

BCT3661C

White LED driver with digital pulse brightness control

Features

- 3.0V to 5.5V Input Voltage Range
- 28V Open LED Protection for up to 7 LEDs in series
- Max current 50mA
- Current accuracy, $\pm 3\%$
- 1-Wire 256 Level Digital Pulse Brightness Control
- Over current/voltage protection
- Inrush current protection
- Up to 90% Efficiency
- RoHS Compliant and 100% Lead Free
- Package DFN2x2-6

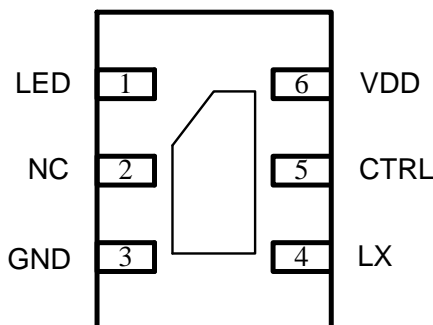
Description

BCT3661C is a boost converter that drives up to 14 LEDs in 7 series 2 parallels. It runs at 600kHz fixed switching frequency to reduce output ripple and EMI, improve conversion efficiency, and allow for the use of small external components. During the operation, the LED current can be controlled by using the 1-wire digital interface through the CTRL pin. BCT3661C does not burst LED current, therefore, it does not generate audible noise on the output capacitor. The device integrated open LED protection, that disables the BCT3661C to prevent the output from exceeding the absolute to prevent the output from exceeding the absolute maximum ratings during open LED conditions. The BCT3661C is available in a space saving 2mm x 2mm 6-pin DFN package and is specified over the -40°C to 85°C extended temperature range.

Applications

Cellular Phones
 Ultra Mobile Devices
 Portable Media Players
 PDAs, GPS Receivers

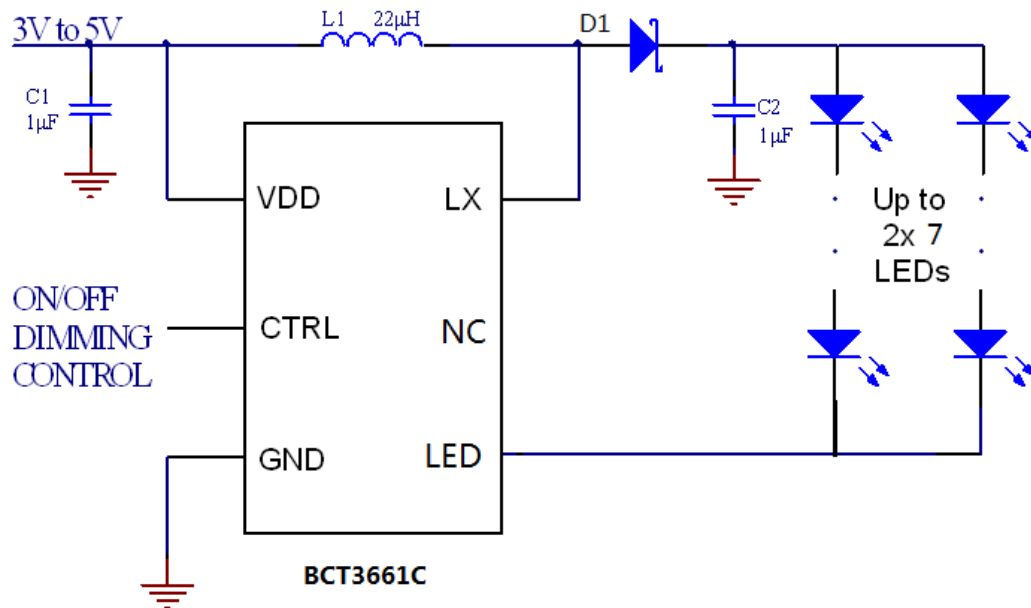
Pin Configurations (Top View)



Ordering Information

Part	Pin-Package	Temp-Range	Top Mark	Supplied as:
BCT3661CELT-TR	DFN2x2-6	-40°C to $+85^{\circ}\text{C}$	3661C	3000units/Tape & Reel

Typical Application Circuit



Pin Description

NO.	NAME	I/O	DESCRIPTION
1	LED	I	Serial LED string input Pins.
2	NC	I	No connect.
3	GND	G	Ground.
4	LX	I	This is the switching node of the IC. Connect the inductor between the VIN and LX pin.
5	CTRL	I	Control pin of the boost regulator. It is a multi-functional pin which can be used for enable control and digital dimming.
6	VDD	I	Power supply .

