NEC

MOS INTEGRATED CIRCUIT
μ PD168113

SERIAL CONTROL 7-CHANNEL H-BRIDGE DRIVER

DESCRIPTION

The μ PD168113 is a serial control 7-channel H-bridge driver that consists of a CMOS controller and a MOS output stage. It can reduce the current consumption and the voltage loss at the output stage compared with a conventional driver using bipolar transistors, thanks to employment of a MOS process. The μ PD168113 can drive various motor coils by controlling the serial, so that the number of signal lines necessary for controlling the motor can be decreased.

The package is a 56-pin WQFN that helps reduce the mounting area and height.

The μ PD168113 can be used to drive two stepping motors, or two DC motors and one coil.

FEATURES

- Seven H-bridge circuits employing power MOS FET
- Low-voltage driving
    V_{DD} = 2.7 to 3.6 V
    V_M = 2.7 to 5.5 V
- Output on-state resistance: 1.0 Ω TYP., 1.5 Ω MAX. (sum of top and bottom stage)
- Output current
    <1 ch to 6 ch>
      DC current: 0.4 A/ch (when each channel is used independently)
      Peak current: 0.7 A/ch (when each channel is used independently)
    <7 ch>
      DC current: 0.5 A/ch (when used independently)
      Peak current: 0.7 A/ch (when used independently)
- Input logic frequency: 6 MHz supported
- Undervoltage lockout circuit
    Shuts down the internal circuit at V_{DD} = 1.7 V TYP.
- Overheat protection circuit
    Operates at 150°C or more and shuts down internal circuitry.
- 56-pin WQFN (□8 mm, 0.5 mm pitch)
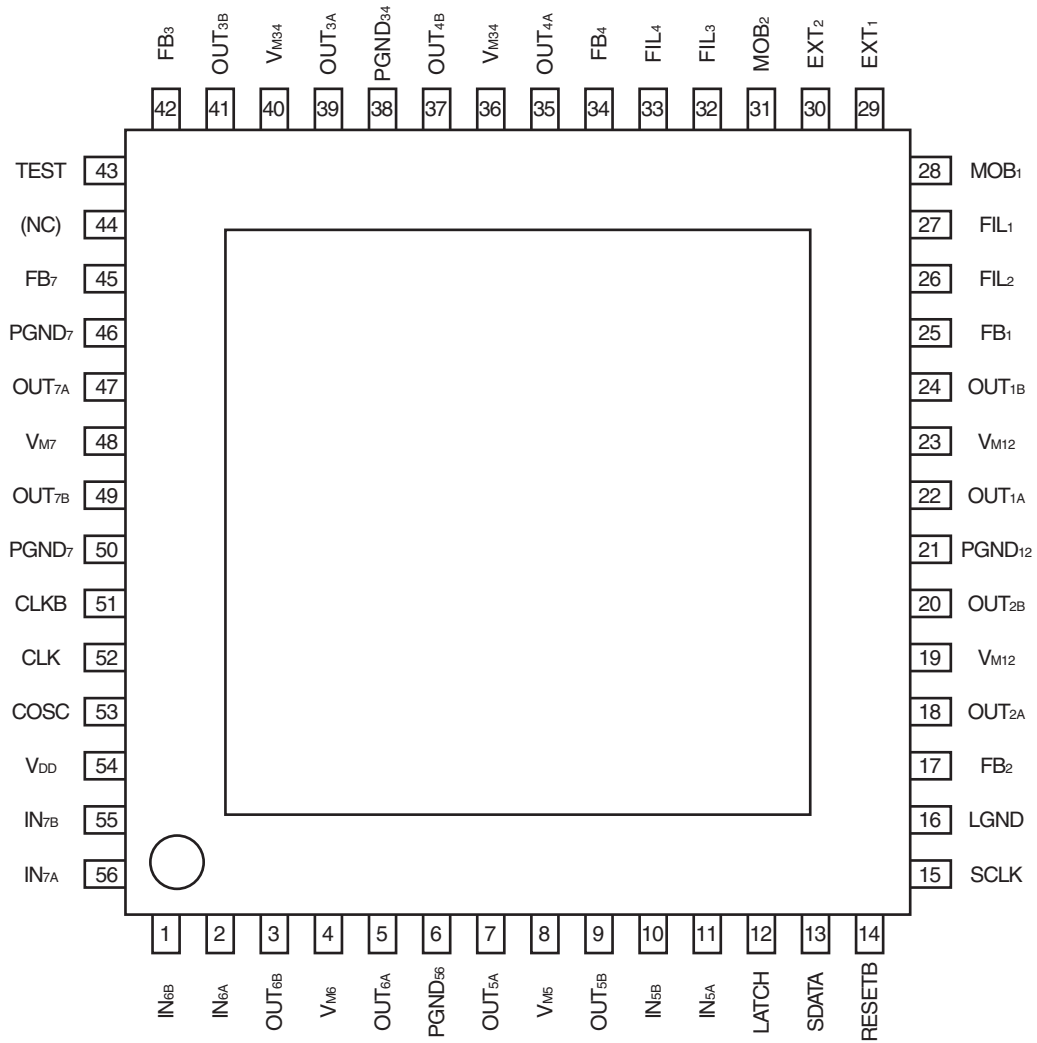
ORDERING INFORMATION

Part Number	Package
μ PD168113K9-9B4-A	56-pin plastic WQFN (8 x 8)

The mark ★ shows major revised points.

1. PIN CONFIGURATION

Package: 56-pin plastic WQFN (8 x 8)

Top pins (left to right): 42 FB_3, 41 OUT_{3B}, 40 V_{M34}, 39 OUT_{3A}, 38 $PGND_{34}$, 37 OUT_{4B}, 36 V_{M34}, 35 OUT_{4A}, 34 FB_4, 33 FIL_4, 32 FIL_3, 31 MOB_2, 30 EXT_2, 29 EXT_1

Left pins (top to bottom):
- 43 TEST
- 44 (NC)
- 45 FB_7
- 46 $PGND_7$
- 47 OUT_{7A}
- 48 V_{M7}
- 49 OUT_{7B}
- 50 $PGND_7$
- 51 CLKB
- 52 CLK
- 53 COSC
- 54 V_{DD}
- 55 IN_{7B}
- 56 IN_{7A}

Right pins (top to bottom):
- 28 MOB_1
- 27 FIL_1
- 26 FIL_2
- 25 FB_1
- 24 OUT_{1B}
- 23 V_{M12}
- 22 OUT_{1A}
- 21 $PGND_{12}$
- 20 OUT_{2B}
- 19 V_{M12}
- 18 OUT_{2A}
- 17 FB_2
- 16 LGND
- 15 SCLK

Bottom pins (left to right): 1 IN_{6B}, 2 IN_{6A}, 3 OUT_{6B}, 4 V_{M6}, 5 OUT_{6A}, 6 $PGND_{56}$, 7 OUT_{5A}, 8 V_{M5}, 9 OUT_{5B}, 10 IN_{5B}, 11 IN_{5A}, 12 LATCH, 13 SDATA, 14 RESETB

2. PIN FUNCTIONS

(1/2)

Pin No.	Pin Name	Function
1	IN_{6B}	H-bridge 6 input pin B
2	IN_{6A}	H-bridge 6 input pin A
3	OUT_{6B}	H-bridge 6 output pin B
4	V_{M6}	H-bridge 6 power supply pin
5	OUT_{6A}	H-bridge 6 output pin A
6	$PGND_{56}$	H-bridge 5, H-bridge 6 GND pin
7	OUT_{5A}	H-bridge 5 output pin A
8	V_{M5}	H-bridge 5 power supply pin
9	OUT_{5B}	H-bridge 5 output pin B
10	IN_{5B}	H-bridge 5 input pin B
11	IN_{5A}	H-bridge 5 input pin A
12	LATCH	Chip select input pin
13	SDATA	Serial data input pin
14	RESETB	Reset pin (low active)
15	SCLK	Serial clock input pin
16	LGND	Logic block GND pin
17	FB_2	Current detection resistor connection pin 2
18	OUT_{2A}	H-bridge 2 output pin A
19	V_{M12}	H-bridge 1, H-bridge 2 power supply pin
20	OUT_{2B}	H-bridge 2 output pin B
21	$PGND_{12}$	H-bridge 1, H-bridge 2 GND pin
22	OUT_{1A}	H-bridge 1 output pin A
23	V_{M12}	H-bridge 1, H-bridge 2 power supply pin
24	OUT_{1B}	H-bridge 1 output pin B
25	FB_1	Current detection resistor connection pin 1
26	FIL_2	Filter capacitor connection pin 2
27	FIL_1	Filter capacitor connection pin 1
28	MOB_1	MOB signal output pin 1 (open-drain output)
29	EXT_1	EXT signal output pin 1
30	EXT_2	EXT signal output pin 2
31	MOB_2	MOB signal output pin 2 (open-drain output)
32	FIL_3	Filter capacitor connection pin 3
33	FIL_4	Filter capacitor connection pin 4
34	FB_4	Current detection resistor connection pin 4
35	OUT_{4A}	H-bridge 4 output pin A
36	V_{M34}	H-bridge 3, H-bridge 4 power supply pin
37	OUT_{4B}	H-bridge 4 output pin B
38	$PGND_{34}$	H-bridge 3, H-bridge 4 GND pin

| Pin No.	Pin Name	Function
39	OUT$_{3A}$	H-bridge 3 output pin A
40	V$_{M34}$	H-bridge 3, H-bridge 4 power supply pin
41	OUT$_{3B}$	H-bridge 3 output pin B
42	FB$_3$	Current detection resistor connection pin 3
43	TEST	Test input pin (Connect to GND when normal using.)
44	(NC)	Unused
45	FB$_7$	Current detection resistor connection pin 7
46	PGND$_7$	H-bridge 7 GND pin
47	OUT$_{7A}$	H-bridge 7 output pin A
48	V$_{M7}$	H-bridge 7 power supply pin
49	OUT$_{7B}$	H-bridge 7 output pin B
50	PGND$_7$	H-bridge 7 GND pin
51	CLKB	External clock output pin/crystal oscillator connection pin 2
52	CLK	External clock output pin/crystal oscillator connection pin 1
53	COSC	Chopping frequency setting capacitor connection pin
54	V$_{DD}$	Logic block power supply pin
55	IN$_{7B}$	H-bridge 7 input pin B
56	IN$_{7A}$	H-bridge 7 input pin A

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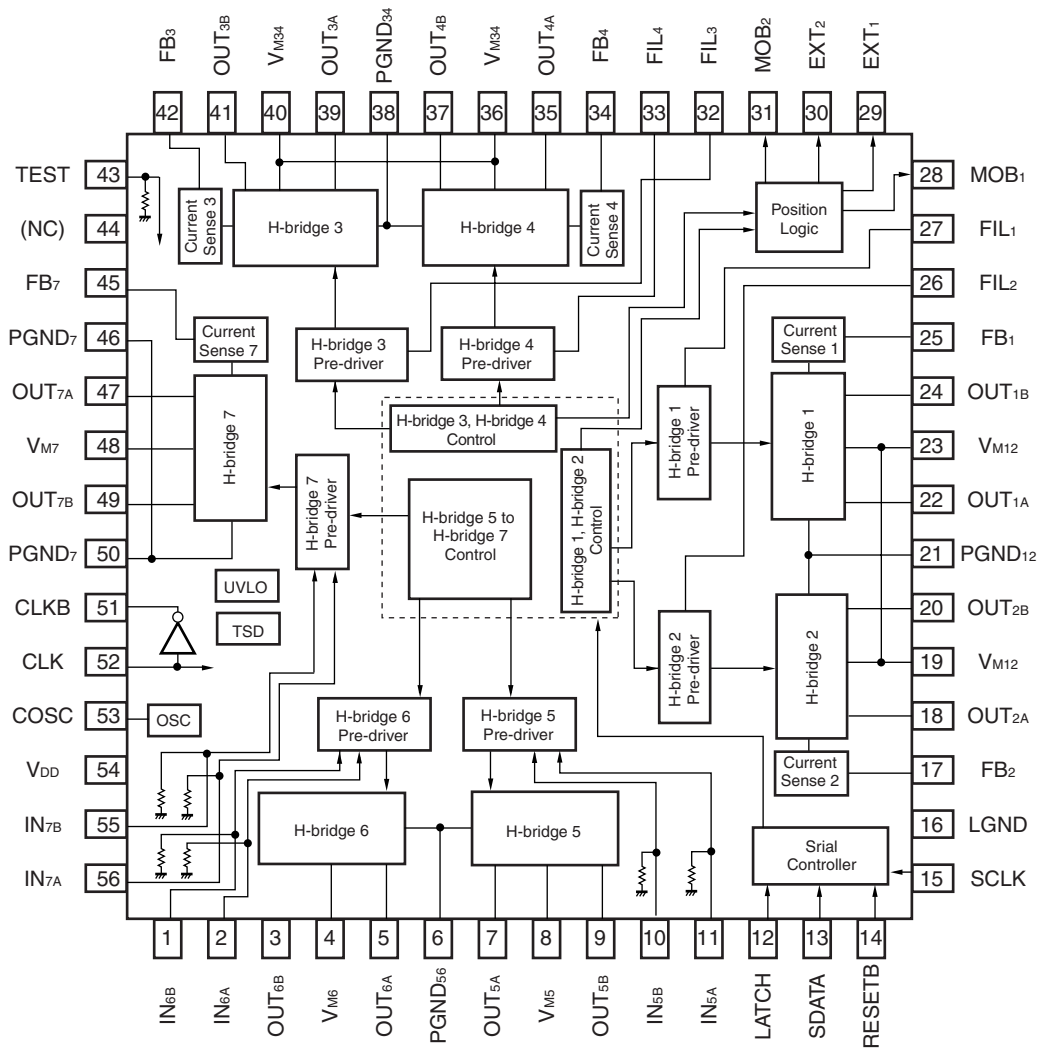
Cautions 1. Be sure to connect all of the pins which have more than one.

