LED Drivers for LCD Backlights

Backlight LED Driver for Small LCD Panels (Charge Pump Type)

Pb Free ROHM Electronic Components RoHS Directive Compliance

BD1601MUV

No.11040EBT22

●Description

The multi-level brightness control white LED driver not only ensures efficient boost by automatically changing the boost rate but also works as a constant current driver in 64 steps, so that the driving current can be adjusted finely. This IC is best suited to turn on white LEDs that require high-accuracy LED brightness control.

●Features

1) Built-in parallel LED driver for 4 to 6 lamps.
2) 64-step LED current adjust function.
3) Inter-LED relative current accuracy: 3% or less
4) Lighting/dimming control via a single-line digital control interface.
5) Automatic transition charge pump type DC/DC converter (×1,×1.5 and ×2).
6) High efficiency achieved (90% or more at maximum).
7) Various protection functions such as output voltage protection, over current limiter and thermal shutdown circuit are mounted.
8) Small QFN package.

●Applications

This driver is applicable for various fields such as mobile phones, portable game machines and white goods.

●Absolute Maximum Ratings

(Ta=25℃)

Parameter	Symbol	Ratings	Unit
Power supply voltage	VMAX	7	V
Operating temperature range	Topr	-30 ~ +85	℃
Storage temperature range	Tstg	-55 ~ +150	℃
Power dissipation	Pd	700 (*1)	mW

(*1) When a glass epoxy substrate (70mm × 70mm × 1.6mm) has been mounted, this loss will decrease 5.6mW/℃ if Ta is higher than or equal to 25℃.

●Operating Conditions

(Ta = -30 ~ 85℃)

Parameter	Symbol	Ratings	Unit
Operating power supply voltage	VCC	2.7~5.5	V

●Electrical Characteristics

Unless otherwise noted, Ta = +25℃, VBAT=3.6V

Parameter	Symbol	Limits			Units	Condition
		Min.	Typ.	Max.		
Overall						
Input voltage range	V_{in}	2.7	3.6	5.5	V	VBAT terminal
Quiescent Current	I_q	-	0.1	1	μA	EN=0V
Current Consumption1	I_{dd1}	-	1.0	2.4	mA	x1.0 Mode, Except LED current
Current Consumption2	I_{dd2}	-	2.5	3.5	mA	x2.0 Mode, Except LED current
Charge Pump						
Oscillator frequency	f_{OSC}	0.8	1.0	1.2	MHz	
Current Source						
LED maximum current	$I_{LED-max}$	28.5	30	31.5	mA	
LED current accuracy	$I_{LED-diff}$	-	-	5.0	%	When LED current 15.5mA setting and LED terminal voltage 1.0V
LED current matching (*1)	$I_{LED-match}$	-	0.5	3.0	%	When LED current 15.5mA setting and LED terminal voltage 1.0V
LED control voltage	V_{LED}	-	0.2	0.25	V	minimum voltage at LED1~LED4 pins
Logic control terminal						
Low threshold voltage	V_{IL}	-	-	0.4	V	
High threshold voltage	V_{IH}	1.4	-	-	V	
High level Input current	I_{IH}	-	0.1	2	μA	EN=V_{in}
Low level Input current	I_{IL}	-2	-0.1	-	μA	EN=0V
Minimum EN High time	T_{HI}	50	-	-	nsec	
Minimum EN Low time	T_{LO}	0.05	-	100	μsec	
EN Off Timeout	T_{OFF}	-	512	640	μsec	

(*1) The following expression is used for calculation:

$I_{LED-match}$={(Imax-Imin)/(Imax+Imin)} × 100

Imax= Current value in a channel with the maximum current value among all channels

Imin=Current value in a channel with the minimum current value among all channels

