

High Voltage 4-Channel LED Controller Driver

REV: 01

General Description

The LD7890 is a 4-channel LED controller with a boost switching controller. It's an ideal solution for driving high power LED backlights. The LD7890 can deliver high accuracy of constant current to 4 individual LED strings with 4 External MOSFET without cross-reference.

The LD7890 is designed for Current-Mode Boost Controller, capable to operate over a wide range VIN from 9V to 28V and build in the High voltage MOSFET gate to reduce external Power MOSFET thermal issue.

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

Features

- Input Voltage range: 9V to 28V
- 4 Channel LED Controller
- External and Internal PWM dimming control
- LED short circuit protection
- LED open string protection
- Cycle-by-Cycle Current Limit
- Over-temperature protection
- Status output

Applications

- LED TV Backlight
- LED Monitor Backlight
- LED Lighting

Typical Application

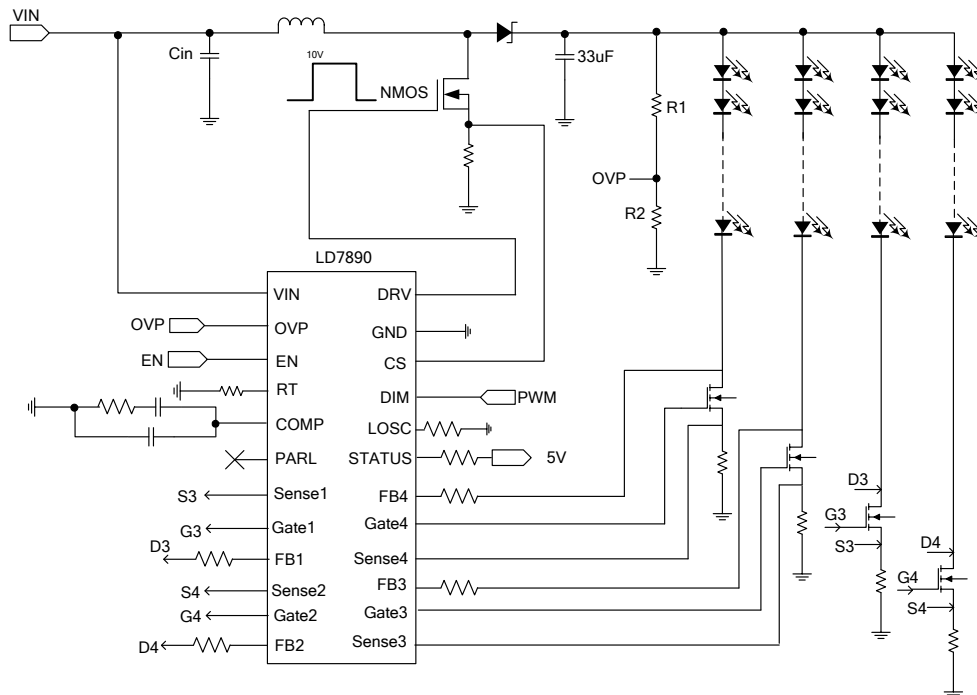


Fig. 1 Application circuit for 4 strings of LED light bar with External PWM

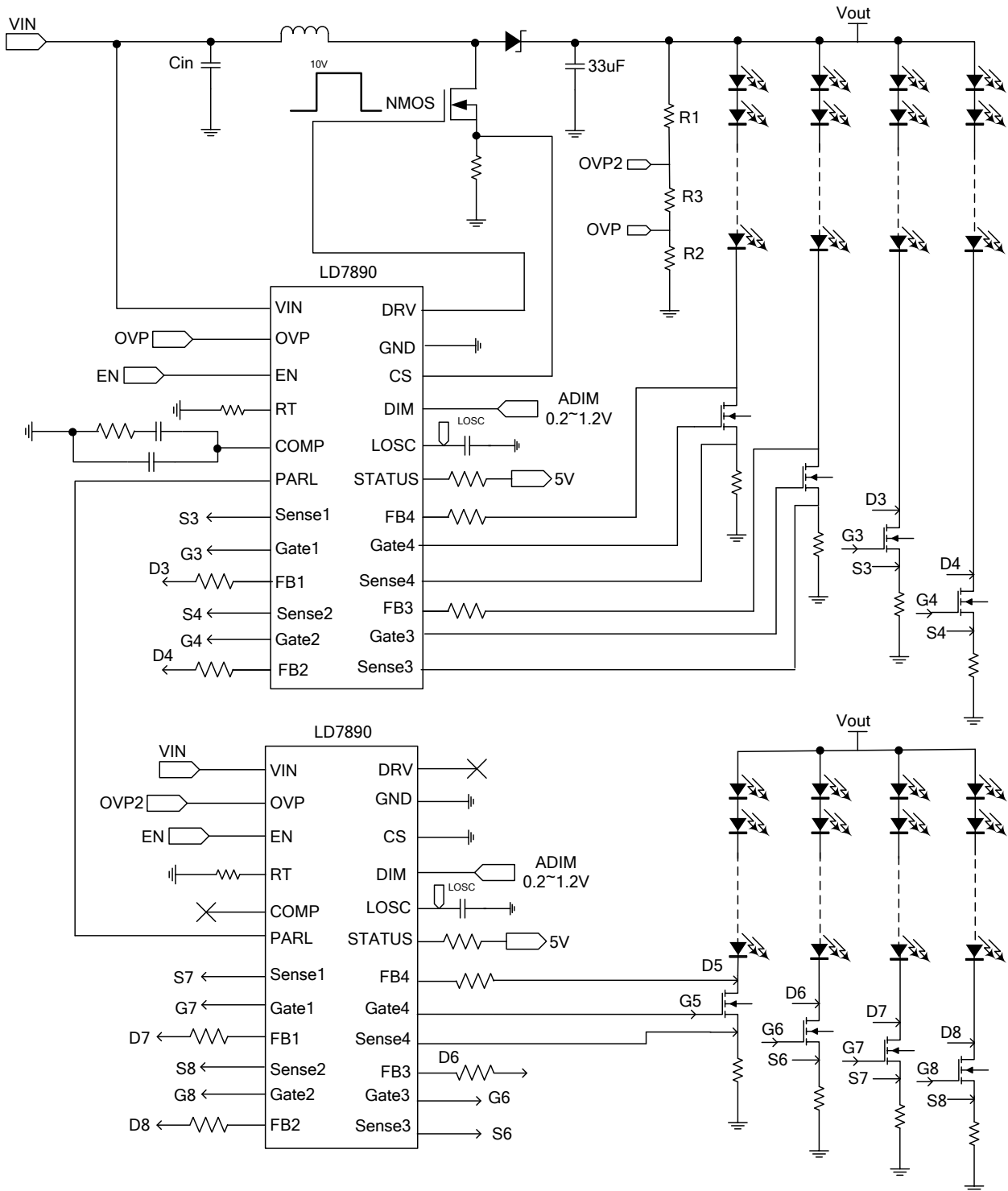
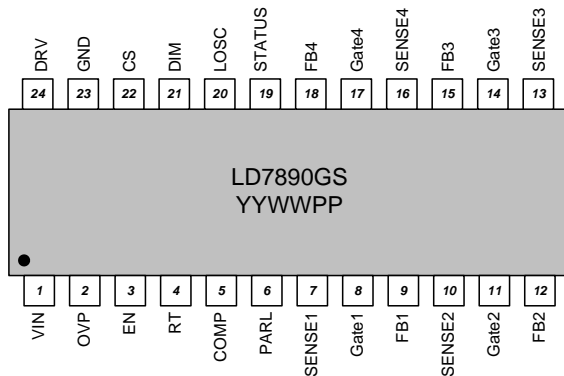


Fig. 2 Application Circuit for PARL 8 Strings of LED Light Bar with Internal PWM

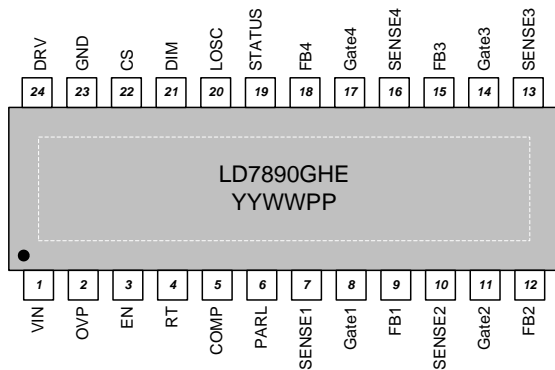
Pin Configuration

SOP-24



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

TSSOP-EP-24



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

Ordering Information

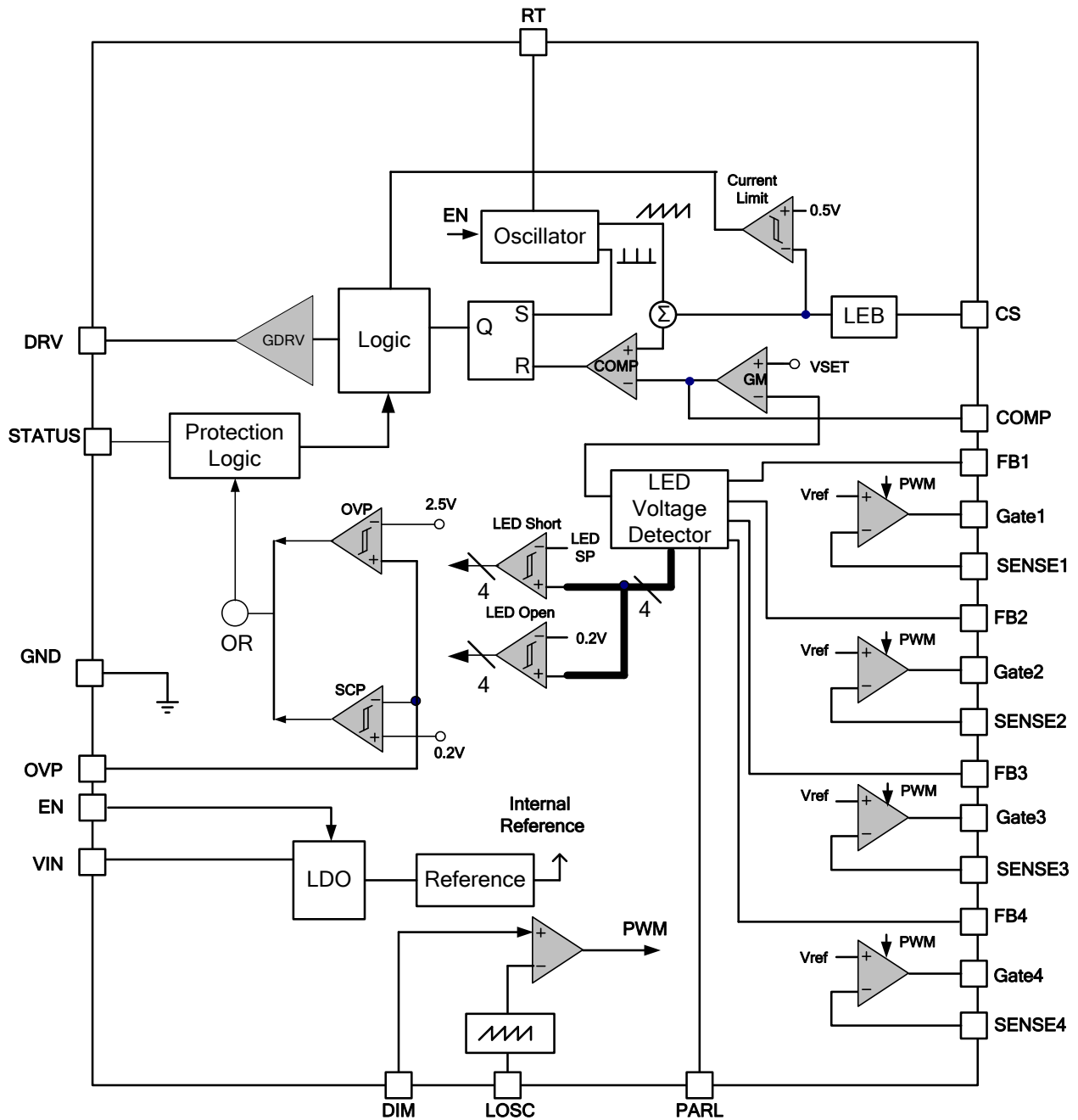
Part number	Package	Top Mark	Shipping
LD7890GS	SOP-24	LD7890GS	1000 /tape & reel
LD7890GHE	TSSOP-EP-24	LD7890GHE	2500 /tape & reel

