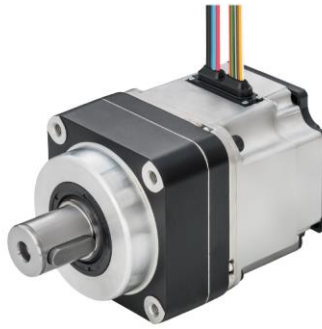


Brushless Motor/Controller

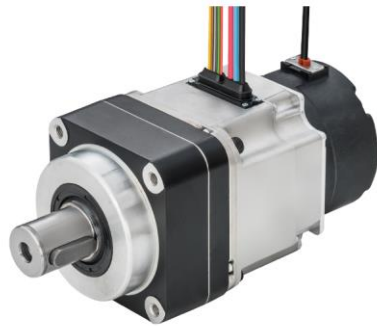
Instruction Manual



IR-94BZA



MR-94BZA



MR-94BZB



DR-40FC1/FC3

Brushless motor:

IR-94BZA

Geared motor:

MR-94BZA

Geared motor with brake:

MR-94BZB

Controller:

DR-40FC1/FC3

Note to Users

Read the safety warnings for proper use of this product.

Mabuchi Motor Co., Ltd. has no liability to indemnity damages, including any malfunction of the motor resulting from failure to follow this instruction manual.

The performance, specifications and appearance of this product are subject to change without notice.

- This manual is intended for engineers who are experienced with installation and setting of brushless motors/controllers.
- Please keep this manual in a safe place so that you can refer to it whenever necessary.
- We have made every effort to ensure that the contents of this manual are correct, but if you have any questions, concerns, or notice any errors, please contact us.
- The description may differ in details due to improvements made to certain parts. If you have any questions, please contact us.

Table of Contents



NOTE TO USERS	1	5.6.1 ON_OFF signal input circuit.....	31
TABLE OF CONTENTS	2	5.6.2 CAN communication circuit.....	33
1 SAFETY	3	5.7 Ground	33
1.1 Safety Signs	3	6 OPERATION FLOWCHARTS	34
1.2 Safety Precautions	4	6.1 Flowchart for Ordinary Operation	34
1.2.1 Warnings and precautions on the motor and controller	4	6.2 Flowchart When an Error Occurs	36
1.2.2 Precautions regarding motor	6	7 CAN COMMUNICATION SETTING	37
1.2.3 Warnings and precautions regarding controller	7	7.1 CAN ID Setting Rules.....	37
2 OVERVIEW	9	7.2 List of CAN Communication Setting/Read Functions	38
2.1 Product Summary	9	7.3 Reading/Setting Content for CAN Communication	39
2.2 Product Features.....	9	7.4 Setting Content for WID/PID Signals..	42
2.3 Scope of Application.....	9	8 ERROR LIST	44
3 PARTS DESCRIPTION	10	8.1 Error Codes.....	44
3.1 Motor Parts Description.....	10	8.2 Warning Codes	45
3.2 Controller Parts Description	12	9 SUPPLEMENTARY INFORMATION AND PRECAUTIONS FOR OPERATION	46
4 INSTALLATION	13	9.1 Setting Rotation Speed	46
4.1 Installation Environment.....	13	9.2 Switching Motor Running Direction	47
4.2 Motor Installation.....	14	9.3 Torque Limit Function.....	48
4.2.1 IR-94BZA installation method	14	9.4 Points to Check at Installation	50
4.2.2 MR-94BZA/MR-94BZB installation method.....	15	9.5 Precautions regarding Cables.....	50
4.3 Controller Installation	16	10 TROUBLESHOOTING	51
5 CONNECTION	17	10.1 Motor does not run	51
5.1 Connection Specifications.....	17	10.2 Unstable operation, large vibration.....	52
5.1.1 Example of connection between motor and controller	17	10.3 Cannot Perform CAN Communication	52
5.1.2 Parts prepared by the customer	18	11 SPECIFICATIONS	53
5.1.3 Functional block diagrams	19	11.1 Product Specifications.....	53
5.2 Connections between Motor and Controller.....	21	11.1.1 Motor Specifications.....	53
5.3 Connection of Motor and Electromagnetic Brake (MR-94BZB).....	23	11.1.2 Controller Specifications.....	54
5.4 Connection of Controller and Power Supply	25	11.1.3 Motor extension cable, controller connection cable (sold separately)	55
5.4.1 Preparation and checking before connecting power supply	25	11.2 Technical Drawings.....	56
5.4.2 Method of connecting power supply ...	27	11.2.1 Motor Technical Drawings.....	56
5.4.3 Controller startup and stopping.....	28	11.2.2 Controller Technical Drawings	57
5.5 Connection of Controller and Input/Output Signals	29	11.3 Motor Continuous Drive Range	58
5.6 Controller ON_OFF Signal, CAN Comm unication Circuit.....	31	12 LAWS AND STANDARDS	59
		13 PRODUCT WARRANTY	59
		14 AFTER SALES SERVICE	60

1 Safety

1.1 Safety Signs



Signal words

The following signal words are used to indicate the level of harm or damage that may be caused by improper use as a result of ignoring the instruction.

 WARNING	Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
 CAUTION	Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury or property damage.

Explanation of graphic symbols

The following symbols are used to indicate specific types of actions.

	Indicates prohibited actions.
	Indicates mandatory actions.

1.2 Safety Precautions

1.2.1 Warnings and precautions on the motor and controller



WARNING

- Always connect our dedicated controller (DR-40FC1 or DR-40FC3) to this brushless motor.
If the product is used with an incorrect combination of motor and controller, performance cannot be guaranteed and there is a risk of accident or fire.
- Do not use in atmospheres with the presence of corrosive or flammable gas(es), or near combustible materials.
Doing so may result in fire, injury, or damage to equipment.
- Do not plug the lead wire or motor terminal into a household electrical outlet.
It may cause electric shock, injury, or damage to equipment.
- Do not touch live parts such as terminals while the power is on. There is a risk of electric shock.
- Do not disassemble or modify the motor and controller.
It may result in electric shock, injury, or damage to equipment.



CAUTION

- This product is intended for general use.
This product cannot be used for special applications such as medical, military, or aerospace purposes, or as in-vehicle equipment.
 - When using lead wires, switches, relays, controllers, etc., give due consideration to electrical capacity and heat resistance.
Failure to comply with the appropriate standards may cause equipment damage such as burning.
 - It is the responsibility of the purchaser to confirm and assure the matching and the reliability of the motor in actual set or unit application along with confirming the service life and carrying out quality assurance.
Examples of items to confirm when configuring:

Applicable laws, standards, service life, various electrical characteristics, mechanical characteristics, mechanical/electrical noise, environmental exposure, ambient gas, etc.
 - Startability and rotational stability may be affected depending on the internal resistance and capacity of the motor drive power supply (including circuits).
Also, check the actual operating conditions not only at room temperature but also at low and high temperatures.
 - When inserting or disconnecting cable connectors, hold the plug with your fingers, release the retainer mechanism, and insert or disconnect in the connector pin direction.
When inserting/disconnecting, be careful not to apply excessive force to the connector.
 - Be sure to use the specified part as the extension cable connector.
-



CAUTION

- Do not apply excessive force to the cables and connectors.
Do not move or transport the motor by pulling the cable.
- Plug in the cable connector securely until it is fixed with the lock mechanism.
The connector of the controller section may be damaged if excessive force is applied to the cable connector while it is half-inserted and not fixed with the lock mechanism.
To disconnect, release the lock mechanism, and be careful not to apply excessive force on the plug side.
- Do not damage the cable connector, forcefully pull it, apply excessive force, place a heavy object on top, or allow pinching.
- Wiring and inspection of the electric equipment must be performed by a qualified electrician.
- Purchase connection cables that are sold separately as necessary.
- Never disconnect the connectors while the motor is running.
Also, be sure to turn off the power before inserting the connectors.
In some cases, the controller may be damaged.
- If an abnormality occurs, immediately turn off the power.
- Note that the temperature of the motor and controller will rise while the motor is rotating or immediately after stopping.
There is a risk of burns.
- When disposing of this product, dispose of it according to the laws and regulations and the instructions of the local authority.
- Avoid storing the motor and controller in hot and humid places and in the presence of corrosive gases.
The recommended environment is +10 to +30°C and 30 to 95% relative humidity.
- Agents used for fumigation can contaminate metal parts of the motor.
When fumigating the packaging of the motor or products containing the motor (e.g. pallets), do not expose the motor to the fumigant and its gases.
- The ambient temperature (motor temperature) when the motor is in use affects its performance and life.
Be especially careful when ambient conditions are hot and humid.

1.2.2 Precautions regarding motor



WARNING

- Do not touch the rotating parts including accessories while the power is on. There is a risk of injury.
- Be careful not to fix (lock) the shaft while the motor power is on. There is a danger of burning out even if the lock is held for a short time. It may cause damage to the equipment.
- Depending on the operating conditions of the motor (mounting condition, load, environmental temperature), heat generation may increase, and cause burns.



CAUTION

- If wiring of the main power supply or motor power lines is long or thin, motor torque will drop due to wiring impedance. When selecting a motor, ensure an adequate margin in terms of acceleration/deceleration torque, and check in the final product state.
 - When fixing a motor or geared motor, do not apply force that might deform the motor main unit. Also, do not unevenly tighten screws. Doing so may adversely affect motor installation surface flatness or characteristics.
 - Using the output shaft with an excessive load may shorten product life. Also, be careful when handling not to allow any impact load in the thrust direction.
 - If a transmission system such as belt drive, in which lateral pressure is applied to the motor, is used for the output shaft, service life may be shortened due to lateral pressure applied to the bearing.
 - If a large radial load, due to a mechanism such as an eccentric cam, is applied during motor operation, or vibration is applied from the outside, this may affect motor life. Check under actual operating conditions.
 - Do not apply excessive pressure on or to the motor output shaft. It may cause equipment damage.
 - Follow the precautions below when the electromagnetic brake actuates.
 - 1) Do not allow actuation of the electromagnetic brake for braking purposes during motor rotation.
 - 2) Apply voltage to the electromagnetic brake and release the brake before starting the motor.
 - 3) To stop the motor, shut off the electromagnetic brake voltage after rotation stops, and actuate the electromagnetic brake. (MR-94BZB)
 - When used for a long period of time, a small amount of grease may seep out from the gear part of MR-94BZA and MR-94BZB in rare cases. This will not change the characteristics of MR-94BZA and MR-94BZB, but inspect periodically that no problems have arisen with the equipment where the motor is installed.
-

1.2.3 Warnings and precautions regarding controller



WARNING

- Use a power supply matching the specifications of the product equipped with this controller.
Failure to do so may result in burning, fire, or electric shock.
- Use a wire size conforming to specifications.
Failure to do so may result in burning, fire, or electric shock.
- This controller is not equipped with a reverse connection protection circuit.
The customer should select the appropriate protection circuit as necessary.
Failure to do so may result in fire or failure.
- Motor surface temperature may be high while on, and for some time after power is turned off. Take necessary precautions to avoid burns.
- If an abnormality or failure occurs, immediately send a system stop command to the controller, and turn off the power supply to the controller.
Failure to do so may cause fire, electric shock, or injury.
- Do not use the controller if it has damage, deformation, corrosion, etc.
Doing so may result in fire or failure.



CAUTION

- Do not use the controller outside the scope of specifications.
 - Carry out design while taking into account the maximum input current to the controller.
 - When handling the controller, be careful of sharp parts such as corners.
There is a risk of injury.
 - Install the controller inside a housing.
 - Do not place anything heavy on top of the controller.
It may cause failure.
 - Provide a separate mechanism (e.g., power shutdown and emergency stop brake) to perform emergency stopping, such as emergency stop braking, so that the machine or equipment does not fall into a dangerous state, even if the controller fails. Even if drive stop operation is performed, there are cases where output will not stop due to the setting state and external force.
 - Before attaching the controller to the machine and starting operation, set parameters to suit that machine.
 - Do not set extreme parameters.
It may cause instability, and result in machine damage or injury.
 - Design the system so that safety can be ensured, even if a problem occurs such as disconnection of signal wires.
 - Do not use in applications where power goes on and off frequently.
-



CAUTION

- When an error is detected, the motor performs a free-run stop.
The inertia distance varies depending on the moment of inertia of the load and the motor rotation speed, so consider appropriate safety equipment on the machine side.
- When fixing the controller, do not apply force that might deform the controller main unit.
Also, do not unevenly tighten screws.
Doing so may adversely affect characteristics.
- Do not attach a phase advance capacitor or noise filter between the controller and motor.
Doing so poses a risk of overheating and burning.
- The controller is protected by its case, but carefully handle it and consider its installation location so that excessive electrical and mechanical stress are not applied.
- Make sure that combustible foreign matter such as oil, and conductive foreign matter such as metal fragments, do not get inside the controller.
- Correctly and surely perform wiring of power supply polarity (+ and -) and signal lines, etc.
Failure to do so poses a risk of damage, rupture, etc.
- To prevent damage due to static electricity, remove all static electricity from your body before touching the product. This can be done by touching metal nearby.
Take necessary measures to prevent electrostatic charge during handling.
- To operate, turn on power connected to the controller after all wiring is finished.
- When operating the controller after long-term storage, perform inspection and trial operation.
- The controller is precision equipment.
Do not drop the controller or allow any strong impact.
- When an error is detected, ensure safety by eliminating the cause of the error.
After that, cancel the error, turn on power again, and resume operation.
- Before performing wiring work and inspection, turn off power, wait for five minutes or more, and check voltage with a tester or similar device.
Voltage sometimes remains in the controller, which poses a risk of electric shock.
- Use a power supply whose regenerative electric power is sufficiently allowable.

2 Overview

2.1 Product Summary

This brushless motor can be used in a wide range of mobile system applications, such as autonomous running robots (AGV, AMR, etc.), personal mobility, and power assist robots. Combining with the dedicated controller enables use while bringing out motor characteristics to the fullest.



- In brushless motors (IR-94BZA, MR-94BZA/BZB), a resolver is used as the rotation sensor. Therefore, be sure to use in combination with the specified controller (DR-40FC1/FC3). Never use in combination with our other controllers (DS-34EC1-IS221/DS-34EC1-IS311) or a general-purpose controller.
- This controller (DR-40FC1/FC3) is special for resolvers. Never use in combination with a motor other than that specified.

2.2 Product Features

- A resolver-equipped motor + dedicated controller enables stable control and smooth acceleration/deceleration in the range of 100 r/min or less.
- Both motor and controller are compact and lightweight. Waterproofing: IPX4 guaranteed.
- Use in a set enables immediate control from 0 r/min.
- Motor is compatible with attachment of speed reducers, electromagnetic brakes, and wheels.
- Low radiated electrical noise characteristics (compatible even with standards for home use).

2.3 Scope of Application

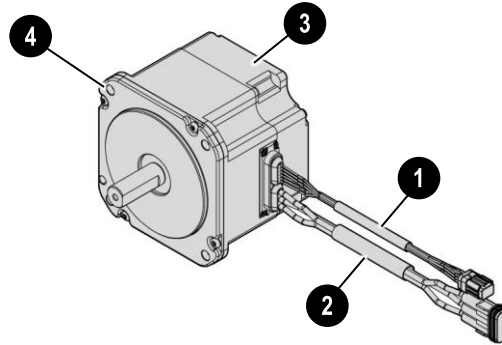
This product is intended for general use.

This product cannot be used for special applications such as medical, military, aerospace, or for in-vehicle equipment.

