4 Channel LED Backlight Driver

REV: 05

General Description

The LD7889 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 LD7889 can deliver 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 240mA.

The LD7889 incorporates 4 individual current regulator channels to give accurate driving current for each LED string. The string-to-string tolerance is set within ±2%.

PWM input pin controls LED brightness from PWM control signals.

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

Features

- Input Voltage range: 4.5V to 36V
- Drives up to 4 strings in parallel, up to 240mA per string
- Time-shift PWM dimming control
- External PWM dimming control
- LED short circuit protection
- LED open string protection
- MOSFET over-current protection
- Over-temperature protection
- Status output

Applications

- UMPC and Notebook Computer Backlight
- Backlight for GPS, Portable DVD
- LED Backlight for LCD Monitor/ TV

Typical Application

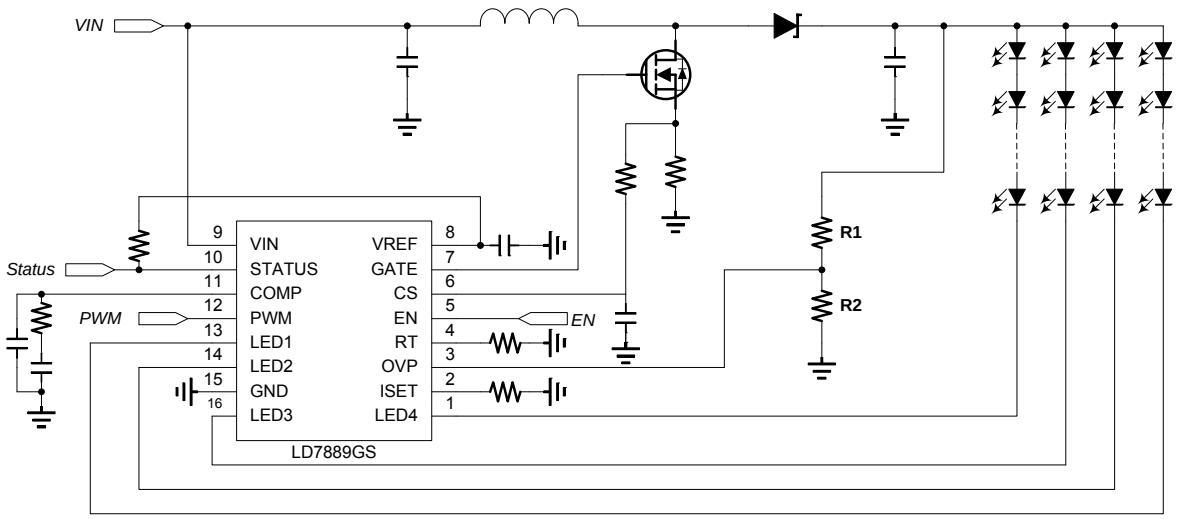
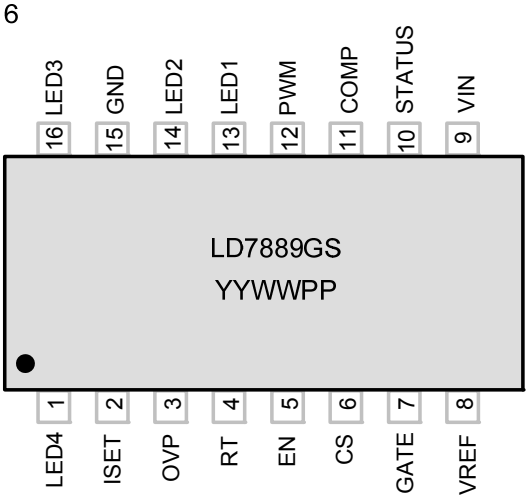


