

# 36 V High Performance, High Reliability 2ch DC Brush Motor Driver

## BD62221MUV

### General Description

BD62221MUV is a built in 2 channel H-bridge motor driver for 2 DC brush motors or 1 stepper motor. This driver can facilitate low power consumption by direct PWM control or PWM constant current control. There are built in protection circuits in this IC. It is possible to output an abnormal detection signal that notifies each protection circuit operation, which contributes to set high reliability.

### Features

- Single Power Supply Input (Rated Voltage of 36V)
- Rated Output Current: 2.0A/Phase
- Rated Output Current (Peak): 3.0 A/Phase
- Low ON Resistance DMOS Output
- Forward, Reverse, Brake, Open Function
- Power Save Function
- Direct PWM Control
- PWM Constant Current Control (Current Limit Function)
- Peak Current Limit (Current Limit Function)
- Built-in Spike Noise Cancel Function (External Noise Filter is Unnecessary)
- Driver for 2 DC Brush Motor
- Driver for 1 Stepper Motor
- FULL STEP and HALF STEP Functionality (Driving Stepper Motor)
- $\mu$ STEP Drive Functionality by External DAC (Driving Stepper motor)
- Built-in Logic Input Pull-Down Resistor
- Cross Conduction Prevention Circuit
- Output Detection Signal during Abnormal States
- Thermal Shutdown Circuit (TSD)
- Over Current Protection Circuit (OCP)
- Under Voltage Lock Out Circuit (UVLO)
- Over Voltage Lock Out Circuit (OVLO)
- Protects Against Malfunction when Power Supply is Disconnected (Ghost Supply Prevention Function)
- Adjacent Pins Short Protection
- Microminiature, Ultra-thin and High Heat-radiation (Exposed Metal Type) Package

### Applications

- PPC, Multi-function Printer, Laser Printer, Inkjet Printer, Photo Printer, FAX, Mini Printer and etc.

### Key Specifications

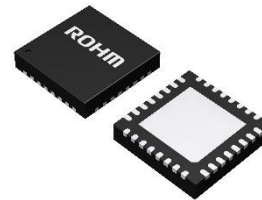
- Input Voltage Range: 8 V to 28 V
- Rated Output Current (Continuous): 2.0 A/Phase
- Rated Output Current (Peak Value): 3.0 A/Phase
- Operating Temperature Range: -25 °C to +85 °C
- Output ON Resistance: 0.55  $\Omega$  (Typ)

### Package

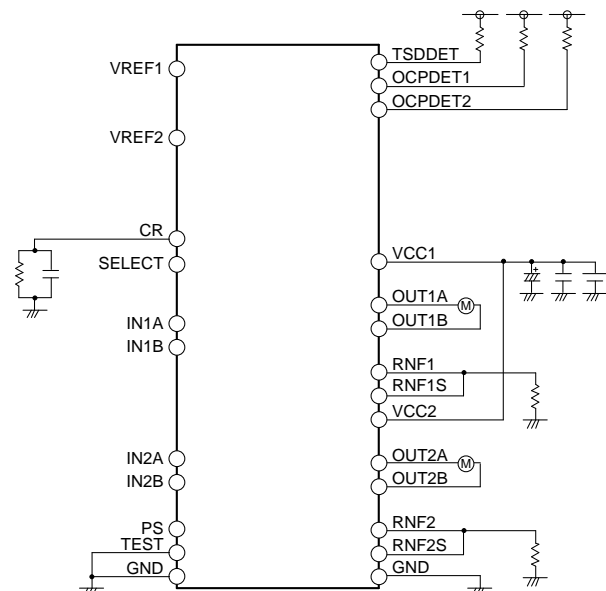
WQFN032V5050

### W (Typ) x D (Typ) x H (Max)

5.0 mm x 5.0 mm x 1.0 mm

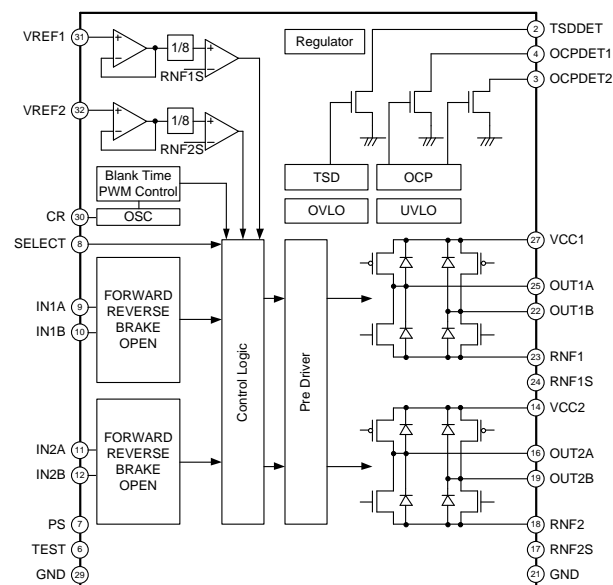
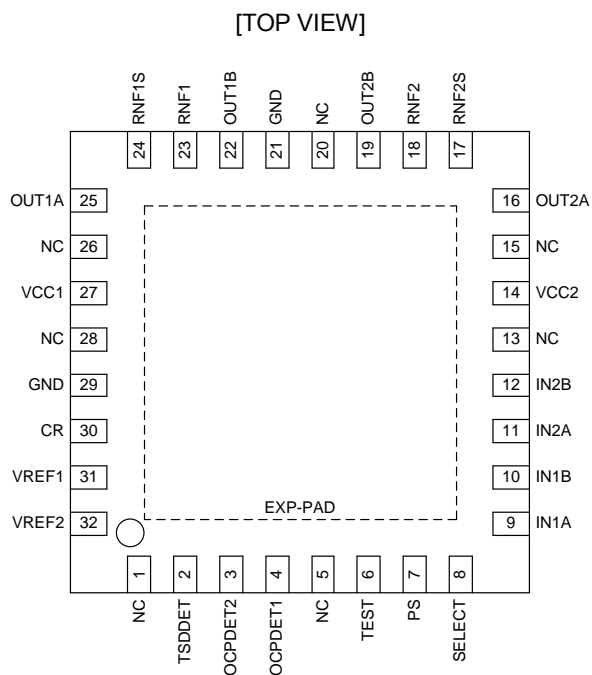


### Typical Application Circuit



Pin Configuration

Block Diagram



Pin Descriptions

Pin No.	Pin Name	Function	Pin No.	Pin Name	Function
1	NC	No connection	17	RNF2S	Input pin of current detection comparator
2	TSDDET	Output signal pin to detect abnormal states	18	RNF2	Connection pin of resistor for output current detection
3	OCPDET2	Output signal pin to detect abnormal states	19	OUT2B	H bridge output pin
4	OCPDET1	Output signal pin to detect abnormal states	20	NC	No connection
5	NC	No connection	21	GND	Ground pin
6	TEST	Pin for testing (Used by connecting with GND)	22	OUT1B	H bridge output pin
7	PS	Power save pin	23	RNF1	Connection pin of resistor for output current detection
8	SELECT	Mode selecting pin	24	RNF1S	Input pin of current detection comparator
9	IN1A	H bridge control pin	25	OUT1A	H bridge output pin
10	IN1B	H bridge control pin	26	NC	No connection
11	IN2A	H bridge control pin	27	VCC1	Power Supply pin
12	IN2B	H bridge control pin	28	NC	No connection
13	NC	No connection	29	GND	Ground pin
14	VCC2	Power supply pin	30	CR	Connection pin of CR for setting chopping frequency
15	NC	No connection	31	VREF1	Current limit value setting pin
16	OUT2A	H bridge output pin	32	VREF2	Current limit value setting pin
-	EXP-PAD	The EXP-PAD of the product connect to GND.	-	-	-

## Function Explanation

### 1 VCCx<sup>(Note 1)</sup>/Power supply pin

Motor's drive current is flowing in it, so please connect it in such a way that the wire is thick & short and has low impedance. VCCx voltage may have great fluctuation, so please connect the bypass capacitor (100 μF to 470 μF) as close as possible to the pin. Adjust in such a way that the VCC voltage is stable. Please increase the capacitance if needed, especially when large current or motors that have great back electromotive force are used.

In addition, to reduce the power supply's impedance in wide frequency bandwidth, parallel connection of multi-layered ceramic capacitor (0.01 μF to 0.1 μF) is recommended. Extreme care must be observed to make sure that the VCCx voltage does not exceed the rating even for a moment. VCC1 & VCC2 are shorted inside IC, so please be sure to short VCC1 & VCC2 externally when using. If used without shorting, malfunction or destruction may occur because of concentration of current routes etc., so please make sure that they are shorted when in use.

