

# White LED Driver with Synchronous Boost Converter and PWM Brightness Control for up to 4 LEDs in Series



## BD6076GUT

### ●General Description

The BD6076GUT is a white LED driver IC with synchronous rectification that can drive up to 4LEDs. With synchronous rectification (no external schottky diode required) and small package, they can save mount space. And the brightness of LED can be adjusted by using PWM pulse on EN pin.

### ●Features

- Synchronous rectification Boost DC/DC converter
- No external schottky diode required
- Driving 4 series white LEDs
- Internal Load Disconnect SW
- Over voltage protection
- Protect open and short output
- Thermal shut down
- Brightness adjustment by external PWM pulse
- Small and Thin CSP package in 8pins

### ●Key Specifications

- Power supply voltage range: 2.7V to 5.5V
- Switching Frequency: 1.25MHz(Typ.)
- Quiescent Current: 0.1μA(Typ.)
- Operating temperature range: -30°C to +85°C

### ●Package

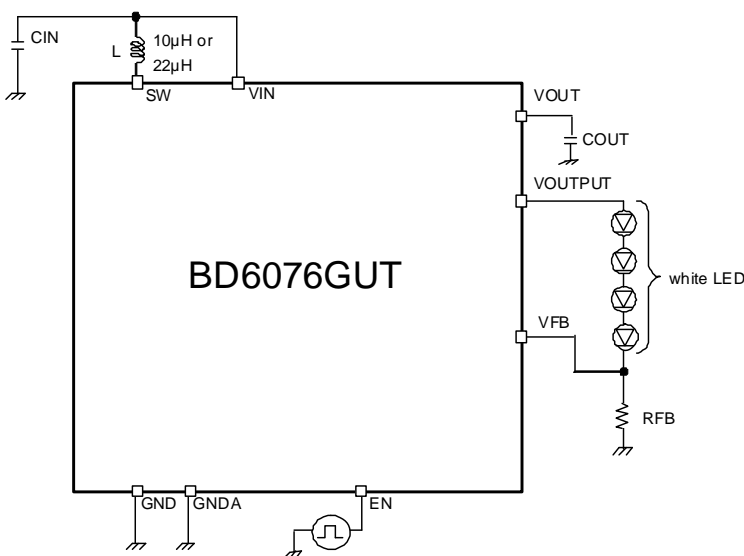
VCSP60N1 W(Typ.) x D(Typ.) x H(Max.)  
1.68mm x 1.68mm x 0.68mm



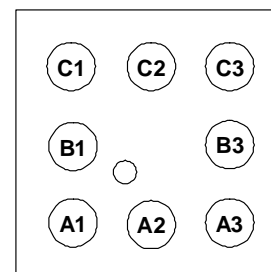
### ●Applications

White LED Backlight  
Torch light and easy flash for camera of mobile phone

### ●Typical Application Circuit



### ●Pin Configuration



<BOTTOM VIEW>

**● Absolute Maximum Ratings (Ta=25°C)**

Parameter	Symbol	Ratings	Unit	Condition
Maximum applied voltage 1	VMAX1	7 * <sup>1</sup>	V	VIN, EN, VFB, TEST pin
Maximum applied voltage 2	VMAX2	20 * <sup>1</sup>	V	SW, VOUT, VOUTPUT pin
Power dissipation	Pd	800 * <sup>2</sup>	mW	
Operating temperature range	Topr	-30 to +85	°C	
Storage temperature range	Tstg	-55 to +150	°C	

\*1 These values are based on GND and GNDA pins.

\*2 50mmx58mmx1.75mm At glass epoxy board mounting. When it's used by more than Ta=25°C, it's reduced by 6.4mW/°C.

**● Recommended Operating Ratings (Ta=-30°C to +85°C)**

Parameter	Symbol	Ratings			Unit	Condition
		Min.	Typ.	Max.		
Power supply voltage	Vin	2.7	3.6	5.5	V	

**● Electrical Characteristics** Unless otherwise specified Ta =-30°C to +85°C, VIN=3.1 to 5.5V

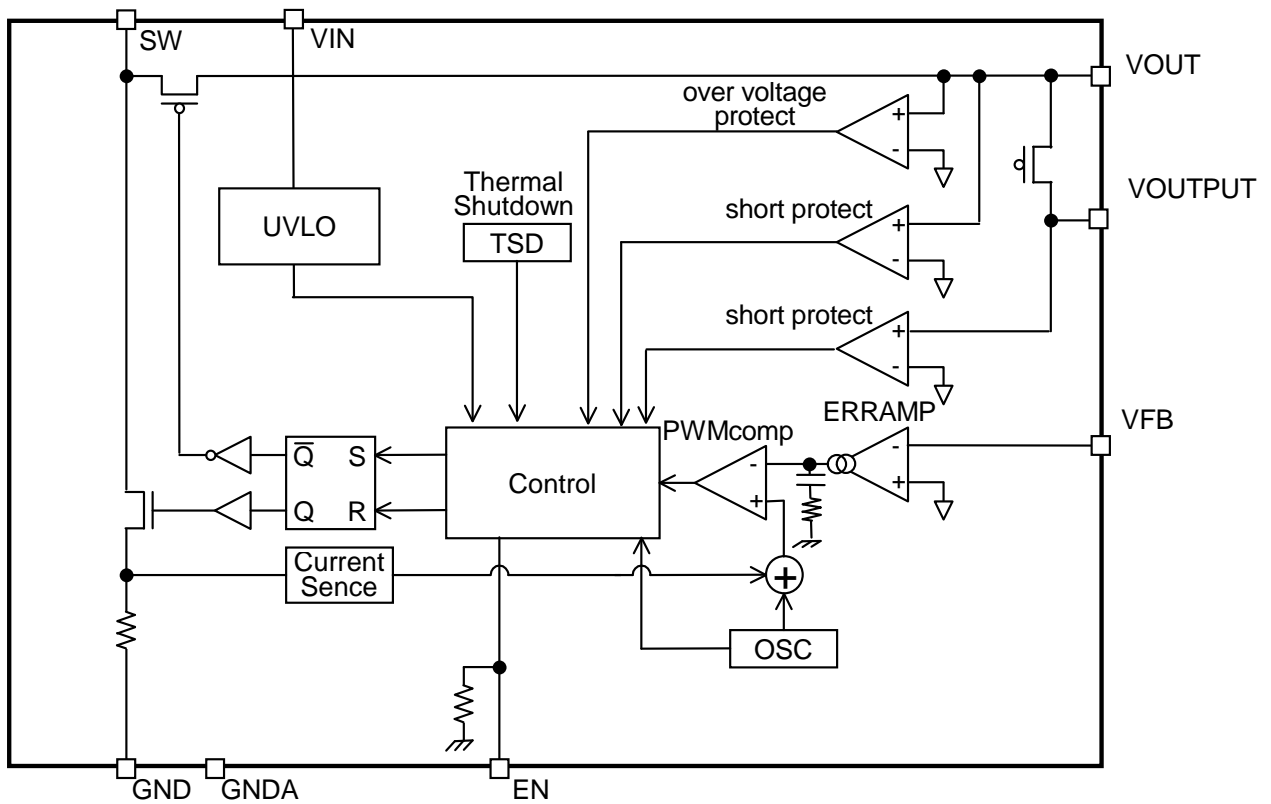
Parameter	Symbol	Limits			Unit	Condition
		Min.	Typ.	Max.		
[ EN terminal ]						
EN threshold voltage (Low)	VthL	-	-	0.4	V	
EN threshold voltage (High)	VthH	1.2	-	-	V	
EN terminal input current	Iin	-	18.3	30.0	μA	EN=5.5V
EN terminal output current	Iout	-2.0	0.0	-	μA	EN=0V
[ Switching regulator ]						
Quiescent Current	Iq	-	0.1	2.0	μA	EN=0V
Current Consumption	Idd	-	1.0	1.5	mA	EN=2.6V, VFB=1.0V, VIN=3.6V
Feedback voltage	Vfb	0.47	0.50	0.53	V	
Inductor current limit	Icoil	310	400	490	mA	VIN=3.6V * <sup>1</sup>
SW saturation voltage	Vsat	-	0.14	0.28	V	Isw=200mA
Vout PMOS resistance	Ronp	-	2.1	3.2	Ω	Ipch=200mA, VOUT=13V
Voutput PMOS resistance	Rpsw	-	1.8	2.0	Ω	Ipsw=20mA, VOUT=13V
Switching frequency	fSW	1.0	1.25	1.5	MHz	
Duty cycle limit	Duty	83.0	91.0	99.0	%	VFB=0V
Output voltage range	Vo	-	-	18.0	V	
Over voltage limit	Ovl	18.0	18.5	19.0	V	VFB=0V
UVLO detect voltage	UVLOD	1.75	-	2.25	V	Falling VIN level

