BCT3142
1.1A Buck/Boost Charge Pump LED Driver

GENERAL DESCRIPTION

The BCT3142 is a current-regulated charge pump ideal for powering high brightness LEDs for camera flash applications. The charge pump can be set to regulate two current levels for FLASH and TORCH modes.

The BCT3142 incorporates a 1-wire interface to program the flash LED current at 8 levels and flash timeout at 2 leve.

The BCT3142 supports PWM dimming to adjust the LED brightness during torch application by simply providing a PWM signal to flash pin.

The BCT3142 automatically switches modes between step-up 2x and step-down 1x ensuring that LED current does not depend on the forward voltage. It switches at 1.9MHz, allowing the use of tiny components. The supply voltage ranges from 2.7V to 5.5V and is ideally suited for all applications powered by a single LI-Ion battery cell or three to four NiCd, NiMH, or Alkaline battery cells.

The BCT3142 also features a very low shutdown current, an automatic soft-start mode to limit inrush current, as well as voltage and over thermal shutdown control.
A low current sense reference voltage (47mV) allows the use of small 0603 current sensing resistors.

The BCT3142 is available in Green DFN3x3-10L package and is specified over an ambient temperature range of -40°C to +85°C.

FEATURES

- Output Current up to 1.1A
- 8 FLASH LED Current Levels Selectable by 1-wire Interface: 100%*I_{FLASH},90%*I_{FLASH}……30%*I_{FLASH}
- 2 Flash Timeout Levels Selectable by 1-wire Interface: 220ms,1.3s
- PWM Dimming Control in Torch Mode
- Ultra low RDSON:0.4Ω（1x Mode），2Ω（2x Mode）
- Up to 92% Efficiency in Torch Mode
- Adjustable FLASH Mode Current
- 1x and 2x Automatic Modes for High Efficiency
- Input Voltage Range: 2.7V to 5.5V
- Minimum External Components: No Inductors
- High Frequency Operation: 1.9MHz
- Low 47mV Reference For Low Loss Sensing
- Built-In Soft Start Limits Inrush Current
- Low Input and Output Ripple and Low EMI
- Output Over Voltage Protection
- Over-temperature Protection
- Available in Green DFN3x3-10L Package

APPLICATIONS

White LED Torch, Flash for Cell Phones,PADs, DSCs and Camcorders
White LED Backlighting
Generic Lighting, Flash and Strobe Applications
General Purpose High Current Boost

ORDERING INFORMATION

Order Number	Package Type	Temperature Range	Marking	QTY/Reel
BCT3142EGB-TR	DFN3x3-10L	-40°C to +85°C	DQKP XXXXX	6000

Note: "XXXXX" in Marking will be appeared as the batch code.