Moreover, there is a built-in clamp component in the output pin to prevent electrostatic destruction. If sudden pulse or surge voltage of more than the maximum absolute rating is applied, the clamp component operates which can result to destruction. Please be sure to not exceed the maximum absolute rating. It is effective to mount a Zener diode with maximum absolute rating. Also, diode is inserted between VCCx pin and GND pin to prevent electrostatic destruction. If reverse voltage is applied between VCCx pin and GND pin, there is a danger of IC destruction so please be careful.

(Note 1) x = 1, 2

### 2 GND/Ground pin

In order to reduce the noise caused by switching current and to stabilize the internal reference voltage of IC, please connect it in such a way that the wiring impedance from this pin is made as low as possible to achieve the lowest electrical potential no matter what operating state it may be.

Design the pattern so that it does not have a common impedance with other GND patterns.

### 3 PS/Power save pin

The PS pin can make circuit in standby state and make motor output OPEN.

When PS = L to 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	State
L	STANDBY
H	ACTIVE

### 4 INxA<sup>(Note 2)</sup>, INxB<sup>(Note 2)</sup>/H bridge control pin

It decides output logic for H bridge.

Input			Output		State
PS	INxA	INxB	OUTxA <sup>(Note 2)</sup>	OUTxB <sup>(Note 2)</sup>	
L	X <sup>(Note 3)</sup>	X <sup>(Note 3)</sup>	OPEN	OPEN	STANDBY
H	L	L	OPEN	OPEN	STOP
H	H	L	H	L	FORWARD
H	L	H	L	H	REVERSE
H	H	H	L	L	BRAKE

(Note 2) x = 1, 2

(Note 3) X = H or L

### 5 OUT1A,OUT1B,OUT2A,OUT2B/H bridge output pin

Motor's drive current is flowing in it, so please connect it in such a way that the wire is thick & short and has low impedance. It is also effective to add a Schottky diode if output has great positive or negative fluctuation when large current is applied. For example, a counter electromotive voltage etc. is great.

Moreover, there is a built-in clamp component in the output pin to prevent electrostatic destruction. If sudden pulse or surge voltage of more than the maximum absolute rating is applied, the clamp component operates which can result to destruction. Please be sure to not exceed the maximum absolute rating.

## Function Explanation – continued

**6 RNF<sub>x</sub><sup>(Note 1)</sup>/ Connection pin of resistor for output current detection**

Insert current detecting resistor of 0.1 Ω to 0.2 Ω between RNF<sub>x</sub> and GND.

The power consumption of current detecting resistor (W) can be calculated by the motor output current value (I<sub>OUT</sub>) and resistance for current detecting resistor (R).

$$W = I_{OUT}^2 \times R \text{ [W]}$$

Where:

W : is the power consumption of current detecting resistor [W]  
 I<sub>OUT</sub> : is the motor output current value [A]  
 R : is the current-detecting resistor [Ω]

To avoid exceeding the rated power consumption of the resistor, consider its power consumption.

In addition, design it in such a way that it has low impedance and does not have a common impedance with other GND patterns because motor's drive current flows through this pattern from the RNF<sub>x</sub> pin to current-detecting resistor to GND.

Do not exceed the rating because there is the possibility of circuits' malfunction etc., if the RNF<sub>x</sub> voltage has exceeded the maximum rating (0.7 V). If the RNF<sub>x</sub> pin is open, then there is the possibility of such malfunction as output current does not flow either, so do not let it open.

(Note 1) x = 1, 2

**7 RNF<sub>xS</sub><sup>(Note 2)</sup>/Input pin of current detection comparator**

RNF<sub>xS</sub> pin, which is the input pin of current detection comparator, is independently arranged in order to decrease the lowering of current-detection accuracy caused by the wire impedance inside the IC of RNF<sub>x</sub> pin. Therefore, please make sure to connect RNF<sub>x</sub> pin and RNF<sub>xS</sub> pin together when using PWM constant current control.

In addition, in case of interconnection, the lowering of current-detection accuracy caused by the impedance of board pattern between RNF<sub>x</sub> pin and the current-detecting resistor can be decreased because the wires from RNF<sub>xS</sub> pin is connected near the current-detecting resistor.

Moreover, please design the pattern in such a way that there is no noise spike.

(Note 2) x = 1, 2

**8 VREF<sub>x</sub><sup>(Note 3)</sup>/Current limit value setting pin**

This is the pin to set the output current value for PWM constant current control or peak current limit.

The output current value can be set by VREF<sub>x</sub><sup>(Note 3)</sup> voltage and current-detecting resistor (RNF<sub>x</sub><sup>(Note 3)</sup> resistor).

$$I_{OUT} = \frac{V_{REFx}}{8} \times \frac{1}{R_{NFx}} \text{ [A]}$$

Where:

I<sub>OUT</sub> : is the motor output current value [A]  
 VREF<sub>x</sub> : is the voltage of current limit value setting pin [V]  
 RNF<sub>x</sub> : is the current-detecting resistor [Ω]

Please avoid using it with VREF<sub>x</sub> pin open. If VREF<sub>x</sub> pin is open, there is possibility of malfunctions as the setting current increases and a large current flows etc. This is caused by unstable input and increasing VREF<sub>x</sub> voltage. Please take note of the input voltage range because if voltage of over 3 V is applied on VREF<sub>x</sub> pin, there is also a danger that large current flows in the output and OCP or TSD will operate.

Also, when selecting the resistance value please take into consideration the outflow current (Max 2 μA) produced by resistance division. The minimum current, which can be controlled by VREF<sub>x</sub> voltage, is determined by motor coil's L & R values and minimum ON time. There is a minimum ON time in PWM drive.

(Note 3) x = 1, 2

**9 SELECT/Mode selecting pin**

This is the pin to select a mode under Current Limit Function. It allows you to select PWM Constant Current Control (Refer to [page 10](#)), and Peak Current Limit (Refer to [page 12](#)).

SELECT	Mode
L	PWM Constant Current Control
H	Peak Current Limit

## Function Explanation – continued

**10 CR/Connection pin of CR for setting chopping frequency**

This is the pin to set the switching frequency of the output for PWM constant current control. Please connect the external C (330 pF to 680 pF) and R (10 kΩ to 150 kΩ) between this pin and GND. Please refer to [page 10](#). Please connect the external components to GND in such a way that the interconnection does not have impedance in common with other GND patterns. In addition, please create the pattern design in such a way to keep such sudden pulses as square wave etc. away and that there is no noise spike. Please mount the two components of C and R if PWM constant current control is being used. This is because normal PWM constant current control cannot be used if CR pin is open or it is biased externally. When not using PWM constant current control, connect this pin to GND.

**11 TSDDDET, OCPDET1, OCPDET2/Output signal pin to detect abnormal states**

TSDDDET, OCPDET1 and OCPDET2 outputs low signal when Over Current Protection (OCP) or Thermal Shutdown (TSD) operates. Even if Under Voltage Lock Out (UVLO) or Over Voltage Lock Out (OVLO) operates, TSDDDET, OCPDET1 and OCPDET2 signal doesn't turn low (i.e. high). This pin is an open drain type, so please set the pull up resistor (5 kΩ to 100 kΩ) to power supply less than 7 V (i.e. 5 V or 3.3 V). If not using this pin, please connect it to GND.

Pin Name	Detection Protection Circuit	State	Output
TSDDDET	TSD	OFF	H
		ON	L
OCPDET1	1ch H Bridge OCP	OFF	H
		ON	L
OCPDET2	2ch H Bridge OCP	OFF	H
		ON	L

**12 TEST/Pin for testing**

It is a pin to use at the time of an IC shipment test. Use it in GND connection. In addition, malfunctions may be caused by application without grounding.

**13 NC/No connection**

This pin is unconnected electrically with IC internal circuit.

**14 IC Back Metal**

VQFN032V5050 package has a metal for heat dissipation on the back of the IC. Since it is assumed to be used by applying heat dissipation treatment to this metal, always GND on the substrate connect with the plane and solder, and use the GND pattern widely to ensure sufficient heat dissipation area. In addition, the backside metal is short and the back of the IC chip, so it has become a GND potential. Because there is a possibility of malfunction and destruction when it is short and the potential other than GND, never pass the wiring pattern other than GND on the back of the IC.

## 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 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, even when TSD is in operation, if heat is continued to be added externally, 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 VCC-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 by 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 by the PS pin, 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, the motor outputs are shorted each other or VCC-motor output or motor output-GND is shorted., if the output pin voltage jumps up and the absolute maximum values can be exceeded after the over current has flowed, there is a possibility of destruction. 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  $T_{jmax} = 150\text{ °C}$  exceeds and can deteriorate, so current which or more 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 is low. When the applied voltage to the  $VCC_x$ <sup>(Note 1)</sup> 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 false operation by 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.

