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Datasheet

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)
- µSTEP 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

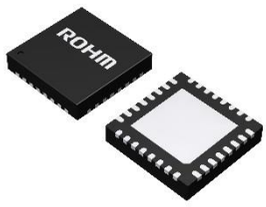
Applications

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

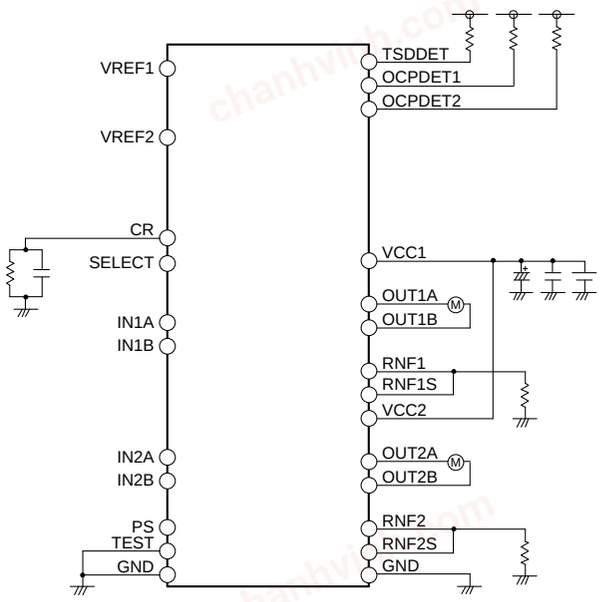
Key Specifications

- 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 Ω (Typ)

Package	W (Typ) x D (Typ) x H (Max)
VQFN032V5050	5.0 mm x 5.0 mm x 1.0 mm



Typical Application Circuit



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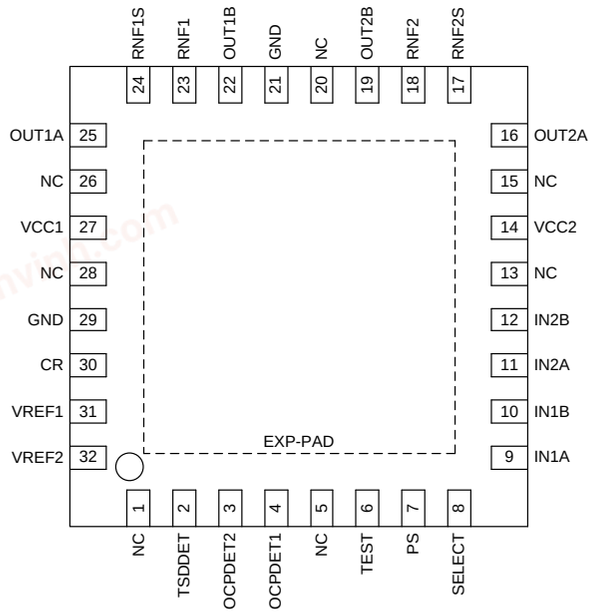
○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays.

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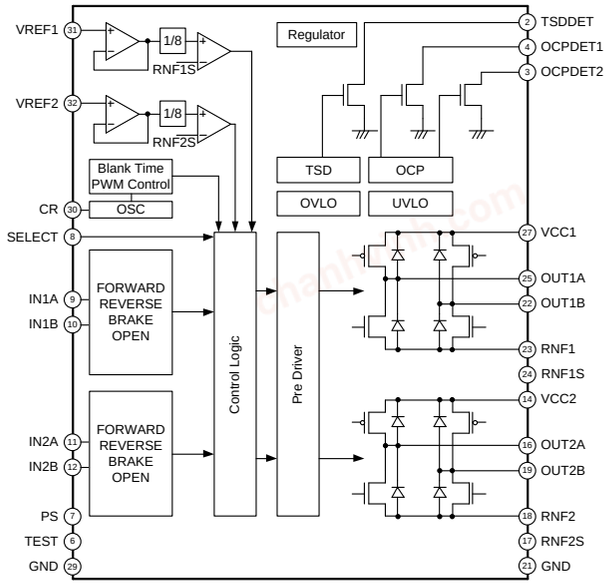
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Pin Configuration

[TOP VIEW]



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.	-	-	-

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Function Explanation

1 VCCx(Note 1)/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(Note 2), INxB(Note 2)/H bridge control pin

It decides output logic for H bridge.

Input			Output		State
PS	INxA	INxB	OUTxA(Note 2)	OUTxB(Note 2)	
L	X(Note 3)	X(Note 3)	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.

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Function Explanation – continued

6 RNFx(Note 1)/ Connection pin of resistor for output current detection

Insert current detecting resistor of 0.1 Ω to 0.2 Ω between RNF$_X$ and GND.
The power consumption of current detecting resistor (W) can be calculated by the motor output current value (I_{OUT}) 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_{OUT} : 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 it 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$_X$ pin to current-detecting resistor to GND.
Do not exceed the rating because there is the possibility of circuits' malfunction etc., if the RNF$_X$ voltage has exceeded the maximum rating (0.7 V). If the RNF$_X$ 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 RNFxS(Note 2)/Input pin of current detection comparator

RNFxS 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 RNFx pin. Therefore, please make sure to connect RNFx pin and RNFxS 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 RNFx pin and the current-detecting resistor can be decreased because the wires from RNFxS 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 VREFx(Note 3)/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 VREFx(Note 3) voltage and current-detecting resistor (RNFx(Note 3) resistor).

$$I_{OUT} = \frac{VREFx}{8} \times \frac{1}{RNFx} \text{ [A]}$$

Where:
I_{OUT} : is the motor output current value [A]
$VREFx$: is the voltage of current limit value setting pin [V]
$RNFx$: is the current-detecting resistor [Ω]

Please avoid using it with VREFx pin open. If VREFx 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 VREFx voltage. Please take note of the input voltage range because if voltage of over 3 V is applied on VREFx 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 VREFx 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

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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 TSDDET, OCPDET1, OCPDET2/Output signal pin to detect abnormal states

TSDDET, 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, TSDDET, 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
TSDDET	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.

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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 Tjmax = 150 °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 *(Note 1)* 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 he 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 *(Note 2)* 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 *(Note 3)* 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 *(Note 4)*. 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.

