NEC

MOS INTEGRATED CIRCUIT
μPD168102

MONOLITHIC 6-CHANNEL H BRIDGE DRIVER

DESCRIPTION

The μPD168102 is a monolithic 6-channel H bridge driver IC consisting of a CMOS controller and a MOS output stage. Because it uses a MOS process, this driver IC consumes less current and loses less voltage at the output stage than conventional driver ICs that use bipolar transistors. In addition, the μPD168102 employs P-channel MOSFETs in its output stage, eliminating the need for an on-chip the charge pump circuit. Therefore, the current consumption during circuit operation can be significantly reduced.

Of the six output channels, four channels are voltage drive type and two channels are current drive type (voltage drive is also possible). The current drive method of the μPD168102 is the output chopping method, which realizes lower power consumption drive than the conventional high-power-dissipation linear drive method.

The μPD168102 is housed in a 48-pin WQFN to decrease the mounting area and height. The μPD168102 can simultaneously drive two stepper motors and two DC motors and is ideal for the motor driver of digital still cameras.

FEATURES

- Six H bridge circuits employing power MOSFETs
- Voltage drive type: 4 channels, current drive type (constant current chopping type): 2 channels
- Low current consumption due to elimination of charge pump circuit
- Input logic frequency: 100 kHz supported
- 3 V power supply supported
  Minimum operating supply voltage: 2.5 V
- Low voltage malfunction prevention circuit
  Internal circuit shutdown at V_{DD} < 2.5 V
- On-chip overheat protection circuit
- 48-pin WQFN (7 mm × 7 mm)

ORDERING INFORMATION

Part Number	Package
μPD168102K9-5B4	48-pin plastic WQFN (7 mm × 7 mm)

Document No. S15301EJ1V0DS00 (1st edition)
Date Published April 2002 N CP(K)
Printed in Japan

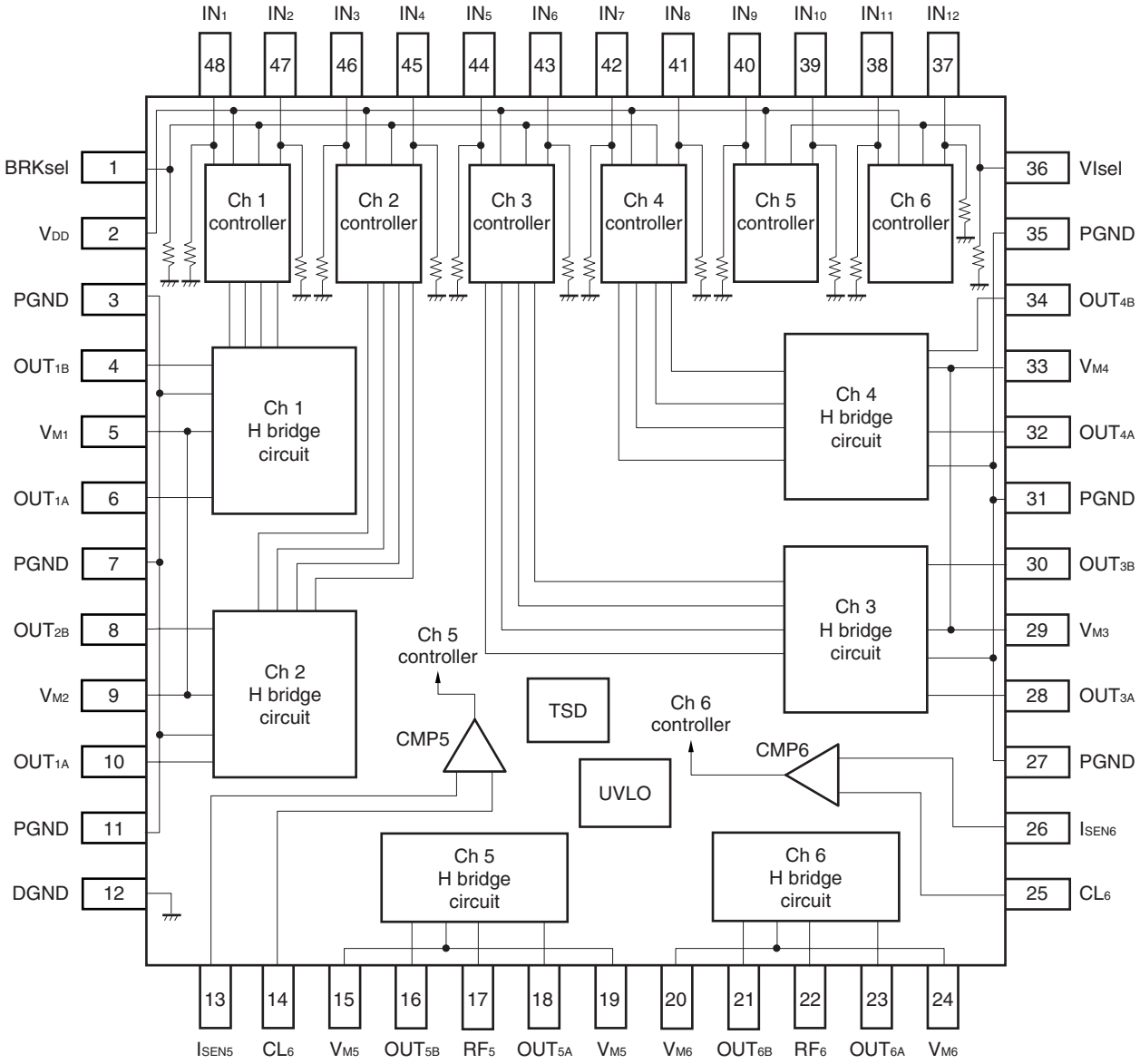
PIN FUNCTIONS

Package: 48-pin WQFN (7 mm × 7 mm)