●Block Diagram

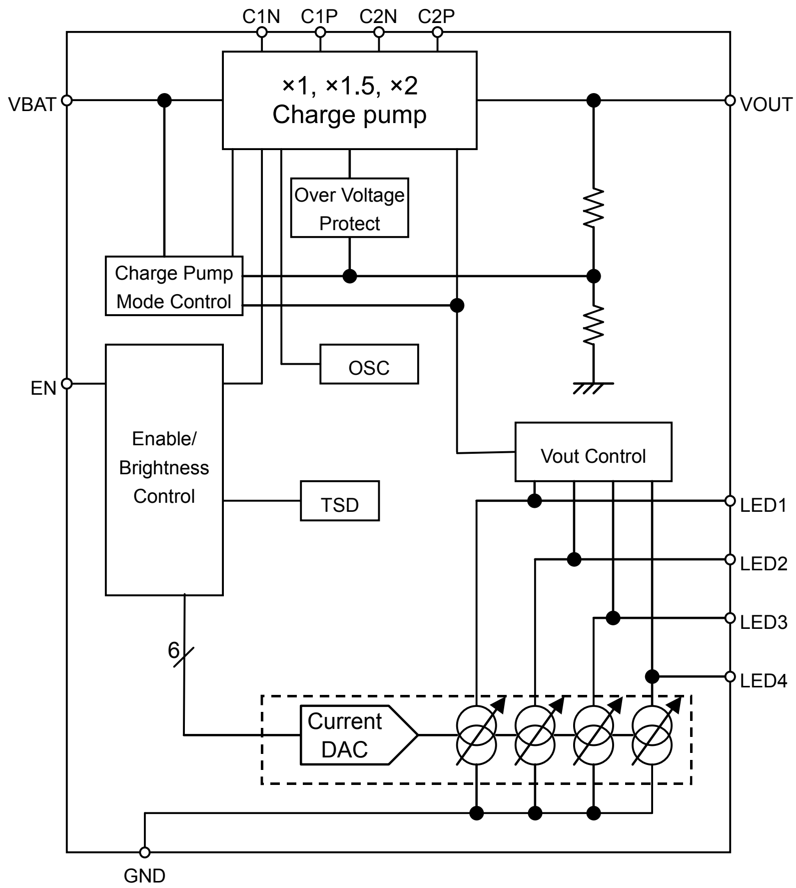


Fig.1 Block Diagram

●Pin Configuration

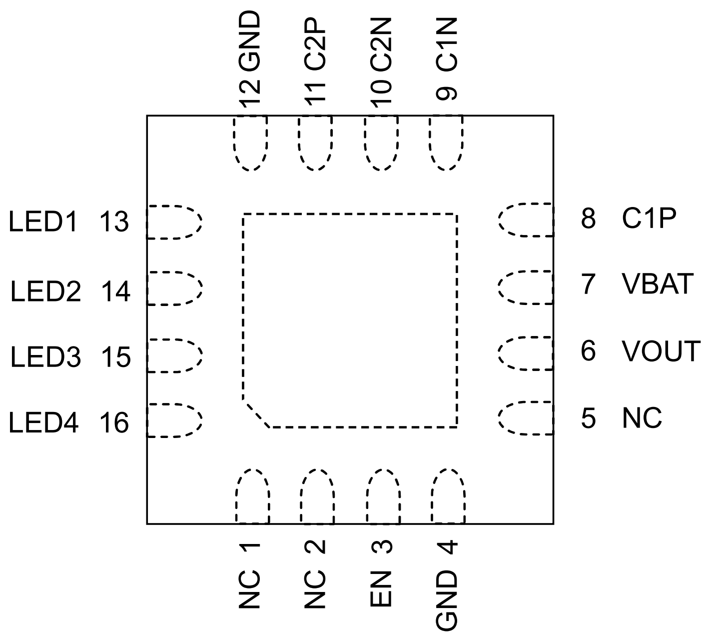


Fig. 2 Pin Configuration

●Pin Descriptions

Pin No.	Pin name	In/Out	Type	Function
1	NC	-	-	No connect
2	NC	-	-	No connect
3	EN	In	C	ON/OFF and dimming control
4	GND	-	D	GND
5	NC	-	-	No connect
6	VOUT	Out	A	Charge pump output
7	VBAT	-	A	Power supply
8	C1P	In/Out	A	Flying capacitor pin positive (+) side
9	C1N	In/Out	B	Flying capacitor pin negative (-) side
10	C2N	In/Out	B	Flying capacitor pin negative (-) side
11	C2P	In/Out	A	Flying capacitor pin positive (+) side
12	GND	-	D	GND
13	LED1	Out	-	LED current driver output 1
14	LED2	Out	B	LED current driver output 2
15	LED3	Out	B	LED current driver output 3
16	LED4	Out	B	LED current driver output 4