(Note 1) x = 1, 2

### 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  $VCC_x$ <sup>(Note 2)</sup> 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 false operation by 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.

(Note 2) x = 1, 2

### 5 Protects against malfunction when power supply is disconnected (Ghost Supply Prevention Function)

If a control signal<sup>(Note 3)</sup> 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  $VCC_x$ <sup>(Note 4)</sup>. Therefore, there is no malfunction of the circuit even when voltage is supplied to these input pins while there is no power supply.

(Note 3) control signal = PS, IN1A, IN1B, IN2A, IN2B, VREF1, VREF2, SELECT

(Note 4) x = 1, 2

### 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.

## Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V <sub>CC</sub>	-0.2 to +36.0	V
Input Voltage for Control Pin <sup>(Note 1)</sup>	V <sub>IN</sub>	-0.2 to +5.5	V
Input Voltage for VREFx <sup>(Note 2)</sup> Pin	V <sub>VREF</sub>	-0.2 to +5.5	V
RNFx <sup>(Note 2)</sup> Maximum Voltage	V <sub>RNF</sub>	0.7	V
Output Current (Continuous)	I <sub>OUT</sub>	2.0 <sup>(Note 3)</sup>	A/Phase
Output Current (Peak Value)	I <sub>OUTPEAK</sub>	3.0 <sup>(Note 3)(Note 4)</sup>	A/Phase
Storage Temperature Range	T <sub>stg</sub>	-25 to +150	°C
Maximum Junction Temperature	T <sub>jmax</sub>	+150	°C

(Note 1) Input Voltage for Control Pin = PS, IN1A, IN1B, IN2A, IN2B, VREF1, VREF2, SELECT

(Note 2) x = 1, 2

(Note 3) Do not exceed T<sub>jmax</sub> = 150 °C

(Note 4) Pulse width tw ≤ 1ms, duty 20ms

**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.

## Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Supply Voltage	V <sub>CC</sub>	8	24	28	V
Operating Temperature	T <sub>opr</sub>	-25	+25	+85	°C
Maximum Output Current (Continuous)	I <sub>OUT</sub>	-	-	1.4 <sup>(Note 5)</sup>	A/Phase

(Note 5) Do not exceed T<sub>jmax</sub> = 150 °C

Thermal Resistance <sup>(Note 6)</sup>

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s <sup>(Note 8)</sup>	2s2p <sup>(Note 9)</sup>	
VQFN032V5050				
Junction to Ambient	θ <sub>JA</sub>	90.5	24.8	°C/W
Junction to Top Characterization Parameter <sup>(Note 7)</sup>	Ψ <sub>JT</sub>	9	5	°C/W

(Note 6) Based on JESD51-2A (Still-Air), using a BD62221MUV Chip.

(Note 7) 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 8) Using a PCB board based on JESD51-3.

(Note 9) 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 <sup>(Note 10)</sup>	
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt		Pitch	Diameter
				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 10) This thermal via connects with the copper pattern of all layers.

Electrical Characteristics (Unless otherwise specified  $V_{CC} = 24\text{ V}$ ,  $T_a = 25\text{ }^\circ\text{C}$ )

Item	Symbol	Min	Typ	Max	Unit	Condition
<b>[Whole]</b>						
Circuit Current at Standby	$I_{CCST}$	-	0	10	$\mu\text{A}$	PS = L
Circuit Current	$I_{CC}$	-	2.0	5.0	mA	PS = H, $V_{REFx}^{(Note\ 1)} = 3\text{ V}$
<b>[Control Logic Input<sup>(Note 2)</sup>]</b>						
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	$\mu\text{A}$	$V_{IN} = 5\text{ V}$
L-level Input Current	$I_{INL}$	-10	0	-	$\mu\text{A}$	$V_{IN} = 0\text{ V}$
<b>[Output<sup>(Note 3)</sup>]</b>						
Output ON Resistance	$R_{ON}$	-	0.55	0.75	$\Omega$	$I_{OUT} = \pm 1.0\text{ A}$ (Sum of upper and lower)
Output Leak Current	$I_{LEAK}$	-	-	10	$\mu\text{A}$	
<b>[Output to Detect Abnormal States<sup>(Note 4)</sup>]</b>						
Output L Voltage	$V_{DET}$	-	300	600	mV	TSDDET = 6 mA <sup>(Note 5)</sup> OCPDET1 = 6 mA <sup>(Note 5)</sup> OCPDET2 = 6 mA <sup>(Note 5)</sup>
Output Leak Current	$I_{DET\_LEAK}$	-	-	10	$\mu\text{A}$	TSDDET = 5 V OCPDET1 = 5 V OCPDET2 = 5 V
<b>[Current Control]</b>						
$RNFxS^{(Note\ 1)}$ Input Current	$I_{RNFS}$	-2.0	-0.1	-	$\mu\text{A}$	$RNFxS = 0\text{ V}$
$RNFx^{(Note\ 1)}$ Input Current	$I_{RNF}$	-80	-40	-	$\mu\text{A}$	$RNFx = 0\text{ V}$
$VREFx^{(Note\ 1)}$ Input Current	$I_{VREF}$	-2.0	-0.1	-	$\mu\text{A}$	$VREFx = 0\text{ V}$
$VREFx^{(Note\ 1)}$ Input Voltage Range	$V_{VREF}$	0	-	3.0	V	
Minimum ON Time (Cancel Time)	$t_{ONMIN}$	0.7	1.5	3.0	$\mu\text{s}$	
$RNFxS^{(Note\ 1)}$ Comparator Threshold	$V_{CTH}$	0.356	0.375	0.394	V	$V_{REFx}^{(Note\ 1)} = 3\text{ V}$

(Note 1) x = 1, 2

(Note 2) Control Logic Input = PS, IN1A, IN1B, IN2A, IN2B, SELECT

(Note 3) Output = OUT1A, OUT1B, OUT2A, OUT2B

(Note 4) Output to Detect Abnormal States = TSDDET, OCPDET1, OCPDET2

(Note 5) Input Current



**External PWM Control**

This series can drive motors by IN1A, IN1B, IN2A, and IN2B input directly from the microcomputer (up to 5 μs pulse width). Decay mode can be SLOW DECAY or FAST DECAY.

The control sequence example and the current decay route are shown below:

**1 SLOW DECAY (Forward Rotation)**

Input			Output		State
PS	INxA <sup>(Note 1)</sup>	INxB <sup>(Note 1)</sup>	OUTxA <sup>(Note 1)</sup>	OUTxB <sup>(Note 1)</sup>	
H	H	L	H	L	ON
H	H	H	L	L	SLOW DECAY
H	H	L	H	L	ON
H	H	H	L	L	SLOW DECAY
H	H	L	H	L	ON

(Note 1) x = 1, 2

**2 FAST DECAY (Forward Rotation)**

Input			Output		State
PS	INxA <sup>(Note 2)</sup>	INxB <sup>(Note 2)</sup>	OUTxA <sup>(Note 2)</sup>	OUTxB <sup>(Note 2)</sup>	
H	H	L	H	L	ON
H	L	H	L	H	FAST DECAY
H	H	L	H	L	ON
H	L	H	L	H	FAST DECAY
H	H	L	H	L	ON

(Note 2) x = 1, 2

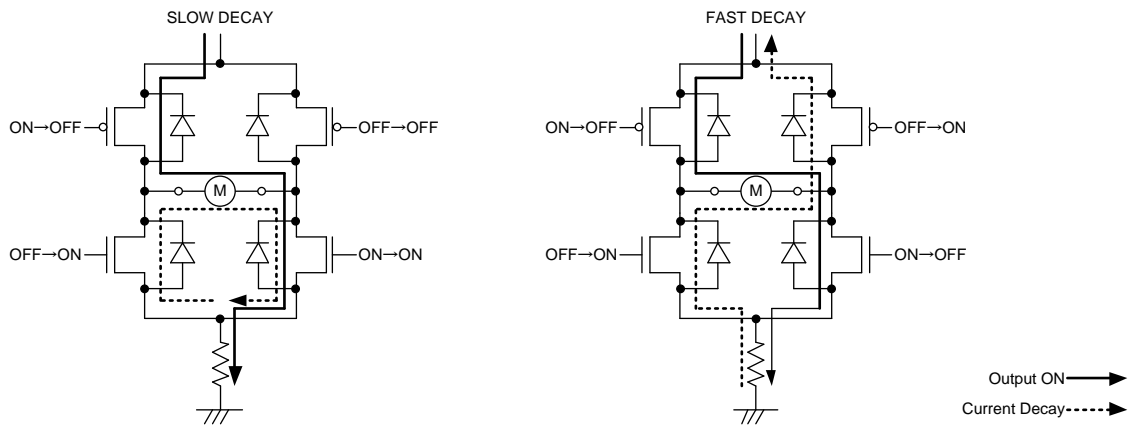


Figure 1. Route of Regenerative Current during Current Decay

## PWM Constant Current Control

This function can limit the peak current or switching current in driving DC brush motor. In addition, it can drive bipolar stepper motor by PWM constant current control.

