Built-in Charge Pump 3ch Linear LED Driver

BD2801MUV

General Description

The BD2801MUV is a 3ch linear constant-current LED driver IC with a built-in charge pump power supply, allowing the output current of each channel to be adjusted by external resistors connected to the IREF pin.
In addition, each ch can be controlled ON/OFF by inputting an external signal.
It is suitable for R, G, and B LED driver IC for CIS type sensors.

Key Specifications

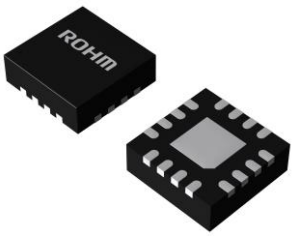
- Input Voltage Range: 3.135 V to 3.465 V
- Output Current Accuracy: ±9.1 %
- Maximum Output Current: 100 mA (DC)
- Operating Temperature: 0 °C to 70 °C

Package

	W (Typ) x D (Typ) x H (Max)
VQFN016V3030	3.0 mm x 3.0 mm x 1.0 mm

Features

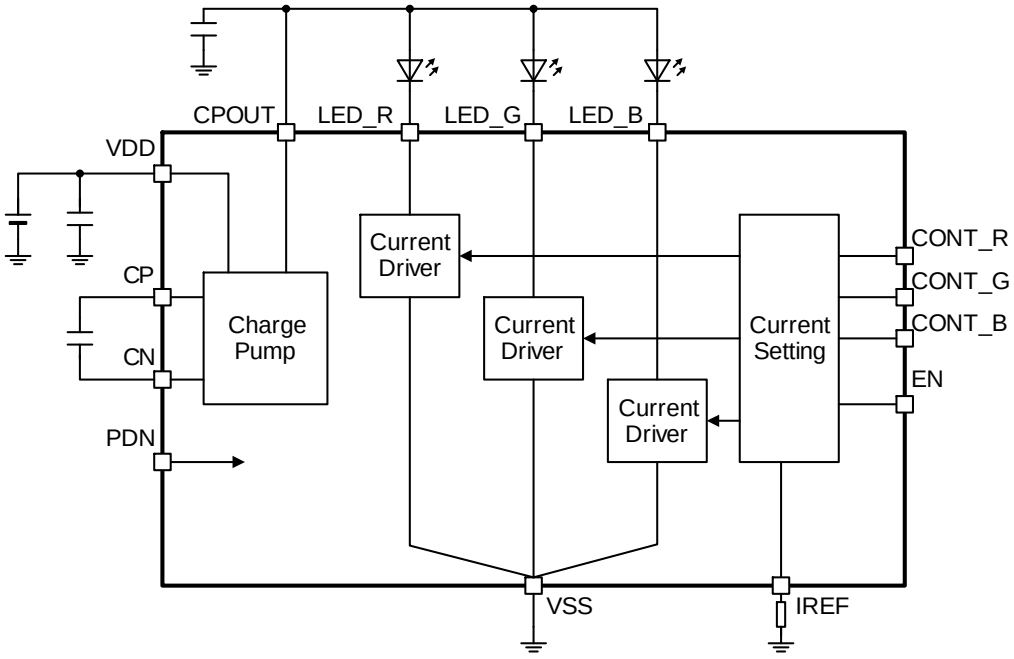
- Built-in Charge Pump Power Supply
- 3ch Independent ON/OFF
- 8-step Current Setting
- IREF Pin Ground Fault Protection (IREF SCP)



