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High-Voltage, Linear High-Brightness LED Driver IC with Analog and PWM Dimming Control

CN5502

General Description:

The CN5502 current regulator operates from a 4V to 32V input voltage range and delivers up to a total of 1A to one or more strings of high-brightness LEDs. The output current of the CN5502 is adjusted by using an external current-sense resistor in series with the LEDs. A dual-mode DIM pin and on-chip 130Hz PWM generator allow PWM dimming with an analog or PWM input signal. The analog control signal at dimming input DIM allows for a theater-dimming effect to be implemented. The CN5502 is well suited for applications requiring high-voltage input and is able to withstand automotive load-dump events up to 32V. An on-chip power MOSFET minimizes external components while providing $\pm 5\%$ output current accuracy. Also an EQ pin is adopted for equalizing LED current among multiple CN5502 used in parallel. Additional features include a 5V regulated output and thermal regulation, etc. The CN5502 is available in a thermally enhanced 8-pin eSOP package.

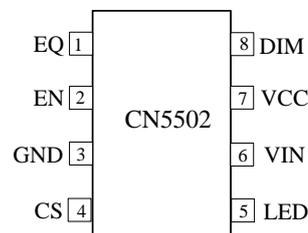
Applications:

- Lighting Systems
- Automotive Interior and Exterior
- Navigation indicators
- Instrumentation illumination
- Signage and Beacons

Features:

- 4V to 32V Operating Voltage
- Adjustable LED Current up to 1A
- On-chip 130Hz PWM Generator
- Flexible Dimming Control, Analog or PWM Control Signal for PWM and Theater Dimming
- External PWM Frequency: 80Hz to 400Hz
- Integrated 32V, 1A MOSFET with 1.5A Current Limit(Typical)
- Low Current-Sense Voltage Reduces Power Loss
- Typical 5% LED Current Accuracy
- High-Voltage Chip Enable Input for Dimming Interface
- Current Equalizing Among Multiple CN5502 Used in Parallel
- Thermal Regulation
- Operating Temperature Range:
-40°C to 85°C
- Available in Thermally-enhanced 8 pin eSOP package.
- Pb-free, Rohs Compliant and Halogen Free

Pin Assignment



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Typical Application Circuit

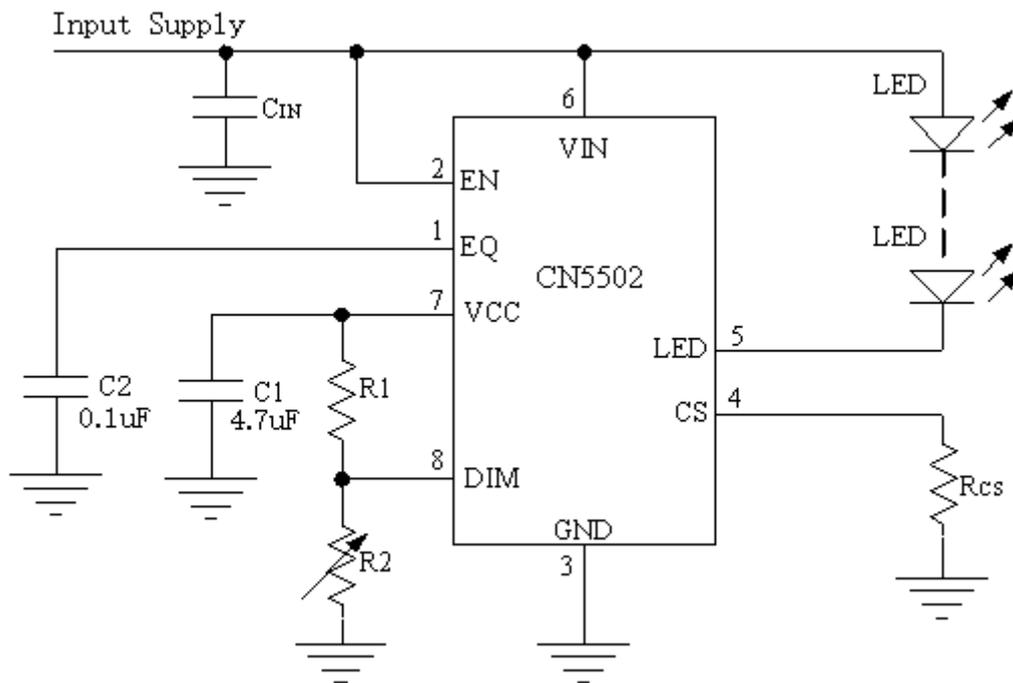


Figure 1 Typical Application Circuit(Analog Dimming)