Absolute Maximum Ratings⁽¹⁾

Symbol	Description	Value	Unit
V _{IN}	Supply Voltages on VDD ⁽²⁾	-0.3 to 6	V
V _{CTRL}	Voltages on CTRL ⁽²⁾	-0.3 to 6	V
V _{LX}	Voltage on LX ⁽²⁾	-0.3 to 28	V
P _D	Continuous Power Dissipation	See Dissipation Rating Table	
T _J	Operating Junction Temperature Range	-40 to 150	°C
T _{STG}	Storage Temperature Range	-65 to 150	°C

(1) 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 beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltage values are with respect to network ground terminal.

Recommended Operating Conditions

Symbol	Description	MIN	TYP	MAX	UNIT
V _{IN}	Input voltage range, V _{IN}	3.0		5.5	V
L	Inductor(1)	10		22	μH
C _{IN}	Input capacitor	1		10	μF
C _O	Output capacitor(1)	1		10	uF
T _A	Operating ambient temperature	-40		85	°C
T _J	Operating junction temperature	-40		125	°C

(1) These values are recommended values that have been successfully tested in several applications. Other values may be acceptable in other applications but should be fully tested by the user.

Dissipation Ratings

RqJC	RqJA	DERATING FACTOR ABOVE TA = 25°C	T _A < 25°C	T _A = 70°C	T _A = 85°C
20°C/W	140°C/W	7.1 mW/°C	715 mW	395 mW	285 mW

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Electrical Characteristics

 $V_{IN} = 3.6\text{ V}$, $CTRL = V_{IN}$, $T_A = -40^{\circ}\text{C}$ to 85°C , typical values are at $T_A = 25^{\circ}\text{C}$ (unless otherwise noted)

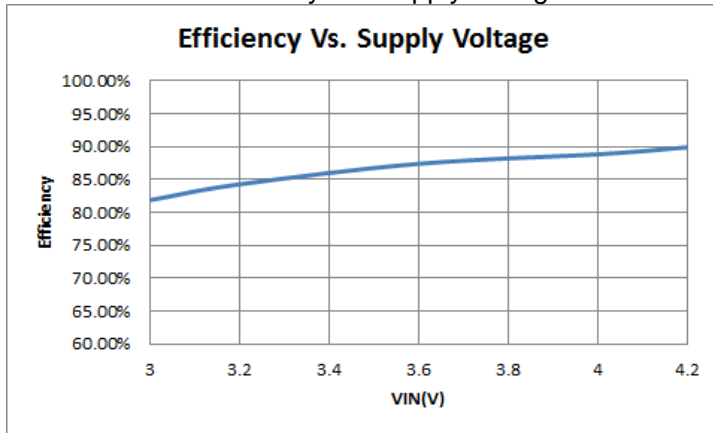
Parameter	Symbol	Test Condition	Min	Typ	Max	Units
General						
Input voltage range	V_{IN}		3.0		5.5	V
Quiescent supply current	I_Q	$V_{CTRL} = \text{high}$		1		mA
Input shutdown current	I_{SHDN}	$V_{CTRL} = \text{low}$			1	μA
DC/DC Boost Section						
Logic threshold: Low	V_{IL}	CTRL pin			0.4	V
Logic threshold: High	V_{IH}	CTRL pin	1.4			V
Internal NMOS "on" resistance	$R_{DS(ON)N}$	$T_A = 25^{\circ}\text{C}$		250		$\text{m}\Omega$
Switching frequency	f_{OSC}	$T_A = 25^{\circ}\text{C}$		600		KHz
Maximum duty cycle	DMAX		90			%
Current sink voltage	V_{LED}	$I_{OUT} = 50\text{ mA}$		500		mV
Switching current limit	I_{LX}		0.8		1.2	A
Current sink accuracy	$I_{CS(ACC)}$	Duty = 100%, max brightness,	-3		+3	%
CTRL pin internal pull-down resistance	$R_{PULL-DOWN}$			350		$\text{K}\Omega$
Over-voltage threshold level accuracy	$V_{OVP(ACC)}$	$V_{OVP} = 28\text{V}$	-5		+5	%
DIGITAL PROG TIMING						
Start time of program pulse	t_{READY}		30			us
High time	t_{HI}		1			us
Low pulse width	t_{L_LB}		1		50	us
Shutdown pulse width timing	t_{SHDN}		1			ms