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Absolute Maximum Ratings (Ta = 25 °C)

Parameter	Symbol	Rating	Unit
Supply Voltage	V_{CC}	-0.2 to +36.0	V
Input Voltage for Control Pin *(Note 1)*	V_{IN}	-0.2 to +5.5	V
Input Voltage for VREFx *(Note 2)* Pin	V_{VREF}	-0.2 to +5.5	V
RNFx *(Note 2)* Maximum Voltage	V_{RNF}	0.7	V
Output Current (Continuous)	I_{OUT}	2.0 *(Note 3)*	A/Phase
Output Current (Peak Value)	$I_{OUTPEAK}$	3.0 *(Note 3)(Note 4)*	A/Phase
Storage Temperature Range	Tstg	-25 to +150	°C
Maximum Junction Temperature	Tjmax	+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 Tjmax = 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_{CC}	8	24	28	V
Operating Temperature	Topr	-25	+25	+85	°C
Maximam Output Current (Continuous)	I_{OUT}	-	-	1.4 *(Note 5)*	A/Phase

(Note 5) Do not exceed Tjmax = 150 °C

Thermal Resistance *(Note 6)*

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s *(Note 8)*	2s2p *(Note 9)*	
VQFN032V5050				
Junction to Ambient	θ_{JA}	90.5	24.8	°C/W
Junction to Top Characterization Parameter *(Note 7)*	Ψ_{JT}	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 *(Note 10)*	
			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 10) This thermal via connects with the copper pattern of all layers.

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Electrical Characteristics (Unless otherwise specified V_{CC} = 24 V, Ta = 25 °C)

Item	Symbol	Min	Typ	Max	Unit	Condition
[Whole]						
Circuit Current at Standby	I_{CCST}	-	0	10	µA	PS = L
Circuit Current	I_{CC}	-	2.0	5.0	mA	PS = H, VREFx*(Note 1)* = 3 V
[Control Logic Input*(Note 2)*]						
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 3)*]						
Output ON Resistance	R_{ON}	-	0.55	0.75	Ω	I_{OUT} = ±1.0 A (Sum of upper and lower)
Output Leak Current	I_{LEAK}	-	-	10	µA	
[Output to Detect Abnormal States*(Note 4)*]						
Output L Voltage	V_{DET}	-	300	600	mV	TSDDET = 6 mA*(Note 5)* OCPDET1 = 6 mA*(Note 5)* OCPDET2 = 6 mA*(Note 5)*
Output Leak Current	I_{DET_LEAK}	-	-	10	µA	TSDDET = 5 V OCPDET1 = 5 V OCPDET2 = 5 V
[Current Control]						
RNFxS*(Note 1)* Input Current	I_{RNFS}	-2.0	-0.1	-	µA	RNFxS = 0 V
RNFx*(Note 1)* Input Current	I_{RNF}	-80	-40	-	µA	RNFx = 0 V
VREFx*(Note 1)* Input Current	I_{VREF}	-2.0	-0.1	-	µA	VREFx = 0 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	µs	
RNFxS*(Note 1)* Comparator Threshold	V_{CTH}	0.356	0.375	0.394	V	VREFx*(Note 1)* = 3 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

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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 *(Note 1)*	INxB *(Note 1)*	OUTxA *(Note 1)*	OUTxB *(Note 1)*	
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 *(Note 2)*	INxB *(Note 2)*	OUTxA *(Note 2)*	OUTxB *(Note 2)*	
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

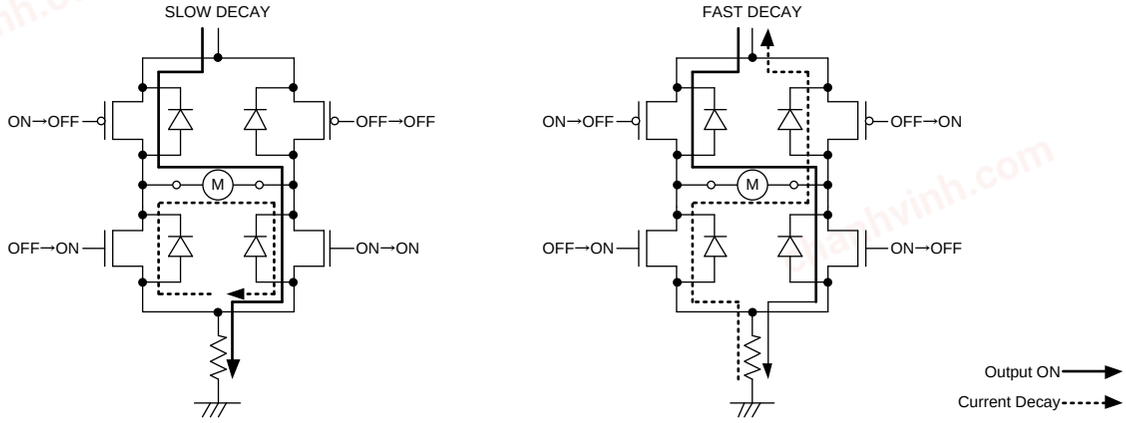


Figure 1. Route of Regenerative Current during Current Decay

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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 VREFx*(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 RNFx*(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 µs (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 V, V_{CRH} = 1.0 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}.

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

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 [Ω]
R' : is the CR Pin internal impedance 5 kΩ (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 V (Typ)