3 Parts Description

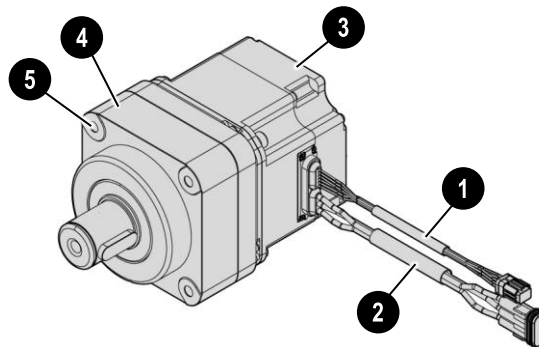
3.1 Motor Parts Description

IR-94BZA

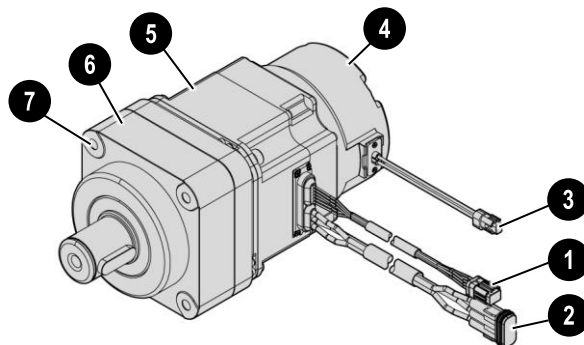


Number	Name	Function/Remarks
1	Motor sensor cable	Connect to CN_C of controller.
2	Motor power cable	Connect to CN_B of controller.
3	Motor	Motor main unit. Equipped with resolver sensor equivalent to 15-bit resolution.
4	Attachment hole ($\phi 5.3 \times 4$ locations)	Attach using M5 screws x 4 (not included). (Through hole)

MR-94BZA



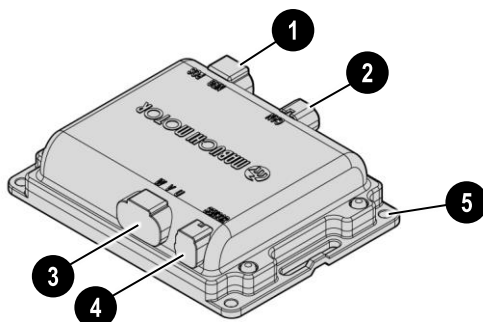
Number	Name	Function/Remarks
1	Motor sensor cable	Connect to CN_C of controller.
2	Motor power cable	Connect to CN_B of controller.
3	Motor	Motor main unit. Equipped with resolver sensor equivalent to 15-bit resolution.
4	Gear reducer	Torque is increased by reducing motor rotation speed. (Speed reduction ratio 10.33)
5	Attachment hole (M6 \times 4 locations)	Attach using M6 screws x 4 (not included).

MR-94BZB

Number	Name	Function/Remarks
1	Motor sensor cable	Connect to CN_C of controller.
2	Motor power cable	Connect to CN_B of controller.
3	Electromagnetic brake cable	Connect to electromagnetic brake power supply.
4	Electromagnetic brake	Electromagnetic brake of the non-exciting actuation type (open operation when on)
5	Motor	Motor main unit. Equipped with resolver sensor equivalent to 15-bit resolution.
6	Gear reducer	Torque is increased by reducing motor rotation speed. (Speed reduction ratio 10.33)
7	Attachment hole (M6 × 4 locations)	Attach to the equipment with M6 screws x 4 (not included).

3.2 Controller Parts Description

DR-40FC1



Number	Name	Function/Remarks
1	CN_A Controller power connection port	Connect controller power cable.
2	CN_D Controller signal (CAN communication) connection port	Connect controller signal cable.
3	CN_B Motor power connection port	Connect motor power cable.
4	CN_C Motor sensor connection port	Connect motor sensor cable.
5	Attachment hole ($\varnothing 4.5 \times 4$ locations)	Attach to a flat metal surface where a good heat dissipation effect can be achieved, using M4 screws x 4 (not included).

4 Installation

4.1 Installation Environment

In order to ensure safety in use and to fully demonstrate the performance of this product, install it in a location that satisfies the following conditions.

Power Supply

- Rated voltage: 24 V, 36 V, 48 V, battery drive ^{*1}
- Operating voltage range: 17 to 60 V ^{*1, 2}
 - *1 These are the controller power supply voltages when using the DR-40FC1 and DR-40FC3.
 - *2 Use within the operating voltage range.

Temperature and Humidity

- Temperature: -10 to 50°C ^{*1, 2}
- Humidity: 20% to 95% RH (with no condensation)
 - *1 Depending on the operating conditions of the motor (mounting condition, load, environmental temperature), heat generation by the motor may increase. Ensure that the temperature does not exceed 100°C.
 - *2 The ambient temperature (motor temperature) when the motor is in use affects its performance and life.

Ambient Conditions

Install and store this product in a location that meets the following conditions.

- Places free of volatile, flammable, corrosive gases and liquids.
- Places not exposed to chemicals used for fumigation.
- Places not exposed to oil.
- Places with no infiltration of combustible foreign matter, or conductive foreign matter such as metal fragments.
- Places where there are no noise radiation sources such as high-frequency furnaces.

4.2 Motor Installation

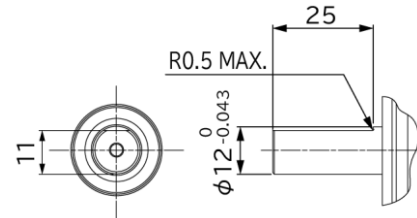
This section describes how to install the motor.

Before starting work, carefully read section “1.2 Safety Precautions.” Start work only after these precautions are well understood.

4.2.1 IR-94BZA installation method

Preparation

For the shaft hole on the load side, refer to the diagram at right, and process to match the D cut dimension.



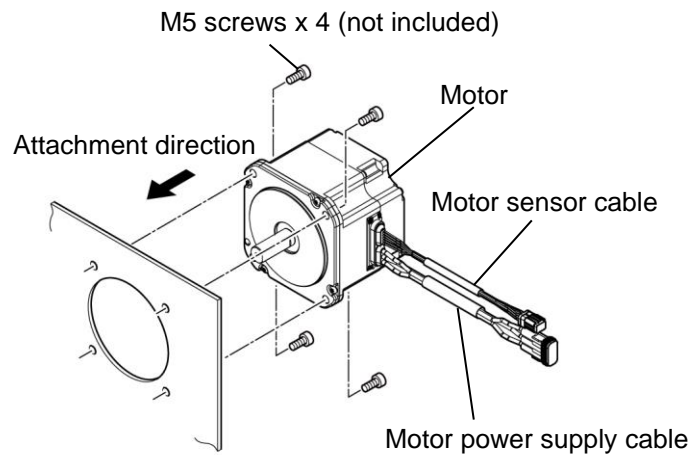
Shaft detail

Installation

- 1) Attach the motor to the attachment surface on the load side.
- 2) Fix the motor with M5 screws x 4 (not included).



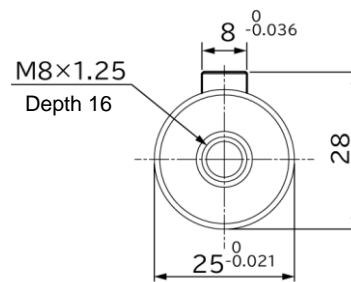
Fasten securely so there is no gap between the motor and attachment surface on the load side.



4.2.2 MR-94BZA/MR-94BZB installation method

Preparation

If there is no key groove in the shaft hole on the load side for attaching the motor output shaft, machine a key groove by referring to the diagram at right.



Shaft detail

Installation

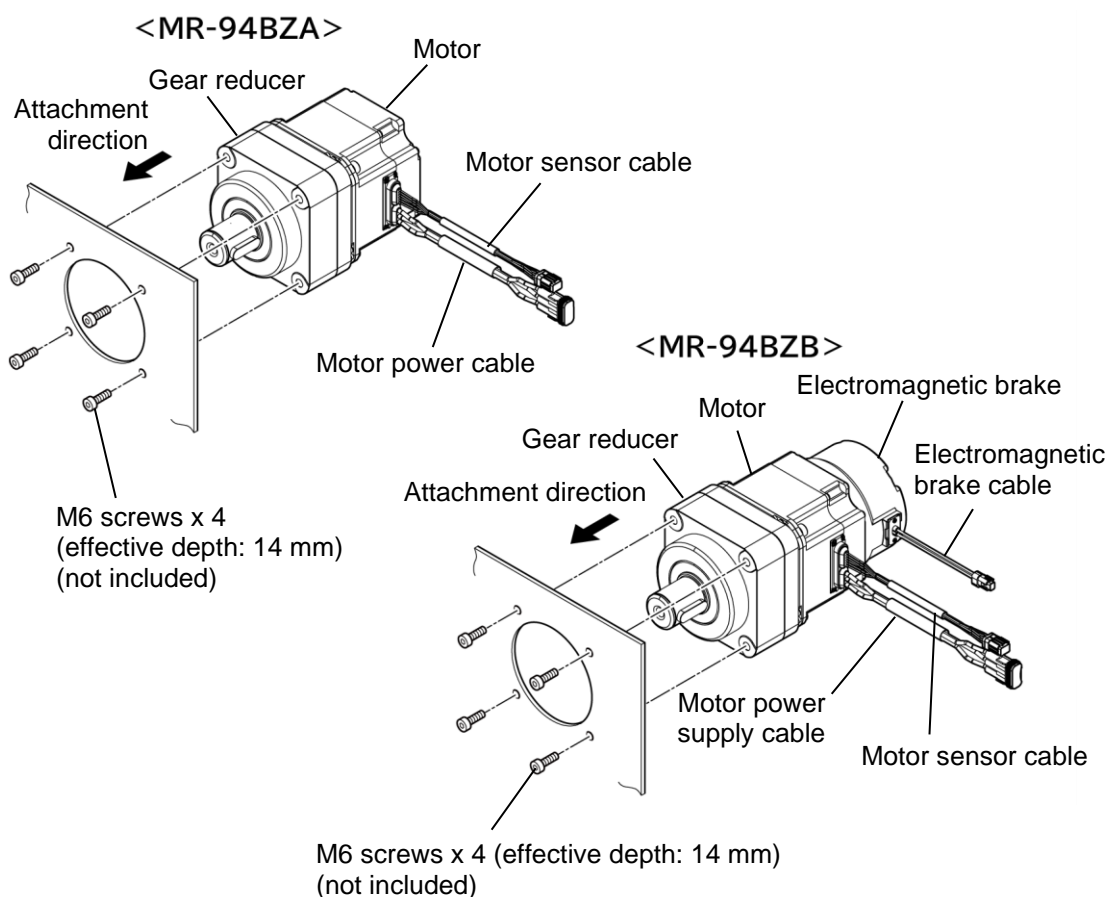
- 1) Attach the motor to the attachment surface on the load side.
- 2) Fix the motor with M6 screws x 4 (not included).



CAUTION



Fasten securely so there is no gap between the motor and attachment surface on the load side.



4.3 Controller Installation

Installation Environment

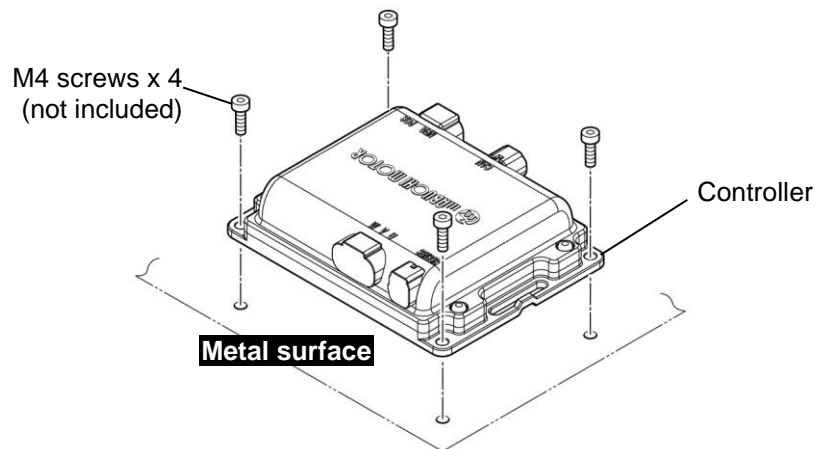
To fully demonstrate the performance of this controller, install it in a location that satisfies “Ambient conditions” in section 4.1 and the following conditions.

Installation method

- 1) Install the controller.
- 2) Fix the controller with M4 screws x 4 (not included).



Fasten securely so there is no gap between the controller and the metal surface.

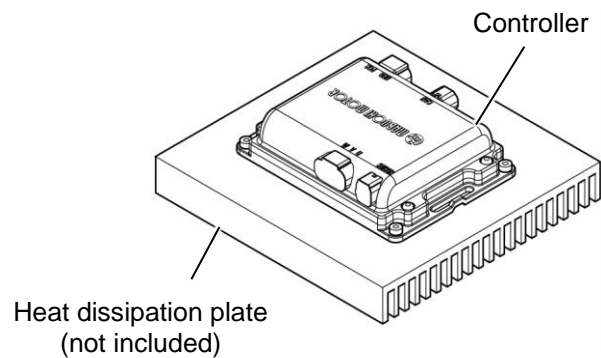


Heat dissipation plate

If the controller generates heat, the torque limiting function will activate.

The activation of torque limiting function can be delayed if a heat dissipation plate (not included) is attached to the aluminum housing part, which is the heat dissipation point of the controller.

Secure a heat dissipation path so the attached plate temperature is 50°C or less.



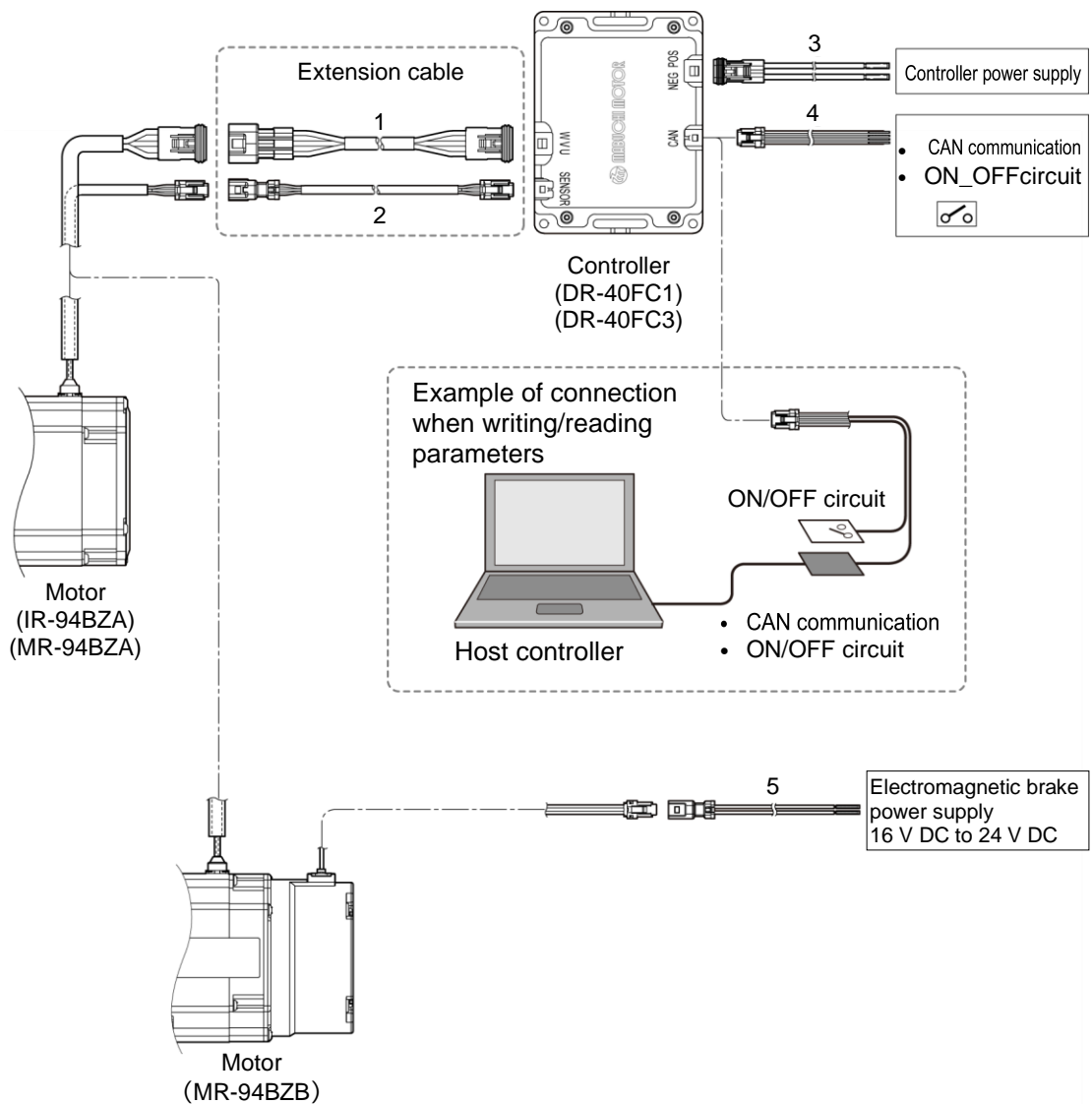
5 Connection

5.1 Connection Specifications

5.1.1 Example of connection between motor and controller

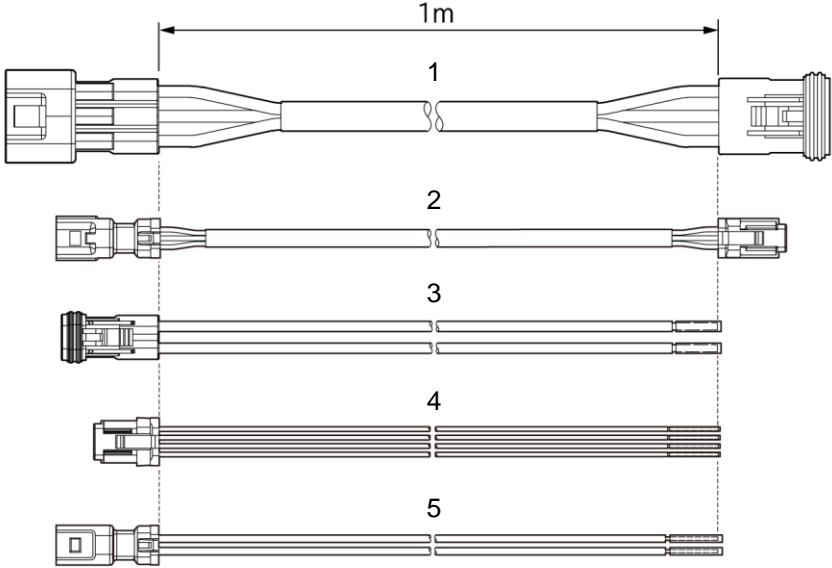


- Cables indicated with numbers are not included and must be purchased separately. For details, see section 5.1.2.
- Before attaching the controller to the machine and starting operation, set parameters to suit that machine.