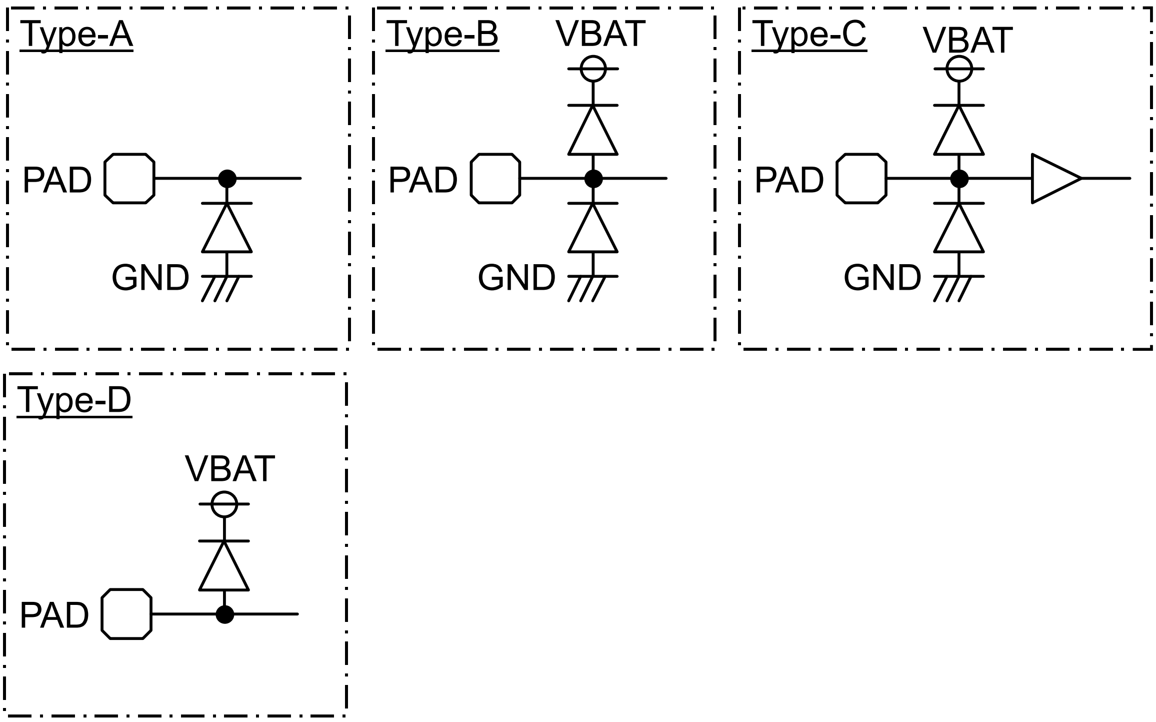


Fig.3 Equivalent circuit diagram for ESD

●Typical Application Circuit

White LED Application(Recommended)

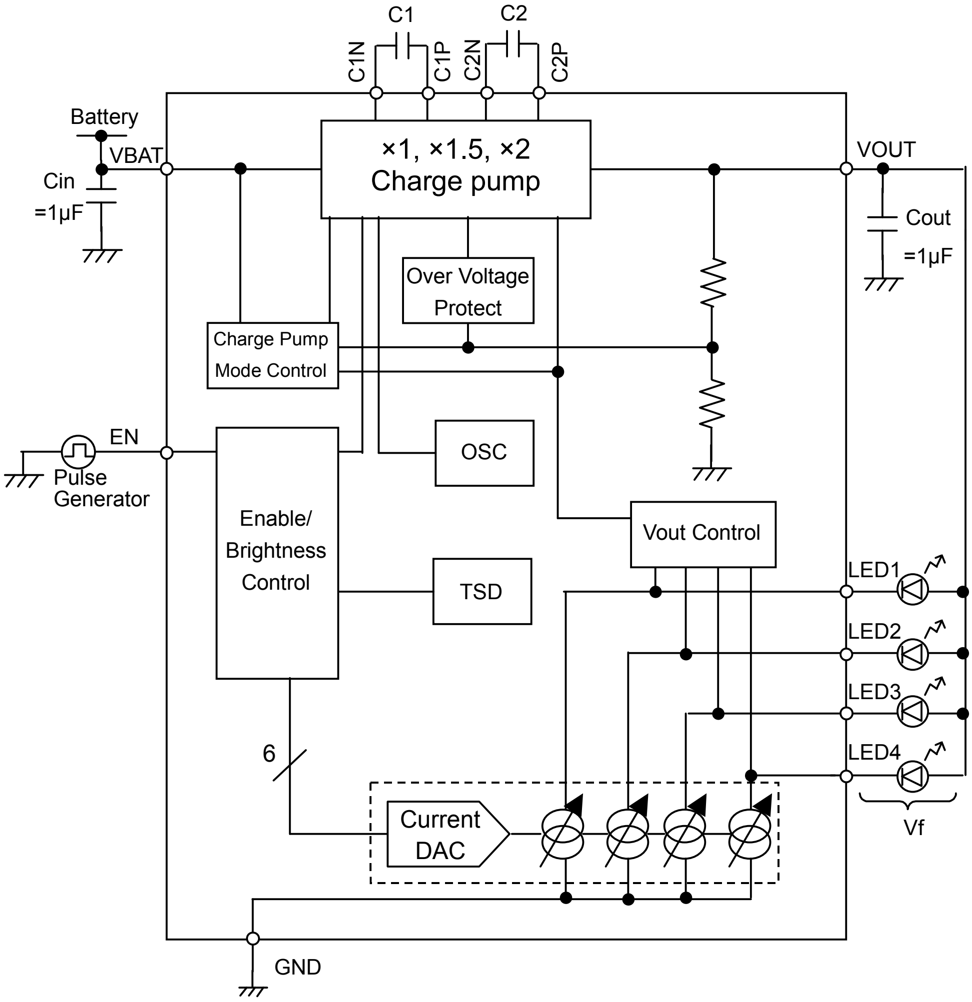


Fig. 4 Block Diagram and Recommended Circuit Example.

