Constant Frequency Mode:

The SMD804 is the PWM controller for peak current controlled buck converters. The buck circuit is easy to design as no feedback compensation is required, thus only few components is required.

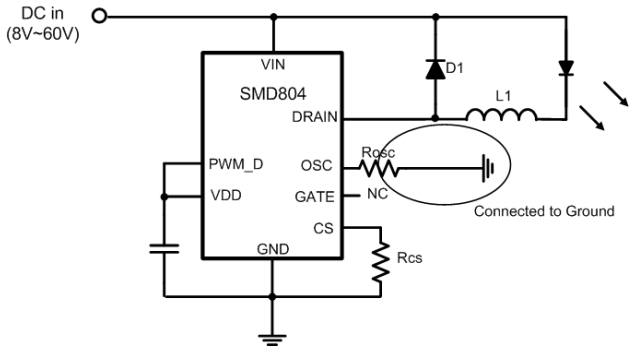


Fig.1 Constant frequency mode

Constant-Off Time Frequency Mode :

The SMD804 can be set to work in constant-off time frequency mode while the input voltage is less than the twice of the output voltage, which is also for the duty cycle greater than 50%.

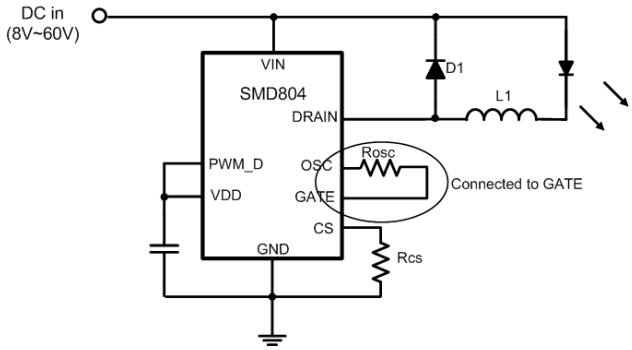
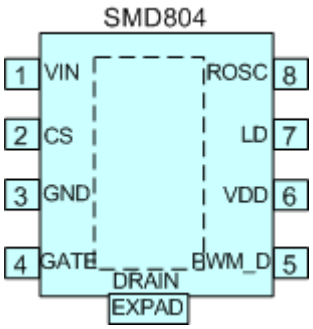


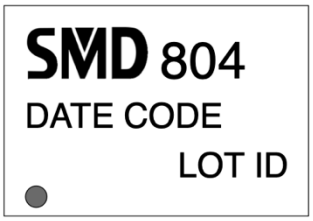
Fig.2 Constant-off time frequency mode

Pinout Reference



ESOP-8

Top Marking



Pin Description

Pin	Name	Function
1	V_{IN}	Input Voltage.
2	CS	Current Sense pin by an external sense resistor. When the voltage of this pin over the internal 250mV, the output is in OFF cycle.
3	GND	Ground.
4	GATE	Output to drive MOSFET.
5	PWM_D	PWM dimming input pin. When pulled to Ground or left OPEN (Internal 100KΩ pull-down to GND), there is no switching output. When pulled to High, the switching output operates normally.
6	V_{DD}	Power supply for internal circuit. Should bypass a low ESR capacitor to GND at least 1uF.
7	LD	CCR (Constant Current Reduction) dimming pin by change the current sense threshold voltage.
8	R_{OSC}	Setting the operation frequency by an external resistor. To operate in contsnat frequency mode the resistor is connected between ROSC and Ground. To operate in constant-off frequency mode, the resistor is connected between ROSC and GATE.
Expad	DRAIN	The internal MOSFET Drain terminal. The low R_{DS_ON} NMOS provides low power loss of switching. Exposed thermal pad should be connected to this pin.

