

BCT3660C

High Brightness, Large Current, High Efficiency LED Driver

Features

- 3.0V to 5.5V Input Voltage Range
- 28V Open LED Protection for up to 7LEDs in series
- Max current 50mA
- Current accuracy, $\pm 3\%$
- PWM Brightness Dimming (Minimum Duty Cycle 0.8%)
- Over current/voltage protection
- Inrush current protection
- Up to 90% Efficiency
- RoHS Compliant and 100% Lead Free
- Package DFN2x2-6

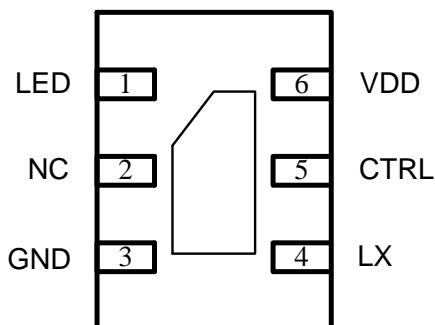
Description

BCT3660C 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 dimming control can be done by CTRL pin. The device integrated open LED protection, that disables the BCT3660C to prevent the output from exceeding the absolute to prevent the output from exceeding the absolute maximum ratings during open LED conditions. The BCT3660C 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

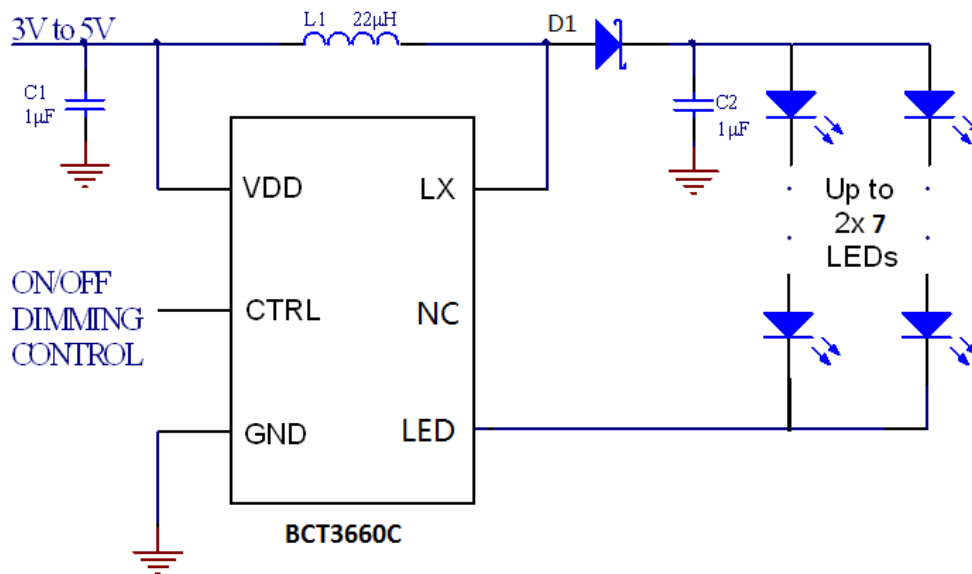
Pin Configurations (Top View)



Ordering Information

| Part | Pin-Package | Temp-Range | Top Mark | Supplied as: |
|----------------|-------------|--|----------|-----------------------|
| BCT3660CELT-TR | DFN2x2-6 | -40°C to $+85^{\circ}\text{C}$ | 3660C | 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 |