2. A pull-down resistor (50 to 200 kΩ) is connected to the TEST, IN$_{5A}$, IN$_{5B}$, IN$_{6A}$, IN$_{6B}$, IN$_{7A}$ and IN$_{7B}$ pins.
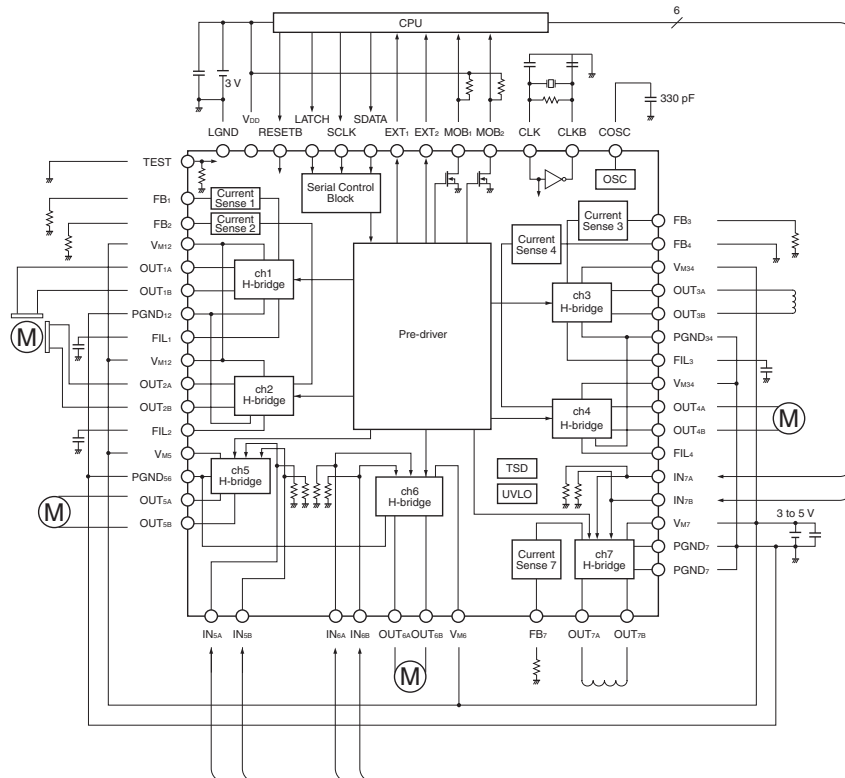
Fix these input pins to GND when they are not used.

4. STANDARD CONNECTION EXAMPLES

(1) For external control of only ch7 when external CLK is input and two stepping motors are used
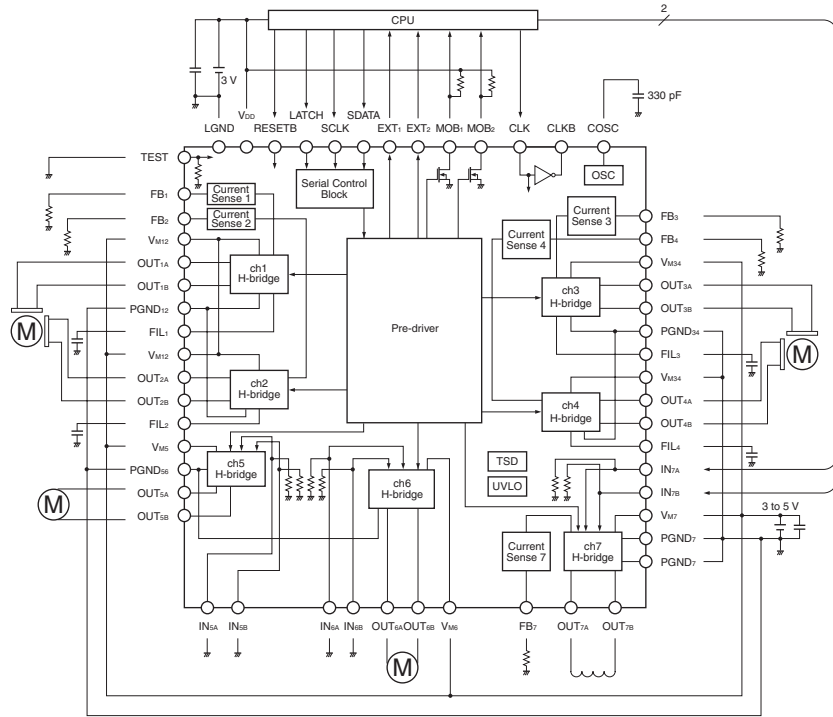
(2) For external control of ch5 to ch7 when crystal oscillator and one stepping motor are used

5. FUNCTIONAL DEPLOYMENT

5.1 Serial Control

All information for driving the motor is processed by serial data from the CPU. The following parameters can be set by commands.

- Control of DC motor driving and output duty
- Control during constant-current driving and current setting
- Wait value for setting timing during stepping motor driving
- Motor current, motor revolution direction, and output excitation mode
- Pulse cycle, and number of pulses

Each command is assigned an address. Each data can be updated by inputting 16-bit data. For the configuration of the data and details of commands, refer to **9. SERIAL INTERFACE SPECIFICATIONS**.

5.2 Reset Function

An initialization operation is performed and all the internal data is cleared to 0 when RESETB = L. The output remains in the Hi-Z state.

When RESETB = H, commands can be input.

Once it sets the address 0 to address 2 for an initialization setting, they carry out latch operation inside, and prohibit overwriting. In order that initialization operation is performed again, the reset operation is needed.

Be sure to perform a reset operation after turning on power supply. When RESETB = L, the internal circuitry is stopped whenever possible, so that the self current consumption can be reduced. When input of the external CLK is stopped, the current consumption can be lowered to 1 μA MAX.

Immediately after release of reset, excitation is started from the position where the current of ch1 is 100% and the current of ch2 is 0%, in the micro step drive mode and 1-2 phase excitation drive mode. In the 2-phase excitation drive mode, excitation is started from the position where the currents of ch1 and ch2 are 100%.

Remark L: Low level, H: High level, Hi-Z: High impedance

5.3 Current Detection Resistor Connection (FB) Pin

The current detection resistor is connected when current driving is necessary.

For example: When micro step driving, when solenoid driving.

The current that flows into the output is {set voltage value/FB pin resistance x 1000}.

Example) Where the set voltage value is 200 mV, FB = 2 kΩ

Output current value = 200 (mV) /2 (kΩ) x 1000

= 100 (mA)

Therefore, the load is driven at a constant current of 100 mA.

The set voltage value is a value that can be set by serial control.

5.4 Undervoltage Lockout (UVLO) Circuit

This function is to forcibly stop the operation of the IC to prevent malfunctioning if V_{DD} drops.

If V_{DD} drops abruptly in the order of several μs, this function may not operate.

5.5 Overheat Protection (TSD) Circuit

This function is to forcibly stop the operation of the IC to protect it from destruction due to overheating if the chip temperature of the IC rises.

The overheat protection circuit operates when the chip temperature rises to 150°C or more. When overheat is detected, all the circuits are stopped. When reset is performed or when UVLO is detected, the overheat protection circuit does not operate.

5.6 Power Up Sequence

This IC has a circuit that prevents current from flowing into the V_M pin when V_{DD} = 0 V. Therefore, the current that flows into the V_M pin is cut off when V_{DD} = 0 V.

Because the V_{DD} pin voltage and V_M pin voltage are monitored, a current of 3 μA MAX. flows into the V_M pin when V_{DD} is applied.

6. COMMAND INPUT TIMING CHART

This IC can drive a stepping motor, DC motor, and solenoid by serial control if serial control is set during initialization. If direct input is set, this IC can drive the load by an input/output PWM control method.

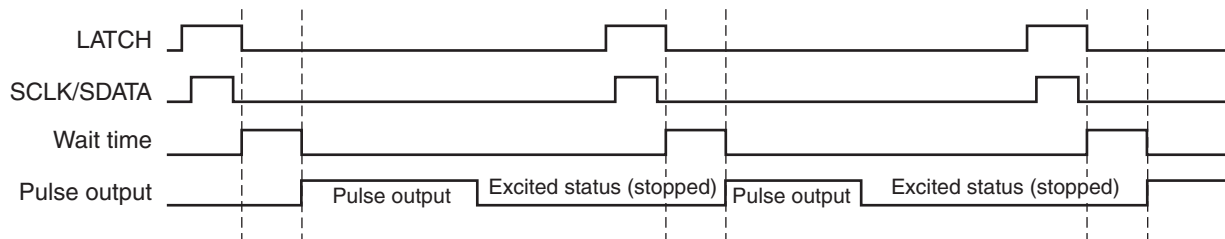With the serial control setting, two or more motors can be simultaneously controlled by commands.

Be sure to execute initialization (addresses 0 to 2) immediately after power application and immediately after reset. After initialization, the motors can be controlled simply by inputting driving data (addresses 3 to F).

To execute initialization again from the start, the RESET pin must be made high and data of addresses 0 to 2 must be input.
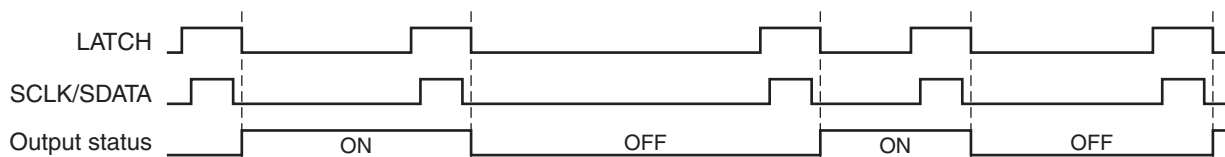
6.1 Setting Examples

6.1.1 Stepping motor

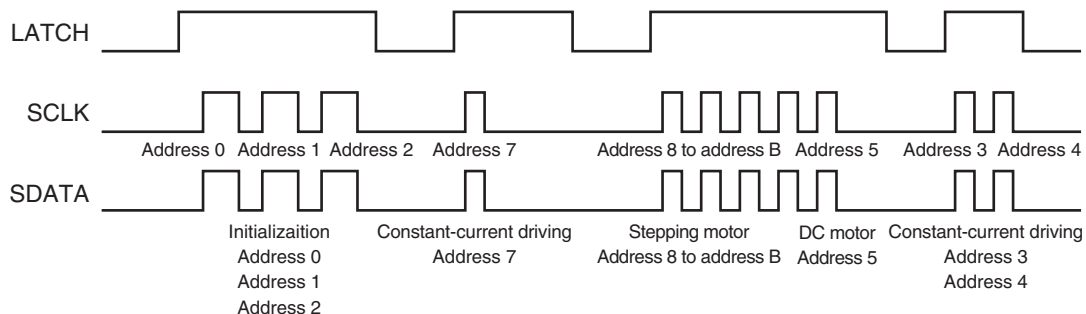Starts output after wait time synchronized with LATCH has fallen.