Absolute Maximum Rating

Item	Rating	Unit
VDD pin voltage	-0.3 to 13.5	V
Drain-Source Voltage	-0.3 to 60	V
GATE to GND	-0.3 to (VDD+0.3)	V
PWM_D to GND	-0.3 to (VDD-0.3)	V
CS pin voltage	-0.3 to (VDD+0.3)	V
Operating Junction temperature (T_J)	-40 °C to OTP	°C
Storage temperature range (T_{STG})	-65°C to 150°C	°C

Block Diagram :

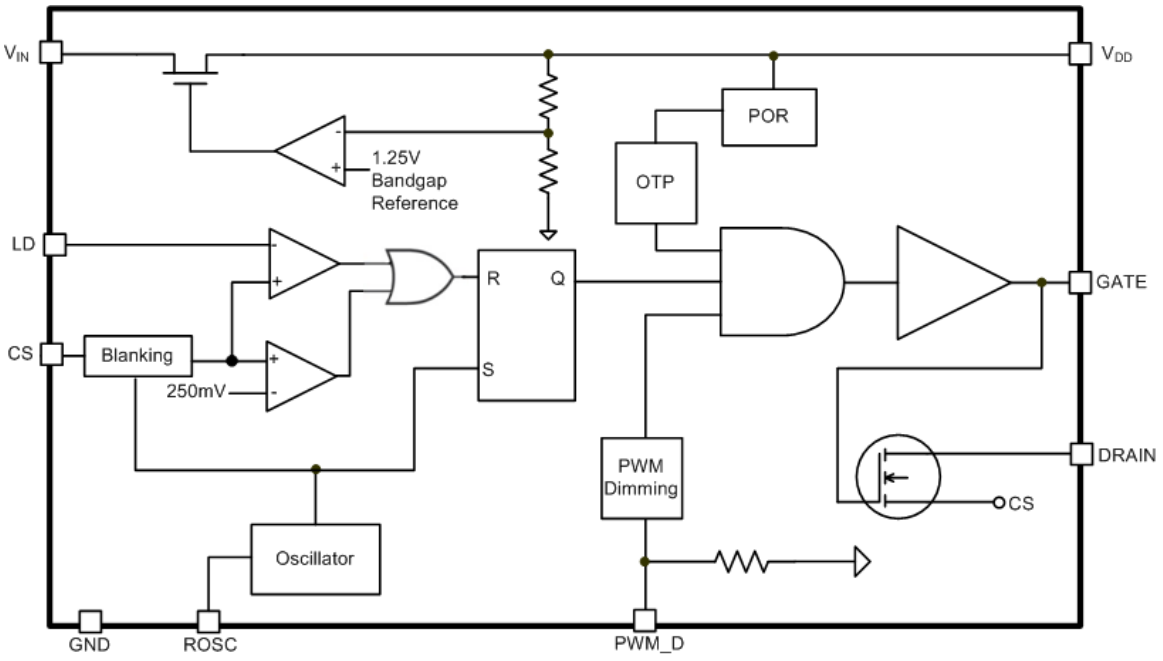


Fig.3 Function Block Diagram

Electrical Characteristics Unless otherwise specified, T_A=25°C~85°C, VDD=12V_{DC}

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
Input DC supply voltage range	DC input voltage	V_{INDC}	8		60	V
Shut-Down mode supply current	Pin PWM_D to GND, V_{IN} = 15V	I_{INsd}		0.4	1	mA
Internal supply VDD voltage	An external voltage applied to pin VDD	V_{DDmax}			13.5	V
V_{DD} under voltage lockout threshold	VDD rising	UVLO	6.45	6.7	6.95	V
V_{DD} under voltage lockout hysteresis	VDD falling	ΔUVLO		520		mV
Current sense pull-in threshold voltage	@TA = -40°C to +85°C	$V_{CS(hi)}$	240	250	260	mV
GATE high output voltage	I_{OUT} = 10mA	$V_{GATE(hi)}$	V_{DD} -0.3		V_{DD}	V
GATE low output voltage	I_{OUT} = -10mA	$V_{GATE(lo)}$	0		0.3	V
Oscillator frequency at fixed frequency mode	R_{OSC} = 1.00MΩ	f_{OSC}	20	24	30	kHz
	R_{OSC} = 226kΩ		80	96	120	
Maximum Oscillator PWM Duty Cycle	F_{PWMhf} = 25kHz, at GATE, CS to GND.	D_{MAXhf}			100	%
Current sense blanking interval	V_{CS} = 0.55V_{LD}, V_{LD} = V_{DD}	T_{BLANK}	200	280	360	ns
Delay from CS trip to GATE lo	VDD=12V, V_{LD} = 0.15, V_{CS} = 0 to 0.22V after T_{BLANK}	t_{DELAY}			300	ns
GATE output rise time	C_{GATE} = 500pF	t_{RISE}		25	50	ns
GATE output fall time	C_{GATE} = 500pF	t_{FALL}		20	50	ns
Thermal shut down		T_{SD}		150		°C

