MITSUBISHI ELECTRIC

Changes for the Better

Numerical Control (CNC)

Specifications Manual

MDS-DJ Series

IB-1501130(ENG)-E

Introduction

Thank you for selecting the Mitsubishi numerical control unit. This instruction manual describes the handling and caution points for using this AC servo/spindle.Incorrect handling may lead to unforeseen accidents, so always read this instruction manual thoroughly to ensure correct usage.
In order to confirm if all function specifications described in this manual are applicable, refer to the specifications for each CNC.

Notes on Reading This Manual

(1) Since the description of this specification manual deals with NC in general, for the specifications of individual machine tools, refer to the manuals issued by the respective machine tool builders. The "restrictions" and "available functions" described in the manuals issued by the machine tool builders have precedence to those in this manual.
(2) This manual describes as many special operations as possible, but it should be kept in mind that items not mentioned in this manual cannot be performed.
(3) The characteristic values and numerical values without tolerances mentioned in this manual are representative values.

In this manual, the following abbreviations might be used.
MTB: Machine tool builder

Precautions for Safety

Please read this manual and auxiliary documents before starting installation, operation, maintenance or inspection to ensure correct usage. Thoroughly understand the device, safety information and precautions before starting operation.
The safety precautions in this instruction manual are ranked as "WARNING" and "CAUTION".

⚠ DANGER

When there is a potential risk of fatal or serious injuries if handling is mistaken.

⚠ WARNING

When a dangerous situation, or fatal or serious injuries may occur if handling is mistaken.

⚠ CAUTION

When a dangerous situation may occur if handling is mistaken leading to medium or minor injuries, or physical damage.

Note that some items described as "⚠CAUTION" may lead to major results depending on the situation. In any case, important information that must be observed is described.

The signs indicating prohibited and mandatory matters are explained below.

	**Indicates a prohibited matter. For example, "Fire Prohibited" is indicated as  .**
	**Indicates a mandatory matter. For example, grounding is indicated as  .**

The meaning of each pictorial sign is as follows.

 **CAUTION**	 **CAUTION rotated object**	 **CAUTION HOT**	 **Danger Electric shock risk**	 **Danger explosive**
 **Prohibited**	 **Disassembly is prohibited**	 **KEEP FIRE AWAY**	 **General instruction**	 **Earth ground**

After reading this specifications and instructions manual, store it where the user can access it easily for reference.

The numeric control unit is configured of the control unit, operation board, servo drive unit, spindle drive unit, power supply, servo motor and spindle motor, etc.
In this section "Precautions for safety", the following items are generically called the "motor".

- Servo motor
- Linear servo motor
- Spindle motor
- Direct-drive motor

In this section "Precautions for safety", the following items are generically called the "unit".

- Servo drive unit
- Spindle drive unit
- Power supply unit
- Scale interface unit
- Magnetic pole detection unit

POINT

Important matters that should be understood for operation of this machine are indicated as a POINT in this manual.

⚠ WARNING

1. Electric shock prevention

- **Make sure the power is shut OFF before connecting a unit and a motor to the power.**
- **Do not open the front cover while the power is ON or during operation. Failure to observe this could lead to electric shocks.**
- **Do not operate the unit with the front cover removed. The high voltage terminals and charged sections will be exposed, and can cause electric shocks.**
- **Do not remove the front cover and connector even when the power is OFF unless carrying out wiring work or periodic inspections. The inside of the units is charged, and can cause electric shocks.**
- **Since the high voltage is supplied to the main circuit connector while the power is ON or during operation, do not touch the main circuit connector with an adjustment screwdriver or the pen tip. Failure to observe this could lead to electric shocks.**
- **Wait at least 15 minutes after turning the power OFF, confirm that the CHARGE lamp has gone out, and check the voltage between P and N terminals with a tester, etc., before starting wiring, maintenance or inspections. Failure to observe this could lead to electric shocks.**
- **Ground the unit and motor. For the motor, ground it via the drive unit.**
- **Wiring, maintenance and inspection work must be done by a qualified technician.**
- **Wire the servo drive unit and servo motor after installation. Failure to observe this could lead to electric shocks.**
- **Do not touch the switches with wet hands. Failure to observe this could lead to electric shocks.**
- **Do not damage, apply forcible stress, place heavy items on the cables or get them caught. Failure to observe this could lead to electric shocks.**
- **Always insulate the power terminal connection section. Failure to observe this could lead to electric shocks.**
- **After assembling the built-in IPM spindle motor, if the rotor is rotated by hand etc., voltage occurs between the terminals of lead. Take care not to get electric shocks.**

⚠ WARNING

2. Injury prevention

⚠ **When handling a motor, perform operations in safe clothing.**

⚠ **In the system where the optical communication with CNC is executed, do not see directly the light generated from CN1A/CN1B connector of drive unit or the end of cable. When the light gets into eye, you may feel something is wrong for eye.**
(The light source of optical communication corresponds to class1 defined in JISC6802 or IEC60825-1.)

⚠ **The linear servo motor, direct-drive motor and built-in IPM spindle motor uses permanent magnets in the rotor, so observe the following precautions.**

(1)Handling

- The linear servo motor, direct-drive motor and built-in IPM spindle motor could adversely affect medical electronics such as pacemakers, etc., therefore, do not approach the rotor.
- Do not place magnetic materials as iron.
- When a magnetic material as iron is placed, take safety measure not to pinch fingers or hands due to the magnetic attraction force.
- Remove metal items such as watch, piercing jewelry, necklace, etc.
- Do not place portable items that could malfunction or fail due to the influence of the magnetic force.
- When the rotor is not securely fixed to the machine or device, do not leave it unattended but store it in the package properly.
- When installing the motor to the machine, take it out from the package one by one, and then install it.
- It is highly dangerous to lay out the motor or magnetic plates together on the table or pallet, therefore never do so.

(2)Transportation and storage

- Correctly store the rotor in the package to transport and store.
- During transportation and storage, draw people's attention by applying a notice saying "Strong magnet-Handle with care" to the package or storage shelf.
- Do not use a damaged package.

(3)Installation

- Take special care not to pinch fingers, etc., when installing (and unpacking) the linear servo motor.

⚠ **Incorrect wiring could lead to smoke or fire in the unit and the reactor, resulting in faults. Be careful when wiring.**

⚠ CAUTION

1. Fire prevention

- **Install the units, motors and regenerative resistor on non-combustible material. Direct installation on combustible material or near combustible materials could lead to fires.**
- **Always install a circuit protector and contactor on the servo drive unit power input as explained in this manual. Refer to this manual and select the correct circuit protector and contactor. An incorrect selection could result in fire.**
- **Shut off the power on the unit side if a fault occurs in the units. Fires could be caused if a large current continues to flow.**
- **When using a regenerative resistor, provide a sequence that shuts off the power with the regenerative resistor's error signal. The regenerative resistor could abnormally overheat and cause a fire due to a fault in the regenerative transistor, etc.**
- **The battery unit could heat up, ignite or rupture if submerged in water, or if the poles are incorrectly wired.**
- **Cut off the main circuit power with the contactor when an alarm or emergency stop occurs.**

2. Injury prevention

- **Do not apply a voltage other than that specified in this manual, on each terminal. Failure to observe this item could lead to ruptures or damage, etc.**
- **Do not mistake the terminal connections. Failure to observe this item could lead to ruptures or damage, etc.**
- **Do not mistake the polarity (+,-). Failure to observe this item could lead to ruptures or damage, etc.**
- **Do not touch the radiation fin on unit back face, regenerative resistor or motor, etc., or place parts (cables, etc.) while the power is turned ON or immediately after turning the power OFF. These parts may reach high temperatures, and can cause burns or part damage.**
- **Structure the cooling fan on the unit back face, etc., etc so that it cannot be touched after installation. Touching the cooling fan during operation could lead to injuries.**
- **Take care not to suck hair, clothes, etc. into the cooling fan.**

⚠ CAUTION

3. Various precautions

Observe the following precautions. Incorrect handling of the unit could lead to faults, injuries and electric shocks, etc.

(1) Transportation and installation

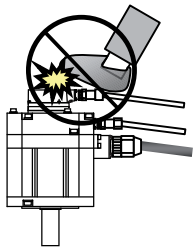
⚠ **Correctly transport the product according to its weight.**

❗ **Use the motor's hanging bolts only when transporting the motor itself. Do not use the motor's hanging bolts to transport a motor with other parts installed, or to transport a machine with a motor installed.**

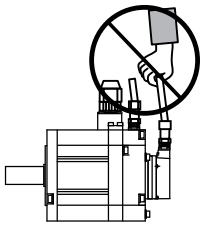
⚠ **Do not stack the products above the tolerable number.**

⚠ **Follow this manual and install the unit or motor securely in a place where it can be borne and noncombustible. Insufficient fixing could lead to the unit or the motor slipping off during operation.**

⚠ **Do not get on top of or place heavy objects on the unit.**



⚠ **Do not hold the cables, axis or encoder when transporting the motor.**



⚠ **Do not hold the connected wires or cables when transporting the units.**

⚠ **Do not hold the front cover when transporting the unit. The unit could drop.**

⚠ **Always observe the installation directions of the units or motors.**

⚠ **Secure the specified distance between the units and control panel, or between the servo drive unit and other devices.**

⚠ **Do not install or run a unit or motor that is damaged or missing parts.**

⚠ **Do not block the intake or exhaust ports of the motor provided with a cooling fan.**

⚠ **Do not let foreign objects enter the units or motors. In particular, if conductive objects such as screws or metal chips, etc., or combustible materials such as oil enter, rupture or breakage could occur.**

⚠ **Provide adequate protection using a material such as connector for conduit to prevent screws, metallic detritus, water and other conductive matter or oil and other combustible matter from entering the motor through the power line lead-out port.**

⚠ **The units, motors and encoders are precision devices, so do not drop them or apply strong impacts to them.**

⚠ **Always operate the motor, which has a shaft with keyway, with the key attached.**

⚠ CAUTION

⚠ **Store and use the units under the following environment conditions.**

Environment	Unit	Servo motor	Spindle motor
Ambient temperature	Operation: 0 to +55°C (with no freezing), Storage / Transportation: -15°C to +70°C (with no freezing)	Operation: 0 to +40°C (with no freezing), Storage: -15°C to +70°C (with no freezing)	Operation: 0 to +40°C (with no freezing), Storage: -20°C to +65°C (with no freezing)
Ambient humidity	Operation: 90%RH or less (with no dew condensation) Storage / Transportation: 90%RH or less (with no dew condensation)	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)	Operation: 90%RH or less (with no dew condensation) Storage: 90%RH or less (with no dew condensation)
Atmosphere	Indoors (no direct sunlight) With no corrosive gas, inflammable gas, oil mist, dust or conductive fine particles		
Altitude	Operation/Storage: 1000 meters or less above sea level, Transportation: 13000 meters or less above sea level	Operation/Storage: 1000 meters or less above sea level, Transportation: 10000 meters or less above sea level	
Vibration/impact	According to each unit or motor specification		

(Note) For details, confirm each unit or motor specifications in addition.

⚠ **When disinfectants or insecticides must be used to treat wood packaging materials, always use methods other than fumigation (for example, apply heat treatment at the minimum wood core temperature of 56 °C for a minimum duration of 30 minutes (ISPM No. 15 (2009))).**
If products such as units are directly fumigated or packed with fumigated wooden materials, halogen substances (including fluorine, chlorine, bromine and iodine) contained in fumes may contribute to the erosion of the capacitors.
When exporting the products, make sure to comply with the laws and regulations of each country.

⚠ **Do not use the products in conjunction with any components that contain halogenated flame retardants (bromine, etc). Failure to observe this may cause the erosion of the capacitors.**

⚠ **Securely fix the servo motor to the machine. Insufficient fixing could lead to the servo motor slipping off during operation.**

⚠ **Always install the servo motor with reduction gear in the designated direction. Failure to do so could lead to oil leaks.**

⚠ **Structure the rotary sections of the motor so that it can never be touched during operation. Install a cover, etc., on the shaft.**

⚠ **When installing a coupling to a servo motor shaft end, do not apply an impact by hammering, etc. The encoder could be damaged.**

⚠ **Do not apply a load exceeding the tolerable load onto the servo motor shaft. The shaft could break.**

⚠ **Store the motor in the package box.**

⚠ **When inserting the shaft into the built-in IPM spindle motor, do not heat the rotor higher than 130°C. The magnet could be demagnetized, and the specifications characteristics will not be ensured.**

⚠ **Always use a nonmagnetic tool (explosion-proof beryllium copper alloy safety tool: NGK Insulators, etc.) when installing the built-in IPM spindle motor, direct-drive motor and linear servo motor.**

⚠ **Always provide a mechanical stopper on the end of the linear servo motor's travel path.**

If the unit has been stored for a long time, always check the operation before starting actual operation. Please contact the Service Center, Sales Office or dealer.

⚠ **Install the heavy peripheral devices to the lower part in the panel and securely fix it not to be moved due to vibration.**

⚠ CAUTION

(2) Wiring

⚠ **Correctly and securely perform the wiring. Failure to do so could lead to abnormal operation of the motor.**

⚠ **Do not install a condensing capacitor, surge absorber or radio noise filter on the output side of the drive unit.**

⚠ **Correctly connect the output side of the drive unit (terminals U, V, W). Failure to do so could lead to abnormal operation of the motor.**

⚠ **When using a power regenerative power supply unit, always install an AC reactor for each power supply unit.**

⚠ **In the main circuit power supply side of the unit, always install an appropriate circuit protector or contactor for each unit. Circuit protector or contactor cannot be shared by several units.**

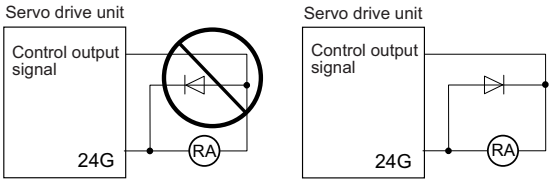
⚠ **Always connect the motor to the drive unit's output terminals (U, V, W).**

⚠ **Do not directly connect a commercial power supply to the servo motor. Failure to observe this could result in a fault.**

⚠ **When using an inductive load such as a relay, always connect a diode as a noise measure parallel to the load.**

⚠ **When using a capacitance load such as a lamp, always connect a protective resistor as a noise measure serial to the load.**

⚠ **Do not reverse the direction of a diode which connect to a DC relay for the control output signals such as contractor and motor brake output, etc. to suppress a surge. Connecting it backwards could cause the drive unit to malfunction so that signals are not output, and emergency stop and other safety circuits are inoperable.**



⚠ **Do not connect/disconnect the cables connected between the units while the power is ON.**

⚠ **Securely tighten the cable connector fixing screw or fixing mechanism. An insecure fixing could cause the cable to fall off while the power is ON.**

⚠ **When using a shielded cable instructed in the instruction manual, always ground the cable with a cable clamp, etc. (Refer to "EMC Installation Guidelines")**

⚠ **Always separate the signals wires from the power line.**

⚠ **Use wires and cables that have a wire diameter, heat resistance and flexibility that conforms to the system.**

(3) Trial operation and adjustment

⚠ **Check and adjust each program and parameter before starting operation. Failure to do so could lead to unforeseen operation of the machine.**

⚠ **Do not make remarkable adjustments and changes of parameter as the operation could become unstable.**

⚠ **The usable motor and unit combination is predetermined. Always check the combinations and parameters before starting trial operation.**

⚠ **The direct-drive motor and linear servo motor do not have a stopping device such as magnetic brakes. Install a stopping device on the machine side.**

⚠ **When using the linear servo motor for an unbalance axis, adjust the unbalance weight to 0 by installing an air cylinder, etc. on the machine side. The unbalance weight disables the initial magnetic pole adjustment.**

⚠ CAUTION

(4) Usage methods

In abnormal state, install an external emergency stop circuit so that the operation can be stopped and power shut off immediately.

Turn the power OFF immediately if smoke, abnormal noise or odors are generated from the unit or motor.

Do not disassemble or repair this product.

Never make modifications.

When an alarm occurs, the machine will start suddenly if an alarm reset (RST) is carried out while an operation start signal (ST) is being input. Always confirm that the operation signal is OFF before carrying out an alarm reset. Failure to do so could lead to accidents or injuries.

Reduce magnetic damage by installing a noise filter. The electronic devices used near the unit could be affected by magnetic noise. Install a line noise filter, etc., if there is a risk of magnetic noise.

Use the unit, motor and regenerative resistor with the designated combination. Failure to do so could lead to fires or trouble.

The brake (magnetic brake) of the servo motor are for holding, and must not be used for normal braking.

There may be cases when holding is not possible due to the magnetic brake's life, the machine construction (when ball screw and servo motor are coupled via a timing belt, etc.) or the magnetic brake's failure. Install a stop device to ensure safety on the machine side.

After changing the programs/parameters or after maintenance and inspection, always test the operation before starting actual operation.

Do not enter the movable range of the machine during automatic operation. Never place body parts near or touch the spindle during rotation.

Follow the power supply specification conditions given in each specification for the power (input voltage, input frequency, etc.).

Set all bits to "0" if they are indicated as not used or empty in the explanation on the bits.

Do not use the dynamic brakes except during the emergency stop. Continued use of the dynamic brakes could result in brake damage.

If a circuit protector for the main circuit power supply is shared by several units, the circuit protector may not activate when a short-circuit fault occurs in a small capacity unit. This is dangerous, so never share the circuit protector.

Mitsubishi spindle motor is dedicated to machine tools. Do not use for other purposes.

This unit is not intended for use in low voltage public networks that supply power to households. Using this unit in such networks may cause radio frequency interference.

Do not use this unit in residential areas.

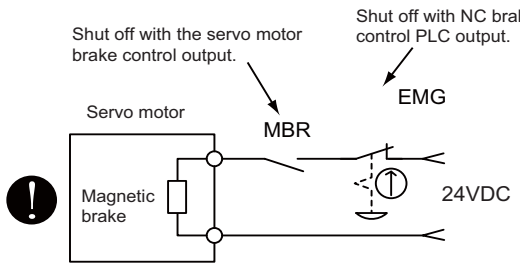
(5) Troubleshooting

If a hazardous situation is predicted during power failure or product trouble, use a servo motor with magnetic brakes or install an external brake mechanism.

Use a double circuit configuration that allows the operation circuit for the magnetic brakes to be operated even by the external emergency stop signal.

Always turn the main circuit power of the motor OFF when an alarm occurs.

If an alarm occurs, remove the cause, and secure the safety before resetting the alarm.



⚠ CAUTION

(6) Maintenance, inspection and part replacement

⚠ **Always backup the programs and parameters before starting maintenance or inspections.**

⚠ **The capacity of the electrolytic capacitor will drop over time due to self-discharging, etc. To prevent secondary disasters due to failures, replacing this part every five years when used under a normal environment is recommended. Contact the Service Center, Sales Office or dealer for repairs or part replacement.**

⚠ **Do not perform a megger test (insulation resistance measurement) during inspections.**

⚠ **If the battery low warning is issued, immediately replace the battery. Replace the batteries while applying the drive unit's control power.**

⚠ **Do not short circuit, charge, overheat, incinerate or disassemble the battery.**

⚠ **For after-purchase servicing of the built-in motor, only the servicing parts for MITSUBISHI encoder can be supplied. For the motor body, prepare the spare parts at the machine tool builders.**

⚠ **For maintenance, part replacement, and services in case of failures in the built-in motor (including the encoder), take necessary actions at the machine tool builders. For drive unit, Mitsubishi can offer the after-purchase servicing as with the general drive unit.**

(7) Disposal

⚠ **Take the batteries and backlights for LCD, etc., off from the controller, drive unit and motor, and dispose of them as industrial wastes.**

⚠ **Do not disassemble the unit or motor.**

⚠ **Dispose of the battery according to local laws.**

⚠ **Dispose of the primary side of the linear servo motor as industrial waste. For the secondary side, dispose of it as industrial waste after demagnetizing it by heating it to 300°C or higher.**

⚠ **When incinerating optical communication cable, hydrogen fluoride gas or hydrogen chloride gas which is corrosive and harmful may be generated. For disposal of optical communication cable, request for specialized industrial waste disposal services that has incineration facility for disposing hydrogen fluoride gas or hydrogen chloride gas.**

(8) Transportation

⚠ **The unit and motor are precision parts and must be handled carefully.**

⚠ **According to a United Nations Advisory, the battery unit and battery must be transported according to the rules set forth by the International Civil Aviation Organization (ICAO), International Air Transportation Association (IATA), International Maritime Organization (IMO), and United States Department of Transportation (DOT), etc.**

(9) General precautions

The drawings given in this manual show the covers and safety partitions, etc., removed to provide a clearer explanation. Always return the covers or partitions to their respective places before starting operation, and always follow the instructions given in this manual.

Treatment of waste

The following two laws will apply when disposing of this product. Considerations must be made to each law. The following laws are in effect in Japan. Thus, when using this product overseas, the local laws will have a priority. If necessary, indicate or notify these laws to the final user of the product.

(1) Requirements for "Law for Promotion of Effective Utilization of Resources"
   (a) Recycle as much of this product as possible when finished with use.
   (b) When recycling, often parts are sorted into steel scraps and electric parts, etc., and sold to scrap contractors. Mitsubishi Electric recommends sorting the product and selling the members to appropriate contractors.

(2) Requirements for "Law for Treatment of Waste and Cleaning"
   (a) Mitsubishi Electric recommends recycling and selling the product when no longer needed according to item (1) above. The user should make an effort to reduce waste in this manner.
   (b) When disposing a product that cannot be resold, it shall be treated as a waste product.
   (c) The treatment of industrial waste must be commissioned to a licensed industrial waste treatment contractor, and appropriate measures, including a manifest control, must be taken.
   (d) Batteries correspond to "primary batteries", and must be disposed of according to local disposal laws.

Disposal

(Note) This symbol mark is for EU countries only.
This symbol mark is according to the directive 2006/66/EC Article 20 Information for end-users and Annex II.

Your MITSUBISHI ELECTRIC product is designed and manufactured with high quality materials and components which can be recycled and/or reused.
This symbol means that batteries and accumulators, at their end-of-life, should be disposed of separately from your household waste.
If a chemical symbol is printed beneath the symbol shown above, this chemical symbol means that the battery or accumulator contains a heavy metal at a certain concentration. This will be indicated as follows:
Hg: mercury (0,0005%), Cd: cadmium (0,002%), Pb: lead (0,004%)
In the European Union there are separate collection systems for used batteries and accumulators.
Please, dispose of batteries and accumulators correctly at your local community waste collection/recycling centre.

Please, help us to conserve the environment we live in!

Trademarks

MELDAS, MELSEC, EZSocket, EZMotion, iQ Platform, MELSOFT, GOT, CC-Link, CC-Link/LT and CC-Link IE are either trademarks or registered trademarks of Mitsubishi Electric Corporation in Japan and/or other countries.

Other company and product names that appear in this manual are trademarks or registered trademarks of the respective companies.

本製品の取扱いについて

(日本語 /Japanese)
本製品は工業用 (クラス A) 電磁環境適合機器です。販売者あるいは使用者はこの点に注意し、住商業環境以外での使用をお願いいたします。

Handling of our product

(English)
This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

본 제품의 취급에 대해서

(한국어 /Korean)
이 기기는 업무용 (A 급) 전자파적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정외의 지역에 서 사용하는 것을 목적으로 합니다 .

WARRANTY

Please confirm the following product warranty details before using Mitsubishi Electric CNC.

1. Warranty Period and Coverage

Should any fault or defect (hereafter called "failure") for which we are liable occur in this product during the warranty period, repair services shall be provided at no cost through the distributor from which the product was purchased or through a Mitsubishi Electric service provider. Note, however, that this does not apply if the customer was informed prior to purchasing the product that the product is not covered under warranty. Also note that we are not responsible for any on-site readjustment and/or trial run that may be required after a defective unit is replaced.

[Warranty Term]
The term of warranty for this product shall be twenty-four (24) months from the date of delivery of the product to the end user, provided the product purchased from Mitsubishi Electric or a distributor in Japan is installed in Japan (but in no event longer than thirty (30) months, including distribution time after shipment from Mitsubishi Electric or a distributor).
Note that, in the case where the product purchased from Mitsubishi Electric or a distributor in or outside Japan is exported and installed in any country other than where it was purchased, please refer to "2. Service in Overseas Countries" below.

[Limitations]
(1) The machine tool builder is requested to conduct an initial failure diagnosis, as a general rule. The diagnosis may also be carried out by Mitsubishi Electric or our service provider for a fee at the machine tool builder's request.
(2) This warranty applies only when the conditions, method, environment, etc., of use are in compliance with the terms, conditions and instructions that are set forth in the instruction manual, user's manual, and the caution label affixed to the product, etc.
(3) Even during the term of warranty, repair costs will be charged to the customer in the following cases:
  (a) a failure caused by improper storage or handling, carelessness or negligence, etc., or a failure caused by a problem with the customer's hardware or software
  (b) a failure caused by any alteration, etc., to the product made by the customer without Mitsubishi Electric's approval
  (c) a failure which may be regarded as avoidable, if the customer's equipment in which this product is incorporated is equipped with a safety device required by applicable laws or has any function or structure considered to be indispensable in the light of common sense in the industry
  (d) a failure which could have been avoided if consumable parts designated in the instruction manual, etc. had been duly maintained and replaced
  (e) any replacement of consumable parts (including the battery, relay and fuse)
  (f) a failure caused by external factors such as inevitable accidents, including without limitation fire and abnormal fluctuation of voltage, and acts of God, including without limitation earthquakes, lightning, and natural disasters
  (g) a failure which could not have been foreseen under technologies available at the time of shipment of this product from Mitsubishi Electric
  (h) any other failures which are not attributable to Mitsubishi Electric or which the customer acknowledges are not attributable to Mitsubishi Electric

2. Service in Overseas Countries

If the customer installs a product purchased from Mitsubishi Electric in a machine or equipment and exports it to any country other than where it was purchased, the customer may sign a paid warranty contract with our local FA center.
This applies in the case where the product purchased from us in or outside Japan is exported and installed in any country other than where it was purchased.
For details please contact the distributor from which the product was purchased.

3. Exclusion of Responsibility for Compensation against Loss of Opportunity, Secondary Loss, etc.

Regardless of the gratis warranty term, Mitsubishi Electric shall not be liable for compensation for:
(1) Damage arising from any cause found not to be the responsibility of Mitsubishi Electric.
(2) Lost opportunity or lost profit incurred by the user due to a failure of a Mitsubishi Electric product.
(3) Special damage or secondary damage, whether foreseeable or not, compensation for accidents, and compensation for damages to products other than Mitsubishi Electric products.
(4) Replacement by the user, maintenance of on-site equipment, start-up test run and other tasks.

4. Changes in Product Specifications

Specifications shown in our catalogs, manuals or technical documents are subject to change without notice.

5. Product Application

(1) For use of this product, applications should be those that will not result in a serious damage even if a failure or malfunction occurs in the product, and a backup or failsafe function should operate on an external system when any failure or malfunction occurs to the product.
(2) Mitsubishi Electric CNC is designed and manufactured solely for applications to machine tools for industrial purposes. Do not use this product in applications other than those specified above, especially those which have substantial influence on public interest or which are expected to have significant influence on human lives or properties.

Contents

Outline for MDS-DJ Series Instruction Manual (IB-1501133-D)

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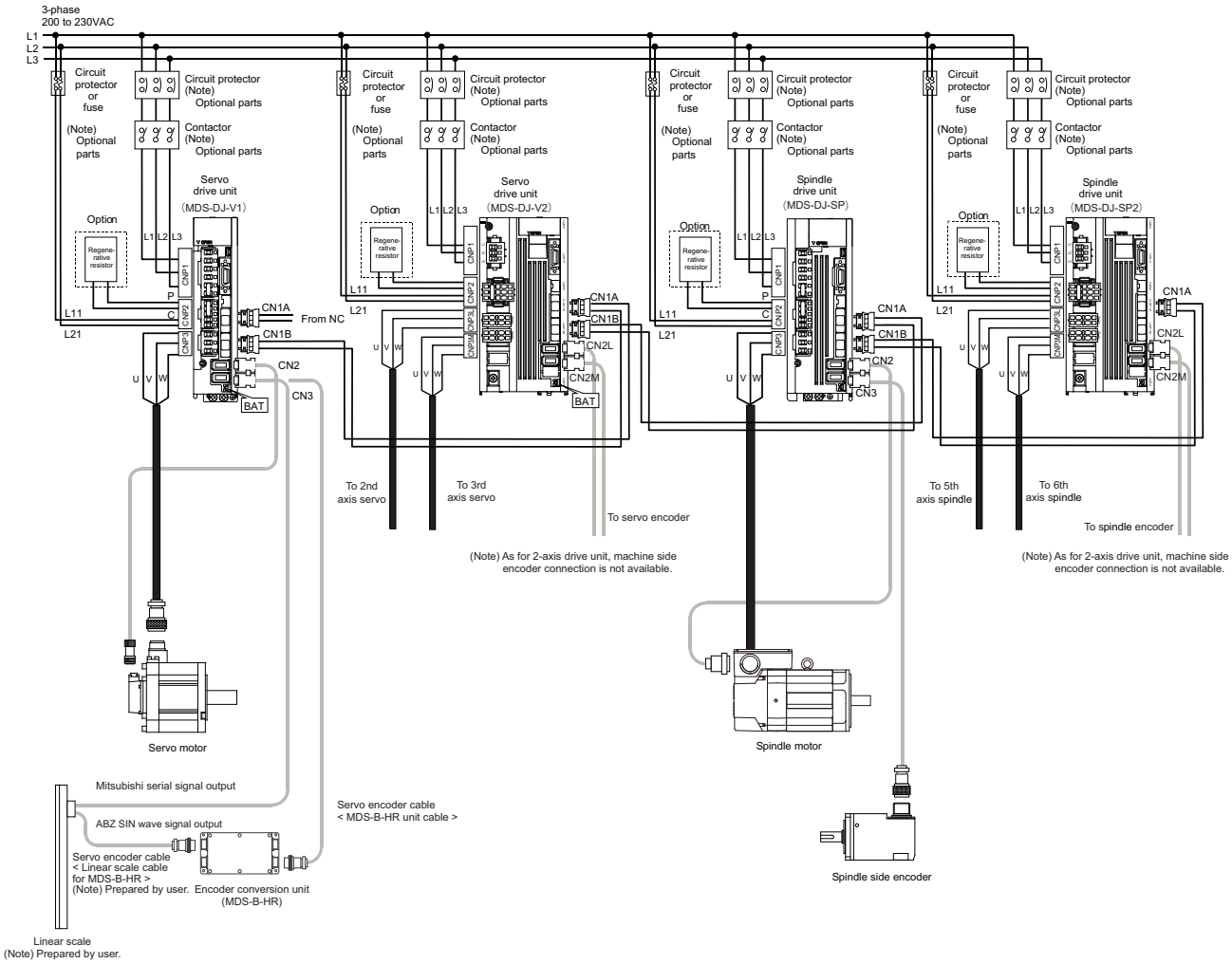
Introduction

1.1 Servo/Spindle Drive System Configuration

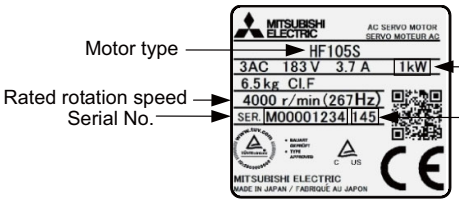
1.1.1 System Configuration



(Note) For details of cables and connectors, refer to "List of Cables and Connectors" later in this manual.

1.2 Explanation of Type

1.2.1 Servo Motor Type



Motor rating nameplate

< HF Series >

HF (1) (2) (3) (4)

(1) Rated output · Maximum rotation speed

Symbol	Rated output	Maximum rotation speed	Flange size (mm)
75	0.75 kW	5000 r/min	90 SQ.
105	1.0 kW	5000 r/min	90 SQ.
54	0.5 kW	4000 r/min	130 SQ.
104	1.0 kW	4000 r/min	130 SQ.
154	1.5 kW	4000 r/min	130 SQ.
224	2.2 kW	4000 r/min	130 SQ.
204	2.0 kW	4000 r/min	176 SQ.
354	3.5 kW	3500 r/min	176 SQ.
123	1.2 kW	3000 r/min	130 SQ.
223	2.2 kW	3000 r/min	130 SQ.
303	3.0 kW	3000 r/min	176 SQ.
142	1.4 kW	2000 r/min	130 SQ.
302	3.0 kW	2000 r/min	176 SQ.

(3) Shaft end structure

Symbol	Shaft end structure
S	Straight
T	Taper

(Note) "Taper" is available for the motor whose flange size is 90 SQ. mm or 130 SQ. mm.

(4) Encoder

Symbol	Type	Detection method	Resolution
A48	OSA18-100	Absolute position	260,001 p/rev
A51	OSA105S5A		1,000,001 p/rev

(2) Magnetic brakes

Symbol	Magnetic brake
None	None
B	With magnetic brakes

< HF-KP Series >

HF-KP 13 (1) J-S17

Rated output · Maximum rotation speed

Symbol	Rated output	Maximum rotation speed	Flange size (mm)
13	0.1 kW	6000 r/min	40 SQ.

(1) Magnetic brake

Symbol	Magnetic brake
None	None
B	With magnetic brakes

(Note) The motor-end encoder has absolute position specifications, but is not equipped with the capacitor for data backup. Thus, absolute position is lost immediately after disconnection of the encoder cable.

HF-KP (1) (2) JW04-S6

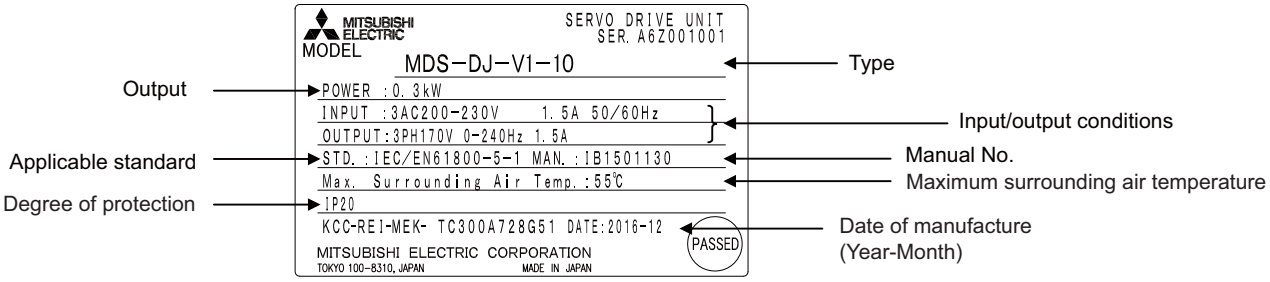
(1) Rated output · Maximum rotation speed

Symbol	Rated output	Maximum rotation speed	Flange size (mm)
23	0.2 kW	6000 r/min	60 SQ.
43	0.4 kW	6000 r/min	60 SQ.
73	0.75 kW	6000 r/min	80 SQ.

(2) Magnetic brake

Symbol	Magnetic brake
None	None
B	With magnetic brake

1.2.2 Servo Drive Unit Type



Rating nameplate

(a) 1-axis servo drive unit

MDS-DJ-V1- (1)

(1) Unit Type MDS-DJ-V1-	Unit width	Compatible motor type (Unit nominal maximum current / Stall torque (N·m))	HF□ 75	105	54	104	154	224	204	354	123	223	303	142	302	HF-KP□ 13	23	43	73
			2.0	3.0	2.9	5.9	9.0	12.0	13.7	22.5	7.0	12.0	22.5	11.0	20.0	0.32	0.64	1.3	2.4
10	40mm	10A														●	●		
15	40mm	15A																●	
30	60mm	30A	●	●	●														●
40	90mm	40A				●					●	●		●	●				
80	90mm	80A					●	●	●				●						
100	90mm	100A								●									

● Indicates the compatible motor for each servo drive unit.

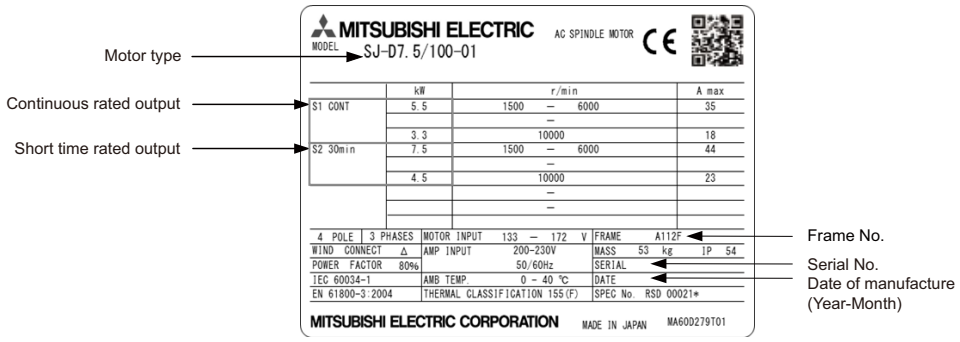
(b) 2-axis servo drive unit

MDS-DJ-V2- (1)

(1) Unit Type MDS-DJ-V2-	Unit width	Unit nominal maximum current	Compatible motor type (Axis / Stall torque (N·m))	HF□ 75	105	54	104	154	224	204	354	123	223	303	142	302	HF-KP□ 13	23	43	73
				2.0	3.0	2.9	5.9	9.0	12.0	13.7	22.5	7.0	12.0	22.5	11.0	20.0	0.32	0.64	1.3	2.4
3030	85mm	30+30A	LM	●	●	●														●

● Indicates the compatible motor for each servo drive unit.

1.2.3 Spindle Motor Type



Rating nameplate

< SJ-D Series >

SJ-D (1) (2) / (3) – (4) (5) – (6)

(1)Series

Symbol	Series
None	Standard
J	Compact & lightweight specifications
L	Low-inertia specifications

(2) Short time (or %ED) rated output

Symbol	Short-time rated output
3.7	3.7 kW
5.5	5.5 kW
7.5	7.5 kW
11	11 kW
15	15 kW

(3) Maximum rotation speed
Indicates the hundreds place and higher order digits.

(4) Specification code
Indicates a specification code (01 to 99).

(5) Encoder

Symbol	Type
None	Type 1
T	Type 2

(6) Specificactions (Note)

Symbol	Specifications
None	Standard (flange type, without oil seal, without key, coil changeover unavailable, air-cooling, solid shaft)
C	With key
J	Oil seal
S	Hollow shaft
X	Reversed cooling air

(Note) If more than one option is included, the symbols are in alphabetical order.

(Note) This explains the model name system of spindle motors, but does not mean all the combinations are available.

< SJ-V/VL Series >

SJ- (1) (2) (3) (4) – (5) (6) T

(1) Motor series

Symbol	Motor series
V	Medium-inertia series
VL	Low-inertia series

(4) Short time rated output
(For normal specification)

Symbol	Short time rated output
0.75	0.75 kW
1.5	1.5 kW
2.2	2.2 kW
3.7	3.7 kW
5.5	5.5 kW
7.5	7.5 kW
11	11 kW

(6) Special specification

Symbol	Special specification
None	Standard
Z	High-speed bearing
FZ	High-speed bearing front-lock

(5) Specification code
The SJ-V/VL Series is indicated with a specification code (01 to 99).

(3) Shaft configuration

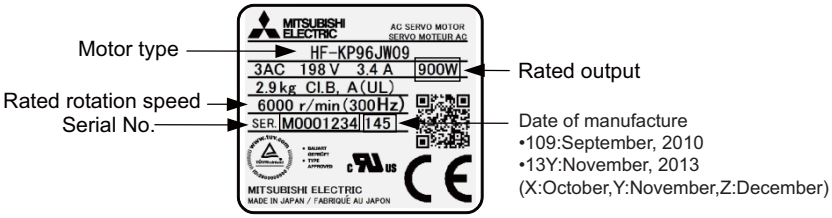
Symbol	Axis configuration
None	Standard
S	Hollow shaft

(2) Coil changeover

Symbol	Coil changeover
None	Unavailable

(Note) This explains the model name system of spindle motors, but does not mean all the combinations are available.

1.2.4 Tool Spindle Motor Type



Motor rating nameplate

Rating nameplate

< HF-KP Series >

HF-KP (1) J (2) W09

(1) Rated output and maximum rotation speed

Symbol	Rated output	Maximum rotation speed	Flange size (mm)
46	0.4 kW	6000 r/min	60 SQ.
56	0.5 kW	6000 r/min	60 SQ.
96	0.9 kW	6000 r/min	80 SQ.

(2) Option

Symbol	Option
None	Without keyway
K	With keyway (with key)

< HF Series >

HF (1) (2) - (3)

(1) Rated output · Maximum rotation speed

Symbol	Rated output	Maximum rotation speed	Flange size (mm)
75	0.75 kW	4000 r/min	90 SQ.
105	1.0 kW	4000 r/min	90 SQ.
54	0.5 kW	3000 r/min	130 SQ.
104	1.0 kW	3000 r/min	130 SQ.
154	1.5 kW	3000 r/min	130 SQ.
224	2.2 kW	3000 r/min	130 SQ.
204	2.0 kW	3000 r/min	176 SQ.

(2) Shaft end structure

Symbol	Shaft end structure
S	Straight

(3) Encoder

Symbol	Type	Resolution
A48	OSA18-100	260,000 p/rev

(Note) Encoder A51 can not beused with the tool spindle motor.

< Combination with spindle drive unit >

(a) 1-axis spindle drive unit

Unit Type MDS-DJ-SP-	Unit width	Compatible motor type / Unit nominal maximum current \ Rated torque (N·m)	HF□ 75	HF□ 105	HF□ 54	HF□ 104	HF□ 154	HF□ 224	HF□ 204	HF-KP□ 46	HF-KP□ 56	HF-KP□ 96
			1.8	2.4	1.6	3.2	4.8	7.0	6.4	0.64	0.8	1.43
20	60mm	20A	●	●	●					●	●	●
40	90mm	40A				●						
80		80A					●	●	●			
100	105mm	100A										
120		120A										
160	172mm	160A										

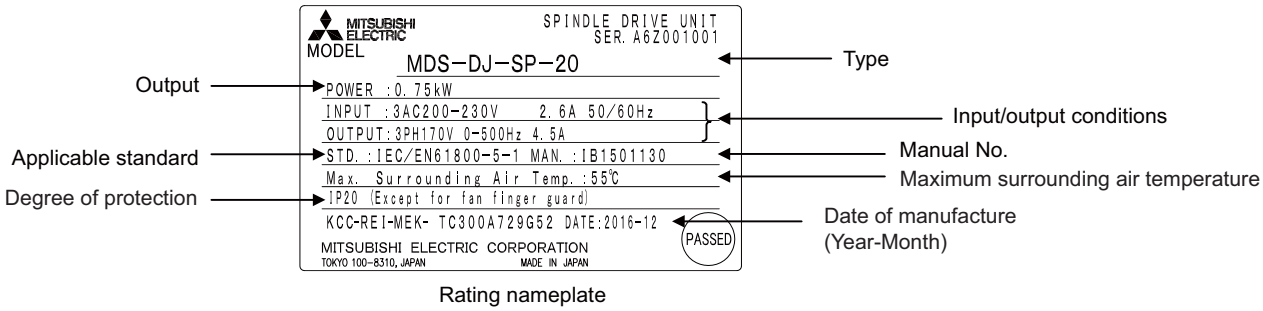
● Indicates the compatible motor for each spindle drive unit.

(b) 2-axis spindle drive unit

Unit Type MDS-DJ-SP2-	Unit width	Compatible motor type / Unit nominal maximum current \ Rated torque (N·m)	HF□ 75	HF□ 105	HF□ 54	HF□ 104	HF□ 154	HF□ 224	HF□ 204	HF-KP□ 46	HF-KP□ 56	HF-KP□ 96
			1.8	2.4	1.6	3.2	4.8	7.0	6.4	0.64	0.8	1.43
2020	85mm	20+20A	●	●	●					●	●	●

● Indicates the compatible motor for each spindle drive unit.

1.2.5 Spindle Drive Unit Type



Rating nameplate

(a) 1-axis spindle drive unit

MDS-DJ-SP- **(1)**

(1) Capacity

Symbol	Unit nominal maximum current	Unit width
20	20A	60mm
40	40A	90mm
80	80A	
100	100A	105mm
120	120A	
160	160A	172mm

(b) 2-axis spindle drive unit

MDS-DJ-SP2- **(1)**

(1) Capacity

Symbol	Unit nominal maximum current	Unit width
2020	20+20A	85mm

2

Specifications

2.1 Servo Motor

2.1.1 Specifications List

< HF Series >

Servo motor type		HF Series							
		ABS specifications: HF □ -A51 / -A48							
		HF75	HF105	HF54	HF104	HF154	HF224	HF204	HF354
Compatible servo drive unit type	MDS-DJ-V1	30	30	30	40	80	80	80	100
	MDS-DJ-V2-	3030	3030	3030	-	-	-	-	-
Continuous characteristics	Rated output [kW]	0.75	1.0	0.5	1.0	1.5	2.2	2.0	3.5
	Rated current [A]	3.1	3.7	2.0	3.9	5.6	8.6	6.8	12
	Rated torque [N•m]	1.8	2.4	1.6	3.2	4.8	7.0	6.4	11.1
	Stall current [A]	3.2	4.6	3.2	6.6	11	15	15	22
	Stall torque [N•m]	2.0	3.0	2.9	5.9	9.0	12.0	13.7	22.5
Power facility capacity [kVA]		1.5	2.0	1.1	2.0	2.8	4.1	3.7	6.4
Rated rotation speed [r/min]		4000		3000					
Maximum rotation speed [r/min]		5000		4000					3500
Maximum current [A]		14.0	15.5	16.8	29.0	52.0	57.0	52.0	64.0
Maximum torque [N•m]		8.0	11.0	13.0	23.3	42.0	46.5	42.0	65.0
Power rate at continuous rated torque [kW/s]		12.3	11.2	4.1	8.42	12.7	20.7	10.6	16.5
Motor inertia [$\times 10^{-4}$kg•m^2]		2.6	5.1	6.1	11.9	17.8	23.7	38.3	75.0
Motor inertia with brake [$\times 10^{-4}$kg•m^2]		2.8	5.3	8.3	14.1	20.0	25.9	48.0	84.7
Maximum motor shaft conversion load inertia ratio		High-speed, high-accuracy machine: 3 times or less of motor inertia General machine tool (interpolation axis): 5 times or less of motor inertia General machine (non-interpolation axis): 7 times or less of motor inertia							
Motor side encoder		Resolution per motor revolution A51: 1,000,000 pulse/rev, A48: 260,000 pulse/rev							
Degree of protection		IP67 (The shaft-through portion is excluded.))							
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -15°C to 70°C (with no freezing)							
	Ambient humidity	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)							
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust							
	Altitude	Operation: 1000 meters or less above sea level, Storage: 10000 meters or less above sea level							
	Vibration	X,Y:24.5m/s^2 (2.5G)						X:24.5m/s^2 (2.5G) Y:29.4m/s^2 (3G)	
Flange size [mm]		90 SQ.	90 SQ.	130 SQ.	130 SQ.	130 SQ.	130 SQ.	176 SQ.	176 SQ.
Total length (excluding shaft) [mm] (Note 2)		126.5	162.5	118.5	140.5	162.5	184.5	143.5	183.5
Flange fitting diameter [mm]		Φ80	Φ80	Φ110	Φ110	Φ110	Φ110	Φ114.3	Φ114.3
Shaft diameter [mm]		Φ14	Φ14	Φ24	Φ24	Φ24	Φ24	Φ35	Φ35
Mass Without / with brake [kg]		2.5/3.9	4.3/5.7	4.8/6.7	6.5/8.5	8.3/10.3	10.0/12.0	12.0/18.0	19.0/25.0
Heat-resistant class		155(F)							

(Note 1) The above characteristics values are representative values. The maximum current and maximum torque are the values when combined with the drive unit.

(Note 2) The total length will be 3.5mm longer when using an A51 encoder.

(Note 3) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 4) Stall torque is the maximum torque that can be output continuously when the motor rotation is stopped.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< HF Series >

Servo motor type		HF Series				
		ABS specifications: HF □ -A51 / -A48				
		HF123	HF223	HF303	HF142	HF302
Compatible servo drive unit type	MDS-DJ-V1	40	40	80	40	40
Continuous characteristics	Rated output [kW]	1.2	2.2	3.0	1.4	3.0
	Rated current [A]	5.2	9.0	11	5.2	11
	Rated torque [N•m]	5.7	10.5	14.3	6.7	14.3
	Stall current [A]	6.4	11	16	6.4	11
	Stall torque [N•m]	7.0	12.0	22.5	11.0	20.0
Power facility capacity [kVA]		2.3	4.1	5.5	2.7	5.5
Rated rotation speed [r/min]		2000			2000	
Maximum rotation speed [r/min]		3000			2000	
Maximum current [A]		15.5	29.0	48.0	15.5	29.0
Maximum torque [N•m]		17.0	32.0	64.0	26.5	50.0
Power rate at continuous rated torque [kW/s]		27.3	46.5	27.3	25.2	27.3
Motor inertia [$\times 10^{-4}$kg•m^2]		11.9	23.7	75.0	17.8	75.0
Motor inertia with brake [$\times 10^{-4}$kg•m^2]		14.1	25.9	84.7	20.0	84.7
Maximum motor shaft conversion load inertia ratio		High-speed, high-accuracy machine: 3 times or less of motor inertia General machine tool (interpolation axis): 5 times or less of motor inertia General machine (non-interpolation axis): 7 times or less of motor inertia				
Motor side encoder		Resolution per motor revolution A51: 1,000,000 pulse/rev, A48: 260,000 pulse/rev				
Degree of protection		P67 (The shaft-through portion is excluded.)				
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -15°C to 70°C (with no freezing)				
	Ambient humidity	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)				
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust				
	Altitude	Operation: 1000 meters or less above sea level, Storage: 10000 meters or less above sea level				
	Vibration	X,Y:24.5m/s^2 (2.5G)		X:24.5m/s^2 (2.5G) Y:29.4m/s^2 (3G)	X,Y:24.5m/s^2 (2.5G)	X:24.5m/s^2 (2.5G) Y:29.4m/s^2 (3G)
Flange size [mm]		130 SQ.	130 SQ.	176 SQ.	130 SQ.	176 SQ.
Total length (excluding shaft) [mm] (Note 2)		140.5	184.5	183.5	162.5	183.5
Flange fitting diameter [mm]		Φ110	Φ110	Φ114.3	Φ110	Φ114.3
Shaft diameter [mm]		Φ24	Φ24	Φ35	Φ24	Φ35
Mass Without / with brake [kg]		6.5/8.5	10.0/12.0	19.0/25.0	8.3/11	19.0/25.0
Heat-resistant class		155 (F)				

(Note 1) The above characteristics values are representative values. The maximum current and maximum torque are the values when combined with the drive unit.

(Note 2) The total length will be 3.5mm longer when using an A51 encoder.

(Note 3) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 4) Stall torque is the maximum torque that can be output continuously when the motor rotation is stopped.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< HF-KP Series >

Servo motor type		HF-KP Series			
		Absolute position standard			
		HF-KP13J-S17	HF-KP23JW04-S6	HF-KP43JW04-S6	HF-KP73JW04-S6
Compatible servo drive unit type	MDS-DJ-V1	10	10	15	30
	MDS-DJ-V2-	-	-	-	3030 (L,M)
Continuous characteristics	Rated output [kW]	0.1	0.2	0.4	0.75
	Rated current [A]	0.8	1.4	2.9	5.2
	Rated torque [N•m]	0.32	0.64	1.3	2.4
	Stall current [A]	0.8	1.4	2.9	5.2
	Stall torque [N•m]	0.32	0.64	1.3	2.4
Power facility capacity [kVA]		0.4	0.6	0.9	1.5
Rated rotation speed [r/min]		3000			
Maximum rotation speed [r/min]		6000			
Maximum current [A]		2.31	4.3	8.5	15.5
Maximum torque [N•m]		0.95	1.9	3.8	7.2
Power rate at continuous rated torque [kW/s]		11.5	16.9	38.6	39.9
Motor inertia [$\times 10^{-4}$kg•m^2]		0.088	0.23	0.42	1.43
Motor inertia with brake [$\times 10^{-4}$kg•m^2]		0.090	0.31	0.50	1.63
Maximum motor shaft conversion load inertia ratio		General machine (non-interpolation axis): 15 times or less of motor inertia			
Motor side encoder		Resolution per motor revolution: 260,000 pulse/rev (Note 2)			
Degree of protection		IP65 (The shaft-through portion is excluded.)			
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -15°C to 70°C (with no freezing)			
	Ambient humidity	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)			
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust			
	Altitude	Operation: 1000 meters or less above sea level, Storage: 10000 meters or less above sea level			
	Vibration	X,Y: 49m/s^2 (5G)			
Flange size [mm]		40 SQ. (Note 3)	60 SQ.	60 SQ.	80 SQ.
Total length (excluding shaft) [mm]		92.8	98	119.9	134.2
Flange fitting diameter [mm]		Φ30	Φ50	Φ50	Φ70
Shaft diameter [mm]		Φ8	Φ14	Φ14	Φ19
Mass Without / with brake [kg]		0.66/0.96	1.2/1.8	1.7/2.3	2.9/4.1
Heat-resistant class		130 (B)			

(Note 1) The above characteristics values are representative values. The maximum current and maximum torque are the values when combined with the drive unit.

(Note 2) HF-KP13J-S17 is an absolute position specification motor, however this motor is not equipped with a capacitor for data backup.Thus the absolute position is lost as soon as the encoder cable is disconnected.

(Note 3) The outside dimensions of the encoder part are 50 sq. mm.

(Note 4) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

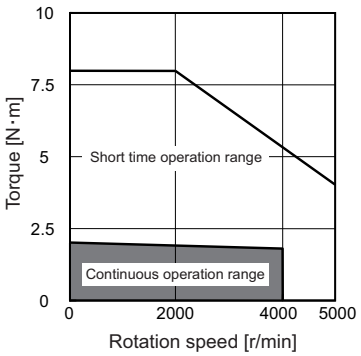
(Note 5) Stall torque is the maximum torque that can be output continuously when the motor rotation is stopped.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

2.1.2 Torque Characteristics

< HF Series >

[HF75]



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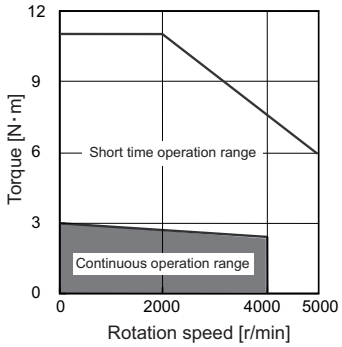

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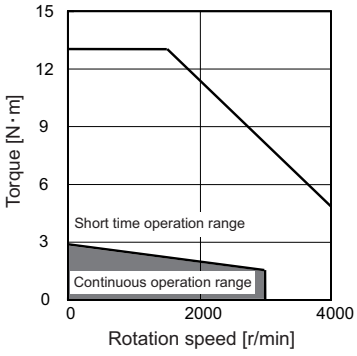

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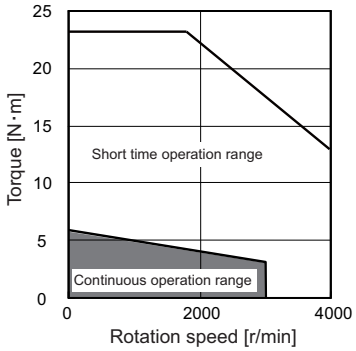

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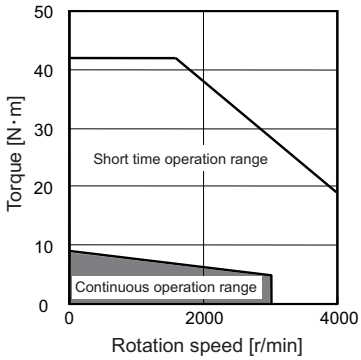

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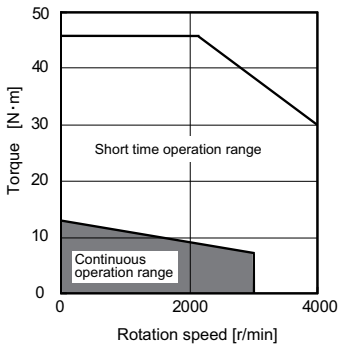
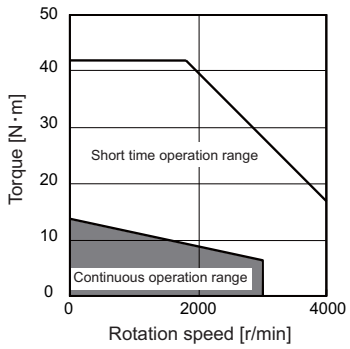


[HF204]



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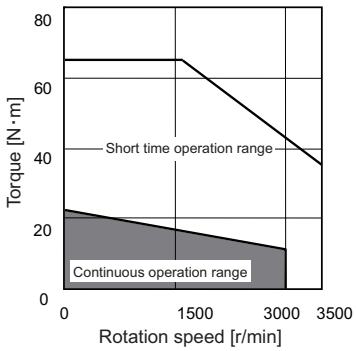

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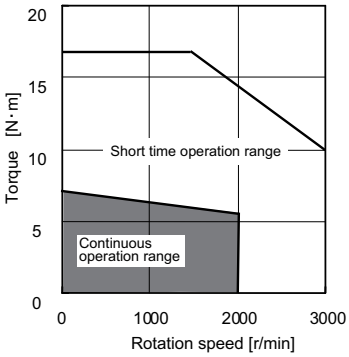

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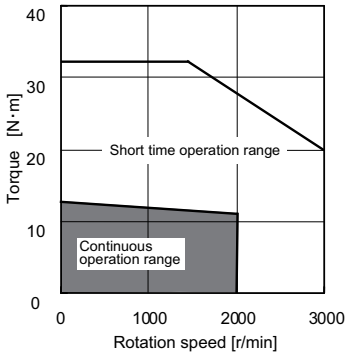

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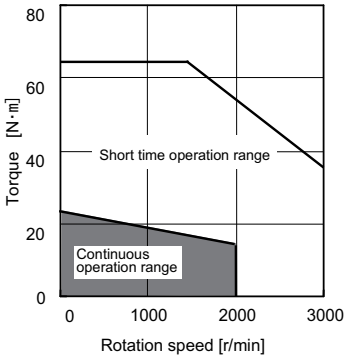
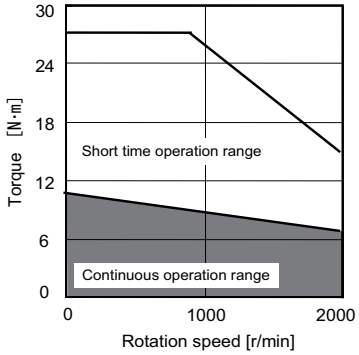


(Note) The solid line of short time operation range shows the characteristics of 3-phase 200V input.