\*1 This parameter is tested with DC measurement.

● Pin Description

PIN Name	In/Out	Ball number	Function
GND	-	A1	Analog GND
EN	In	A2	Enable control (pull down by inner resistor)
VOUTPUT	Out	A3	Switching output
VIN	In	B1	Power supply input
VFB	In	B3	Feedback voltage input
VOUT	Out	C1	VOUT, connected to output capacitor
SW	In	C2	Switching terminal
GND	-	C3	Power GND

● Block Diagram



● Typical Performance Curves

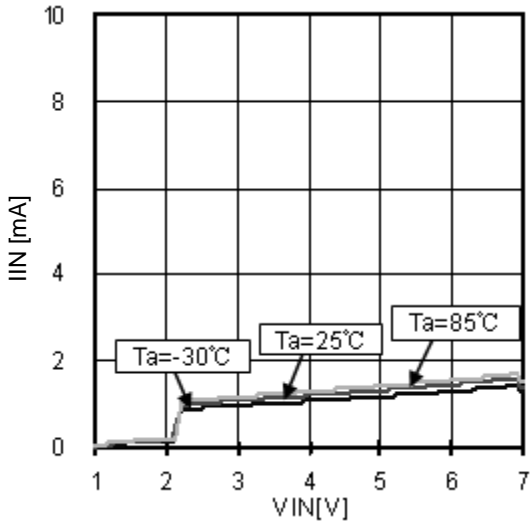


Figure 1. Current consumption vs. Power supply voltage

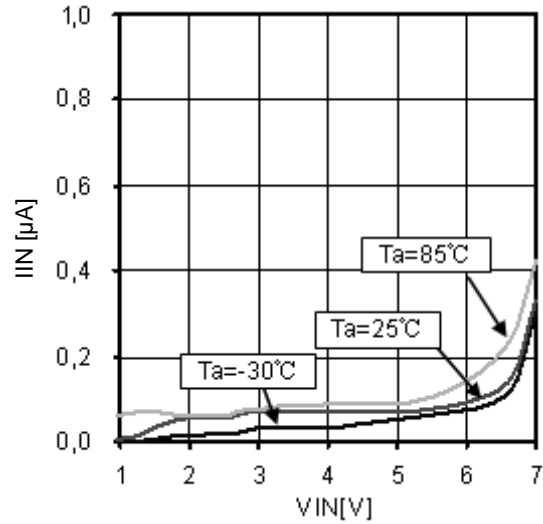


Figure 2. Quiescent current vs. Power supply voltage

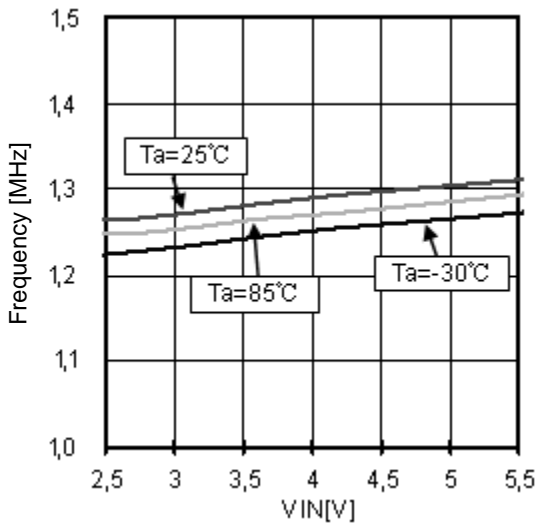


Figure 3. Oscillation frequency vs. Power supply voltage

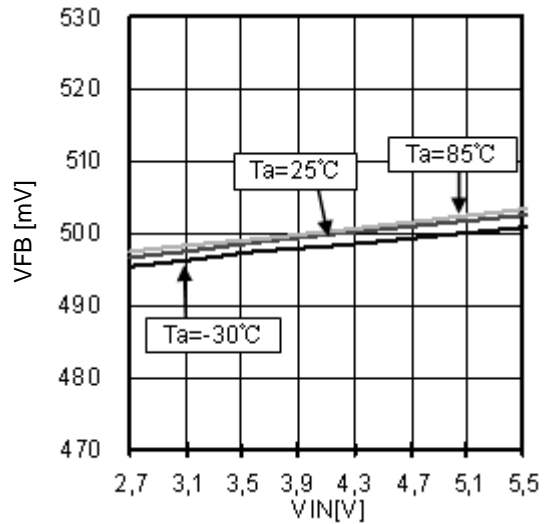


Figure 4. Feedback voltage vs. Power supply voltage