TYPICAL OPERATING CIRCUIT

The typical application is shown Figure1，where I_{FLASH}=1.073A，I_{TORCH}=214mA

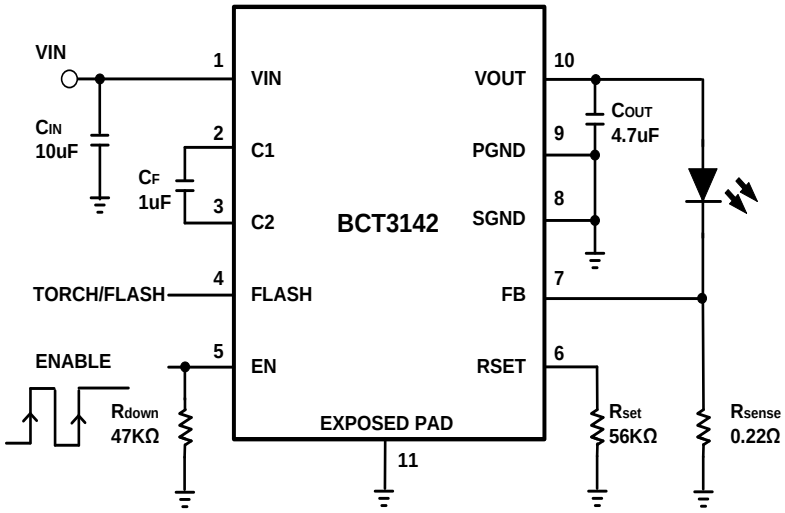


Figure 1. Typical application of 1.1A flash current

TYPICAL OPERATING CIRCUIT

The typical application is shown Figure2，where I_{FLASH}=694mA，I_{TORCH}=214mA

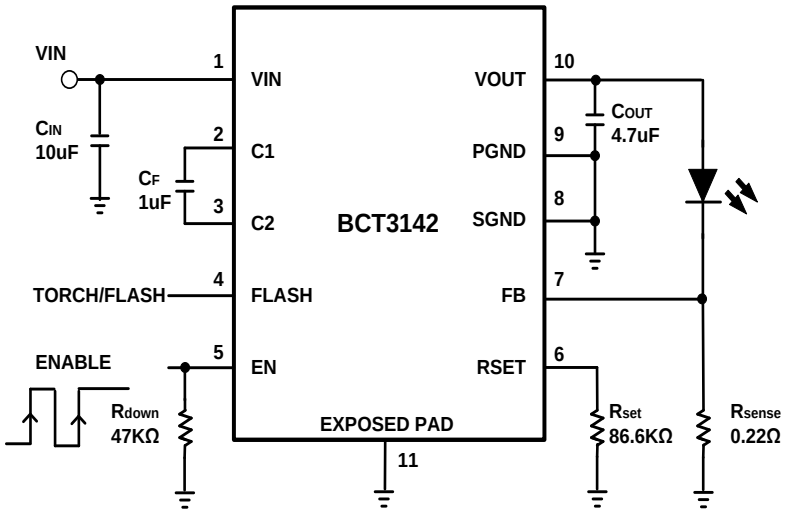


Figure 2. Typical application of 700mA flash current

The Two Flash LEDs application is shown Figure3，where $I_{FLASH\_D1+IFLASH\_D2}$=1006mA，I_{TORCH_D1}+ I_{TORCH_D2}=200mA

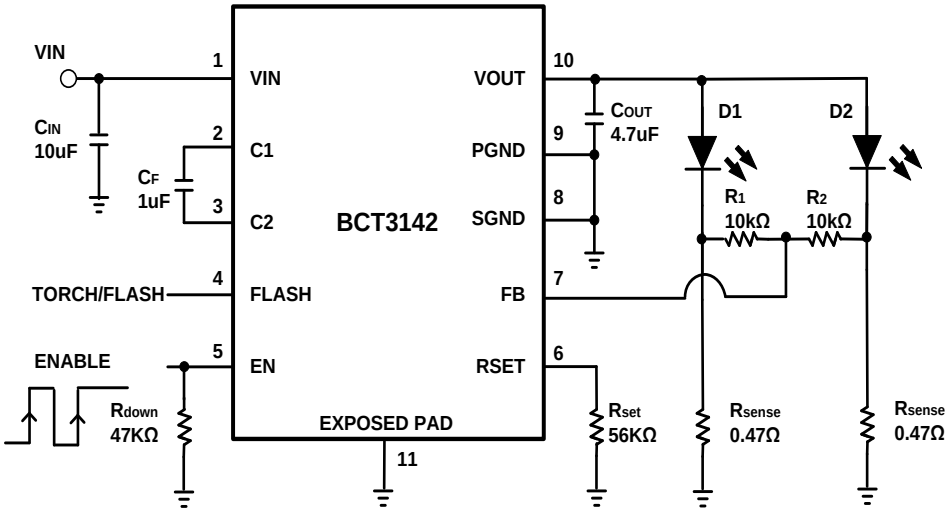


Figure 3. Two Flash LEDs application of 1A flash current

ABSOLUTE MAXIMUM RATINGS

V_{IN}, V_{OUT}.....-0.3V to 6V
V_{EN},Flash.....0V to(VIN+0.3V)/ 6V max
Output Current Pulse (Flash).....1.2A
Output Current Continuous (Torch).....0.4A
Package Thermal Resistance
DFN3x3-10L,θ_{JA}.....57℃/W
Storage Temperature Range.....-65℃ to +150℃
Junction Temperature.....150℃
Operating Temperature Range.....-40℃ to +85℃
Lead Temperature (Soldering, 10 sec).....260℃
ESD Susceptibility
HBM.....8000V

NOTE:

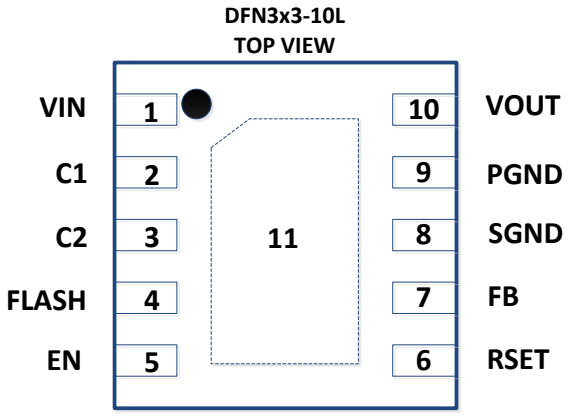
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

CAUTION

This integrated circuit can be damaged by ESD if you don’t pay attention to ESD protection. Broadchip recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Broadchip reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact Broadchip sales office to get the latest datasheet.

PIN CONFIGURATION



PIN DESCRIPTION

PIN	NAME	FUNCTION
1	VIN	Input voltage for the charge pump. Decouple with 4.7μF or 10μF ceramic capacitor close to the pins of the IC.
2	C1	Positive input for the external flying capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.
3	C2	Negative input for the external flying capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.
4	FLASH	Logic input to toggle operation between FLASH and TORCH mode. In TORCH mode FB is regulated to the internal 47mV reference. In FLASH mode FB reference voltage can be adjusted by changing the resistor from RSET pin to ground. Choose the external current sense resistor (R_{SENSE}) based on desired current in TORCH mode and FLASH mode.
5	EN	Shutdown control input. Connect to VIN for normal operation, connect to ground for shutdown. In FLASH mode,the flash current and timeout period can be adjust by EN 1-wire pulse control signal.
6	RSET	Connect a resistor from this pin to ground. When in FLASH mode (FLASH = High) this resistor sets the current regulation point according to the following: V_{FB}=(1.26V/R_{SET}) X 10.5 KΩ
7	FB	Feedback input for the current control loop. Connect directly to the current sense resistor.
8	SGND	Internal ground pin. Control circuitry returns current to this pin.
9	PGND	Power ground pin. Flying capacitor current returns through this pin.
10	VOUT	Charge Pump Output Voltage. Decouple with an external capacitor. A 4.7μF is recommended. If Higher value capacitor is used, output ripple is smaller.
11	Exposed Pad	Exposed pad should be soldered to PCB board and connected to GND.