●Reference Data

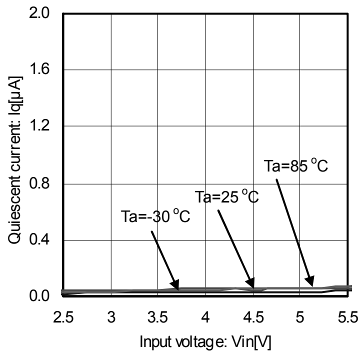


Fig.5 Circuit Current
(Standby)

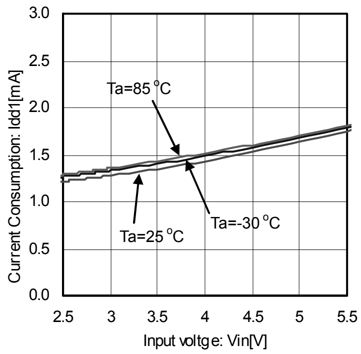


Fig.6 Circuit Current
(operation in × 1.0Mode)

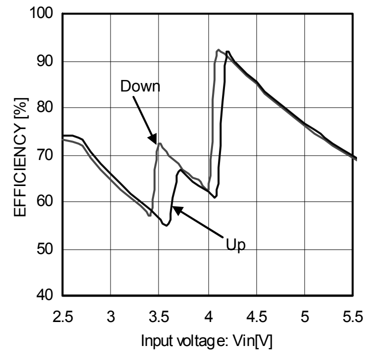


Fig.7 Efficiency
(20mA × 4Lights)

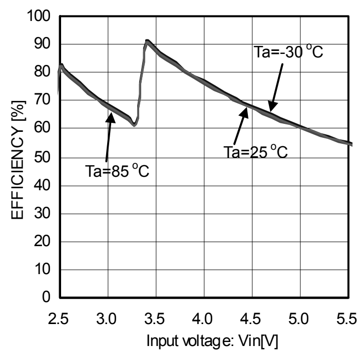


Fig.8 Efficiency
(5mA × 4Lights)

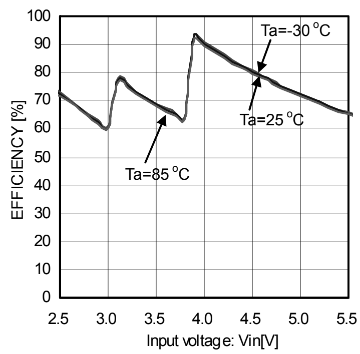


Fig.9 Efficiency
(15mA × 4 Lights)

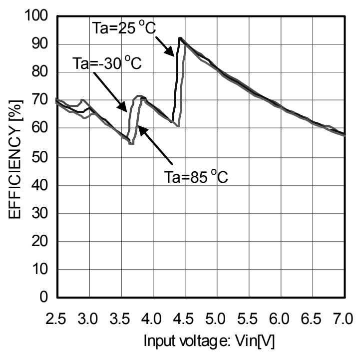


Fig.10 Efficiency
(30mA × 4Lights

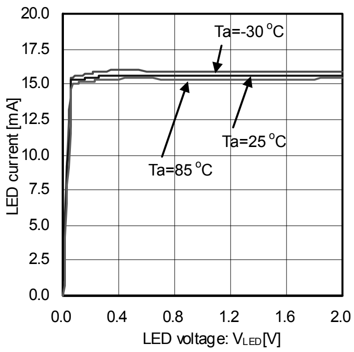


Fig.11 LED Current Characteristics
(LED current 15.5mA)

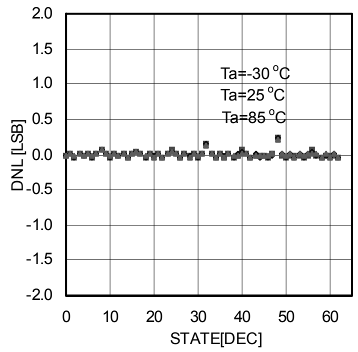


Fig.12 LED Current Characteristics
(Differential Linearity error)

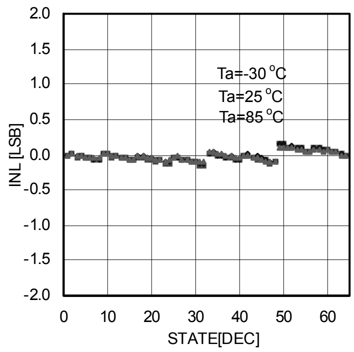


Fig.13 LED Current Characteristics
(Integral Linearity Error)