The LD7890 is ROHS compliant /green packaged.

Pin Descriptions

PIN	NAME	FUNCTION
1	VIN	Power Input pin. Bypass it with a ceramic capacitor of 1 μ F or greater and place it close around VIN pin.
2	OVP	Over-voltage protection and Output short protection.
3	EN	Chip enable pin, with internal 950K Ω pull-down resistance.
4	RT	To set the resistor for operation frequency.
5	COMP	Compensation circuit for Boost topology.
6	PARL	Multi-chip parallel operation pin.
7,10,13,16	SENSE x	LED Current sense input pin. Connect it to GND through a sense resistor to regulate to 0.4V. The LED current is programmable according to the equation: $I_{LED}=0.4V/(\text{sense resistance})$.
8,11,14,17	Gate x	Gate pin, connection to external current source MOSFET. It sends a drive signal to the external MOSFET to regulate the LED current.
9,12,15,18	FB x	Detection pin for minimal voltage of LED light bar. The Boost Controller loop would select minimal LED Drain pin voltage to regulate output voltage and detect LED status. The reference voltage for FB pin is 0.8V.
19	STATUS	This pin is open drain output and indicates LED fault operation. Connector resistor > 50K Ω .
20	LOSC	Low frequency dimming frequency setting pin.
21	DIM	PWM or DC signal for duty cycle of dimming control signal, with internal pull down 950K Ω Resistance.
22	CS	Current sensing pin for power MOSFET, with threshold voltage of 0.5V and LEB time of 330nS.
23	GND	IC ground.
24	DRV	Power MOSFET Driver, supplying output voltage level up to 10V.

Block Diagram



Absolute Maximum Ratings

VIN.....	30V
V _{FB1} to V _{FB4} , V _{GATE1} to V _{GATE4} , CS	-0.3V ~ 30V
DRV	-0.3V ~ 16V
V _{SENSE1} to V _{SENSE4}	-0.3V ~ 5.5V
COMP, RT, OVP, DIM, EN, PARL, STATUS, LOSC.....	-0.3V ~ 5.5V
GND	±0.3V
Package Thermal Resistance	
TSSOP-EP-24, θ_{JA}	50 °C/W
SOP-24, θ_{JA}	75 °C/W
Power Dissipation (Ta=85°C)	
TSSOP-EP-24.....	800mW
SOP-24.....	867mW
Storage Temperature Range.....	-65°C ~ 150°C
Junction Temperature	150°C
Lead Temperature (Soldering, 10sec)	260°C
ESD Level, Human Body Model	
(V _{SENSE1} to V _{SENSE4} , COMP, RT, OVP, DIM, EN, PARL, STATUS, LOSC) ...	3.5KV
(VIN, V _{FB1} to V _{FB4} , V _{GATE1} to V _{GATE4} , CS, DRV).....	2.5KV
ESD Level, Machine Model.....	200V

Recommended Operating Conditions

Input Supply Voltage	12V ~ 24V
Switching Frequency.....	100K ~ 600KHz
DIM, EN	0V ~ 5V
PWM Frequency.....	100Hz ~ 800Hz
PWM Dimming Duty.....	5% ~ 100%
Operating Junction Temperature Range	-40°C~125°C

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.