### 1 Current Control Operation

When the output transistor is turned on, the output current increases. The output current is converted to voltage due to the connected external resistance to the  $RNF_X^{(Note\ 1)}$  pin. When the voltage on the  $RNF_X$  pin reaches the voltage value set by the  $VREF_X^{(Note\ 1)}$  input voltage, the current limit comparator operates and enters current decay mode. Output turns on again after changing CR pin to charge from discharge. The process repeats itself with chopping period ( $t_{CHOP}$ ).

(Note 1)  $x = 1, 2$

### 2 Cancel Time (Fixed in Internal Circuit)

In order to avoid misdetection of current detection comparator due to  $RNF_X^{(Note\ 2)}$  spike noise that may occur when the output turns ON, the IC has the minimum ON time  $t_{ONMIN}$  (Cancel Time). The current detection is invalid from the output transistor turned on to  $1.5\ \mu\text{s}$  (Typ). This allows for constant-current drive without the need for an external filter.

(Note 2)  $x = 1, 2$

### 3 CR Timer

The external capacitor and resistor connected to the CR pin is repeatedly charged and discharged between the  $V_{CRH}$  and  $V_{CRL}$  levels. The CR pin voltage decides in IC and it is  $V_{CRL} = 0.4\ \text{V}$ ,  $V_{CRH} = 1.0\ \text{V}$  respectively. When the output current reaches the current limit during this period, then the IC enters decay mode. The CR continues to discharge during this period until it reaches  $V_{CRL}$ , at which point the IC output is switched back ON.

The current output and the CR pin begin charging simultaneously. The CR charge time ( $t_{CHARGE}$ ) and discharge time ( $t_{DISCHARGE}$ ) are set by external components, according to the following formulas. The total of  $t_{CHARGE}$  and  $t_{DISCHARGE}$  yield the chopping period,  $t_{CHOP}$ .

$$t_{CHARGE} \cong C \times \frac{R' \times R}{R' + R} \times \ln \left( \frac{V_{CR} - 0.4}{V_{CR} - 1.0} \right) \text{ [s]}$$

$t_{CHARGE}$  : is the minimum ON-time [s]  
 $C$  : is the capacitance of the CR Pin [F]  
 $R$  : is the resistance of the CR Pin [ $\Omega$ ]  
 $R'$  : is the CR Pin internal impedance  $5\ \text{k}\Omega$  (Typ)  
 $V_{CR}$  : is the CR Pin voltage [V]

$$V_{CR} = V \times \frac{R}{R' + R} \text{ [V]}$$

$V$  : is the internal regulator voltage  $5\ \text{V}$  (Typ)

$$t_{DISCHARGE} \cong C \times R \times \ln \left( \frac{1 + \alpha}{0.4} \right) \text{ [s]}$$

$t_{DISCHARGE}$  : is the CR discharge time. [s]  
 $\alpha$  : Refer to the right graph.

$$t_{CHOP} = t_{CHARGE} + t_{DISCHARGE} \text{ [s]}$$

$t_{CHOP}$  : is the chopping period. [s]

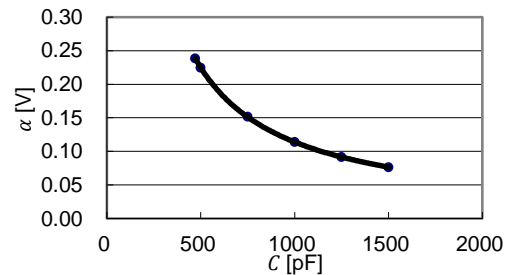


Figure 2. CR Coefficient for Calculation of Discharge Time

3 CR Timer – continued

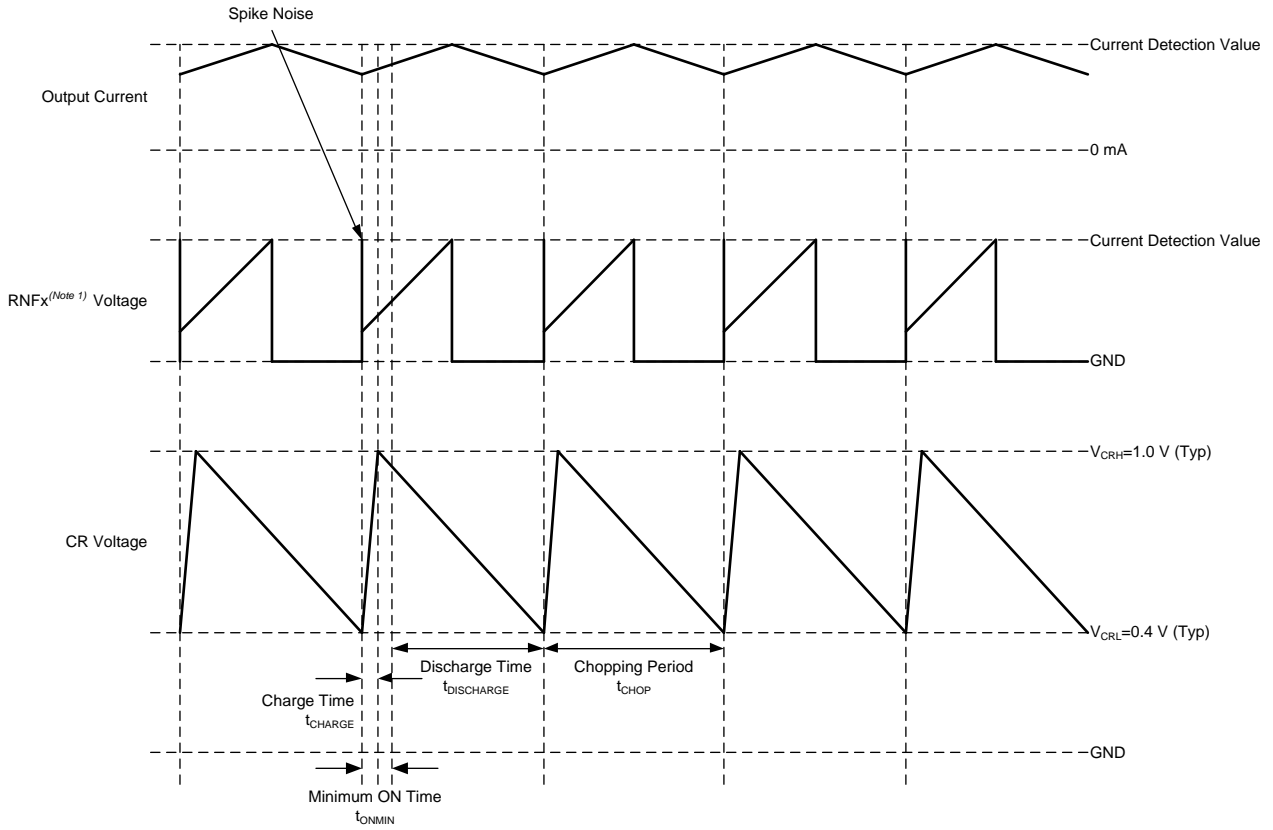


Figure 3. Timing Chart of CR Voltage, RNFX Voltage and Output Current

Setting range: C (330 pF to 680 pF), R (10 kΩ to 150 kΩ)  
 (Note 1) x = 1, 2

**Peak Current Limit**

This function can limit the peak current including over current when DC brush motor is locked.

The timing when the IC output switches back ON can be controlled by a microcomputer and etc., to synchronize the timing with PWM input to INxA<sup>(Note 1)</sup> or INxB<sup>(Note 1)</sup>.

(Note 1) x = 1, 2

**1 Current Control Operation**

The output current increases when the motor is locked. This output current is converted to voltage by the connected external resistor to the RNF<sub>x</sub><sup>(Note 2)</sup> pin. When the voltage on the RNF<sub>x</sub> pin reaches the voltage value set by the VREF<sub>x</sub><sup>(Note 2)</sup> input voltage, the current limit comparator operates and enters current decay mode. Then, output turns on again after changing PWM logic input to INxA or INxB to “FORWARD” or “REVERSE”.

(Note 2) x = 1, 2

**2 Cancel Time (Fixed in Internal Circuit)**

In order to avoid misdetection of current detection comparator due to RNF<sub>x</sub><sup>(Note 3)</sup> spike noise that may occur when the output turns ON, the IC has the minimum ON time  $t_{ONMIN}$  (Cancel Time). The current detection is invalid from the output transistor turned on to 1.5  $\mu$ s (Typ). This allows for constant-current drive without the need for an external filter.