Pin No.	Pin Name	Pin Function
1	BRKsel	Stop mode switching pin when output open
2	V_{DD}	Control block power supply pin
3	PGND	Output GND pin
4	OUT_{1B}	Ch 1 output pin
5	V_{M1}	Ch 1 output block power supply pin
6	OUT_{1A}	Ch 1 output pin
7	PGND	Output block GND pin
8	OUT_{2B}	Ch 2 output pin
9	V_{M2}	Ch 2 output block power supply pin
10	OUT_{2A}	Ch 2 output pin
11	PGND	Output block GND pin
12	DGND	Control block GND pin
13	I_{SEN5}	Ch 5 current sense signal input pin
14	CL_5	Ch 5 reference voltage input pin
15	V_{M5}	Ch 5 output block power supply pin
16	OUT_{5B}	Ch 5 output pin
17	RF_5	Ch 5 sense resistor connection pin
18	OUT_{5A}	Ch 5 output pin
19	V_{M5}	Ch 5 output block power supply pin
20	V_{M6}	Ch 6 output block power supply pin
21	OUT_{6B}	Ch 6 output pin
22	RF_6	Ch 6 sense resistor connection pin
23	OUT_{6A}	Ch 6 output pin
24	V_{M6}	Ch 6 output block power supply pin
25	CL_6	Ch 6 reference voltage input pin
26	I_{SEN6}	Ch 6 current sense signal input pin
27	PGND	Output block GND pin
28	OUT_{3A}	Ch 3 output pin
29	V_{M3}	Ch 3 output block power supply pin
30	OUT_{3B}	Ch 3 output pin
31	PGND	Output block GND pin
32	OUT_{4A}	Ch 4 output pin
33	V_{M4}	Ch 4 output block power supply pin
34	OUT_{4B}	Ch 4 output pin
35	PGND	Output block GND pin
36	VIsel	Voltage/current control switching pin (ch 5, ch 6)
37	IN_{12}	Ch 6 input pin
38	IN_{11}	Ch 6 input pin
39	IN_{10}	Ch 5 input pin
40	IN_9	Ch 5 input pin
41	IN_8	Ch 4 input pin
42	IN_7	Ch 4 input pin
43	IN_6	Ch 3 input pin
44	IN_5	Ch 3 input pin
45	IN_4	Ch 2 input pin
46	IN_3	Ch 2 input pin
47	IN_2	Ch 1 input pin
48	IN_1	Ch 1 input pin

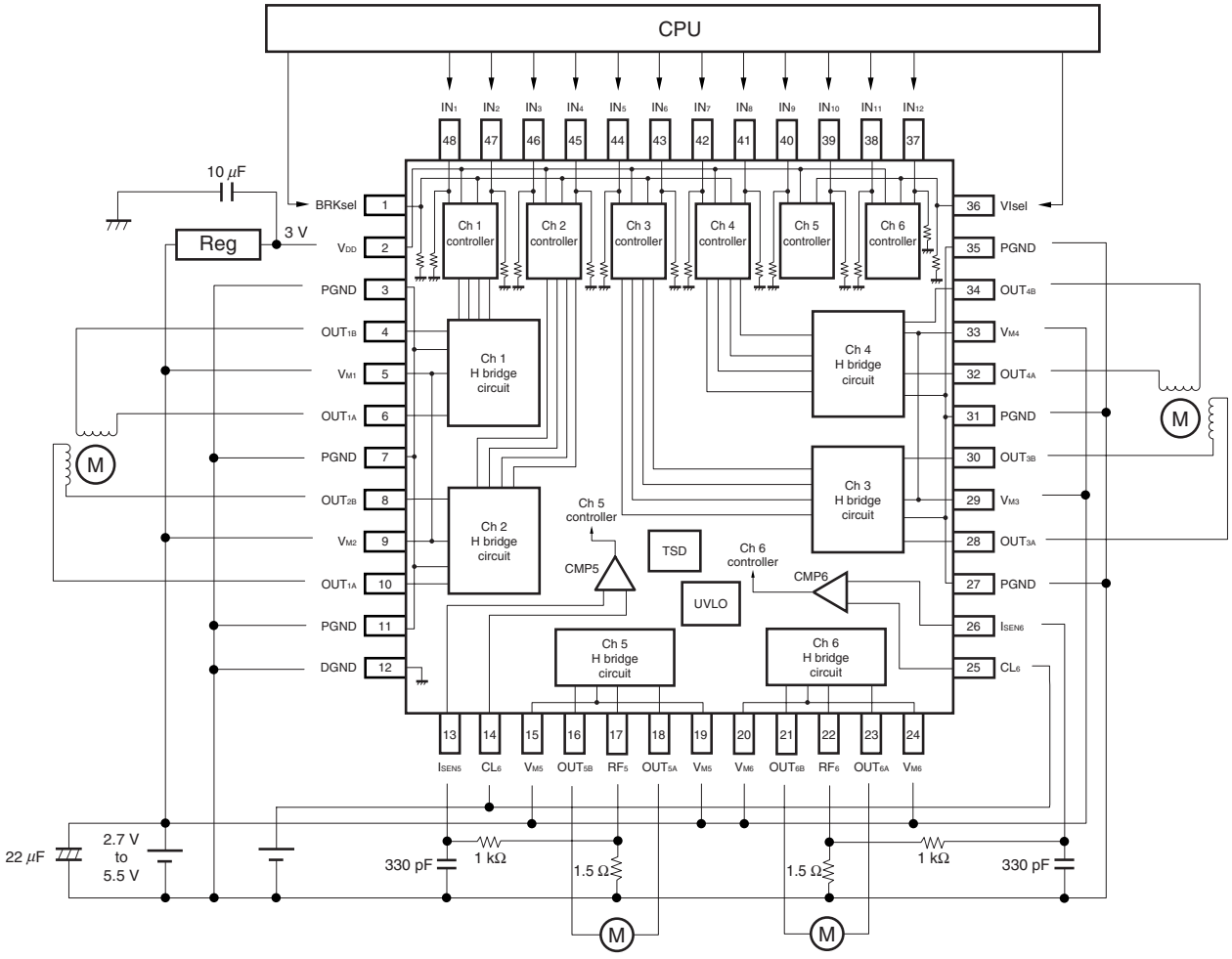
Caution Multiple pins with the same function must all be connected.