ELECTRICAL CHARACTERISTICS

(VIN= 3.6V, C_{IN}=10uF, C_{OUT}=4.7uF， C_F=1uF, V_{SHDN}=V_{IN}, T_A = 25℃, unless otherwise specified.)

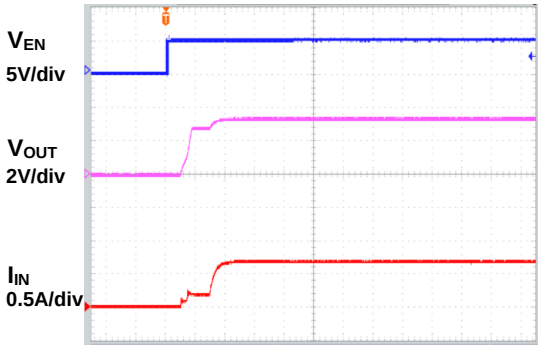
PARAMETER	SYM	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		2.7		5.5	V
Quiescent Current	I_Q	V_{IN}=2.7V to 5.5V, FLASH=0V, I_{LOAD}=100uA		0.4		mA
		FLASH=V_{IN}, 2x Mode		6		
Shutdown Current	I_{SHDN}	V_{EN}=0V, V_{IN}=5.5V		0.1	1	uA
Oscillator Frequency	F_{OSC}		1.4	1.9	2.4	MHz
Charge Pump Equivalent Resistance (2x mode)	R_{DSON_2x}			2		Ω
Equivalent Resistance (1x mode)	R_{DSON_1x}			0.4		Ω
FB Reference Voltage	V_{FB}	FLASH=VIN, RSET=86.6KΩ	140	153	163	mV
		FLASH=GND	42	47	52	
FB Pin Current	I_{FB}	V_{FB}=0.3V			1	uA
EN, FLASH Logic Low					0.4	V
EN, FLASH Logic High			1.3			V
EN, FLASH Pin Current				5		uA
FLASH Timeout		1 wire pulse rise edge number:1~8	180	220	310	ms
		1 wire pulse rise edge number:9~16	1.05	1.3	1.85	s
VOUT Turn-on Time		VIN=3.6V, FB within 90% regulation		400		us
Thermal Shutdown Temperature				147		℃

TYPICAL CHARACTERISTICS

Test Condition：C_{IN}=10uF, C_{OUT}=4.7uF，C_F=1uF (unless otherwise specified)

Soft Start

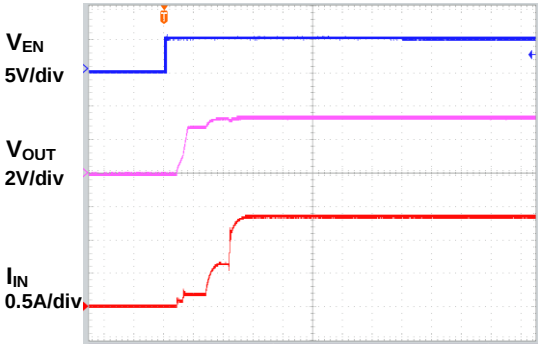
V_{IN}=4.2V,1× Mode,Flash,I_{FLASH}=660mA



Time 200us/div

Soft Start

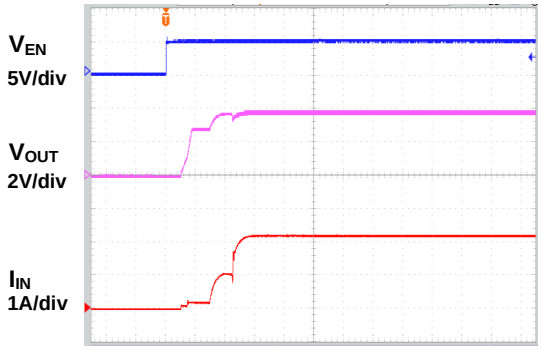
V_{IN}=3.6V,2× Mode,Flash,I_{FLASH}=660mA



Time 200us/div

Soft Start

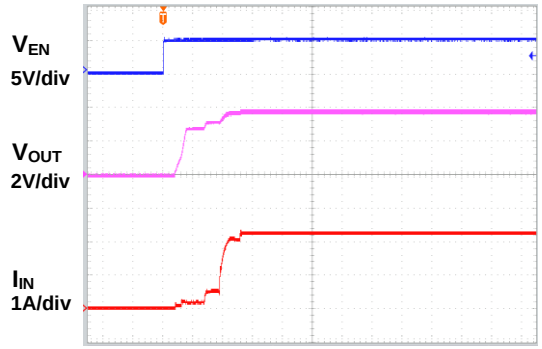
V_{IN}=4.2V,2× Mode,Flash,I_{FLASH}=1.1A



