Step up, 4 strings, Max. 250mA/string, Multi-dimming mode WLED Backlight Controller

REV. 01

General Description

The LD5805 is a 4-channel linear current controller which combines with a boost switching controller. It's an ideal solution for driving high power LED backlights. The LD5805 can achieve high accuracy of constant current to 4 LED strings with 4 internal MOSFET. For each LED string, the current is adjustable to drive up to 250mA.

The LD5805 features 4 individual current regulator channels to give accurate driving current for each LED string. The current balance rate is ± 2.7%. The 10V gate driver allows the use of standard level MOSFETs. It can provide a PDIM or ADIM dimming control.

The LD5805 eliminates the audio noise by maintaining constant LED current regulation during ADIM dimming. The other features include LED short and open protection, cycle by cycle current limit, and thermal shutdown.

Features

- Input Voltage range: 6V to 36V
- Drives up to 4 strings in parallel, up to 250mA per string
- LED current balance rate is ± 2.7%
- Programmable switching frequency
- PWM Input for PDIM or ADIM dimming control
  Use PDIM mode: PWM Input frequency Range 100Hz ~ 1kHz
  Use ADIM mode: PWM Input frequency Range 1kHz ~ 30kHz
- HV gate Voltage of 10V for driver
- Multi-chip parallel operation
- LED short and open protection
- LED pin short to ground protection
- Programmable over-voltage protection
- Thermal shutdown

