Oriental motor

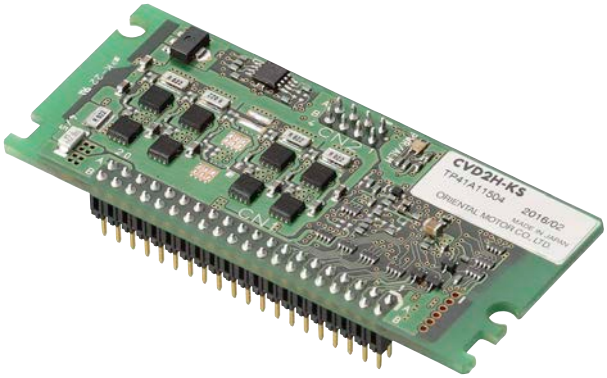
Technical Note

Stepping Motor Driver

CVD driver S Type

SPI communication setting

24 VDC input
2-phase/5-phase bipolar
Microstepping drive



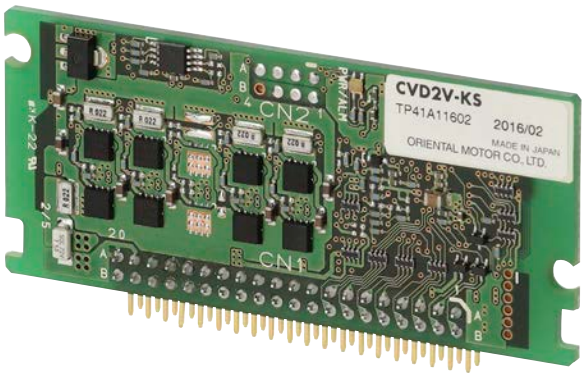


Table of contents

Product introduction

■ Features

Driver module enabling to downsize equipment

- This is a board mounting type driver module allowing flexible design of equipment.
- Two installation directions, "horizontal placing" and "vertical placing," are available.
- Two setting methods, "I/O" and "SPI communication," are available to set parameters and motor selection.

Only an aluminum electrolytic capacitor required as an external component

- All functions required to drive a motor are equipped in the driver.
- Simply mounting an aluminum electrolytic capacitor on a mother board can operate a motor easily.
- Managing new components can be minimized.
- The mounting time of the driver circuit components can be shortened.

Possible to combine with motors of high-current specification

- Connecting a motor possible to combine can supply the rated current up to the maximum.
- Limiting the motor output will not be required in consideration of the heat generation of the driver circuit.

Same basic performance as CVK Series

- The basic performance is the same as the **CVK** Series.

■ Driver type

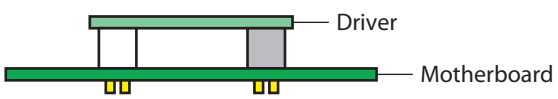
Number of phases	Model			
	I/O setting		SPI communication	
2-phase	**CVD2H-K**	**CVD2V-K**	**CVD2H-KS**	**CVD2V-KS**
5-phase	**CVD5H-K**	**CVD5V-K**	**CVD5H-KS**	**CVD5V-KS**

■ Motors for possible combinations

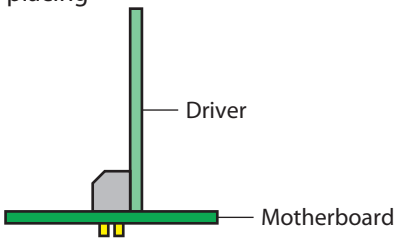
Driver				Motor rated current (A/phase)
Setting method	Number of phases	Installation direction	Model	
I/O	2-phase	Horizontal placing	**CVD2H-K**	0.5, 0.6, 1.5, 2.3, 2.8
		Vertical placing	**CVD2V-K**	
	5-phase	Horizontal placing	**CVD5H-K**	0.35, 0.75, 1.2, 1.4, 1.8, 2.4
		Vertical placing	**CVD5V-K**	
SPI communication	2-phase	Horizontal placing	**CVD2H-KS**	0.5, 0.6, 1.5, 2.3, 2.8
		Vertical placing	**CVD2V-KS**	
	5-phase	Horizontal placing	**CVD5H-KS**	0.35, 0.75, 1.2, 1.4, 1.8, 2.4
		Vertical placing	**CVD5V-KS**	

■ Installation direction (2 types)

● Horizontal placing



● Vertical placing



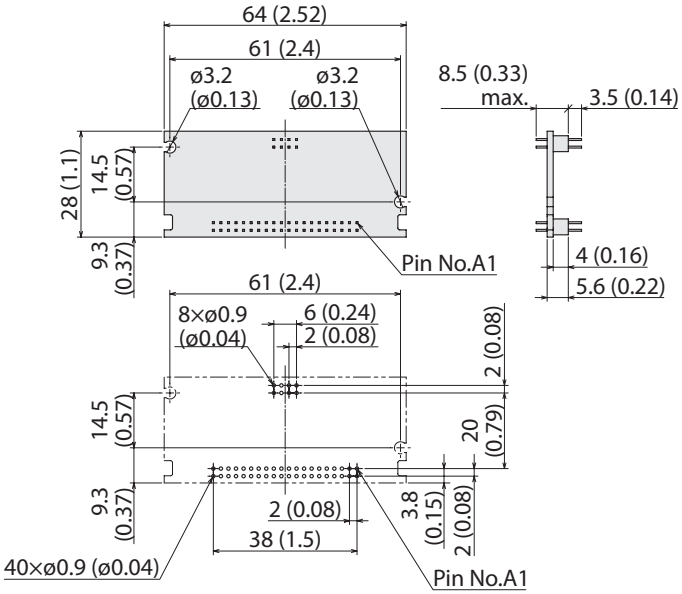
■ Dimension [unit: mm (in.)]

● Horizontal placing

Number of phases	Model
2-phase	**CVD2H-K**
	CVD2H-KS
5-phase	**CVD5H-K**
	CVD5H-KS

• Pin header

CN1	IMSA-9224B-40Z10-GF (IRISO ELECTRONICS CO., LTD.)
CN2	IMSA-9220B-08Z89-GF (IRISO ELECTRONICS CO., LTD.)

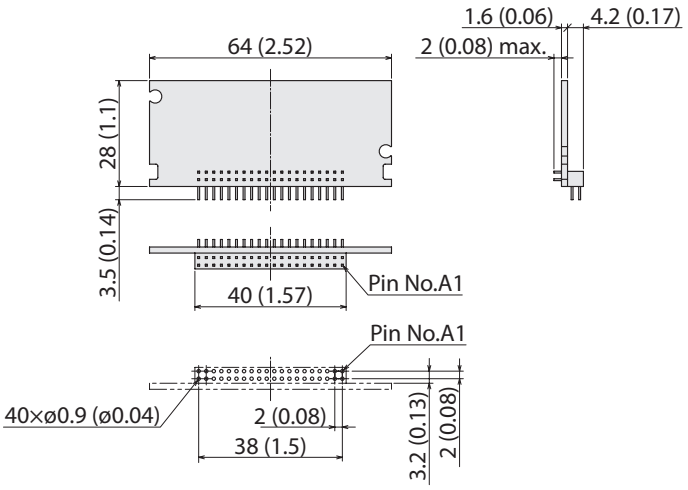


● Vertical placing

Number of phases	Model
2-phase	**CVD2V-K**
	CVD2V-KS
5-phase	**CVD5V-K**
	CVD5V-KS

• Pin header

CN1	IMSA-9224B-40A-GF (IRISO ELECTRONICS CO., LTD.)



■ Function setting method

Driver functions are set via I/O or SPI communication.
With the driver of SPI communication, select whether to use I/O or SPI communication to set the driver functions.
Differences between I/O setting and SPI communication setting are shown in the table below.

Function	I/O setting	SPI communication	
	Setting via I/O	Setting via I/O	Setting via SPI communication
Resolution	○	×	○
Motor frame size	○	○	○
Pulse input mode	○	×	○
Smooth drive	○	○	○
Command filter	× (Always OFF)	×	○
Operating current	○	○	○
Standstill current	○	○	○
Excitation ON/OFF	○	○	○
Alarm	○	○	○
Positioning operation	Operation by inputting pulses		

1 Before use

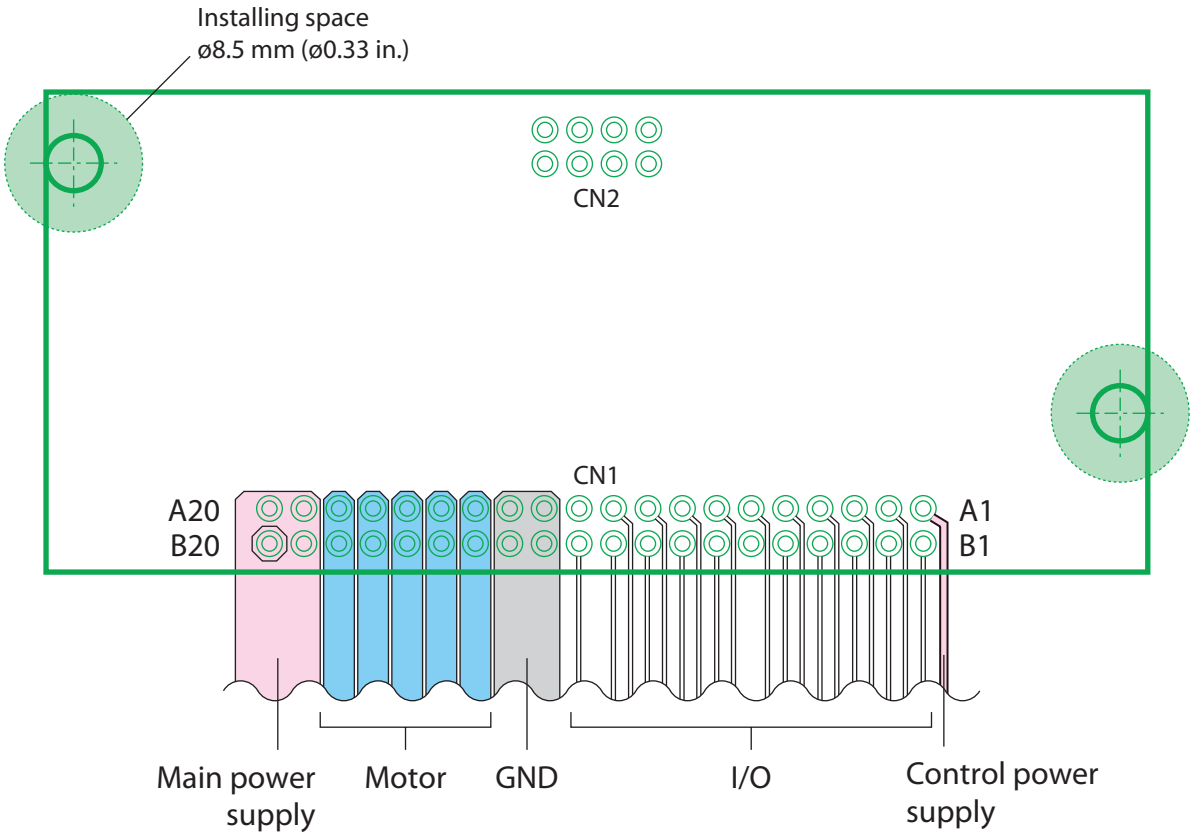
Only qualified personnel should work with the product.
Use the product correctly after thoroughly reading the "2 Safety precautions" on p.6. In addition, be sure to observe the contents described in warning, caution, and note in this document.
The product described in this document has been designed and manufactured to be incorporated in general industrial equipment. Do not use for any other purpose. Oriental Motor Co., Ltd. is not responsible for any damage caused through failure to observe this warning.

■ About pattern wiring

Design a wiring pattern considering the following points.

- Lay out an external aluminum electrolytic capacitor as close to the driver as possible.
- Do not lay out the motor pattern close to the I/O pattern or cross them. Doing so may result in malfunction.
- A large current flows in the patterns of the main power supply, motor, and GND. Lay out as thick and short as possible.
- If the thickness of copper foil is 35 µm (0.0014 in.), ensure the pattern width of 1 mm (0.04 in.) per 1 A. When the pattern width cannot be ensured, take measures to use a multi-layer board to wire in multiple layers in parallel or increase the thickness of copper foil.
- Do not connect anything to the pin numbers A7, A8, A11, B6, and B20. Doing so may cause a failure.
- The CN2 is a connector to fix the horizontal placing driver. Do not wire anything.
- Since the installing space is used when the horizontal placing driver is fixed on the motherboard, do not lay out any component other than a screw and spacer. About the outer diameters of the screw and spacer that are used for fixing, keep within the installing space.
- For the patterns of the CW (PLS) input (pin A10), the CCW (DIR) input (pin B10), and the AN-CRNT input (pin B11), lay out them as short as possible, in addition to keeping away from the patterns of power supply and motor.

● Pattern wiring example

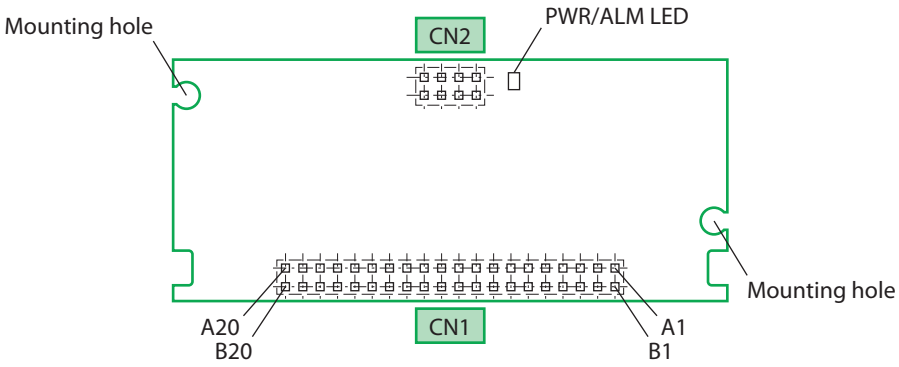


■ RoHS Directive

The products do not contain the substances exceeding the restriction values of RoHS Directive (2011/65/EU).

■ Names and functions of parts

This section explains using the driver which installation direction is the horizontal placing as an example.



Name	Description
PWR/ALM LED	• This LED is lit in green while the control power supply and the main power supply are supplied. It blinks twice in green while the control power supply is only supplied. • If an alarm generates, the LED will blink in red.
CN1	Connects I/O signals, power supplies, GND, and a motor.
CN2	This is a pin header to fix the horizontal placing driver. The vertical placing driver does not use it.
Mounting hole	Uses when fixing the horizontal placing driver and motherboard.