Fig.1 LD7889 SOP-16 package application circuit for 4 strings of LED line bar

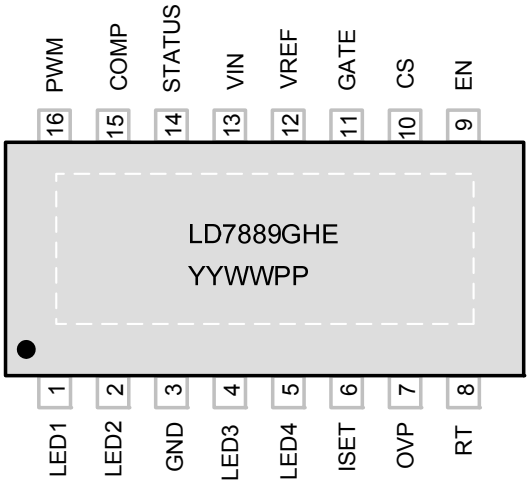
Pin Configuration

SOP-16

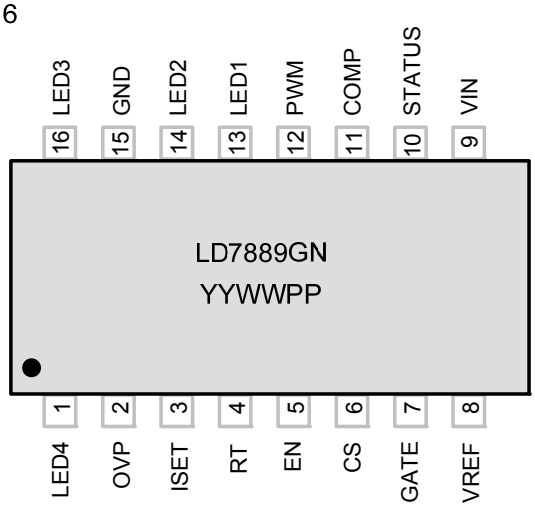


YY: Year Code
WW: Week Code
PP: Production Code

TSSOP-EP-16



DIP-16



Ordering Information

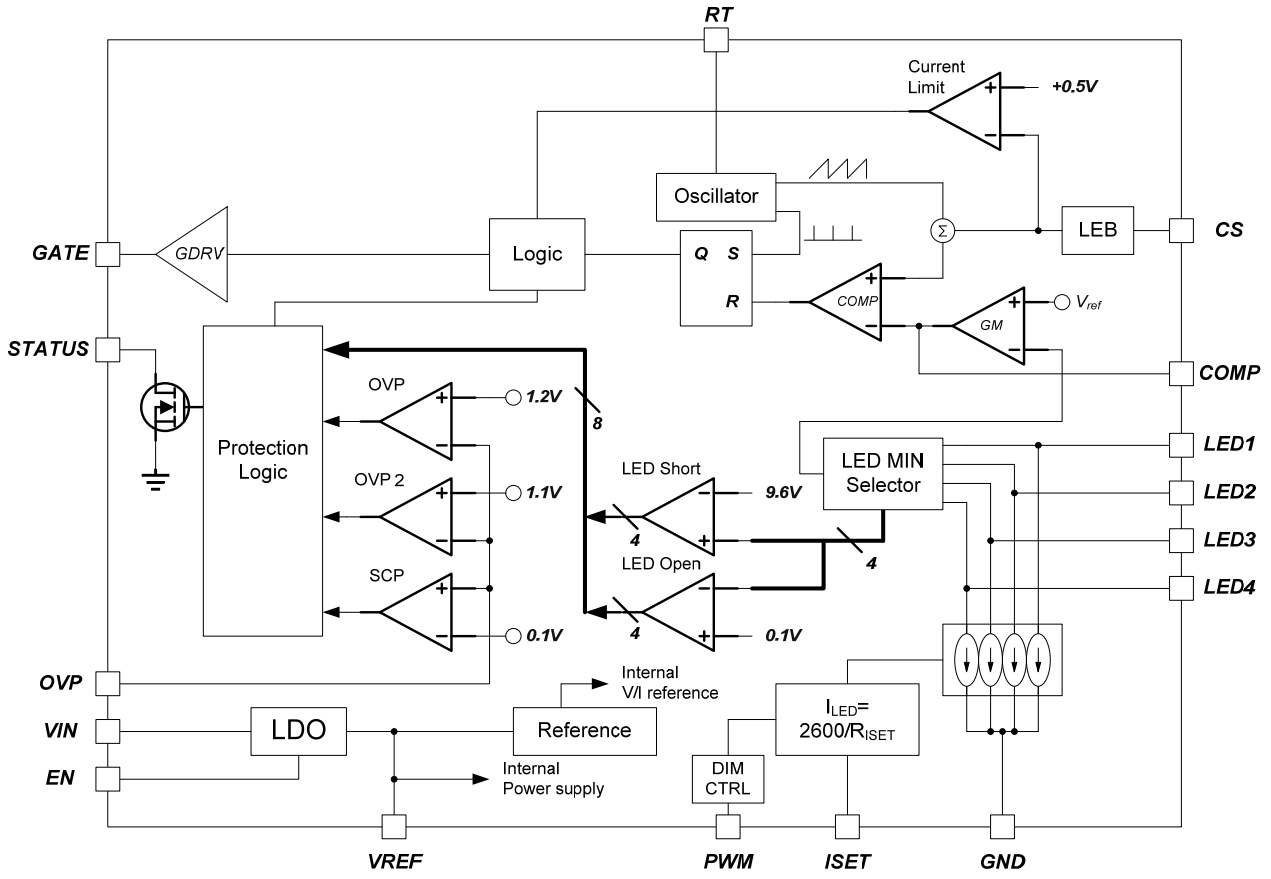
Part number	Package	Top Mark	Shipping
LD7889GS	SOP-16	LD7889GS	2500 /tape & reel
LD7889GHE	TSSOP-EP-16	LD7889GHE	2500 /tape & reel
LD7889GN	DIP-16	LD7889GN	1800 /Tube/ Carton

The LD7889 is green packaged.

Pin Descriptions

PIN SOP-16	PIN TSSOP-16	PIN DIP-16	NAME	FUNCTION
1	5	1	LED4	LED string #4 current input.
2	6	3	ISET	LED current resistor setting
3	7	2	OVP	Over-voltage protection
4	8	4	RT	Operating frequency resistor setting
5	9	5	EN	Chip enable pin.
6	10	6	CS	Power MOSFET current sense pin.
7	11	7	GATE	Low side Power MOSFET Driver
8	12	8	VREF	5V Internal linear regulator output pin with an external ceramic capacitor of 1μF or greater.
9	13	9	VIN	Input Power of the chip. Bypass with at least 1μF ceramic capacitor and place it close to VIN pin.
10	14	10	STATUS	LED operation status output
11	15	11	COMP	Soft start and control loop Compensation.
12	16	12	PWM	PWM dimming input.
13	1	13	LED1	LED string #1 current input.
14	2	14	LED2	LED string #2 current input.
15	3	15	GND	IC ground
16	4	16	LED3	LED string #3 current input.

