

■ Electrical Characteristics

(1) DC characteristics

(Ta = 25° C)

Item	Symbol	Conditions	Standard values				Unit	Target terminals
			VDD	Min.	Typ.	Max.		
Input leakage current 1	IL1	VI = VDD/0 V	3.6 V 5.5 V	-15	-	15	μA	SDA, SCL, XTI, ADR0 to 2, COM, $\overline{CE}$, DRVTA, DRVTB, ENCTA, ENCTB, ENCA0 to 2, ENCB0 to 2
Input leakage current 2	IL2	VI = VDD/0 V	3.6 V	-100	-	15	μA	$\overline{RST}$, INSA, INSB, INP0 to 3
			5.5 V	-250	-	15		
High level input voltage	VIH	-	3.3 V	2.4	-	-	V	SDA, SCL, ADR0 to 2, COM, $\overline{CE}$, DRVTA, DRVTB, ENCTA, ENCTB, ENCA0 to 2, ENCB0 to 2, $\overline{RST}$, INSA, INSB, INP0 to 3
			5.0 V	4.0	-	-		
Low level input voltage	VIL	-	3.3 V	-	-	0.6	V	ENCA0 to 2, ENCB0 to 2, $\overline{RST}$, INSA, INSB, INP0 to 3
			5.0 V	-	-	0.8		
Output leakage current at OFF state	IOZ	-	3.6 V 5.5 V	-15	-	15	μA	SDO, $\overline{INT}$
High level output voltage	VOH	IOUT = -6 mA	3.0 V	VDD -0.3	-	-	V	OUTA0 to 3, OUTB0 to 3, DBGA, DBGB
		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 3, OUTB0 to 3, DBGA, DBGB SDO, $\overline{INT}$
		IOUT = 8 mA	4.5 V	-	-	0.4		
Current consumption during operation	IDD	SDA, SCL, ADR, COM, DRVTX, ENCTX, ENCX, $\overline{CE}$ = 0 V, INSX, INP, SDO, $\overline{INT}$, OUTX = Open, fXT = 4.096 MHz, Standby state	3.6 V	-	2.8	5.6	mA	VDD
			3.6 V	-	4.8	9.6		

(2) Timing characteristics

(2)-1 Primary oscillation input

(Ta = -20 to 85° C, VDD = 3.0 to 5.5 V)

Item	Symbol	Conditions	Standard values				Unit	Target terminals
			VDD	Min.	Typ.	Max.		
Clock cycle time	tXT	-	3.3 V	200	-	-	ns	XTI
			5.0 V	100	-	-		
Clock H period pulse width	tXTH	-	3.3 V	96	-	-	ns	XTI
			5.0 V	48	-	-		
Clock L period pulse width	tXTL	-	3.3 V	96	-	-	ns	XTI
			5.0 V	48	-	-		

(2)-2 Oscillation frequency and operating time

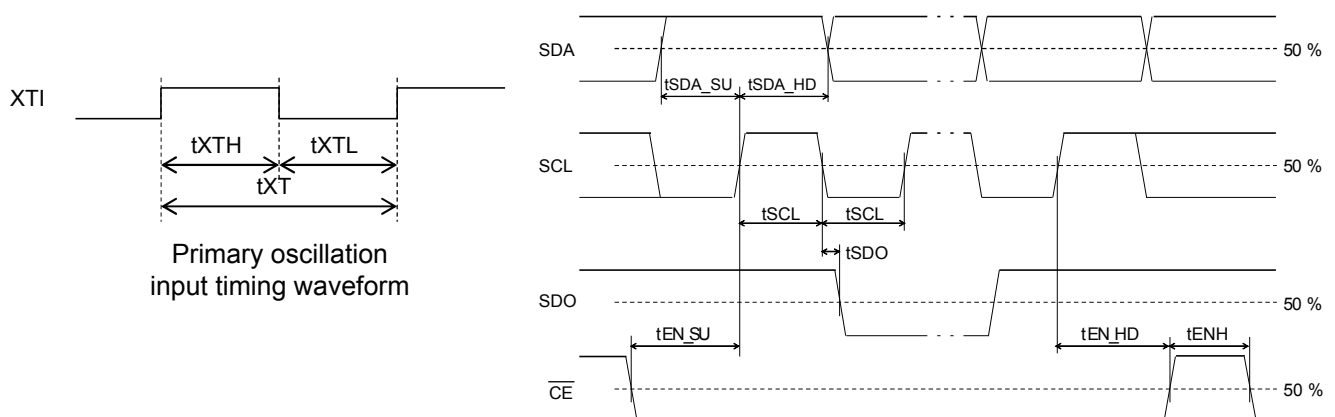
(fXT = 4.096 MHz)