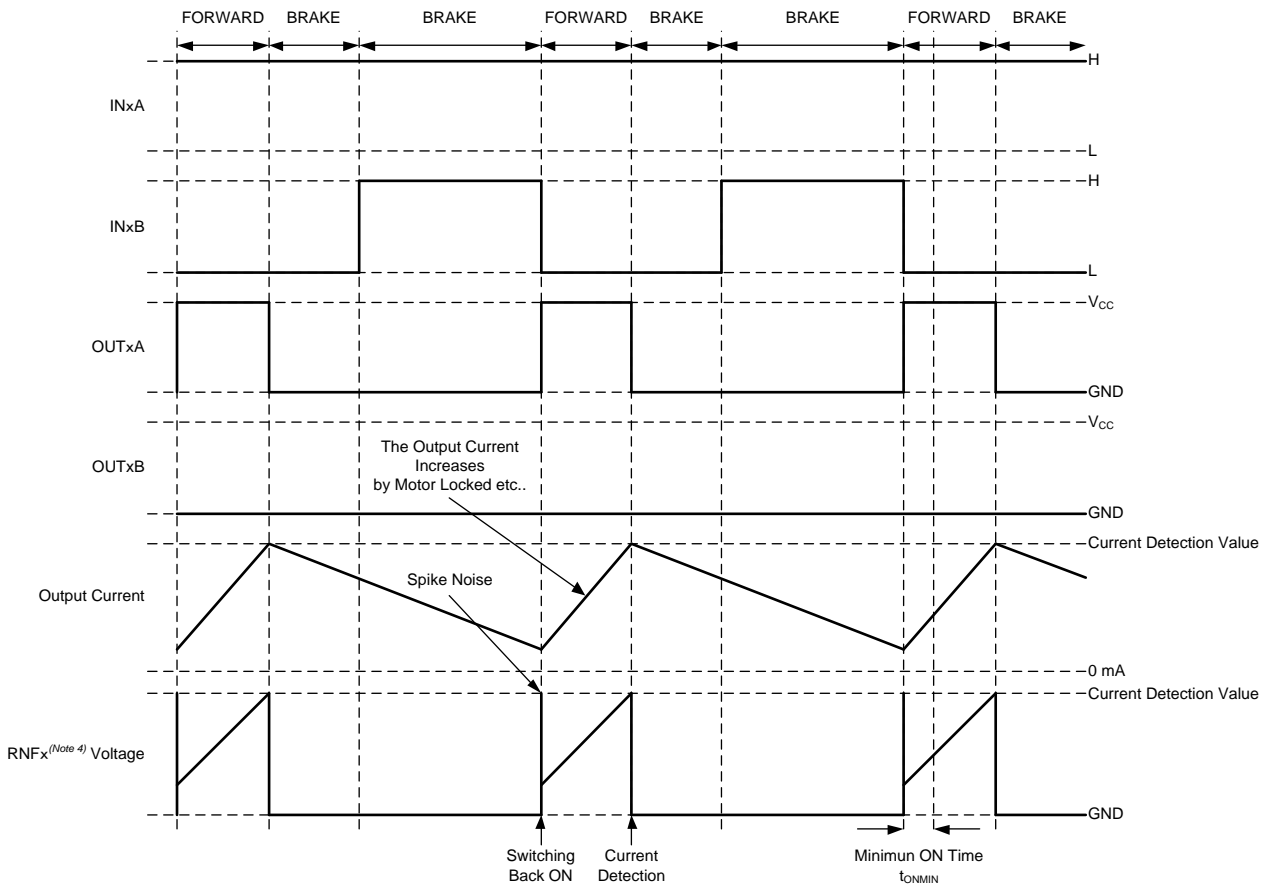
(Note 3) x = 1, 2

**3 Timing Chart**

This function can be used when driving with either INxA or INxB fixed to H, while the other is with PWM input. The timing chart in each drive state is shown below.

**3.1 FORWARD-BRAKE**

The timing chart in driving with FORWARD-BRAKE (INxA fixed to H and PWM input to INxB) is shown in Figure 4. When INxA is H and INxB is L, OUTxA<sup>(Note 4)</sup> and OUTxB<sup>(Note 4)</sup> become FORWARD logic if the output current doesn't reach the current setting value. On the other hand, OUTxA and OUTxB become BRAKE logic if the output current increases due to locked motor, and reaches the current setting value. Then, INxB becomes H, and the IC output switches back ON at the next fall timing of INxB.



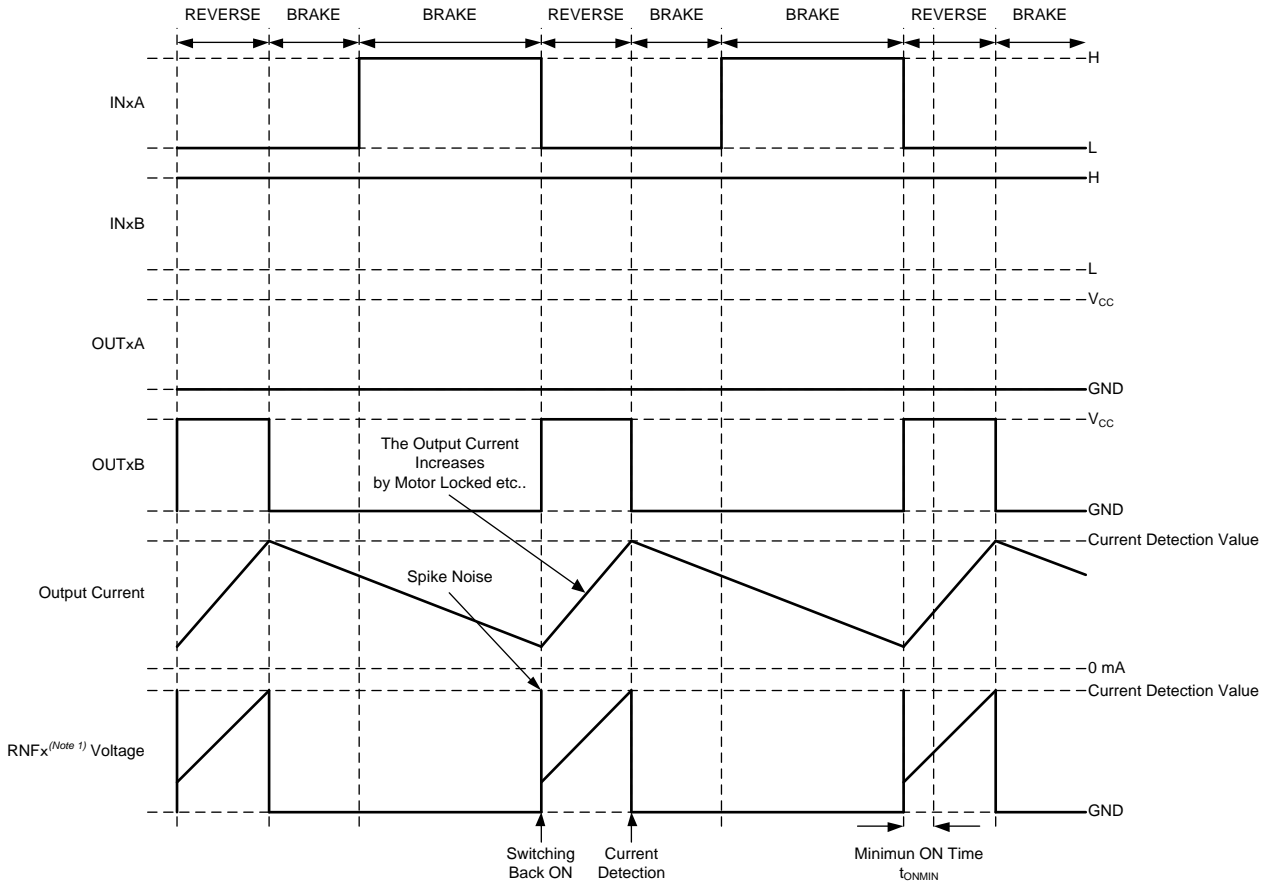
(Note 4) x = 1, 2

Figure 4. FORWARD-BRAKE Timing Chart

3 Timing Chart – continued

3.2 REVERSE-BRAKE

The timing chart in driving with REVERSE-BRAKE (PWM input to INxA and INxB fixed to H) is shown in Figure 5. When INxA is L and INxB is H, OUTxA<sup>(Note 1)</sup> and OUTxB<sup>(Note 1)</sup> become REVERSE logic, if the output current doesn't reach the current setting value. If the output current increase by motor locked and reaches the current detection value, OUTxA and OUTxB become BRAKE logic. On the other hand, OUTxA and OUTxB become BRAKE logic if the output current increases due to locked motor, and reaches the current setting value. Then, INxA becomes H, and the IC output switches back ON at the next fall timing of INxA.