BLOCK DIAGRAM



Caution Multiple pins with the same function must all be connected. The motor power supply pins V_{M1} and V_{M2}, and V_{M3} and V_{M4} are internally connected, so be sure to apply the same potential to them.

EXAMPLE OF STANDARD CONNECTION



This circuit diagram is shown as an example of connection, and is not intended for mass production design.

FUNCTION OPERATION TABLE

The logic of each channel is shown in the table below.

I/O Truth Table for Channels 1 to 6

Input			Output		Output Status	Operating Mode of Ch 5 and Ch 6
VIsel	IN1, 3, 5, 7, 9, 11	IN2, 4, 6, 8, 10, 12	OUTA	OUTB		
L	L	L	Z	Z	Stopped (output open, standby)	Voltage control output
	L	H	L	H	Reverse (OUTB → OUTA)	
	H	L	H	L	Forward (OUTA → OUTB)	
	H	H	L	L	Stopped (short brake)	
H	L	L	Z	Z	Stopped (output open)	Constant current chopping
	L	H	L	H	Reverse (OUTB → OUTA)	
	H	L	H	L	Forward (OUTA → OUTB)	
	H	H	L	L	Stopped (short brake)	

H: High level, L: Low level, Z: High impedance

Constant current chopping is possible for channels 5 and 6.

When VIsel is set to high level, if the voltage becomes higher than the reference voltage (external input) and the current becomes higher than the current set by the feedback resistor, the output can be forcibly chopped.

When VIsel is set to low level, channels 5 and 6 function in the same way as channels 1 to 4.

Standby function

The μPD168102 realizes a standby function by combining the input signals.

By setting all the control input signals of channels 1 to 6 to low level, a standby mode in which the current consumption of the internal circuit is suppressed is entered. Note that the output status is high impedance (output open).

BRKsel pin function

By using the logic of BRKsel, whether the function that prevents the motor power supply rising in the Hi-Z output status (input L, L) is enabled or disabled can be selected. Refer to the truth table below.

BRKsel Truth Table

BRKsel	Function
L	Hi-Z status
H	Regenerates output current using an internal channel. An internal timer is incorporated, through which the regeneration period is set for approx. 1 ms, and then the Hi-Z status is entered.

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C: MOUNTED ON GLASS EPOXY BOARD 100 mm × 100 mm × 1 mm, COPPER FILM AREA: 15%)

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{DD}	Control block	–0.5 to +6.0	V
	V_M	Motor block	–0.5 to +6.0	
Input voltage	V_{IN}		–0.5 to V_{DD}+0.5	V
Output pin voltage	V_{OUT}	Ch 1 to ch 4	6.2	V
		Ch 5, ch 6	5.7	
DC output current 1 (ch 1 to ch 4)	$I_{D(DC)1}$	DC	±0.3	A/ch
DC output current 2 (ch 5, ch 6)	$I_{D(DC)2}$	DC	±0.5	A/ch
Instantaneous output current 1 (ch 1 to ch 4)	$I_{D(pulse)1}$	PW < 10 ms, duty ≤ 20%	±0.6	A/ch
Instantaneous output current 2 (ch 5, ch 6)	$I_{D(pulse)2}$	PW < 10 ms, duty ≤ 20%	±1.0	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

RECOMMENDED OPERATING CONDITIONS (T_A = 25°C: MOUNTED ON GLASS EPOXY BOARD 100 mm × 100 mm × 1 mm, COPPER FILM AREA: 15%)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Supply voltage	V_{DD}	Control block	2.5		5.5	V
	V_M	Motor block	2.7		5.5	V
Input voltage	V_{IN1}		0		V_{DD}	V
	V_{IN2}	CL pin	0.1		0.5	V
DC output current 1 (ch 1 to ch 4)	$I_{D(DC)1}$	DC	–0.2		+0.2	A/ch
DC output current 2 (ch 5, ch 6)	$I_{D(DC)2}$	DC	–0.4		+0.4	A/ch
Instantaneous output current 1 (ch 1 to ch 4)	$I_{D(pulse)1}$	PW < 10 ms, duty ≤ 20%	–0.4		+0.4	A/ch
Instantaneous output current 2 (ch 5, ch 6)	$I_{D(pulse)2}$	PW < 10 ms, duty ≤ 20%	–0.8		+0.8	A/ch
Logic input frequency	f_{IN}				100	kHz
Operating temperature range	T_A		–10		85	°C
Peak junction temperature	$T_{CH(MAX)}$				125	°C