● PWR/ALM LED

The status of the driver can be checked with the PWR/ALM LED.

LED indication	Control power supply input	Main power supply input	Alarm
OFF	OFF	–	–
Green blinking twice	ON	OFF	No alarm
Green Lit		ON	
Red blinking/Red Lit		–	Alarm generates

2 Safety precautions

The precautions described below are intended to prevent danger or injury to the user and other personnel through safe, correct use of the product. Use the product only after carefully reading and fully understanding these instructions.

Description of signs

⚠Warning	Handling the product without observing the instructions that accompany a "Warning" symbol may result in serious injury or death.
⚠Caution	Handling the product without observing the instructions that accompany a "Caution" symbol may result in injury or property damage.
Note	The items under this heading contain important handling instructions that the user should observe to ensure the safe use of the product.

Description of graphic symbols

	Indicates "prohibited" actions that must not be performed.
	Indicates "compulsory" actions that must be performed.

⚠Warning	
	• Do not use the product in explosive or corrosive environments, in the presence of flammable gases, locations subjected to splashing water, or near combustibles. This may cause fire or injury. • Do not forcibly bend, pull or pinch the cable. This may cause fire. • Do not turn the ENABLE input to H-level and the RST input to L-level during operation. Also, do not send the DEACTIVATE command. Doing so may result in injury or damage to equipment. • Do not disassemble or modify the driver. This may cause injury.
	• Assign qualified personnel the task of installing, wiring, operating/controlling, inspecting and troubleshooting the product. Failure to do so my result in fire or injury. • If this product is used in a vertical application, be sure to provide a measure for the position retention of moving parts. Failure to do so may result in injury or damage to equipment. • When the driver generates an alarm (any of the driver's protective functions is triggered), first remove the cause and then clear the protective function. Continuing the operation without removing the cause of the problem may cause malfunction of the driver, leading to injury or damage to equipment. • Install the driver in an enclosure. Failure to do so may result in injury. • Keep the driver's input-power voltage within the specified range. Failure to do so may result in fire. • For the driver's power supply, use a DC power supply with reinforced insulation on its primary and secondary sides. Failure to do so may result in electric shock. • Connect the cables securely according to the wiring diagram. Failure to do so may result in fire. • Turn off the driver power in the event of a power failure. Failure to do so may result in injury or damage to equipment.

⚠Caution	
	• Do not use the driver beyond its specifications. This may cause injury or damage to equipment. • Do not touch the driver during operation or immediately after stopping. This may cause a skin burn(s). • Do not forcibly bend or pull the cable that was connected to the driver. Doing so may cause damage. • Keep the area around the driver free of combustible materials. Failure to do so may result in fire or a skin burn(s). • Leave nothing around the driver that would obstruct ventilation. Failure to do so may result in damage to equipment. • Do not place heat generation parts around the driver. A function of overheat protection may not activate properly depending on a use method or condition, leading to injury or damage to equipment.
	• Use a motor and driver only in the specified combination. Failure to do so may result in fire. • Provide an emergency stop device or emergency stop circuit external to the equipment so that the entire equipment will operate safely in the event of a system failure or malfunction. Failure to do so may result in injury. • Before supplying power to the driver, turn all input signals to the driver to OFF. Failure to do so may result in injury or damage to equipment. • Before moving the motor output shaft directly by hands (manual alignment, etc.), confirm that the PLS-RDY output of the driver is in an open state. Failure to do so may cause injury. • When an abnormal condition has occurred, immediately stop operation and turn off the driver power. Failure to do so may result in fire or injury. • Take measures against static electricity when touching the driver. Failure to do so may result in damage to equipment.

3 Precautions for use

- **When conducting the insulation resistance measurement and the dielectric strength test, be sure to separate the connection between the motor and the driver.**

  Conducting the insulation resistance measurement or the dielectric strength test with the motor and driver connected may result in damage to the equipment.

- **Regeneration**

  When a large inertial load is operated at high speed, regeneration energy will generate and increase the power supply voltage, leading to damage to the driver. Check the operating condition so that regeneration voltage will not generate, or increase a capacitance of the external aluminum electrolytic capacitor.

4 Connection

4-1 Connection method

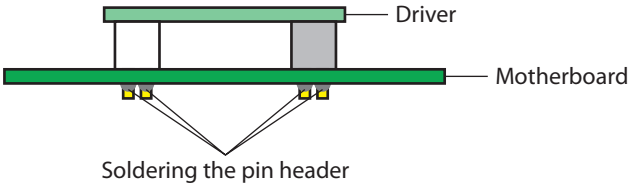
The following two methods are available for connection.

Note The driver uses parts that are sensitive to electrostatic charge. Take measures against static electricity since static electricity may cause the driver to malfunction or suffer damage.

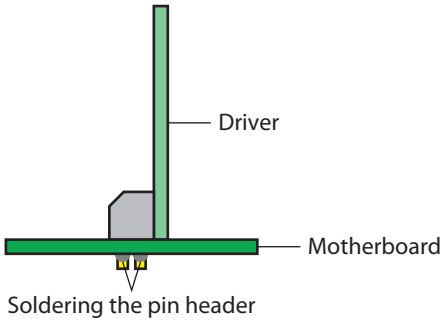
■ Soldering on a board

This is how to install the driver on a motherboard and solder the pin header.

- **Horizontal placing**



- **Vertical placing**



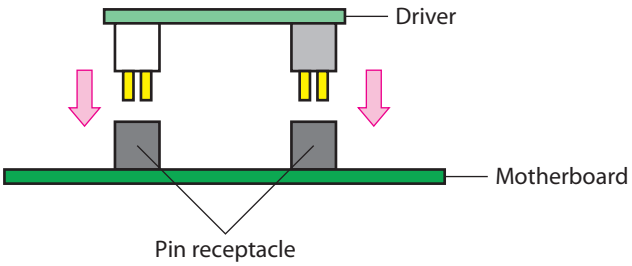
When soldering, do not exceed the following conditions.
Soldering by a reflow furnace is not available.

Method	Temperature	Time	Number of times (maximum)
Flow soldering bath	250±5 °C (482±9 °F)	5±0.5 s	Once
Soldering iron	350±5 °C (662±9 °F)	3±0.5 s	Once

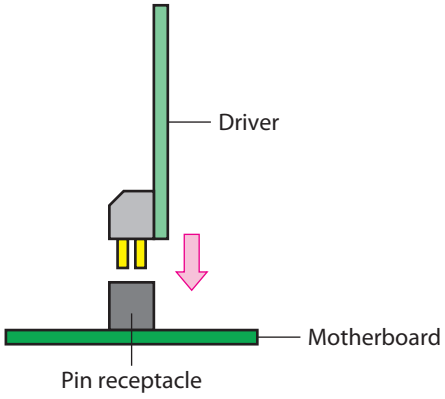
■ Using a pin receptacle

This is a method to connect the driver after soldering the specified pin receptacle on a motherboard.

- **Horizontal placing**



- **Vertical placing**



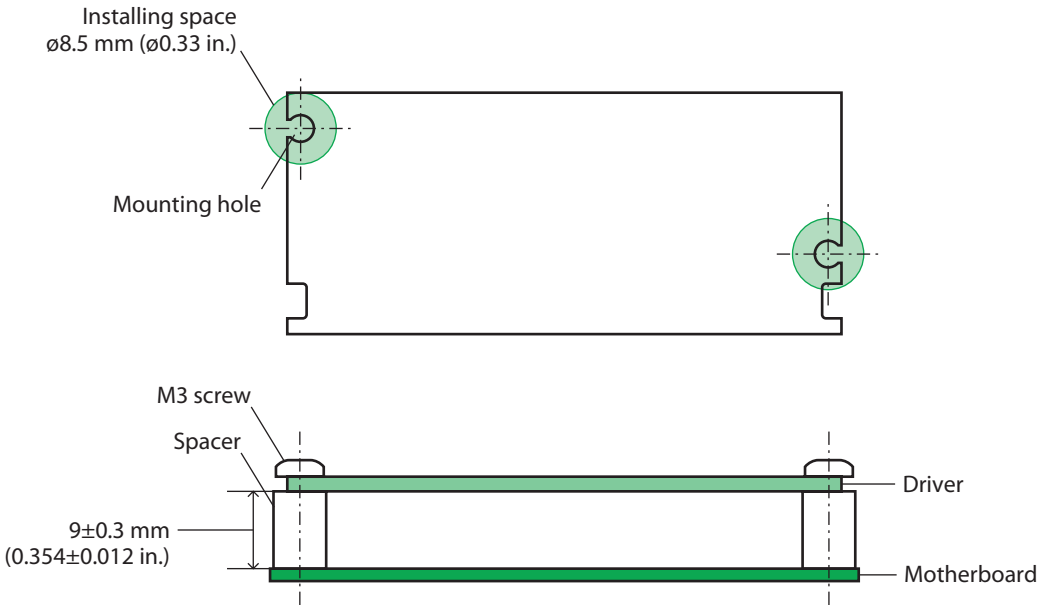
Specified pin receptacle

CN1	IMSA-9269S-40B-GFC (IRISO ELECTRONICS CO., LTD.)
CN2 *	IMSA-9269S-08B-GFC (IRISO ELECTRONICS CO., LTD.)

* The vertical placing driver does not use it.

Fixing method (horizontal placing driver only)

When mounting the driver using a pin receptacle, fix the driver and motherboard with screws (M3) so as not to fall off.



Note

- Use a screw and spacer for fixing which outer diameters fit within the installing space. Exceeding the installing space may cause damage to mounted components or a short of pattern.
- Use washers which outer diameters are ø7 mm (ø0.28 in.) or less if used.
  Larger washers may contact with mounted components, leading to a short of pattern.
- Provide 9±0.3 mm (0.354±0.012 in.) for the distance between the driver and the motherboard.
  Failure to do so may cause the CN1 and CN2 connectors to float, leading to contact failure.

4-2 Functions of CN1 connector

This section explains functions of the CN1 connector.
Driver functions are set via I/O or SPI communication. Select the setting method via SPI communication.

- **Terminals list**

Pin No.	Signal name	Description
A1	VCC	Control power supply input
B1	ALM	Alarm output
A2	TIM	Timing output
B2	PLS-RDY	Pulse ready output
A3	SPI-MISO	SPI bus data output
B3	SPI-MOSI	SPI bus data input
A4	SPI-SCK	SPI bus serial clock input
B4	SPI-SS	SPI bus sending/receiving enable/disable input
A5	MOT-SEL0	Motor frame size setting input (bit0)
B5	MOT-SEL1	Motor frame size setting input (bit1)
A6	MOT-SEL2	Motor frame size setting input (bit2)
B6	–	Do not connect.
A7	–	Do not connect.
B7	SD-EN *1	Smooth drive function setting input
A8	–	Do not connect.
B8	STOP-CRNT *1	Standstill current setting input
A9	RST	Reset input
B9	ENABLE	Excitation ON input
A10	CW (PLS)	CW pulse input (Pulse input)
B10	CCW (DIR)	CCW pulse input (Rotation direction input)
A11	–	Do not connect.
B11	AN-CRNT *1	Operating current setting input
A12	GND	GND
B12		
A13		
B13		
A14	MOTOR (BLUE)	Blue motor lead wire
B14		
A15	MOTOR (RED)	Red motor lead wire
B15		
A16	MOTOR (ORANGE)	Orange motor lead wire *2
B16		
A17	MOTOR (GREEN)	Green motor lead wire
B17		
A18	MOTOR (BLACK)	Black motor lead wire
B18		
A19	POWER	Main power supply input
B19		
A20		
B20	–	Do not connect.

*1 SPI communication is enabled at the initial setting. I/O can be enabled via SPI communication.
*2 Not used when combining with 2-phase stepping motors. Do not connect.

● **Setting method of driver functions**

The following functions can be set with 2 methods, I/O or SPI communication. Select the setting method with the SETTING register of SPI communication before use. For the SETTING register, refer to p.37.

Function	Input signal	SPI communication command	Initial setting
Motor frame size setting	MOT-SEL0 to MOT-SEL2	MOT-SEL	I/O
Smooth drive function	SD-EN	SD-EN	SPI communication
Standstill current	STOP-CRNT	STOP-CRNT	SPI communication
Excitation switching	ENABLE	ENABLE	I/O
Operating current	AN-CRNT	RUN-CRNT	SPI communication

■ Power supply

Note If the motor is in a state of regeneration operation, the current may flow backward to the power supply from the main power-supply input of the driver. Also, if the main power supply voltage exceeds the permissible value by regeneration, the overvoltage alarm of the driver will generate. Reconsider the operating condition, or increase a capacitance of the external aluminum electrolytic capacitor.

● **VCC**

This is an input of a control power supply of the driver.

● **POWER**

- This is an input of a main power supply of the driver.
- It is a power supply of an inverter to drive a motor.

■ Input signal

● **MOT-SEL0 to MOT-SEL2 input**

Set the rated current (A/phase) of the motor used. Match the motor rated current with the settings of the MOT-SEL0 to MOT-SEL2. The settings of the MOT-SEL0 to MOT-SEL2 will be applied if the ACTIVATE command is executed via SPI communication when the driver is in the setting state.

Initial setting MOT-SEL0 to MOT-SEL2: All H level

MOT-SEL input			2-phase		5-phase	
2	1	0	Rated current (A/phase)	Motor model *	Rated current (A/phase)	Motor model *
H	H	H	0.5	**PKP213D**	0.35	**PK513** **PK52□**
H	H	L	0.6	**PKP214D**	0.75	**PK52□H** **PK54□**
H	L	H	1.5	**PKP22□D15** **PKP23□D15** **PKP24□MD15** **PKP262FD**	1.2	**PKP52□**
H	L	L	2.3	**PKP23□D23** **PKP24□D23**	1.4	**PK56□**
L	H	H	2.3	**PKP24□D15■2** **PKP24□D23■2**	1.8	**PKP54□**
L	H	L	2.8	**PKP26□D14■2** **PKP26□D28■2** **PKP26□MD28**	2.4	**PKP56□FN24** **PKP56□FMN**

* □ in the model names indicates a number representing the motor length.
■ in the model names indicates **A** (single shaft) or **B** (double shaft) representing the motor type.

memo Setting with combinations other than the values in the table may generate the command execution disable alarm when the ACTIVATE command is executed.

- **SD-EN input**

Select whether to enable or disable the smooth drive.
The smooth drive is a function to achieve lower vibration and noise at low speeds operation without changing the step angle setting.