Time 200us/div

Soft Start

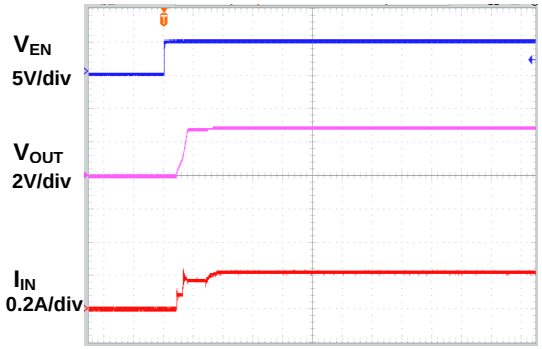
V_{IN}=3.4V,2× Mode,Flash,I_{FLASH}=1.1A



Time 200us/div

Soft Start

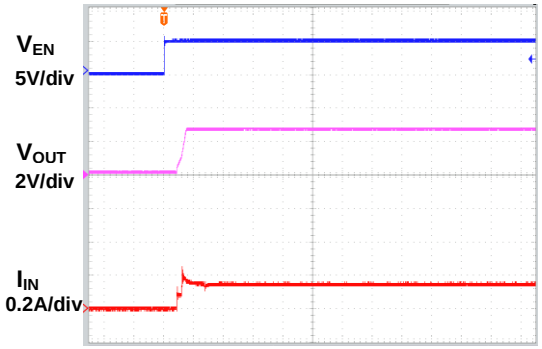
V_{IN}=3.6V,1× Mode,Torch,I_{TORCH}=214mA



Time 200us/div

Soft Start

V_{IN}=3.6V,1× Mode,Torch,I_{TORCH}=140mA



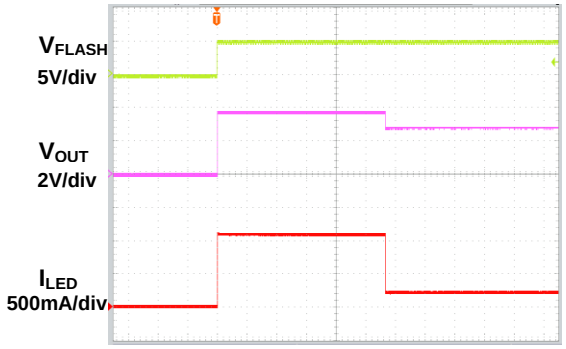
Time 200us/div

TYPICAL CHARACTERISTICS

Test Condition：C_{IN}=10uF, C_{OUT}=4.7uF，C_F=1uF (unless otherwise specified)

Flash Time 220ms

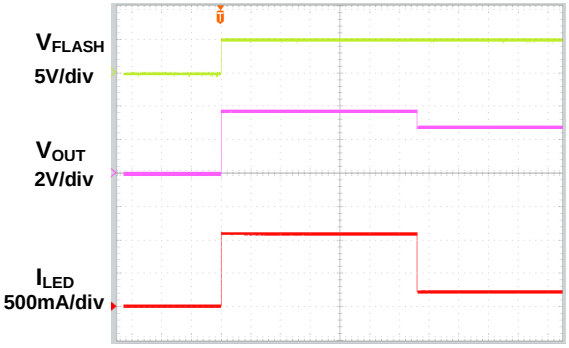
V_{IN}=4.2V,I_{FLASH}=1.1A



Time 40ms/div

Flash Time 1.3s

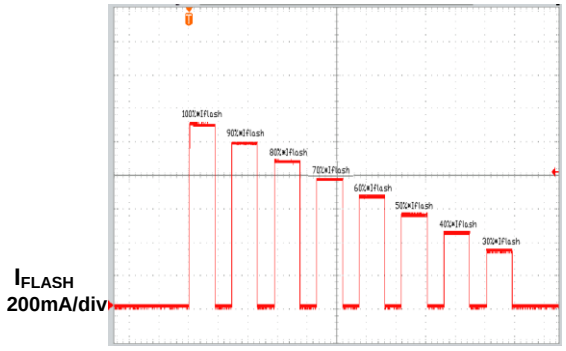
V_{IN}=4.2V,I_{FLASH}=1.1A



Time 200ms/div

Flash Current Setting by 1-wire Interface

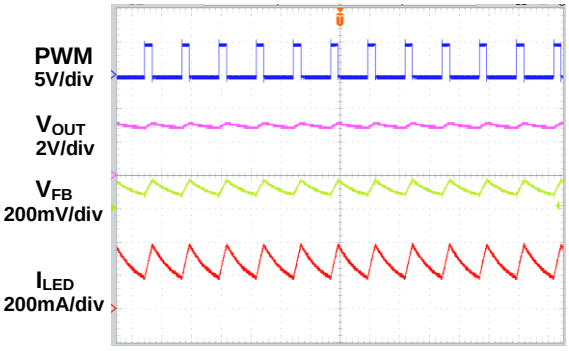
V_{IN}=4.2V,I_{FLASH}=1.1A



Time 200ms/div

Flash Current Setting by 1-wire Interface

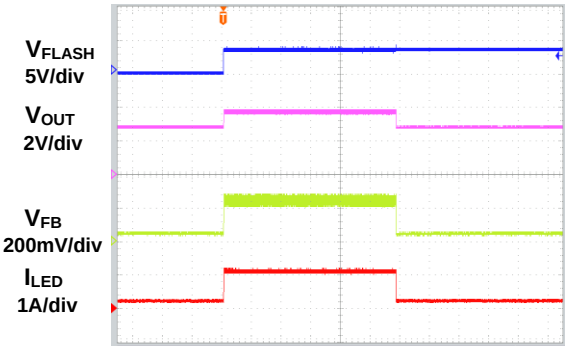
V_{IN}=4.2V,I_{FLASH}=1.1A,I_{TORCH}=0.1A,Duty=20%