● Typical Performance Curves - continued

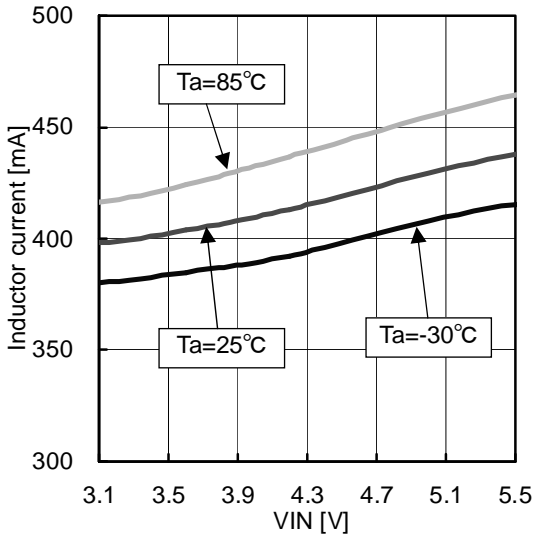


Figure 5. Inductor current limit vs. Power supply voltage

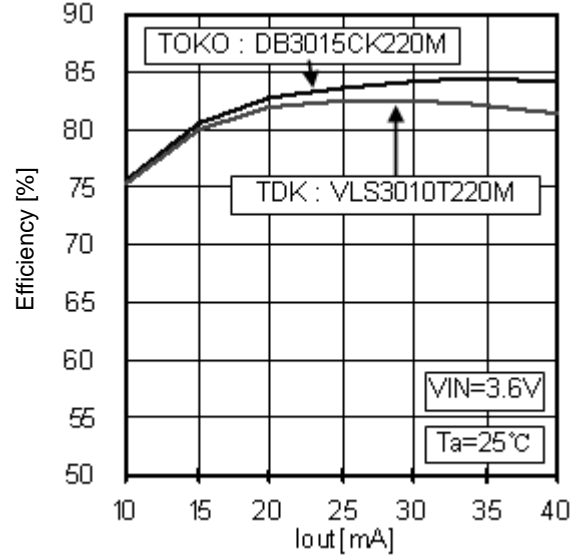


Figure 6. Efficiency vs. LED current (4LED=VOUT13V)

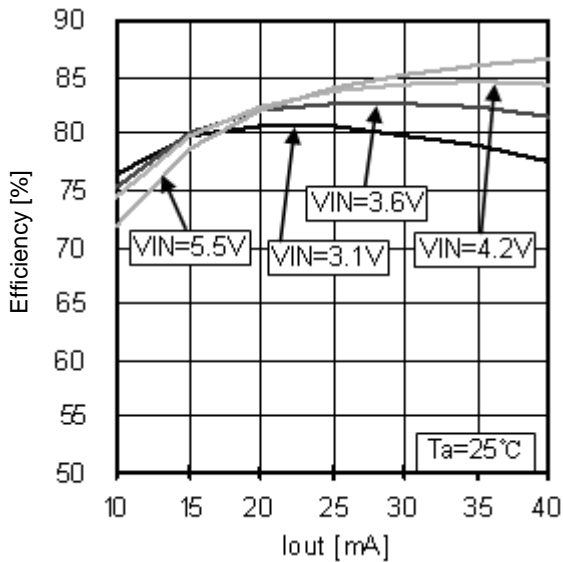


Figure 7. Efficiency vs. LED current (4LED=VOUT13V) coil : TDK VLS3010T220M

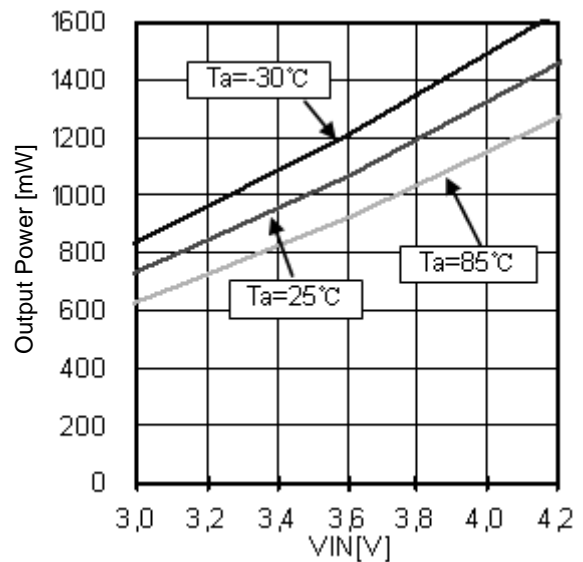


Figure 8. Output power vs. Power supply voltage coil : TDK VLS3010T220M

● Typical Performance Curves - continued

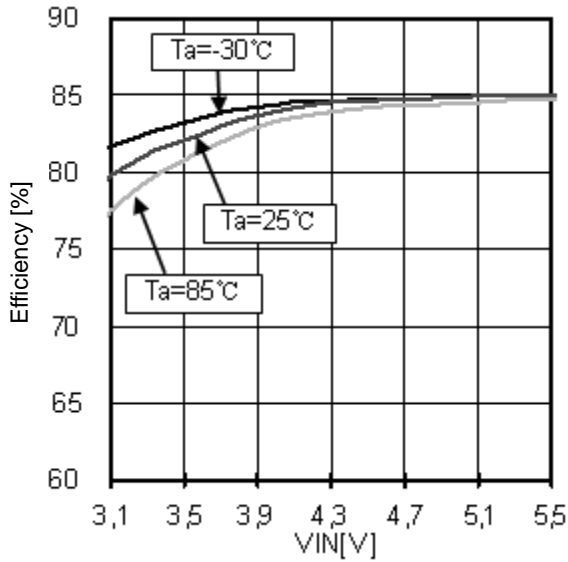


Figure 9. Efficiency vs. power supply voltage coil ; TDK VLS3010T220M

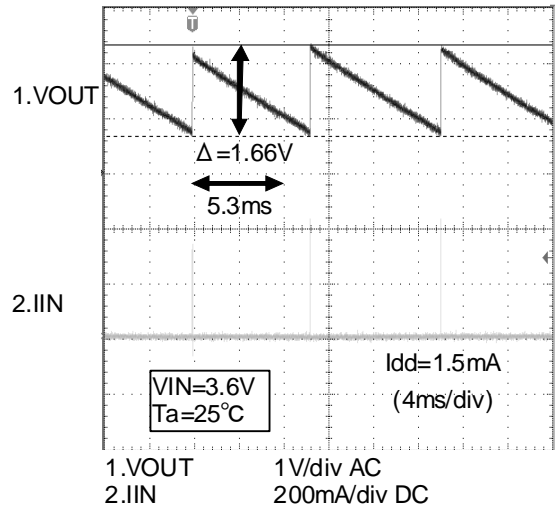


Figure 10. LED Open output voltage

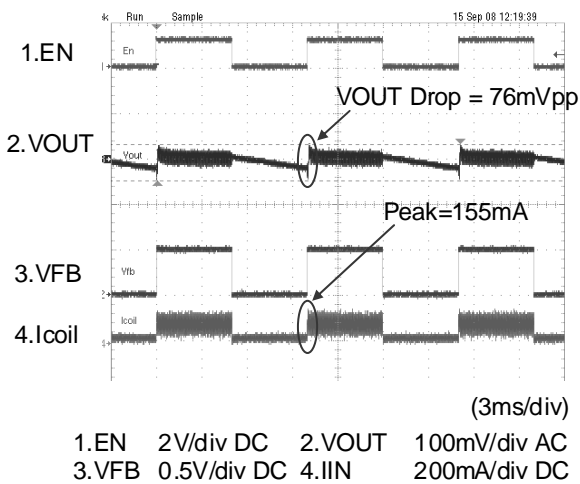


Figure 11. LED brightness adjustment (COUT=4.7μF, ILED=15mA)