Ver 1.6

Electrical Characteristics

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

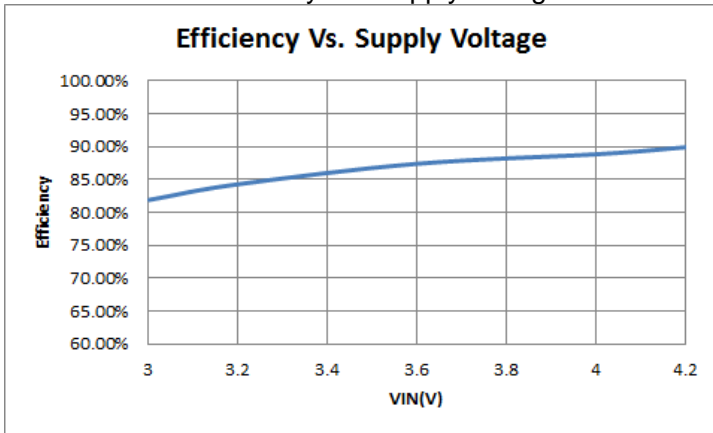
| Parameter | Symbol | Test Condition | Min | Typ | Max | Units |
|--|------------------|------------------------------|-----|-----|-----|------------------|
| General | | | | | | |
| Input voltage range | V_{IN} | | 3.0 | | 5.5 | V |
| Quiescent supply current | I_Q | $V_{CTRL} = \text{high}$ | | 1 | | 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 | D _{MAX} | | 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 | % |
| PWM Dimming Control Section | | | | | | |
| PWM input frequency range | f_{PWM} | | 2 | | 60 | kHz |
| PWM Dimming Duty Cycle | D | | 0.2 | | 100 | % |
| Logic threshold: Low | V_{IL} | PWM input signal | | | 0.4 | V |
| Logic threshold: High | V_{IH} | PWM input signal | 1.4 | | | V |
| PWM input deglitch filter | $t_{DEGLITCH}$ | | | 100 | | ns |
| CTRL pin minimum shutdown pulse width timing | t_{OFF} | | | | 1 | ms |

Ver 1.6

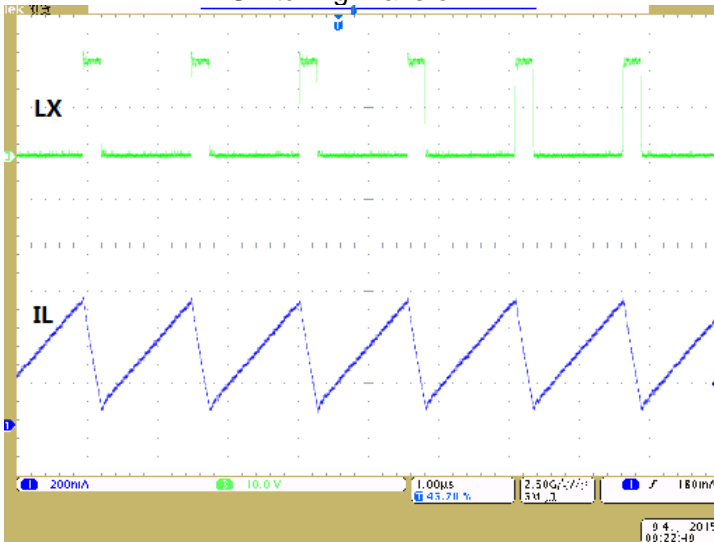
Typical Performance Characteristics

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

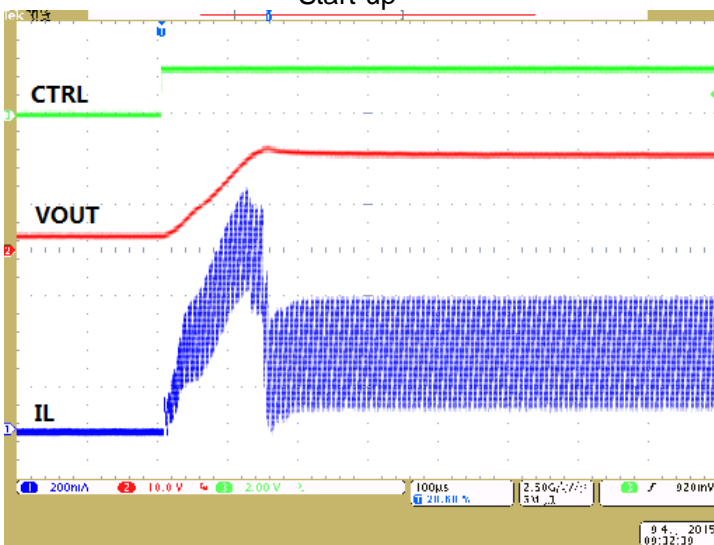
Efficiency Vs. Supply Voltage



Switching Waveform



Start-up



Detailed Description

OPERATION

The BCT3660C 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 BCT3660C 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 BCT3660C 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.

PWM BRIGHTNESS DIMMING

The CTRL pin is used for PWM dimming. When the CTRL pin is constantly high, the LED current is regulated to 50mA typically. However, the CTRL pin allows a PWM signal to reduce this LED current, therefore, it achieves LED brightness dimming. The relationship between the duty cycle and LED current is given by Equation 1.

$$I_{LED} = \text{Duty} \times 50\text{mA} \quad (1)$$

Where

Duty = duty cycle of the PWM signal

For optimum performance, use the PWM dimming frequency in the range of 20kHz to 60kHz.