Applications

- Backlight for GPS, Portable DVD
- LED Backlight for LCD Monitor/ TV

Typical Application

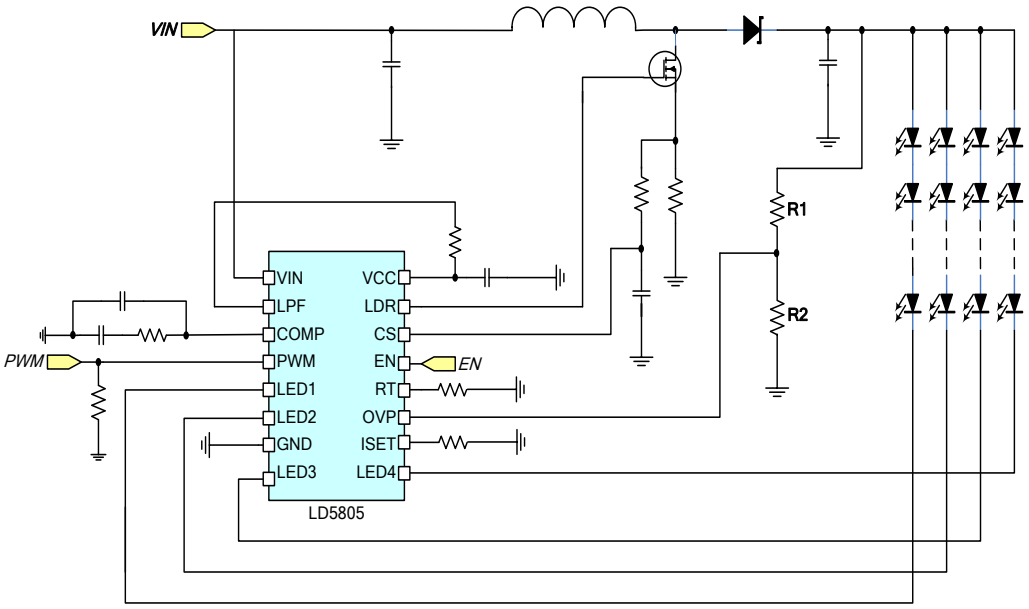


Fig. 1: Application circuit for P-DIM 4 string LED light bar

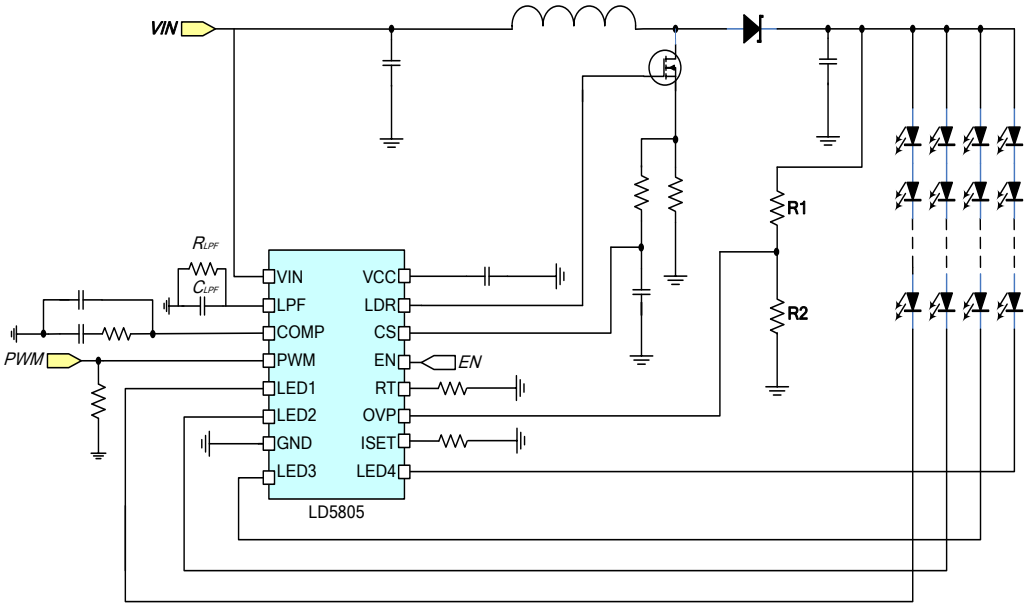


Fig. 2: Application circuit for A-DIM 4 string LED light bar

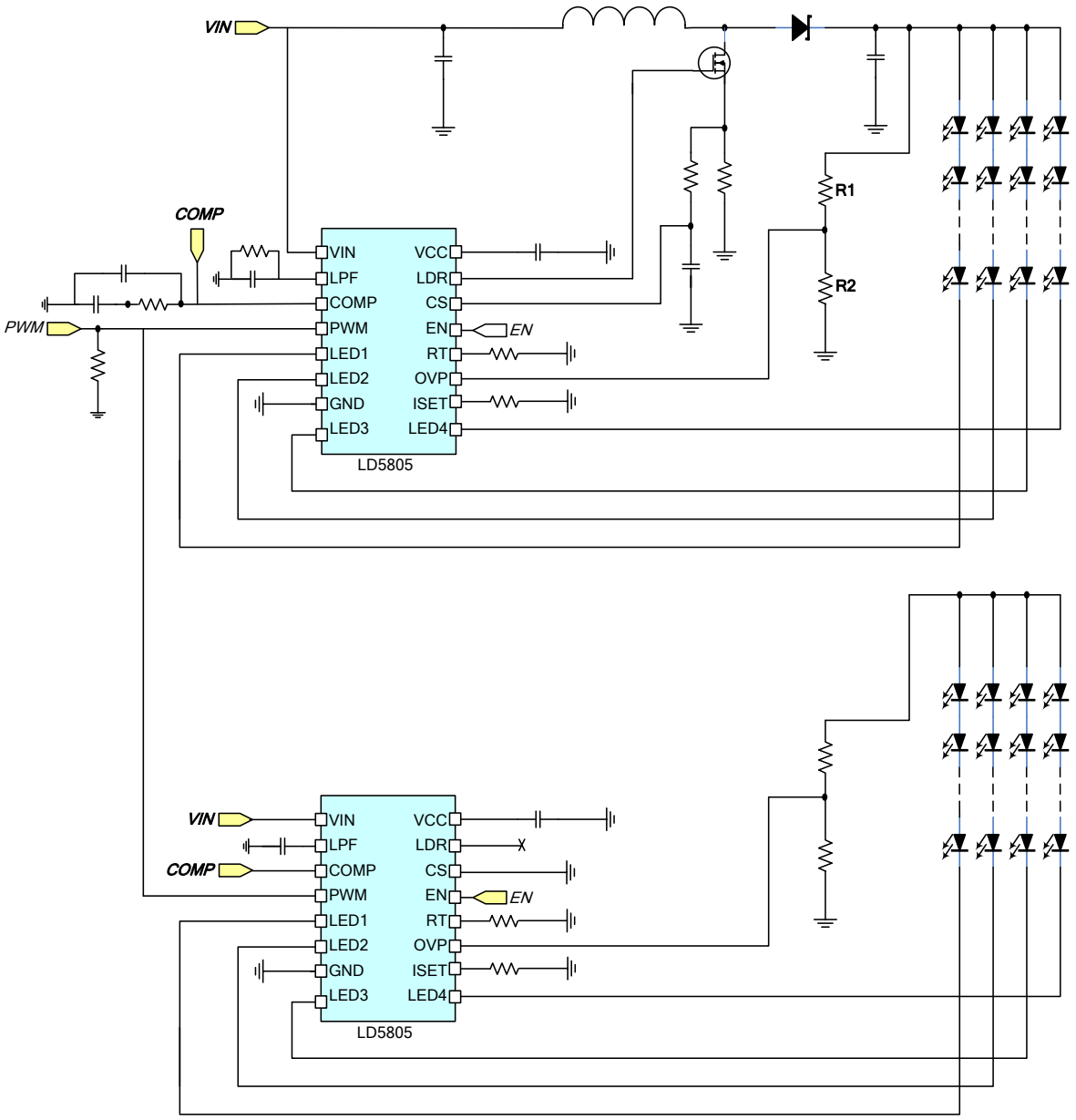


Fig. 3: Multi-chip parallel operation for 8 string LED light bar

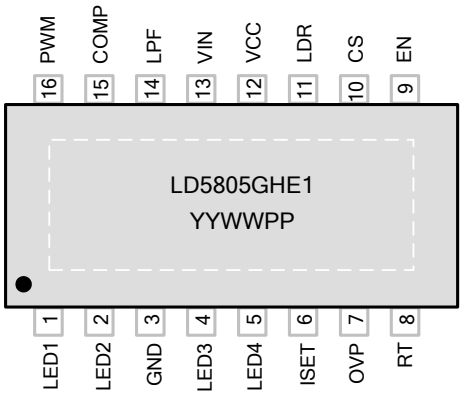