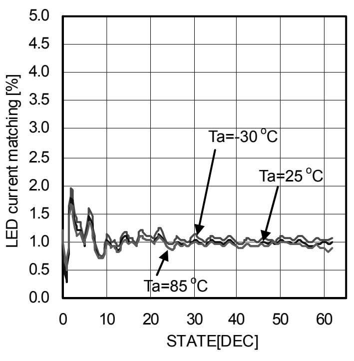


Fig.14 LED current matching

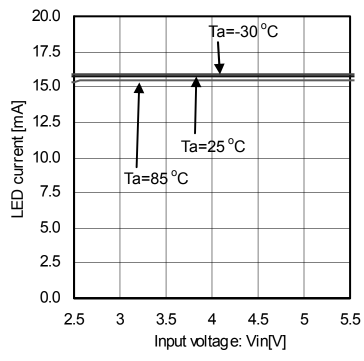


Fig.15 LED Current – Input voltage
(LED current 15.5mA)

●Function Description

(1) LED driver

▪ UPIC interface

BD1601MUV is a single line digital interface control (Uni-port Interface Control=UPIC) that can control the power ON/OFF and LED current value through the EN pin only. The LED current increments by about 0.5mA depending on the number of leading edges. When the number of leading edge is added at the maximum output current of 30mA (64 leading edges), the current is almost equal to 0.5mA at startup time. To maintain any output current, the EN pin must be kept at “H” level. To power off, the EN pin must be kept at “L” level for more than 640µsec.

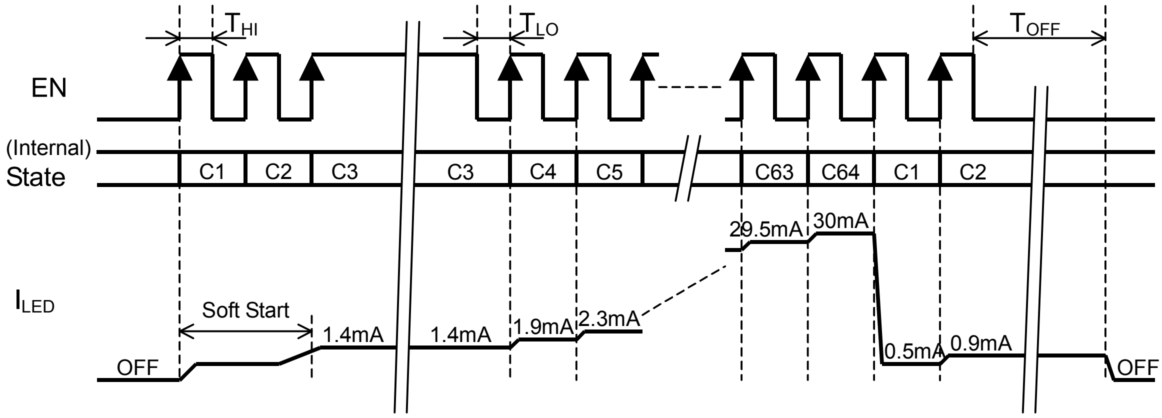


Fig.16 Brightness Control Method

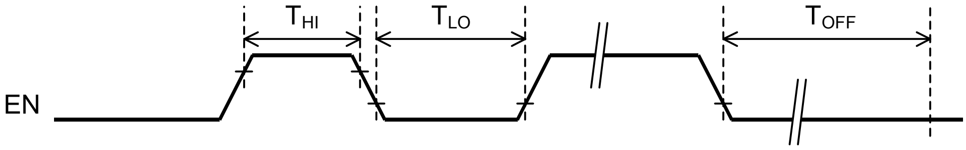


Fig.17 UPIC Interface

▪ LED current level

The LED current state can be changed by the EN control signal. When the current level is Cn, the basic LED current (ILED) can be obtained from the following expression (where, n indicates a state number).

$I_{LED} = 30 / 64 \times n$ [mA]

State	Output current [mA]]	State	Output current [mA]	State	Output current [mA]	State	Output current [mA]
C1	0.5	C14	8.0	C33	15.5	C49	23.0
C2	0.9	C18	8.4	C34	15.9	C50	23.4
C3	1.4	C19	8.9	C35	16.4	C51	23.9
C4	1.9	C20	9.4	C36	16.9	C52	24.4
C5	2.3	C21	9.8	C37	17.3	C53	24.8
C6	2.8	C22	10.3	C38	17.8	C54	25.3
C7	3.3	C23	10.8	C39	18.3	C55	25.8
C8	3.8	C24	11.3	C40	18.8	C56	26.3
C9	4.2	C25	11.7	C41	19.2	C57	26.7
C10	4.7	C26	12.2	C42	19.7	C58	27.2
C11	5.2	C27	12.7	C43	20.2	C59	27.7
C12	5.6	C28	13.1	C44	20.6	C60	28.1
C13	6.1	C29	13.6	C45	21.1	C61	28.6
C14	6.6	C30	14.1	C46	21.6	C62	29.1
C15	7.0	C31	14.5	C47	22.0	C63	29.5
C16	7.5	C32	15.0	C48	22.5	C64	30.0