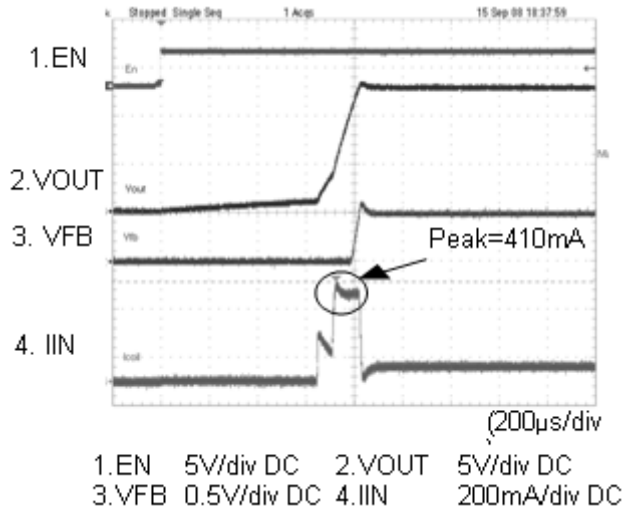


Figure 12. Soft Start (COUT=4.7μF, ILED=15mA)

● Typical Performance Curves - continued

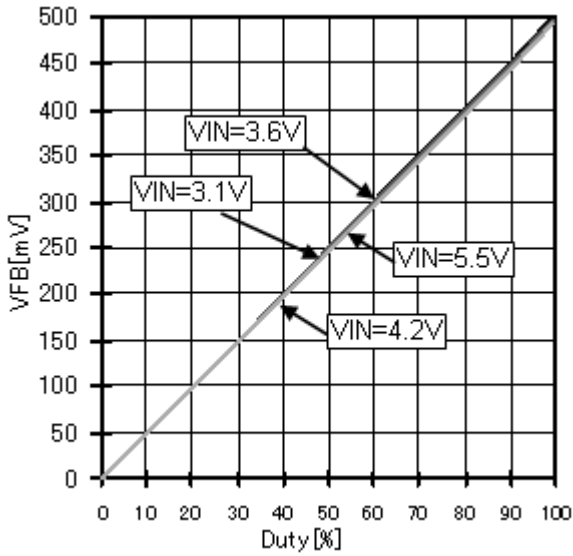


Figure 13. LED brightness adjustment For PWM control

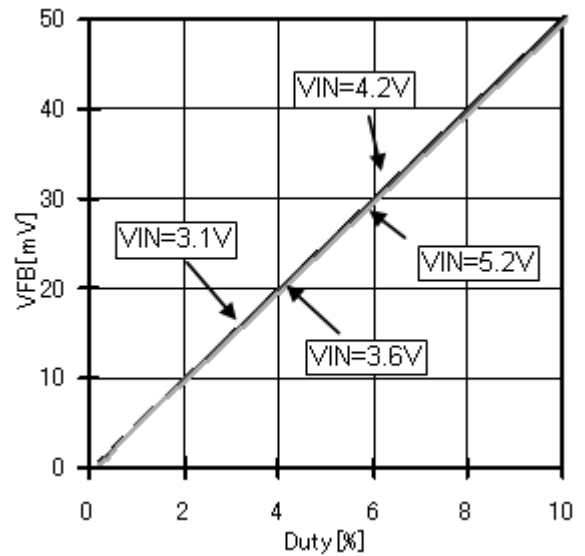


Figure 14. LED brightness adjustment For PWM control (Expansion)

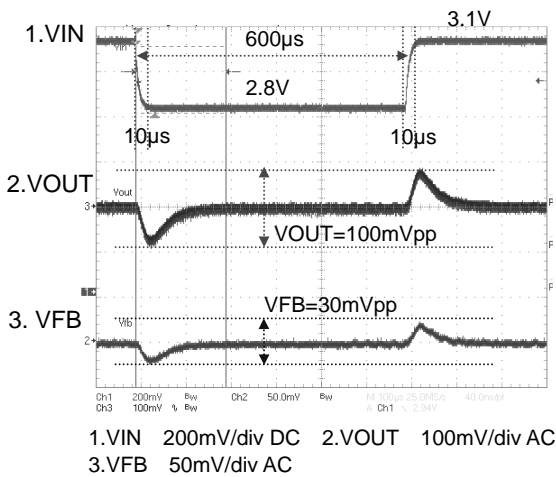


Figure 15. VIN Line Transient (COU<sub>T</sub>=4.7μF, I<sub>LED</sub>=15mA) VIN: 3.1V ⇔ 2.8V

● Test circuit

\*Test circuit A (for Inductor current limit, Feedback voltage.)

Procedure

~Inductor current limit~

1. Start to increase Iout from 0mA gradually.
2. You will find that VOUT will start to go down and the duty will be decreased.
3. Then, you can measure the coil current as "inductor current limit"

~VFB voltage~

1. Supply 0mA to Iout
2. Then, you can measure the VFB voltage as "Feedback voltage".

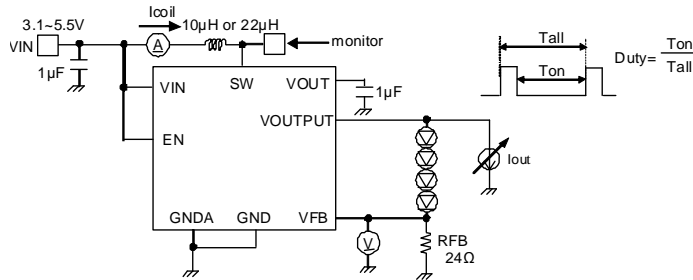


Figure 16. Test Circuit A

\*Test circuit B (for Over voltage limit, Duty cycle limit, Switching frequency)

Procedure

~Over voltage limit~

1. Start to increase VOUT from 9V to 20V
2. You will find frequency change from around 1MHz to 0Hz
3. Then, it is "Over Voltage limit"

~Duty cycle limit, Switching frequency ~

1. Supply 9V to VOUT terminal
2. Then, you can measure the duty as "Duty cycle limit" and the frequency and "Switching frequency".