Block Diagram



Absolute Maximum Ratings

VIN	40V
CS	-0.3V ~ 5.5V
V_{LED1} to V_{LED4}	-0.3V ~ 60V
STATUS, OVP, PWM, EN	-0.3V ~ 5.5V
VREF, COMP, RT, GATE, ISET	-0.3V ~ 6V
GND	±0.3V
I_{LEDx} pulse forward current (Pulse time≤2ms)	400mA
I_{LED1} to I_{LED4}	330mA
Package Thermal Resistance	
TSSOP-EP-16, θ_{JA}	60 °C/W
SOP-16, θ_{JA}	110 °C/W
DIP-16, θ_{JA}	80 °C/W
Operating Temperature Range	-40°C to 85°C
Storage Temperature Range	-55°C to 125°C
Junction Temperature	150°C
Lead Temperature (Soldering, 10sec)	260°C
ESD Level (Human Body Model)	2KV
ESD Level (Machine Model)	200V

Recommended Operating Conditions

Input Supply Voltage	4.5V to 36V
I_{LED1} to I_{LED4}	20mA to 240mA

Caution:

Stresses beyond the ratings specified in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

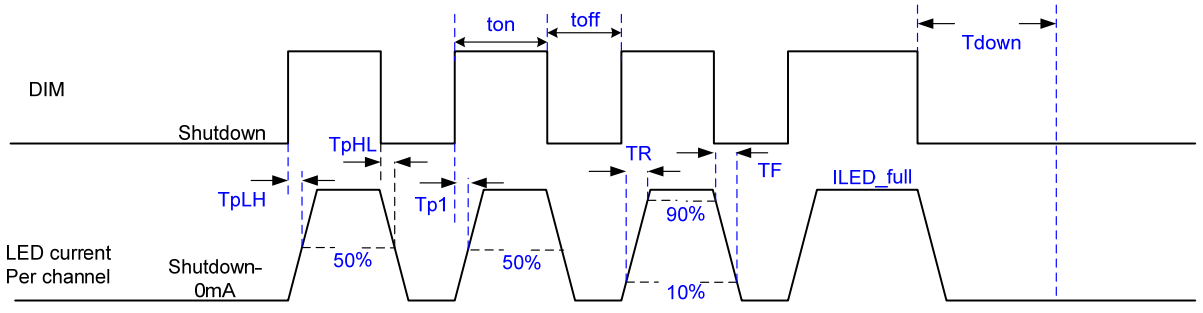
Electrical Characteristics

(V_{IN}=24V, T_A=25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Power					
Input Voltage range		4.5		36	V
VIN Operating Current	EN=PWM=5V		7	10	mA
VIN Shutdown Current	EN=PWM=0V		4	7	μA
VIN Stand-By Current	EN=5V, PWM=0V		600	700	μA
Under Voltage Lockout					
Lockout Threshold	$VREF_{LOCKOUT}$	3.6	4.1	4.2	V
Resume Threshold	$VREF_{RESUME}$	4.2	4.4	4.6	V
Reference Voltage					
Reference Voltage	V_{REF}, V_{IN}>6V	5.25	5.5	5.75	V
VREF Output Current Capability	I_{VREF}			30	mA
Drive Logic					
GATE Sink Resistance	V_{IN}>6V		3.5		Ω
GATE Source Resistance	V_{IN}>6V		5		Ω
Minimum MOSFET ON Time			150		ns
LED Current Regulation					
Regulation LED Current per Channel	I_{SET}=26KΩ ,K_{ISET}=2600 Chip to chip average current	96	100	104	mA
Voltage at ISET pin		1.225	1.25	1.275	V
LEDs Current Matching	LED current=100mA Calculating: $\frac{I_{MAX}-I_{MIN}}{2\times I_{Average}}\times 100\%$		±1.5	±2	%
LED regulation voltage	I_{LED}=100mA/ per channel		250		mV
Boost Controller					
Adjustable Switching frequency		100		1000	kHz
Default Switching frequency	R_{RT} =150kΩ	558	620	682	kHz
Leading edge blanking time			150		ns
Voltage at RT pin		1.176	1.2	1.224	V
Boost Maximum duty cycle	Fsw=500kHz	90	93	96	%

