Description

The SE3362 is a charge pump operating in either 1x mode or 2x fractional mode regulating current through each of the 4 LED pins. Operation at a fixed high frequency of 1MHz typical allows the use of very small value ceramic capacitors.

The SE3362 drives white light-emitting diodes (LED's) connected in parallel and provides tightly matched regulated current to achieve uniformity of brightness in LCD backlighting applications. An external resistor RSET controls the output current level. LED currents of up to 30mA are supported over a range of input supply voltages from 2.85V to 5.5V, making the device ideal for battery-powered applications.

LED dimming can be accomplished by several methods including using a resistor Rset (the exact formula will be provided in the Application Section) to set the RSET pin current, applying a PWM signal on the Control signals, or adding a switched resistor in parallel with Rset. The Enable input pin allows the device to be placed in power-down mode with close to "zero" quiescent current. The SE3362 features short circuit and Over Temperature Protection (OTP). The device is available in a 16- lead thin QFN package with a max height of 0.8mm.

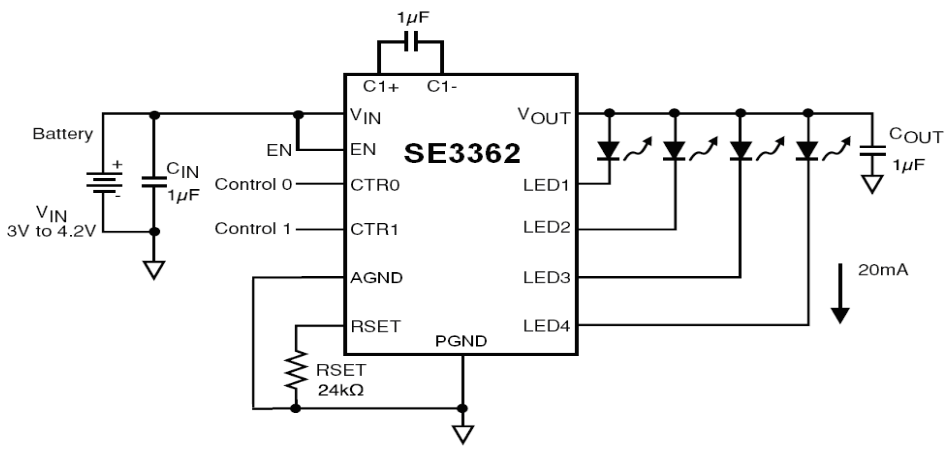
Features

- Drives individually up to 4 LEDs
- Output current up to 30mA per LED
- Digital control On/Off of each LED
- Compatible with supply voltage of 2.85V to 5.5V
- Power efficiency up to 90%
- 2 modes of operation 1x and 2x
- Automatic short circuit detect/disable
- High-frequency Operation at 1MHz
- Low value ceramic capacitors
- Automatically switch to power save mode if no LED is deteted to be connected to the IC
- Thin QFN 16-lead package, 3×3mm
- 100% Lead (Pb)-Free

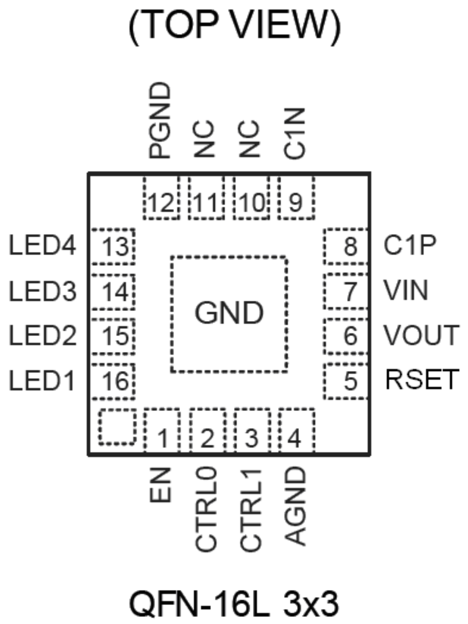
Application

- Color LCD and keypad Backlighting
- Cellular Phones
- Handheld Devices
- Digital Cameras
- PDAs
- Portable MP3 players

Application Diagram



Pin Configuration



Note: The package exposed pad is electrically connected inside the package to AGND.