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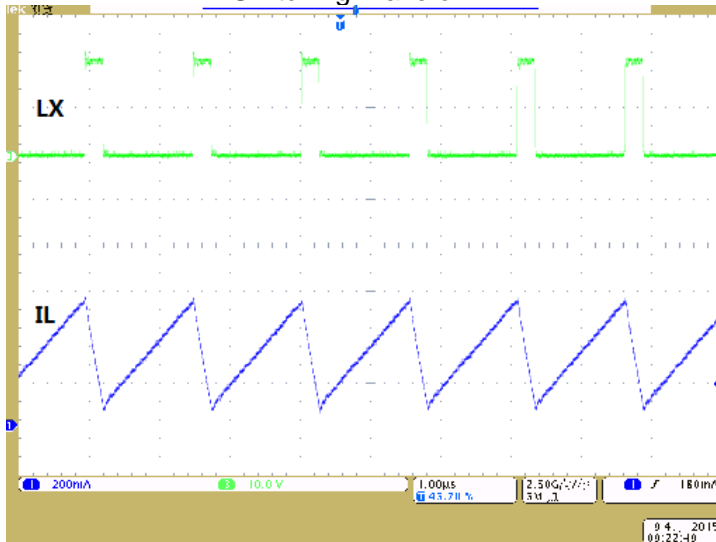
Typical Performance Characteristics

$T_A=25^{\circ}\text{C}$, $L=22\mu\text{H}$, $C_{IN}=10\mu\text{F}$, $C_{OUT}=1\mu\text{F}$, unless otherwise noted.

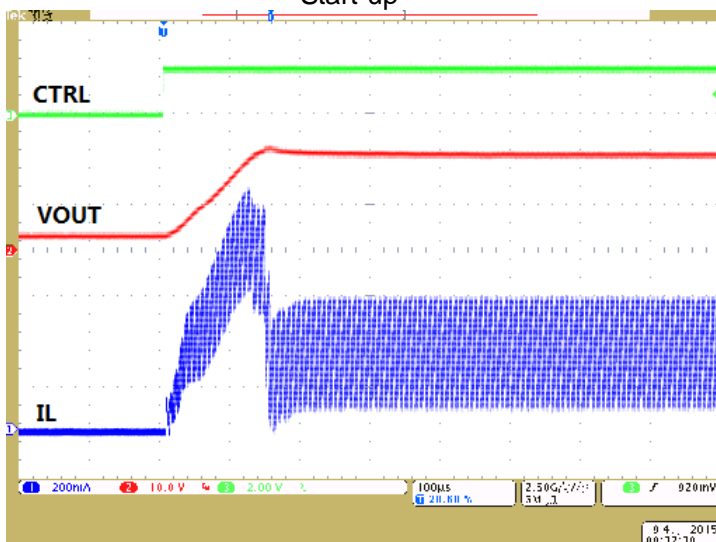
Efficiency Vs. Supply Voltage



Switching Waveform



Start-up



Detailed Description

OPERATION

The BCT3661C is a high efficiency, high output voltage boost converter in small package size, The device is ideal for driving up to 14 white LEDs in 7 series 2 parallels. Two serials of LED provide even illumination by sourcing the same output current through all LEDs, eliminating the need for expensive factory calibration. The device integrates 28V/1.2A switch FET and operates in pulse width modulation (PWM) with 600kHz fixed switching frequency. The duty cycle of the converter is set by the error amplifier output and the current signal applied to the PWM control comparator. The control architecture is based on traditional current-mode control, therefore, a slope compensation is added to the current signal to allow stable operation for duty cycles larger than 50%.