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
EN and PWM Dimming					
EN and PWM Logic	Enable	1.8			V
	Disable			0.7	V
Turn-on time, PWM rising to ILED from shutdown (Tp1)	(Note1)		1000		ns
LED rise time (TR)	(Note1)		600		ns
LED fall time(TF)	(Note1)		600		ns
Shutdown Recover Delay Time (T_{DOWN})	(Note1)		2^{15}		cycle
LED "ON" Period (t_{ON})	(Note1)		1		cycle
LED "OFF" Period (t_{OFF})	(Note1)		1		cycle
PWM dimming frequency		100		25k	Hz
Protection					
LED Open String Protection Threshold	OVP	1.07	1.1	1.13	V
Shutdown Under Abnormal condition	OVP	1.17	1.2	1.23	V
LED Short Circuit Protection Threshold	LED1~LED4	9.1	9.6	10.1	V
Boost- Short circuit startup	During start-up,		0.1		V
Boost- Short circuit startup Hysteresis			50		mV
Thermal Shutdown threshold			140		°C
Thermal Shutdown hysteresis			30		°C
MOSFET Over-Current Protection					
N-FET Over-Current Protection	CS	0.47	0.5	0.53	V
STATUS Output					
Sink Resistance			20	100	Ω

Note1:



Typical Performance Characteristics

22 LEDs in series, 4 strings parallel, 120mA/string, C_{OUT}=4.7μF, unless otherwise noted.

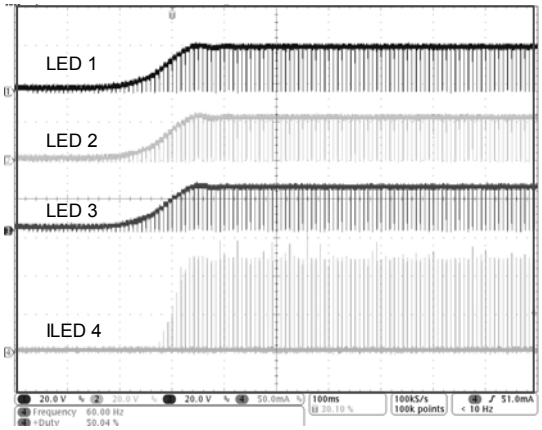


Fig. 2 V_{IN}=16V, "F_{DIM}=120Hz, Duty=5%"

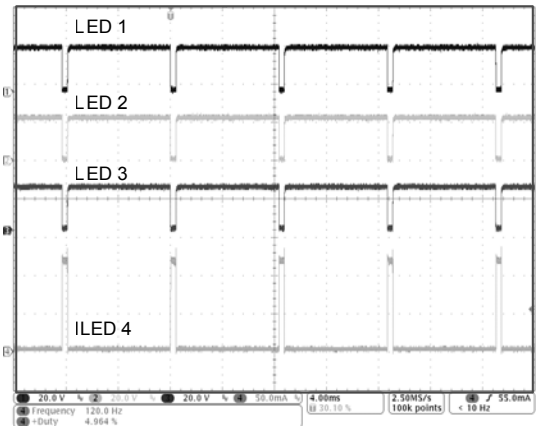


Fig. 3 V_{IN}=16V, "F_{DIM}=120Hz, Duty=5%"

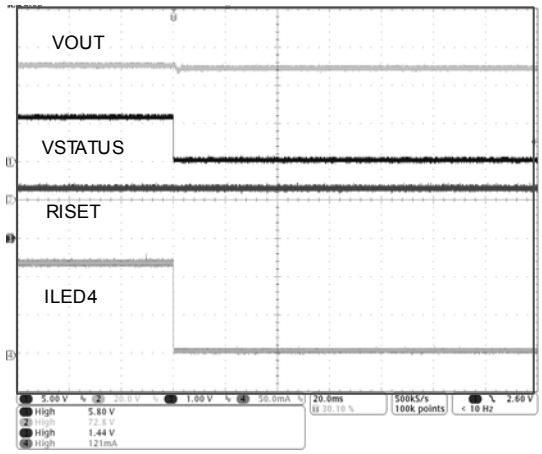


Fig. 4 V_{IN}=16V, "LED Short Protection ,Dim Duty=100%"

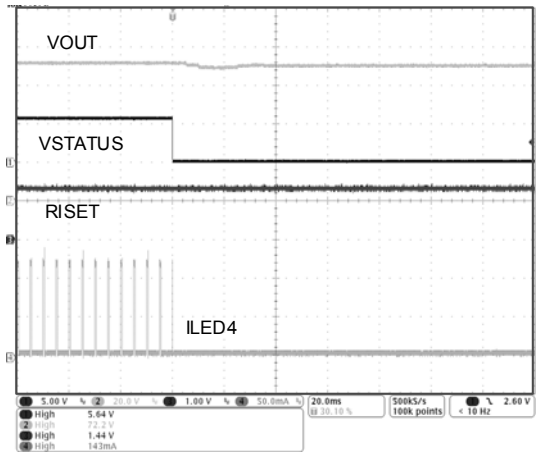


Fig. 5 V_{IN}=16V, "LED Short Protection, f_{DIM}=200Hz, Duty=10%

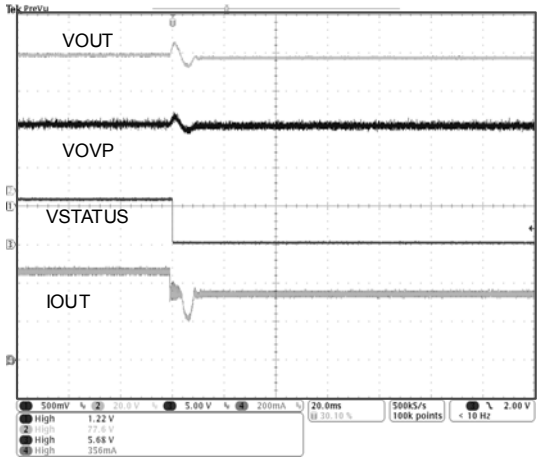


Fig. 6 V_{IN}=16V, "LED Open Protection ,Dim Duty=100%"

