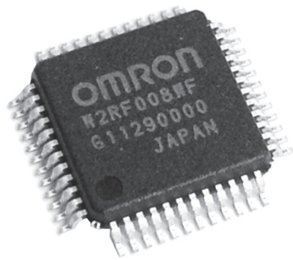
Motor Control IC

W2RF008WF

■ Features

Optimal IC for performance operation control

- Controls 2 motor channels and 4 channels including solenoids.
- Outputs pulses for the number of movement steps to the specified coordinates at 63 different speeds.
- Enables continuous operation with multi-stage (5-stage) buffer.
- Controls 2-phase/1-2-phase/microstep excitation control and power-saving.
- Outputs received commands and external input signals as serial signals.
- Controls up to 15 ICs individually via serial bus connection.



■ Model Number Legend

W2R F008WF
(1) (2)

(1) IC
(2) Series name

■ Absolute Maximum Ratings

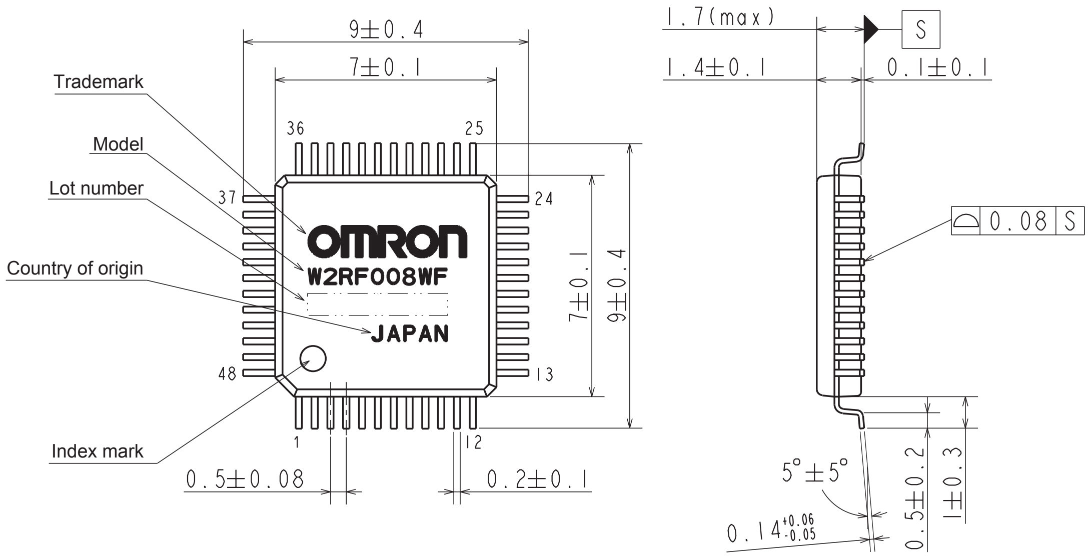
Item	Symbol	Ratings	Unit
Power supply voltage	VDD	-0.3 to 7.0	V
Input voltage	VIN	-0.3 to VDD+0.5	V
Output voltage	VOUT	-0.3 to VDD+0.5	V
Output current	IOUT	±25	mA
Operating ambient temperature	Topr	-20 to 85	°C
Storage ambient temperature	Tstg	-40 to 150	°C

■ Recommended Operating Conditions

Item	Symbol	Ratings	Unit
Power supply voltage	VDD	3.0 to 5.5	V
Input voltage	VIN	0 to VDD	V
Output current / Pin	IOUT	±8	mA
Communication clock frequency	fSCL	Max. 10	MHz
Oscillation frequency *1	fXT	0.1 to 15	MHz

*1. Refer to the table in the Terminal description (2) Primary Oscillation section.

■ External Dimensions



[Unit: mm]

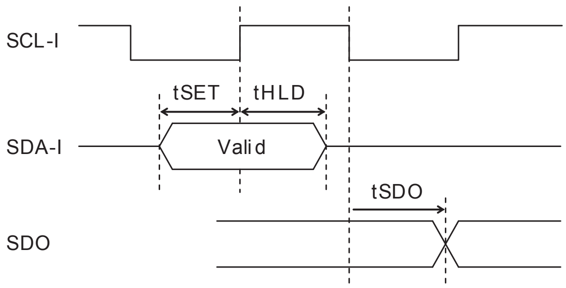
■ Electrical Characteristics

(1) DC characteristics (Ta＝25 °C)

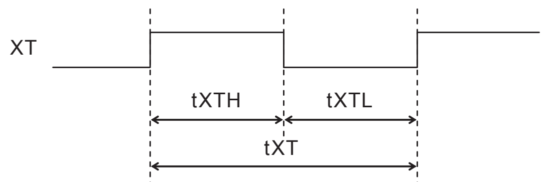
Item	Symbol	Conditions		Standard values			Unit	Target terminals
			VDD	Min.	Typ.	Max.		
High level input voltage	VIH	–	3.3 V	2.4	–	–	V	SDA-I, SCL-I, ADR0 to 3, SETA0 to 1, SETB0 to 1, RST, IN0 to 3
			5.0 V	4.0	–	–		
Low level output voltage	VIL	–	3.3 V	–	–	0.6	V	
			5.0 V	–	–	0.8		
High level output voltage	VOH	IOUT= –6 mA	3.0 V	VDD –0.3	–	–	V	OUTA0 to 5, OUTB0 to 5, OUTP0 to 3
		IOUT= –8 mA	4.5 V	VDD –0.4	–	–		
Low level output voltage	VOL	IOUT= 6 mA	3.0 V	–	–	0.3	V	OUTA0 to 5, OUTB0 to 5, OUTP0 to 3, SDO, INTA, INTB, INTS
		IOUT= 8 mA	4.5 V	–	–	0.4		
Current consumption during operation	IDD	ADR, IN0 to 3= 0 V, OUTX = Open, XTI = 4.096 MHz, Standby state	3.6 V	–	3.5	4.0	mA	VDD
			5.5 V	–	7.5	8.0		

(2) Timing characteristics (Ta=25°C, Output load capacitance = 20 pF)

Item	Symbol	Conditions		Standard values			Unit	Target terminals
			VDD	Min.	Typ.	Max		
Setup time	tSET	–	3.3 V	7	–	–	ns	SDA-I
			5.0 V	5	–	–		
Hold time	tHLD	–	3.3 V	7	–	–	ns	
			5.0 V	5	–	–		
Output delay time	tSDO	–	3.3 V	–	–	19	ns	SDO
			5.0 V	–	–	14		
Clock cycle time	tXT	–	3.3 V 5.0 V	66.6	–	–	ns	XTI
Clock H period pulse width	tXTH	–	3.3 V 5.0 V	32	–	–	ns	XTI
Clock L period pulse width	tXTL	–	3.3 V 5.0 V	32	–	–	ns	XTI