Item	Symbol	Conditions	Standard values			Unit	Target terminals
			Min.	Typ.	Max.		
Basic cycle	Tbase	-	-	0.244	-	μA	XTI, XTO
Interrupt output pulse width	tINT	-	-	31.25	-	μA	INT
PWM output frequency	fPWM	-	-	32.0	-	kHz	OUTA0 to 3, OUTB0 to 3
Input hold time	tENC	-	1.95	-	-	μA	ENCA0 to 2, ENCB0 to 2
	tINP	-	250.0	-	-	μA	INSA, INSB, INP0 to 3
Lock detection time	tLCK1	Lock detection = "00"	0.77	-	0.90	sec	OUTA0 to 3, OUTB0 to 3
	tLCK2	Lock detection = "01"	1.66	-	1.79		
	tLCK3	Lock detection = "10"	2.56	-	2.69		
Torque retention period	tHLD	-	0.77	-	0.90	sec	OUTA0 to 3, OUTB0 to 3
Debug output cycle	tDBG	-	-	1	-	ms	DBGA, DBGB

(2)-3 Addressed serial communication

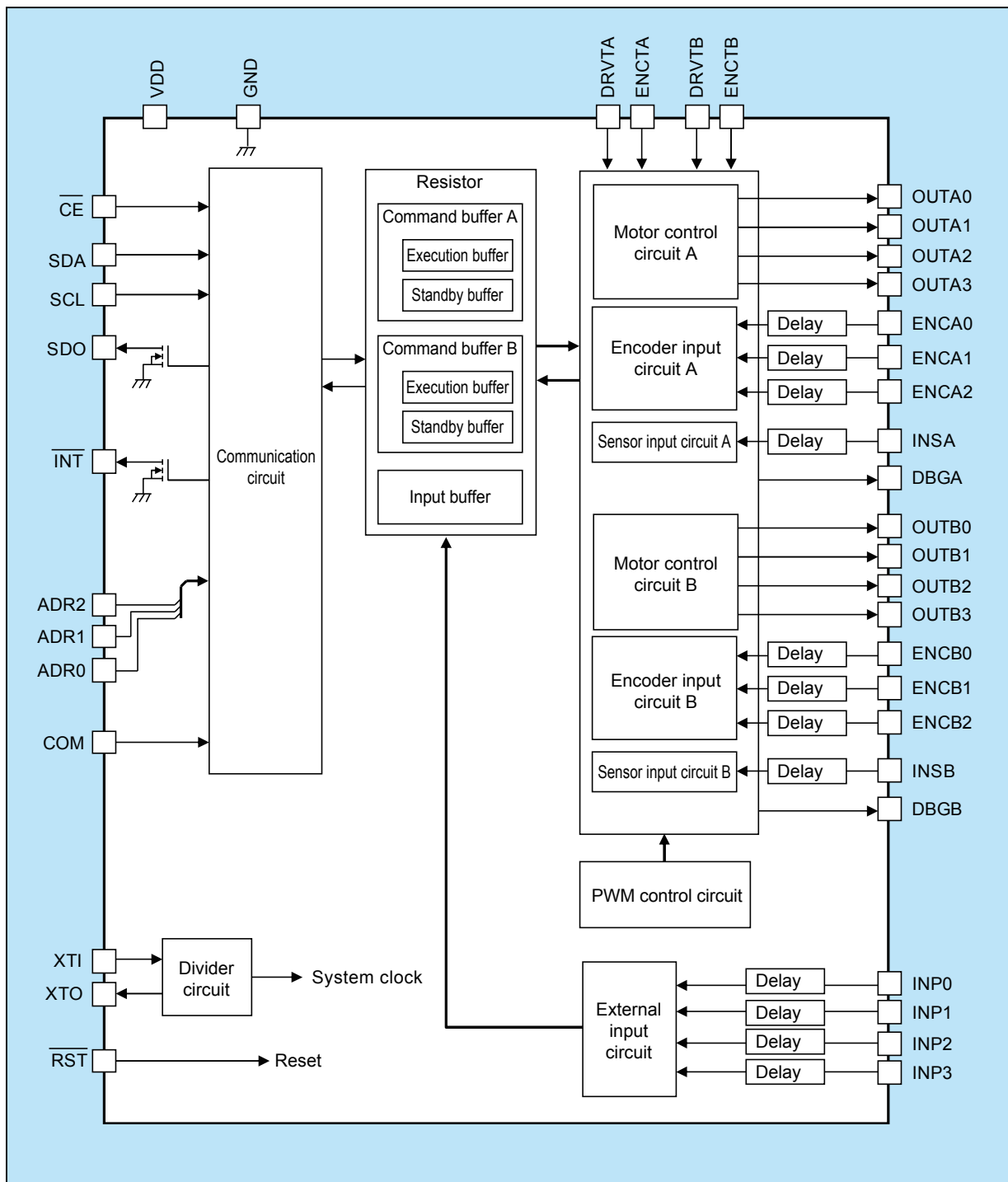
(Ta = -20 to 85°C, VDD = 3.0 to 5.5V)