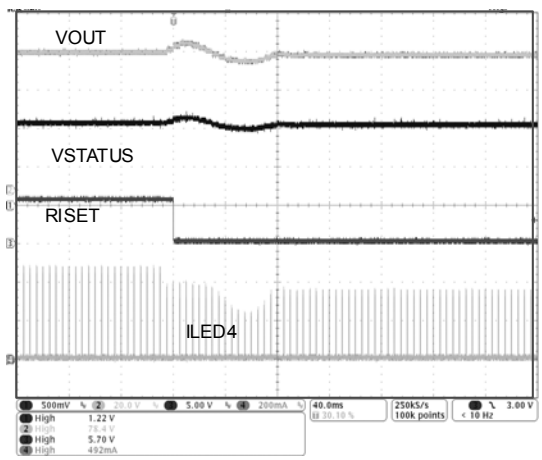


Fig. 7 V_{IN}=16V, "LED Open Protection , f_{DIM} =200Hz,Duty=10%

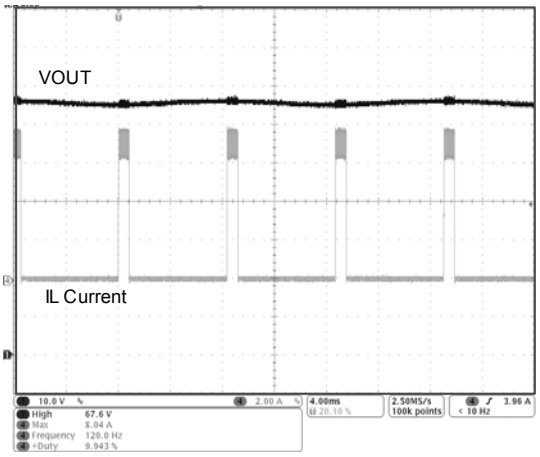


Fig. 8 V_{IN}=16V, V_{LED}=70V , 320mA/string, "f_{DIM} = 120Hz,Duty=10%"

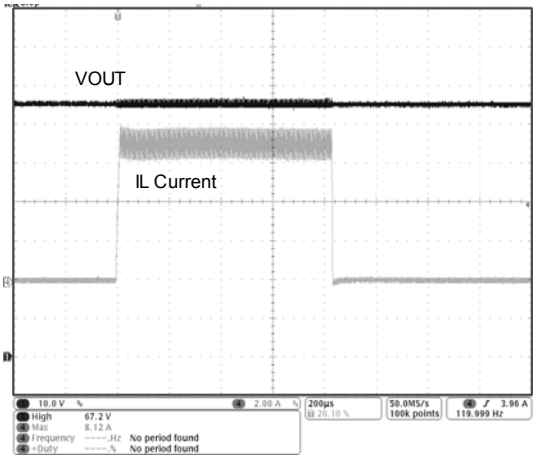


Fig. 9 V_{IN}=16V, V_{LED}=70V , 320mA/string, "f_{DIM} = 120Hz, Duty=10%"

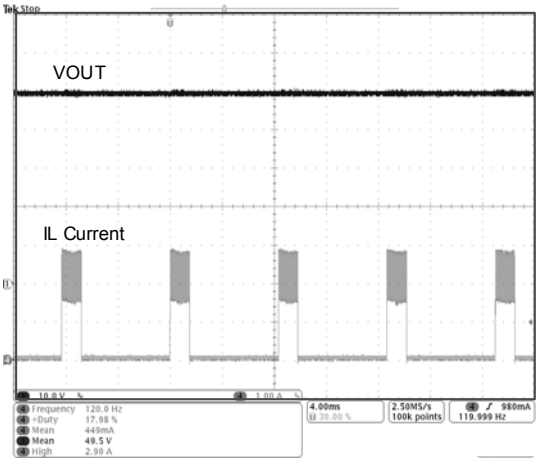


Fig. 10 V_{IN}=16V, V_{LED}=50V, 160mA/string, "f_{DIM} = 120Hz,Duty=20%"

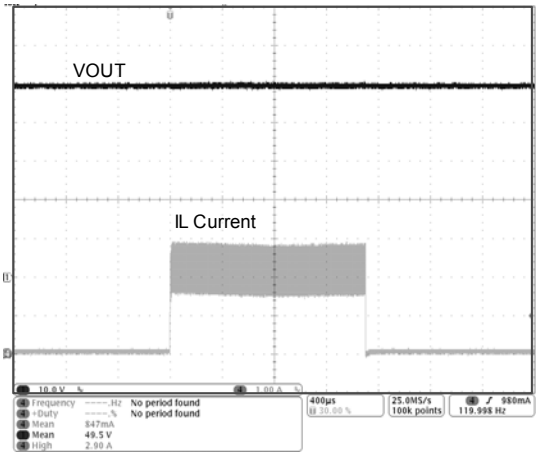


Fig. 11 V_{IN}=16V,VLED=50V, 160mA/string, "f_{DIM} =120Hz, Duty=20%"

Application Information

General Description

The LD7889 is a high-efficiency driver, ideally for LED backlight application. It incorporates with two major functions, a DC-DC boost controller with peak current-mode control and a 4-channel LED driver with constant current of sink capability from 20mA to 240mA per channel.