Electrical Characteristics

($V_{IN}=12V$, $V_{EN}=5V$, $GND=0V$, $T_A=25^{\circ}C$, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Input Power					
Input Voltage range		9		28	V
VIN Operating Current	EN=DIM=5V, No load with switching			10	mA
VIN Shutdown Current	EN=DIM=0V		40	80	μA
VIN Stand-By Current	EN=5V, DIM=0V			3	mA
Under Voltage Lockout					
Lockout Threshold	$V_{IN_LOCKOUT}$	7.5			V
Resume Threshold	V_{IN_RESUME}			8.9	V
Drive Logic					
DRV gate driver *	Source current, $V_{IN}=12V$		1		A
	Sink current, $V_{IN}=12V$		1.3		A
DRV Output Clamp Level	$V_{IN}=24V$	8.5	10	13	V
Boost Controller					
Adjustable Switching frequency		50		700	kHz
	$R_{RT}=200k\Omega$	290	325	360	kHz
Boost Maximum duty cycle	$F_{SW}=300kHz$	90		96	%
Current Sense Threshold		0.45	0.5	0.55	V
Current Sense LEB Time	Leading edge blanking time	270	330	410	ns
VSET Reference Voltage		0.64	0.8	0.96	V
LED Current Source Regulator :					
Reference Voltage for $SENSE_N$ Voltage 0.4V. ($I_{LED}=V_{SENSE}/R_{SENSE}$)	$V_{IN}=12V\sim 24V$ $V_{SENSE_REF}=0.4V$			$\pm 3\%$	V
SENSE Voltage CH to CH Matching	$\frac{V_{sense_max} - V_{sense_min}}{2 \times V_{sense_average}}$			$\pm 2\%$	%
GATE1~GATE4 High Voltage	EN=DIM=5V, $SENSE[1\sim 4]=0.2V$,	5.5		7	V
GATE1~GATE4 Low Voltage	EN=DIM=5V, $SENSE[1\sim 4]=0.6V$,	-0.3		0.25	V

PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
PWM Dimming and EN					
EN Logic	Enable	1.5			V
	Disable			0.7	V
PWM Pull Down Resistance			950		K Ω
EN Pull Down Resistance			950		K Ω
PWM dimming frequency		100		1k	Hz
LOSC Frequency	C _{LOSC} =2.2nF		0.9		KHz
LOSC Ramp Amplitude *	Peak		1.2		V
	Valley		200		mV
Protection					
LED Over Voltage Threshold	OVP	2.4	2.5	2.6	V
LED Over Voltage Hysteresis	OVP Hysteresis		50	80	mV
Short Protection Current	I _{SP}	7.5	10	12.5	μ A
Short Protection Threshold Voltage	V _{LEDSP}	2.8	3	3.2	V
SENSE _N Under Voltage Protection Threshold	LED Open Protection	0.15	0.2	0.25	V
Boost- Short circuit Protection	OVP pin voltage	0.15	0.2	0.25	V
Thermal Shutdown threshold			150		$^{\circ}$ C
Thermal Shutdown hysteresis			30		$^{\circ}$ C
STATUS Output					
Sink Resistance				100	Ω

* Guaranteed by design

Typical Performance Characteristics

$V_{IN}=24V$, $V_{OUT} \sim 45V$ (13 LEDs), 4 channels, 250mA/sting, Freq $\sim 150KHz$, $C_{out}=100\mu F$, unless otherwise noted.

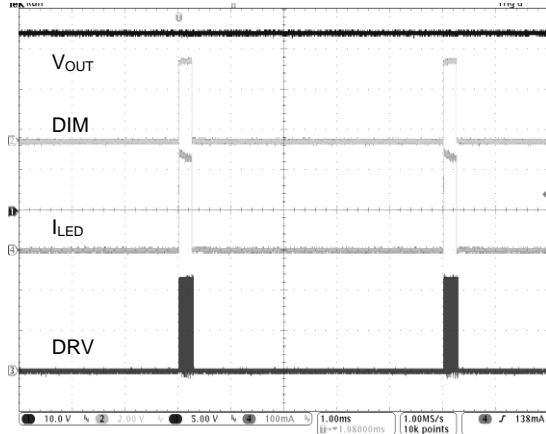


Fig. 1 $V_{IN}=24V$, " $F_{DIM}=200Hz$, Duty=5%"

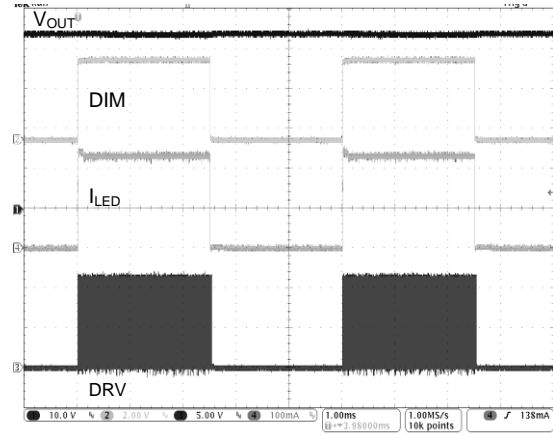


Fig. 2 $V_{IN}=24V$, " $F_{DIM}=200Hz$, Duty=50%"