< HF Series >

[HF142]



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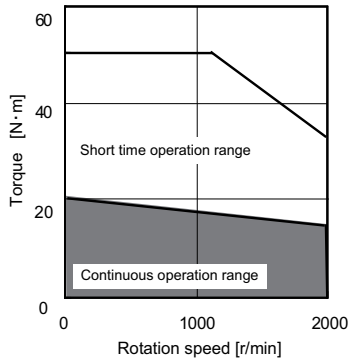
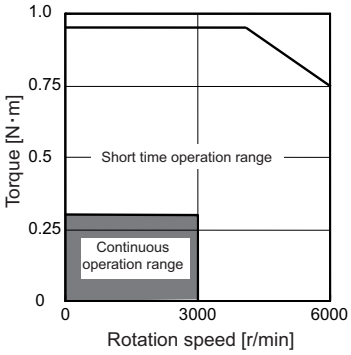


< HF-KP Series >

[HF-KP13J-S17]



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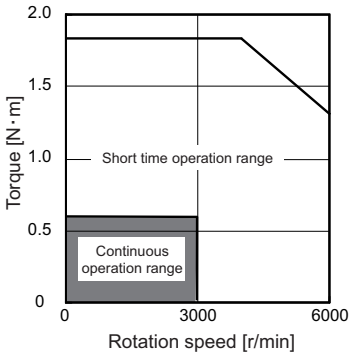

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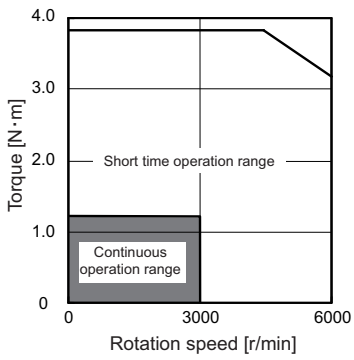

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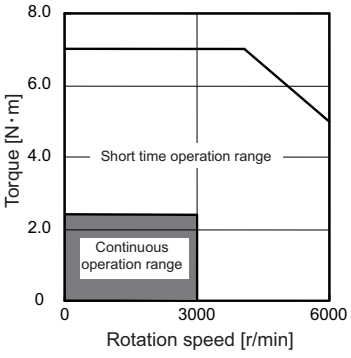


(Note) The solid line of short time operation range shows the characteristics of 3-phase 200V input.

2.2 Spindle Motor

2.2.1 Specifications

< SJ-D Series (Normal) >

Spindle motor type		SJ-D3.7/100-01	SJ-D5.5/100-01	SJ-D5.5/120-01	SJ-D7.5/100-01	SJ-D7.5/120-01	SJ-D11/100-01
Compatible spindle drive unit type	MDS-DJ-SP	80	100	100	120	120	160
Output capacity [kW]	Continuous rated output	2.2	3.7	3.7	5.5	5.5	7.5
	Short time rated output	3.7 (15-minute rating)	5.5 (30-minute rating)	5.5 (30-minute rating)	7.5 (30-minute rating)	7.5 (30-minute rating)	11 (30-minute rating)
	Standard output during acceleration/deceleration	3.7	5.5	5.5	7.5	7.5	11
	Actual acceleration/ deceleration output (Note 3)	4.44	6.6	6.6	9	9	13.2
Power facility capacity [kVA]		6.7	9.9	9.9	13.4	13.4	19.6
Base rotation speed [r/min]		1500	1500	1500	1500	1500	1500
Maximum rotation speed [r/min]		10000	10000	12000	10000	12000	10000
Frame No.		B90	D90	D90	A112	A112	B112
Continuous rated torque [N•m]		14.0	23.6	23.6	35.0	35.0	47.7
GD^2 [kg•m^2]		0.030	0.053	0.053	0.094	0.094	0.122
Inertia [kg•m^2]		0.0074	0.013	0.013	0.023	0.023	0.031
Tolerable radial load [N]		980	1470	1470	1960	1960	1960
Cooling fan	Input voltage	3-phase 200V					
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -20°C to 65°C (with no freezing)					
	Ambient humidity	Operation: 90%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)					
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust					
	Altitude	Operation: 1000 meters or less above sea level, Storage: 1000 meters or less above sea level, Transportation: 10000 meters or less above sea level					
Degree of protection		IP54 (The shaft-through portion is excluded.)					
Flange size [mm]		174 SQ.	174 SQ.	174 SQ.	204 SQ.	204 SQ.	204 SQ.
Total length (excluding shaft) [mm]		327	417	417	439	439	489
Flange fitting diameter [mm]		Φ150	Φ150	Φ150	Φ180	Φ180	Φ180
Shaft diameter [mm]		Φ28	Φ28	Φ28	Φ32	Φ32	Φ48
Mass [kg]		26	39	39	53	53	64
Heat-resistant class		155 (F)					

(Note 1) The tolerable radial load is the value calculated at the center of output shaft.

(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 3) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

(Note 4) IP code classifies the degree of protection of the motor body. It does not apply to the other electronic parts such as the cooling fan and the encoder.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< SJ-DJ Series (Compact & lightweight) >

Spindle motor type		SJ-DJ5.5/100-01	SJ-DJ5.5/120-01	SJ-DJ7.5/100-01	SJ-DJ7.5/120-01	SJ-DJ11/100-01
Compatible spindle drive unit type	MDS-DJ-SP	100	100	120	120	160
Output capacity [kW]	Continuous rated output	3.7	3.7	5.5	5.5	7.5
	Short time rated output	5.5 (25%ED rating)	5.5 (25%ED rating)	7.5 (15-minute rating)	7.5 (15-minute rating)	11 (15-minute rating)
	Standard output during acceleration/deceleration	5.5	5.5	7.5	7.5	11
	Actual acceleration/ deceleration output (Note 3)	6.6	6.6	9	9	13.2
Power facility capacity [kVA]		9.9	9.9	13.4	13.4	19.6
Base rotation speed [r/min]		1500	1500 (25%ED rating:2000)	1500	(Continuous) 2000 / (Short time) 1500	1500
Maximum rotation speed [r/min]		10000	12000	10000	12000	10000
Frame No.		B90	B90	D90	D90	A112
Continuous rated torque [N•m]		17.7	17.7	26.3	26.3	35.8
GD^2 [kg•m^2]		0.030	0.030	0.053	0.053	0.094
Inertia [kg•m^2]		0.0074	0.0074	0.013	0.013	0.023
Tolerable radial load [N]		980	980	1470	1470	1960
Cooling fan	Input voltage	3-phase 200V				
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -20°C to 65°C (with no freezing)				
	Ambient humidity	Operation: 90%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)				
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust				
	Altitude	Operation: 1000 meters or less above sea level, Storage: 1000 meters or less above sea level, Transportation: 10000 meters or less above sea level				
Degree of protection		IP54 (The shaft-through portion is excluded.)				
Flange size [mm]		174 SQ.	174 SQ.	174 SQ.	174 SQ.	204 SQ.
Total length (excluding shaft) [mm]		327	327	417	417	439
Flange fitting diameter [mm]		Φ150	Φ150	Φ150	Φ150	Φ180
Shaft diameter [mm]		Φ28	Φ28	Φ28	Φ28	Φ32
Mass [kg]		26	26	39	39	53
Heat-resistant class		155 (F)				

(Note 1) The tolerable radial load is the value calculated at the center of output shaft.

(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 3) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

(Note 4) IP code classifies the degree of protection of the motor body. It does not apply to the other electronic parts such as the cooling fan and the encoder.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< SJ-V Series (Normal) >

Spindle motor type		SJ-V2.2-01T	SJ-VL2.2-02ZT	SJ-V7.5-03ZT
Compatible spindle drive unit type	MDS-DJ-SP	40	80	160
	MDS-DJ-SP2-	-	-	-
Output capacity [kW]	Continuous rated output	1.5	1.5	5.5
	Short time rated output	2.2 (15-minute rating)	2.2 (15-minute rating)	7.5 (30-minute rating)
	Standard output during acceleration/deceleration	2.2	2.2	7.5
	Actual acceleration/ deceleration output (Note 3)	2.64	2.64	9
Power facility capacity [kVA]		4.1	4.1	13.4
Base rotation speed [r/min]		1500	3000	1500
Maximum rotation speed [r/min]		10000	15000	10000
Frame No.		A90	B71	A112
Continuous rated torque [N•m]		9.5	4.77	35
GD^2 [kg•m^2]		0.027	0.0096	0.098
Inertia [kg•m^2]		0.00675	0.0024	0.0245
Tolerable radial load [N]		980	196	980
Cooling fan	Input voltage	Single-phase 200V	Single-phase 200V	3-phase 200V
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -20°C to 65°C (with no freezing)		
	Ambient humidity	Operation: 90%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)		
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust		
	Altitude	Operation: 1000 meters or less above sea level, Storage: 1000 meters or less above sea level, Transportation: 10000 meters or less above sea level		
Degree of protection		IP44		
Flange size [mm]		174 SQ.	130 SQ.	204 SQ.
Total length (excluding shaft) [mm]		300	325	440
Flange fitting diameter [mm]		Φ150	Φ110	Φ180
Shaft diameter [mm]		Φ28	Φ22	Φ32
Mass [kg]		25	20	60
Heat-resistant class		155 (F)		

(Note 1) The tolerable radial load is the value calculated at the center of output shaft.

(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 3) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

(Note 4) IP code classifies the degree of protection of the motor body. It does not apply to the other electronic parts such as the cooling fan and the encoder.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< SJ-VL Series (Low-inertia) >

Spindle motor type		SJ-VL11-05FZT-S01
Compatible spindle drive unit type	MDS-DJ-SP	160
Output capacity [kW]	Continuous rated output	1.5
	Short time rated output	3 (10-minute rating)
	Standard output during acceleration/deceleration	11
	Actual acceleration/ deceleration output (Note 3)	13.2
Power facility capacity [kVA]		5.5
Base rotation speed [r/min]		5000
Maximum rotation speed [r/min]		12000
Frame No.		B71
Continuous rated torque [N•m]		2.8
GD^2 [kg•m^2]		0.0096
Inertia [kg•m^2]		0.0024
Tolerable radial load [N]		98
Cooling fan	Input voltage	Single-phase 200V
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -20°C to 65°C (with no freezing)
	Ambient humidity	Operation: 90%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust
	Altitude	Operation: 1000 meters or less above sea level, Storage: 1000 meters or less above sea level Transportation: 10000 meters or less above sea level
Degree of protection		IP44
Flange size [mm]		130 SQ.
Total length (excluding shaft) [mm]		335
Flange fitting diameter [mm]		Φ110
Shaft diameter [mm]		Φ22
Mass [kg]		20
Heat-resistant class		155 (F)

(Note 1) The tolerable radial load is the value calculated at the center of output shaft.

(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

(Note 3) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

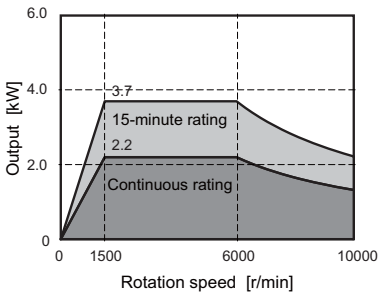
(Note 4) IP code classifies the degree of protection of the motor body. It does not apply to the other electronic parts such as the cooling fan and the encoder.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

2.2.2 Output Characteristics

< SJ-D Series (Normal) >

[SJ-D3.7/100-01]



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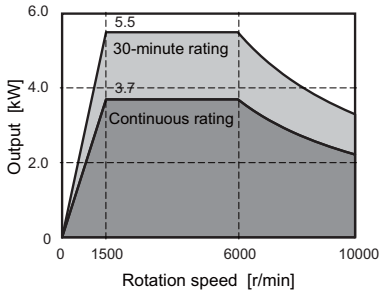

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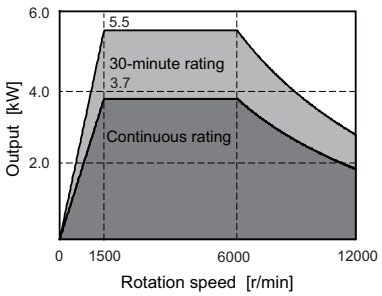

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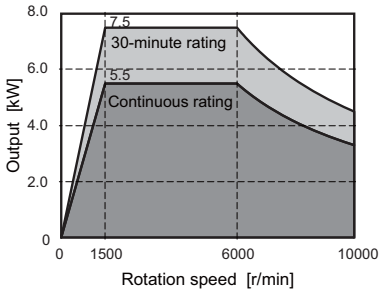

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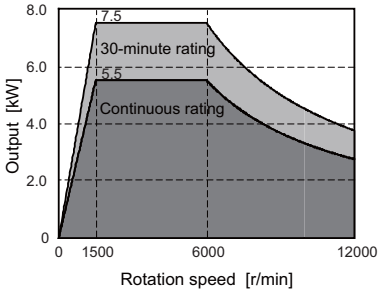

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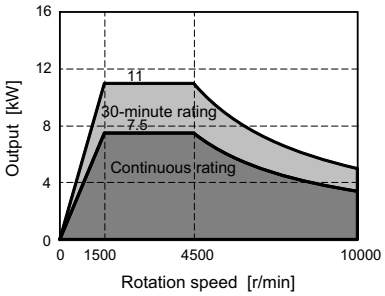

< SJ-DJ Series (Compact & lightweight) >

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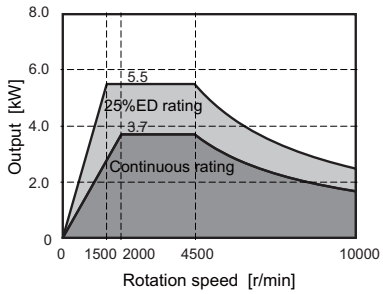
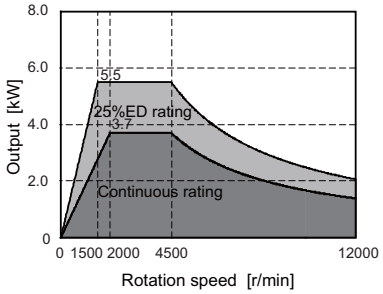


[SJ-DJ5.5/120-01]



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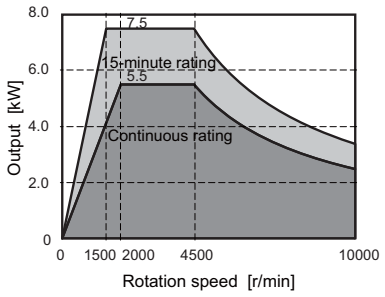

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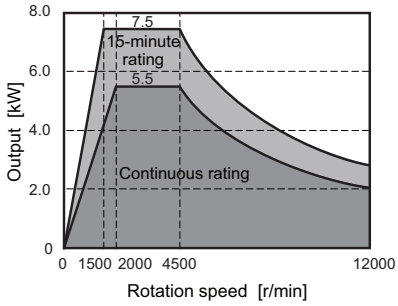

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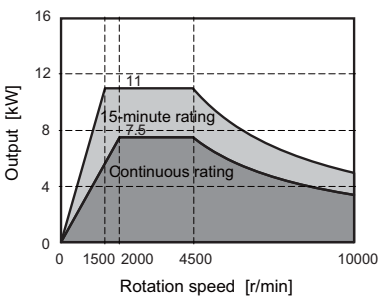
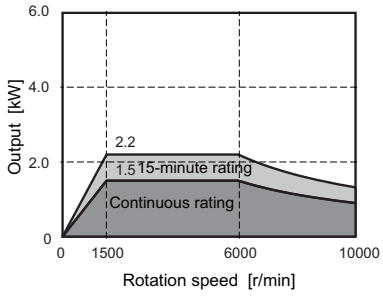


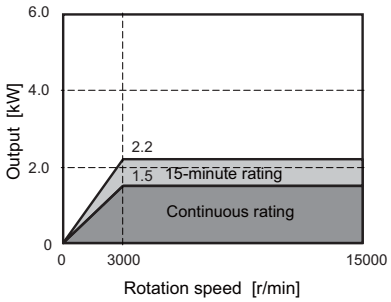
(Note) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

< SJ-V Series (Normal) >

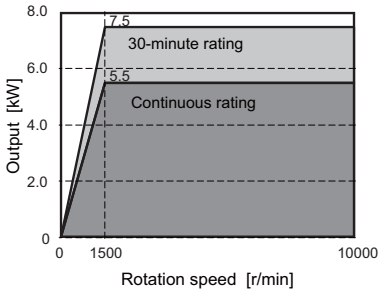
[SJ-V2.2-01T]



[SJ-VL2.2-02ZT]

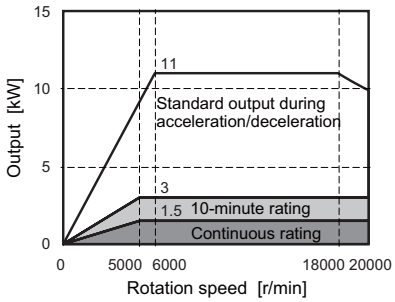


[SJ-V7.5-03ZT]



< SJ-VL Series (Low-inertia) >

[SJ-VL11-05FZT-S01]



(Note) Actual acceleration/deceleration output is 1.2-fold of "Standard output during acceleration/deceleration" or "Short time rated output".

2.3 Tool Spindle Motor

2.3.1 Specifications

< HF-KP Series >

Tool spindle motor type		HF-KP Series		
		HF-KP □ JW09		
		HF-KP46	HF-KP56	HF-KP96
Compatible spindle drive unit type	MDS-DJ-SP	20	20	20
	MDS-DJ-SP2-	2020	2020	2020
Continuous characteristics	Rated output [kW]	0.4	0.5	0.9
	Rated current [A]	1.5	1.8	3.4
	Rated torque [N•m]	0.64	0.80	1.43
Power facility capacity [kVA]		0.9	1.1	1.8
Rated rotation speed [r/min]		6000		
Maximum rotation speed [r/min]		6000		
Maximum current [A]		5.5	11.3	15.5
Maximum torque [N•m]		2.5	5.0	6.5
Motor inertia [$\times 10^{-4}$kg•m^2]		0.24	0.42	1.43
Motor side encoder		Resolution per motor revolution 260,000 pulse/rev		
Degree of protection		IP67 (The shaft-through portion is excluded.)		
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -15°C to 70°C (with no freezing)		
	Ambient humidity	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)		
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust		
	Altitude	Operation: 1000 meters or less above sea level, Storage: 10000 meters or less above sea level		
	Vibration	X,Y: 49m/s^2 (5G)		
Flange size [mm]		60 SQ.	60 SQ.	80 SQ.
Total length (excluding shaft) [mm]		118.7	140.6	149.1
Flange fitting diameter [mm]		Φ50	Φ50	Φ70
Shaft diameter [mm]		Φ14	Φ14	Φ19
Mass [kg]		1.2	1.7	2.9
Heat-resistant class		130 (B)		

(Note 1) The above characteristics values are representative values. The maximum current and maximum torque are the values when combined with the drive unit.

(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

< HF Series >

Tool spindle motor type		HF Series						
		HF □ -A48						
		HF75	HF105	HF54	HF104	HF154	HF224	HF204
Compatible spindle drive unit type	MDS-DJ-SP	20	20	20	40	80	80	80
	MDS-DJ-SP2-	2020	2020	2020	-	-	-	-
Continuous characteristics	Rated output [kW]	0.75	1.0	0.5	1.0	1.5	2.2	2.0
	Rated current [A]	3.1	3.7	2.0	3.9	5.6	8.6	6.8
	Rated torque [N•m]	1.8	2.4	1.6	3.2	4.8	7.0	6.4
Power facility capacity [kVA]		1.5	2.0	1.1	2.0	2.8	4.1	3.7
Rated rotation speed [r/min]		4000		3000				
Maximum rotation speed [r/min]		4000		3000				
Maximum current [A]		14.0	15.5	16.8	29.0	52.0	57.0	52.0
Maximum torque [N•m]		7.0	8.1	12.1	23.3	33.9	46.5	46.5
Motor inertia [$\times 10^{-4}$kg•m^2]		2.6	5.1	6.1	11.9	17.8	23.7	38.3
Motor side encoder		Resolution per motor revolution 260,000 pulse/rev						
Degree of protection		IP67 (The shaft-through portion is excluded.)						
Environment	Ambient temperature	Operation: 0 to 40°C (with no freezing), Storage: -15°C to 70°C (with no freezing)						
	Ambient humidity	Operation: 80%RH or less (with no dew condensation), Storage: 90%RH or less (with no dew condensation)						
	Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, or dust						
	Altitude	Operation: 1000 meters or less above sea level, Storage: 10000 meters or less above sea level						
	Vibration	X:19.6m/s^2 (2G) Y:19.6m/s^2(2G)						
Flange size [mm]		90 SQ.	90 SQ.	130 SQ.	130 SQ.	130 SQ.	130 SQ.	176 SQ.
Total length (excluding shaft) [mm]		126.5	162.5	118.5	140.5	162.5	184.5	143.5
Flange fitting diameter [mm]		Φ80	Φ80	Φ110	Φ110	Φ110	Φ110	Φ114.3
Shaft diameter [mm]		Φ14	Φ14	Φ24	Φ24	Φ24	Φ24	Φ35
Mass [kg]		2.5	4.3	4.8	6.5	8.3	10.0	12.0
Heat-resistant class		155 (F)						

(Note 1) The above characteristics values are representative values. The maximum current and maximum torque are the values when combined with the drive unit.

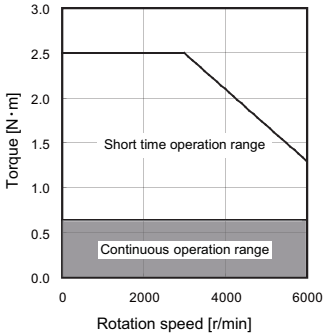
(Note 2) Only the combination designated in this manual can be used for the motor and drive unit. Always use the designated combination.

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

2.3.2 Torque Characteristics

< HF-KP Series >

[HF-KP46JW09]



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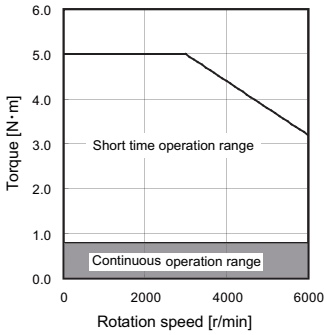

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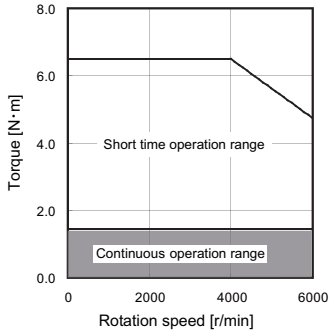
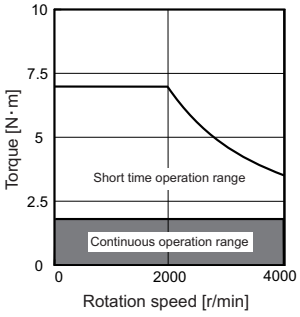


< HF Series >

[HF75]



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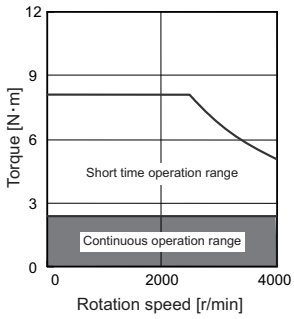
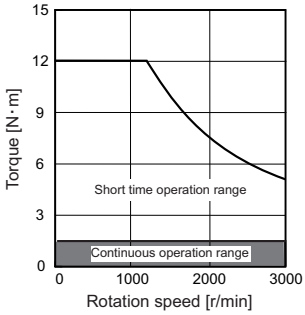


[HF54]



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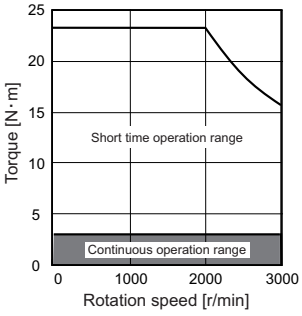

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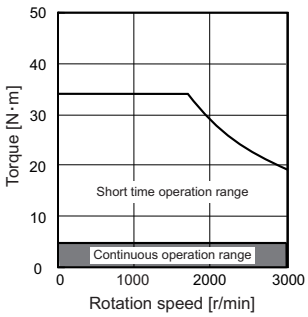

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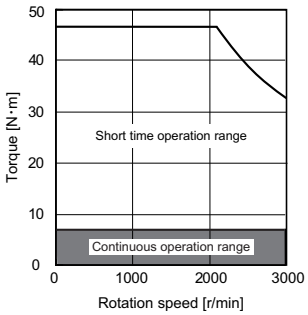

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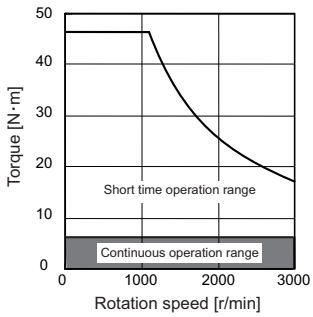


(Note) The above graphs show the data when applied the input voltage of 200VAC. When the input voltage is 200VAC or less, the short time operation range is limited.

2.4 Drive Unit

2.4.1 Installation Environment Conditions

Common installation environment conditions for servo and spindle are shown below.

Environment	**Ambient temperature**	Operation: 0 to 55°C (with no freezing), Storage / Transportation: -15°C to 70°C (with no freezing)
	Ambient humidity	Operation: 90%RH or less (with no dew condensation) Storage / Transportation: 90%RH or less (with no dew condensation)
	Atmosphere	Indoors (no direct sunlight) With no corrosive gas, inflammable gas, oil mist, dust or conductive fine particles
	Altitude	Operation/Storage: 1000 meters or less above sea level, Transportation: 13000 meters or less above sea level
	Vibration/impact	4.9m/s^2 (0.5G) / 49m/s^2 (5G)

2.4.2 Servo Drive Unit

		Servo drive unit MDS-DJ-V1 Series					
Servo drive unit type MDS-DJ-V1-		10	15	30	40	80	100
Nominal maximum current (peak) [A]		10	15	30	40	80	100
Output	Rated voltage [V]	AC155					
	Rated current [A]	1.5	3.2	5.8	11	16	22
Input	Rated voltage [V]	3-phase 200AC(50Hz)/ 3-phase 200 to 230AC(60Hz) Tolerable fluctuation: between +10% and -15%					
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%					
	Rated current [A]	1.5	2.9	3.8	8.0	10.5	16
Control power	Voltage [V]	Single-phase 200 to 230AC (50Hz/60Hz) Tolerable fluctuation: between +10% and -15%					
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%					
	Maximum current [A]	0.2					
	Maximum rush current [A]	30					
	Maximum rush conductivity time [ms]	6					
Maximum earth leakage current [mA]		2					
Main circuit method		Converter with resistor regeneration circuit					
Control method		Sine wave PWM control method					
Braking		Regenerative braking and dynamic brakes					
	Dynamic brakes	Built-in					
External analog output		0 to +5V, 2ch (data for various adjustments)					
Degree of protection		IP20					
Cooling method		Natural-cooling		Forced wind cooling			
Mass [kg]		0.8	1.0	1.4	2.1	2.1	2.3
Heat radiated at rated output [W]		25	35	50	90	130	195
Unit outline dimension drawing		J1	J2	J3	J4a	J4a	J4b

		Servo drive unit MDS-DJ-V2 Series
Servo drive unit type MDS-DJ-V2-		3030
Nominal maximum current (peak) [A]		30/30
Output	Rated voltage [V]	AC155
	Rated current [A]	5.8×2
Input	Rated voltage [V]	3-phase 200AC (50Hz) / 3-phase 200 to 230AC (60Hz) Tolerable fluctuation: between +10% and -15%
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%
	Rated current [A]	7.5
Control power	Voltage [V]	Single-phase 200 to 230AC (50Hz/60Hz) Tolerable fluctuation: between +10% and -15%
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%
	Maximum current [A]	0.4
	Maximum rush current [A]	30
	Maximum rush conductivity time [ms]	6
Maximum earth leakage current [mA]		4
Main circuit method		Converter with resistor regeneration circuit
Control method		Sine wave PWM control method
Braking		Regenerative braking and dynamic brakes
	Dynamic brakes	Built-in
External analog output		0 to +5V, 2ch (data for various adjustments)
Degree of protection		IP00
Cooling method		Forced wind cooling
Mass [kg]		1.9
Heat radiated at rated output [W]		90
Unit outline dimension drawing		JW1

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

2.4.3 Spindle Drive Unit

		Spindle drive unit MDS-DJ-SP Series					
Spindle drive unit type MDS-DJ-SP-		20	40	80	100	120	160
Nominal maximum current (peak) [A]		20	40	80	100	120	160
Output	Rated voltage [V]	155AC					
	Rated current [A]	4.5	10	11	18	26	36
Input	Rated voltage [V]	3-phase 200AC (50Hz) / 3-phase 200 to 230AC (60Hz) Tolerable fluctuation: between +10% and -15%					
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%					
	Rated current [A]	2.6	9.0	10.5	16	26	35.4
Control power	Voltage [V]	Single-phase 200 to 230AC (50Hz/60Hz) Tolerable fluctuation: between +10% and -15%					
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%					
	Maximum current [A]	0.2					
	Maximum rush current [A]	0.75 to 3.7kW:30, 5.5 to 11kW:34					
	Maximum rush conductivity time [ms]	0.75 to 3.7kW:6, 5.5 to 11kW:7					
Maximum earth leakage current [mA]		15					
Main circuit method		Converter with resistor regeneration circuit					
Control method		Sine wave PWM control method					
Braking		Regenerative braking					
External analog output		0 to +5V, 2ch (data for various adjustments)					
Degree of protection		IP20			IP20 (excluding terminal block)		
Cooling method		Forced wind cooling					
Mass [kg]		1.4	2.1	2.3	4.0	4.0	6.2
Heat radiated at continuous rated output [W]		50	90	130	150	200	300
Unit outline dimension drawing		J3	J4a	J4b	J5	J5	J6

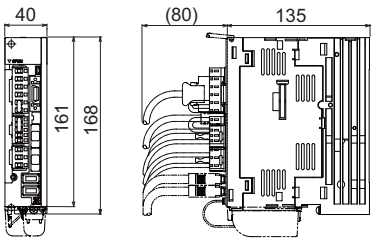
		Spindle drive unit MDS-DJ-SP2 Series
Spindle drive unit type MDS-DJ-SP2-		2020
Nominal maximum current (peak) [A]		20/20
Output	Rated voltage [V]	AC155
	Rated current [A]	4.5×2
Input	Rated voltage [V]	3-phase 200AC (50Hz) / 3-phase 200 to 230AC (60Hz) Tolerable fluctuation: between +10% and -15%
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%
	Rated current [A]	5.2
Control power	Voltage [V]	Single-phase 200 to 230AC (50Hz/60Hz) Tolerable fluctuation: between +10% and -15%
	Frequency [Hz]	50/60 Tolerable fluctuation: between +5% and -5%
	Maximum current [A]	0.4
	Maximum rush current [A]	30
	Maximum rush conductivity time [ms]	6
Maximum earth leakage current [mA]		30
Main circuit method		Converter with resistor regeneration circuit
Control method		Sine wave PWM control method
Braking		Regenerative braking
External analog output		0 to +5V, 2ch (data for various adjustments)
Degree of protection		IP00
Cooling method		Forced wind cooling
Mass [kg]		1.8
Heat radiated at continuous rated output [W]		90
Unit outline dimension drawing		JW1

For outline dimension drawings, refer to "DRIVE SYSTEM DATA BOOK" (IB-1501142(ENG)).

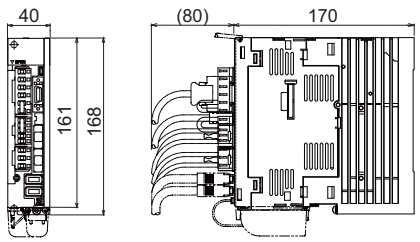
2.4.4 Unit Outline Dimension Drawing

Unit [mm]

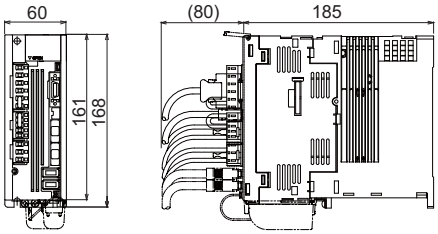
J1



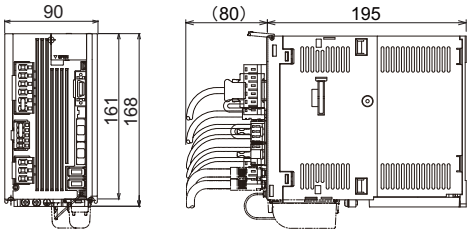
J2



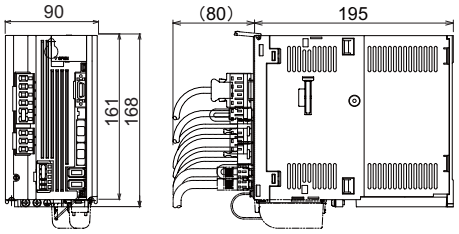
J3



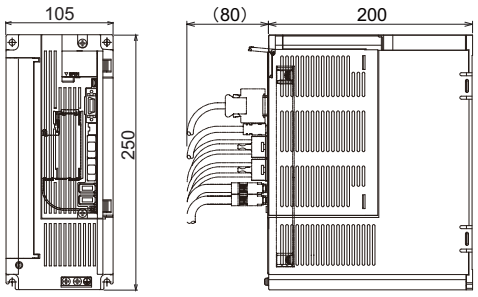
J4a



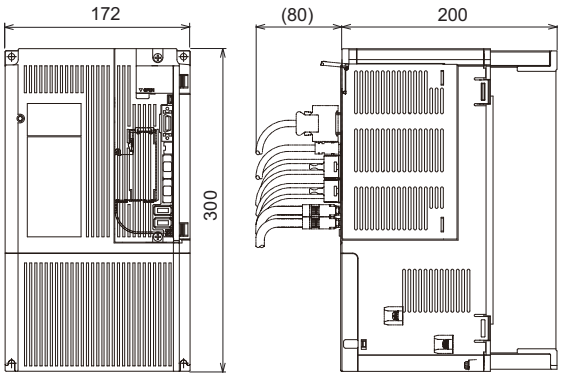
J4b



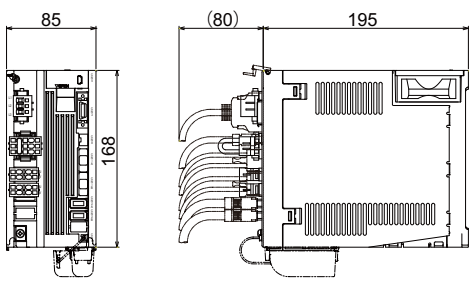
J5



J6

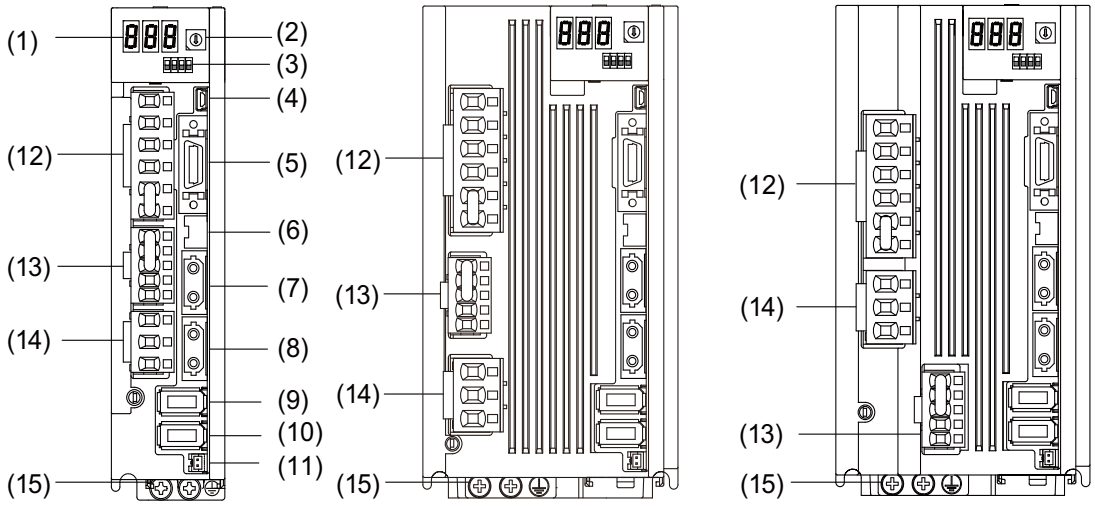


JW1



2.4.5 Explanation of Each Part

(1) Explanation of each servo drive unit (MDS-DJ-V1) part



MDS-DJ-V1-10/15/30 MDS-DJ-V1-40/80 MDS-DJ-V1-100

The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

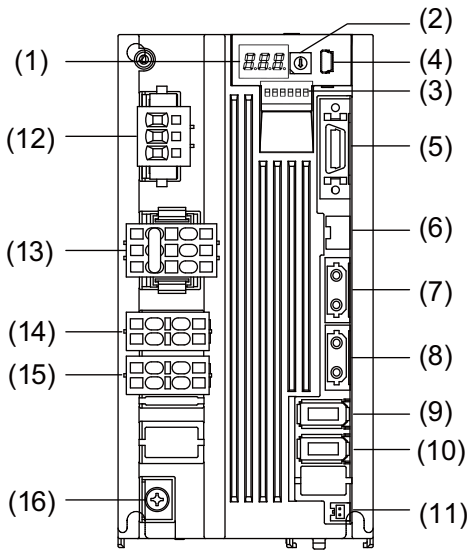
<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch	---
(3)		SW2	---	For machine tool builder adjustment: Always OFF (facing bottom)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2	---	Motor side encoder connection connector 5V power supply capacity: 0.35A	---
(10)		CN3	---	Machine side encoder connection connector 5V power supply capacity: 0.35A	---
(11)		BAT	---	Battery connection connector	---
(12)	Main circuit	CNP1	L1,L2,L3 N-,P3,P4	L1,L2,L3: 3-phase AC power input N-: Test terminal for the manufacturer (Do not connect.) P3,P4: Not used (short-circuit between the P3 and P4.)	---
(13)		CNP2	P+,C,D L11,L21	Regenerative resistor connection terminal Control power input terminal (single-phase AC input)	---
(14)		CNP3	U, V, W	Motor power supply output connector (3-phase AC output)	---
(15)		PE	⏚	Grounding terminal	M4 x 12

⚠ CAUTION

Do not connect the N terminal of CNP1 because it is the test terminal for the manufacturer.

(2) Explanation of each servo drive unit (MDS-DJ-V2-3030) part



MDS-DJ-V2-3030

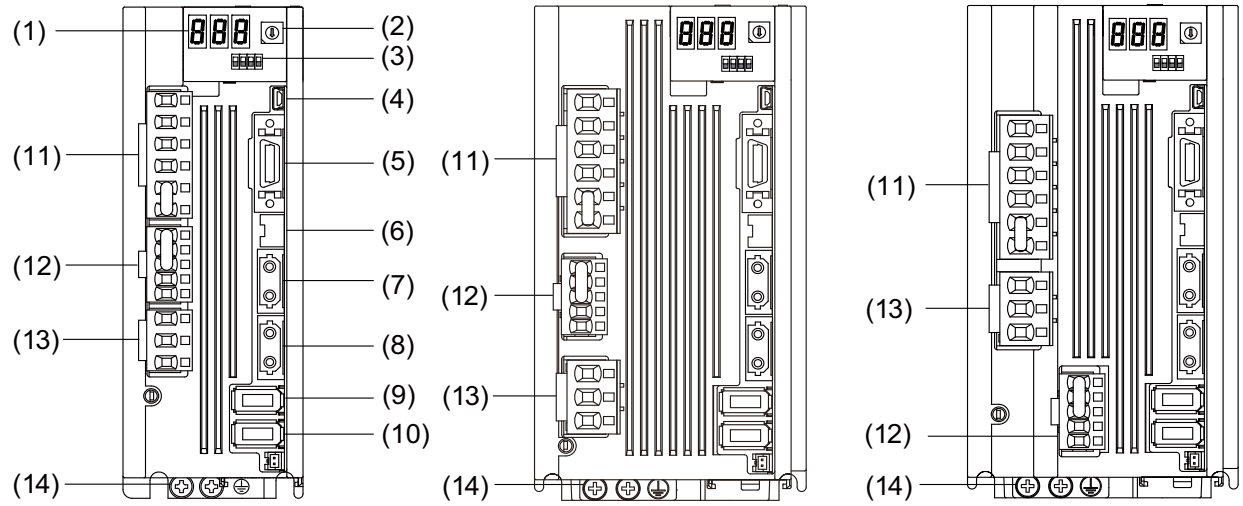
The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch (L, M axis)	---
(3)		SW2	---	Unused axis setting switch (L, M axis)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2L	---	Motor side encoder connection connector (L axis) 5V power supply capacity: 0.35A	---
(10)		CN2M	---	Motor side encoder connection connector (M axis) 5V power supply capacity: 0.35A	---
(11)		BAT	---	Battery connection connector	---
(12)	Main circuit	CNP1	L1,L2,L3	L1,L2,L3: 3-phase AC power input	---
(13)		CNP2	P+,C,D L11,L21, N-	Regenerative resistor connection terminal Control power input terminal (single-phase AC input) Test terminal for the manufacturer (Do not connect.)	---
(14)		CNP3L	U, V, W, ⏚	Motor power supply output connector (3-phase AC output) (L axis)	---
(15)		CNP3M	U, V, W, ⏚	Motor power supply output connector (3-phase AC output) (M axis)	---
(16)		PE	⏚	Grounding terminal	M4×8.5

> **⚠ CAUTION**
>
> Do not connect the N terminal of CNP2 because it is the test terminal for the manufacturer.

(3) Explanation of each spindle drive unit (MDS-DJ-SP-20/40/80) part



MDS-DJ-SP-20 MDS-DJ-SP-40 MDS-DJ-SP-80

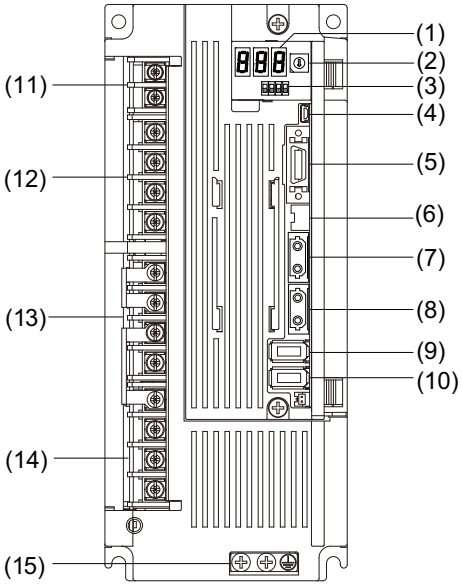
The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch	---
(3)		SW2	---	For machine tool builder adjustment: Always OFF (facing bottom)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2	---	Motor side encoder connection connector 5V power supply capacity: 0.35A	---
(10)		CN3	---	Machine side encoder connection connector 5V power supply capacity: 0.35A	---
(11)	Main circuit	CNP1	L1,L2,L3 N-,P3,P4	L1,L2,L3: 3-phase AC power input N-: Test terminal for the manufacturer (Do not connect.) P3,P4: Not used (short-circuit between the P3 and P4.)	---
(12)		CNP2	P+,C,D L11,L21	Regenerative resistor connection terminal Control power input terminal (single-phase AC input)	---
(13)		CNP3	U, V, W	Motor power output terminal (3-phase AC output)	---
(14)		PE	⏚	Grounding terminal	M4 x 12

> **⚠ CAUTION**
>
> Do not connect the N terminal of CNP1 because it is the test terminal for the manufacturer.

(4) Explanation of each spindle drive unit (MDS-DJ-SP-100/120) part



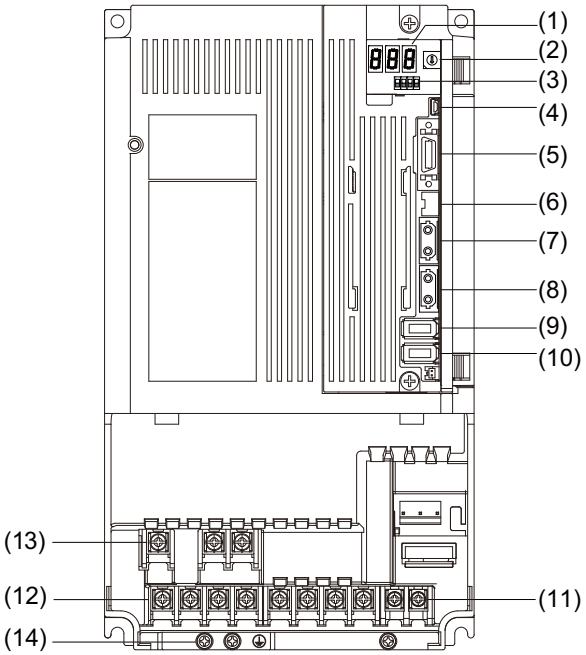
MDS-DJ-SP-100/120

The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch	---
(3)		SW2	---	For machine tool builder adjustment: Always OFF (facing bottom)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2	---	Motor side encoder connection connector 5V power supply capacity: 0.35A	---
(10)		CN3	---	Machine side encoder connection connector 5V power supply capacity: 0.35A	---
(11)	Main circuit	TE2	L11,L21	Control power input terminal (single-phase AC input)	M3.5×8
(12)		TE1	L1,L2,L3,N-	L1,L2,L3,N-: 3-phase AC power input	M4×10
(13)		TE3	P3,P4,P+,C,D	P3,P4,P+,C,D: Regenerative resistor connection terminal	
(14)		TE4	U, V, W	U,V,W: Motor power output terminal (3-phase AC output)	
(15)		PE	⏚	Grounding terminal	M4×12

(5) Explanation of each spindle drive unit (MDS-DJ-SP-160) part



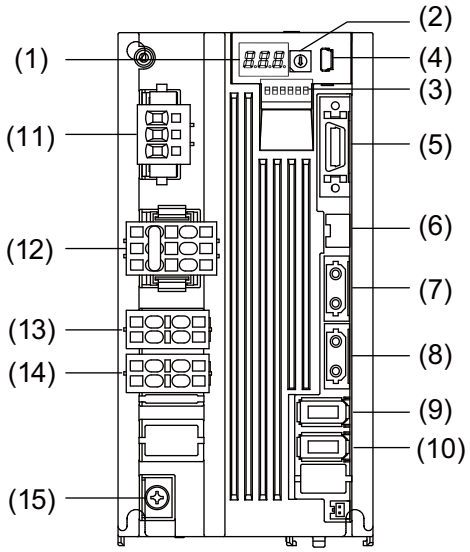
MDS-DJ-SP-160

The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch	---
(3)		SW2	---	For machine tool builder adjustment: Always OFF (facing bottom)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2	---	Motor side encoder connection connector 5V power supply capacity: 0.35A	---
(10)		CN3	---	Machine side encoder connection connector 5V power supply capacity: 0.35A	---
(11)	Main circuit	TE2	L11,L21	Control power input terminal (single-phase AC input)	M3.5×8
(12)		TE1	L1,L2,L3, P+,C, U,V,W	L1,L2,L3: 3-phase AC power input P+,C: Regenerative resistor connection terminal U,V,W: Motor power output terminal (3-phase AC output)	M4×10
(13)		TE3	N-, P3,P4	N-: 3-phase AC power input P3,P4: Regenerative resistor connection terminal	
(14)		PE	⏚	Grounding terminal	M4×12

(6) Explanation of each servo drive unit (MDS-DJ-SP2-2020) part



MDS-DJ-SP2-2020

The connector and terminal block layout may differ according to the unit being used. Refer to each unit outline drawing for details.

<Each part name>

		Name		Description	Screw size
(1)	Control circuit	LED	---	Unit status indication LED	---
(2)		SW1	---	Axis No. setting switch (L, M axis)	---
(3)		SW2	---	Unused axis setting switch (L, M axis)	---
(4)		CN5	---	USB maintenance connector usually not used	---
(5)		CN9	---	DI/O or maintenance connector	---
(6)		CN8	---	External STO input connector (Insert the provided STO short-circuit connector when not using external STO input.)	---
(7)		CN1A	---	NC or master axis optical communication connector	---
(8)		CN1B	---	Slave axis optical communication connector	---
(9)		CN2L	---	Motor side encoder connection connector (L axis) 5V power supply capacity: 0.35A	---
(10)		CN2M	---	Motor side encoder connection connector (M axis) 5V power supply capacity: 0.35A	---
(11)	Main circuit	CNP1	L1,L2,L3	L1,L2,L3: 3-phase AC power input	---
(12)		CNP2	P+,C,D L11,L21, N-	Regenerative resistor connection terminal Control power input terminal (single-phase AC input) Test terminal for the manufacturer (Do not connect.)	---
(13)		CNP3L	U, V, W, ⏚	Motor power supply output connector (3-phase AC output) (L axis)	---
(14)		CNP3M	U, V, W, ⏚	Motor power supply output connector (3-phase AC output) (M axis)	---
(13)		PE	⏚	Grounding terminal	M4×8.5

> **⚠ CAUTION**
>
> Do not connect the N terminal of CNP1 because it is the test terminal for the manufacturer.

3

Function Specifications

Function Specifications List

< Power supply specification >

Item		MDS-D2-CV	MDS-DH2-CV	MDS-DM2-SPV2/3,SPHV3 built-in converter	MDS-DJ-V1/V2 built-in converter	MDS-DJ-SP/SP2 built-in converter
1 Base control functions	1.14 Power regeneration control	●	●	●	-	-
	1.15 Resistor regeneration control	-	-	-	●	●
4 Protection function	4.6 Fan stop detection	●	●	●	●	●
	4.7 Open-phase detection	●	●	●	-	-
	4.8 Contactor weld detection	●	●	●	●	●
	4.10 Deceleration and stop function at power failure (Note 1)	●	●	-	-	-
	4.11 Retraction function at power failure (Note 2)	●	●	-	-	-
5 Sequence function	5.1 Contactor control function	●	●	●	●	●
	5.3 External emergency stop function	●	●	●	●	●
	5.5 High-speed READY ON sequence	●	●	●	-	-
6 Diagnosis function	6.7 Power supply diagnosis display function	●	●	●	-	-

(Note 1) The power backup unit and resistor unit option are required.

(Note 2) The power backup unit and capacitor unit option are required.

< Servo specification >

Item		MDS-D2-V1/ V2/V3	MDS-DH2-V1/ V2	MDS-DM2-SPV2/3, SPHV3	MDS-DJ-V1	MDS-DJ-V2
1 Base control functions	1.1 Full closed loop control	●	●	●	●	-
	1.2 Position command synchronous control	●	●	●	●	●
	1.3 Speed command synchronous control	● (Note 2)	●	-	-	-
	1.4 Distance-coded reference position control	●	●	●	●	-
2 Servo control function	2.1 Torque limit function (stopper function)	●	●	●	●	●
	2.2 Variable speed loop gain control	●	●	●	●	●
	2.3 Gain changeover for synchronous tapping control	●	●	●	●	●
	2.4 Speed loop PID changeover control	●	●	●	●	●
	2.5 Disturbance torque observer	●	●	●	●	●
	2.6 Smooth High Gain control (SHG control)	●	●	●	●	●
	2.7 High-speed synchronous tapping control (OMR-DD control)	●	●	●	●	●
	2.8 Dual feedback control	●	●	●	●	-
	2.9 HAS control	●	●	●	●	●
	2.10 OMR-FF control	●	●	●	●	●
3 Compensation control function	3.1 Jitter compensation	●	●	●	●	●
	3.2 Notch filter	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1
	3.3 Adaptive tracking-type notch filter	●	●	●	●	●
	3.4 Overshooting compensation	●	●	●	●	●
	3.5 Machine end compensation control	●	●	●	●	●
	3.6 Lost motion compensation type 2	●	●	●	●	●
	3.7 Lost motion compensation type 3	●	●	●	●	●
4 Protection function	4.1 Deceleration control at emergency stop	●	●	●	●	●
	4.2 Vertical axis drop prevention/pull-up control	●	●	●	●	●
	4.3 Earth fault detection	●	●	●	●	●
	4.4 Collision detection function	●	●	●	●	●
	4.5 SLS (Safely Limited Speed) function	●	●	●	●	●
	4.6 Fan stop detection	●	●	●	●	●
	4.9 STO (Safe Torque Off) function	●	●	●	●	●
5 Sequence function	5.2 Motor brake control function (Note 1)	●	●	●	●	●
	5.4 Specified speed output	●	●	●	-	-
	5.5 Quick READY ON sequence	●	●	●	-	-
6 Diagnosis function	6.1 Monitor output function	●	●	●	●	●
	6.2 Machine resonance frequency display function	●	●	●	●	●
	6.3 Machine inertia display function	●	●	●	●	●

(Note 1) For the multiaxis drive unit, a control by each axis is not available.
It is required to turn the servo of all axes OFF in the drive unit in order to enable a motor brake output.

(Note 2) Always set L-axis as primary axis and M-axis as secondary axis for the speed command synchronous control using MDS-D2-V3. Other settings cause the initial parameter error alarm.

< Spindle specifications >

Item		MDS-D2-SP	MDS-DH2-SP	MDS-D2-SP2	MDS-DM2-SPV2/3, SPHV3	MDS-DJ-SP	MDS-DJ-SP2
1 Base control functions	1.1 Full closed loop control	●	●	●	●	●	-
	1.5 Spindle's continuous position loop control	●	●	●	●	●	●
	1.6 Coil changeover control	●	●	-	●	-	-
	1.7 Gear changeover control	●	●	●	●	●	●
	1.8 Orientation control	●	●	●	●	●	●
	1.9 Indexing control	●	●	●	●	●	●
	1.10 Synchronous tapping control	●	●	●	●	●	●
	1.11 Spindle synchronous control	●	●	●	●	●	●
	1.12 Spindle/C axis control	●	●	●	●	●	●
	1.13 Proximity switch orientation control	●	●	● (Note)	●	●	● (Note)
2 Spindle control functions	2.1 Torque limit function	●	●	●	●	●	●
	2.2 Variable speed loop gain control	●	●	●	●	●	●
	2.5 Disturbance torque observer	●	●	●	●	●	●
	2.6 Smooth High Gain control (SHG control)	●	●	●	●	●	●
	2.7 High-speed synchronous tapping control (OMR-DD control)	●	●	●	●	●	●
	2.8 Dual feedback control	●	●	●	●	●	-
	2.11 Control loop gain changeover	●	●	●	●	●	●
	2.12 Spindle output stabilizing control	●	●	●	●	●	●
	2.13 High-response spindle acceleration/ deceleration function	●	●	●	●	●	●
3 Compensation control function	3.1 Jitter compensation	●	●	●	●	●	●
	3.2 Notch filter	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1	Variable frequency: 4 Fixed frequency: 1
	3.3 Adaptive tracking-type notch filter	●	●	●	●	●	●
	3.4 Overshooting compensation	●	●	●	●	●	●
	3.6 Lost motion compensation type 2	●	●	●	●	●	●
	3.9 Spindle motor temperature compensation function	●	●	●	●	●	●
4 Protection function	4.1 Deceleration control at emergency stop	●	●	●	●	●	●
	4.3 Earth fault detection	●	●	●	●	●	●
	4.5 SLS (Safely Limited Speed) function	●	●	●	●	●	●
	4.6 Fan stop detection	●	●	●	●	●	●
	4.9 STO (Safe Torque Off) function	●	●	●	●	●	●
5 Sequence functions	5.4 Specified speed output	●	●	●	●	-	-
	5.5 Quick READY ON sequence	●	●	●	●	-	-
6 Diagnosis functions	6.1 Monitor output function	●	●	●	●	●	●
	6.2 Machine resonance frequency display function	●	●	●	●	●	●
	6.3 Machine inertia display function	●	●	●	●	●	●
	6.4 Motor temperature display function	●	●	●	●	●	●
	6.5 Load monitor output function	●	●	●	●	●	●

(Note) As for 2-axis spindle drive unit, setting is available only for one of the axes.