6.1.2 DC motor/coil

Starts output after LATCH has fallen.

### 6.2 Example of Address Setting

7. SERIAL DATA INPUT SEQUENCE

The μ PD168113 can control driving of two or more motors with only a few CPU signals by using a serial data input method. The serial data is input as follows.

(1) Input addresses 0 to 2 after power up and initialization.

(2) Depending on the type of the motor set, input the necessary data of addresses 3 to F (two or more addresses may be input).

(3) When performing the driving setting, only the necessary data of addresses 3 to F has to be input because the previous data is retained.

Only the output related to the input address will change.

To perform an initialization operation such as selecting the motor, initialize the internal registers by using the RESETB pin.

Figure 7–1. Operation Sequence When Serial Data Is Input
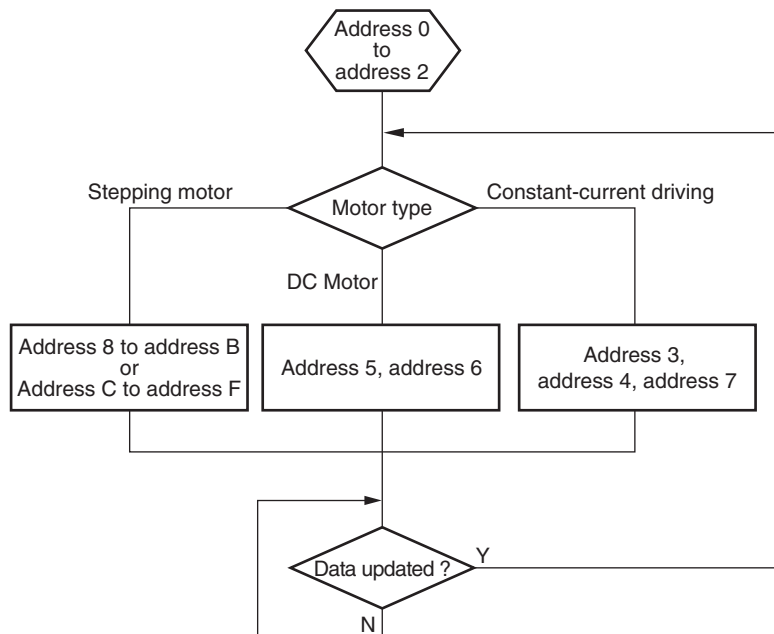
8. NOTES ON TRANSMITTING DATA

- The first input data is loaded when SCLK changes from L to H after LATCH has changed from L to H.

  Data is transmitted in 16-bit units, and is determined when LATCH changes from H to L. Invalid data of less than

  16-bit is discarded.
- Data of different addresses can be input successively while LATCH = H.
- The access time can be shortened by updating only the necessary data after initialization has been performed.

  If an address is not input, the previous value of that address is held as the data.

  Examples)   DC motor and constant current: The ON/OFF state is held.

  Stepping motor: The excitation position is held if the excitation state is in ON.

- If the same address is input more than one while LATCH = H, the last input data is valid.
- If invalid data and correct data are input while LATCH = H, only the correct data is valid.
- If only LATCH is input, the data is not updated, and the driver holds the current status.
- If a command related to stepping motors (addresses 8 to F) is input during the "wait period" that lasts from input of

  the preceding data to the start of counting, the data is ignored. A command related to the DC motor and coil

  (addresses 3 to 7) is valid during the synchronization period.
- Data that is input when RESETB = L is ignored.

9. SERIAL INTERFACE SPECIFICATIONS

The internal data is determined by inputting 16-bit serial data SDATA synchronized with serial clock SCLK, and making LATCH = L. Serial data is input from the LSB (D0) to the MSB (Df).

SDATA: When LATCH = H, data is loaded to the internal circuitry at the rising edge of SCLK, and latch operation performed a the falling of SCLK

LATCH: Inputting SDATA is prohibited when LATCH is L. Inputting SDATA is enabled when it is H. The internal data is determined when LATCH changes from H to L.

Because this IC generates the internal timing via the external CLK (OSCIN) its set values depend upon the frequency of CLK.

An example where CLK = 5 MHz is given below. To input a frequency other than 5 MHz to CLK, use the following expression. Items related to the serial register are marked ☆.

Time: Set value = Setting example x (5/CLK [MHz])
Frequency: Set value = Setting example x (CLK [MHz] /5)

<Data configuration>

16-bit data consists of address: 4-bit and data: 12-bit.

Four bits (Dc, Dd, De and Df) are used to set an address. Sixteen types of addresses 0 to F can be used.

Twelve bits (D0 to Db) are used to set data.

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	Address				Data											

Examples) Address 1: (Df, De, Dd, Dc) = (0, 0, 0, 1)
Address A: (Df, De, Dd, Dc) = (1, 0, 1, 0)

For how to set data, refer to **Table 10–1. to Table 10–4. Serial Register List**, and **11. SERIAL COMMAND DETAILS**.

The following chart shows an example of serial command waveforms.
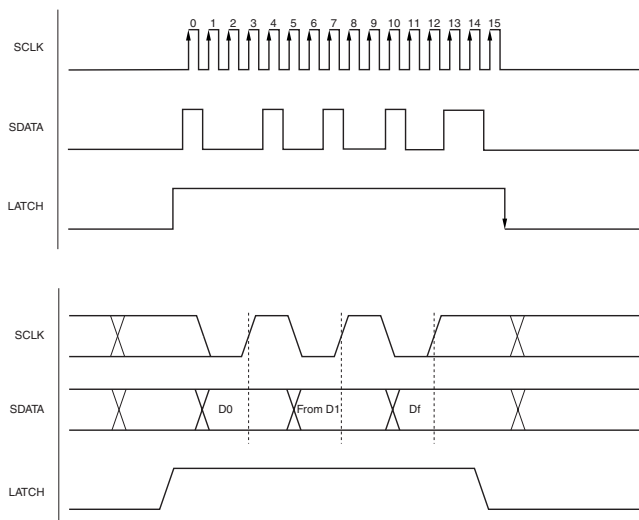
10. ADDRESS LIST

Address	Address Data				Item to Be Set
	Df	De	Dd	Dc	
Address 0	0	0	0	0	Input mode selection, motor selection, wait setting
Address 1	0	0	0	1	Chopping frequency setting, MOB output selection
Address 2	0	0	1	0	Test function
Address 3	0	0	1	1	Constant current ch3
Address 4	0	1	0	0	Constant current ch4
Address 5	0	1	0	1	DC motor ch5
Address 6	0	1	1	0	DC motor ch6
Address 7	0	1	1	1	Constant current ch7
Address 8	1	0	0	0	Motor driving initialization setting, motor current setting
Address 9	1	0	0	1	Acceleration/deceleration parameter setting, plus number multiplication factor setting
Address A	1	0	1	0	Pulse cycle setting
Address B	1	0	1	1	Number of pulses setting
Address C	1	1	0	0	Motor driving initialization setting, motor current setting
Address D	1	1	0	1	Acceleration/deceleration parameter setting, plus number multiplication factor setting
Address E	1	1	1	0	Pulse cycle setting
Address F	1	1	1	1	Number of pulses setting

Table 10–1. Serial Register List (Address 0 to Address 3)

Bit	Address 0 (0000)	
f	Address	0
e		0
d		0
c		0
b	0 (unused)	
a	0 (unused)	
9	ch7 serial/direct input mode selection	
8	ch6 serial/direct input mode selection	
7	ch5 serial/direct input mode selection	
6	ch3, ch4 driving motor setting	
5	Wait setting 5	
4	Wait setting 4	
3	Wait setting 3	
2	Wait setting 2	
1	Wait setting 1	
0	Wait setting 0	

Bit	Address 1 (0001)	
f	Address	0
e		0
d		0
c		1
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	MOB output position setting (when micro step driving or 1-2 phase excitation driving)	
7	MOB output selection setting (only when micro step driving)	
6	Pulse output function selection when EXT output	
5	Chopping frequency 5	
4	Chopping frequency 4	
3	Chopping frequency 3	
2	Chopping frequency 2	
1	Chopping frequency 1	
0	Chopping frequency 0	

Bit	Address 2 (0010)	
f	Address	0
e		0
d		1
c		0
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	0 (unused)	
6	0 (unused)	
5	0 (unused)	
4	0 (unused)	
3	0 (unused)	
2	0 (unused)	
1	0 (unused)	
0	0 (unused)	

Bit	Address 3 (0011)	
f	Address	0
e		0
d		1
c		1
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	ch3 output current value setting 4	
6	ch3 output current value setting 3	
5	ch3 output current value setting 2	
4	ch3 output current value setting 1	
3	ch3 output current value setting 0	
2	0 (unused)	
1	ch3 excitation direction	
0	ch3 excitation ON/OFF	

Table 10–2. Serial Register List (Address 4 to Address 7)

Bit	Address 4 (0100)	
f		0
e	Address	1
d		0
c		0
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	ch4 output current value setting 4	
6	ch4 output current value setting 3	
5	ch4 output current value setting 2	
4	ch4 output current value setting 1	
3	ch4 output current value setting 0	
2	0 (unused)	
1	ch4 excitation direction	
0	ch4 excitation ON/OFF	

Bit	Address 5 (0101)	
f		0
e	Address	1
d		0
c		1
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	ch5 output duty setting 4	
6	ch5 output duty setting 3	
5	ch5 output duty setting 2	
4	ch5 output duty setting 1	
3	ch5 output duty setting 0	
2	ch5 brake mode	
1	ch5 revolution direction	
0	ch5 motor ON/OFF	

Bit	Address 6 (0110)	
f		0
e	Address	1
d		1
c		0
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	ch6 output duty setting 4	
6	ch6 output duty setting 3	
5	ch6 output duty setting 2	
4	ch6 output duty setting 1	
3	ch6 output duty setting 0	
2	ch6 brake mode	
1	ch6 revolution direction	
0	ch6 motor ON/OFF	

Bit	Address 7 (0111)	
f		0
e	Address	1
d		1
c		1
b	0 (unused)	
a	0 (unused)	
9	0 (unused)	
8	0 (unused)	
7	ch7 output current value setting 4	
6	ch7 output current value setting 3	
5	ch7 output current value setting 2	
4	ch7 output current value setting 1	
3	ch7 output current value setting 0	
2	0 (unused)	
1	ch7 excitation direction	
0	ch7 excitation ON/OFF	

Table 10–3. Serial Register List (Address 8 to Address B)

Bit	Address 8 (1000)	
f	Address	1
e		0
d		0
c		0
b	0 (unused)	
a	Constant-current changing when two-phase/1-2 phase driving	
9	Driving mode selection 1	
8	Driving mode selection 0	
7	Output enable setting	
6	Stop mode setting	
5	Revolution direction mode (CW/CCW)	
4	Motor current setting 4	
3	Motor current setting 3	
2	Motor current setting 2	
1	Motor current setting 1	
0	Motor current setting 0	

Bit	Address 9 (1001)	
f	Address	1
e		0
d		0
c		1
b	0 (unused)	
a	Acceleration valid/invalid change	
9	Deceleration valid/invalid change	
8	For acceleration/deceleration control	
7	For acceleration/deceleration control	
6	For acceleration/deceleration control	
5	For acceleration/deceleration control	
4	For acceleration/deceleration control	
3	For acceleration/deceleration control	
2	For acceleration/deceleration control	
1	Motor pulse multiplication factor setting 1	
0	Motor pulse multiplication factor setting 0	

Bit	Address A (1010)	
f	Address	1
e		0
d		1
c		0
b	Motor pulse cycle setting 11	
a	Motor pulse cycle setting 10	
9	Motor pulse cycle setting 9	
8	Motor pulse cycle setting 8	
7	Motor pulse cycle setting 7	
6	Motor pulse cycle setting 6	
5	Motor pulse cycle setting 5	
4	Motor pulse cycle setting 4	
3	Motor pulse cycle setting 3	
2	Motor pulse cycle setting 2	
1	Motor pulse cycle setting 1	
0	Motor pulse cycle setting 0	