ELECTRICAL SPECIFICATIONS (Unless otherwise specified, V_{DD} = V_M = 3 V, T_A = 25°C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
V_{DD} pin current in standby mode	$I_{DD(STB)}$				1.0	μA
V_{DD} pin current when operating	$I_{DD(ACT)}$				1.0	mA
Input current, high	I_{IH}	$V_{IN} = V_{DD}$			60	μA
Input current, low	I_{IL}	$V_{IN} = 0$	−1.0			μA
Input pull-down resistor	R_{IND}		50		200	kΩ
Input voltage, high	V_{IH}	2.5 V ≤ V_{DD} ≤ 5.5 V	0.7 × V_{DD}			V
Input voltage, low	V_{IL}	2.5 V ≤ V_{DD} ≤ 5.5 V			0.3 × V_{DD}	V
H bridge on-resistance 1 (ch 1 to ch 4)	R_{ON1}	I_M = 0.2 A, sum of the top and bottom stages		1.5	2.0	Ω
H bridge on-resistance 2 (ch 5, ch 6)	R_{ON2}	I_M = 0.4 A, RF_5, RF_6 = 0 V, sum of the top and bottom stages		1.0	1.5	Ω
Output leakage current	$I_{M(OFF)}$	Per V_M pin, V_M = 5.5 V, all control pins are low level			10	μA
Current detection comparator offset voltage	V_{CO}	V_{CL} = 0.1 V	−10		10	mV
Detection voltage at low voltage	V_{DDS}				2.5	V
Output turn-on time	t_{ON}	R_M = 20 Ω, see **Figure 1**		0.7	2.0	μs
Output turn-off time	t_{OFF}			0.2	0.5	μs
All-off time at mode change	t_{HIZ}		50			ns
Rise time	t_r	R_M = 20 Ω, see **Figure 1**		0.3		μs
Fall time	t_f			0.1		μs
Current detection comparator operation delay time	t_{CDL}	V_{CL} = 0.1 V, V_{ISEN} = 0 V ⟷ 0.2 V, see **Figure 2**		0.4	1.0	μs

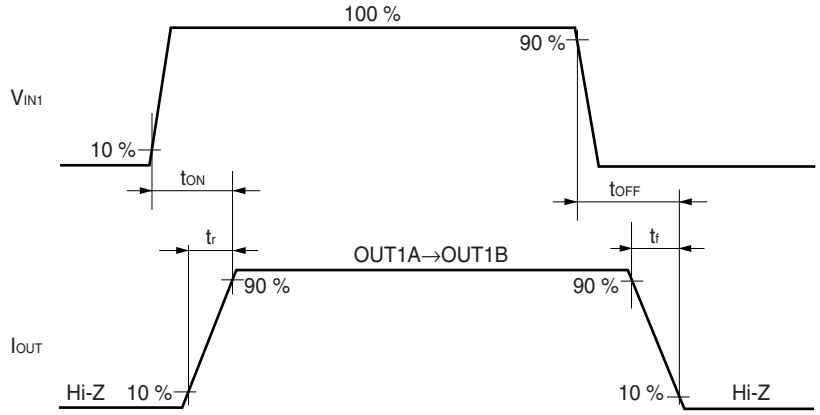
The overheat protection circuit operates at T_{ch} > 150°C. In the overheat protected status, all outputs are high impedance.

In the standby mode, the overheat protection circuit and the low-voltage malfunction prevention circuit do not operate.