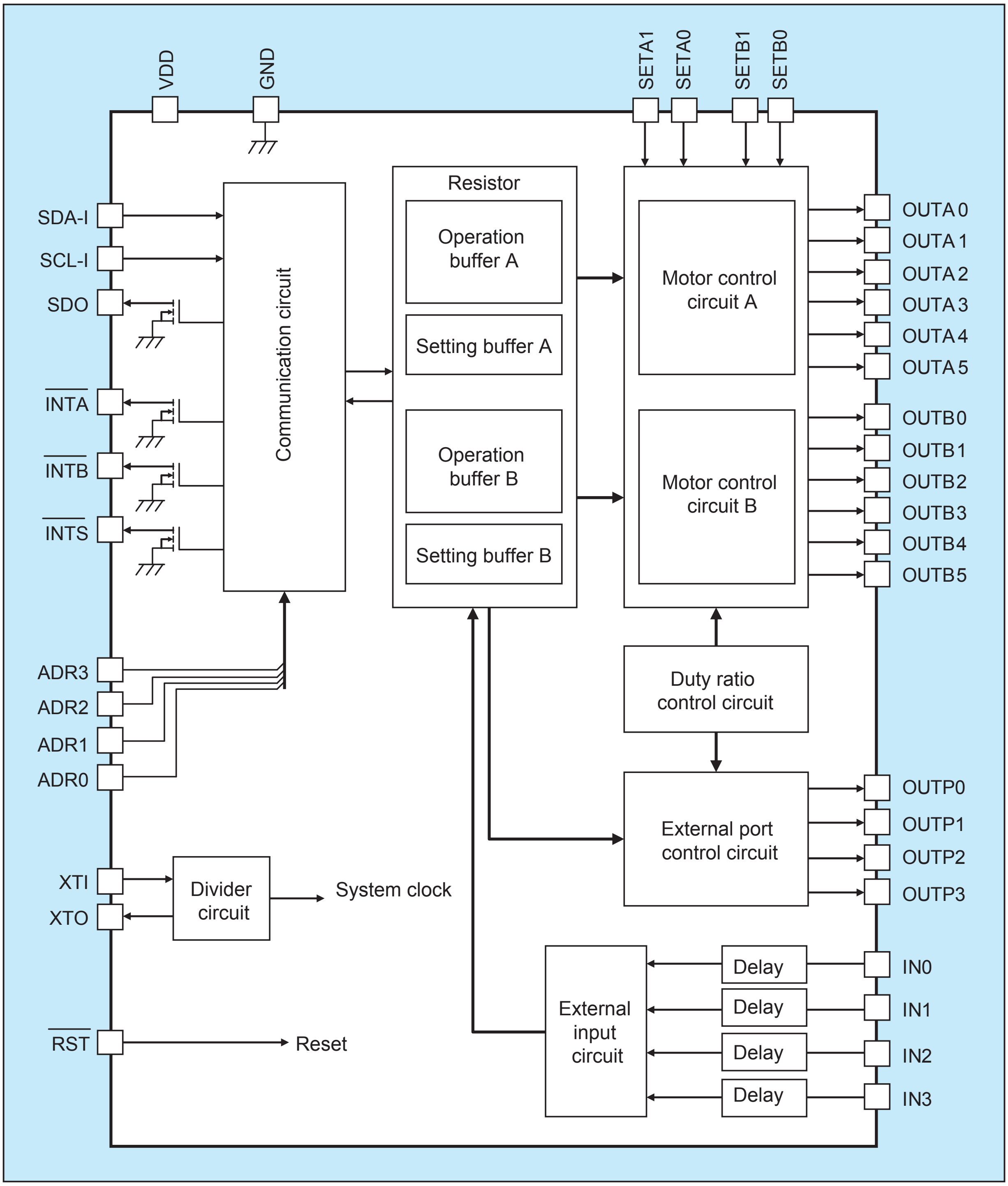


Input/output timing waveform



Clock timing waveform

■ Block Diagram



■ Terminal Layout

No.	Terminal name	Terminal description	I/O	Logic	Function
1	SDA-I	Serial data input	I		CMOS, Schmitt
2	SCL-I	Serial clock input	I		CMOS, Schmitt
3	$\overline{RST}$	Reset	I	L: Reset	CMOS, Schmitt, Pull-up, Filter
4	SDO	Serial data output	O		N-ch open drain (normally open)
5	$\overline{INTA}$	Channel A interrupt output	O	See Terminal description (6)	N-ch open drain (normally open)
6	$\overline{INTB}$	Channel B interrupt output	O		
7	$\overline{INTS}$	Input interrupt output	O		
8	GND	Ground	P		
9	XTI	Oscillation input	I	Terminal description (2)	
10	VDD	Power supply	P		
11	XTO	Oscillation output	O	Terminal description (2)	
12	GND	Ground	P		
13	ADR3	Device address 3	I	See Terminal description (3)	CMOS, Schmitt
14	ADR2	Device address 2	I		
15	ADR1	Device address 1	I		
16	ADR0	Device address 0	I		
17	GND	Ground	P		
18	OUTA0	Channel A output 0	O		CMOS
19	OUTA1	Channel A output 1	O		
20	OUTA2	Channel A output 2	O		
21	OUTA3	Channel A output 3	O		
22	OUTA4	Channel A output 4	O		
23	OUTA5	Channel A output 5	O		
24	VDD	Power supply	P		
25	GND	Ground	P		
26	OUTB0	Channel B output 0	O		CMOS
27	OUTB1	Channel B output 1	O		
28	OUTB2	Channel B output 2	O		
29	OUTB3	Channel B output 3	O		
30	OUTB4	Channel B output 4	O		
31	OUTB5	Channel B output 5	O		
32	OUTP0	External output 0	O		CMOS
33	OUTP1	External output 1	O		
34	OUTP2	External output 2	O		
35	OUTP3	External output 3	O		
36	VDD	Power supply	P		
37	GND	Ground	P		
38	IN0	External input 0	I	See Terminal description (5)	CMOS, Schmitt, Pull-up, Delay
39	IN1	External input 1	I		
40	IN2	External input 2	I		
41	IN3	External input 3	I		
42	VDD	Power supply	P		
43	TST1	Not used (*4)	—		
44	TST2	Not used (*4)	—		
45	SETA1	Channel A output setting 1	I	See Terminal description (4)	CMOS, Schmitt
46	SETA0	Channel A output setting 0	I		
47	SETB1	Channel B output setting 1	I		
48	SETB0	Channel B output setting 0	I		

*1. The $\overline{RST}$ and IN0 to 3 terminals have built-in pull-up resistors (50 kΩ at VDD = 5 V), so they will operate in the high state (H) when open.
*2. When using an oscillator, connect the clock to the XTI terminal and put the output terminal in the open state.
*3. Put unnecessary output terminals in the open state.
*4. Put unused terminals in the open state.

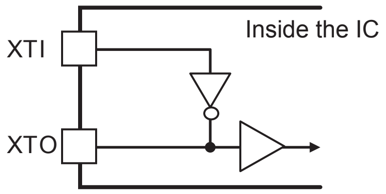
■ Terminal Description

(1) Communication terminal

1. Reception
The SDA-I signal input to the communication circuit is captured as serial data at the rising edge of the SCL-I signal.
Serial data corresponds to "0" for the "L" input and "1" for the "H" input.

2. Transmission
Serial data is output from the SDO terminal in synchronization with the falling edge of the SCL-I signal.
The SDO terminal is a normally-open (on when data is "0") open drain output.