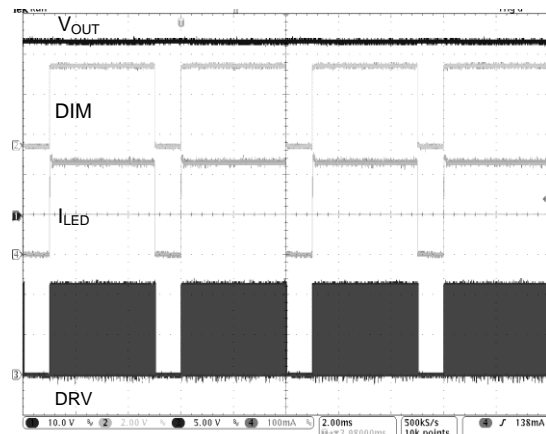


Fig. 3 $V_{IN}=24V$, " $F_{DIM}=200Hz$, Dim Duty=80%"

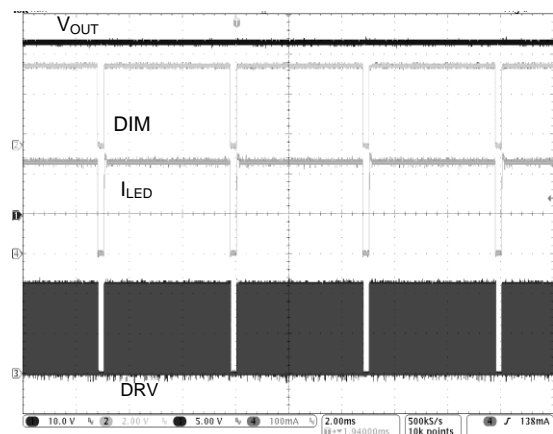


Fig. 4 $V_{IN}=24V$, " $F_{DIM}=200Hz$, Duty=95%"

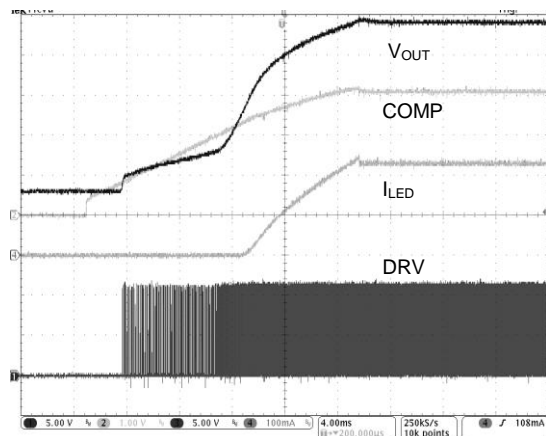


Fig. 5 $V_{IN}=24V$, "Power ON, Dim Duty=100%"

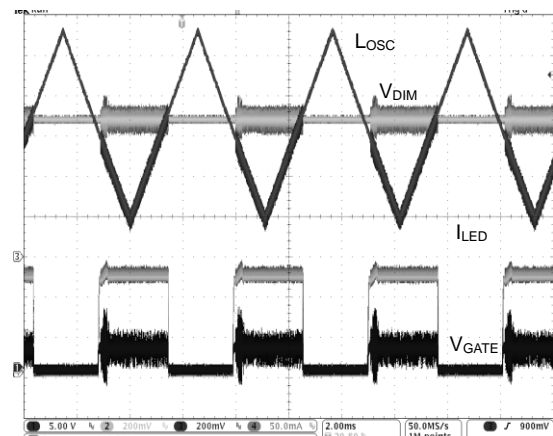


Fig. 6 $V_{IN}=24V$, " $V_{DIM}=0.7V$, $C_{Losc}=10nF$ "

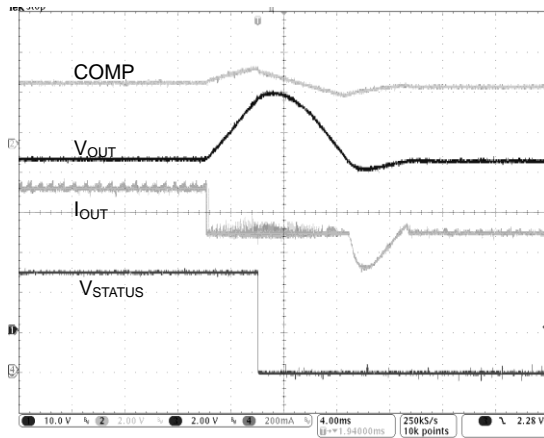


Fig. 7 $V_{IN}=24V$, $V_{OVP}=60V$, 250mA/string "LED OPEN"

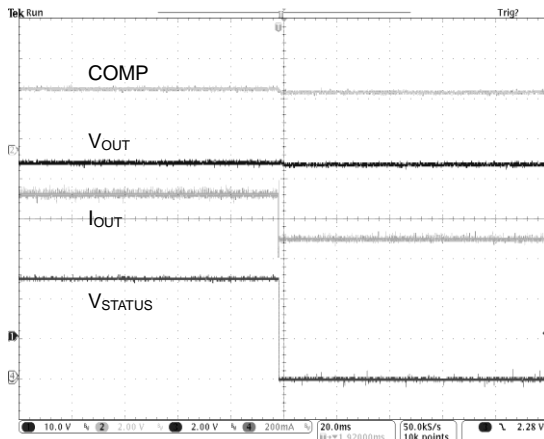


Fig. 9 $V_{IN}=24V$, 250mA/string, $R_{FB}=820k$, "LED Short"