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

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

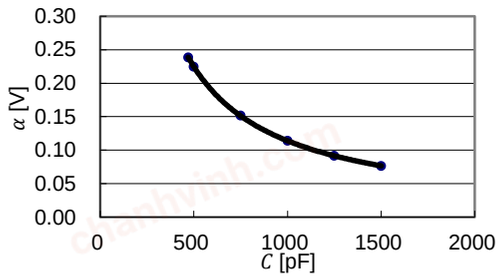


Figure 2. CR Coefficient for Calculation of Discharge Time

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

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

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3 CR Timer – continued

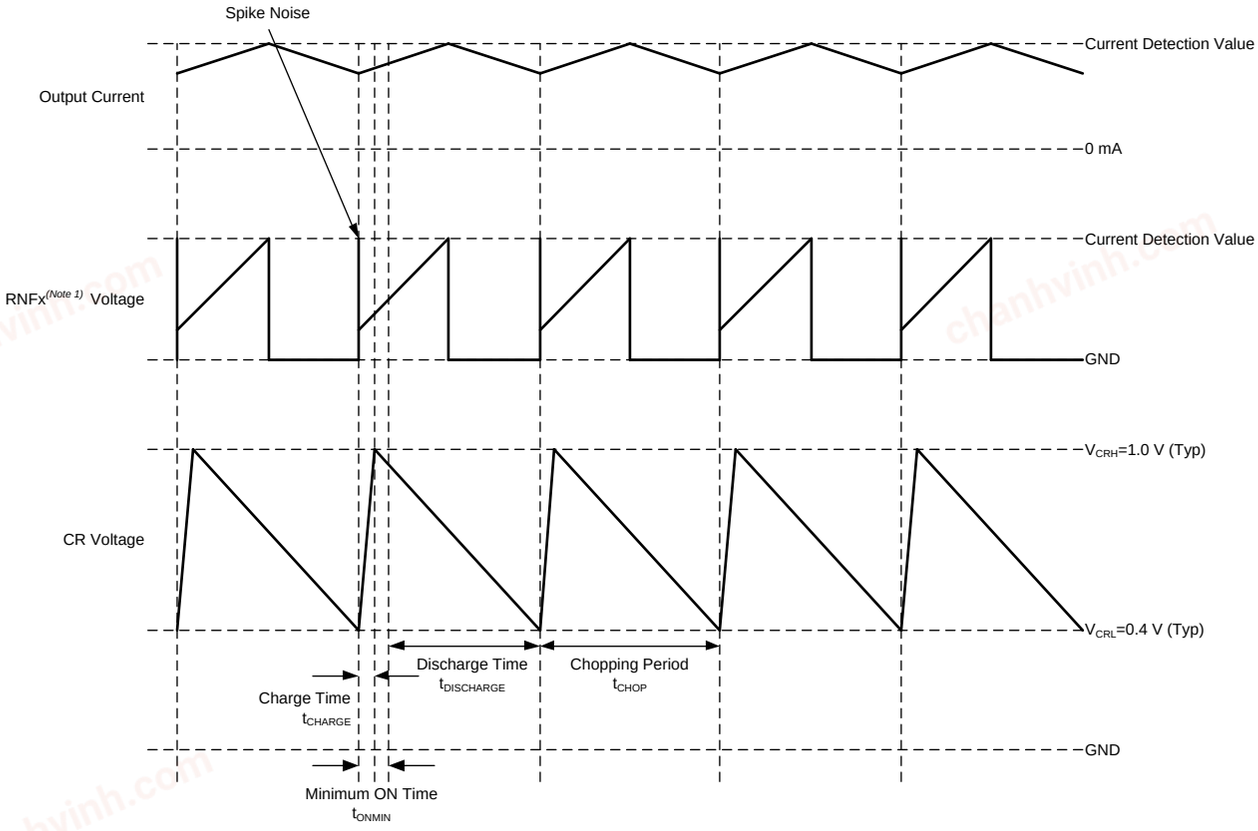


Figure 3. Timing Chart of CR Voltage, RNFx Voltage and Output Current

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

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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(Note 1) or INxB(Note 1).
(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_X(Note 2) pin. When the voltage on the RNF_X pin reaches the voltage value set by the VREFx(Note 2) 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 Intenal Circuit)

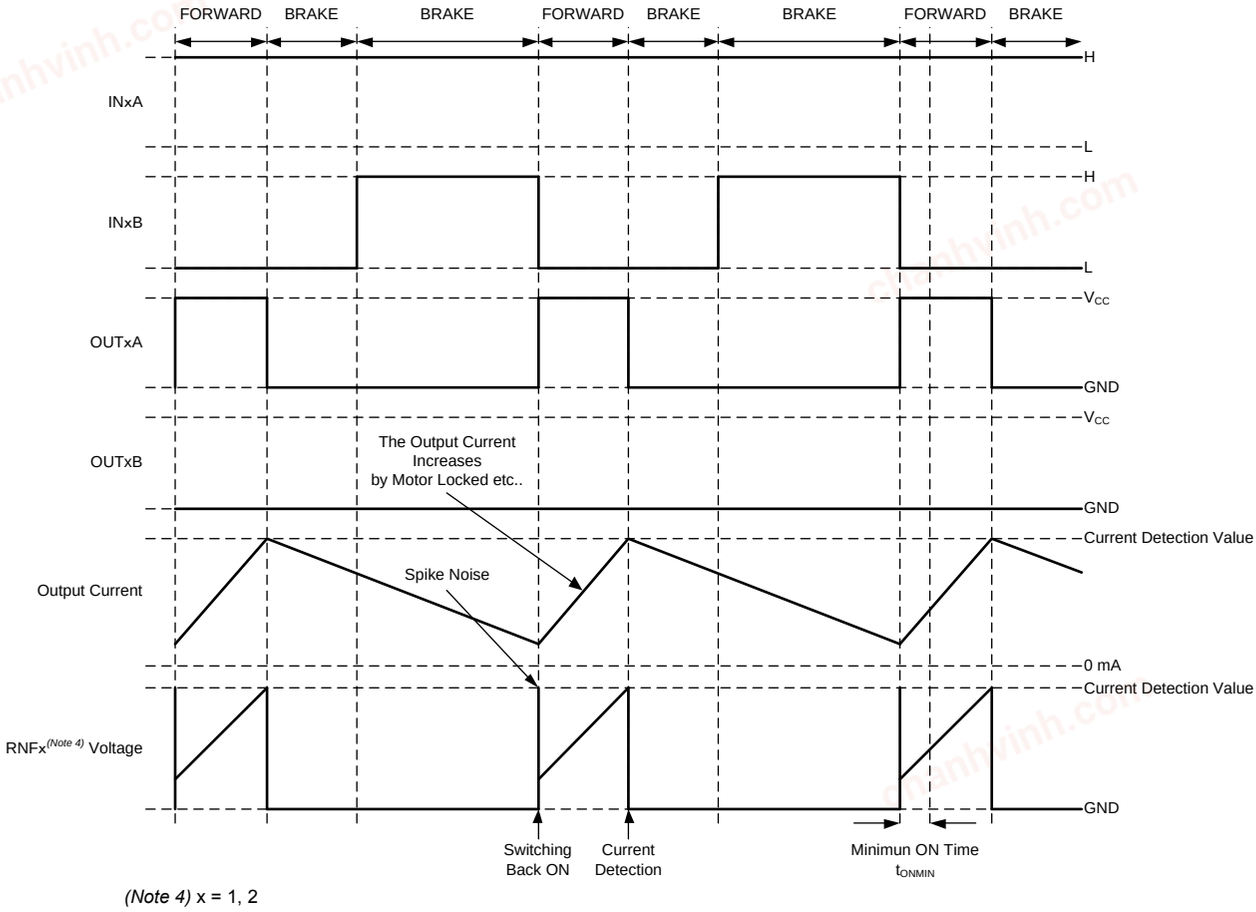
In order to avoid misdetection of current detection comparator due to RNFx(Note 3) spike noise that may occur when the output turns ON, the IC has the minimum ON time t_{ONMIN} (Cancel Time). The current detection is invalid from the output transistor turned on to 1.5 µs (Typ). This allows for constant-current 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(Note 4) and OUTxB(Note 4) 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