Time 40us/div

Torch 1× to Flash 2×

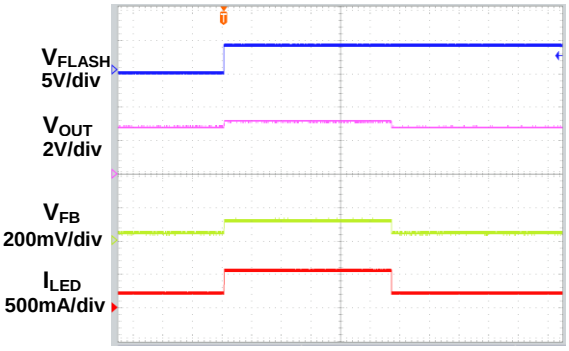
V_{IN}=3.6V,I_{FLASH}=1.1A，I_{TORCH}=214mA



Time 40ms/div

Torch 1× to Flash 1×

V_{IN}=4.2V,I_{FLASH}=550mA,I_{TORCH}=214mA



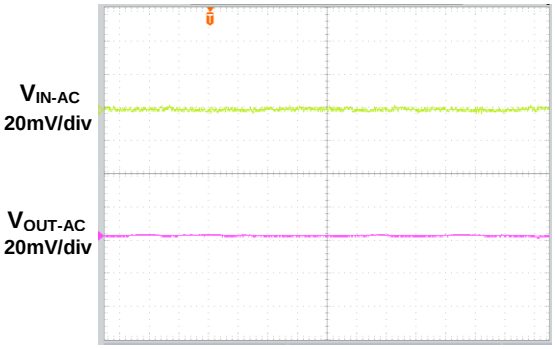
Time 40ms/div

TYPICAL CHARACTERISTICS

Test Condition：C_{IN}=10uF, C_{OUT}=4.7uF，C_F=1uF (unless otherwise specified)

Output Ripple

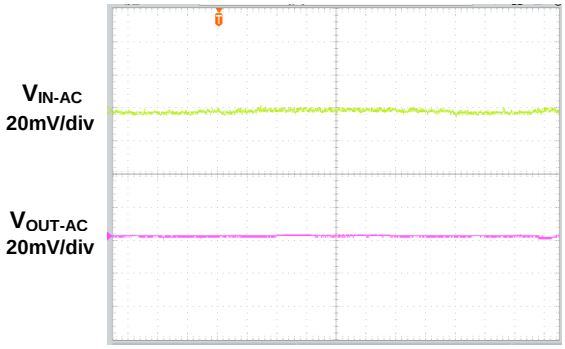
V_{IN}=4.2V,1× Mode,Torch,I_{TORCH}=214mA



Time 1us/div

Output Ripple

V_{IN}=4.2V,1× Mode,Flash,I_{FLASH}=550mA



Time 1us/div

Output Ripple

V_{IN}=3.6V,2× Mode, Flash,I_{FLASH}=550mA

Time 1us/div

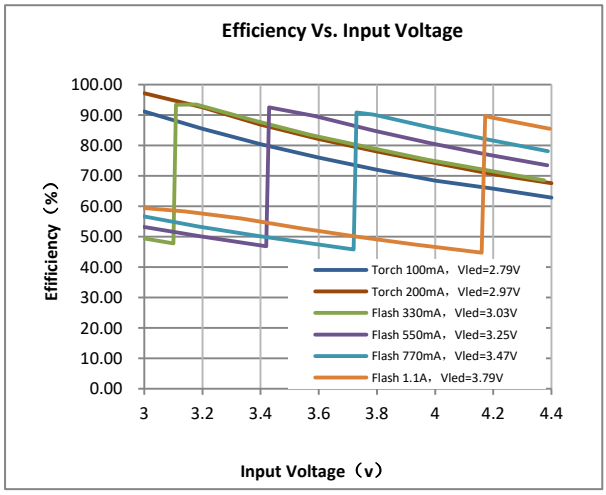
Output Ripple

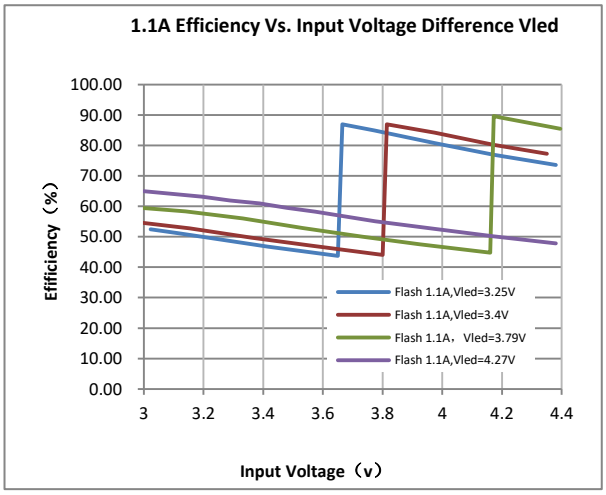
V_{IN}=3.6V,2× Mode,Flash,I_{FLASH}=1.1A