Functional Pin Description

Pin Number	Name	Function
1	EN	Chip Enable (Active High). Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
2	CTR0	Output Control Bit 0. (See Table 1)
3	CTR1	Output Control Bit 1. (See Table 1)
4	AGND	Analog Ground
5	RSET	LED current is set by the value of the resistor RSET connected from the RSET pin to ground. Do not short the RSET pin. VISET is typically 1.1V. All external capacitance at this pin, including board parasitic capacitance, must be less than or equal to 30pF.
6	VOUT	Output Voltage Source for connection to the LED anodes.
7	VIN	Input Voltage
8	C1+	Positive Terminal of Bucket Capacitor 1
9	C1-	Negative Terminal of Bucket Capacitor 1
10	NC	No Connection
11	NC	No Connection
12	PGND	Power Ground. This ground should be connected to Power GND on PCB.
13 to16	LED 4 to 1	Current Sink for LED. (If not in use, pin should be connected to VOUT)
Exposed Pad	GND	Exposed pad should be soldered to PCB board and connected to GND.

Absolute Maximum Rating (1)

Parameter	Value	Units
VIN, VOUT, LEDx voltage	-0.3～7V	V
EN, CTRx,RSET voltage	-0.3 to VIN	V
RSET current	±1	mA
Lead Temperature (Soldering, 5 sec.)	260	°C
Junction Temperature	0 to +150	°C
Storage Temperature	-40 to +150	°C

Operating Rating (2)

Parameter	Symbol	Value	Units
Supply Input Voltage Range	V_{IN}	5.5	V
Junction Temperature Range	T_J	0 to +125	°C
I_{LED} per LED pin		0to 30	mA

Electrical Characteristics

VIN = 3.5V; C1＝1.0μF; T_J = 25°C; unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Supply Voltage	V_{IN}		2.85	--	5.5	V
RSET Regulated Voltage	V_{RSET}		1.22	1.25	1.28	V
Current into LEDs	I_{LED}	R_{SET}=100K	--	5	--	mA
		R_{SET}=25.0 K	--	20	--	mA
		R_{SET}=16.7 K	--	30	--	mA
Quiescent Current	I_Q	EN=Low, Shutdown Mode	--	1	--	uA
		1x Mode , No Load	--	170	--	uA
		2x Mode, No Load	--	2.5	--	mA
I_{LED} Accuracy	$I_{LED-ERR}$	2mA<I_{LED}<30mA	--	2	7.5	%
Current Matching(3)	$I_{LED-LED-ERR}$	2mA<I_{LED}<30mA	--	1	5	%
x1 mode to x2 mode Transition Voltage(V_{IN} falling)	V_{TRANS}	V_{LED}=3.5V,I_{OUT}=80mA,I_{LED}=20mA	--	3.8	--	V
Oscillator Frenquency	F_{OSC}	V_{LED}=3.5V,I_{OUT}=80mA,I_{LED}=20mA	--	1.0	--	MHz
Input High Threshold	V_{IH}	Input high logic threshold	1.5	--	--	V
Input Low Threshold	V_{IL}	Input low logic threshold	--	--	0.4	V
Input Leakage Current	IIN		--	--	1	μA
$T_{PROTECTION}$	Thermal Protection	Thermal Protection Temperature	--	150	--	°C
		Protection Hysterisys	--	20	--	

	Control Inputs		Output Status			
Table1	CTRL1	CTRL0	LED4	LED3	LED2	LED1
	0	0	OFF	OFF	ON	ON
	0	1	OFF	ON	ON	ON
	1	0	ON	ON	ON	ON
	1	1	OFF	OFF	OFF	OFF

Note 1: Exceeding the absolute maximum rating may damage the device.

Note 2: The device is not guaranteed to function outside its operating rating.