Item	Symbol	Conditions	Standard values			Unit	Target terminals
			Min.	Typ.	Max.		
Communication clock pulse width	tSCL	-	100	-	-	ns	SCL
Data setup time	tSDA_SU	-	90	-	-	ns	SDA, SCL
Data hold time	tSDA_HD	-	90	-	-	ns	SDA, SCL
Enable setup time	tEN_SU	-	50	-	-	ns	CE
Enable hold time	tEN_HD	-	50	-	-	ns	CE
Enable H period pulse width	tENH	-	100	-	-	ns	CE
Output delay time	tSDO	Load capacitance = 20 pF	-	-	80	ns	SDO, SCL



Addressed serial communication timing waveform

■ Block Diagram



■ Terminal Layout

No.	Terminal name	Terminal description	I/O	Logic
1	SDA	Serial data input	I	CMOS, Schmitt
2	SCL	Serial clock input	I	
3	SDO	Serial data output	O	N-ch open drain (normally open)
4	INT	Interrupt output	O	
5	GND	Ground	P	
6	XTI	Oscillation input	I	
7	VDD	Power supply	P	
8	XTO	Oscillation output	O	
9	GND	Ground	P	
10	RST	Reset	I	CMOS, Schmitt, Pull-up, Filter
11	ADR2	Device address 2	I	CMOS, Schmitt
12	ADR1	Device address 1	I	
13	ADR0	Device address 0	I	
14	COM	Communication mode setting	I	
15	DRVTA	Drive device setting A	I	
16	DRVTB	Drive device setting B	I	
17	ENCTA	Encoder setting A	I	
18	ENCTB	Encoder setting B	I	
19	OUTA0	Motor output A0	O	CMOS
20	OUTA1	Motor output A1	O	
21	OUTA2	Motor output A2	O	
22	OUTA3	Motor output A3	O	
23	ENCA0	Encoder input A0	I	CMOS, Schmitt, Filter
24	ENCA1	Encoder input A1	I	
25	ENCA2	Encoder input A2	I	
26	VDD	Power supply	P	
27	GND	Ground	P	
28	OUTB0	Motor output B0	O	CMOS
29	OUTB1	Motor output B1	O	
30	OUTB2	Motor output B2	O	
31	OUTB3	Motor output B3	O	
32	ENCB0	Encoder input B0	I	CMOS, Schmitt, Filter
33	ENCB1	Encoder input B1	I	
34	ENCB2	Encoder input B2	I	
35	VDD	Power supply	P	
36	GND	Ground	P	
37	INSA	Origin sensor input A	I	CMOS, Schmitt, Pull-up, Filter
38	INSB	Origin sensor input B	I	
39	INP0	External input 0	I	
40	INP1	External input 1	I	
41	INP2	External input 2	I	
42	INP3	External input 3	I	
43	VDD	Power supply	P	
44	TST1	Not used (*4)	-	
45	TST2	Not used (*4)	-	
46	DBGA	Debug output A	O	CMOS
47	DBGB	Debug output B	O	
48	CE	Chip enable	I	CMOS, Schmitt, Filter