Initial setting H level (enable)

SD-EN input	Smooth drive
H level	Enable
L level	Disable

memo Since SPI communication is enabled at the initial setting, the driver operates at the initial value of SPI communication (smooth drive enable). When setting with input signals (SD-EN input), set the SD-EN-SRC of the SETTING register to "0: I/O" via SPI communication before use.

- **STOP-CRNT input**

Select the standstill current rate of the driver.
The actual standstill current is a value that the set operating current is multiplied by the standstill current rate.
- Standstill current = Set operating current × standstill current rate

Initial setting H level (50%)

STOP-CRNT input	Standstill current rate
H level	50%
L level	25%

memo Since SPI communication is enabled at the initial setting, the driver operates at the initial value of SPI communication (50%). When setting with input signals (STOP-CRNT input), set the STOP-CRNT-SRC of the SETTING register to "0: I/O" via SPI communication before use.

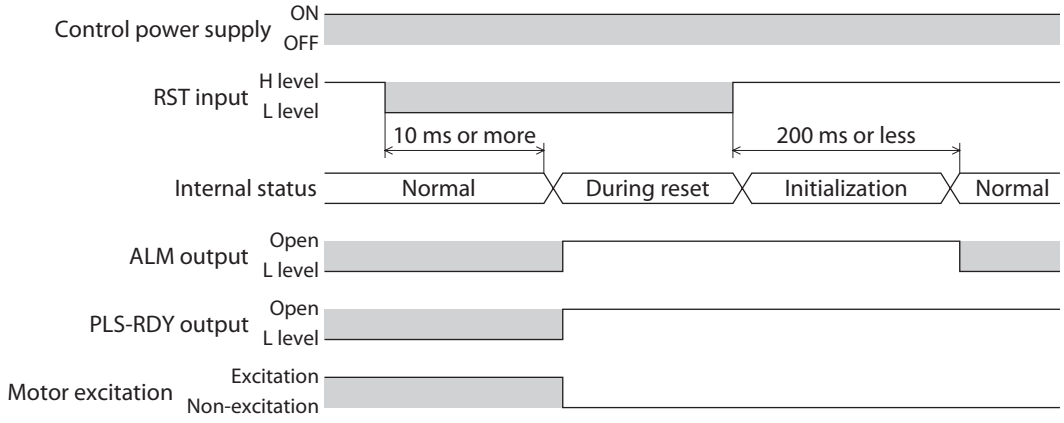
- **RST input**

Turning the RST input from H-level to L-level will reset the internal status of the driver.
The status for when the driver is reset is shown below.

Item	Status
Excitation state	Motor non-excitation
Excitation position	Returns to the step "0" position
Alarm	Released
Internal state	Returns to the setting state
Resistor	Returns to the initial value

memo Input the RST input while the motor is stopped.

Timing of reading the RST input



- **ENABLE input**

If the following conditions are satisfied, the motor will be excited when the ENABLE input turns to L-level.

- The control power supply is turned ON.
- The main power supply is turned ON.
- An alarm is not present.
- The RST input is in H-level.
- The internal state of the driver is in the operation state.
- The excitation switching setting source of SPI communication is set to I/O.

- **CW (PLS) input, CCW (DIR) input**

These are positioning pulse signal inputs. Signal functions differ in the 1-pulse input mode and the 2-pulse input mode.

memo The driver can receive pulse input when the PLS-RDY output is in L-level.

1-pulse input mode

The PLS input and the DIR input are enabled.

PLS input	DIR input	Operation
↑	H level	The motor will rotate by one step in CW direction.
	L level	The motor will rotate by one step in CCW direction.
↓	H level	The motor will not rotate.
	L level	

2-pulse input mode

The CW input and the CCW input are enabled.

CW input	CCW input	Operation
↑	L level	The motor will rotate by one step in CW direction.
	H level	The motor will not rotate.
L level	↑	The motor will rotate by one step in CCW direction.
H level		The motor will not rotate.

- **AN-CRNT input**

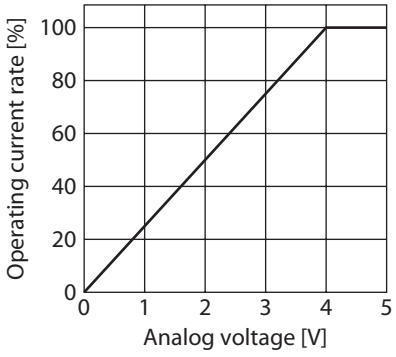
Set the operating current rate with the analog voltage.
If the load is small and there is an ample allowance for torque, motor temperature rise can be suppressed by setting a lower operating current rate.
The actual operating current is a value in which the operating current rate is multiplied by the motor rated current (100%).

- Operating current = Motor rated current × operating current rate

Initial setting 0.1% (0 V)
Setting range 0.1% to 100.0%

memo
- Since SPI communication is enabled at the initial setting, the driver operates at the initial value of SPI communication (100%). When setting with input signals (AN-CRNT input), set the RUNCRNT-SRC of the SETTING register to "0: I/O" via SPI communication before use.
- Note that the initial value of the operating current rate varies according to the setting method.

The figure below shows relations between the analog voltage and the operating current rate.



■ Output signal

The output circuit is of open collector.

● ALM output

If an alarm generates, the ALM output will be open, and the motor excitation will be cut off. At the same time, the PWR/ALM LED will blink in red. Refer to p.44 for reset an alarm.

● TIM output

Output L-level when the motor excitation state is in the step "0" position.
Every time the motor output shaft rotates by 7.2° (3.6° for high-resolution type), the motor excitation state becomes the initial setting state.
If an AND circuit is configured with signals of the home sensor and TIM output when the home position in the equipment is detected, the tolerance for the motor stop positions in a detection range of the home sensor can be reduced and the further accurate home position can be detected.

memo

- The TIM output will be output properly when the pulse frequency is 500 Hz or less.
- When the internal state transitioned from the setting state to the operation state, the motor excitation state will also return to the step "0" position.

● PLS-RDY output

Output L-level when an operation is possible.
If the following conditions are satisfied, the PLS-RDY output will turn to L-level.

- The control power supply is turned ON.
- The main power supply is turned ON.
- An alarm is not present.
- The RST input is in H-level.
- The internal state of the driver is in the operation state.
- The motor is in an excitation state by the method set in the excitation switching setting source of SPI communication.

■ SPI communication input-output

SPI communication is performed using the 4 signal lines of SPI-MISO, SPI-MOSI, SPI-SCK, and SPI-SS.

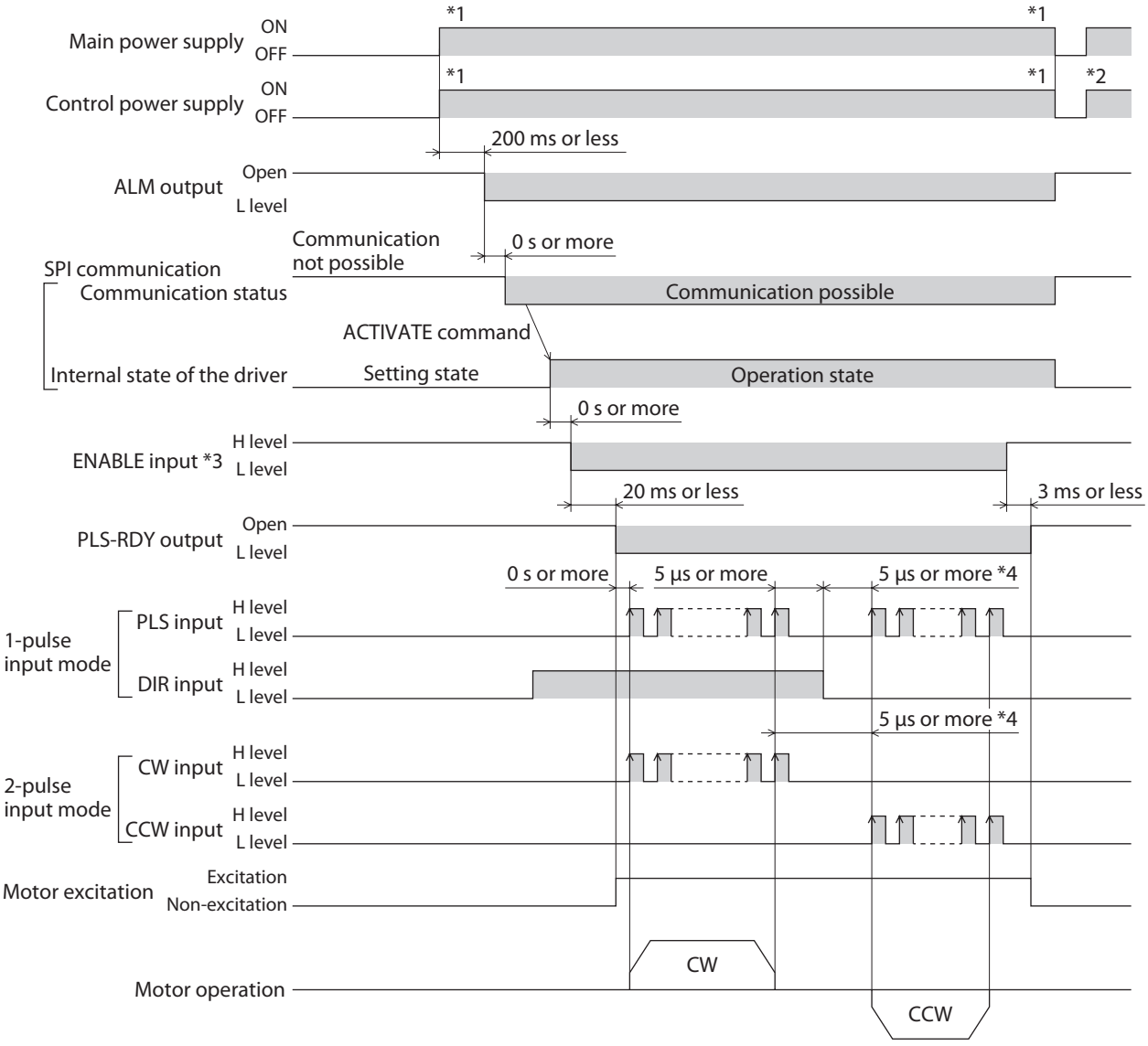
■ Motor

● MOTOR

Connect a motor. Do not connect anything to the MOTOR (ORANGE) when combining with a 2-phase stepping motor.

4-3 Timing chart

■ Power activation and operation



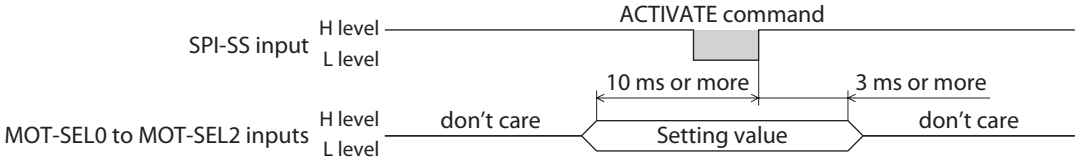
*1 The main power supply and the control power supply can be turned on or off in an arbitrary order.

*2 When cycling the control power, turn off the power and wait for the PWR/ALM LED to turn off.

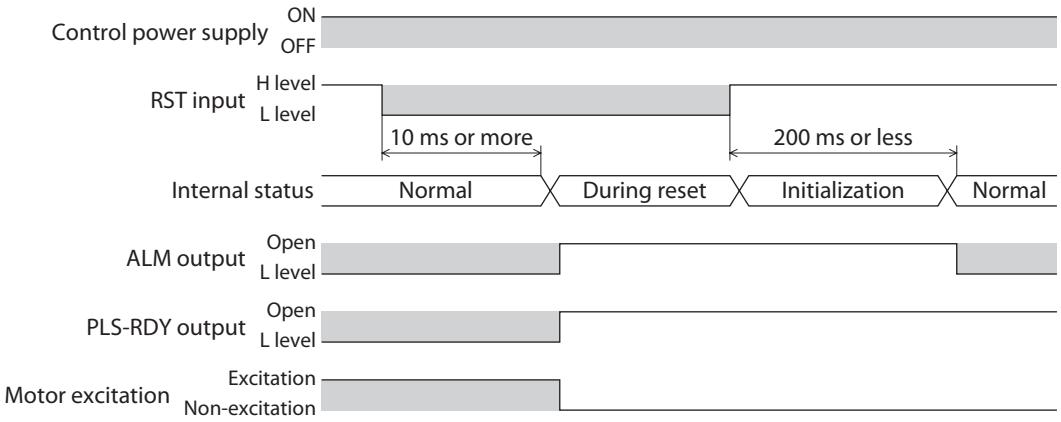
*3 To excite a motor, the internal state is required to transition to the operation state. Although the ENABLE input is possible to turn to L-level even in the setting state, the motor will actually be excited after the internal state transitioned to the operation state with the ACTIVATE command.

*4 The interval for when the rotation direction is switched represents the response time of the driver. Set it to the time required for the motor to respond to the applicable pulse input.