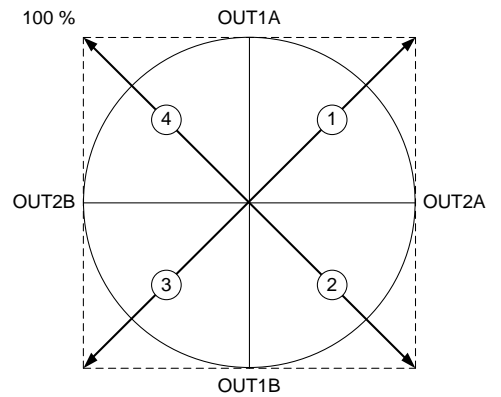
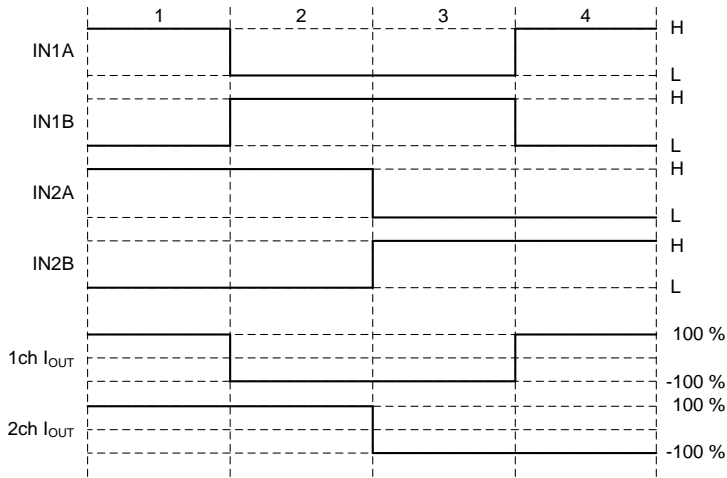
(Note 1) x = 1, 2

Figure 5. REVERSE-BRAKE Timing Chart

**Control Sequence of Stepper Motor**

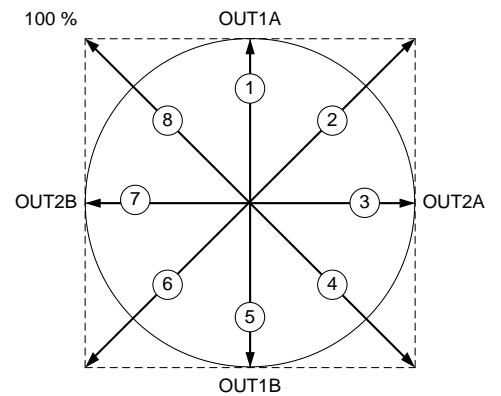
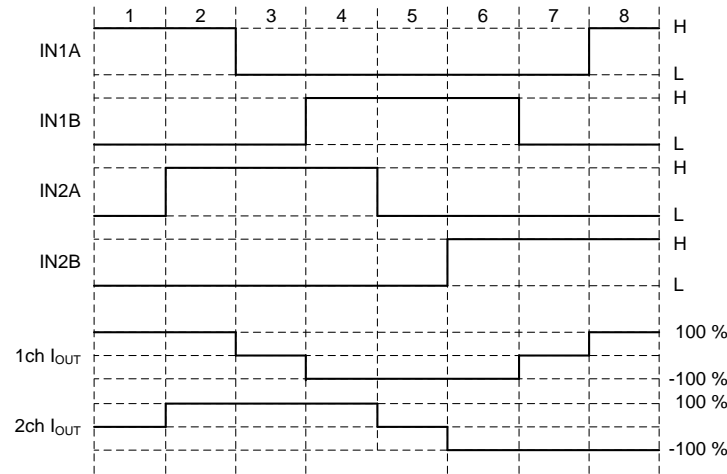
The following sequence can control the stepper motor by FULL STEP or HALF STEP mode.  
The control sequence example and the torque vector are shown below.

**1 FULL STEP Control Sequence**



	IN1A	IN1B	IN2A	IN2B	OUT1A	OUT1B	OUT2A	OUT2B
1	H	L	H	L	H	L	H	L
2	L	H	H	L	L	H	H	L
3	L	H	L	H	L	H	L	H
4	H	L	L	H	H	L	L	H

**2 HALF STEP Control Sequence**



	IN1A	IN1B	IN2A	IN2B	OUT1A	OUT1B	OUT2A	OUT2B
1	H	L	L	L	H	L	OPEN	OPEN
2	H	L	H	L	H	L	H	L
3	L	L	H	L	OPEN	OPEN	H	L
4	L	H	H	L	L	H	H	L
5	L	H	L	L	L	H	OPEN	OPEN
6	L	H	L	H	L	H	L	H
7	L	L	L	H	OPEN	OPEN	L	H
8	H	L	L	H	H	L	L	H

### μSTEP Drive for Stepper Motor

Output current of channel 1 and channel 2 can be determined by  $VREF_x$ <sup>(Note 1)</sup>. 1ch and 2ch output logic can be done by  $INxA$ <sup>(Note 1)</sup>,  $INxB$ <sup>(Note 1)</sup>. Therefore, linear voltage input by external DAC to  $VREF_x$  enables to drive stepper motor in μSTEP mode.

(Note 1)  $x = 1, 2$

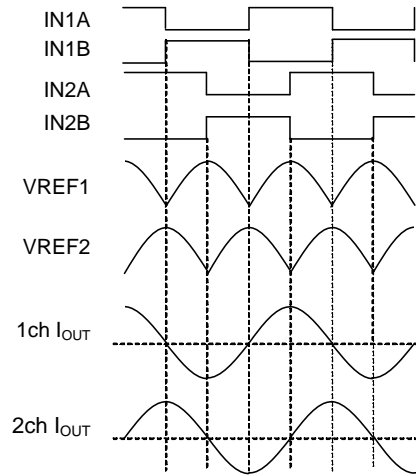


Figure 6. μSTEP Control Sequence and Output Current

## Power Dissipation

Please confirm that the IC's chip temperature  $T_j$  is not over 150 °C. Consider 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 parasitic and leaks occur. Constant use under these conditions 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 ( $V_{CC}$ ), circuit current ( $I_{CC}$ ), output ON-Resistance ( $R_{ONH}$ ,  $R_{ONL}$ ) and motor output current value ( $I_{OUT}$ ). The calculation method during external PWM drive, SLOW DECAY is shown here:

When using both channel 1 and channel 2, calculate for each H bridge.

$$W_{VCC} = V_{CC} \times I_{CC} \text{ [W]}$$

$W_{VCC}$  : Consumed power of the  $V_{CC}$  [W]  
 $V_{CC}$  : Power supply voltage [V]  
 $I_{CC}$  : Circuit current [A]

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

$$W_{ON} = (R_{ONH} + R_{ONL}) \times I_{OUT}^2 \times \frac{on\_duty}{100} \text{ [W]}$$

$$W_{DECAY} = (2 \times R_{ONL}) \times I_{OUT}^2 \times \left(1 - \frac{on\_duty}{100}\right) \text{ [W]}$$

$W_{DMOS}$  : Consumed power of the output DMOS [W]  
 $W_{ON}$  : Consumed power during output ON [W]  
 $W_{DECAY}$  : Consumed power during current decay [W]  
 $R_{ONH}$  : Upper P-Channel DMOS ON-Resistance [ $\Omega$ ]  
 $R_{ONL}$  : Lower N-Channel DMOS ON-Resistance [ $\Omega$ ]  
 $I_{OUT}$  : Motor output current [A]  
 $on\_duty$  : PWM on duty [%]

Model Number	Upper P-Channel DMOS ON-Resistance $R_{ONH}$ [ $\Omega$ ] (Typ)	Lower N-Channel DMOS ON-Resistance $R_{ONL}$ [ $\Omega$ ] (Typ)
BD62221MUV	0.33	0.22

$$W_{TOTAL} = W_{VCC} + W_{DMOS} \text{ [W]}$$

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

$W_{TOTAL}$  : Consumed total power of IC [W]  
 $T_j$  : Junction temperature [°C]  
 $T_a$  : ambient temperature [°C]  
 $\theta_{ja}$  : Thermal resistance value [°C/W]

However, the thermal resistance value  $\theta_{ja}$  [°C/W] differs significantly depending on circuit board conditions. The calculated values above are only theoretical. For actual thermal design, please perform sufficient thermal evaluation for the application board used, and create the thermal design with enough margin to not exceed  $T_{jmax} = 150$  °C. Although not normally used, if the IC is to be used under specific or strict heat conditions, please consider attaching an external Schottky diode between the motor output terminal and GND to decrease heat from the IC.



