

To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: <http://www.renesas.com>

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (<http://www.renesas.com>)

Send any inquiries to <http://www.renesas.com/inquiry>.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.
 - “Standard”: Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.
 - “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.
 - “Specific”: Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

MONOLITHIC 6-CHANNEL H-BRIDGE DRIVER

DESCRIPTION

The μ PD168002 is a monolithic 6-channel H-bridge driver that consists of a CMOS control circuit and a MOS output stage. It can reduce the current consumption and the voltage loss at the output stage compared with conventional driver using bipolar transistors, thanks to employment of a MOS process. The μ PD168002 employs P-channel MOS FET in the output stage, and is eliminated the charge pump circuit. Therefore, the circuit current consumption during operation can be significantly reduced.

The package is a 48-pin TQFP that helps reduce the mounting area and height.

The μ PD168002 can be used to drive one stepping motor and four DC motors, and is suitable for the motor driver of CD-ROM/CD audios.

FEATURES

- Six H-bridge circuits employing power MOS FET
- Low current consumption due to elimination of charge pump circuit
- Input logic frequency: 100 kHz supported
- 3 V power supply supported for logic

Minimum operating supply voltage: 2.7 V

- 5 V, 10 V power supply supported for motor
 - ch1, ch2, ch5 and ch6: 10 V driving
 - ch3 and ch4: 5 V driving

- Undervoltage lockout circuit

Shuts down the internal circuit at $V_{DD} = 1.7 \text{ V TYP.}$

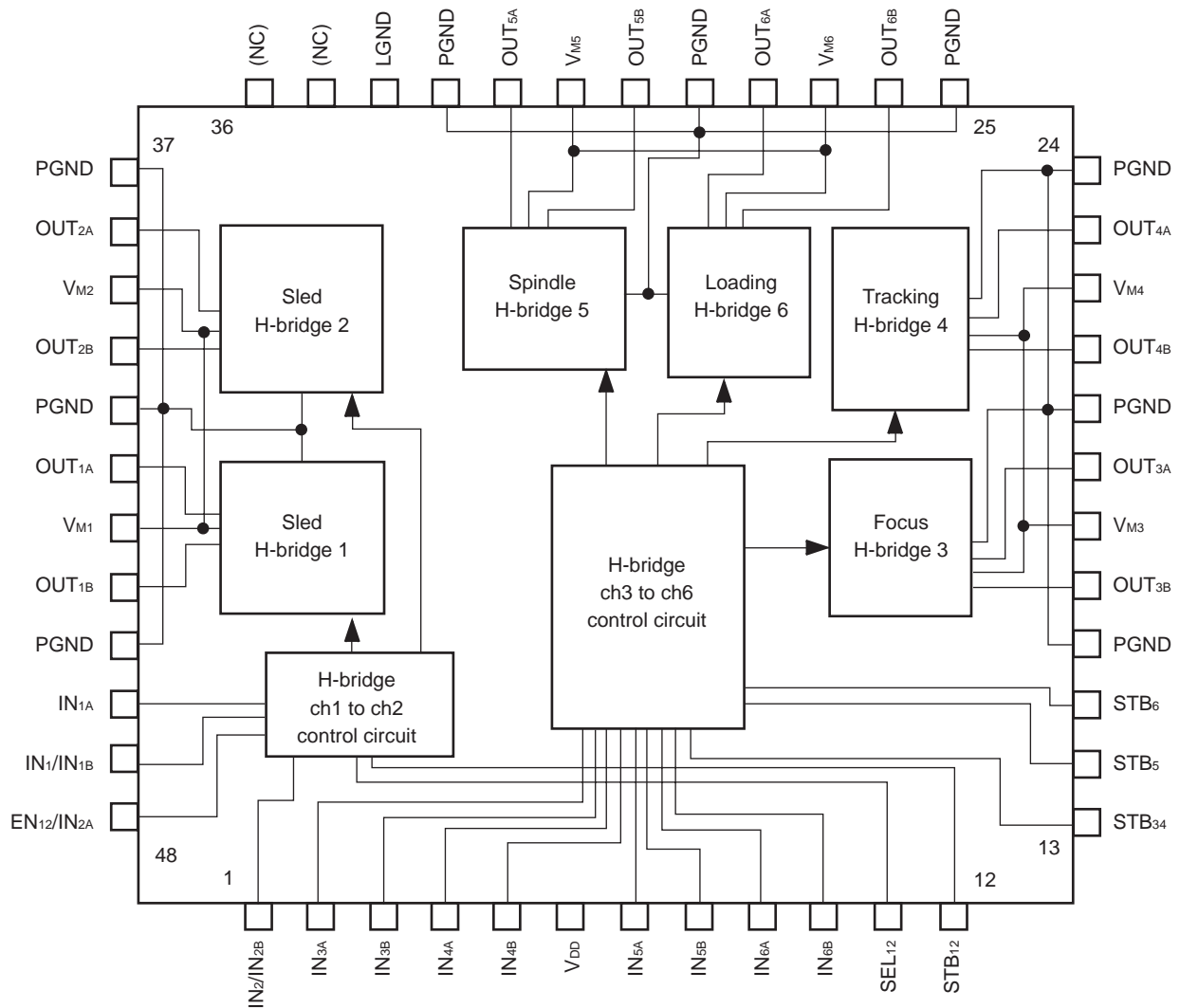
- Overheat protection circuit
- 48-pin TQFP (□7 mm)

ORDERING INFORMATION

Part Number	Package
μ PD168002GA-9EU	48-pin plastic TQFP (fine pitch) (7 x 7)

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.
 Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.