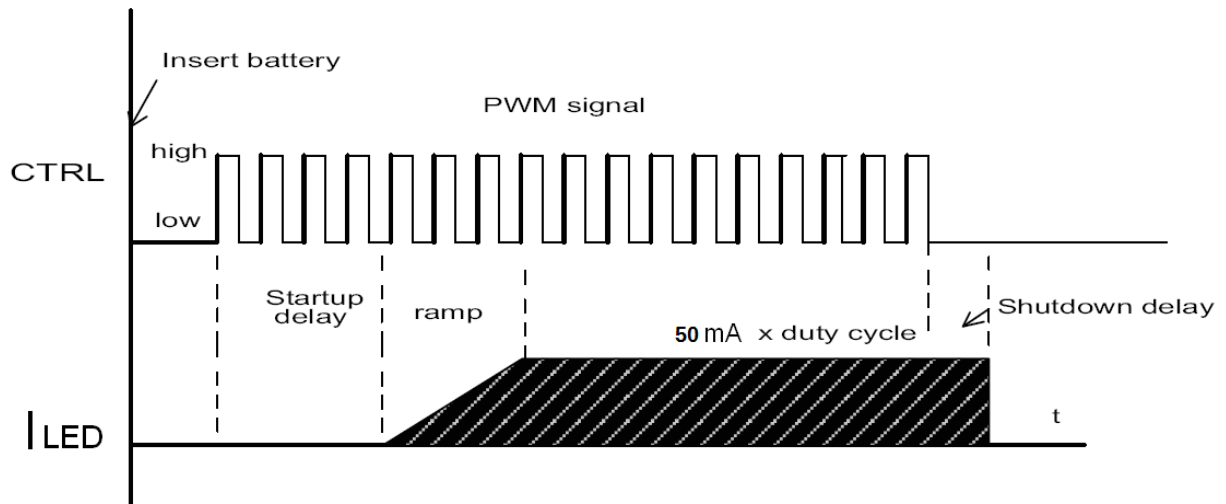


Figure 1. Soft Start PWM Brightness Dimming

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 BCT3660C.

The suitable inductance range for this device is 10 μH to 22 μH . 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 μH inductance is recommended. The below table lists some recommended inductors for the BCT3660C.

Table1. Recommend Inductors

| Part Number | L(μH) | 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 BCT3660C 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 BCT3660C.

Output Capacitor Selection

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

Ver 1.6

stability.

The output voltage of the BCT3660C 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 1 μ F to 10 μ F is recommended for input side. The recommended output capacitor value is 1 μ F.

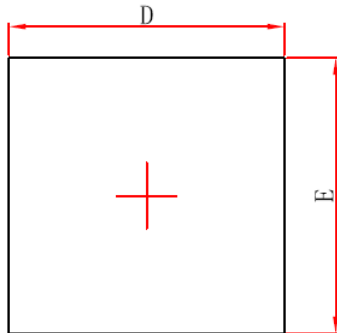
PCB Layout Consideration

For best performance of the BCT3660C, the following guidelines must be followed.

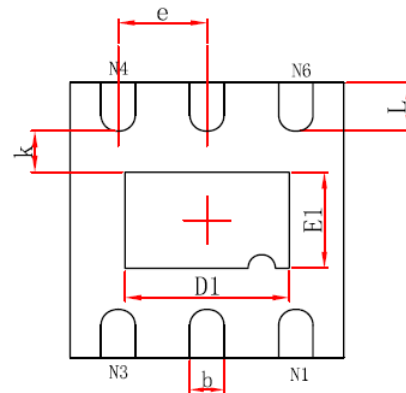
1. Input /Output capacitors should be placed close to the IC and connected to ground to reduce noise coupling.
2. The Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.
3. Keep the main current traces as possible as short and wide.
4. Vin will be connected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

Ver 1.6

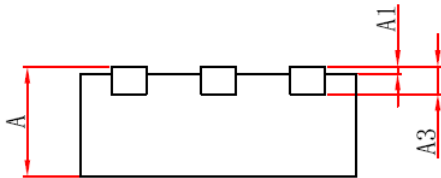
Package Information
DFN2x2-6



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 |

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