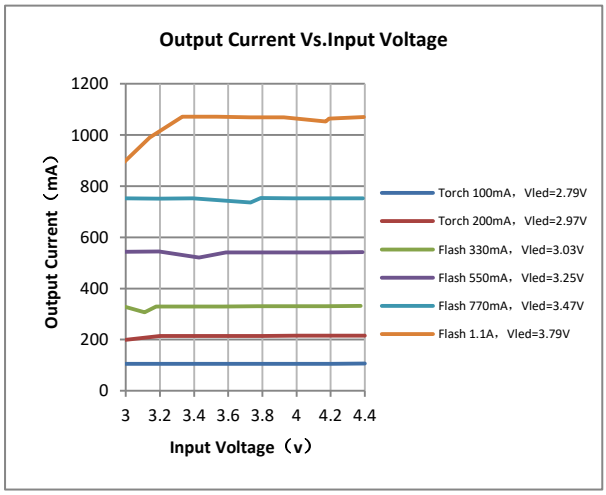
Time 1us/div

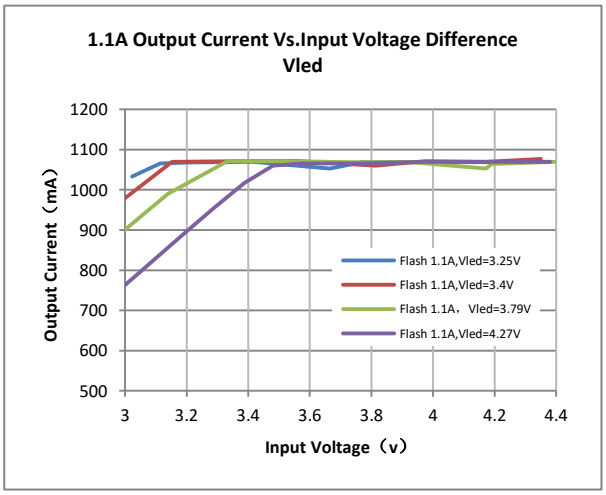
TYPICAL CHARACTERISTICS

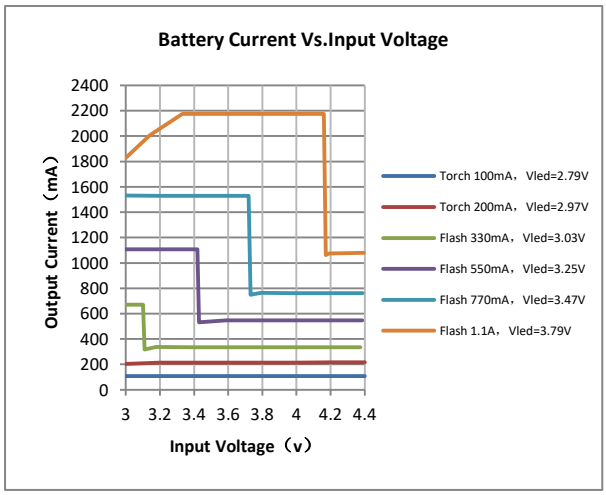
Test Condition：C_{IN}=10uF, C_{OUT}=4.7uF，C_F=1uF (unless otherwise specified)











FUNCTIONAL DESCRIPTION

The BCT3142 is a charge pump regulator designed for converting a Li-Ion battery voltage of 2.7V to 4.4V to drive a white LED used in digital still camera Flash and Torch applications. The BCT3142 has two modes of operation which are pin selectable for either Flash or Torch. Flash mode is usually used with a pulse of about 200 to 300 milliseconds to generate a high intensity Flash. Torch can be used continuously at a lower output current than Flash and is often used for several seconds in a digital still camera “movie” mode.

Adaptive charge pump(1x mode and 2x mode)

The BCT3142 also has two modes of operation to control the output current: the 1x mode and 2x mode. Operation begins after the enable pin EN receives a logic high, the bandgap reference wakes up after 50μs, and then BCT3142 goes through a soft-start mode designed to reduce inrush current. The BCT3142 starts in the 1x mode, which acts like a linear regulator to control the output current by continuously monitoring the feedback pin FB. In 1x mode, if the BCT3142 auto detects a dropout condition, which is when the FB pin is below the regulation point for more than 8μs, the BCT3142 automatically switches to the 2x mode. If the working condition satisfy $V_{IN}>V_{OUT}+I_{OUT}*R_{DSON}\_1x+\Delta V$ for more than 32us, it will switch back to 1x mode, otherwise stay in 2x mode. Where in ΔV is a fixed hysteresis voltage, R_{DSON}_1x is the equivalent resistance in 1x mode .