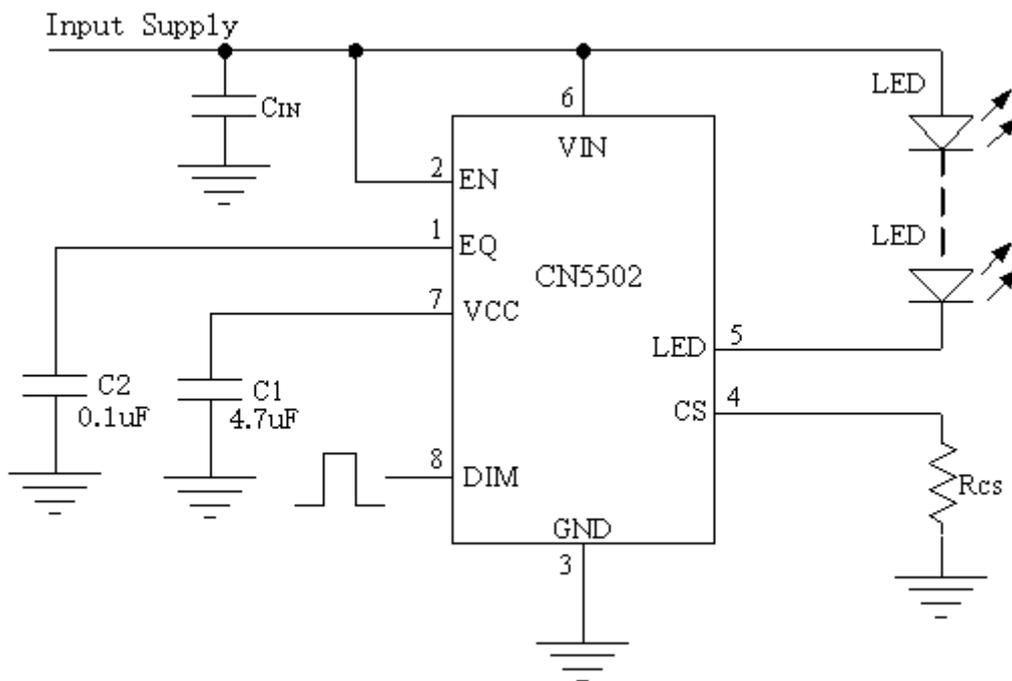


Figure 2 Typical Application Circuit(PWM Dimming)

Ordering Information

Part Number	Package	Shipping	Operating temperature
CN5502	eSOP8	Tape and Reel, 4000/Reel	-40°C to 85°C

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Pin Description

Pin No.	Name	Function Description
1	EQ	LED Current Equalizing Pin. This pin should be connected to other CN5502's EQ pin for equalizing LED current when multiple CN5502 are used in parallel to drive multiple LED strings, otherwise, EQ pin should be left floating.
2	EN	High Voltage Enable Pin. Drive EN pin to high to enable the output.
3	GND	Ground Terminal. This pin is the negative terminal of input supply.
4	CS	LED Current Sense Pin. The LED current is sensed and set by the resistor between CS pin and GND. The equation to calculate the LED current is: $I_{LED} = 0.153 \div (R_{CS} + 0.03)$ Where, I_{LED} is the LED current in ampere(A) R_{CS} is the resistance from CS pin to GND in ohm(Ω)
5	LED	Current Sink Pin. Drain of the on-chip power MOSFET, the LED string(s) should be connected between LED pin and VIN.
6	VIN	Positive Terminal of Input Supply. This pin is the power supply of internal circuit.
7	VCC	+5V Regulator Output Pin. A voltage of 5V(Typical) is output out of this pin with 3mA output capability. Connect a capacitor of 2.2uF to 10uF from VCC pin to GND.
8	DIM	Dimming Control Input. Either an analog or PWM control signal can be input to this pin to control LED's brightness.
-	EP	Exposed Pad. Connect to the GND plane for effective power dissipation. Do not use as the only ground connection.