Electrical Characteristics of MOSFET Unless otherwise specified, T_J = 25°C

Parameter	Test Conditions	Symbol	Min	Typ	Max	Units
Drain-Source Breakdown voltage	V_{GS} = 0V, I_{DS} = 250uA	BV_{DSS}	60			V
Zero Gate voltage Drain current	V_{DS} = 49V, V_{GS} = 0V	I_{DSS}			1	mA
Gate-Body leakage	V_{GS} = ±20V, V_{DS} = 0V	I_{GSS}			±100	nA
Gate threshold voltage	V_{DS} = VGS, I_{DS} = 250uA	$V_{GD(TH)}$			2.5	V
Drain-Source On-State resistance at SOP-8	V_{GS} = 10V, I_{DS} = 2A	$R_{DS(ON)}$			75	mΩ
	V_{GS} = 4.5V, I_{DS} = 2A				90	
Total Gate Charge	VDS=12V, VGS=10V, ID=5A	Qg		5.5		nC
Gate-Source Charge		Qgs		1.8		
Gate-Drain Charge		Qgd		2.4		

Constant-off time frequency mode design

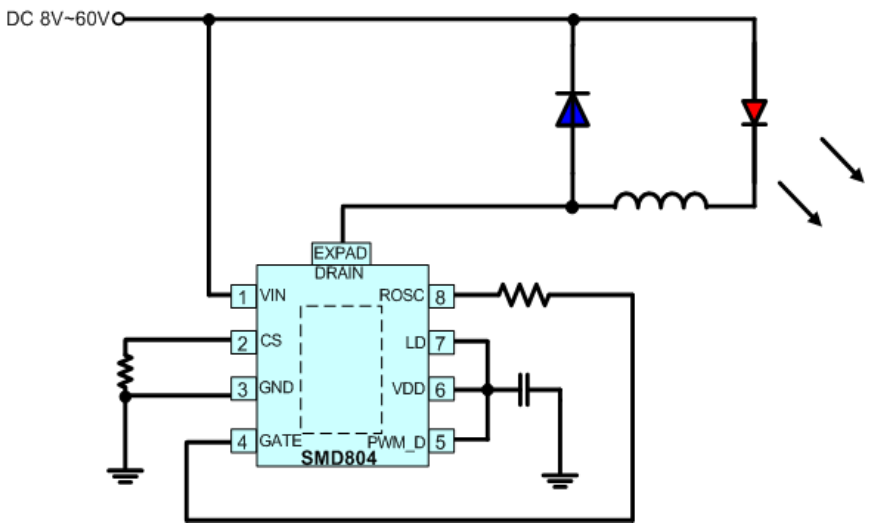


Fig.4 SMD804 constant-off time constant current buck converter

To design the constant-off time buck converter circuit, as shown in Fig.4, the following 4 parameters are calculated :

(1) Constant-off time T_{OFF}

(2) Resistor R_{OSC} for maximal switching frequency

(3) Inductor L_1 for the peak-to-peak ripple current of output LED current

(4) Sense resistor R_{CS} for LED peak current

Defined the constant-off time and R_{OSC}

For fixed frequency mode, the resistor R_{OSC} is connected between ROSC pin and GND pin, the oscillator time period is given by :

$$T_{OSC}\,(us) = \frac{R_{OSC}\,(K\Omega) + 22}{25}$$

If the resistor is connected between R_{OSC} pin and GATE pin, SMD804 operates in a constant-off time mode and the equation above is the off-time.