LD7889 features adaptive voltage control that adjusts the converter output voltage according to the total forward voltage of LED strings. It minimizes the voltage drop 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 1 MHz 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. LD7889 features leading edge blanking time to suppress the switching noise from the external MOSFET. A PWM 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 in every switching cycle to achieve peak current-mode control.

Switching Frequency Selection

LD7889 can operate in fixed frequency mode. The constant operation frequency is set by an external resistor connected between RT pin and ground. The resistor sets the charging current for internal oscillator.

$$F_{SW}\,(kHz) = \frac{21822}{[RT\,(k\Omega)]^{0.711}}$$

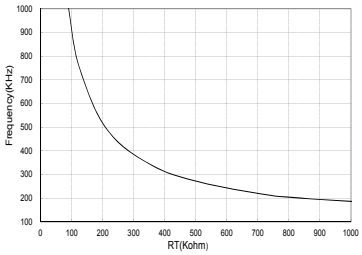


Fig. 12 Frequency vs. RT

Programming the LED Current

The LED current is programmable by placing a resistor between the ISET pin and ground. The ISET pin resistor is recommended to select in the range from 11kΩ to 130kΩ. Set the desired LED current according to the following equation:

$$I_{LED}(mA) = \frac{2600}{R_{ISET}(k\Omega)}$$

PWM dimming

PWM dimming control is achieved by applying an external PWM signal of 100Hz to 25kHz to the PWM pin.

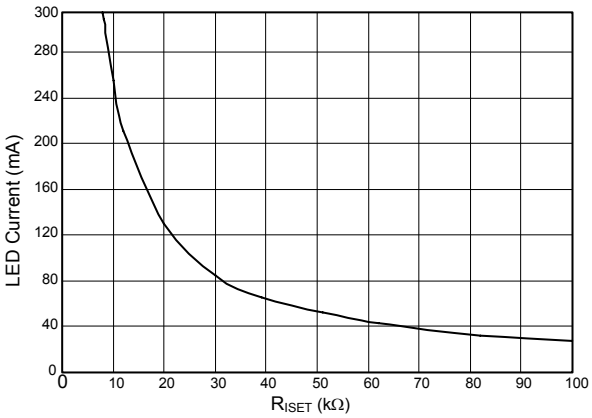
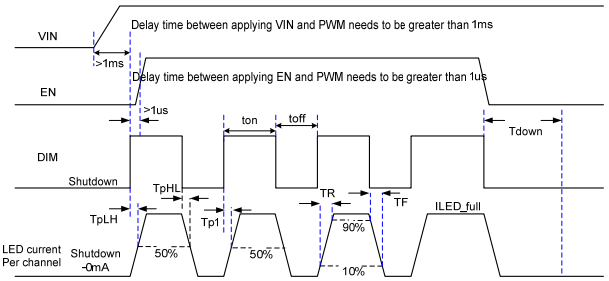


Fig. 13 LED Current vs. R_{ISET}

Power Sequence and Timing Chart

That is, the supply voltage must be applied to VIN pin before the dimming signal (to DIM pin) by at least 1ms and then the shutdown signal (to EN pin). Please follow the proper power sequence in below timing chart.



MOSFET Over-Current Protection

The LD7889 provides cycle-by-cycle current limit to protect the MOSFET. During the MOSFET turning on, LD7889 detects the CS pin voltage and if V_{CS} rises above approximately 0.5V, the GATE will shut off.

For suppress switch transients could add the RC filter to close the LD7889 CS pin. The typical suggestion value is R=1kΩ, C=100pF.

Loop compensation

The LD7889 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. For typical LED applications, a 0.22μF compensation capacitor in series with a 3kΩ resistor at COMP is adequate.

LED Short Circuit Protection

The voltage of LED1 ~ LED4 pins exceeds a typical threshold of approximately 9.6V during of normal operation, the corresponding string be turned off and latched.

LED Open String Protection

When LED1-4 pins voltage falls below about 0.1V and V_{out} will boost up until the voltage at pin OVP reaches a typical threshold of approximately 1.1V threshold. That will set the LED output over voltage (V_{LED_OVP2}) as following equation:

$$V_{LED\_OVP2}(V) = 1.1 \times \frac{R_1 + R_2}{R_2}$$

Thermal protection

Thermal protection limits total power dissipation in this device. When the junction temperature reaches 140°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 30°C.