5.1.2 Parts prepared by the customer

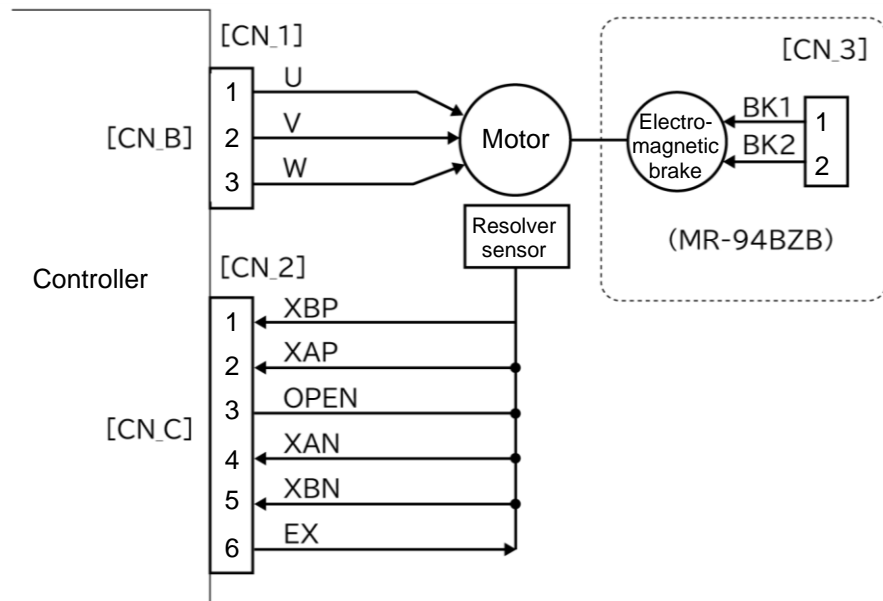
Cables



No.	Cable	Type	Length
1	Motor power extension cable	67-Q22AA	1 m
2	Motor sensor extension cable	67-Q23AA	1 m
3	Controller power cable	41-L11XA	1 m
4	Controller signal cable	41-L12XA	1 m
5	Electromagnetic brake extension cable	41-L15XA	1 m

5.1.3 Functional block diagrams

Motor

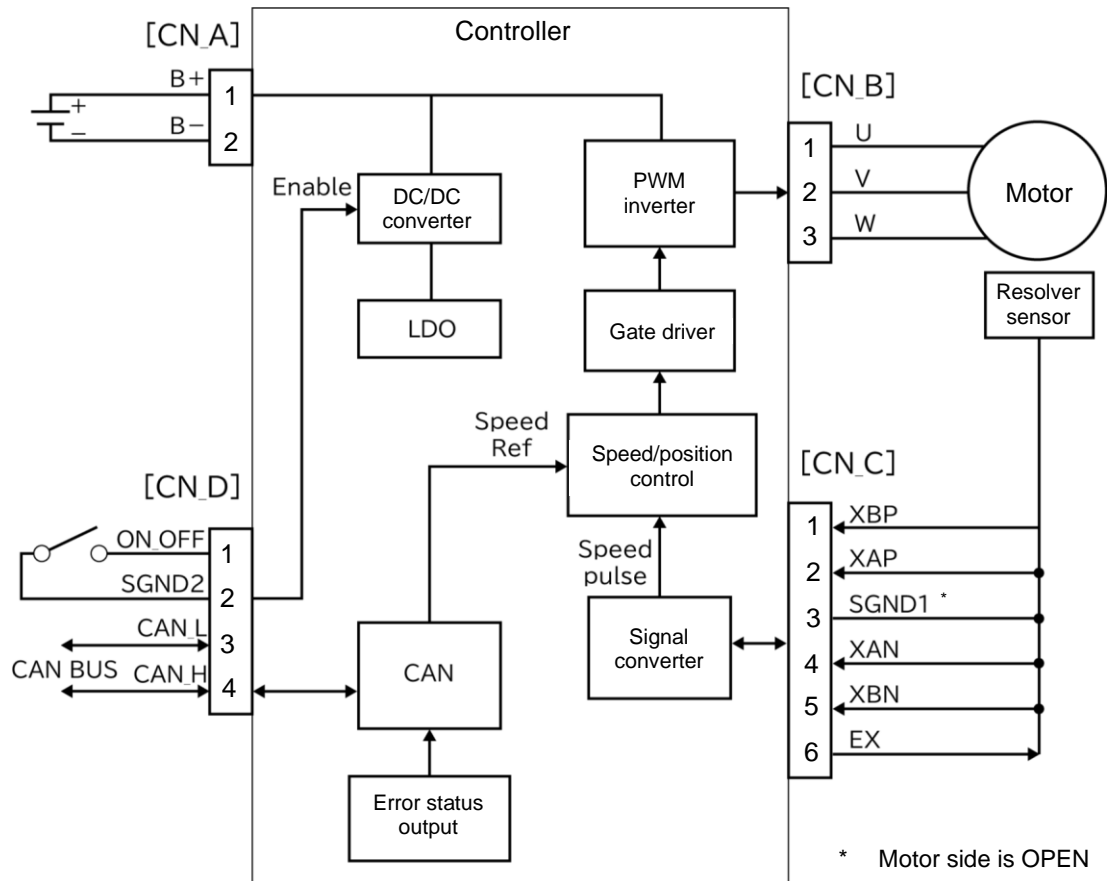


Abbreviations for connector signal names

Connector	No.	Signal name	Abbreviation
CN_1	1	Stator winding: U	U
	2	Stator winding: V	V
	3	Stator winding: W	W
CN_2	1	Resolver detection signal: XBP	XBP
	2	Resolver detection signal: XAP	XAP
	3	Unconnected terminal: OPEN	OPEN
	4	Resolver detection signal: XAN	XAN
	5	Resolver detection signal: XBN	XBN
	6	Resolver excitation signal: EX	EX
CN_3	1	Electromagnetic brake winding*	BK1
	2	Electromagnetic brake winding*	BK2

* The electromagnetic brake winding has no polarity.

Controller



Abbreviations for connector signal names

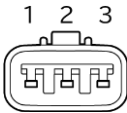
Connector	No.	Signal name	Abbreviation
CN_A	1	Battery input: +	B+
	2	Battery input: -	B-*
CN_B	1	Stator winding: U	U
	2	Stator winding: V	V
	3	Stator winding: W	W
CN_C	1	Resolver detection signal: XBP	XBP
	2	Resolver detection signal: XAP	XAP
	3	Signal ground 1 (motor side is OPEN)	SGND1*
	4	Resolver detection signal: XAN	XAN
	5	Resolver detection signal: XBN	XBN
	6	Resolver excitation signal: EX	EX
CN_D	1	ON_OFF signal input terminal	ON_OFF
	2	Signal ground 2	SGND2*
	3	CAN communication line: CANL	CAN_L
	4	CAN communication line: CANH	CAN_H


* B-, SGND1, and SGND2 are connected inside the controller and are not insulated.

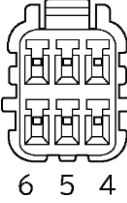
5.2 Connections between Motor and Controller

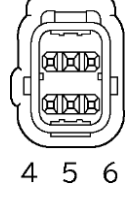


Do not apply tension to the motor power cable or motor sensor cable.

CN_1	Connector shape: Conforms to CL07D03A made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	U	Motor power supply	Red
	2	V		Blue
	3	W		Black

CN_B	Connector shape: Conforms to CL07D03M made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	U	Motor power supply	Red
	2	V		Blue
	3	W		Black

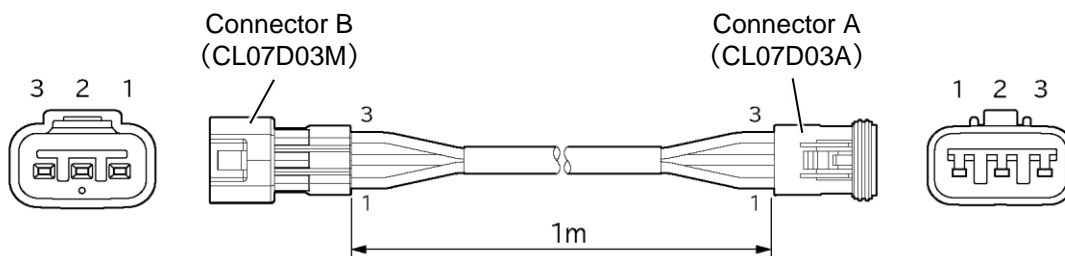
CN_2	Connector shape: Conforms to CA01A6-06B0 made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	XBP	Motor sensor signal	Red
	2	XAP		Green
	3	OPEN	Signal ground	Black
	4	XAN	Motor sensor signal	Brown
	5	XBN		Yellow
	6	EX	Sensor drive	White

CN_C	Connector shape: Conforms to CA01A5-06B0 made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	XBP	Motor sensor signal	Red
	2	XAP		Green
	3	SGND1	Signal ground	Black
	4	XAN	Motor sensor signal	Brown
	5	XBN		Yellow
	6	EX	Sensor drive	White

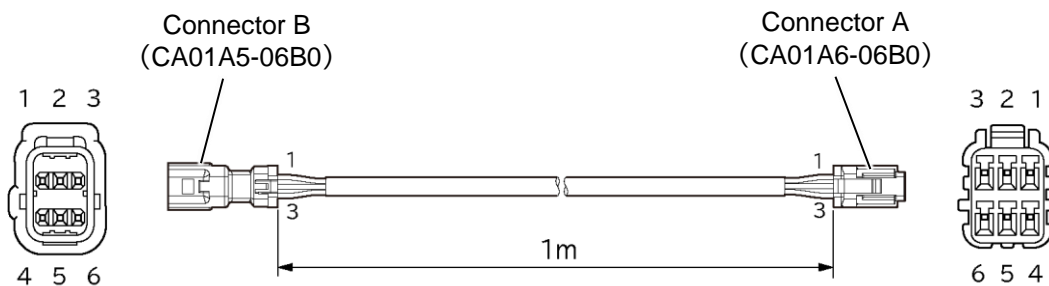
Connection method

- 1) Connect [CN_1] of the motor power cable to [CN_B] (WVU) of the controller.
If an extension is necessary, use the motor power extension cable (67-Q22AA).
 - Maximum extension distance (motor power cable + extension cable): 2 m
- 2) Connect [CN_2] of the motor sensor cable to [CN_C] (SENSOR) of the controller.
If an extension is necessary, use the motor sensor extension cable (67-Q23AA).
 - Maximum extension distance (motor sensor cable + extension cable): 2 m

<Motor power extension cable: 67-Q22AA>



<Motor sensor extension cable: 67-Q23AA>



5.3 Connection of Motor and Electromagnetic Brake (MR-94BZB)



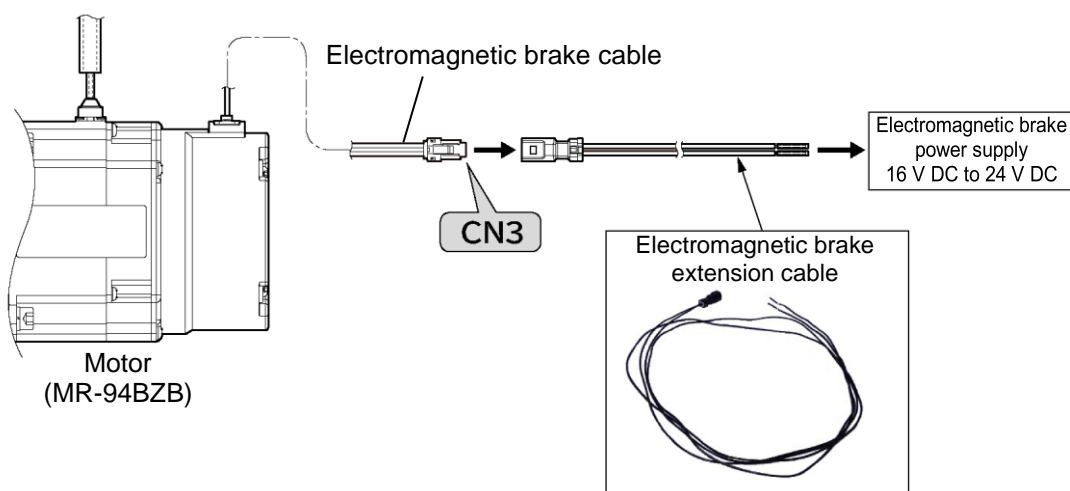
WARNING

Do not use the electromagnetic brake for braking. Handling methods for when an abnormality occurs should be prepared separately by the customer.



CAUTION

- Before actuating the electromagnetic brake, check that the output shaft of the motor is stopped. Failure to do so poses a risk of damage to the electromagnetic brake.
- Apply voltage to the electromagnetic brake to release before starting the motor. To stop the motor, shut off the electromagnetic brake voltage after rotation stops, and actuate the electromagnetic brake.



CN3	Connector shape: Conforms to CB01A6-02B0-02 made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	BK1	Circuit power supply	Black
	2	BK2		Black

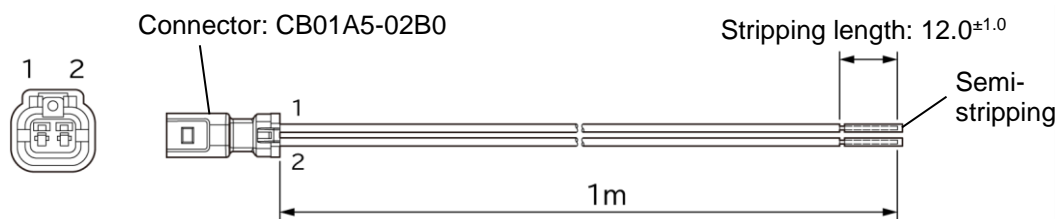
* The electromagnetic brake winding has no polarity.

Connection method

Connect the electromagnetic brake cable to the electromagnetic brake power supply.
If an extension is necessary, use the electromagnetic brake extension cable (41-L15XA).


- Maximum extension distance (electromagnetic brake cable + extension cable): 2 m
- The electromagnetic brake cannot be controlled with the controller (DR-40FC1).
- The electromagnetic brake power supply has no polarity, but be sure to use a direct current (DC) power supply.
- Braking (brake actuation) of the electromagnetic brake is released when turned on. (Non-exciting actuation type)
- Provide control so that braking is not applied at motor startup or during rotation.
- The electromagnetic brake is an inductive load. Provide a protection circuit if necessary.