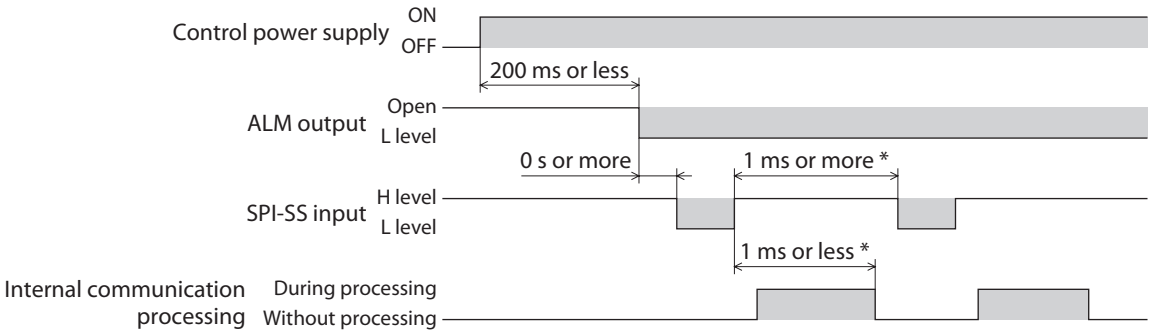
■ Reading MOT-SEL0 to MOT-SEL2 inputs



■ Reading RST input

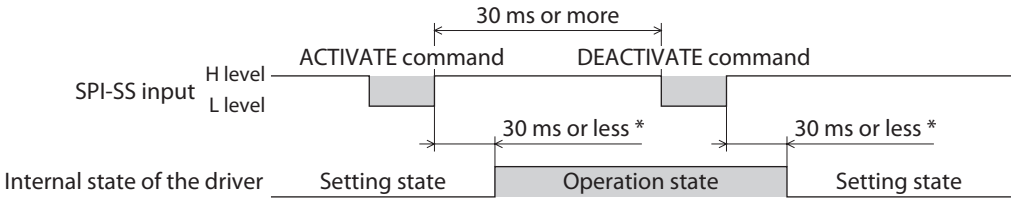


■ SPI communication



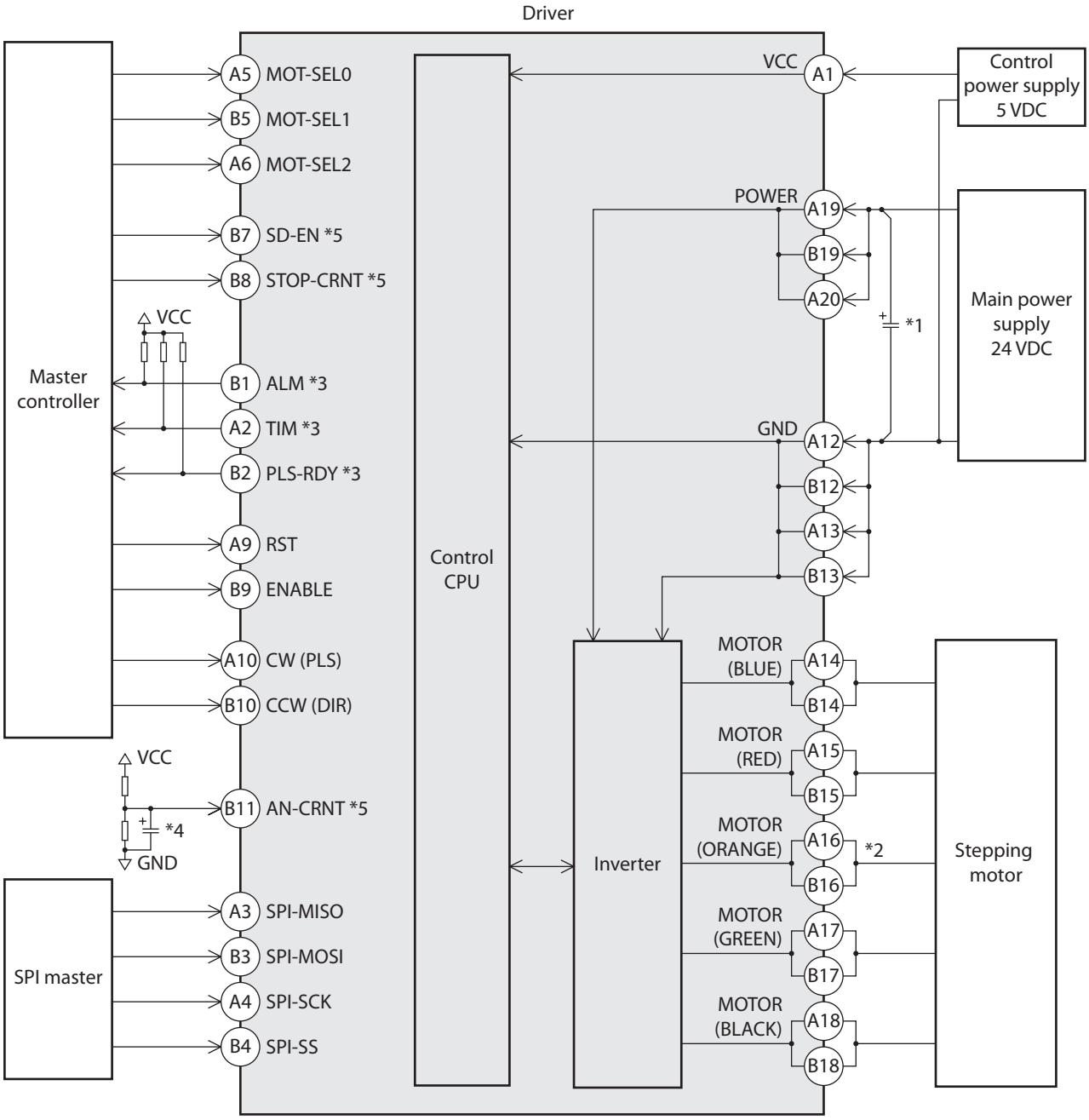
* When the driver confirms the SPI-SS input has turned from H-level to L-level, it starts processing the received data. Since SPI communication cannot be sent and received while the driver processes the received data, be sure to provide an interval of the communication frame of 1 ms or more.

■ State transition



* The internal state of the driver is being switched. Commands other than the state transition command can be received.

4-4 Connection example



*1 An external aluminum electrolytic capacitor is required in the main power supply line. Place as close to terminals as possible. The aluminum electrolytic capacitor of a capacitance of 680 uF and a dielectric strength of 50 V is recommended. Contact us if you plan to change.

*2 When using in combination with a 2-phase stepping motor, do not connect anything to the pin A16 and the pin B16.

*3 To output H-level, an external pull-up resistor is required. Make sure the resistance value does not exceed the permissible current (10 mA) of the output.

*4 Inserting a capacitor is recommended for protection against noise.

*5 SPI communication is enabled at the initial setting. I/O can be enabled via SPI communication.

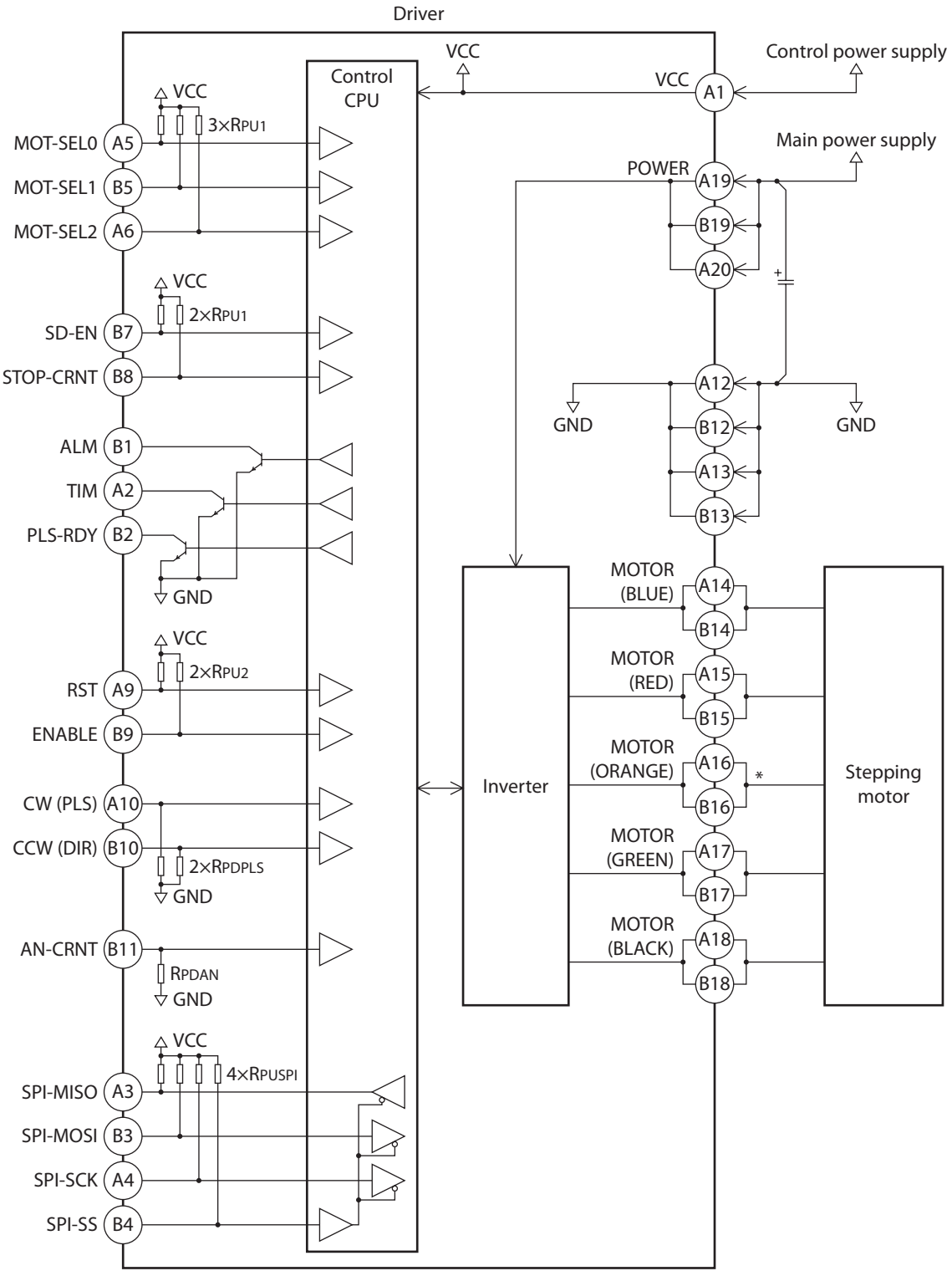
Note

- Do not connect a control power supply and a main power supply in reverse. Doing so may cause damage.
- Do not connect anything to the pin numbers A7, A8, A11, B6, and B20. Doing so may cause a failure.
- Do not externally apply a voltage to input terminals when a control power supply is not supplied. The setting may change before the power is supplied.

memo

- I/O terminals, power supplies, and motor output terminals are not insulated.
- Be sure to connect all terminals for power supplies, GND, and a motor. However, when using in combination with a 2-phase stepping motor, do not connect anything to the pin numbers A16 and B16.
- Be sure to connect a control power supply and a main power supply. A motor does not operate unless connected.

4-5 Internal circuit



* Not used when combining with 2-phase stepping motors. Do not connect anything.

4-6 Electrical specifications

● Absolute maximum rating

Type	Signal name	min	max	Unit
Power supply input	VCC	–	5.5	V
	POWER	–	40 *1	V
Control input	MOT-SEL0 MOT-SEL1 MOT-SEL2 SD-EN STOP-CRNT RST ENABLE	–0.3	VCC+0.3	V
Control output	ALM TIM PLS-RDY	–0.3	30	V
Analog input	AN-CRNT	–0.3	VCC+0.3	V
Pulse input	CW (PLS) CCW (DIR)	–0.3	VCC+0.3	V
SPI communication input-output	SPI-MISO SPI-MOSI SPI-SCK SPI-SS	–0.3	VCC+0.3	V
Board temperature	–	–	75 (167) *2	°C (°F)

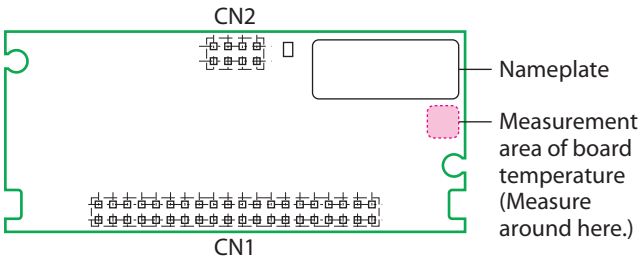
*1 To satisfy the specifications, use the input voltage to be in a range of 24 VDC±10%.

*2 Use in consideration of the derating.

About board temperature

To measure the surface temperature of the board, use the measurement area of the board temperature in the figure.

Number of phases	Rated current [A/phase]	Board temperature max (reference)
2-phase	0.5, 0.6, 1.5	75 °C (167 °F)
	2.3	60 °C (140 °F)
	2.8	50 °C (122 °F)
5-phase	0.35, 0.75, 1.2, 1.4	75 °C (167 °F)
	1.8	65 °C (149 °F)
	2.4	50 °C (122 °F)



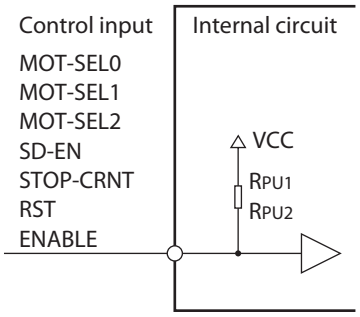
● Electrical characteristics

This shows under the terms of control power supply VCC=5.0 V±5% and ambient temperature 25 °C (77 °F).

Signal name	Item	Code	min	typ	max	Unit
VCC	VCC rising gradient	SV_{CC}	–	–	20	ms/V
	Operation start voltage	V_{DET}	3.95	4.15	4.35	V

- **Control input**

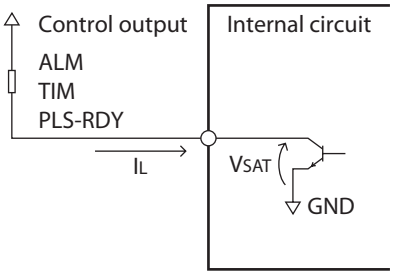
Signal name	Item	Code	min	typ	max	Unit
MOT-SEL0 MOT-SEL1 MOT-SEL2 SD-EN STOP-CRNT	Input voltage	V_{IH1}	4.25	–	–	V
		V_{IL1}	–	–	0.9	
	Built-in pull-up resistor	R_{PU1}	95 k	100 k	105 k	Ω
RST ENABLE	Input voltage	V_{IH2}	4.25	–	–	V
		V_{IL2}	–	–	0.9	
	Built-in pull-up resistor	R_{PU2}	9.5 k	10 k	10.5 k	Ω



- **Control output**

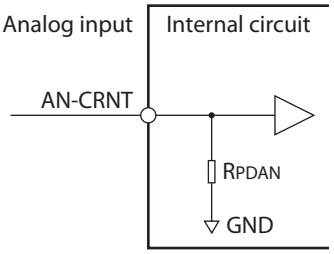
The control output is of open collector.