*1. The RST, INSA, INSB, and INP0 to INP3 terminals have built-in pull-up resistors (60 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. Connect unused input terminals to GND and put the output terminal in the open state.

*4. Be sure to connect unused terminals to GND.

■ Terminal Description

(1) Communication input/output terminals

1. Reception

The SDA signal input to the communication terminal is captured as serial data at the rising edge of the SCL signal. SDA 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 signal.

3. Chip enable

Communication is enabled when the $\overline{CE}$ terminal input is "L". The behavior changes depending on the communication mode.

(2) Communication mode setting terminal

Set the communication mode at the communication mode terminal COM.

The relationship between terminal settings and communication mode is shown in the table below.

Terminal setting	Communication mode	
COM	Abbreviation	Name (method, data length)
L	SP-D8	Addressed serial communication (SP, 8 bit)
H	CE-D8	Addressed serial communication (CE, 8 bit)

(3) Device address terminal

It is used to identify the control target during serial communication.

Communication is accepted when the device address specification for serial communication and the pin setting match.

The "L" input corresponds to data "0" and the "H" input corresponds to data "1". Addresses can be assigned from among the seven possible values from "000" to "110". The relationship between terminal settings and data is shown in the table below.

"111" is a special address. When the control command specifies "111", it means that all addresses are specified in one batch.

Device address	[2]	[1]	[0]
Terminal setting	ADR2	ADR1	ADR0

(4) Interrupt output terminal

The completion of an operation command and changes in the origin sensor inputs (INSA, INSB) and external inputs (INP0 to 3) are notified by the interrupt terminal.

The interrupt output terminal is an open drain output ("L" output upon notification).

The interrupt output terminals of multiple ICs can be connected in parallel (wired OR connection).

(5) Motor output terminal

The output of the output terminal fluctuates depending on the motor control state.

The relationship between motor control and output is shown in the table below.

The output logic of the output terminal can be changed by setting.

The output is fixed at high (H) in the reset state.

The table below shows the outputs when the output logic is "L" active.

Motor control	Output			
	OUT0 [PWM]	OUT1 [DIR]	OUT2 [BRK]	OUT3 [EN]
Standby (open)	H	H	H	H
Forward	L (PWM)	H	H	L
Reverse	L (PWM)	L	H	L
Short brake	H	H	L	L
Reset state	H	H	H	H

(6) Encoder setting terminal

Set the encoder input method at the encoder setting terminal. The relationship between the terminal setting and input method is shown in the table below.

Terminal setting	Input method	
ENCT	Abbreviation	Connection destination
L	3-phase input	Hall IC for brushless DC motor
H	2-phase input	External optical encoder

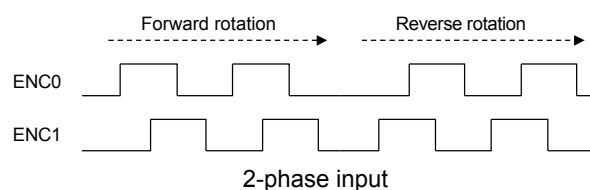
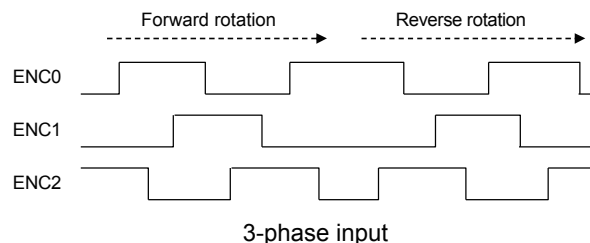
(7) Encoder input terminal

The motor position information is updated based on the input from the encoder (ENC0, 1, 2).