<Electromagnetic brake extension cable: 41-L15XA>




5.4 Connection of Controller and Power Supply


5.4.1 Preparation and checking before connecting power supply

- 

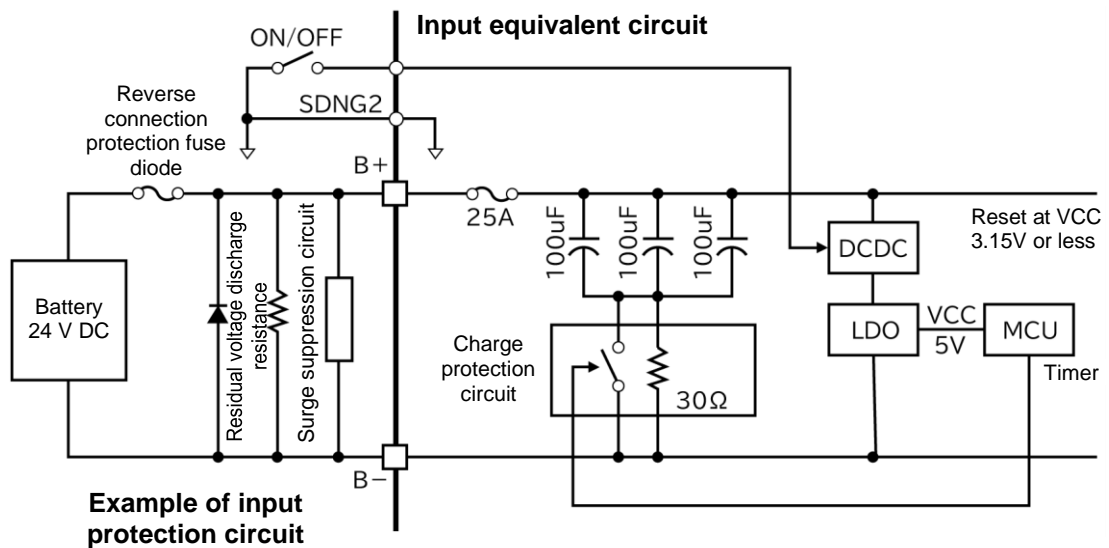
 - Do not connect the battery in reverse.
The circuits of this controller are not equipped with protection against battery reverse connection. There is a risk of controller damage if there is reverse connection.
- 

 - If there is discharge of electric charge accumulated in a capacitor of the controller circuit when the battery is cut off, add an external discharge resistance.
Current consumption between the B+ and B- terminals during standby is kept low at 2 mA or less (with 48 V).
- 

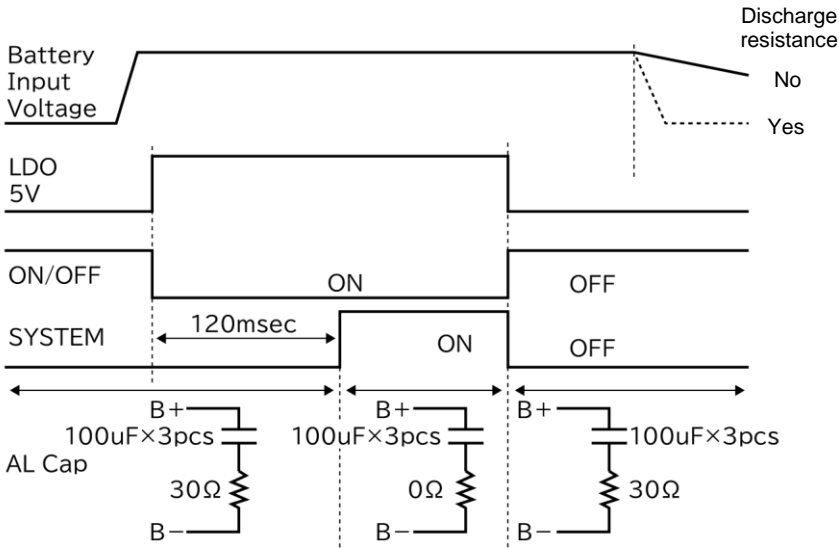
CAUTION

 - If there may be influx of a surge voltage of 60 V or more when the battery is connected, add a surge suppression circuit.
 - A circuit for limiting capacitor charging current during voltage input is connected to this circuit board to prevent damage to the fuse (rated 25 A) on the board.
 - An electrolytic capacitor is connected in series to a 30 Ω resistance until LDO: 5 V starts up, and the internal system boots up 120 msec later.
 - When the internal system starts up, the 30 Ω resistance is shorted.
 - Until the system in the circuit starts up, the input capacity is low, and surge voltage cannot be adequately absorbed.
- 

Input equivalent circuit



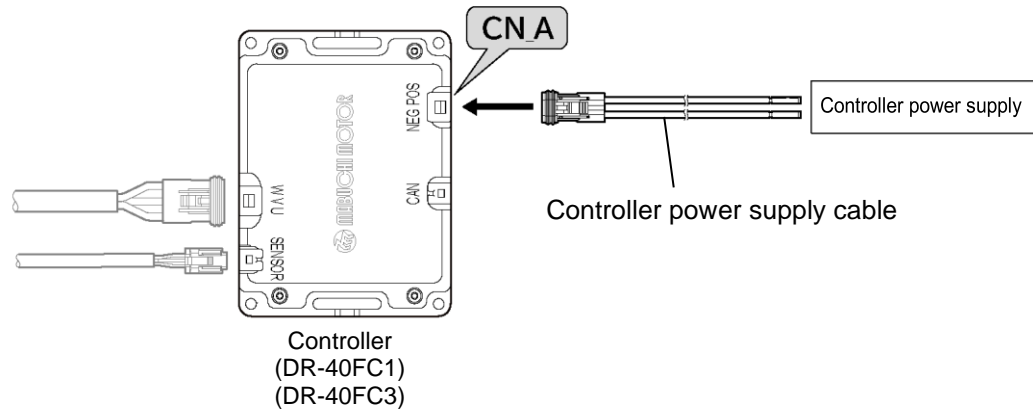
Change in connection of electrolytic capacitor



5.4.2 Method of connecting power supply

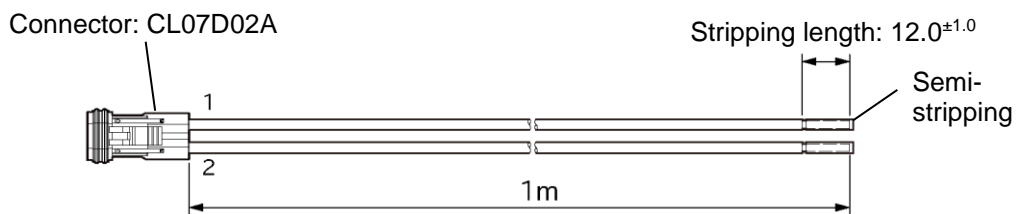


Before connecting, check polarity of the controller power supply, and be sure to connect correctly.
There is a risk of controller damage if polarity is reversed.



CN_A	Connector shape: Conforms to CL07D02M made by Sumiko Tec			
	ID	Signal name	Function	Line color
	1	B+	Circuit power supply	Red
	2	B-		Black

<Controller power cable: 41-L11XA>



Connection method

Connect the controller power cable to [CN_A] (B+ B-) of the controller.

Points to check

If wiring of the main power supply or motor power lines is long or thin, motor torque will drop due to wiring impedance. When selecting a motor, ensure an adequate margin in terms of acceleration/deceleration torque, and check in the final product state.

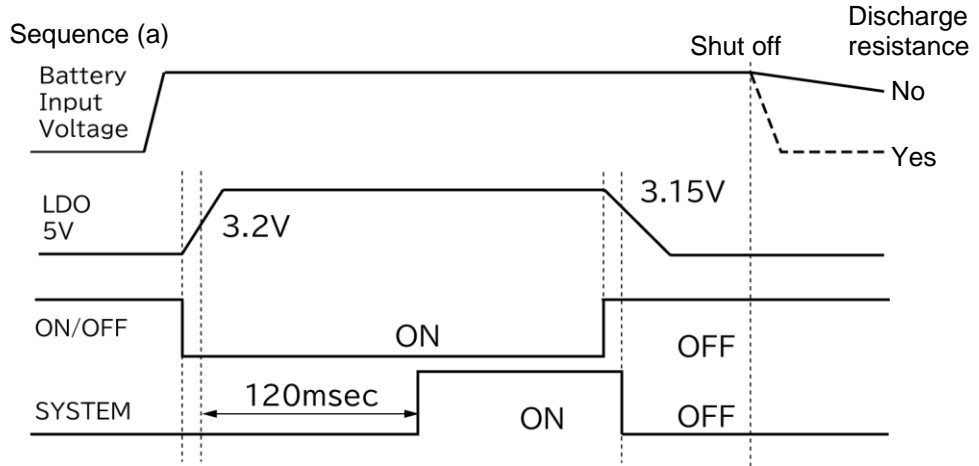
5.4.3 Controller startup and stopping



If an abnormality occurs at the controller, immediately set the ON_OFF terminal to open (set the system to the standby state), stop the system, and turn off the supply of power to the controller.

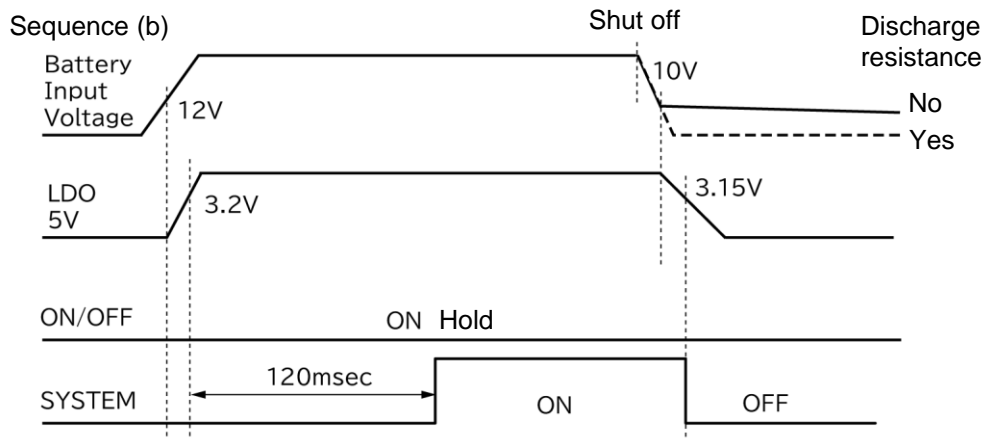
Starting and stopping using ON_OFF terminal

After connecting the controller to the power supply, set the ON_OFF terminal to ON. The timing chart for controller startup and stopping using the ON_OFF terminal is indicated below.



Startup and stopping when ON_OFF terminal has been turned ON

Connect the controller to the power supply when the ON_OFF terminal has been set to ON. The following shows the timing chart for controller startup and stopping when the ON_OFF terminal has been set to ON before power supply connection.

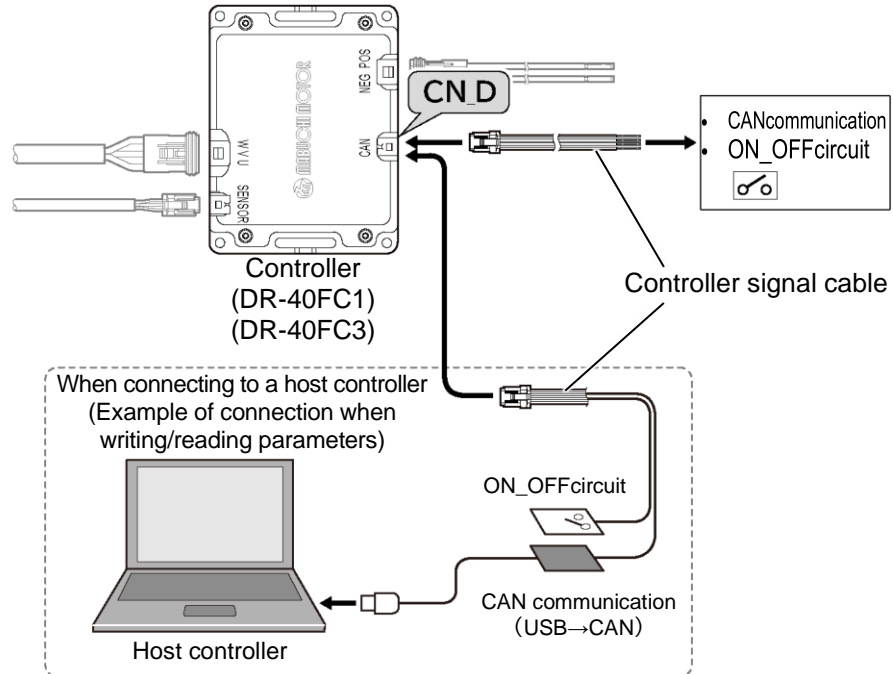


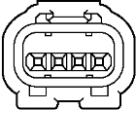
5.5 Connection of Controller and Input/Output Signals



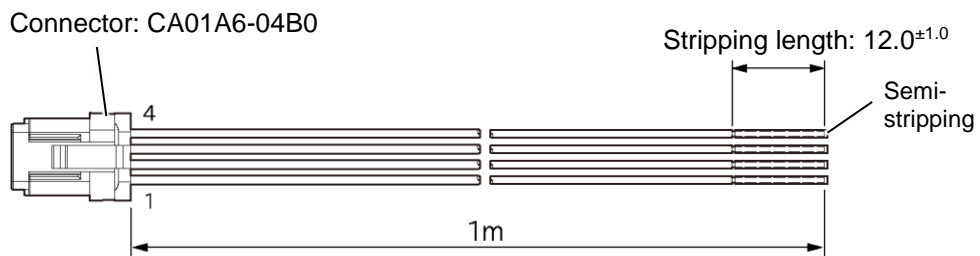
When connecting the controller signal cable to the terminal, be careful that it is not exposed to moisture.

The semi-stripped (stripped) side of the controller signal cable does not have a waterproof structure.



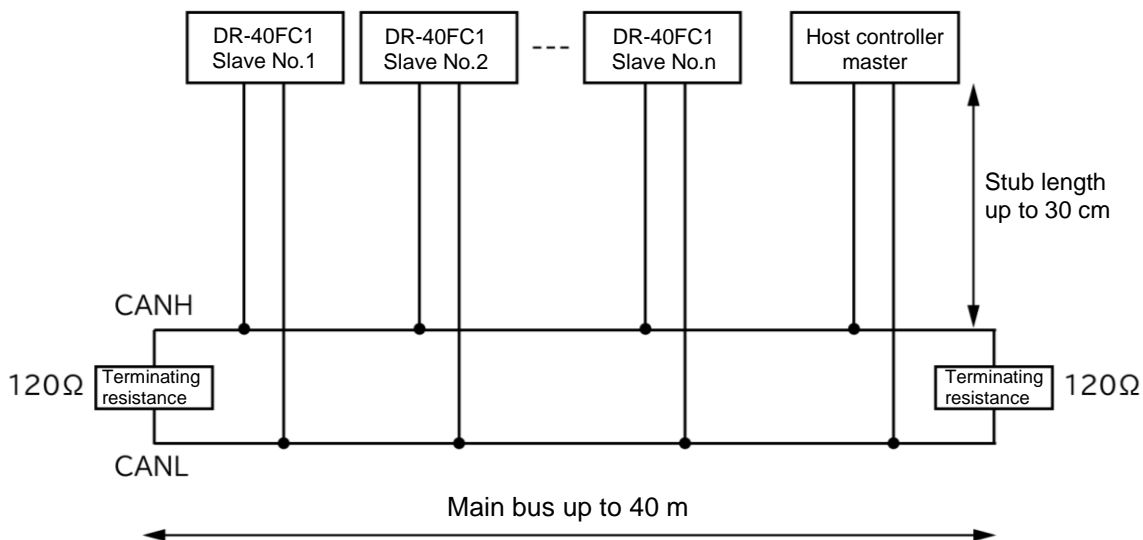
CN_D	Connector shape: Conforms to CA01A6-04B0 made by Sumiko Tec			
	ID	Signal name	Function	Line color
1 2 3 4 	1	ON_OFF	ON_OFF switch circuit	Orange
	2	SGND2	Signal ground	Black
	3	CAN_L	CAN_L signal	Brown
	4	CAN_H	CAN_H signal	Blue

<Controller signal cable: 41-L12XA>



Position of terminating resistance

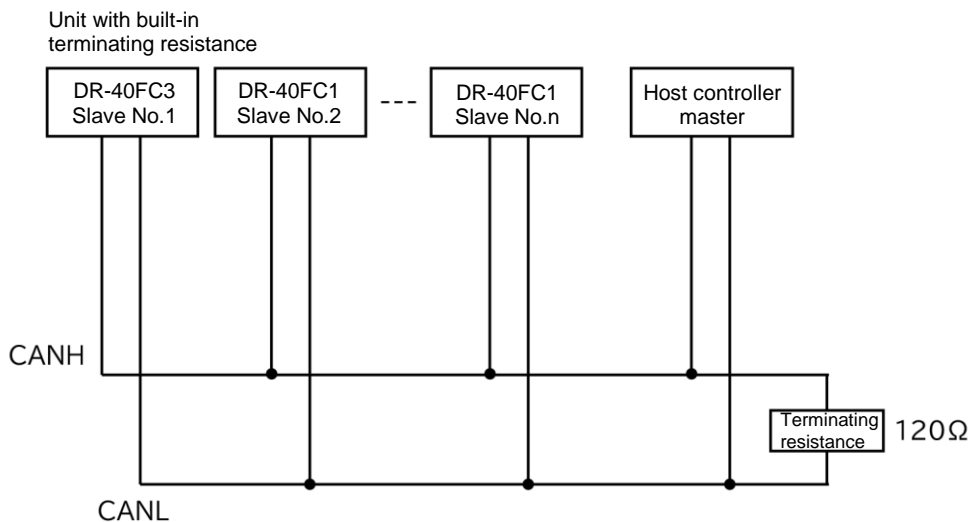
<Requirements for CAN communication>



- Two terminating resistances (at a minimum one) are needed, regardless of the number of slaves.
- The host controller cannot be stopped by a communications error.
- Connect the host controller ground level to the same level as the battery ground.