Signal name	Item	Code	min	typ	max	Unit
ALM TIM PLS-RDY	Output saturated voltage	V_{SAT}	–	–	0.3	V
	Load current	I_L	–	–	10	mA



- **Analog input**

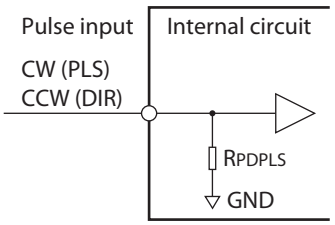
Signal name	Item	Code	min	typ	max	Unit
AN-CRNT	Input voltage range	V_{IAN}	0	–	4.0	V
	Built-in pull-down resistor	R_{PDAN}	95 k	100 k	105 k	Ω



- **Pulse input**

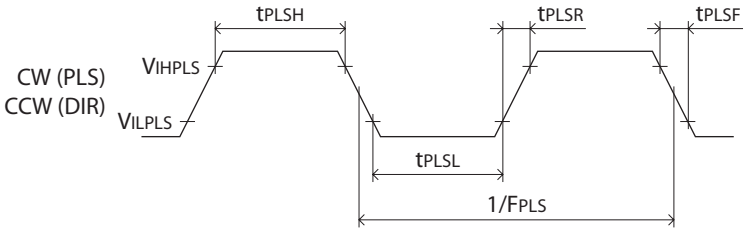
DC characteristics

Signal name	Item	Code	min	typ	max	Unit
CW (PLS) CCW (DIR)	Input voltage	V_{IHPLS}	3.8	–	–	V
		V_{ILPLS}	–	–	1.0	
	Built-in pull-down resistor	R_{PDPLS}	9.5 k	10 k	10.5 k	Ω



AC characteristics

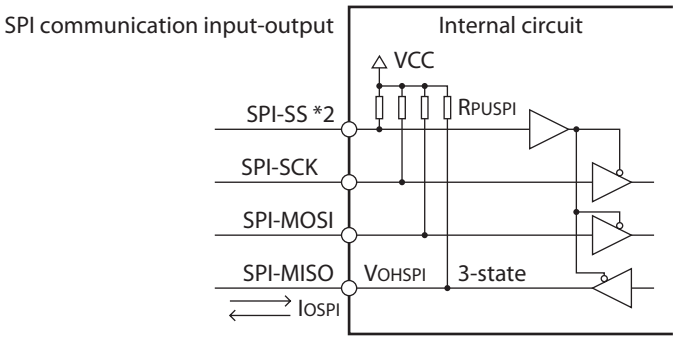
Signal name	Item	Code	min	typ	max	Unit
CW (PLS) CCW (DIR)	Input pulse frequency	F_{PLS}	–	–	1	MHz
	Pulse H-level width	t_{PLSH}	0.4	–	–	µs
	Pulse L-level width	t_{PLSL}	0.4	–	–	µs
	Rise time	t_{PLSR}	–	–	2	µs
	Fall time	t_{PLSF}	–	–	2	µs



- **SPI communication input-output**

DC characteristics

Signal name	Item	Code	min	typ	max	Unit
SPI-SS, SPI-SCK, SPI-MOSI	Input voltage	V_{IHSPI}	4.25	–	–	V
		V_{ILSPI}	–	–	0.9	V
SPI-MISO	Output voltage	V_{OHSPI}	VCC−0.5	–	–	V
		V_{OLSPI}	–	–	0.5	V
	Permissible output current	I_{OSPI}	–	–	±1	mA
SPI-SS, SPI-SCK, SPI-MOSI, SPI-MISO	Built-in pull-up resistor *1	R_{PUSPI}	95 k	100 k	105 k	Ω

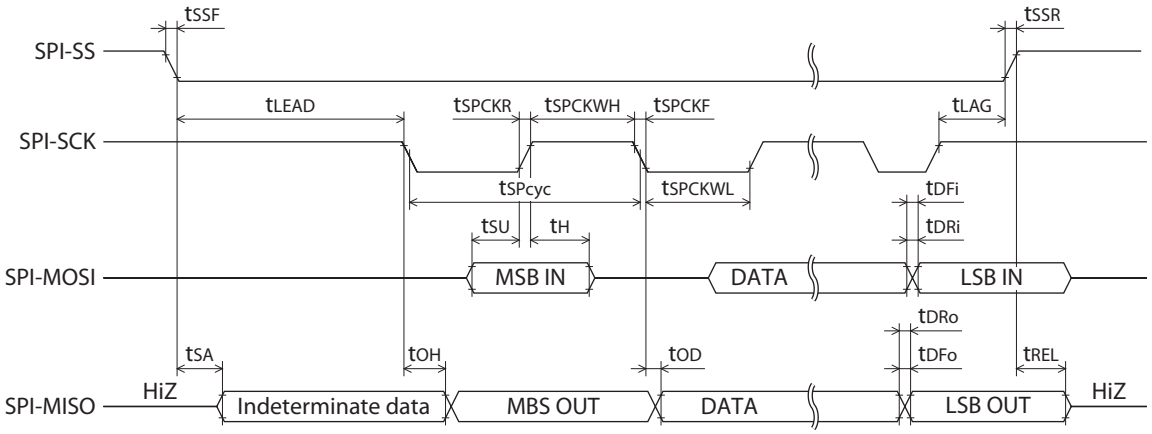


*1 Since the pull-up resistors are connected in parallel, note a decrease in a resistance value when multiple drivers are connected to the SPI bus-line. Also, when externally attaching pull-up resistors to the input-output of SPI communication, determine the value considering the constant of the built-in pull-up resistor.

*2 The SPI-SS input is of active-low.

Timing regulation

Item	Code	min	max	Unit
SPI-SCK clock cycle	t_{SPcyc}	1	–	µs
SPI-SCK clock high-level pulse width	t_{SPCKWH}	$(t_{SPcyc} - t_{SPCKR} - t_{SPCKF})/2$	–	ns
SPI-SCK clock low-level pulse width	t_{SPCKWL}	$(t_{SPcyc} - t_{SPCKR} - t_{SPCKF})/2$	–	ns
SPI-SCK rise time	t_{SPCKR}	–	1	µs
SPI-SCK fall time	t_{SPCKF}	–	1	µs
Data input setup time	t_{SU}	0	–	ns
Data input hold time	t_{H}	70	–	ns
SPI-SS setup time	t_{LEAD}	90	–	ns
SPI-SS hold time	t_{LAG}	90	–	ns
Data output delay time	t_{OD}	–	110	ns
Data output hold time	t_{OH}	0	–	ns
SPI-MOSI rise time	t_{DRi}	–	1	µs
SPI-MOSI fall time	t_{DFi}	–	1	µs
SPI-MISO rise time	t_{DRo}	–	15	ns
SPI-MISO fall time	t_{DFo}	–	15	ns
SPI-SS rise time	t_{SSR}	–	1	µs
SPI-SS fall time	t_{SSF}	–	1	µs
Slave access time	t_{SA}	–	90	ns
Slave output release time	t_{REL}	–	70	ns



5 SPI communication

With SPI communication, in addition to settings of the operating current, standstill current and resolution, monitoring of the driver status can be performed.

5-1 Specifications of SPI communication

■ Specifications of physical layer

Item	Description
Voltage level	5 V CMOS level Single-ended signaling, with reference to GND
Numbers of signal line	4 pcs. (SPI-SS, SPI-SCK, SPI-MISO, SPI-MOSI) Daisy chain-connection is possible
Clock polarity	Mode 3
Maximum clock frequency	1 MHz

● Input-output signals of SPI communication

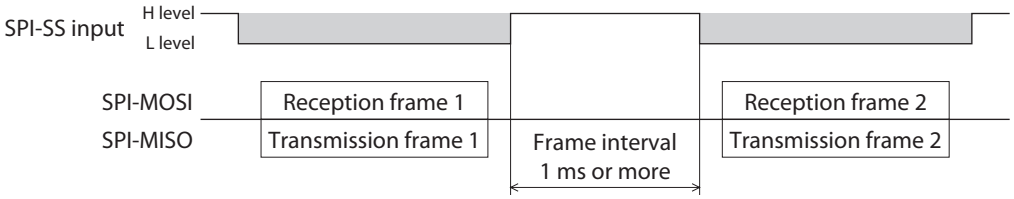
A driver operates as a slave of the SPI master controller.

Signal name	Input/output		Description
	Master	Slave (driver)	
SPI-MISO (Master In Slave Out)	Input	Three-state output	This is a signal to output the SPI bus data. Due to three-state output, it can make a daisy chain connection with the SPI-MISO output of other slaves.
SPI-MOSI (Master Out Slave In)	Output	Input	This is a signal to input the SPI bus data. It is disabled when the SPI-SS input is in H-level.
SPI-SCK (Serial Clock)	Output	Input	This is a serial clock input of SPI bus. Data of the SPI-MOSI input is latched at the rise edge of the SPI-SCK input, and data of the SPI-MISO output is shifted out at the fall edge. It is disabled when the SPI-SS input is in H-level.
SPI-SS (Slave Select)	Output	Input	This is a signal to switch whether to enable or disable sending/receiving of SPI bus. The SPI-SS input is of active-low. When the SPI-SS input is in H-level, the SPI-MISO output will be a high impedance (HiZ). When performing SPI communication, turn the SPI-SS input to L-level. The SPI-MISO output will be the CMOS push-pull output by turning to L-level.

■ Specifications of data link layer

Item	Specification
Data length	Variable length (Data field 0 to 32 words *)
Data format	Big endian, MSB first
Protocol	Specific protocol
Minimum frame interval	1 ms

* A word consists of 16-Bit.



memo Be sure to keep 1 ms or more for a frame interval. If the frame interval is shorter than 1 ms, the driver doesn't work properly.

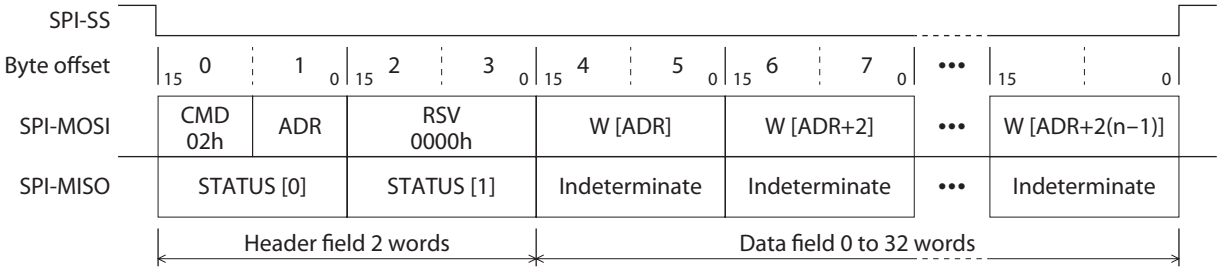
5-2 Command

■ Command list

Command	Command name	Value (Hex)	Description
WRITE	Write	02h	Writes the setting value to the register.
READ	Read	03h	Reads the setting value from the register.
ACTIVATE	Operation state transition	08h	Transitions to the operation state.
DEACTIVATE	Setting state transition	09h	Transitions to the setting state.
NOP	No operation	00h	Checks the communication status.

■ Write command (WRITE: 02h)

This command is used to write the setting value to a register.



* n indicates the number of words of the data field.

● **SPI-MOSI [Master to slave (driver)]**

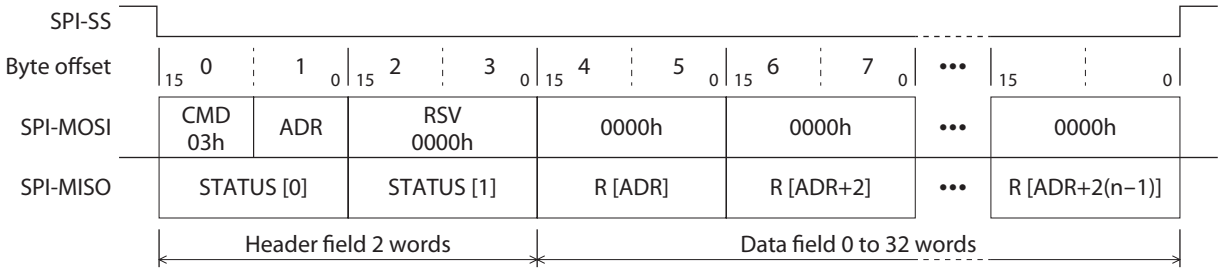
Area	Name	Bit width	Byte offset	Description
Header field	CMD	8	0	Specifies the write command (WRITE: 02h).
	ADR	8	1	Specifies the address to start writing. Specify an even number for the value of address. Specifying an odd-numbered address will specify an address that the lowest Bit has converted to 0. Example) Specifying 03h (0000 0011) will convert to 02h (0000 0010).
	RSV	16	2, 3	This is a reserved area. Specify 0000h.
Data field	W [ADR] ~	A multiple of 16	4~	Specifies the write data. Keep the data length to 32 words or less. When writing multiple data consecutively, send the data and the SPI-SCK consecutively. Data will be written while adding 2 to an address automatically. Keep the data length to 32 words or less when writing consecutively.

● **SPI-MISO [Slave (driver) to master]**

Area	Name	Bit width	Byte offset	Description
Header field	STATUS [0]	16	0, 1	Outputs the value that represents the driver status.
	STATUS [1]	16	2, 3	
Data field	–	–	–	Outputs an indeterminate value.

■ Read command (READ: 03h)

This command is used to read the setting value from a register or to monitor the driver status.



* n indicates the number of words of the data field.

● **SPI-MOSI [Master to slave (driver)]**

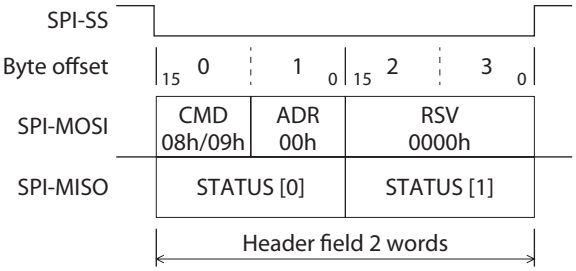
Area	Name	Bit width	Byte offset	Description
Header field	CMD	8	0	Specifies the read command (READ: 03h).
	ADR	8	1	Specifies the address to start reading. Specify an even number for the value of address. Specifying an odd-numbered address will specify an address that the lowest Bit has converted to 0. Example) Specifying 03h (0000 0011) will convert to 02h (0000 0010).
	RSV	16	2, 3	This is a reserved area. Specify 0000h.
Data field	–	–	–	Specify 0000h.

● **SPI-MISO [Slave (driver) to master]**

Area	Name	Bit width	Byte offset	Description
Header field	STATUS [0]	16	0, 1	Outputs the value that represents the driver status.
	STATUS [1]	16	2, 3	
Data field	R [ADR] ~	A multiple of 16	4~	Outputs the read data. Keep the data length to 32 words or less. When reading multiple data consecutively, send the SPI-SCK consecutively. Data will be read while adding 2 to an address automatically. Keep the data length to 32 words or less when reading consecutively.

■ Operation state transition command (ACTIVATE: 08h)/ Setting state transition command (DEACTIVATE: 09h)

These commands are used to transition an internal state of the driver.
There are two different types of commands: operation state transition command (ACTIVATE: 08h) and setting state transition command (DEACTIVATE: 09h).