1. BLOCK DIAGRAM



Cautions 1. Be sure to connect all of the pins which have more than one.

2. A pull-down resistor (50 to 200 kΩ) is internally connected to the logic input pins.

Logic input pins: IN_{1A}, IN₁/IN_{1B}, EN₁₂/IN_{2A}, IN₂/IN_{2B}, IN_{3A}, IN_{3B}, IN_{4A}, IN_{4B}, IN_{5A}, IN_{5B}, IN_{6A}, IN_{6B}, SEL₁₂, STB₁₂, STB₃₄, STB₅ and STB₆

3. The power supply pins for motor, VM₁ and VM₂, VM₃ and VM₄, and VM₅ and VM₆, are connected each other inside. These pins must be applied from the same potential.

2. PIN FUNCTIONS

Package: 48-pin plastic TQFP (fine pitch) (7 x 7)

(1/2)

Pin No.	Pin Name	Function
1	IN ₂ /IN _{2B}	ch2 input pin or ch2 input pin B
2	IN _{3A}	ch3 input pin A
3	IN _{3B}	ch3 input pin B
4	IN _{4A}	ch4 input pin A
5	IN _{4B}	ch4 input pin B
6	V _{DD}	Logic power supply pin
7	IN _{5A}	ch5 input pin A
8	IN _{5B}	ch5 input pin B
9	IN _{6A}	ch6 input pin A
10	IN _{6B}	ch6 input pin B
11	SEL ₁₂	ch1 and ch2 input logic selection pin
12	STB ₁₂	ch1 and ch2 standby pin
13	STB ₃₄	ch3 and ch4 standby pin
14	STB ₅	ch5 standby pin
15	STB ₆	ch6 standby pin
16	PGND	GND pin
17	OUT _{3B}	ch3 output B
18	V _{M3}	ch3 power supply pin
19	OUT _{3A}	ch3 output A
20	PGND	GND pin
21	OUT _{4B}	ch4 output B
22	V _{M4}	ch4 power supply pin
23	OUT _{4A}	ch4 output A
24	PGND	GND pin
25	PGND	GND pin
26	OUT _{6B}	ch6 output B
27	V _{M6}	ch6 power supply pin
28	OUT _{6A}	ch6 output A
29	PGND	GND pin
30	OUT _{5B}	ch5 output B
31	V _{M5}	ch5 power supply pin
32	OUT _{5A}	ch5 output A
33	PGND	GND pin
34	LGND	GND pin
35	(NC)	Unused