(2) Primary oscillation
The primary oscillation uses either a resonator or an oscillator. When using a resonator, determine the constant of the external circuit in accordance with the resonator. The circuit between XTI and XTO is a CMOS inverter circuit. Make sure that the characteristics are stable. When using an oscillator, connect it to the XTI terminal. At this time, put the XTO terminal in the open state.



Oscillator circuit configuration

The frequency of the primary oscillator that can be used ranges from 100 kHz to 15 MHz. The primary oscillation frequency determines the control range of the motor's rotation speed, the duty ratio output period for power saving and port control, and the input delay of the external input terminal, as well as the pulse width of the interrupt output.

Item	Value	fXT = 4.096 MHz	Unit
Rotation speed	$fXT/2^{17}$ to $fXT/2^{12}$	31.25 to 1000	pps
Duty ratio output cycle	192/fXT	47.85	μs
External input delay	1024/fXT	250	μs
Interrupt output pulse width	128/fXT	31.25	μs
Max. communication frequency	3/4×fXT	3.072	MHz

Accel-eration	Speed setting change time		Accel-eration	Speed setting change time	
	N×4.096/fXT	fXT = 4.096 MHz		N×4.096/fXT	fXT = 4.096 MHz
0	1/128	0.0078	8	2	2
1	1/64	0.0156	9	4	4
2	1/32	0.0317	10	8	8
3	1/16	0.0625	11	16	16
4	1/8	0.125	12	32	32
5	1/4	0.25	13	64	64
6	1/2	0.5	14	128	128
7	1	1	15	256	256

(3) Device address terminal
Set the device address with 4 bits (total 15 device addresses, "1111" specifies all devices at once). The "L" input corresponds to data "0" and the "H" input corresponds to "1".
The device ID is fixed as "1010".

(4) Output setting terminal
Select the output method using the output setting terminal of each channel.

Output setting (SET)		Mode	Output (OUT)					
1	0		OUT0	OUT1	OUT2	OUT3	OUT4	OUT5
L	L	Unipolar	Phase A	Phase B	Phase $\overline{A}$	Phase $\overline{B}$	—	—
L	H	Bipolar Phase-Enable	Phase A Phase	Phase A Enable	Phase B Phase	Phase B Enable	—	—
H	L	Bipolar Phase-2IN	Phase A Phase	Phase A IN0	Phase A IN1	Phase B Phase	Phase B IN0	Phase B IN1
H	H	Bipolar Phase-$\overline{2IN}$	Phase A Phase	Phase A $\overline{IN0}$	Phase A $\overline{IN1}$	Phase B Phase	Phase B $\overline{IN0}$	Phase B $\overline{IN1}$

(5) External output terminal
An external input signal is stored in the register through the external input circuit. The "L" input corresponds to data "0" and the "H" input corresponds to "1". The external input circuit has an input delay that depends on the primary oscillation. For external input terminals that are not used, we recommend that the input be fixed to "L".
The following input terminals correspond to the designation of valid input signals for operation control commands.

Input	IN3	IN2	IN1	IN0
Channel	B1	B0	A1	A0

(6) Interrupt output terminal
Pulse signals are output upon completion of motion control instruction execution and changes in the external input terminals.
The interrupt output terminal is an open drain output (normally open, ON when enabled). The output is synchronized with the primary oscillator, and the pulse width depends on the frequency of the primary oscillator.

(7) Reset terminal
When the $\overline{RST}$ terminal input is "L", all internal circuits are in a reset state and each output terminal is all "L" output.
When the $\overline{RST}$ terminal input changes from "L" to "H", operation starts from the initial state.
To ensure stable operation, we recommend connecting a capacitor of about 0.1 μF.
(See: Application Circuit Example)

■ Command System

(1) Communication format

			10		19		28		37		
SDA-I	bit	1, 2, ~, 8, 9	10	11, 12, 13, 14, 15, 16, 17, 18	19	20, 21, 22, 23, 24, 25, 26, 27	28	29, 30, 31, 32, 33, 34, 35, 36	37	38, 39, 40, 41, 42, 43, 44, 45	46, 47, 48
	Data	1 1 1 1 1	0	1 0 1 0	0		0		0		0 x x
	Content	START (9 bits)	Delimiter	Device data dvc_dat[7:0]	Delimiter	Control data 0 ctrl_dat0[7:0]	Delimiter	Control data 1 ctrl_dat1[7:0]	Delimiter	Control data 2 ctrl_dat2[7:0]	END
SCL-I											
SDO	bit	1, 2, ~, 8, 9	10	11, 12, 13, 14, 15, 16, 17, 18	19	20, 21, 22, 23, 24, 25, 26, 27	28	29, 30, 31, 32, 33, 34, 35, 36	37	38, 39, 40, 41, 42, 43, 44, 45	46, 47, 48
	Data	1 1 1 1 1	1	1 1 1 1 1 1 1 1	1	1 1 1 1 1 1 1 1	0		0		1 1 0
	Content	BLANK					GO	Transmission data 0 send_dat0[7:0]	Delimiter	Transmission data 1 send_dat1[7:0]	ACK

(2) Operation control instruction

bit	1 to 9	10	11 to 18		19	20	21	22–27	28	29	30	31	32	33	34–36	37	38–45	46	47	48
Name	START	Sp	Device Data dvc_dat[7:0]		Sp	Control Data0 ctrl_dat0[7:0]			Sp	Control Data1 ctrl_dat1[7:0]						Sp	Control Data2 ctrl_dat2[7:0]	END		
SDA	"111 111 111"	0	Device ID	Device address	0	Mode	Channel	Speed	0	Latch	Wait	Automatic correction	Acceleration/deceleration	Coordinate specification		0	Step	0	X	X

- Mode — Operation control mode: 0
- Channel — Channel A: 0 / Channel B: 1
- Speed — 0: Stop; 1 to 63: 32 to 1000 pps (@4.096 MHz)
- Latch — Without latch: 0 / With latch: 1
- Wait — Normal mode: 0 / Wait mode: 1
- Automatic correction — 0: Automatic acceleration/deceleration OFF / 1: Automatic acceleration/deceleration ON
- Acceleration/deceleration — 0: Automatic acceleration/deceleration OFF / 1: Automatic acceleration/deceleration ON
- Coordinate specification — 0: Absolute coordinate specification mode / 1: Add mode
- Step — -1023 to +1022: Coordinates/step specification; -1024/+1023: Automatic return mode/ infinite rotation mode*

* If automatic correction function is ON: Automatic return mode OFF: Infinite rotation mode

(3) Setup write instruction

bit	1 to 9	10	11 to 18		19	20	21	22–23	24–27	28	29–36	37	38–45	46	47	48
Name	START	Sp	Device Data dvc_dat[7:0]		Sp	Control Data0 ctrl_dat0[7:0]				Sp	Control Data1 ctrl_dat1[7:0]	Sp	Control Data2 ctrl_dat2[7:0]	END		
SDA	"111 111 111"	0	Device ID	Device address	0	Mode	Channel	Details	Individual setting	0	Individual setting	0	Individual setting	0	X	X

- Mode — Setting write/read mode: 1
- Channel — Channel A: 0 / Channel B: 1
- Details:

00: Operation setting

24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41	42	43	44	45
Lat	Stopped			●		◎		Acceleration				x	x	x	x	x	x	x	x