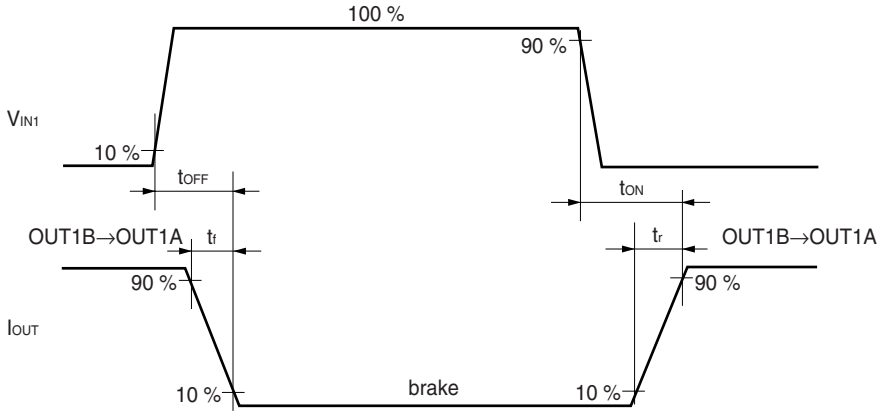
SWITCHING CHARACTERISTICS WAVEFORMS

Figure 1. H Bridge Switching Waveform

(1) IN2 = Low level

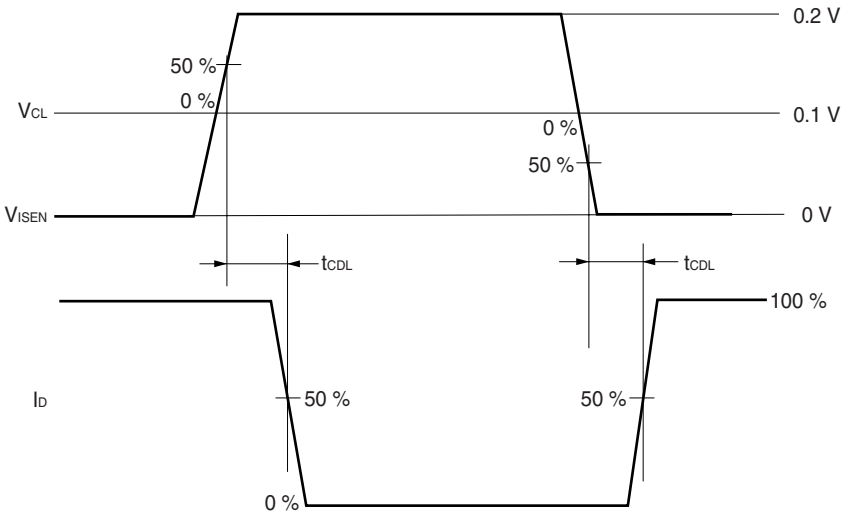


(2) IN2 = High level

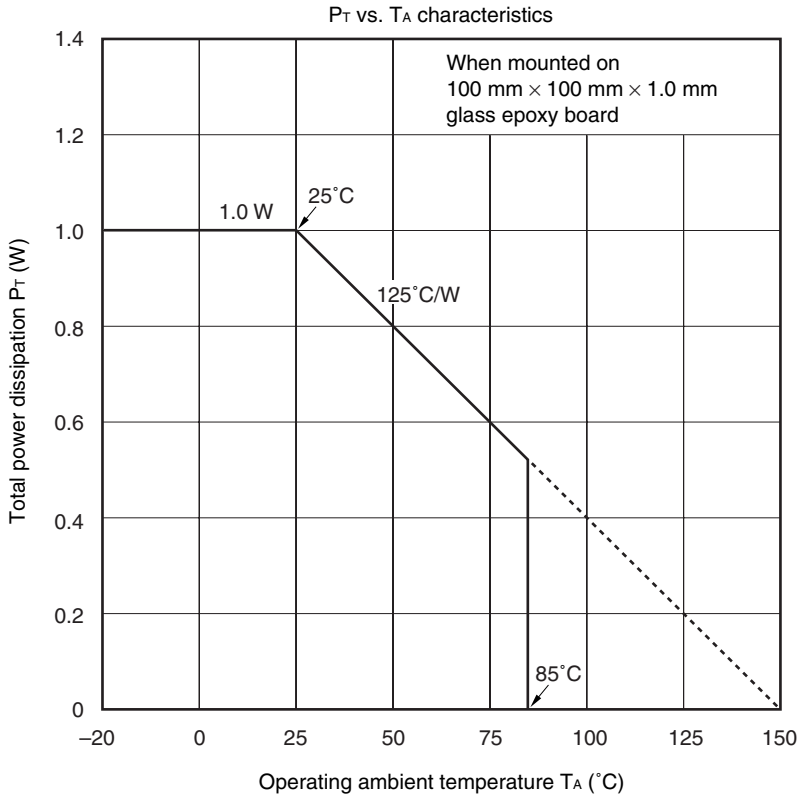


A high impedance period of approx. 50 ns is secured to prevent through current when switching the mode.

Figure 2. Current Detection Comparator Switching Waveform



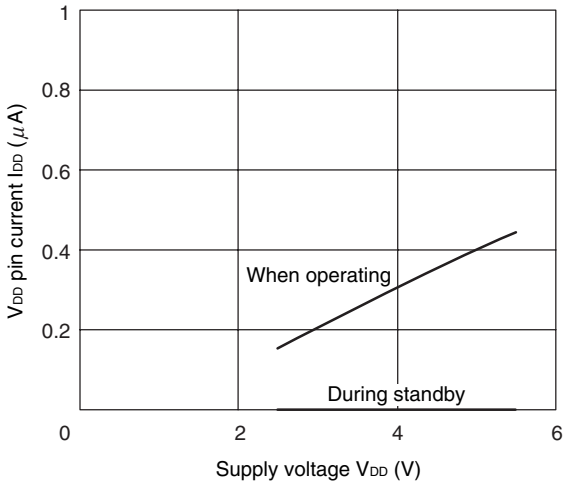
TOTAL POWER DISSIPATION AND OPERATING AMBIENT TEMPERATURE CHARACTERISTICS



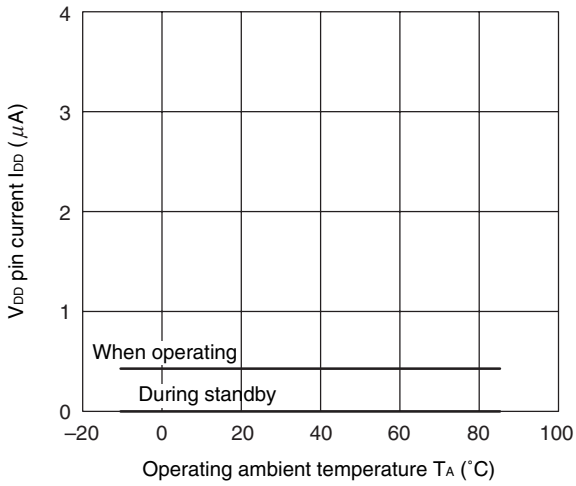
Remark When the operating ambient temperature is 25°C or lower, power application up to 1 W is possible. When the operating ambient temperature is higher than 25°C, perform derating in accordance with the above figure. In addition, when at 85°C (operating ambient temperature recommended condition), power application up to 0.52 W is possible.

CHARACTERISTICS CURVES

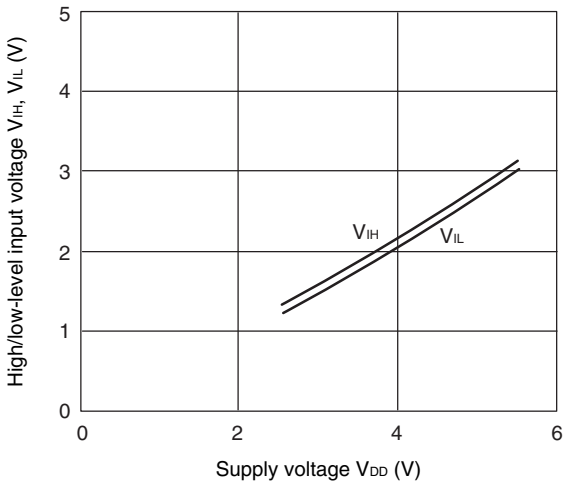
I_{DD} vs. V_{DD} characteristics (V_M = 3.0 V, T_A = 25˚C)



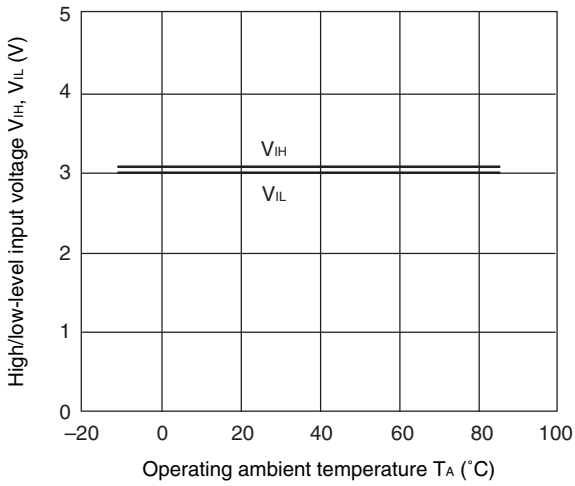
I_{DD} vs. T_A characteristics (V_{DD} = 5.5 V, V_M = 3.0 V)