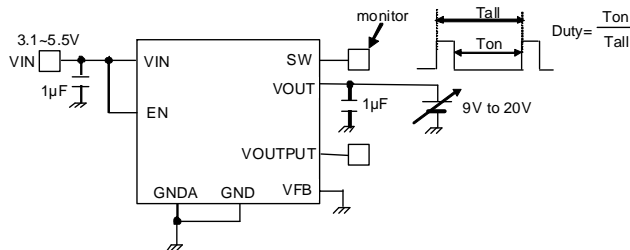


Figure 17. Test Circuit B

\*Test circuit C

(for Quiescent current, current consumption, EN Terminal input/output current, EN threshold voltage(Low/High))

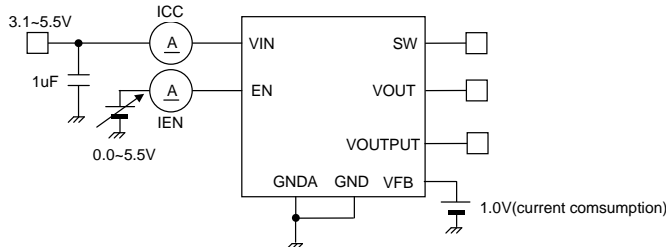


Figure 18. Test Circuit C



● Operation

BD6076GUT is PWM current mode DC/DC converter with fixed frequency. It adopts synchronous rectification architecture. The feature of the PWM current mode is that input is the combination of error components from the error amplifier, and a current sense signal that controls the inductor current into Slope waveform for sub harmonic oscillation prevention. This output controls Q1 and Q2 via the RS latch (Refer to Page 3). Timing of Q1 and Q2 is precisely adjusted so that they will not turn ON at the same time, thus putting them into non-overlapped relation. In the period when Q1 is ON, energy is accumulated in the external inductor, and in the period when Q1 is OFF, energy is transferred to the capacitor of VOUT via Q2. Further more, BD6076GUT has many safety functions, and their detection signals stop switching operation at once.

● Functional descriptions

1) Soft start and off status

BD6076 has soft start function and off status function.

The soft start function and the off status function prevent large current from flowing to the IC via coil.

Occurrence of rush current at turning on is prevented by the soft start function, and occurrence of invalid current at turning off is prevented by the off status function.

As for detailed actions, refer to the block diagram (Figure 19) and the timing chart (Figure 20).

· Soft start

When VOUT is smaller than Vshort, to decrease charge current PMOS is set to off by PMOS Startup Control (in Term "I"). Vshort means "VOUT short detect voltage". After VOUT is bigger than Vshort, PMOS is turned on and start switching. In term "II" ( $V_{short} < V_{OUT} < V_{IN}$ ), status of Current Limiter is "soft mode". So "A" voltage is restricted and "D" duty is kept low. Therefore VOUT voltage goes up slowly and coil current is restricted. In term III ( $V_{OUT} > V_{IN}$ ), status of Current Limiter is "normal mode". So "A" voltage goes up suitable voltage, and "D" duty goes up slowly. And then VOUT voltage goes up to required voltage.

Operation	Max current
Current at start	450mA
Current at PWM	300mA

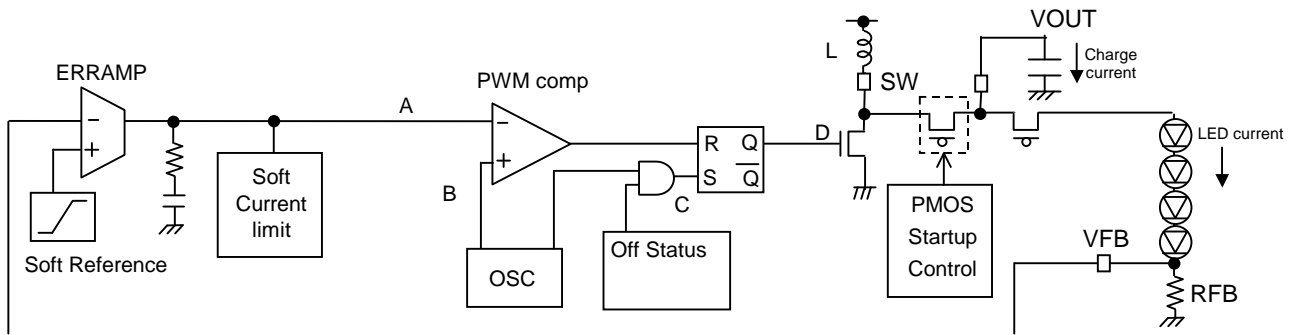


Figure 19. Block diagram of soft start and off status

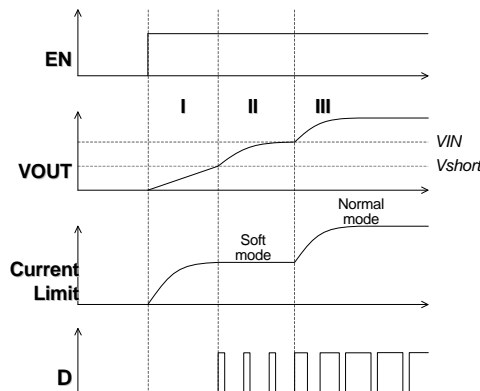


Figure 20. timing chart

· Off status

The gate voltage of the switching Tr either "H" or "L" at power off depends on the operation conditions at that time. When it is fixed to "H", the switching Tr remains to be ON, and invalid current from the battery is consumed. In order to prevent this, at power off, D is always fixed to L level. So that, it is possible to prevent invalid current at power off.

## 2) Isolation control

BD6076GUT has isolation control to prevent LED wrong lighting at power off.

The cause of the LED wrong lighting is leak current from VIN to the white LED.

Therefore, when BD6076GUT powered off (EN = L), the isolation control cuts the DC path between SW and VOUT, so that, it prevents from leak current from VIN to LED.

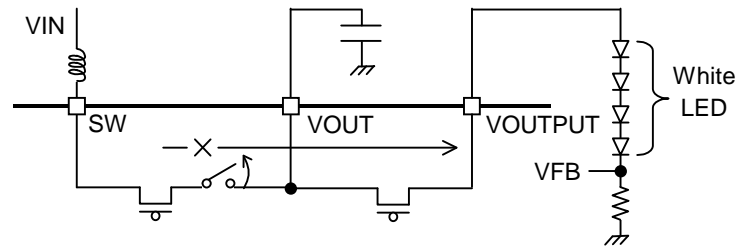


Figure 21. Isolation control

## 3) Short-circuit protection and over voltage protection

BD6076 has short-circuit protection and over voltage protection. These detect the voltage of VOUT, VOUTPUT, and at error, they stop the output Tr. Details are as shown below.

## • Short-circuit protection

In the case of short-circuit of the DC/DC output (VOUT) and switched output (VOUTPUT) to GND, the coil or the IC may be destructed.

Therefore, at such an error as VOUT, VOUTPUT becoming 0.7V or below, the Under Detector shown in the figure works, and turns off the output Tr, and prevents the coil and the IC from being destructed.

And the IC changes from its action condition into its non action condition, and current does not flow to the coil (0mA).

## • Over voltage protection

In a case of error as the IC and the LED being cut off, over voltage causes the SW terminal and the VOUT terminal exceed the absolute maximum ratings, and may destroy the IC. Therefore, when VOUT becomes 18.5V or higher, the over voltage limits works, and turns off the output Tr, and prevents the SW terminal and the VOUT terminal from exceeding the absolute maximum ratings.

At this moment, turns into non operation condition from operation condition, and the output voltage goes down slowly. And, when the output voltage becomes the hysteresis of the over voltage limit or below, the output voltage goes on up to 18.5V once again.