Bit	Address B (1011)	
f	Address	1
e		0
d		1
c		1
b	Number of motor pulses setting 11	
a	Number of motor pulses setting 10	
9	Number of motor pulses setting 9	
8	Number of motor pulses setting 8	
7	Number of motor pulses setting 7	
6	Number of motor pulses setting 6	
5	Number of motor pulses setting 5	
4	Number of motor pulses setting 4	
3	Number of motor pulses setting 3	
2	Number of motor pulses setting 2	
1	Number of motor pulses setting 1	
0	Number of motor pulses setting 0	

Table 10–4. Serial Register List (Address C to Address F)

Bit	Address C (1100)	
f	Address	1
e		1
d		0
c		0
b	0 (unused)	
a	Constant-current changing when two-phase/1-2 phase driving	
9	Driving mode selection 1	
8	Driving mode selection 0	
7	Output enable setting	
6	Stop mode setting	
5	Revolution direction mode (CW/CCW)	
4	Motor current setting 4	
3	Motor current setting 3	
2	Motor current setting 2	
1	Motor current setting 1	
0	Motor current setting 0	

Bit	Address D (1101)	
f	Address	1
e		1
d		0
c		1
b	0 (unused)	
a	Acceleration valid/invalid change	
9	Deceleration valid/invalid change	
8	For acceleration/deceleration control	
7	For acceleration/deceleration control	
6	For acceleration/deceleration control	
5	For acceleration/deceleration control	
4	For acceleration/deceleration control	
3	For acceleration/deceleration control	
2	For acceleration/deceleration control	
1	Motor pulse multiplication factor setting 1	
0	Motor pulse multiplication factor setting 0	

Bit	Address E (1110)	
f	Address	1
e		1
d		1
c		0
b	Motor pulse cycle setting 11	
a	Motor pulse cycle setting 10	
9	Motor pulse cycle setting 9	
8	Motor pulse cycle setting 8	
7	Motor pulse cycle setting 7	
6	Motor pulse cycle setting 6	
5	Motor pulse cycle setting 5	
4	Motor pulse cycle setting 4	
3	Motor pulse cycle setting 3	
2	Motor pulse cycle setting 2	
1	Motor pulse cycle setting 1	
0	Motor pulse cycle setting 0	

Bit	Address F (1111)	
f	Address	1
e		1
d		1
c		1
b	Number of motor pulses setting 11	
a	Number of motor pulses setting 10	
9	Number of motor pulses setting 9	
8	Number of motor pulses setting 8	
7	Number of motor pulses setting 7	
6	Number of motor pulses setting 6	
5	Number of motor pulses setting 5	
4	Number of motor pulses setting 4	
3	Number of motor pulses setting 3	
2	Number of motor pulses setting 2	
1	Number of motor pulses setting 1	
0	Number of motor pulses setting 0	

11. SERIAL COMMAND DETAILS

11.1 Address 0

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	0	0	0	0	0	Note 4	Note 3	Note 2	Note 1	Wait setting					

Notes 1. ch3, ch4 driving motor setting   **3.** ch6 serial/direct input mode selection

   2. ch5 serial/direct input mode selection   **4.** ch7 serial/direct input mode selection

☆ **11.1.1 Wait value**

When the stepping motor is to be controlled, counting is started from the falling of the LATCH signal and the motor is excited when the count value reaches 0. Even if transmission of serial data is delayed by the wait value, the stepping motor can be driven at a predetermined timing if the LATCH signal is periodically input.

Note that the wait value must not be set to 0. The wait time can be set in a range of 64 to 2048 μs with a resolution of 32 μs using data.

11.1.2 Example of setting wait value

D5......D0	Set Value (μs)
000000	Input prohibited
000001	64
000010	96
:	:
111101	1984
111110	2016
111111	2048

11.1.3 Definition by wait value
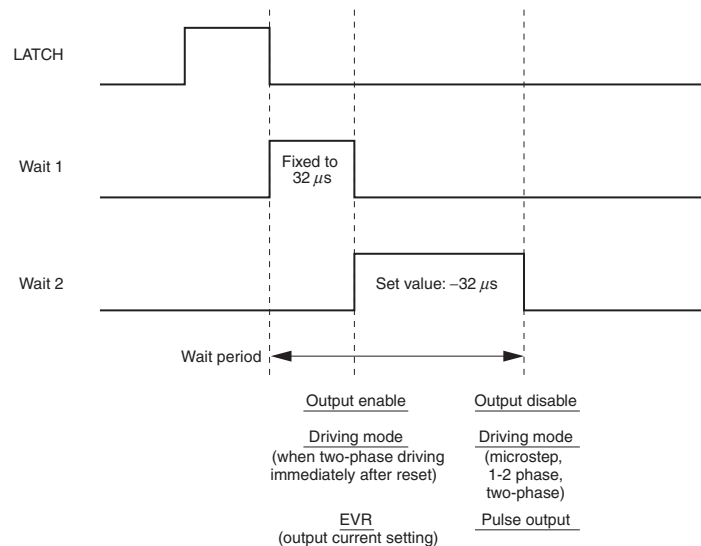
11.1.4 ch3, ch4 driving motor setting

D6 = 0: Stepping motor driving

D6 = 1: Constant-current driving mode that can be set only by serial mode.

When D6 = 0, ch3 and ch4 have functions equivalent to ch1 and ch2, and can be used to drive a stepping motor.

When D6 = 1, ch3 and ch4 are independently used for constant-current driving. However, because ch3 and ch4 internally share the same driving power supply, these channels must be supplied from the same source.

11.1.5 ch5 to ch7 serial/direct input mode selection

<ch5 serial/direct input mode selection>

D7 = 0: ch5 is a setting mode by serial mode

D7 = 1: ch5 is a setting mode by direct input mode

<ch6 serial/direct input mode selection>

D8 = 0: ch6 is a setting mode by serial mode

D8 = 1: ch6 is a setting mode by direct input mode

<ch7 serial/direct input mode selection>

D9 = 0: ch7 is a setting mode by serial mode

D9 = 1: ch7 is a setting mode by direct input mode

If each or all of ch5 to ch7 is setting mode by direct input mode, refer to **13. FUNCTION OPERATION TABLE.**

11.2 Address 1

This address is used to set a chopping frequency that is the reference of PWM output.

									MSB				LSB			
Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	0	0	1	0	0	0	Note 3	Note 2	Note 1	Chopping frequency					

Notes 1. Pulse output function selection when EXT output

     2. MOB output selection setting

     3. MOB output position setting

☆ **11.2.1 Chopping frequency**

A chopping mode is employed for the output to drive the motor on a constant current.

The chopping frequency that is the reference of the output can be changed with data, so that the PWM output does not interfere with the other signals.

The chopping frequency can be set in a range of 40 to 250 kHz by the data of D0 to D5.

The set chopping frequency is used for output when executing stepping motor and constant-current driving.

<Output in accordance with set chopping frequency>

• For constant-current driving with stepping motor (ch1 to ch4)

• For constant-current driving (ch3, ch4, ch7)

Refer to the following table for the set value.

D5......D0	Chopping Frequency (kHz)	D5......D0	Chopping Frequency (kHz)	D5......D0	Chopping Frequency (kHz)
000000	0 (no pulse output)	011000	120	101100	225
000001	0 (no pulse output)	011001	125	101101	
:	:	011010	130	101110	
000111	0 (no pulse output)	011011		101111	
001000	40	011100	140	110000	250
001001	45	011101	145	110001	
001010	50	011110		110010	
001011	55	011111	155	110011	
001100	60	100000		110100	
001101	65	100001	165	110101	
001110	70	100010		110110	
001111	75	100011	180	110111	
010000	80	100100		111000	
010001	85	100101		111001	
010010	90	100110	190	111010	
010011	95	100111		111011	
010100	10	101000		111100	
010101	105	101001	210	111101	
010110	110	101010		111110	
010111	115	101011		111111	

11.2.2 Pulse output function selection when EXT output

If D6 is set, the function which acts as the monitor of the output state of the driving pulse by the EXT pin can be selected.

When D6 = 0,

      EXT$_1$: Output pulse synchronization mode of the micro step output 1

      EXT$_2$: Output pulse synchronization mode of the micro step output 2

When D6 = 1,

      EXT$_1$: Mode with output time of micro step output 1 fixed to H

      EXT$_2$: Mode with output time of micro step output 2 fixed to H

The output synchronization mode is duty 50% TYP. in accordance with the pulse frequency setting.

To count the number of pulses, count the rising edges.

11.2.3 Restrictions in pulse output synchronization mode

(1) Output is not guaranteed if the pulse period is 2 μs (Db to D0: 000000000001).

(2) Output is equivalent to the H time during steady-state driving (equivalent to pulse period setting) while an acceleration/deceleration operation is performed.

(3) If the multiplication factor of the number of pulses is set to other than 1, the set number of pulses (address 5 x m) is output.

11.2.4 Restrictions in mode in which output time is fixed to H

The output falls in synchronization with the falling of the pulse that is to be output at the same timing in the pulse output synchronization mode.

When the last pulse is output , therefore, it rises earlier than the period of the pulse cycle (50% of pulse cycle or less)

11.2.5 MOB output selection setting (only when micro step driving)

The output function of MOB can be selected by D7. It becomes effective only when the micro step driving mode selected.

D7 = 0: MOB is output once per cycle.

D7 = 1: MOB is output four times per cycle.

For the output position of MOB, refer to **11.2.6 MOB output position setting** (set by D8).

D7	MOB Output
0	1 pulse/cycle
1	4 pulses/cycle

11.2.6 MOB output position setting (when micro step driving or 1-2 phase excitation driving)

The MOB output timing position can be selected by D8. It becomes effective when the micro step driving mode or the 1-2 phase excitation driving mode selected.

D8 = 0: MOB is output at the one-phase excitation position (where the current of ch1 or ch2 is 100%) .

D8 = 1: MOB is output at the two-phase excitation position (where the currents of ch1 and ch2 are the same) .

Selection of MOB output (D7) is made in accordance with the setting of D8.

When D8 = 1, no signal is output from the MOB pin immediately after reset. In addition, MOB_1 and MOB_2 cannot be set individually.

D8	MOB Output Position
0	one-phase excitation position
1	two-phase excitation position

11.2.7 MOB output timing chart

Figure 11–1. MOB Output Timing Chart When Micro Step Driving
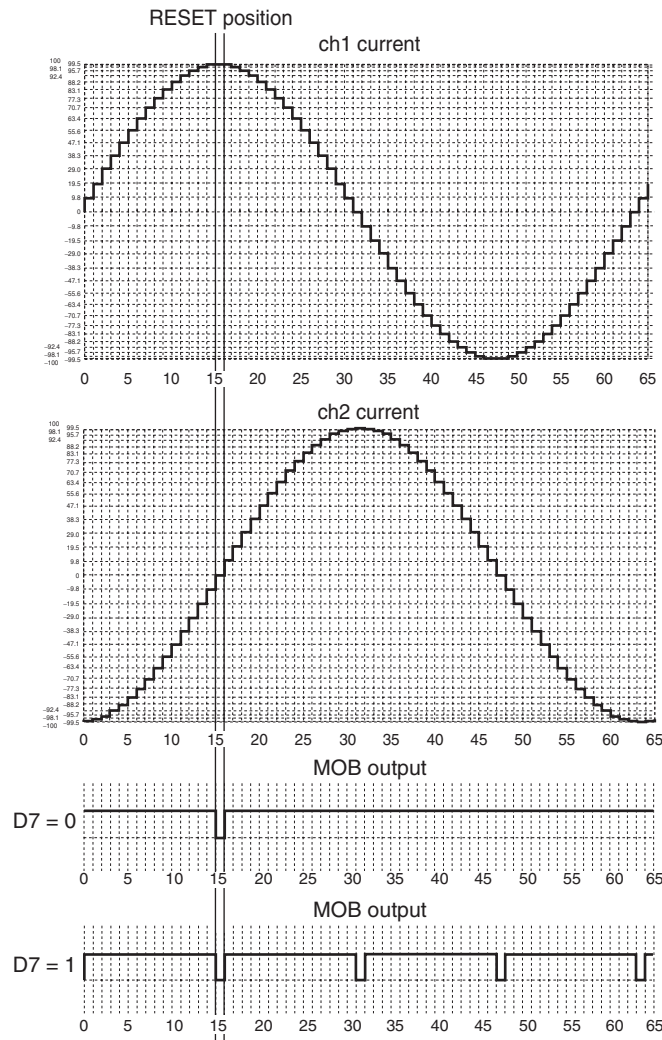
11.3 Address 2

This address is used as the test function for internal of the IC.