## Power Dissipation – continued

### 2 Temperature Monitoring

In respect of BD62221MUV, there is a way to directly measure the approximate chip temperature by using the TEST pin with a protection diode for prevention from electrostatic discharge. However, temperature monitor way is used only for evaluation and experimenting, and must not be used in actual usage conditions.

Process 1 Measure the pin voltage when a current of  $I_{DIODE} = 50 \mu\text{A}$  flows from the TEST pin to the GND, without supplying  $V_{CC}$  to the IC. This measurement is for measuring the  $V_F$  voltage of the internal 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 can be calibrated from the TEST pin voltage.

Process 3 Supply  $V_{CC}$ , confirm the TEST pin voltage while running the motor, and the chip temperature can be approximated from the results of Process 2.

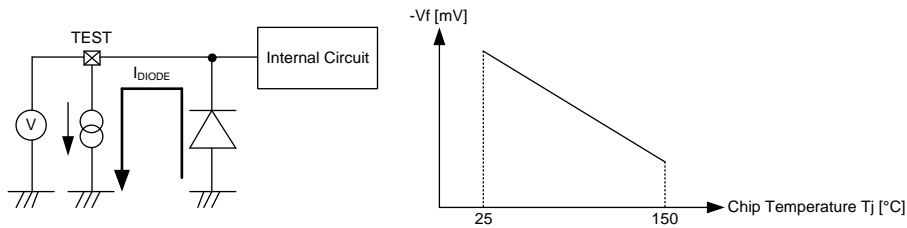
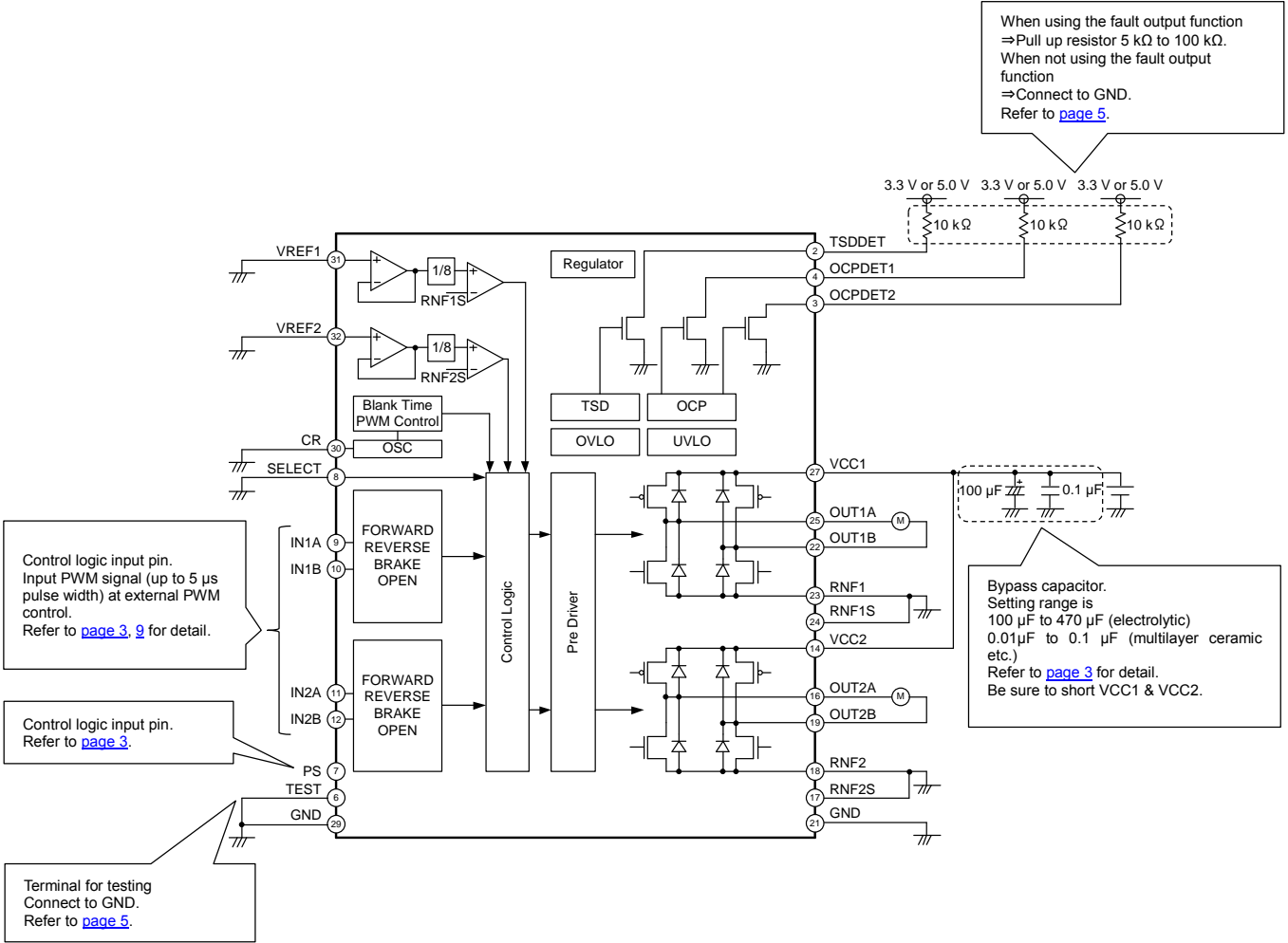