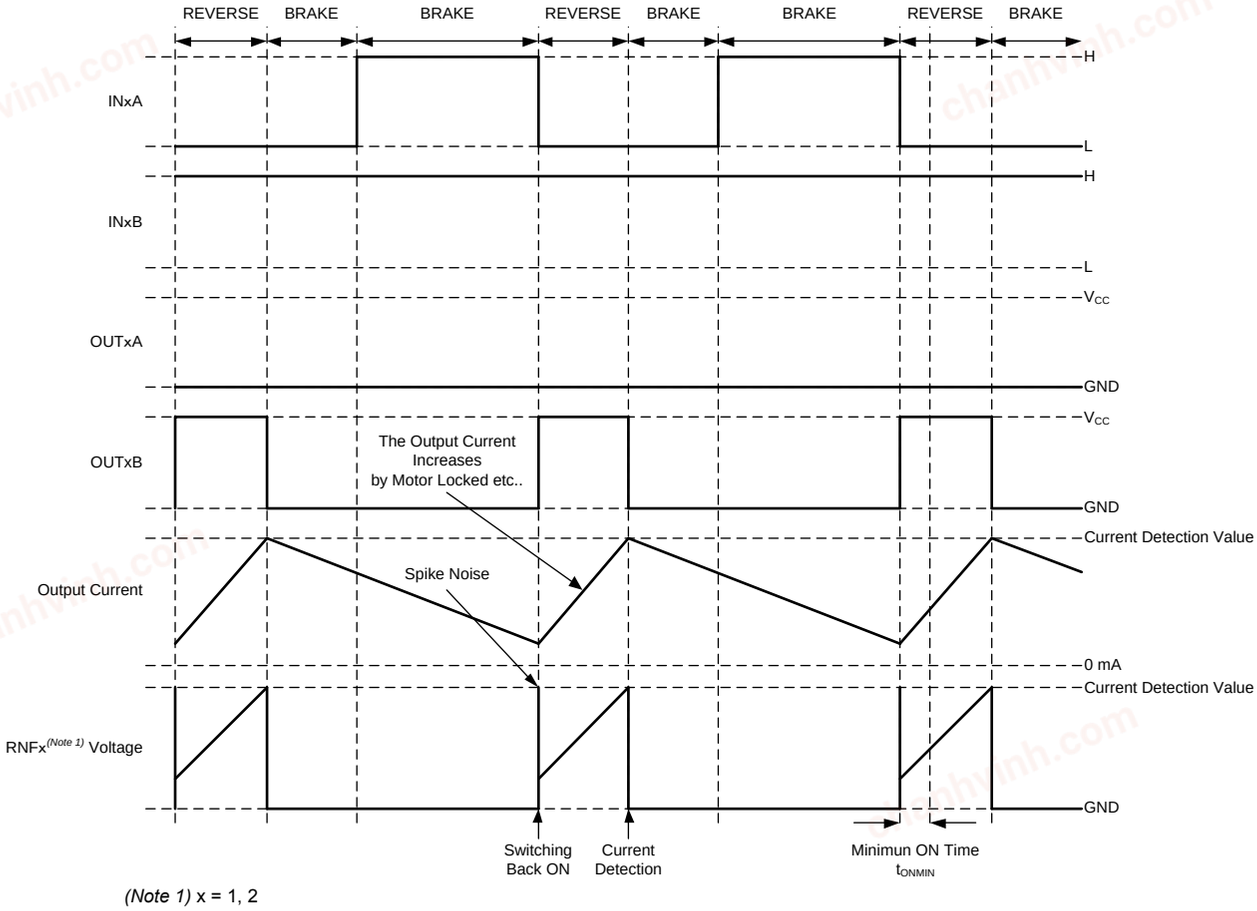
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3 Timing Chart – continued

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(Note 1) and OUTxB(Note 1) 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

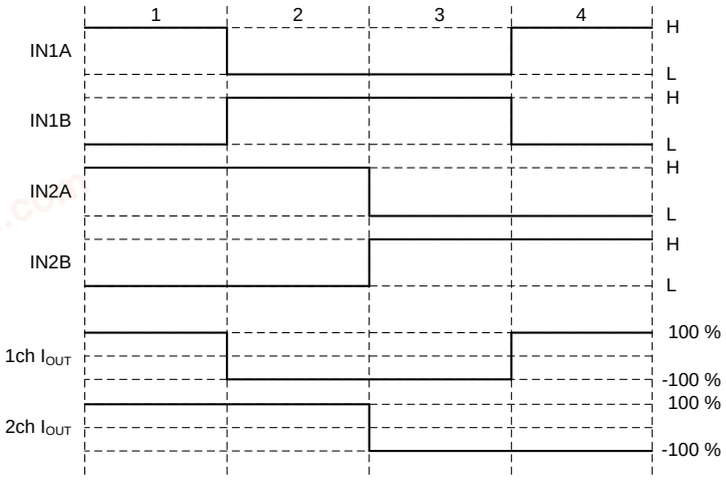
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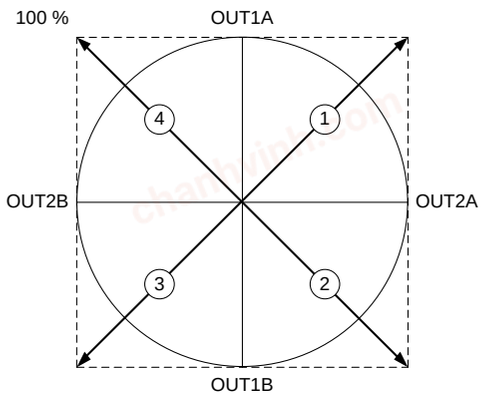
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Control Sequence of Stepper Motor

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.