Absolute Maximum Ratings

VIN, EN and LED Pin Voltage.....-0.3V to 36V
 Other Pins Voltage.....-0.3V to 6.5V
 Thermal Resistance(Junction to Case)65°C/W
 Lead Temperature(Soldering).....260°C

Operating Temperature.....-40°C to 85°C
 Maximum Junction Temperature.....150°C
 Storage Temperature.....-65°C to 150°C

Stresses beyond those listed under 'Absolute Maximum Ratings' may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

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Electrical Characteristics

(VIN=15V, TA= -40°C to 85°C, unless otherwise noted)

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Supply Voltage	VIN		4		32	V
Operating Current	I _{VIN}	V _{EN} =VIN, no LED current	340	455	570	uA
Shutdown Supply Current	I _{SD}	V _{EN} ≤0.3V			3	uA
VIN Under Voltage Lockout	V _{UVLO}	V _{EN} =VIN and VIN rises from 2.5V until V _{CS} >100mV		2.85	3.35	V
VIN Under Voltage Lockout Hysteresis	H _{UVLO}			0.22		V
CURRENT REGULATION						
The CS pin voltage	V _{CS}	R _{CS} =3Ω, normal operation	144	152	160	mV
LED pin Leakage	I _{LKG}	VIN=32V, V _{EN} =0V			10	uA
Current Limit	I _{LIMIT}		1.15	1.5	2	A
Dropout Voltage (Note 1)	V _{DROP}	I _{LED} =100mA		0.18		V
		I _{LED} =300mA		0.36		
		I _{LED} =500mA		0.5		
		I _{LED} =750mA		0.7		
		I _{LED} =1A		0.9		
Thermal Regulation						
Thermal Regulation Temperature	T _{REG}		110	125	140	°C
EN Pin						
EN Input Voltage High	V _{IH}		3.1			V
EN Input Voltage Low	V _{IL}				0.6	V
EN Bias Current	I _{EN}		-100		+100	nA
EN Turn-on Time	t _{ON}	EN's rising edge to 90% of LED current		270		uS
DIM Pin						
DIM Input Current	I _{DIM}				1	uA
Analog Input Range			1.2		2.88	V
Time for Analog Input	t _{analog}		30			mS
Internal PWM Frequency	F _{intPWM}		100	130	160	Hz
External PWM Frequency Range	F _{extPWM}		80		400	Hz
External PWM Low					0.3	V
External PWM High			1.25			V
+5V Regulator(VCC Pin)						
VCC Voltage	VCC	0≤I _{VCC} ≤2mA, VIN≥5.5V	4.7	5	5.35	V
Short Circuit Current		VCC=0V		4.4		mA

Note 1: Dropout voltage is measured across LED pin and CS pin when LED current is decreased by 5%.

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Detailed Description

The CN5502 is a high-current regulator capable of providing up to a total of 1A of current to one or more strings of high-brightness LEDs. A wide operating input voltage range of +4V to +32V makes the CN5502 ideal for automotive applications.

A +5V regulated output provides up to 3mA of current to power external circuitry. EQ pin can equalize the LED current among multiple CN5502 used in parallel to drive multiple LED strings. In addition, the CN5502 features thermal regulation instead of thermal shutdown. If the voltage drop across LED pin and CS pin is high, or the LED current is large, or both the voltage drop and LED current are large, CN5502 will become heater, when the silicon temperature reaches 125°C, the on-chip thermal regulation circuit begins to function, the LED current will be decreased to keep CN5502's silicon temperature at 125°C (typical).

The wide operating voltage range helps protect the CN5502 against large transients such as those found in load-dump situations up to 32V.

The CN5502 uses a feedback loop to control the LED current. The voltage across the sense resistor R_{CS} is compared to a fixed reference voltage, and the error is amplified to serve as the drive to the internal power MOSFET. The regulated LED current is user defined by the value of R_{CS} between CS pin and GND.