Note 3: Current Matching refers to the difference in current from on LED to the next.

$$\text{ILED Current Matching} = \pm \frac{I_{LED(MAX)} - I_{LED(MIN)}}{I_{LED(MAX)} + I_{LED(MIN)}} \times 100\%$$

Operations

The SE3362 is a high efficiency charge pump white LED driver. It provides 4 channels low drop-out voltage current source to regulated 4 white LED's current. For high efficiency, the SE3362 implements x1/x2 mode charge pump. An external R_{SET} is used to set the current of white LED.

Dimming Control

CTRL0 and CTRL1 are used to control the on/off of White LED. When an external PWM signal is connected to the control pin, brightness of white LED is adjusted by the duty cycle. The SE3362 supports the dimming control frequency up to 1KHz.

LED Current Setting

The current of white LED connected to SE3362 can be set by R_{SET}. The channel current that flows through the white LED is 400 times greater than the current of R_{SET}. The white LED can be estimated by following equation:

$$\text{ILED} = 400 \times \left(\frac{V_{RSET}}{R_{SET}} \right)$$

where V_{RSET} = 1.25V, and R_{SET} is the resistance connected from RSET to GND.

Thermal Shutdown

The SE3362 provides a high current capability to drive 4 white LEDs. A thermal shutdown circuit is needed to protect the chip from thermal damage. When the chip reaches the shutdown temperature 150°C, the thermal shutdown circuit turns off the chip to prevent the thermal accumulation in the chip.

Short Circuit Protection

The SE3362 provides short circuit protection function. When output Voltage is shorted to GND, short circuit protection cell shutdown ChargePump and current source, and consequently the IC and the related LED's are protected.

Applications Information

Selecting Capacitors

To get the better performance of SE3362, the selecting of peripherally appropriate capacitor and value is very important. These capacitors determine some parameters such as input and output ripple, power efficiency, maximum supply current by charge pump, and start-up time. To reduce the input and output ripple effectively, the low ESR ceramic capacitors are recommended. Generally, to reduce the output ripple, increasing the output capacitance C_{OUT} is necessary. However, this will increase the start-up time of output voltage.

For LED driving applications, the input voltage ripple is more important than output ripple. Input ripple is controlled by input capacitor C_{IN}, increasing the value of input capacitance can further reduce the ripple. Practically, the input voltage ripple depends on the power supply's impedance. If a single input capacitor C_{IN} cannot satisfy the requirement of application, it is necessary to add a low-pass filter as shows in Figure 1.

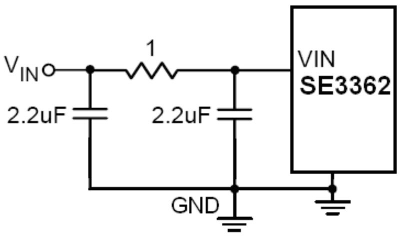


Figure1. C-R-C filter used to reduce input ripple

The flying capacitor C1 determines the supply current capability of the charge pump and to influence the overall efficiency of system. The lower value will improve efficiency, but it will limit the LED' s current at low input voltage.

Setting the LED Current

The SE3362 can be set a fixed LED's current by a resister R_{SET} connected from RSET to GND. R_{SET} establishes the reference current and mirrors the current into LED1, LED2, LED3, and LED4. The current into LED is about 400 times of the current flows through the RSET, the approximate setting formula is given as follows:

$$I_{LED}(A) = \frac{500(V)}{R_{SET}(\Omega)}$$

LED current and Table 2 shows the values of R_{SET} for a fixed LED current.

	I_{LED}(mA)	R_{SET} (KΩ)
Table 2	**5**	**100**
	10	**50**
	15	**33.3**
	20	**25.0**
	25	**20**
	30	**16.7**

LED current setting with NMOS

LED current setting control can also be achieved by using the external NMOS to change equivalent resister of RSET pin. Figure 2 shows this application circuit of method. For this example, a 3 bit signals can set 8 kinds of different equivalent resister of RSET pin, i.e. produce 8 kinds of LED current level. Table 3 shows the relation between equivalent resister of RSET pin and control signal.