● **SPI-MOSI [Master to slave (driver)]**

Area	Name	Bit width	Byte offset	Description
Header field	CMD	8	0	Specifies the operation state transition command (ACTIVATE: 08h) or the setting state transition command (DEACTIVATE: 09h).
	ADR	8	1	Ignored. Specify 00h.
	RSV	16	2, 3	This is a reserved area. Specify 0000h.

● **SPI-MISO [Slave (driver) to master]**

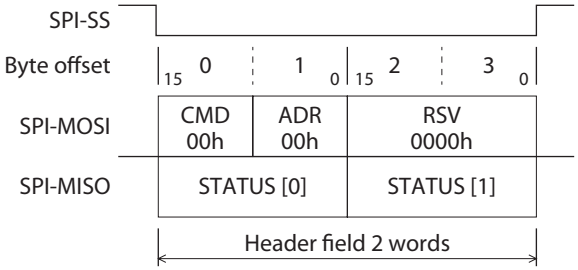
Area	Name	Bit width	Byte offset	Description
Header field	STATUS [0]	16	0, 1	Outputs the value that represents the driver status.
	STATUS [1]	16	2, 3	

Note Send the DEACTIVATE command while the motor stops. If this command is sent while the motor operates, the motor will change to a non-excitation state, leading to injury or damage to equipment.

memo
- The ACTIVATE command and the DEACTIVATE command do not use the data field area. Even if a value is specified in the data field area, it is ignored, and an indeterminate value will be output from the driver.
- When changing the internal state of the driver with the state transition command, confirm the previous state transition has been completed before doing so. Refer to p.16 for the timing of the state transition.

■ No-operation command (NOP: 00h)

This command is used to check the status of communication.



● **SPI-MOSI [Master to slave (driver)]**

Area	Name	Bit width	Byte offset	Description
Header field	CMD	8	0	Specifies the no-operation command (NOP: 00h).
	ADR	8	1	Ignored. Specify 00h.
	RSV	16	2, 3	This is a reserved area. Specify 0000h.

● **SPI-MISO [Slave (driver) to master]**

Area	Name	Bit width	Byte offset	Description
Header field	STATUS [0]	16	0, 1	Outputs the value that represents the driver status.
	STATUS [1]	16	2, 3	

memo The NOP command does not use the data field area. Even if a value is specified in the data field area, it is ignored, and an indeterminate value will be output from the driver.

5-3 STATUS area

Values representing the driver status are stored in the STATUS area.
The STATUS area consists of STATUS [0] and STATUS [1].

■ STATUS [0] area

The STATUS [0] is the area of 16-Bit width representing communication status. The value for when the previous communication frame was received is stored in the STATUS [0].

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8
STATE-REQ [1:0]		MF-ERR	HDR-ERR	–	PRM-ERR	CMD-ERR	EXE-ERR

B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
ERR-CNT [7:0]							

- **Bit details**

Bit	Symbol	Name	Description
B15, B14	STATE-REQ	State request	Returns the request state of the state transition to the driver. You can check the driver received the state transition command. 1h: Setting state (binary number: 01) 2h: Operation state (binary number: 10) [Initial value: 1h (Setting state)]
B13	MF-ERR *1	Mode fault error	If the mode fault error occurs, 1 is set.
B12	HDR-ERR *1	Header invalid error	If the header invalid error occurs, 1 is set.
B11	Reserved	–	This is a reserved area. An indeterminate value is read.
B10	PRM-ERR *1	Data out-of-range error	If the data out-of-range error occurs, 1 is set.
B9	CMD-ERR *1	Command indeterminate error	If the command indeterminate error occurs, 1 is set.
B8	EXE-ERR *1	Command execution disable error	If the command execution disable error occurs, 1 is set.
B7 to B0	ERR-CNT *2	Error counter	This is an 8-Bit width counter that counts the number of communication error. Every time the communication error occurs, the value increases 1. If the communication error occurs when the value is FFh, the value will return to 00h. [Initial value: 00h]

*1 Even if the cause of the error is removed, the error is not cleared automatically. To clear the communication error flag, turn the ERR-CLR of the NET-IN register from 0 to 1.

*2 To reset the error counter to 00h, turn the ERR-CLR of the NET-IN register from 0 to 1.

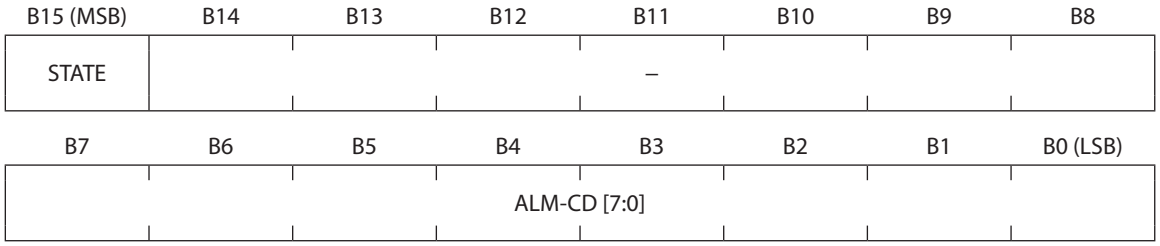
- **Communication error list**

The table below shows conditions and actions for when a communication error occurs.

Symbol	Name	Occurrence condition	Action for when an error occurs
MF-ERR	Mode fault error	• The number of the clock of SPI-SCK is not a multiple of 16. • The SPI-SS turned from L-level to H-level without a clock. • The overrun error occurred since an invalid clock was input.	Frame discard
HDR-ERR	Header invalid error	The SPI-SS turned from L-level to H-level in a state where a header has not completed sending.	Frame discard
PRM-ERR	Data out-of-range error	Data outside a range was written.	Discard the data outside a range
CMD-ERR	Command indeterminate error	An indeterminate command was specified.	Frame discard
EXE-ERR	Command execution disable error	A transition of the state was failed.	Frame discard

■ STATUS [1] area

The STATUS [1] is the area of 16-Bit width representing the present state and alarm status.



● Bit details

Bit	Symbol	Name	Description
B15	STATE	Present state	Returns the present state of the driver. You can check the transition of the state was complete. 0: Setting state 1: Operation state
B14 to B8	–	Reserved Bit	This is a reserved area. An indeterminate value is read.
B7 to B0	ALM-CD	Alarm code	Stores the alarm code presently being generated.

5-4 Clock polarity of SPI communication and data timing

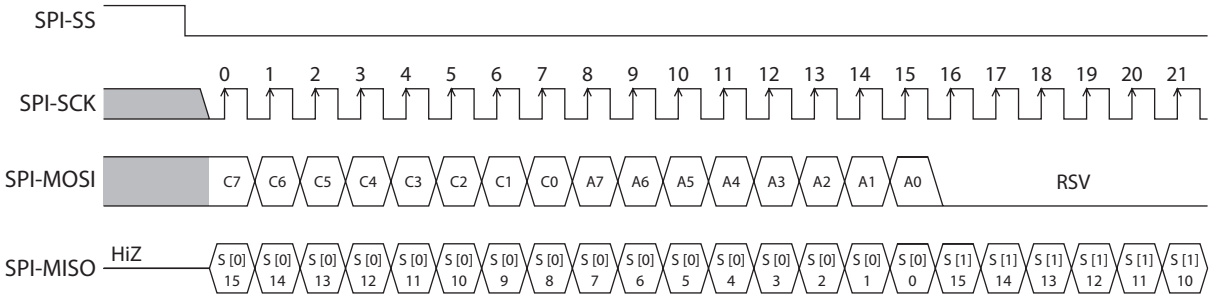
This section shows examples for the write command and the read command.

How to read the figure

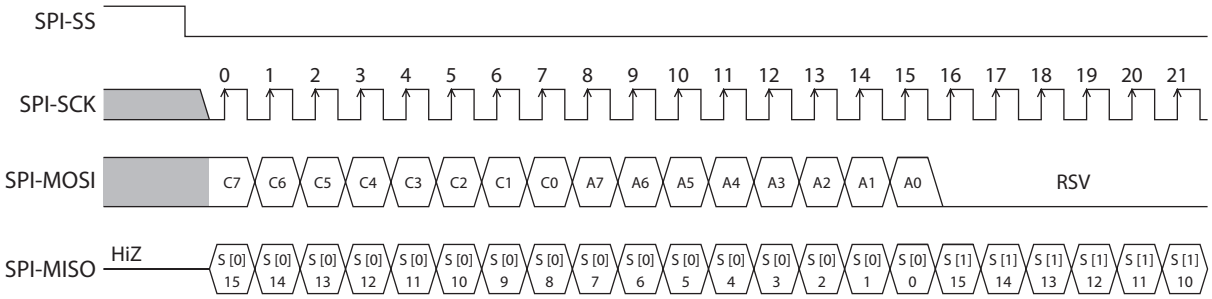
- : Shows Don't care or an indeterminate value.
- Cb : Command
- S[n]b : Status
- Ab : Address
- Wb : Write data
- Rb : Read data

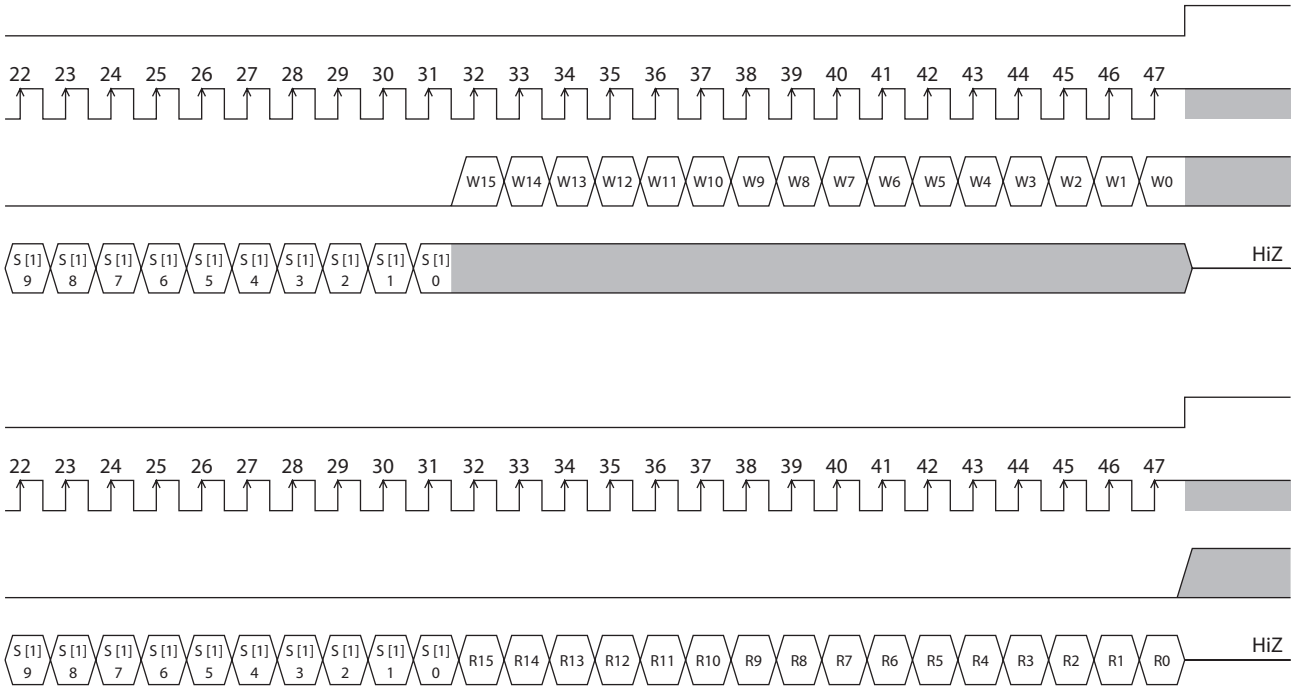
* b indicates a number representing Bit.

● **When writing a word**



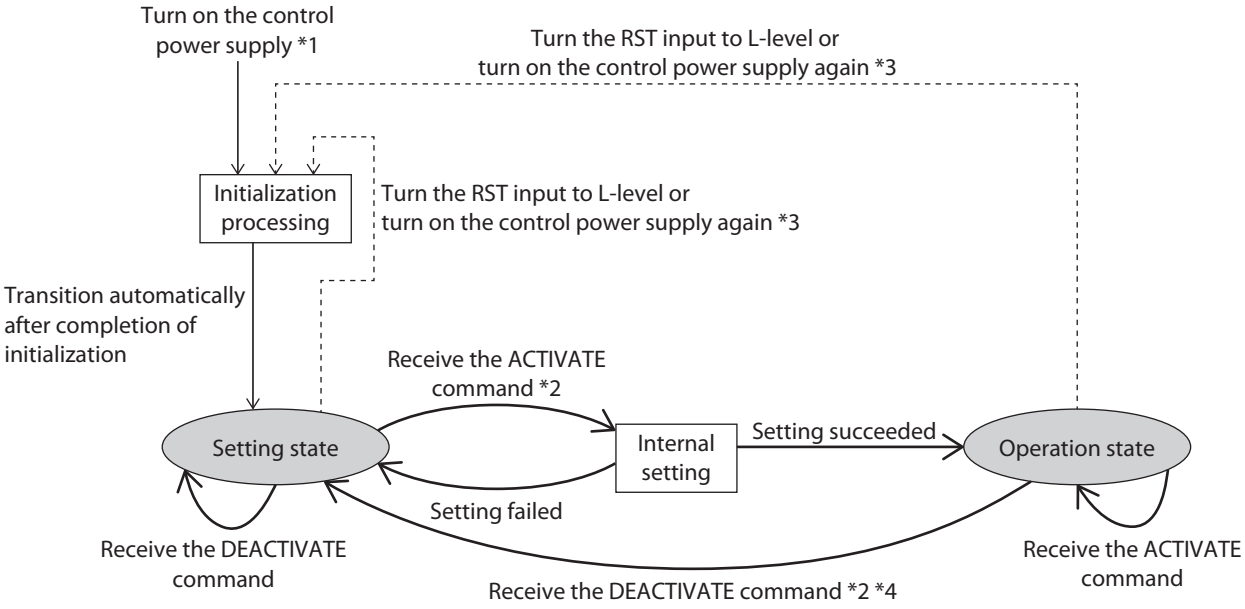
● **When reading a word**




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
W15 W14 W13 W12 W11 W10 W9 W8 W7 W6 W5 W4 W3 W2 W1 W0
S [1] 9 S [1] 8 S [1] 7 S [1] 6 S [1] 5 S [1] 4 S [1] 3 S [1] 2 S [1] 1 S [1] 0
HiZ
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
S [1] 9 S [1] 8 S [1] 7 S [1] 6 S [1] 5 S [1] 4 S [1] 3 S [1] 2 S [1] 1 S [1] 0 R15 R14 R13 R12 R11 R10 R9 R8 R7 R6 R5 R4 R3 R2 R1 R0
HiZ

5-5 Internal state

The driver internal state has two different types: setting state and operation state.



