

36V 2ch Stepping Motor Driver

BD68888MUV

General Description

BD68888MUV is a bipolar low-consumption driver that driven by PWM constant current. Rated power supply voltage of the device is 36 V, and rated output current is 1.65 A. PARA-IN drive mode is adopted for input interface. This motor driver can drive 2ch bipolar stepping motors. In addition, the power supply can be driven by one single system, which simplifies the design.

Features

- Two bipolar stepping motors can be driven
- Rated Output Current 1.65 A/Phase
- Low ON Resistance DMOS Output
- PARA-IN Drive Mode correspondence
- PWM Constant Current control (the other excitation method)
- Built-in Spike Noise Blanking Function (external noise filter is unnecessary)
- Full-, Half (two kinds)-, Quarter-step correspondence
- Power Save Function
- Built-in Logic Input Pull-down Resistor
- Thermal Shutdown Circuit (TSD)
- Over-current Protection Circuit (OCP)
- Under Voltage Lockout Circuit (UVLO)
- Over Voltage Lockout Circuit (OVLO)
- Ghost Supply Prevention (protects against malfunction when power supply is disconnected)

Application

- Monitoring Camera, WEB Camera, PPC, Multi-function Printer, Laser Beam Printer, Ink-jet Printer, Sewing Machine, Photo Printer, FAX, Scanner, Mini Printer, Toy and Robot

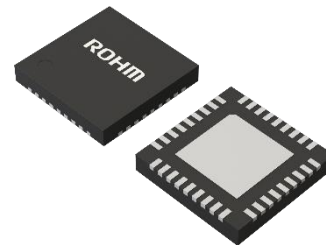
Key Specifications

- Range of Power Supply Voltage 8 V to 28 V
- Rated Output Current 1.65 A/Phase
- Range of Operating Temperature -25 °C to +85 °C
- Output ON Resistance 1.0 Ω (Typ)
(total of upper and lower resistors)

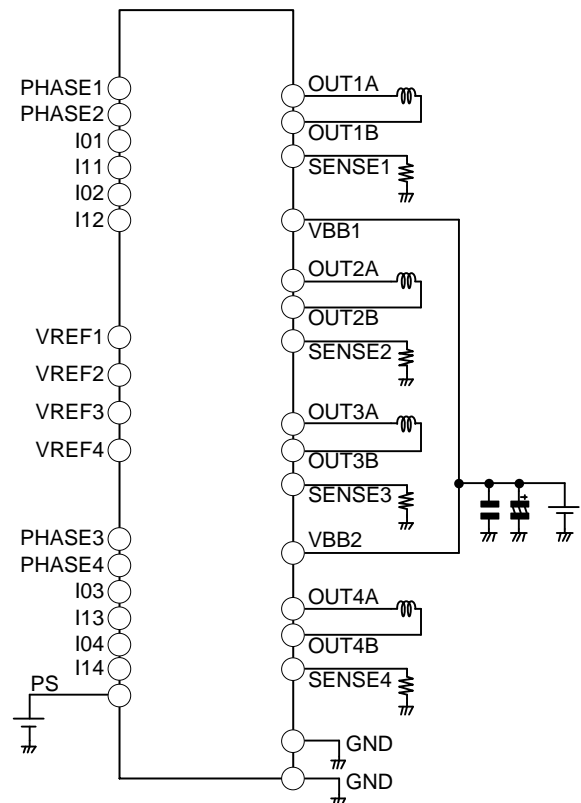
Package

VQFN036V6060

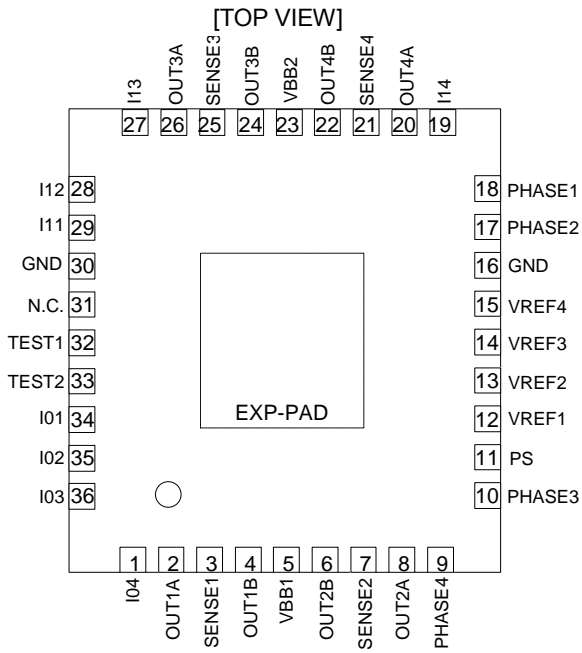
W (Typ) x D (Typ) x H (Max)
6.0 mm x 6.0 mm x 1.0 mm



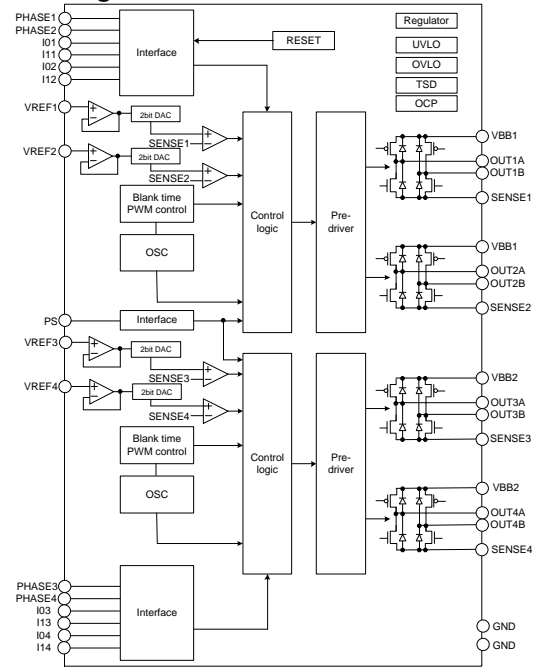
Typical Application Circuit



Pin Configuration



Block Diagram



Pin Descriptions

Pin No.	Pin Name	Function	Pin No.	Pin name	Function
1	I04	VREF division ratio setting pin	19	I14	VREF division ratio setting pin
2	OUT1A	H bridge output pin	20	OUT4A	H bridge output pin
3	SENSE1	Connection pin of resistor for output current detection	21	SENSE4	Connection pin of resistor for output current detection
4	OUT1B	H bridge output pin	22	OUT4B	H bridge output pin
5	VBB1	Power supply pin	23	VBB2	Power supply pin
6	OUT2B	H bridge output pin	24	OUT3B	H bridge output pin
7	SENSE2	Connection pin of resistor for output current detection	25	SENSE3	Connection pin of resistor for output current detection
8	OUT2A	H bridge output pin	26	OUT3A	H bridge output pin
9	PHASE4	Phase selection pin	27	I13	VREF division ratio setting pin
10	PHASE3	Phase selection pin	28	I12	VREF division ratio setting pin
11	PS	Power save pin	29	I11	VREF division ratio setting pin
12	VREF1	Output current value setting pin	30	GND	Ground pin
13	VREF2	Output current value setting pin	31	NC	Non connection
14	VREF3	Output current value setting pin	32	TEST1	Pin for testing
15	VREF4	Output current value setting pin	33	TEST2	Pin for testing
16	GND	Ground pin	34	I01	VREF division ratio setting pin
17	PHASE2	Phase selection pin	35	I02	VREF division ratio setting pin
18	PHASE1	Phase selection pin	36	I03	VREF division ratio setting pin
-	EXP-PAD	The EXP-PAD connect to GND.	-	-	-

