SY22122L

60V High Efficiency Four-String Boost LED Driver

General Description

SY22122L is a high efficiency peak current mode boost controller with four matching current sources to drive WLED arrays of LCD backlight.

The device has a wide input voltage range from 4.5V to 30V. The LED current is programmable through a resistor. It also integrates both PWM and Analog dimming function for accurate LED current control.

Features

- 4.5-30V Wide Input Voltage Range
- Programmable 5mA~240mA LED Current Per String
- LED Current with +/-6% Accuracy at 5mA per String
- +/-2% Current Matching Among Strings at 5mA per String
- PWM and Analog Mode Dimming Frequency: 100Hz~50 kHz
- Programmable Boost Switching Frequency: 100kHz-1MHz
- Open and Short LED Protection
- Output Over Voltage Protection
- Boost Inductor/Diode Short Protection
- LEDN short to GND Protection
- RoHS Compliant and Halogen Free
- Compact Package: SOP16/SOP16E

Applications

- Monitor Panel Backlight

Typical Applications

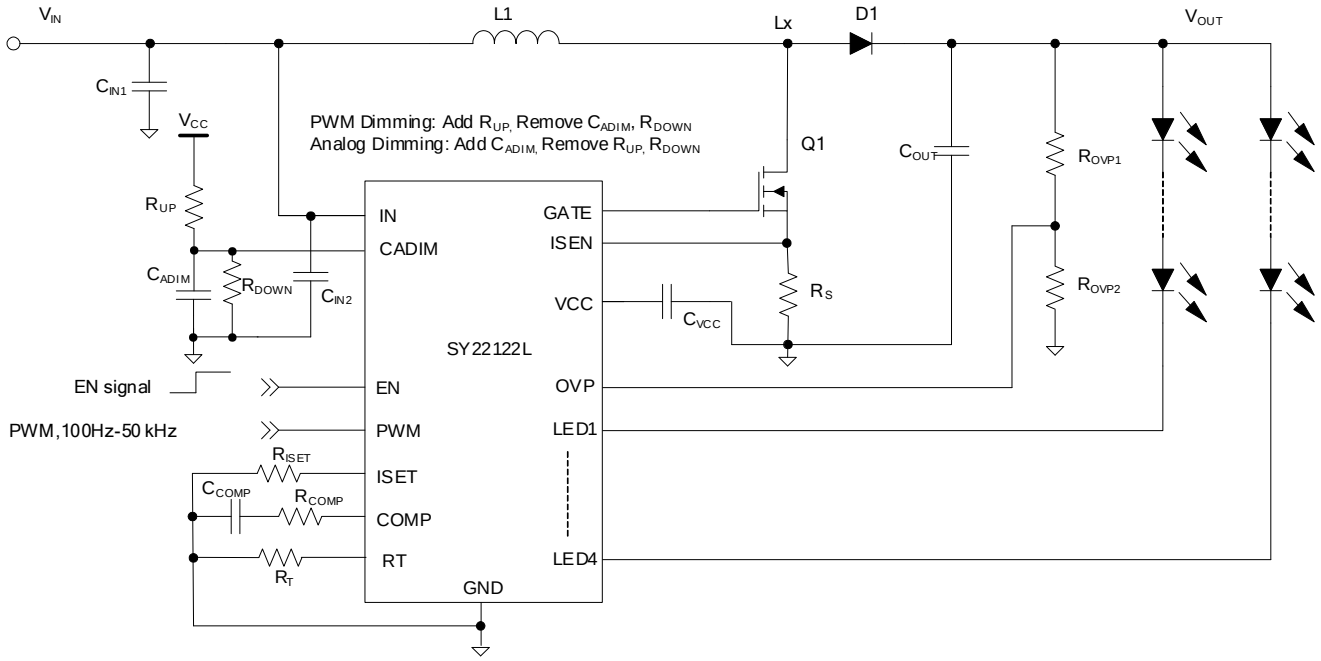


Figure 1. Typical Application Circuit

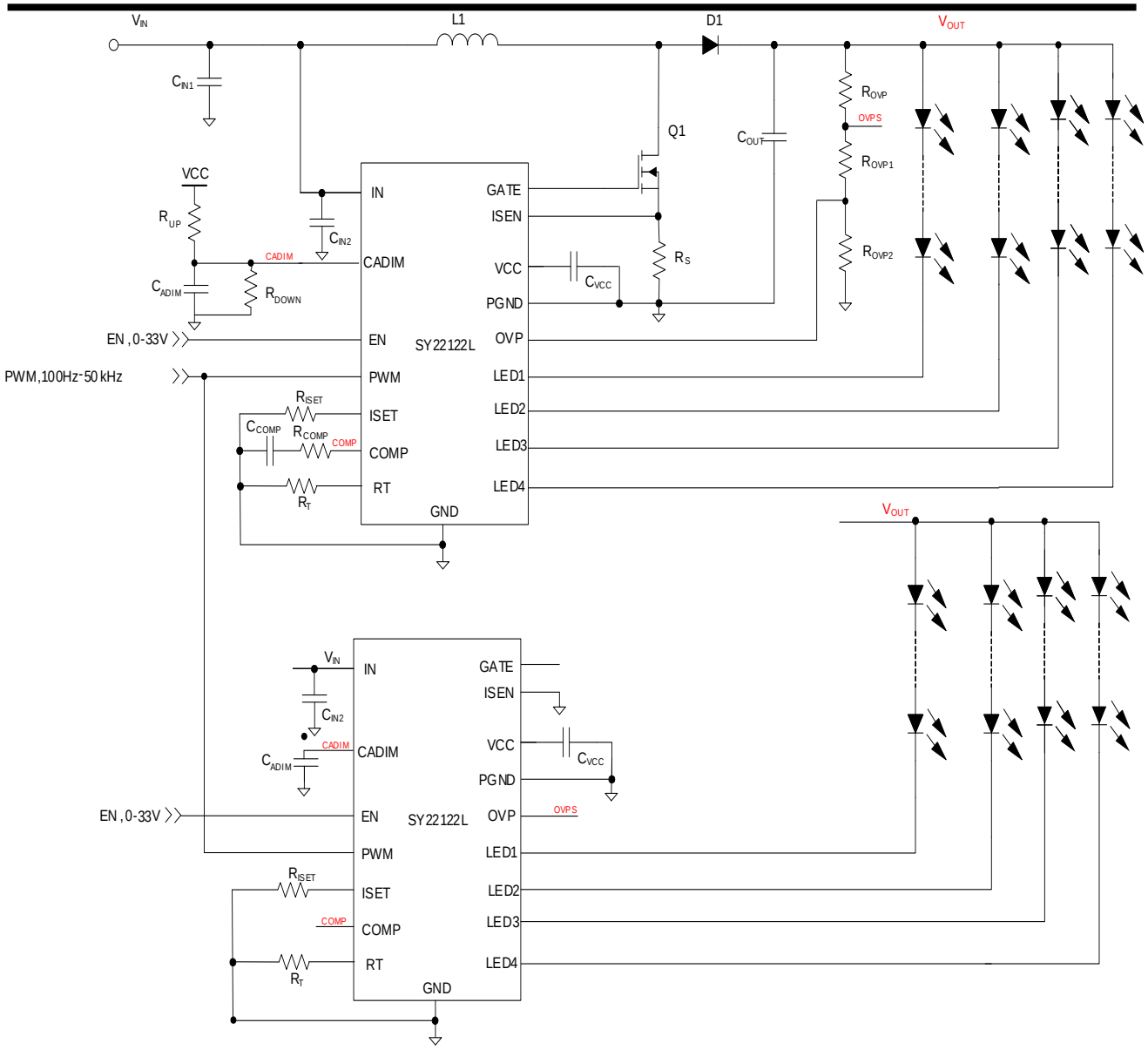


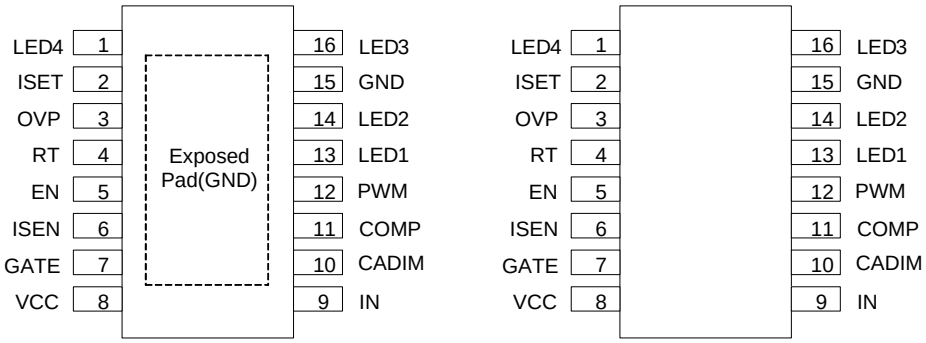
Figure 2. Typical Application Circuit for two Controllers in Parallel Operation

Ordering Information

Ordering Part Number	Package type	Top Mark
SY22122LFFC	SOP16 RoHS Compliant and Halogen Free	GCZ ***xyz***
SY22122LFEC	SOP16E RoHS Compliant and Halogen Free	GDA ***xyz***