3.1 Base Control Functions

3.1.1 Full Closed Loop Control

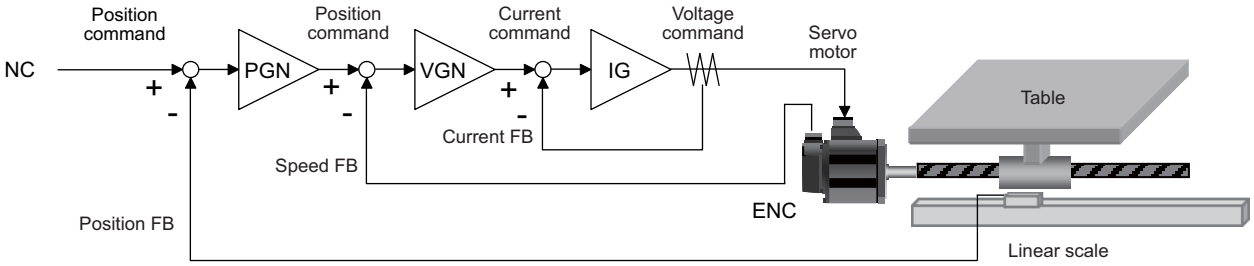
The servo control is all closed loop control using the encoder's feedback. "Full closed loop control" is the system that directly detects the machine position using a linear scale, whereas the general "semi-closed loop" is the one that detects the motor position.

In a machine that drives a table with a ball screw, the following factors exist between the motor and table end:

(1) Coupling or ball screw table bracket's backlash

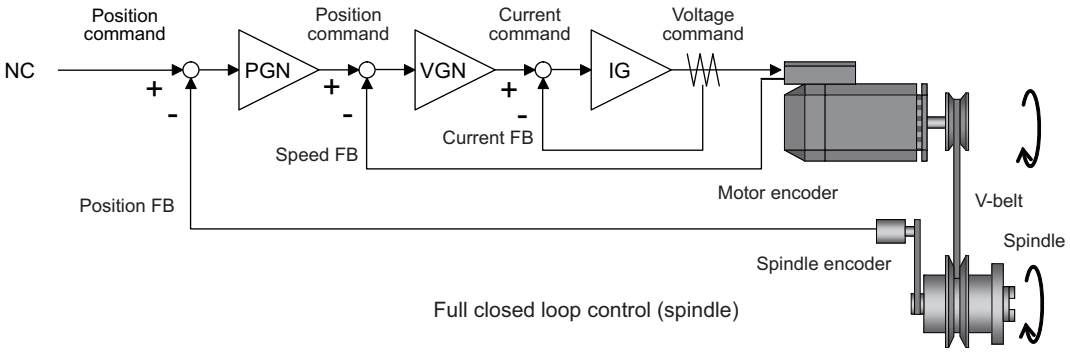
(2) Ball screw pitch error

These can adversely affect the accuracy. If the table position of the machine side is directly detected with a linear scale, high-accuracy position control which is not affected by backlash or pitch error is possible.



Full closed loop control (servo)

The ball screw side encoder is also applied.



Full closed loop control (spindle)

3.1.2 Position Command Synchronous Control

This is one of the controls which enable two servo motors to drive the same axis. This is also called "Position tandem control".

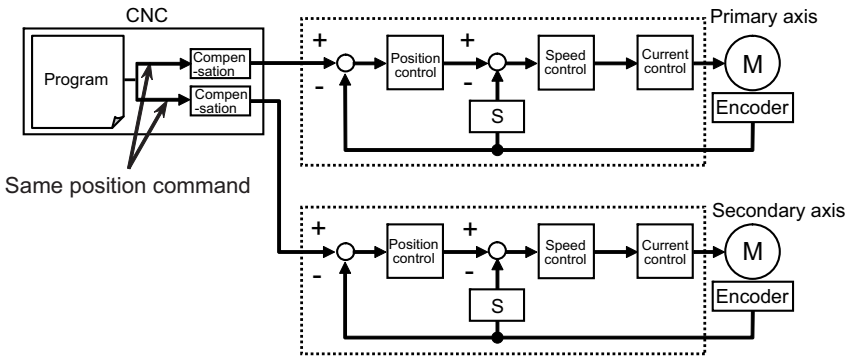
The same position command is issued to the 2-axis servo control, and the control is carried out according to each axis' position and speed feedbacks.

<Features>

(1) The position commands in which machine's mechanical errors (pitch error, backlash, etc.) have been compensated, can be output to each axis.

(2) Each axis conducts independent position control, therefore the machine posture can be kept constant.

(3) Deviation between the two axes is always monitored, and if excessive, the alarm is detected.



⚠ CAUTION

When the rigidity between two axes is high, such as when the ball screw interval between the tandem axes is narrow in full closed control, use the speed command synchronous control.

3.1.3 Speed Command Synchronous Control

This is one of the controls which enable two servo motors to drive the same axis. This is also called "Speed tandem control".

The same position command is issued to the 2-axis servo control, and the control is carried out according to each axis' position and speed feedbacks.

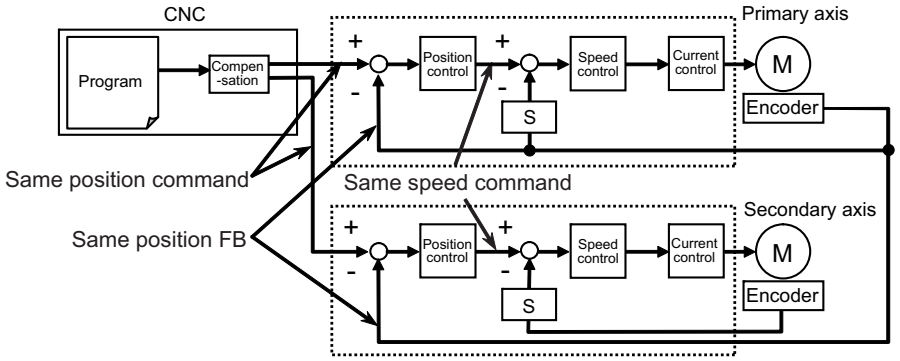
This function is usually used when the control is performed with one linear scale during the full closed loop control.

<Features>

(1) When a linear scale is used, two axes can share the position feedback signal from one linear scale.

(2) Feed rates of each axis are controlled with each axis' speed feedback signals, which allows stable control.

(3) Mechanical errors (pitch error, backlash, etc.) are compensated using the common values.



⚠ CAUTION

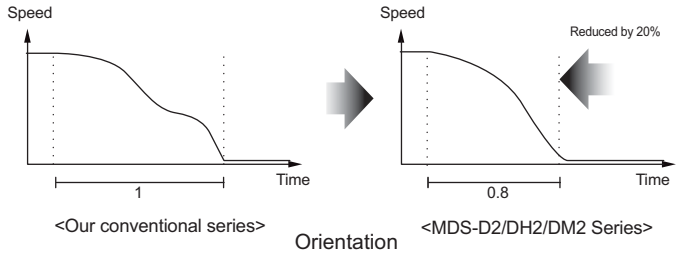
1. The speed command synchronous control cannot be used for a primary or secondary axis on which load unbalance is generated (Example: an axis carrying an operating axis). Use the position command synchronous control.
2. Disturbance observer cannot be used during the speed command synchronous control.
3. The speed command synchronous control cannot be performed with the distance-coded reference scale.

3.1.4 Distance-coded Reference Position Control

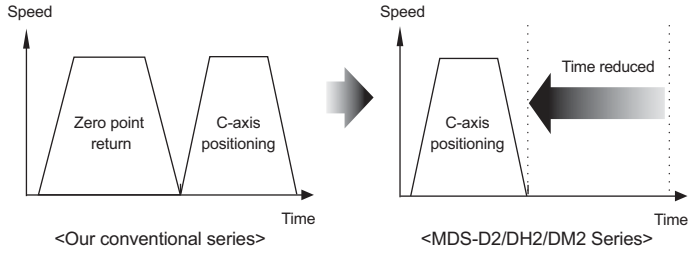
This is the function to establish the reference point from axis movements of the reference points using a scale with distance-coded reference mark.
Since it is not necessary to move the axis to the reference point, the axis movement amount to establish the reference point can be reduced.
No dog is used as the position is calculated using reference marks.
If the distance-coded reference check function is used to verify the motor end encoder data, select a battery option before setting the parameter.

3.1.5 Spindle's Continuous Position Loop Control

Under this control, position loop control is always applied to spindle, including when speed command is issued (in cutting). There is no need for control changeover nor zero point return during orientation and C axis control changeover. Therefore, the operation can be completed in a shorter time than the previous.
In acceleration/deceleration with S command, the acceleration/deceleration and orientation are always controlled with the spindle motor's maximum torque.



Orientation



C-axis changeover

3.1.6 Coil Changeover Control

A signal output from the spindle drive unit controls the changeover of the low-speed and high-speed specification coils in a spindle motor.
The drive unit automatically outputs the coil changeover sequence in accordance with the motor speed.

3.1.7 Gear Changeover Control

This function enables a spindle motor to perform both high-speed light cutting and low-speed heavy cutting by changing the gear ratio between the motor and spindle.
The gear change is carried out while the spindle is not running.

3.1.8 Orientation Control

This control enables a spindle motor to stop at a designated angle when the motor is rotating at a high-speed with a speed command. This control is used for exchanging the tools in machining centers and performing index positioning in lathes, etc.

3.1.9 Indexing Control

This control enables positioning of a spindle motor at an arbitrary angle (in increments of 0.01 degrees) from the orientation stop position. This control is used for positioning in lathes for hole drilling, etc.

3.1.10 Synchronous Tapping Control

Under synchronous tapping control, spindle control is completely synchronized with Z axis servo control, and Z axis is accurately fed by one screw pitch in accordance with one tap revolution. The tap is completely fixed to the spindle head. As a result, feed pitch error is less likely to occur, which allows high-speed, high-accuracy and high-durable tapping.

3.1.11 Spindle Synchronous Control

This control enables two spindles to run at the same speed. A spindle being driven with a speed command is synchronized with another spindle at a constant rate or acceleration/deceleration rate.
This control is applied such as when a workpiece is transferred between two rotating chucks in lathe or a workpiece is held with two chucks.

3.1.12 Spindle/C Axis Control

An axis rotating about Z axis is called C axis, whose rotation direction is normally the same as of spindle. This function enables high-accuracy spindle control including interpolation control, like servo axis, when a high-resolution position encoder is attached to the spindle motor.

3.1.13 Proximity Switch Orientation Control

Orientation control is carried out based on the leading edge position of the proximity switch output signal (ON/OFF) after the spindle is stopped.

3.1.14 Power Regeneration Control

This control enables the regeneration energy generated when the motor decelerates to return to the power supply.
This is an energy saving method because regeneration energy is hardly converted to heat.

3.1.15 Resistor Regeneration Control

This control enables the regeneration energy generated when the motor decelerates to convert to heat with regenerative resistance.
The drive system can be downsized because the regeneration capacity is also small in the motor of relatively small capacity.
Select a suitable regenerative resistance according to the load inertia, motor operation speed, etc.

3.2 Servo/Spindle Control Functions

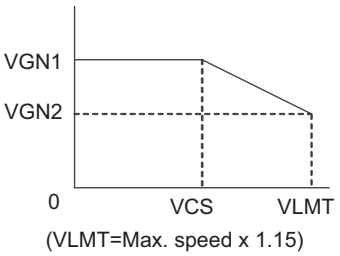
3.2.1 Torque Limit Function

This control suppresses the motor output torque with the parameter values (SV013, SV014).
This function is used for stopper positioning control and stopper reference position establishment, by switching the two setting values.

3.2.2 Variable Speed Loop Gain Control

< Servo >

If disturbing noise occurs when the motor is rotating at a high speed, such as during rapid traverse, the high speed loop gain during high-speed rotation can be lowered with this function.

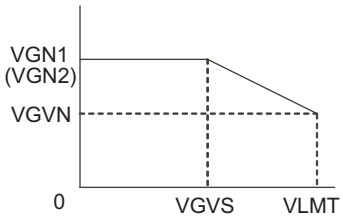


(VLMT=Max. speed x 1.15)

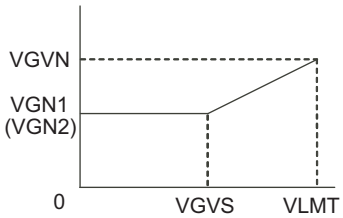
VGN1:SV005
VGN2:SV006
VCS :SV029
VLMT:Servo motor maximum speed×1.15

< Spindle >

For a high-speed spindle of machining center etc., adequate response can be ensured with this function by suppressing noise and vibration at low speeds and increasing the speed loop gain at high-speeds.



(VLMT=Max. speed x 1.15)

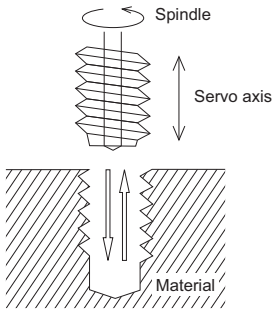


(VLMT=Max. speed x 1.15)

VGN1:SP005
VGN2:SP008
VGVN:SP005×SP073/100
VGVS:SP074
VLMT:SP026×1.15

3.2.3 Gain Changeover for Synchronous Tapping Control

SV003, SV004 and SV057 are used as the position loop gain for normal control. Under synchronous tapping control, SV049, SV050 and SV058 are used instead to meet the spindle characteristics.



3.2.4 Speed Loop PID Changeover Control

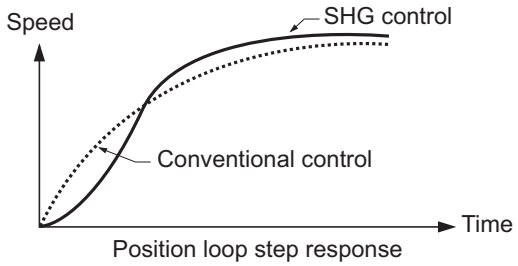
This function is used under full-closed loop control. Normally, machine-end position tracking delays compared with the motor-end position.
Under full-closed position loop control, machine-end position is used for position feedback. Therefore, the motor-end position tends to advance too much, which may cause overshooting of the machine-end position.
This function can suppress the generation of overshoot by adding the D (delay) control to the speed control, which is normally controlled with PI (proportional integral), in order to weaken the PI control after the position droop becomes 0.

3.2.5 Disturbance Torque Observer

The effect caused by disturbance, frictional resistance or torsion vibration during cutting can be reduced by estimating the disturbance torque and compensating it.

3.2.6 Smooth High Gain Control (SHG Control)

A high-response control and smooth control (reduced impact on machine) were conventionally conflicting elements; however, SHG control enables the two elements to function simultaneously by controlling the motor torque (current FB) with an ideal waveform during acceleration/deceleration.

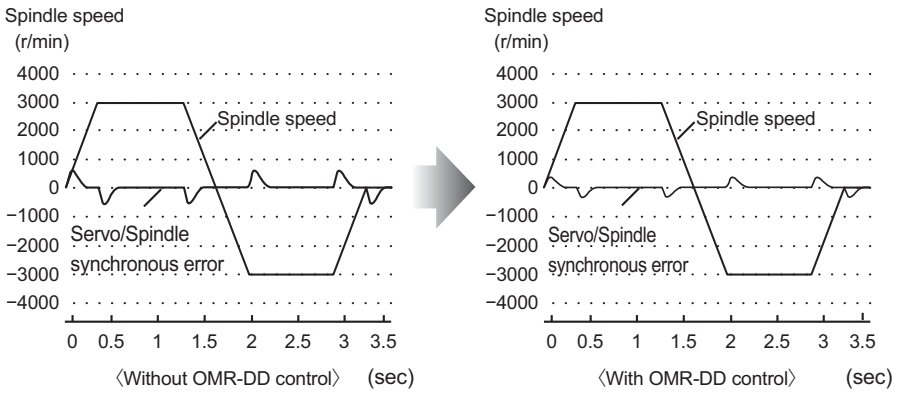


Position loop step response

3.2.7 High-speed Synchronous Tapping Control (OMR-DD Control)

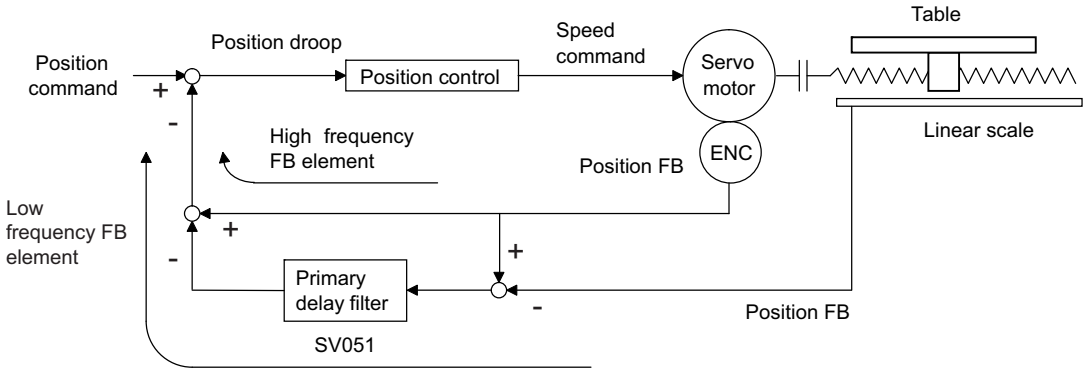
Servo drive unit detects the spindle position, and compensates the synchronization errors. This control enables more accurate tapping than the previous.

(Note) A spindle drive unit that controls the high-speed synchronous tapping (OMR-DD control) has to be connected on the farther side from the NC than the servo drive unit that is subject to the synchronous tapping control.



3.2.8 Dual Feedback Control

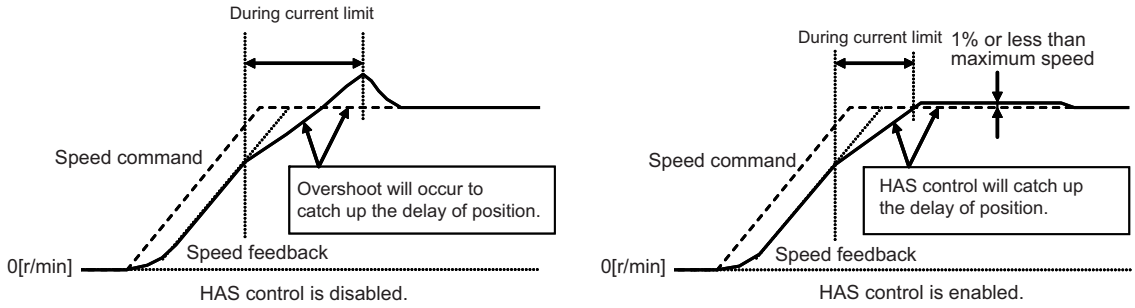
This function is used under full-closed loop control.
When a linear scale is used, the machine-end position, such as a table, is directly detected, which may render the position loop control unstable.
With this control, however, high-frequency components are eliminated from the machine-end feedback signals, which will lead to stable control.



Dual feedback control

3.2.9 HAS Control

If the torque output during acceleration/deceleration is close to the servo motor's maximum torque, the motor cannot accelerate with the commanded time constant when the torque is saturated due to input voltage fluctuation, etc. As a result, speed overshoot occurs when a constant speed command is issued, because the position droop for the delay is canceled.
With HAS control, however, this overshoot is smoothened so that the machine operation can be stable.



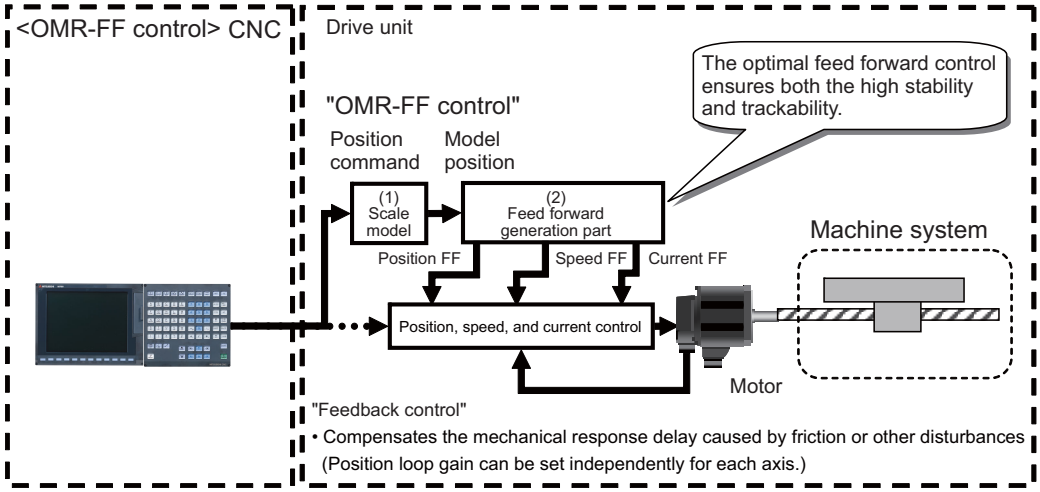
3.2.10 OMR-FF Control

OMR-FF control enables fine control by generating feed forward inside the drive unit and can realize the strict feedback control to the program command than the conventional high-speed accuracy control.
The conventional position control method causes machine vibration when increasing the gain because it ensures both the trackability to the position command and the servo rigidity to the friction or cutting load, etc. by setting the position loop gain (PGN).
OMR-FF function allows the improvement of the command trackability by independently deciding the trackability with the scale model position loop gain (PGM) and the servo rigidity with the position control gain (PGN).

OMR-FF control option for NC side is required when using this function.
It is recommended that this function is used for linear motors, direct-drive motors, or general motors in semi-closed loop control.

< Features >

(1) The command trackability can be decided independently of the position control gain (PGN) with the scale model position loop gain (PGM).
(2) Position loop gain (PGN) can be set for each axis.
-> Delay in the machine's response caused by friction or cutting load, etc. can be compensated with high gain.



3.2.11 Control Loop Gain Changeover

Position loop gain and speed loop gain are switched between non-interpolation mode, which is used during speed command, and interpolation mode, which is used during synchronous tapping and C axis control. By switching these gains, optimum control for each mode can be realized.

3.2.12 Spindle Output Stabilizing Control

Spindle motor's torque characteristic is suppressed due to voltage saturation in the high-speed rotation range, therefore the current control responsiveness significantly degrades, which may cause excessive current.
With this control, however, the current and flux commands are compensated to avoid the voltage saturation so that the current control responsiveness will not degrade.

3.2.13 High-response Spindle Acceleration/Deceleration Function

This function enables reduction of the spindle motor's setting time (from when the command value becomes 0 until when the motor actually stops) without being affected by the position loop gain, when the spindle motor stops under deceleration stop control using the S command.
This function is not active when the spindle is stopped while performing position control, such as orientation control and synchronous tapping control.

3.3 Compensation Control Function

3.3.1 Jitter Compensation

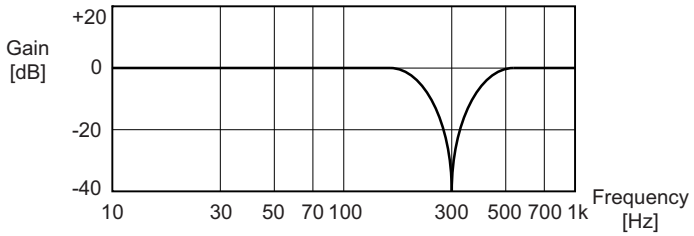
The load inertia becomes much smaller than usual if the motor position enters the machine backlash when the motor is stopped.
Because this means that an extremely large VGN1 is set for the load inertia, vibration may occur.
Jitter compensation can suppress the vibration that occurs at the motor stop by ignoring the backlash amount of speed feedback pulses when the speed feedback polarity changes.

3.3.2 Notch Filter

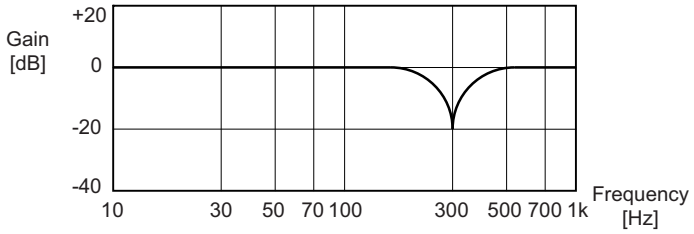
This filter can damp vibrations of servo torque commands at a specified frequency.
Machine vibrations can be suppressed by adjusting the notch filter frequency to the machine's resonance frequency.
Filter depth adjustment is also available that allows stable control even when the filter is set to an extremely low frequency.

<Specifications>

Notch filter	Frequency	Depth compensation
Notch filter 1	50Hz to 2250Hz	Enabled
Notch filter 2	50Hz to 2250Hz	Enabled
Notch filter 3	Fixed at 1125Hz	Disabled
Notch filter 4	50Hz to 2250Hz	Enabled
Notch filter 5	50Hz to 2250Hz	Enabled



Example of filter characteristic set to 300Hz



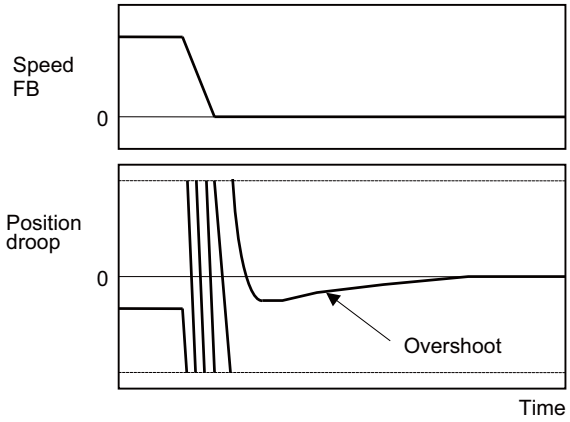
For shallow setting by additionally using the depth compensation at 300Hz

3.3.3 Adaptive Tracking-type Notch Filter

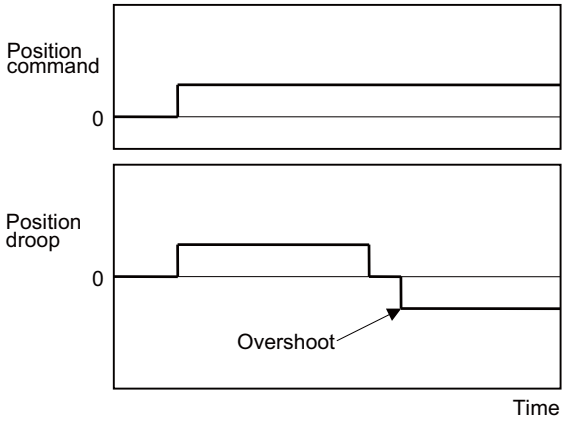
Machine's specific resonance frequency tends to change due to aged deterioration or according to machine's operation conditions. Therefore, the frequency may be deviated from the filter frequency set at the initial adjustment. With adaptive tracking-type notch filter, resonance point fluctuation due to the machine's condition change is estimated using the vibration components of the current commands, and effective notch filter frequency, which has been deviated from the setting value, is automatically corrected to suppress the resonance.

3.3.4 Overshooting Compensation

The phenomenon when the machine position goes past or exceeds the command during feed stopping is called overshooting.
In OVS compensation, the overshooting is suppressed by subtracting the torque command set in the parameters when the motor stops.



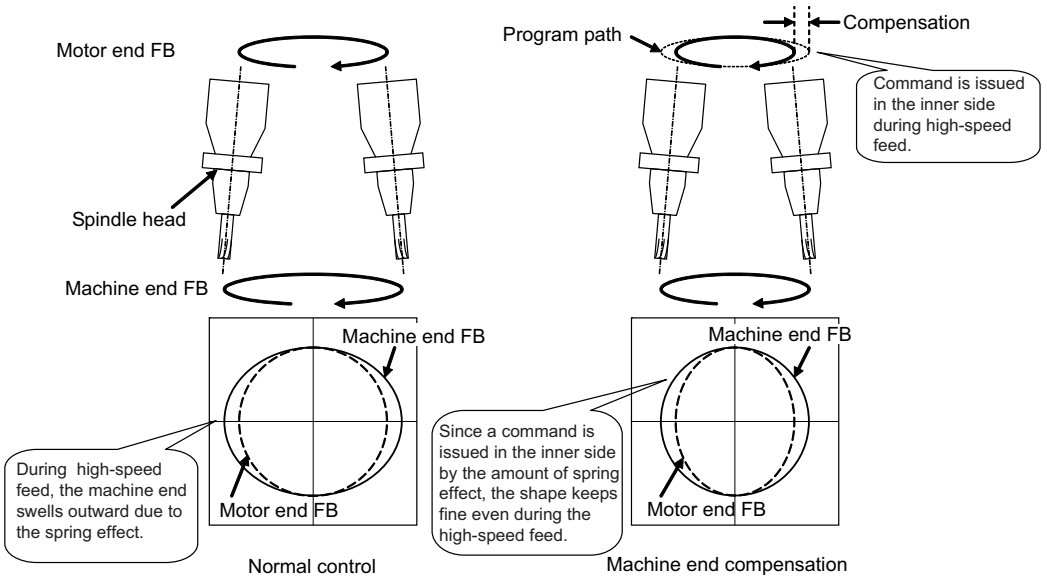
[1] Overshooting during rapid traverse settling



[2] Overshooting during pulse feed

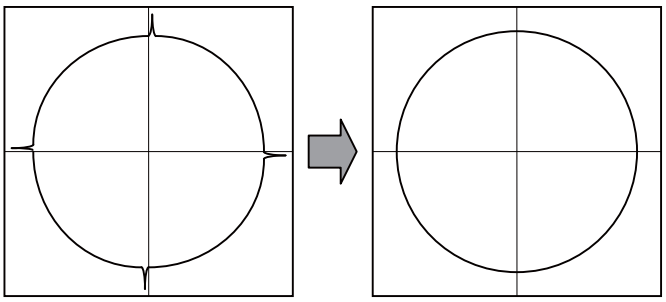
3.3.5 Machine End Compensation Control

The shape of the machine end during high-speed and high-speed acceleration operation is compensated by compensating the spring effect from the machine end to the motor end.
The shape may be fine during low-speed operation. However, at high speeds, the section from the machine end to the outer sides could swell. This function compensates that phenomenon.



3.3.6 Lost Motion Compensation Type 2

Servo motor always drives the machine opposing to the frictional force, and the torque which is required to oppose the friction during the axis movement is outputted by I control (Integral control) of the speed loop PI control. When the movement direction is changed, the frictional force works in the opposite direction momentarily, however, the machine will stop while the command torque is less than the frictional force as it takes some time to reverse the command torque in I control.
When the movement direction is changed, the frictional force works in the opposite direction momentarily, however, the machine will stop while the command torque is less than the frictional force as it takes some time to reverse the command torque in I control.
With the this lost motion compensation function improves the accuracy worsened by the stick motion.



No compensation　　With compensation

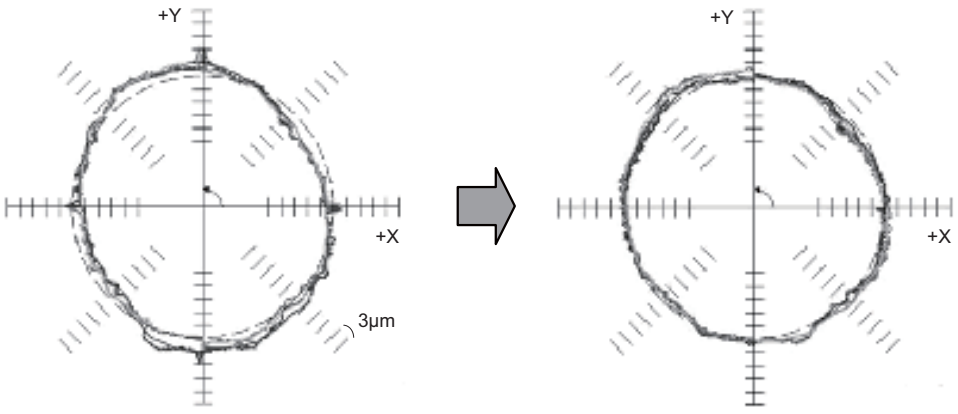
3.3.7 Lost Motion Compensation Type 3

For a machine model where the travel direction is reversed, the compensation in accordance with the changes in the cutting conditions is enabled by also considering the spring component and viscosity component in addition to the friction.
This function can be used to accommodate quadrant projection changes that accompany feed rate and circular radius changes which could not be compensated by Lost motion compensation type 2.

1.Mechanical spring elements can't be ignored.
2.Changes between static and dynamic frictions are wide and steep.

Conventional control can't perform enough compensation.

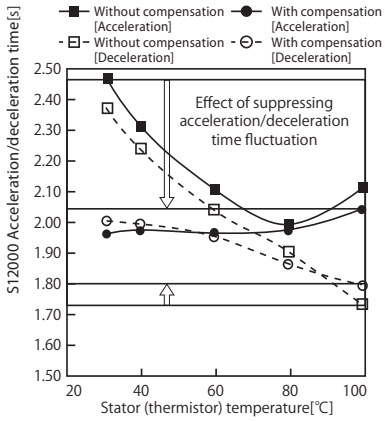
Not only frictions but spring element and viscosity element can be compensated, thus quadrant protrusions are suppressed within a wide band.



Conventional compensation control　　Lost motion compensation control type 3

3.3.8 Spindle Motor Temperature Compensation Function

As for the low-temperature state of the IM spindle motor, the output characteristic may deteriorate in comparison with the warm-up state and the acceleration/deceleration time may become long, or the load display during cutting may become high immediately after operation. This function performs the control compensation depending on the motor temperature with the thermistor built into the spindle motor and suppresses the output characteristic deterioration when the temperature is low. Temperature compensation function is not required for IPM spindle motor in principle.



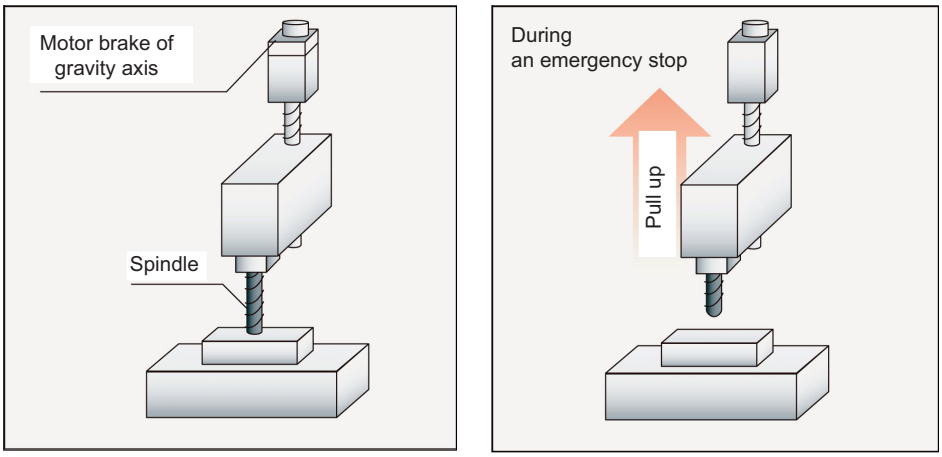
3.4 Protection Function

3.4.1 Deceleration Control at Emergency Stop

When an emergency stop (including NC failure, servo alarm) occurs, the motor will decelerate following the set time constant while maintaining the READY ON state.
READY will turn OFF and the dynamic brakes will function after stopping. The deceleration stop can be executed at a shorter distance than the dynamic brakes.

3.4.2 Vertical Axis Drop Prevention/Pull-up Control

If the READY OFF and brake operation are commanded at same time when an emergency stop occurs, the axis drops due to a delay in the brake operation.
The no-control time until the brakes activate can be eliminated by delaying the servo READY OFF sequence by the time set in the parameters.
Always use this function together with deceleration control.
When an emergency stop occurs in a vertical machining center, the Z axis is slightly pulled upwards before braking to compensate the drop of even a few μm caused by the brake backlash.



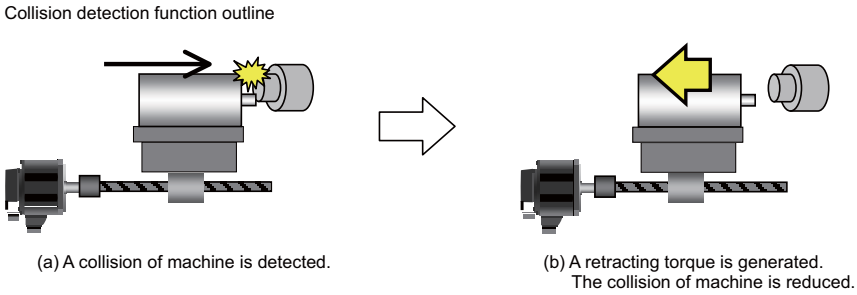
3.4.3 Earth Fault Detection

When an emergency stop is canceled, the earth fault current is measured using the power module's special switching circuit before Servo ready ON.
Specifying the faulty axis is possible in this detection, as the detection is carried out for each axis.

3.4.4 Collision Detection Function

Collision detection function quickly detects a collision of the motor shaft, and decelerates and stops the motor. This suppresses the generation of an excessive torque in the machine tool, and helps to prevent an abnormal state from occurring.Impact at a collision will not be prevented by using this collision detection function, so this function does not necessarily guarantee that the machine tool will not be damaged or that the machine accuracy will be maintained after a collision.

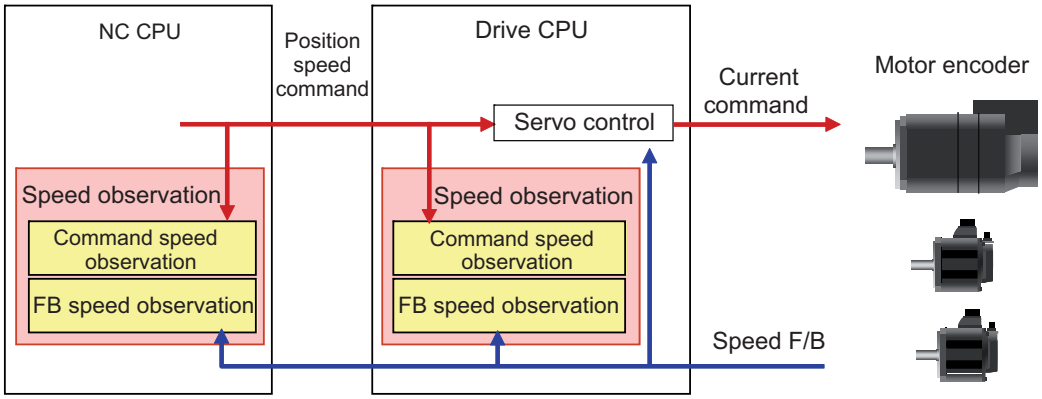
The same caution as during regular operation is required to prevent the machine from colliding.



3.4.5 SLS (Safely Limited Speed) Function

This function is aimed at allowing a safety access to the machine's working part by opening the safety door, etc. without shutting the power for saving the setup time.

Both the NC control system and drive system (servo and spindle drive units) doubly observe the axis feed rate so that it will not exceed the safety speed. If it exceeds the set safety speed, emergency stop occurs and the power is shut OFF.



3.4.6 Fan Stop Detection

The rotation of the radiation fin cooling fan is observed and when the fan stops rotating for a breakdown of the fan or an external factor, warning is detected.(The system will not be stopped.) Before sudden system down by the power module overheat, inspection and replacement of the fan are prompted.

3.4.7 Open-phase Detection

Disconnection of a phase of the 3-phase input power is detected.

The occurrence of abnormal operation will be avoided by open-phase detection because open-phase does not cause a power failure, however, abnormal operation will occur when the motor load becomes large.

3.4.8 Contactor Weld Detection

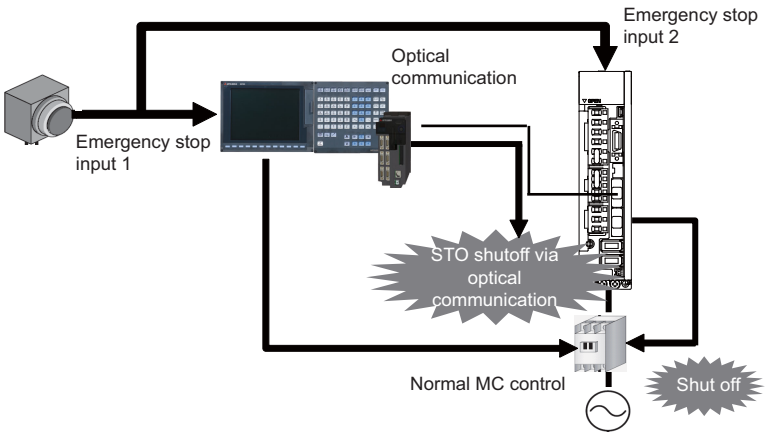
It detects that a contact of the external contactor is welding and cannot be opened.

3.4.9 STO (Safe Torque Off) Function

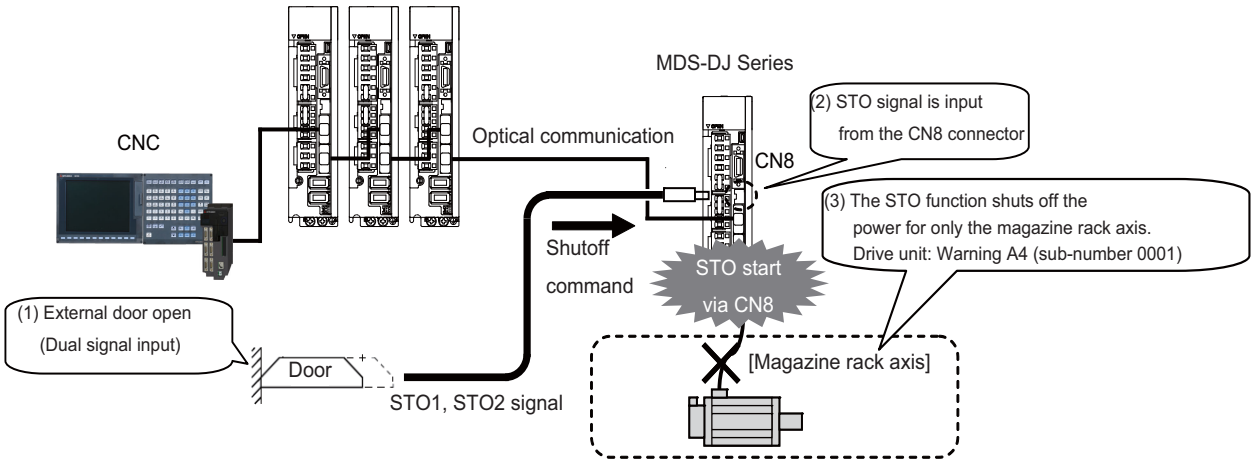
STO (Safe Torque Off) function is a shutoff function which stops the supply of energy to the motor capable of generating torque. It shuts off an energy supply electronically inside the drive unit.
It is an uncontrolled stop function in accordance with "IEC60204-1 Stop Category 0".

STO function can be used in the following two ways ([1] and [2] below), which directly input the STO signal from the external device by using a network cable and CN8 connector.

[1] When using network STO function
STO function shuts off the motor power of all axes in the system.

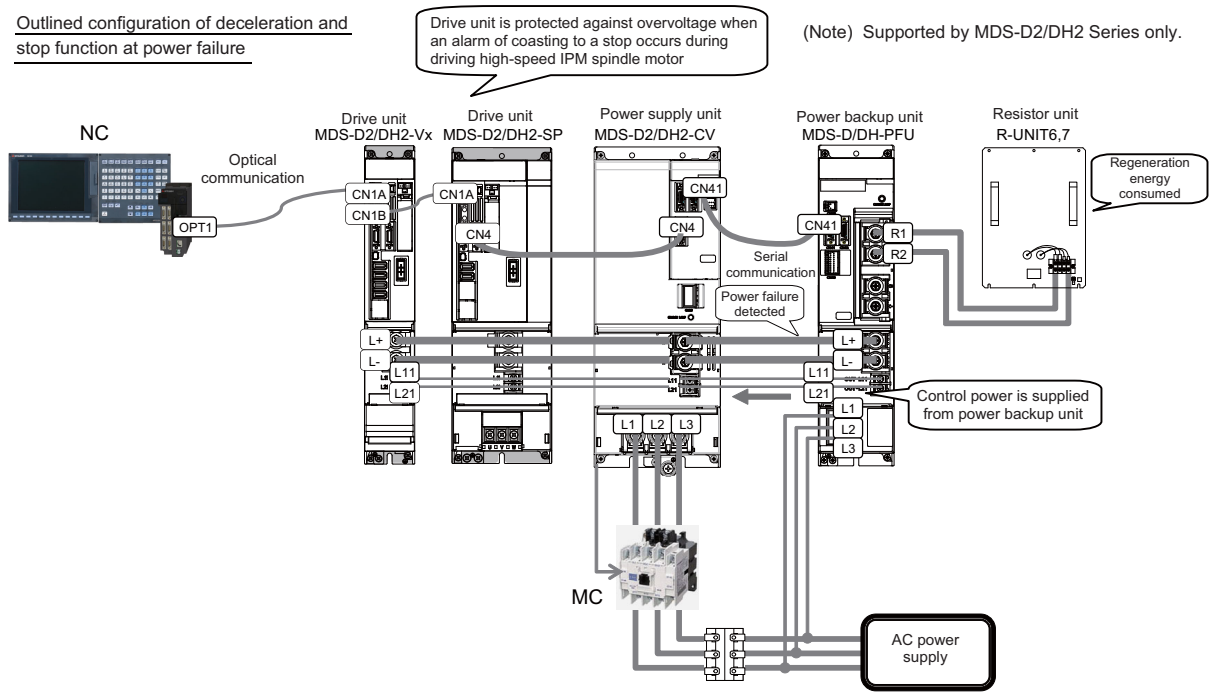


[2] When using dedicated wiring STO function
This method is used to shut off the motor power with STO function only for the specific axis.



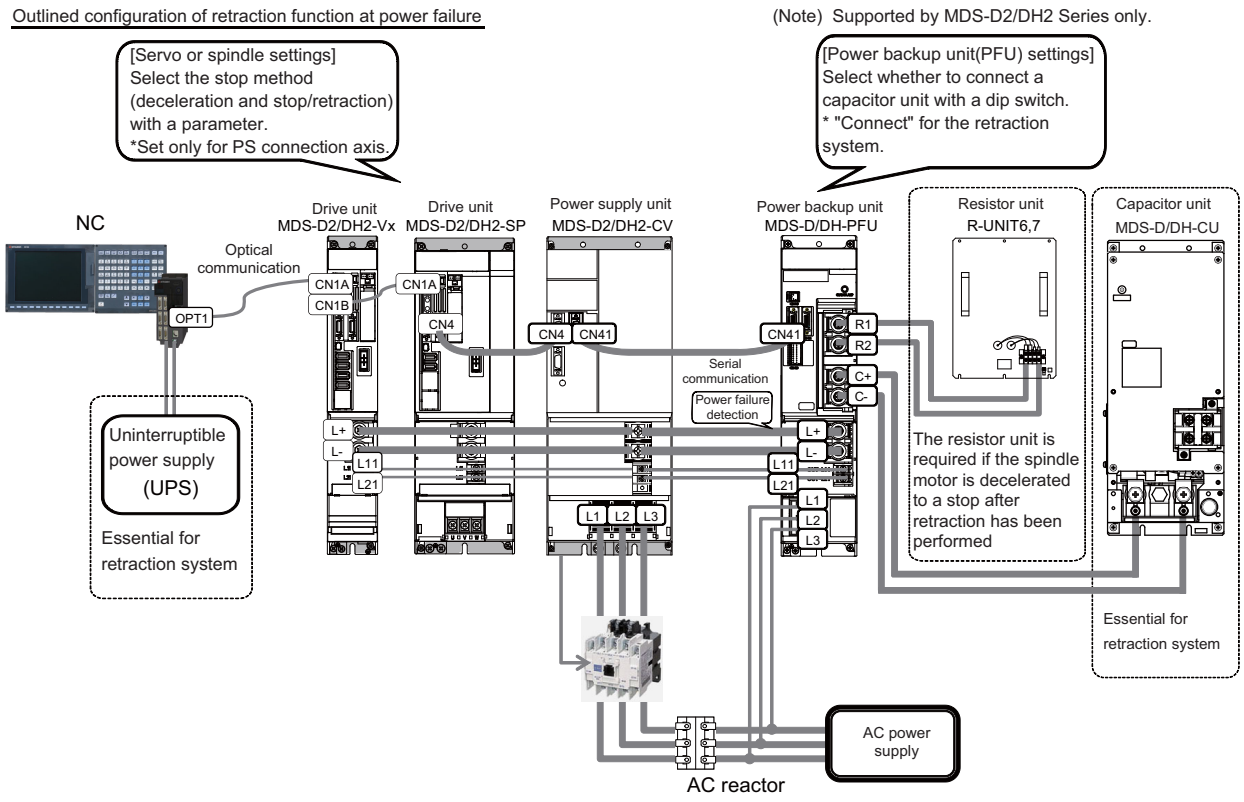
3.4.10 Deceleration and Stop Function at Power Failure

The deceleration and stop function at power failure is a function to safely decelerate the servo axes and the spindle when a power failure occurs. This function prevents a damage on the machine due to an overrun of the servo axes, and at the same time, realizes a protection against overvoltage for high-speed IPM spindle motors and high-speed DDMs.



3.4.11 Retraction Function at Power Failure

The retraction function at power failure is a function to backup the power of the main circuit from the capacitor unit and perform a tool escape by the retraction operation with the NC command when a power failure occurs.



3.5 Sequence Functions

3.5.1 Contactor Control Function

With this function, the contactor ON/OFF command is output from the power supply unit (or servo/spindle drive unit for integrated type) based on the judgement as to whether it is in emergency stop, emergency stop cancel, spindle deceleration and stop or vertical axis drop prevention control, etc.

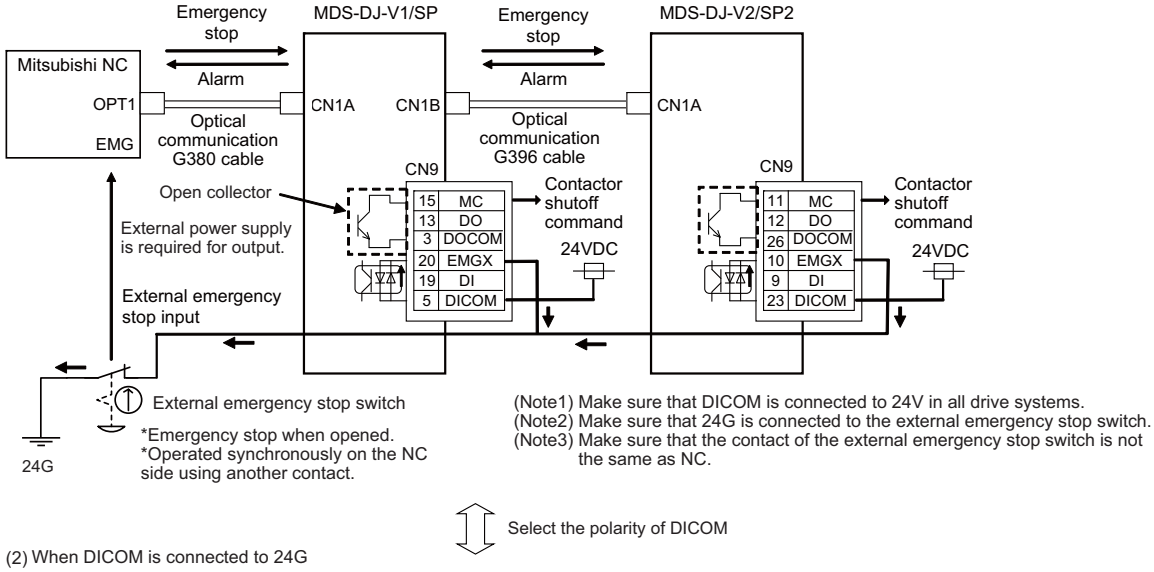
3.5.2 Motor Brake Control Function

With this function, the brake ON/OFF command is output from the servo drive unit based on the judgement as to whether it is in emergency stop, emergency stop cancel or vertical axis drop prevention/pull-up control, etc.
When a multiaxis drive unit is connected, all the axes are simultaneously controlled.

3.5.3 External Emergency Stop Function

Besides the emergency stop input from the NC, double-protection when an emergency stop occurs can be provided by directly inputting an external emergency stop, which is a second emergency stop input, to the power supply unit (servo/spindle drive unit for integrated type).
Even if the emergency stop is not input from NC for some reason, the contactors will be activated by the external emergency stop input, and the power can be shut off.

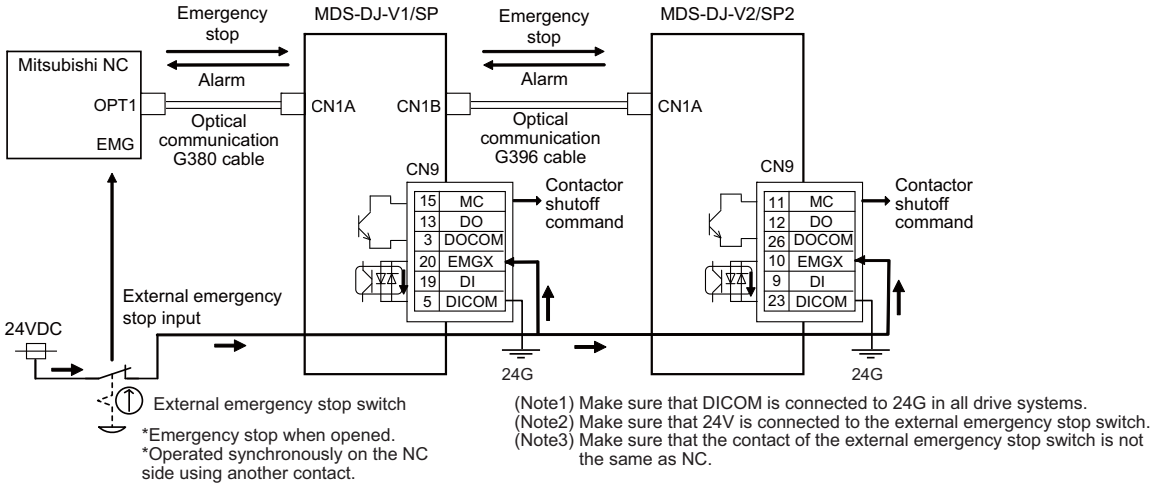
(1) When DICOM is connected to 24V



(Note1) Make sure that DICOM is connected to 24V in all drive systems.
(Note2) Make sure that 24G is connected to the external emergency stop switch.
(Note3) Make sure that the contact of the external emergency stop switch is not the same as NC.

Select the polarity of DICOM

(2) When DICOM is connected to 24G



(Note1) Make sure that DICOM is connected to 24G in all drive systems.
(Note2) Make sure that 24V is connected to the external emergency stop switch.
(Note3) Make sure that the contact of the external emergency stop switch is not the same as NC.

3.5.4 Specified Speed Output

This function is to output a signal that indicates whether the machine-end speed has exceeded the speed specified with the parameter.
With this function, the safety door, etc. can be locked to secure the machine operator when the machine-end speed has exceeded the specified speed. This function can also be used for judging whether the current machine-end speed is higher than the specified speed.

3.5.5 Quick READY ON Sequence

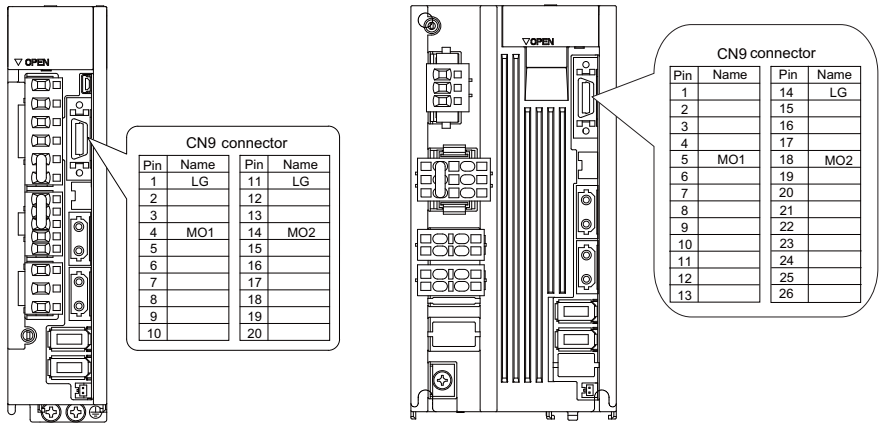
With this function, the charging time during READY ON is shortened according to the remaining charge capacity of the power supply unit. When returning to READY ON status immediately after the emergency stop input, the charging time can be shortened according to the remaining charge capacity and the time to READY ON is shortened.