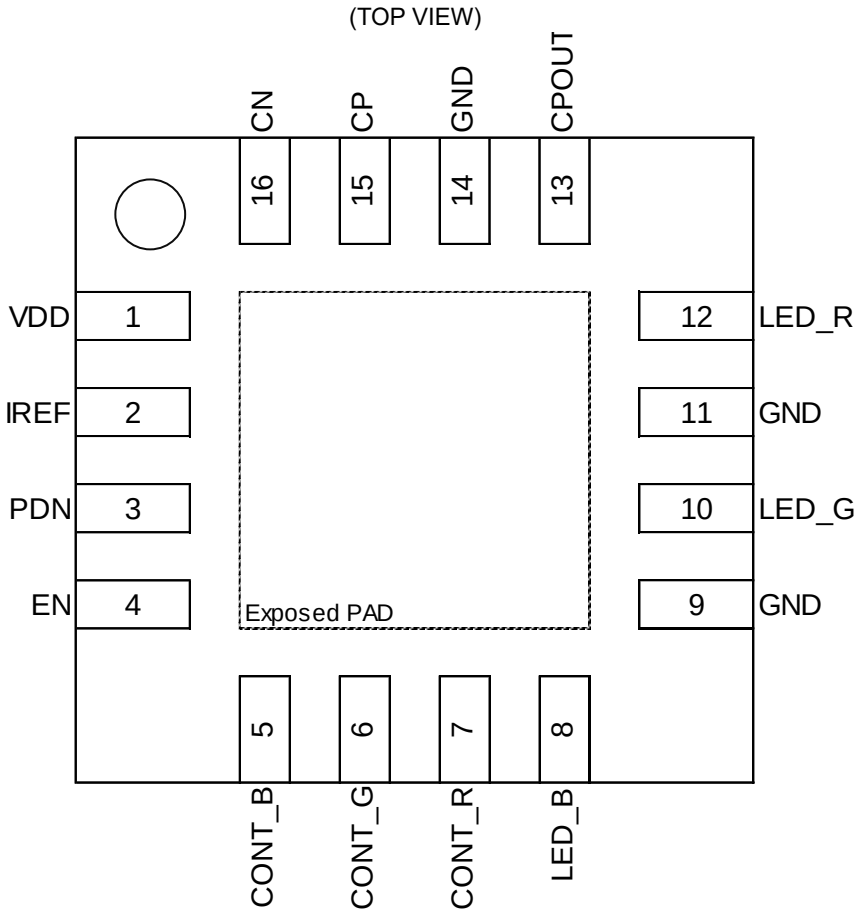
Application

- LED Driver for CIS Type Sensor

Typical Application Circuit



Pin Configuration

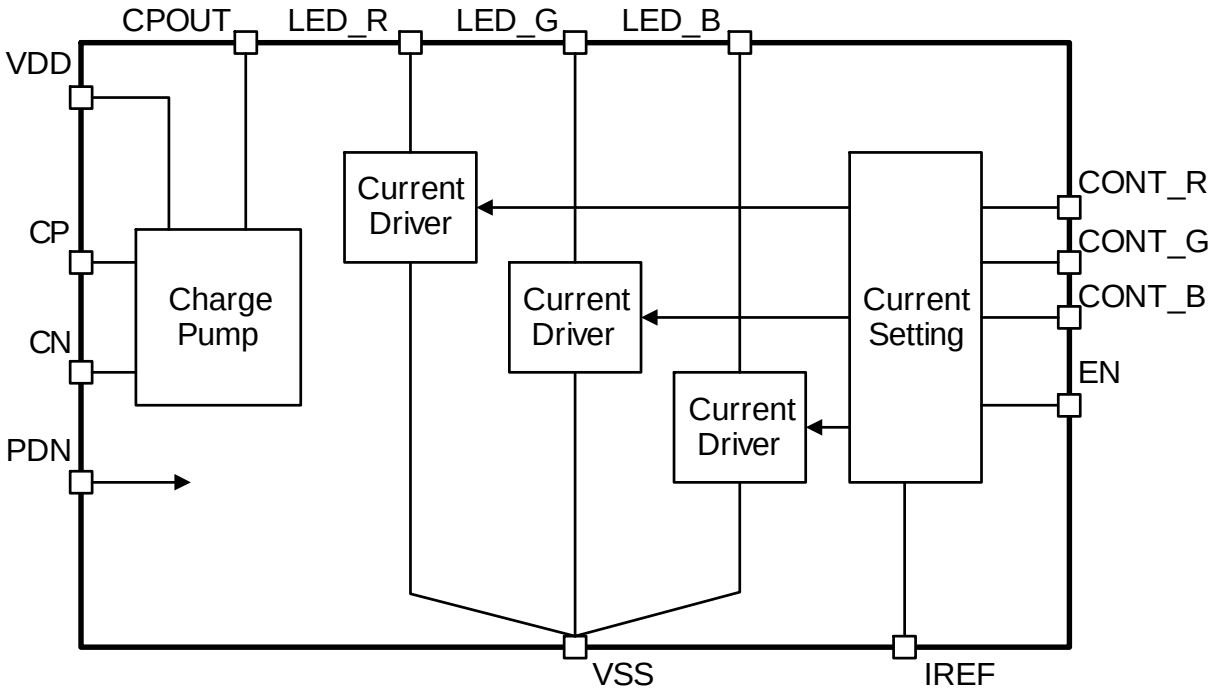


Pin Descriptions

Pin No.	Pin Name	Function
1	VDD	Power supply
2	IREF	Output current setting*(Note 1)*
3	PDN	Power-down mode input
4	EN	Enable Input
5	CONT_B	LED control signal input B
6	CONT_G	LED control signal input G
7	CONT_R	LED control signal input R
8	LED_B	LED current output B
9	GND	GND
10	LED_G	LED current output G
11	GND	GND
12	LED_R	LED current output R
13	CPOUT	Charge pump power output
14	GND	GND
15	CP	Charge pump positive side
16	CN	Charge pump negative side
-	EXP-PAD	Exposed pad. Connect EXP-PAD to the GND

(Note 1) Do not connect external capacitors.

Block Diagram



Description of Blocks

1 Charge Pump Block

Generates the voltage required to light the LEDs from the voltage supplied to the VDD pin.

2 LED Driver Block

This product is a 3-channel LED driver that drives anode common R, G, and B LEDs with constant current. The current applied to each channel can be adjusted with external resistors, and the current can be turned ON/OFF with the CONT_R, CONT_G and CONT_B pins.
The current can be set in 8 steps by the CONT_R, CONT_G, CONT_B and EN pins.
In case of 3-channel simultaneous lighting, the current setting shall be 50 % or less. (In case of 66 mA)

3 Power Down Function

When the PDN pin is set to Low during VDD power-up, the device enters a power-down state.
During power-down, the current supply inside the device stops, the LED_R, LED_G and LED_B pins are High-Z, and the CPOUT pin is Low. At startup, VDD should be started up with PDN = Low.

4 LED Current Setting Method