x=year code, y=week code, z= lot number code

Pinout (top view)



(SOP16E) (SOP16)

Pin Name	Pin Number	Pin Description
LED1-4	1,13,14,16	The current source pin for the xth string of LEDs. Connect this pin to the cathode of the LED.
ISET	2	LED current programming pin. Connect a resistor to ground to program the current in each LED string between 5mA and 240mA. The LED current equals to: For PWM Dimming ILED=ISET(mA)=Dpwm*1200/RISET(KΩ); For Analog Dimming ILED=ISET(mA)=Dpwm*1200*RDOWN/RISET/(RDOWN+50)(KΩ)
OVP	3	Output over voltage setting pin. Apply a resistor divider from V_{OUT} to Ground.
RT	4	Boost Frequency Resistor Setting Pin .F_{SW} [MHz] =52/R_T [KΩ]. The frequency can be programmed from 100KHz to 1MHz.
EN	5	Enable Pin. Pull high to enable the chip.
ISEN	6	Current sense input for peak current mode control in Boost switch.
GATE	7	Gate driver output pin.
VCC	8	LDO supply generated from V_{IN} and used to power the GATE driver.
IN	9	Input pin. Decouple this pin to GND pin with 1μF or more ceramic cap. It receives the input from 4.5V to 30V
CADIM	10	Bypass this pin to GND with enough capacitance (such as 1μF ceramic capacitor) to hold on internal voltage reference when used in Analog dimming mode. PWM dimming mode will be selected if this Pin is pulled up to V_{CC}.
COMP	11	Compensation pin.
PWM	12	Dimming signal input, 100Hz~50KHz PWM frequency.
GND	15	IC ground pin.
	Exposed Pad (GND)	Connect the exposed pad to GND plane for maximum power dissipation.