Example of wiring using DR-40FC3

The external terminating resistance can be eliminated by using the DR-40FC3 with built-in terminating resistance.



5.6 Controller ON_OFF Signal, CAN Communication Circuit

5.6.1 ON_OFF signal input circuit

-
- 


- If an abnormality occurs at the controller, immediately set the ON_OFF terminal to open (set the system to the standby state), stop the system, and turn off the supply of power to the controller.
 - Do not use in applications where power goes on and off frequently.
-

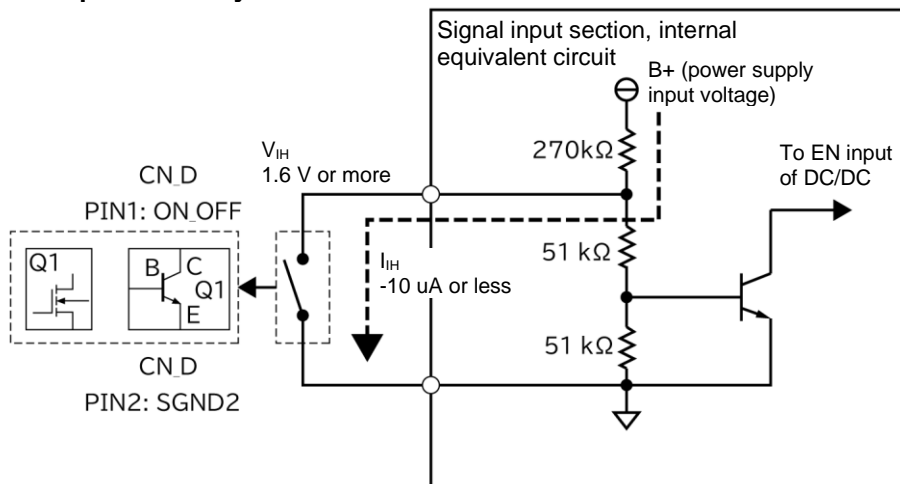
Only an open collector (NPN type), open drain (N channel) or mechanical contact switch can be connected to the ON_OFF terminal.

- CND_Pin: ON_OFF signal input terminal
- System active: Pin1–Pin2 = short or low level
- System standby: Pin1–Pin2 = open or high level

Category	Item: Symbol	Condition	Minimum	Standard	Maximum	Unit
System Active	ON_OFF terminal Voltage threshold: V_{IL}	Power supply voltage: 17 to 60 V	-0.3		0.3	V
	ON_OFF terminal Input current: I_{IL}	Power supply voltage: 17 to 60 V			-300	μA
System Standby	ON_OFF terminal Voltage threshold: V_{IH}	Power supply voltage: 17 to 60 V	1.6			V
	ON_OFF terminal Input current: I_{IH}	Power supply voltage: 17 to 60 V			-10	μA

ON_OFF signal, internal equivalent circuit

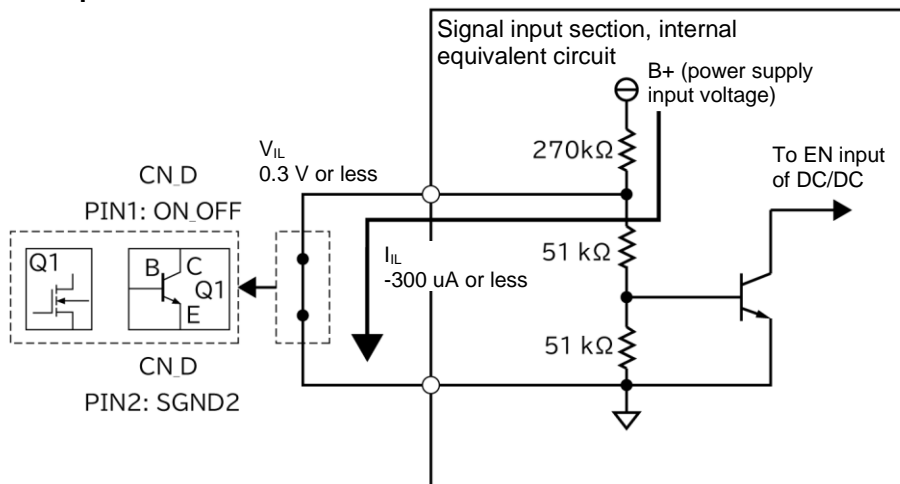
<Pin1-Pin2 = Open: Standby>



Specs when Q1 is OFF:

- Set Q1 or switch leak current to 10 uA or less.

<Pin1-Pin2 = Open: Active>



Specs when Q1 is ON:

- Terminal voltage VCE, VDS: 0.3 V or less
- When connecting a protection resistance to the output signal line, set to 0.3 V or less including the voltage drop of the resistance.

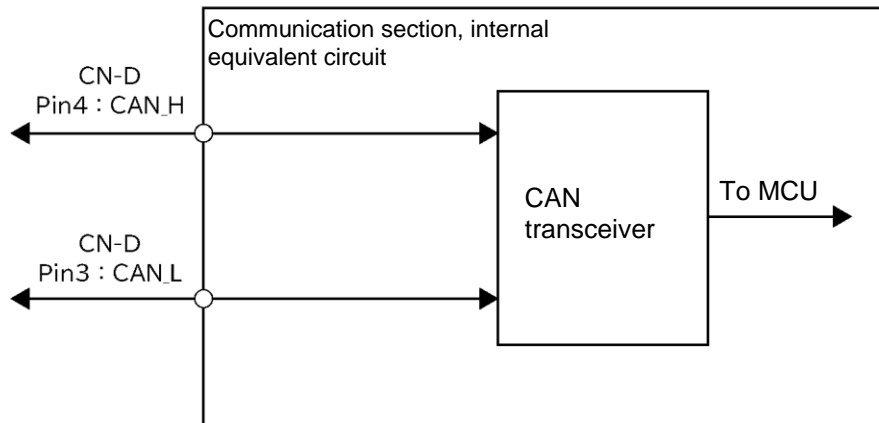
5.6.2 CAN communication circuit

No.	Item	Description
1	Communication system	CAN communication (high-speed CAN compatible)* Conforms to CAN 2.0B
2	Signal connection terminal	CN_D Pin4: CAN High level signal CN_D Pin3: CAN Low level signal
3	Communication speed	500 kbps
4	Terminating resistance between lines	DR-40FC1: No DR-40FC3: Yes (124 Ω)

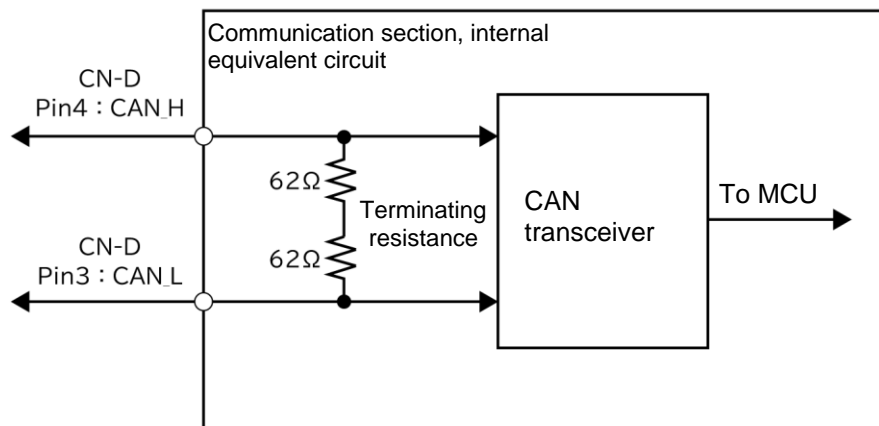
* Conforms to ISO11898-2

CAN communication, internal equivalent circuit

DR-40FC1



DR-40FC3



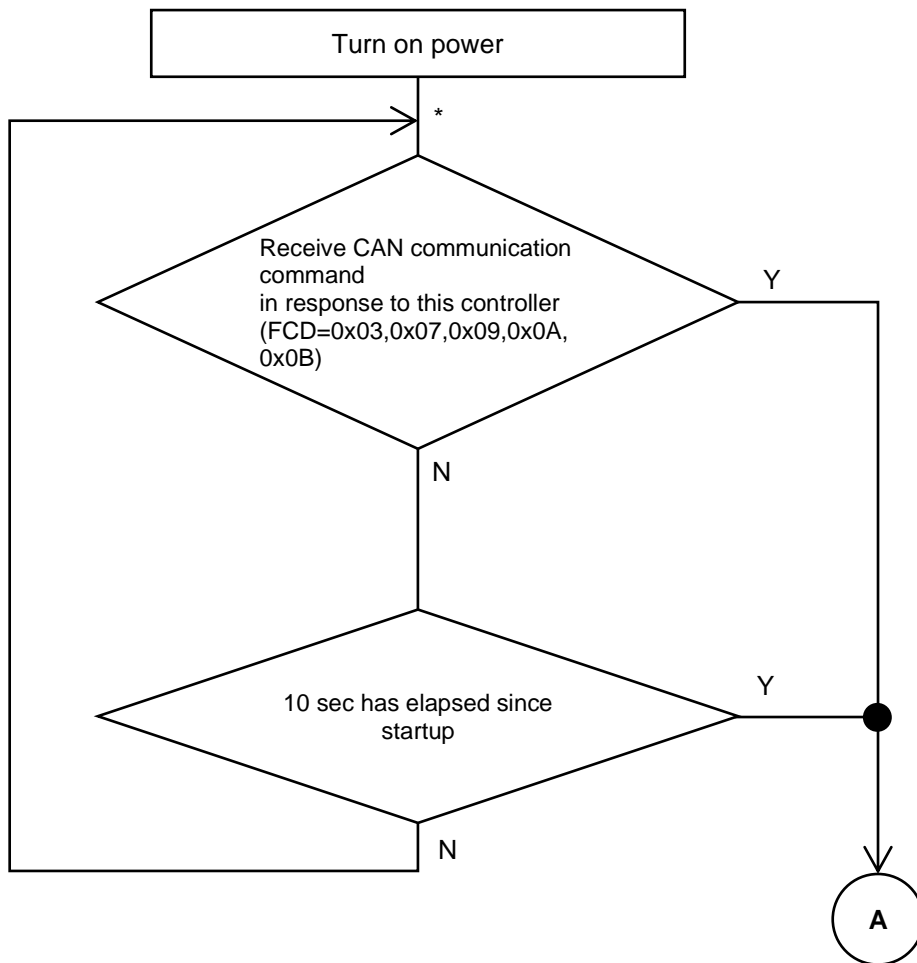
5.7 Ground

This product does not require a ground, but as a measure to counteract static electricity, install the motor and controller in the same metal housing.

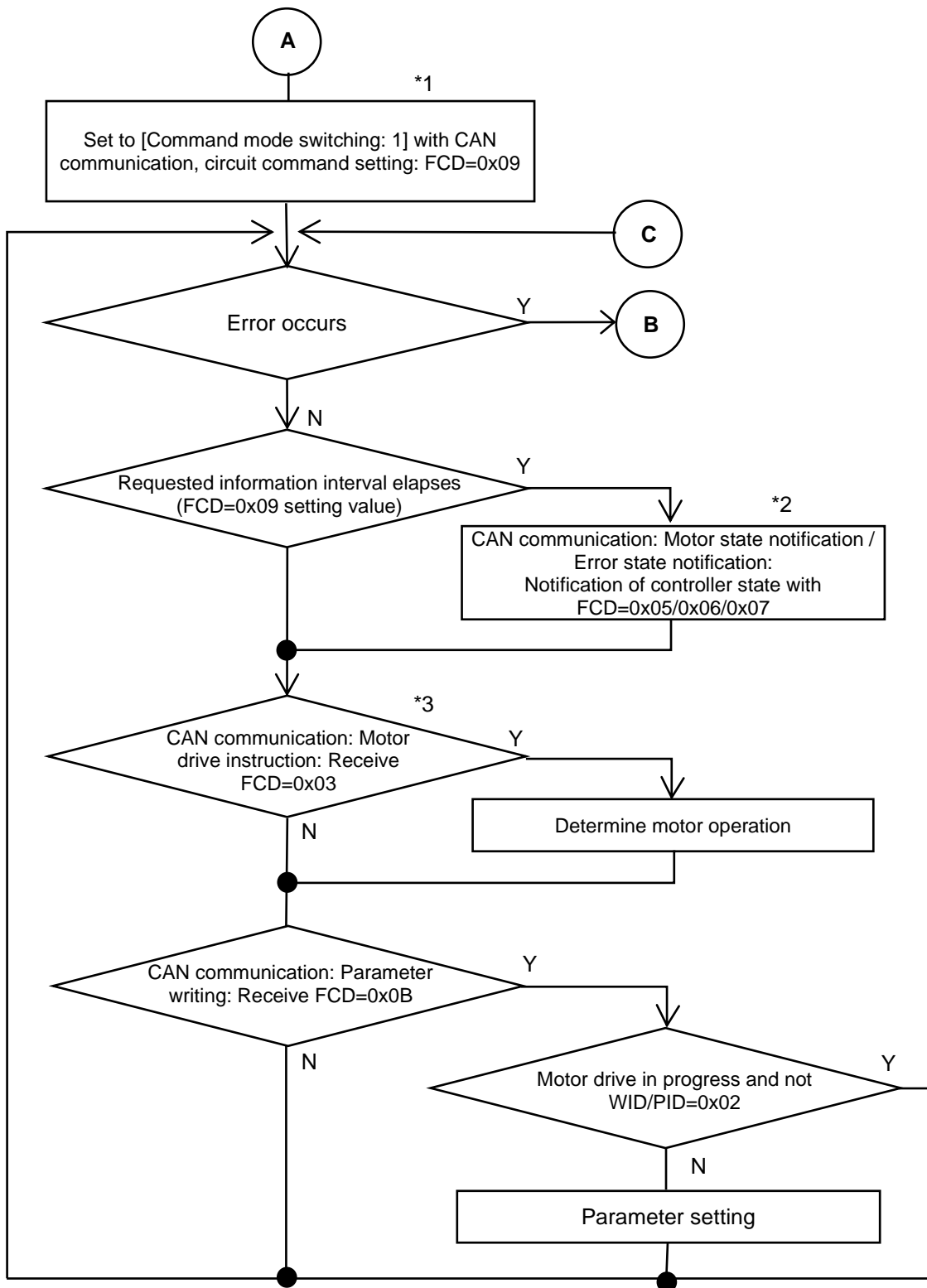
6 Operation Flowcharts

This section describes the flow of operation separately for ordinary operation and when an error occurs.