On the rising edge of the EN pin, the pattern on the CONT_R, CONT_G and CONT_B pins is latched to determine the current value. Then, once the CONT_R, CONT_G and CONT_B pins are set to Low, the LED current is turned on and off according to the CONT_R, CONT_G and CONT_B.

Absolute Maximum Ratings (Ta = 25 °C)

No.	Parameter	Symbol	Rating	Unit
A-1	VDD Pin Voltage	V_{DD}	-0.3 to +4.0	V
A-2	IREF, PDN, EN, CONT_B, CONT_G, CONT_R Pin Voltage	V_{IREF}, V_{PDN}, V_{EN}, V_{CONT_B}, V_{CONT_G}, V_{CONT_R},	-0.3 to VDD + 0.3	V
A-3	LED_B, LED_G, LED_R, CPOUT Pin Voltage	V_{LED_B}, V_{LED_G}, V_{LED_R} V_{CPOUT}	-0.3 to +8.0	V
A-4	CP to CN Pin Voltage	V_{CP-CN}	-0.3 to +8.0	V
A-5	Storage Temperature Range	Tstg	-55 to +150	°C
A-6	Maximum Junction Temperature	Tjmax	150	°C

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

Thermal Resistance *(Note 1)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s*(Note 3)*	2s2p*(Note 4)*	
VQFN016V3030				
Junction to Ambient	θ_{JA}	189.0	57.5	°C/W
Junction to Top Characterization Parameter*(Note 2)*	Ψ_{JT}	23	10	°C/W

(Note 1) Based on JESD51-2A (Still-Air).
(Note 2) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 3) Using a PCB board based on JESD51-3.
(Note 4) Using a PCB board based on JESD51-5, 7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3 mm x 76.2 mm x 1.57 mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70 µm

Layer Number of Measurement Board	Material	Board Size	Thermal Via*(Note 5)*	
			Pitch	Diameter
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt	1.20 mm	Φ0.30 mm

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 µm	74.2 mm x 74.2 mm	35 µm	74.2 mm x 74.2 mm	70 µm

(Note 5) This thermal via connect with the copper pattern of layers 1,2, and 4. The placement and dimensions obey a land pattern.