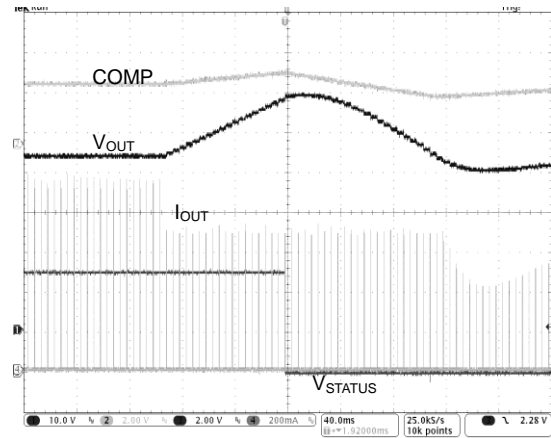


Fig. 8 $V_{IN}=24V$, $V_{OVP}=60V$, $F_{DIM}=200Hz$, Duty=5%, "LED Open"

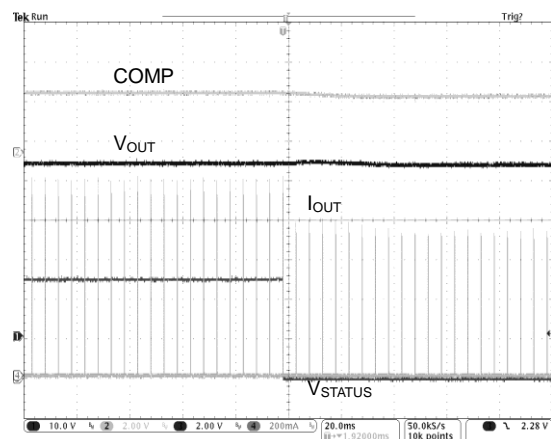


Fig. 10 $V_{IN}=24V$, 250mA/string, $R_{FB}=820k$, "LED Short"

Application Information

The LD7890 high-efficiency driver is ideal for LED backlight application. It incorporates DC-DC boost controller of peak current-mode control and 4 channel LED driver.

LD7890 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. It also integrates with LED short and open protection, cycle by cycle current limit, and thermal shutdown.

Current-Mode DC-DC Controller and UVLO

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 100kHz and 600kHz through a resistor connected between RT pin and ground.

As the external MOSFET is turned on, the inductor current will ramp up linearly until it 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 between the source of external MOSFET and ground. LD7890 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 across CS exceeds the error amplifier's output voltage. This process repeats every switching cycle to achieve peak current-mode control.

The LD7890 is integrated with under-voltage lockout (UVLO) function. The device will be disabled as VIN pin's voltage drops below UVLO threshold of 7.5V and will not resume until it rises up to 8.9V.

Start Up Sequence

As EN is activated, the IC will start to check if OVP's voltage is above 0.2V. If confirmed, the DIM pin will signal high to boost internal soft start. The Soft start function would limit inductor current to let it rise linearly and minimize the input inrush current.

Multi-Chip Parallel Operation

If used in some applications requiring more than 4 strings or LED, just connect desired numbers of LD7890 in parallel in a single power stage for it.

In multiple chips operation, each PARL pins should be connected together and set the master chip to control the driving signal to the external NMOSFET. Leave the remaining chips work in slave mode according to the following terms

- (1): Float DRV pin
- (2): Short CS to AGND
- (3): Slave OVP pin Setting lower than Master
- (4): LOSC pin parallel.

Loop compensation

The LD7890 has an internal error amplifier for LED current regulation for COMP output to compensate the control loop. The selection of the inductor, output capacitor, compensation resistor and capacitor would

affect the loop stability. The inductor and output capacitor are determined based on the terms of performance, size and cost, while the compensation resistor and capacitor for COMP are according to the criteria to optimize control loop stability.

Switching Frequency Selection

LD7890 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.

$$F_{SW} \text{ (kHz)} = \frac{70750}{[RT(\text{k}\Omega)]} - 28.3$$

Programming the LED Current

The SENSE pins detect the voltage of the external LED current bias resistors and individually regulate accurate voltage to 0.4V. They cooperate with the internal compensation circuits to eliminate the operating GATE [1:4] current for NMOS's use to secure extremely accurate LED current matching with each the individual and independent channel.

$$I_{LED} \text{ (A)} = \frac{0.4V}{R_{SENSE} \text{ (}\Omega\text{)}}$$

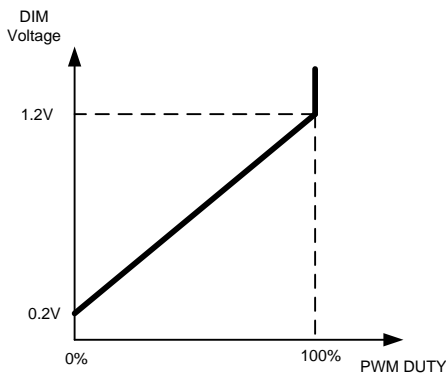
External PWM dimming

PWM dimming control will be achieved by applying an external PWM signal between 100Hz and 800Hz to the DIM pin.

Internal PWM dimming

Apply DC Voltage (0.2~1.2V) to the DIM Pin in compare with the LOSC signal to enable PWM Dimming. The internal frequency is determined by the external capacitor. If the external capacitor is 2.2nF, its internal frequency is 1KHz typically.

The PWM dimming duty is determined by the DC voltage ranging between 0.2V and 1.2V. Larger DC voltage usually produces greater brightness.