3.6 Diagnosis Function

3.6.1 Monitor Output Function

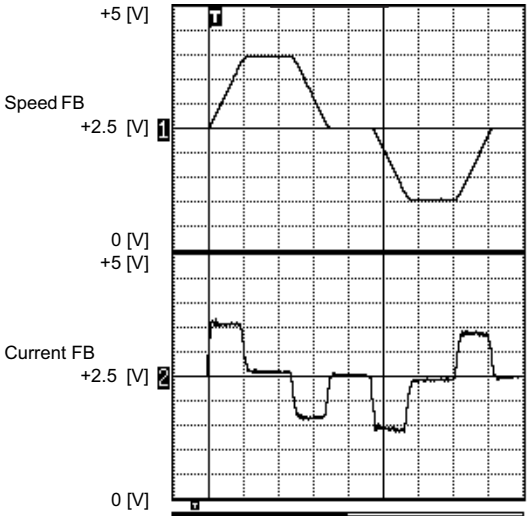
Drive unit has a function to D/A output the various control data. The servo and spindle adjustment data required for setting the servo and spindle parameters to match the machine can be D/A output. Measure using a high-speed waveform recorder, oscilloscope, etc.
Note that the output pins differ between MDS-DJ-V1/SP and MDS-DJ-V2/SP2.

D/A output specifications



Item	Explanation
No. of channels	2ch
Output cycle	0.8ms (min. value)
Output precision	12bit
Output voltage range	0V to 2.5V (zero) to +5V
Output magnification setting	32768 to 32767 (1/100-fold)
Output pin (MDS-DJ-V1/SP Series: CN9 connector)	MO1 = Pin 4, MO2 = Pin 14, LG = Pin 1,11
Output pin (MDS-DJ-V2/SP2 Series: CN9 connector)	MO1 = Pin 5, MO2 = Pin 18, LG = Pin 14
Others	The D/A output for the 2nd axis is also 2ch. When using the 2nd axis, set "-1" for the output data (servo axis: SV061, SV062, spindle: SP125, SP126) that is not to be measured.

When the output data is 0, the offset voltage is 2.5V. If there is an offset voltage, adjust the zero level position in the measuring instrument side.



Example of D/A output waveform

3.6.2 Machine Resonance Frequency Display Function

If resonance is generated and it causes vibrations of the current commands, this function estimates the vibration frequency and displays it on the NC monitor screen (AFLT frequency).
This is useful in setting the notch filter frequencies during servo adjustment. This function constantly operates with no need of parameter setting.

3.6.3 Machine Inertia Display Function

With this function, the load current and acceleration rate during motor acceleration are measured to estimate the load inertia.
According to the parameter setting, the estimated load inertia is displayed on the NC monitor screen, expressed as its percentage to the motor inertia.

3.6.4 Motor Temperature Display Function

The temperature sensed by the thermal sensor attached to the motor coil is displayed on the NC screen.
(Note) This function is only compatible with Spindle motor.

3.6.5 Load Monitor Output Function

A spindle motor's load is output as an analog voltage of 0 to 3V (0 to 120%). To use this function, connect a load meter that meets the specifications.

3.6.6 Power Supply Diagnosis Display Function

The diagnosis information of the power supply (bus voltage and current) is displayed on the NC monitor screen.

4

Characteristics

4.1 Servo Motor

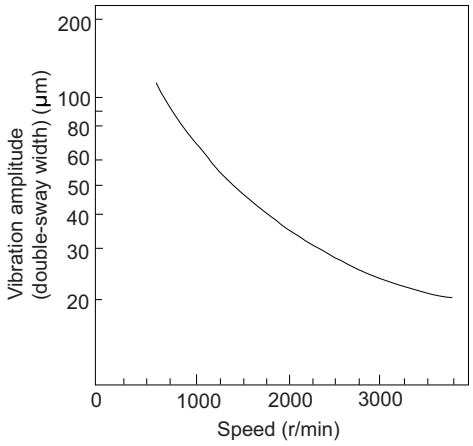
4.1.1 Environmental Conditions

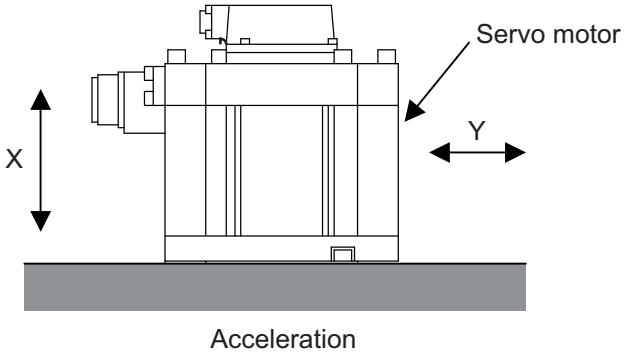
Environment	Conditions
Ambient temperature	0°C to +40°C (with no freezing)
Ambient humidity	80% RH or less (with no dew condensation)
Storage temperature	-15°C to +70°C (with no freezing)
Storage humidity	90% RH or less (with no dew condensation)
Atmosphere	Indoors (no direct sunlight) No corrosive gas, inflammable gas, oil mist or dust
Altitude	Operation / storage: 1000m or less above sea level Transportation: 10000m or less above sea level

4.1.2 Quakeproof Level

Motor type	Acceleration direction	
	Axis direction (X)	**Direction at right angle to axis (Y)**
HF75, 105 **HF54, 104, 154, 224, 123, 223, 142**	24.5m/s^2(2.5G) or less	24.5m/s^2(2.5G) or less
HF204, 354, 303, 302	24.5m/s^2(2.5G) or less	29.4m/s^2(3G) or less
HF-KP13, 23, 43, 73	49m/s^2(5G) or less	49m/s^2(5G) or less

The vibration conditions are as shown below.





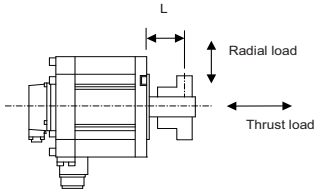
4.1.3 Shaft Characteristics

There is a limit to the load that can be applied on the motor shaft. Make sure that the load applied on the radial direction and thrust direction, when mounted on the machine, is below the tolerable values given below. These loads may affect the motor output torque, so consider them when designing the machine.

Servo motor	Tolerable radial load	Tolerable thrust load
HF75T, 105T (Taper shaft))	245N (L=33)	147N
HF75S, 105S (Straight shaft)	245N (L=33)	147N
HF54T, 104T, 154T, 224T, 123T, 223T, 142T (Taper shaft))	392N (L=58)	490N
HF54S, 104S, 154S, 224S, 123S, 223S, 142S (Straight shaft)	980N (L=55)	490N
HF204S, 354S, 303S, 302S (Straight shaft)	2058N (L=79)	980N
HF-KP13 (Straight shaft)	88N (L=25)	59N
HF-KP23, 43 (Straight shaft)	245N (L=30)	98N
HF-KP73 (Straight shaft	392N (L=40)	147N

(Note 1) The tolerable radial load and thrust load in the above table are values applied when each motor is used independently.

(Note 2) The symbol L in the table refers to the value of L below.



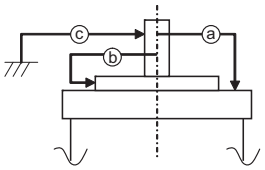
L: Length from flange installation surface to center of load mass [mm]

> **⚠ CAUTION**
>
> 1. Use a flexible coupling when connecting with a ball screw, etc., and keep the shaft core deviation to below the tolerable radial load of the shaft.
> 2. When directly installing the gear on the motor shaft, the radial load increases as the diameter of the gear decreases. This should be carefully considered when designing the machine.
> 3. When directly installing the pulley on the motor shaft, carefully consider so that the radial load (double the tension) generated from the timing belt tension is less than the values shown in the table above.
> 4. In machines where thrust loads such as a worm gear are applied, carefully consider providing separate bearings, etc., on the machine side so that loads exceeding the tolerable thrust loads are not applied to the motor.
> 5. Do not apply the loads exceeding the tolerable level. Failure to observe this may lead to the axis or bearing damage.

4.1.4 Machine Accuracy

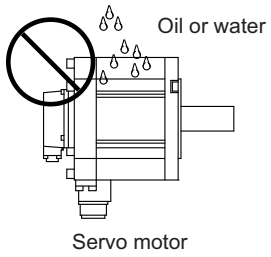
Machine accuracy of the servo motor's output shaft and around the installation part is as below.
(Excluding special products)

Accuracy	Measurement point	Flange size [mm]			
		Less than 100 SQ.	100 SQ., 130 SQ.	176 SQ. - 250 SQ.	280 SQ. or over
Run-out of the flange surface to the output shaft	a	0.05mm	0.06mm	0.08mm	0.08mm
Run-out of the flange surface's fitting outer diameter	b	0.04mm	0.04mm	0.06mm	0.08mm
Run-out of the output shaft end	c	0.02mm	0.02mm	0.03mm	0.03mm



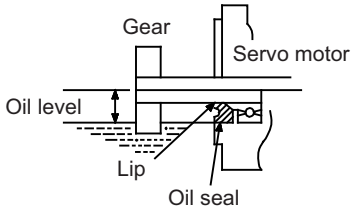
4.1.5 Oil / Water Standards

(1) The motor protective format uses the IP type, which complies with IEC Standard. (Refer to the section "Specifications List".)
However, these Standards are short-term performance specifications. They do not guarantee continuous environmental protection characteristics. Measures such as covers, etc., must be taken if there is any possibility that oil or water will fall on the motor, and the motor will be constantly wet and permeated by water. Note that the motor's IP-type is not indicated as corrosion-resistant.

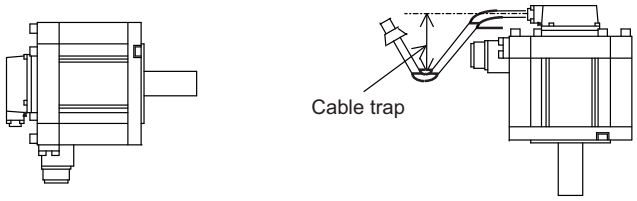


(2) When a gear box is installed on the servo motor, make sure that the oil level height from the center of the shaft is higher than the values given below. Open a breathing hole on the gear box so that the inner pressure does not rise.

Servo motor	Oil level(mm)
HF75, 105	15
HF54, 104, 154, 224, 123, 223, 142	22.5
HF204, 354, 303, 302	30
HF-KP13	9.5
HF-KP23, 43	12.5
HF-KP73	15



(3) When installing the servo motor horizontally, set the connector to face downward. When installing vertically or on an inclination, provide a cable trap because the liquid such as oil or water may enter the motor from the connector by running along the cable.



⚠ CAUTION

1. The servo motors, including those having IP67 specifications, do not have a completely waterproof (oil-proof) structure. Do not allow oil or water to constantly contact the motor, enter the motor, or accumulate on the motor. Oil can also enter the motor through cutting chip accumulation, so be careful of this also.
2. Oil may enter the motor from the clearance between the cable and connector. Protect with silicon not to make the clearance.
3. When the motor is installed facing upwards, take measures on the machine side so that gear oil, etc., does not flow onto the motor shaft.

4.1.6 Installation of Servo Motor

Mount the servo motor on a flange which has the following size or produces an equivalent or higher heat dissipation effect:

Flange size (mm)	Servo motor capacity
150×150×6	100W
250×250×6	200 to 400W
250×250×12	0.5 to 1.5kW
300×300×20	2.0 to 7.0kW
800×800×35	9.0 to 11.0kW

(Note 1) These flange sizes are recommended dimensions when the flange material is an aluminum.

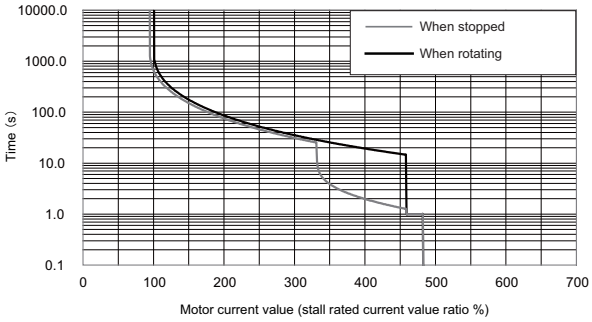
(Note 2) If enough flange size cannot be ensured, ensure the cooling performance by a cooling fan or operate the motor in the state that the motor overheat alarm does not occur.

4.1.7 Overload Protection Characteristics

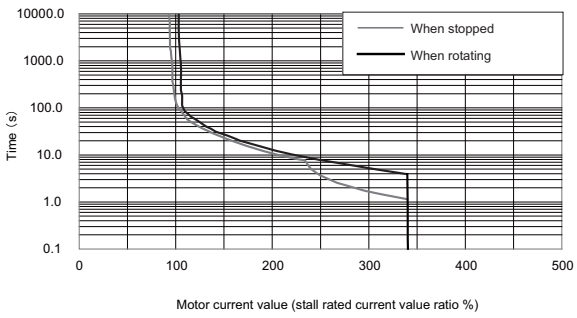
The servo drive unit has an electronic thermal relay to protect the servo motor and servo drive unit from overloads. The operation characteristics of the electronic thermal relay are shown below when standard parameters (SV021=60, SV022=150) are set. If overload operation over the electronic thermal relay protection curve shown below is carried out, overload 1 (alarm 50) will occur. If the maximum torque is commanded continuously for one second or more due to a machine collision, etc., overload 2 (alarm 51) will occur.

< HF Series >

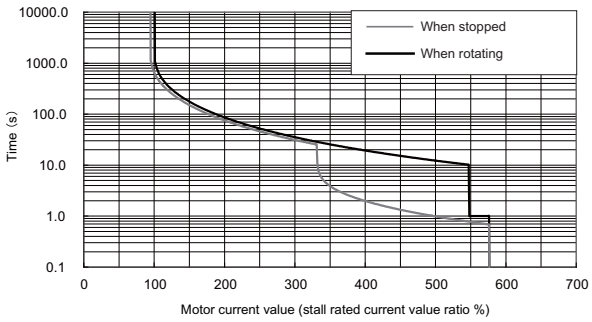
HF75



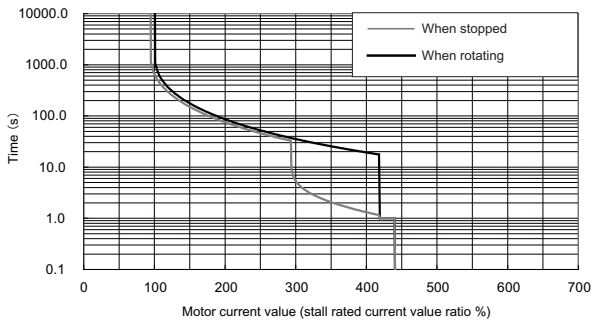
HF105



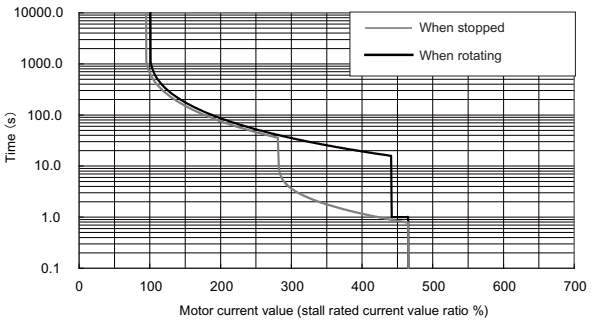
HF54



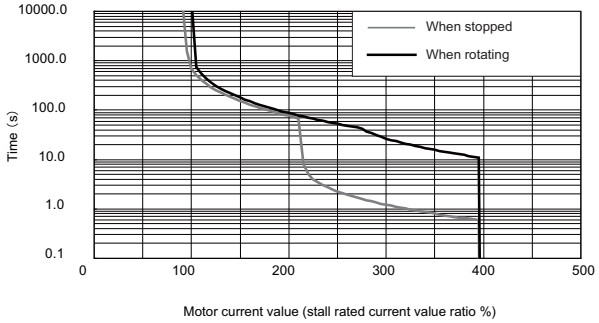
HF104



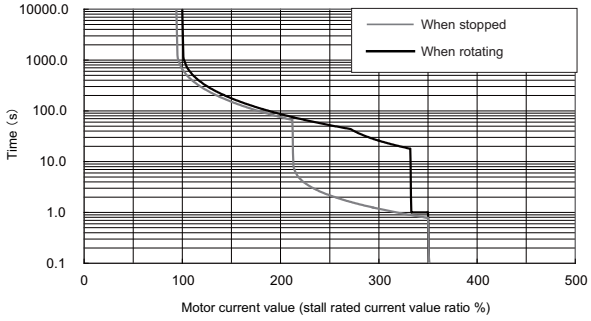
HF154



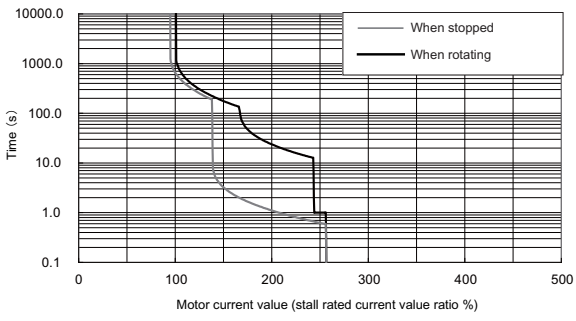
HF224



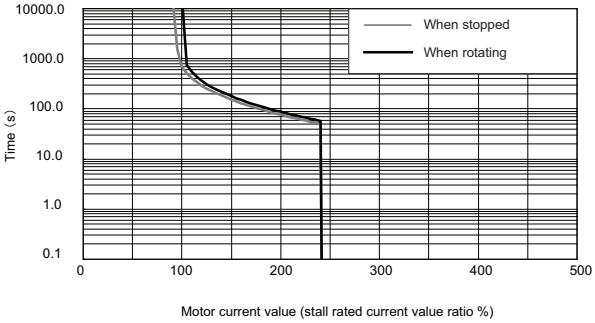
HF204



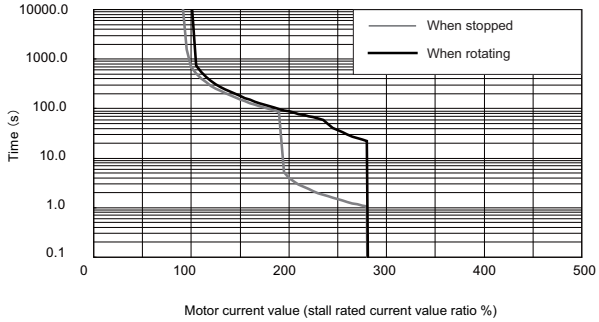
HF354



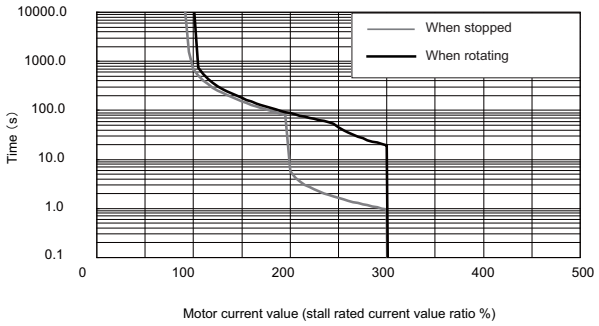
HF123



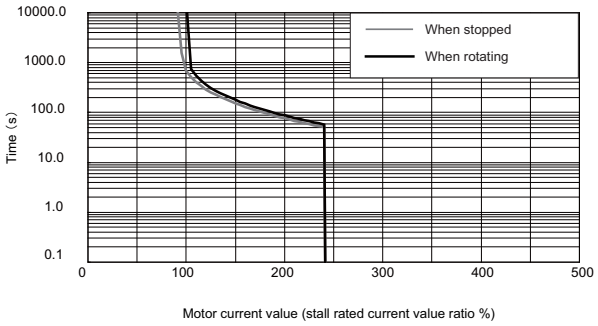
HF223



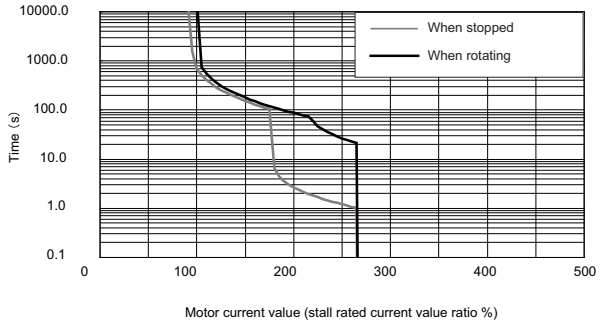
HF303



HF142

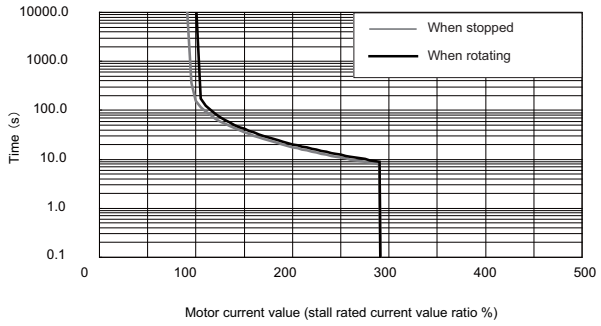


HF302

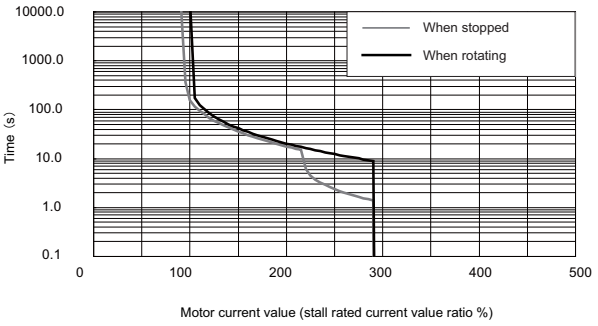


< HF-KP Series >

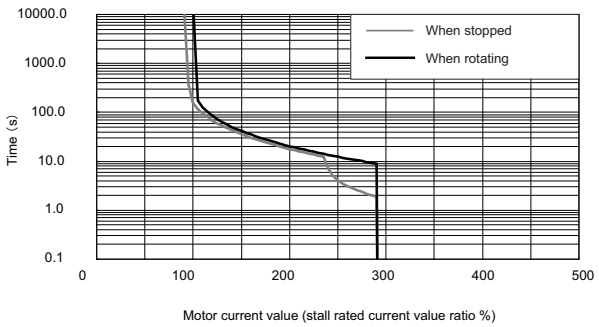
HF-KP13



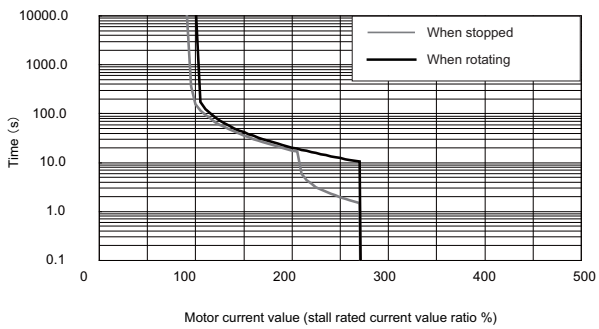
HF-KP23



HF-KP43



HF-KP73



4.1.8 Magnetic Brake

> **⚠ CAUTION**
>
> 1. The axis will not be mechanically held even when the dynamic brakes are used. If the machine could drop when the power fails, use a servo motor with magnetic brakes or provide an external brake mechanism as holding means to prevent dropping.
> 2. The magnetic brakes are used for holding, and must not be used for normal braking. There may be cases when holding is not possible due to the life or machine structure (when ball screw and servo motor are coupled with a timing belt, etc.). Provide a stop device on the machine side to ensure safety.
> 3. When operating the brakes, always turn the servo OFF (or ready OFF). When releasing the brakes, always confirm that the servo is ON first. Sequence control considering this condition is possible by using the brake contact connection terminal on the servo drive unit.
> 4. When the vertical axis drop prevention function is used, the drop of the vertical axis during an emergency stop can be suppressed to the minimum.

(1) Motor with magnetic brake

(a) Types

The motor with a magnetic brake is set for each motor. The "B" following the standard motor model stands for the motor with a brake.

(b) Applications

When this type of motor is used for the vertical feed axis in a machining center, etc., slipping and dropping of the spindle head can be prevented even when the hydraulic balancer's hydraulic pressure reaches zero when the power turns OFF. When used with a robot, deviation of the posture when the power is turned OFF can be prevented.

When used for the feed axis of a grinding machine, a double safety measures is formed with the deceleration stop (dynamic brake stop) during emergency stop, and the risks of colliding with the grinding stone and scattering can be prevented.

This motor cannot be used for the purposes other than holding and braking during a power failure (emergency stop). (This cannot be used for normal deceleration, etc.)

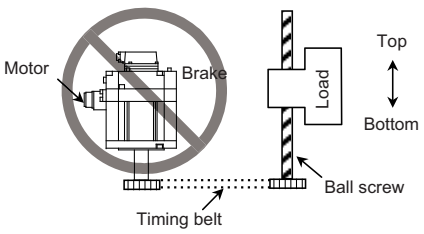
(c) Features

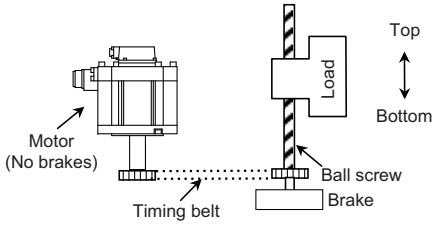
[1] The magnetic brakes use a DC excitation method, thus:
- The brake mechanism is simple and the reliability is high.
- There is no need to change the brake tap between 50Hz and 60Hz.
- There is no rush current when the excitation occurs, and shock does not occur.
- The brake section is not larger than the motor section.

[2] The magnetic brake is built into the motor, and the installation dimensions are the same as the motor without brake.

(d) Cautions for using a timing belt

Connecting the motor with magnetic brakes and the load (ball screw, etc.) with a timing belt as shown on the left below could pose a hazard if the belt snaps. Even if the belt's safety coefficient is increased, the belt could snap if the tension is too high or if cutting chips get imbedded. Safety can be maintained by using the method shown on the right below.





(2) Magnetic brake characteristics

< HF Series >

Item		Motor type		
		HF75B, HF105B	HF54B, HF104B HF154B, HF224B HF123B, HF223B HF142B	HF204B, HF354B HF303B, HF302B
Type (Note 1)		Spring closed non-exciting operation magnetic brakes (for maintenance and emergency braking)		
Rated voltage		DC24V 0V-10%		
Rated current at 20°C (A)		0.38	0.8	1.4
Capacity (W)		9	19	34
Static friction torque (N.m)		2.4	8.3	43.1
Inertia (Note 2) (kg•cm^2)		0.2	2.2	9.7
Release delay time (Note 3) (s)		0.03	0.04	0.1
Braking delay time (DC OFF) (Note 3) (s)		0.03	0.03	0.03
Tolerable braking work amount	Per braking (J)	64	400	4,500
	Per hour (J)	640	4,000	45,000
Brake play at motor axis (degree)		0.1 to 0.9	0.2 to 0.6	0.2 to 0.6
Brake life (Note 4)	No. of braking operations (times)	20,000	20,000	20,000
	Work amount per braking (J)	32	200	1,000

< HF-KP Series >

Item		Motor type		
		HF-KP13B	HF-KP23B, HF-KP43B	HF-KP73B
Type (Note 1)		Spring closed non-exciting operation magnetic brakes (for maintenance and emergency braking)		
Rated voltage		DC24V 0V-10%		
Rated current at 20°C (A)		0.26	0.33	0.42
Capacity (W)		6.3	7.9	10
Static friction torque (N.m)		0.32	1.3	2.4
Inertia (Note 2) (kg•cm^2)		0.002	0.08	0.2
Release delay time (Note 3) (s)		0.03	0.03	0.04
Braking delay time (DC OFF) (Note 3) (s)		0.01	0.02	0.02
Tolerable braking work amount	Per braking (J)	5.6	22	64
	Per hour (J)	56	220	640
Brake play at motor axis (degree)		2.5	1.2	0.9
Brake life (Note 4)	No. of braking operations (times)	20,000	20,000	20,000
	Work amount per braking (J)	5.6	22	64

(Note 1) There is no manual release mechanism. If handling is required such as during the machine core alignment work, prepare a separate 24VDC power supply, and electrically release a brake.

(Note 2) These are the values added to the servo motor without a brake.

(Note 3) This is the representative value for the initial attraction gap at 20°C.

(Note 4) The brake gap will widen through brake lining wear caused by braking. However, the gap cannot be adjusted. Thus, the brake life is considered to be reached when adjustments are required.

(Note 5) A leakage flux will be generated at the shaft end of the servo motor with a magnetic brake.

(Note 6) When operating in low speed regions, the sound of loose brake lining may be heard. However, this is not a problem in terms of function.

(3) Magnetic brake power supply

> **⚠ CAUTION**
>
> 1. Always install a surge absorber on the brake terminal when using DC OFF.
> 2. Do not pull out the cannon plug while the brake power is ON. The cannon plug pins could be damaged by sparks.

(a) Brake excitation power supply

[1] Prepare a brake excitation power supply that can accurately ensure the attraction current in consideration of the voltage fluctuation and excitation coil temperature.

[2] The brake terminal polarity is random. Make sure not to mistake the terminals with other circuits.

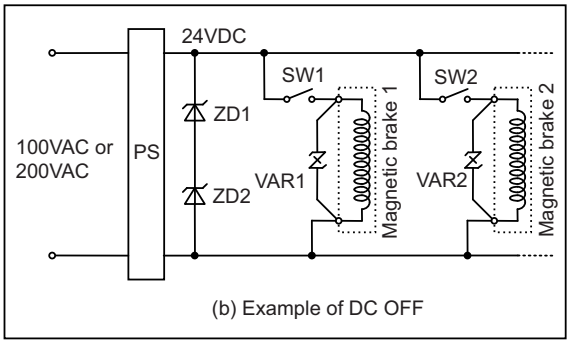
(b) Bake excitation circuit

When turning OFF the brake excitation power supply (to apply the brake), DC OFF is used to shorten the braking delay time.

A surge absorber will be required. Pay attention to the relay cut off capacity.

<Cautions>

- Provide sufficient DC cut off capacity at the contact.
- Always use a surge absorber.
- When using the cannon plug type, the surge absorber will be further away, so use shielded wires between the motor and surge absorber.



PS : 24VDC stabilized power supply
ZD1,ZD2 : Zener diode for power supply protection (1W, 24V)
VAR1,VAR2 : Surge absorber

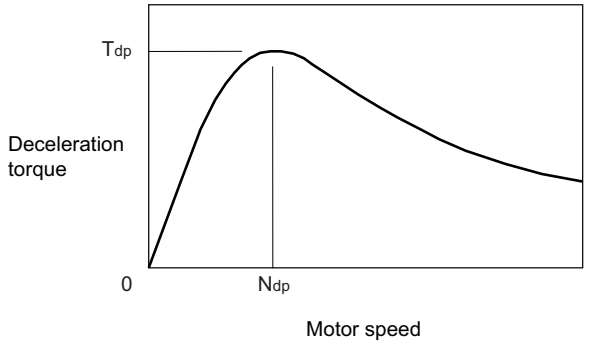
Magnetic brake circuits

4.1.9 Dynamic Brake Characteristics

If a servo alarm that cannot control the motor occurs, the dynamic brakes will function to stop the servo motor regardless of the parameter settings.

(1) Deceleration torque

The dynamic brake uses the motor as a generator, and obtains the deceleration torque by consuming that energy with the dynamic brake resistance. The characteristics of this deceleration torque have a maximum deceleration torque (Tdp) regarding the motor speed as shown in the following drawing. The torque for each motor is shown in the following table.



Deceleration torque characteristics of a dynamic brake

Max. deceleration torque of a dynamic brake

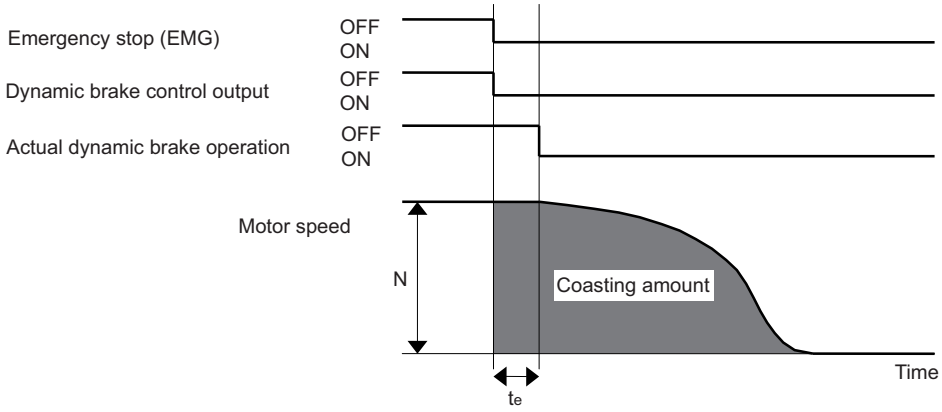
Motor type	Stall torque (N•m)	Tdp (N•m)	Ndp (r/min)
HF75	2.0	2.71	4120
HF105	3.0	5.10	5544
HF54	2.9	1.98	1886
HF104	5.9	10.02	1242
HF154	9.0	15.64	1639
HF224	12.0	20.07	2170
HF204	13.7	15.95	1260
HF354	22.5	35.25	2050
HF123	7.0	9.80	856
HF223	12.0	19.93	1268
HF303	22.5	30.40	1182
HF142	11.0	14.43	614
HF302	20.0	29.42	769
HF-KP13	0.32	0.22	1522
HF-KP23	0.64	0.52	1062
HF-KP43	1.3	1.30	822
HF-KP73	2.4	1.48	3449

(2) Coasting rotation distance during emergency stop

The distance that the motor coasts (angle for rotary axis) when stopping with the dynamic brakes can be approximated with the following expression.

$$L_{MAX} = \frac{F}{60} \cdot \{ t_e + (1 + \frac{J_L}{J_M}) \cdot (A \cdot N^2 + B) \}$$

L_{MAX}	: Motor coasting distance (angle)	[mm, (deg)]
F	: Axis feedrate	[mm/min, (deg/min)]
N	: Motor speed	[r/min]
J_M	: Motor inertia	[$\times 10^{-4}$kg•m^2]
J_L	: Motor shaft conversion load inertia	[$\times 10^{-4}$kg•m^2]
t_e	: Brake drive relay delay time	[s] (Normally, 0.03s)
A	: Coefficient A (Refer to the following table)	
B	: Coefficient B (Refer to the following table)	



Dynamic brake braking diagram

Coasting amount calculation coefficients table

Motor type	J_M(kg•cm^2)	A	B
HF75	2.6	0.41×10^{-9}	20.67×10^{-3}
HF105	5.1	0.31×10^{-9}	29.00×10^{-3}
HF54	6.1	2.85×10^{-9}	30.35×10^{-3}
HF104	11.9	1.67×10^{-9}	7.73×10^{-3}
HF154	17.8	1.21×10^{-9}	9.76×10^{-3}
HF224	23.7	0.95×10^{-9}	13.42×10^{-3}
HF204	38.3	3.33×10^{-9}	15.84×10^{-3}
HF354	75.0	1.81×10^{-9}	22.84×10^{-3}
HF123	11.9	2.47×10^{-9}	5.44×10^{-3}
HF223	23.7	1.64×10^{-9}	7.90×10^{-3}
HF303	75.0	3.64×10^{-9}	15.26×10^{-3}
HF142	17.8	3.51×10^{-9}	3.96×10^{-3}
HF302	75.0	5.79×10^{-9}	10.26×10^{-3}
HF-KP13	0.088	0.25×10^{-9}	3.12×10^{-3}
HF-KP23	0.23	0.41×10^{-9}	2.48×10^{-3}
HF-KP43	0.42	0.39×10^{-9}	1.39×10^{-3}
HF-KP73	1.43	0.27×10^{-9}	17.42×10^{-3}

4.2 Spindle Motor

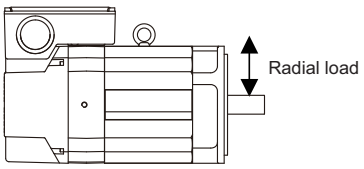
4.2.1 Environmental Conditions

Environment	Conditions
Ambient temperature	0°C to +40°C (with no freezing)
Ambient humidity	90%RH or less (with no dew condensation)
Storage temperature	-20°C to +65°C (with no freezing)
Storage humidity	90%RH or less (with no dew condensation)
Atmosphere	Indoors (Where unit is not subject to direct sunlight) No corrosive gases, flammable gases, oil mist or dust
Altitude	Operation/storage: 1000m or less above sea level Transportation: 10000m or less above sea level
Vibration	X:29.4m/s^2 (3G) Y:29.4m/s^2 (3G)

4.2.2 Shaft Characteristics

There is a limit to the load that can be applied on the motor shaft. Make sure that the load applied on the radial direction, when mounted on the machine, is below the tolerable values given below. These loads may affect the motor output torque, so consider them when designing the machine.

Spindle motor	Tolerable radial load
SJ-VL11-05FZT-S01	98N
SJ-VL2.2-02ZT	196N
SJ-D3.7/100-01, SJ-DJ5.5/100-01 SJ-V2.2-01T, SJ-V7.5-03ZT, SJ-DJ5.5/120-01	980N
SJ-D5.5/100-01, SJ-D5.5/120-01, SJ-DJ7.5/100-01, SJ-DJ7.5/120-01	1470N
SJ-D7.5/100-01, SJ-D7.5/120-01, SJ-D11/100-01, SJ-DJ11/100-01	1960N



(Note) The load point is at the one-half of the shaft length.

⚠ CAUTION

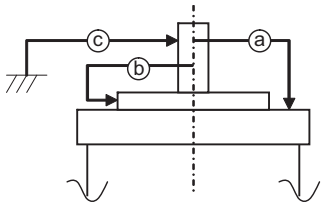
Consider on the machine side so that the thrust loads are not applied to the spindle motor.

4.2.3 Machine Accuracy

Machine accuracy of the spindle motor's output shaft and around the installation part is as below.
(Excluding special products)

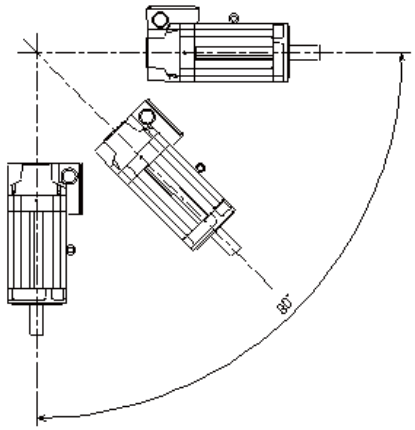
Accuracy	Measurement point	Frame No.	
		A71, B71, A90, B90, C90, D90, A112, B112	A160, B160, C160, A180, B180, A225
Run-out of the flange surface to the output shaft	a	0.03mm	0.05mm
Run-out of the flange surface's fitting outer diameter	b	0.02mm	0.04mm
Run-out of the output shaft end	c	0.01mm	0.02mm

(Note) Refer to Specifications Manual for the frame number of each spindle motor.



4.2.4 Installation of Spindle Motor

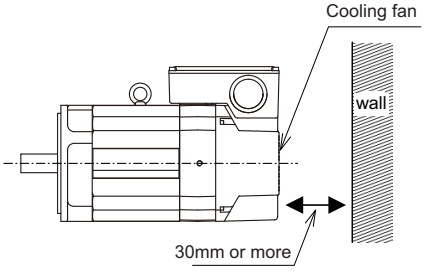
Make sure that the spindle motor is installed so that the motor shaft points from downward to 90° as shown below. When installing upward more than 90°, contact your Mitsubishi Electric dealer.



⚠ CAUTION

1. Rubber packing for waterproof is attached on the inner surface of the top cover of terminal block, and on the fan lead. After checking that the packing is installed, install the top cover so that no foreign objects are stuck in between.
2. When installing a motor on a flange, chamfer(C1) the part of flange that touches inside low part of the motor.

To yield good cooling performance, provide a space of at least 30mm between the cooling fan and wall. If the motor is covered by a structure and the air is not exchanged, its cooling performance degrades and the motor is unable to fully exercise its performance, which may cause the spindle motor overheat alarm. Do not use the spindle motor in an enclosed space with little ventilation.



4.3 Tool Spindle Motor

4.3.1 Environmental Conditions

Environment	Conditions
Ambient temperature	0°C to +40°C (with no freezing)
Ambient humidity	80% RH or less (with no dew condensation)
Storage temperature	-15°C to +70°C (with no freezing)
Storage humidity	90% RH or less (with no dew condensation)
Atmosphere	Indoors (no direct sunlight) No corrosive gas, inflammable gas, oil mist or dust
Altitude	Operation/storage: 1000m or less above sea level Transportation: 10000m or less above sea level
Vibration	X:19.6m/s^2 (2G) Y:19.6m/s^2 (2G)

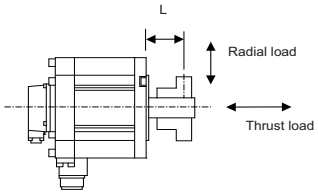
4.3.2 Shaft Characteristics

There is a limit to the load that can be applied on the motor shaft. Make sure that the load applied on the radial direction, when mounted on the machine, is below the tolerable values given below. These loads may affect the motor output torque, so consider them when designing the machine.

Tool spindle motor	Tolerable radial load	Tolerable thrust load
HF-KP46, 56	245N (L=30)	98N
HF-KP96	392N (L=40)	147N
HF75S, 105S	245N (L=33)	147N
HF54S, 104S, 154S, 224S	980N (L=55)	490N
HF204S	2058N (L=79)	980N

(Note 1) The tolerable radial load and thrust load in the above table are values applied when each motor is used independently.

(Note 2) The symbol L in the table refers to the value of L below.



L: Length from flange installation surface to center of load mass [mm]

4.3.3 Tool Spindle Temperature Characteristics

The tool spindle motor temperature tends to rise in a high-speed rotation even if the load rate is low. At the rotation speed of 6000r/min, even if the load rate is 0%, temperature rises about 50 to 60°C.

4.3.4 Installation of Tool Spindle Motor

Mount the servo motor on a flange which has the following size or produces an equivalent or higher heat dissipation effect:

Flange size (mm)	Tool spindle motor capacity
250×250×6	400W
250×250×12	0.5 to 1.5kW
300×300×20	2.0 to 3.0kW

4.4 Drive Unit

4.4.1 Environmental Conditions

Environment	Conditions
Ambient temperature	0°C to +55°C (with no freezing)
Ambient humidity	90% RH or less (with no dew condensation)
Storage temperature	-15°C to +70°C (with no freezing)
Storage humidity	90% RH or less (with no dew condensation)
Atmosphere	Indoors (no direct sunlight); no corrosive gas, inflammable gas, oil mist, dust or conductive fine particles
Altitude	Operation/storage: 1000m or less above sea level Transportation: 13000m or less above sea level
Vibration	Operation/storage: 4.9m/s^2 (0.5G) or less Transportation: 49m/s^2(5G) or less

(Note) When installing the machine at 1,000m or more above sea level, the heat dissipation characteristics will drop as the altitude increases in proportion to the air density. The ambient temperature drops 1% with every 100m increase in altitude.
When installing the machine at 1,800m altitude, the heating value of the drive unit must be reduced to 92% or less. The heating value is proportional to the square of the current, and required current decreasing rate follows the expression below.

$$\text{Required current decreasing rate} = \sqrt{0.92} = 0.95$$

Therefore, use the unit with the reduced effective load rate to 95% or less.

4.4.2 Heating Value

Each heating value is calculated with the following values.
The values for the servo drive unit apply at 50% of the stall output. The values for the spindle drive unit apply for the continuous rated output.

Servo drive unit		Spindle drive unit	
Type MDS-DJ-	Heating value [W] Inside panel	Type MDS-DJ-	Heating value [W] Inside panel
V1-10	25	**SP-20**	50
V1-15	35	**SP-40**	90
V1-30	50	**SP-80**	130
V1-40	90	**SP-100**	150
V1-80	130	**SP-120**	200
V1-100	195	**SP-160**	300
V2-3030	70	**SP2-2020**	70

POINT

1. Design the panel's heating value taking the actual axis operation (load rate) into consideration.
2. The heating values in the above tables are calculated with the following load rates.

Unit	Load rate
Servo drive unit	50%
Spindle drive unit	100%
Power supply unit	100%

5

Dedicated Options

5.1 Servo Options

The interface units or battery options are required depending on the type of machine end encoder in the full closed loopcontrol system. Check the options to be required referring the following lists.

POINT

The scales shown in this manual are examples which the connectivity is verified by Mitsubishi Electric.
Connectable scales besides these are also marketed. Contact each scale manufacturer for details.
For the specifications of the scale, including the scales shown in this manual, refer to the manuals issued by the manufacturer.

(a) Full closed loop control for linear axis

Machine side encoder to be used			Encoder signal output	Interface unit	Drive unit input signal	Battery option	Remarks
Incre-mental encoder	Rectangular wave signal output	SR74, SR84 (Magnescale)	Rectangular wave signal	-	Rectangular wave signal	-	
		Various scale	Rectangular wave signal	-	Rectangular wave signal	-	
	SIN wave signal output	LS187, LS487 (HEIDENHAIN)	SIN wave signal	IBV series (HEIDENHAIN)	Rectangular wave signal	-	
				EIB series (HEIDENHAIN)	Mitsubishi serial signal	-	
				APE series (HEIDENHAIN)	Mitsubishi serial signal	-	
		LS187C, LS487C (HEIDENHAIN)	SIN wave signal	MDS-B-HR-11(P) (Mitsubishi Electric)	Mitsubishi serial signal	(Required) (Note 1)	Distance-coded reference scale (Note 2)
				EIB series (HEIDENHAIN)			
		Various scale	SIN wave signal	MDS-B-HR-11(P) (Mitsubishi Electric)	Mitsubishi serial signal	(Required) (Note 1)	Distance-coded reference scale is also available (Note 2)
				EIB series (HEIDENHAIN)			
	Mitsubishi serial signal output	SR75, SR85 (Magnescale)	Mitsubishi serial signal	-	Mitsubishi serial signal	-	
Abso-lute position encoder	Mitsubishi serial signal output	OSA105ET2A (Mitsubishi Electric)	Mitsubishi serial signal	-	Mitsubishi serial signal	Required	Ball screw side encoder
		SR27, SR77, SR87, SR67A (Magnescale)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		LC195M, LC495M, LC291M (HEIDENHAIN)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	Mitsu03-4
		LC193M, LC493M (HEIDENHAIN)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	Mitsu02-4
		AT343, AT543, AT545, ST748 (Mitutoyo)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		SAM Series (FAGOR)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		SVAM Series (FAGOR)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		GAM Series (FAGOR)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		LAM Series (FAGOR)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		RL40N Series (Renishaw)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		AMS-ABS-3B Series (Schneeberger)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		LMFA Series (AMO)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		LMBA Series (AMO)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	

(Note 1) When using the distance-coded reference scale, it is recommended to use with distance-coded reference check function. In this case, the battery option is required.

(Note 2) The distance-coded reference scale is the supported option for M700V Series.

Machine side encoder to be used			Encoder signal output	Interface unit	Drive unit input signal	Battery option	Remarks
Abso-lute position encoder	SIN wave signal output	MPS Series (NIDEC MACHINE TOOL)	SIN wave signal	ADB-20J60 (NIDEC MACHINE TOOL)	Mitsubishi serial signal	Required	
		MPI Series (NIDEC MACHINE TOOL)	SIN wave signal	ADS-20J60 (NIDEC MACHINE TOOL)	Mitsubishi serial signal		

(b) Full closed loop control for rotary axis

Machine side encoder to be used			Encoder signal output	Interface unit	Output signal	Battery option	Remarks
Incre-mental encoder	Rectangular wave signal output	Various scale	Rectangular wave signal	-	Rectangular wave signal	-	
	SIN wave signal output	ERM280 Series (HEIDENHAIN)	SIN wave signal	EIB series (HEIDENHAIN)	Mitsubishi serial signal	-	
		Various scale	SIN wave signal	MDS-B-HR-11(P) (Mitsubishi Electric)	Mitsubishi serial signal	(Required) (Note 1)	Distance-coded reference scale is also available (Note 2)
Abso-lute position encoder	Mitsubishi serial signal output	MBA405W Series (Mitsubishi Electric)	Mitsubishi serial signal	(Provided)	Mitsubishi serial signal	Not required	
		RU77 (Magnescale)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		RCN223M, RCN227M (HEIDENHAIN)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	Mitsu02-4
		RCN727M, RCN827M (HEIDENHAIN)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	Mitsu02-4
		RA Series (Renishaw)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		HAM Series (FAGOR)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
		WMFA Series WMBA Series WMRA Series (AMO)	Mitsubishi serial signal	-	Mitsubishi serial signal	Not required	
	SIN wave signal output	MPRZ Series (NIDEC MACHINE TOOL)	SIN wave signal	ADB-20J71 (NIDEC MACHINE TOOL)	Mitsubishi serial signal	Not required	
		MPI Series (NIDEC MACHINE TOOL)	SIN wave signal	ADB-20J60 (NIDEC MACHINE TOOL)	Mitsubishi serial signal	Required	

(Note 1) When using the distance-coded reference scale, it is recommended to use with distance-coded reference check function. In this case, the battery option is required.

(Note 2) The distance-coded reference scale is the supported option for M700V Series.

<Contact information about machine side encoder>

- Magnescale Co., Ltd.: http://www.mgscale.com/mgs/language/english/
- HEIDENHAIN CORPORATION: http://www.heidenhain.com/
- Mitutoyo Corporation: http://www.mitutoyo.co.jp/eng/
- NIDEC MACHINE TOOL CORPORATION: http://www.nidec.com/en/nidec-machinetool/
- FAGOR Automation: http://www.fagorautomation.com/
- Renishaw plc.: http://www.renishaw.com/en/renishaw-enhancing-efficiency-in-manufacturing-and-healthcare--1030
- SCHNEEBERGER AG: https://www.schneeberger.com
- AMO (Automatisierung Messtechnik Optik) GmbH: http://www.amo-gmbh.com/en/

POINT

The absolute position system cannot be established in combination with the relative position (incremental) machine side encoder and absolute position motor side encoder.

(2) System establishment in the synchronous control

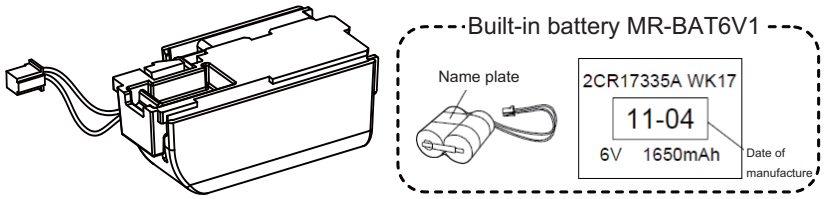
(a) Position command synchronous control

The synchronous control is all executed in the NC, and the each servo is controlled as an independent axis. Therefore, preparing special options for the synchronous control is not required on the servo side.

> **POINT**
>
> When executing the synchronous control, use the servo motors of which the type and encoder specifications are same.

5.1.1 Battery Option

This battery option may be required to establish absolute position system. Refer to "Servo Option" and use the following battery option depending on the servo system.

Type	MR-BAT6V1SET
Installation type	Drive unit installation
Hazard class	Not applicable
Number of connectable axes	1 axis
Change method	Battery option change
Appearance	(1) 

⚠ CAUTION

1. When transporting lithium batteries with means such as by air transport, measures corresponding to the United Nations Dangerous Goods Regulations must be taken. (Refer to "Appendix 2 Restrictions for Lithium Batteries".)
2. The lithium battery must be transported according to the rules set forth by the International Civil Aviation Organization (ICAO), International Air Transportation Association (IATA), International Maritime Organization (IMO), and United States Department of Transportation (DOT), etc. The packaging methods, correct transportation methods, and special regulations are specified according to the quantity of lithium alloys. The battery unit exported from Mitsubishi is packaged in a container (UN approved part) satisfying the standards set forth in this UN Advisory.
3. To protect the absolute value, do not shut off the servo drive unit control power supply if the battery voltage becomes low (warning 9F).
4. The battery life (backup time) is greatly affected by the working ambient temperature. Generally, if the ambient temperature increases, the backup time and useful life will both decrease.

(1) Cell battery (MR-BAT6V1SET)

(a) Specifications

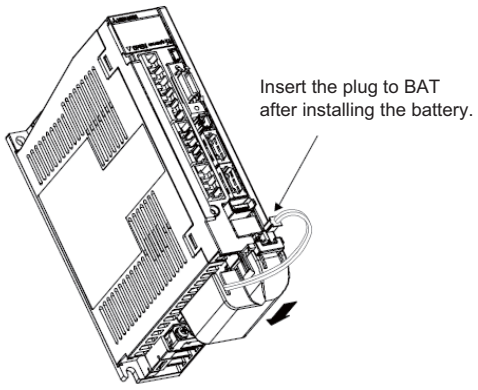
Battery option type		Cell battery MR-BAT6V1SET
Battery model name		2CR17335A
Nominal voltage		6V
Nominal capacity		1650mAh
Battery safety	Hazard class	Class 9 Not applicable
	Battery shape	Set battery
	Number of batteries used	2
	Lithium alloy content	1.2g
	Mercury content	Less than 1ppm
Number of connectable axes (Note 1)		1 axis
Battery continuous backup time		Approx. 20,000 hours
Battery useful life (From date of unit manufacture)		5 years
Data save time in battery replacement		HF series: approx. 20 hours at time of delivery, approx. 10 hours after 5 years
Back up time from battery warning to alarm occurrence (Note 2)		Approx. 100 hours
Mass		34g

(Note 1) When using ball screw side encoder, both ball screw side encoder and motor side encoder need to be backed up by a battery, so the load becomes double.

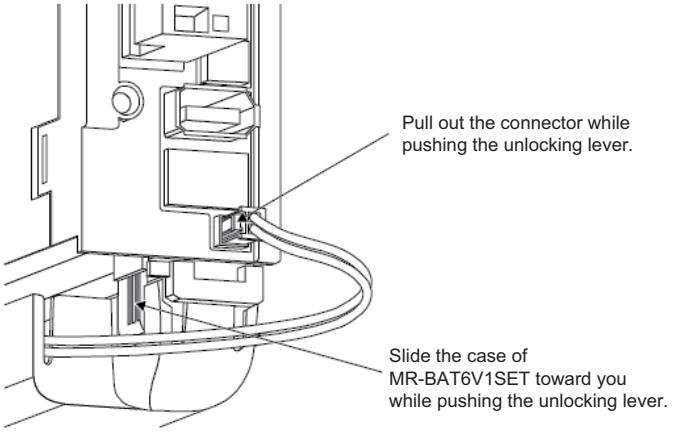
(Note 2) This time is a guideline, so does not guarantee the back up time. Replace the battery with a new battery as soon as a battery alarm occurs.

(Note 3) A battery load is generated in the axis for which the incremental control is set when a battery is connected.

(b) Installing and removing the cell battery



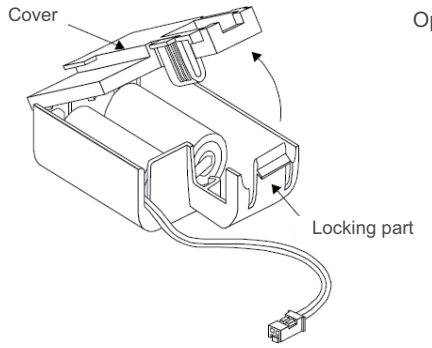
Installation



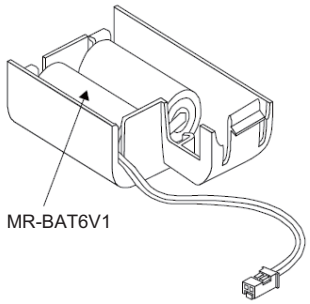
Removal

(c) Replacing the built-in battery

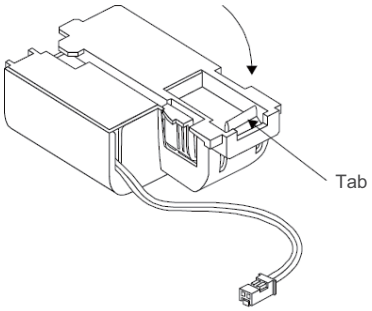
MR-BAT6V1SET that reached the end of the life can be reused by replacing the MR-BAT6V1 battery.



Open the cover while pushing the locking part.



Replace the built-in battery with a new battery for MR-BAT6V1.



Close the cover by pushing until it is fixed with the tab of the locking part.