Flash Mode

When in Flash mode, (Flash = “High”), the FB regulation voltage is set by the resistor R_{SET} connected between the R_{SET} pin and SGND and the equation:

$$V_{FB} = (1.26V/ R_{SET}) \times 10.5K\Omega \text{ (Flash Mode)}$$

Where 1.26V is the internal bandgap reference voltage and 10.5KΩ is an internal resistance used to scale the R_{SET} current. Typical values of R_{SET} are 42KΩ to 170KΩ for a range of V_{FB} = 315mV to 77mV in Flash mode. The output current is then set in either Flash or Torch mode by the equation:

$$I_{OUT} = V_{FB} / R_{SENSE}$$

Once the R_{SENSE} and R_{SET} is selected, the BCT3142 Provides 8 flash LED Current levels from 100%*I_{FLASH} to 30%*I_{FLASH} in 10%*I_{FLASH} steps by 1-wire interface in the EN pin.

Torch Mode

In the Torch mode, (Flash = “GND”) the Flash pin is set to logic low and the BCT3142 FB pin regulates to 47mV output:

$$V_{FB} = 47mV \text{ (Torch Mode)}$$

$$I_{OUT} = V_{FB} / R_{SENSE}$$

Flash Timeout Protection

The timeout protection is applied only for flash mode. This protects the flash LED against thermal damage .The BCT3142 also Provides 2 flash timeout levels 220ms/1.3s by 1-wire interface in the EN Pin.

FUNCTIONAL DESCRIPTION

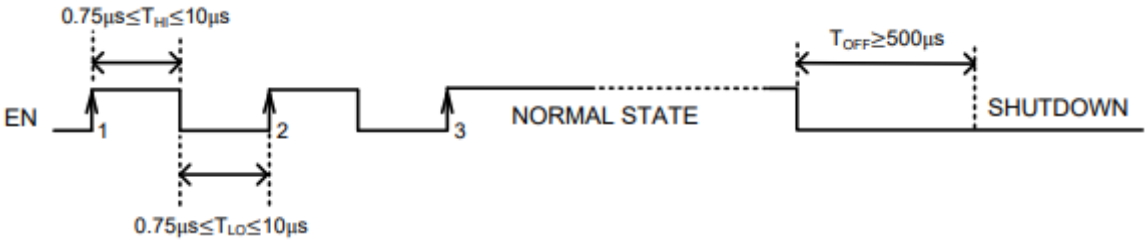
1- Wire Interface(Flash)

The BCT3142 incorporates a 1-wire interface to program the flash LED current at 8 levels and flash timeout at 2 levels

The relationship between the number of 1-wire pulse rising edge and flash LED current and flash timeout is shown in below table:.

Pulse	EN Waveform	Flash Timeout	Flash Current
1		220ms	100%*I_{FLASH}
2			90%*I_{FLASH}
3			80%*I_{FLASH}
4			70%*I_{FLASH}
5	.....		60%*I_{FLASH}
6	.....		50%*I_{FLASH}
7	.....		40%*I_{FLASH}
8	.....		30%*I_{FLASH}
9	.....	1.3s	100%*I_{FLASH}
10	.....		90%*I_{FLASH}
11	.....		80%*I_{FLASH}
12	.....		70%*I_{FLASH}
13	.....		60%*I_{FLASH}
14	.....		50%*I_{FLASH}
15	.....		40%*I_{FLASH}
16	.....		30%*I_{FLASH}

1-wire pulse timing sequence is shown(take 80%*I_{FLASH}/220ms for example) :



PWM Dimming(Torch)

Dimming control can be achieved by applying a PWM control signal to the Flash pin. In this condition, the BCT3142 switches between FLASH mode and TORCH mode. For BCT3142, the dimming frequency is recommended between 20kHz to 50kHz. The relationship between the output current IOUT and the duty cycle of PWM signal D is written as below:

$$I_{TORCH\_PWM}=I_{FLASH}*D+I_{TORCH}*(1-D)$$

In which I_{FLASH} is output current setting for FLASH mode and I_{TORCH} is output current setting for TORCH mode.

FUNCTIONAL DESCRIPTION

Over-temperature Protection

When the temperature of BCT3142 rises above 135℃, the BCT3142 begins to reduce the output current, and when the temperature rises above 147℃, the over temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 125℃, the part automatically recovers and executes a soft start cycle.

Over-voltage Protection

The BCT3142 has over voltage protection. If the output voltage rises above the 5.5V threshold, the over voltage protection shuts off all of the output switches to prevent the output voltage from rising further. When the output decreases below 5.3V, the device resumes normal operation.

Short-current Protection

When The V_{OUT} Pin shorted to GND, Which makes the V_{OUT} falls below to 1V, the device stops switching and operates as a current source limiting the output current to 70mA.

Component Selection

The BCT3142 charge pump circuit requires 3 capacitors: 10μF input, 4.7μF output and 1μF flying capacitors are typically recommended. For the input capacitor, a larger value of 10μF will help reduce input voltage ripple for applications sensitive to ripple on the battery voltage. All the capacitors should be surface mount ceramic for low lead inductance necessary at the 1.9MHz switching frequency of the BCT3142 and to obtain low ESR, which improves bypassing on the input and output and improves output voltage drive by reducing output resistance. Ceramic capacitors with X5R or X7R temperature grade are recommended for most applications.