MOSFET Over-Current Protection

The LD7890 provides cycle-by-cycle current limit to protect the MOSFET. During the MOSFET turn-on, LD7890 will reduce DRV duty cycle once it detects V_{CS} rises above 0.5V, approximately.

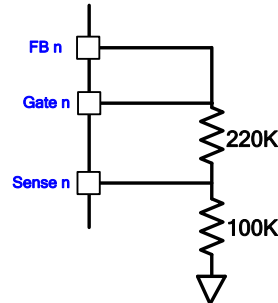
Output over Voltage and LED Open Protection

As OVP pin is approaching the threshold voltage 2.5V, the device will start to detect the SENSE pins. If there is any of these pins stays below 0.2V, it appears to have some channel failure. The LED driver will turn off the failure ones and pull low the STATUS pin.

Place the bypass capacitor between OVP and signal ground as close as possible. It will suppress the noise and protect OVP from abnormal condition.

Unused LED Channel

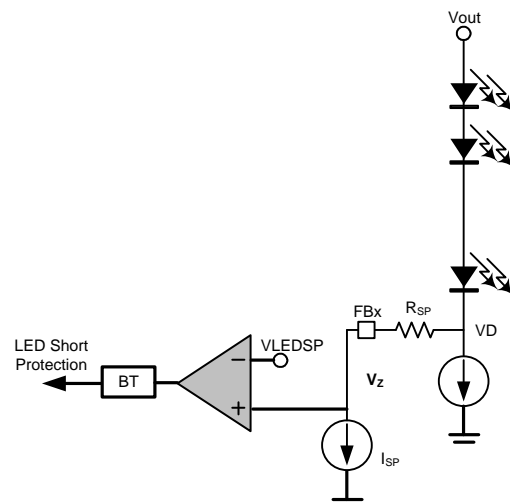
If there's any output channel is unused, connect the particular $SENSE_N$ with $100K\Omega$ resistor to GND and short $Gate_N$ and FB_N together with a $220k\Omega$ resistor to route with $Sense_N$ pin.



LED String Short Protection

The function block below provides LED short-circuit protection whenever short circuit of LED module occurs.

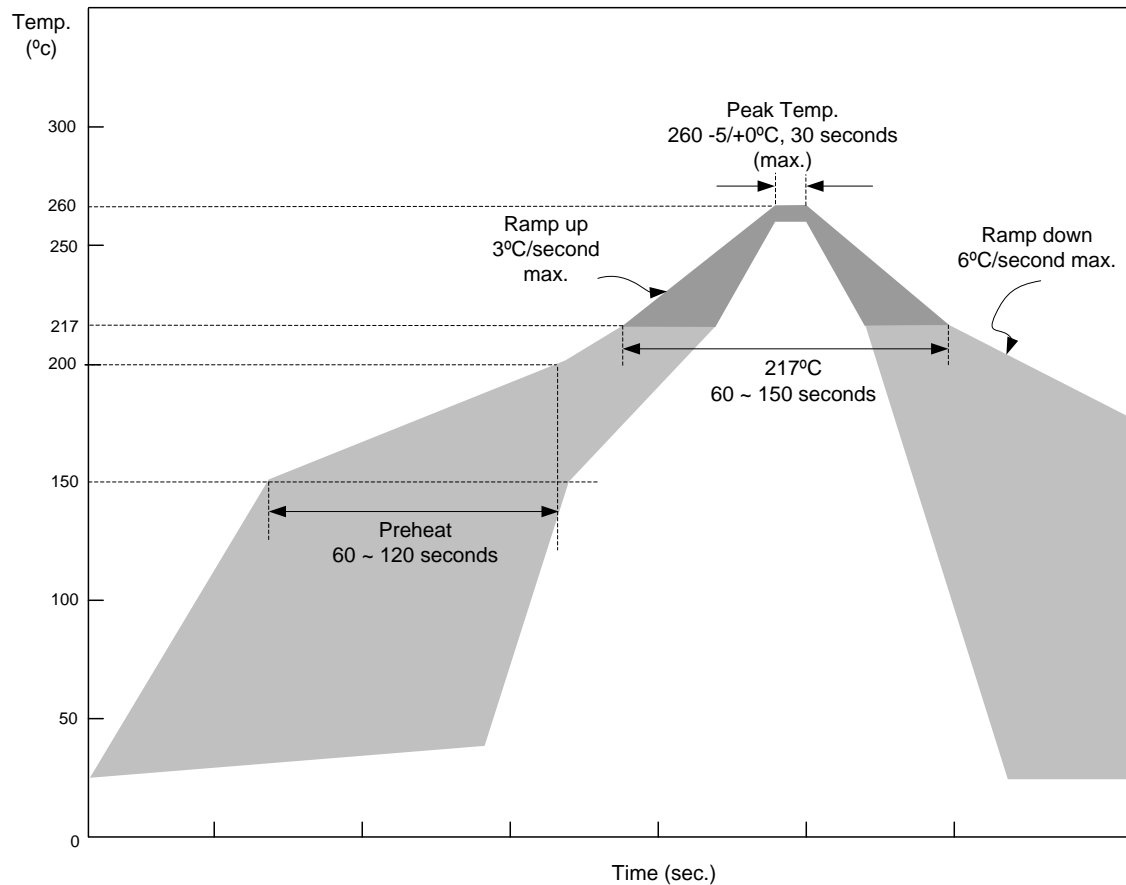
In condition of $V_D - I_{SP} \times R_{SP} > V_{LEDSP}$, it will send a signal to pull low STATUS and turn off the failed LED channel.