For the operation frequency of the constant-off time mode,

$$F_{OSC} = \frac{1 - D}{T_{OFF}} = \frac{1 - \frac{V_{LED}}{V_{IN}}}{T_{OFF}}$$

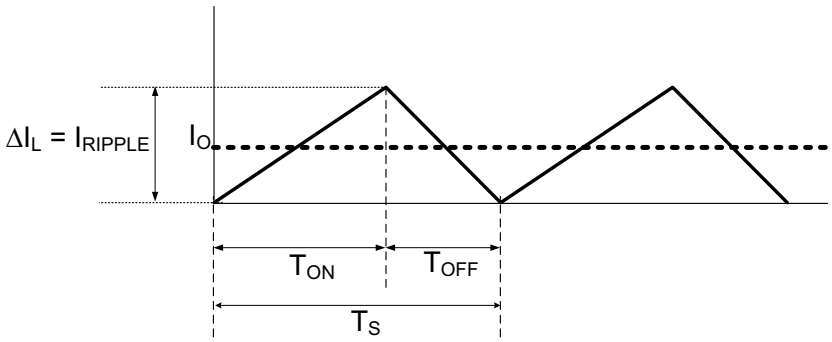
It is requested that the F_{OCS} should be located in 25KHz~300KHz, by considering

(1) The minimal operation frequency should be designed to be higher than the Audio band noise (20KHz in usual).

(2)The maximal operation frequency should be considered no larger than SMD804 core circuit design limitation (that is 300KHz).

Define the inductor :

To keep the circuit in continuous conduction mode (CCM), the maximum ripple current should be less than the twice the minimum load current.



Boundary between CCM and DCM

The minimum average inductor current to maintain in CCM is given by

$$I_O = \frac{\Delta I_L}{2} = \frac{I_{RIPPLE}}{2}$$

The minimum value of inductor to maintain in CCM can be determined by

$$\Delta V_L = L \times \frac{\Delta I_L}{\Delta t} = L \times \frac{I_{RIPPLE}}{T_{ON}} = L \times \frac{2 \times Io}{T_{ON}}$$

$$L = \frac{V_{out}\,(V_{in(max)} - V_{out})}{V_{in(max)} \times F_{OSC} \times I_{RIPPLE}} \quad \text{Buck Mode}$$

For constant-off time mode, the equation above can be modified as :

$$L = \frac{V_{LED} \times T_{OFF}}{0.3 \times I_{LED}}$$

where the ripple is 30% of LED current.

Define the peak current sense resistor

The LED current is derived from the current sense resistor R_{CS},

can be set by using :