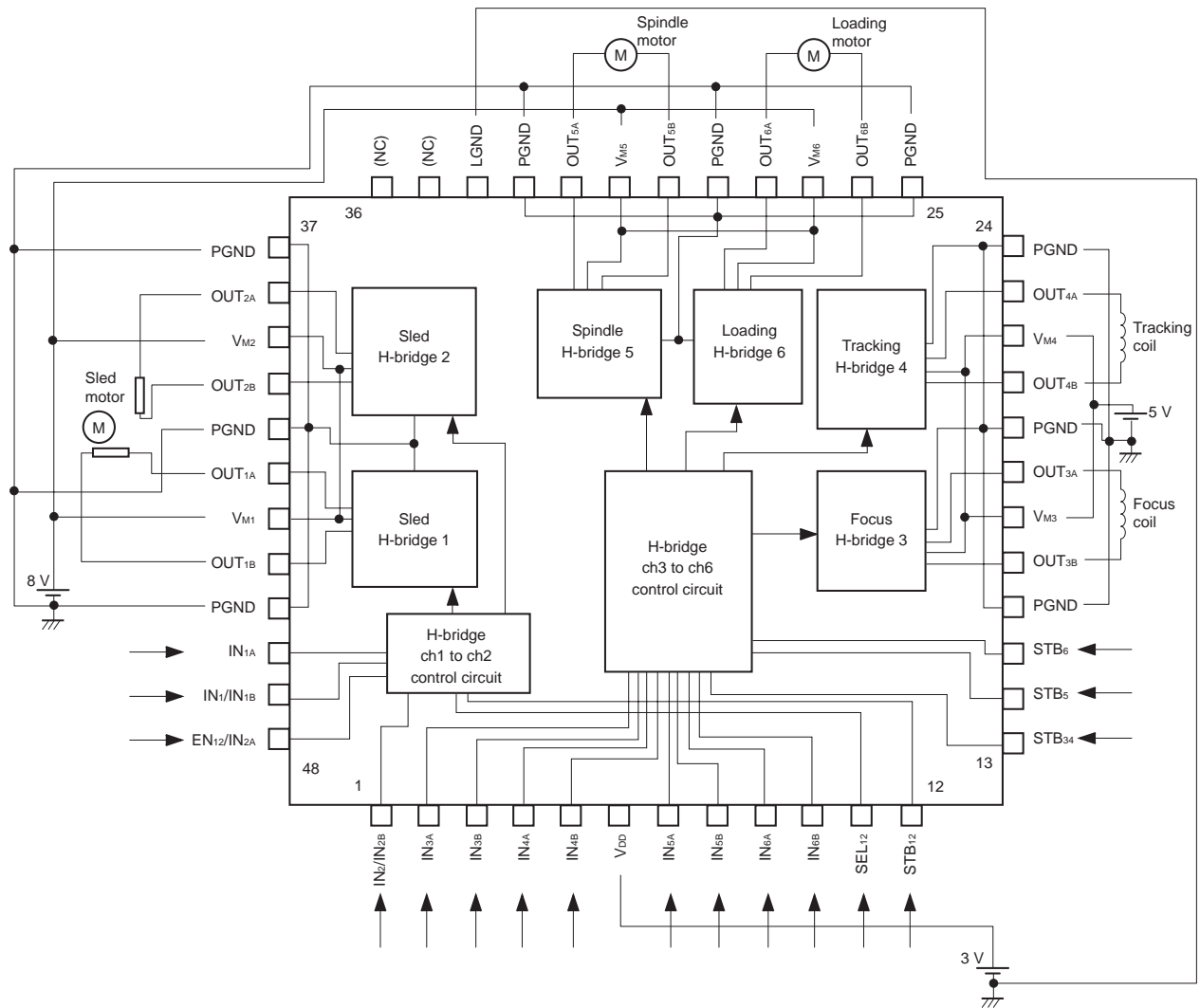
Caution Be sure to connect all of the pins which have more than one.

(2/2)

Pin No.	Pin Name	Function
36	(NC)	Unused
37	PGND	GND pin
38	OUT _{2A}	ch2 output A
39	V _{M2}	ch2 power supply pin
40	OUT _{2B}	ch2 output B
41	PGND	GND pin
42	OUT _{1A}	ch1 output A
43	V _{M1}	ch1 power supply pin
44	OUT _{1B}	ch1 output B
45	PGND	GND pin
46	IN _{1A}	ch1 input pin A
47	IN ₁ /IN _{1B}	ch1 input pin or ch1 input pin B
48	EN ₁₂ /IN _{2A}	ch1 and ch2 control pin or ch2 input pin A

Caution Be sure to connect all of the pins which have more than one.

3. STANDARD CONNECTION EXAMPLE



Caution This diagram is the example of connection and is not what was created as a purpose of mass production.

4. FUNCTION OPERATION TABLE

4.1 Relationship between SEL Pin and Input Pins

SEL pin	46-pin	47-pin	48-pin	1-pin
L	Unused	ch1 input pin IN ₁	ch1 and ch2 control pin EN ₁₂	ch2 input pin IN ₂
H	ch1 input pin IN _{1A}	ch1 input pin IN _{1B}	ch2 input pin IN _{2A}	ch2 input pin IN _{2B}

Remark L: Low level, H: High level

4.2 ch1 and ch2 Input/output Truth Table

(1) SEL₁₂ = L

Input		Output		Output Status
EN ₁₂	IN	OUT _A	OUT _B	
L	x	Z	Z	Stop (output high impedance)
H	L	H	L	Forward revolution (OUT _A → OUT _B)
H	H	L	H	Reverse revolution (OUT _B → OUT _A)

Remark x: High level or low level, Z: Output high impedance

(2) SEL₁₂ = H

Input		Output		Output Status
IN _A	IN _B	OUT _A	OUT _B	
L	L	L	L	Stop (short brake)
L	H	L	H	Reverse revolution (OUT _B → OUT _A)
H	L	H	L	Forward revolution (OUT _A → OUT _B)
H	H	H	H	Stop (short brake)

4.3 ch3 to ch5 Input/output Truth Table

Input		Output		Output Status
IN _A	IN _B	OUT _A	OUT _B	
L	L	L	L	Stop (short brake)
L	H	L	H	Reverse revolution (OUT _B → OUT _A)
H	L	H	L	Forward revolution (OUT _A → OUT _B)
(H)	(H)	(H)	(H)	Stop (short brake)

Caution At ch3 to ch5, inputting IN_A = H and IN_B = H prohibits.