Absolute Maximum Ratings (Ta = 25 °C)

Item	Symbol	Rated Value	Unit
Supply Voltage	VBB1,VBB2	-0.2 to +36.0	V
Input Voltage for Control Pin ^(Note 1)	V _{IN}	-0.2 to +5.5	V
SENSE _x ^(Note 2) Maximum Input Voltage	V _{SENSE}	0.7	V
Output Current	I _{OUT}	1.65 ^(Note 3)	A/Phase
Storage Temperature Range	T _{stg}	-55 to +150	°C
Maximum Junction Temperature	T _{jmax}	+150	°C

(Note 1) Control pin = PHASE1, PHASE2, PHASE3, PHASE4, VREF1, VREF2, VREF3, VREF4, I01, I02, I03, I04, I11, I12, I13, I14.

(Note 2) x = 1, 2, 3 or 4

(Note 3) Do not exceed T_{jmax} = 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 boards with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.

Recommended Operating Conditions

Item	Symbol	Min	Typ	Max	Unit
Operating Temperature	Topr	-25	+25	+85	°C
Supply Voltage	VBB1,VBB2	+8	+24	+28	V
Maximum Output Current (DC)	I _{OUT}	-	-	+1.2 ^(Note 4)	A/ Phase

(Note 4) Do not exceed T_{jmax} = 150 °C.

Thermal Resistance^(Note 5)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s ^(Note 7)	2s2p ^(Note 8)	
VQFN036V6060				
Junction to Ambient	θ _{JA}	103.9	24.5	°C/W
Junction to Top Characterization Parameter ^(Note 6)	Ψ _{JT}	4	2	°C/W

(Note 5) Based on JESD51-2A (Still-Air).

(Note 6) 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 7) Using a PCB board based on JESD51-3.

(Note 8) 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 9)	
			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 9) This thermal via connects with the copper pattern of all layers.

Electrical Characteristics (Unless otherwise specified Ta = 25 °C, VBB1, VBB2 = 24 V)

Item	Symbol	Limit			Unit	Condition
		Min	Typ	Max		
[Whole]						
Circuit Current at Standby	I _{CCST}	-	0	10	μA	PS = L
Circuit Current	I _{CC}	-	5.0	8.0	mA	PS = H, VREF _x = 1.5 V
[Control Logic Input^(Note 1)]						
H-level Input Voltage	V _{INH}	2.0	-	-	V	
L-level Input Voltage	V _{INL}	-	-	0.8	V	
H-level Input Current	I _{INH}	35	50	100	μA	V _{IN} = 5 V
L-level Input Current	I _{INL}	-10	0	-	μA	V _{IN} = 0 V
[Output^(Note 2)]						
Output ON Resistance	R _{ON}	-	1.0	1.4	Ω	I _{OUT} = ±1.0 A (total of upper and lower)
Output Leak Current	I _{LEAK}	-	-	10	μA	
[Current Control]						
SENSE _x ^(Note 3) Input Current	I _{SENSE}	-80	-40	-	μA	SENSE _x = 0 V
VREF _x ^(Note 3) Input Current	I _{VREF}	-2.0	-0.1	-	μA	VREF _x = 0 V
VREF _x ^(Note 3) Input Voltage Range	V _{VREF}	0	-	1.5	V	
Minimum ON Time (Blank Time)	t _{ONMIN}	0.3	1.0	1.5	μs	
Comparator Threshold	V _{CTH}	0.48	0.50	0.52	V	VREF _x = 1.5 V

(Note 1) Control Logic input = PHASE1, PHASE2, PHASE3, PHASE4, I01, I02, I03, I04, I11, I12, I13, I14

(Note 2) Output = OUT1A, OUT1B, OUT2A, OUT2B, OUT3A, OUT3B, OUT4A, OUT4B

(Note 3) x = 1, 2, 3 or 4

Function Explanation

1 PS/Power Save Pin

The PS pin can make the circuit standby state and make the motor output OPEN. When PS = L→H, be careful because there is a delay of 40 μs (Max) before it is returned from standby state to normal state and the motor output becomes ACTIVE.

PS	Status
L	Standby state
H	ACTIVE

2 PHASEx (Note 1)/Phase Selection Pin

These pins determine output state.

PHASEx	OUTxA ^(Note 1)	OUTxB ^(Note 1)
L	L	H
H	H	L

(Note 1) x = 1, 2, 3 or 4

3 IOx (Note 2), I1x^(Note 2)/VREF Division Ratio Setting Pin

Although VREF pins voltage is input to 2bit-DAC, these pins set the split ratio of 2bit-DAC output voltage.

IOx	I1x	Output Current Level (%)
L	L	100
H	L	67
L	H	33
H	H	0

(IOx, I1x) = (H, H): motor outputs are open.

(Note 2) x = 1, 2, 3 or 4

4 VBB1, VBB2/Power Supply Pin

The wire should be thick, short and has low impedance, because Motor's drive current is flowing in it. The VBB1 pin and the VBB2 pin voltage may have great fluctuation, so arrange the bypass capacitor of about 100 μF to 470 μF as close to the pin as possible and adjust the VBB1 pin and the VBB2 pin voltage is stable. Increase the capacity as needed especially, when a large current is used or those motors that have great back electromotive force are used.

In addition, for the purpose of reducing of power supply's impedance in wideband, it is recommended to set parallel connection of multi-layered ceramic capacitor of 0.01 μF to 0.1 μF etc. Extreme care must be used to make sure that the VBB1 pin and the VBB2 pin voltage do not exceed the rating even for a moment. The VBB1 pin and the VBB2 pin are shorted inside the IC, but be sure to short externally the VBB1 pin and the VBB2 pin when using. If used without shorting, malfunction or destruction may occur because of concentration of current routes etc. Still more, in the power supply pin, there is built-in clamp component for preventing of electrostatic destruction. When a steep pulse signal or voltage such as a surge exceeding the absolute maximum rating is applied, this clamp component operates, and the IC might be destroyed as a result. Be sure that the maximum absolute rating must not be exceeded. It is effective to mount a Zener diode of about the maximum absolute rating. Moreover, the diode for preventing electrostatic destruction is inserted between the VBB1 pin, the VBB2 pin and the GND pin. Be careful about the reverse voltage because the IC might be destroyed as a result if reverse voltage is applied to the VBB1 pin, the VBB2 pin and the GND pin.