Pin Configuration

SOP-16

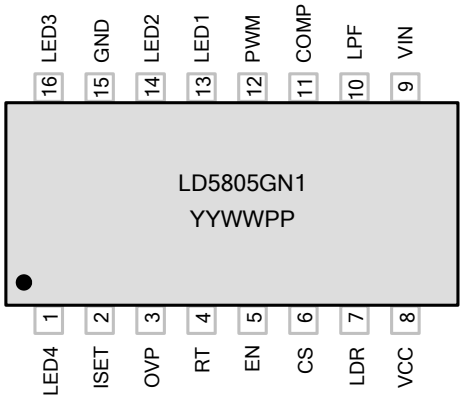


YY: Year Code
WW: Week Code
PP: Production Code

TSSOP-EP-16



DIP-16



Ordering Information

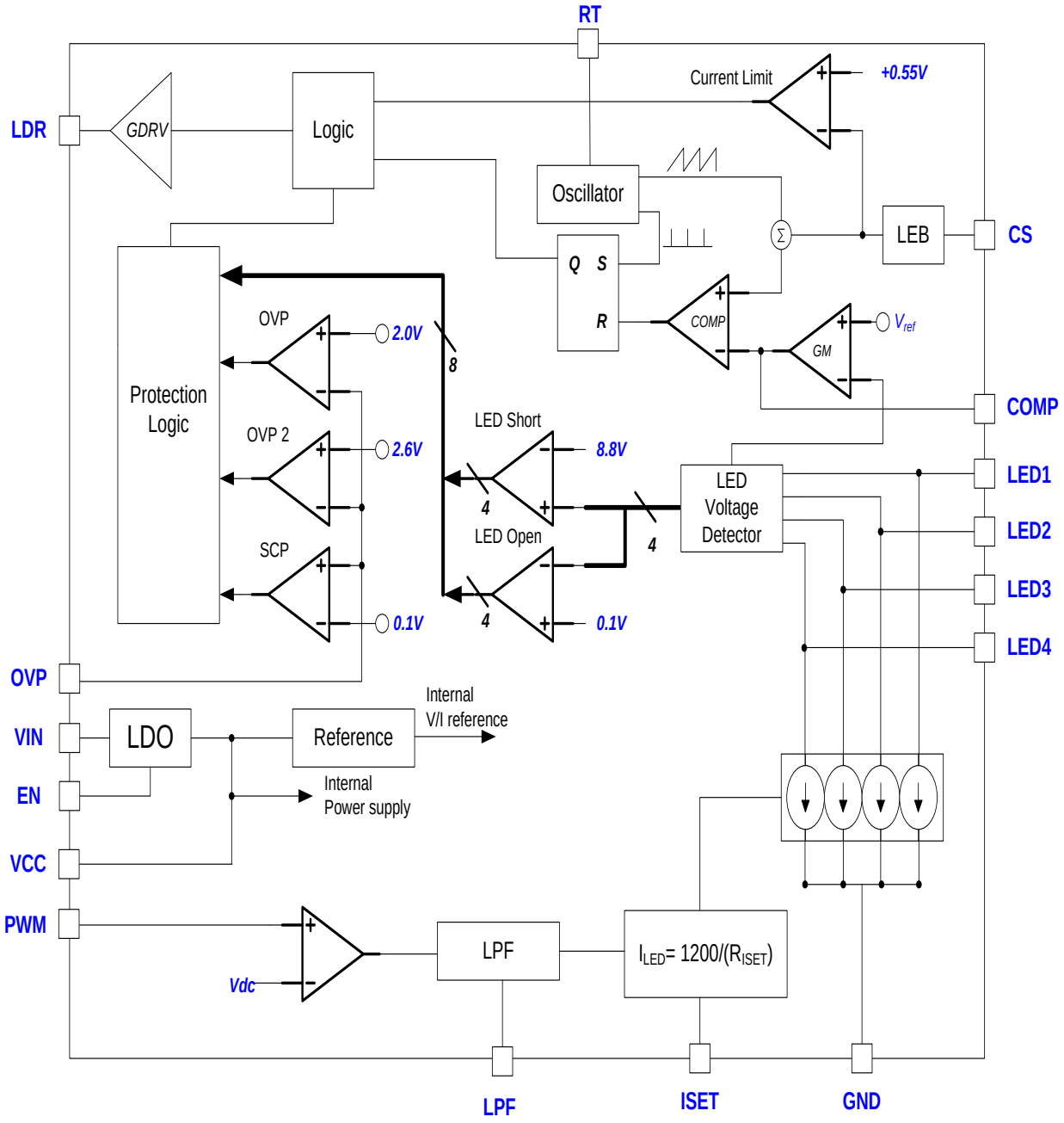
Part number	Package	Top Mark	Shipping
LD5805GHE1	TSSOP-EP-16	LD5805GHE1	2500 /tape & reel
LD5805GS1	SOP-16	LD5805GS1	2500 /tape & reel
LD5805GN1	DIP-16	LD5805GN1	1800 /Tube/ Carton

The LD5805 is ROHS compliant/Green packaged.