4.4 ch6 Input/output Truth Table

Input		Output		Output Status
IN _A	IN _B	OUT _A	OUT _B	
L	L	L	L	Stop (short brake)
L	H	L	H	Reverse revolution (OUT _B → OUT _A)
H	L	H	L	Forward revolution (OUT _A → OUT _B)
H	H	H	H	Stop (short brake)

5. STANDBY FUNCTION

The μ PD168002 realizes a standby function by combination of an input signal.

The specified output is set to high impedance (Hi-Z) status by setting STB to low level.

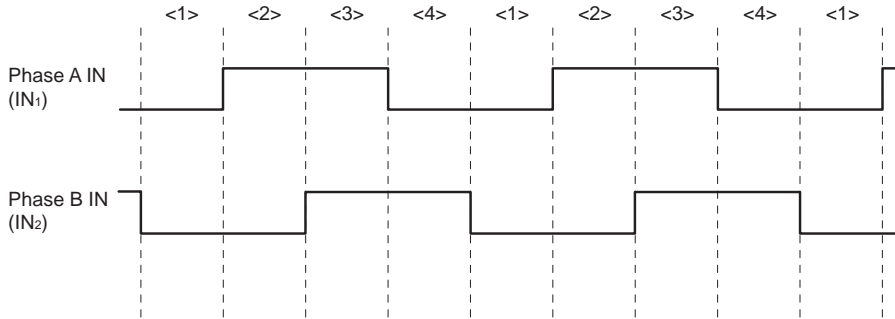
Each pin can be independently controlled, and can be set to standby status of the self current consumption of the IC reduced as much as possible by setting all pins to low level. In the standby status, the overheat protection circuit and the undervoltage lockout circuit do not operate.

Pin	Function	Output Status when Pin = L					
		ch1	ch2	ch3	ch4	ch5	ch6
STB ₁₂	Sled block standby	Hi-Z	Hi-Z	ON	ON	ON	ON
STB ₃₄	Focus and tracking block standby	ON	ON	Hi-Z	Hi-Z	ON	ON
STB ₅	Spindle block standby	ON	ON	ON	ON	Hi-Z	ON
STB ₆	Loading block standby	ON	ON	ON	ON	ON	Hi-Z

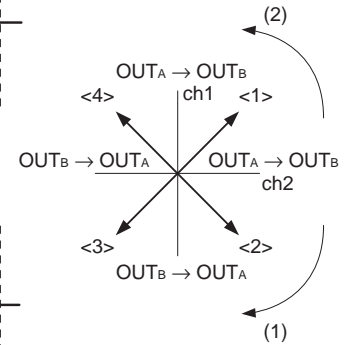
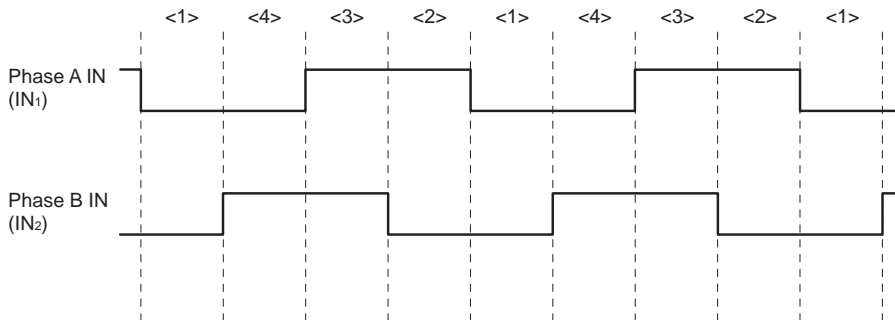
Remark ON: Status which can turn on output, Hi-Z: High impedance

6. OPERATION WAVEFORM EXAMPLES

(1) Example of the clockwise revolution of the right figure when 2-phase diving



(2) Example of the counter-clockwise revolution of the right figure when 2-phase diving



Remark SEL₁₂ = L, EN₁₂ = H

7. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

(T_A = 25°C, glass epoxy board of 100 mm x 100 mm x 1 mm with copper foil area of 15%)

Parameter	Symbol	Condition	Rating	Unit
Power supply voltage	V _{DD}	Control block	-0.5 to +6.0	V
	V _M	Motor block (ch3 and ch4)	-0.5 to +6.0	V
		Motor block (ch1, ch2, ch5 and ch6)	-0.5 to +12.0	V
Input voltage	V _{IN}		-0.5 to V _{DD} + 0.5	V
Output pin voltage 1	V _{OUT1}	Motor block (ch3 and ch4)	6.2	V
Output pin voltage 2	V _{OUT2}	Motor block (ch1, ch2, ch5 and ch6)	12.2	V
DC output current 1	I _{D(DC)1}	DC (ch3 to ch5)	±0.3	A/ch
DC output current 2	I _{D(DC)2}	DC (ch1, ch2 and ch6)	±0.15	A/ch
Instantaneous output current 1	I _{D(pulse)1}	PW < 10 ms, Duty Cycle ≤ 20% (ch3 to ch5)	±0.6	A/ch
Instantaneous output current 2	I _{D(pulse)2}	PW < 10 ms, Duty Cycle ≤ 20% (ch1, ch2 and ch6)	±0.3	A/ch
Power consumption	P _T		1.0	W
Peak junction temperature	T _{ch(MAX)}		150	°C
Storage temperature	T _{stg}		-55 to +150	°C