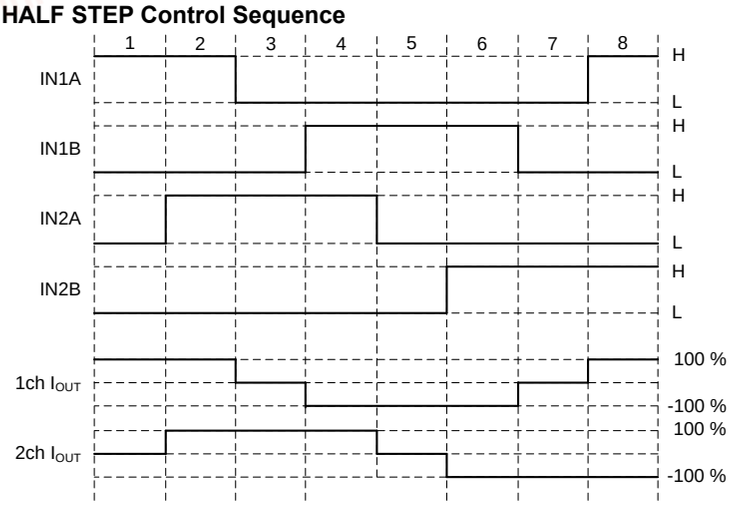
1 FULL STEP Control Sequence

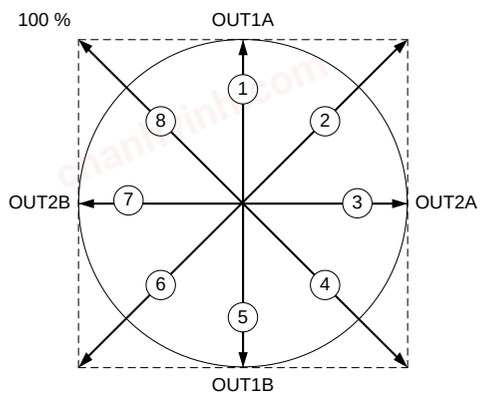




	IN1A	IN1B	IN2A	IN2B	OUT1A	OUT1B	OUT2A	OUT2B
1	H	L	H	L	H	L	H	L
2	L	H	H	L	L	H	H	L
3	L	H	L	H	L	H	L	H
4	H	L	L	H	H	L	L	H

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

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µSTEP Drive for Stepper Motor

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

(Note 1) x = 1, 2

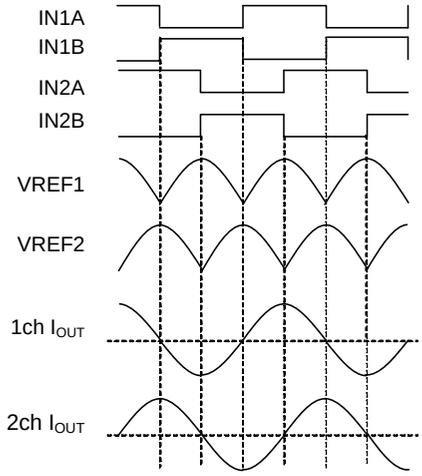


Figure 6. µSTEP Control Sequence and Output Current

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Power Dissipation

Please confirm that the IC's chip temperature Tj is not over 150 °C. Consider the IC's power consumption (W), thermal resistance (°C/W) and ambient temperature (Ta). When Tj = 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. Tjmax = 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 [Ω]
R_{ONL} : Lower N-Channel DMOS ON-Resistance [Ω]
I_{OUT} : Motor output current [A]
on_duty : PWM on duty [%]

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

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

$$Tj = Ta + \theta ja \times W_total \text{ [°C]}$$

W_{TOTAL} : Consumed total power of IC [W]
Tj : Junction temperature [°C]
Ta : ambient temperature [°C]
θja : Thermal resistance value [°C/W]

However, the thermal resistance value θja [°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 Tjmax = 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.

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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 μA 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 VCC, confirm the TEST pin voltage while running the motor, and the chip temperature can be approximated from the results of Process 2.

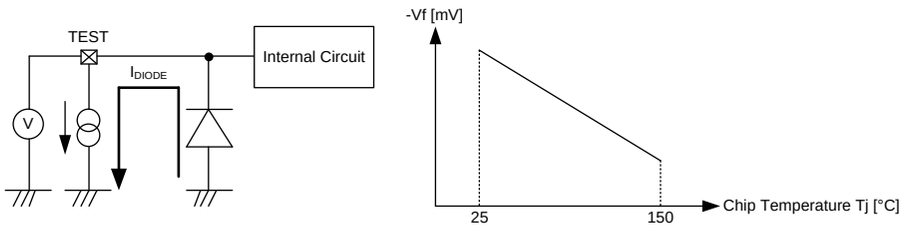


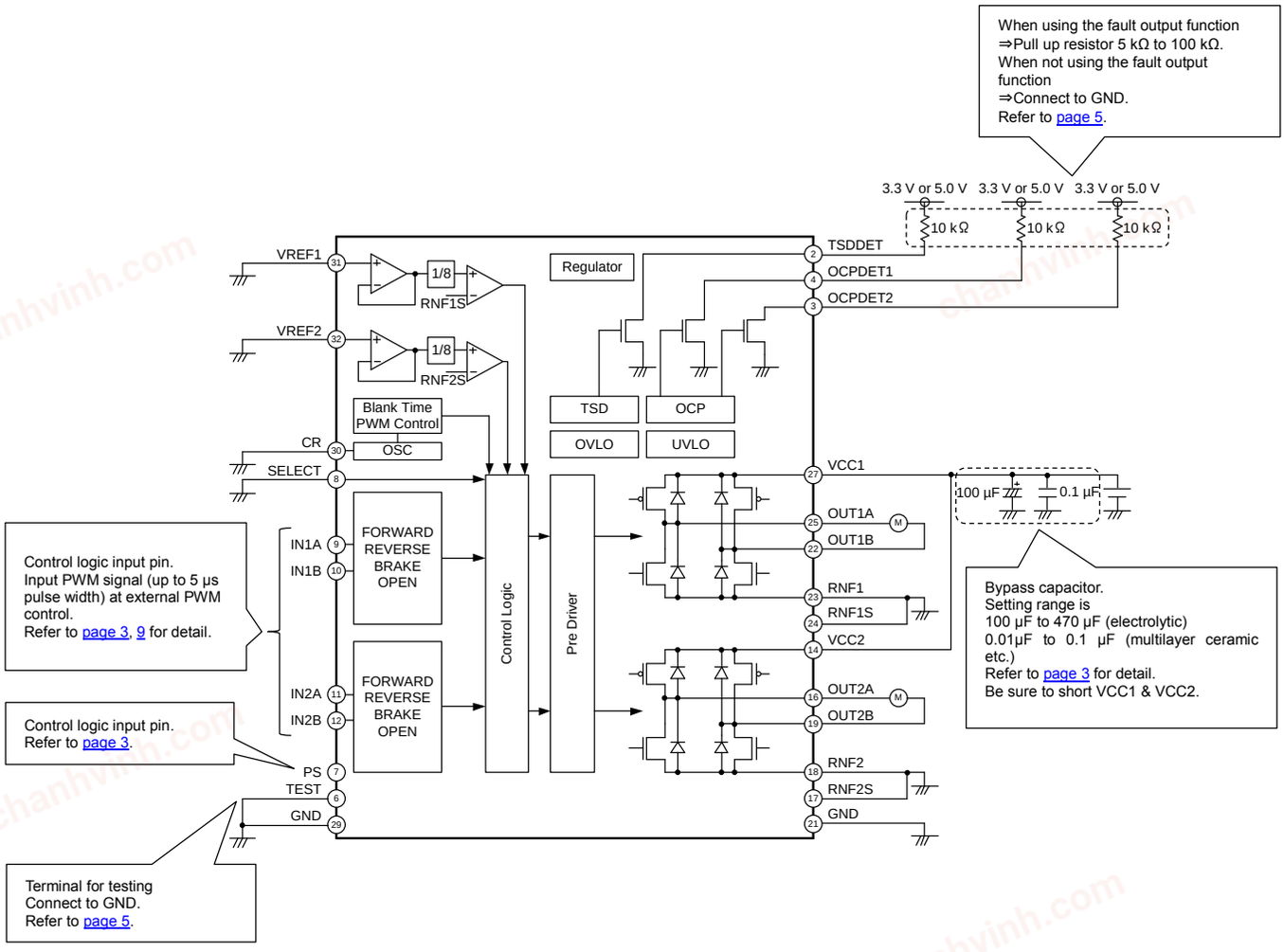
Figure 7. Model diagram for measuring chip temperature