- Lat — 0: Buffer setting / 1: Latch setting
- *Initial settings - same as default operation settings

●In operation
◎Excitation

01: Initial setting

0: Default operation setting

24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41	42	43	44	45
0	Stopped			●		◎		Acceleration				Deceleration				x	x	x	x

- Stopped: 000 : OFF★, 001 : 17%H, 010 : 25%H, 011 : 33%H, 100 : 50%H, 101 : 67%H, 110 : 75%H, 111 : 100%H
- ● / ◎: 00 : 50%H, 01 : 67%H, 10 : 75%H, 11 : 100%H★
- Acceleration: 00 : 2-phase excitation★, 01 : 1-2-phase excitation, 10 : W1-2-phase excitation, 11 : 2W1-2-phase excitation
- Deceleration: 0000 : Acceleration 0★, 0001 : Acceleration 1, 0010 : Acceleration 2, 0011 : Acceleration 3, 0100 : Acceleration 4, ⋮, 1110 : Acceleration 14, 1111 : Acceleration 15

100: Input setting

24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41	42	43	44	45
1	0	0	x		No	En	Edg		±	Coordinates		Coordinates							

- No — 0: Sensor 0 / 1: Sensor 1
- En — 0: Input disabled★ / 1: Input enabled
- Edg — 0: Lo active★ / 1: Hi active
- Coordinates — -1023 to +1022: Coordinates (★0)

101: Coordinates setting

24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41	42	43	44	45
1	0	1	X	x	x	x	x	x	±	Coordinates		Coordinates							

- 27 — 0: Current coordinates / 1: End point coordinates
- Coordinates — -1023 to +1022: Coordinates (★ Current coordinates: 0, End point: +1022, -1023)

11x: External port setting

24	25	26	27	29	30	31	32	33	34	35	36	38	39	40	41	42	43	44	45
1	1	x	x	OUTP3		OUTP2		OUTP1		OUTP0		x	x	x	x	x	x	x	x

- OUTP: 00: 0% (OFF) ★, 01: 50%H, 10: 70%H, 11: 100%H

★ indicates the setting value for the initial state.

(4) Load and read instructions

bit	1 to 9	10	11 to 18	19	20	21	22 to 27	28	29 to 36	37	38 to 45	46	47	48
Name	START	Sp	Device Data dvc_dat[7:0]	Sp	Control Data0 ctrl_dat0[7:0]			Sp	Control Data1 ctrl_dat1[7:0]	Sp	Control Data2 ctrl_dat2[7:0]	END		
SDA	"111 111 111"	0	Device ID, Device address	0	Mode	Channel	Details, Individual setting	0	"0000 0000"	0	"0000 0000"	0	X	X
Name								Sp	Send_Data0 send_dat0[7:0]	Sp	Send_Data1 send_dat1[7:0]	ACK		
SDO								0	7 6 5 4 3 2 1 0	0	7 6 5 4 3 2 1 0	1	1	0

Register read/load command: 1

23	24	25	26	27	Readout item	send_dat0 7	6	5	4	3	2	1	0	send_dat1 7	6	5	4	3	2	1	0
0	0	0	0	0	Operation buffer 0 - ①	●	Wait	◎	▲	○				Step data							
0	0	0	0	1	Operation buffer 1 - ①	●	Wait	◎	▲	○				Step data							
0	0	0	1	0	Operation buffer 2 - ①	●	Wait	◎	▲	○				Step data							
0	0	0	1	1	Operation buffer 3 - ①	●	Wait	◎	▲	○				Step data							
0	0	1	0	0	Operation buffer 4 - ①	●	Wait	◎	▲	○				Step data							
0	0	1	0	1	Latch operation buffer - ①	●	Wait	◎	▲	○				Step data							
0	0	1	1	0	Operation buffer 0 - ②	0	Direction	Current speed data						00		Speed data					
0	0	1	1	1	Operation buffer 1 - ②	00000000								00		Speed data					
0	1	0	0	0	Operation buffer 2 - ②	00000000								00		Speed data					
0	1	0	0	1	Operation buffer 3 - ②	00000000								00		Speed data					
0	1	0	1	0	Operation buffer 4 - ②	00000000								00		Speed data					
0	1	0	1	1	Latch operation buffer - ②	00000000								00		Speed data					
0	1	1	0	0	Individual setting buffer 0	Channel	Duty when stopped			In operation		Excitation		Acceleration				Deceleration			
0	1	1	0	1	Individual setting buffer 1	●	Duty when stopped			In operation		Excitation		Acceleration				0000			
0	1	1	1	0	Individual setting buffer 2	●	Duty when stopped			In operation		Excitation		Acceleration				0000			
0	1	1	1	1	Individual setting buffer 3	●	Duty when stopped			In operation		Excitation		Acceleration				0000			
1	0	0	0	0	Individual setting buffer 4	●	Duty when stopped			In operation		Excitation		Acceleration				0000			
1	0	0	0	1	Latch setting buffer	●	Duty when stopped			In operation		Excitation		Acceleration				0000			
1	0	0	1	0	Default setting buffer	Channel	Duty when stopped			In operation		Excitation		Acceleration				Deceleration			
1	0	0	1	1	Operation buffer & External port	Channel B buffer				Channel A buffer				External port output							
1	0	1	0	0	Current coordinates	0 0000								Current coordinates							
1	0	1	0	1	Target coordinates	0 0000								Target coordinates							
1	0	1	1	0	End point coordinates (+)	0 0000					0			End point coordinates (+)							
1	0	1	1	1	End point coordinates (-)	0 0000					1			End point coordinates (-)							
1	1	0	0	0	Input 0(2) setting	ch	0	Enabled	Edge	0				Sensor coordinates							
1	1	0	0	1	Input 1(3) setting	ch	1	Enabled	Edge	0				Wait count value							
1	1	0	1	0	Wait count value	0 0000								Wait count value							
1	1	0	1	1	Active IC address	Active IC address															
1	1	1	0	0	Interrupt generating IC address	Interrupt generating IC address															
1	1	1	0	1	Internal status	000			Channel B status			IN3	IN2	000			Channel A status			IN1	IN0
1	1	1	1	0	Load command																
1	1	1	1	1	All Load command																