Function Block

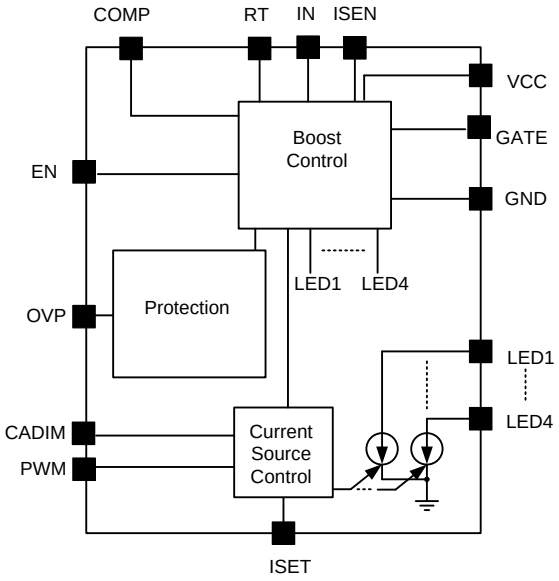


Figure 3. Block Diagram

Absolute Maximum Ratings (1)	Min	Max	Unit
LED1, LED2, LED3, LED4	-0.3	60	V
IN, EN,CADIM	-0.3	33	
Gate, VCC	-0.3	MIN(15,IN+0.3)	
RT, COMP, ISEN, ISET	0.3	4	
OVP, PWM	-0.3	6	
Junction Temperature, Operating		150	°C
Lead Temperature (Soldering,10sec.)		260	
Storage Temperature	-65	150	

Thermal Information (2)	SOP16	SOP16E	Unit
θ_{JA}	80	40	°C/W
θ_{JC}	18	20	
P_D Power Dissipation T_A=25°C	2.5	2.5	W

Recommended Operating Conditions (3)	Min	Max	Unit
IN	4.5	30	V
PWM	0	5.5	
LED1, LED2, LED3, LED4 voltage	0	58	
EN	0	30	
ISEN	0	4	
CADIM	0	30	
LED1, LED2, LED3, LED4 Current	5	240	mA
Operating Frequency	0.1	1	MHz
PWM Frequency	0.1	50	KHz
Minimum PWM on Time		1	μs
Junction Temperature		125	°C
Ambient Temperature	-20	85	°C

Electrical Characteristics

Electrical Characteristics (V_{IN} = 12V, T_A = 25°C, unless otherwise specified)						
Parameter	**Symbol**	**Test Conditions**	**Min**	**Typ**	**Max**	**Unit**
Input Voltage Range	V_{IN}		4.5		30	V
Operating Current	I_{OP}	EN="1",PWM="1",Qg=40nC Note 4		6		mA
Quiescent Current	I_Q	EN="1", PWM="0"		1		mA
Shutdown Current	I_{SD}	EN="0"		1.4		μA
VCC Voltage	VCC	Vin=12V, EN="1"	9	10	11	V
Gate Sink Current		Note4		1		A
Gate Source Current		Note4		0.8		A
LED Current per Channel Note: Include Balance Rate	$I_{LED1-4(100\%)}$	R_{ISET}=12kΩ, Analog Dimming, Dpwm=100%, Cadim=1μF $I_{LEDmatch}=(I_{LEDmax}-I_{LEDmin})/(I_{LEDave*2})$	97	100	103	mA
LED Current Balance Rate	$I_{LEDmatch\ (100\%)}$		-	±0.3	±1	%
LED Current per Channel Note: Include Balance Rate	$I_{LED1-4\ (5\%)}$	R_{ISET}=12kΩ, Analog Dimming, Dpwm=5%, Cadim=1μF $I_{LEDmatch}=(I_{LEDmax}-I_{LEDmin})/(I_{LEDave*2})$	4.7	5	5.3	m A
LED Current Balance Rate	$I_{LEDmatch\ (5\%)}$		-	±1	±2	%
LED Regulation Voltage	V_{REG}	R_{ISET}=12kΩ	510	590	670	mV
IN UVLO Rising Threshold	V_{IN_UVLO}				4.49	V
UVLO Hysteresis	V_{UVLO_HYS}			0.22		V
Thermal Shutdown Temperature	T_{SD}	Note4		150		℃
Thermal Recovery Temperature	$T_{recovery}$	Note4		130		℃
OVP Rising Threshold	V_{OVP_TH}		1.9	2	2.1	V
OVP Hystersis	V_{OVP_HYS}			100		mV
OSP Falling Threshold	V_{OSP_TH}			50		mV
Peak current limitation threshold	V_{ISEN}	Boost Duty=40%	430	480	530	mV
EN Input Low Threshold					0.8	V
EN Input High threshold			2			V
PWM Input Low Threshold					0.8	V
PWM Input High Threshold			2			V
CADIM Output Resistance	R_{ADIM}			50		kohm
PWM Mode Threshold	V_{CADIM}		1.2	1.5	1.8	V
LED Short Protection Threshold	V_{SCP_TH}		8.9	9.9	10.4	V
Switching Frequency	F_{SW}	R_T=100kΩ		520		kHz
Maximum duty cycle	D_{MAX}	Note4			90	%

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

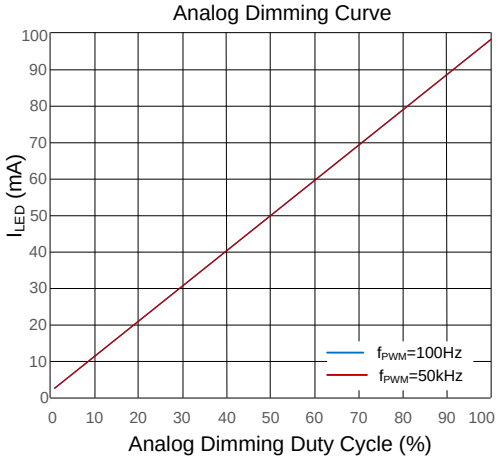
Note 2: θJA is measured according to JESD51-2, 51-7 while ambient temperature=25℃, θJC is measured in accordance with JESD51-14.

Note 3: The device is not guaranteed to function outside its operating conditions.