*1 If the control power supply is turned on, the internal state will transition to the setting state after the initialization processing is performed. The initialization processing restores the setting to the initial value.

*2 The internal state will transition with the state transition command (ACTIVATE, DEACTIVATE).

*3 You can forcibly return to the setting state by resetting with the RST input or by turning on the control power supply again. At this time, since the internal state transitions via the initialization processing, all values having set will be initialized.

*4 When the internal state transitioned to the setting state with the DEACTIVATE command, the setting will not be initialized.

■ Action capable in each state

Action		Setting state (Initial state)	Operation state *1
Excitation		×	○
Operation		×	○
Setting (update timing)	When executing ACTIVATE	○	× *2
	Immediately	○	○
Monitor		○	○

*1 When the internal state transitions to the operation state, the motor excitation state will return to the step "0" position. The pulse counter will be cleared to 0.

*2 Even if the ACTIVATE command is executed in the operation state, the setting value will not apply.

5-6 Setting item

This section shows items possible to set via SPI communication, and action instructions.

memo For the items that the update timing is "When executing ACTIVATE," write the setting value when the driver is in the setting state. Even if the setting value is written while the driver is in the operation state, it will not apply. Also, a communication error will not occur.

- **Setting item list**

Name	Description	Initial value	Update timing
Motor frame size setting	Sets the rated current of the motor used. **[Setting range]** FF00h to FA05h (2-phase: 0.5 to 2.8 A/phase, 5-phase: 0.35 to 2.4 A/phase)	FF00h (2-phase: 0.5A/phase, 5-phase: 0.35A/phase)	When executing ACTIVATE
Resolution	Sets the motor resolution. **[Setting range]** 4 to 2,500 (200 to 125,000 P/R)	10 (500 P/R)	When executing ACTIVATE
Pulse input mode	Selects the pulse input mode. **[Setting range]** 0: 1-pulse input mode 1: 2-pulse input mode	0: 1-pulse input mode	When executing ACTIVATE
Operating current	Sets the operating current rate. **[Setting range]** 1 to 1,000 (0.1 to 100.0%)	1,000 (100.0%)	Immediately
Standstill current	Sets the standstill current rate. **[Setting range]** 1 to 500 (0.1 to 50.0%)	500 (50.0%)	Immediately
Smooth drive function	Selects whether to enable or disable smooth drive function. **[Setting range]** 0: Disable 1: Enable	1: Enable	Immediately
Command filter	Selects whether to enable or disable command filter. **[Setting range]** 0: Disable 1: Enable	0: Disable	Immediately
Standstill current interlock setting	Selects whether to cause the ratio of standstill current to interlock with the operating current or the rated current. (⇨p.38) **[Setting range]** 0: Ratio to rated current 1: Ratio to operating current	0: Ratio to rated current	Immediately
Alarm LED lighting prohibition	Selects lighting permission or lighting prohibition for the ALM LED. **[Setting range]** 0: Lighting permission 1: Lighting prohibition	0: Lighting permission	Immediately
Power LED lighting prohibition	Selects lighting permission or lighting prohibition for the PWR LED. **[Setting range]** 0: Lighting permission 1: Lighting prohibition	0: Lighting permission	Immediately

Name	Description	Initial value	Update timing
Motor frame size setting source *1	Selects the setting method of the MOT-SEL. **[Setting range]** 0: I/O 1: SPI communication	0: I/O	When executing ACTIVATE
Operating current setting source	Selects the setting method of the RUN-CRNT (*2). **[Setting range]** 0: I/O 1: SPI communication	1: SPI communication	When executing ACTIVATE
Standstill current setting source	Selects the setting method of the STOP-CRNT. **[Setting range]** 0: I/O 1: SPI communication	1: SPI communication	When executing ACTIVATE
Smooth drive function setting source	Selects the setting method of the SD-EN. **[Setting range]** 0: I/O 1: SPI communication	1: SPI communication	When executing ACTIVATE
Excitation switching setting source *1	Selects the setting method of the ENABLE. **[Setting range]** 0: I/O 1: SPI communication	0: I/O	When executing ACTIVATE

*1 The initial value is I/O. When setting via SPI communication, change to "1: SPI communication" before use.
*2 It is the AN-CRNT when setting via I/O.

- **Action instructions list**

Name	Description	Initial value	Update timing
Excitation switching	Switches the motor excitation between excitation and non-excitation. **[Setting range]** 0: Motor non-excitation 1: Motor excitation	0: Motor non-excitation	Immediately
Alarm reset	Resets the alarm presently generated. **[Setting range]** 0: No request 1: Reset alarm	0: No request	Immediately
Communication errors clear	Clears the communication error presently generated. **[Setting range]** 0: No request 1: Clear communication error	0: No request	Immediately

5-7 Function setting register

The function setting register is used to set the driver.
A function is assigned to each register address or each Bit.
1 register consists of 2-byte (16-Bit).
The function setting register is the area of 16-byte starting from 00h. Do not access areas other than this.

■ Function setting register list

Address (Hex)	R/W *1	Name	Symbol	Update timing	Setting	
					Setting state	Operation state
00h	R/W	Reserved *2	–	–	–	–
02h	R/W	Network input	NET-IN	Immediately	Possible	Possible
04h	R/W	Operating current	RUN-CRNT	Immediately	Possible	Possible
06h	R/W	Standstill current	STOP-CRNT	Immediately	Possible	Possible
08h	R/W	Reserved *2	–	–	–	–
0Ah	R/W	Driver setting	SETTING	When executing ACTIVATE	Possible	Not possible
0Ch	R/W	Resolution	RESOLUTION	When executing ACTIVATE	Possible	Not possible
0Eh	R/W	Motor frame size setting	MOT-SEL	When executing ACTIVATE	Possible	Not possible

*1 R represents "possible to read," and "W" represents "possible to write."

*2 If the reserved address (00h, 08h) is included in the area that writes consecutively, write 0000h in the data field of the reserved address. An indeterminate value is read from the reserved address (00h, 08h).

- **Timing to update the register**

Update timing	Description
Immediately	In spite of the status of the internal state of the driver, a value will apply immediately when writing it with the WRITE command. However, it will not apply if the setting value is abnormal.
When executing ACTIVATE	When the internal state transitions from the setting state to the operation state, the setting value will apply. Before executing the ACTIVATE command, write the setting value with the WRITE command while the driver is in the setting state. If an abnormal setting value is found, the command execution disable error and the command execution disable alarm will occur when the ACTIVATE command is executed, and the value will not apply. Also, the internal state will not transition to the operation state.

■ Details of function setting register

- **NET-IN (02h)**

A function is assigned to each Bit. For details, refer to following table.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8
ALM-LED-DIS	PWR-LED-DIS	–				FIL-EN	SD-EN

B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
–				ERR-CLR	ALM-RST	ENABLE	–

Bit details

Bit	Symbol	Name	Description	Initial value
B15	ALM-LED-DIS	Alarm LED lighting prohibition	0: Lighting permission 1: Lighting prohibition	0
B14	PWR-LED-DIS	Power LED lighting prohibition	0: Lighting permission 1: Lighting prohibition	0
B13 to B10	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate
B9	FIL-EN	Command filter	0: Disable 1: Enable	0
B8	SD-EN	Smooth drive function	0: Disable 1: Enable	1
B7 to B4	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate
B3	ERR-CLR	Communication errors clear	0: No request 1: Clear communication error *1 *2	0
B2	ALM-RST	Alarm reset	0: No request 1: Reset alarm *1	0
B1	ENABLE	Excitation switching	0: Motor non-excitation 1: Motor excitation	0
B0	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate

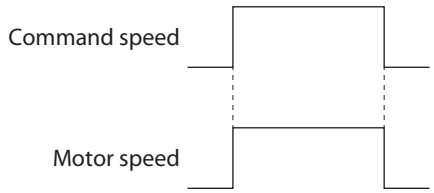
*1 The ERR-CLR and the ALM-RST are enabled at the rise edge. If you change the value from 0 to 1, the assigned function will be executed. After the function was executed, the value will not return to 0 automatically. When you execute the function again, once return the value to 0, and write 1.

*2 It clears the error counter and the communication error flag.

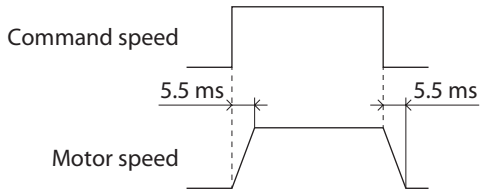
Command filter

If the command filter is enabled, the motor operation at starting/stopping will become smooth. Note, however, that synchronization performance in response to the commands is decreased. Set an appropriate value according to the specific load and purpose.

• When the command filter is disable



• When the command filter is enable



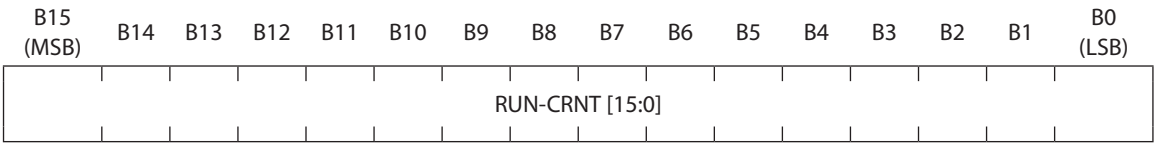
Smooth drive function

The smooth drive is a function to achieve lower vibration and noise at low speeds operation without changing the step angle setting.

- **RUN-CRNT (04h)**

Set the operating current ratio.
1 (0001h) corresponds to 0.1%. When setting to 100.0%, specify 1000 (03E8h). The operating current is calculated by multiplying the rated current, which is set in the MOT-SEL, by the operating current rate.
Example: When setting the rated current to 2.4 A in the MOT-SEL and the operating current rate to 500 in the RUN-CRNT
Operating current = 2.4 × (500 / 1000) = 1.2 A

Initial value 1000 [03E8h] (100%)
Setting range 1 to 1000 (0001h to 03E8h)



- **STOP-CRNT (06h)**

Set the standstill current ratio.
1 (0001h) corresponds to 0.1%. When setting to 50.0%, specify 500 (01F4h).
Using the standstill current interlock setting, you can switch whether to cause the standstill current rate to interlock with the operating current or the rated current. For details, refer to "SETTING (0Ah)".

Initial value 500 [01F4h] (50%)
Setting range 1 to 500 (0001h to 01F4h)

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
STOP-CRNT [15:0]															

memo Do not set a value exceeding 50% in the STOP-CRNT.

- **SETTING (0Ah)**

A function is assigned to each Bit. For details, refer to following table.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8
–	1P/2P-SRC	SD-EN-SRC	RUN-CRNT-SRC	STOP-CRNT-SRC	MOT-SEL-SRC	ENABLE-SRC	–

B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
–	1P/2P	–		STOP-CRNT-RELATE	–		

Bit details

Bit	Symbol	Name	Description	Initial value
B15	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate
B14	1P/2P-SRC	Pulse input mode setting source	1: SPI communication 0: Writing is prohibited	1
B13	SD-EN-SRC	Smooth drive function setting source	0: I/O 1: SPI communication	1
B12	RUN-CRNT-SRC	Operating current setting source	0: I/O 1: SPI communication	1
B11	STOP-CRNT-SRC	Standstill current setting source	0: I/O 1: SPI communication	1
B10	MOT-SEL-SRC	Motor frame size setting source	0: I/O 1: SPI communication	0
B9	ENABLE-SRC	Excitation switching setting source	0: I/O 1: SPI communication	0
B8, B7	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate
B6	1P/2P	Pulse input mode	0: 1-pulse input mode 1: 2-pulse input mode	0
B5, B4	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate
B3	STOP-CRNT-RELATE	Standstill current interlock setting	0: Ratio to rated current 1: Ratio to operating current	0
B2 to B0	–	Reserved	An indeterminate value is read. Write 0 when writing a value.	Indeterminate

About standstill current interlock setting

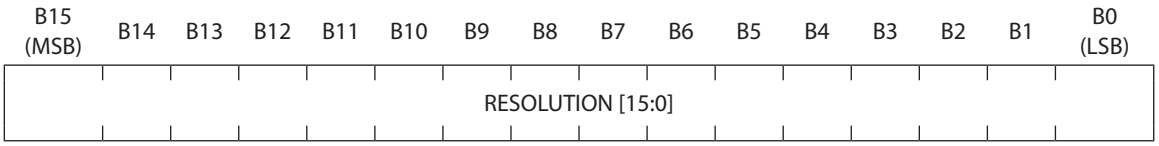
Whether to cause the standstill current rate to interlock with the operating current or the rated current is switched according to the setting values of the STOP-CRNT-SRC and STOP-CRNT-RELATE.
The table below shows relations between the setting of each register and the standstill current.

STOP-CRNT-SRC (Standstill current setting source)	STOP-CRNT-RELATE (Standstill current interlock setting)	Standstill current
0: I/O	–	Interlocks with the operating current. H level: 50% of operating current L level: 25% of operating current
1: SPI communication (initial value)	0: Ratio to rated current (initial value)	Interlocks with the rated current. This is a value calculated by multiplying the rated current by the standstill current rate which is set in the STOP-CRNT.
	1: Ratio to operating current	Interlocks with the operating current. This is a value calculated by multiplying the operating current by the standstill current rate which is set in the STOP-CRNT.

- **RESOLUTION (0Ch)**

Set the motor resolution.
Set a value that a desired resolution [P/R] is divided by 50 (100 for the high-resolution type).
If you execute the ACTIVATE command in a state of setting the value not in the table, the command execution disable error and alarm will occur.