●Existence ▲Acceleration
◎Correction ○Coordinates

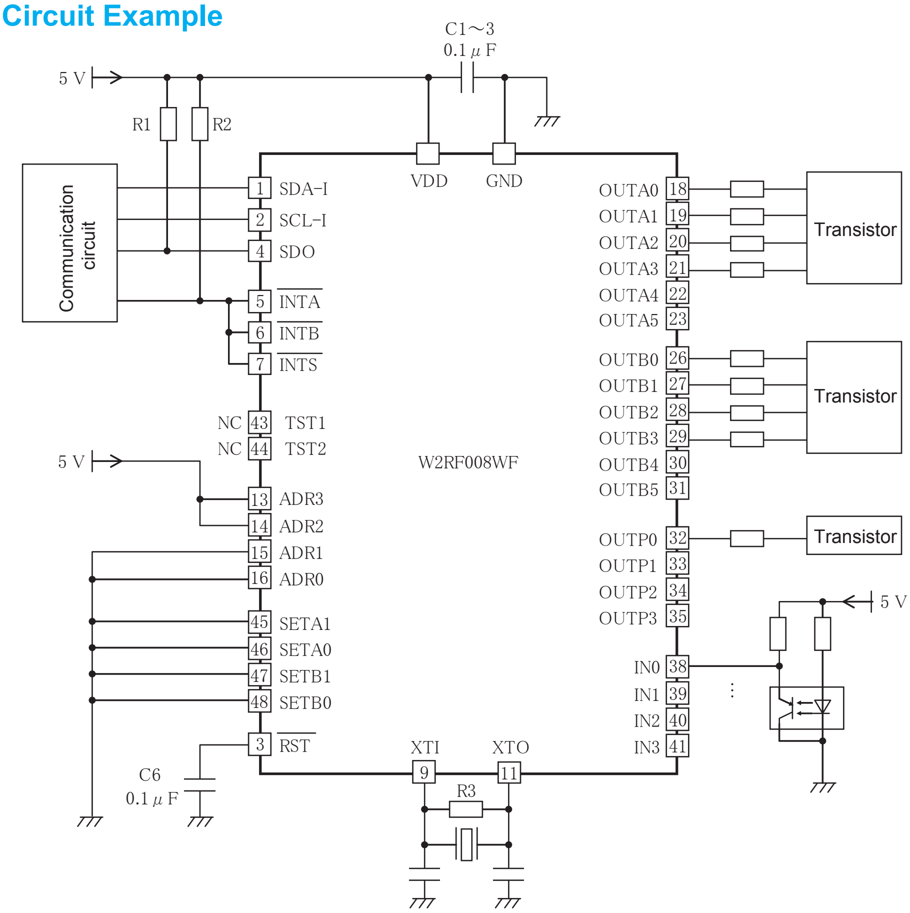
■ Speed Setting List

Example:
In the case of 4.096 MHz primary oscillation and 2-phase excitation

Speed data	Pulse period [ms]	Speed [pps]	Speed data	Pulse period [ms]	Speed [pps]
0	-	Stopped	32	1.97	507.9
1	32.00	31.3	33	1.94	516.1
2	24.00	41.7	34	1.91	524.6
3	16.00	62.5	35	1.88	533.3
4	14.00	71.4	36	1.84	542.4
5	12.00	83.3	37	1.81	551.7
6	10.00	100.0	38	1.78	561.4
7	8.00	125.0	39	1.75	571.4
8	7.50	133.3	40	1.72	581.8
9	7.00	142.9	41	1.69	592.6
10	6.50	153.8	42	1.66	603.8
11	6.00	166.7	43	1.63	615.4
12	5.50	181.8	44	1.59	627.5
13	5.00	200.0	45	1.56	640.0
14	4.50	222.2	46	1.53	653.1
15	4.00	250.0	47	1.50	666.7
16	3.88	258.1	48	1.47	680.9
17	3.75	266.7	49	1.44	695.7
18	3.63	275.9	50	1.41	711.1
19	3.50	285.7	51	1.38	727.3
20	3.38	296.3	52	1.34	744.2
21	3.25	307.7	53	1.31	761.9
22	3.13	320.0	54	1.28	780.5
23	3.00	333.3	55	1.25	800.0

Speed data	Pulse period [ms]	Speed [pps]	Speed data	Pulse period [ms]	Speed [pps]
24	2.88	347.8	56	1.22	820.5
25	2.75	363.6	57	1.19	842.1
26	2.63	381.0	58	1.16	864.9
27	2.50	400.0	59	1.13	888.9
28	2.38	421.1	60	1.09	914.3
29	2.25	444.4	61	1.06	941.2
30	2.13	470.6	62	1.03	969.7
31	2.00	500.0	63	1.00	1000.0

■ Application Circuit Example



■ Precautions for Use

(1) Check the operation of communication and primary oscillation at the frequency you are using before use.
(2) Each input circuit should be determined with due consideration of the voltage, chattering, and static electricity of the input to be connected.
(3) An electrostatic discharge (ESD) protection circuit is built in, but if static electricity exceeding its function is applied, it may be destroyed. When handling, take sufficient precautions such as human body grounding.

Cat. No. XXXXXXXXXXX(E)

W2RF008WF Motor Control IC
Frequently Asked Questions (FAQ)

■ 1 Questions about basic IC operation

Q 1-1
What initialization procedure should I follow at startup?

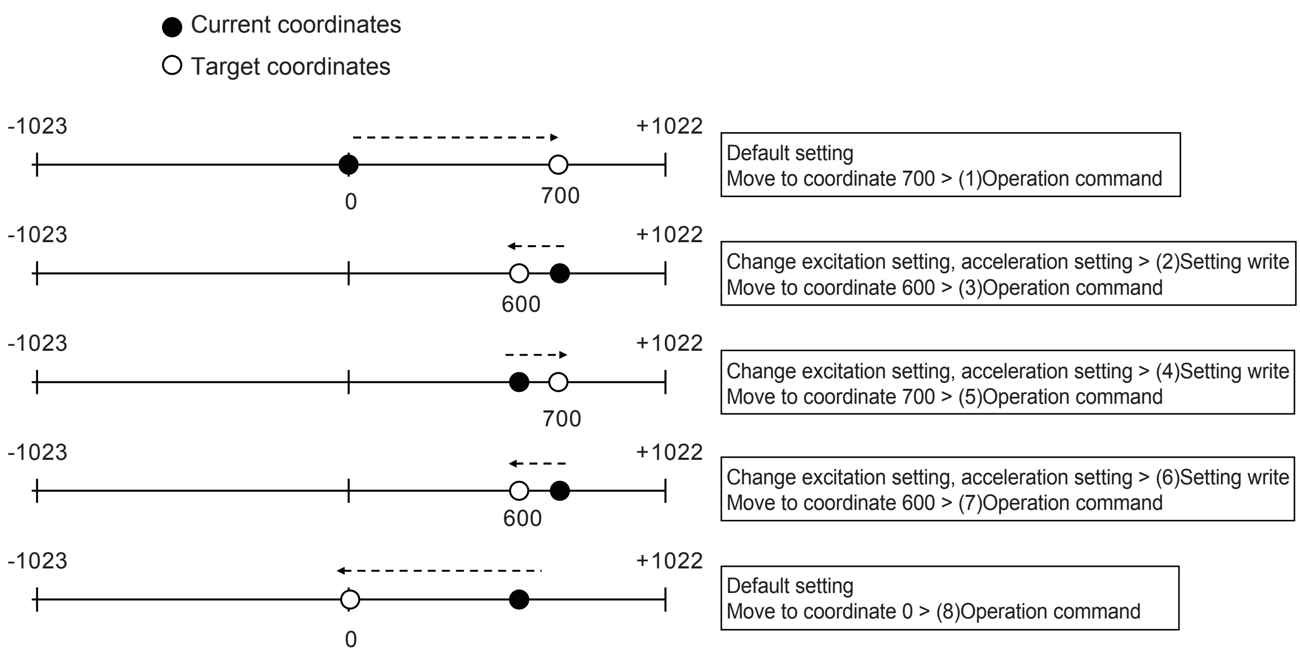
A 1-1
Write the initial settings.
Then write the default settings.
None of the above is necessary if the default values are used as they are.
In the initial setup write, "input settings" and "coordinate settings" are performed. This is to set the coordinate range, the judgment logic of the sensor input to be used, and coordinate for the motor to be controlled, and is mainly hardware-dependent.
Writing default settings sets the standard excitation method used for the motor to be controlled, the output duty ratio, acceleration, and deceleration during operation and shutdown.