Pin Descriptions

SOP/DIP	TSSOP	NAME	FUNCTION
1	5	LED4	LED String 4 Current Input.
2	6	ISET	LED current resistor setting
3	7	OVP	Output voltage and short detection pin.
4	8	RT	Operating frequency resistor setting
5	9	EN	Chip Enable pin, when pull-low is in shutdown mode.
6	10	CS	Power MOSFET Current Sense
7	11	LDR	Gate drive signal for external MOSFET.
8	12	VCC	Internal linear regulator output pin. Bypass with VCC to GND with a ceramic capacitor of 1μF or greater. VCC is for chip internal use only.
9	13	VIN	Input Power of the chip. Bypass with at least 1μF ceramic capacitor close to VIN pin.
10	14	LPF	Output dimming mode selection, This pin is connected with capacitance for Analog dimming output.
11	15	COMP	Soft star Compensation circuit for Boost topology.
12	16	PWM	Input PWM Dimming Signal for brightness control
13	1	LED1	LED String 1 Current Input.
14	2	LED2	LED String 2 Current Input.
15	3	GND	Ground
16	4	LED3	LED String 3 Current.

Block Diagram



Absolute Maximum Ratings

VIN, EN	40V
LED1 to LED4	-0.3V ~ 85V
CS	-0.3V ~ 60V
LDR, VCC, LPF	-0.3V ~ 16V
PWM, COMP, RT, ISET, OVP	-0.3V ~ 5.5V
GND	+/-0.3V
I_{LED1} to I_{LED4}	400mA
Package Thermal Resistance	
SOP-16, θ_{JA}	110 °C/W
TSSOP-EP-16, θ_{JA}	60 °C/W
DIP-16, θ_{JA}	80 °C/W
Power Dissipation (Ta=85°C, T_J=125°C)	
SOP-16	363mW
TSSOP-EP-16	666mW
DIP-16	500Mw
Maximum Junction Temperature	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10sec)	260°C
ESD Voltage Protection, Human Body Model	2.5 KV
ESD Voltage Protection, Machine Model	250 V

Caution:

Stress exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stress above Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions(1)

Item	Min.	Max.	Unit
Operating Junction Temperature	-40	125	°C
Input Supply Voltage	6	36	V
PWM, EN	0	5	V
I_{LED1} to I_{LED4}(2)	60	250	mA
Switching Frequency	100	500	kHz

Note:

1. The device is not guaranteed to function outside of its operating conditions.
2. Its ILED1~ILED2 recommend range is defined by PWM is 100% dimming duty. If all the channels are in use, IC's thermal would be affected due to the voltage tolerance between the light bars and layout condition. It's recommended to choose a fit package to improve it. The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

Electrical Characteristics

(V_{IN}=12V, T_A=25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Input Power						
Input Voltage range			6		36	V
VIN Operating Current	EN=PWM=5V	I_{QVIN}		6	15	mA
VIN Shutdown Current	EN=PWM=0V	I_{VI_OFF}		10	15	uA
Under Voltage Lockout						
Turn ON Level	UVLO(ON)	V_{IN_ON}			6.5	V
Turn OFF Level	UVLO(OFF)	V_{IN_OFF}	4			V
Hysteresis		UVLO_HYS	0.2	0.45	0.7	V
LDO Regulator						
LDO output voltage for VCC pin	V_{IN} >12V	V_{VCC}	9	10	11	V
VCC Output Current Capability	V_{IN} >12V	I_{VCC}			15	mA
Drive Logic						
DRV Output Clamp Level	V_{IN} >12V	V_{DRV_H}	9	10	11	V
DRV Output Rise Time	C_{DRV}=1nF, V_{IN} ≥ 12V, *	T_{r_DRV}	25	45	65	ns
DRV Output Fall Time	C_{DRV}=1nF, V_{IN} ≥ 12V, *	T_{f_DRV}	10	30	50	ns
LED Current Regulation						
Absolute tolerance of regulation LED Current per Channel, I_{LEDX} (mA)= 1200 / R_{ISET}(kΩ)	ISET=12Kohm	I_{LED}	97	100	103	mA
LEDs Current Matching Calculating ($I_{(MAX)}$-$I_{(MIN)}$)/2x$I_{Average}$x100%	LED current= 100mA	MATCH			±2.7	%
Absolute Tolerance of Regulation LED Current per Channel at Minimum Dimming	ISET=12Kohm ADIM=0V	I_{LEDA0_CAL}	2		6	%
LEDs Current Matching Calculating at Minimum Dimming (I(MAX)-I(MIN))/2xIAveragex100%	ISET=12Kohm ADIM=0V	M_{ATCH0}		+/-3	+/-5	%
LED regulation voltage	I_{LED}=100mA/per channel	V_{LEDRG}		0.45		V
Boost Controller						
Switching frequency			100		500	kHz
Operating Frequency	R_{RT} =148 k	F_{SW200}	189	210	231	kHz
Boost Maximum duty cycle	F_{SW}=210kHz	D_{MAX}	85		95	%
Leading edge blanking time		T_{LEB}		200	300	ns