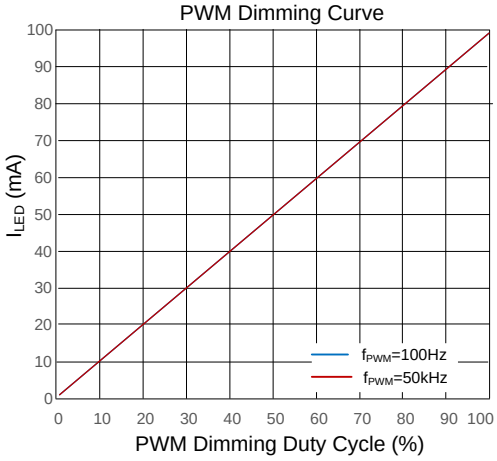
Note 4: This parameter is guaranteed by design.

Typical Performance Characteristics (V_{IN}=12V, I_{LED}=100mA, 54V per string, 4 strings)

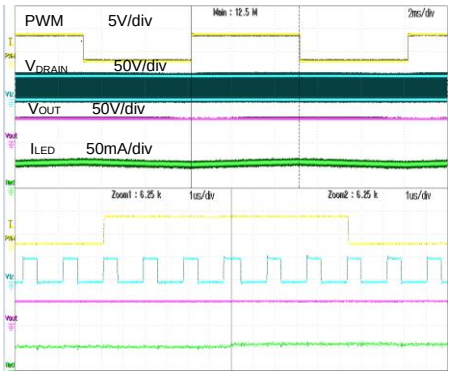
Analog Dimming Curve



PWM Dimming Curve

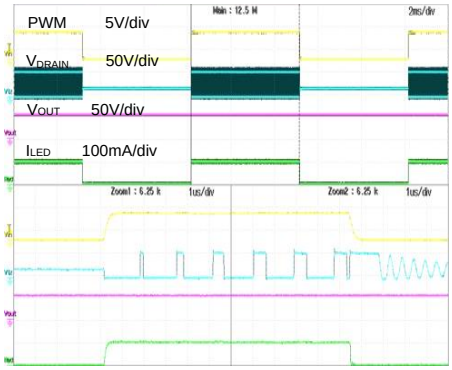


Analog Dimming
(f_{ADIM}=100Hz, d=50%)



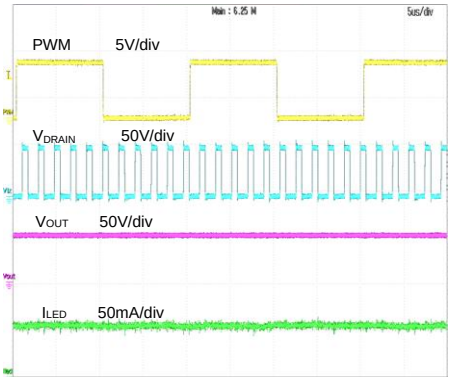
Time (2ms/div and 1μs/div)

PWM Dimming
(f_{ADIM}=100Hz, d=50%)



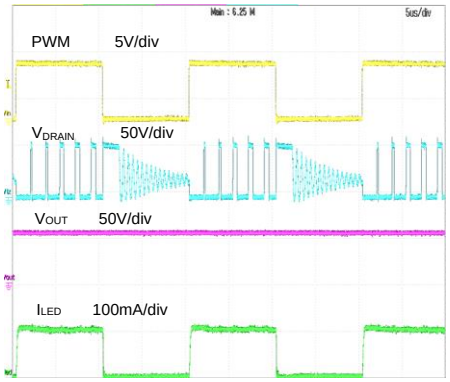
Time (2ms/div and 1μs/div)

Analog Dimming
(f_{ADIM}=50kHz, d=50%)



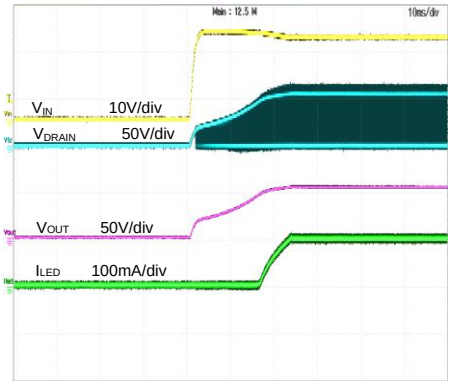
Time (5μs/div)

PWM Dimming
(f_{ADIM}=50kHz, d=50%)



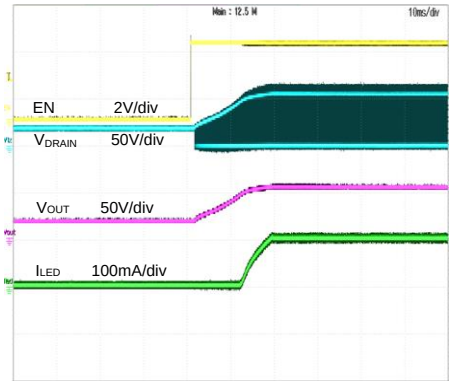
Time (5μs/div)

Startup from V_{IN}



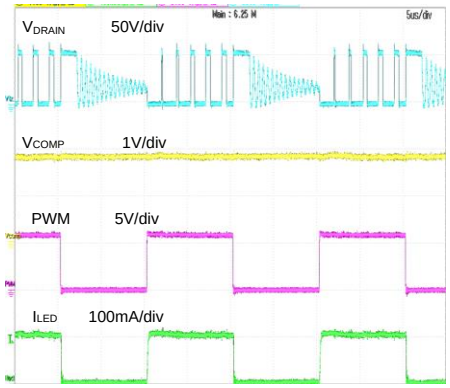
Time (10ms/div)

Startup from EN



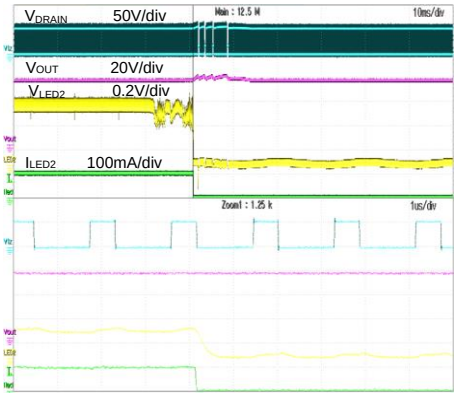
Time (10ms/div)