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	0	1	0	(Test function)											

<Test function>

The test function is used to check the internal operations of the IC. Be sure to input the data of D0 to Db when usually using.

11.4 Address 3, Address 4 and Address 7

These addresses set constant-current driving.

Address 3

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	0	1	1	0	0	0	0	ch3 output current value setting					0	Note 2	Note 1

Address 4

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	1	0	0	0	0	0	0	ch4 output current value setting					0	Note 2	Note 1

Address 7

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	1	1	1	0	0	0	0	ch7 output current value setting					0	Note 2	Note 1

Notes 1. Excitation ON/OFF

   2. Excitation direction

11.4.1 Excitation ON/OFF

D0 selects whether the coil is to be driven.

D0 = 0: The output goes into a Hi-Z state.

D0 = 1: The output is turned ON, and the coil is driven in accordance with the revolution direction and the output

current value setting.

D0	Driving Mode
0	Hi-Z
1	Output ON

11.4.2 Excitation direction

D1 selects the direction in which the coil is to be excited.

In the forward direction, the current flows from phase A to B. In the reverse direction, the current flows from phase B

to A.

D1	Operation Mode
0	Current direction A $\rightarrow$ B (forward direction)
1	Current direction B $\rightarrow$ A (reverse direction)

11.4.3 Output current value setting

Data of D3 to D7 sets the current value for constant-current control. These bits select the internal voltage that serves as a reference with a resolution of 20 mV. The current that flows to the output is { set voltage value/FB x 1000 } .

A voltage lower than 100 mV is fixed to 100 mV, and a voltage exceeding 500 mV is fixed to 500 mV. Therefore, the reference voltage can be set in a range of 100 to 500 mV. The operation frequency of the output is the frequency oscillation by the oscillator connected to COSC (100 kHz TYP.).

Example)
The set output current is calculated as follows where FB = 2 kΩ for constant-current driving at 100 mA.
Set voltage value = 100 (mA) x 2 (kΩ) /1000 = 200 (mV) $\rightarrow$ (D7......D3) = (01010)

D7......D3	Reference Voltage (mV)	D7......D3	Reference Voltage (mV)
00000	100	10110	440
00001	100	10111	460
:	:	11000	480
00101	100	11001	500
00110	120	:	:
00111	140	11110	500
:	:	11111	500

11.5 Address 5 and Address 6

These addresses specify how a DC motor is to be driven.

Address 5

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	1	0	1	0	0	0	0	ch5 output duty setting					**Note 3**	**Note 2**	**Note 1**

Address 6

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	0	1	1	0	0	0	0	0	ch6 output duty setting					**Note 3**	**Note 2**	**Note 1**

Notes 1. Motor ON/OFF

   2. Revolution direction

   3. Brake mode

11.5.1 Motor ON/OFF

D0 specifies whether the motor is to be driven.

D0 = 0: The motor is stopped (stop mode) .

The output status in the stop mode is Hi-Z or short brake mode, depending on the value of D2, which selects a brake mode.

D0 = 1: The start mode is selected, and the motor is driven in accordance with the revolution direction and the output duty setting.

D0	Driving Mode
0	Stop mode
1	Start mode

11.5.2 Revolution direction

D1 selects the revolution direction of the motor.

In the forward direction, the current flows from phase A to B. In the reverse direction, the current flows from phase B to A.

D1	Operation Mode
0	Current direction A $\rightarrow$ B (forward direction)
1	Current direction B $\rightarrow$ A (reverse direction)

11.5.3 Brake mode

D2 is used to select the output status in the stop mode.

D2 = 0: The output goes into a Hi-Z state.

D2 = 1: The high side of both phase A and B is ON, and the short brake status is selected. At this time, the output goes H.

D2	Operation Mode
0	Hi-Z
1	Short brake (both phases A and B output H)

☆ 11.5.4 Output duty setting

The output duty for current control is selected, and can be selected in 32 steps by data of D3 to D7.

The operation frequency of the output is set by counting the external CLK.

Operation frequency = 1/ (200 ns x 32) = 156.25 kHz (at 5 MHz)

D7......D3	Output Duty (%)	D7......D3	Output Duty (%)
00000	100	10000	50
00001	3.125	10001	53.125
00010	6.25	10010	56.25
00011	9.375	:	:
:	:	11110	93.75
01111	46.875	11111	96.875

Caution When all of D3 to D7 is 0, the output duty is 100%. Be sure to use the stop mode when the output duty is 0%.

11.6 Address 8

This address selects basic-operation setting of stepping motor (the maximum current value, the revolution direction of the motor and the operation mode).

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	1	0	0	0	0	Note 6	Note 5	Note 4	Note 3	Note 2	Note 1	Output current setting				

Notes 1. Motor revolution direction   **4.** Driving mode selection 0

　　　2. Stop mode   　　　　　　　　　**5.** Driving mode selection 1

　　　3. Output enable setting   　　　　**6.** Constant-current changing when two-phase excitation driving or 1-2 phase excitation driving

11.6.1 Output current setting

An internal reference voltage value (EVRMAX) for constant-current driving is set. The internal reference voltage is specified by data of D0 to D4 at a resolution of 20 mV. Micro step driving can be performed with the set reference voltage as the maximum value. The peak value of the drive current is EVRMAX (V) /FB (Ω) x 1000.

Set value: EVRMAX = (D4......D0) x 20 mV

However, 100 mV $\leq$ EVRMAX $\leq$ 500 mV

D4......D0	Reference Voltage (mV)	D4......D0	Reference Voltage (mV)
00000	100	10110	440
00001	100	10111	460
:	:	11000	480
00101	100	11001	500
00110	120	:	:
00111	140	11110	500
:	:	11111	500

Remark If a voltage less than 100 mV is set, the reference voltage is fixed to 100 mV. If a voltage higher than 500 mV is set, it is fixed to 500 mV.

11.6.2 Motor revolution direction setting

D5 is used to specify the motor revolution direction.

In the CW mode, the current of ch2 (ch4 in the case of address C) is output, 90° degrees in phase behind the current of ch1 (ch3 in the case of address C).

In the CCW mode, the current of ch2 (ch4 in the case of address C) is output, 90° ahead in phase behind the current of ch1 (ch3 in the case of address C).

D5	Operation Mode
0	CW mode (forward revolution)
1	CCW mode (reverse revolution)

11.6.3 Stop mode setting

When D6 = 1, the motor advances to the position of MOB_1 output = L, and the output status is held.

The set number of pulses is held even in the stop mode.

Because the motor is driven regardless of the set number of pulses, however, the position information of the motor must be taken into consideration when a command is set to resume driving.

D6	Operation Mode
0	Normal mode
1	Stop mode

Caution Inputting data is prohibited while the stop mode is set (MOB_1 reaches L). Do not update the data.

No pulse is output if the stop mode is set while MOB_1 = L

In addition, MOB_2 is output in the case of address C.

11.6.4 Output enable setting

D7 = 1: The motor can be driven. To drive the motor, be sure to set this bit to 1.

D7 = 0: The output goes into a Hi-Z state, regardless of the other settings.

If D7 is changed from 0 to 1, the internal information is held and therefore the excitation position is recorded.

Therefore, excitation is started from the position where D7 is cleared to 0.

D7	Operation Mode
0	Output Hi-Z
1	Enable mode

11.6.5 Driving mode selection 0 and driving mode selection 1

D8 and D9 can be used to select driving mode of two-phase excitation, 1-2 phase excitation and micro step.

D8 = 0: The micro step driving mode is selected.

D8 = 1, D9 = 0: The two-phase excitation driving mode is selected.

D8 = 1, D9 = 1: The 1-2 phase excitation driving mode is selected.

Immediately after rest, The micro step driving mode is selected.

When changing the driving mode from micro step to two-phase excitation or 1-2 phase excitation, note the following points.

<If the number of pulses is set to 0>

The stop position when the constant current is changed may differ depending on Da, which selects a constant current in the two-phase or 1-2 phase excitation mode.

When Da = 0, the execution jumps to the two-phase or 1-2 phase position on the quadrant at the excitation position after completion of wait, and the motor is excited at a duty factor of 100%. When Da = 1, the stop position is excited and held.

<If pulse output is started by command setting to set a number of pulses of 1 or more>

At the first pulse, the operation skips to the two-phase excitation position or the1-2 phase excitation position of the next quadrant and driving is started.

If the two-phase excitation driving mode is changed while the motor is stopped at the one-phase excitation position, it is judged that the position is included in the quadrant in the CW direction, and motor operates.

Refer to **Figure11–3. Transition of Switching of Micro Step Driving ←→ 1-2 Phase Excitation ←→ 2-phase Excitation (If Number of Pulses Is Set to 1 for Switching**) for details.

D8	D9	Operation Mode
0	0	Micro step driving
0	1	
1	0	Two-phase excitation driving
1	1	1-2 phase excitation driving

Figure 11–2. Concept of Changing Driving Mode from Micro Step to Two-phase Excitation
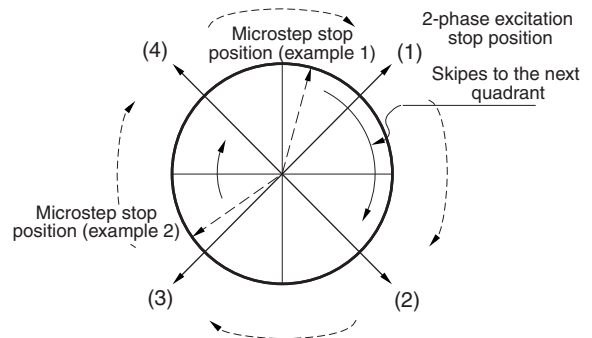
Figure 11–3. Transition of Switching of Micro Step Driving ←→ 1-2 Phase Excitation ←→ 2-phase Excitation

(If Number of Pulses Is Set to 1 for Switching)
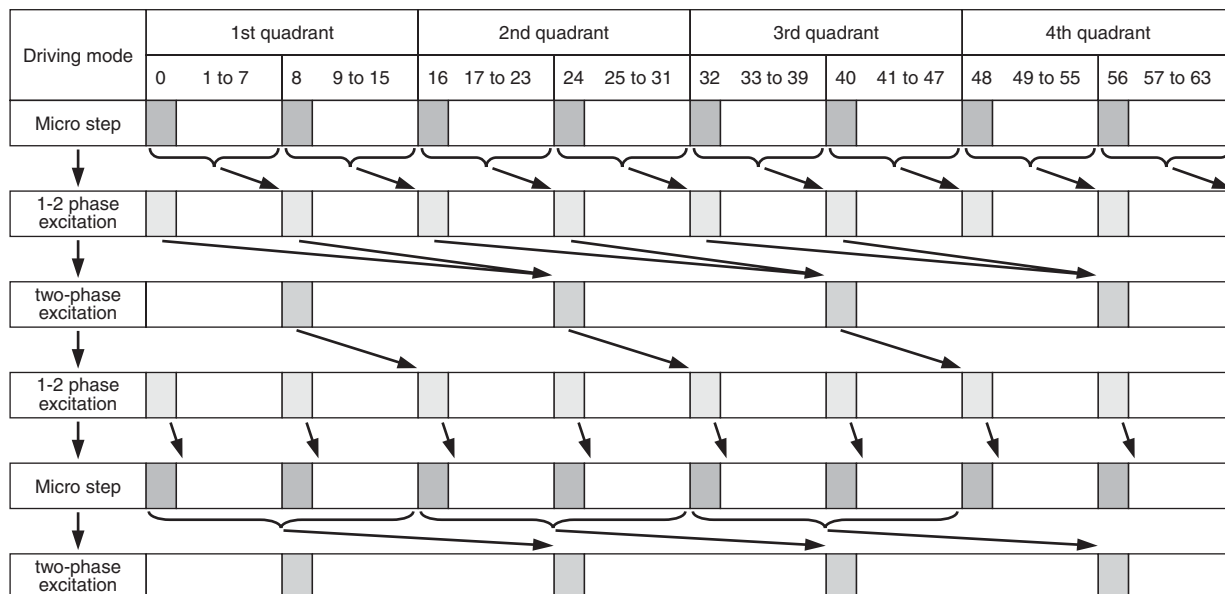
11.6.6 Constant-current changing when two-phase excitation/1-2 phase excitation

Da is used to select whether the motor is driven at an output duty of 100% (maximum torque operation) or under constant-current control when the two-phase excitation driving or the 1-2 phase excitation driving is selected.