6.1 Flowchart for Ordinary Operation

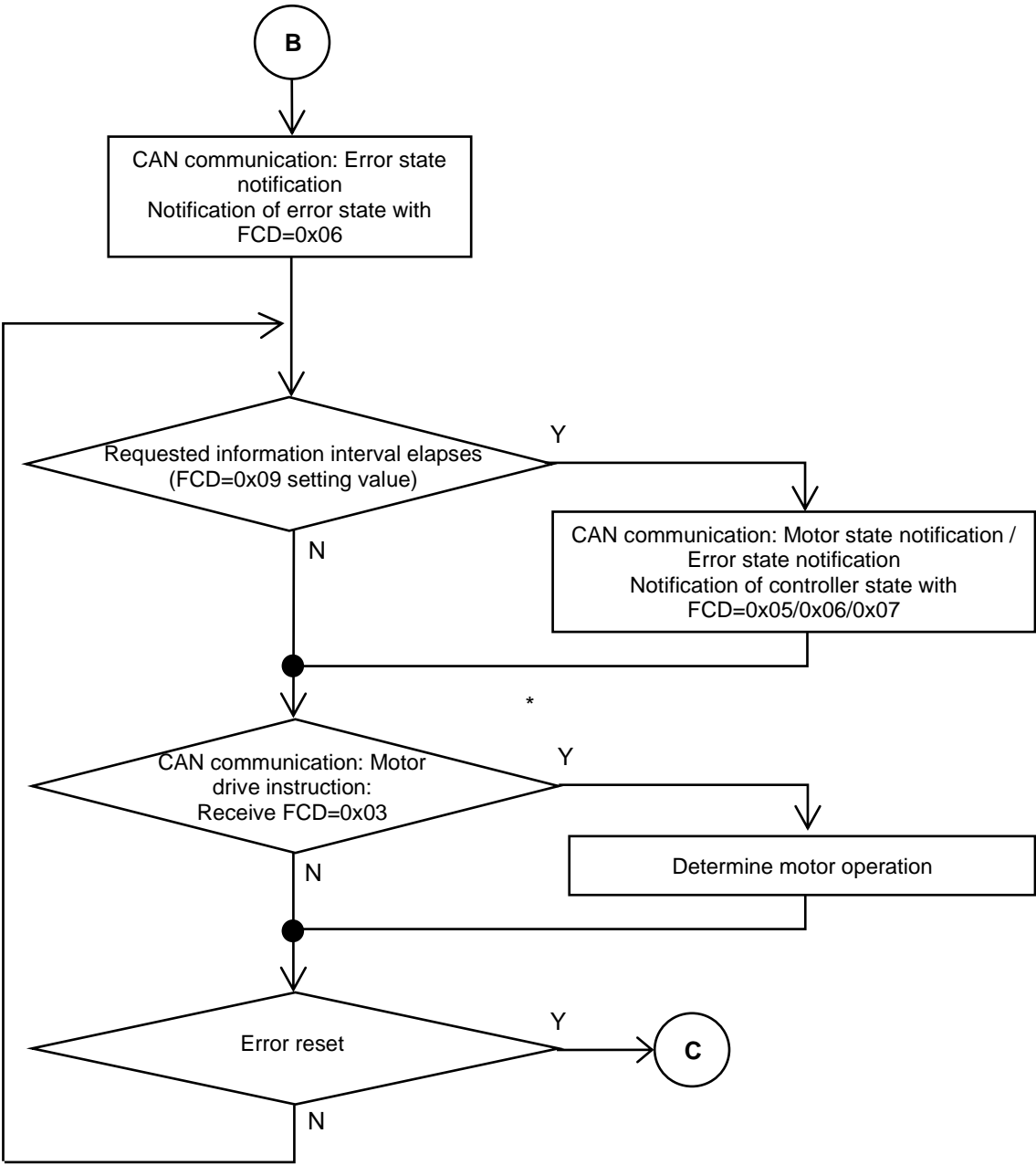


- * Start communication after turning on power, and leaving an interval of 0.3 sec or more after system startup.



- *1 This setting is unnecessary when the startup interface has been set to CAN with "Parameter write request [FCD=0x0B], WID=0x11".
- *2 For 0x05/0x06/0x07, communication is done continuously.
- *3 Issue commands with a 0.001 to 0.5 second cycle. (If an interval of 0.5 sec or more is left open, a CAN communication error will result.)

6.2 Flowchart When an Error Occurs



* Issue commands with a 0.001 to 0.5 second cycle. (If an interval of 0.5 sec or more is left open, a CAN communication error will result.)

7 CAN Communication Setting

7.1 CAN ID Setting Rules

- Composition of CAN communication ID
 - Higher-order 4 bits: Function code
 - Lower-order 7 bits: Node device ID
- Function code (=FCD): Function identification no.
- Node device ID (=NID): Individual identification no. when using multiple units

<CAN ID setting>

Function code				Node device ID								
MSB	11	10	9	8	7	6	5	4	3	2	1	LSB

<Function code allocation>

Code	Description
0x03	Motor drive instruction
0x05	Drive state notification 1
0x06	Error state notification
0x07	Drive state notification 2
0x09	Controller setting
0x0A	Flag setting
0x0B/0x0C	Parameter setting

<Setting example>

The following shows an example of setting CAN IDs for issuing drive instructions to the circuit for motor R, when the settings of the node device IDs * are as indicated in the following table and two motors are being used.

ID	Specified device
0x01 (Default)	Circuit for motor L
0x02	Circuit for motor R

* The node device ID can be set with WID (=0x10) of parameter writing (=0x0B).
For details, see "7.4 Setting Content for WID/PID Signals."

- Example of setting CAN ID when issuing drive instruction to circuit for motor R:
FCD(0x03) * 0x80 + NID(0x02) = 0x182

7.2 List of CAN Communication Setting/Read Functions

- CAN ID=0x7E0 and 0x7E1 are used for reprogramming via CAN. Be sure to secure a CAN ID.
- Data made up of two bytes or more is represented with MSB first. In CAN communication, sending is done in the order: higher-order byte / lower-order byte.

CAN communication, communication setting/read function ^{*4, *5}										
Function	Direction ^{*1}	FCD [CAN ID] ^{*2}	Data content							
			1 byte	2 bytes	3 bytes	4 bytes	5 bytes	6 bytes	7 bytes	8 bytes
Motor drive instruction	R	0x03 [0x181,0x182]	Operation state setting	Operation speed setting		Acceleration setting		Current limit value		
Reserved ^{*3}	–	0x04 [0x201,0x202]	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Drive state notification 1	S	0x05 [0x281,0x282]	Motor speed		Current		Torque		Board temperature 1	Reserved
Error state notification	S	0x06 [0x301,0x302]	Error code		Warning code					
Drive state notification 2	S	0x07 [0x381,0x382]	Movement distance				DC voltage		Reserved	Board temperature 2
Reserved ^{*3}	–	0x08 [0x401,0x402]	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Controller setting	R	0x09 [0x481,0x482]	Command mode	Communication request	Requested information interval	Reserved	Reserved	Reserved		
Flag setting	R	0x0A [0x501,0x502]	Reset setting	Reserved						
Parameter writing/reading request	R	0x0B [0x581,0x582]	Data length	Writing/reading identification no.	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
Parameter writing/reading result reply	S	0x0C [0x601,0x602]	Data length	Correctness judgment	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5

*1 The direction of notification from the controller to the external device is indicated by S, and the direction of receiving instructions from the external device is indicated by R.

*2 An example is shown for the case where the [CAN ID] is set to node device 0x01 and 0x02.

*3 Secure the CAN IDs FCD=0x04 and 0x08 for expansion use.

*4 CAN ID=0x7E0 and 0x7E1 are used for reprogramming via CAN, so secure the CAN IDs.

*5 Data made up of two bytes or more is represented with MSB first. In CAN communication, sending is done in the order: higher-order byte / lower-order byte.

FCD	Data	Type	Unit	Resolution	Offset
0x03	Operation speed setting	unsigned	r/min	1	0
	Acceleration setting	unsigned	r/min/s	1	0
	Current limit value	unsigned	0.1 Apeak	1	0
0x05	Motor speed	signed	r/min	1	0
	Current value	signed	0.01 Atmd	1	0
	Torque	signed	0.01 Nm	1	0
	Board temperature 1	signed	°C	1	0
0x07	Movement distance	signed	1/8000 rotation	1	0
	DC voltage	unsigned	0.1 V	1	0
	Board temperature 2	unsigned	°C	1	0
0x09	Requested information interval	unsigned	ms	10	10

7.3 Reading/Setting Content for CAN Communication

Motor drive instruction [FCD=0x03]

Item	Setting content		Default value
Operation state setting	1 bit	<ul style="list-style-type: none"> 0: Motor stop^{*2} 1: Motor drive 	0
	2 bits	<ul style="list-style-type: none"> 0: CCW drive 1: CW drive 	0
	3 to 8 bits	<ul style="list-style-type: none"> –: Setting value disabled 	0
Operation speed setting	Motor operation speed command: 0 to 4,000 r/min ^{*1}		0
Acceleration setting	Acceleration command: 0 to 32,767 r/min/s ^{*1}		0
Current limit value	Set the current limit value setting [Apeak] x10 Setting range: 0 to 370 [0.1 Apeak]		0

*1 When the setting is at or above the setting range, this is set to the upper limit value.
When the setting is at or below the setting range, this is set to the lower limit value.

*2 Motor stop is the state where the six FETs that correct 3-phase inverter output are all off, and power to the motor is turned off.

Drive state notification 1 [FCD=0x05]

Item	Reading content	Data range
Motor speed*	Notification of motor rotation speed [r/min] <ul style="list-style-type: none"> + value: CCW direction - value: CW direction 	-32768 to 32767
Current value *	Notification of motor supply phase current [Arms] × 100 <ul style="list-style-type: none"> + value: Motor supply current - value: Motor regenerative current 	-32768 to 32767
Torque*	Notification of motor output torque [Nm] × 100 <ul style="list-style-type: none"> + value: Torque in specified rotation direction - value: Torque in opposite of specified rotation direction 	-32768 to 32767
Board temperature 1*	Notification of board (motor output circuit) temperature [°C]	0 to 255

* When an IC error occurs (detection of abnormality of internal IC), notification is provided of the abnormal value.
When there is notification of an IC error, do not use the notified value in the table.

Error state notification [FCD=0x06]

Item	Reading content	Data range
Error code	Sending of error state* <ul style="list-style-type: none"> 0: No error Other than 0: Error 	–
Warning code	Sending of warning state* <ul style="list-style-type: none"> 0: No warning Other than 0: Warning 	–

* For details, see “8.1 Error Codes” and “8.2 Warning Codes.”

Drive state notification 2 [FCD=0x07]

Item	Reading content	Data range
Motor running distance [rotation/8000]	Count + when moving in the CCW direction and - when moving in the CW direction for each 1/8,000 rotations ^{*1, *2}	-2147483648 to 2147483647
DC voltage	Notification of input DC voltage[V]x10	0 to 700
Board temperature 2	Notification of board (power input circuit) temperature [°C]	0 to 255

*1 Count continues with the - maximum value when there is overflow, and the + maximum value when there is underflow.

*2 Movement distance is reset when power is turned off.

Controller setting [FCD=0x09]

Item	Setting content	Default value
Command mode	• 1: CAN communication command mode	1 ^{*1, *2, *4}
Communication request	• 0: No request • 1: Request to send drive state	1 ^{*2, *3, *4}
Requested information interval	Drive state sending interval setting: (Setting value +1) x10 [msec]	1 ^{*4}

*1 In the CAN communication command mode, provide the motor drive instruction [FCD=0x03] at a cycle of 0.5 sec or less.

If there is no drive instruction for 0.5 sec or more, there is determined to be a CAN communication line disconnection, and an error stop occurs.

If the interval is less than 0.5 sec, there will be no communication error even if the cycle changes.

*2 The value when power is turned on can be set with WID [=0x11] of parameter writing [=0x0B].

• When WID[=0x11] has been set to [0]: Command mode: 1, Communication request: 0

• When WID[=0x11] has been set to [1]: Command mode: 1, Communication request: 1

*3 For details, see “6 Operation Flowcharts.”

*4 Settings are saved even when power is turned off.

Flag setting [FCD=0x0A]

Item	Setting content	Default value
Reset setting	1 bit	• -: Setting value disabled 0
	2 bits	• 0: Disabled • 1: Movement distance reset 0*
	3 to 8 bits	• -: Setting value disabled 0

* When [1] is sent, the count is reset immediately after it is received.

Parameter writing/reading request [FCD=0x0B]

Item	Setting content	Default value
Data length	Effective data length among data 1 to 5 (0 to 5 bytes)	-
Writing/reading identification no.	• 0x3B: Writing • 0x21: Reading	-
WID/PID	Writing/reading identification data no.*	-
Data 1 to 5	Writing data content	-

* For details, see “7.4 Setting Content for WID/PID Signals.”

Parameter writing/reading result reply [FCD=0x0C]

Item	Reading content	Default value
Data length	Effective data length among data 1 to 5 (0 to 5 bytes)	–
Writing/reading success judgment	<ul style="list-style-type: none">• 0x7B: Writing success• 0x61: Reading success• 0x7F: Abnormality received	–
WID/PID	Writing/reading identification data no.*	–
Data 1 to 5	Reading data content	–

* For details, see “7.4 Setting Content for WID/PID Signals.”

7.4 Setting Content for WID/PID Signals

WID/PID indicates a number for identifying the content used when there is a parameter writing/reading request, or response.

- WID: ID for writing
- PID: ID for reading

WID PID	Data length	Data name	Data placement	Description	Default value	Setting range
0x00 (Read Only)	3	Main version	1	Indicate software version.	-	-
		Minor version	2			-
		Sub version	3			-
0x01	4	Speed proportional gain	1 to 2	Set proportional gain for speed control.	400	0 to 65535
		Disturbance observer gain	3 to 4	Set disturbance observer gain for speed control.	800	0 to 65535
0x02	2	High temperature torque limit	1	Set the torque limit function when board temperature is high. • 0: OFF • 1: ON	1	0 to 1
		Stop error due to overload	2	Set the operation when in the overloaded state. • 0: Continuation of warning state • 1: Stop	1	0 to 1
0x03	1	Control system selection	1	• 0: Speed control	0	0
0x10	1	Node device ID setting	1	Set node device ID for identifying individual controllers.	1	1 to 127

WID/PID setting

- 1) When issuing the command "Parameter writing/reading request [FCD=0x0B]" to this circuit from an external device, replying is done with "Parameter writing/reading result reply [FCD=0x0C]".
- 2) Whether it is a writing request or a reading request is determined with the 2nd byte of the "Parameter writing/reading request": "Writing/reading identification no.". When writing, input the necessary number of data items corresponding to "WID/PID" in the above table at the 1st byte: "Data length". (Example: To specify 0x01, input 4) When reading, specification of "Data length" is unnecessary.
- 3) Parameter writing/reading is received only in the normal stop / error state. Note that there is a writing hold in the drive state. Content set with WID=0x10 and 0x11 is enabled at restarting.
- 4) The setting content normally returned with a writing request is stored in flash memory, and thus setting is unnecessary for the next and subsequent times.
- 5) If parameter writing was accomplished normally, the correctness judgement data 0x7B is returned. (Example: Case of WID/PID=0x01 gain setting, NID=0x01)

<Writing request (set speed proportional gain = 400, disturbance observer gain = 800)>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Write	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x581	0x08	0x04	0x38	0x01	0x01	0x90	0x03	0x20	0x00

<Response when writing request normal is received>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Correctness judgment	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x601	0x08	0x04	0x7B	0x01	0x00	0x00	0x00	0x00	0x00

- 6) When receiving is accomplished normally in parameter reading, data corresponding to the correctness judgment data 0x61 is returned. (Example: Case of WID/PID=0x01 gain setting, NID=0x01)

<Reading request (store in memory speed proportional gain = 400, disturbance observer gain = 800)>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Read	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x581	0x08	0x00	0x21	0x01	0x00	0x00	0x00	0x00	0x00

<Response when reading request normal is received>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Correctness judgment	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x601	0x08	0x04	0x61	0x01	0x01	0x90	0x03	0x20	0x00

- 7) If reception failed due to an abnormal value in parameter writing/reading, the correctness judgment data 0x7F is returned. (Example: Case of value not compatible with parameter reading WID/PID=0x25)

<Reading request>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Read	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x581	0x08	0x00	0x21	0x25	0x00	0x00	0x00	0x00	0x00

<Abnormality reception response>

CAN ID	DLC	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	DATA7	DATA8
		Data length	Correctness judgment	WID/PID	Data 1	Data 2	Data 3	Data 4	Data 5
0x601	0x08	0x00	0x7F	0x05	0x00	0x00	0x00	0x00	0x00

8 Error List

For the purpose of safety, and to protect equipment, warnings and errors are sent from the controller due to detected conditions. Cancellation conditions for warnings and errors are shown below. Ensure proper corrective actions are in place.

8.1 Error Codes

Error codes are sent periodically (at set times) via CAN communication.

If information reception from the controller via CAN communication is turned OFF, be careful because an error code is sent only once when an error occurs.



- When an error is detected, the motor performs a free-run stop. The inertia distance varies depending on the moment of inertia of the load and the motor rotation speed, so consider appropriate safety equipment on the machine side.
- When an error is detected, ensure safety by eliminating the cause of the error. After that, cancel the error, turn on power again, and resume operation.