Steady State(PWM Dimming)



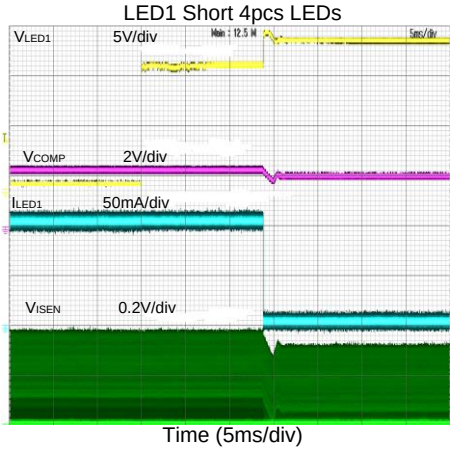
Time (5μs/div)

Open LED Protection (Open LED2)



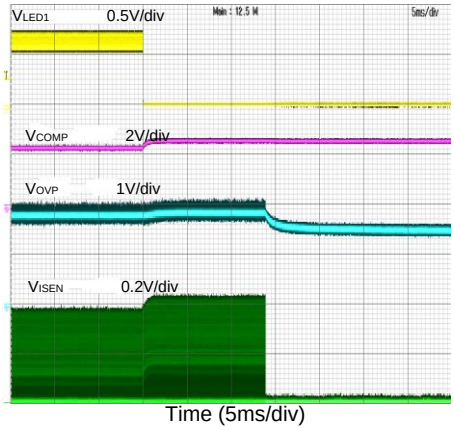
Time (10ms/div and 1μs/div)

LED1 Short 4pcs LEDs



Time (5ms/div)

LED1 Short to GND Protection



Time (5ms/div)

Applications Information

The SY22122L contains a peak current mode boost controller and 4-channel matching current sources to drive WLED arrays of LCD backlight.

LED Current Setting:

LED1~LED4 are the 4-channel LED driver outputs. The sinking current of each channel can be programmed with a resistor R_{ISET} connecting from ISET pin to ground:

$$I_{LED}=I_{SET}(mA)=\frac{1200\times D_{pwm}}{R_{ISET}(Kohm)}\ (PWM)$$

$$I_{LED}=I_{SET}(mA)=\frac{1200\times D_{pwm}\times R_{DOWN}}{R_{ISET}\times(R_{DOWN}+50)(Kohm)}\ (Ana\ log)$$

For PWM mode R_{ISET}=12KΩ(ohm), the LED current is set to 100mA. The maximum sinking current of each channel is 240mA. For higher current application, different channels can be paralleled. The LED current evenly flow through the paralleled channels because of good current matching.

Input capacitor CIN1:

The ripple current through input capacitor is calculated as:

$$I_{CIN\_RMS}=\frac{V_{IN}\times(V_{OUT}-V_{IN})}{2\sqrt{3}\times L\times F_{SW}\times V_{OUT}}$$

X5R or X7R ceramic capacitors with greater than 4.7μF capacitance are recommended to handle this ripple current. To minimize the potential noise problem, place this ceramic capacitor close to the IN and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and IN/GND pins.

Output capacitor C_{OUT}:

The output capacitor is selected to handle the output ripple noise requirements. This ripple voltage is related to the capacitor's capacitance and its equivalent series resistance (ESR). For the best performance, it is recommended to use better grade low ESR ceramic capacitor. The voltage rating of the output capacitor should be higher than the maximum output voltage. The minimum required capacitance can be calculated as:

$$C_{OUT}=\frac{n\times I_{LED}\times(V_{OUT}-V_{IN})}{F_{SW}\times V_{OUT}\times V_{RIPPLE}}$$

V_{RIPPLE} is the peak to peak output ripple, n is the number of LED string.

For LED applications, the output capacitance should be large enough to attenuate the V_{LEDX} ripple voltage.

Inductor L:

There are several considerations in choosing this inductor.

1) Choose the inductance to provide the desired ripple current. The inductance is calculated as:

$$L=(\frac{V_{in}}{V_{out}})^2\times\frac{(V_{out}-V_{in})\times\eta}{n\times I_{led}\times F_{sw}\times\frac{\Delta I_L}{I_L}}\ (for\ CCM)$$

$$Select\ \frac{\Delta I_L}{I_L}=0.4\sim2(for\ CCM)$$

Where F_{SW} is the switching frequency, n is the number of LED string, I_{LED} is the current of each LED string,Vin is input voltage,Vout is output voltage ,$\Delta I_L$is total inductor current ripple, I_L is inductor average current.

2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

$$I_{sat\_min}>\frac{V_{out}\times n\times I_{led}}{V_{in}\times\eta}+\frac{V_{in}\times(V_{out}-V_{in})}{V_{out}\times L\times F_{sw}\times 2}\ (for\ CCM)$$

Where η is total efficiency.

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement.

Main MOSFET Selection:

The choice of the main MOSFET depends on the current through MOSFET, the maximum V_{DS} voltage, the switching frequency, the capability of the MOSFET to dissipate heat.

The maximum RMS current through MOSFET is given by:

$$I_{mos\_rms}=\frac{V_{out}\times n\times I_{led}}{V_{in}\times\eta}\sqrt{\frac{(V_{out}-V_{in})}{V_{out}}}\sqrt{1+\frac{1}{3}(\frac{\Delta I_L}{2\times I_L})^2}\ \ (for\ CCM)$$

The maximum drain to source voltage equals the output voltage plus output diode forward voltage.