When Da = 0, the motor is driven at an output duty of 100%. It is excited in two-phase or 1-2 phase and driven at the maximum torque regardless of the current setting.

When Da = 1, the motor is excited in two-phase or 1-2 phase at the motor current setting. The output current value is controlled to be the same value as the driving current at the phase A = phase B position (position of step $\theta 8$) in the micro step driving mode.

Da	Operation Mode
0	Output duty 100% drive
1	Constant-current control drive

Examples of the motor current waveform is shown **12. STEPPING MOTOR DRIVING WAVEFORM.**

11.7 Address 9

  This address is used to set parameters for acceleration/deceleration control, the pulse multiplication factor.

  By setting the parameters for acceleration/deceleration control, the pulse cycle can be gradually changed while the motor is accelerated or decelerated, so that step out of the motor can prevent.

  By setting the pulse number multiplication factor to a value other than 1, the number of pulses can be extended in combination with the number of pulses set by address B. If the default value is not changed, the motor is driven without being accelerated or decelerated, and under the condition that the pulse number multiplication factor is 1.

							MSB							LSB	MSB	LSB
Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	1	0	0	1	0	**Note 2**	**Note 1**	For acceleration/deceleration control							Pulse multiplication factor setting	

 Notes 1. Selects whether deceleration is valid or invalid

   2. Selects whether acceleration is valid or invalid

11.7.1 Pulse number multiplication factor

  D1 and D0 are used to set the pulse number multiplication factor.

  By setting a multiplication factor, if the number of motor pulses set at address B is insufficient, the number of pulses can be extended maintaining 64 steps/cycle.

D1	D0	Pulse Number Multiplication Factor m
0	0	m = 1
0	1	
1	0	m = 2
1	1	m = 4

11.7.2 For acceleration/deceleration control

Seven bits, D2 to D8, are used to set a driving profile for acceleration/deceleration.

The pulse rate vs. time draws an S-shaped curve. The shape of this S-curve can be changed according to the values set to D2 to D7.

The image of the operation during acceleration or deceleration is shown below.

94 pulses[Note] each are necessary for acceleration and deceleration.

Usually, therefore, set 188 pulses[Note] or more (acceleration pulses + deceleration pulses) to perform acceleration and deceleration. If the set number of pulses is less than 94 [Note] during acceleration or deceleration, refer to **11.7.10 Example of acceleration/deceleration operation**.

★
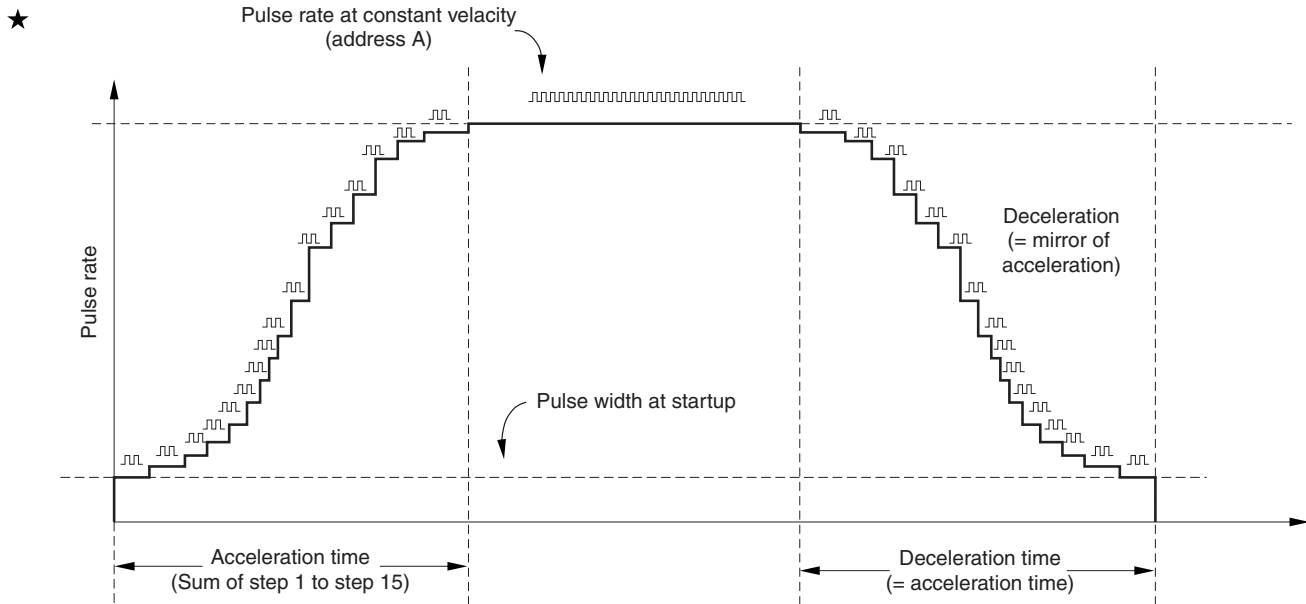
Acceleration pulse number or deceleration pulse number: 94 pulses[Note]

Note The number of pulses when startup time setting is one time is shown. If the startup time setting is two times and four times, the number of pulses is 188 pulses and 376 pulses. It is twice further the number of the pulses in acceleration/deceleration operation, and it is 376 pulses and 752 pulses.

★ **11.7.3 Parameter for acceleration/deceleration control**

Reference increment = pulse cycle (address A) /reference increment setting

Pulse cycle of each step = pulse cycle (address A) + reference increment x pulse cycle increment table

Time of each step = pulse cycle of each step x selected data table (number of pulses)

Table 11–1. Selected Data Table List

Table	STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7	STEP 8	STEP 9	STEP 10	STEP 11	STEP 12	STEP 13	STEP 14	STEP 15
1	2	5	2	1	1	1	1	1	1	1	2	3	11	31	31
2	1	4	4	3	2	2	2	2	2	2	4	6	12	17	31
3	1	3	3	4	3	4	3	3	3	3	5	9	13	15	22

Total: 94 pulses

Table 11–2. Pulse Cycle Increment Table List

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7	STEP 8	STEP 9	STEP 10	STEP 11	STEP 12	STEP 13	STEP 14	STEP 15
120	56	35	24	18	13	10	8	7	6	5	4	3	2	1

Example) Driving time at each step in case of table 1

STEP 1	(Pulse cycle + reference increment x 120)	x 2
STEP 2	(Pulse cycle + reference increment x 56)	x 5
STEP 3	(Pulse cycle + reference increment x 35)	x 2
STEP 4	(Pulse cycle + reference increment x 24)	x 1
STEP 5	(Pulse cycle + reference increment x 18)	x 1
STEP 6	(Pulse cycle + reference increment x 13)	x 1
STEP 7	(Pulse cycle + reference increment x 10)	x 1
STEP 8	(Pulse cycle + reference increment x 8)	x 1
STEP 9	(Pulse cycle + reference increment x 7)	x 1
STEP 10	(Pulse cycle + reference increment x 6)	x 1
STEP 11	(Pulse cycle + reference increment x 5)	x 2
STEP 12	(Pulse cycle + reference increment x 4)	x 3
STEP13	(Pulse cycle + reference increment x 3)	x 11
STEP 14	(Pulse cycle + reference increment x 2)	x 31
STEP 15	(Pulse cycle + reference increment x 1)	x 31

Remark The number of an end indicates the number of pulses in the case of table 1. To use table 2 or table 3, refer to **Table 11–1. Selected Data Table List**.

Acceleration time = deceleration time = sum of STEP 1 to STEP 15

★ **11.7.4 Reference increment setting**

D2 to D4 are sued to set a parameter that determines the pulse cycle at each step.

The reference increment is the pulse frequency set by address A that is divided by the reference increment setting.

So that the speed changes draw a typical S-shape curve, it is recommended to set a value of 8 ((D4, D3, D2) = (1, 0, 0)) .

Reference increment = pulse cycle (address A) /reference increment setting

D4	D3	D2	Reference Increment Setting
0	0	0	2
0	0	1	
0	1	0	
0	1	1	4
1	0	0	8
1	0	1	16
1	1	0	32
1	1	1	

11.7.5 Table selection

This IC approximates the speed change curve during acceleration/deceleration operation to the shape S.

The speed change curve can be changed by selecting an internal table.

Table 1: S curve with abrupt speed change

Table 2: S curve with gentle speed change

Table 3: S curve with linear speed change (equivalent to trapezoid waveform)

D6	D5	Table Selection
0	0	Table 1
0	1	
1	0	Table 2
1	1	Table 3

11.7.6 Start time setting

D7 and D8 are used to select the operation time multiplication factor during an acceleration/deceleration operation.

The number of pulses necessary for each step during acceleration/deceleration can be selected from x 1, x 2 and x 4. For the number of pulses at each step, refer to **Table 11–1. Selected Data Table List**.

D8	D7	Startup Time Setting	Number of Pulses Necessary for Acceleration or Deceleration
0	0	x 1	94
0	1		
1	0	x 2	188
1	1	x 4	376

11.7.7 Selects whether acceleration is valid or invalid

An acceleration operation can be performed in accordance with the acceleration control setting. The acceleration function can be valid or invalid by Da.

11.7.8 Selects whether deceleration is valid or invalid

An deceleration operation can be performed in accordance with the deceleration control setting. The deceleration function can be valid or invalid by D9.

Da	D9	Operation Mode	
		Acceleration	Deceleration
0	0	Invalid	Invalid
1	0	Valid	Invalid
0	1	Invalid	Valid
1	1	Valid	Valid

11.7.9 Example of recommended setting

The following values are recommended for the parameters for acceleration and deceleration.

Note, however, that the characteristics differ depending on the motor to be used. Be sure to evaluate and confirm the values with the motor to be actually used, and set the parameters correctly.

Reference increment setting: 8 ((D4, D3, D2) = (1, 0, 0))

Table selection: Table 1 ((D6, D5) = (0, 0))

Start time setting: x 1 ((D8, D7) = (0, 0))

Acceleration/deceleration valid/invalid: Acceleration/deceleration valid ((Da, D9) = (1, 1))

11.7.10 Example of acceleration/deceleration operation

(1) Acceleration valid/deceleration valid
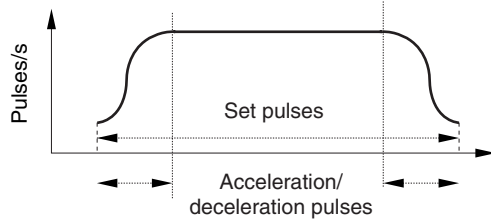
(1') Acceleration valid/deceleration valid [Note1]

Condition: Set pulses/2 < acceleration/deceleration pulses
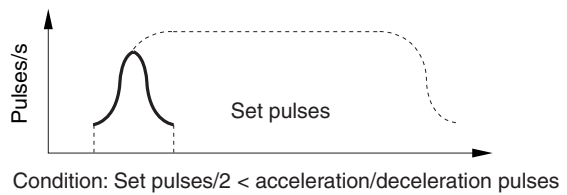
(2) Acceleration valid/deceleration invalid

(2') Acceleration valid/deceleration invalid [Note2]

Condition: Set pulses < acceleration/deceleration pulses
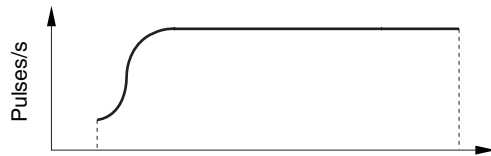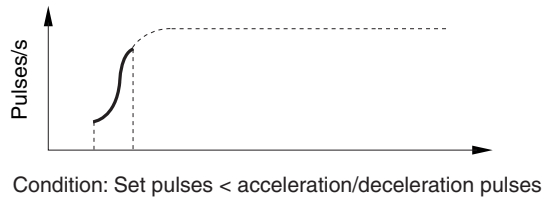
(3) Acceleration invalid/deceleration invalid
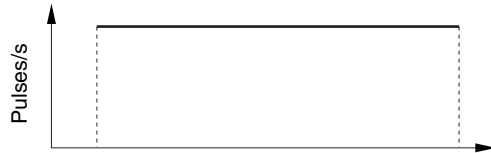
(4) Acceleration invalid/deceleration valid

(4') Acceleration invalid/deceleration valid [Note3]
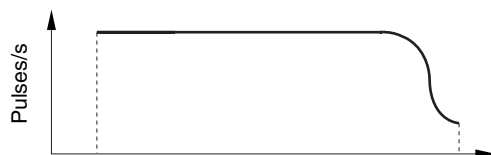
Condition: Set pulses < acceleration/deceleration pulses
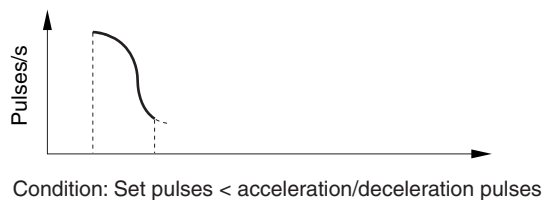
The left side figures in upper figures show the ideal operation waveform. If the number of set pulses is less than the number of acceleration/deceleration control pulses, the operation as the right side figures in upper figures.