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Application Example

1 Constant Voltage Control or Direct PWM Control

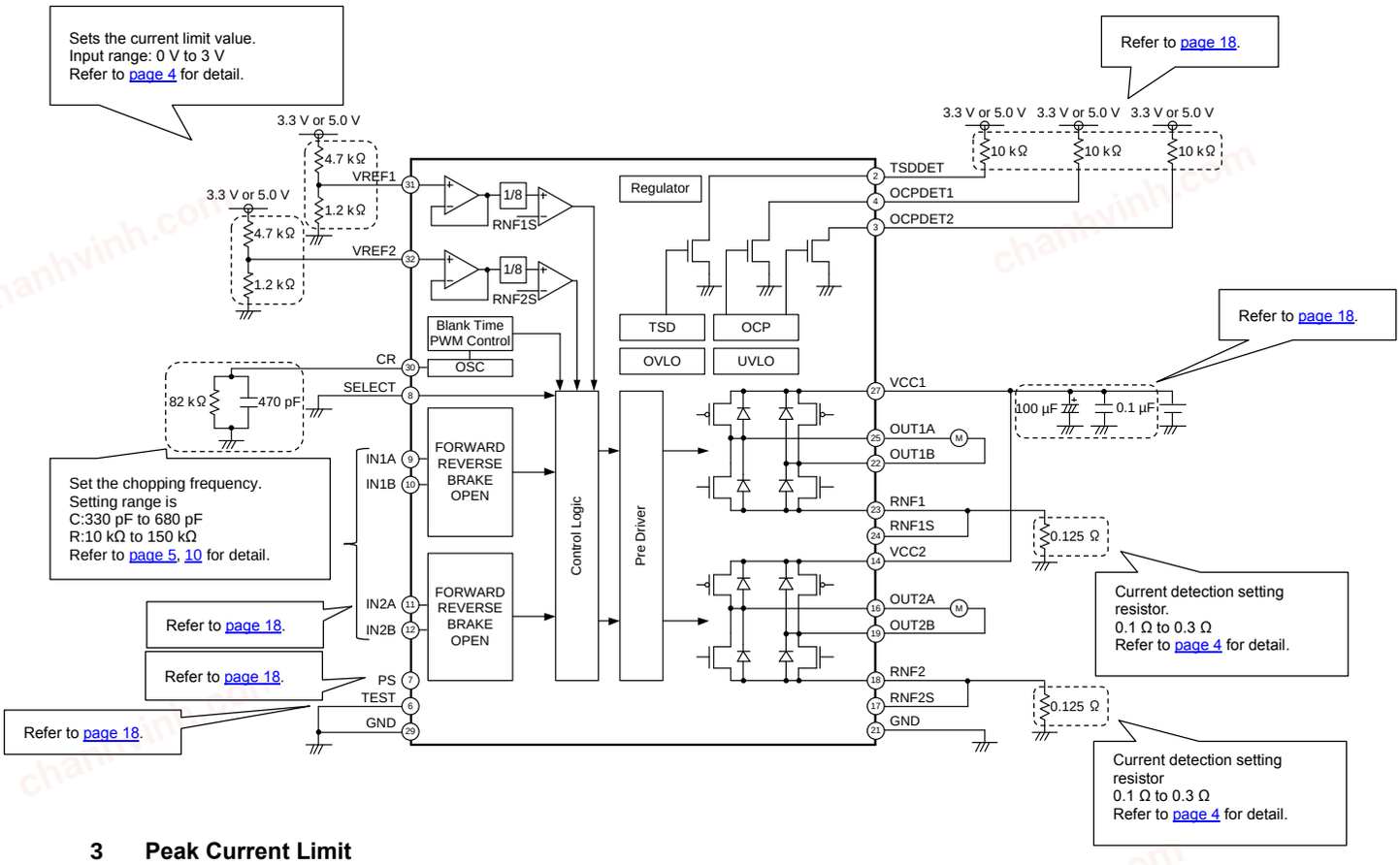


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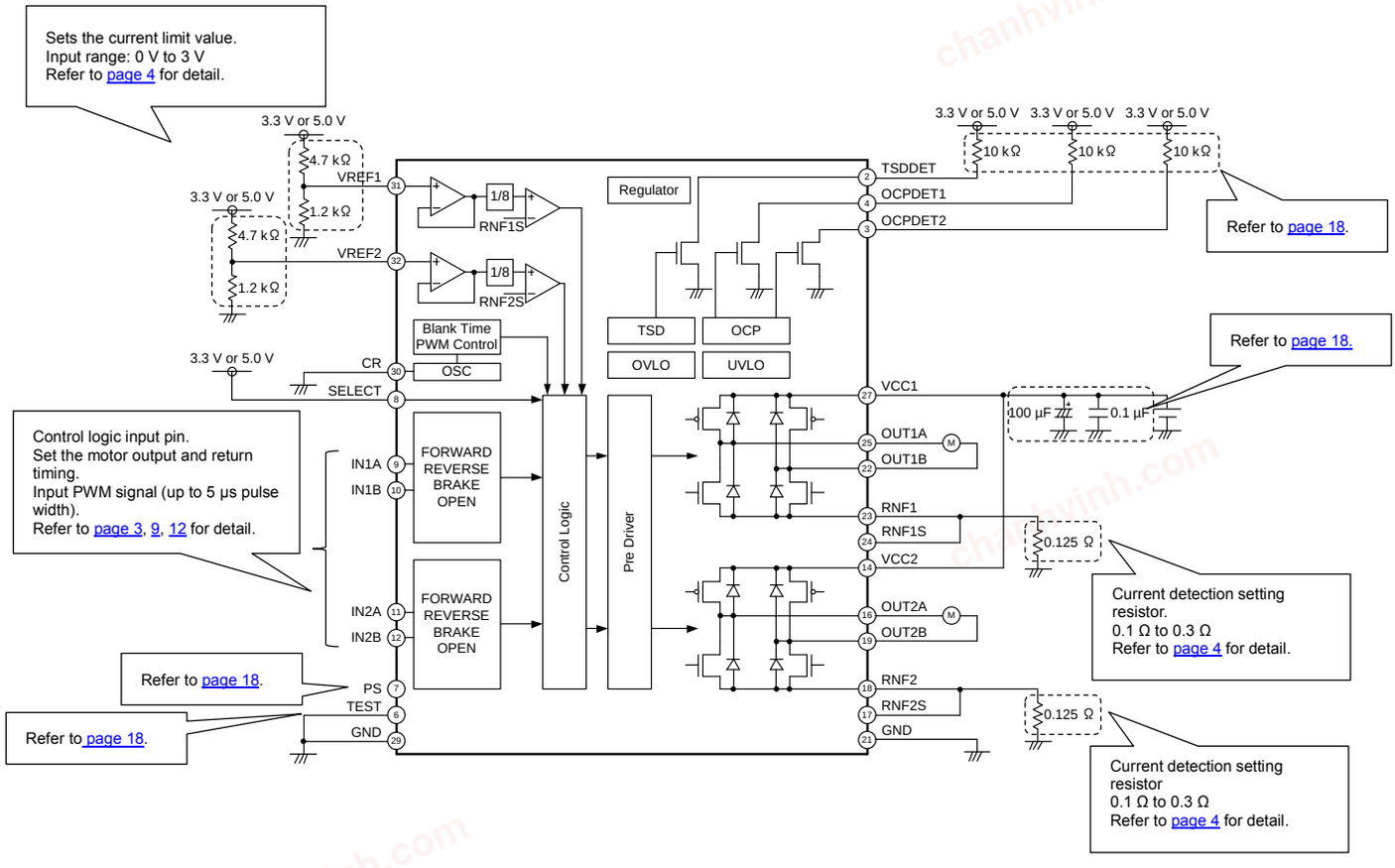
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Application Example – continued

2 PWM Constant Current Control



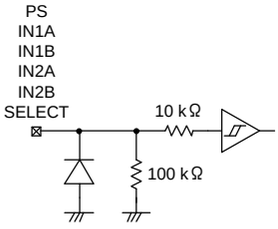
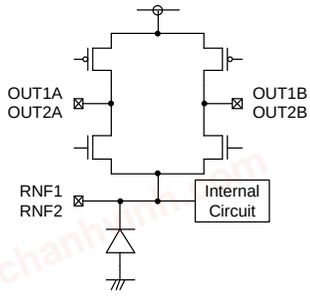
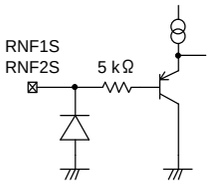
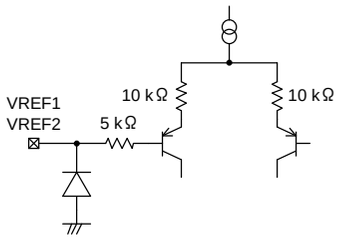
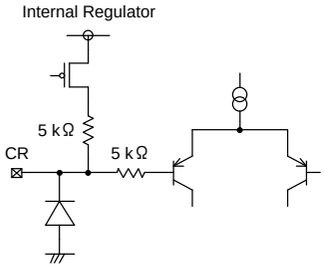
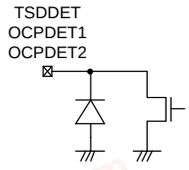
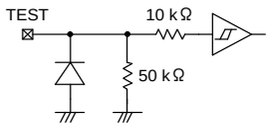
3 Peak Current Limit



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I/O Equivalent Circuits