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Conditions

(T_A = 25°C, glass epoxy board of 100 mm x 100 mm x 1 mm with copper foil area of 15%)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Power supply voltage	V _{DD}	Control block	2.7		5.5	V
	V _M	Motor block (ch3 and ch4)	2.7		5.5	V
		Motor block (ch1, ch2, ch5 and ch6)	6.0		11.0	V
Input voltage	V _{IN}		0		V _{DD}	V
DC output current 1	I _{D(DC)1}	DC (ch3 to ch5)	-0.2		+0.2	A/ch
DC output current 2	I _{D(DC)2}	DC (ch1, ch2 and ch6)	-0.1		+0.1	A/ch
Instantaneous output current 1	I _{D(pulse)1}	PW < 10 ms, Duty Cycle ≤ 20% (ch3 to ch5)	-0.4		+0.4	A/ch
Instantaneous output current 2	I _{D(pulse)2}	PW < 10 ms, Duty Cycle ≤ 20% (ch1, ch2 and ch6)	-0.2		+0.2	A/ch
Logic input frequency	f _{IN}				100	kHz
Operating temperature range	T _A		-40		85	°C

Electrical Characteristics

(Unless otherwise specified, T_A = 25°C, V_{DD} = 3 V, V_M = 5 V (ch3 and ch4), V_M = 8 V (ch1, ch2, ch5 and ch6))