Notes 1. The deceleration operation is stared when 1/2 of the set number of pulses has been reached during the acceleration operation. Therefore, acceleration and deceleration are always mirrored.

2. If the set number of pulses is less than the number of acceleration/deceleration control pulses during only the acceleration operation, the operation is stopped at the pulse rate in the middle of acceleration.

3. If the set number of pulses is less than the number of acceleration/deceleration control pulses during only the deceleration operation, the last pulse rate does not reach the target value. The set number of pulses is output in accordance with the deceleration pulse curve, and the operation is stopped.

11.8 Address A

This address is used to set the pulse cycle per step (64 steps/cycle) .

	MSB															LSB
Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	1	0	1	0	Pulse cycle											

☆ **11.8.1 Pulse cycle**

Twelve bits, D0 to Db, are used to set the pulse cycle per step.

The pulse cycle can be set in a range of 0 to 8190 μs at a resolution of 2.0 μs.

If all of the twelve-bit is 0, no pulse is output and the driving status is maintained.

The pulse period indicates the time per step regardless of the driving mode (micro step, 1-2 phase excitation, or 2-phase excitation). Therefore, the number of revolutions of the motor differs depending on the driving mode, even if the number of pulses is the same.

11.8.2 Example of pulse cycle setting

Db......D0	Set Value (μs)
000000000000	0
000000000001	2.0
000000000010	4.0
:	:
111111111101	8186
111111111110	8188
111111111111	8190

11.9 Address B

This address is used to set the number of pulses.

The actual number of pulses is set by the product to the pulse number multiplication factor and the number of pulses sets at address 9.

					MSB										LSB
Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	1	0	1	1	Number of pulses										

11.9.1 Number of pulses

Set the number of pulses to drive the motor. D0 to Db can be set a pulse in a range of 0 to 4095 pulses.

If the pulse number multiplication factor is set to a value other than 1 at address 9, the number of pulses set here is multiplied by the set multiplication factor (m).

The number of pulses is internally multiplied by (m) and then counted. If it is set to output pulses to EXT_1 (EXT_2 in the case of address F), the number of counts output is the set value itself (0 to 4095 x m) .

The number of pulses indicates the number of pulses per pulse period regardless of the driving mode (micro step, 1-2 phase excitation, or 2-phase excitation). Therefore, the number of revolutions of the motor differs depending on the driving mode, even if the number of pulses is the same.

11.9.2 Example of pulse cycle setting

Db......D0	Set Value
000000000000	0
000000000001	m
000000000010	2 x m
:	:
111111111101	4093 x m
111111111110	4094 x m
111111111111	4095 x m

Remark m indicates the set value of the pulse number multiplication factor of address 9. If the value of the twelve-bit, D0 to Db, is 0, no pulse is output and the driving state is maintained.

11.10 Address C to Address F

Addresses C to F are used for setting stepping motor 2 (ch3 and ch4). The settings of other than addresses Dc, Dd, De, and Df are identical to the contents of addresses 8 to B. For details, refer to **11.6 Address 8** to **11.9 Address B**.

Address C

Bit	Df	De	Dd	Dc	Db	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
Data	1	1	0	0	0	**Note 6**	**Note 5**	**Note 4**	**Note 3**	**Note 2**	**Note 1**	Output current setting				

Notes 1. Motor revolution direction   **4.** Driving mode selection 0

   2. Stop mode   **5.** Driving mode selection 1

   3. Output enable setting   **6.** Constant-current changing when two-phase excitation driving or 1-2 phase excitation driving

Address D

Bit	Df	De	Dd	Dc	Db	Da	D9	D8 (MSB)	D7	D6	D5	D4	D3	D2 (LSB)	D1 (MSB)	D0 (LSB)
Data	1	1	0	1	0	**Note 2**	**Note 1**	For acceleration/deceleration control							Pulse multiplication factor setting	

Notes 1. Selects whether deceleration is valid or invalid

   2. Selects whether acceleration is valid or invalid

Address E

Bit	Df	De	Dd	Dc	Db (MSB)	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
Data	1	1	1	0	Pulse cycle											

Address F

Bit	Df	De	Dd	Dc	Db (MSB)	Da	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
Data	1	1	1	1	Number of pulses											

12. STEPPING MOTOR DRIVING WAVEFORM

Figure 12–1. Two-phase Excitation Output Mode

Phase A current
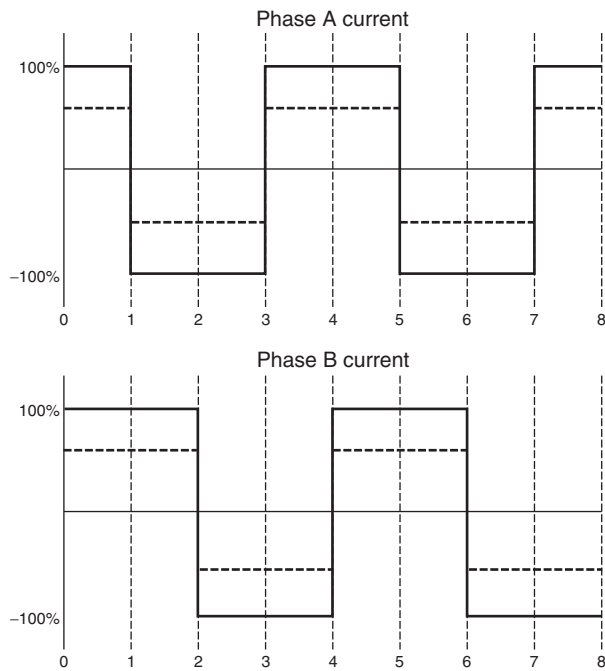
Phase B current

Figure 12–2. 1-2 Phase Excitation Output Mode

Phase A current

Phase B current
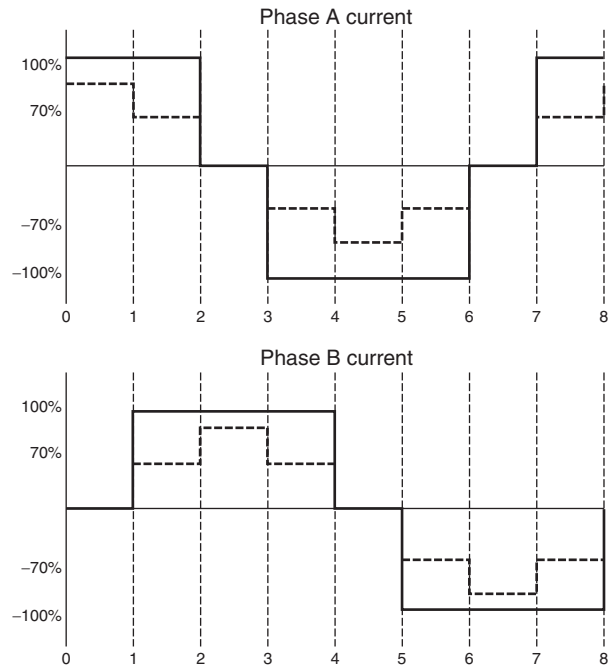
Remarks 1. Solid line: Output duty 100% drive, Dotted line: Current control drive (The current is in accordance with the current setting.)

2. The horizontal axis of the above charts indicates the number of steps. The above charts show an example in the CW (forward) mode.

The current flowing into phases A and B is positive in the direction from OUT pin A to OUT pin B, and negative in the direction from OUT pin B to OUT pin A.

Figure 12–3. Micro Step Driving Mode

RESET position   ch1 current

ch2 current
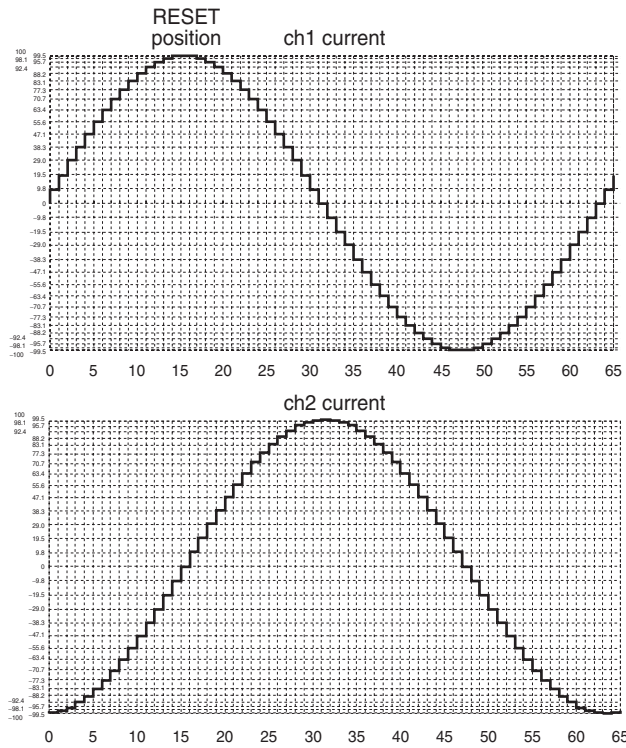
Remark The horizontal axis of the above charts indicates the number of steps. The above charts show an example in the CW (forward) mode.

The current flowing into phases A and B is positive in the direction from OUT pin A to OUT pin B, and negative in the direction from OUT pin B to OUT pin A.

13. FUNCTION OPERATION TABLE

The table below shows the input/output logic when ch5 to ch7 are set in the external control mode by initialization.

With ch7, an H-bridge current can be controlled by an external resistor for constant-current driving (output chopping operation by PWM driving).

The external control mode is invalid immediately after reset and before an address is set.

Therefore, address setting is necessary even when the external control mode is used.

13.1 Serial Setting Contents of ch5 and ch6

Even when the external control mode is selected, the contents of the set output duty factor of ch5 (address 5) and ch6 (address 6) are reflected. As the output duty factor of the output stage, therefore, the logical product of an external control signal and the serial command setting is output. For the setting method by a command, refer to **11.5 Address 5 and Address 6**.

13.2 Setting of ch7

ch7 is used for constant-current driving with a resistor connected to the FB pin. The current that serves as a reference is set by a serial command. Therefore, set the current of ch7 (address 7) even when the external control mode is selected.

For the setting method by a command, refer to **11.4 Address 3, Address 4, and Address 7**.