This protection action is shown in Figure 22.

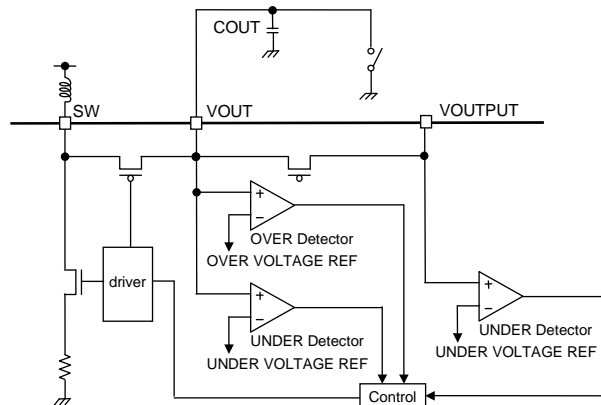


Figure 22. Block diagram of short-circuit protection and over voltage

## 4) Thermal shut down

BD6076GUT has thermal shut down function.

The thermal shut down works at 175°C or higher, and while holding the setting of EN control from the outside, turns into non operation condition from operation condition. And at 175°C or below, the IC gets back to its normal operation.

●Start control and brightness control

BD6076GUT can control the start conditions by its EN terminal, and power off at 0.4V or below, and power on at 1.2V or higher. And by changing the duty of power on and off by PWM control, the LED brightness can be adjusted.

1. PWM brightness adjustment is done by giving PWM signal to EN as shown in Figure 23.

The BD6076GUT is powered on/off by the PWM signal. By this method, LED current is controlled from 0 to the maximum current. The average LED current increases with proportion to the duty cycle of PWM signal. While in PWM off-cycle mode, the IC and LED both consume no currents, thus providing a high-efficiency operation. The recommended PWM frequency is 100Hz to 300Hz.

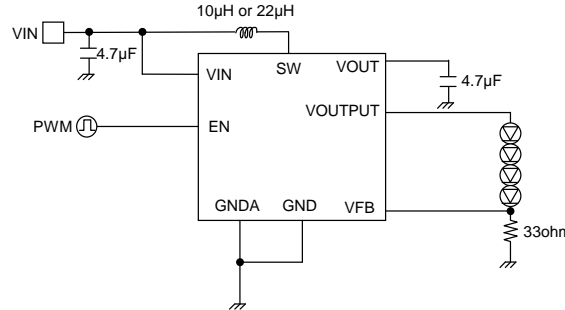


Figure 23. The brightness adjustment example of EN terminal by PWM (fPWM = 100 to 300Hz)

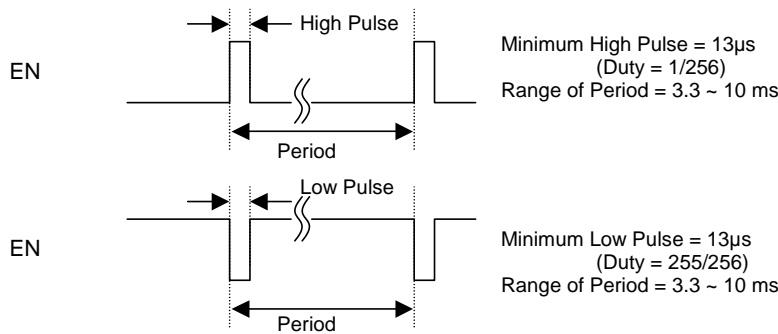


Figure 24. The Rule of PWM signal of EN

●VFB characteristic on PWM function

BD6076GUT constantly controls the rising time to decrease the tolerance of the VFB voltage at PWM function.

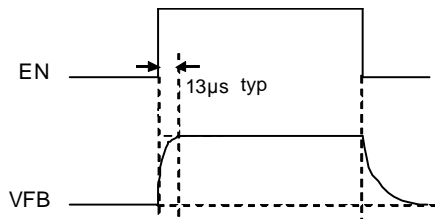


Figure 25. VFB signal at PWM

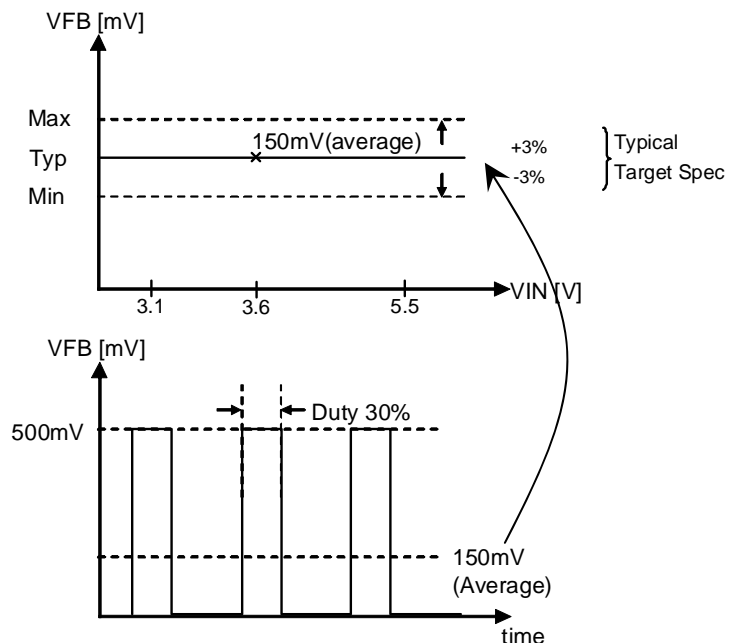


Figure 26. VFB Voltage Line Regulation (PWM Duty=30%)

●VIN characteristic in Battery charge

Transient during Battery charger is normally +300mV, 250Hz(duty 85%) from a baseline Battery Voltage 3.1 to 2.8V. In this term, it is necessary that VOUT Voltage noise is less than 200mVp-p.

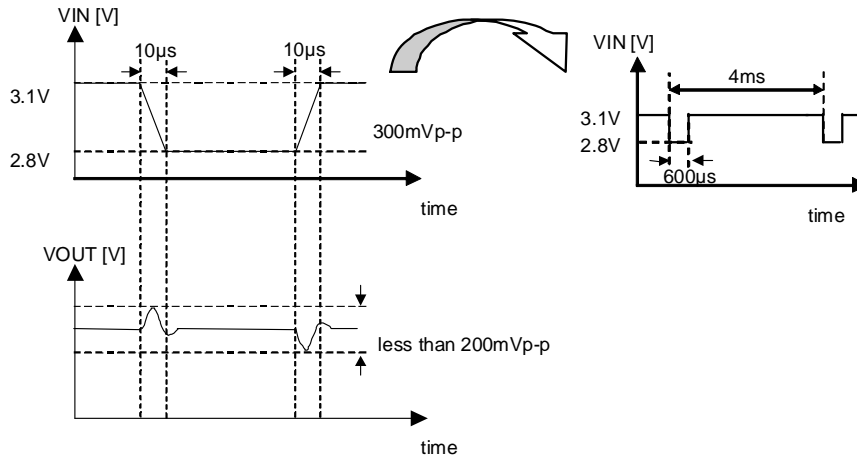


Figure 27. Battery Voltage transient during charger

●Setting range of LED current

LED current is determined by the voltage of VFB and the resistor connected to VFB terminal. ILED is given as shown below.