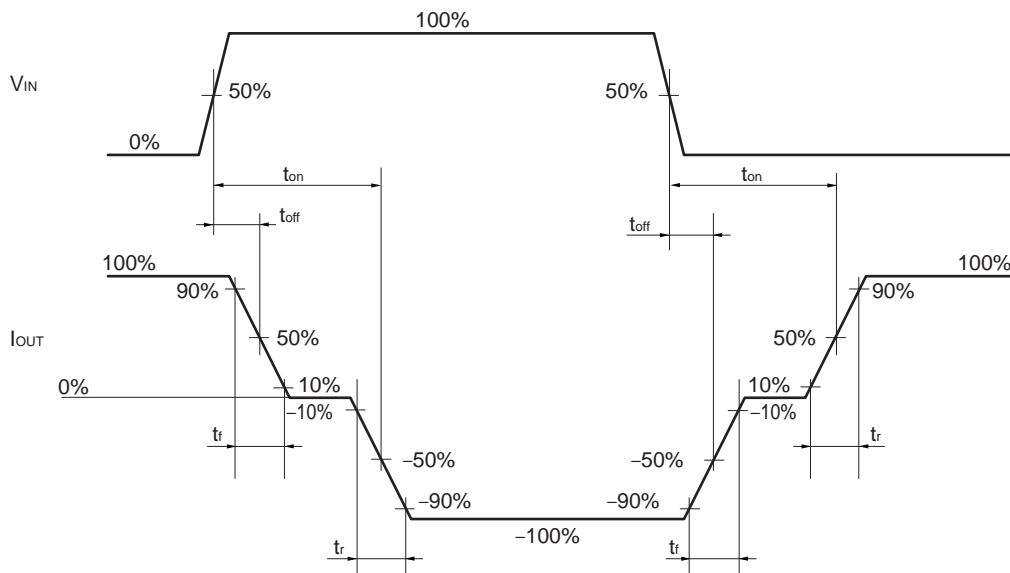
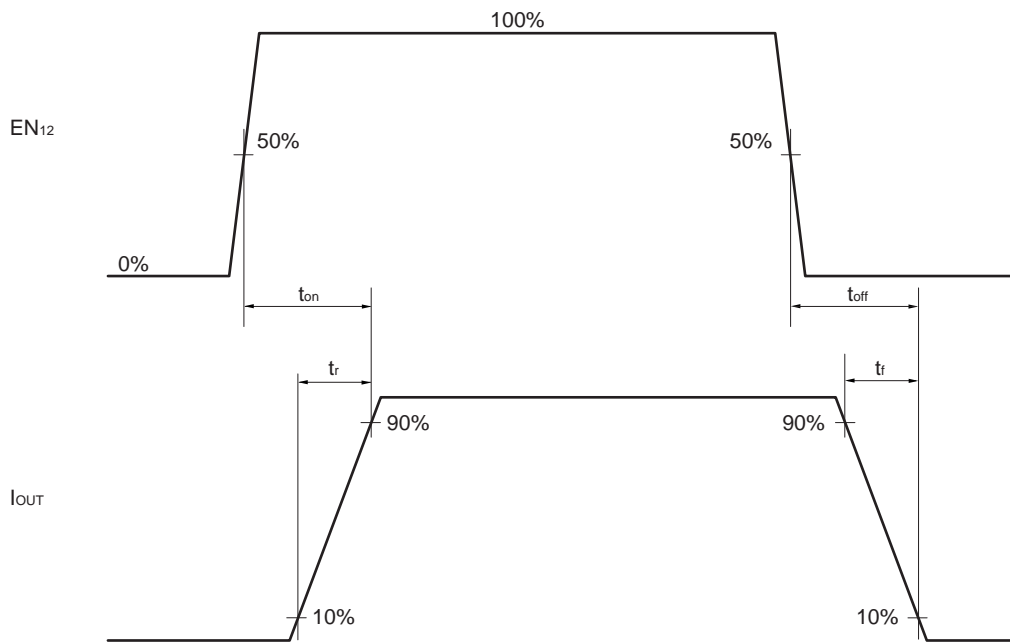
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
V _{DD} pin current in standby mode	I _{DD(STB)}	All control pin: Low level			1.0	μA
V _{DD} pin current in during operation	I _{DD(ACT)}				1.0	mA
V _M pin current in during operation	I _M	Output with no load, I _N pin, EN pin: Low level			100	μA
High-level input current	I _{IH}	V _{IN} = V _{DD}			60	μA
Low-level input current	I _{IL}	V _{IN} = 0 V	-1.0			μA
Input pull-down resistance	R _{IND}		50		200	kΩ
High-level input voltage	V _{IH}	2.7 V ≤ V _{DD} ≤ 5.5 V	0.7 x V _{DD}			V
Low-level input voltage	V _{IL}	2.7 V ≤ V _{DD} ≤ 5.5 V			0.3 x V _{DD}	V
H-bridge on-state resistance 1 (ch1, ch2 and ch5)	R _{on1}	I _M = 0.1 A (ch1 and ch2), I _M = 0.2 A (ch5), sum of upper and lower stages		2.0	3.0	Ω
H-bridge on-state resistance 2 (ch3 and ch4)	R _{on2}	I _M = 0.2 A, sum of upper and lower stages		1.2	2.0	Ω
H-bridge on-state resistance 3 (ch6)	R _{on3}	I _M = 0.1 A, sum of upper and lower stages		3.5	5.0	Ω
Output leakage current	I _{M(off)}	Per V _M pin, All control pin: Low level (V _M = MAX. value in the recommended range)			10	μA
Low-voltage detection voltage	V _{DSD}			1.7	2.5	V
Output turn-on time ^{Note}	t _{on2}	I _M = 0.1 A (ch1, ch2 and ch6),	0.2	0.6	2.0	μs
Output turn-off time ^{Note}	t _{off2}	Refer to Figure 7-1. H-bridge Switching Waveform (when SEL₁₂ = L) and Figure 7-2. H-bridge Switching Waveform (when SEL₁₂ = H) .	0.05	0.3	1.0	μs
Output turn-on time ^{Note}	t _{on1}	I _M = 0.2 A (ch3 to ch5),	0.05	0.15	1.0	μs
Output turn-off time ^{Note}	t _{off1}	Refer to Figure 7-2. H-bridge Switching Waveform (when SEL₁₂ = H) (only when V _{INB} = L) .	0.05	0.2	1.0	μs

Note For the turn-on time and the turn-off time, to fix one of two input pins to low level is conditions.

Remark The overheat protection circuit operates under T_{ch} > 150°C. All outputs goes high impedance in the protection status. Note that the overheat protection circuit and the undervoltage lockout circuit do not operate in the standby status.