The rotation direction is determined by the input sequence of ENC0, 1, and 2.

The encoder input can be switched between 3-phase input and 2-phase input by setting the encoder setting terminal ENCT.

When set to 2-phase input, ENC0 and ENC1 are used, and ENC2 is not used, so connect it to GND.



(8) Origin sensor input terminal

INSA and INSB are origin sensors for motors.

Used in origin return operation.

The "L" input corresponds to "0" and the "H" input corresponds to "1".

(9) External input terminal

An external input signal is stored in the internal register through the external input circuit, and the stored value can be read out via serial communication. The external input terminal is used only for notification and not for motor control. The "L" input corresponds to "0" and the "H" input corresponds to "1".

(10) Drive device setting terminal

Select the operating path of the drive device using the drive device setting terminal DRV T for each channel.

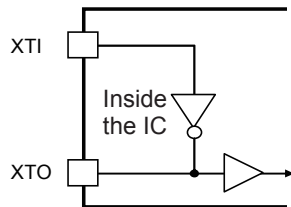
Terminal setting	Drive device operation path
DRV T	
L	Linear type
H	Rotary type

(11) Debug output terminal

This terminal is used for debugging and outputs the internal state of the motor via UART communication.

(12) Primary oscillation input terminal

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. If using an oscillator, connect to the XTI terminal. At this time, XTO terminal should be left open.



Oscillator circuit configuration

(13) Reset terminal

When the $\overline{\text{RST}}$ terminal input is "L", all internal circuits are in the reset state, each buffer is in the initial state, and each output terminal is set to "H". When the $\overline{\text{RST}}$ 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 .

Communication Specifications

This IC is controlled by 48-bit (SP-D8) or 32-bit (CE-D8) addressed serial communication. The communication method can be switched at the COM terminal.

(1) SP-D8 mode communication specifications

bit		1	2	3	4	5	6	7	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																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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(2) CE-D8 mode communication specifications

bit		1	2	3	4	5	6	7	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		
CE																																			
SCL																																			
SDA	X	1	1	0	0																													X	
Name	START	Device ID			Device address			Mode 1	Mode 0	Command data								Command data								Command data								END	
SDO	1	1	1	1	1	1	1	1	1	0																								1	
Name		Blank								SYN	Response data								Response data								Response data								Blank

Command System

(1) Operation command

Name	Blank																		SYN		INP3	INP2	INP1	INP0	INSA	B	Standby buffer	Execution buffer	SYN	Error							SYN	Current coordinates										SYN		
SDO	Always '1'																		0	0									0		0	0	[12]	[11]	[10]	[9]	[8]	0	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]	0	1	1	

bit	1 to 10										11 to 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
Name	START										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 [3:0]	Device address [2:0]			Mode 1	0	Mode 0	Channel	Rapid acceleration	Deceleration	Speed			0	Repetition	Reciprocation	Coordinate specification				0	Coordinate data							0	X	X						