Rectifier Diode Selection:

A Schottky diode with low forward voltage drop and fast switching speed is desirable for the application. The voltage rating of the diode must be higher than maximum output voltage. The diode's average and peak current rating should exceed the average output current and peak inductor current.

Internal 10V LDO:

VCC is the output of internal LDO. Connect a 1μF capacitor from VCC pin to ground. This LDO provides 10V power supply for the external MOSFET gate driver. The typical dropout voltage of the LDO is 200mV. VCC drops to 0 when the IC shuts down.

Open LED Protection:

When any LED string is open, the respective LEDx pin will be pulled to ground. IC continues charging the output voltage until over voltage protection is triggered. Then the part stops switching and checks the condition of all the LEDx pins. The part will mark off and disable the one which voltage is below 100mV. Then the output of boost slowly drops because of the load current. The IC resumes switching once the OVP pin voltage drop below Vovp_th minus Vovp_hys. When all strings are marked off, the IC latch off the Boost converter. Recycling input power or enable signal to turn on the connected string after fault condition is removed.

Short LED Protection:

When any diode on the LED string becomes shorted, the LEDx voltage on that string may exceed V_{SCP_TH} (typical 9.9V), and short LED fault is detected. If short LED fault lasts for more than about 15ms in LED ON time, the IC will mark off and disable that string. When all strings are marked off, the IC will also latch off the boost converter.

No Rectifier Diode Protection:

When the chip is enabled, IC will check the connection of the rectifier diode by sensing the voltage on OVP pin. If the voltage on OVP pin is lower than V_{OSP_TH} (typical 50mV), the IC will shut down.

LEDx pin short to GND Protection:

When LEDx pin short to GND, the respective LEDx pin voltage is below about 100mV and COMP pin voltage is higher than about 2.3V, if last for about 15ms in LED ON time. IC will latch off boost converter.

Peak Current limitation:

The device employs cycle by cycle current limitation to protect Boost Inductor and MOSFET. When the peak current sensing voltage (VISEN) exceeds 480mV (typical value), the device will turn off MOSFET. MOSFET will turn on again until next clock signal arrives.

Diode/Inductor Short-Circuit Protection:

When Diode/Inductor Short is happened, the current flow through Boost MOSFET will increase significantly. If the voltage on ISEN pin exceeds approximately 0.58V during the ON period of the boost MOSFET and last for about 15ms in LED ON time. The IC will shut off and stay latched. 15ms timer will be reset if ISEN pin voltage drops below 0.58V for eight (8) consecutive clock cycles during gate on time.

LED1/2/3 Channels Operation:

For applications where only three LED strings are used, IC provides design flexibly by disabling the fourth channel. It is required that a resistor (510 ohm to 820ohm) is connected between LED4 pin and GND. The three LED strings should be connected to LED1/2/3 correspondingly.

Over Temperature Protection:

To prevent the IC from over temperature, the device will shutdown when the junction temperature exceeds 150℃ (typical). When the junction temperature decreases to 130℃ (typical), IC will resume to switching.

Power ON and OFF Sequence

Power on sequence:
VIN ON→PWM ON→EN ON
Power off sequence:
EN OFF→PWM OFF→VIN OFF

Multiple Controllers in Parallel operation：

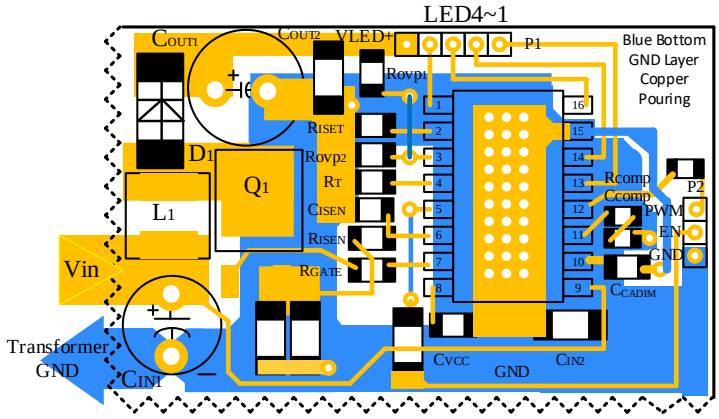
For applications having more than 4 LED strings, designer can use multiple controllers for parallel operation. A reference circuit is illustrated in Figure 2. Both controllers share the common Boost converter power train for 8 strings of LED operation.

Layout Design:

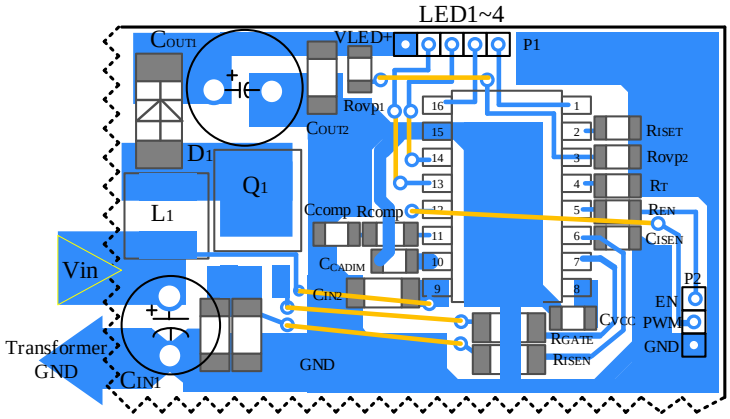
Proper PCB layout and components placement are critical to the performance of the IC and to prevent noise and electromagnetic interference problems. Following are some rules for the PCB layout:

1) The loop of main MOSFET, rectifier diode, and output capacitor must be as short as possible
2) It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance.
3) C_{IN2} must be close to Pins IN and GND.
4) The PCB copper area associated with main MOSFET drain must be minimized to avoid noise problem.
5) The small signal components must be placed close to IC and must NOT be adjacent to the main MOSFET drain net on the PCB layout to avoid the noise problem.
6) For high accuracy at low dimming duty in analog dimming mode, the capacitor CADIM must be placed as closed as GND pin and CADIM PIN. DO NOT connect CADIM and GND wire under IC.
7) Boost rectifier diode/inductor short protection is achieved by detecting the voltage between ISEN pin and GND pin. The current is very high when short fault occurs, the trace between the source pole of boost main MOSFET and current sense resistor, the trace between the drain pole of boost main MOSFET and anode of boost rectifier diode/inductor must be as short and wide as possible.