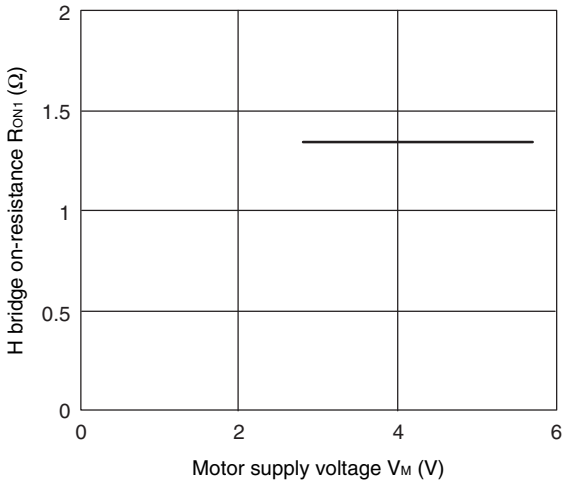
V_{IH}, V_{IL} vs. V_{DD} characteristics (V_M = 3.0 V, T_A = 25˚C)



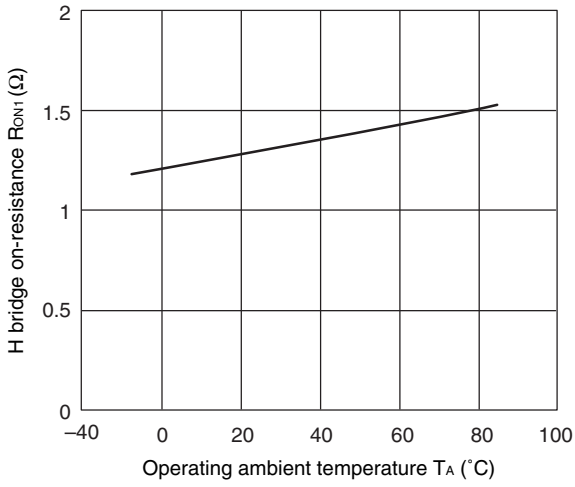
V_{IH}, V_{IL} vs. T_A characteristics (V_{DD} = 5.5 V, V_M = 3.0 V)



R_{ON1} (ch 1 to ch 4) vs. V_M characteristics (V_{DD} = 3.0 V, T_A = 25˚C)

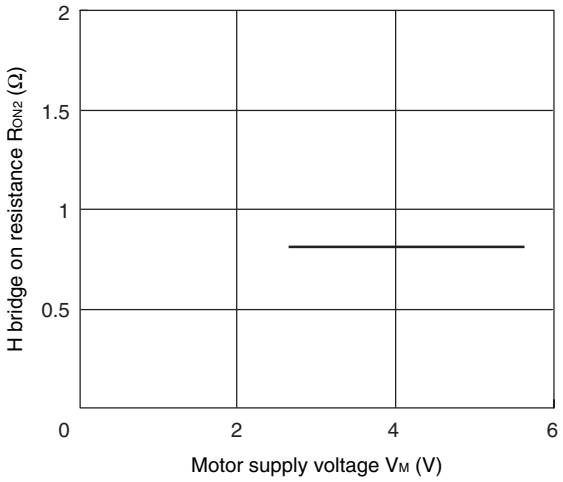


R_{ON1} (ch 1 to ch 4) vs. T_A characteristics (V_{DD} = 3.0 V, V_M 5.5 V)

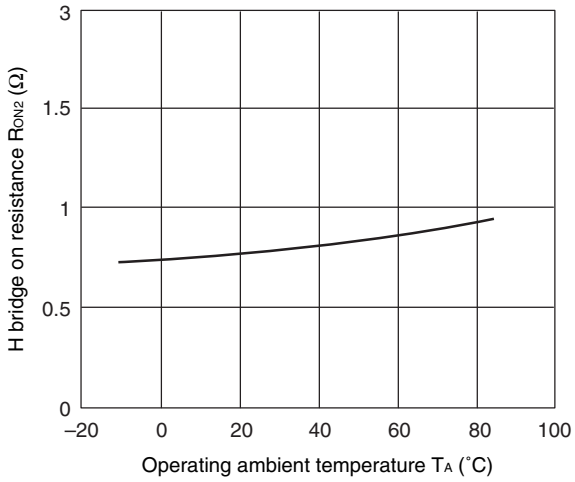


CHARACTERISTICS CURVES

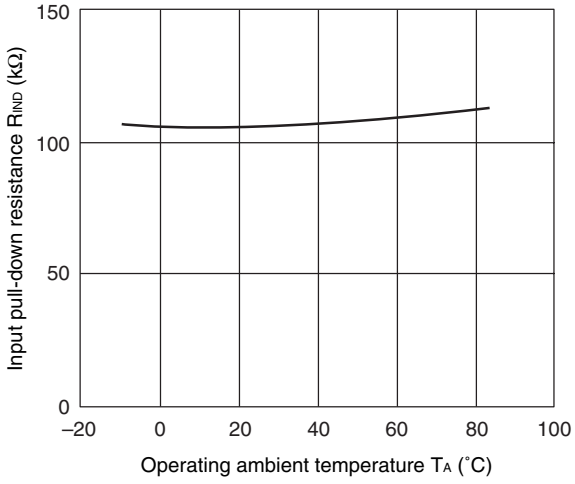
R_{ON2} (ch 5, ch 6) vs. V_M characteristics (V_{DD} = 3.0 V, T_A = 25˚C)