1100: ID

0 to 7: Address

Write mode: 0

Operation control: 0

Channel A: 0
Channel B: 1

0: Rapid acceleration disabled
1: Rapid acceleration enabled

0: Deceleration disabled
1: Deceleration enabled

0: Stop
1 to 15: Low speed to
High speed

0: Repetition disabled
1: Repetition enabled

0: Reciprocation disabled
1: Reciprocation enabled

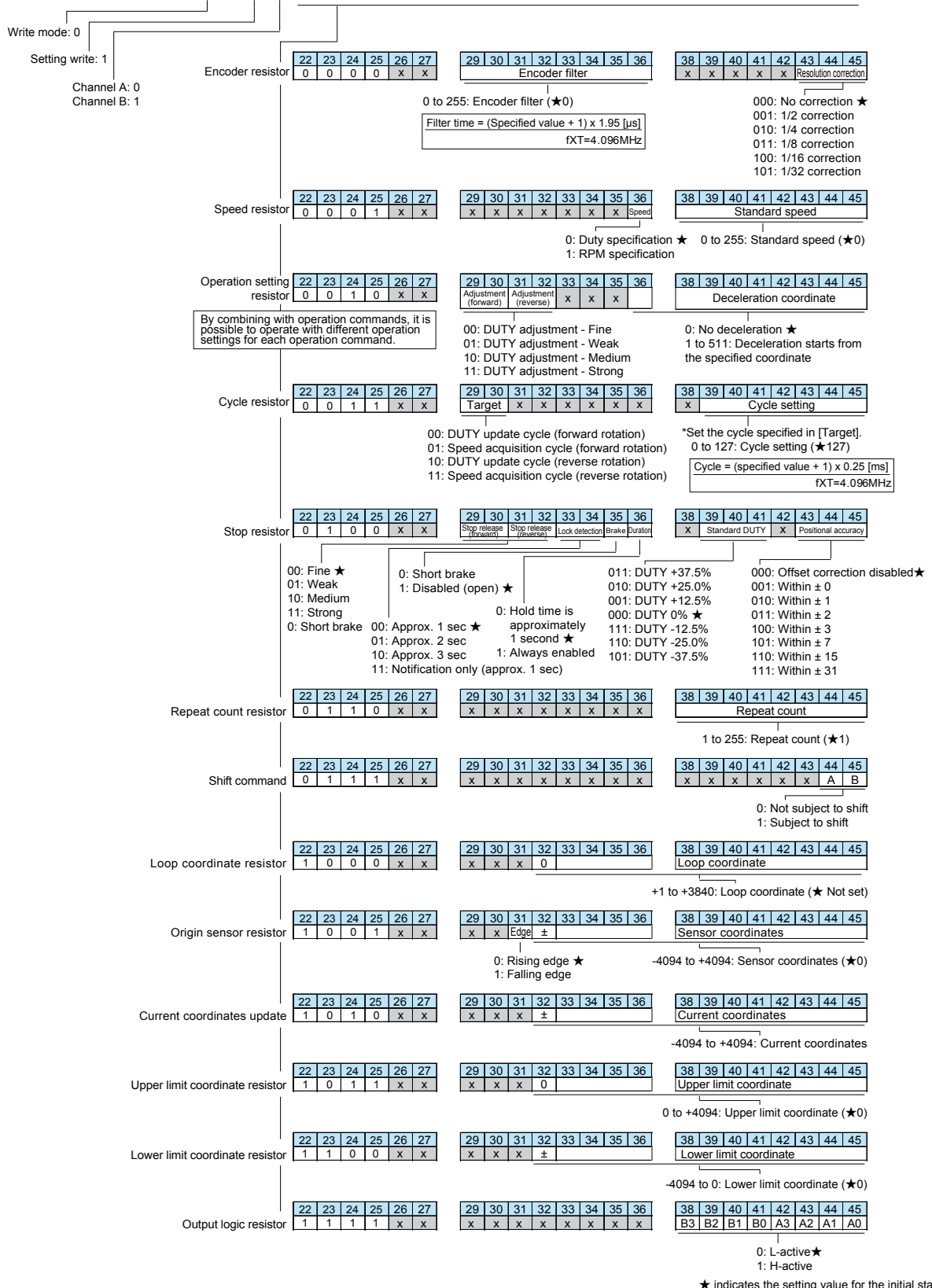
0: Absolute coordinate specification mode
1: Relative coordinate specification mode

-4094 to +4094: Coordinate specification
-4095/+4095: Origin return

(2) Setting command

Name	Blank										SYN		INP3	INP2	INP1	INP0	INSA.B	Standby buffer	Execution buffer	SYN	Error					SYN	Current coordinates										SYN				
SDO	Always'1'										0	0									0		0	0	[12]	[11]	[10]	[9]	[8]	0	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]	0	1	1

bit	1 to 10		11 to 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
Name	START		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 [3:0]	Device address [2:0]	Mode 1	0	Mode 0	Channel	Address for setting			X	X	0	Address for setting								0	Address for setting								0	X	X	



★ indicates the setting value for the initial state.