Layout Example



SY22122L Double Layer Layout

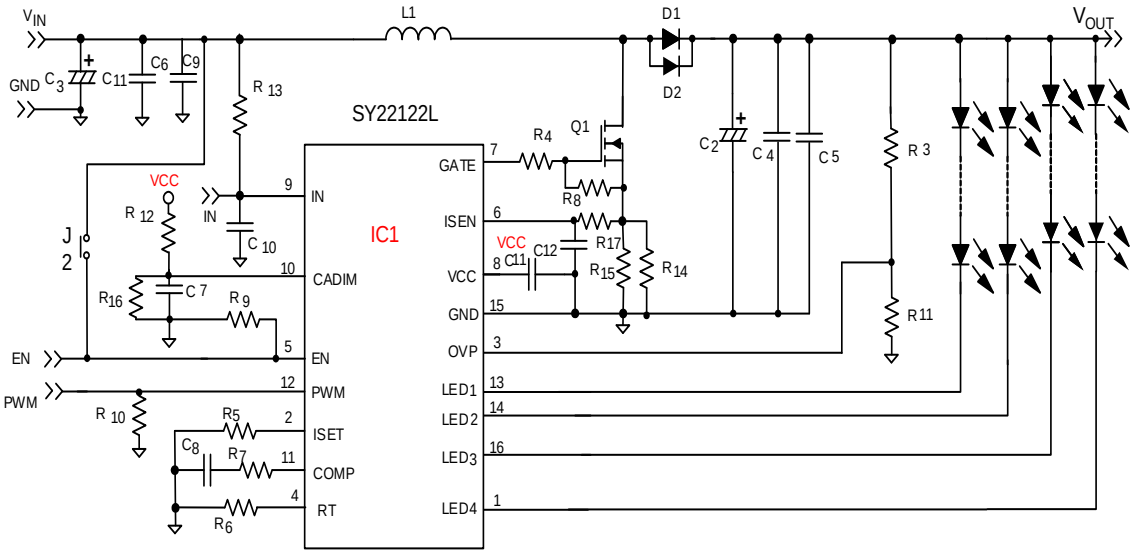


SY22122L Single Layer Layout

Design Specifications

Input Voltage (V)	LED configuration
12-28	4 strings, 100mA per string, 16s LEDs

Application Schematic

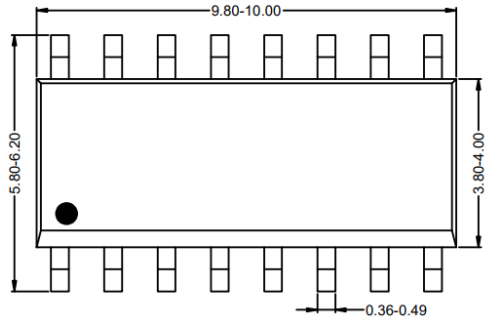


BOM List

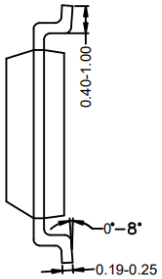
Reference Designator	Description	Part Number	Manufacturer
IC1	4-String LED driver	SY22122LFFC	Silergy
C2	47uF/100V/ECAP	860020673013	Wurth Electronics
C3	47uF/50V/ ECAP	860040875002	Wurth Electronics
C4, C5	1uF/100V/1206		
C6,C9,C10,C11	1uF/50V/1206		
C7	NC (PWM Dimming)		
	1uF/0603(Analog Dimming)		
C8	1uF/25V/0603		
D1, D2	100V/3A, Schotty Diode	SS310	
J2	JUMPER		
L1	15uH/5A,Inductor	744770115	Wurth Electronics
Q1	100V/9.4A, 210mΩ, NMOS	IRFR120N	IR
R3	1MΩ /0603		
R4	10Ω /1206		
R5	12kΩ /0603		
R6, R8	100kΩ /0603		
R7	100Ω /0603		
R9, R10	200kΩ /0603		

R11	33kΩ /0603		
R12	100kΩ/0603 (PWM Dimming)		
	NC(Analog Dimming)		
R14,R15	200mΩ /1206		
R13, R17	10 Ω /0603		

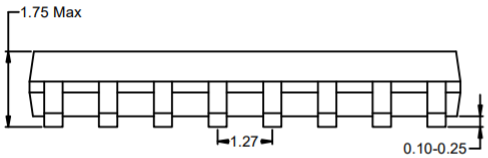
SOP16 Package Outline Drawing



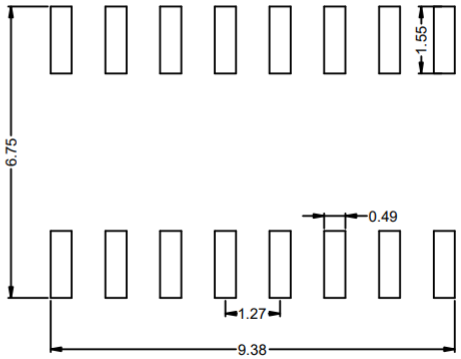
Top View



Side View



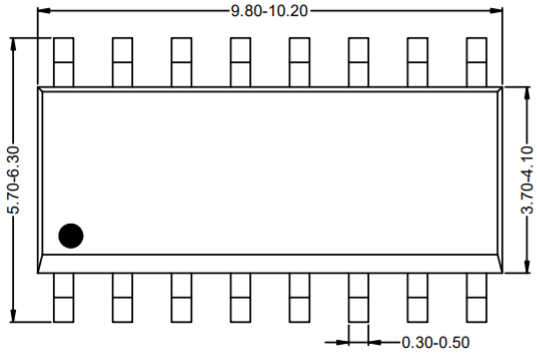
Front View



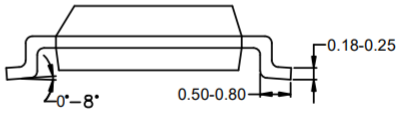
PCB layout (Recommended)

Notes: All dimension in millimeter and exclude mold flash & metal burr.