Error code list

Error code	Error description	Error detection conditions	Error cancel conditions
0x0001	Overheat error	Board temperature 1, 2: 100°C or more	Board temperature: 75°C or less and [Operation state setting = 0]
0x0002	Overspeed error	Speed: 5,500 r/min or more	Speed: 0.5 r/min or less and [Operation state setting = 0]
0x0004	Low voltage error	Power supply voltage: 15 V or less	Power supply voltage: 16.5 V or more and [Operation state setting = 0]
0x0008	Overvoltage error	Power supply voltage: 63 V or more	Power supply voltage: 61 V or less and [Operation state setting = 0]
0x0010	Stall error	<ul style="list-style-type: none"> • Speed: Less than 80% of command value • Elapse of continuous 16 sec or more 	Speed: 0.5 r/min or less and [Operation state setting = 0]
0x0020	Sensor error	<ul style="list-style-type: none"> • Sensor voltage abnormal detection • Position count abnormality detection 	Turn on power again, or restart with ON_OFF switch
0x0040	CAN communication error	When motor drive instruction not received or CAN communication failure (ACK not received, etc.) continues for 0.5 sec or more during CAN communication drive	Motor drive instruction reception
0x0100	Overload error	Elapse of cumulative 16 sec or more while in the overload state	Elapse of 25 sec after error stop and [Operation state setting = 0]
0x0800	During initialization	Turn on power	Cancellation after CAN communication setting
0x1000	AD initialization error	Current offset value of 410 or more is set with 12-bit AD	Turn on power again, or restart with ON_OFF switch
0x2000	System error	<ul style="list-style-type: none"> • Controller internal voltage abnormality • Initialization error 	Turn on power again, or restart with ON_OFF switch
0x4000	Overcurrent error	Output current: 51 A _{peak} or more	Turn on power again, or restart with ON_OFF switch
0x8000	IC error*1	Detection of internal IC abnormality	Turn on power again, or restart with ON_OFF switch

*1 When an IC error is detected, the current value notification and board temperature 1 notification take on abnormal values.

There is also a possibility of misdetection or notification of other errors caused by the IC error.

8.2 Warning Codes

When a warning is detected, a warning code is sent from the controller. If the warning is kept active, an error will result and the motor will stop. Take corrective actions quickly.

Warning code list

Warning code	Warning description	Warning detection condition	Warning cancellation condition
0x0001	Overheating warning	Board temperature 1, 2: 90°C or more	Board temperature: 75°C or less
0x0002	Overspeed warning	Speed: 5,000 r/min or more	Speed: 4,800 r/min or less
0x0004	Low voltage warning	Power supply voltage: 16.5 V or less	Power supply voltage: 17.0 V or more
0x0008	Overvoltage warning	Power supply voltage: 60.0 V or more	Power supply voltage: 58.0 V or less
0x0010	Stall warning	Speed: Elapse of 2 continuous sec or more at less than 80% of the command value	Speed: 80% or more of command value or [Operation state setting = 0]
0x0100	Overload warning*	Elapse of cumulative 10 sec or more while in the overload state	Cumulative time less than 10 sec

* When there is an overload warning, torque is limited by gradually reducing the current limit value.

9 Supplementary Information and Precautions for Operation

9.1 Setting Rotation Speed

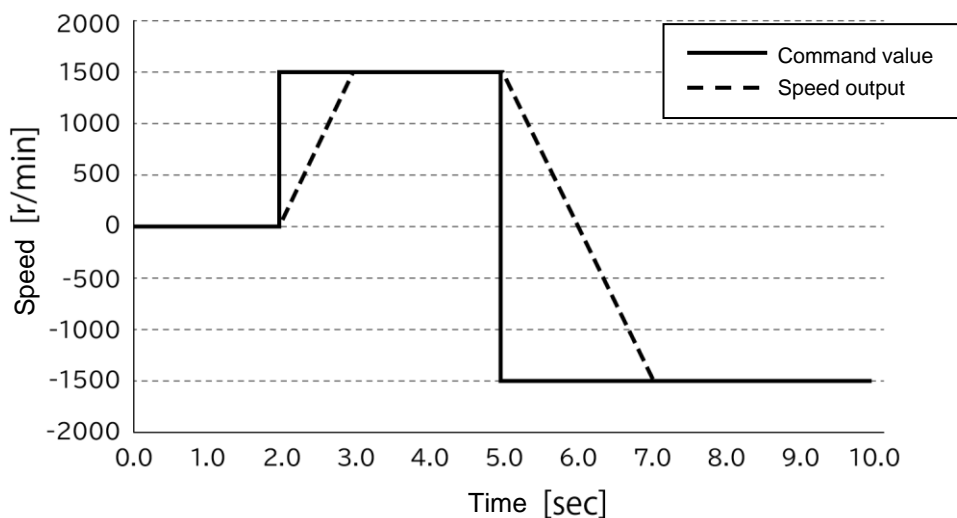
The motor is driven when the 1st bit is set to 1 in operation state setting (= 1st byte) in the “motor drive instruction” using CAN communication.

At the same time, the motor’s operation speed and acceleration are set, and the motor is driven using those setting values as targets.

If the motor operation speed and acceleration have been set at or above the setting range, then setting is done to the upper limit value, and if they have been set at or below the setting range, then setting is done to the lower limit value.

Example of operation

Operation proceeds as in the diagram below if motor acceleration is set to 1,500 [r/min/sec], and commands are issued for 1,500 [r/min] at 2 [sec] and -1,500 [r/min] at 5 [sec].



When the current limit value of the motor is set using commands the same as above, the maximum output torque is limited by the limited current value. The speed in the setting value is not achieved in the current limited state.

A stall warning is sent if 2 continuous sec or more elapse where speed is less than 80% of the setting value in the current limited state. (See section 8.2.)

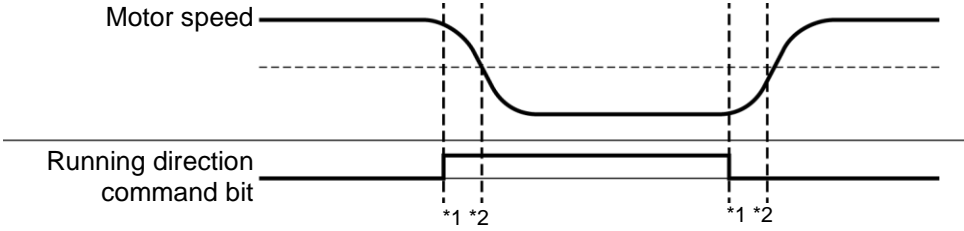
If the current limit value has been set at or above the setting range, then setting is done to the upper limit value, and if it has been set at or below the setting range, then setting is done to the lower limit value.

9.2 Switching Motor Running Direction

The running direction switches when the 2nd bit (hereafter called the running direction command bit) is switched in operation state setting (= 1st byte) in the "motor drive instruction" using CAN communication.

When the running direction command bit is changed, the motor performs stop processing (= brake operation), and is driven in the direction opposite to the previous running direction.

Timing chart for motor running direction switching (CAN command)



*1 Motor stop processing due to switching of drive command bit.

*2 Reverse drive because internal command speed became 0.

9.3 Torque Limit Function

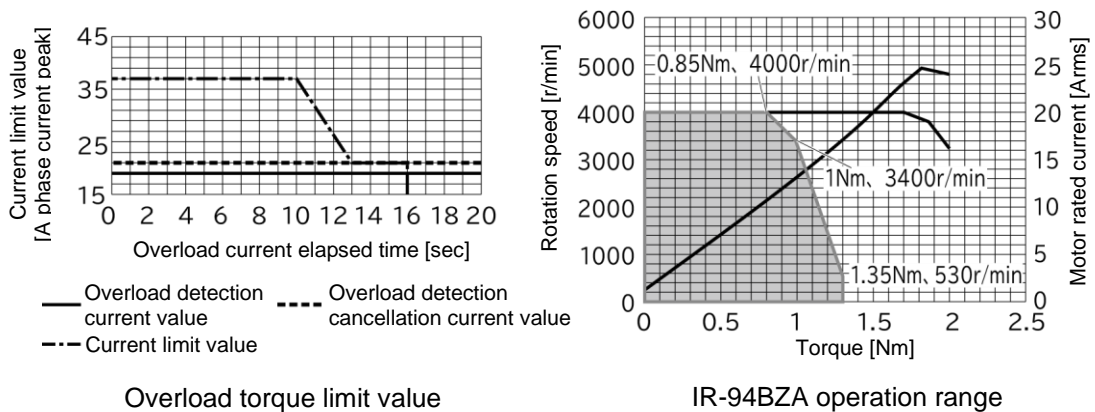
This product is equipped with an overload torque limit function and high temperature torque limit function, which enable motor drive with greater safety.

The following explanation uses, as an example, the combination of a motor (IR-94BZA) and controller (DR-40FC1).

For details on warnings and errors, see “8. Error List.”

Overload torque limit

Current limitation is performed as indicated in the diagram below, according to the time that current of 21 A or more (the phase current peak value) continuously flows to the maximum load of 1.35 Nm within the IR-94BZA continuous operation range.



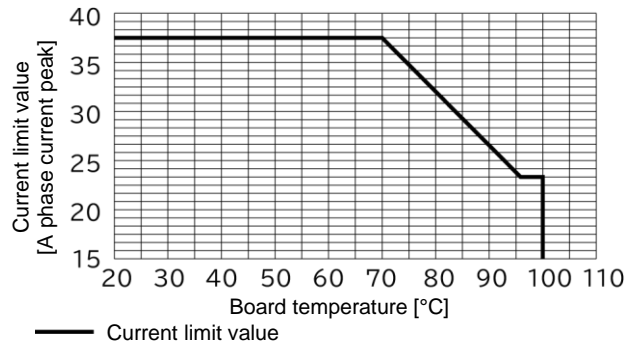
- If overload current flows continuously for a cumulative 10 seconds* or more, a warning is sent to the host controller.
- If overload current flows continuously for a cumulative 16 seconds* or more, an error is sent to the host controller, and it stops.
- The warning is canceled if at or below the phase current peak value of 19.5 A, and cumulative time is 10 seconds* or less.
- After an error stop, supply of power cannot be started for 25 seconds.

* When the current goes to 21 A or more, the cumulative time is added, and when the current goes to 19.5 A or less, the cumulative time is subtracted.

Example: 5 sec 22 A (cumulative time 5 sec) → 3 sec 18 A (cumulative time 5 – 3 = 2 sec)
 → 8 sec 22 A (cumulative time 2 + 8 = 10 sec)

High temperature torque limit function

Current limiting is performed, as indicated in the diagram below, according to temperature of the thermistor installed on the controller board.



High temperature torque limit value

- When thermistor temperature rises to 90°C or more, a warning is sent to the host controller.
- When thermistor temperature rises to 100°C or more, an error is sent to the host controller, and it stops.
- When thermistor temperature falls to 75°C or less, the warning is canceled.
- When thermistor temperature falls to 75°C or less and the operation state setting is set equal to 0, the error is canceled.

9.4 Points to Check at Installation

- It is the responsibility of the purchaser to confirm and assure the matching and the reliability of the motor and controller in actual set or unit application along with confirming the service life and carrying out quality assurance.

<Examples of items to confirm when configuring>

Applicable laws, standards, service life, various electrical characteristics, mechanical characteristics, mechanical/electrical noise, environmental exposure, ambient gas, etc.

- Startability and rotational stability may be affected depending on the internal resistance and capacity of the motor drive power supply (including circuits). Also, check the actual operating conditions not only at room temperature but also at low and high temperatures.

9.5 Precautions regarding Cables

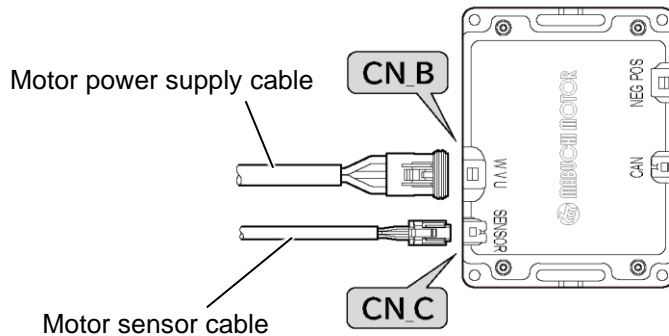

CAUTION



- If there is any abnormal noise, quickly stop motor drive, and check that the motor power cable is not disconnected
The motor may continue rotation while making noise if one phase of the motor power cable connected to the connector: CN_B (motor power supply) is disconnected.



- If a difference continually appears between the motor operation speed commands and motor speed, quickly stop motor drive, and check that the motor sensor cable is not shorted.
If an adjacent short has occurred in the motor sensor cable connected to the connector: CN_C (motor sensor input/output terminal), rotation may continue in a state where there is a difference between the motor operation speed command and motor speed.



10 Troubleshooting

This section describes corrective actions when an abnormality occurs. Check the following items before starting troubleshooting.

- Check whether there are any error notifications.
If any errors have occurred, check the locations relating to the error content.
- Check whether the NID is correct.



If the abnormality occurs again even after measures have been taken, immediately stop the machine and contact us.

Using a product with an abnormality poses a risk of an accident.

10.1 Motor does not run

No.	Cause	Possible solution	Reference
1	Power supply is not connected correctly	Check if the power supply is connected correctly.	5.2 5.4
2	Controller is not connected correctly	Check if the controller is connected correctly.	5.2 5.4
3	Controller and CAN communication cable are not connected correctly	Check if controller and CAN communication cable are connected correctly.	5.6
4	Electromagnetic brake is not connected correctly (MR-94BZB)	Check if the electromagnetic brake is connected correctly.	5.3
5	Cables are broken	Replace the broken cable with a new cable.	—
6	CAN communication settings are incorrect	Check settings of FCD and NID.	7.1 7.2 7.3 7.4
7	There is a difference between motor voltage specifications and power supply voltage specifications	Use a power supply suited to motor voltage specifications.	11.1
8	Electromagnetic brake of motor has not been released (MR-94BZB)	1. Check that the output shaft is locked in the state where voltage is not applied to the electromagnetic brake. 2. Apply voltage to the electromagnetic brake, and check that the output shaft is in a state where it can rotate.	11.1
9	The motor is overloaded	Remove the motor from the machine, and check whether the motor rotates. 1. If the motor rotates, set the load on the machine side to a load in the allowable range. 2. If the motor does not rotate, check for other causes. 3. If the cause cannot be found, contact us.	11.1
10	Controller are hot	Adjust settings so that the controller temperature are 75°C or less.	8.1 8.2

10.2 Unstable operation, large vibration

No.	Cause	Possible solution	Reference
1	Motor is not attached correctly	Attach the motor correctly.	4.2

10.3 Cannot Perform CAN Communication

No.	Cause	Possible solution	Reference
1	Communication settings for CAN communication are incorrect	Change to the correct settings. (Set sending interval to 0.5 sec.)	Chapter 7
2	Wiring between CAN communication units is incorrect	Change wiring distance and terminating resistance for correct connection.	5.5
3	Incorrect setting of NID	Change the NID setting to the correct value.	7.1

11 Specifications

11.1 Product Specifications

11.1.1 Motor Specifications

Type		IR-94BZA	MR-94BZA	MR-94BZB
Component parts	Motor	•	•	•
	Gear reducer	-	•	•
	Electromagnetic brake	-	-	•
Mechanical properties	Appearance	See appearance diagram		
	Weight (for reference)	1.1 kg	2.5 kg	3.1 kg
	Speed reduction ratio	-	10.33	
	Cable length (for reference)	Motor power/sensor: 300 mm		Motor power/sensor: 300 mm Brake: 220 mm
	Cable, connector tensile strength	9.8 N or more		
	Waterproof function	IPX4 (use dedicated connector) ^{*1}	IPX4 (use dedicated connector)	
Standard usage	Rated voltage	48 V (Controller power voltage)	24 V (Controller power voltage)	
	Operating voltage range ^{*2}	17 to 60 V		
	Operating temperature range	+10°C to +50°C		
	Operating humidity range	20% RH to 95% RH (with no condensation)		
	Rotation direction	CCW/CW direction viewing from the output shaft side		
	Storage temperature range	+10°C to +30°C		
	Storage humidity range	30% RH to 95% RH (with no condensation)		
	Allowable inertial load (for reference) ^{*3}	2.2x10 ⁻³ kg·m ² or less	0.2 kg·m ² or less	
	Allowable radial withstand load	-	700 N (15 mm from output shaft end)	
Motor electrical characteristics	No-load current	1.3 A or less (at 4,000 r/min)	2.5 A or less (at 200 r/min)	
	Rated torque (for reference)	1.0 Nm	8.6 Nm	
	Rated rotation speed	3,400 r/min	200 r/min	
	Rated output (for reference)	355 W	180 W	
	Instant peak torque (for reference)	2.0 Nm (up to 10 seconds)	17.2 Nm (up to 10 seconds)	
	Maximum output (for reference)	710 W (at rated rotation speed)	320 W	
	Insulation resistance	10 MΩ or more (500 V DC)		
	Withstand voltage	500 V AC for 1 minute (between terminal and case)		
Electromagnetic brake characteristics	Electromagnetic brake type	-	-	Non-exciting actuation type (open operation when on)
	Electromagnetic brake release voltage			Continuous application of 16 to 24 V DC
	Electromagnetic brake release current (for reference)			0.45 A (With power supply voltage of 24 V)
	Control torque (static friction)			20 Nm (output shaft conversion)

*1 Area around the output shaft is not subject to waterproofing.