(2) Charge pump

a) Description of operations

Pin voltage comparison takes place at Vout control section, and then Vout generaton takes place so that the LED cathode voltage with the highest Vf is set to 0.2V. A boost rate is changed automatically to a proper one at the Charge Pump Mode Control section so that operation can take place at possible low boost rate. When the current taken from VBAT exceeds 600mA, the overcurrent limiter is activated and this IC is reset. In addition, if the output voltage falls below 1.5V, this IC is reset for short-circuit at output.

b) Soft start function

BD1601MUV have a soft start function that prevents the rush current.

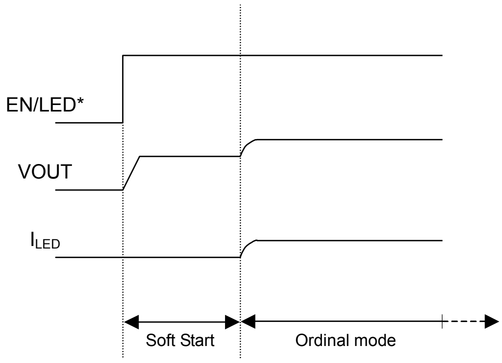


Fig.18 Soft Start

c) Automatic boost rate change

The boost rate automatically switches to the best mode.

*** (×1 mode -> ×1.5 mode) or (×1.5 mode -> ×2 mode)**

If a battery voltage drop occursBD1601MUV cannot maintain the LED constant current, and then mode transition begins.

*** (×1.5 mode -> ×1 mode) or (×2 mode -> ×1.5 mode)**

If a battery voltage rise occurs, VOUT and VBAT detection are activated, and then mode transition begins.

(3) UVLO (Ultra low Voltage Lock Out)

If the input voltage falls below 2.2V, BD1601MUV is shut down to prevent malfunction due to ultra-low voltage.

(4) OVP (Over Voltage Protection)

This circuit protects this IC against damage when the C/P output voltage (VOUT) rises extremely for some external factors.

(5) Thermal shutdown (TSD)

To protect this IC against thermal damage or heat-driven uncontrolled operations, this circuit turns off the output if the chip temperature rises over 175℃. In addition, it turns on the output if the temperature returns to the normal temperature. Because the built-in thermal protection circuit is intended to protect the IC itself, the thermal shutdown detection temperature must be set to below 175℃ in thermal design.

(6) Power sequence

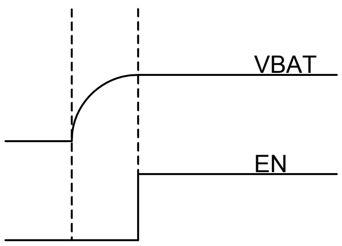


Fig.19 Power sequence

●Application Circuit Example

White LED Application(VOUT not used)