(3) State read command

Name	Blank																	SYN		Response data [22:16]								SYN	Response data [15:8]								SYN	Response data [7:0]								SYN		
SDO	Always '1'																	0	0	[22]	[21]	[20]	[19]	[18]	[17]	[16]	0	[15]	[14]	[13]	[12]	[11]	[10]	[9]	[8]	0	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]	0	1	1	

bit	1 to 10		11 to 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
Name	START		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 [3:0]	Device address [2:0]	Mode 1	0	Mode 0	Channel	Address for reading				X	X	0	"XXXX XXXX"								0	"XXXX XXXX"								0	X	X

Read mode: 1

State read: 0

Channel A: 0
Channel B: 1

22	23	24	25	Read item	Response data [22:16]	Response data [15:8]	Response data [7:0]
0	0	0	0	Execution buffer - Lower	INP3 INP2 INP1 INP0 INSA, B Standby buffer existence Execution buffer existence	Repetition	Coordinate data
0	0	0	1	Standby buffer - Lower		Reciprocation	Coordinate data
0	0	1	0	Execution buffer - Upper		Coordinates	Coordinate data
0	0	1	1	Standby buffer - Upper		0000 0000	00 Rapid acceleration Deceleration Speed data
0	1	0	0	Execution buffer - Setting		0000 0000	00 Rapid acceleration Deceleration Speed data
0	1	0	1	Standby buffer - Setting		Adjustment (forward)	Deceleration coordinate
0	1	1	0	Current coordinates		Adjustment (reverse)	Deceleration coordinate
0	1	1	1	Offset coordinates		Error	Current coordinates
1	0	0	0	Repeat count setting		0000 00	Offset coordinates
1	1	1	1	Status flag		0000 0000	Repeat count
					B channel status flag		A channel status flag

Status flag details							
Channel B	[15]	[14]	[13]	[12]	[11]	[10]	[9]
Channel A	[7]	[6]	[5]	[4]	[3]	[2]	[1]
Status flag	0	Origin return error	Offset correction error	End point reached	Lock detection	Overflow	Origin detect

Origin return error, termination arrival, lock detection, and origin detection are cleared by reading the status flag.
Misalignment correction errors and overflows are cleared by returning to the origin or updating the current coordinates.

(4) Communication check command

Name	Blank			SYN		Response data [22:16]							SYN	Response data [15:8]							SYN	Response data [7:0]							SYN				
SDO	Always'1'			0	0	[22]	[21]	[20]	[19]	[18]	[17]	[16]	0	[15]	[14]	[13]	[12]	[11]	[10]	[9]	[8]	0	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]	0	1	1