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 to turn off the device. The thermal sensor will not resume until the IC's junction temperature cools down approximately 30°C .

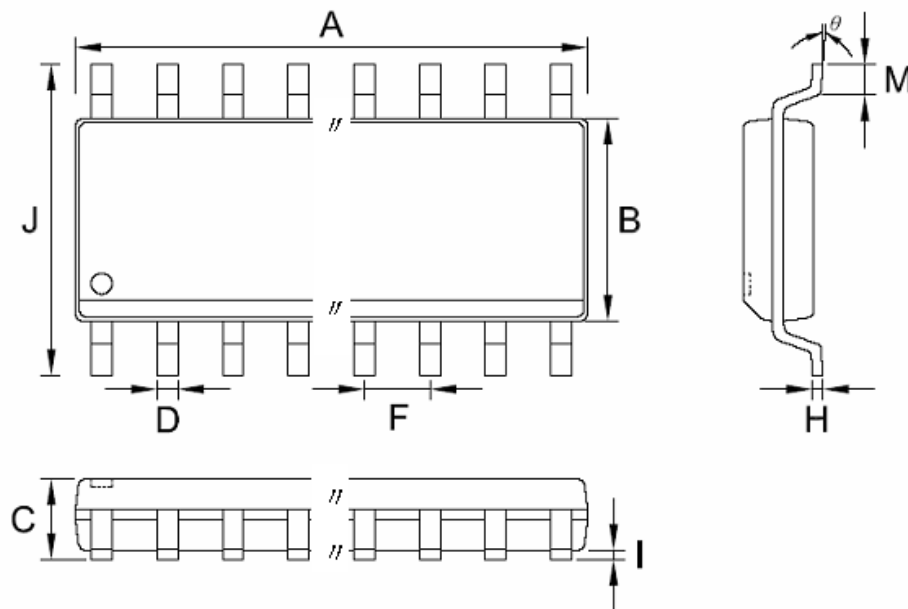
IR Profile for SMD Devices



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

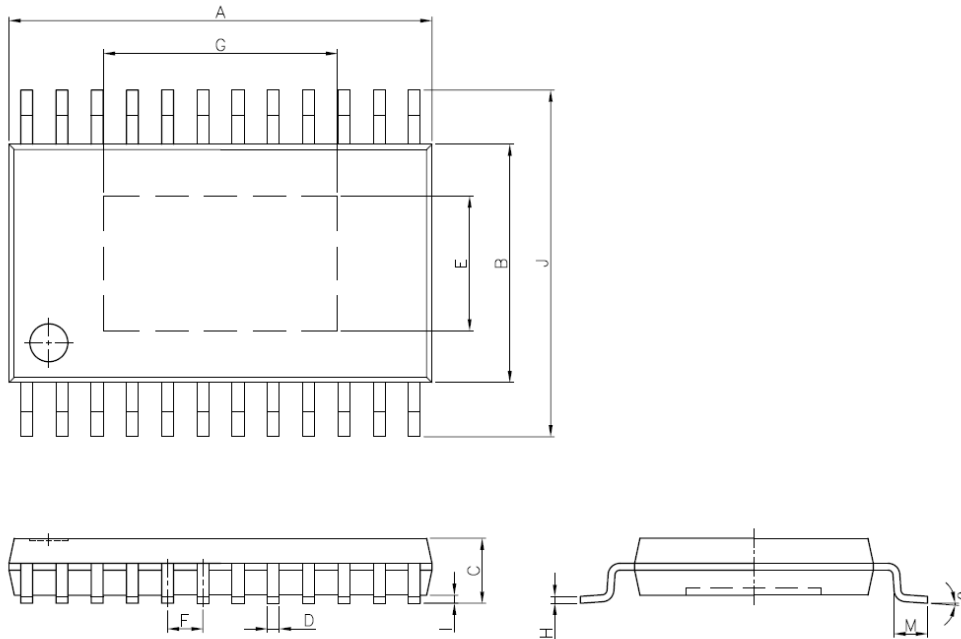
Package Information

SOP-24



	Dimension in Millimeters		Dimensions in Inches	
Symbol	Min	Max	Min	Max
A	15.190	15.590	0.598	0.614
B	7.390	7.595	0.291	0.299
C	2.360	2.642	0.093	0.104
D	0.330	0.510	0.013	0.020
F	1.27 TYP.		0.05 TYP.	
H	0.230	0.330	0.009	0.013
I	0.100	0.305	0.004	0.012
J	10.010	10.642	0.394	0.419
M	0.380	1.270	0.015	0.050
θ	0°	8°	0°	8°

TSSOP-EP-24



	Dimension in Millimeters		Dimensions in Inches	
Symbol	Min	Max	Min	Max
A	7.700	7.900	0.303	0.311
B	4.300	4.500	0.169	0.177
C	0.840	1.200	0.033	0.047
D	0.190	0.300	0.007	0.012
E	2.480	***	0.098	***
F	0.650 TYP.		0.026 TYP.	
G	4.300	***	0.169	***
H	0.090	0.200	0.004	0.008
I	0.050	0.150	0.002	0.006
J	6.300	6.500	0.248	0.256
M	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

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	06/03/2013	Original Specification
01	11/05/2013	EC table test condition VIN=24V→12V