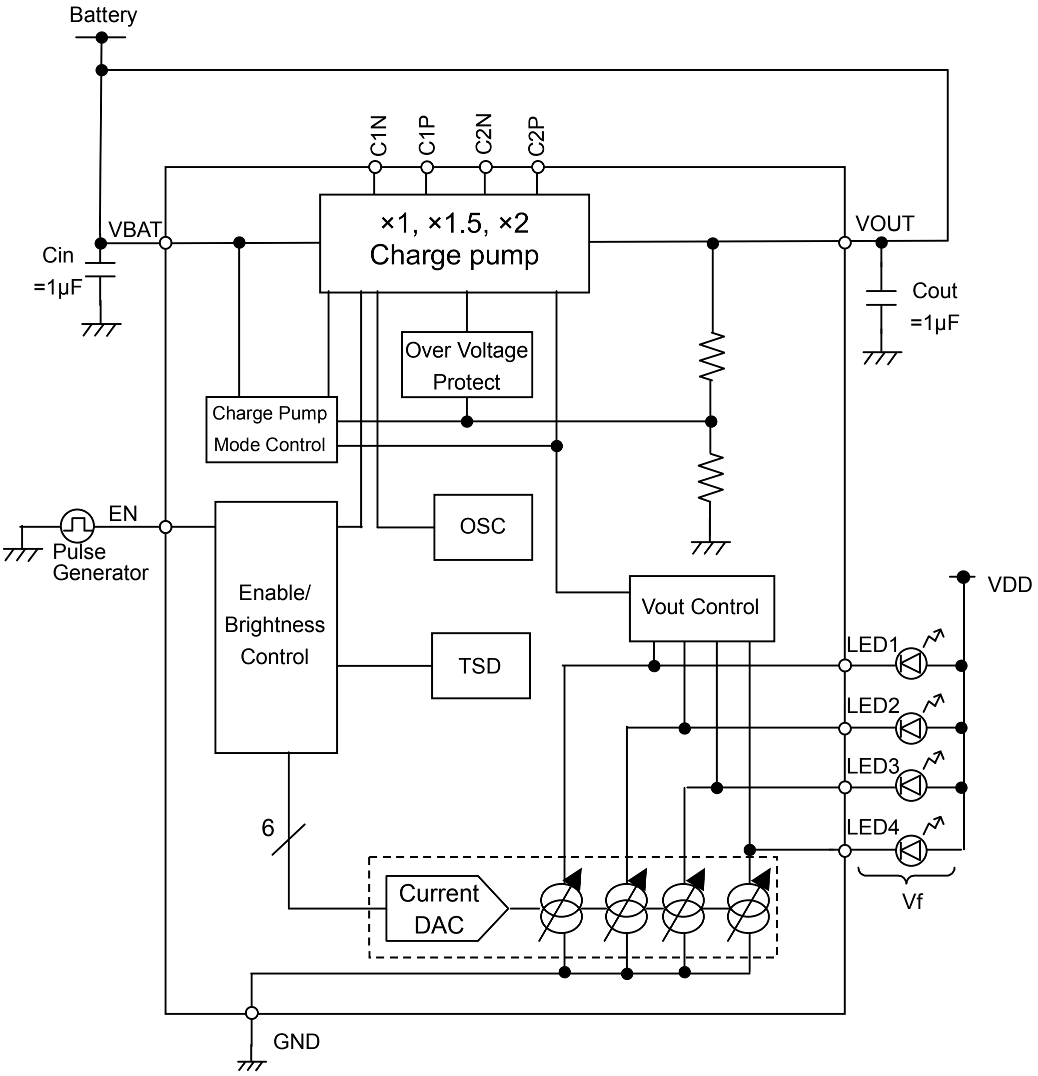


Fig. 20 Block Diagram and Circuit Example

●Application Parts Selection Method

Capacitor (Use a ceramics capacitor with good frequency and temperature characteristics.)

Symbol	Recommended value	Recommended parts	Type
Cout,Cin,C1,C2	1μF	GRM188B11A105KA61B(MURATA)	Ceramics capacitor

Connect an input bypass capacitor Cin between VBAT and GND pin and an output capacitor Cout between VOUT and GND pin in proximity. Place both C1P-C1N and C2P-C2N capacitors in proximity to the chip. Furthermore, select a ceramics capacitor with a sufficient rating for voltage to be applied.

When the parts not listed above are used, the equivalent parts must be used.

●Recommended PCB Layout

In PCB design, wire the power supply line in a way that the PCB impedance goes low and provide a bypass capacitor if needed.

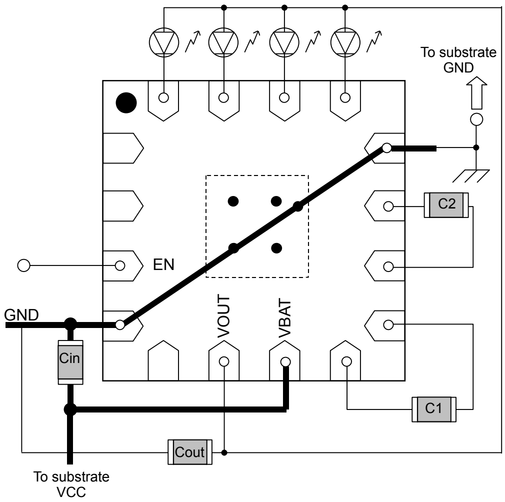


Fig.21 Application Layout Image (Top View)

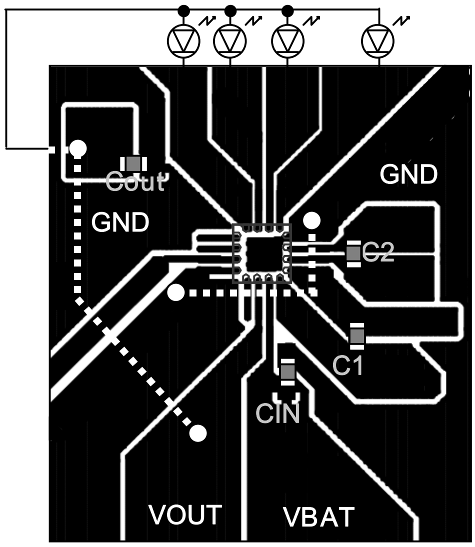


Fig.22 BD1601MUV Front (Top View)

●Notes for use

(1) Absolute Maximum Ratings
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given to take physical safety measures including the use of fuses, etc.