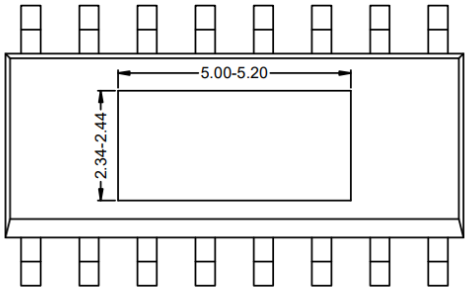
SOP16E Package Outline Drawing



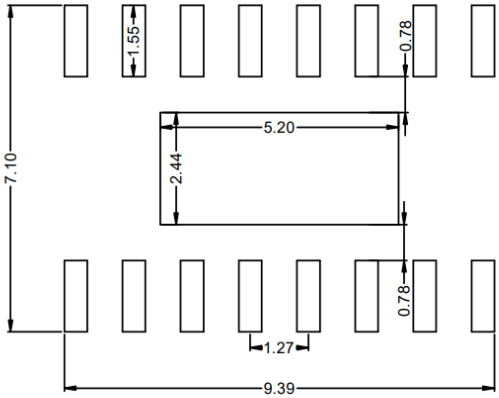
Top View



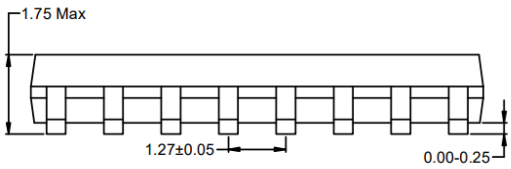
Side View



Bottom View



PCB Layout (Recommended)



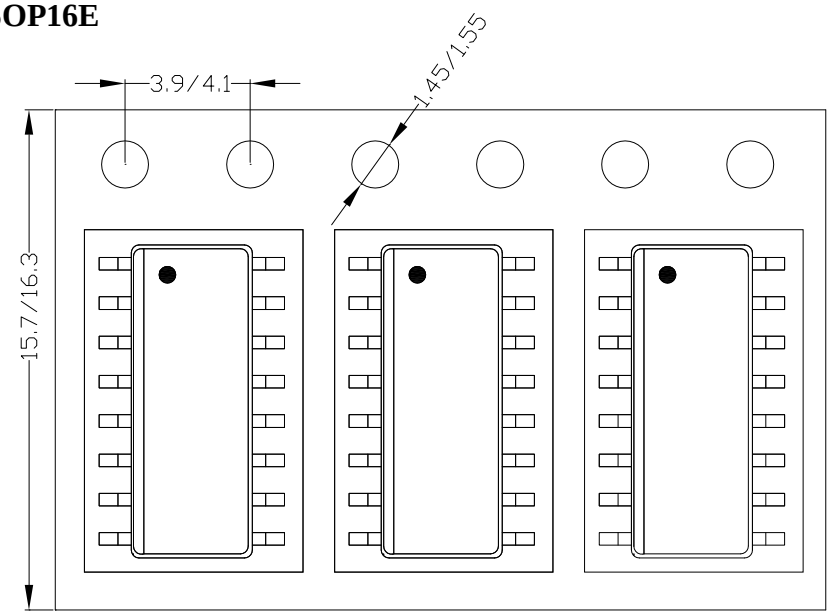
Front view

Notes: All dimension in millimeter and exclude mold flash & metal burr.

Taping & Reel Specification

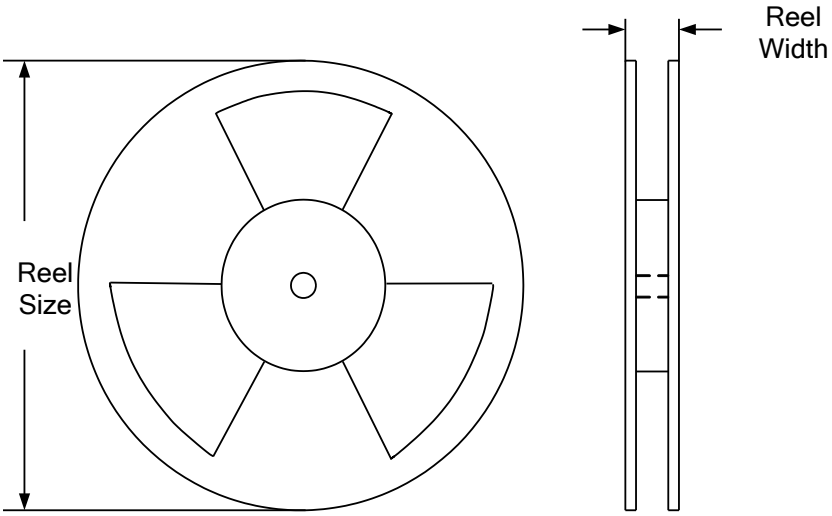
1. Taping orientation

SOP16&SOP16E



Feeding direction ⟶

2. Carrier Tape & Reel specification for packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Reel width(mm)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOP16 & SOP16E	16	8	13"	12.4	400	400	2500

3. Others: NA

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