5 GND/Ground Pin

In order to reduce the electric noise by switching current and to stabilize the internal reference voltage of the IC, make the wiring impedance from this pin as low as possible to achieve the lowest electrical potential no matter what operating state it can be. Moreover, design the patterns not to have any common impedance with other GND patterns.

6 OUTxA^(Note 3), OUTxB^(Note 3)/H Bridge Output Pin

Motor's drive current is flowing in it, so the wire should be thick, short and has low impedance. It is also effective to add a schottky diode if output has positive or negative great fluctuation when large current is used. For example, counter electromotive voltage etc. Moreover, in the output pin, there is built-in clamp component for preventing of electrostatic destruction. When a steep pulse signal or voltage such as a surge exceeding the absolute maximum rating is applied, this clamp component operates, and the IC might be destroyed in the end. Be sure that the maximum absolute rating must not exceeded.

(Note 3) x = 1, 2, 3 or 4

Function Explanation – continued

7 SENSE_x(Note 1)/Connection Pin of Resistor for Detecting of Output Current

Connect the resistor of 0.1 Ω to 0.3 Ω for current detection between this pin and GND. Determine the resistor so that power consumption $W = I_{OUT}^2 \cdot R$ [W] of the current-detecting resistor does not exceed the maximum absolute rating of the resistor. In addition, it has a low impedance and does not have a common impedance with other GND patterns because motor's drive current flows in the pattern through the SENSE_x pin to current-detecting resistor to GND. Do not exceed the rating because there is the possibility of circuits' malfunction etc., if the SENSE pin voltage exceeds the maximum rating (0.7V). Moreover, be careful because if the SENSE_x pin is shorted to GND, large current flows without normal PWM constant current control, and OCP or TSD might operate. If there is a possibility of malfunction, such as output does not flow even when the SENSE_x pin is open, please do not put to such a state.

(Note 1) x = 1, 2, 3 or 4

8 VREF_x(Note 2)/Output Current Value Setting Pin

This is the pin to set the output current value. It can be set by the VREF pin voltage and current-detecting resistor (SENSE resistor).

$$I_{OUT} = \frac{VREF_x}{3} / SENSE_x \quad [A]$$

Where

I_{OUT} : The output current.

$VREF_x$: The voltage of output current value-setting pin.

$SENSE_x$: The current-detecting resistor.

Avoid using the IC with the VREF_x pin is open because if it is open, it may have malfunctions such as flowing a large current by unstable input, the increased the VREF_x pin voltage and increased setting current. The input voltage range must be kept because a large current might flow to output and OCP or TSD might operate if the voltage of over 1.5 V is applied on the VREF_x pin. Besides, select the resistance value in consideration of the outflow current (Max 2 μA) if it is inputted by resistance division. The minimum current, which can be controlled by the VREF_x pin voltage, is determined by motor coil's L, R values and minimum ON time because there is a minimum ON time in PWM drive.

(Note 2) x = 1, 2, 3 or 4

9 TEST_x(Note 3)/Pin for Inspection

This pin is used for delivery inspection of the IC, and shall be grounded before use.

In addition, malfunctions can be caused by application without grounding.

(Note 3) x = 1 or 2

10 NC Pin

This pin is unconnected electrically with the IC internal circuit.

11 EXP-PAD

For VQFN036V6060 package, the heat-radiating metal is mounted on the IC's backside. It is the precondition that making the heat-radiating treatment when in use. Therefore, it must be connected by solder with the GND plane on the board and ensure the sufficient heat-radiation area by taking the GND pattern as wide as possible. Moreover, the back side metal is shorted with IC chip's back side and becomes the GND potential, so there is the danger of malfunction and destruction if shorted with potentials other than GND. Never design any wiring patterns other than GND through the IC's backside.

Protection Circuits

1 Thermal Shutdown (TSD)

This IC has a built-in thermal shutdown circuit for thermal protection. When the IC's chip temperature rises to 175 °C (Typ) or more, the motor output becomes OPEN. Also, when the temperature returns to 150 °C (Typ) or less, it automatically returns to normal operation. However, if heat is continued to be added externally even while TSD is in operation, heat overdrive can lead to destruction.

2 Over Current Protection (OCP)

This IC has a built in over current protection circuit as a provision against destruction when the motor outputs are shorted each other or VBB1, VBB2-motor output or motor output-GND is shorted. This circuit latches the motor output to OPEN condition when the regulated current flows for 4 μs (Typ). It returns with power reactivation or a reset of the PS pin. The over current protection circuit's only aim is to prevent the destruction of the IC from irregular situations such as motor output shorts, and is not meant to be used as protection or security for the set. Therefore, sets should not be designed to take into account this circuit's functions. After OCP operating, if irregular situations continue and the return by power reactivation or a reset of the PS pin is carried out repeatedly, then OCP operates repeatedly and the IC may generate heat or otherwise deteriorate. When the L value of the wiring is great due to the wiring being long of faults, ground faults and shorting, there is a possibility of destruction after the over current has flowed and the output pin voltage jumps up and the absolute maximum values can be exceeded. Also, when current which is the output current rating or more and the OCP detection current or less flows, the IC can heat up to over $T_{jmax} = 150\text{ °C}$ and can deteriorate, so current which exceeds the output rating should not be applied.

3 Under Voltage Lock Out (UVLO)

This IC has a built-in under voltage lock out function to prevent false operation such as IC output during power supply under voltage. When the applied voltage to the VBB1 pin and the VBB2 pin goes 5 V (Typ) or less, the motor output is set to OPEN. This switching voltage has a 1 V (Typ) hysteresis to prevent malfunction due to noise etc. Be aware that this circuit does not operate during power save mode. Also, the electrical angle is reset when the UVLO circuit operates.

4 Over Voltage Lock Out (OVLO)

This IC has a built-in over voltage lock out function to protect the IC output and the motor during power supply over voltage. When the applied voltage to the VBB1 pin and the VBB2 pin goes 32 V (Typ) or more, the motor output is set to OPEN. This switching voltage has a 1 V (Typ) hysteresis and a 4 μs (Typ) mask time to prevent malfunction due to noise etc.

Although this over voltage locked out circuit is built-in, there is a possibility of destruction if the absolute maximum value for power supply voltage is exceeded, therefore the absolute maximum value should not be exceeded. Be aware that this circuit does not operate during power save mode.

5 Ghost Supply Prevention (protects against malfunction when power supply is disconnected)

If a control signal (logic input, $VREFx^{(Note\ 1)}$) is input when there is no power supplied to this IC, there is a function which prevents a malfunction where voltage is supplied to power supply of this IC or other IC in the set via the electrostatic destruction prevention diode from these input pins to the VBB1 pin and the VBB2 pin. Therefore, there is no malfunction of the circuit even when voltage is supplied to these input pins while there is no power supply.