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
EN and PWM Dimming						
EN Logic	Enable	V_{EN_H}	2.2			V
	Disable	V_{EN_L}			0.8	V
PWM Logic	Enable	V_{PWM_H}	2.2			V
	Disable	V_{PWM_L}			0.8	V
EN Pull Down Resistance	*	R_{EN}	100		300	kΩ
LPF						
LPF Output Resistance	*	R_{LPF}	35		65	kΩ
Protection						
LED Open String Protection Threshold	OVP1	V_{OVP1}	1.88	2	2.12	V
Shutdown Under Abnormal condition	OVP2	V_{OVP2}	2.36	2.6	2.84	V
LED Short Circuit Protection Threshold	LED1~LED4	V_{LSCP}	8.0	8.8	9.5	V
Boost Output Protection - Short circuit	SCP	V_{SCP}		0.1	0.2	V
Boost Output Protection - Short circuit Hysteresis		V_{SCPY}		50	100	mV
Thermal Shutdown threshold	*			150		°C
Thermal Shutdown hysteresis	*			20		°C
MOSFET Over-Current Protection						
Current Sense Threshold		V_{OCP}	0.45	0.55	0.65	V
Over load protection voltage		V_{OLP}		1		V

*: Guaranteed by Design.

Typical Performance Characteristics

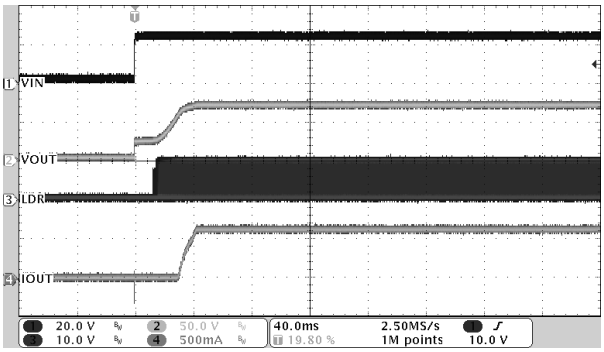


Fig. 4 System Startup, PWM Duty=100%

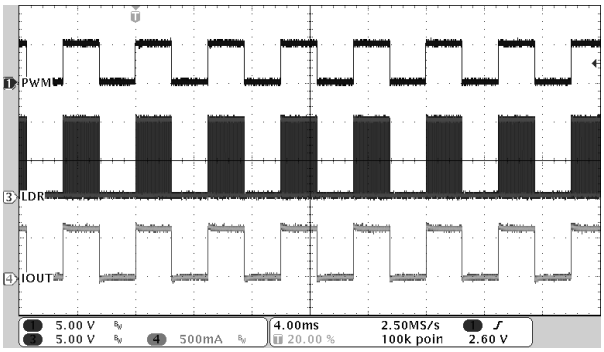


Fig. 5 PWM Dimming, F_{PWM}=200Hz, Duty=50%

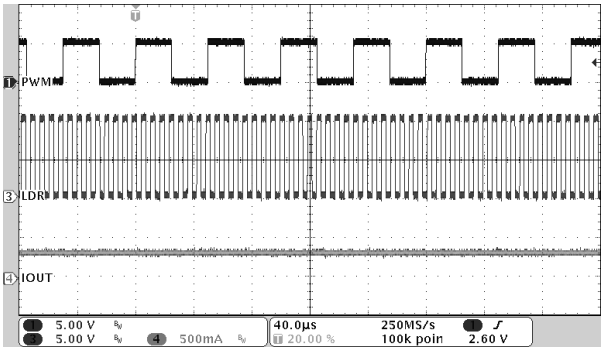


Fig. 6 Analog Dimming, F_{PWM}=20kHz, Duty=50%

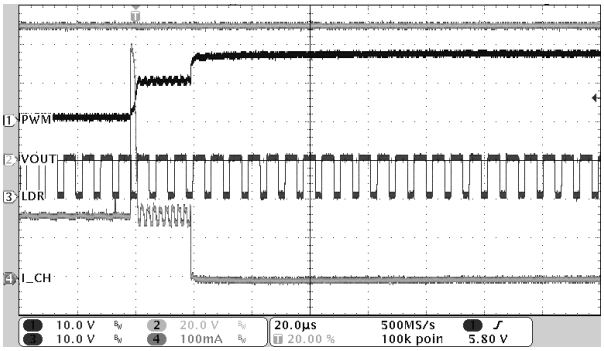


Fig. 7 LED Short Protection , PWM Duty=100%

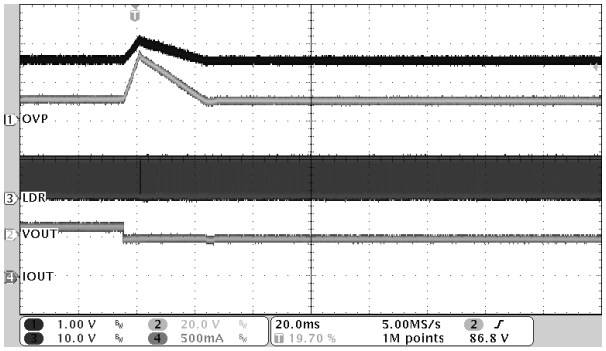


Fig. 8 LED Open Protection, PWM Duty=100%

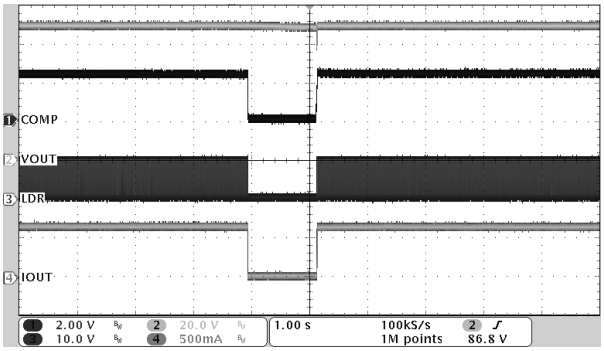


Fig. 9 Over Temperature Protection, PWM Duty=100%

Application Information

Basic Description

The LD5805 is a high-efficiency driver, ideally for LED backlight application. It incorporates with two major blocks: a DC-DC boost controller with peak current-mode control and a 4-channel LED driver with constant current of sink capability from 60mA to 250mA per channel.

LD5805 features adaptive voltage control that adjusts the converter output voltage according to the total forward voltage of LED strings. It detects the drop of LED voltage across the constant current-sink drivers and enhances power dissipation in the device.

The other features include LED short and open protection, cycle by cycle current limit, and thermal shutdown.

Current-Mode DC-DC Controller.

The peak current-mode controller allows boost converter to generate the required output voltage for LED strings. The switching frequency is programmable in the range between 100 kHz and 500 kHz through a resistor connected from RT pin to ground.

Once the device is turned on, the external MOSFET will drive the inductor current to ramp up linearly until the MOSFET reaches the peak current level set by CS pin. The peak inductor current is sensed by measuring the voltage across the current-sense resistor $R_{CS,}$ which is connected from the source of external MOSFET to ground. LD5805 features leading edge blanking time to suppress the switching noise from the external MOSFET. A DIM comparator compares the current-sense voltage and the slop compensation signal with the output of the GM error amplifier. The device will turn off the external MOSFET when the voltage over CS exceeds the error amplifier's output voltage. This process repeats during every switching cycle to achieve peak current-mode control.