Figure 7. Model diagram for measuring chip temperature

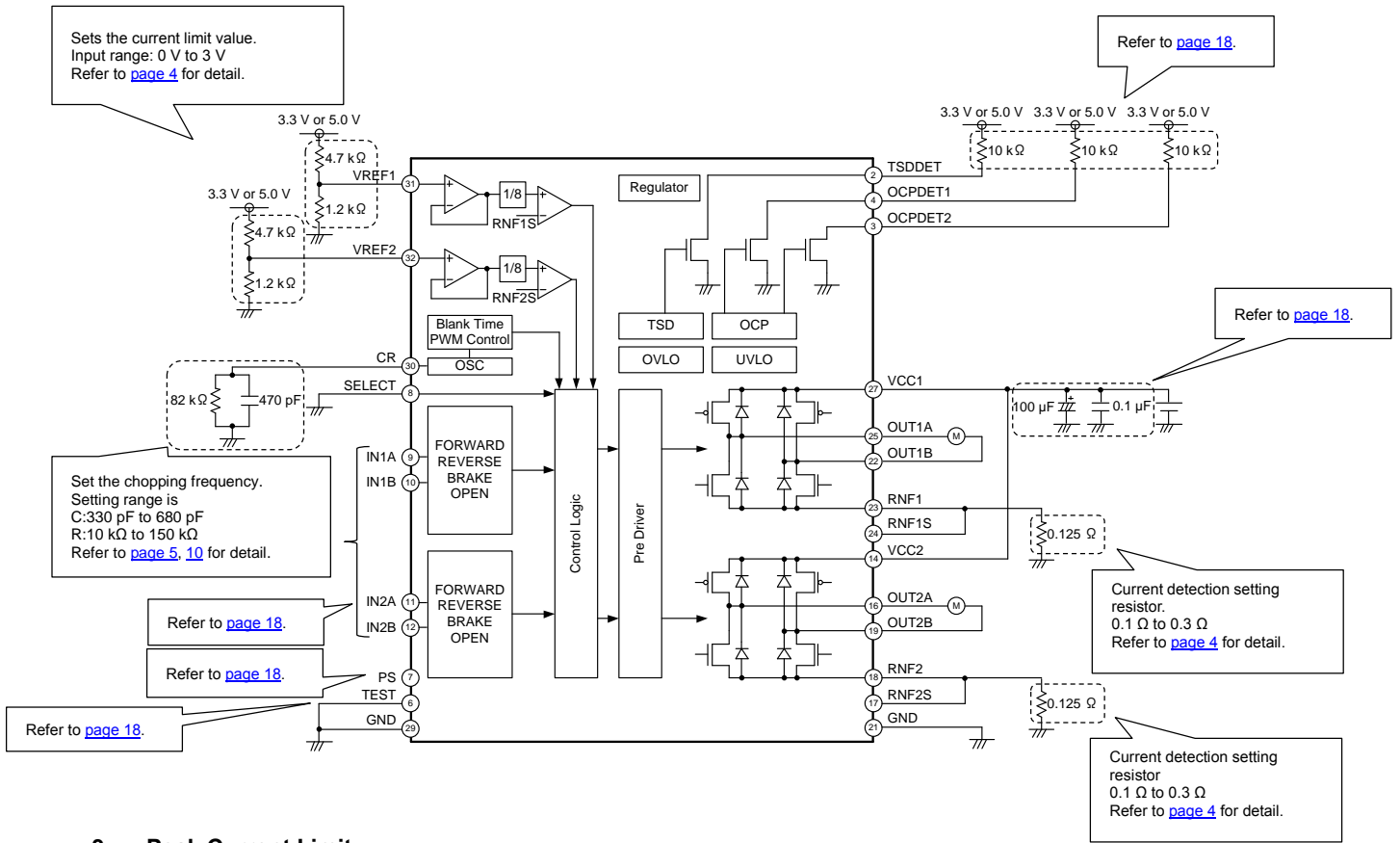
Application Example

1 Constant Voltage Control or Direct PWM Control

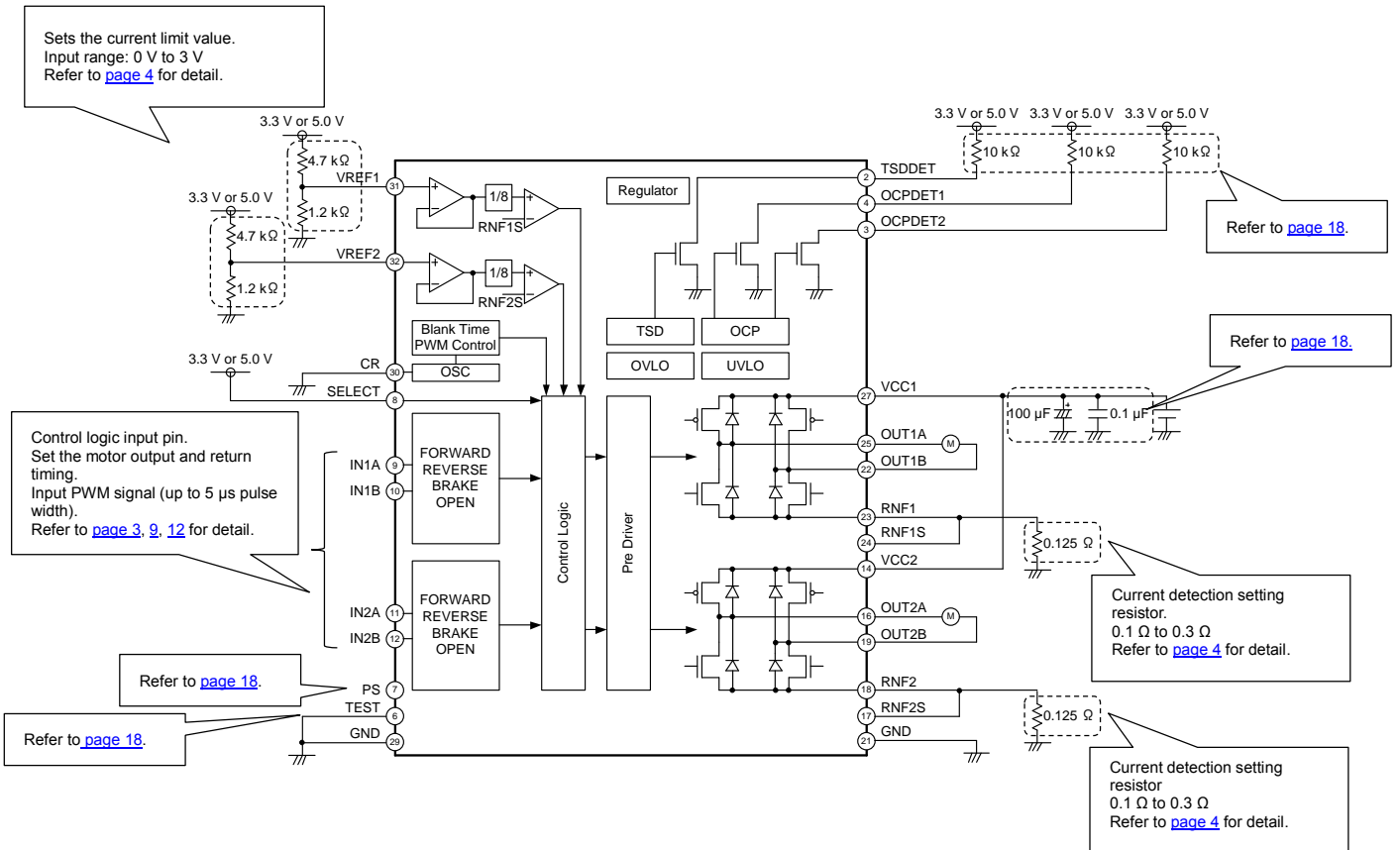


Application Example – continued

2 PWM Constant Current Control



3 Peak Current Limit



I/O Equivalent Circuits

Pin No.	Pin Name	Equivalent Circuits	Pin No.	Pin Name	Equivalent Circuits
7	PS		25	OUT1A	
9	IN1A				
10	IN1B				
11	IN2A				
12	IN2B				
8	SELECT				
24	RNF1S		31	VREF1	
17	RNF2S				
30	CR		2	TSDDET	
			4	OCPDET1	
			3	OCPDET2	
6	TEST		-	-	

## 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.

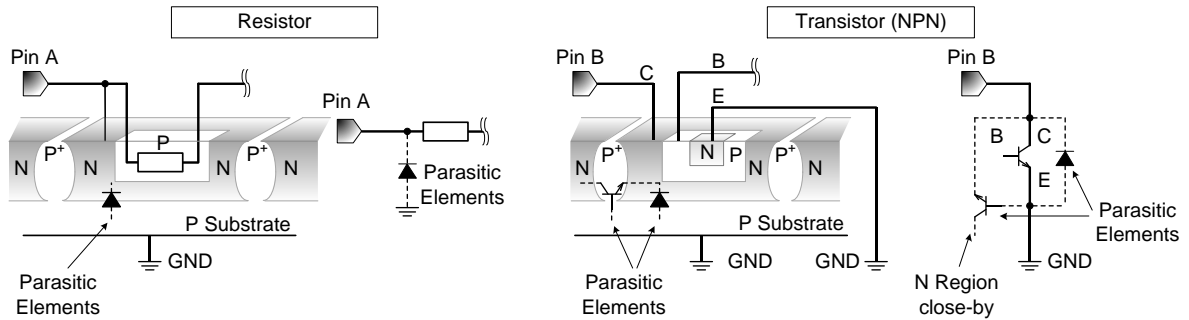


Figure 8. Example of Monolithic IC Structure

**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)**

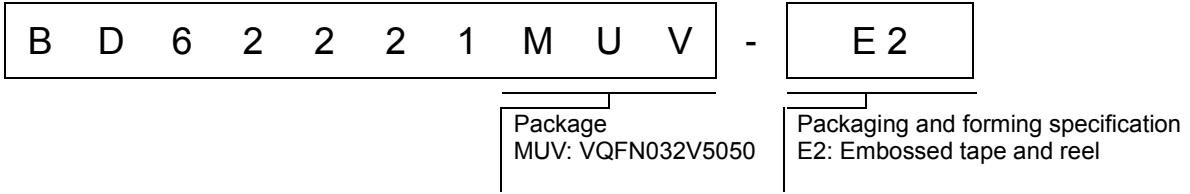
This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD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

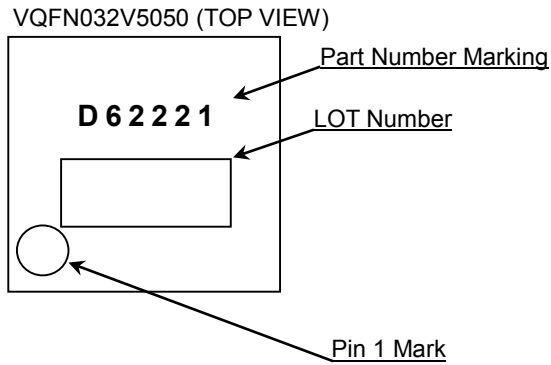
**13 Over Current Protection Circuit (OCP)**

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







**Revision History**

Date	Revision	Changes
30.Apr.2020	001	New Release

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[AH293-PL-B](#) [AH2984-PG-B](#) [AH2985-P-B](#) [AH5772-P-B](#) [AH5773-FDC-7](#) [AH5773-MP-13](#) [AH5775-P-B](#) [AH9485-WUF-7](#) [AH9486-WUF-7](#)  
[AiP6150](#) [AM4406FMTR-G1](#) [AM4962GHTR-G1](#) [AMC6821SDBQ](#) [AMC6821SDBQR](#) [AMIS-30543 STEPPER MOTOR DRIVER CARRIER](#)  
[AMIS30621C6213G](#) [AMIS30623C6238G](#) [AMIS30624C6245RG](#) [AN44063A-VF](#) [AN44069A-VF](#) [AP1511B](#) [APX284EI-PBG](#) [APX9166EI-](#)  
[PBG](#) [APX9358PQFI-TRG](#)