(Note 1) x = 1, 2, 3 or 4

6 Operation Under Strong Electromagnetic Field

The IC is not designed for using in the presence of strong electromagnetic field. Be sure to confirm that no malfunction is found when using the IC in a strong electromagnetic field.

PWM Constant Current Control

1 Current control operation

The output current increases due to the output transistor turned on. When the voltage on the SENSEx^(Note 1) pin, the output current is converted voltage due to connect the external resistance to the SENSEx pin, reaches the voltage value set by the internal 2-bit DAC and the VREFx^(Note 1) input voltage, the current limit comparator engages and enters current decay mode. Thereafter the output turned on again after a period of time determined the internal timer. The process repeats itself constantly.

(Note 1) x = 1, 2, 3 or 4

2 Noise-masking function

In order to avoid misdetection of current detection comparator due to SENSEx spike noise that may occur when the output turns on, the IC employs the minimum ON-time (t_{ONMIN}). It invalids the current detection for the minimum ON-time of 1 μs (Typ) from the output transistor turned on. This allows constant-current drive without the need for an external filter.

3 Internal Timer

IC internal voltage repeat charging and discharging between VL to VH.

The detection of the internal comparator is masked while charging from VL to VH. This period defines the minimum ON-time (t_{ONMIN}). The internal voltage begins discharging once the voltage reaches VH. When the output current reaches the current limit during this period, then the IC enters decay mode. It reaches VL, at which point the IC internal voltage is switched back ON. The current output and internal terminal begin charging simultaneously.

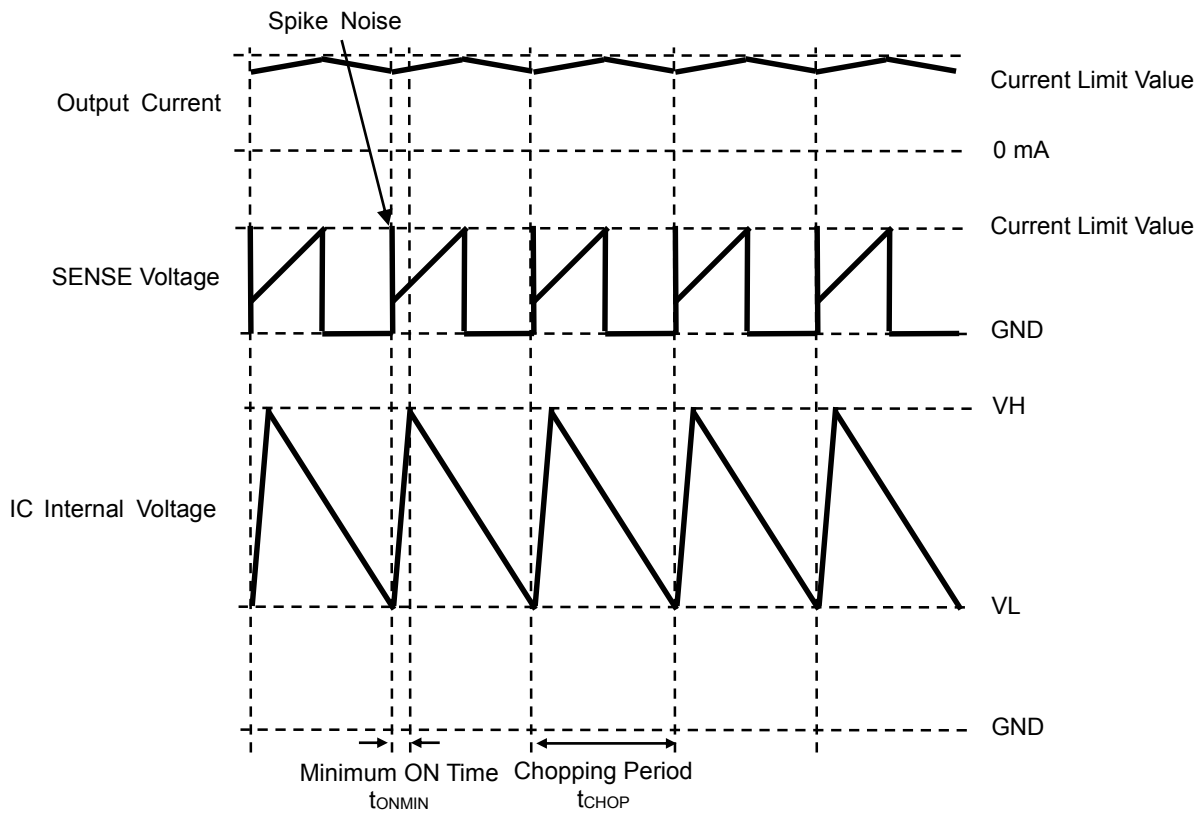


Figure 1. Timing Chart of IC Internal Voltage, the SENSEx pin voltage and Output Current

PWM Constant Current Control – continued

4 Current Decay Mode

The current decay method is SLOW DECAY for PWM Constant Current Control.

The following diagrams show the state of each transistor and the regenerative current path during the current decay for SLOW DECAY mode:

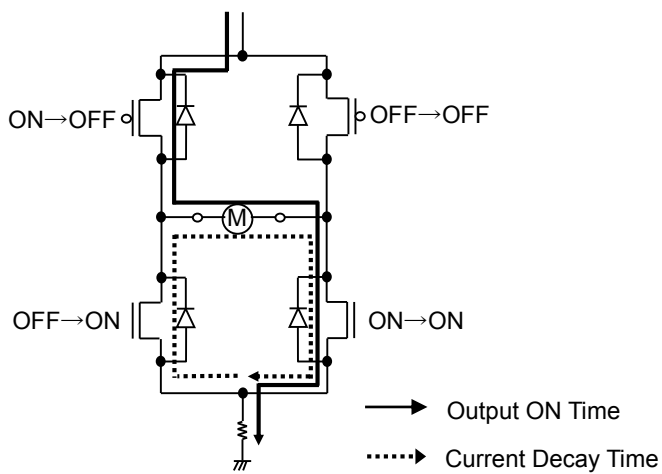


Figure 2. Route of Regenerated Current during Current Decay

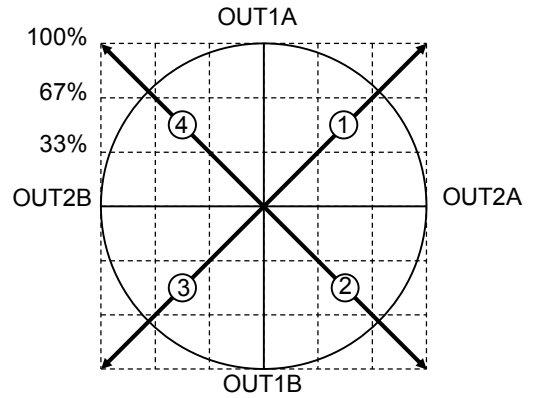
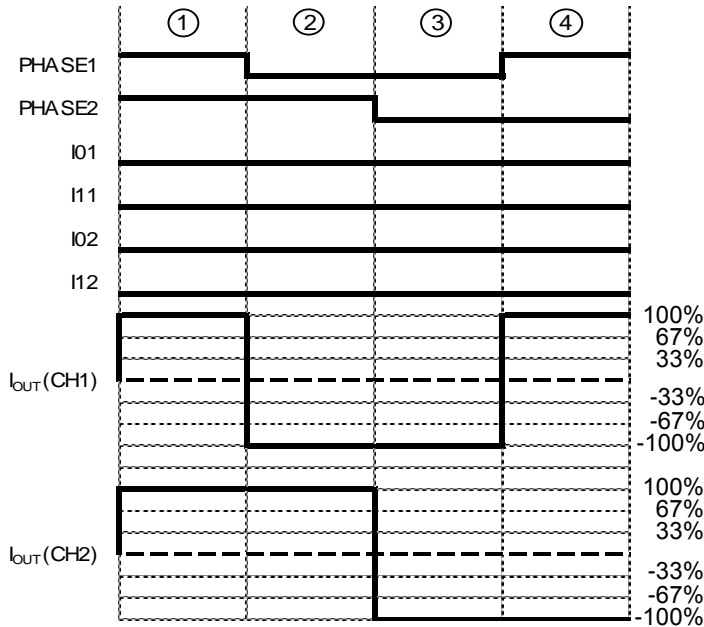
PARALLEL-IN Drive Mode - Description for CH1 (CH2: same as CH1)-

It is possible to drive stepping motor with FULL STEP, HALF STEP, and QUARTER STEP by inputting the following motor control signals using PARALLEL-IN drive mode.

Examples of control sequence and torque vector

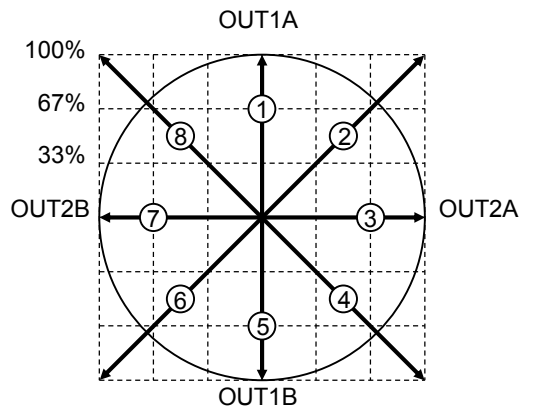
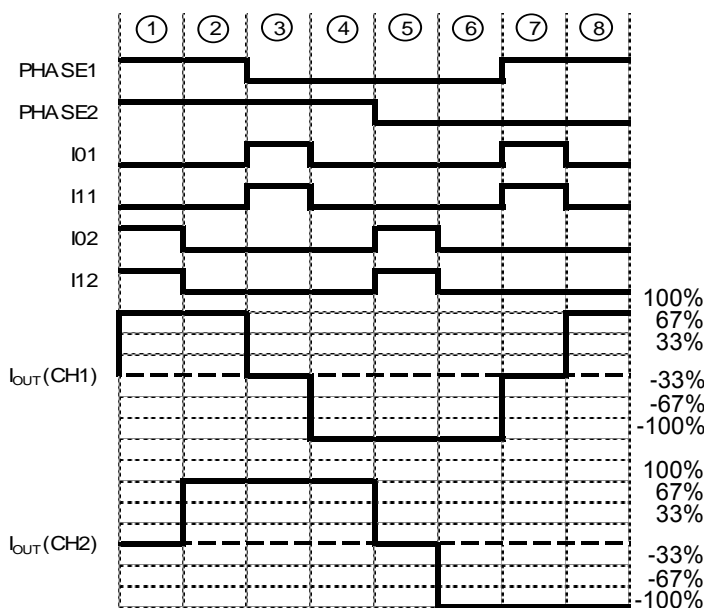
FULL STEP

Controlled by 2 logic signals of PHASE1 and PHASE2



HALF STEP A

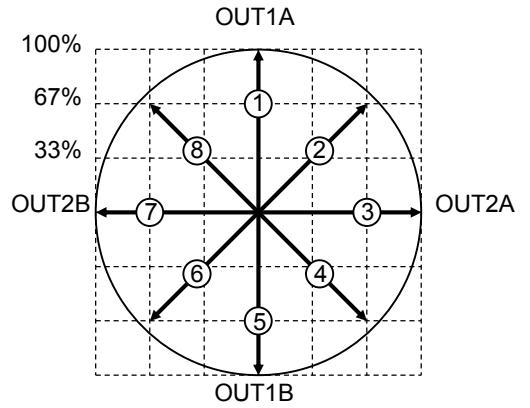
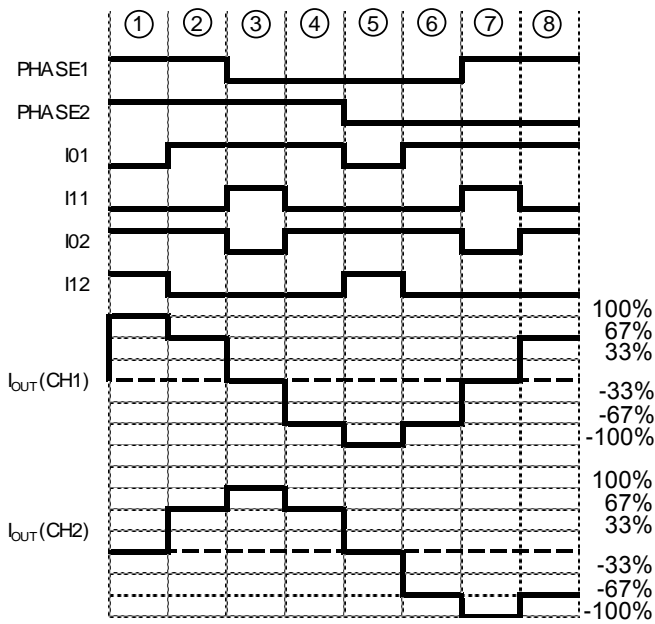
Controlled by 4 logic signals of PHASE1, PHASE2, I01 (I11), and I02 (I12)