A dual-mode DIM pin and on-chip 130Hz PWM generator allow PWM dimming with an analog or PWM input signal. The analog control signal at dimming input DIM allows for a theater-dimming effect to be implemented.

Application Information

Input Voltage Considerations

The operating voltage range of the CN5502 is +4V to +32V. The device may operate below +4V, however, LED current may not meet the full regulation specification. For proper operation, the minimum input voltage must always be higher than the worst-case sum of the forward drops of all series-connected LEDs at the output of the CN5502.

+5V Regulator

The CN5502 includes a fixed +5V output regulator that delivers up to 3mA of load current for low-power applications throughout the +5.5V to +32V input voltage range. Connect a 2.2μF to 10μF compensation capacitor from VCC pin to GND.

The +5V output can be used to power the external circuitry.

Thermal Regulation

The CN5502 features thermal regulation instead of thermal shutdown. If the voltage drop across LED pin and CS pin is high, or the LED current is large, or both the voltage drop and LED current are large, CN5502 will become heater, when the silicon temperature reaches 125°C, the on-chip thermal regulation circuit begins to function, the LED current will be decreased to keep the silicon temperature at 125°C (typical). This typically occurs in overload or LED short-circuit conditions.

Setting the LED Current

The CN5502 uses a current sense resistor between CS pin and GND to set the LED current. The LED current is given by the equation below:

$$I_{LED} = 0.153 \div (R_{CS} + 0.03)$$

Where, I_{LED} is the LED current in ampere(A)

R_{CS} is the resistance from CS pin to GND in ohm(Ω)

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LED Dimming

Generally, high-brightness LEDs are binned to match at their full-rated current. However, LEDs from the same bin exhibit poor matching at currents other than full-rated current. To achieve uniformity, high brightness LED manufacturers recommend PWM pulsing of the LED current at their full-rated value.

The CN5502's dimming input (DIM pin) functions with either an analog or PWM control signal.

If a PWM signal with a frequency range between 80Hz to 400Hz, the CN5502 synchronizes to the external PWM input signal and pulse-width modulates the LED current. The PWM signal's low level should be less than 0.3V, and the high level should be higher than 1.25V.

If an analog signal is applied to DIM pin for more than 30ms, the CN5502 compares the DC input to an internally generated 130Hz ramp to pulse width-modulate the LED current. The duty cycle is adjustable from 0% to 100%. Using the following formula to calculate the duty cycle:

$$\text{Duty cycle} = (V_{\text{DIM}} - 1.2) / 1.68$$

The analog dimming feature can be used to achieve theater dimming effect. If an external PWM signal is used, the theater dimming effect can be achieved by varying the PWM duty cycle. Figure 1 shows a simple circuit that implements theater dimming with a DC input signal.

If a DC voltage of less than 0.3V is applied to DIM pin, then LED will be turned off.

Driving Multiple LED Strings

When multiple LED strings need to be driven, multiple CN5502 can be used in parallel, each CN5502 drives one LED string. In this case, the current flowing through each LED string can be equalized by connecting every CN5502's EQ pin together, as shown in Figure 3.