Figure 13–1. Truth Table of ch5 to ch7

Input			Output		Current Direction
IN_A	IN_B	RESETB	OUT_A	OUT_B	
L	L	H	Hi-Z	Hi-Z	Stop (stop)
H	L	H	H	L	$OUT_A \rightarrow OUT_B$ (forward)
L	H	H	L	H	$OUT_B \rightarrow OUT_A$ (reverse)
H	H	H	H	H	Brake (regenerative mode)
x	x	L	Hi-Z	Hi-Z	All output stop

Remark x: Don't care
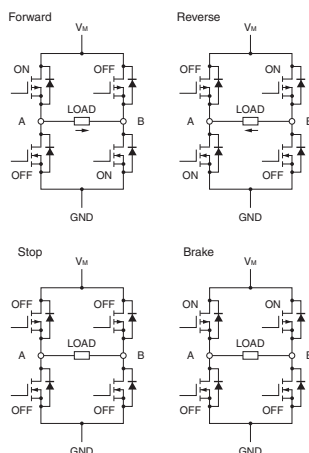
14. ELECTRICAL SPECIFICATIONS

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	−0.5 to +6.0	V
Input voltage	V_{IN}		−0.5 to V_{DD} +0.5	V
Output pin voltage	V_{OUT}	Motor block	6.2	V
DC output current (1 ch to 6 ch)	$I_{D(DC)}$	DC (during output independent operation)	±0.4	A/ch
DC output current (7 ch)	$I_{D(DC)}$	DC (during output independent operation)	±0.5	A/ch
Instantaneous output current	$I_{D(pulse)}$	PW < 10 ms, Duty Cycle ≤ 20% (during output independent operation)	±0.7	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

Remark The overheat protection circuit operates at T_{ch} > 150°C. When overheat is detected, all the circuits are stopped. The overheat protection circuit does not operate at reset or on detection of UVLO

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		3.6	V
	V_M	Motor block	2.7		5.5	V
Input voltage	V_{IN}		0		V_{DD}	V
DC output current (1 ch to 6 ch)	$I_{D(DC)}$	DC (during output independent operation)	−0.3		+0.3	A/ch
DC output current (7 ch)	$I_{D(DC)}$	DC (during output independent operation)	−0.4		+0.4	A/ch
Instantaneous output current	$I_{D(pulse)}$	PW < 10 ms, Duty Cycle ≤ 20% (during output independent operation)	−0.6		+0.6	A/ch
Capacitor capacitance		COSC		330		pF
External CLK input frequency	OSC_{IN}		1	5	6	MHz
SCLK input frequency	f_{CLK}				6	MHz
LATCH - SCLK time	f_{L-S}		200			ns
SDATA setup time	f_{SETUP}		80			ns
SDATA hold time	f_{HOLD}		80			ns
EXT pin output drive current	I_{EXT}	Buffer output	−5		5	mA
MOB pin output sink current	I_{MOB}	Open-drain output			5	mA
Logic input frequency	f_{IN}	IN_{5A}, IN_{5B}, IN_{6A}, IN_{6B}, IN_{7A}, IN_{7B}			100	kHz
Operating temperature range	T_A		−10		75	°C

Figure 14–1. Serial Command Timing Waveform

$t_{SETUP} = 80$ ns MIN.

SCLK

SDATA

D0   D1 to De   Df

$t_{HOLD} = 80$ ns MIN.

LATCH

$t_{L-S} = 200$ ns MIN.

$t_{L-S} = 200$ ns MIN.
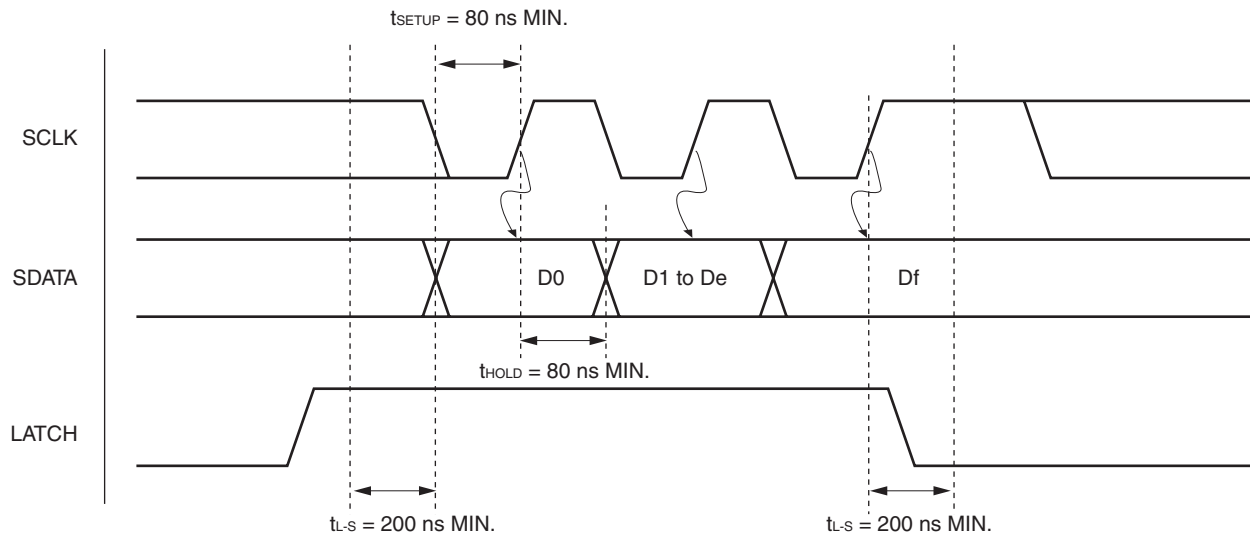
★ **Electrical Characteristics (Unless otherwise specified, T$_A$ = 25°C, V$_{DD}$ = 3.0 V, V$_M$ = 3.0 V)**

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
V$_{DD}$ pin current in standby mode	I$_{DD(STB)}$	RESETB pin: Low level			1.0	μA
V$_{DD}$ pin current in during operation	I$_{DD(ACT)}$	RESETB pin: High level			5.0	mA
High-level input current	I$_{IH}$	V$_{IN}$ = V$_{DD}$			50	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$_{DD}$ ≤ 3.6 V	0.7 x V$_{DD}$			V
Low-level input voltage	V$_{IL}$	2.7 V ≤ V$_{DD}$ ≤ 3.6 V			0.3 x V$_{DD}$	V
H-bridge on-state resistance	R$_{on}$	I$_M$ = 0.3 A, sum of upper and lower stages		1.0	1.5	Ω
Output leakage current [Note 1]	I$_{M(off)}$	Per V$_M$ pin, all control pins: Low level			1.0	μA
Low-voltage detection voltage	V$_{DDS}$			1.7	2.5	V
Internal reference voltage [Note 2]	V$_{REF}$		450	500	550	mV
Current detection ratio (ch1 to ch4) [Note 2]		I$_M$ = 0.1 A, with sense resistor (connect to FB) of 2 kΩ	900	1000	1100	
Current detection ratio (ch7) [Note 2]			950	1050	1150	
Output turn-on time	t$_{on}$	R$_L$ = 20 Ω	0.02	0.5	1.0	μs
Output turn-off time	t$_{off}$		0.02	0.5	1.0	μs
EXT high-level output voltage	V$_{extH}$	I$_O$ = −100 μA	0.9 x V$_{DD}$			V
EXT low-level output voltage	V$_{extL}$	I$_O$ = +100 μA			0.1 x V$_{DD}$	V
EVRMAX voltage	EVRMAX	(D0 to D4) = (1, 1, 1, 1, 1) [Note 3]	450	500	550	mV

Notes 1. This IC has a circuit that prevents current from flowing into the V$_M$ pin when V$_{DD}$ = 0 V.

   2. The motor current accuracy varies depending on the motor actually used. With this IC, the total of the reference voltage V$_{REF}$ error and the current sense circuit error is within ±10%.

   3. Current setting parameter for address 3, address 4, address 7, address 8 and address C.

15. PACKAGE DRAWING

56-PIN PLASTIC WQFN (8x8)

DETAIL OF (P) PART

TERMINAL SECTION

	(UNIT:mm)
ITEM	**DIMENSIONS**
D	7.75
E	7.75
f	0.20
HD	8.00
HE	8.00
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

P56K9-50-9B4
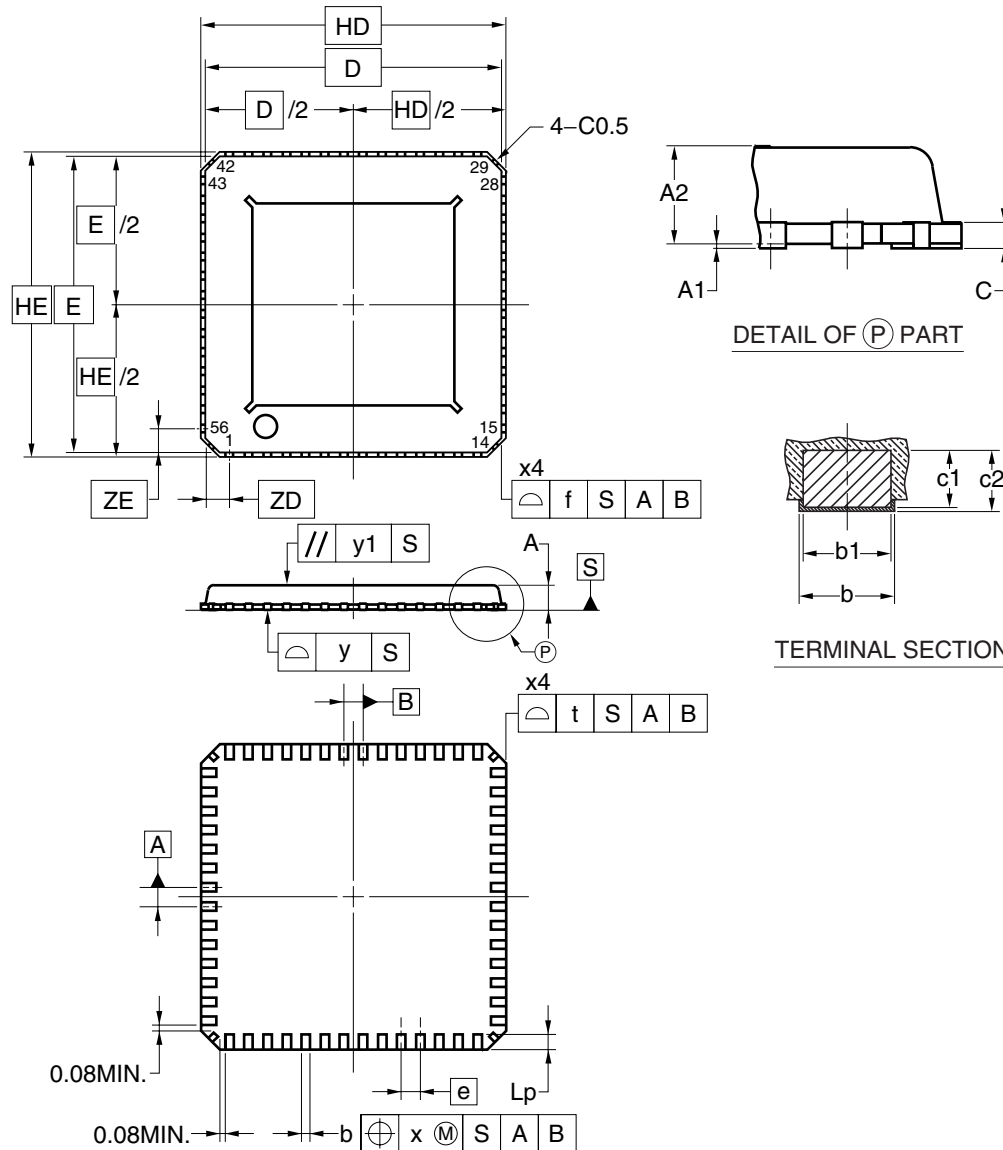
NOTES
※1 "t" AND "f" EXCLUDES MOLD FLASH
※2 ALTHOUGH THERE ARE 4 TERMINALS IN THE CORNER PART
OF A PACKAGE, THESE TERMINALS ARE NOT DESIGNED FOR
INTERCONNECTION, BUT FOR MANUFACTURING PROCESS OF
THE PACKAGE, THEREFOR DO NOT INTEND TO SOLDER THESE
4 TERMINALS, SOLDERABLITY OF THE 4 TERMINALS ARE NOT
GUARANTEED.

16. RECOMMENDED SOLDERING CONDITIONS

The μPD168113 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

★ μPD168113K9-9B4-A: 56-pin plastic WQFN (8 x 8)

Process	Conditions	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, Flux: Rosin flux with low chlorine (0.2 Wt% or below) recommended	IR60-103-3

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

NOTES FOR CMOS DEVICES

① **VOLTAGE APPLICATION WAVEFORM AT INPUT PIN**

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② **HANDLING OF UNUSED INPUT PINS**

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ **PRECAUTION AGAINST ESD**

A 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 when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up 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 benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ **STATUS BEFORE INITIALIZATION**

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

Reference Documents

NEC Semiconductor Device Reliability/Quality Control System (C10983E)

Quality Grades On NEC Semiconductor Devices (C11531E)