PARALLEL-IN Drive Mode – continued

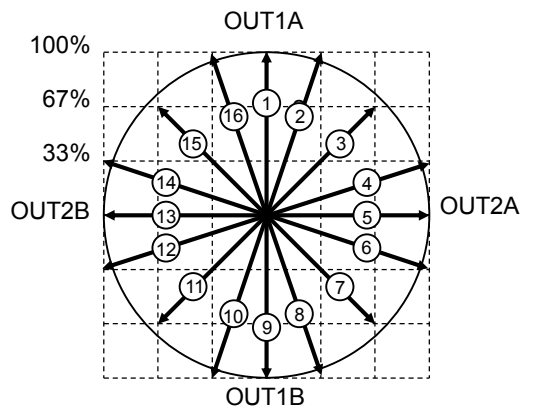
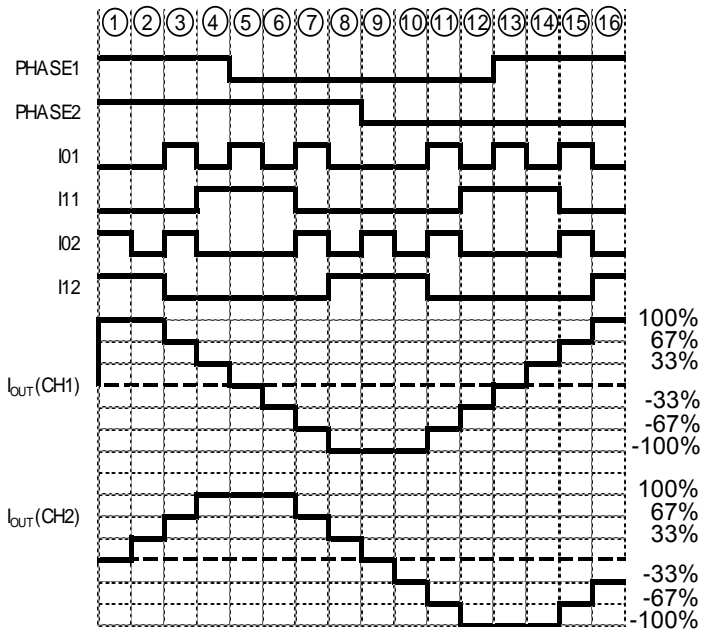
HALF STEP B

Controlled by 6 logic signals of PHASE1, PHASE2, I01, I11, I02 and I12



QUARTER STEP

Controlled by 6 logic signals of PHASE1, PHASE2, I01, I11, I02 and I12



Power Dissipation

Confirm that the IC’s chip temperature T_j is not over 150 °C in consideration of the IC’s power consumption (W), thermal resistance (°C/W) and ambient temperature (T_a). When $T_j = 150$ °C is exceeded, the functions as a semiconductor do not operate and problems such as parasitism and leaks occur. Constant use under these circumstances leads to deterioration and eventually destruction of the IC. $T_{jmax} = 150$ °C must be strictly obeyed under all circumstances.

1 Thermal Calculation

The IC’s consumed power can be estimated roughly with the power supply voltage (VBB1 and VBB2), circuit current (I_{CC}), output ON resistance (R_{ONH} , R_{ONL}) and motor output current value (I_{OUT}).

The calculation method during FULL STEP drive, SLOW DECAY mode is shown here:

$$W_{VBB} = VBB \times I_{CC} \quad [W]$$

where:

- W_{VBB} is the consumed power of the VBB.
- VBB is the power supply voltage.
- I_{CC} is the circuit current.

$$W_{DMOS} = W_{ON} + W_{DECAY} \quad [W]$$

$$W_{ON} = (R_{ONH} + R_{ONL}) \times I_{OUT}^2 \times 2 \times on_duty \quad [W]$$

$$W_{DECAY} = (2 \times R_{ONL}) \times I_{OUT}^2 \times 2 \times (1 - on_duty) \quad [W]$$

where:

- W_{DMOS} is the consumed power of the output DMOS.
- W_{ON} is the consumed power during output ON.
- W_{DECAY} is the consumed power during current decay.
- R_{ONH} is the upper P-channel DMOS ON-resistance.
- R_{ONL} is the lower N-channel DMOS ON-resistance.
- I_{OUT} is the motor output current value.
- on_duty PWM on duty= t_{ON} / t_{CHOP}
- “2” is the H bridge A and B.

t_{ON} varies depending on the L and R values of the motor coil and the current set value. Confirm by actual measurement, or make an approximate calculation.

t_{CHOP} is the chopping period, which is determined by the internal timer. Refer to [P.8](#), [9](#) for details.

IC number	Upper Pch DMOS ON Resistance $R_{ONH}[\Omega]$ (Typ)	Lower Nch DMOS ON Resistance $R_{ONL}[\Omega]$ (Typ)
BD68888MUV	0.70	0.30

$$W_{total} = W_{VBB} + W_{DMOS} \quad [W]$$

$$T_j = T_a + \theta_{ja} \times W_{total} \quad [^{\circ}C]$$

where:

- W_{total} is the consumed total power of IC.
- T_j is the junction temperature.
- T_a is the air temperature.
- θ_{ja} is the thermal resistance value.

However, the thermal resistance value θ_{ja} [°C/W] differs greatly depending on circuit board conditions. The calculated values above are only theoretical. For actual thermal design, perform sufficient thermal evaluation for the application board used, and create the thermal design with enough margin not to exceed $T_{jmax} = 150$ °C. Although unnecessary with normal use, if the IC is to be used under especially strict heat conditions, consider externally attaching a Schottky diode between the motor output pin and GND to abate heat from the IC.

Power Dissipation – continued

2 Temperature Monitoring

In respect of BD68888MUV, there is a way to directly measure the approximate chip temperature by using the LOGIC pin ($I_{0x}^{(Note\ 1)}$ or $I_{1x}^{(Note\ 1)}$) with a protection diode for prevention from electrostatic discharge. However, temperature monitor using this LOGIC pin is only for evaluation and experimenting, and must not be used in actual usage conditions.

(Note 1) x = 1, 2, 3 or 4

Process 1 Measure the pin voltage when a current of $I_{DIODE} = 50\ \mu A$ flows from the LOGIC pin to the GND, without supplying VBB1 and VBB2 to the IC. This measurement is of the V_F voltage inside the diode.

Process 2 Measure the temperature characteristics of this pin voltage. (V_F has a linear negative temperature factor against the temperature.) With the results of these temperature characteristics, chip temperature may be calibrated from the LOGIC pin voltage.

Process 3 Supply VBB1 and VBB2, confirm the LOGIC pin voltage while running the motor, and calculate approximately the chip temperature from the results of Process 2.