5.1.2 Ball Screw Side Encoder (OSA105ET2A)

(1) Specifications

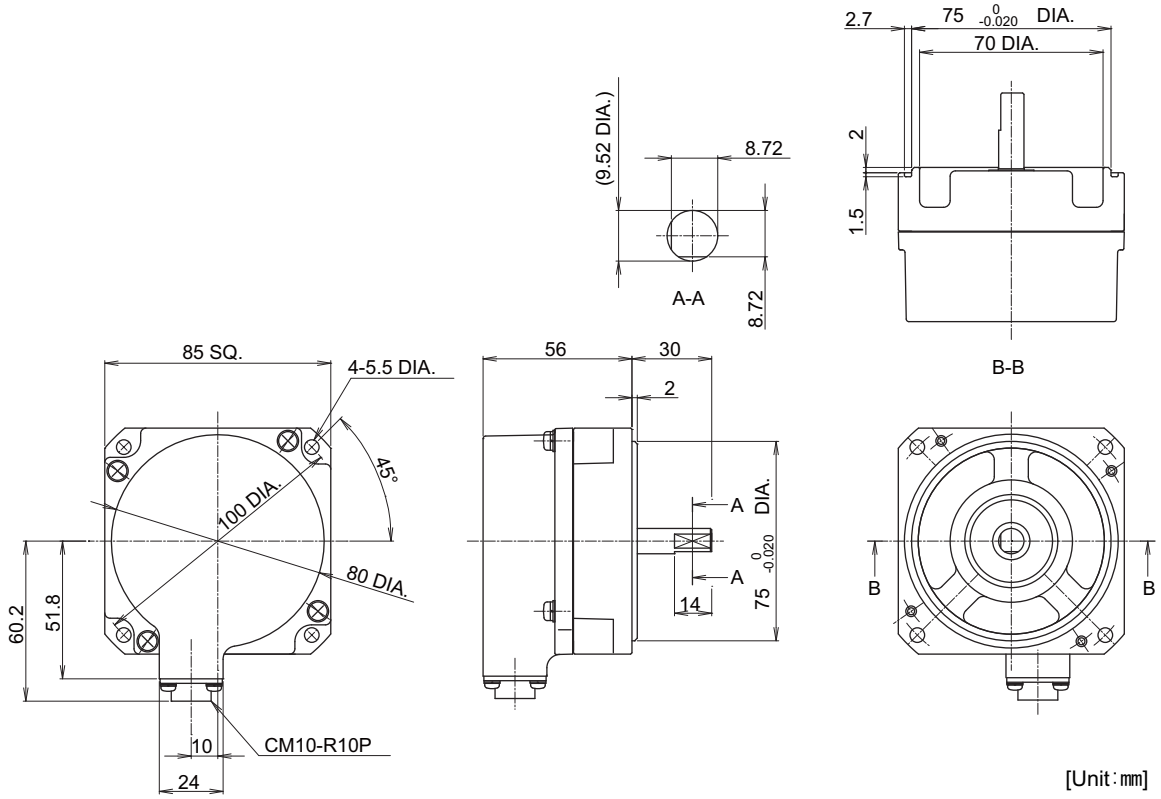
Encoder type		OSA105ET2A
Electrical characteristics	Encoder resolution	1,000,000 pulse/rev
	Detection method	Absolute position method (battery backup method)
	Accuracy (*1)	±3 seconds
	Tolerable rotation speed at power off (*2)	500r/min
	Encoder output data	Serial data
	Power consumption	0.3A
Mechanical characteristics for rotation	Inertia	0.5×10^{-4}kgm^2 or less
	Shaft friction torque	0.1Nm or less
	Shaft angle acceleration	4×10^4rad/s^2 or less
	Tolerable continuous rotation speed	4000r/min
Mechanical configuration	Shaft run-out (position 15mm from end)	0.02mm or less
	Tolerable load (thrust direction/radial direction)	9.8N/19.6N
	Mass	0.6kg
	Degree of protection	IP67 (The shaft-through portion is excluded.)
	Recommended coupling	bellows coupling
Working environment	Ambient temperature	0°C to +55°C
	Storage temperature	-20°C to +85°C
	Humidity	95%Ph
	Vibration resistance	5 to 50Hz, total vibration width 1.5mm, each shaft for 30min
	Impact resistance	490m/s^2 (50G)

(*1) The values above are typical values after the calibration with our shipping test device and are not guaranteed.

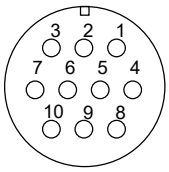
(*2) If the tolerable rotation speed at power off is exceeded, the absolute position cannot be repaired.

(2) Outline dimension drawings

OSA105ET2A



(3) Explanation of connectors



Connector pin layout

Pin	Function	Pin	Function
1	RQ	**6**	SD
2	RQ*	**7**	SD*
3	-	**8**	P5(+5V)
4	BAT	**9**	-
5	LG(GND)	**10**	SHD

5.1.3 Machine Side Encoder

(1) Relative position encoder

Depending on the output signal specifications, select a machine side relative position encoder with which the following (a), (b) or (c) is applied.

(a) Serial signal type (serial conversion unit made by each manufacture)

The following serial conversion unit converts the encoder output signal and transmits the signal to the drive unit in serial communication.

For details on the specifications of each conversion unit scale and for purchase, contact each corresponding manufacture directly.

Manufacturer	Encoder type	Interface unit type	Minimum detection resolution	Tolerable maximum speed
Magnescale Co., Ltd	SR75 SR85	Not required	0.1μm	200m/min
			0.05μm	
			0.01μm	
HEIDENHAIN CORPORATION	LS187 LS487	EIB192M A4 20μm	0.0012μm	120m/min
		EIB392M A4 20μm		
	ERM280 1200	EIB192M C4 1200	0.0000183° (19,660,800p/rev)	20000r/min
		EIB392M C4 1200		
	ERM280 2048	EIB192M C6 2048	0.0000107° (33,554,432p/rev)	11718r/min
		EIB392M C6 2048		

< Contact information about machine side encoder >

- Magnescale Co., Ltd.: http://www.mgscale.com/mgs/language/english/
- HEIDENHAIN CORPORATION: http://www.heidenhain.com/

⚠ CAUTION

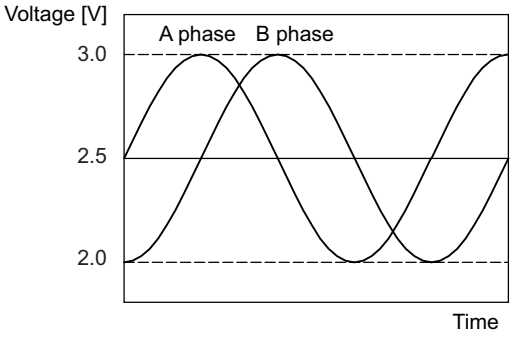
1. The above value does not guarantee the accuracy of the system.
2. The user shall prepare the above-mentioned detector after inquiring of each manufacturer about the specifications and confirm them.
3. When using an encoder not listed above, contact the manufacturer to make sure that the encoder is compatible with Mitsubishi interface.

(b) SIN wave output (using MDS-B-HR)

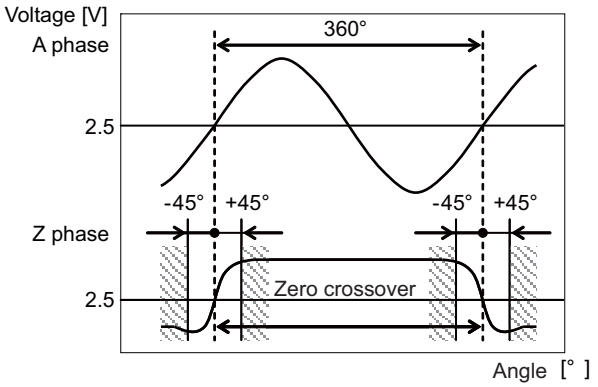
When using a relative position encoder that the signal is the SIN wave output, the encoder output signal is converted in the encoder conversion unit (MDS-B-HR), and then the signal is transmitted to the drive unit in the serial communication. Select a relative position encoder with A/B phase SIN wave signal that satisfies the following conditions. For details on the specifications of MDS-B-HR, refer to the section "MDS-B-HR".

< Encoder output signal >

- 1Vp-p analog A-phase, B-phase, Z-phase differential output
- Output signal frequency 200kHz or less



A/B phase output signal waveform during forward run



Relationship between A phase and Z phase
(When the differential output waveform is measured)

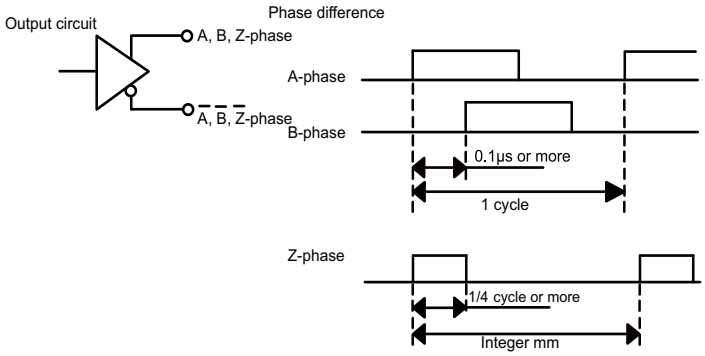
- Combination speed / rotation speed
  - In use of linear scale:
  - Maximum speed (m/min) = scale analog signal frequency (m) × 200,000 × 60
  - In use of rotary encoder:
  - Maximum rotation speed (r/min) = 200,000 / numbers of encoder scale (1/rev) × 60
  - An actual Maximum speed/ rotary speed is limited by the mechanical specifications and electrical specifications, etc. of the connected scale, so contact the manufacture of the purchased scale.
- Division number 512 divisions per 1 cycle of signal
  - In use of linear scale:
  - Minimum resolution (m) = scale analog signal frequency (m) / 512
  - In use of rotary encoder:
  - Minimum resolution (pulse/rev) = numbers of encoder scale (1/rev) × 512

> **⚠ CAUTION**
>
> The above value does not guarantee the accuracy of the system.

(c) Rectangular wave output

Select a relative position encoder with an A/B phase difference and Z-phase width at the maximum feedrate that satisfies the following conditions.

Use an A, B, Z-phase signal type with differential output (RS-422 standard product) for the output signal.



(Note 1) For a scale having multiple Z phases, select the neighboring Z phases whose distance is an integer multiple or 1/integer of the ball screw pitch.

(Note 2) The above value is minimum value that can be received normally in the servo drive unit side.
In an actual selection, ensure margin of 20% or more in consideration of degradation of electrical wave and speed overshoot.

< Example of scale specifications >

The example of using representative rectangular wave scale is shown below.

For specifications of each conversion unit and scale and for purchase, Contact each corresponding manufacture directly.

Manufacturer	Encoder type	Interface unit type	Minimum detection resolution	Tolerable maximum speed
Magnescale Co., Ltd	SR67A SR74 SR84	Not required	1.0μm	180m/min
			0.5μm	125m/min
			0.1μm	25m/min
			0.05μm	12m/min
HEIDENHAIN CORPORATION	LS187 LS487	IBV 101 (10 divisions)	0.5μm	120m/min
		IBV 102 (100divisions)	0.05μm	24m/min
		IBV 660B (400divisions)	0.0125μm	7.5m/min

< Contact information about machine side encoder >

- Magnescale Co., Ltd: http://www.mgscale.com/mgs/language/english/
- HEIDENHAIN CORPORATION: http://www.heidenhain.com/

(2) Absolute position encoder

The applicable absolute position encoders are as follows.

Manufacturer	Encoder type	Interface unit type	Minimum detection resolution	Tolerable maximum speed
Mitsubishi Electric Corporation	MBA405W Series	(Provided)	0.00009° (4,000,000p/rev)	3000r/min
Magnescale	SR67A SR77 SR87	Not required	0.1μm	200m/min
			0.05μm	
			0.01μm	
	RU77	Not required	0.0000429° (8,388,608p/rev)	2,000r/min
			0.0000107 (33,554,432p/rev)	2,000r/min
HEIDENHAIN CORPORATION	LC193M LC493M	Not required	0.05μm	180m/min
			0.01μm	
	LC195M LC495M	Not required	0.01μm 0.001μm	180m/min
	LC291M	Not required	0.01μm	180m/min
	RCN223M	Not required	0.0000429° (8,388,608p/rev)	1,500r/min
	RCN227M	Not required	0.0000027° (134,217,728p/rev)	1,500r/min
	RCN727M RCN827M	Not required	0.0000027° (134,217,728p/rev)	300r/min
Mitutoyo Corporation	AT343	Not required	0.05μm	120m/min
	AT543	Not required	0.05μm	150m/min
	AT545	Not required	0.00488 (20/4096)μm	150m/min
	ST748	Not required	0.1μm	300m/min
NIDEC MACHINE TOOL CORPORATION	MPRZ Series	ADB-20J71	0.000043° (8,388,608p/rev)	10,000r/min
	MPS Series	ADB-20J60	0.05μm	3600m/min
	MPI Series	ADB-20J60	0.00005° (7,200,000p/rev) or 0.000025° (14,400,000p/rev)	5,000r/min
FAGOR Automation	SAM Series	Not required	0.05μm	120m/min
	SVAM Series	Not required	0.05μm	120m/min
	GAM Series	Not required	0.05μm	120m/min
	LAM Series	Not required	0.1μm	120m/min
	HAM Series	Not required	0.0000429° (8,388,608p/rev)	6000r/min
			0.0000027° (134,217,728p/rev)	6000r/min
Renishaw plc.	RL40N Series	Not required	0.05μm	6,000m/min
			0.001μm	
	RA Series	Not required	0.0000429° (8,388,608p/rev)	36000r/min
			0.0000027° (134,217,728p/rev)	36000r/min
AMO	LMFA Series	Not required	1μm	600 m/min
			0.25μm	150m/min
	LMBA Series		1μm	300m/min
			0.25μm	150m/min
	WMFA Series WMBA Series WMRA Series	Not required	250,000r/rev 500,000r/rev 1,000,000r/rev 2,000,000r/rev 4,000,000r/rev 8,000,000r/rev	14000r/min
Schneeberger	AMS-ABS-3B Series	Not required	0.05μm	180m/min

< Contact information about machine side encoder >

- Magnescale Co., Ltd.: http://www.mgscale.com/mgs/language/english/
- HEIDENHAIN CORPORATION: http://www.heidenhain.com/
- Mitutoyo Corporation: http://www.mitutoyo.co.jp/eng/
- NIDEC MACHINE TOOL CORPORATION: http://www.nidec.com/en/nidec-machinetool/
- FAGOR Automation: http://www.fagorautomation.com/
- Renishaw plc.: http://www.renishaw.com/en/renishaw-enhancing-efficiency-in-manufacturing-and-healthcare--1030
- SCHNEEBERGER AG: https://www.schneeberger.com
- AMO (Automatisierung Messtechnik Optik) GmbH : http://www.amo-gmbh.com/en/

⚠ CAUTION

1. Confirm the specifications of each encoder manufacturer before using machine side encoders made by other manufacturers.
2. Refer to "Twin-head Magnetic Encoder (MBA Series)" for details of the specifications of MBA405W.

5.1.4 Twin-head Magnetic Encoder (MBA Series)

(1) Type description

MBA405W-B (1) (2)

(1)

Symbol	Drum outer diameter
E	Φ100 mm
F	Φ150.3 mm
G	Φ200.6 mm

(2)

Symbol	Drum inner diameter
082	Φ82 mm
125	Φ125 mm
160	Φ160 mm

(2) Specifications

Encoder type		MBA405W-BE082	MBA405W-BF125	MBA405W-BG160
Electrical characteristics	Encoder resolution	4,000,000p/rev		
	Detection method	Absolute position method (battery backup method)		
	Accuracy (*1) (*2)	±4 seconds	±3 seconds	±2 seconds
	Wave number within one rotation	512 waves	768 waves	1024 waves
	Encoder output data	Serial data		
	Power consumption	0.2A or less		
Mechanical characteristics for rotation	Inertia	0.5×10^{-3}kg・m^2	2.4×10^{-3}kg・m^2	8.7×10^{-3}kg・m^2
	Tolerable continuous rotation speed	3000r/min	2000r/min	1500r/min
Mechanical configuration	Drum inner diameter	Φ82mm	Φ125mm	Φ160mm
	Drum outer diameter	Φ100mm	Φ150.3mm	Φ200.6mm
	Drum mass	0.2kg	0.46kg	1.0kg
	Degree of protection (*3)	IP67		
Working environment	Ambient temperature range	0°C to +55°C		
	Storage temperature range	-20°C to +85°C		
	Humidity	95%RH		
	Vibration resistance	Horizontal direction to the axis: 5G or less, Vertical direction to the axis: 5G or less		
	Impact resistance	490m/s^2 (50G)		

(*1) The values above are typical values after the calibration with our shipping test device and are not guaranteed.

(*2) The user is requested to install the magnetic drum and installation ring in the encoder within the accuracy range specified herein. Even when the accuracy of the encoder when shipped and when installed by the user is both within the specified range, there is a difference in the installation position. Therefore, the accuracy at the time of our shipment may not be acquired.

(*3) It is the degree of protection when fitted with a connector.

(3) Specifications of preamplifier

Item	Specified value
Output communication style	High-speed serial communication I/F
Working ambient temperature	0°C to +55°C
Working ambient humidity	90%RH or less (with no dew condensation)
Atmosphere	No toxic gases
Tolerable vibration	Horizontal direction to the axis: 5G or less, Vertical direction to the axis: 5G or less
Tolerable impact	490m/s^2 (50G)
Tolerable power voltage	DC5V±10%
Mass	0.33kg
Degree of protection (*2)	IP67

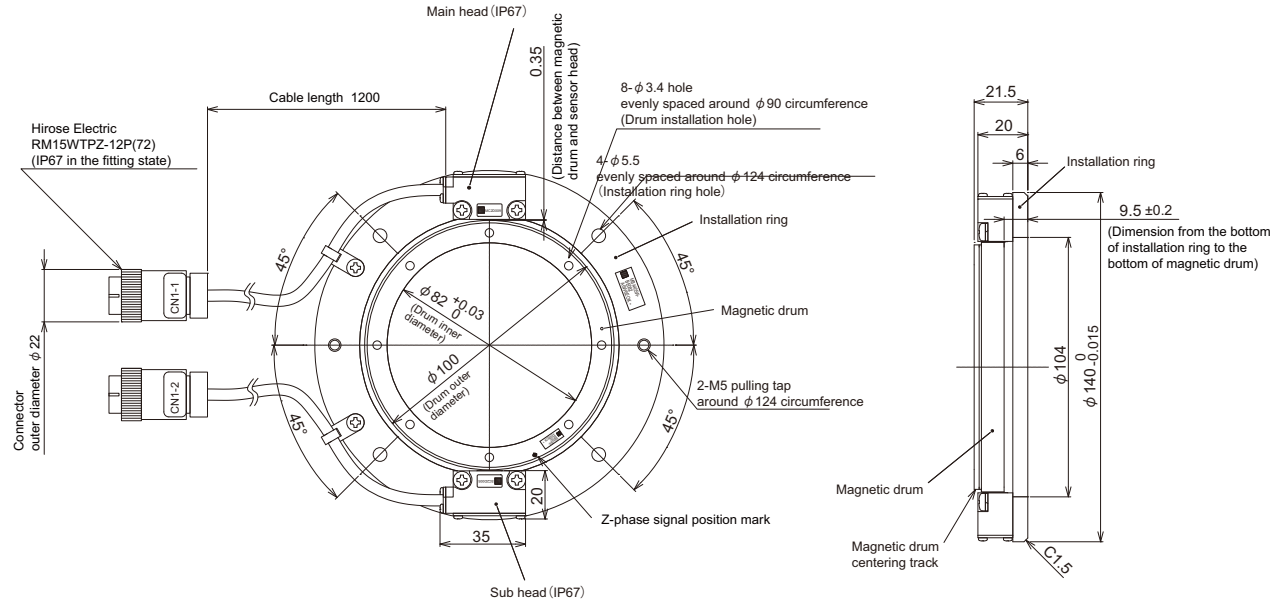
(*1) The values above are the specified values for the preamplifier provided with a twin-head magnetic encoder.

(*2) It is the degree of protection when fitted with a connector.

(4) Outline dimension drawing

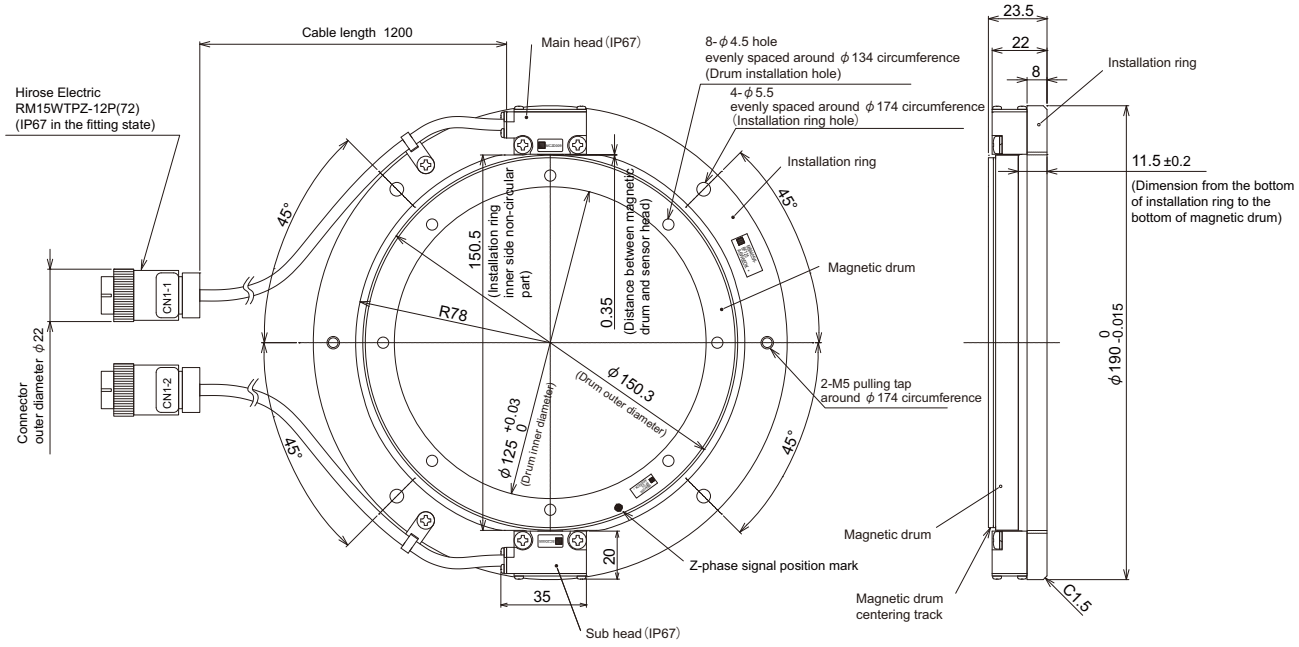
< MBA405W-BE082 >

[Unit: mm]



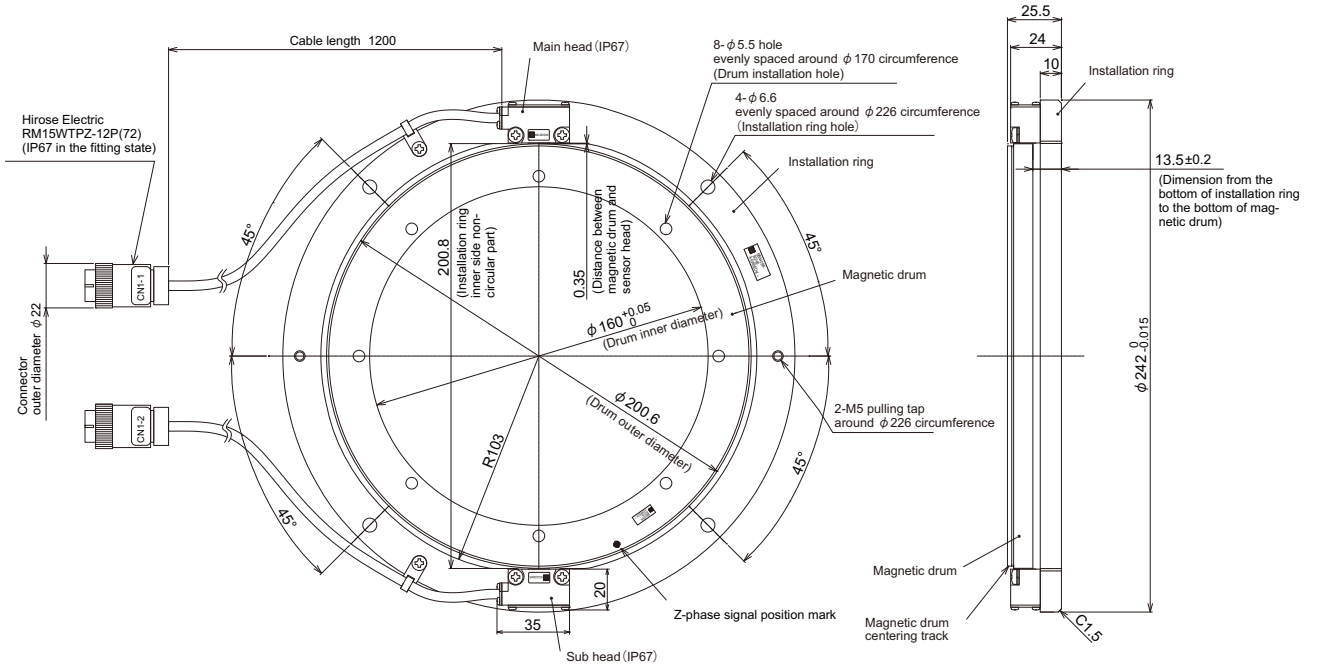
< MBA405W-BF125 >

[Unit: mm]



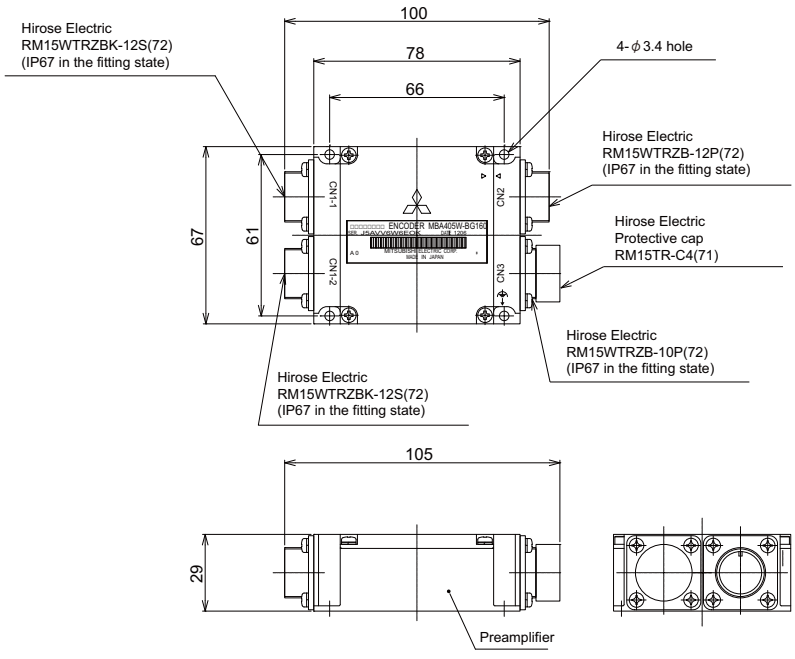
< MBA405W-BG160 >

[Unit: mm]



< Preamplifier (common) >

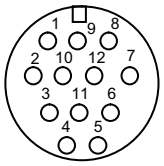
[Unit: mm]



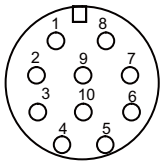
< Explanation of connectors >

Connector name	Application
CN1-1	For connection with scale (main head)
CN1-2	For connection with scale (sub head)
CN2	For connection with servo drive unit
CN3	For connection with motor thermistor

< Connector pin layout >



CN2 < Drive unit >



CN3 < Thermistor>

Pin No.	Function	Pin No.	Function
1	-	**1**	-
2	BT	**2**	-
3	SD	**3**	MT1-i
4	SD*	**4**	-
5	SHD	**5**	-
6	MT1	**6**	-
7	RQ	**7**	-
8	RQ*	**8**	-
9	P5	**9**	MT2-i
10	LG	**10**	-
11	MT2	**11**	-
12	CNT	**12**	-

5.2 Spindle Options

According to the spindle control to be adopted, select the spindle side encoder based on the following table.

(1) No-variable speed control
(When spindle and motor are directly coupled or coupled with a 1:1 gear ratio)

Spindle control item	Control specifications	Without spindle side encoder	With spindle side encoder
Spindle control	Normal cutting control	●	This normally is not used for no-variable speed control.
	Constant surface speed control (lathe)	●	
	Thread cutting (lathe)	●	
Orientation control	1-point orientation control	●	
	Multi-point orientation control	●	
	Orientation indexing	●	
Synchronous tap control	Standard synchronous tap	●	
	Synchronous tap after zero point return	●	
Spindle synchronous control	Without phase alignment function	●	
	With phase alignment function	●	
C-axis control	C-axis control	● (Note 2)	●

(Note 1) ● :Control possible
x :Control not possible
(Note 2) When spindle and motor are coupled with a 1:1 gear ratio, use of a spindle side encoder is recommended to assure the precision.

(2) Variable speed control
(When using V-belt, or when spindle and motor are connected with a gear ratio other than 1:1)

Spindle control item	Control specifications	Without spindle side encoder	With spindle side encoder		
			TS5690/ERM280/ MPCI/MBE405W Series	OSE-1024	Proximity switch
Spindle control	Normal cutting control	●	●	●	●
	Constant surface speed control (lathe)	● (Note 2)	●	●	● (Note 2)
	Thread cutting (lathe)	x	●	●	x
Orientation control	1-point orientation control	x	●	●	● (Note 4)
	Multi-point orientation control	x	●	●	x
	Orientation indexing	x	●	●	x
Synchronous tap control	Standard synchronous tap	● (Note 3)	●	●	● (Note 3)
	Synchronous tap after zero point return	x	●	●	x
Spindle synchronous control	Without phase alignment function	● (Note 2)	●	●	● (Note 2)
	With phase alignment function	x	●	●	x
C-axis control	C-axis control	x	●	x	x

(Note 1) ● :Control possible
x :Control not possible
(Note 2) Control not possible when connected with the V-belt.
(Note 3) Control not possible when connected with other than the gears.
(Note 4) Orientation is carried out after the spindle is stopped when a proximity switch is used.
As for 2-axis spindle drive unit, setting is available only for one of the axes.

5.2.1 Spindle Side ABZ Pulse Output Encoder (OSE-1024 Series)

When a spindle and motor are connected with a V-belt, or connected with a gear ratio other than 1:1, use this spindle side encoder to detect the position and speed of the spindle. Also use this encoder when orientation control and synchronous tap control, etc are executed under the above conditions.

(1) Specifications

Encoder type		OSE-1024-3-15-68	OSE-1024-3-15-68-8
Mechanical characteristics for rotation	Inertia	$0.1x10^{-4}kgm^2$ or less	$0.1x10^{-4}kgm^2$ or less
	Shaft friction torque	0.98Nm or less	0.98Nm or less
	Shaft angle acceleration	$10^4rad/s^2$ or less	$10^4rad/s^2$ or less
	Tolerable continuous rotation speed	6000 r/min	8000 r/min
Mechanical configuration	Bearing maximum non-lubrication time	20000h/6000r/min	20000h/8000r/min
	Shaft run-out (position 15mm from end)	0.02mm or less	0.02mm or less
	Tolerable load (thrust direction/radial direction)	10kg/20kg Half of value during operation	10kg/20kg Half of value during operation
	Mass	1.5kg	1.5kg
	Degree of protection	IP54	
	Squareness of flange to shaft	0.05mm or less	
	Flange matching eccentricity	0.05mm or less	
Working environment	Ambient temperature range	-5°C to +55°C	
	Storage temperature range	-20°C to +85°C	
	Humidity	95%Ph	
	Vibration resistance	5 to 50Hz, total vibration width 1.5mm, each shaft for 30min.	
	Impact resistance	$294.20m/s^2$ (30G)	

(2) Detection signals

Signal name	Number of detection pulses
A, B phase	1024p/rev
Z phase	1p/rev

Connector pin layout

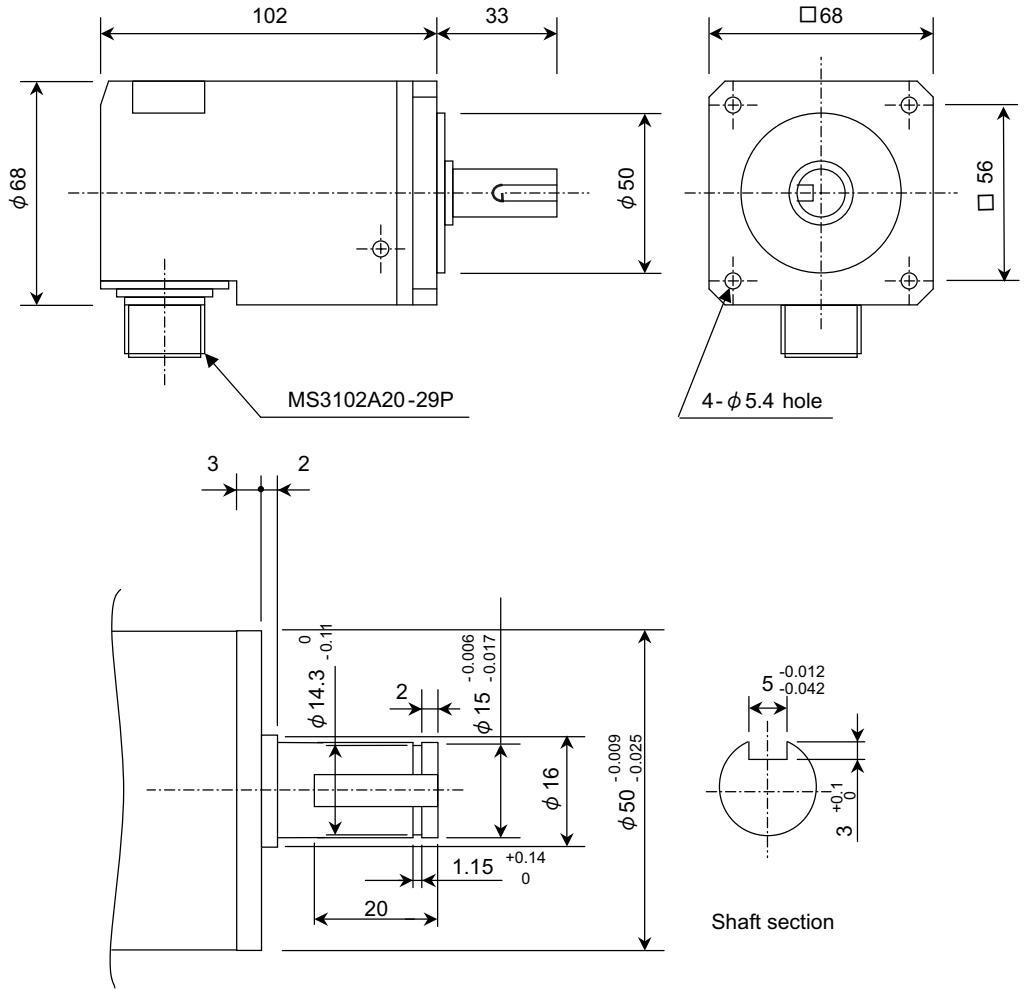
Pin	Function	Pin	Function
A	A+ signal	K	0V
B	Z+ signal	L	-
C	B+ signal	M	-
D	-	N	A- signal
E	Case grounding	P	Z- signal
F	-	R	B- signal
G	-	S	-
H	+5V	T	-
J	-		

⚠ CAUTION

Cautions for connecting the spindle end with an OSE-1024 encoder

1. Confirm that the gear ratio (pulley ratio) of the spindle end to the encoder is 1:1.
2. Use a timing belt when connecting by a belt.

(3) Outline dimension drawings



[Unit: mm]

Spindle side encoder (OSE-1024-3-15-68, OSE-1024-3-15-68-8)

5.2.2 Spindle Side PLG Serial Output Encoder (TS5690, MU1606 Series)

This encoder is used when a more accurate synchronous tapping control or C-axis control than OSE encoder is performed to the spindle which is not directly-connected to the spindle motor.

(1) Type configuration

<Sensor type>

TS5690N (1) (2)

(1)

Symbol	The number of compatible detection gear teeth
64	64
12	128
25	256

(2)

Symbol	Length of the cable
10	400mm
20	800mm
30	1200mm
40	1600mm
60	2000mm

<Detection gear type>

MU1606N (1) (2)

(1)

Symbol	The number of detection gear teeth
6	64
7	128
8	256

(2) Each specification number

(2) Specifications

	Series type	TS5690N64xx					TS5690N12xx					TS5690N25xx				
Sensor	xx (The end of the type name)	10	20	30	40	60	10	20	30	40	60	10	20	30	40	60
	Length of lead [mm]	400 ±10	800 ±20	1200 ±20	1600 ±30	2000 ±30	400 ±10	800 ±20	1200 ±20	1600 ±30	2000 ±30	400 ±10	800 ±20	1200 ±20	1600 ±30	2000 ±30
Detection gear	Type	MU1606N601					MU1606N709					MU1606N805				
	The number of teeth	64					128					256				
	Outer diameter [mm]	Φ52.8					Φ104.0					Φ206.4				
	Inner diameter [mm]	Φ40H5					Φ80H5					Φ140H5				
	Thickness [mm]	12					12					14				
	Shrink fitting [mm]	0.020 to 0.040					0.030 to 0.055					0.050 to 0.085				
Notched fitting section	Outer diameter [mm]	Φ72.0					Φ122.0					Φ223.6				
	Outer diameter tolerance [mm]	+0.010 to +0.060					-0.025 to +0.025					-0.025 to +0.025				
The number of output pulse	A/B phase	64					128					256				
	Z phase	1					1					1				
Detection resolution [p/rev]		2 million					4 million					8 million				
Absolute accuracy at stop		150"					100"					95"				
Tolerable speed [r/min]		40,000					20,000					10,000				
Signal output		Mitsubishi high-speed serial														

⚠ CAUTION

1.Selected encoders must be able to tolerate the maximum rotation speed of the spindle.

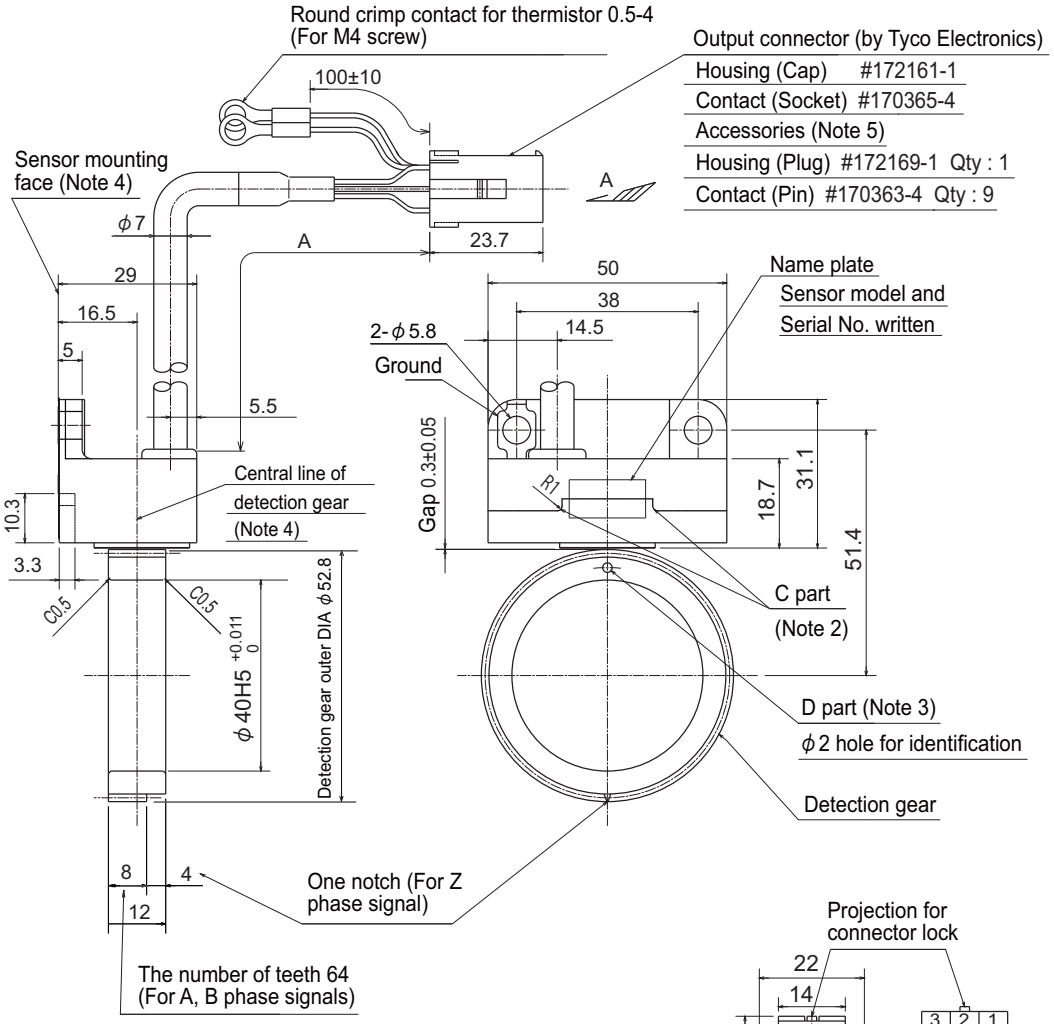
2.Please contact your Mitsubishi Electric dealer for the special products not listed above.

(3) Outline dimension drawings

> **⚠ CAUTION**
>
> Always apply the notched fitting section machining with the specified dimensions to the sensor installation surface.

< TS5690N64xx + MU1606N601 >

[Unit: mm]



(Note 1) Handle with care as this is a precision component.
Pay special attention not to apply excessive external force on the sensor's detection face. Applying such force will cause a fault.

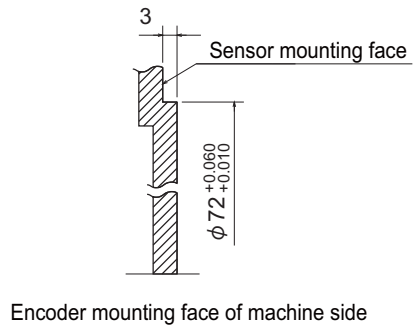
(Note 2) In installing the sensor, keep the protruding fitting of $\phi 72^{+0.060}_{+0.010}$ mm on the machine side, and push the C part of the sensor mounting seat against the fitting.

(Note 3) In installing the detection gear, make sure that the D part side comes the opposite side of the sensor installation side (sensor's lead wire side).

(Note 4) The diviation of the center of the detection gear is 16.5±0.25mm from the sensor mounting face.

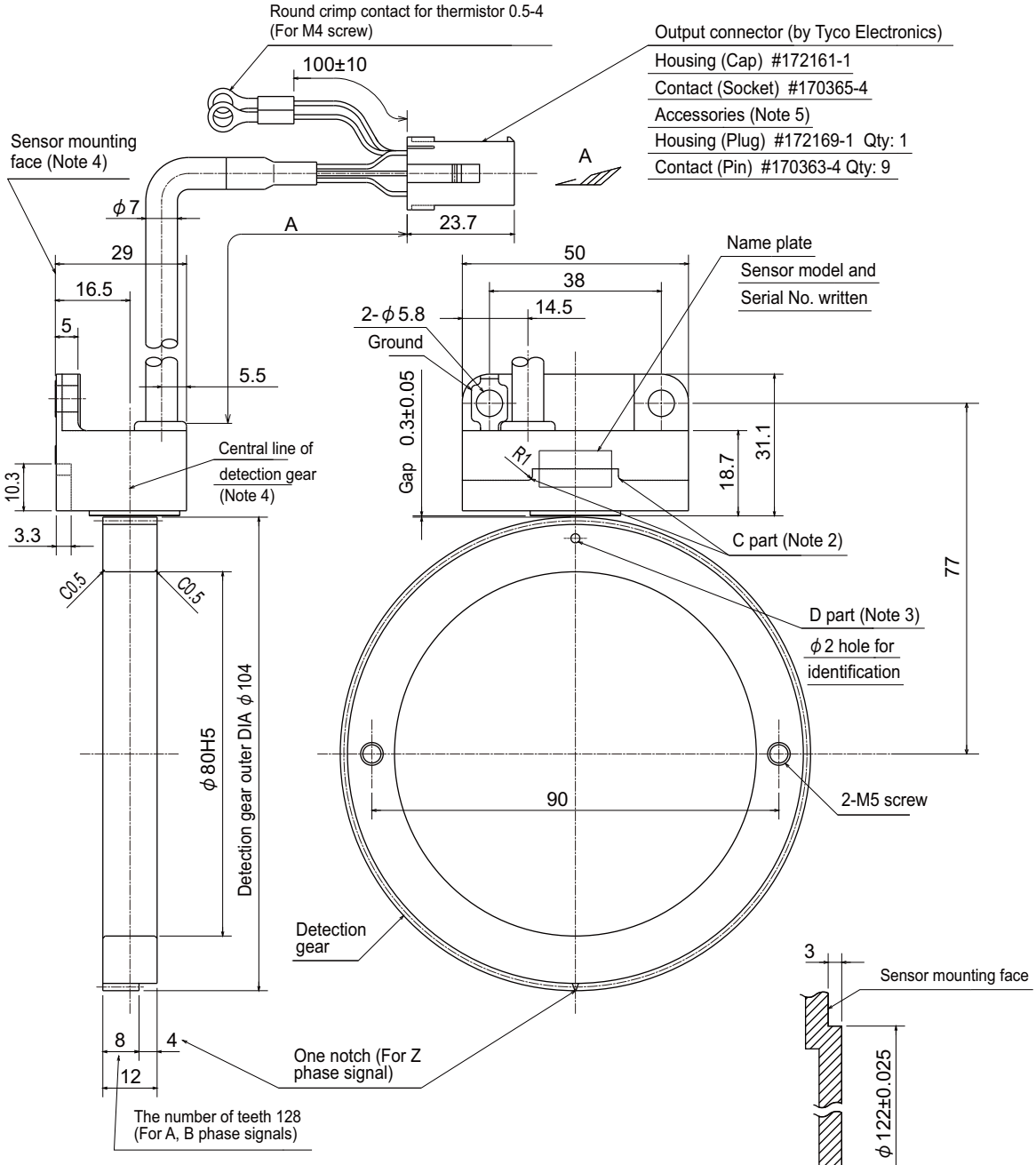
(Note 5) A connector of the signal cable side (one plug and nine pins) is attached.

Sensor		Detection gear
Parts name	Lead wire length A [mm]	Parts name
TS5690N6410	400±10	MU1606N601
TS5690N6420	800±20	
TS5690N6430	1200±20	
TS5690N6440	1600±30	
TS5690N6460	2000±30	



< TS5690N12xx + MU1606N709 >

[Unit: mm]



(Note 1) Handle with care as this is a precision component.
Pay special attention not to apply excessive external force on the sensor's detection face. Applying such force will cause a fault.

(Note 2) In installing the sensor, keep the protruding fitting of ϕ122±0.025 mm on the machine side, and push the C part of the sensor mounting seat against the fitting.

(Note 3) In installing the detection gear, make sure that the D part side comes the opposite side of the sensor installation side (sensor's lead wire side).

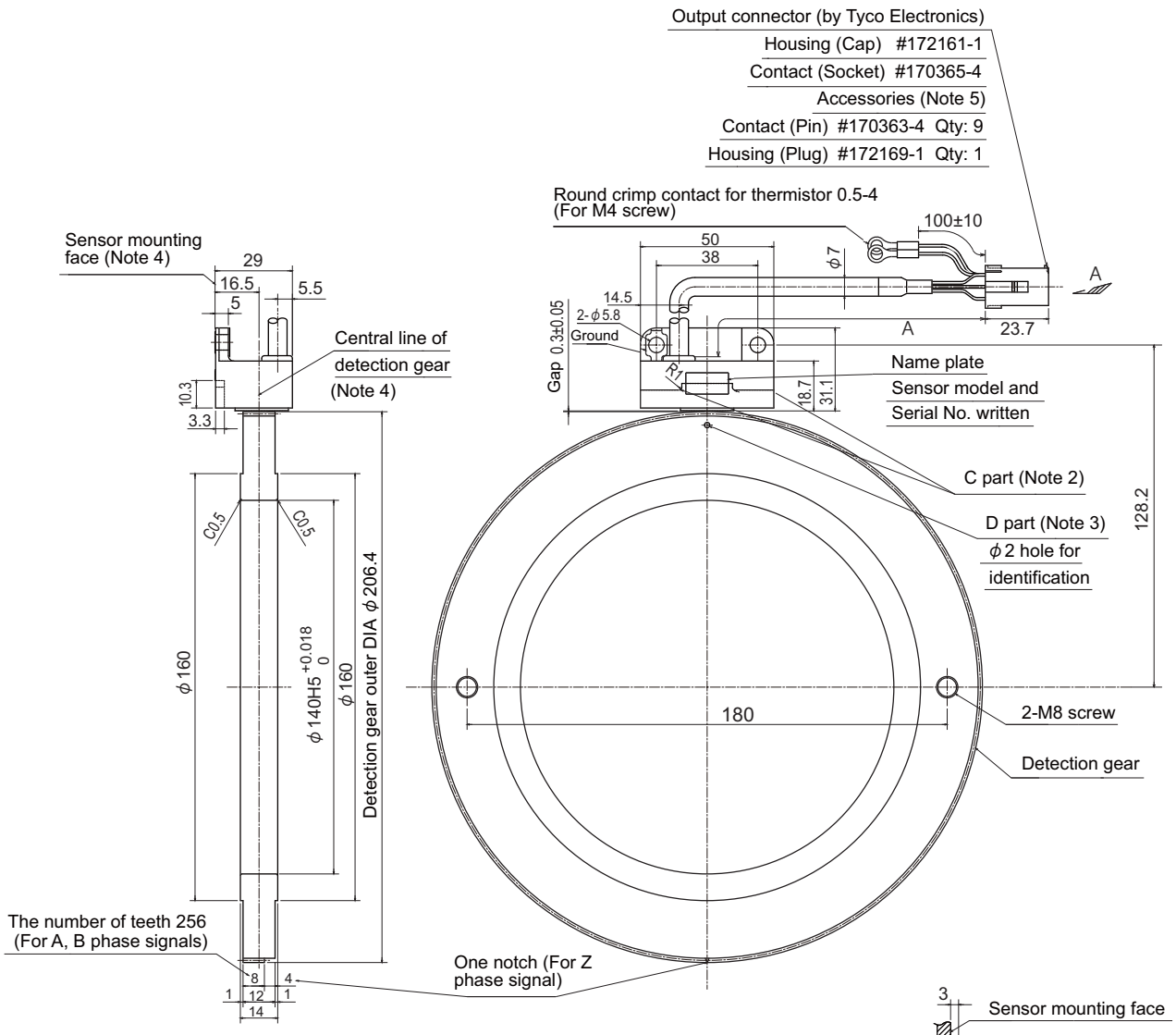
(Note 4) The diviation of the center of the detection gear is 16.5±0.25mm from the sensor mounting face.

(Note 5) A connector of the signal cable side (one plug and nine pins) is attached.

Sensor		Detection gear
Parts name	Lead wire length A [mm]	Parts name
TS5690N1210	400±10	MU1606N709
TS5690N1220	800±20	
TS5690N1230	1200±20	
TS5690N1240	1600±30	
TS5690N1260	2000±30	

< TS5690N25xx + MU1606N805 >

[Unit: mm]



(Note 1) Handle with care as this is a precision component.
Pay special attention not to apply excessive external force on the sensor's detection face. Applying such force will cause a fault.

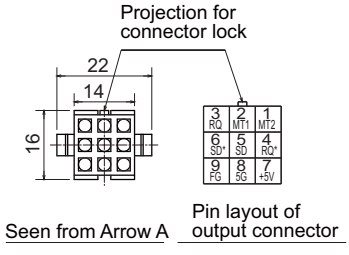
(Note 2) In installing the sensor, keep the protruding fitting of φ223.6±0.025 mm on the machine side, and push the C part of the sensor mounting seat against the fitting.

(Note 3) In installing the detection gear, make sure that the D part side comes the opposite side of the sensor installation side (sensor's lead wire side).

(Note 4) The diviation of the center of the detection gear is 16.5±0.25mm from the sensor mounting face.

(Note 5) A connector of the signal cable side (one plug and nine pins) is attached.

Sensor		Detection gear
Parts name	Lead wire length A [mm]	Parts name
TS5690N2510	400±10	MU1606N805
TS5690N2520	800±20	
TS5690N2530	1200±20	
TS5690N2540	1600±30	
TS5690N2560	2000±30	



5.2.3 Twin-head Magnetic Encoder (MBE Series)

(1) Type description

MBE405W-B (1) (2)

(1)

Symbol	Drum outer diameter
E	Φ100mm
F	Φ150.3mm
G	Φ200.6mm

(2)

Symbol	Drum inner diameter
082	Φ82mm
125	Φ125mm
160	Φ160mm

(2) Specifications

Encoder type		MBE405W-BE082	MBE405W-BF125	MBE405W-BG160
Electrical characteristics	Encoder resolution	4,000,000p/rev		
	Detection method	Incremental		
	Accuracy (*1) (*2)	±4 seconds	±3 seconds	±2 seconds
	Wave number within one rotation	512 waves	768 waves	1024 waves
	Encoder output data	Serial data		
	Power consumption	0.2A or less		
Mechanical characteristics for rotation	Inertia	0.5×10^{-3}kg・m^2	2.4×10^{-3}kg・m^2	8.7×10^{-3}kg・m^2
	Tolerable continuous rotation speed	15000r/min	10000r/min	8000r/min
Mechanical configuration	Drum inner diameter	Φ82mm	Φ125mm	Φ160mm
	Drum outer diameter	Φ100mm	Φ150.3mm	Φ200.6mm
	Drum mass	0.2kg	0.46kg	1.0kg
	Degree of protection (*3)	IP67		
Working environment	Ambient temperature range	0°C to +55°C		
	Storage temperature range	-20°C to +85°C		
	Humidity	95%RH		
	Vibration resistance	Horizontal direction to the axis: 5G or less, Vertical direction to the axis: 5G or less		
	Impact resistance	490m/s^2 (50G)		

(*1) The values above are typical values after the calibration with our shipping test device and are not guaranteed.

(*2) The user is requested to install the magnetic drum and installation ring in the encoder within the accuracy range specified herein. Even when the accuracy of the encoder when shipped and when installed by the user is both within the specified range, there is a difference in the installation position. Therefore, the accuracy at the time of our shipment may not be acquired.

(*3) It is the degree of protection when fitted with a connector.

(3) Specifications of preamplifier

Item	Specified value
Output communication style	High-speed serial communication I/F
Working ambient temperature	0°C to +55°C
Working ambient humidity	90%RH or less (with no dew condensation)
Atmosphere	No toxic gases
Tolerable vibration	Horizontal direction to the axis: 5G or less, Vertical direction to the axis: 5G or less
Tolerable impact	490m/s^2 (50G)
Tolerable power voltage	DC5V±10%
Mass	0.33kg
Degree of protection (*2)	IP67

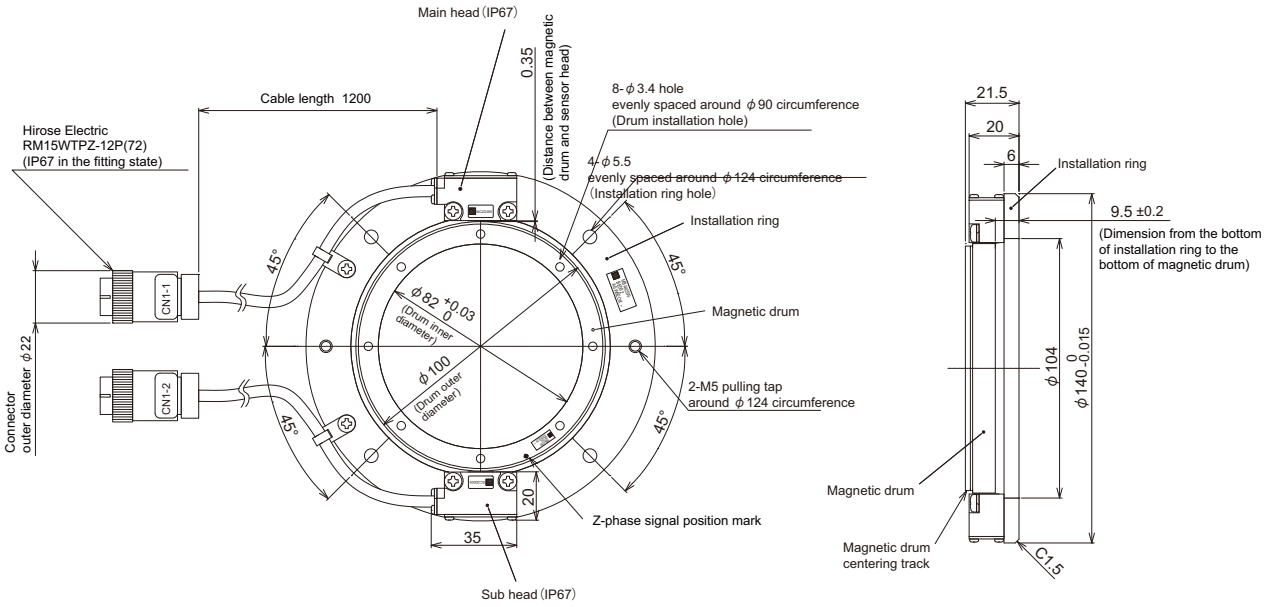
(*1) The values above are the specified values for the preamplifier provided with a twin-head magnetic encoder.