*2 Use the product after checking that the controller power voltage is within the specified range.

*3 Output shaft conversion value.

11.1.2 Controller Specifications

Type		DR-40FC1	DR-40FC3	
Standard usage	Applicable motor	IR-94BZA, MR-94BZA, MR-94BZB		
	Drive system	Vector control		
	Control system	Speed control		
	Speed position detection system	Resolver sensor		
	Power supply voltage specifications	24 to 48 V DC (battery) Input voltage range: 17 to 60 V DC		
	Maximum regenerative current	-25 A DC		
	Maximum input current	25 A DC		
	Rotation direction	CCW/CW direction viewing from the output shaft side		
	Speed range	0 r/min to 4,000 r/min		
	Operating voltage range	+10°C to +50°C		
	Operating temperature range	20% RH to 95% RH		
	Connector lead terminal section temperature	105°C or less		
	Electrical characteristics (initial)	Power supply voltage range	17 to 60 V	
Standby current		2 mA or less (CN_D Pin1-Pin2 = Open)		
Drive stop current		100 mA or less (CN_D Pin1-Pin2 = Short)		
Rated input current		8.7 A DC (48 V)		
Output current limit value		37 A peak		
Insulation resistance		10 MΩ or more (500 V DC)		
Dielectric strength		500 V AC for 1 minute (Between power input terminal and case)		
Rated output current		11.5 A rms		
Maximum output current		37 A peak		
Drive system		Vector control		
Provided control functions		Speed control (in preparation: torque control, position control)		
Rotation speed command range		0 to 4,000 r/min		
Interface		CAN communication (terminal resistance: no)	CAN communication (terminal resistance: yes)	
Size		W:116 mm × D:88 mm × H:29 mm		
Weight		220 g		
Waterproofing		IPX4		
Low radiated noise	Conforms to CISPR 32 Class B Conforms to EN 55011 Class B			

11.1.3 Motor extension cable, controller connection cable (sold separately)

The motor extension cable and controller connection cable are sold separately.

For details on connector specifications, see the webpages of each connector manufacturer.

Motor extension cable

Item name	For motor power supply	For motor sensor	For electromagnetic brake
Model no.	67-Q22AA	67-Q23AA	41-L15XA
Length	1 m	1 m	1 m
Applicable model	IR and MR series	IR and MR series	MR series (with brake)

Controller connection cable

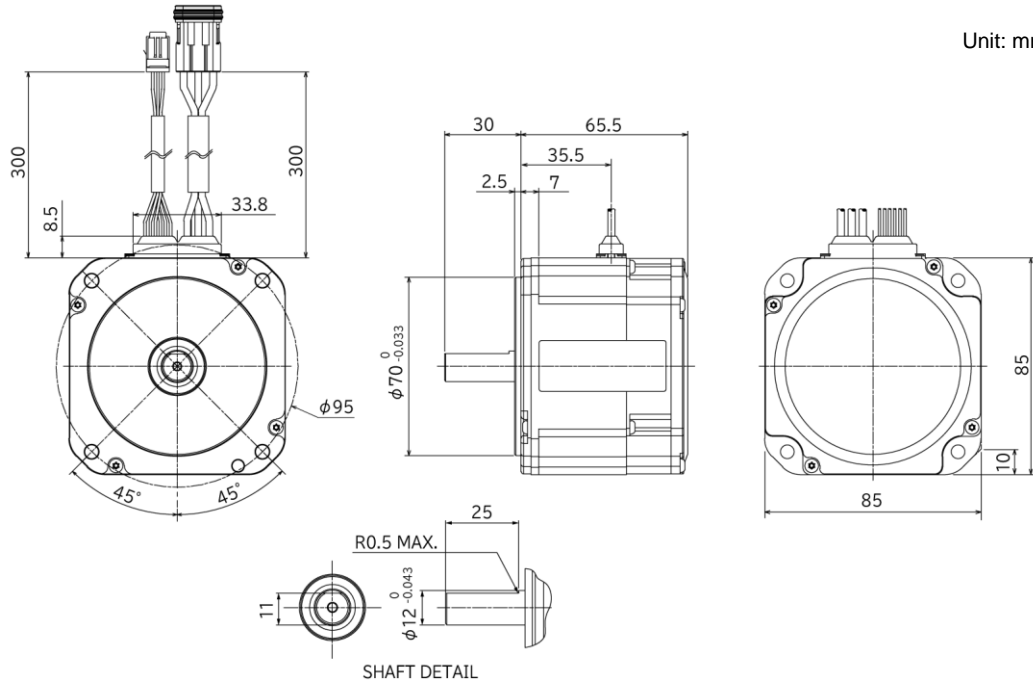
Item name	For power supply	For communication
Model no.	41-L11XA	41-L12XA
Length	1 m	1 m
Applicable model	DR40FC1, DR40FC3	DR40FC1, DR40FC3

11.2 Technical Drawings

11.2.1 Motor Technical Drawings

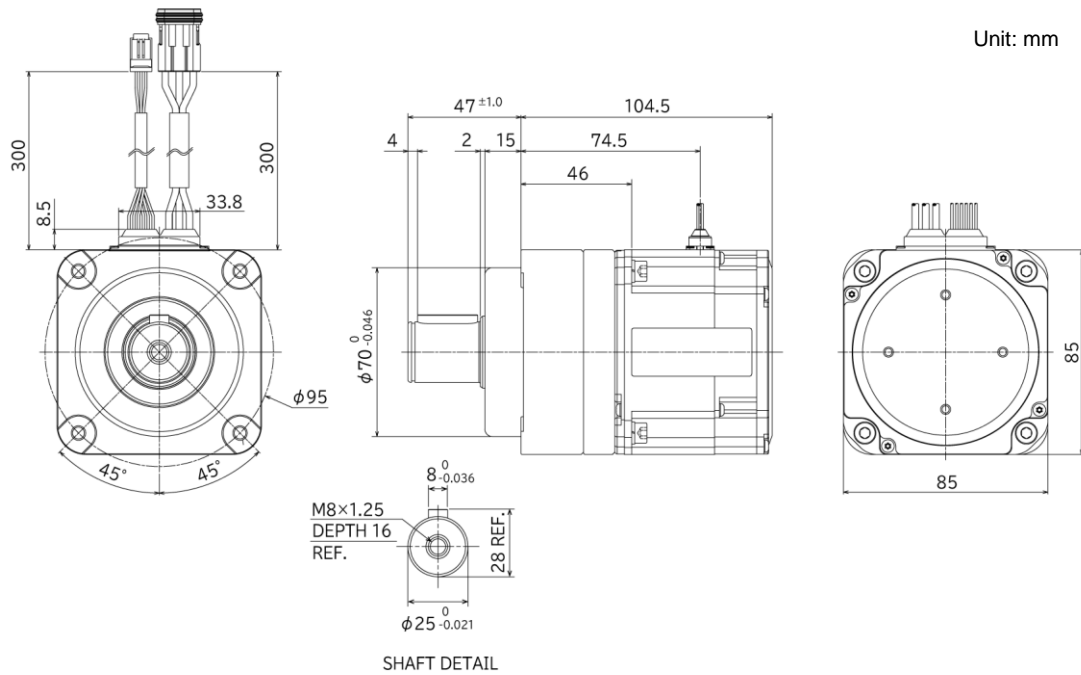
IR-94BZA

Unit: mm

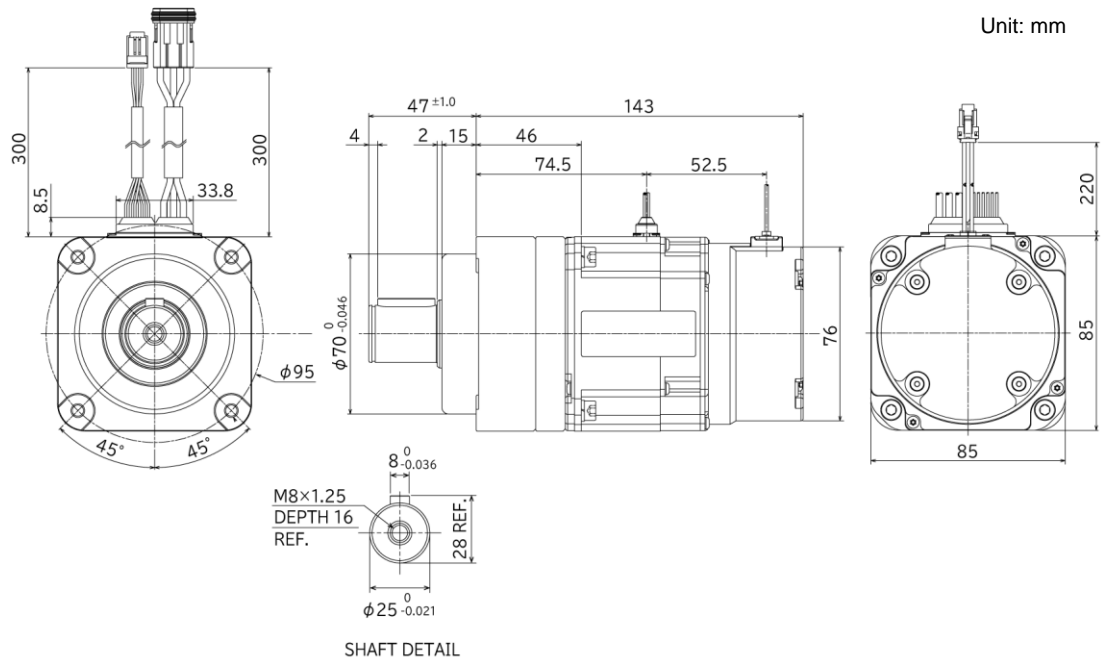


MR-94BZA

Unit: mm



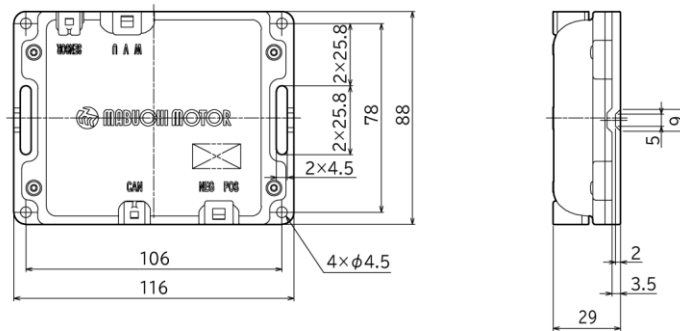
MR-94BZB



11.2.2 Controller Technical Drawings

DR-40FC1, DR-40FC3

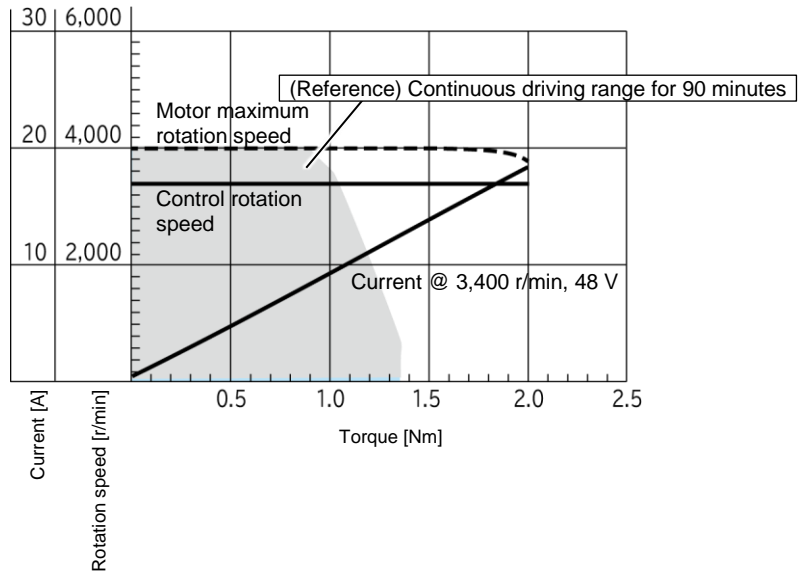
Unit: mm



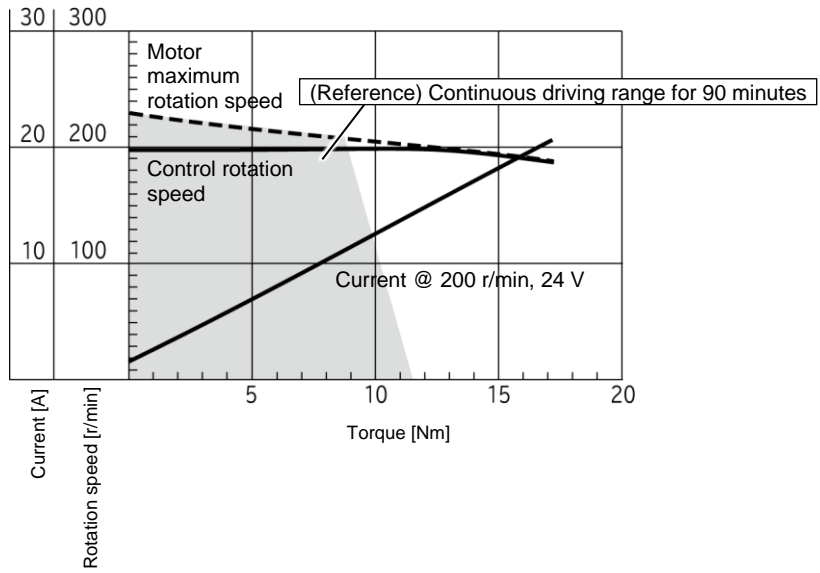
11.3 Motor Continuous Drive Range

When using the motor continuously, stay within the continuous drive range.

IR-94BZA



MR-94BZA, MR-94BZB



12 Laws and Standards

Conforms to the European RoHS Directive.

13 Product Warranty

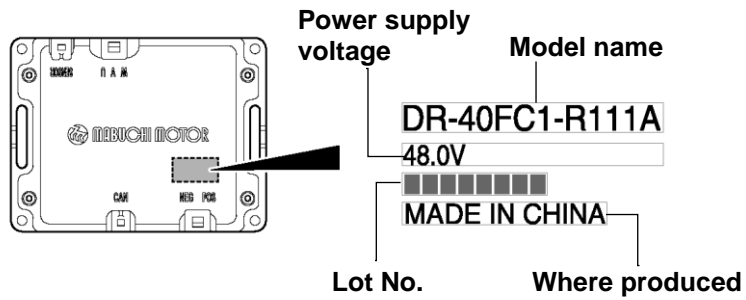
- 1.** Product warranty period is 1-year from the date of delivery.
- 2.** Warranty Coverage
During the warranty period, should a failure occur that we are liable for, we will repair or replace parts free of charge. However, even within the warranty period, the following failures will not be covered.
 - (1) Wear and deterioration due to normal use.
 - (2) Failure due to improper handling, or failure to follow the instructions in this manual.
 - (3) Failure due to use with unauthorized components.
 - (4) Failure due to disassembly, modification, or repair conducted by an unauthorized entity.
 - (5) Failure due to natural disasters or unexpected external factors.
 - (6) Failure due to unforeseeable reasons at the time of shipment based on scientific and technical standards.
 - (7) Other failures not attributable to our company.
- 3.** We make no warranties, express, implied, or statutory, as to fitness for general use or fitness for any particular use.
- 4.** Covered by warranty
This limited warranty applies to the original owner of this product during the warranty period provided the product was purchased from Mabuchi or an authorized distributor/dealer.
- 5.** Limitation of Liability
We are not responsible for any damage caused by failure of our products.
- 6.** Specification Changes
For purposes of improvement, the specifications in this document are subject to change without notice.
- 7.** Range of Service
Technician dispatch costs are not included in the product sales price. If you wish, we will consult with you separately.

14 After Sales Service

Make a note of the "model name", "lot number", and "order number" and contact the dealer where you purchased the product.

Checking controller product information

The product information in the diagram below will be necessary when making an inquiry, so please make a note of it.



Contact

Mabuchi Motor Co., Ltd. Sales Group 1

Please fill in the inquiry form using the QR code.

430 Matsuhidai, Matsudo City, Chiba Prefecture 270-2280, Japan
Phone: +81-47-710-1868
Hours: 10:00-16:00 (excluding weekends, company or national holidays)



Brushless Motor/Controller Instruction Manual

Date of issue: 1st edition 4/1/ 2023

Issue number: TKS-A10-001716

Copyright © 2023 MABUCHI MOTOR Co., LTD. All Rights Reserved

Unauthorized reproduction or duplication of part or all of this document is prohibited.

Publisher: Mabuchi Motor Co., Ltd.