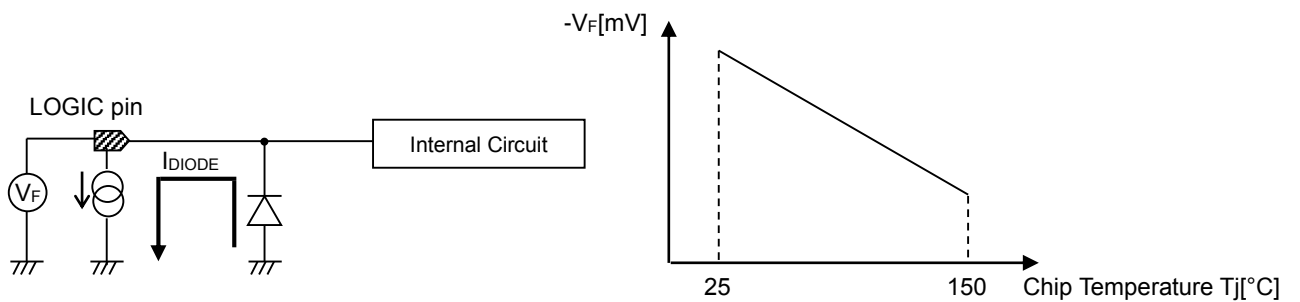
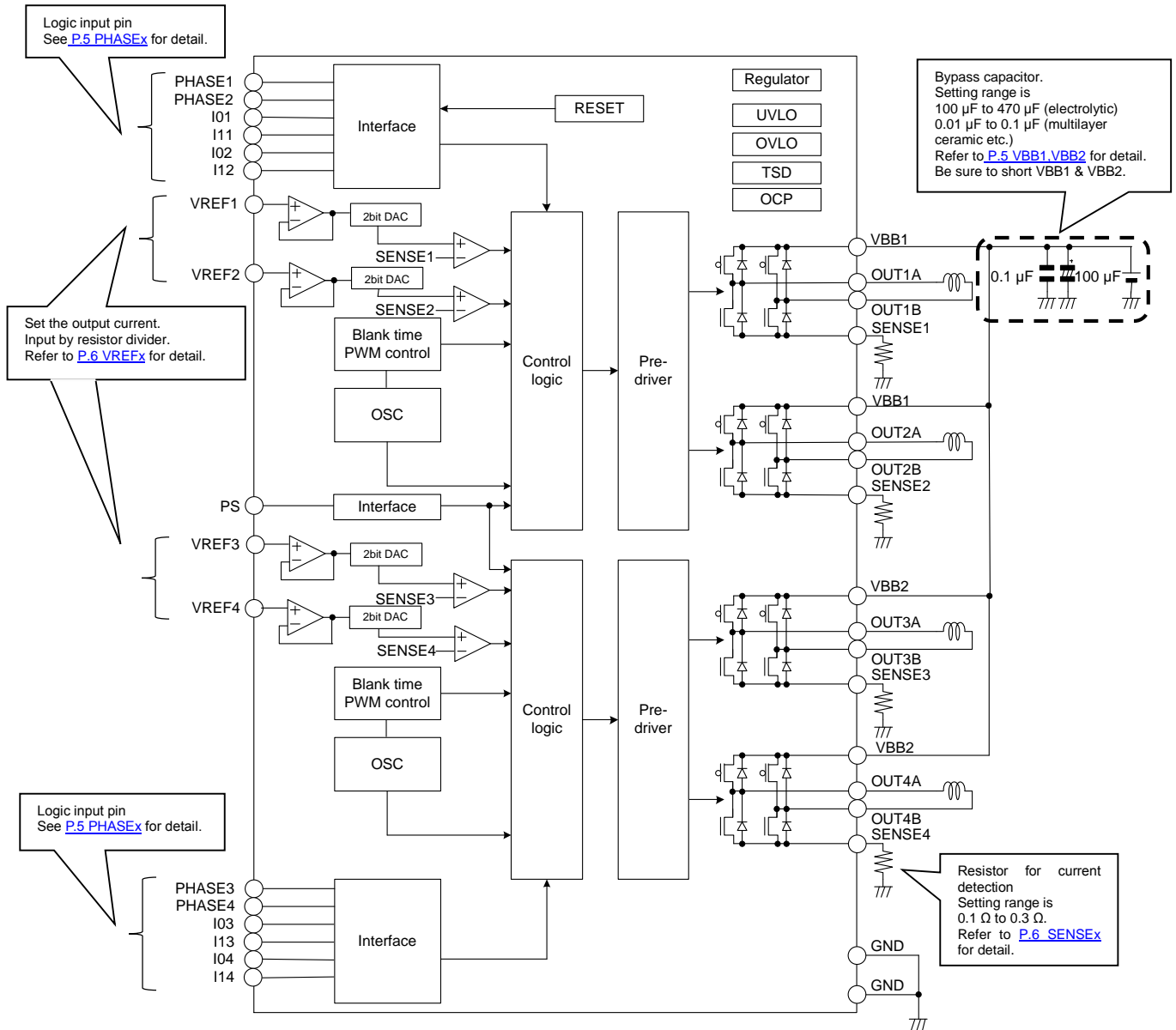
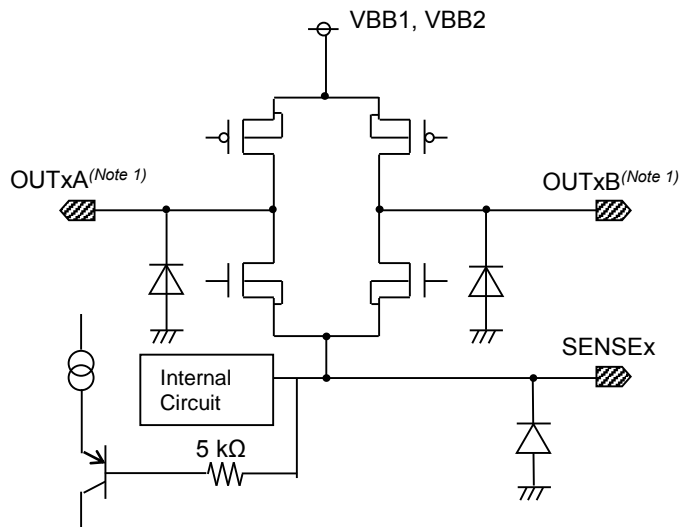
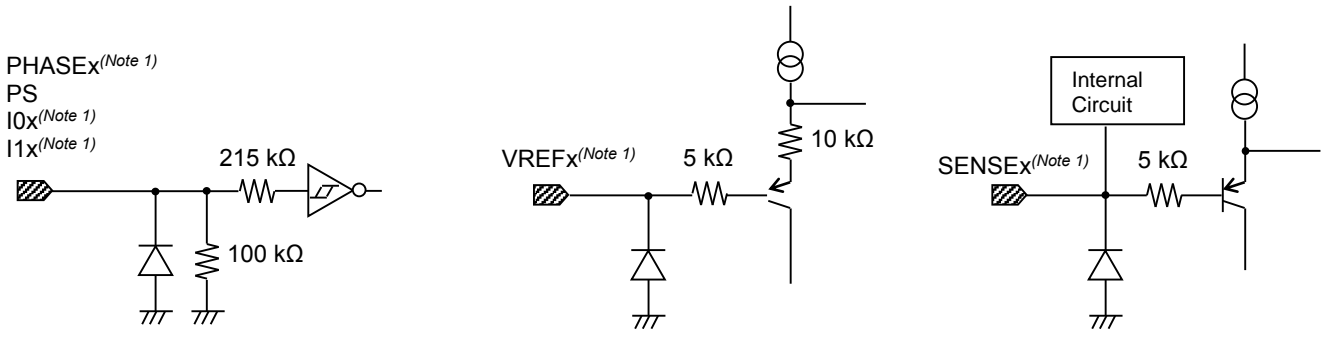


Figure 3. Model Diagram for Measuring Chip Temperature

Application Example



I/O Equivalence Circuit



(Note 1) x = 1, 2, 3 or 4

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.