Recommended Operating Conditions

No.	Parameter	Symbol	Min	Typ	Max	Unit
O-1	VDD Power Supply Voltage*(Note 1)*	V_{DD}	3.135	3.300	3.465	V
O-2	Operating Temperature	Topr	0	-	70	°C

(Note 1) ASO should not be exceeded.

Operating Conditions

No.	Parameter	Symbol	Min	Typ	Max	Unit
P-1	VDD Pin Connection Capacitor*(Note 2)*	C_{VDD}	10	-	-	µF
P-2	CP to CN Pins Connection Capacitor*(Note 2)*	C_{CP-CN}	1.0	-	-	µF
P-3	CPOUT Pin Connection Capacitor*(Note 2)*	C_{CPOUT}	1.0	-	-	µF
P-4	Output Current Setting Resistor	R_{IREF}	3.4	4.7	14.1	kΩ
P-5	LED Vf	Vf	1.1	-	4.8	V

(Note 2) Connect the capacitor within 10 mm from the IC; if the capacitor is connected beyond 10 mm, the output current $I_{LED\_X\ (X = R,G,B)}$ may oscillate or otherwise become unstable, so evaluate the capacitor thoroughly on the actual device for confirmation.

Electrical Characteristics

(Unless otherwise specified Ta = 0 °C to 70 °C, V_{DD} = 3.135 V to 3.465 V)