Initial value 10 (000Ah)



Resolution setting list (setting example)

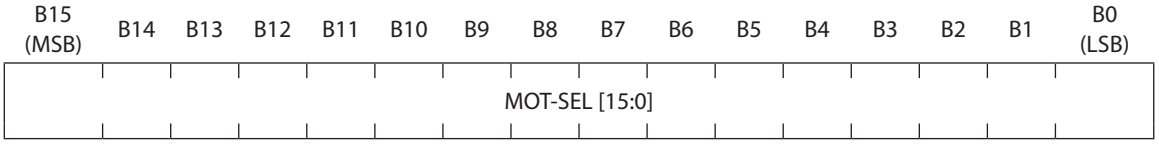
Setting value (Dec)	Resolution [P/R] Standard type	Resolution [P/R] High-resolution type	Number of divisions which corresponds to
4	200	400	2-phase Full-step setting
8	400	800	2-phase Half-step setting
10	500	1,000	5-phase Full-step setting
16	800	1,600	2-phase 4-division
20	1,000	2,000	5-phase Half-step setting
25	1,250	2,500	5-phase 2.5-devision
32	1,600	3,200	2-phase 8-devision
40	2,000	4,000	5-phase 4-devision
50	2,500	5,000	5-phase 5-devision
64	3,200	6,400	2-phase 16-devision
80	4,000	8,000	5-phase 8-devision
100	5,000	10,000	5-phase 10-devision
128	6,400	12,800	2-phase 32-devision
200	10,000	20,000	5-phase 20-devision
250	12,500	25,000	5-phase 25-devision
256	12,800	25,600	2-phase 64-devision
400	20,000	40,000	5-phase 40-devision
500	25,000	50,000	5-phase 50-devision
512	25,600	51,200	2-phase 128-devision
800	40,000	80,000	5-phase 80-devision
1000	50,000	100,000	5-phase 100-devision

Setting value (Dec)	Resolution [P/R] Standard type	Resolution [P/R] High-resolution type	Number of divisions which corresponds to
1024	51,200	102,400	2-phase 256-devision
1250	62,500	125,000	5-phase 125-devision
2000	100,000	200,000	5-phase 200-devision
2500	125,000	250,000	5-phase 250-devision

- **MOT-SEL (0Eh)**

Set the rated current (A/phase) of the motor used. Match the motor operating current with the setting of MOT-SEL. If you execute the ACTIVATE command in a state of setting the value not in the table, the command execution disable error and alarm will occur.

Initial value FF00h



Setting value	2-phase		5-phase	
	Rated current (A/phase)	Motor model *	Rated current (A/phase)	Motor model *
FF00h	0.5	**PKP213D**	0.35	**PK513** **PK52□**
FE01h	0.6	**PKP214D**	0.75	**PK52□H** **PK54□**
FD02h	1.5	**PKP22□D15** **PKP23□D15** **PKP24□MD15** **PKP262FD**	1.2	**PKP52□**
FC03h	2.3	**PKP23□D23** **PKP24□D23**	1.4	**PK56□**
FB04h	2.3	**PKP24□D15■2** **PKP24□D23■2**	1.8	**PKP54□**
FA05h	2.8	**PKP26□D14■2** **PKP26□D28■2** **PKP26□MD28**	2.4	**PKP56□FN24** **PKP56□FMN**

* □ in the model names indicates a number representing the motor length.
■ in the model names indicates **A** (single shaft) or **B** (double shaft) representing the motor type.

5-8 Monitor register

These registers are used to monitor the driver status.
A function is assigned to each register address or each Bit. The monitor register is the area of 14-byte starting from 20h and 6-byte starting from 40h. Do not access areas other than this.

memo
- The monitor register is for read-only. Write commands are ignored.
- Reading by the monitor register can be executed in spite of the status of internal state.

■ Monitor register list

Addres	R/W *1	Name	Symbol
20h	R	Reserved *2	–
22h	R	Network output	NET-OUT
24h	R	Alarm	ALM-MON
26h	R	Driver temperature	TEMP-MON
28h	R	Main power supply voltage	PWR-MON
2Ah	R	Analog input voltage	ANIN-MON
2Ch	R	Pulse counter	PLSCNT-MON
2Eh to 3Eh	R	Reserved *2	–
40h	R	Driver type	DRIVER-TYPE
42h	R	Software	SOFTWARE
44h	R	Software version	SOFTWARE-VER

*1 R represents "possible to read."
*2 An indeterminate value is read from the reserved address.

■ Details of monitor register

● NET-OUT (22h)

Read the driver status.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8
–							

B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
–		PWR-ON	O.H.	CRNT-ON	PLS-RDY	TIM	ALM

Bit details

Bit	Symbol	Name	Description
B15 to B6	–	Reserved	An indeterminate value is read.
B5	PWR-ON	Main power supply status	0: Main power supply OFF 1: Main power supply ON
B4	O.H.	Overheat	0: Not overheat status 1: Overheat status
B3	CRNT-ON	Excitation status	0: Excitation OFF 1: Excitation ON
B2	PLS-RDY	Pulse ready	0: Not ready 1: Ready
B1	TIM	Excitation home	0: Not step "0" position 1: Step "0" position
B0	ALM	Alarm	0: Alarm not present 1: Alarm present

- **ALM-MON (24h)**

Read the alarm code presently being generated.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8
–							

B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
ALM-CD [7:0]							

Bit details

Bit	Symbol	Name	Description
B15 to B8	–	Reserved	This is a reserved area. An indeterminate value is read.
B7 to B0	ALM-CD	Alarm code	The alarm code of present alarm is read.

- **TEMP-MON (26h)**

Read the driver temperature.
1 corresponds to 0.1 °C. When 500 is stored, it represents the driver temperature is 50.0 °C.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
TEMP-MON [15:0]															

- **PWR-MON (28h)**

Read the main power supply voltage.
1 corresponds to 0.1 V. When 240 is stored, it represents the main power supply voltage is 24.0 V.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
PWR-MON [15:0]															

- **ANIN-MON (2Ah)**

Read the input voltage of the analog input voltage terminal.
1 corresponds to 0.01 V. When 250 is stored, it represents the analog input voltage is 2.50 V.

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
ANIN-MON [15:0]															

- **PLSCNT-MON (2Ch)**

Read the number of pulses the driver received. Use when checking the number of pulses.

- If 1 pulse is input in the CW direction while an operation is possible, the value increases 1. If 1 pulse is input in the CCW direction, the value decreases 1.
- If 1 pulse is input in the CW direction when the number of pulses is 32,767, the value becomes –32,768 to overflow. If 1 pulse is input in the CCW direction when the number of pulses is -32,768, the value becomes 32,767 to underflow.

Initial value 0000h

B15 (MSB)	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0 (LSB)
PLSCNT-MON [15:0]															

memo
- The read value is not the position of the motor output shaft.
- If the internal state transitions from the setting state to the operation state, the pulse counter will be cleared to 0.

● **DRIVER-TYPE (40h)**

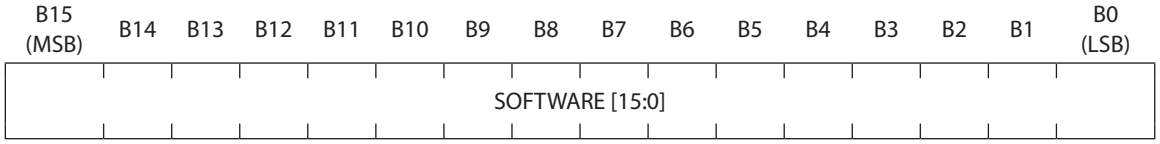
Read a value representing the number of phases of the motor which can be combined.

Bit details

Bit	Symbol	Name	Description
B15 to B1	–	Reserved	This is a reserved area. An indeterminate value is read.
B0	MOTOR-PHASE	Number of phases of motor	0: 5-phase motor 1: 2-phase motor

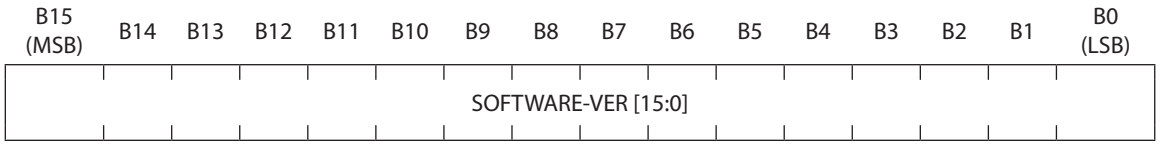
● **SOFTWARE (42h)**

Read an identification value representing the software type.



● **SOFTWARE-VER (44h)**

Read the version of software.
1 corresponds to 0.01. If the read value is 0105, it represents Ver.1.05.



5-9 Setting example of SPI communication

This section shows an example to initialize a driver. For items other than the table below, use the initial values.

● **Initialization items**

Set the following items in the driver.

Item	Setting
Motor frame size setting	**PKP569FN24A2**
Resolution	2000
Operating current	75.0%
Standstill current	40.0%
Motor frame size setting source	SPI communication

- **Setting value**

Address	Name	Setting value	Description
04h	Operating current	02EEh	Set the operating current to 75.0%. (decimal: 750)
06h	Standstill current	0190h	Set the standstill current to 40.0%. (decimal: 400)
08h	Reserved	0000h	This is a reserved area. Set 0000h.
0Ah	Driver setting	7C00h	Sets the motor frame size setting source (B10: MOT-SEL-SRC) to "1: SPI communication." Keeps other Bit to be remained as the initial value.
0Ch	Resolution	0028h	Sets a value that 2000 is divided by 50 in order to set the resolution to 2000. (decimal: 40)
0Eh	Motor frame size setting	FA05h	Sets a value corresponding to the rated current 2.4 A of **PKP569FN24A2**.

- **Communication frame**

Byte offset	Value	Description
0	02h	Specifies the write command.
1	04h	Specifies the address to start writing. Specify the address of the operating current here.
2, 3	0000h	This is a reserved area. Specify 0000h.
4, 5	02EEh	Specifies the setting value of the operating current. Specify 02h in the byte offset 4 and EEh in the byte offset 5 due to big endian.
6, 7	0190h	Standstill current
8, 9	0000h	This is a reserved area.
10, 11	7C00h	Driver setting
12, 13	0028h	Resolution
14, 15	FA05h	Motor frame size setting

- **Initialization procedure**

Start of initialization

↓

Turn on the control power supply

↓

Waiting time: 200 ms or more

This is a time until the driver becomes possible to receive SPI communication after turning on the control power supply.

↓

Send the write command from the SPI master controller

The setting value is written to the function setting register.
The setting value of items that the update timing is "Immediately" will be applied.

↓

Waiting time: 1 ms or more

This is an interval of the communication frame of SPI communication.

↓

Send the ACTIVATE command from the SPI master controller

- This causes the internal state of the driver to transition from the setting state to the operation state. The communication data is 0800 0000h. If the internal state transitions to the operation state, the motor will be excited.
- The setting value of items that the update timing is "When executing ACTIVATE" is applied.

↓

Completion of initialization

6 Alarm

If an alarm generates, a protective function of the driver will activate to open the ALM output. At the same time, the motor excitation will shut off, and the PWR/ALM LED on the driver will blink in red.

■ Alarm reset

Perform one of the reset operations specified below.

- Cycle the control power supply.
- Turn the RST input to L-level.
- Turn the ALM-RST from 0 to 1 via SPI communication.

memo Some alarms cannot be reset with the ALM-RST via SPI communication. Check the "Descriptions of alarms" shown below. To reset these alarms, turn on the power supply again or turn the RST input to L-level.

■ Descriptions of alarms

Alarm code	Number of LED blinks	Alarm type	Cause	Reset using the ALM-RST	Motor excitation
21h	2	Overheat	The temperature of the circuit board exceeded the permissible value.	Possible	Non-excitation
22h	3	Overvoltage	• The main power supply voltage exceeded the permissible value. • A large inertial load was stopped abruptly or vertical operation was performed. • The capacitance of aluminum electrolytic capacitor connected to the main power supply was insufficient.	Possible	Non-excitation
20h	5	Overcurrent	An excessive current was flowed through the motor output circuit.	Not possible	Non-excitation
8Dh	7	Command execute disable	The SPI communication command was failed to execute.	Possible	Non-excitation
41h	9	EEPROM error	The stored data in the driver was damaged.	Not possible	Non-excitation
–	Lit	CPU error	• An error or a malfunction was occurred in the CPU. • An error of the CPU clock was detected.	Not possible	Non-excitation

7 Specification

7-1 Basic specifications

■ General specifications

Main power supply	24 VDC±10%
Control power supply	5 VDC±5% 0.12 A
Driving method	Bipolar constant current drive
Excitation mode	Microstepping
Cooling method	Natural cooling
Degree of protection	IP00
Mass	10 g (0.35 oz.)
Insulation resistance	Non-isolated
Dielectric strength	Non-isolated

■ Input current

- **2-phase**

Rated current [A/phase] (setting value)	0.5	0.6	1.5	2.3	2.8
Input current [A]	0.5	0.5	1.3	2.0	3.0

- **5-phase**

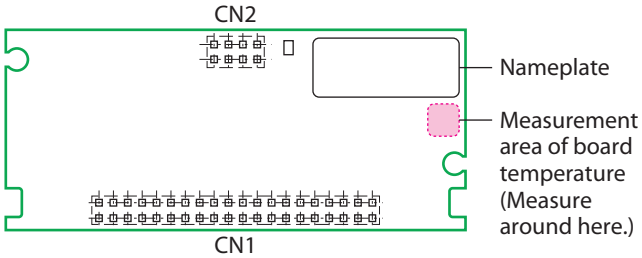
Rated current [A/phase] (setting value)	0.35	0.75	1.2	1.4	1.8	2.4
Input current [A]	0.6	1.4	1.7	1.8	2.8	3.0

7-2 Environmental conditions

■ Environmental conditions

Operation environment	Board temperature	0 to +75 °C (+32 to +167 °F) * (non-freezing)
	Ambient humidity	85% or less (non-condensing)
	Altitude	Up to 1,000 m (3,300 ft.) above sea level
	Surrounding atmosphere	No corrosive gas, dust, water or oil
Storage environment	Ambient temperature	−10 to +60 °C (+14 to +140 °F) (non-freezing)
	Ambient humidity	75% or less (non-condensing)
	Altitude	Up to 3,000 m (10,000 ft.) above sea level
	Surrounding atmosphere	No corrosive gas, dust, water or oil
Shipping environment	Ambient temperature	−10 to +60 °C (+14 to +140 °F) (non-freezing)
	Ambient humidity	75% or less (non-condensing)
	Altitude	Up to 3,000 m (10,000 ft.) above sea level
	Surrounding atmosphere	No corrosive gas, dust, water or oil

* Measure the surface temperature of the board under the actual operating environment. To measure the surface temperature of the board, use the measurement area of the board temperature in the figure.



■ Revision record

Revision number	Revised contents
First edition	

Published in November 2016

TN-CVDS-SPI-E