Switching Frequency Selection

LD5805 operate in fixed frequency mode. The constant operation frequency is set by an external connected resistor between RT pin and ground. The resistor value is follow as:

$$F_{sw}(kHz) = \frac{31050}{R_T(k\Omega)}$$

Programming the LED Current

The LED current is programmable by placing a resistor between ISET pin and ground. Set the desired LED current according to the following equation:

$$I_{LED}(mA) = \frac{1200}{R_{ISET}(k\Omega)}$$

Dimming Control

The LD5805 provides two dimming control is achieved by applying an external PWM signal to the PWM pin.

Dimming control by dimming duty cycle and recommend input frequency is:

When use PDIM mode, Input frequency Range on PWM pin is 100Hz to 1kHz. If use ADIM mode, Input frequency Range on PWM pin is 1kHz to 30kHz.

PWM signal input for analog dimming, When a capacitor C_{LPF} is connected between LPF pin and GND. IC provides analog dimming function while receiving an external PWM signal at PWM pin. The capacitor performs the integration of the external PWM signal to a DC level for regulating the amplitude of the LED current. Varying the PWM duty cycle form 100% to 5% controls the amplitude of LED current from Maximum to Minimum of about 20:1 ratio. The LED current amplitude can calculated approximately according equation

$$I_{LED}(mA) = D \times \frac{1200}{R_{ISET}(k\Omega)} \times \frac{R_{LPF}(k\Omega)}{R_{LPF}(k\Omega) + 50}$$

Where: D is PWM duty cycle value. RLPF is optional resistor to keep LPF pin voltage low under IC disable condition.

Short LED protection

The voltage of LED1 ~ LED4 pins exceeds a typical threshold of approximately 8.8V during of normal operation, the corresponding string be turned off and latched.

Suggest to check LED1~LED4 pins voltage is under 90% of VLSCP value at input voltage is maximum and LED string voltage is minimum condition. To avoid IC is latched risk by short LED protection at enable moment.

LED Open String Protection

When any one of the LED strings is open, the output voltage will boost up until the voltage of OVP reaches the threshold of 2.0V approximately. The IC will ignore the opened string and the others will remain operation. If all the strings are opened and the voltage at OVP reaches 2.0V, the MOSFET drive output will be turned off and the IC will shut off and stay latched. Toggle ENA to resume the operation.

MOSFET Over-Current Protection

The LD5805 provides cycle-by-cycle current limit to protect the MOSFET. During the MOSFET turning on, LD5805 detects the CS pin voltage and if inductor peak current to cause to V_{CS} rises above approximately 0.55V, the LDR will shut off.

Output Terminal Short-circuit to ground Protection

When output terminal is short circuit to ground then OVP voltage falls below about 0.1V, MOSFET driving output (LDR pin) will turn off. This will protect the converter from damage.