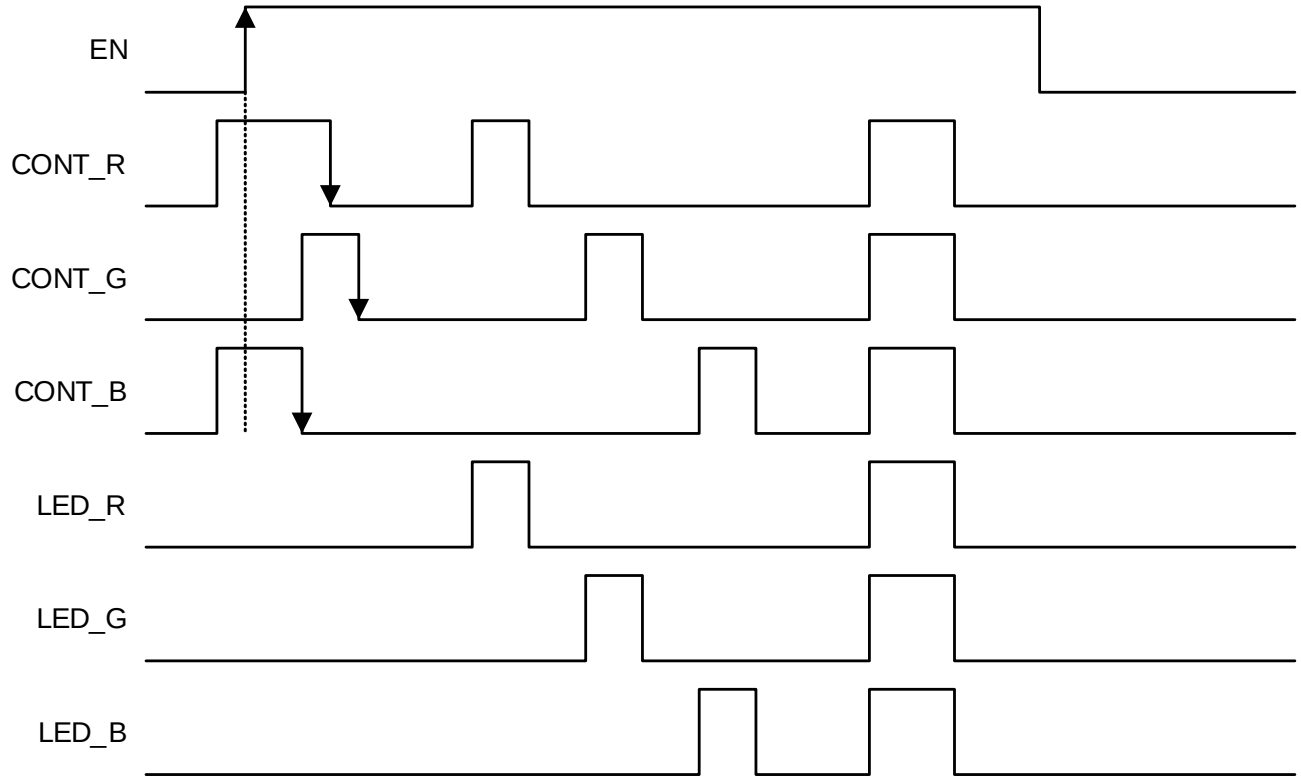
No.	Parameter	Symbol	Standard Value			Unit	Condition
			Min	Typ	Max		
Circuit Current							
E-1	VDD Pin Circuit Current	I_{VDD}	-	5.0	-	mA	R_{IREF} = 4.7 kΩ
Digital Input DC Characteristic							
E-2	Input High Voltage	V_{IH}	V_{DD} x 0.7	-	-	V	PDN, EN, CONT_R, CONT_G, CONT_B
E-3	Input Low Voltage	V_{IL}	-	-	V_{DD} x 0.3	V	
E-4	Input Leakage Current	I_{LEAK}	-2	0	+2	µA	
Charge Pump							
E-5	CPOUT Voltage	V_{CPO}	6.27	6.60	6.93	V	V_{DD} = 3.3 V At LED current disable
E-6	CPOUT Rise Time	t_{CPON}			1	ms	
E-7	CPOUT Fall Time	t_{CPOFF}			20	ms	
LED Driver							
E-8	LED Current Setting Range	I_{RANGE}	22	-	80	mA	
E-9	IREF Pin Output Current at Ground Fault	I_{REF}	120	150	180	mA	V_{IREF} = 0 V
E-10	LED Current (R/G/B)	I_{LED}	60	66	72	mA	R_{IREF} = 4.7 kΩ, LED pin voltage = (2 x V_{DD} - 3.1) V
E-11	LED Current Accuracy (R/G/B)	A_{LED}	-	100	-	%	LED Pin Voltage = (2 x V_{DD} - 3.1) V CONT_X (X = R, G, B) 000
E-12			86.0	87.5	89.0	%	001
E-13			73.5	75.0	76.5	%	010