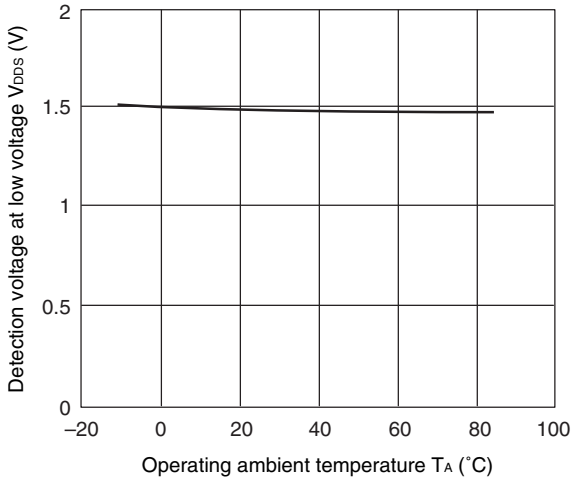
R_{ON2} (ch 5, ch 6) vs. T_A characteristics (V_{DD} = 3.0 V, V_M = 5.5 V)



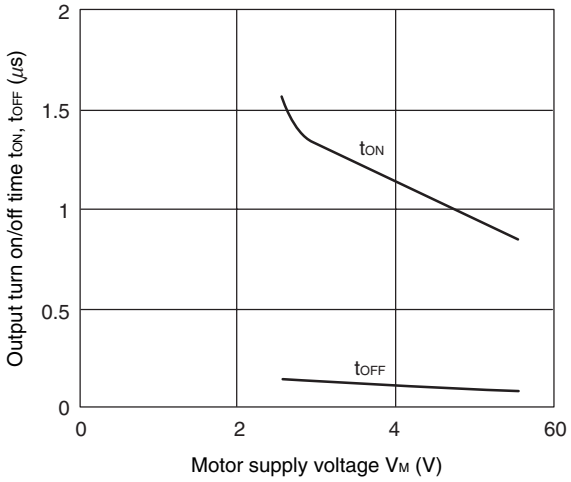
R_{IND} vs. T_A characteristics (V_{DD} = V_M = 3.0 V)



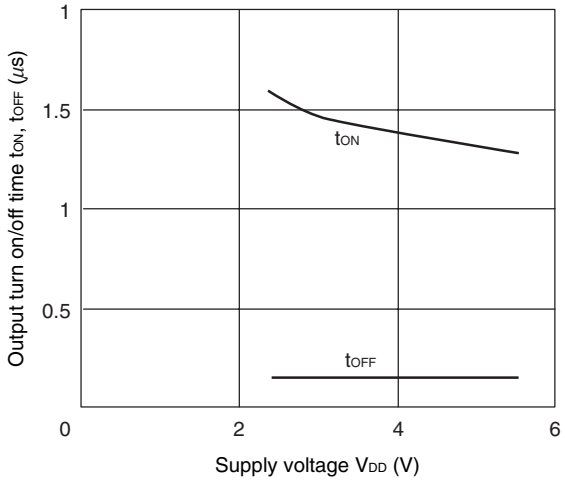
V_{DDS} vs. T_A characteristics (V_{DD} = V_M = 3.0 V)



t_{ON}, t_{OFF} vs. V_M characteristics (V_M = 2.5 V, T_A = 25˚C)

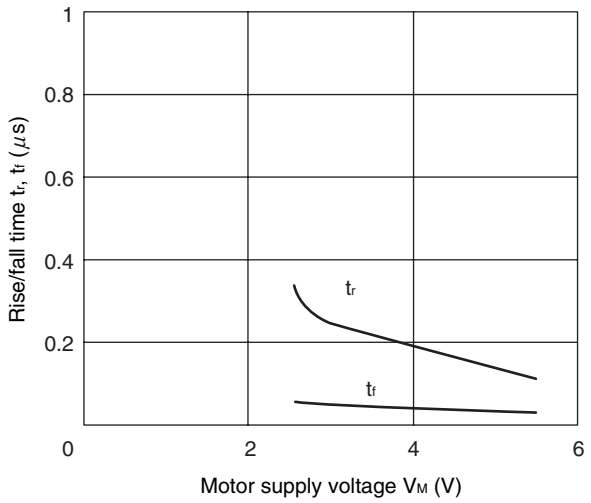


t_{ON}, t_{OFF} vs. V_{DD} characteristics (V_M = 2.7 V, T_A = 25˚C)

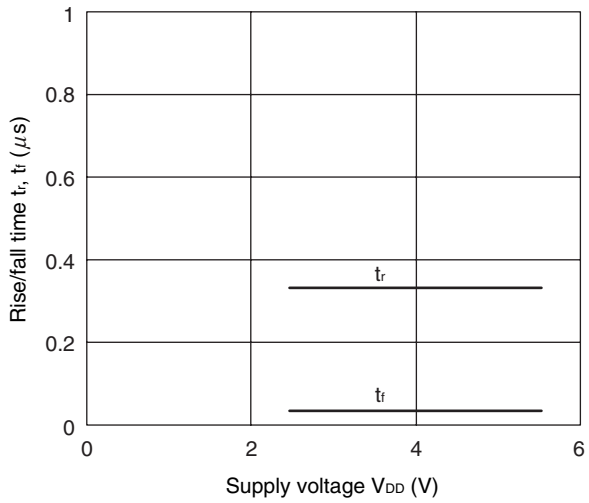


CHARACTERISTICS CURVES

t_r, t_f vs. V_M characteristics (V_{DD} = 2.5V, T_A = 25˚C)