SOFT START-UP

Soft-start circuitry is integrated into the IC to avoid a high inrush current during start-up. After the device is enabled, the current starts ramp up to the maximum in 2ms. This ensures that the output voltage rises slowly to reduce the input current.

OPEN LED PROTECTION

Open LED protection circuitry prevents IC damage as the result of white LED disconnection. The BCT3661C monitors the voltage at the LX pin during each switching cycle. The circuitry turns off the switch FET and shuts down the IC as soon as the LX voltage exceeds the V_{ovp} threshold for 8 clock cycles. As a result, the output voltage falls to the level of the input supply. The device remains in shutdown mode until it is enabled by toggling the CTRL pin logic.

SHUTDOWN

The BCT3661C enters shutdown mode when the CTRL voltage is logic low for more than 1 ms. During shutdown, the input supply current for the device is less than 1uA (max). Although the internal FET does not switch in shutdown, there is still a DC current path between the input and the LEDs through the inductor and Schottky diode. The minimum forward voltage of the LED array must exceed the maximum input voltage to ensure that the LEDs remain off in shutdown. However, in the typical application with two or more LEDs, the forward voltage is large enough to reverse bias the Schottky and keep leakage current low.

DIGITAL PULSE DIMMING

The CTRL pin is used for digital pulse dimming. When the CTRL pin is constantly high, the LED current is regulated to 50mA typically. The dimming can be achieved by applying a pulse signal to the CTRL pin. The number of falling edges is detected internally and decoded as illustrated in Table 1. There are totally 256 steps of current value can be set by users. When the CTRL pin is held low for 1ms or more, the BCT3661C enters the shutdown mode and draw "zero" current from VIN.

Number of Pulse Falling Edge	I _{LED} (mA)
0	50
1	49.8
2	49.6
...	
N	$50 - (50/256) \times N$
...	
254	0.392
255	0.196

Table 1: Current Setting

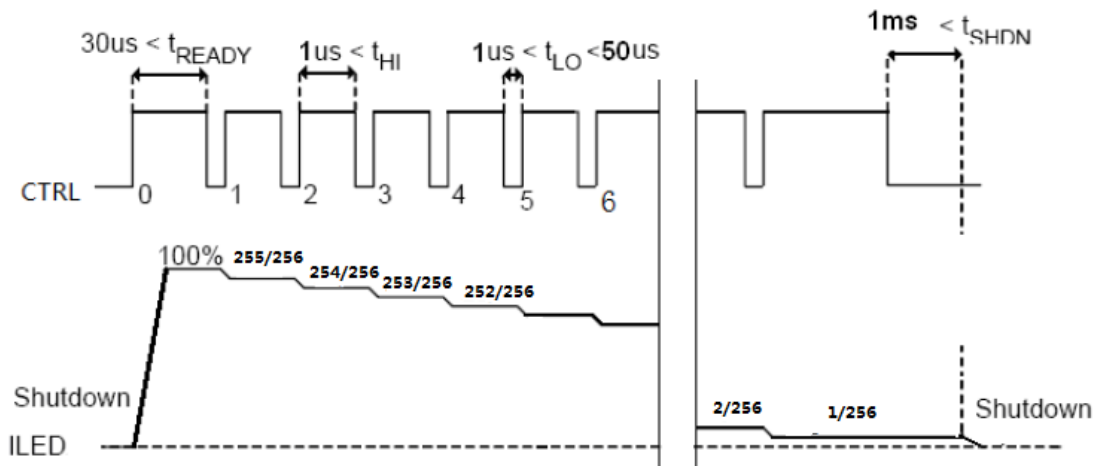


Figure 1. Brightness Control by Pulse Dimming

Application Information

External component and layout are critical and should be considered carefully.