E-14			60.5	62.5	64.5	%	011
E-15			48.0	50.0	52.0	%	100
E-16			35.5	37.5	39.5	%	101
E-17			23.0	25.0	27.0	%	110
E-18			10.5	12.5	14.5	%	111
E-19	Dependence of LED Current on LED Pin Voltage	D_{LEDVF}	-2.5	-	+2.5	%	When $I_{LED\_X\ (X = R, G, B)}$ = 49.5 mA setting, LED pin voltage range = 1.1 V to 6.6 V, $V_{LED\_\ X\ (X = R, G, B)}$ = 2.0 V reference

Electrical Characteristics - continued

(Unless otherwise specified Ta = 0 °C to 70 °C, V_{DD} = 3.135 V to 3.465 V)

No.	Parameter	Symbol	Standard Value			Unit	Condition
			Min	Typ	Max		
LED Driver							
E-20	LED Current Rise Time	t_{ON}	-	10	-	µs	
E-21	LED Current Fall Time	t_{OFF}	-	10	-	µs	
E-22	Current Setting Setup Time	t_S	1	-	-	µs	CONT_X (X = R, G, B) to EN(0.3V_{DD})
E-23	Current Setting Hold Time	t_H	1	-	-	µs	EN(0.7V_{DD}) to CONT_X (X = R, G, B)
E-24	Current Setting Mode Clear Time	t_{CL}	1	-	-	µs	CONT_X (X = R, G, B): 0.7V_{DD}
PDN							
E-25	Power Down Period	t_{PD}	150	-	-	ns	
E-26	Startup Time	t_{STUP}	-	-	1	ms	
E-27	Power Down Current	I_{PDN}	-	-	20	µA	