* When using setting values other than these standard settings, it is necessary to write each operation instruction as an operation setting.

Section in Specifications: 10.2-(2), 11.1, 11.3.1 Example of use

Q 1-2
How do I use the 5-stage buffer?

A 1-2
The IC has up to five buffers for continuous operation. For example, it is effective for continuous movements such as the one below in a linear motion. Commands are sent in the order (1) to (8).



(2) is sent before the movement command if the setting is different from the default one.
Even if (4) and (6) are the same settings as (2), they are different from the default settings and sent in pairs with operation commands.

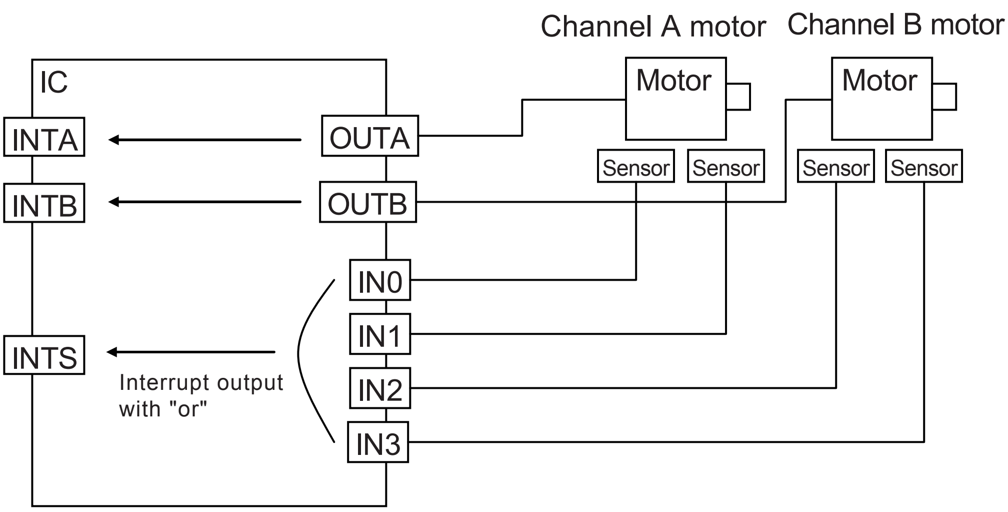
Check the following buffer constitution together with the above command transmission order.

Operation buffer		Individual setting buffer		
Operation buffer 4	(8)Operation command	Individual setting buffer 4	Blank	
Operation buffer 3	(7)Operation command	Individual setting buffer 3	(6)Setting write	
Operation buffer 2	(5)Operation command	Individual setting buffer 2	(4)Setting write	
Operation buffer 1	(3)Operation command	Individual setting buffer 1	(2)Setting write	
Operation buffer 0	(1)Operation command	Individual setting buffer 0	Blank	-> Execution

Section in Specifications: 11.3.1

Q 1-3
How do I know when an operation is complete?

A 1-3
When the operation instruction is completed. the IC outputs input interrupt signals from the INTA and INTB terminals for channels A and B, respectively. When multiple ICs are used and the interrupt terminals of each IC are ORed together, the IC cannot be identified simply by monitoring this interrupt. In such a case, it can be identified by the "interrupt generating IC address" using a read command. When INTA and INTB are ORed, it is necessary to further check the "internal status" since the above "interrupt generation IC address" alone is not enough to identify whether the interrupt is generated by channel A or channel B.



- Output from INTA to indicate completion of operation of the motor for channel A connected to OUTA
  The sensors associated with the motor for channel A are IN0 and IN1.
- Output from INTB to indicate completion of operation of the motor for channel B connected to OUTB
  The sensors associated with the motor for channel B are IN2 and IN3.

Section in Specifications: 13.1.2

Q 1-4
How do I know sensor detection?

A 1-4
An input interrupt signal is output from the INTS terminal when a sensor (IN0, IN1, IN2, or IN3) detection occurs. Check the "internal status" to identify the sensor. Also, when INTS of multiple ICs are ORed, check the "interrupt generating IC address" as above.
Without using interrupts, the "internal status" can be monitored to know if the sensor changes.
In other words, it is the same as directly watching the sensor signal.

Section in Specifications: 13.1.2

Q 1-5
How do I specify negative coordinates?

A 1-5
Coordinate values are expressed as 11-bit signed integers or two's complement.
The range of coordinates that can be specified is -1 to -1023 for negative coordinates and 0 to 1022 for positive coordinates.
Note that -1024 and 1023 are special values for executing return or infinite rotation operations.

The following is command examples that specify negative coordinates.

Command description:
Command 1: Movement instruction to -1 in absolute coordinate specification mode.
Command 2: Movement instruction to +1 in absolute coordinate specification mode.
Command 3: Movement instruction to -1023 in absolute coordinate specification mode.

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34 to 36	(34 to 36)	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1							Sp	Control Data2	END		
SDA	111111111 0	0	Device ID	Device address	0	Mode	Channel	Speed	0	Latch	Wait	●	▲	★	±	Coordinates	0	Coordinates	0	0	0
Command 1	111111111	0	1010	0000	0	0	0	001010	0	0	0	0	0	0	111		0	11111111	0	0	0
Outline								Speed =10							Coordinates: -1						
Command 2	111111111	0	1010	0000	0	0	0	001010	0	0	0	0	0	0	000		0	00000001	0	0	0
Outline								Speed =10							Coordinates: +1						
Command 3	111111111	0	1010	0000	0	0	0	001010	0	0	0	0	0	0	100		0	00000001	0	0	0
Outline								Speed =10							Coordinates: -1023						

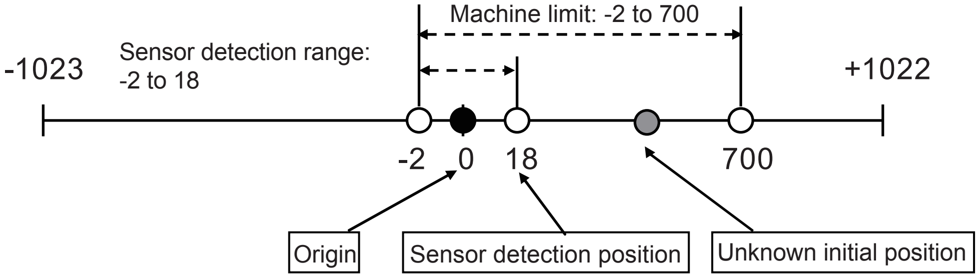
●Automatic correction ▲Acceleration/deceleration ★Coordinate specification

Section in Specifications: 10.2(1), 11.2.1

Q 1-6
How can I execute origin return?

A 1-6
The following example illustrates how to perform origin return at startup.

The example assumes that the machine limit coordinates of the motor are -2 to 700 and the sensor detection range is -2 to 18.