(2) Operating conditions
These conditions represent a range within which characteristics can be provided approximately as expected. The electrical characteristics are guaranteed under the conditions of each parameter.

(3) Reverse connection of power supply connector
The reverse connection of power supply connector can break down ICs. Take protective measures against the breakdown due to the reverse connection, such as mounting an external diode between the power supply and the IC's power supply terminal.

(4) Power supply line
Design PCB pattern to provide low impedance for the wiring between the power supply and the GND lines. Furthermore, for all power supply terminals to ICs, mount a capacitor between the power supply and the GND terminal. At the same time, in order to use an electrolytic capacitor, thoroughly check to be sure the characteristics of the capacitor to be used present no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.

(5) GND voltage
Make setting of the potential of the GND terminal so that it will be maintained at the minimum in any operating state.
Furthermore, check to be sure no terminals are at a potential lower than the GND voltage including an actual electric transient.

(6)Short circuit between terminals and erroneous mounting
In order to mount ICs on a set PCB, pay thorough attention to the direction and offset of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign matters entering between terminals or between the terminal and the power supply or the GND terminal, the ICs can break down.

(7) Operation in strong electromagnetic field
Be noted that using ICs in the strong electromagnetic field can malfunction them.

(8) Inspection with set PCB
On the inspection with the set PCB, if a capacitor is connected to a low-impedance IC terminal, the IC can suffer stress. Therefore, be sure to discharge from the set PCB by each process. Furthermore, in order to mount or dismount the set PCB to/from the jig for the inspection process, be sure to turn OFF the power supply and then mount the set PCB to the jig. After the completion of the inspection, be sure to turn OFF the power supply and then dismount it from the jig. In addition, for protection against static electricity, establish a ground for the assembly process and pay thorough attention to the transportation and the storage of the set PCB.

(9) Input terminals
In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input terminal. Therefore, pay thorough attention not to handle the input terminals, such as to apply to the input terminals a voltage lower than the GND respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input terminals when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input terminals a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.

(10) Ground wiring pattern
If small-signal GND and large-current GND are provided, It will be recommended to separate the large-current GND pattern from the small-signal GND pattern and establish a single ground at the reference point of the set PCB so that resistance to the wiring pattern and voltage fluctuations due to a large current will cause no fluctuations in voltages of the small-signal GND. Pay attention not to cause fluctuations in the GND wiring pattern of external parts as well.

(11) External capacitor
In order to use a ceramic capacitor as the external capacitor, determine the constant with consideration given to a degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.

(12) Thermal shutdown circuit (TSD)
When junction temperatures become 175℃ (typ) or higher, the thermal shutdown circuit operates and turns a switch OFF. The thermal shutdown circuit, which is aimed at isolating the LSI from thermal runaway as much as possible, is not aimed at the protection or guarantee of the LSI. Therefore, do not continuously use the LSI with this circuit operating or use the LSI assuming its operation.

(13) Thermal design
Perform thermal design in which there are adequate margins by taking into account the permissible dissipation (Pd) in actual states of use.

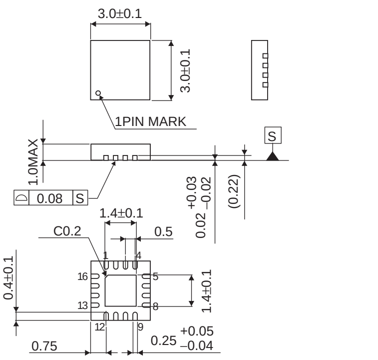
(14) Coil selection
To reduce the loss, select a coil with a small wound resistor for DC/DC converter output.

●Ordering part number

B	D		1	6	0	1		M	U	V	-	E	2

- BD: Part No.
- 1601: Part No.
- MUV: Package — MUV: VQFN016V3030
- E2: Packaging and forming specification — E2: Embossed tape and reel

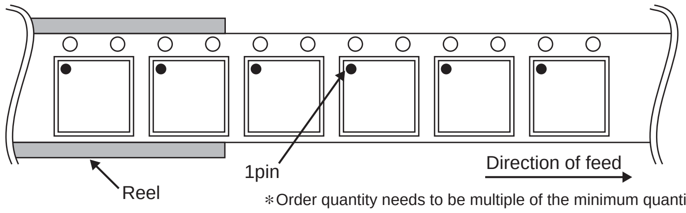
VQFN016V3030



(Unit : mm)

<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



※Order quantity needs to be multiple of the minimum quantity.

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