Inductor Selection

Inductor value, saturation current, and Direct Current Resistance (DCR) are the most important parameters used to select an inductor for the BCT3661C.

The suitable inductance range for this device is 10 μ H to 22 μ H. Higher inductance lowers the value of the RMS current of the step-up converter. Together with a lower DCR value of the inductor, the total inductor power loss becomes much lower. Considering inductor size and cost, 10 μ H inductance is recommended. The below table lists some recommended inductors for the BCT3661C.

Recommend Inductors

Part Number	L(μ H)	DCR MAX (Ω)	Saturation Current (mA)	Size(L x W x H mm)	Vendor
LQH3NPN100NM0	10	0.3	750	3x3x1.5	Murata
VLCF5020T-220MR75-1	22	0.4	750	5x5x2.0	TDK
CDH3809/SLD	10	0.3	570	4x4x1.0	Sumida
A997AS-220M	22	0.4	510	4x4x1.8	TOKO

Schottky Diode Selection

The high switching frequency of the BCT3661C demands a high-speed rectification for optimum efficiency. Ensure that the diode average and peak current rating exceeds the average output current and peak inductor current. In addition, the diode's reverse breakdown voltage must exceed the open LED protection voltage. To achieve better efficiency, a low VF Schottky diode is recommended. ONSem MBR0540 and ZETEX ZHCS400 are recommended for the BCT3661C.

Output Capacitor Selection

The output capacitor is mainly selected to meet the requirements for the output ripple and loop stability.

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The output voltage of the BCT3661C could reach up to 28 V. X7R type output capacitor rated of 50 V is suggested. To reduce power loss, a ceramic capacitor with a low Effective Series Resistance (ESR) is better. The capacitor in the range of 1uF to 4.7uF is recommended for input side. The recommended output capacitor value is 1uF.

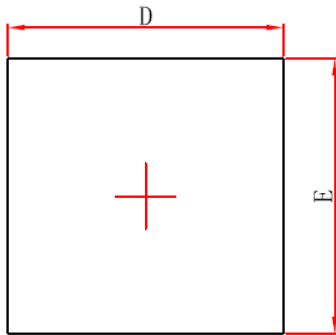
PCB Layout Consideration

For best performance of the BCT3661C, the following guidelines must be followed.

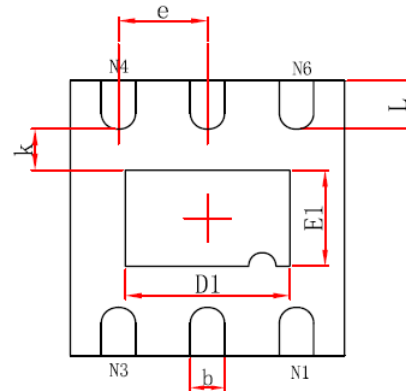
1. Input /Output capacitors should be placed close to the IC and connected to ground to reduce noise coupling.
2. The Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.
3. Keep the main current traces as possible as short and wide.
4. Vin will be connected with Vbattery with wide track, to avoid the interference of RF PA and Audio PA.

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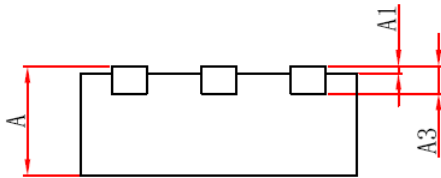
Package Information
DFN2x2-6



Top View



Bottom View



Side View

Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.7	0.75	0.8	0.028	0.0295	0.031
A1	0	0.025	0.05	0	0.001	0.002
A3	0.203REF.			0.008REF.		
D	1.924	2.0	2.076	0.076	0.079	0.082
E	1.924	2.0	2.076	0.076	0.079	0.082
D1	1.1	1.2	1.3	0.043	0.047	0.051
E1	0.6	0.7	0.8	0.024	0.027	0.031
k	0.2TYP.			0.008TYP.		
b	0.2	0.25	0.3	0.007	0.01	0.012
e	0.65TYP.			0.026TYP.		
L	0.274	0.35	0.426	0.011	0.014	0.017