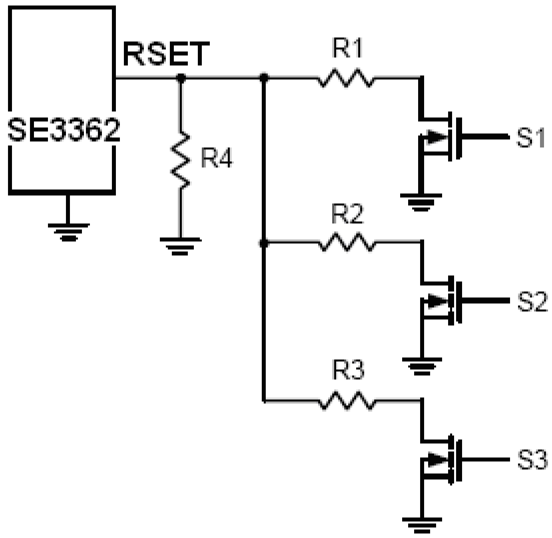


Figure 2. The application circuit of setting LED current which using a NMOS to set R_{SET}.

Table 3. The relation between control signal and equivalent resister of RSET pin			
S1	S2	S3	Equivalent Resister of RSET pin (R_{SET})
0	0	0	RSET = R4
0	0	1	RSET = R3//R4
0	1	0	RSET = R2//R4
0	1	1	RSET = R2//R3//R4
1	0	0	RSET = R1//R4
1	0	1	RSET = R1//R3//R4
1	1	0	RSET = R1//R2//R4
1	1	1	RSET = R1//R2//R3//R4

LED Dimming Control Methods

The SE3362 can use two methods to achieve the LED dimming control. These methods are detailed described as following:

(1) Dimming using PWM signal into CTRL0 and CTRL1

LED current can be controlled by applying a PWM signal to CTRL0 or CTRL1. Table 1 shows the relationship between CTRLx and 4 LED's current states. For an example, as the CTRL1 is pulled logical high and CTRL0 receives a PWM signal, then, four LED's will be dimmed synchronously. Here, the PWM signal setting the LED's current ON/OFF can achieve the average LED's current which in design. The application circuit is shown in Figure 3. Figure 4, and Figure 5 show 3WLEDs and 2WLEDs PWM dimming application circuit, respectively. During the time of PWM signal logical low, the current is a fixed value and setting by RSET resistor. So the average LEDs current can be approximated as Equation.

$$I_{LED(AVG)} = \frac{T_{OFF} \times I_{LED(ON)}}{T_{PWM}}$$

Where:

T_{PWM} is the period of PWM dimming signal T_{OFF} is the time of PWM signal at low. $I_{LED(ON)}$ is LED on state current.

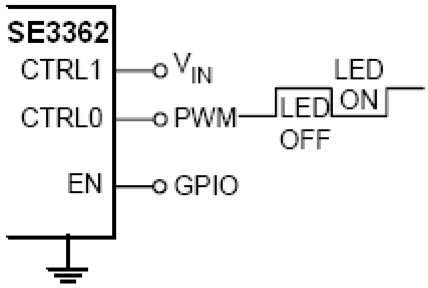


Figure 3. The PWM dimming application circuit for 4WLEDs

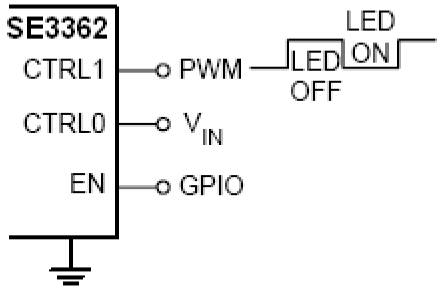


Figure 4. The PWM dimming application circuit for 3WLEDs

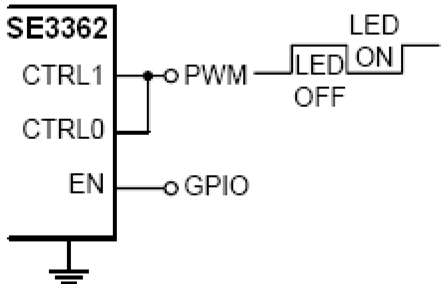


Figure 5. The PWM dimming application circuit for 2WLEDs

Additionally, SE3362 has 100us delay time between mode transfer. This delay time makes different dimming frequency corresponds to different maximum duty of CTRLX pin. Please note that the maximum dimming frequency can not exceed the maximum dimming frequency which is internally set at 1KHz.