Timing Chart



CONT_R	CONT_G	CONT_B	Current Setting (Typ)
0	0	0	100 %
0	0	1	87.5 %
0	1	0	75 %
0	1	1	62.5 %
1	0	0	50 %
1	0	1	37.5 %
1	1	0	25 %
1	1	1	12.5 %

Figure 1. Output current setting

Timing Chart - continued

LED Driver Block Switching Characteristics

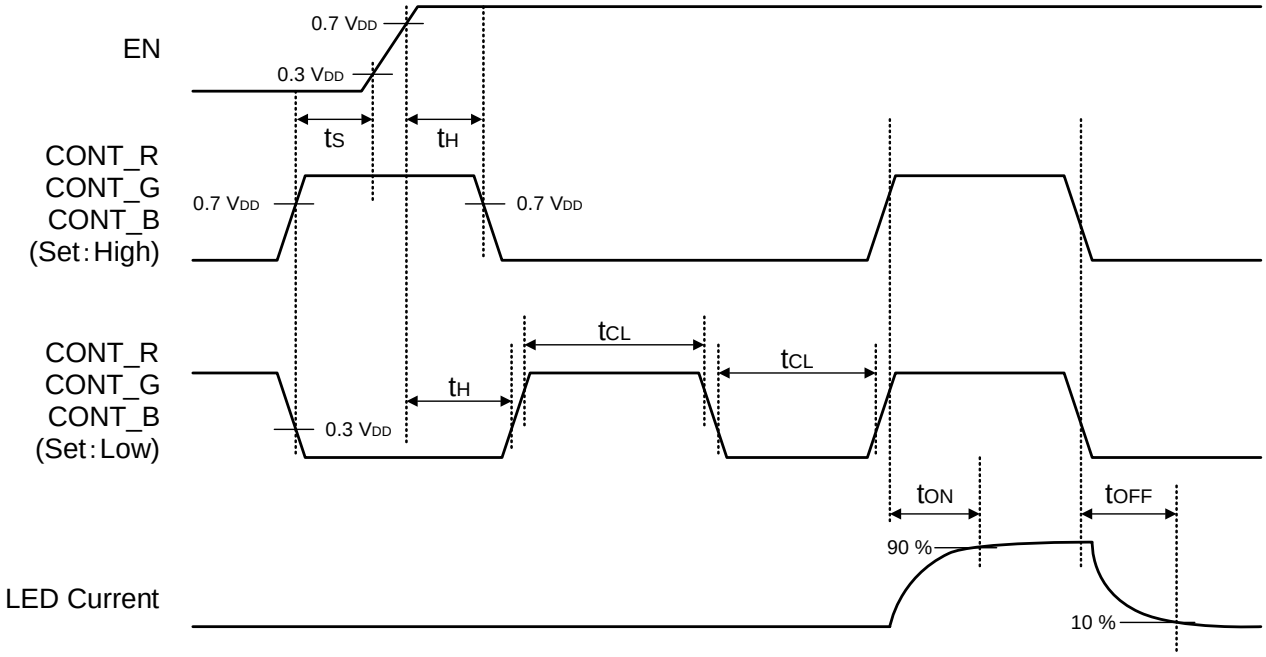


Figure 2. LED current switching

PDN Switching Characteristics

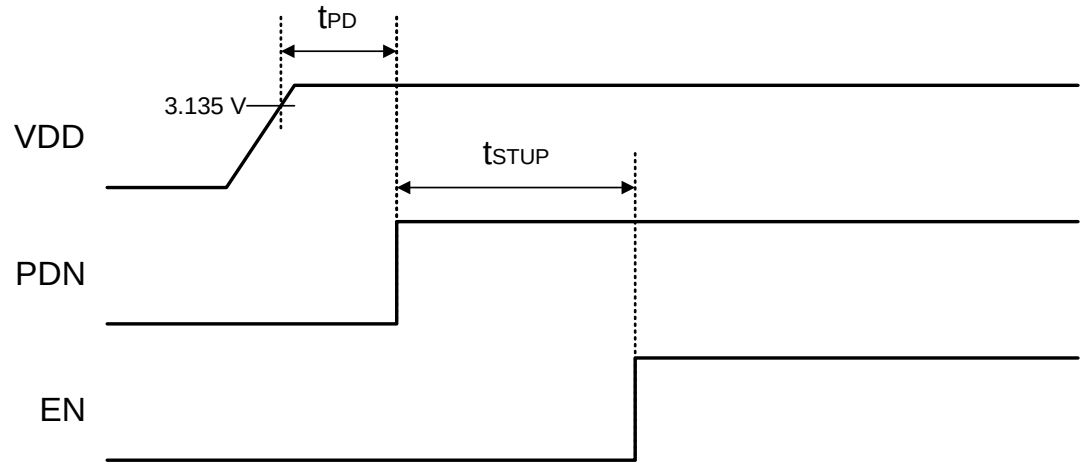


Figure 3. Startup input switching

Operational Notes

1. **Reverse Connection of Power Supply**
   Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
   Design the PCB layout pattern to provide low impedance supply lines. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
   Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
   When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
   The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
   When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Testing on Application Boards**
   When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

8. **Inter-pin Short and Mounting Errors**
   Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

9. **Unused Input Pins**
   Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

10. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

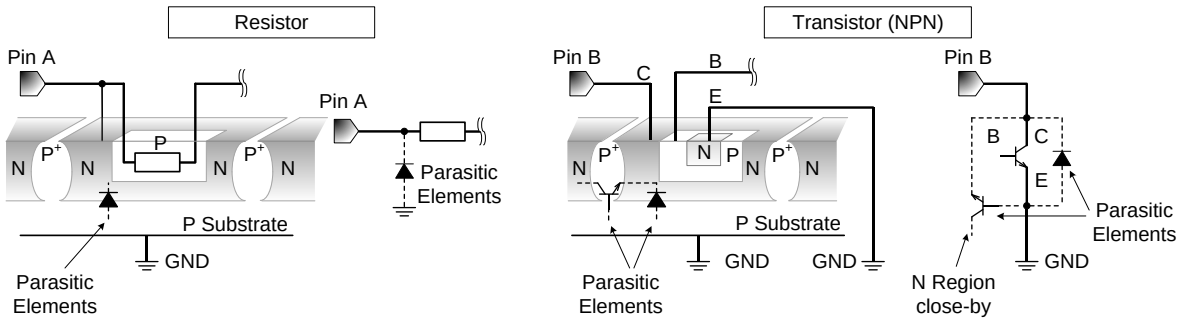


Figure 4. Example of Monolithic IC Structure

11. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

12. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF power output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