Pin No.	Pin Name	Equivalent Circuits	Pin No.	Pin Name	Equivalent Circuits
7	PS		25	OUT1A	
9	IN1A		22	OUT1B	
10	IN1B		16	OUT2A	
11	IN2A		19	OUT2B	
12	IN2B		23	RNF1	
8	SELECT		18	RNF2	
24	RNF1S		31	VREF1	
17	RNF2S		32	VREF2	
30	CR		2	TSDDET	
			4	OCPDET1	
			3	OCPDET2	
6	TEST		-	-	

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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.

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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.

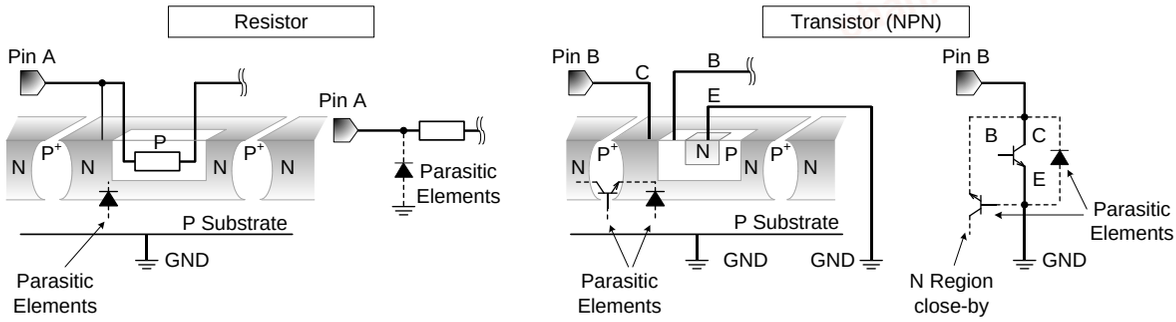


Figure 8. Example of Monolithic IC Structure

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 (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.