Switching Characteristics Waveform

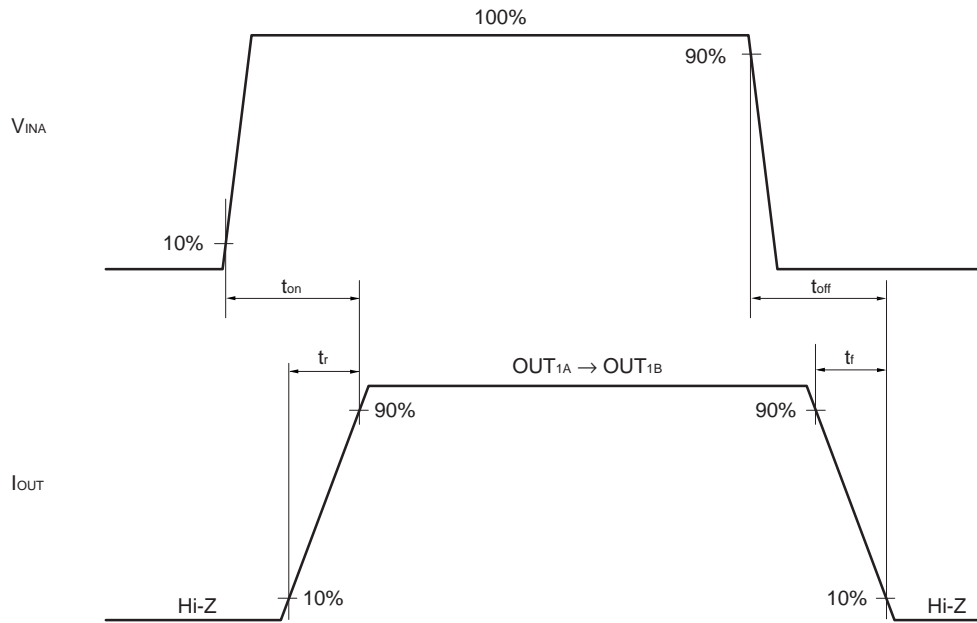
Figure7-1. H-bridge Switching Waveform (when SEL₁₂ = L)



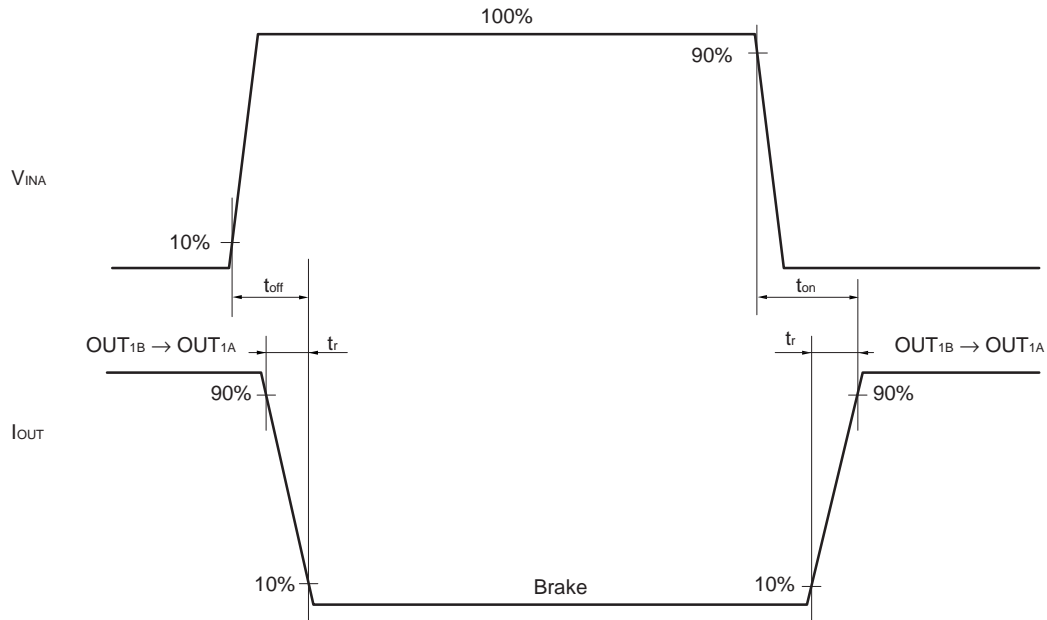
Remark The high impedance period of about 50 ns is prepared for the through-current prevention at the time of mode switching. The t_r (rise time) is designed as 50 ns, and the t_f (fall time) is designed as about 50 ns.

Figure7-2. H-bridge Switching Waveform (when SEL₁₂ = H)