The following equation shows the relation between maximum duty of CTRLX pin and PWM dimming frequency. Table 4 is shown the common dimming frequency and its corresponding maximum duty. For better performance consideration, the maximum PWM dimming frequency is recommended below 1kHz.

$$D_{(MAX)} = (1-100\times10^{-6}\times F_D)$$

Table 4. The common dimming frequency and its corresponding maximum duty.

Dimming Frequency (Hz)	CTRLX Maximum Duty	RLED Minimum Duty
1000	0.90	0.10
900	0.91	0.09
800	0.92	0.08
700	0.93	0.07
600	0.94	0.06
500	0.95	0.05
400	0.96	0.04
300	0.97	0.03
200	0.98	0.02

(2). The PWM dimming by GPIO

The PWM dimming by GPIO is shown as Figure 6. DZ shall be a Schottky diode with forward voltage less than 0.3V at I_F = 1mA. C3 is a capacitor to keep the enable pin voltage is higher than the threshold voltage. R1 is discharge resister and it should be not too high to prevent the off time too long while turned-off. The recommended conditions are shown as following.

1. The recommended value for R1 and C3 are 200kΩ (±5%) and 0.22μF (X7R, ±10%).
2. The forward voltage of the Schottky diode shall be less than 0.3V at 1mA.
3. The output voltage of GPIO should be greater than 2.8V and keep the voltage on EN pin is higher than 1.5V.
4. The PWM frequency should be in the range of 500Hz~1.5kHz or 20kHz~30kHz for audio noise consideration.
5. The PWM duty cycle shall be in the range of 30% to 95%.
6. The driving capability of the GPIO should be greater than 2mA @ 2.8V.
7. The LED current can be obtained by the equation,

$$I_{LED} = 400\times\frac{V_{RSET}}{R_{SET}}\times(1-D_{PWM})$$

(The typical value of V_{RSET} is 1.25V)

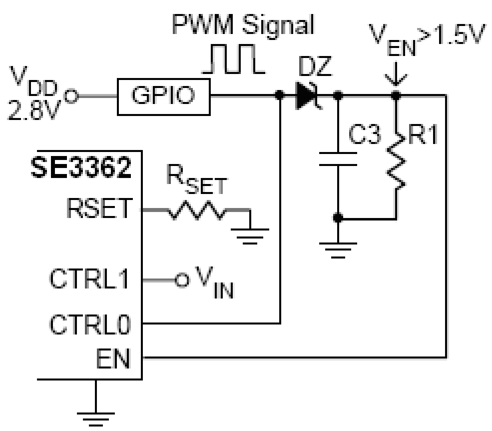
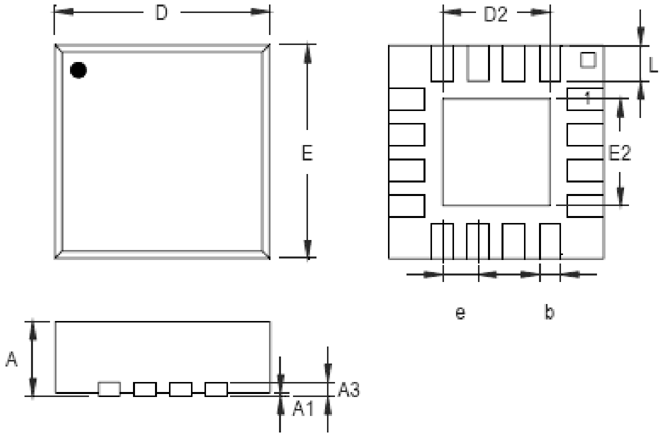


Figure 6. The GPIO PWM dimming application circuit

Outline Drawing for QFN16 3X3



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.000	0.031	0.039
A1	0.000	0.050	0.000	0.002
A3	0.175	0.228	0.007	0.009
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	1.500	1.750	0.059	0.069
E	2.950	3.050	0.116	0.120
E2	1.500	1.750	0.059	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

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