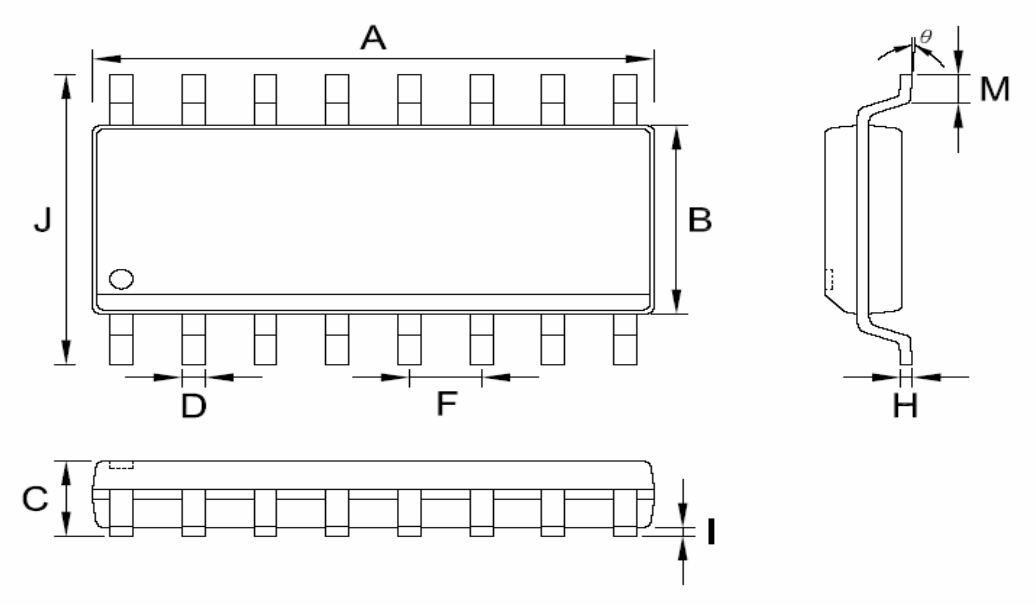
PCB Layout Guideline

It's recommended to separate the high frequency switching current from the low-level control signals in layout. The high switching current (MOSFET, inductor, gate 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. VREF bypass capacitor connected with signal ground must be placed as close as possible to the IC. The traces between capacitor and VREF 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 gate drive traces short and board between the IC driver output, GATE pin, and the power MOSFET. The driving traces have a high current spike during inverter operation. To minimize power MOSFET switching loss or oscillation voltage in the gate driver signal, the drive traces should be as board and short as possible to minimize resistance and parasitic inductance.

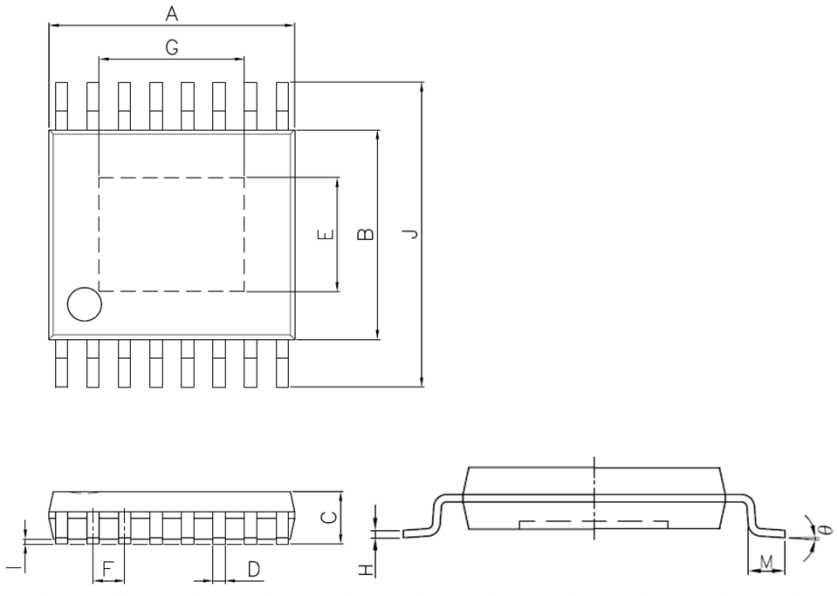
Package Information

SOP-16



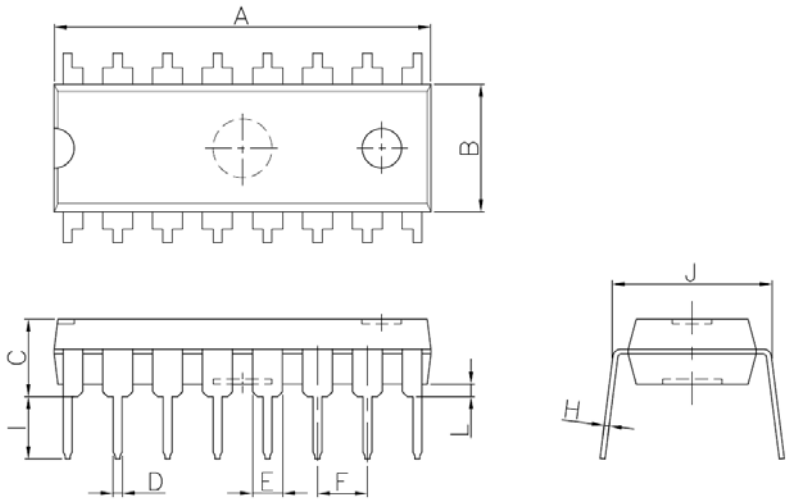
Symbol	Dimension in Millimeter		Dimension in Inch	
	Min	Max	Min	Max
A	9.800	10.010	0.386	0.394
B	3.800	4.000	0.150	0.157
C	1.346	1.753	0.053	0.069
D	0.330	0.510	0.013	0.020
F	1.27 TYP.		0.05 TYP.	
H	0.178	0.254	0.007	0.010
I	0.100	0.254	0.004	0.010
J	5.790	6.200	0.228	0.244
M	0.380	1.270	0.015	0.050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