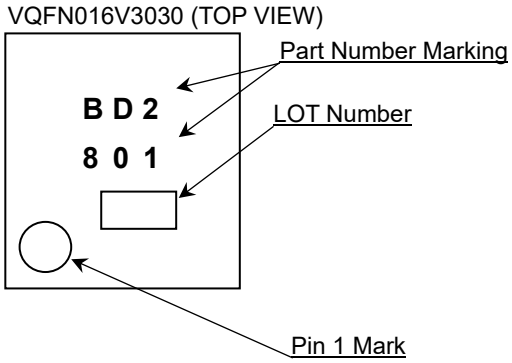
Ordering Information

B	D	2	8	0	1	M	U	V	-	E 2

Package
MUV:
VQFN016V3030

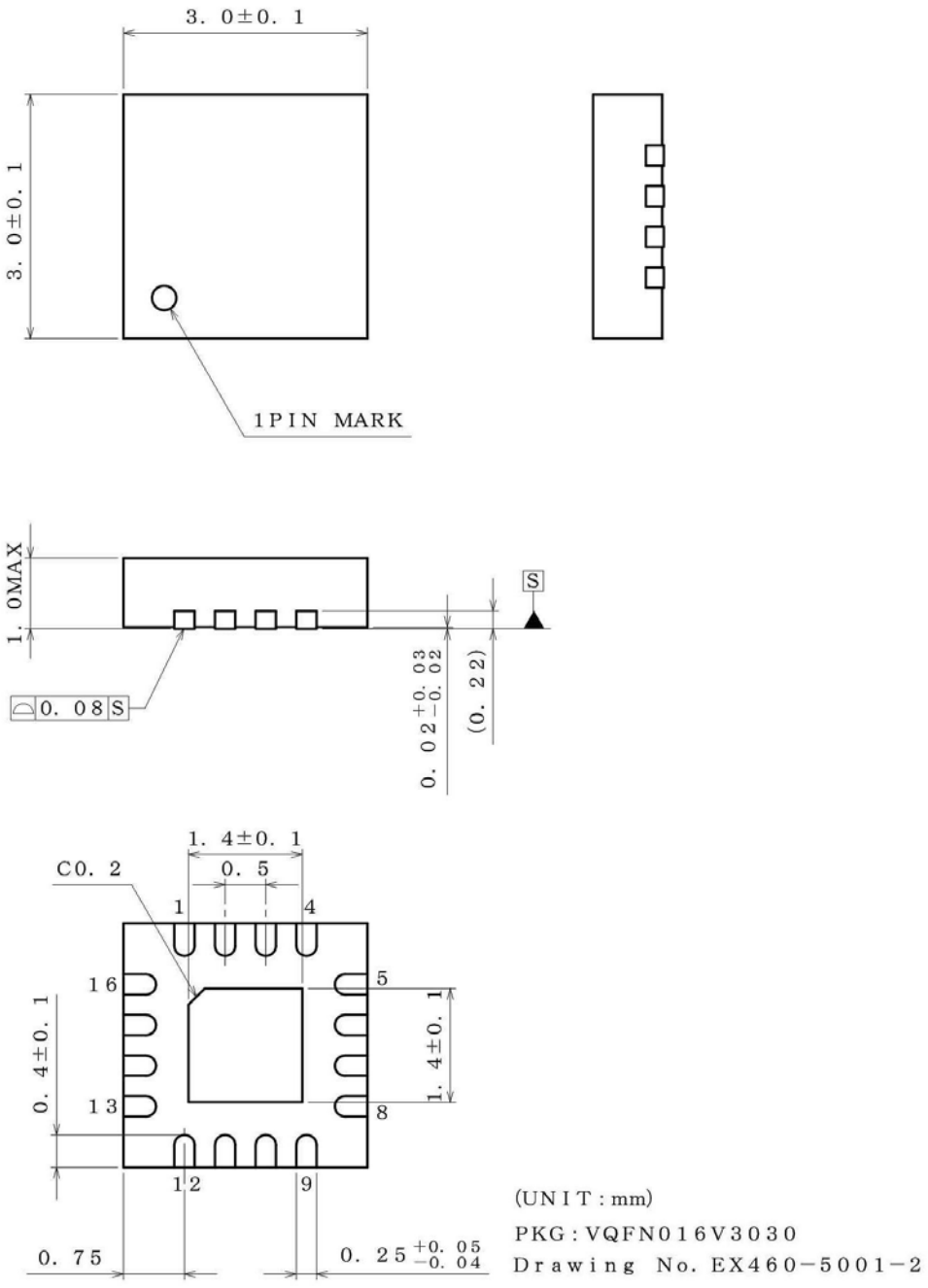
Packaging and forming specification
E2: Embossed tape and reel

Marking Diagram



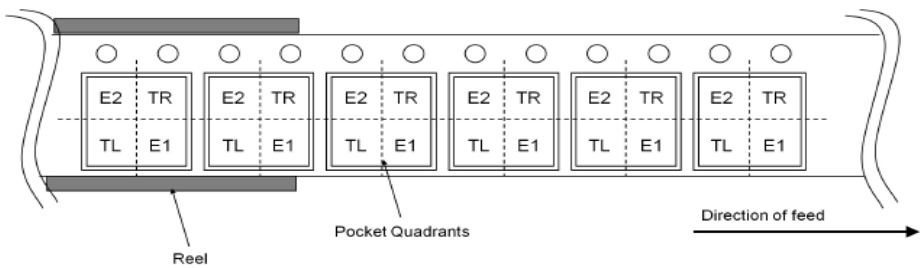
Physical Dimension and Packing Information

Package Name	VQFN016V3030



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	3000pcs
Direction of feed	E2 The direction is the pin 1 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



Revision History

Date	Revision	Changes
24.Aug.2022	001	New Release

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(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
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   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. 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.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. 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

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, 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.

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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_2, H_2S, NH_3, SO_2, and NO_2
   [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.

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