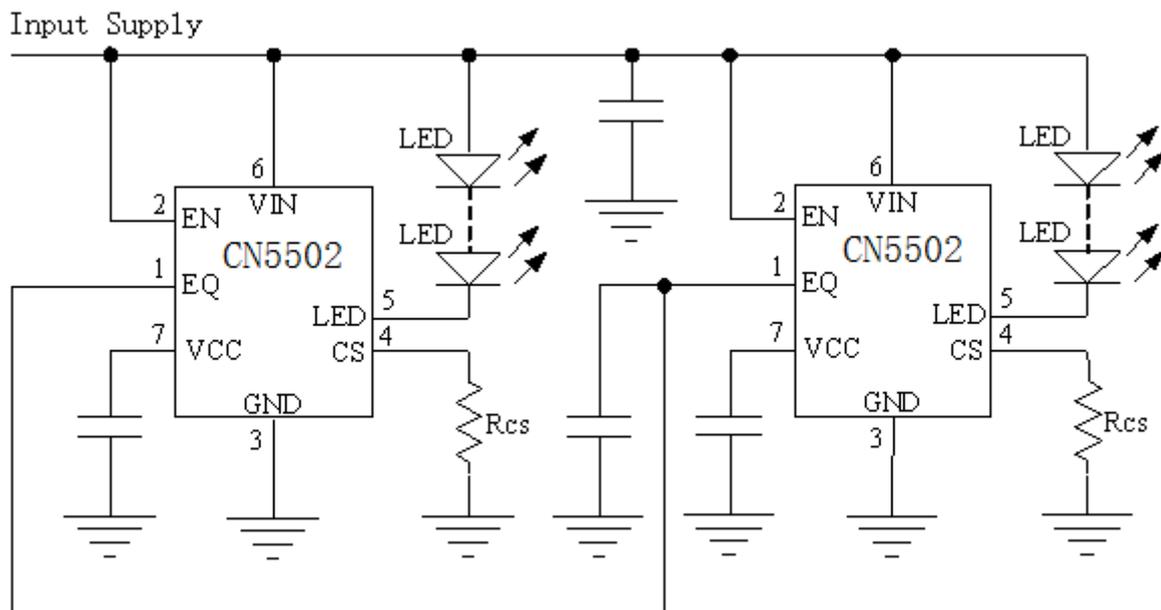


Figure 3 Multiple CN5502 Used In Parallel

If only one CN5502 is used or current equalization is not needed, EQ pin should be left floating.

VIN Bypass Capacitor CIN

In most applications, a high-frequency bypass capacitor at the input is needed. Generally A 1uF ceramic capacitor, placed in close proximity to VIN and GND pins, works well. In some applications depending on the power supply characteristics and cable length, it may be necessary to increase the capacitor's value. For the consideration of the bypass capacitor, please refer to the Application Note AN102 from our website.

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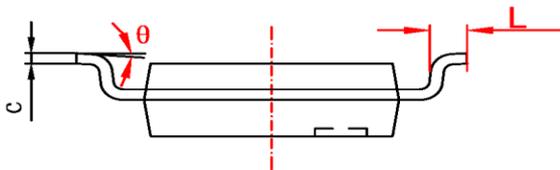
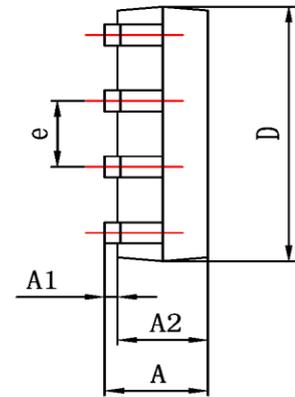
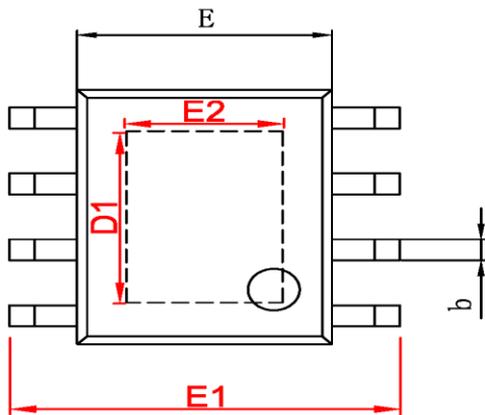
PCB Layout Considerations

1. Rcs at CS pin should be as close to CN5502 as possible.
2. The capacitor at VCC pin should be as close to CN5502 as possible.
3. It is very important to use a good thermal PC board layout to maximize LED current and minimize the drop out voltage. The thermal path for the heat generated by the IC is from the die to the copper lead frame, through the package lead(especially the ground lead) to the PC board copper, the PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feedthrough vias to inner or backside copper layers are also useful in improving the overall thermal performance of the LED driver. Other heat sources on the board, not related to the LED driver, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum LED current.

The ability to deliver maximum LED current under all conditions require that the exposed metal pad on the back side of the CN5502 package be soldered to the PC board ground. Failure to make the thermal contact between the exposed pad on the backside of the package and the copper board will result in larger thermal resistance.

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Package Information (eSOP8)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Important Notice

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