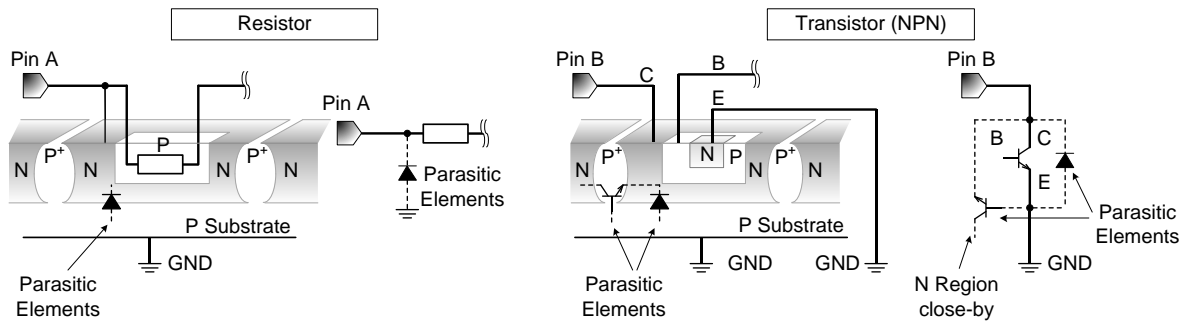


Figure 4. Example of monolithic IC structure

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)

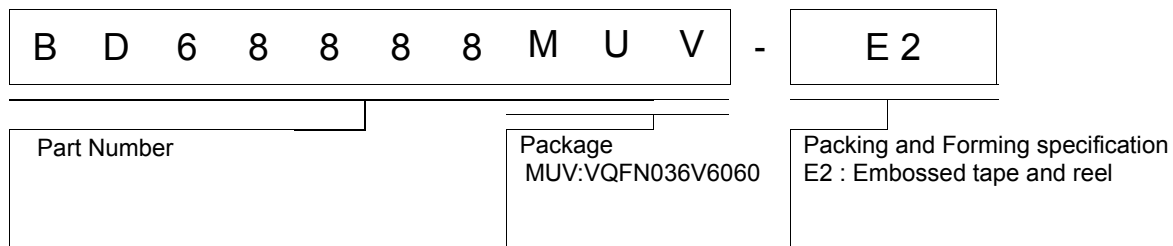
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit 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.

13. Over Current Protection Circuit (OCP)

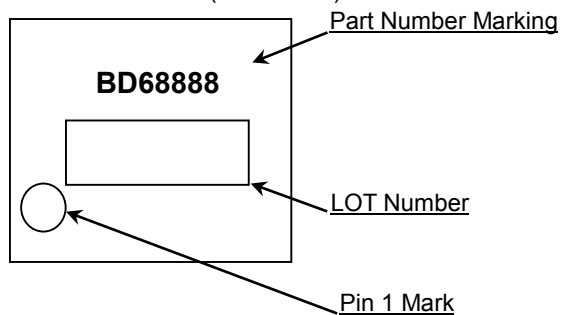
This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

Ordering Information



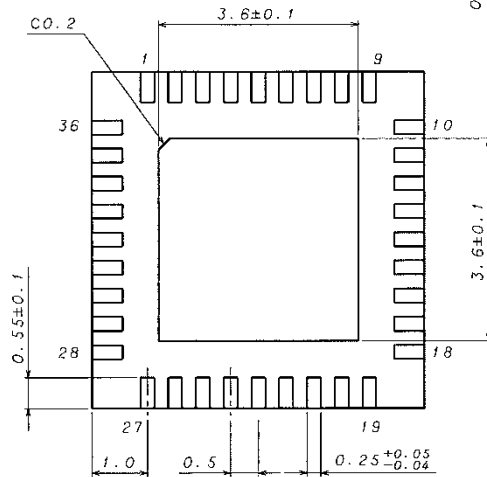
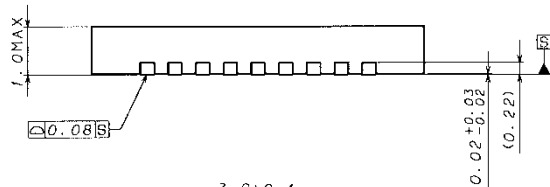
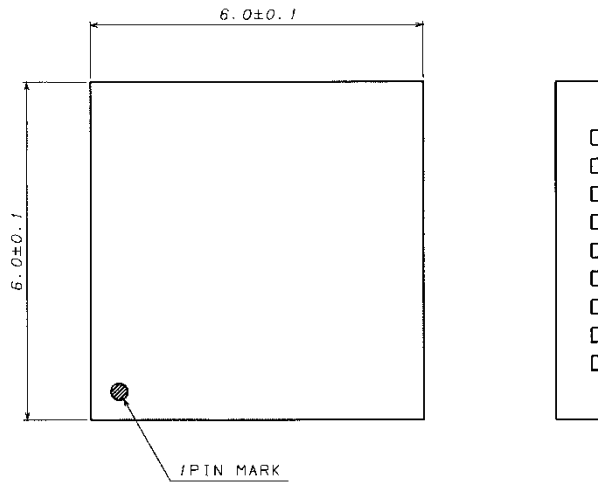
Marking Diagram

VQFN036V6060 (TOP VIEW)



Physical Dimension and Packing Information

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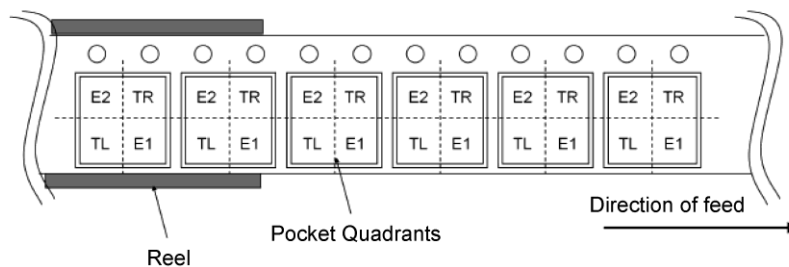


(UNIT: mm)

PKG: VQFN036V6060
Drawing No. EX472-5001

< Tape and Reel Information >

Tape	Embossed carrier tape (with dry pack)
Quantity	2000pcs
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
14.Sep.2020	001	New Release

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(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	

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 - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl₂, H₂S, NH₃, SO₂, and NO₂
 - 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 (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
 - 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 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.
- 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 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

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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:
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 - [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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