Command example description:
Command 1: Specifies the sensor detection position in the setup command to enable sensor input.
Command 2: Reads the sensor input and confirms that it is not in the sensor detection range.
Command 3: Moves the motor out of the detection range by +30 points in relative coordinate if the sensor is within the detection range.
Command 4: Executes the return operation command to move the motor to the sensor detection position.
Command 5: Moves the motor to coordinate:0 by specifying absolute coordinate.

This completes initialization of sensor position information and movement to the motor home position.

Command example of origin return operation

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34	35	36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1								Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Details	0	(Blank)	No	Enabled	Edge	(Blank)	±	Coordinates		0	Coordinates	0	X	X
Command 1	111111111	0	1010	0000	0	1	0	011000	0	0	0	1	0	0	000			0	00010010	0	0	0
Outline								Input 0 setting				Enabled			Coordinates: 18							

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34 to 36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1						Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Details	0	00000000						0	00000000	0	X	X
Command 2	111111111	0	1010	1111	0	1	0	111101	0	00000000						0	00000000	0	0	0
Outline								Internal status read												

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34 to 36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1						Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Speed	0	Latch	Wait	●	▲	★	± Coordinates	0	Coordinates	0	X	X
Command 3	111111111	0	1010	0000	0	0	0	000100	0	0	0	0	0	1	000	0	00011110	0	0	0
Outline								Speed =4						Add	Coordinates: +30					
Command 4	111111111	0	1010	0000	0	0	0	000100	0	0	0	1	0	0	100	0	00000000	0	0	0
Outline								Speed =4				Enabled			Coordinates: -1024 Return command					
Command 5	111111111	0	1010	0000	0	0	0	000100	0	0	0	0	0	0	111	0	11101110	0	0	0
Outline								Speed =4							Coordinates: 0					

●Automatic correction ▲Acceleration/deceleration ★Coordinate specification

Section in Specifications: 11.2.1(3), 11.4.1

■ 2 Questions about mechanical device operation

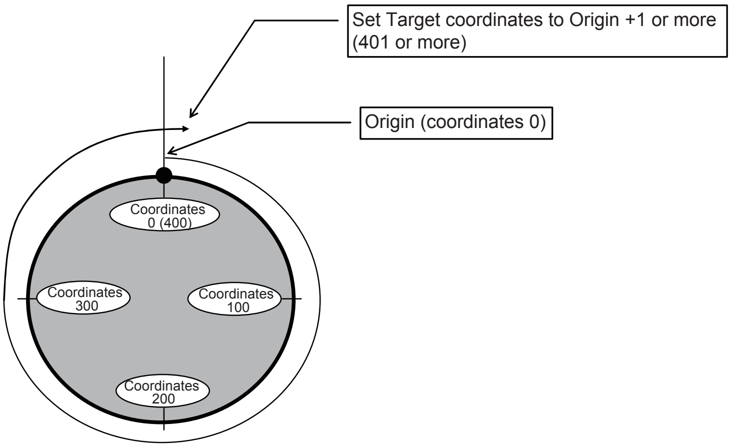
Q 2-1
How do I control a rotating mechanical device that does not require coordinate management (e.g. infinite rotation)?

A 2-1
There are two methods.

Method 1
Since normal rotating mechanical devices do not require coordinate management, "infinite rotation mode" should be used for this IC. If you disable the "automatic correction function" and set the maximum coordinate value (+1023 or -1024), the mechanical device will operate (rotate) indefinitely. The current coordinate during infinite operation is fixed at "0".

Section in Specifications: 11.2.1(4)

Method 2
Enable "coordinate correction by sensor" and set the position beyond the sensor position as the target coordinate. Before reaching the target coordinate, the current coordinates are reset (set to "0") at the sensor position, resulting in infinite rotation.
Set Target coordinates to Origin +1 or more (401 or more)

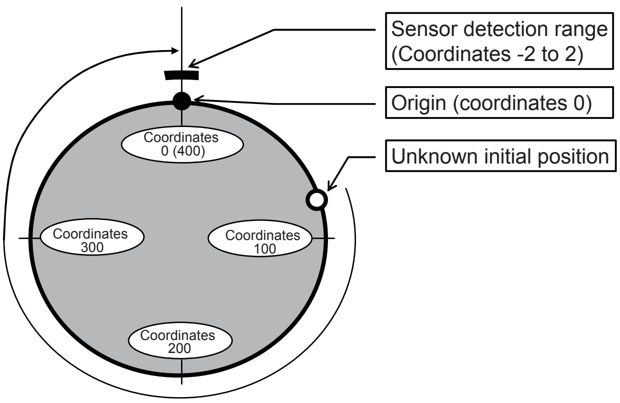


Section in Specifications: 11.3.2, 11.4.1

Q 2-2
How can I execute origin return for a rotating mechanical device?

A 2-2
The following example illustrates how to perform origin return while a mechanical device is in operation.

The example assumes a motor as shown in the figure on the right, with a sensor detection range of -2 to 2.



The following explains how to perform origin return from a clockwise infinite rotation operation.

Command example description:
Command 1: Sets the sensor position to -2.
Command 2: Sets the return operation command in the latch buffer.
Command 3: Executes a latch buffer command to move the motor to the sensor detection position.
The current coordinate is corrected to -2 (sensor position coordinate) by the return operation command.
Command 4: Moves the motor to coordinate:0 by specifying absolute coordinate.

The above procedure enables origin return for rotating mechanical devices.

Command example of origin return operation

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34	35	36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1								Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Details	0	(Blank)	No	Enabled	Edge	(Blank)	±	Coordinates		0	Coordinates	0	X	X
Command 1	111111111	0	1010	0000	0	1	0	011000	0	0	0	1	0	0	111			0	11111110	0	0	0
Outline								Input 0 setting				Enabled			Coordinates:-2							

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34 to 36			37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1								Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Speed	0	Latch	Wait	●	▲	★	±	Coordinates		0	Coordinates	0	X	X
Command 2	111111111	0	1010	0000	0	0	0	000100	0	1	0	1	0	0	011			0	11111111	0	0	0
Outline								Speed=4		Enabled		Enabled			Coordinates:+1023 Return command							

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34 to 36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1						Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Details	0	00000000						0	00000000	0	X	X
Command 3	111111111	0	1010	0000	0	1	0	111110	0	00000000						0	00000000	0	0	0
Outline								Load command												

bit	1 to 9	10	11 to 18		19	20	21	22 to 27	28	29	30	31	32	33	34	35	36	37	38 to 45	46	47	48
Name	START	Sp	Device Data		Sp	Control Data0			Sp	Control Data1								Sp	Control Data2	END		
SDA	111111111	0	Device ID	Device address	0	Mode	Channel	Speed	0	Latch	Wait	●	▲	★	±	Coordinates		0	Coordinates	0	X	X
Command 4	111111111	0	1010	0000	0	0	0	000100	0	0	0	0	0	0	000			0	00000000	0	0	0
Outline								Speed=4							Coordinates: 0							

●Automatic correction ▲Acceleration/deceleration ★Coordinate specification

*Additional note
For counterclockwise rotation, the above commands are used for supplementary explanation.
Please change the following two commands.
Command 1: Change the sensor coordinate to +2
Command 2: Change the target coordinate to -1024

Section in Specifications: 11.2.1(3), 11.3.2

Q 2-3
When I want a mechanical device to move as if it is falling, I need to stop the rotation of the motor to keep the mechanical device in the fallen position. Can it be excited?