LED1-3 Channels Operation

For applications where only three LED strings are used, the LD5805 provides design flexibly by disabling the fourth channel, LED4 opened. It is required that a resistor (R_{SET}) connected between CS pin and Boost MOS Source pin. The three LED strings should be connected to LED1-3 correspondingly.

LED String Setting	R_{SET}
1~3 Channel	4.7KΩ
1~4 Channel	100RΩ

Multi-Chip Parallel Operation

The LD5805 is flexible for extending LED Channels with two or three LD5805s in parallel. For the connection of two LD5805s extending 8 strings LEDs (Max.2 ICs):

(1) Connector the VIN pins of the master IC and the slave IC together to provide the power of the slave IC internal logic circuitry.

(2) Connector the COMP pins of the slave IC and the master IC together to regulate the voltage of all 8 strings LEDs.

(3) The MOS driving signals of the slave IC are not used; the boost converter can be only driven by the master IC.

(4) Do not let the CS pin of the slave IC floating, connector it to GND.

(5) The EN and Dimming signals should be applied to both ICs.

It is recommended to use external PWM dimming mode to achieve the accurate dimming synchronization of both parts.

Loop compensation

The LD5805 has an internal trans-conductance error amplifier for LED current regulation for COMP output to compensate the control loop. In case of open LED event that all LED strings are open, the COMP node will compensate the control loop still. The external inductor, output capacitor, the compensation resistor and the

capacitor determine the loop stability. The inductor and output capacitor are chosen based on the performance, size and cost. The compensation resistor and capacitor at COMP are selected to optimize control loop stability.

Thermal protection

Thermal protection limits total power dissipation in this device. When the junction temperature reaches 150°C approximately, the thermal sensor signals the shutdown logic turning off this device. The thermal sensor will turn this device on again after the IC's junction temperature cools by 20°C.

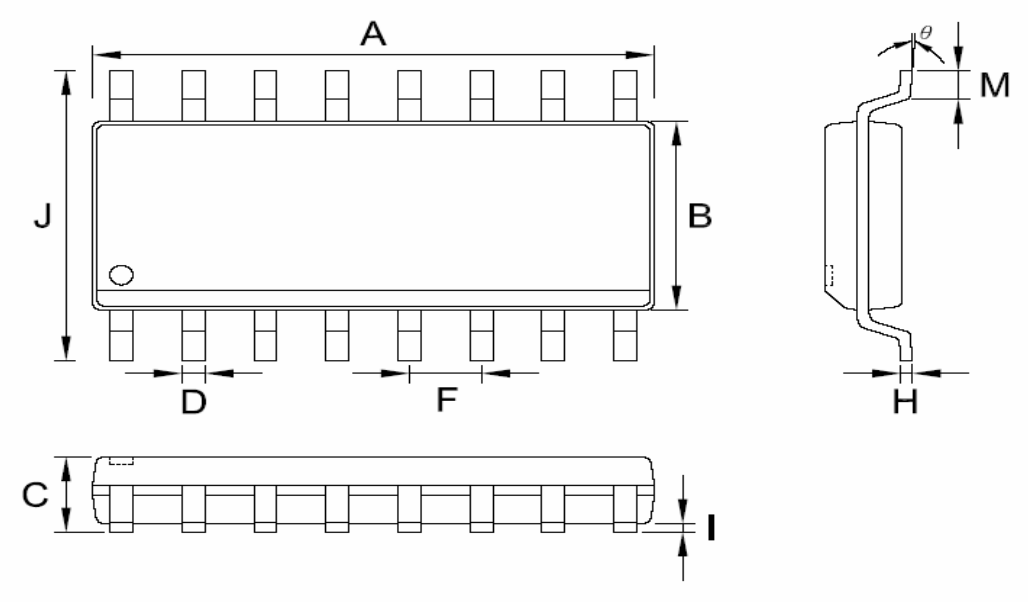
PCB Layout Guideline

It's recommended to separate the high frequency switching current from the low-level control signals in layout. The high switching current (MOSFET, inductor, LDR driver and LED return ends) may disturb the other low-level signals in the feedback loop and protection circuitry. As a result, it may cause the control function to behave abnormally. To avoid these issues, a few guidelines are recommended for the PCB layout, as below.

1. VCC bypass capacitor connected with signal ground must be placed as close as possible to the IC. The traces between capacitor and VCC pin should be kept as short as possible to avoid noise interference.
2. VIN bypass capacitor connected with signal ground must be placed as close as possible to the IC. The traces between capacitor and VIN pin should be kept as short as possible to avoid noise interference.
3. Use broader traces for VIN, VOUT and power ground. Components such as the power MOSFET and decoupling capacitors connected to VIN, VOUT and power ground, have high input/output current. To minimize power loss in these traces, the resistance of traces should be kept as low as possible.
4. Use broader traces between power MOSFET drain, inductor and diode. There is high current in these traces. To minimize power loss in these traces, the resistance of traces should be kept as low as possible.
5. Keep the LDR drive traces short and board between the IC driver output, LDR pin, and the power MOSFET.