The input and output capacitors should be located as close to the VIN and VOUT pins as possible to obtain best bypassing, and the returns should be connected directly to the PGND pin or to the thermal pad ground located under the BCT3142. The flying capacitor should be located as close to the C1 and C2 pins as possible.

To obtain lower output ripple, the C_{OUT} value can be increased from 1μF to 2.2μF or 4.7μF with a corresponding decrease in output ripple. For output currents of 500mA to 700mA, the recommended C_F flying capacitor value of 1μF should be used. Output currents in Flash of 100mA to 400mA can use a 0.47μF C_F but a minimum 1μF C_{OUT} is still needed.

FUNCTIONAL DESCRIPTION

Resister Selection

The sense resistor R_{SENSE} is determined by the value needed in the Torch mode for the desired output current by the equation:

$R_{SENSE} = V_{FB} / I_{TORCH}$ where V_{FB} = 47mV (Torch Mode)

Once the R_{SENSE} resistor has been selected for Torch mode, the V_{FB} voltage can be selected for Flash mode using the following equation:

$V_{FB} = I_{FLASH} \times R_{SENSE}$ (Flash Mode) where I_{FLASH} is for Flash Mode.

Next, the R_{SET} resistor can be selected for Flash mode using the following equation:

$R_{SET} = (1.26V / V_{FB}) \times 10.5K\Omega$ (Flash Mode)

For an example of 190mA Torch mode and 650mA Flash mode, the values R_{SENSE} = 0.25Ω, V_{FB} = 162mV (Flash Mode), and R_{SET} = 81.6KΩ are calculated. The power obtained in the Flash mode would be:

$P_{FLASH} = V_{FB} \times I_{OUT}$ = 162mV × 650mA = 105mW.

The typical 0603 surface mount resistor is rated 1/10 Watt continuous power and 1/5 Watt pulsed power, more than enough for this application. For other applications, the P_{FLASH} power can be calculated and resistor size selected. The R_{SENSE} resistor is recommended to be size 0603 for most applications.

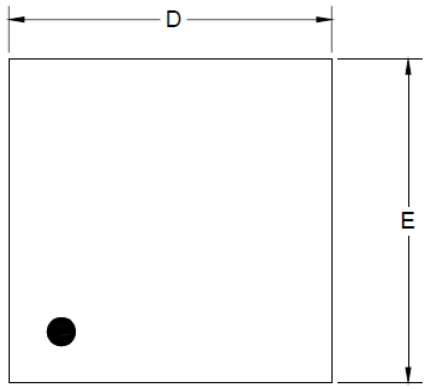
The range of typical resistor values and sizes are shown here in Table

Resistor values and sizes

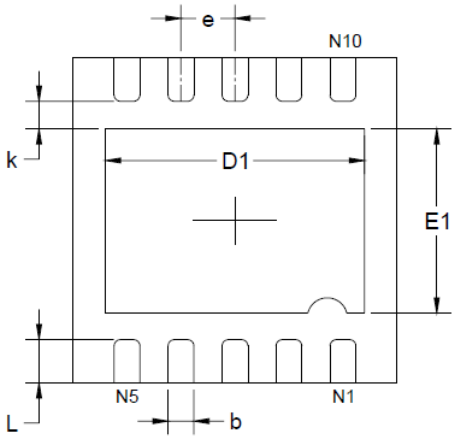
PART REFERENCE	VALUE	TOLERANCE	SIZE	MANUFACTURERS
R_{SET}	47 KΩ	1%	0402	ANY
R_{SET}	51 KΩ	1%	0402	ANY
R_{SET}	56KΩ	1%	0402	ANY
R_{SET}	62KΩ	1%	0402	ANY
R_{SET}	68KΩ	1%	0402	ANY
R_{SET}	75KΩ	1%	0402	ANY
R_{SET}	82KΩ	1%	0402	ANY
R_{SET}	91KΩ	1%	0402	ANY
R_{SET}	100KΩ	1%	0402	ANY
R_{SET}	110KΩ	1%	0402	ANY
R_{SET}	120KΩ	1%	0402	ANY
R_{SET}	130KΩ	1%	0402	ANY
R_{SET}	140KΩ	1%	0402	ANY
R_{SET}	150KΩ	1%	0402	ANY
R_{SENSE}	0.22Ω	1%	0603	Panasonic or Vishay
R_{SENSE}	0.27Ω	1%	0603	Panasonic or Vishay
R_{SENSE}	0.22Ω	1%	0603	Panasonic or Vishay
R_{SENSE}	0.33Ω	1%	0603	Panasonic or Vishay
R_{SENSE}	0.39Ω	1%	0603	Panasonic or Vishay
R_{SENSE}	0.47Ω	1%	0603	Panasonic or Vishay

PACKAGE OUTLINE DIMENSIONS

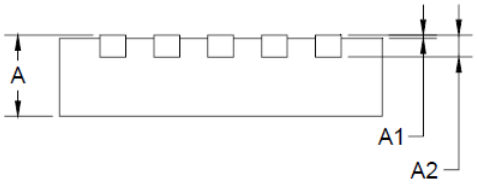
DFN3x3-10L



TOP VIEW



BOTTOM VIEW



SIDE VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.300	2.500	0.091	0.098
E	2.900	3.100	0.114	0.122
E1	1.600	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020