A 2-3
It can be. This IC can output an excitation signal to the motor even when the motor is stopped.
This excitation output can also be PWM output by setting.
PWM settable duty cycles are 0% (stop excitation OFF), 17%, 25%, 33%, 50%, 67%, 75%, and 100%.
Note that the excitation phase is only the phase at stop.

Section in Specifications: 11.5.3

Q 2-4
If I want to make a round trip movement with linear coordinate, do I need to manage the time and timing on the host side if I want it to stop for a certain period of time when it turns around?

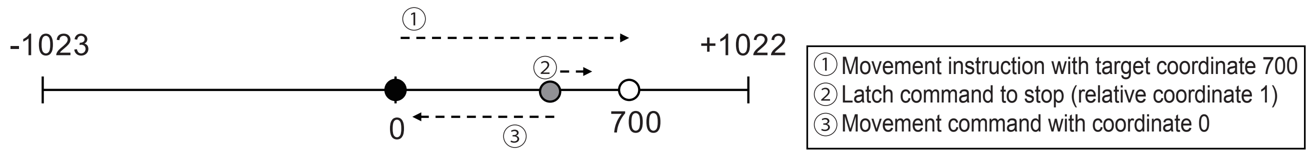
A 2-4
If you want to pause it, you can use the "wait function" to let the main IC manage the time and timing.
When the wait function is in operation, the excitation signal is stopped and the motor is stopped during this time.
The stop time is the time that is expressed by the following equation, handling the coordinate data as a count.

Wait time = Pulse width x number of counts

Section in Specifications: 11.5.1

Q 2-5
Is there anything I should pay attention to if I want to interrupt the current operation and move on to the next operation, for example, to change the target coordinate in the middle of an operation?

A 2-5
To change the target coordinate during operation, be sure to stop the operation with the relative value specified and then operate at the target coordinate you wish to change. If the target coordinate is changed without stopping the motor during operation, an error may occur in the internal absolute coordinate management.



To start from coordinate "0" at target coordinate 700 and set the target coordinate to "0" on the way

Section in Specifications: 11.3.2

Q 2-6
How can I make it run smoothly?

A 2-6
Smooth initial operation can be achieved by using the automatic acceleration function.
There are 16 acceleration settings. Use the value that best suits the machine load and performance.

Example: If acceleration setting 15 is used, it takes about 2.5 seconds to reach speed from 0 to 10 (307 PPS), resulting in smooth initial operation.

Section in Specifications: 11.2.2(2)

■ 3 Questions about circuit

Q 3-1
Are there any precautions when controlling bipolar motors?

A 3-1
The bipolar motor control of this IC has been tested with New Japan Radio's "NJM3717".
If other drivers are used, please check the interface and operation before use.

Section in Specifications: 9.3.2, 14

Q 3-2
What should I connect to the primary oscillator terminals (XTI, XTO)?

A 3-2
Connect a resonator (including ceramic resonator) or oscillator. Each connection method is different.

Section in Specifications: 9.6.1

Q 3-3
Is $\overline{\text{RST}}$ terminal protection required?

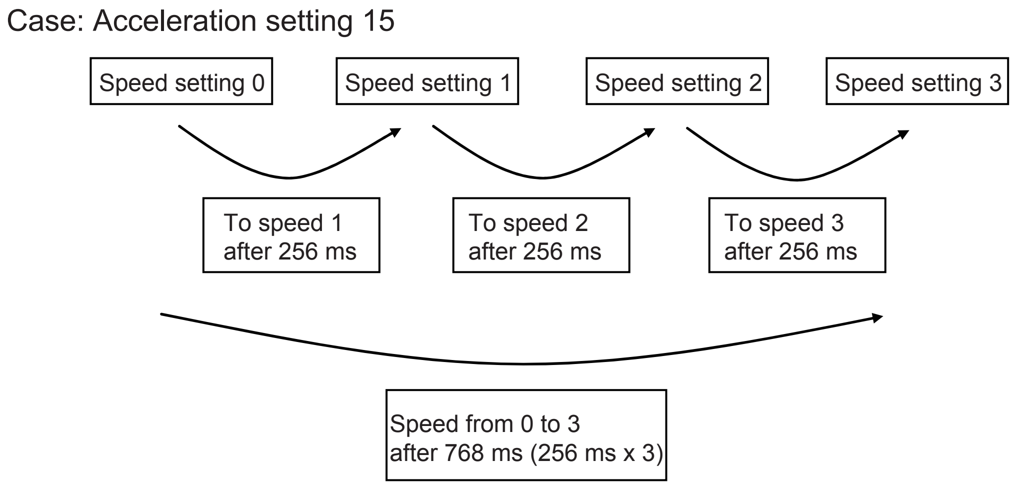
A 3-3
A 0.1 μF capacitor should be added to the $\overline{\text{RST}}$ terminal.
It is required for stable operation when the power is turned on and during operation.

Section in Specifications: 9.6.2, 15

■ 4 Questions about protective operation

Q 4-1
What should I do to prevent loss of synchronism?

A 4-1
Stable initial operation can be achieved by using the "automatic acceleration" function. General trapezoidal control is also possible. There are 16 acceleration settings. Use the value that best suits the machine load and desirable trapezoidal control. Acceleration of this IC is achieved by moving the speed table up one step at a time with the change time determined by the acceleration setting (see P.22 of the specification).

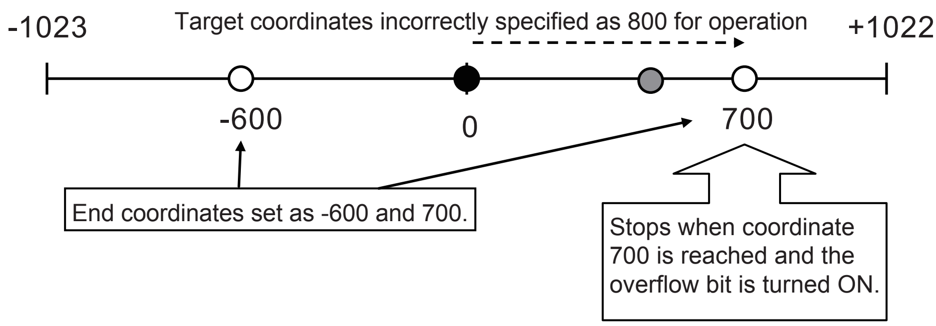


Section in Specifications:11.2.2(2)

Q 4-2
How can I monitor for operational anomalies?

A 4-2
Basically, it is safe to constantly monitor whether or not it is operating as expected by reading the current coordinates. If sensors are used in combination, the approximate expected operation can be monitored by monitoring the passage of the sensors.

Otherwise, if you set the end coordinate, it will always stop at this coordinate. By setting the limit position on the mechanism to this coordinate, mechanism breakdown can be prevented in the event of an abnormality.
If the motor stops at the end coordinate, the "overflow bit" of the internal status turns ON, and you can find out whether or not an error has occurred.



Section in Specifications: 11.5.2, 13.1

■ Memo