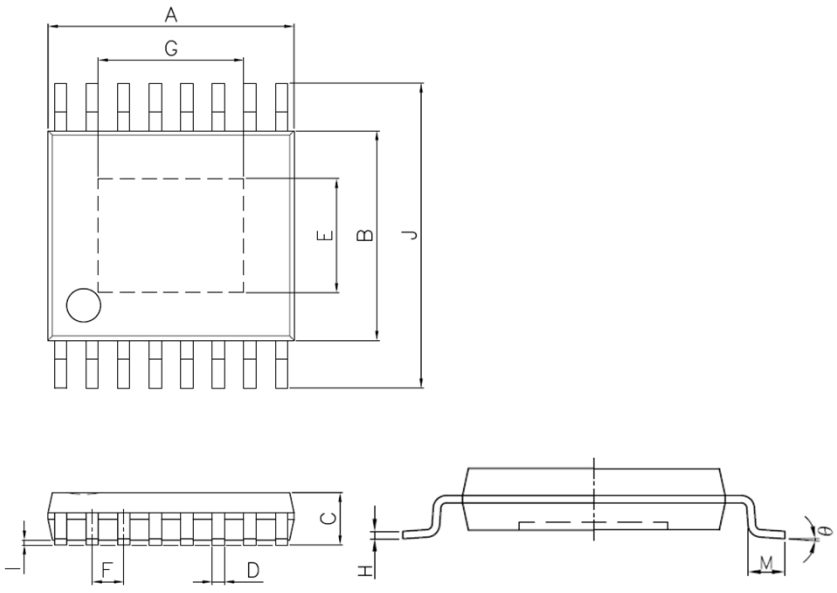
Package Information

SOP-16



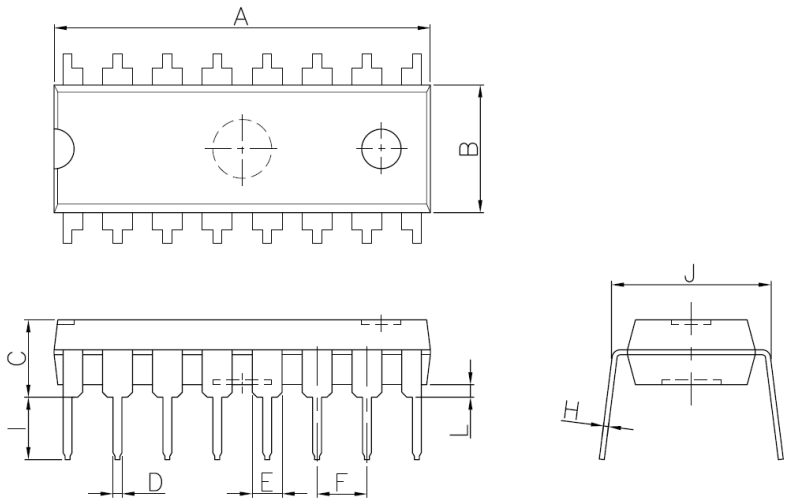
Symbol	Dimension in Millimeter		Dimension in Inch	
	Min	Max	Min	Max
A	9.800	10.010	0.386	0.394
B	3.800	4.000	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.510	0.013	0.020
F	1.27 TYP.		0.05 TYP.	
H	0.178	0.254	0.007	0.010
I	0.100	0.254	0.004	0.010
J	5.790	6.200	0.228	0.244
M	0.380	1.270	0.015	0.050
θ	0°	8°	0°	8°

TSSOP- 16-EP



Symbol	Dimension in Millimeter		Dimension in Inch	
	Min	Max	Min	Max
A	4.900	5.100	0.193	0.201
B	4.300	4.500	0.169	0.177
C	0.850	1.200	0.033	0.047
D	0.190	0.300	0.007	0.012
E	2.000	3.000	0.079	0.118
F	0.65 TYP.		0.026 TYP.	
G	2.000	3.000	0.079	0.118
H	0.127 TYP.		0.005 TYP.	
I	0.005	0.150	0.000	0.006
J	6.200	6.600	0.244	0.260
M	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

DIP-16 (300mil)



Symbol	Dimension in Millimeter		Dimension in Inch	
	Min	Max	Min	Max
A	18.880	19.320	0.743	0.761
B	6.096	7.112	0.240	0.280
C	---	5.334	---	0.210
D	0.356	0.584	0.014	0.023
E	1.140	1.780	0.045	0.070
F	2.337	2.743	0.092	0.108
I	2.921	3.556	0.115	0.140
J	7.366	8.260	0.290	0.325
L	0.380	---	0.015	---

Important Notice

Leadtrend Technology Corp. reserves the right to make changes or corrections to its products at any time without notice. Customers should verify the datasheets are current and complete before placing order.

Revision History

REV.	Date	Change Notice
00	12/17/2014	Original Specification.
01	06/15/2015	1. LED Short Circuit Protection Threshold Modify. 2. Absolute Tolerance of Regulation LED Current per Channel at Minimum Dimming 2%~6% @ ISET=12Kohm ADIM=0V. 3. LEDs Current Matching Calculating at Minimum Dimming +/-5% (Max.) @ ISET=12Kohm ADIM=0V. 4. Change order information LD5805GHE1 for TSSOP-EP-16 LD5805GS1 for SOP-16 LD5805GN1 for DIP-16