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Ordering Information

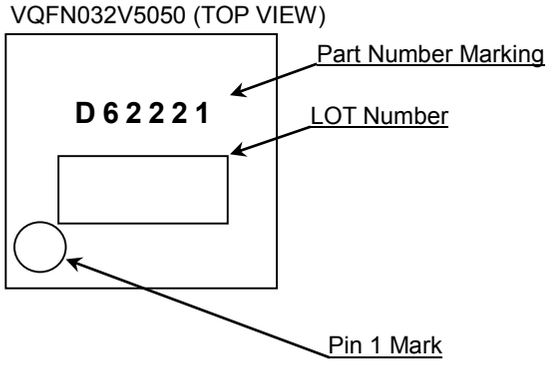
B	D	6	2	2	2	1	M	U	V	-	E 2

Package
MUV: VQFN032V5050

Packaging and forming specification
E2: Embossed tape and reel

Marking Diagram

VQFN032V5050 (TOP VIEW)

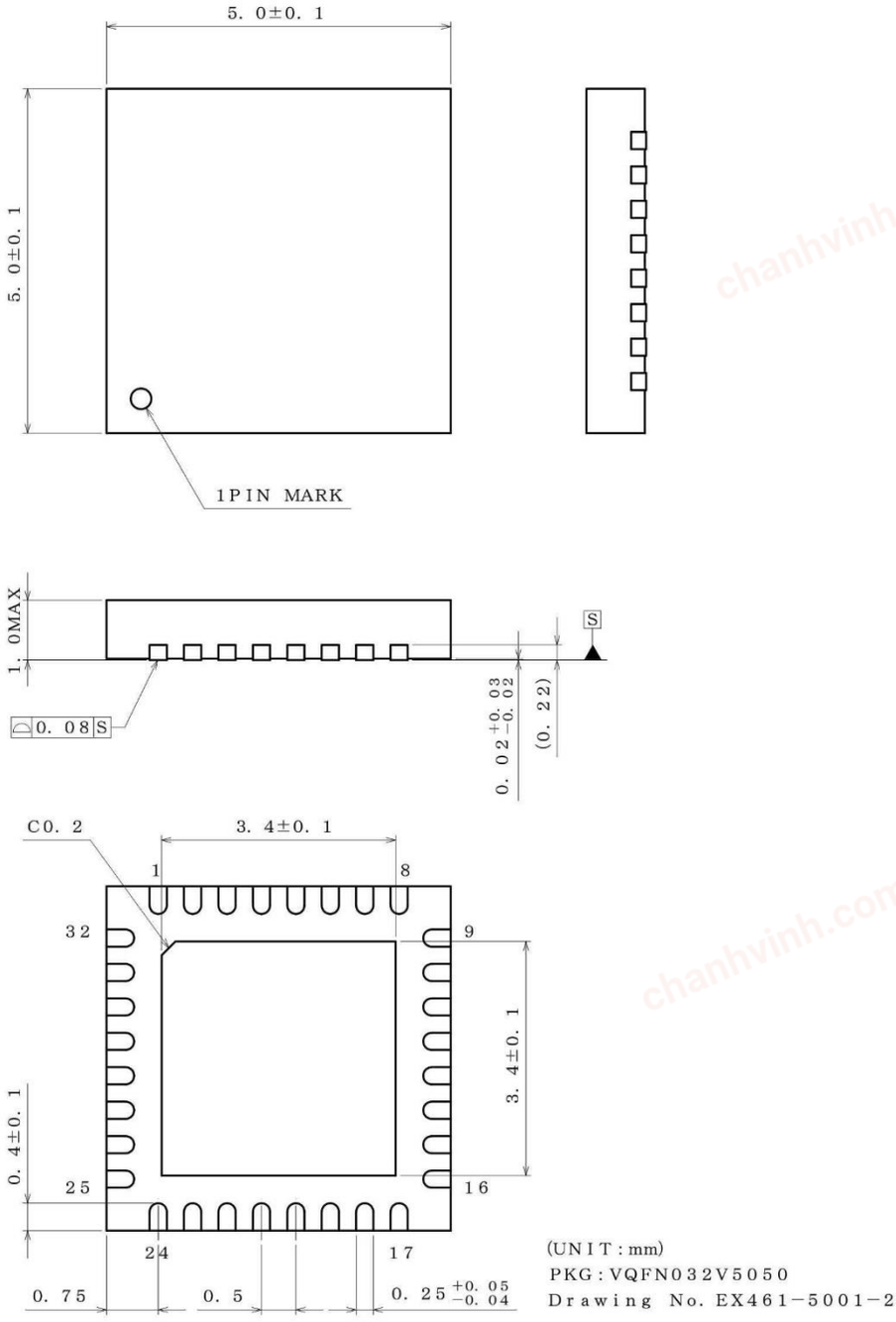


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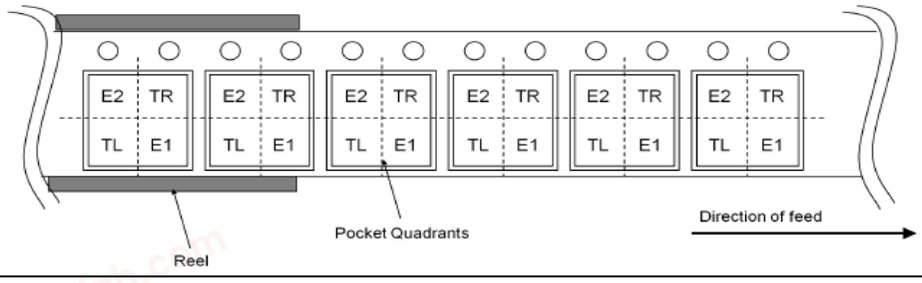
Physical Dimension and Packing Information

Package Name	VQFN032V5050



< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	2500pcs
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



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Revision History

Date	Revision	Changes
30.Apr.2020	001	New Release

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Notice

Precaution on using ROHM Products

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

(Note1) Medical Equipment Classification of the Specific Applications

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [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
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [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

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Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

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

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   - [a] the Products are exposed to sea winds or corrosive gases, including Cl_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.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

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

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

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General Precaution

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