When V_{INB} = L



When V_{INB} = H Note

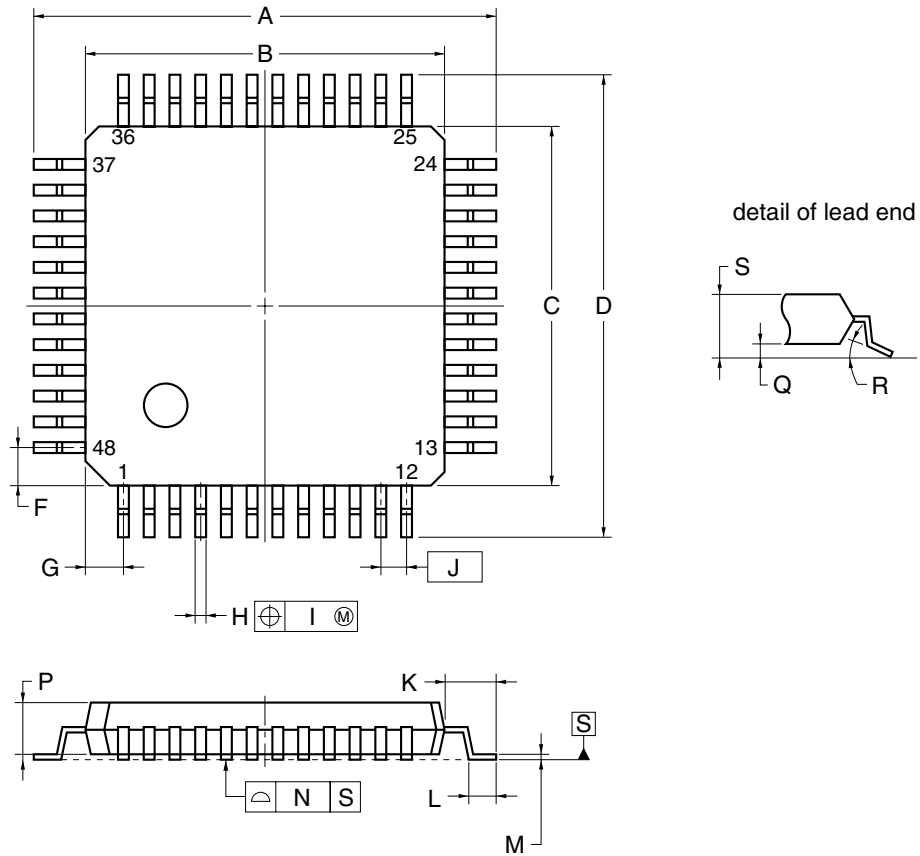


Note The conditions of V_{INB} = H is valid only at ch1, ch2 and ch6. The through current may be flowed, if the switching operation is performed under the conditions of V_{INB} = H at ch3 to ch5.

Remark The high impedance period of about 50 ns is prepared for the through-current prevention at the time of mode switching. The t_r (rise time) is designed as 50 ns, and the t_f (fall time) is designed as about 50 ns.

8. PACKAGE DRAWING

48-PIN PLASTIC TQFP (FINE PITCH) (7x7)



NOTE

Each lead centerline is located within 0.10 mm of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS
A	9.0±0.2
B	7.0±0.2
C	7.0±0.2
D	9.0±0.2
F	0.75
G	0.75
H	0.22 ^{+0.05} _{-0.04}
I	0.10
J	0.5 (T.P.)
K	1.0±0.2
L	0.5±0.2
M	0.145 ^{+0.055} _{-0.045}
N	0.10
P	1.0±0.1
Q	0.1±0.05
R	3° ^{+7°} _{-3°}
S	1.27 MAX.

S48GA-50-9EU-2

9. RECOMMENDED SOLDERING CONDITIONS

The μ PD168002 should be soldered and mounted under the following recommended conditions.

For soldering methods and conditions other than those recommended below, contact an NEC Electronics sales representative.

For technical information, see the following website.

Semiconductor Device Mount Manual (<http://www.necel.com/pkg/en/mount/index.html>)

Type of Surface Mount Device

μ PD168002GA-9EU: 48-pin plastic TQFP (fine pitch) (7 x 7)

Process	Conditions	Symbol
Infrared reflow	Package peak temperature: 235°C, Time: 60 seconds MAX. (at 210°C or higher) , Count: Three times or less, Exposure limit: None, Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended.	IR35-00-3

Caution Do not use different soldering methods together (except for partial heating) .

NOTES FOR CMOS DEVICES**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

Reference Documents**NEC Semiconductor Device Reliability/Quality Control System (C10983E)****Quality Grades on NEC Semiconductor Devices (C11531E)**

- **The information in this document is current as of November, 2003. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC Electronics data sheets or data books, etc., for the most up-to-date specifications of NEC Electronics products. Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.**
- No part of this document may be copied or reproduced in any form or by any means without the prior written consent of NEC Electronics. NEC Electronics assumes no responsibility for any errors that may appear in this document.
- NEC Electronics does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC Electronics products listed in this document or any other liability arising from the use of such products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Electronics or others.
- Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of a customer's equipment shall be done under the full responsibility of the customer. NEC Electronics assumes no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.
- While NEC Electronics endeavors to enhance the quality, reliability and safety of NEC Electronics products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC Electronics products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment and anti-failure features.
- NEC Electronics products are classified into the following three quality grades: "Standard", "Special" and "Specific".

The "Specific" quality grade applies only to NEC Electronics products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of an NEC Electronics product depend on its quality grade, as indicated below. Customers must check the quality grade of each NEC Electronics product before using it in a particular application.

"Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots.

"Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support).

"Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

The quality grade of NEC Electronics products is "Standard" unless otherwise expressly specified in NEC Electronics data sheets or data books, etc. If customers wish to use NEC Electronics products in applications not intended by NEC Electronics, they must contact an NEC Electronics sales representative in advance to determine NEC Electronics' willingness to support a given application.

(Note)

- (1) "NEC Electronics" as used in this statement means NEC Electronics Corporation and also includes its majority-owned subsidiaries.
- (2) "NEC Electronics products" means any product developed or manufactured by or for NEC Electronics (as defined above).