TSSOP-EP-16



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)

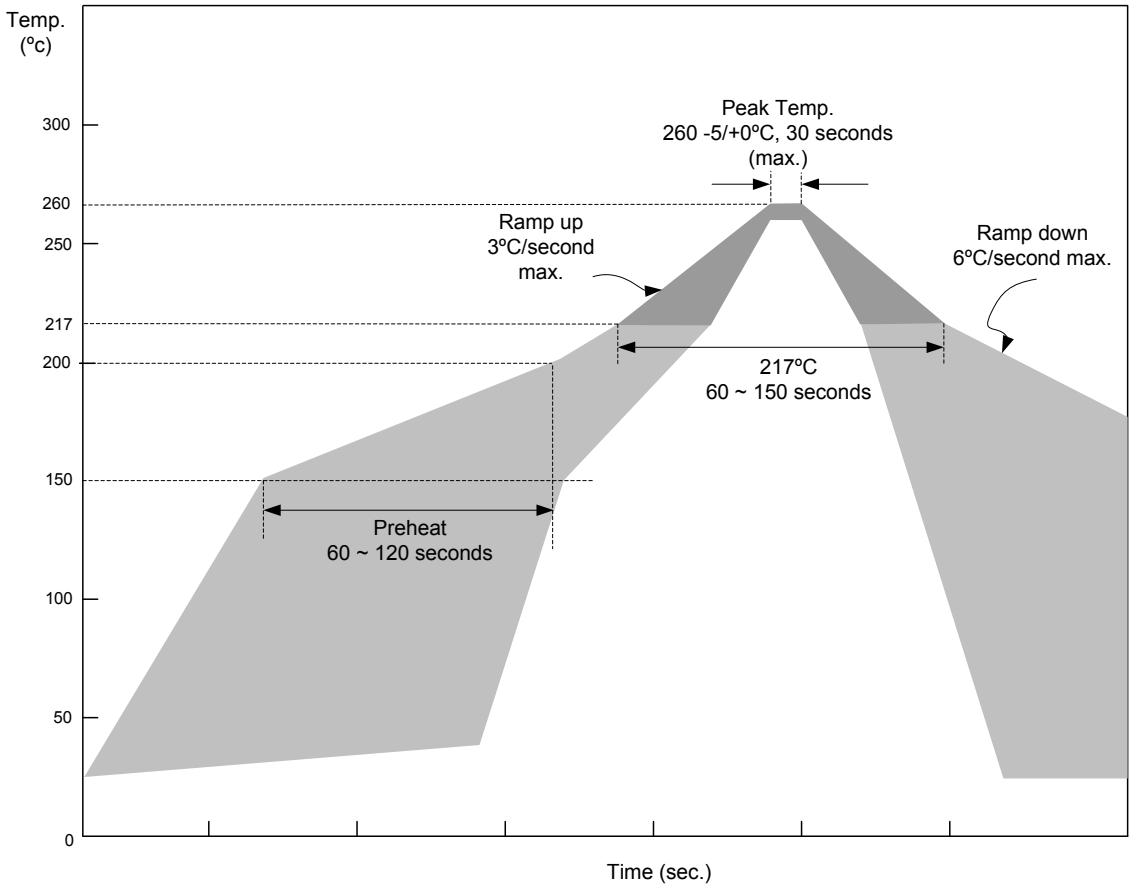


Symbol	Dimension in Millimeter		Dimension in Inch	
	Min	Max	Min	Max
A	18.880	19.320	0.743	0.761
B	6.096	7.112	0.240	0.280
C	---	5.334	---	0.210
D	0.356	0.584	0.014	0.023
E	1.140	1.780	0.045	0.070
F	2.337	2.743	0.092	0.108
I	2.921	3.556	0.115	0.140
J	7.366	8.260	0.290	0.325
L	0.380	---	0.015	0.000

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.

IR Profile for SMD Devices



Item	Average Ramp-up Rate	Pre-heat (150 ~ 200°C)	Time Maintained Above 217°C	Peak Temp.	Ramp-down Rate
Required	3°C(max) /sec	60~120 sec	60~150 seconds	260 +0/-5°C 30 seconds	6°C (max) /sec

Revision History

Rev.	Date	Change Notice
00	3/25/2011	Original Specification
01	5/27/2011	1. Block diagram update. 2. Sink Resistance of status output from 100Ω to 20Ω. 3. Add power sequence and timing chat.
02	7/11/2011	1. Add EC table Max and Min Limits 2. RT formula
03	8/04/2011	1. Add suggestion value for CS pin RC filter 2. Function Block VCC->VREF
04	8/16/2011	1. VREF maximum rating 5.5V→6V 2. COMP, RT, GATE, ISET Maximum rating (VREF+0.3)→6V
05	10/7/2011	1. Default Switching frequency 600kHz→620kHz 2. Switching frequency formula