(*2) It is the degree of protection when fitted with a connector.

(4) Outline dimension drawing

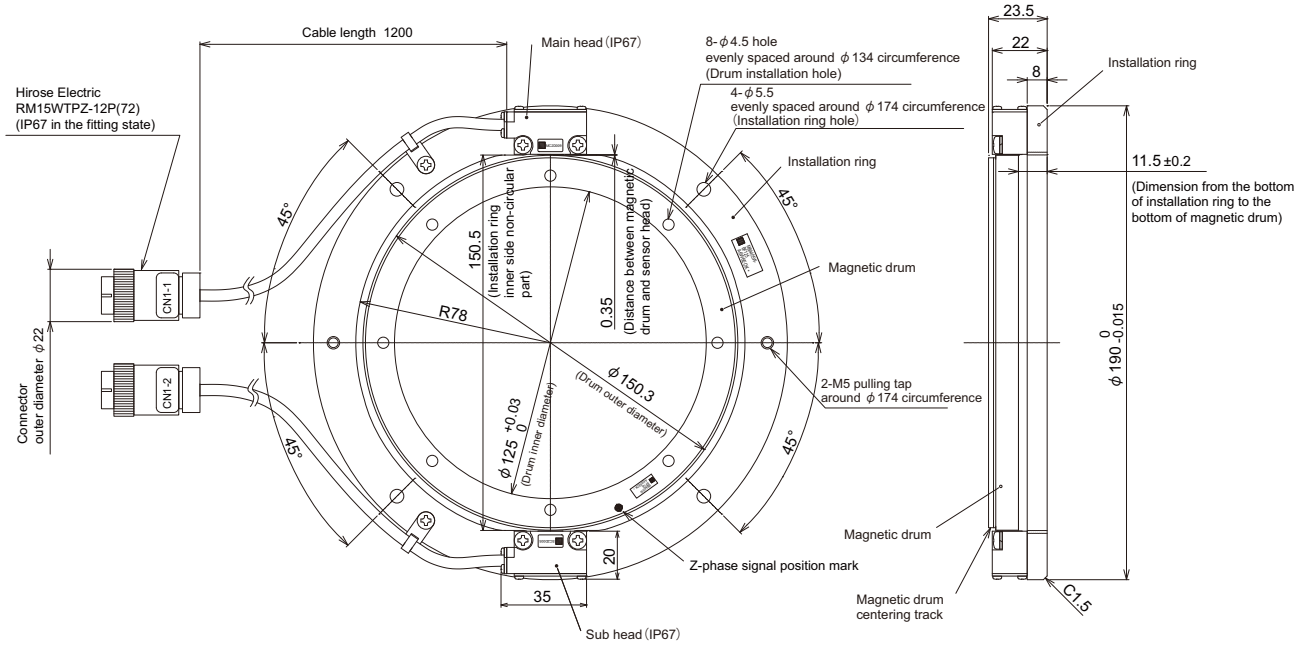
< MBE405W-BE082 >

[Unit: mm]



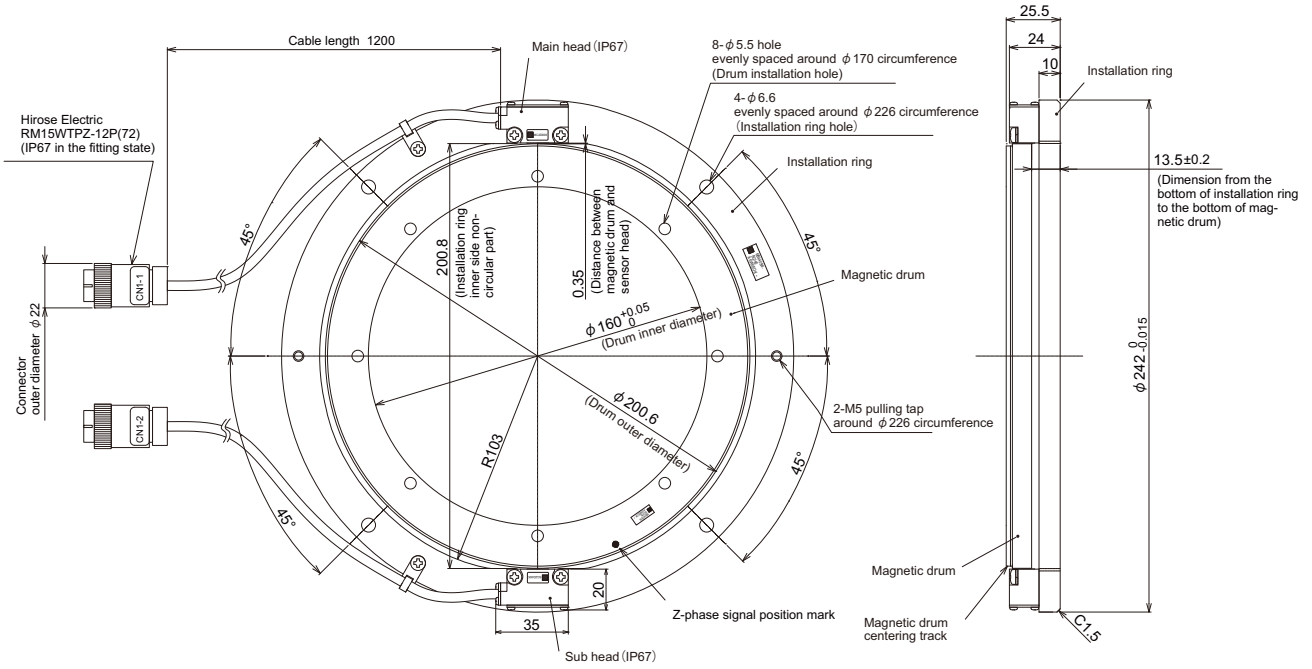
< MBE405W-BF125 >

[Unit: mm]



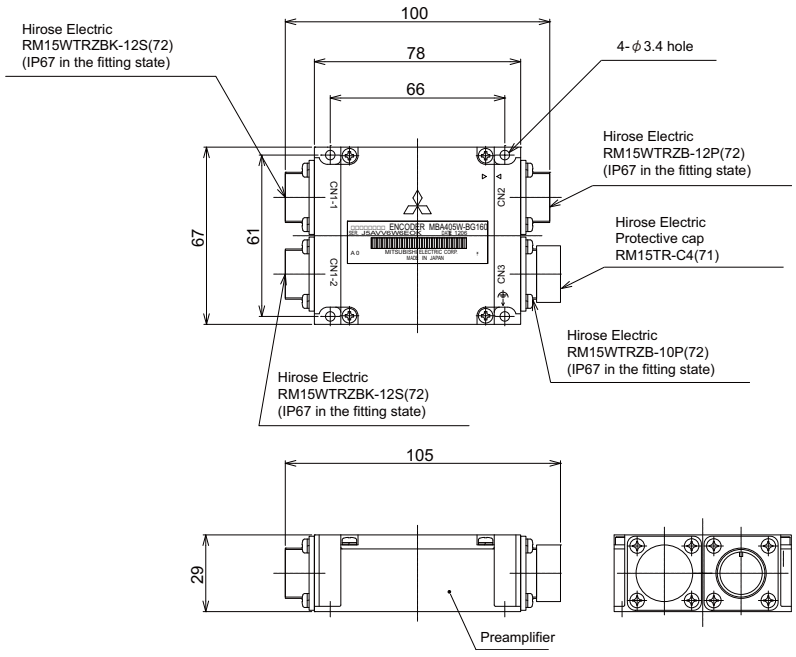
< MBE405W-BG160 >

[Unit: mm]



< Preamplifier (common) >

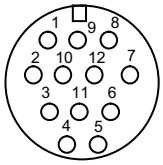
[Unit: mm]



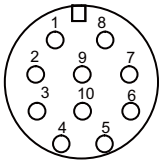
< Explanation of connectors >

Connector name	Application
CN1-1	For connection with scale (main head)
CN1-2	For connection with scale (sub head)
CN2	For connection with spindle drive unit
CN3	For connection with motor thermistor

< Connector pin layout >



CN2 < Drive unit >



CN3 < Thermistor>

Pin No.	Function	Pin No.	Function
1	-	**1**	-
2	-	**2**	-
3	SD	**3**	MT1-i
4	SD*	**4**	-
5	SHD	**5**	-
6	MT1	**6**	-
7	RQ	**7**	-
8	RQ*	**8**	-
9	P5	**9**	MT2-i
10	LG	**10**	-
11	MT2	**11**	-
12	CNT	**12**	-

5.2.4 Spindle Side Accuracy Serial Output Encoder (ERM280, MPCI Series) (Other Manufacturer's Product)

C-axis control encoder is used in order to perform an accurate C-axis control.

Manufacturer	Encoder type	Interface unit type	Minimum detection resolution	Tolerable maximum speed
HEIDENHAIN CORPORATION	ERM280 1200	EIB192M C4 1200	0.0000183° (19,660,800p/rev)	20000 r/min
		EIB392M C4 1200		
	ERM280 2048	EIB192M C6 2048	0.0000107° (33,554,432p/rev)	11718 r/min
		EIB392M C6 2048		
NIDEC MACHINE TOOL CORPORATION	MPCI series	ADB-20J20	0.00005° (7200000p/rev)	10000 r/min

<Contact information about machine side encoder>

- HEIDENHAIN CORPORATION: http://www.heidenhain.com/
- NIDEC MACHINE TOOL CORPORATION: http://www.nidec.com/en/nidec-machinetool/

> ⚠ **CAUTION**
>
> Confirm specifications of each encoder manufacturer before using the machine side encoder.

5.3 Encoder Interface Unit

5.3.1 Serial Output Interface Unit for ABZ Analog Encoder MDS-B-HR

This unit superimposes the scale analog output raw waves, and generates high resolution position data. Increasing the encoder resolution is effective for the servo high-gain. MDS-B-HR-12(P) is used for the synchronous control system that 1-scale 2-drive operation is possible and not used in MDS-DJ-V1.

(1) Type configuration

MDS-B-HR- (1) (2)

(1) Signal division function class

Symbol	Scale output voltage class
11	Output number 1
12	Output number 2 (with division)

(2) Degree of protection

Symbol	Degree of protection
None	IP65
P	IP67

(2) Specifications

Type MDS-B-HR-	11	12	11P	12P
Compatible scale (example)	LS186 / LS486 / LS186C / LS486C (HEIDENHAIN)			
Signal 2-division function	-	*	-	*
Analog signal input specifications	A-phase, B-phase, Z-phase (Amplitude 1Vp-p)			
Compatible frequency	Analog raw waveform max. 200kHz			
Scale resolution	Analog raw waveform/512 division			
Input/output communication style	High-speed serial communication I/F, RS485 or equivalent			
Working ambient temperature	0 to 55°C			
Working ambient humidity	90%RH or less (with no dew condensation)			
Atmosphere	No toxic gases			
Tolerable vibration	98.0 m/s^2 (10G)			
Tolerable impact	294.0 m/s^2 (30G)			
Tolerable power voltage	5VDC±5%			
Maximum heating value	2W			
Mass	0.5kg or less			
Degree of protection	IP65		IP67	

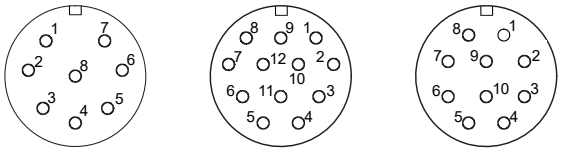
(3) Explanation of connectors

Connector name	Application	Remarks
CON1	For connection with servo drive unit (2nd system)	Not provided for 1-part system specifications
CON2	For connection with servo drive unit	
CON3	For connection with scale	
CON4	For connection with pole detection unit (MDS-B-MD)	*Used for linear servo system

CON1		CON2		CON3		CON4	
Pin No.	Function	Pin No.	Function	Pin No.	Function	Pin No.	Function
1	RQ+ signal	1	RQ+ signal	1	A+ phase signal	1	A phase signal
2	RQ- signal	2	RQ- signal	2	A- phase signal	2	REF signal
3	SD+ signal	3	SD+ signal	3	B+ phase signal	3	B phase signal
4	SD- signal	4	SD- signal	4	B- phase signal	4	REF signal
5	P5	5	P5	5	Z+ phase signal	5	P24
6	P5	6	P5	6	Z- phase signal	6	MOH signal
7	GND	7	GND	7	-	7	P5
8	GND	8	GND	8	-	8	P5
				9	-	9	TH signal
				10	-	10	GND
				11	P5		
				12	GND		

< Connector pin layout >

Connector	Type
CON1	RM15WTR-8P (Hirose Electric)
CON2	
CON3	RM15WTR-12S (Hirose Electric)
CON4	RM15WTR-10S (Hirose Electric)

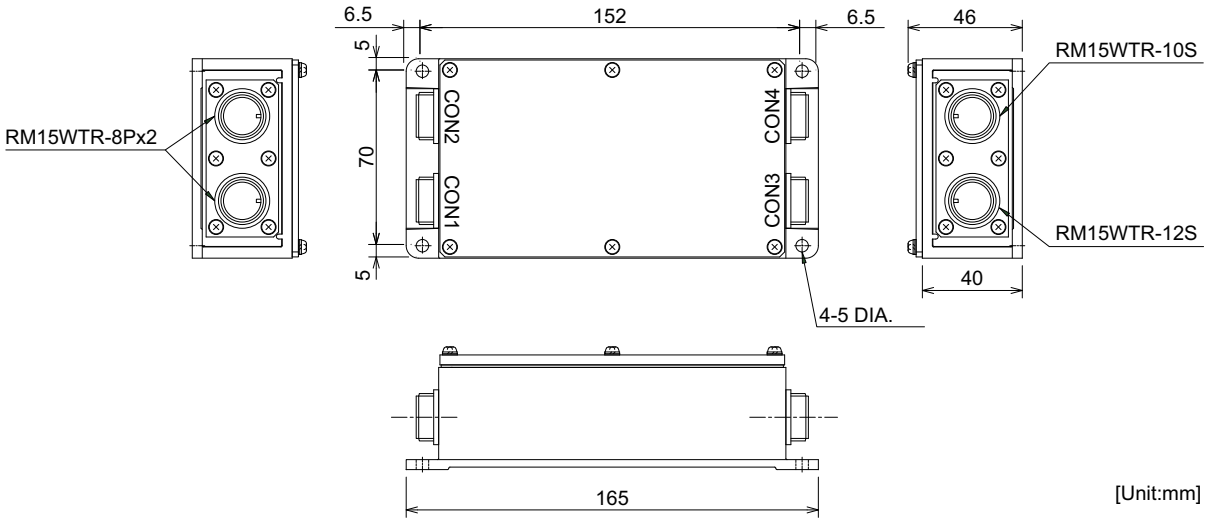


CON1
CON2

CON3

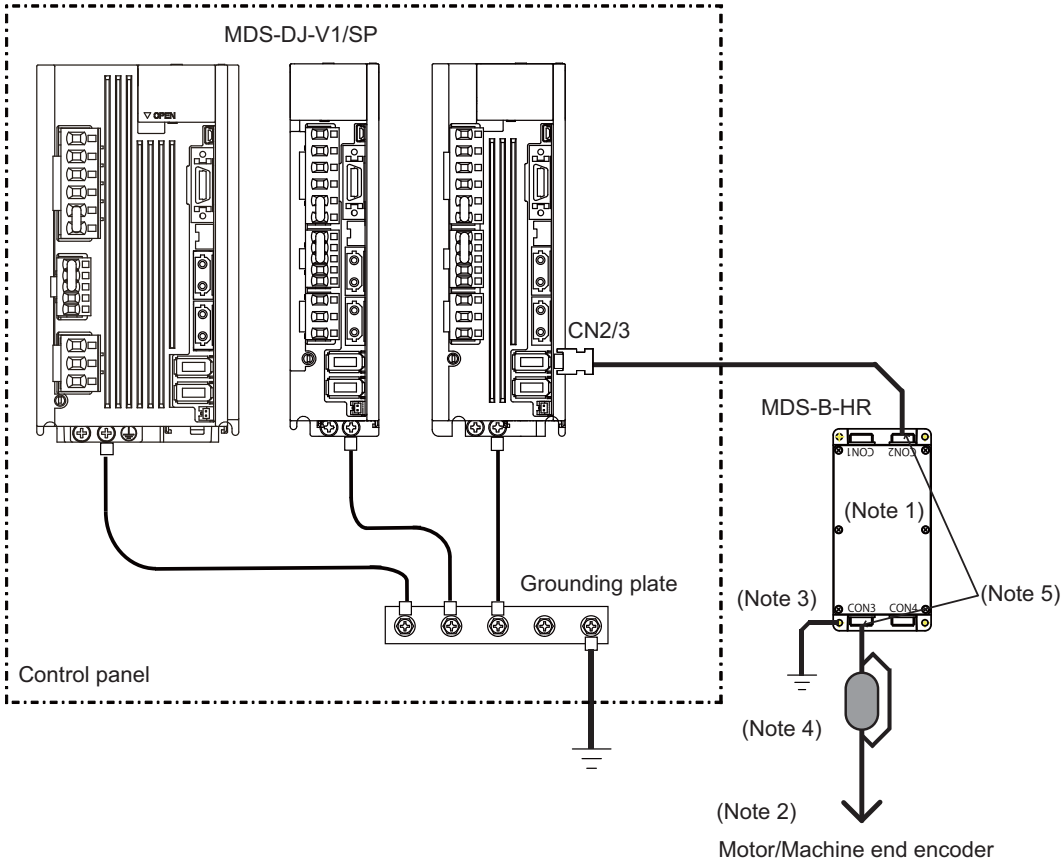
CON4

(4) Outline dimension drawings



[Unit:mm]

(5) Example of wiring



(Note 1) Install the MDS-B-HR unit outside the control panel.
(Note 2) For connections between an encoder and MDS-B-HR unit, keep the cable length as short as possible.
(Note 3) Ground the MDS-B-HR unit.
(Note 4) Place a ferrite core as close as possible to the MDS-B-HR unit.
Wind the cable around the unit one time when installing a ferrite core.
(Note 5) Use shielded cables and join the shield to the connector shell.

5.3.2 Pulse Output Interface Unit for ABZ Analog Encoder IBV Series (Other Manufacturer's Product)

(1) Appearance

IBV100 series

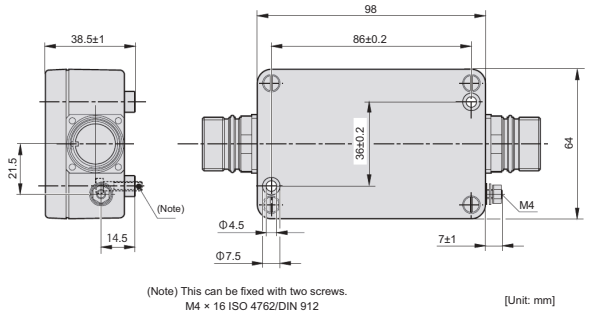
IBV600 series

(2) Specifications

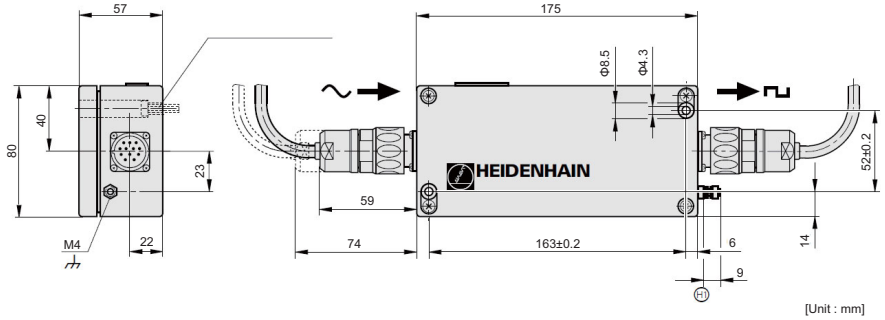
Type	IBV 101	IBV 102	IBV 660B
Manufacturer HEIDENHAIN	HEIDENHAIN CORPORATION		
Input signal	A-phase, B-phase: SIN wave 1Vpp, Z-phase		
Maximum input frequency	400kHz		
Output signal	Rectangular wave pulse signal		
Interpolation division number	Maximum 10 divisions	Maximum 100 divisions	Maximum 400 divisions
Compatible encoder	LS187, LS487	LS187, LS487	LS187, LS487
Minimum detection resolution	0.5µm	0.05µm	0.0125µm
Working temperature	0°C to 70°C		
Degree of protection	IP65		
Mass	300g		

(3) Outline dimension drawings

IBV100 series



IBV600 series



> **⚠ CAUTION**
>
> These are other manufacturer's products. When purchasing these products, refer to the manufacturer's information materials for the product specifications.

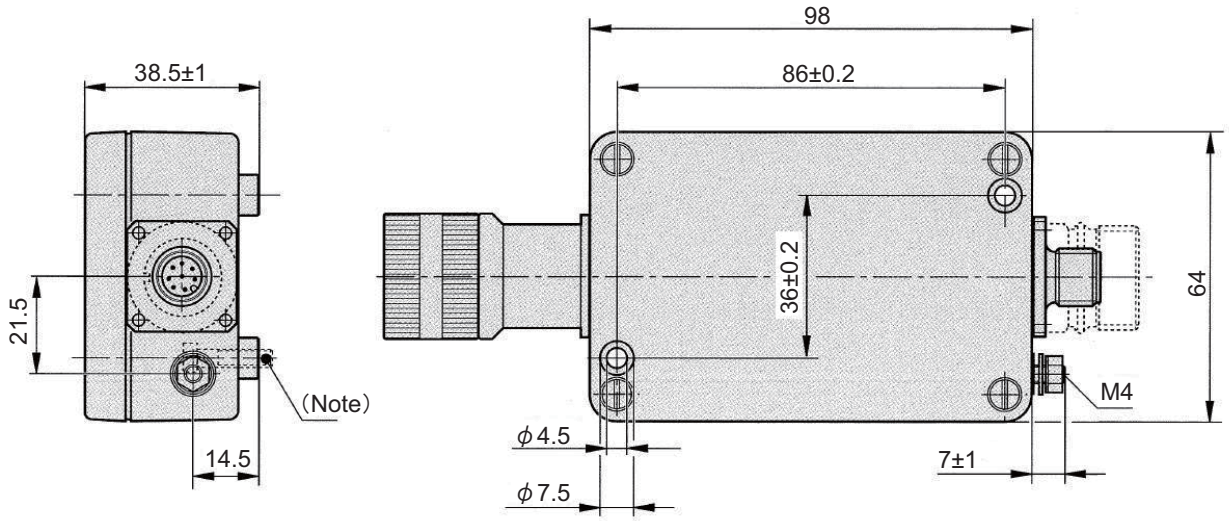
5.3.3 Serial Output Interface Unit for ABZ Analog Encoder EIB192M (Other Manufacturer's Product)

(1) Appearance

(2) Specifications

Type	EIB192M A4 20μm	EIB192M C4 1200	EIB192M C4 2048
Manufacturer	HEIDENHAIN CORPORATION		
Input signal	A-phase, B-phase: SIN wave 1Vpp, Z-phase		
Maximum input frequency	400kHz		
Output signal	Mitsubishi high-speed serial signal (Mitsu02-4)		
Interpolation division number	Maximum 16384 divisions		
Compatible encoder	LS187, LS487	ERM280 1200	ERM280 2048
Minimum detection resolution	0.0012μm	0.0000183° (19,660,800p/rev)	0.0000107° (33,554,432p/rev)
Working temperature	0°C to 70°C		
Degree of protection	IP65		
Mass	300g		

(3) Outline dimension drawings



(Note) Two fixing screws (M4×16 DIN 912/ISO 4762) [Unit : mm]

> **⚠ CAUTION**
>
> These are other manufacturer's products. When purchasing these products, refer to the manufacturer's information materials for the product specifications.

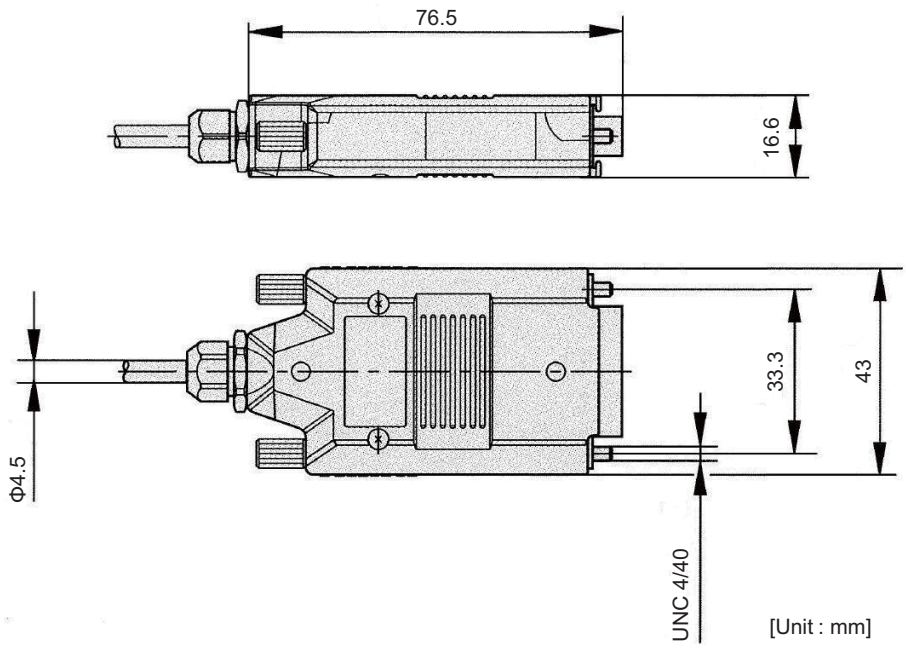
5.3.4 Serial Output Interface Unit for ABZ Analog Encoder EIB392M (Other Manufacturer's Product)

(1) Appearance

(2) Specifications

Type	EIB392M A4 20μm	EIB392M C4 1200	EIB392M C4 2048
Manufacturer	HEIDENHAIN CORPORATION		
Input signal	A-phase, B-phase: SIN wave 1Vpp, Z-phase		
Maximum input frequency	400kHz		
Output signal	Mitsubishi high-speed serial signal (Mitsu02-4)		
Interpolation division number	Maximum 16384 divisions		
Compatible encoder	LS187, LS487	ERM280 1200	ERM280 2048
Minimum detection resolution	0.0012μm	0.0000183° (19,660,800p/rev)	0.0000107° (33,554,432p/rev)
Working temperature	0°C to 70°C		
Degree of protection	IP40		
Mass	140g		

(3) Outline dimension drawings



⚠ CAUTION

These are other manufacturer's products. When purchasing these products, refer to the manufacturer's information materials for the product specifications.

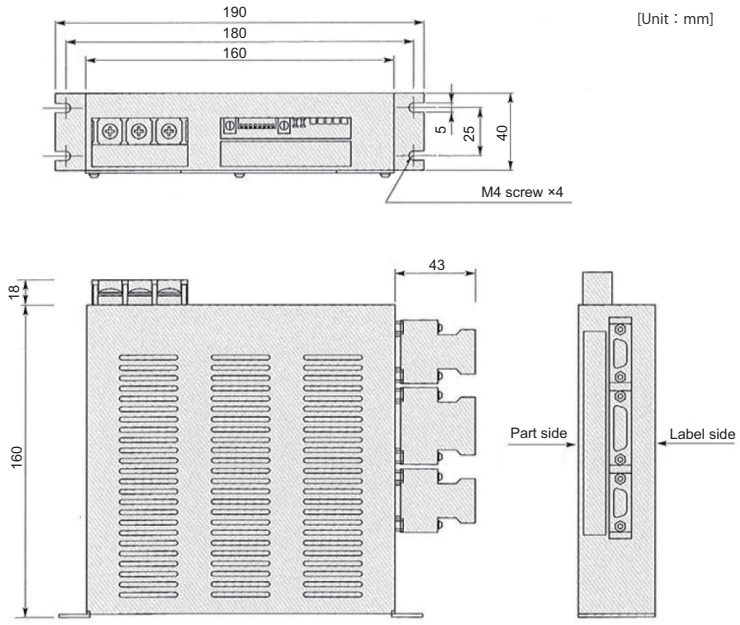
5.3.5 Serial Output Interface Unit for ABZ Analog Encoder ADB-20J Series (Other Manufacturer's Product)

(1) Appearance

(2) Specifications

Type	ADB-20J20	ADB-20J60		ADB-20J71
Manufacturer	NIDEC MACHINE TOOL CORPORATION			
Maximum response speed	10,000r/min	3,600m/min	5,000r/min	10,000r/min
Output signal	Mitsubishi high-speed serial signal			
Compatible encoder	MPCI Series	MPS Series	MPI Series	MPRZ Series
Minimum detection resolution	0.00005° (7,200,000p/rev)	0.05μm	0.000025° (1,440,000p/rev)	0.000043° (8,388,608p/rev)
Working temperature	0°C to 55°C			
Degree of protection	IP20			
Mass	0.9kg			

(3) Outline dimension drawings



> **⚠ CAUTION**
>
> These are other manufacturer's products. When purchasing these products, refer to the manufacturer's information materials for the product specifications.

5.4 Drive Unit Option

5.4.1 Optical Communication Repeater Unit (FCU7-EX022)

When the distance of the optical communication cable between NC control unit and drive unit is over 30m (M700V/M70V/E70 Series: maximum 30m, M700/M70/C70 Series: maximum 20m), the communication can be performed by relaying the optical signal.
Using up to two units, relay of the total length of up to 90m can be performed.

<Product features>

(a) When the distance of the optical communication cable between NC control unit and drive unit is over 30m, the communication can be performed by relaying the optical signal.
(b) The relay between NC control unit and drive unit can be performed for up to two channels.
(c) If the distance between NC control unit and drive unit is even within 30m, the cable can be divided by the relay in transporting the machine.
(d) Same mounting dimension as the remote I/O unit (DX unit).

> **⚠ CAUTION**
>
> This unit can not be used between drive units.

(1) Specifications

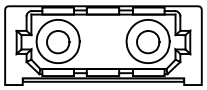
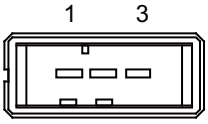
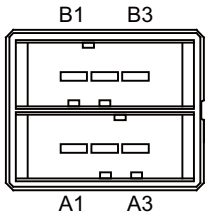
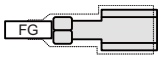
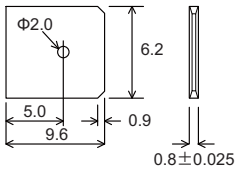
Item			FCU7-EX022
DC24V input	Input voltage		24V±10% (21.6V to 26.4V)
	Inrush current		35A
	Power consumption		10W
	Consumption current		0.4A
Optical interface	Channel number		2 channels
	Connectable number		Maximum 2
Environment	Ambient temperature	Operation	0°C to +55°C
		Storage	-20°C to +60°C
	Ambient humidity	Operation (long term)	+10%RH to +75%RH (with no dew condensation)
		Operation (short term)	+10%RH to +95%RH (with no dew condensation. Short term is within about one month.)
		Storage	+10%RH to +75%RH (with no dew condensation)
	Vibration	Operation	4.9m/s^2
		Transportation	34.3m/s^2
	Impact resistance	Operation	29.4m/s^2
	Atmosphere		No corrosive gas, oil mist, or dust
Dimension	Dimension		(depth)135mm × (width)40mm × (height)168mm
	Mounting method		Screw cramp with M5 2 screw cramps
Mass			0.42kg

(2) Explanation of connectors

Connector name	Application	Remarks
OPT1IN, OPT1OUT, OPT2IN, OPT2OUT	Optical connector	
DCIN	DC24V Power connector	
DCOUT	DC24V/ Power OFF detection output connector	Relays the PD25/27 output to NC control unit.
ACFAIL	Power OFF detection connector	Relays the power OFF detection signal (ACFAIL) when sharing 24V power from PD25/PD27 for NC control unit and optical communication repeater unit. It will not be used when dedicated general-purpose power supply for optical communication repeater unit is prepared.
FG	FG Faston terminal	

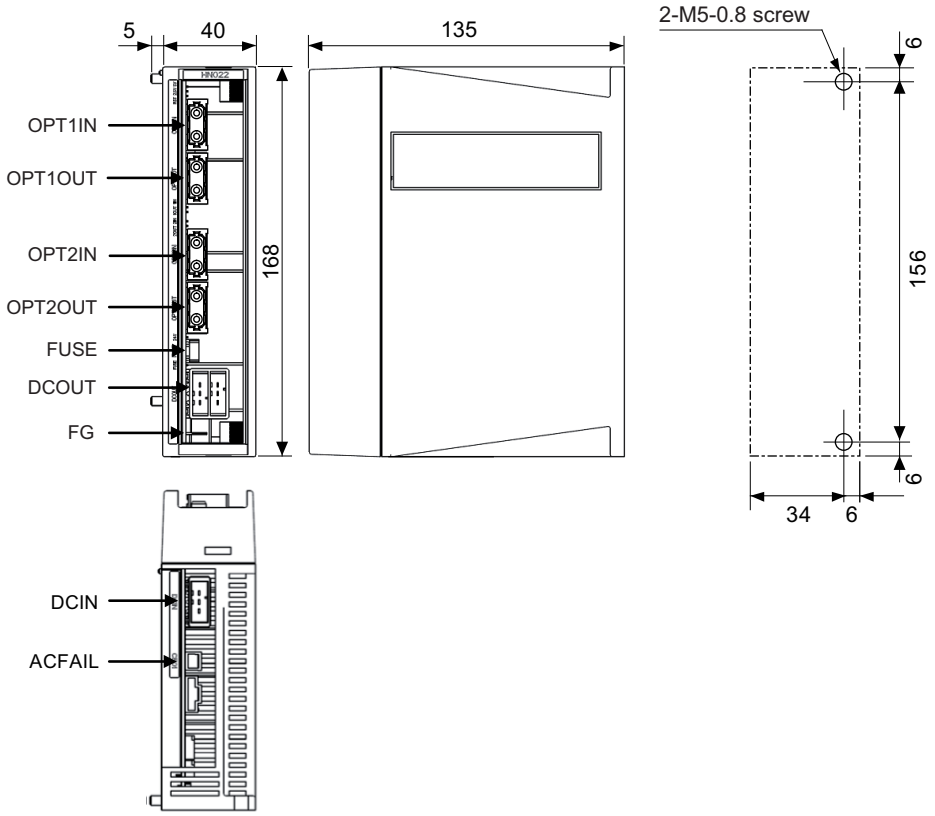
DCIN		DCOUT				ACFAIL	
Pin No.	**Name**	**Pin No.**	**Name**	**Pin No.**	**Name**	**Pin No.**	**Name**
1	DC24V	**A1**	ACFAIL	**B1**	DC24V	**1**	COM
2	0V (RG)	**A2**	COM	**B2**	0V (RG)	**2**	ACFAIL
3	FG	**A3**	NC	**B3**	FG		

< Connector pin layout >

Optical communication I/F (OPT1IN, OPT1OUT, OPT2IN, OPT2OUT)	DC24V input (DCIN)	DC24V output (DCOUT)	Power OFF input ACFAIL (Terminal name:CF01)	FG terminal (FG)
				
< Cable side connector type > (PCF type) Connector: CF-2D101-S Recommended manufacturer: Japan Aviation Electronics (POF type) Connector: PF-2D101 Recommended manufacturer: Japan Aviation Electronics	< PCB side connector type > Connector: 2-178293-5 Recommended manufacturer: Tyco Electronics <Cable side connector type> Connector: 2-178288-3 Contact: 1-175218-5 Recommended manufacturer: Tyco Electronics	< PCB side connector type > Connector: 3-178137-5 Recommended manufacturer: Tyco Electronics <Cable side connector type> Connector: 2-178127-6 Contact: 1-175218-5 Recommended manufacturer: Tyco Electronics	< PCB side connector type > Connector: 53103-0230 Recommended manufacturer: MOLEX <Cable side connector type> Connector: 005057-9402 Contact: 0016020103 Recommended manufacturer: MOLEX	< Cable side faston terminal type name > Type name: 175022-1 (For AWG20-14 250 series) Recommended manufacturer: Tyco Electronics Terminal protection tube: 174817-2 (Yellow) [Unit:mm]  Unit side tab terminal shape (Note) The faston terminal "175022-1" of the cable side is a simple lock type. Make sure to insert until the simple lock pin is in the Φ second hole. Firmly press the simple lock release tab when unplugging it.

(3) Outline dimension drawings

[Unit: mm]



5.4.2 Regenerative Option

Confirm the regeneration resistor capacity and possibility of connecting with the drive unit. Refer to "7.3 Selection of the Regenerative Resistor" for details on selecting an regenerative resistor.
The regenerative resistor generates heats, so wire and install the unit while taking care to safety. When using the regenerative resistor, make sure that flammable matters, such as cables, do not contact the resistor, and provide a cover on the machine so that dust or oil does not accumulate on the resistor and ignite.

(1) Combination with servo drive unit

Corresponding servo drive unit	Standard built-in regenerative resistor		External option regenerative resistor						
			MR-RB032	MR-RB12	MR-RB32	MR-RB30	MR-RB50	MR-RB31	MR-RB51
				GZG200W39 OHMK	GZG200W120 OHMK ×3 units	GZG200W39 OHMK ×3 units	GZG300W39 OHMK ×3 units	GZG200W20 OHMK ×3 unit	GZG300W20 OHMK ×3 unit
	Parameter setting value		1200h	1300h	1400h	1500h	1600h	1700h	1800h
	Regenerative capacity		30W	100W	300W	300W	500W	300W	500W
		Resistance value	40Ω	40Ω	40Ω	13Ω	13Ω	6.7Ω	6.7Ω
MDS-DJ-V1-10	10W	100Ω	○	○					
MDS-DJ-V1-15	10W	100Ω	○	○					
MDS-DJ-V1-30	20W	40Ω	○	○	○				
MDS-DJ-V1-40	100W	13Ω				○	○		
MDS-DJ-V1-80	100W	9Ω				○	○	○	○
MDS-DJ-V1-100	100W	9Ω				○	○	○	○
MDS-DJ-V2-3030	100W	9Ω				○	○		

Corresponding servo drive unit	Standard built-in regenerative resistor		External option regenerative resistor					
			FCUA-RB22	FCUA-RB37	FCUA-RB55	R-UNIT2	FCUA-RB55 2 units connected in parallel	FCUA-RB75/2 2 units connected in parallel
	Parameter setting value		2400h	2500h	2600h	2900h	2E00h	2D00h
	Regenerative capacity		155W	185W	340W	700W	680W	680W
		Resistance value	40Ω	25Ω	20Ω	15Ω	10Ω	15Ω
MDS-DJ-V1-10	10W	100Ω						
MDS-DJ-V1-15	10W	100Ω						
MDS-DJ-V1-30	20W	40Ω	○					
MDS-DJ-V1-40	100W	13Ω		○	○	○		○
MDS-DJ-V1-80	100W	9Ω			○	○	○	○
MDS-DJ-V1-100	100W	9Ω				○	○	○
MDS-DJ-V2-3030	100W	9Ω		○	○			

(2) Combination with servo drive unit

> **⚠ CAUTION**
>
> The regenerative resistor is not incorporated in the spindle drive unit. Make sure to install the external option regenerative resistor.

Corresponding spindle drive unit		External option regenerative resistor			
		MR-RB12	MR-RB32	MR-RB30	MR-RB50
		GZG200W39OHMK	GZG200W120 OHMK×3 units	GZG200W39 OHMK×3 units	GZG300W39 OHMK×3 units
	Parameter setting value	1300h	1400h	1500h	1600h
	Regenerative capacity	100W	300W	300W	500W
	Resistance value	40Ω	40Ω	13Ω	13Ω
MDS-DJ-SP-20	---	○	○		
MDS-DJ-SP-40	---			○	○
MDS-DJ-SP-80	---			○	○
MDS-DJ-SP-100	---			○	○
MDS-DJ-SP-120	---				○
MDS-DJ-SP-160	---				
MDS-DJ-SP2-2020	---			○	○

Corresponding spindle drive unit		External option regenerative resistor			
		FCUA-RB22	FCUA-RB37	FCUA-RB55	FCUA-RB75/2 (1 unit)
	Parameter setting value	2400h	2500h	2600h	2700h
	Regenerative capacity	155W	185W	340W	340W
	Resistance value	40Ω	25Ω	20Ω	30Ω
MDS-DJ-SP-20	---	○	○		
MDS-DJ-SP-40	---	○	○	○	○
MDS-DJ-SP-80	---		○	○	○
MDS-DJ-SP-100	---			○	
MDS-DJ-SP-120	---				
MDS-DJ-SP-160	---				
MDS-DJ-SP2-2020	---	○	○	○	

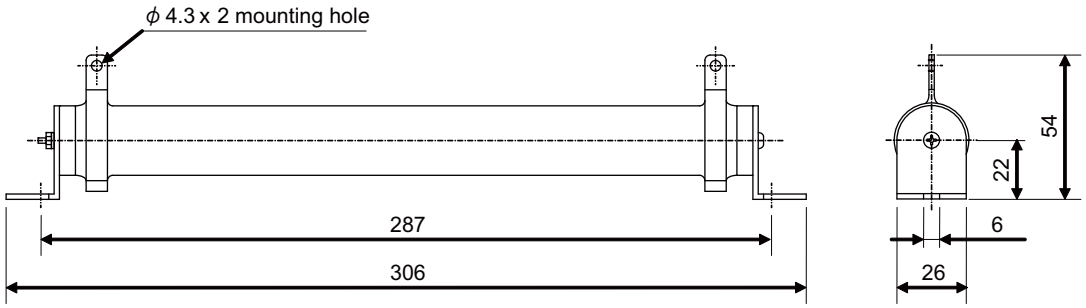
Corresponding spindle drive unit		External option regenerative resistor						
		R-UNIT1	R-UNIT2	R-UNIT3	R-UNIT4	R-UNIT5	FCUA-RB55 2 units connected in parallel	FCUA-RB75/2 2 units connected in parallel
	Parameter setting value	2800h	2900h	2A00h	2B00h	2C00h	2E00h	2D00h
	Regenerative capacity	700W	700W	2100W	2100W	3100W	680W	680W
	Resistance value	30Ω	15Ω	15Ω	10Ω	10Ω	10Ω	15Ω
MDS-DJ-SP-20	---							
MDS-DJ-SP-40	---	○	○	○				○
MDS-DJ-SP-80	---	○	○	○	○	○	○	○
MDS-DJ-SP-100	---		○	○	○	○	○	○
MDS-DJ-SP-120	---		○	○	○	○	○	○
MDS-DJ-SP-160	---				○	○		
MDS-DJ-SP2-2020	---							

> **⚠ CAUTION**
>
> Only the designated combination can be used for the external option regenerative resistor and drive unit.
> There is a risk of fire, so always use the designated combination.

(3) External option regenerative resistor

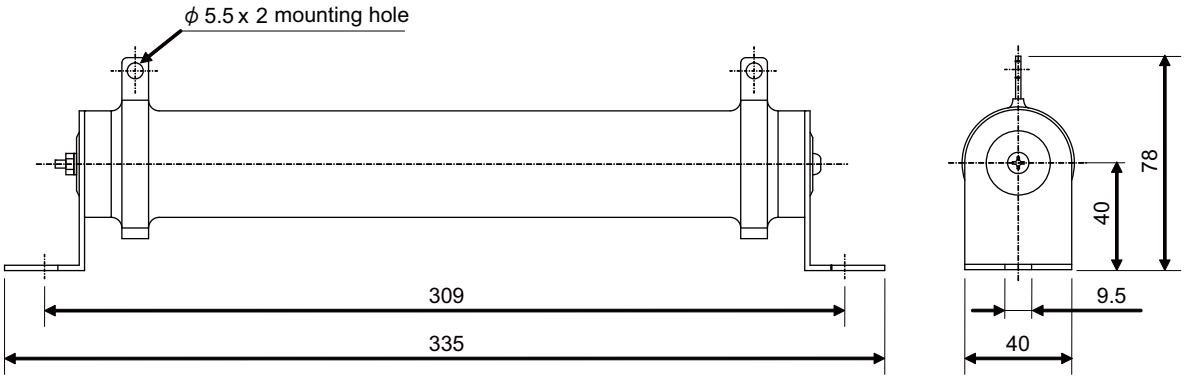
< GZG200W39OHMK, GZG200W120OHMK >

[Unit: mm]



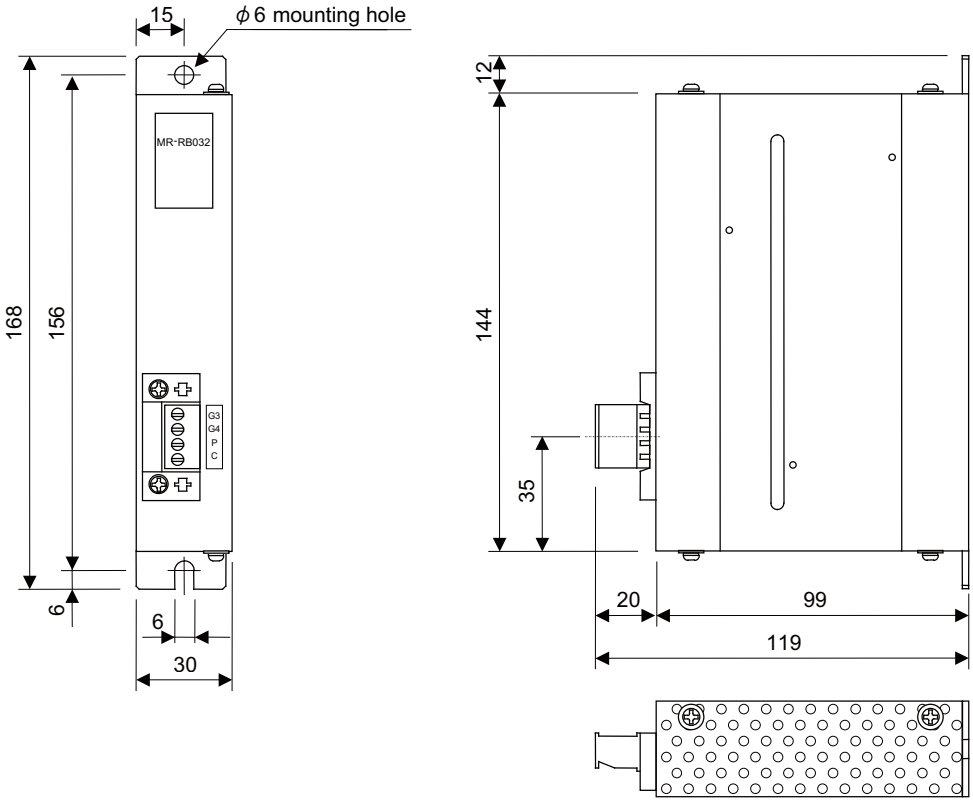
< GZG300W39OHMK >

[Unit: mm]]



(4) External option regenerative resistor unit
< MR-RB032 >

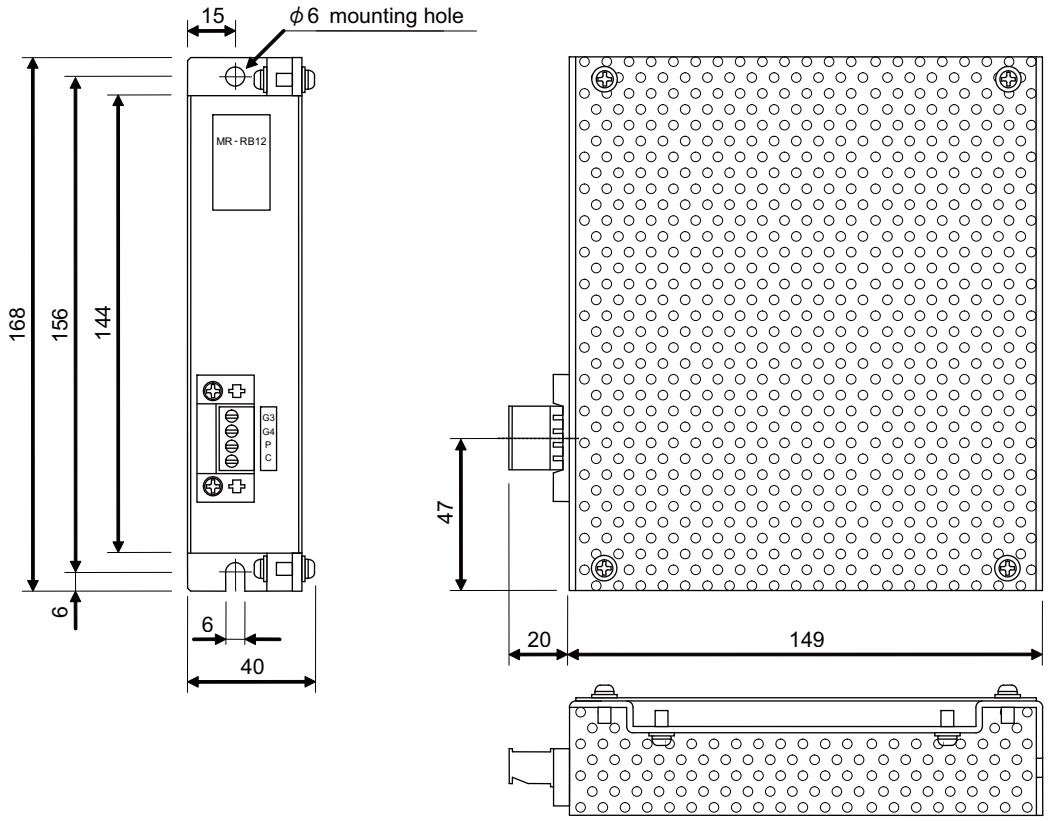
[Unit: mm]



Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
MR-RB032	30	40	0.5

< MR-RB12 >

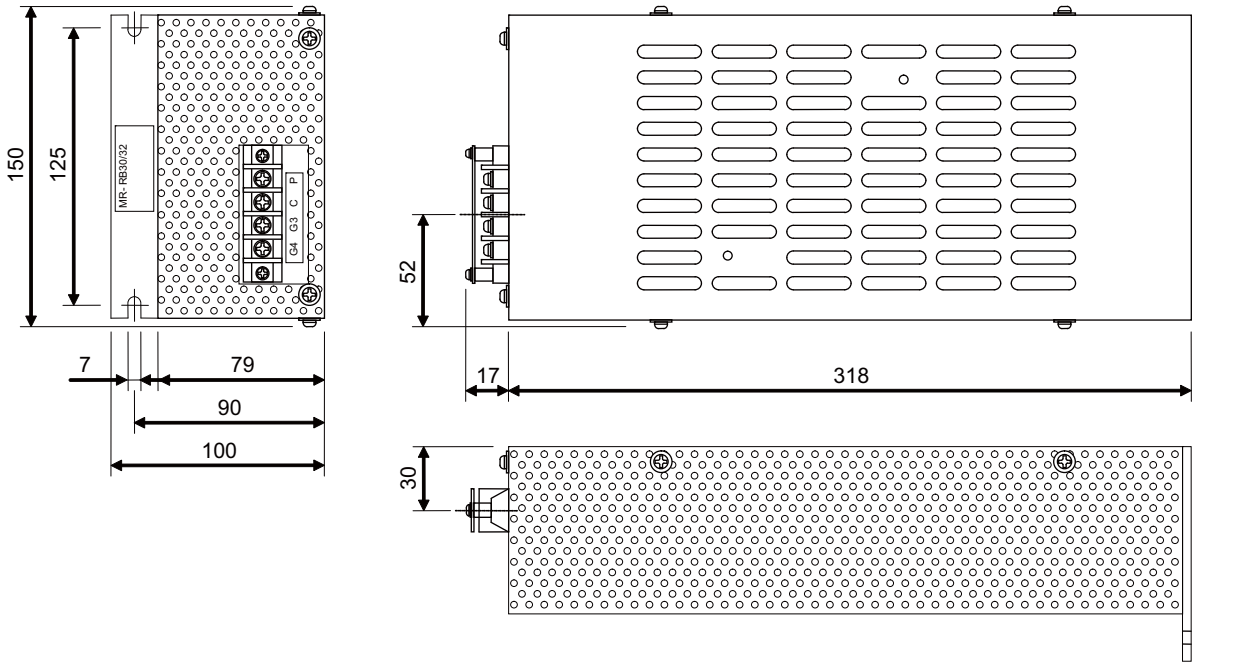
[Unit: mm]



Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
MR-RB12	100	40	0.8

< MR-RB32, MR-RB30, MR-RB31 >

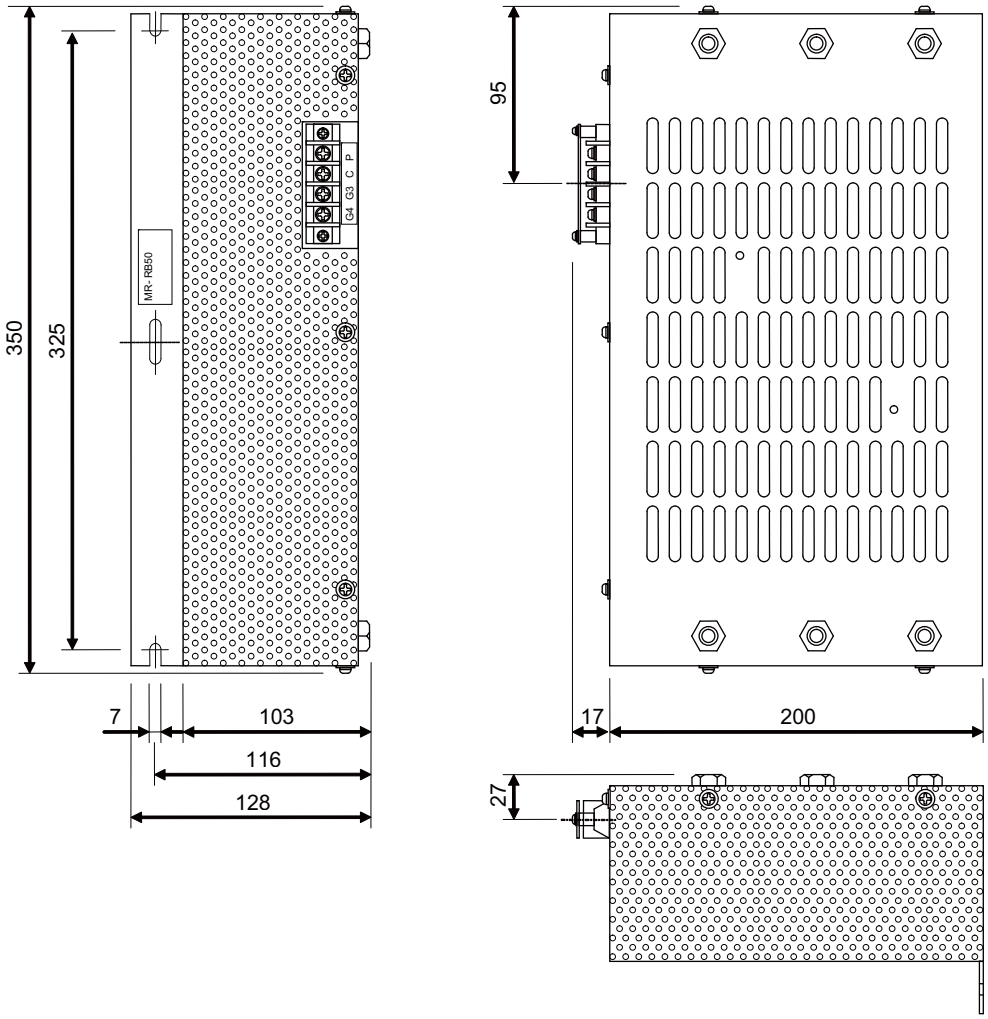
[Unit: mm]



Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
MR-RB32	300	40	2.9
MR-RB30	300	13	2.9
MR-RB31	300	6.7	2.9

< MR-RB50, MR-RB51 >

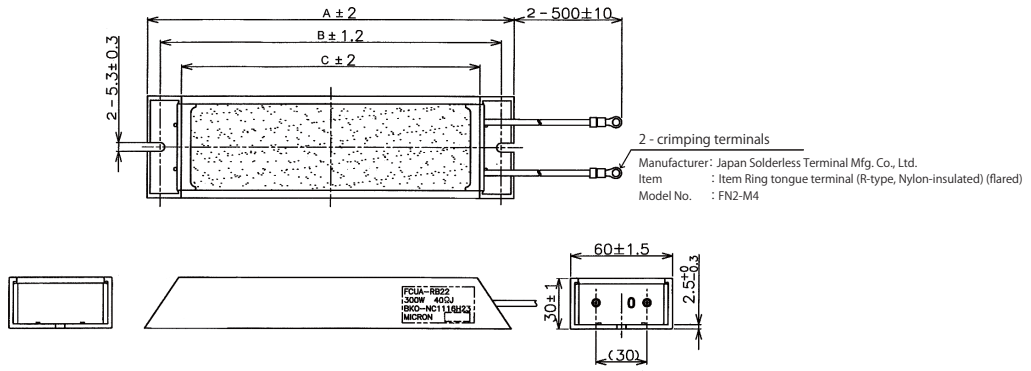
[Unit: mm]



Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
MR-RB50	500	13	5.6
MR-RB51	500	6.7	5.6

< FCUA-RB22, FCUA-RB37>

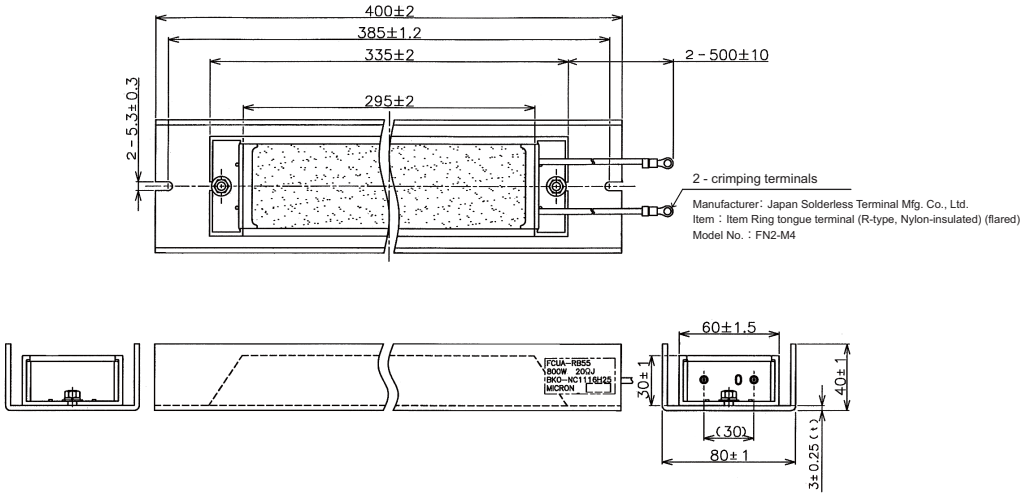
[Unit: mm]



Type	Regenerativ ecapacity (W)	Outline dimension (mm)			Resistance value (Ω)	Mass (kg)
		A	B	C		
FCUA-RB22	155	215	200	175	40	0.8
FCUA-RB37	185	335	320	295	25	1.2

< FCUA-RB55, FCUA-RB75/2>

[Unit: mm]



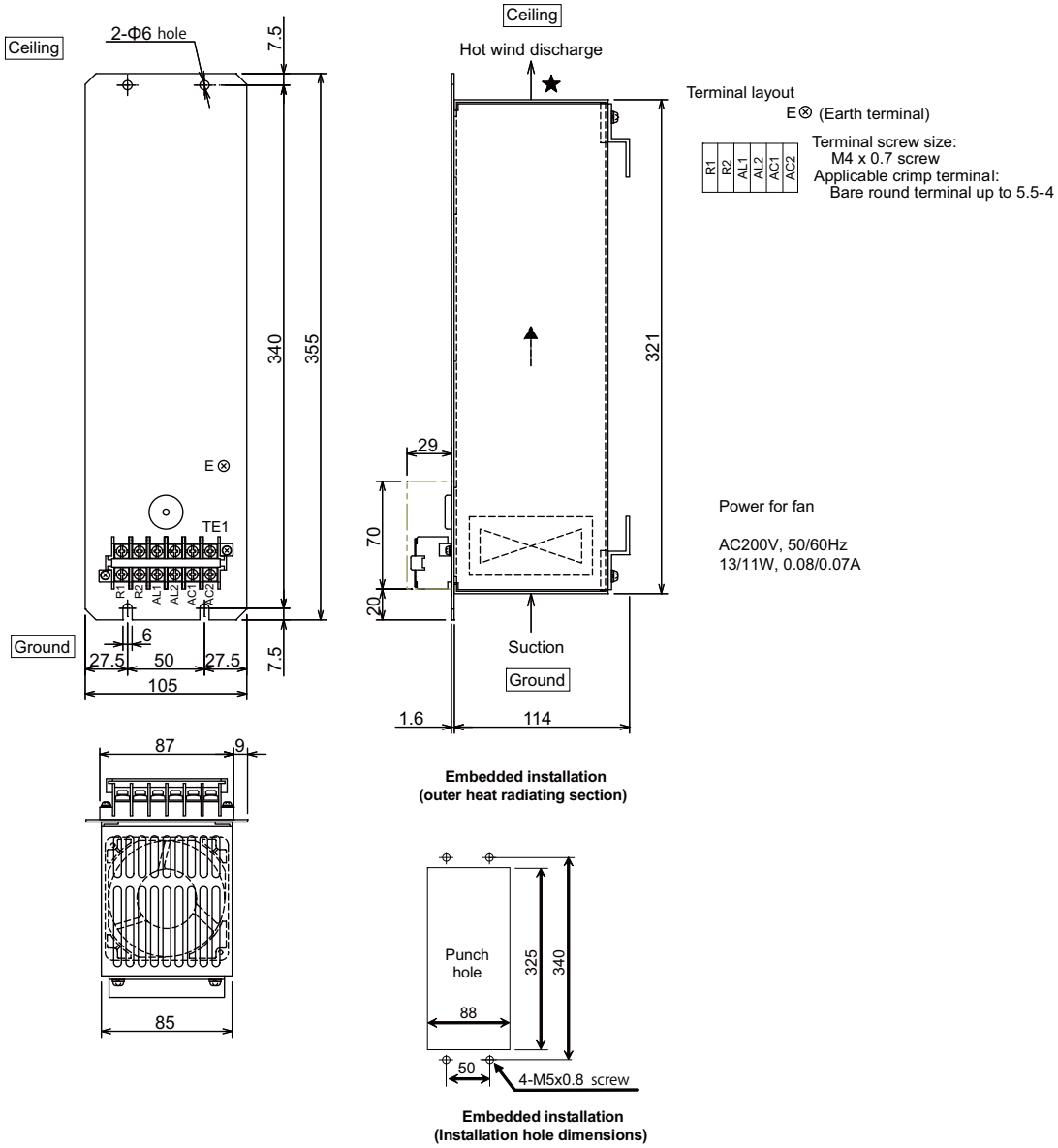
Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
FCUA-RB75/2 (1 unit)	340	30	2.2
FCUA-RB55	340	20	2.2
FCUA-RB75/2 (2 units connected in parallel)	680	15	4.4 (total of 2 units)
FCUA-RB55 (2 units connected in parallel)	680	10	4.4 (total of 2 units)

⚠ CAUTION

1. When using an operation pattern in which the regenerative resistor is used at a high frequency, the surface of the resistor may exceed 300°C, so take care to the installation and the heat radiation.
   Do not install the resistor in a place where it can be easily touched by hand or body parts as touching could lead to burns.
   Install a well-ventilated protective cover (punched metal, etc.) if body parts might come in contact.
2. Installation of the regenerative resistor on a metallic surface outside the panel is recommended to improve the heat radiating effect.
3. Install the regenerative resistor so that the section where the lead wires are led out is not at the top of the resistor.