$$I_{LED} = V_{FB}/R_{FB}$$

The current in the standard application is as shown below.

$$V_{FB}=0.5V, R_{FB}=33\Omega$$

$$I_{LED}=15.2mA$$

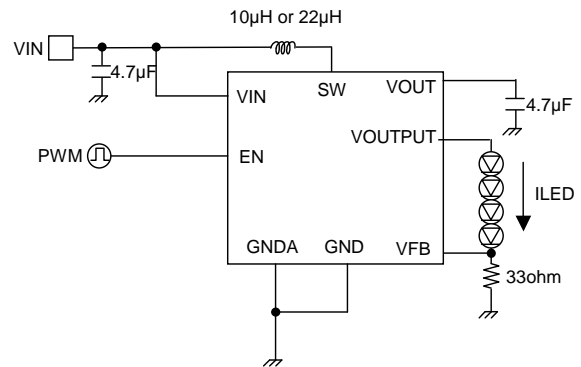


Figure 28. standard application

The shaded portion in the figure below is the setting range of LED current to become the standard. Depending on coils and white LEDs to be used, however, some ICs may not be used at desired currents. Consequently, for the proper setting of LED current, thoroughly check it for the suitability under use conditions including applicable power supply voltage and temperature.

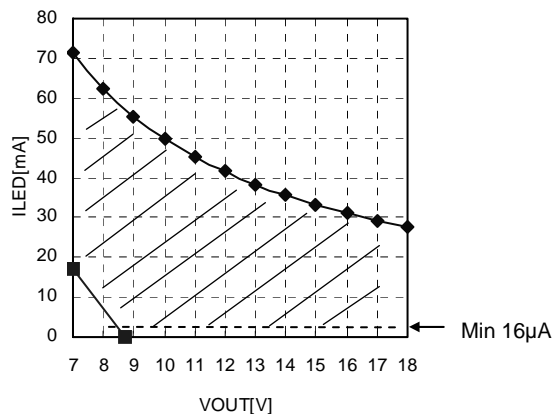


Figure 29. Setting range of LED current

### ● Selection of external parts

Recommended external parts are listed as below.

When to use other parts than these, select the following equivalent components.

#### • Coil

Value	Tolerance	Manufacturer	Product number	Size			DCR (Ω)
				Vertical size	Horizontal size	Height	
22μH	±20%	MURATA	LQH3NPN220MGOL	3.0	3.0	0.9	1.10
10μH	±20%	MURATA	LQH3NPN100MGOL	3.0	3.0	0.9	0.57
22μH	±20%	TDK	VLF3010ST220M	2.8	3.0	1.0	0.90
10μH	±20%	TDK	VLF3010ST100M	2.8	3.0	1.0	0.49
22μH	±20%	TOKO	DB3015C220M	2.6	2.8	1.5	0.60
10μH	±20%	TOKO	DB3015C100M	2.6	2.8	1.5	0.29
22μH	±20%	Taiyo Yuden	NR3010T220M	3.0	3.0	1.0	1.24
10μH	±20%	Taiyo Yuden	NR3010T100M	3.0	3.0	1.0	0.54
22μH	±20%	Panasonic	ELLVEG220NN	3.0	3.0	0.9	1.44
10μH	±20%	Panasonic	ELLVEG100NN	3.0	3.0	0.9	0.48

Please refer to the reference data of p.5 for the change in the efficiency when the coil is changed.

#### • Capacitor

Value	Manufacturer	Product number	Size			Temperature range
			Vertical size	Horizontal size	Height	
【 CIN 】						
1μF	MURATA	GRM188B11A105K	1.6	0.8	0.8	-25°C to +85°C
4.7μF	MURATA	GRM21BB31A475K	2.0	1.25	1.25	-25°C to +85°C
【 COUT 】						
1μF	MURATA	GRM188B31E105K	1.6	0.8	0.8	-25°C to +85°C
4.7μF	MURATA	GRM21BB31E475K	2.0	1.25	1.25	-25°C to +85°C

#### • Resistor

Value	Tolerance	Manufacturer	Product number	Size		
				Vertical size	Horizontal size	Height
【 RFB 】						
24Ω	±1%	ROHM	MCR006YZPF□□□□	0.6	0.3	0.23

Value □□□□

15Ω 15R0

24Ω 24R0

33Ω 33R0

The coil is the component that is most influential to efficiency. Select the coil which direct current resistor (DCR) and current - inductance characteristic are excellent. Select a capacitor of ceramic type with excellent frequency and temperature characteristics. Further, select Capacitor to be used for CIN/COUT with small direct current resistance, and pay much attention to the PCB layout shown in the next page.

●PCB Layout

In order to make the most of the performance of this IC, PCB layout is very important. Please note that characteristics such as efficiency and ripple will likely to change greatly depending on PCB layout.

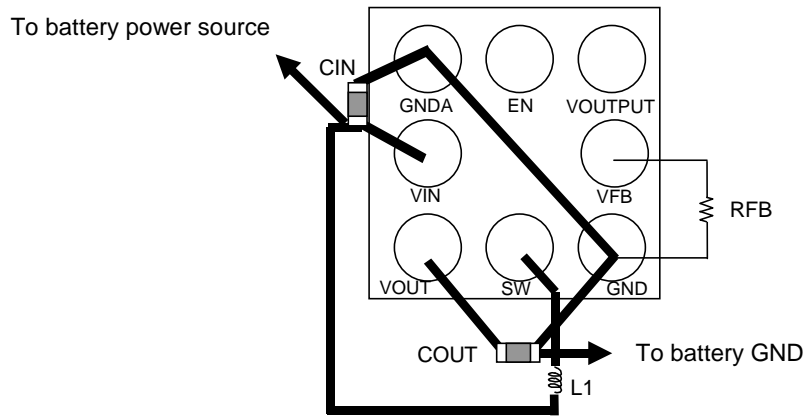
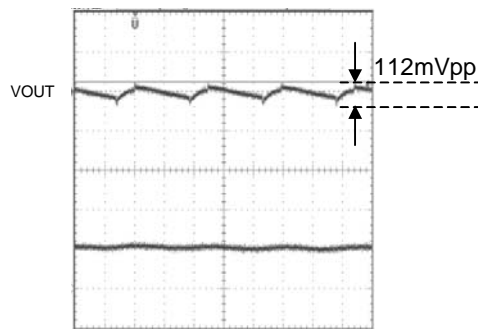


Figure 30. PCB layout

Connect the input bypass capacitor CIN between VIN and GND pin closely, as shown in the upper diagram. Thereby, the input voltage ripple of the IC can be reduced. And, connect the output capacitor COUT between VOUT and GND pin closely. Thereby, the output voltage ripple of the IC can be reduced. Connect the current setting RFB VFB pin closely. Connect the GND closely connection side of RFB directly to GND pin. Connect the GND pin directly near the chip, the performance of BD6076GUT shall be influenced and may limit the current drive performance. As for the wire to the inductor, make its resistance component small to reduce electric power consumption and increase the entire efficiency. Please keep away which are subject to be influenced like VFB pin in wire connection with SW.