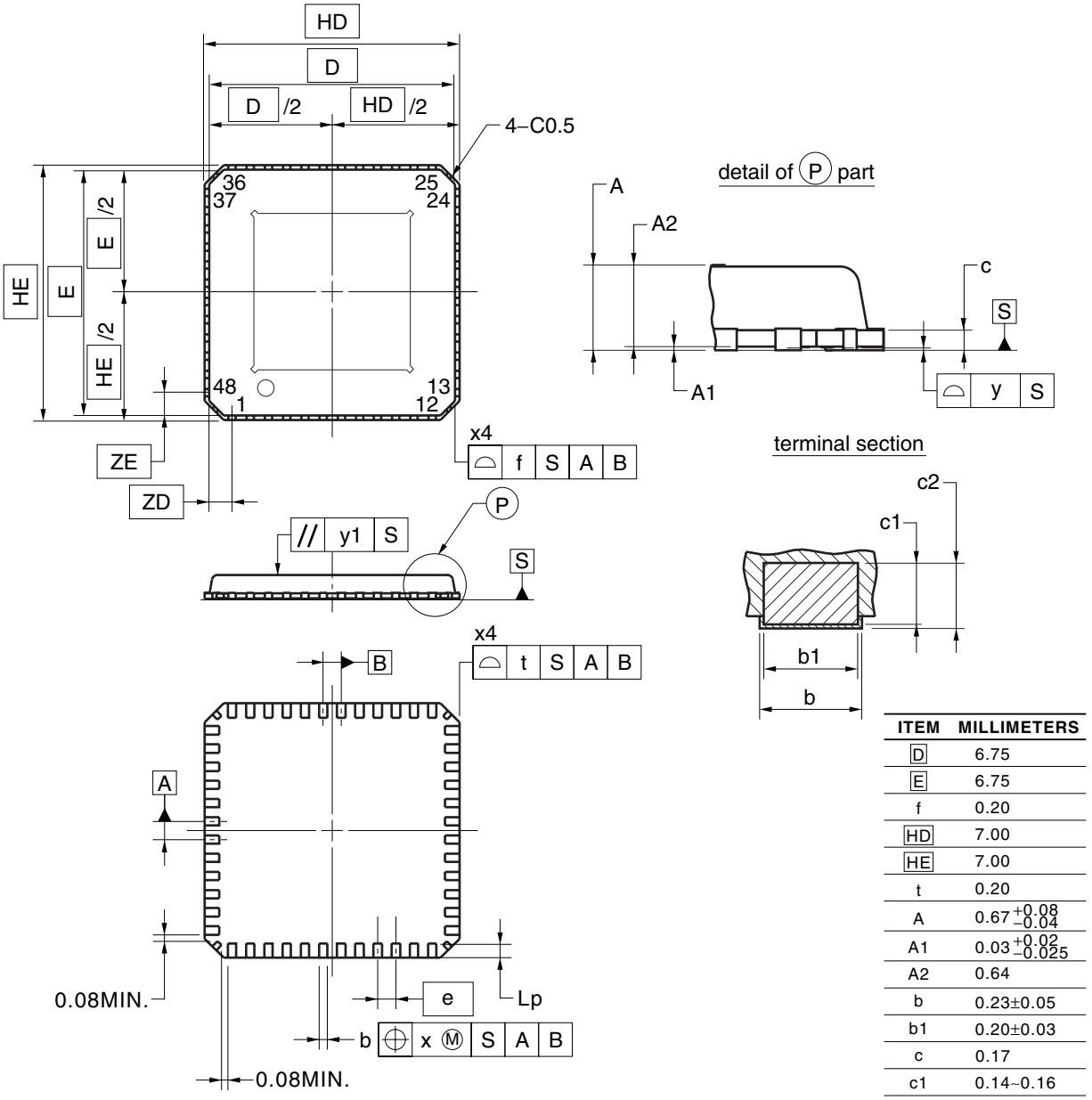


t_r, t_f vs. V_{DD} characteristics (V_M = 2.7 V, T_A = 25˚C)



PACKAGE DRAWING

48-PIN PLASTIC WQFN (7x7)



NOTE
"t" and "f" excludes mold flash

ITEM	MILLIMETERS
D	6.75
E	6.75
f	0.20
HD	7.00
HE	7.00
t	0.20
A	$0.67^{+0.08}_{-0.04}$
A1	$0.03^{+0.02}_{-0.025}$
A2	0.64
b	0.23±0.05
b1	0.20±0.03
c	0.17
c1	0.14~0.16
c2	0.14~0.20
e	0.50
Lp	0.40±0.10
x	0.05
y	0.08
y1	0.10
ZD	0.625
ZE	0.625

P48K9-50-5B4

RECOMMENDED SOLDERING CONDITIONS

The μPD168102 should be soldered and mounted under the following recommended conditions.

For details of the recommended soldering conditions, refer to the document **Semiconductor Device Mounting Technology Manual (C10535E)**. For soldering methods and conditions other than those recommended below, contact an NEC sales representative.

Surface Mounting Type Soldering Conditions

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 260°C, Time: 60 seconds max. (at 220°C or higher), Count: Three times or less, Exposure limit: 3 days[Note] (after that, prebake at 125°C for 10 hours), Flux: Rosin-based flux with low chlorine content (chlorine 0.2 Wt% or below) is recommended	IR60-103-3

Note After opening the dry pack, store it at 25°C or less and 65% RH or less for the allowable storage period.

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.

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- NEC semiconductor products are classified into the following three quality grades:
  "Standard", "Special" and "Specific". The "Specific" quality grade applies only to semiconductor products developed based on a customer-designated "quality assurance program" for a specific application. The recommended applications of a semiconductor product depend on its quality grade, as indicated below. Customers must check the quality grade of each semiconductor 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 semiconductor products is "Standard" unless otherwise expressly specified in NEC's data sheets or data books, etc. If customers wish to use NEC semiconductor products in applications not intended by NEC, they must contact an NEC sales representative in advance to determine NEC's willingness to support a given application.

  (Note)

  (1) "NEC" as used in this statement means NEC Corporation and also includes its majority-owned subsidiaries.

  (2) "NEC semiconductor products" means any semiconductor product developed or manufactured by or for NEC (as defined above).

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