< R-UNIT-1, -2 >

[Unit: mm]



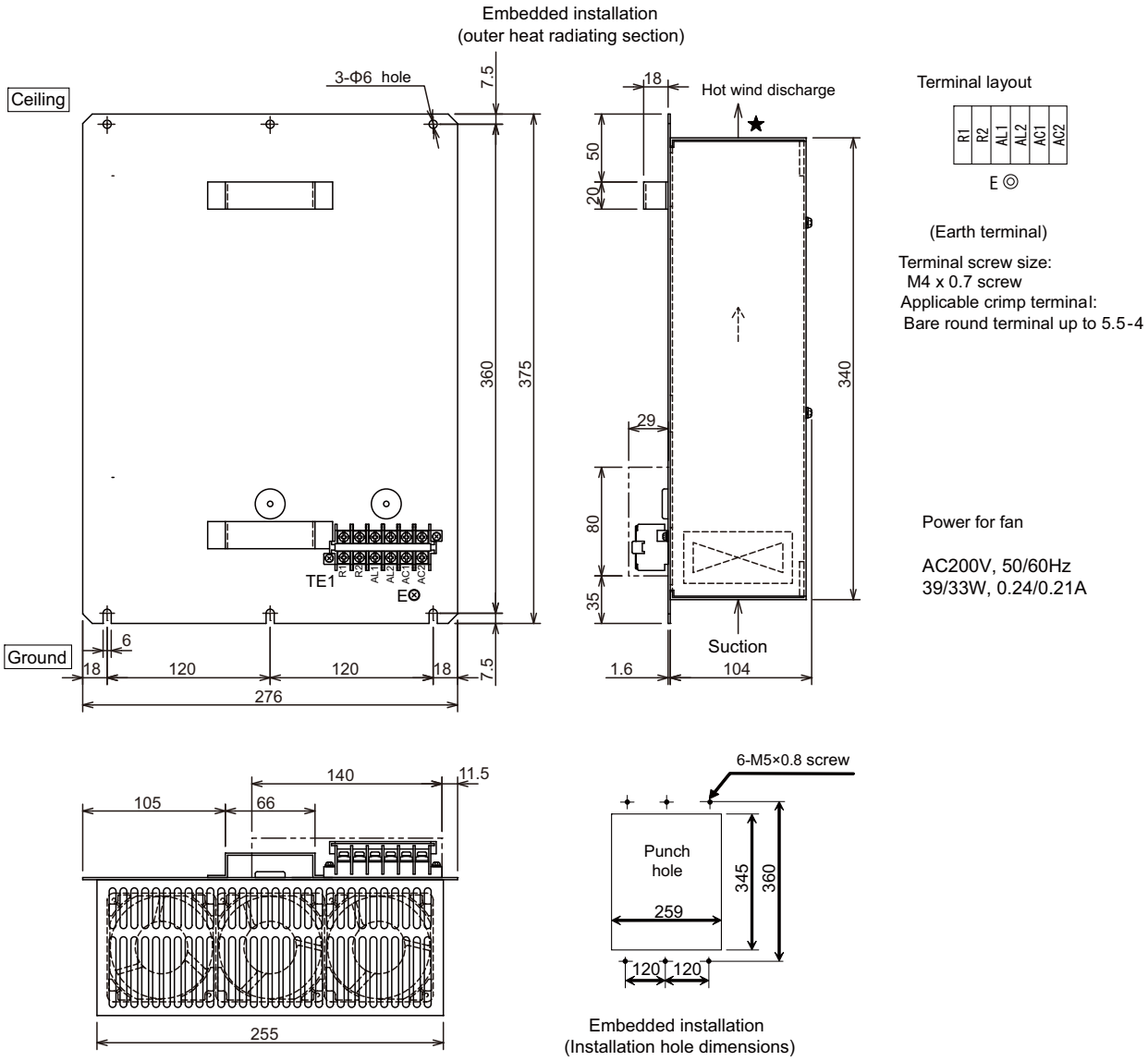
Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
R-UNIT-1	700	30	4.3
R-UNIT -2	700	15	4.4

⚠ CAUTION

1. Do not wire or arrange other devices in front of the section marked with a as extremely hot wind will be blown out.
2. For the installation direction of this resistor, the "Ceiling" is the top and "Ground" is the bottom.
3. Touching the resistor when it is hot could lead to burns. Always install a protective cover or consider the installation site so that workers will not touch the unit.
4. The resistor's heating value will differ according to the acceleration/deceleration frequency, speed being used and the load GD^2 conditions, etc. However, install the resistor so that the hot wind is always exhausted to outside the panel.

< R-UNIT-3, -4 >

[Unit: mm]



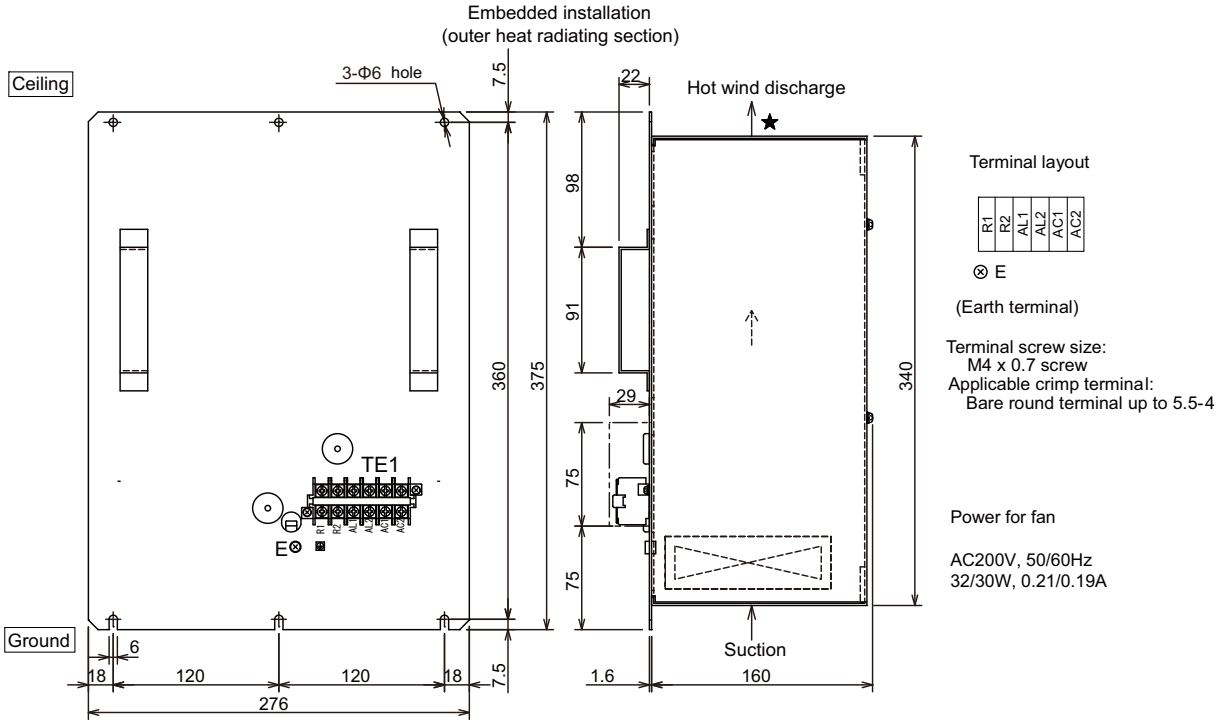
Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
R-UNIT-3	2100	15	10.8
R-UNIT-4	2100	10	11.0

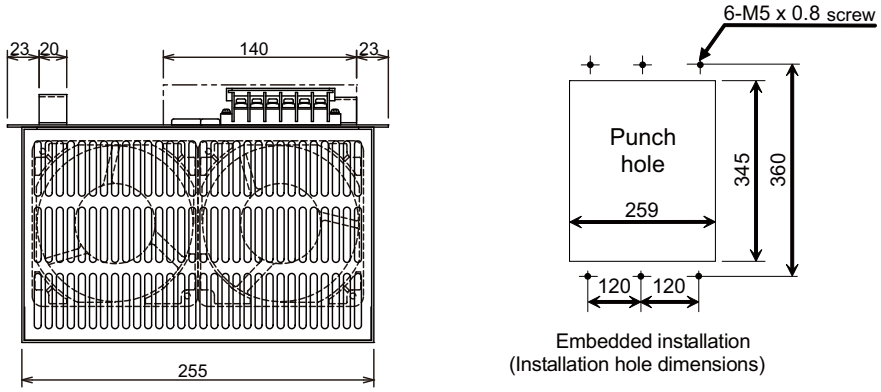
⚠ CAUTION

1. Attach packing to the flange section.
2. Do not wire or arrange other devices in front of the section marked with a as extremely hot wind will be blown out.
3. For the installation direction of this resistor, the "Ceiling" is the top and "Ground" is the bottom.
4. Touching the resistor when it is hot could lead to burns. Always install a protective cover or consider the installation site so that workers will not touch the unit.
5. The resistor's heating value will differ according to the acceleration/deceleration frequency, speed being used and the load GD^2 conditions, etc. However, install the resistor so that the hot wind is always exhausted to outside the panel.

< R-UNIT-5 >

[Unit: mm]





Type	Regenerative capacity (W)	Resistance value (Ω)	Mass (kg)
R-UNIT-5	3100	10	15.0

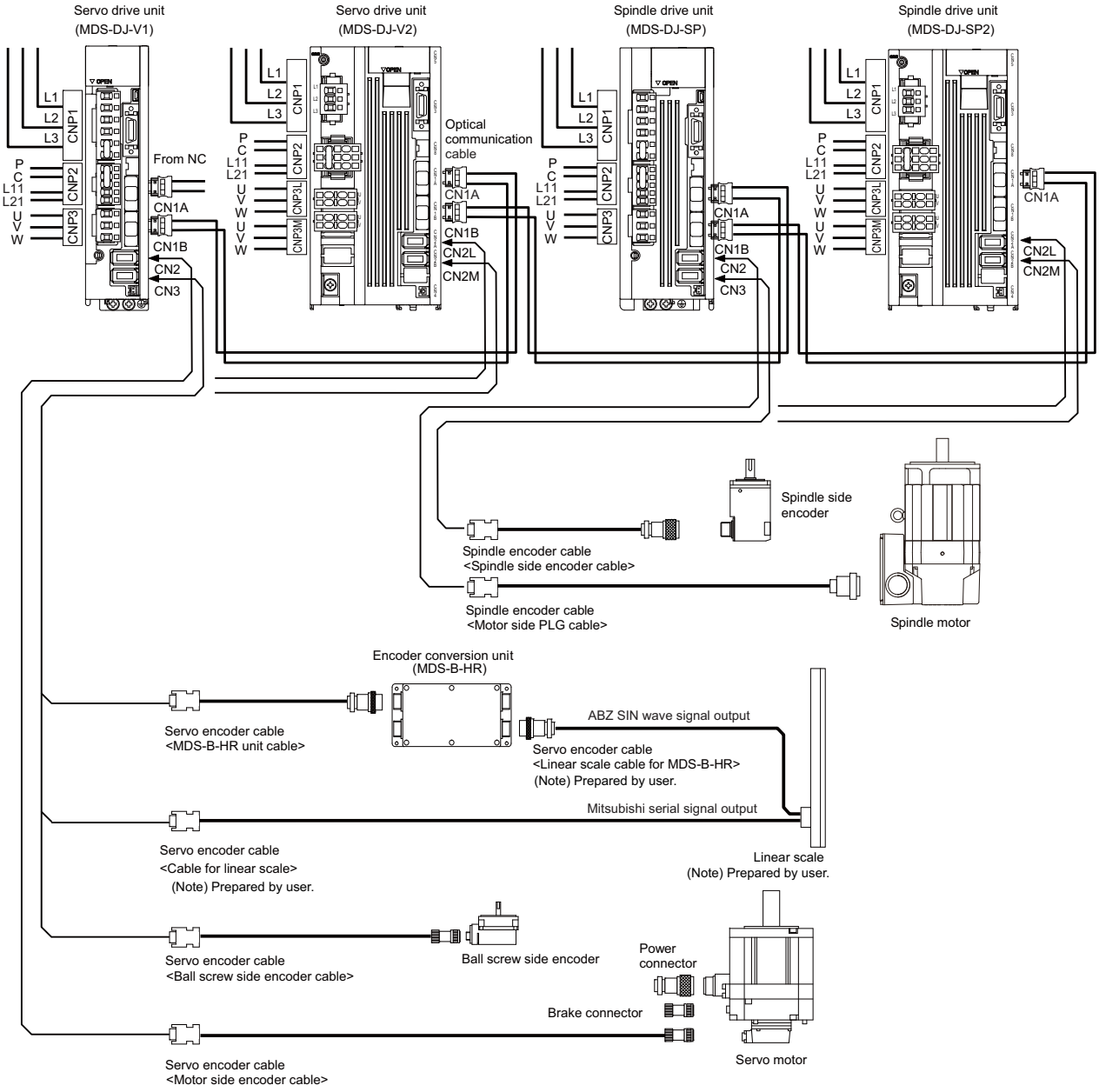
⚠ CAUTION

1. Attach packing to the flange section.
2. Do not wire or arrange other devices in front of the section marked with a as extremely hot wind will be blown out.
3. For the installation direction of this resistor, the "Ceiling" is the top and "Ground" is the bottom.
4. Touching the resistor when it is hot could lead to burns. Always install a protective cover or consider the installation site so that workers will not touch the unit.
5. The resistor's heating value will differ according to the acceleration/deceleration frequency, speed being used and the load GD^2 conditions, etc. However, install the resistor so that the hot wind is always exhausted to outside the panel.

5.5 Cables and Connectors

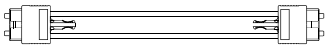
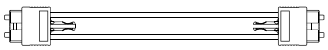
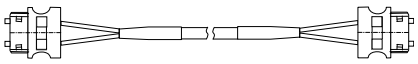
5.5.1 Cable Connection Diagram

The cables and connectors that can be ordered from Mitsubishi Electric Corp. as option parts are shown below. Cables can only be ordered in the designated lengths. Purchase a connector set, etc., to create special length cables.



5.5.2 List of Cables and Connectors

< Optical communication cable >

Item		Model	Contents
For CN1A/ CN1B/ OPT1A	Optical communication cable For wiring between drive units (inside panel)	G396 L ☐ M ☐ : Length 0.3, 0.5, 1, 2, 3, 5m	Drive unit side connector (Japan Aviation Electronics Industry) Connector: PF-2D103 Drive unit side connector (Japan Aviation Electronics Industry) Connector: PF-2D103 
	Optical communication cable For wiring between drive units (outside panel) For NC - drive unit	G395 L ☐ M ☐ : Length 1, 2, 3, 5, 7, 10m	Drive unit side connector (Japan Aviation Electronics Industry) Connector: PF-2D103 Drive unit side connector (Japan Aviation Electronics Industry) Connector: PF-2D103 
	Optical communication cable For wiring between drive units (outside panel) For optical communication repeater unit	G380 L ☐ M ☐ : Length 5, 10, 12, 15, 20, 25, 30m	Drive unit side connector (Tyco Electronics) Connector: 1123445-1 Drive unit side connector (Tyco Electronics) Connector: 1123445-1 

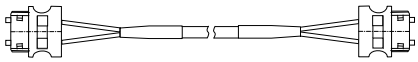
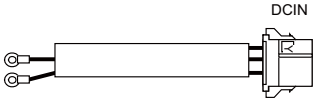
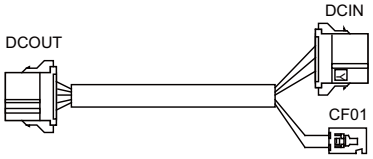
(Note) For details on the optical communication cable, refer to the section "Optical Communication Cable Specification".

< STO input connector >

Item		Model	Contents
For CN8	STO cable	MR-D05UDL3M-B	Connector set : 2069250-1 (Tyco Electronics) 
	STO short-circuit connector	These connectors are supplied for each drive unit.	Required when not using dedicated wiring STO function. Drive unit side connector (Japan Aviation Electronics Industry) DZ02B008DC2 

Item		Model	Contents
For CN9	For MDS-DJ-V1/SP	FCUA-CS000	Connector (3M) Connector: 10120-3000VE Shell kit :10320-52F0-008 
	For MDS-DJ-V2/SP2	FCUA-DJ200	Connector (3M) Connector: 10126-3000PE Shell kit : 10326-52F0-008 

< Optical communication repeater unit >

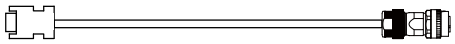
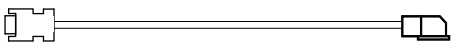
Item		Model	Contents
For OPT1/2	Optical communication cable For wiring between drive unit and optical communication repeater unit/ For wiring between optical communication repeater units	G380-L ☐ M ☐ : Length 5, 10, 12, 15, 20, 25, 30m	Drive unit side/ Optical communication repeater unit side connector (Tyco Electronics) Connector: 1123445-1 Optical communication repeater unit side connector (Tyco Electronics) Connector: 1123445-1 
For DCIN	For optical communication repeater unit DC24V power cable	F070 ☐ : Length 0.5, 1.5, 3, 5, 8, 10, 15, 20m	DC24V power side terminal (J.S.T.) Crimp terminal: V1.25-3 or V1.25-4 × 2 Optical communication repeater unit side connector (Tyco Electronics) Connector: 2-178288-3 Contact: 1-175218-5 × 3 (Note 1) 
For DCIN/ ACFAIL	For optical communication repeater unit/ For connecting Mitsubishi power unit PD25, PD27 DC24V power cable (power OFF detection)	F110 ☐ : Length 0.5, 1.5, 3, 5, 8, 10, 15m	DC24V power side connector (Tyco Electronics) Connector: 3-178127-6 Contact: 1-175218-5 (for AWG16) × 3 (Note 1) 1-175217-5 (for AWG22) × 2 (Note 2) Optical communication repeater unit side connector < DCIN > (Tyco Electronics) Connector: 2-178288-3 Contact: 1-175218-5 × 3 (Note 1) < ACFAIL (CF01) > (MOLEX) 005057-9402 0016020103 × 2 (Note 3) 

(Note 1) Hand crimping tools: 91558-1

(Note 2) Hand crimping tools: 91557-1

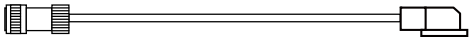
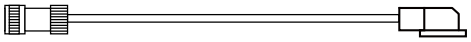
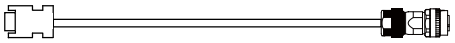
(Note 3) Hand crimping tools: 57036-5000

< Servo / tool spindle encoder cable and connector >

<table>
<tr><th colspan="3">Item</th><th>Model</th><th>Contents</th></tr>
<tr><td rowspan="6">For CN2/3</td><td rowspan="4">For HF/ For HF-KP (Tool spindle)
Motor side encoder cable
Ball screw side encoder cable</td><td rowspan="4"></td><td rowspan="2">CNV2E-8P- ☐ M
☐ :Length
2, 3, 4, 5,
7, 10, 15, 20,
25, 30m</td><td>Drive unit side connector
(3M)
Receptacle :36210-0100PL
Shell kit :36310-3200-008
Motor encoder/
Ball screw side encoder side connector
(DDK)
Plug :CMV1-SP10S-M2
Contact :CMV1-#22ASC-S1
  </td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set : 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td rowspan="2">CNV2E-9P- ☐ M
☐ :Length
2, 3, 4, 5,
7, 10, 15, 20,
25, 30m</td><td>Drive unit side connector
(3M)
Receptacle :36210-0100PL
Shell kit :36310-3200-008
Motor encoder/
Ball screw side encoder side connector
(DDK)
Plug :CMV1-AP10S-M2
Contact :CMV1-#22ASC-S1
  </td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set : 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td rowspan="4">Direct connection type</td><td rowspan="4">For HF-KP (Servo)
Motor side encoder cable</td><td rowspan="2">CNV2E-K1P- ☐ M
Lead out in direction of motor shaft
☐ :Length
2, 3, 5, 7, 10,m
Compatible with only IP65</td><td>Drive unit side connector
(3M)
Receptacle :36210-0100PL
Shell kit :36310-3200-008
Motor encoder/
Ball screw side encoder side connector
(Tyco Electronics)
Connector:1674320-1
  </td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set : 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td rowspan="2">CNV2E-K2P- ☐ M
Lead out in opposite direction
☐ :Length
2, 3, 5, 7, 10,m
Compatible with only IP65</td><td>Drive unit side connector
(3M)
Receptacle :36210-0100PL
Shell kit :36310-3200-008
Motor encoder/
Ball screw side encoder side connector
(Tyco Electronics)
Connector: 1674320-1
  </td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set : 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
</table>

(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

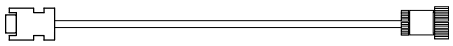
(Note 2) For HF-KP13, lead out in opposite direction of motor shaft cannot be used for power cable.

Item			Model	Contents
For CN2/3	Relay type (Note 1)	For HF-KP (Servo) Motor side encoder relay cable (motor side)	CNV22J-K1P-0.3M Lead out in direction of motor shaft Length:0.3m Compatible with only IP65	Relay side connector (DDK) Plug :CM10-CR10P-M  Motor encoder/ Ball screw side encoder side connector (Tyco Electronics) Plug :1747464-1 Contact :1674335-4
			CNV22J-K2P-0.3M Lead out in opposite direction Length:0.3m Compatible with only IP65 (Note 2)	Relay side connector (DDK) Plug :CM10-CR10P-M  Motor encoder/ Ball screw side encoder side connector (Tyco Electronics) Plug :1747464-1 Contact :1674335-4
		For HF-KP (Servo) Motor side encoder relay cable (Drive unit side)	CNV2E-8P- ☐ M ☐ :Length 2, 3, 4, 5, 7, 10, 15, 20, 25, 30m	Servo drive unit side connector (3M) Receptacle :36210-0100JL Shell kit :36310-3200-008  Motor encoder/ Ball screw side encoder side connector (DDK) Plug :CMV1-SP10S-M2 Contact :CMV1-#22ASC-S1 Compatible part (Note 2) (MOLEX) Connector set : 54599-1019 (J.S.T.) Plug connector : XV-10P-03-L-R Cable kit : XV-PCK10-R
For moter encoder/ Ball screw side encoder	Motor side encoder connector/ Ball screw side encoder connector		CNE10-R10S(9) Applicable cable outline Φ6.0 to 9.0mm	Motor encoder/ Ball screw side encoder side connector (DDK) Plug :CMV1-SP10S-M2 Contact :CMV1-#22ASC-S1 
			CNE10-R10L(9) Applicable cable outline Φ6.0 to 9.0mm	Motor encoder/ Ball screw side encoder side connector (DDK) Plug :CMV1-AP10S-M2 Contact :CMV1-#22ASC-S1 

(Note 1) When using cable of 15m or longer, use relay cable.

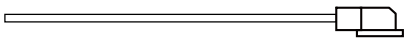
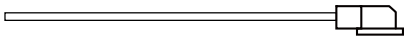
(Note 2) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

(Note 3) For HF-KP13, lead out in opposite direction of motor shaft cannot be used for power cable.

Item		Model	Contents
For CN3	MDS-B-HR unit cable	CNV2E-HP- ☐ M ☐ :Length 2, 3, 4, 5, 7, 10, 15, 20, 25, 30m	Drive unit side connector (3M) Receptacle:36210-0100PL Shell kit :36310-3200-008 MDS-B-HR unit side connector (Hirose Electric) Plug :RM15WTP-8S Clamp :RM15WTP-CP(10)  Compatible part (Note 1) (MOLEX) Connector set : 54599-1019 (J.S.T.) Plug connector : XV-10P-03-L-R Cable kit : XV-PCK10-R
For MDS-B-HR unit	MDS-B-HR connector (For CON1,2: 1) (For CON3: 1)	CNEHRS(10) Applicable cable outline Φ8.5 to 11mm	MDS-B-HR unit side connector (Hirose Electric) Plug :RM15WTP-8S(for CON1, 2) RM15WTP-12P(for CON3) Clamp :RM15WTP-CP(10) * Two clamps are enclosed. 
For CN2/3	Encoder connector	CNU2S(AWG18)	Drive unit side connector (3M) Receptacle:36210-0100PL Shell kit :36310-3200-008  Compatible part (Note 1) (MOLEX) Connector set : 54599-1019 (J.S.T.) Plug connector : XV-10P-03-L-R Cable kit : XV-PCK10-R

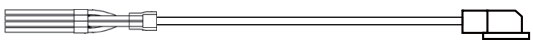
(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

< Brake cable and connector >

Item		Model	Contents
For motor brake	Brake connector for HF	CNB10-R2S(6) Applicable cable outline Φ4.0 to 6.0mm	Servo motor side brake connector (DDK) Plug :CMV1-SP2S-S Contact :CMV1-#22BSC-S2 
		CNB10-R2L(6) Applicable cable outline Φ4.0 to 6.0mm	Servo motor side brake connector (DDK) Plug :CMV1-AP2S-S Contact :CMV1-#22BSC-S2 
	Brake cable for HF-KP	MR-BKS1CBL ☐ M-A1-H Lead out in direction of motor shaft ☐ :Length 2, 3, 5, 7, 10m	Servo motor side brake connector (Japan Aviation Electronics Industry) Plug :JN4FT02SJ1-R Contact :ST-TMH-S-C1B-100-(A534G) 
		MR-BKS1CBL ☐ M-A2-H Lead out in opposite direction of motor shaft (Note) ☐ :Length 2, 3, 5, 7, 10m	Servo motor side brake connector (Japan Aviation Electronics Industry) Plug :JN4FT02SJ1-R Contact :ST-TMH-S-C1B-100-(A534G) 

(Note) For HF-KP13, lead out in opposite direction of motor shaft cannot be used for power cable.

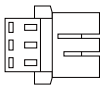
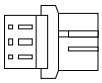
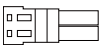
< Power connector >

Item		Model	Contents
For motor power	Power connector for HF75, 105, 54,104,154, 224, 123, 223, 142	CNP18-10S(14) Applicable cable outline Φ10.5 to 14mm	Motor side power connector (DDK) Plug:CE05-6A18-10SD-C-BSS Clamp:CE3057-10A-1(D240) 
		CNP18-10L(14) Applicable cable outline Φ10.5 to 14mm	Motor side power connector (DDK) Plug:CE05-8A18-10SD-C-BAS Clamp:CE3057-10A-1(D240) 
	Power connector for HF204,354, 303, 302	CNP22-22S(16) Applicable cable outline Φ12.5 to 16mm	Motor side power connector (DDK) Plug:CE05-6A22-22SD-C-BSS Clamp:CE3057-12A-1(D240) 
		CNP22-22L(16) Applicable cable outline Φ12.5 to 16mm	Motor side power connector (DDK) Plug:CE05-8A22-22SD-C-BAS Clamp:CE3057-12A-1(D240) 
	Power cable for HF-KP	MR-PWS1CBL ☐ M-A1-H Lead out in direction of motor shaft ☐ :Length 2, 3, 5, 7, 10m	Motor side power connector (Japan Aviation Electronics Industry) Plug:JN4FT04SJ1-R Contact:ST-TMH-S-C1B-100-(A534G) 
		MR-PWS1CBL ☐ M-A2-H Lead out in opposite direction of motor shaft (Note) ☐ :Length 2, 3, 5, 7, 10m	Motor side power connector (Japan Aviation Electronics Industry) Plug:JN4FT04SJ1-R Contact:ST-TMH-S-C1B-100-(A534G) 

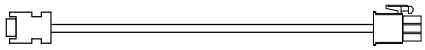
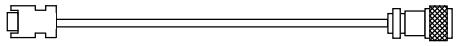
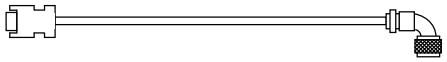
(Note) For HF-KP13, lead out in opposite direction of motor shaft cannot be used for power cable.

< Drive unit side main circuit connector >

Item		Model	Contents
For drive unit	For MDS-DJ-V1-10/15/30 For MDS-DJ-SP-20	These connectors are supplied for each drive unit. Applicable cable size: 0.8mm^2 to 2.1mm^2 Cable finish outside diameter: to Φ3.9mm	For CNP1 (For power supply) 06JFAT-SAXGDK-H7.5 (J.S.T.) 
			For CNP2 (For control power) 05JFAT-SAXGDK-H5.0 (J.S.T.) 
			For CNP3 (For motor power) 03JFAT-SAXGDK-H7.5 (J.S.T.) 
			Connection lever J-FAT-OT (J.S.T.) 
	For MDS-DJ-V1-40/ 80/ 100 For MDS-DJ-SP-40/80	These connectors are supplied for each drive unit. Applicable cable size: (For CNP1 and CNP3) 1.25mm^2 to 5.5mm^2 (For CNP2) 0.8mm^2 to 2.1mm^2 Cable finish outside diameter: ((For CNP1 and CNP3) to Φ4.7mm (For CNP2) to Φ3.9mm	For CNP1 (For power supply) 06JFAT-SAXGFK-XL (J.S.T.) 
			For CNP2 (For control power) 05JFAT-SAXGDK-H5.0 (J.S.T.) 
			For CNP3 (For motor power) 03JFAT-SAXGFK-XL (J.S.T.) 
			Connection lever J-FAT-OT-EXL (J.S.T.) 

Item		Model	Contents
For drive unit	For MDS-DJ-V2-3030 For MDS-DJ-SP2-2020	These connectors are supplied for each drive unit. Applicable cable size: (For CNP1) 1.25mm^2 to 2.0mm^2 (For CNP2) 1.25mm^2 to 2.0mm^2 (For CNP3) 1.25mm^2 to 2.2mm^2 Cable finish outside diameter: (For CNP1) to Φ4.2mm (For CNP2) to Φ3.8mm (For CNP3) to Φ3.8mm	For CNP1 (For power supply) 03JFAT-SAXGFK-43 (J.S.T.) 
			For CNP2 (For control power) 06JFAT-SAXYGG-F-KK (J.S.T.) 
			For CNP3L/CNP3M(For motor power) 04JFAT-SAGG-G-KK (J.S.T.) 
			Connection lever J-FAT-OT-EXL (J.S.T.) 

< Spindle encoder cable and connector >

<table>
<tr><th colspan="2">Item</th><th>Model</th><th>Contents</th></tr>
<tr><td rowspan="2">For CN2</td><td rowspan="2">Motor side PLG cable
Spindle side accuracy encoder TS5690 cable</td><td rowspan="2">CNP2E-1- ☐ M
☐ : Length
2, 3, 4, 5,
7, 10, 15, 20,
25, 30m</td><td>Spindle drive unit side connector
(3M)
Receptacle: 36210-0100PL
Shell kit : 36310-3200-008
 
Spindle motor side connector
(Tyco Electronics)
Connector: 172169-1
Contact:170363-1(AWG26-22)
170364-1(AWG22-18)</td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set: 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td rowspan="4">For CN3</td><td rowspan="4">Spindle side encoder OSE-1024 cable</td><td rowspan="2">CNP3EZ-2P- ☐ M
☐ : Length
2, 3, 4, 5,
7, 10, 15, 20,
25, 30m</td><td>Spindle drive unit side connector
(3M)
Receptacle: 36210-0100PL
Shell kit : 36310-3200-008
 
Spindle motor side connector
(DDK)
Connector: MS3106A20-29S(D190)
Straight back shell: CE02-20BS-S
Clamp: CE3057-12A-3</td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set: 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td rowspan="2">CNP3EZ-3P- ☐ M
☐ : Length
2, 3, 4, 5,
7, 10, 15, 20,
25, 30m</td><td>Spindle drive unit side connector
(3M)
Receptacle: 36210-0100PL
Shell kit : 36310-3200-008
 
Spindle motor side connector
(DDK)
Connector: MS3106A20-29S(D190)
Angle back shell: CE-20BA-S
Clamp : CE3057-12A-3</td></tr>
<tr><td>Compatible part (Note 1)
(MOLEX)
Connector set: 54599-1019
(J.S.T.)
Plug connector : XV-10P-03-L-R
Cable kit : XV-PCK10-R</td></tr>
<tr><td>For spindle motor</td><td>Motor side PLG connector
Spindle side accuracy encoder TS5690 connector</td><td>CNEPGS</td><td>Spindle motor side connector
(Tyco Electronics)
Connector: 172169-1
Contact:170363-1(AWG26-22)
170364-1(AWG22-18)
  </td></tr>
<tr><td rowspan="2">For spindle motor</td><td rowspan="2">Spindle side encoder OSE-1024 cable</td><td>CNE20-29S(10)
Applicable cable outline
Φ6.8 to 10mm</td><td>Spindle motor side connector
(DDK)
Connector:MS3106A20-29S(D190)
Straight back shell: CE02-20BS-S
Clamp: CE3057-12A-3
  </td></tr>
<tr><td>CNE20-29S(10)
Applicable cable outline
Φ6.8 to 10mm</td><td>Spindle motor side connector
(DDK)
Connector:MS3106A20-29S(D190)
Angle back shell: CE-20BA-S
Clamp: CE3057-12A-3
  </td></tr>
</table>

(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

Item		Model	Contents
For CN2/3	Spindle encoder drive unit side connector	CNU2S(AWG18)	Spindle drive unit side connector (3M) Receptacle: 36210-0100PL Shell kit : 36310-3200-008 
			Compatible part (Note 1) (MOLEX) Connector set: 54599-1019 (J.S.T.) Plug connector : XV-10P-03-L-R Cable kit : XV-PCK10-R

(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

< Twin-head magnetic encoder (MBE405W/MBA405W) cable and connector >

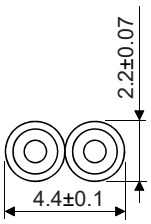
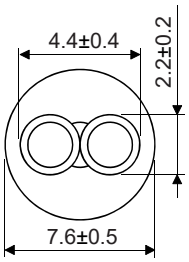
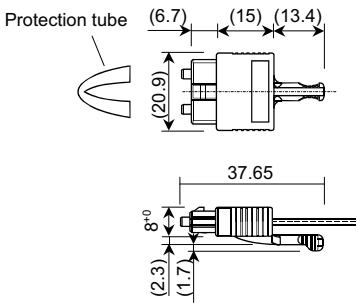
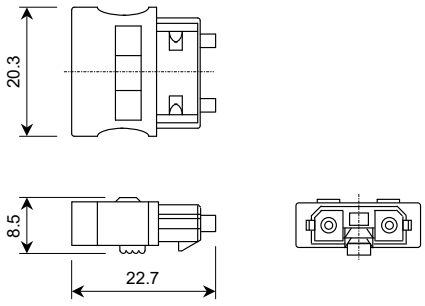
Item		Model	Contents
For CN2	Cable for MBE405W/MBA405W	CNV2E-MB- ☐ M ☐ :Length 2, 3, 4, 5, 7, 10, 15, 20m	Drive unit side connector (3M) Receptacle:36210-0100PL Shell kit:36310-3200-008 Encoder preamplifier side connector (Hirose Electric) Plug:RM15WTPZK-12S Clamp:JR13WCCA-8(72) 
			Compatible part (Note 1) (MOLEX) Connector set: 54599-1019 (J.S.T.) Plug connector : XV-10P-03-L-R Cable kit : XV-PCK10-R
	Connector for MBE405W/MBA405W	CNEMB2S(8)	Encoder preamplifier side connector (Hirose Electric) Plug: RM15WTPZK-12S Cord clamp: JR13WCCA-8 (72) 
For CN3	Thermistor connector for MBE405W/ MBA405W	CNEMB3S(8)	Encoder preamplifier side connector (Hirose Electric) Plug: RM15WTPZ-10S (72) Cord clamp: JR13WCCA-8 (72) 

(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

< Contact information >
Japan Aviation Electronics Industry, Limited: http://www.jae.com/en/index.html
HIROSE ELECTRIC CO., LTD.: https://www.hirose.com/?lang=en
3M: http://www.3m.com/
J.S.T. Mfg. Co., Ltd.: http://www.jst-mfg.com/index_e.php
DDK Ltd.: http://www.ddknet.co.jp/English/index.html
Tyco Electronics Japan G.K.: http://www.te.com/en/home.html
Molex, LLC.: http://www.molex.com/

5.5.3 Optical Communication Cable Specifications

(1) Specifications

Cable model		G396 L ☐ M	G395 L ☐ M	G380 L ☐ M
Specification application		For wiring inside panel	For wiring outside panel	For wiring outside panel For long distance wiring
Cable length		0.3, 0.5, 1.0, 2.0, 3.0, 5.0m	1, 2, 3, 5, 7, 10m	5.0, 10, 12, 15, 20, 25, 30m
Optical communication cable	Minimum bend radius	25mm	Enforced covering cable: 50mm cord: 30mm	
	Tension strength	140N	980N (Enforced covering cable)	
	Temperature range for use (Note1)	-40 to 85°C	-20 to 70°C	
	Ambient	Indoors (no direct sunlight) No solvent or oil		
	Cable appearance [mm]			
	Connector appearance [mm]			

(Note 1) This temperature range for use is the value for optical cable (cord) only. Temperature condition for the connector is the same as that for drive unit.

(Note 2) Do not see directly the light generated from CN1A/CN1B connector of drive unit or the end of cable. When the light gets into eye, you may feel something is wrong for eye.
(The light source of optical communication corresponds to class1 defined in JISC6802 or IEC60825-1.)

(2) Cautions for using optical communication cable

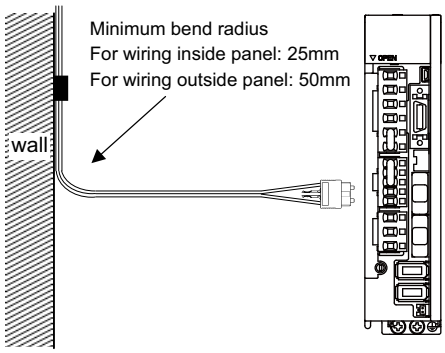
Optical communication cable is made from optical fiber. If optical fiber is added a power such as a major shock, lateral pressure, haul, sudden bending or twist, its inside distorts or breaks, and optical transmission will not be available. Especially, as optical fiber for G396 L □ M is made of synthetic resin, it melts down if being left near the fire or high temperature. Therefore, do not make it touched the part, which becomes high temperature, such as radiator or regenerative brake option of drive unit.
Read described item in this section carefully and handle it with caution.

(a) Minimum bend radius

Make sure to lay the cable with greater radius than the minimum bend radius. Do not press the cable to edges of equipment or others. For the optical communication cable, the appropriate length should be selected with due consideration for the dimensions and arrangement of drive unit so that the cable bend will not become smaller than the minimum bend radius in cable laying. When closing the door of control box, pay careful attention for avoiding the case that optical communication cable is hold down by the door and the cable bend becomes smaller than the minimum bend radius.
Lay the cable so that the numbers of bends will be less than 10 times.

(b) Bundle fixing

When using optical communication cable of 3m or longer, fix the cable at the closest part to the connector with bundle material in order to prevent optical communication cable from putting its own weight on CN1A/CN1B connector of drive unit. Optical cord should be given loose slack to avoid from becoming smaller than the minimum bend radius, and it should not be twisted.
When tightening up the cable with nylon band, the sheath material should not be distorted. Fix the cable with tightening force of 1 to 2kg or less as a guide.



When laying cable, fix and hold it in position with using cushioning such as sponge or rubber which does not contain plasticizing material. If it is fixed by a cable tie and the like without using cushioning, the wire breakage may occur. Never use vinyl tape for cord. Plasticizing material in vinyl tape goes into optical fiber and lowers the optical characteristic. At worst, it may cause wire breakage. If using adhesive tape for cable laying, the fire resistant acetate cloth adhesive tape 570F (Teraoka Seisakusho Co., Ltd) is recommended.
If laying with other wires, do not make the cable touched wires or cables made from material which contains plasticizing material.

(c) Tension

If tension is added on optical fiber, the increase of transmission loss occurs because of external force which concentrates on the fixing part of optical fiber or the connecting part of optical connector. At worst, the breakage of optical fiber or damage of optical connector may occur. For cable laying, handle without putting forced tension.

(d) Lateral pressure

If lateral pressure is added on optical communication cable, the optical cable itself distorts, internal optical fiber gets stressed, and then transmission loss will increase. At worst, the breakage of optical cable may occur. As the same condition also occurs at cable laying, do not tighten up optical communication cable with a thing such as nylon band (TY-RAP).

Do not trample it down or tuck it down with the door of control box or others.

(e) Twisting

If optical fiber is twisted, it will become the same stress added condition as when local lateral pressure or bend is added. Consequently, transmission loss increases, and the breakage of optical fiber may occur at worst.

(f) Cable selection

- When wiring is outside the power distribution panel or machine cabinet, there is a highly possibility that external power is added. Therefore, make sure to use the cable for wiring outside panel (G380 L □ M)
- If a part of the wiring is moved, use the cable for wiring outside panel.
- In a place where sparks may fly and flame may be generated, use the cable for wiring outside panel.

(g) Method to lay cable

When laying the cable, do not haul the optical fiver or connector of the optical communication cable strongly. If strong force is added between the optical fiver and connector, it may lead to a poor connection.

(h) Protection when not in use

When the CN1A/CN1B connector of the drive unite or the optical communication cable connector is not used such as pulling out the optical communication cable from drive unit, protect the joint surface with attached cap or tube for edge protection. If the connector is left with its joint surface bared, it may lead to a poor connection caused by dirty.

(i) Attaching /Detaching optical communication cable connector

With holding the connector body, attach/detach the optical communication cable connector. If attaching/detaching the optical communication cable with directly holding it, the cable may be pulled out, and it may cause a poor connection.

When pulling out the optical communication connector, pull out it after releasing the lock of clock lever.

(j) Cleaning

If CN1A and CN1B connector of the drive unit or optical communication cable connector is dirty, it may cause poor connection. If it becomes dirty, wipe with a bonded textile, etc. Do not use solvent such as alcohol.

(k) Disposal

When incinerating optical communication cable, hydrogen fluoride gas or hydrogen chloride gas which is corrosive and harmful may be generated. For disposal of optical communication cable, request for specialized industrial waste disposal services that has incineration facility for disposing hydrogen fluoride gas or hydrogen chloride gas.

(l) Return in troubles

When asking repair of drive unit for some troubles, make sure to put a cap on CN1A/CN1B connector.

When the connector is not put a cap, the light device may be damaged at the transit. In this case, exchange and repair of light device is required.

6

Specifications of Peripheral Devices

6.1 Selection of Wire

6.1.1 Example of Wires by Unit

Selected wires must be able to tolerate rated current of the unit's terminal to which the wire is connected.
How to calculate tolerable current of an insulated wire or cable is shown in "Tolerable current of electric cable" (1) of Japanese Cable Makers' Association Standard (JCS)-168-E (1995), its electric equipment technical standards or JEAC regulates tolerable current, etc. wire.
When exporting wires, select them according to the related standards of the country or area to export. In the UL standards, certification conditions are to use wires of 60°C and 75°C product. (UL508C)
Wire's tolerable current is different depending on conditions such as its material, structure, ambient temperature, etc. Check the tolerable current described in the specification of the wire to use.
Example of wire selections according to each standard is as follows.

Wire size		Tolerable current	
Conductor（copper） [mm^2]	AWG	60°C (IV wire)	75°C (HIV wire)
2	14	15A	15A
3.5	12	20A	20A
5.5	10	28A	30A
8	8	34A	46A
14	6	50A	65A
22	4	65A	85A
38	2	92A	115A
60	1/0	124A	150A
80	3/0	145A	200A
100	4/0	170A	225A

(Note) The relation between wire size and tolerable current above corresponds to restrictions specified in IEC/EN60204-1,UL508C,JEAC8001.
Wire's tolerable current is different depending on the specifications even for the wires of the same size. Confirm the operating environment and conditions, and wire with the applicable wires.

(1) 600V vinyl insulated wire (IV wire) 60°C product (Example according to IEC/EN60204-1, UL508C)

Unit type	Terminal name	CNP1 (L1, L2, L3, ⏚)		CNP2 (L11, L21)		CNP3 (U, V, W, ⏚)		CNP2 (P,C)		Magnetic brake	
		mm^2	AWG	mm^2	AWG	mm^2	AWG	mm^2	AWG	mm^2	AWG
Spindle drive unit	MDS-DJ-SP-20	2	14	2	14	2	14	2	14	------	---
	MDS-DJ-SP-40	2	14			2	14				
	MDS-DJ-SP-80	2	14			2	14				
	MDS-DJ-SP-100	3.5	12			3.5	12				
	MDS-DJ-SP-120	5.5	10			5.5	10	3.5	12		
	MDS-DJ-SP-160	14	6			14	6				
	MDS-DJ-SP2-2020	2	14			2	14	2	14		
Servo drive unit	MDS-DJ-V1-10	2	14	2	14	2	14	2	14	2	14
	MDS-DJ-V1-15	2	14			2	14				
	MDS-DJ-V1-30	2	14			2	14				
	MDS-DJ-V1-40	2	14			2	14				
	MDS-DJ-V1-80	2	14			3.5	12				
	MDS-DJ-V1-100	3.5	12			5.5	10				
	MDS-DJ-V2-3030	2	14			2	14				

(2) 600V double (heat proof) vinyl insulated wire (HIV wire) 75°C product (Example according to IEC/EN60204-1, UL508C)

Unit type	Terminal name	CNP1 (L1, L2, L3, ⏚)		CNP2 (L11, L21		CNP3 (U, V, W, ⏚)		CNP2 (P,C)		Magnetic brake	
		mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG
Spindle drive unit	MDS-DJ-SP-20	2	14	2	14	2	14	2	14	------	---
	MDS-DJ-SP-40	2	14			2	14				
	MDS-DJ-SP-80	2	14			2	14				
	MDS-DJ-SP-100	3.5	12			3.5	12				
	MDS-DJ-SP-120	5.5	10			5.5	10	3.5	12		
	MDS-DJ-SP-160	8	8			8	8				
	MDS-DJ-SP2-2020	2	14			2	14	2	14		
Servo drive unit	MDS-DJ-V1-10	2	14	2	14	2	14	2	14	2	14
	MDS-DJ-V1-15	2	14			2	14				
	MDS-DJ-V1-30	2	14			2	14				
	MDS-DJ-V1-40	2	14			2	14				
	MDS-DJ-V1-80	2	14			3.5	12				
	MDS-DJ-V1-100	3.5	12			5.5	10				
	MDS-DJ-V2-3030	2	14			2	14				

(3) 600V bridge polyethylene insulated wire (IC) 105 °C product

Unit type	Terminal name	CNP1 (L1, L2, L3, ⏚)		CNP2 (L11, L21		CNP3 (U, V, W, ⏚)		CNP2 (P,C)		Magnetic brake	
		mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG	mm²	AWG
Spindle drive unit	MDS-DJ-SP-20	2	14	1.25	16	2	14	2	14	------	---
	MDS-DJ-SP-40	2	14			2	14				
	MDS-DJ-SP-80	2	14			2	14				
	MDS-DJ-SP-100	2	14			3.5	12				
	MDS-DJ-SP-120	3.5	12			5.5	10	3.5	12		
	MDS-DJ-SP-160	5.5	10			5.5	10				
	MDS-DJ-SP2-2020	2	14	2	14	2	14	2	14		
Servo drive unit	MDS-DJ-V1-10	2	14	1.25	16	2	14	2	14	1.25	16
	MDS-DJ-V1-15	2	14			2	14				
	MDS-DJ-V1-30	2	14			2	14				
	MDS-DJ-V1-40	2	14			2	14				
	MDS-DJ-V1-80	2	14			2	14				
	MDS-DJ-V1-100	2	14			3.5	12				
	MDS-DJ-V2-3030	2	14	2	14	2	14			2	14

⚠ CAUTION

1. Selection conditions follow IEC/EN60204-1, UL508C, JEAC8001.
   - Ambient temperature is maximum 40°C.
   - Cable installed on walls without ducts or conduits.

   To use the wire under conditions other than above, check the standards you are supposed to follow.
2. The maximum wiring length to the motor is 30m.
   If the wiring distance between the drive unit and motor is 20m or longer, use a thick wire so that the cable voltage drop is 2% or less.
3. Always wire the grounding wire.

6.2 Selection of Circuit Protector and Contactor

Always select the circuit protector and contactor properly, and install them to each drive unit to prevent disasters.

6.2.1 Selection of Circuit Protector

Calculate a circuit protector selection current from the nominal input voltage of the drive unit as in the expression below. And then select the minimum capacity circuit protector whose rated current meets the circuit protector selection current.

Circuit protector selection current [A] =
(Circuit protector selection current for 200V input [A] / Nominal input voltage [V])×200 [V]

Selection of circuit protector for 200V input

Unit type MDS-DJ-	V1-10	V1-15	V1-30	V1-40	V1-80	V1-100	V2-3030
Circuit protector selection current for 200V input	2.5A	5A	7A	8A	10A	15A	9A
Selection example of circuit protector (Mitsubishi Electric Corp.)	NF30-SW3P-5A	NF30-SW3P-10A	NF30-SW3P-15A	NF30-SW3P-15A	NF30-SW3P-20A	NF30-SW3P-30A	NF30-SW3P-20A
Rated current of the selection example of circuit protector	5A	10A	15A	15A	20A	30A	20A

Unit type MDS-DJ-	SP-20	SP-40	SP-80	SP-100	SP-120	SP-160	SP2-2020
Circuit protector selection current for 200V input	6A	9A	15A	23A	31A	45A	9A
Selection example of circuit protector (Mitsubishi Electric Corp.)	NF30-SW3P-15A	NF30-SW3P-20A	NF30-SW3P-30A	NF50-SW3P-50A	NF100-SW3P-60A	NF100-SW3P-100A	NF30-SW3P-20A
Rated current of the selection example of circuit protector	15A	20A	30A	50A	60A	100A	20A

Option part: A circuit protector is not prepared as an NC unit accessory, so purchase the part from your dealer, etc.

⚠ CAUTION

1. It is dangerous to share a circuit protector for multiple drive units, so do not share it. Always install the circuit protectors for each drive unit.
2. If the control power (L11, L21) must be protected, select according to the section "Circuit Protector".

6.2.2 Selection of Contactor

Select the contactor selection current that is calculated from the rated output and the nominal input voltage of the drive unit as in the expression below. And then select the contactor whose conventional free-air thermal current meets the contactor selection current.