The layout pattern in consideration of these is shown in the next page.



(VIN=3.6V, Ta=25°C, VOUT=14V, 20mA Load)

Figure 31. Output noise

### ● Recommended PCB layout

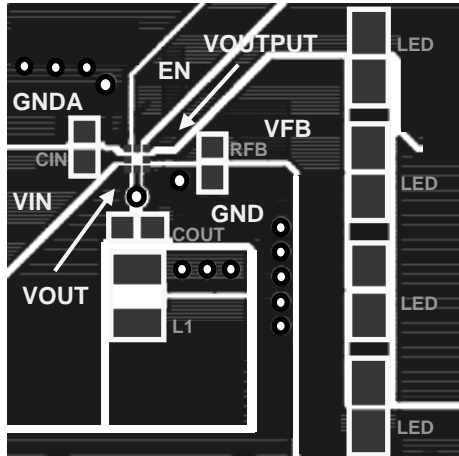


Figure 32. Front surface (TOP VIEW)

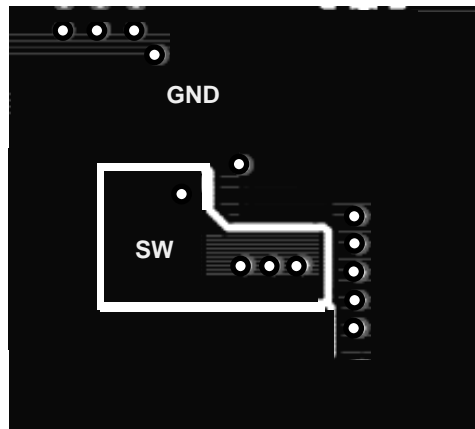


Figure 33. Rear surface (TOP VIEW)

### ● Attention point for PCB layout

For PCB layout design, the wire of power supply line should be low Impedance, and put bypass capacitor if necessary. Especially the wiring impedance must be low around DC/DC converter.

### ● About heat loss

For heat design, operate DC/DC converter in the following condition.  
(The following temperature is a guaranteed temperature, margin will be needed.)

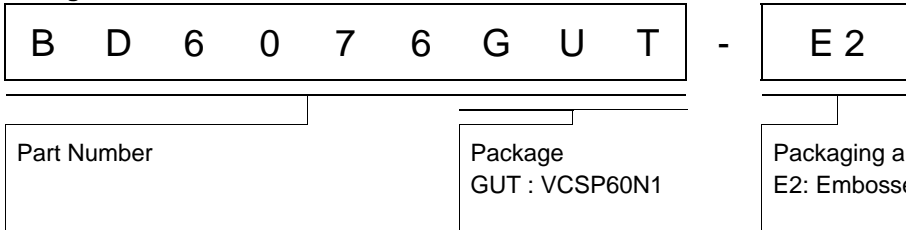
1. Periphery temperature  $T_a$  must be less than 85°C.
2. The loss of IC must be less than dissipation  $P_d$ .

**●Operational Notes**

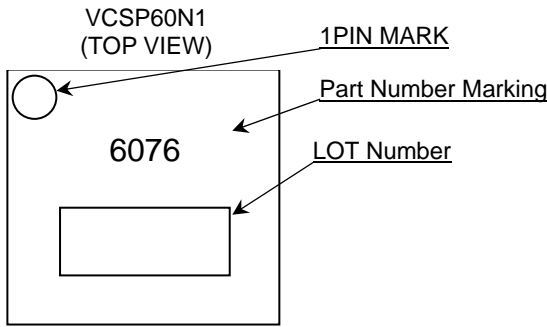
- 1) Absolute Maximum Ratings  
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute 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. In this regard, for the digital block power supply and the analog block power supply, even though these power supplies has the same level of potential, separate the power supply pattern for the digital block from that for the analog block, thus suppressing the diffraction of digital noises to the analog block power supply resulting from impedance common to the wiring patterns. For the GND line, give consideration to design the patterns in a similar manner.  
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°C (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) Selection of coil  
Select the low DCR inductors to decrease power loss for DC/DC converter.



● Ordering Information

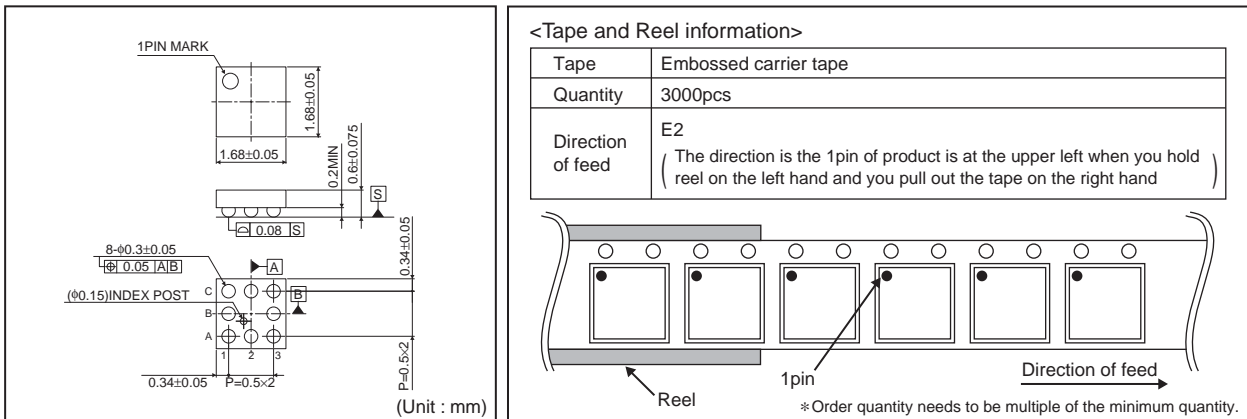


● Marking Diagram



● Physical Dimension Tape and Reel Information

VCSP60N1 (BD6076GUT)



Status of this document

The English version of this document is formal specification. A customer may use this translation version only for a reference to help reading the formal version.

If there are any differences in translation version of this document formal version takes priority.

## ●Revision History

Date	Revision	Changes
12.Sep.2012	001	New Release

# Notice

## Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASS III	CLASS III	CLASS II b	CLASS III
CLASS IV		CLASS III	

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
  - Installation of protection circuits or other protective devices to improve system safety
  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
  - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

### Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

### Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of ionizer, friction prevention and temperature / humidity control).

### Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

### Precaution for Product Label

QR code printed on ROHM Products label is for ROHM's internal use only.

### Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

### Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

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**General Precaution**

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