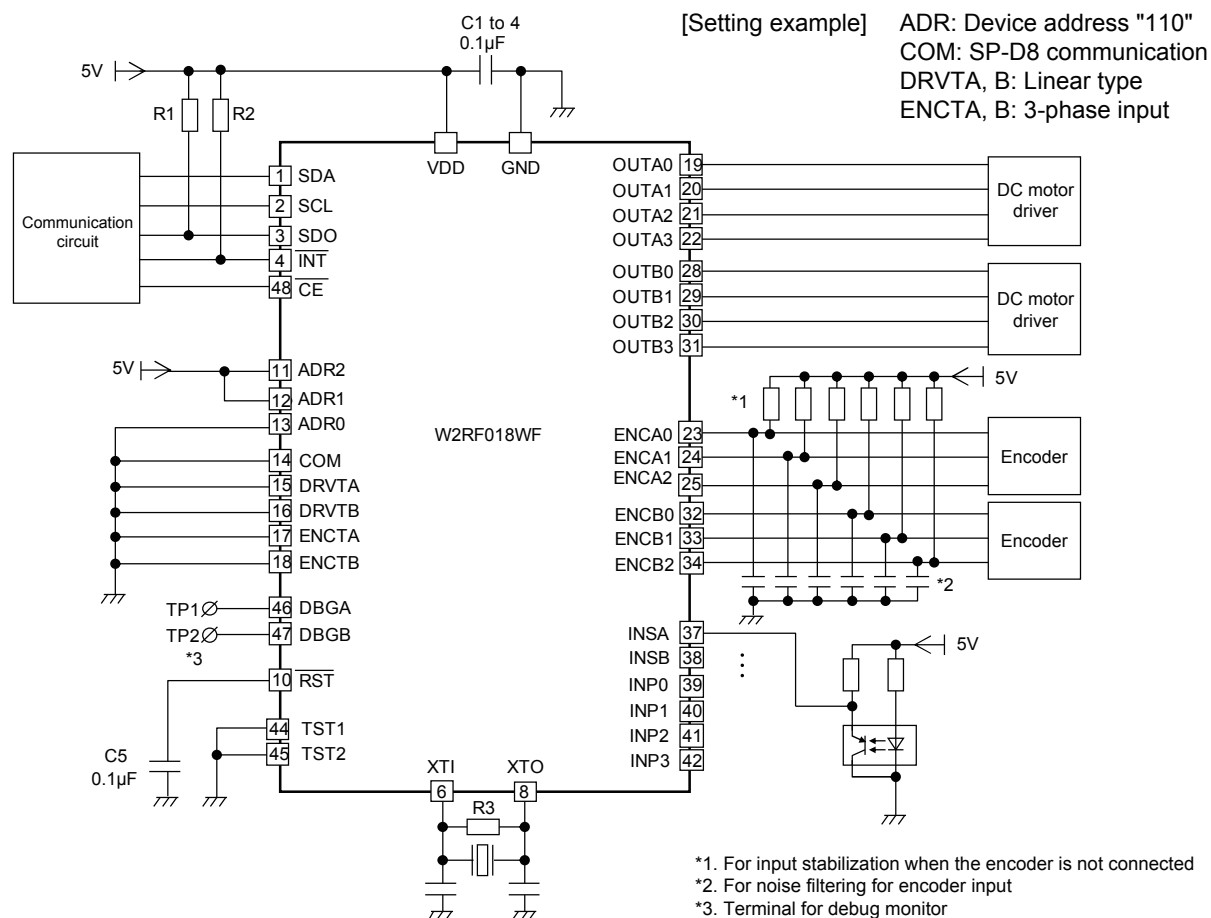
bit	1 to 10	11 to 18			19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Name	START	Device Data dvc_dat[7:0]			Sp	Control Data0 ctrl_dat0[7:0]							Sp	Control Data1 ctrl_dat1[7:0]							Sp	Control Data2 ctrl_dat2[7:0]							END					
SDA	"111 111 111 0"	Device ID [3:0]	Device address [2:0]	Mode 1	0	Mode 0	"XXXX XXXX"							0	"XXXX XXXX"							0	"XXXX XXXX"							0	X	X		

Read mode: 1

Communication check: 1

Read item	Response data [22:16]	Response data [15:8]	Response data [7:0]
Communication check command	Data received in the previous communication	Data received in the previous communication	Data received in the previous communication

■ Application Circuit Example



■ Precautions for Use

- (1) Verify the operation at the intended frequency for both communication and primary oscillation before use.
 - (2) Determine each input circuit with sufficient consideration of the connected input voltage, chattering, and static electricity.
 - (3) An electrostatic discharge (ESD) protection circuit is built in, but if electrostatic discharge exceeding its capability is applied, damage may occur.
- When handling, take sufficient precautions such as grounding the operator's body.

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