$$R_{CS} = \frac{250\ (mV)}{1.15 \times I_{LED}}$$

Frequency variation vs Duty in constant-off time mode

Since $T = T_{ON} + T_{OFF}$,

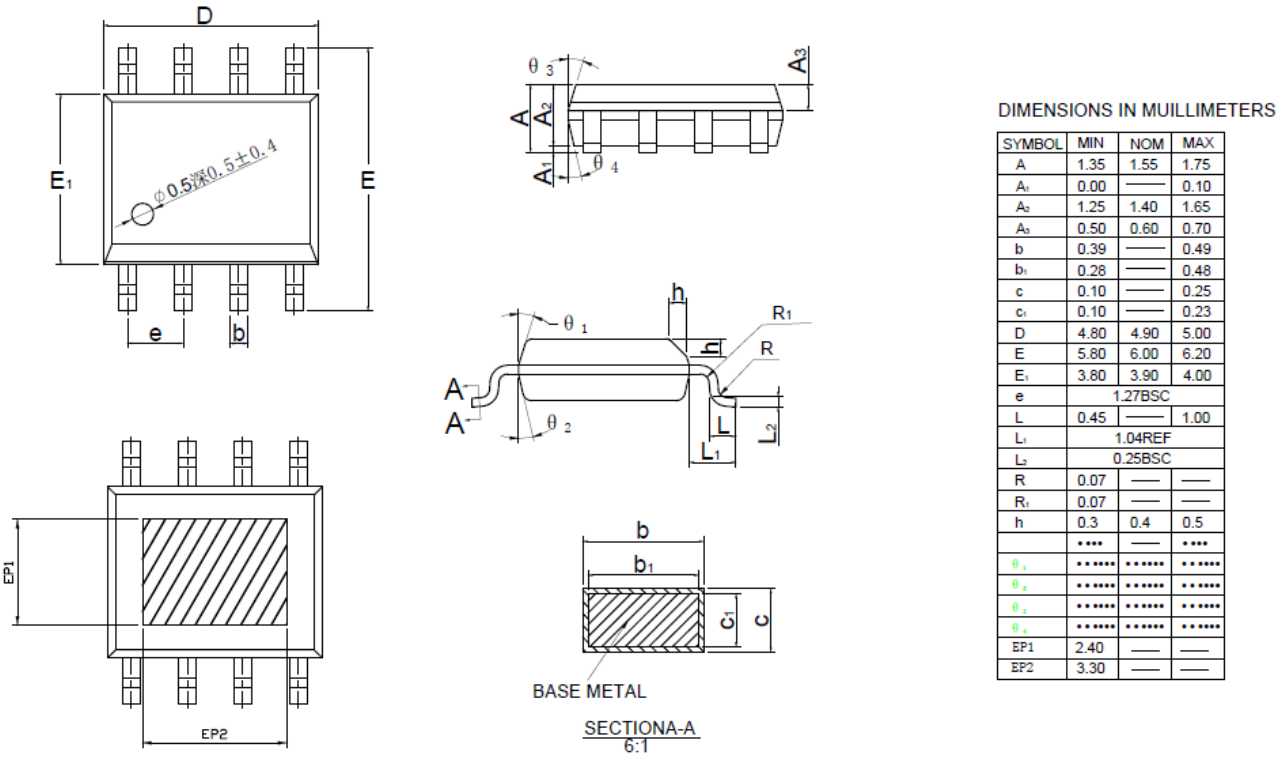
$$F_{OSC} = \frac{1 - D}{T_{OFF}}$$

T_{OFF} is constant, and for a large Duty cycle switching (normally for output voltage close to input voltage or higher current up to 2A output), the frequency F_{OSC} will slow down because cycle-on duration is larger and cycle-off duration is constant, so that in the overall switching cycle the buck circuit operation is always stable.

Ordering Information

Part Number	Package	Shipping	MOQ
SMD804	ESOP-8	Tape & Reel	2,500

Package Outline Drawing



DIMENSIONS IN MUILLIMETERS

SYMBOL	MIN	NOM	MAX
A	1.35	1.55	1.75
A1	0.00	——	0.10
A2	1.25	1.40	1.65
A3	0.50	0.60	0.70
b	0.39	——	0.49
b1	0.28	——	0.48
c	0.10	——	0.25
c1	0.10	——	0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
L	0.45	——	1.00
L1	1.04REF		
L2	0.25BSC		
R	0.07	——	——
R1	0.07	——	——
h	0.3	0.4	0.5
	••••	——	••••
θ1	••••••	••••••	••••••
θ2	••••••	••••••	••••••
θ3	••••••	••••••	••••••
θ4	••••••	••••••	••••••
EP1	2.40	——	——
EP2	3.30	——	——

NOTES:
1. DIMENSIONS IN MILLIMETERS (ANGLES IN DEGREES).
2. ALL DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
3. ALL DIMENSIONS MEET JEDEC STANDRAD MS-012F