Contactor selection current [A] =
(Contactor selection current for 200V input [A] / Nominal input voltage [V]) × 200 [V]

Selection of contactor for 200V input

Unit type MDS-DJ-	V1-10	V1-15	V1-30	V1-40	V1-80	V1-100	V2-3030
Rated output	0.3kW	0.4kW	0.75kW	1.0kW	2.0kW	3.5kW	0.75kW+ 0.75kW
Circuit protector selection current for 200V input	2.5A	5A	7A	8A	10A	15A	9A
Selection example of circuit protector (Mitsubishi Electric Corp.)	S-T12-AC200V	S-T12-AC200V	S-T12-AC200V	S-T12-AC200V	S-T18-AC200V	S-T20-AC200V	S-T12-AC200V
Conventional freeair thermal current of the selection example of contactor	20A	20A	20A	20A	25A	32A	20A

Unit type MDS-DJ-	SP-20	SP-40	SP-80	SP-100	SP-120	SP-160	SP2-2020
Rated output	0.75kW	2.2kW	3.7kW	5.5kW	7.5kW	11kW	0.75kW+ 0.75kW
Circuit protector selection current for 200V input	6A	9A	15A	23A	31A	45A	9A
Selection example of circuit protector (Mitsubishi Electric Corp.)	S-T12-AC200V	S-T18-AC200V	S-T20-AC200V	S-T35-AC200V	S-T35-AC200V	S-T35-AC200V	S-T12-AC200V
Conventional freeair thermal current of the selection example of contactor	20A	25A	32A	50A	50A	60A	20A

Option part: A contactor is not prepared as an NC unit accessory, so purchase the part from your dealer, etc.

POINT

1. Use an alternating contactor.
2. Select a contactor whose excitation coil does not operate at 15mA or less.

6.3 Selection of Earth Leakage Breaker

When installing an earth leakage breaker, select the breaker on the following basis to prevent the breaker from malfunctioning by the higher frequency earth leakage current generated in the servo or spindle drive unit.

(1) Selection

Obtaining the earth leakage current for all drive units referring to the following table, select an earth leakage breaker within the "rated non-operation sensitivity current".
Usually use an earth leakage breaker for inverter products that function at a leakage current within the commercial frequency range (50 to 60Hz).
If a product sensitive to higher frequencies is used, the breaker could malfunction at a level less than the maximum earth leakage current value.

Earth leakage current for each drive unit

Unit	Maximum earth leakage current
MDS-DJ-SP-20 to 160	15mA
MDS-DJ-SP2-2020	30mA (for two axes)
MDS-DJ-V1-10 to 100	2mA
MDS-DJ-V2-3030	4mA (for two axes)

(Note) Maximum earth leakage current: Value that considers wiring length and grounding, etc. (Commercial frequency 50/60Hz)

(2) Measurement of earth leakage current

When actually measuring the earth leakage current, use a product that is not easily affected by the higher frequency earth leakage current. The measurement range should be 50 to 60Hz.

POINT

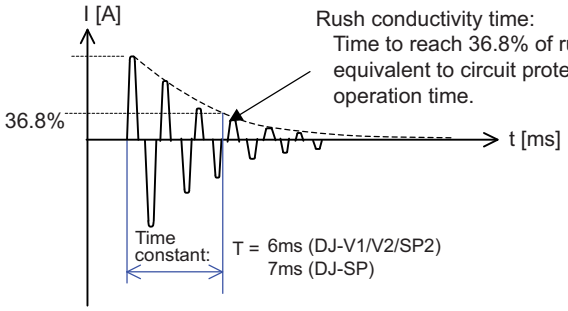
1. The earth leakage current tends to increase as the motor capacity increases.
2. A higher frequency earth leakage current will always be generated because the inverter circuit in the drive unit switches the transistor at high speed. Always ground to reduce the higher frequency earth leakage current as much as possible.
3. An earth leakage current containing higher frequency may reach approx. several hundreds of mA. According to IEC479-2, this level is not hazardous to the human body.

6.4 Branch-circuit Protection (For Control Power Supply)

6.4.1 Circuit Protector

This breaker is used to switch the control power and to provide overload and short-circuit protection.When connecting a circuit protector to the power input (L11 and L21) for the control circuit, use a product that does not trip (incorrectly activate) by a rush current when the power is turned ON. To prevent unnecessary tripping, select a product with inertial delay for the control power circuit protector.
The rush current and rush conductivity time differ according to the power impedance and power ON timing, so select a product that does not trip even under the conditions listed in the following table.

Rush current: Ip
DJ-V1/V2/SP2 and
DJ-SP-20,40,80:Ip=30A
DJ-SP-100,120,160:Ip=34A
(per 1 unit)



POINT

When collectively protecting the control circuit power for multiple units, select a circuit protector that satisfies the total sum of the rush current Ip.
The largest value is used for the rush conductivity time T.

6.4.2 Fuse Protection

The fuse of branch-circuit protection must use UL class CC, J or T. In the selection, please consider rush current and rush conductive time.

Selection of branch-circuit protection fuse

Connected total of unit	Fuse (Class CC)		Wire Size
	Rated [V]	Current [A]	AWG
1 to 4	600	20	16 to 14
5 to 8		35	

CAUTION

For continued protection against risk of fire, replace only with same type 600 V, 80 A or 35 A (UL CLASS CC) fuse.

WARNING

Before replacing fuse, confirm all power controlling the drive system is shut-OFF. Be sure to look out the power source to prevent the power from being turned ON while maintenance is being performed.

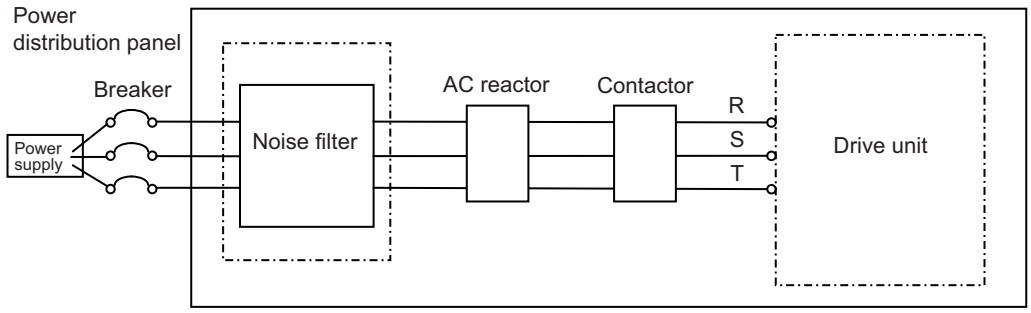
6.5 Noise Filter

(1) Selection

Use an EMC noise filter if the noise conducted to the power line must be reduced. Select an EMC noise filter taking the drive unit's input rated voltage and input rated current into consideration.

(2) Noise filter mounting position

Install the noise filter to the drive unit's power input as the diagram below indicates.



(Note) The noise filter must be prepared by the user.

Recommended devices:

Soshin Electric HF3000C-SZA Series

Contact:

Soshin Electric Co., Ltd. http://www.soshin-ele.com/

(Note) The above devices may be changed at the manufacturer's discretion.
Contact each manufacturer for more information.

6.6 Surge Absorber

When controlling a magnetic brake of a servo motor in DC OFF circuit, a surge absorber must be installed to protect the relay contacts and brakes. Commonly a varistor is used.

(1) Selection of varistor

When a varistor is installed in parallel with the coil, the surge voltage can be adsorbed as heat to protect a circuit. Commonly a 120V product is applied. When the brake operation time is delayed, use a 220V product. Always confirm the operation with an actual machine.

(2) Specifications

Select a varistor with the following or equivalent specifications. To prevent short-circuiting, attach a flame resistant insulation tube, etc., onto the leads as shown in the following outline dimension drawing.

Varistor specifications

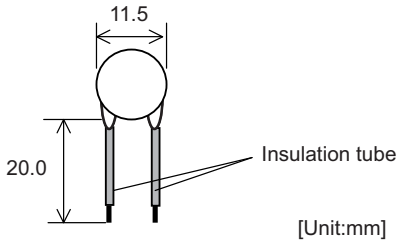
Varistor type	Varistor voltage rating (range)	Rating							Max. limit voltage	Electrostatic capacity (reference value)
		Tolerable circuit voltage		Surge current withstand level (A)		Energy withstand level (J)		Power		
	(V)	AC(V)	DC(V)	1 time	2 times	10/1000μs	2ms	(W)	(V)	(pF)
ERZV10D121 TND10V-121K	120 (108 to 132)	75	100	3500	2500	20	14.5	0.4	200	1400
ERZV10D221 TND10V-221K	220 (198 to 242)	140	180	3500	2500	39	27.5	0.4	360	410

(Note 1) Selection condition: When ON/OFF frequency is 10 times/min or less, and exciting current is 2A or less

(Note 2) ERZV10D121 and ERZV10D221 are manufactured by Panasonic Corporation.
TNR10V121K and TNR10V221K are manufactured by Nippon Chemi-Con Corporation.
Contact: Panasonic Corporation http://www.panasonic.com/global/home.html
Nippon Chemi-Con Corporation http://www.chemi-con.co.jp/e/index.html

(3) Outline dimension drawing

ERZV10D121, ERZV10D221



POINT

Normally use a product with 120V varistor voltage. If there is no allowance for the brake operation time, use the 220V product. A varistor whose voltage exceeds 220V cannot be used, as such varistor will exceed the specifications of the relay in the unit.

6.7 Relay

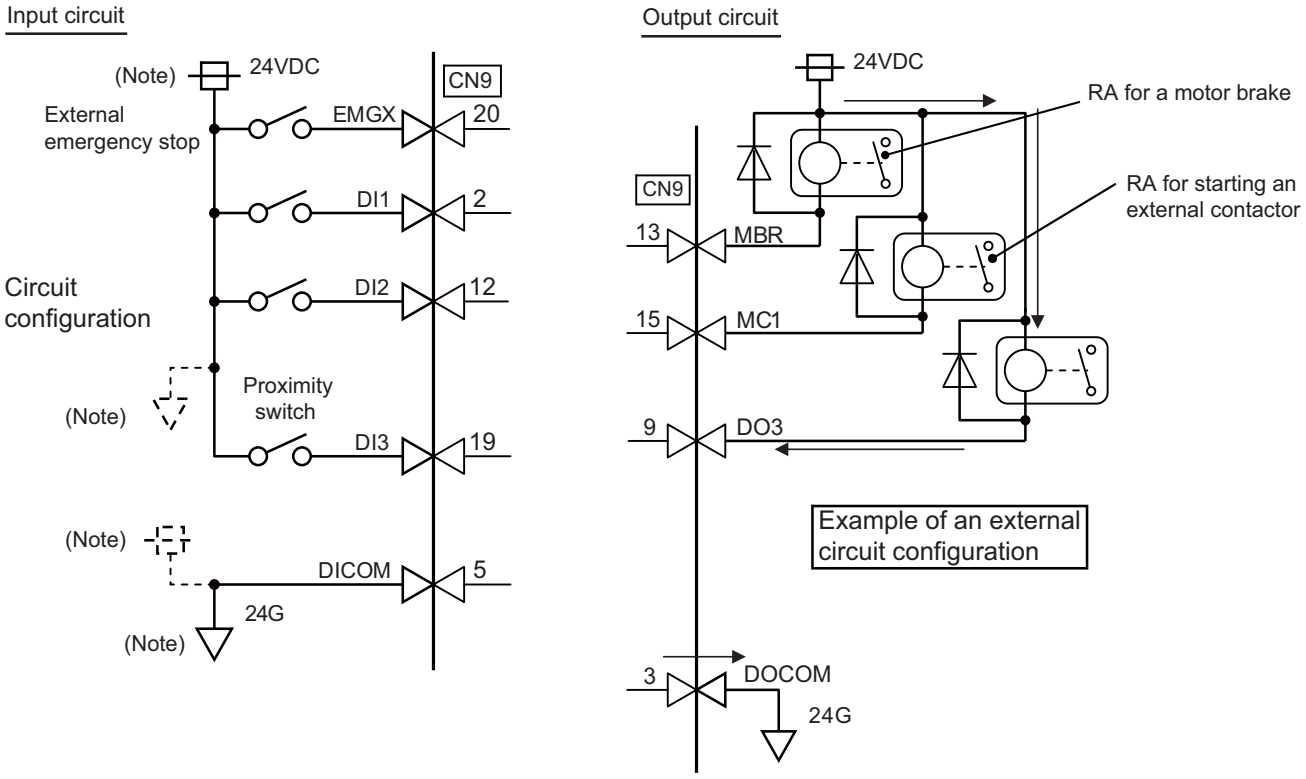
CN9 connector is equipped with 24V input/output circuit for the control of external devices and the control by an external signal.
Set the relevant parameters and use them with care for the wiring since some signals are changeover type, which can be switched over by parameters. Refer to the description of each function in relevant sections for details on the function specifications and settings.

Input condition		Output condition	
Switch ON	DC18V to DC25.2V 5mA or more	**Output voltage**	DC24V ±5%
		Tolerable output current Io	40mA or less
Switch OFF	4VDC or less 1mA or less		

For a switch or relay to be wired, use a switch or relay that satisfies the input/output (voltage, current) conditions.

Interface name	Selection example
For digital input signal (CN9)	Use a minute signal switch which is stably contacted and operated even with low voltage or current. <Example> OMRON: G2A, G6B type, MY type, LY type
For digital input signal (CN9)	Use a compact relay operated with rating of 24VDC, 50mA or less. <Example> OMROM: G6B type, MY type

<MDS-DJ-V1/SP Series>



(Note) For DICOM,
(1) it is a common pattern (24V or 24G) of input signal.
(2) either polarity for the input can be used. However, the direction must be the same.

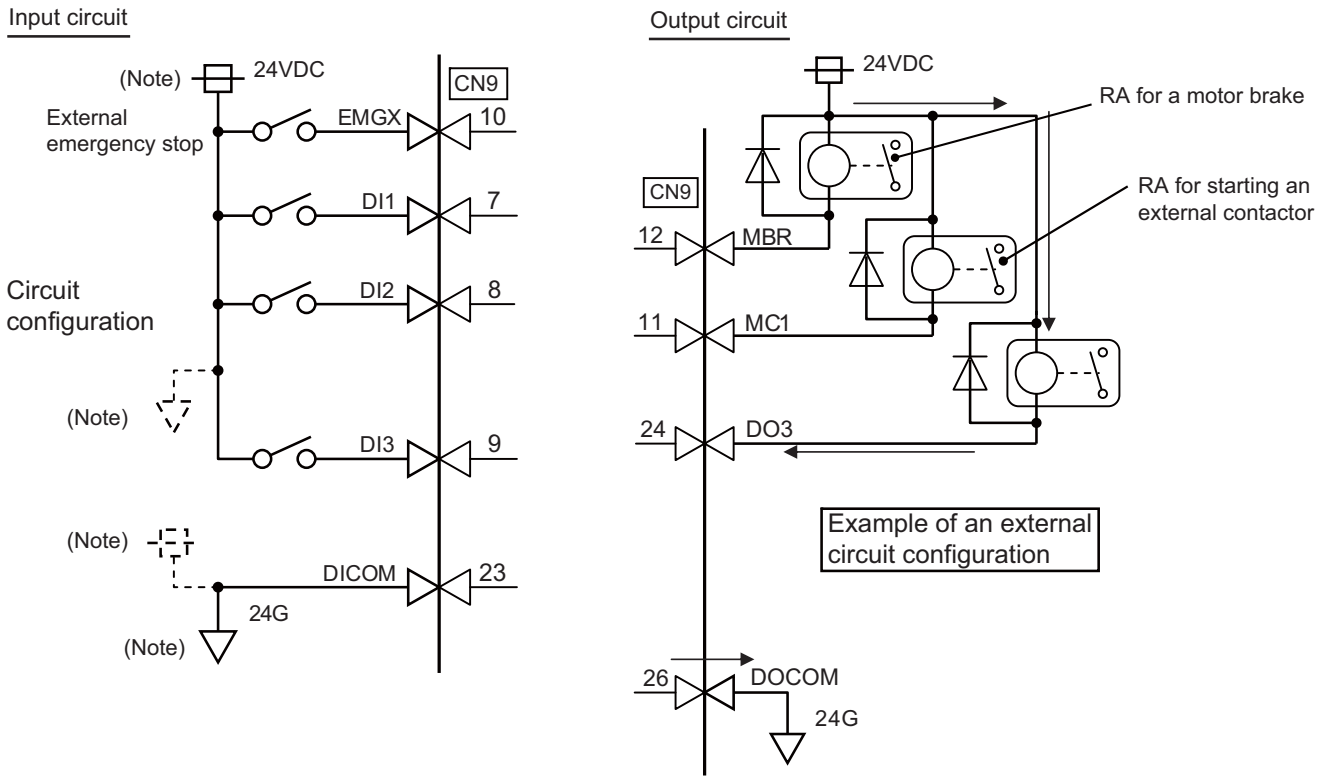
Servo input/output signal (CN9 connector)

	Device name	Connector pin No.	Signal name	Signal changeover parameter
Servo input signal	DI1	CN9-2	(Reservation)	
	DI2	CN9-12	(Reservation)	
	DI3	CN9-19	SLS(Safely Limited Speed) function door state signal	SV082/bitF-C=1
	EMGX	CN9-20	External emergency stop	SV036/bit7-4=4
Servo output signal	MBR	CN9-13	Motor brake control signal	
	MC	CN9-15	Contactor control signal	SV082/bitB,A=10
	DO3	CN9-9	(Reservation)	

Spindle input/output signal (CN9 connector)

	Device name	Connector pin No.	Signal name	Signal changeover parameter
Spindle input signal	DI1	CN9-2	(Reservation)	
	DI2	CN9-12	(Reservation)	
	DI3	CN9-19	SLS(Safely Limited Speed) function door state signal	SP227/bitF-C=1
			Proximity switch signal	SP227/bitF-C=2
	EMGX	CN9-20	External emergency stop signal	SP032/bit7-4=4
Spindle input signal	MBR	CN9-13	(Reservation)	
	MC	CN9-15	Contactor control signal	SP227/bitB,A=10
	DO3	CN9-9	(Reservation)	

<MDS-DJ-V2/SP2 Series>



(Note) For DICOM,
(1) it is a common pattern (24V or 24G) of input signal.
(2) either polarity for the input can be used. However, the direction must be the same.

Servo input/output signal (CN9 connector)

	Device name	Connector pin No.	Signal name	Signal changeover parameter
Servo input signal	DI1	CN9-7	(Reservation)	
	DI2	CN9-8	(Reservation)	
	DI3	CN9-9	SLS(Safely Limited Speed) function door state signal	SV082/bitF-C=1
	EMGX	CN9-10	External emergency stop	SV036/bit7-4=4
Servo output signal	MBR	CN9-12	Motor brake control signal	
	MC	CN9-11	Contactor control signal	SV082/bitB,A=10
	DO3	CN9-24	(Reservation)	

Spindle input/output signal (CN9 connector)

	Device name	Connector pin No.	Signal name	Signal changeover parameter
Spindle input signal	DI1	CN9-7	(Reservation)	
	DI2	CN9-8	(Reservation)	
	DI3	CN9-9	SLS(Safely Limited Speed) function door state signal	SP227/bitF-C=1
	EMGX	CN9-10	External emergency stop signal	SP032/bit7-4=4
Spindle input signal	MBR	CN9-12	(Reservation)	
	MC	CN9-11	Contactor control signal	SP227/bitB,A=10
	DO3	CN9-24	(Reservation)	

⚠ CAUTION

As for 2-axis drive unit, set the signal changeover parameter to either L or M axis.

7

Selection

7.1 Selection of the Servo Motor

7.1.1 Outline

It is important to select a servo motor matched to the purpose of the machine that will be installed. If the servo motor and machine to be installed do not match, the motor performance cannot be fully realized, and it will also be difficult to adjust the parameters. Be sure to understand the servo motor characteristics in this chapter to select the correct motor.

(1) Motor inertia

The servo motor has an optimum load inertia scale. If the load inertia exceeds the optimum range, the control becomes unstable and the servo parameters become difficult to adjust. When the load inertia is too large, decelerate with the gears (The motor axis conversion load inertia is proportional to the square of the deceleration ratio.), or change to a motor with a large inertia.

(2) Rated speed

Even with motors having the same capacity, the rated speed will differ according to the motor.
The motor's rated output is designed to be generated at the rated speed, and the output P (W) is expressed with expression (7-1). Thus, even when the motors have the same capacity, the rated torque will differ according to the rated speed.

$$P = 2\pi NT \text{ (W)} \quad \text{---(7-1)}$$

N: Motor speed (1/sec)
T: Output torque (N.m)

In other words, even with motors having the same capacities, the one with the lower rated speed will generate a larger torque. If generated torque is the same, the drive unit capacity can be downsized. When actually mounted on the machine, if the positioning distance is short and the motor cannot reach the maximum speed, the motor with the lower rated speed will have a shorter positioning time. When selecting the motor, consider the axis stroke and usage methods, and select the motor with the optimum rated speed.

7.1.2 Selection of Servo Motor Capacity

The following three elements are used to determine the servo motor capacity.

1. Load inertia ratio
2. Short time characteristics (acceleration/deceleration torque)
3. Continuous characteristics (continuous effective load torque)

Carry out appropriate measures, such as increasing the motor capacity, if any of the above conditions is not fulfilled.

(1) Load inertia ratio

Each servo motor has an appropriate load inertia ratio (load inertia/motor inertia). The control becomes unstable when the load inertia ratio is too large, and the servo parameter adjustment becomes difficult. It becomes difficult to improve the surface precision in the feed axis, and the positioning time cannot be shortened in the positioning axis because the settling time is longer.

If the load inertia ratio exceeds the recommended value in the servo specifications list, increase the motor capacity, and select so that the load inertia ratio is within the recommended range.

Note that the recommended value for the load inertia ratio is strictly one guideline. This does not mean that controlling of the load with inertia exceeding the recommended value is impossible.

POINT

1. When selecting feed axis servo motors for NC unit machine tools, place importance on the surface precision during machining. To do this, always select a servo motor with a load inertia ratio within the recommended value. Select the lowest value possible within that range.
2. The load inertia ratio for the motor with brakes must be judged based on the motor inertia for the motor without brakes.

(2) Short time characteristics

In addition to the continuous operation range, the servo motor has the short time operation range that can be used only in a short time such as acceleration/deceleration. This range is expressed by the maximum torque and the torque characteristics. The maximum torque or the torque characteristics differ according to each motor, so confirm the specifications in section "2.1 Servo Motor".

The torque required for the servo motor's acceleration/deceleration differs according to the CNC's command pattern or the servo's position control method.

Determine the required maximum motor torque from the following expression, and select the servo motor capacity.

(a) Selection with the maximum torque characteristics

In a low-speed rotation range (approximately less than half of the servo motor maximum speed), the linear acceleration/deceleration time constant "ta" that can be driven depends on the motor maximum torque. That can be approximated from the machine specifications using the expression (7-2).

$$ta = \frac{1.05 \times 10^{-2} \times (J_L/\eta + J_M) \times N}{(0.8 \times T_{MAX} - T_L)} \quad (ms) \quad \cdots (7\text{-}2)$$

N	: Motor reach speed	(r/min)
J_L	: Motor shaft conversion load inertia	($\times 10^{-4}$kg•m^2)
J_M	: Motor inertia	($\times 10^{-4}$kg•m^2)
η	: Drive system efficiency (Normally 0.8 to 0.95)	
T_{MAX}	: Maximum motor torque	(N•m)
T_L	: Motor shaft conversion load (friction, unbalance) torque	(N•m)

Using the approximate linear acceleration/deceleration time constant "ta" calculated above, confirm the torque characteristics of the high-speed rotation range in the CNC's command pattern or the servo's position control method.

(b) Approximation when using the NC command linear acceleration/deceleration pattern + servo standard position control

This is a normal command pattern or servo standard position control method.

Using the expression (7-3) and (7-4), approximate the maximum torque "Ta1" and maximum torque occurrence speed "Nm" required for this acceleration/deceleration pattern.

$$Ta1 = \frac{1.05 \times 10^{-2} \times (J_L/\eta + J_M) \times N}{ta} \times (1 - e^{\frac{-Kp \times ta}{1000}}) + T_L \quad (N \cdot m) \quad \cdots (7\text{-}3)$$

$$Nm = N \times \{1 - \frac{1000}{Kp \times ta} \times (1 - e^{\frac{-Kp \times ta}{1000}})\} \quad (r/min) \quad \cdots (7\text{-}4)$$

ta	: Acceleration/deceleration time constant	(ms)
Kp	: Position loop gain (SV003)	(rad/s)
N	: Motor reach speed	(r/min)
J_L	: Motor shaft conversion load inertia	($\times 10^{-4}$kg•m^2)
J_M	: Motor inertia	($\times 10^{-4}$kg•m^2)
η	: Drive system efficiency (Normally 0.8 to 0.95)	
T_L	: Motor shaft conversion load (friction, unbalance) torque	(N•m)

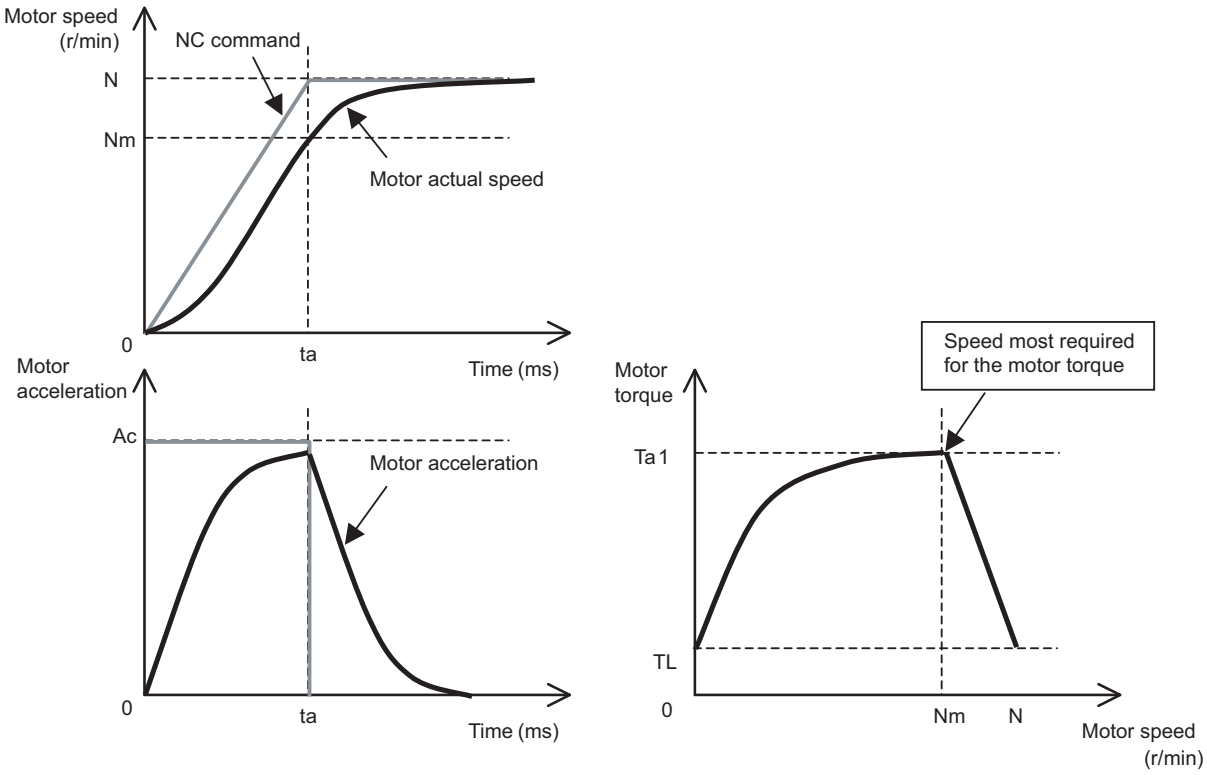


Fig.1 Speed, acceleration and torque characteristics when using the NC command linear acceleration/deceleration pattern + servo standard position control

(c) Approximation when using the NC command linear acceleration/deceleration pattern + servo SHG control (option)
This is a servo's position control method to achieve a normal command pattern and high precision. SHG control improves the position loop gain by stably controlling a delay of the position loop in the servo system. This allows the settling time to be reduced and a high precision to be achieved.
Using the expression (7-5) and (7-6), approximate the maximum torque "Ta1" and maximum torque occurrence speed "Nm" required for this acceleration/deceleration pattern.

$$T_a1 = \frac{1.05 \times 10^{-2} \times (J_L/\eta + J_M) \times N}{ta} \times (1 - 0.586 \times e^{\frac{-2 \times Kp \times ta}{1000}}) + T_L \quad (N \cdot m) \quad \cdots (7\text{-}5)$$

$$Nm = N \times \{1 - \frac{1000}{1.3 \times Kp \times ta} \times (1 - 1.5 \times e^{\frac{-2 \times Kp \times ta}{1000}})\} \quad (r/min) \quad \cdots (7\text{-}6)$$

ta	: Acceleration/deceleration time constant	(ms)
Kp	: Position loop gain (SV003)	(rad/s)
N	: Motor reach speed	(r/min)
J_L	: Motor shaft conversion load inertia	($\times 10^{-4}$kg•m^2)
J_M	: Motor inertia	($\times 10^{-4}$kg•m^2)
η	: Drive system efficiency (Normally 0.8 to 0.95)	
T_L	: Motor shaft conversion load (friction, unbalance) torque	(N•m)

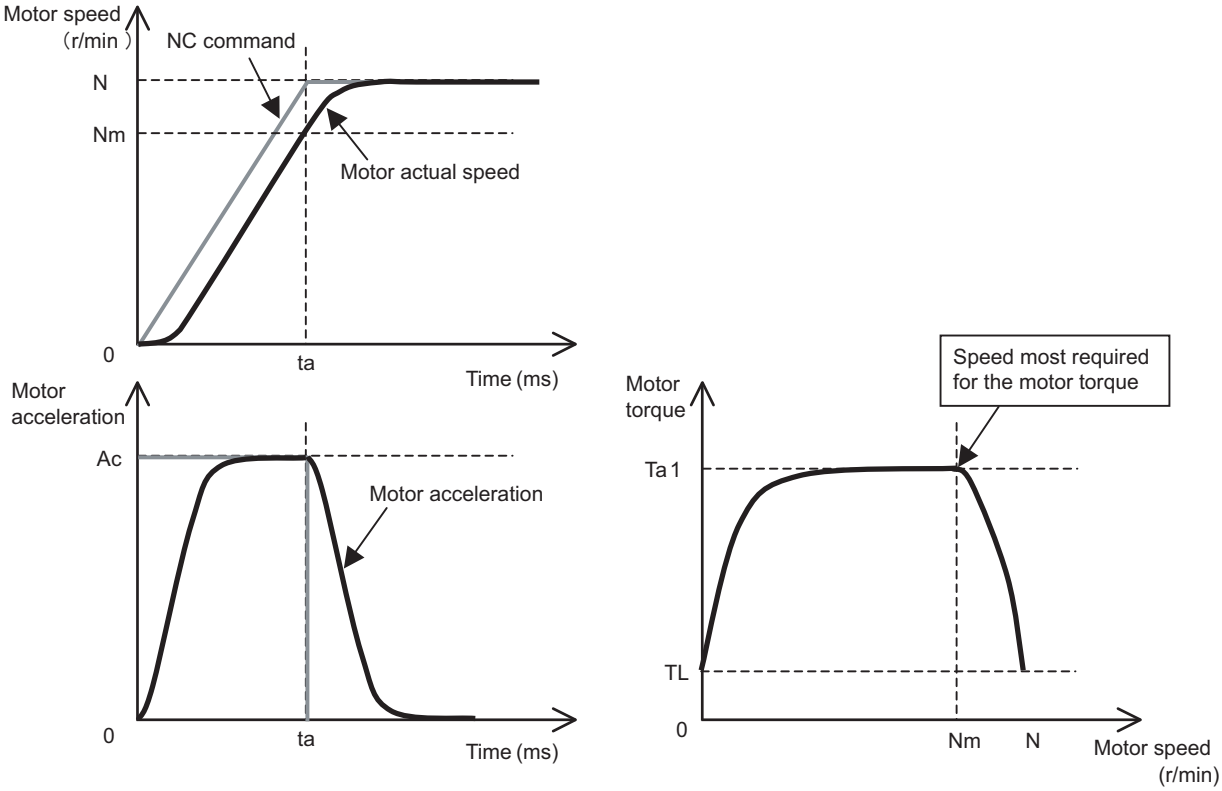


Fig.2 Speed, acceleration and torque characteristics when using the NC command linear acceleration/deceleration pattern + servo SHG control

(d) Approximation when using the NC command soft acceleration/deceleration pattern + feed forward control
This is an approximation when using high-speed high-accuracy control and OMR-FF control.
If the feed forward amount is set properly, the delay of the servo position loop is guaranteed. Therefore, this command acceleration pattern can be approximated to the NC command and does not depend on the servo position control method.
Using the expression (7-7) and (7-8), approximate the maximum torque "Ta1" and maximum torque occurrence speed "Nm" required for this acceleration/deceleration pattern.

$$T_a1 = \frac{1.05 \times 10^{-2} \times (J_L/\eta + J_M) \times N}{ta} + T_L \quad (N \cdot m) \quad \bullet\bullet\bullet (7\text{-}7)$$

$$Nm = N \times (1 - \frac{1}{2} \times \frac{tb}{ta}) \quad (r/min) \quad \bullet\bullet\bullet (7\text{-}8)$$

ta	: Acceleration/deceleration time constant	(ms)
tb	: Acceleration/deceleration time constant	(ms)
N	: Motor reach speed	(r/min)
J_L	: Motor shaft conversion load inertia	($\times 10^{-4}$kg•m^2)
J_M	: Motor inertia	($\times 10^{-4}$kg•m^2)
η	: Drive system efficiency (Normally 0.8 to 0.95)	
T_L	: Motor shaft conversion load (friction, unbalance) torque	(N•m)

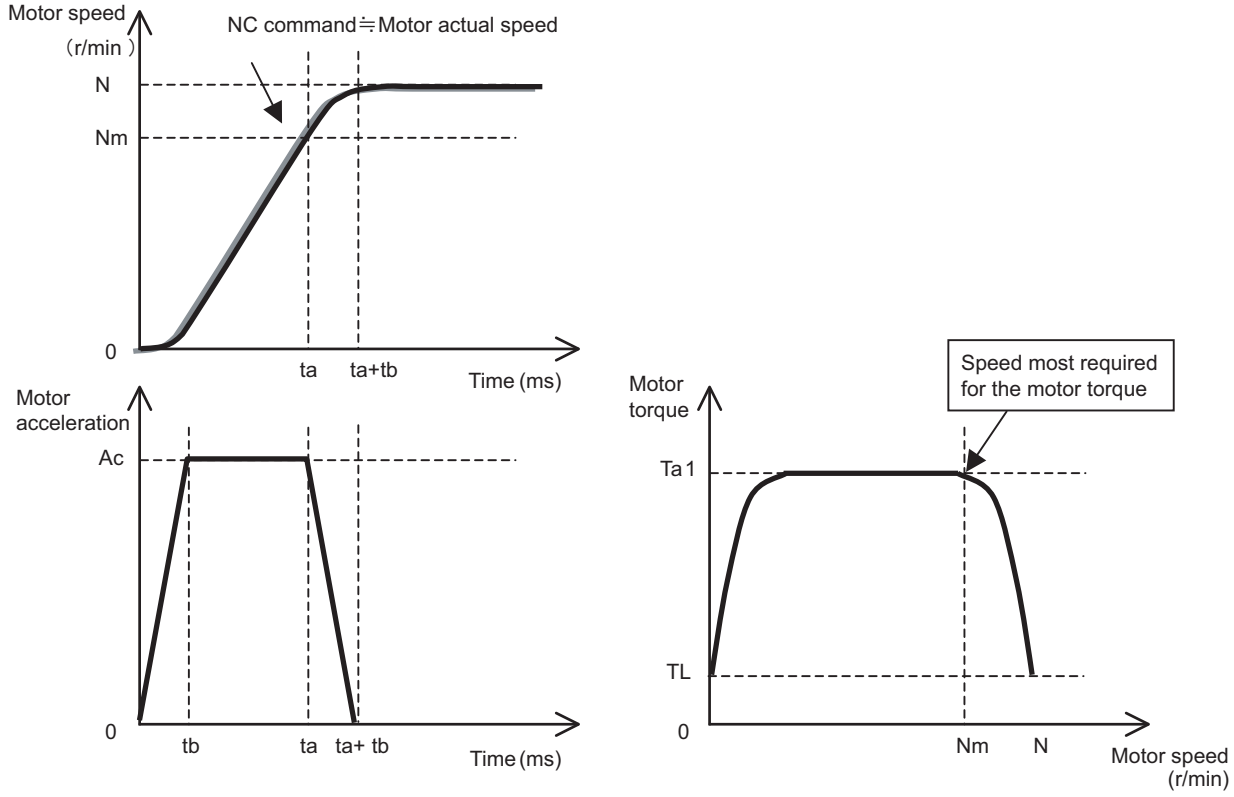
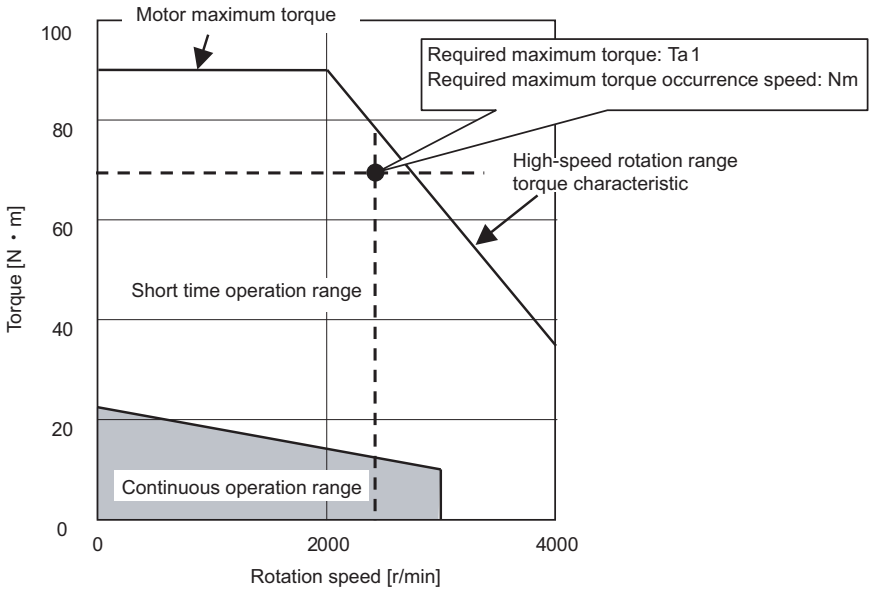


Fig 3. Speed, acceleration and torque characteristic when using the NC command soft acceleration/deceleration pattern + feed forward control

(e) Confirmation in the torque characteristics

Confirm whether the maximum torque "Ta1" and maximum torque occurrence speed "Nm" required for this acceleration/deceleration pattern calculated in the item "(b)" to "(d)" are in the short time operation range of the torque characteristics.



Motor torque characteristics

If they are not in the short time operation range, return to the item "(b)" to "(d)" and make the linear acceleration/deceleration time constant "ta" large.

If the acceleration specification cannot be changed (the linear acceleration/deceleration time constant cannot be increased), reconsider the selection, such as increasing the motor capacity.

POINT

1. In selecting the maximum torque "Ta1" required for this acceleration/deceleration pattern, the measure of it is 80% of the motor maximum torque "T_{MAX} ".
2. In high-speed rotation range, confirm that the maximum torque "Ta1" and maximum torque occurrence speed "Nm" required for this acceleration/deceleration is in the short time operation range.
3. The drive system efficiency is normally approx. 0.95 in the ball screw mechanism and approx. 0.8 in the gear mechanism.
4. For the torque characteristics in the motor high-speed rotation range, the AC input voltage is 200V. If the input voltage is low or if the power wire connecting the servo motor and drive unit is long (20m length), the short time operation range is limited. In this case, an allowance must be provided for the selection of the high-speed rotation range.

(3) Continuous characteristics

A typical operation pattern is assumed, and the motor's continuous effective load torque (Trms) is calculated from the motor shaft conversion and load torque. If numbers <1> to <8> in the following drawing were considered a one cycle operation pattern, the continuous effective load torque is obtained from the root mean square of the torque during each operation, as shown in the expression (7-9).

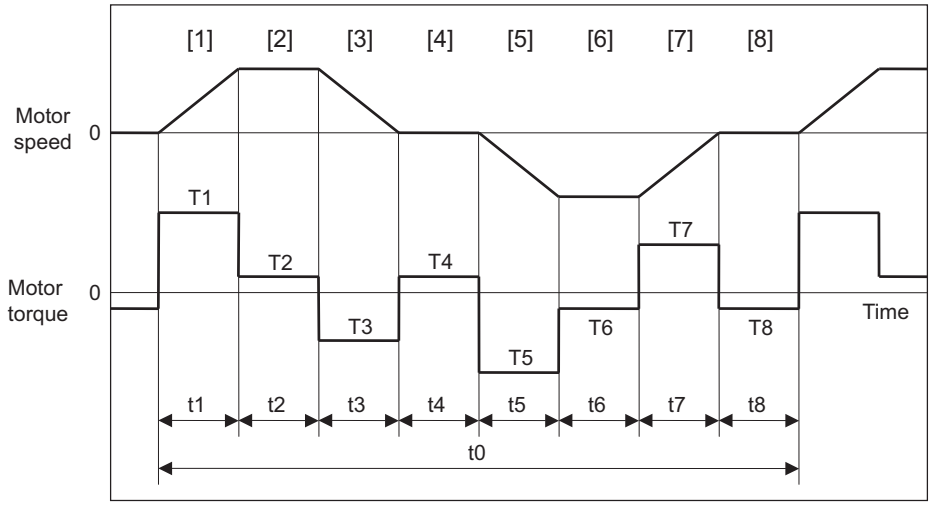


Fig. 1 Continuous operation pattern

$$Trms = \sqrt{\frac{T1^2 \cdot t1 + T2^2 \cdot t2 + T3^2 \cdot t3 + T4^2 \cdot t4 + T5^2 \cdot t5 + T6^2 \cdot t6 + T7^2 \cdot t7 + T8^2 \cdot t8}{t0}} \quad \cdots (7\text{-}9)$$

Select a motor so that the continuous effective load torque Trms is 80% or less of the motor stall torque Tst.

$$Trms \leqq 0.8 \cdot Tst \quad \cdots (7\text{-}10)$$

The amount of acceleration torque (Ta) shown in tables 7-3 and 7-4 is the torque to accelerate the load inertia in a frictionless state. It can be calculated by the expression (7-11). (For Acceleration/deceleration)

$$T_a = \frac{1.05 \times 10^{-2} \times (J_L/\eta + J_M) \times N}{ta} \quad (N \cdot m) \quad \cdots (7\text{-}11)$$

N	: Motor reach speed	(r/min)
J_L	: Motor shaft conversion load inertia	($\times 10^{-4}$kg•m^2)
J_M	: Motor inertia	($\times 10^{-4}$kg•m^2)
ta	: Acceleration/deceleration time constant	(ms)
η	: Drive system efficiency (Normally 0.8 to 0.95)	

For an unbalance axis, select a motor so that the motor shaft conversion load torque (friction torque + unbalance torque) is 60% or less of the stall. Also, select a motor so that the unbalance torque is equal to or less than the static friction torque of the magnetic brake.

$$TL \leqq 0.6 \cdot Tst \quad \cdots (7\text{-}12)$$

(a) Horizontal axis load torque

When operations [1] to [8] are for a horizontal axis, calculate so that the following torques are required in each period.

Table 7-3 Load torques of horizontal axes

Period	Load torque calculation method	Explanation
[1]	(Amount of acceleration torque) + (Kinetic friction torque)	Normally the acceleration/deceleration time constant is calculated so that this torque is 80% of the maximum torque of the motor.
[2]	(Kinetic friction torque)	
[3]	(Amount of deceleration torque) + (Kinetic friction torque)	The absolute value of the acceleration torque amount is same as the one of the deceleration torque amount. The signs for the amount of acceleration torque and amount of deceleration torque are reversed.
[4]	(Static friction torque)	Calculate so that the static friction torque is always required during a stop.
[5]	- (Amount of acceleration torque) - (Kinetic friction torque)	The signs are reversed with period <1> when the kinetic friction does not change according to movement direction.
[6]	- (Kinetic friction torque)	The signs are reversed with period <2> when the kinetic friction does not change according to movement direction.
[7]	- (Amount of deceleration torque) - (Kinetic friction torque)	The signs are reversed with period <3> when the kinetic friction does not change according to movement direction.
[8]	- (Static friction torque)	Calculate so that the static friction torque is always required during a stop.

(b) Unbalance axis load torque

When operations [1] to [8] are for an unbalance axis, calculate so that the following torques are required in each period. Note that the forward speed shall be an upward movement.

Table 7-4 Load torques of unbalance axes

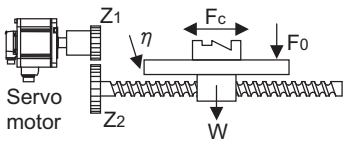
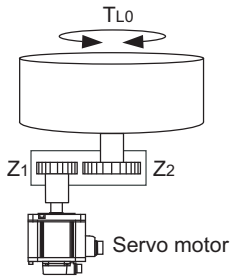
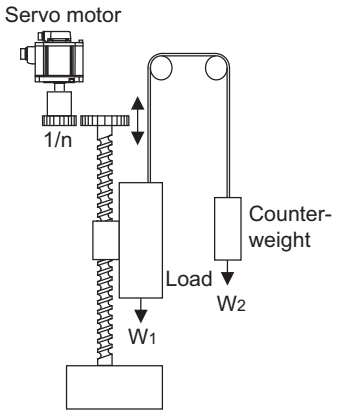
Period	Load torque calculation method	Explanation
[1]	(Amount of acceleration torque) + (Kinetic friction torque) + (Unbalance torque)	Normally the acceleration/deceleration time constant is calculated so that this torque is 80% of the maximum torque of the motor.
[2]	(Kinetic friction torque) + (Unbalance torque)	
[3]	(Amount of deceleration torque) + (Kinetic friction torque) + (Unbalance torque)	The absolute value of the acceleration torque amount is same as the one of the deceleration torque amount. The signs for the amount of acceleration torque and amount of deceleration torque are reversed.
[4]	(Static friction torque) + (Unbalance torque)	The holding torque during a stop becomes fairly large. (Upward stop)
[5]	- (Amount of acceleration torque) - (Kinetic friction torque) + (Unbalance torque)	
[6]	- (Kinetic friction torque) + (Unbalance torque)	The generated torque may be in the reverse of the movement direction, depending on the size of the unbalance torque.
[7]	- (Amount of deceleration torque) - (Kinetic friction torque) + (Unbalance torque)	
[8]	- (Static friction torque) + (Unbalance torque)	The holding torque becomes smaller than the upward stop. (Downward stop)

POINT

During a stop, the static friction torque may constantly be applied. The static friction torque and unbalance torque may be applied during an unbalance axis upward stop, and the torque during a stop may become extremely large. Therefore, caution is advised.

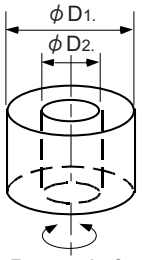
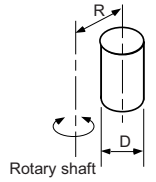
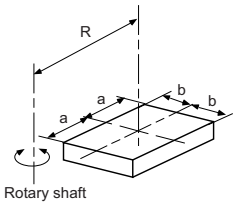
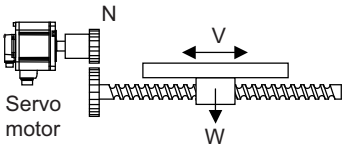
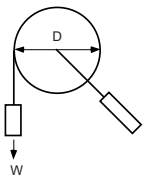
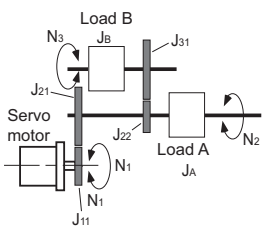
7.1.3 Motor Shaft Conversion Load Torque

The calculation method for a representative load torque is shown.

Type	Mechanism	Calculation expression
Linear movement		$T_L = \frac{F}{2\times10^3\pi\eta}\cdot(\frac{V}{N}) = \frac{F\cdot\Delta S}{2\times10^3\pi\eta}$ T_L:Load torque (N•m) F:Force in axial direction of the machine that moves linearly (N) η: Drive system efficiency V:Speed of object that moves linearly (mm/min) N:Motor speed (r/min) ΔS:Object movement amount per motor rotation (mm) Z_1,Z_2:Deceleration ratio **F in the above expression is obtained from the expression below when the table is moved as shown on the left.** **$F=Fc+\mu(W\cdot g+F_0)$** F_c:Force applied on axial direction of moving section (N) F_0:Tightening force on inner surface of table guide (N) W:Total mass of moving section (kg) g:Gravitational acceleration = 9.8 (m/s^2) μ:Friction coefficient
Rotary movement		$T_L = \frac{Z_1}{Z_2}\cdot\frac{1}{\eta}\cdot T_{L0}+T_F = \frac{1}{n}\cdot\frac{1}{\eta}\cdot T_{L0}+T_F$ T_L:Load torque (N•m) T_{L0}:Load torque on load shaft (N•m) T_F:Motor shaft conversion load friction torque (N•m) η:Drive system efficiency Z_1,Z_2:Deceleration ratio n:Deceleration ratio
Vertical movement		**When rising $T_L=T_U+T_F$ When lowering $T_L=-T_U\cdot\eta^2+T_F$** T_L:Load torque (N•m) T_U:Unbalanced torque (N•m) T_F:Friction torque on moving section (N•m) $T_U = \frac{(W_1-W_2)\cdot g}{2\times10^3\pi\eta}\cdot(\frac{V}{N}) = \frac{(W_1-W_2)\cdot g\cdot\Delta S}{2\times10^3\pi\eta}$ $T_F = \frac{\mu\cdot(W_1+W_2)\cdot g\cdot\Delta S}{2\times10^3\pi\eta}$ W_1:Load mass (kg) W_2:Counterweight mass (kg) η: Drive system efficiency g:Gravitational acceleration = 9.8 (m/s^2) V:Speed of object that moves linearly (mm/min) N:Motor speed (r/min) ΔS:Object movement amount per motor rotation (mm) μ:Friction coefficient

7.1.4 Expressions for Load Inertia Calculation

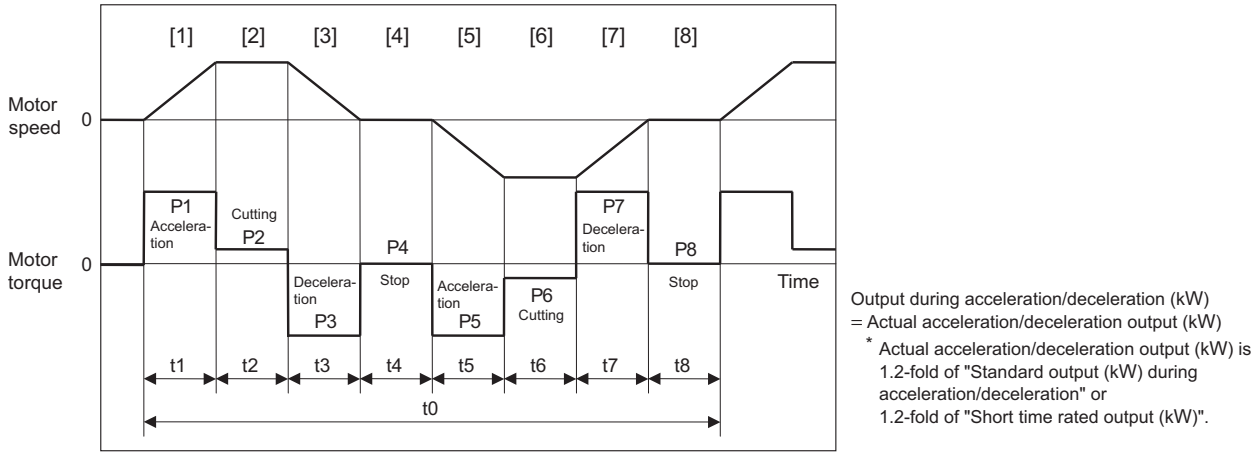
The calculation method for a representative load inertia is shown.

Type	Mechanism	Calculation expression
Cylinder	Rotary shaft is cylinder center 	$J_L = \frac{\pi \cdot \rho \cdot L}{32} \cdot (D_1^4 - D_2^4) = \frac{W}{8} \cdot (D_1^2 + D_2^2)$ T_L:Load inertia (kg•cm^2) ρ: Density of cylinder material (kg/cm^3) L:Length of cylinder (cm) D_1:Outer diameter of cylinder (cm) D_2:Inner diameter of cylinder (cm) W:Mass of cylinder (kg) <Reference data (Material densities)> Iron:7.80×10^{-3}(kg/cm^3) Aluminum:2.70×10^{-3}(kg/cm^3) Copper:8.96×10^{-3}(kg/cm^3)
	When rotary shaft and cylinder shaft are deviated 	$J_L = \frac{W}{8} \cdot (D^2 + 8R^2)$ J_L:Load inertia (kg•cm^2) W:Mass of cylinder (kg) D:Outer diameter of cylinder (cm) R:Distance between rotary axis and cylinder axis (cm)
Column		$J_L = W(\frac{a^2 + b^2}{3} + R^2)$ J_L: Load inertia (kg•cm^2) W:Mass of column (kg) a,b,R:Left diagram (cm)
Object that moves linearly		$J_L = W(\frac{1}{2\pi N} \cdot \frac{V}{10})^2 = W(\frac{\Delta S}{20\pi})^2$ J_L:Load inertia (kg•cm^2) W:Mass of object that moves linearly (kg) N:Motor speed (r/min) V:Speed of object that moves linearly (mm/min) ΔS:Object movement amount per motor rotation (mm)
Suspended object		$J_L = W(\frac{D}{2})^2 + J_p$ J_L:Load inertia (kg•cm^2) W:Object mass (kg) D:Diameter of pulley (cm) Jp:Inertia of pulley (kg•cm^2)
Converted load		$J_L = J_{11} + (J_{21} + J_{22} + J_A) \cdot (\frac{N_2}{N_1})^2 + (J_{31} + J_B) \cdot (\frac{N_3}{N_1})^2$ J_L:Load inertia (kg•cm^2) J_A,J_B:Inertia of load A, B (kg•cm^2) J_{11} to J_{31}:Inertia (kg•cm^2) N_1 to N_3:Each shaft's speed (r/min)

7.2 Selection of the Spindle Motor

(1) Calculation of average output for spindle

In the machine which carries out the spindle's acceleration/deceleration frequently (example: tapping center), short-time rating is frequently used, and a rise in temperature become significant on the spindle motor or drive unit. Thus, calculate the average output (P_{AV}) from one cycle operation pattern and confirm that the calculated value is less than the continuous rating output of the selected spindle motor.



Output during acceleration/deceleration (kW)
= Actual acceleration/deceleration output (kW)
* Actual acceleration/deceleration output (kW) is 1.2-fold of "Standard output (kW) during acceleration/deceleration" or 1.2-fold of "Short time rated output (kW)".

Continuous operation pattern (example)

$$P_{AV} = \sqrt{\frac{P1^2 \cdot t1 + P2^2 \cdot t2 + P3^2 \cdot t3 + P4^2 \cdot t4 + P5^2 \cdot t5 + P6^2 \cdot t6 + P7^2 \cdot t7 + P8^2 \cdot t8}{t0}}$$

P1 to P8 :Output
t1 to t8 :Time
t0 :One cycle operation time

Continuous rated output $\geqq$ One cycle operation pattern average output (P_{AV})

POINT

1. Calculate acceleration/deceleration time by the accurate load inertia because even if the rotation speed is the same, acceleration/deceleration time varies with a tool or workpiece mounted to the spindle.
   Refer to the section "Adjusting the Acceleration/Deceleration Operation" (1) in Instruction Manual.
2. Calculation method of synchronous tapping
   The acceleration/deceleration number of times is twice, for forward run and reverse run are carried out in one machining.
   The output guideline is 50% of the short-time rating. The time is tapping time constant.
3. Calculation method of spindle synchronization
   The output guideline is 70% of the short-time rating. The time is spindle synchronization time constant.

7.3 Selection of the Regenerative Resistor

7.3.1 Regeneration Methods

When the motor decelerates, rotating load inertia or the operation energy of the moving object is returned to the drive unit through the motor as electrical power. This is called "regeneration". The three general methods of processing regeneration energy are shown below.

Table 7-5 Drive unit regeneration methods

Regeneration method	Explanation
1. Condenser regeneration method	This is a regeneration method for small-capacity drive units. The regeneration energy is charged to the condenser in the drive unit, and this energy is used during the next acceleration. The regeneration capacity decreases as the power supply voltage becomes higher.
2. Resistance regeneration method	If the condenser voltage rises too high when regenerating with the condenser only, the regenerative electrical power is consumed using the resistance. If the regeneration energy is small, it will only be charged to the condenser. Because regeneration energy becomes heat due to resistance, heat radiation must be considered. In large capacity drive units the regenerative resistance becomes large and this is not practical.
3. Power supply regeneration method	This is a method to return the regeneration energy to the power supply. The regeneration energy does not become heat as in regenerative resistance. (Heat is generated due to regeneration efficiency problems.) The circuit becomes complicated, but in large capacity drive units having large regeneration capacity this method improves regeneration frequency than regenerative resistor.

The resistance regeneration method are used in the MDS-DJ-V1/V2/SP/SP2. For MDS-DJ-V1/V2 Series (servo), the regenerative resistor is mounted in the drive unit as a standard. If the regenerative capacity becomes large, an option regenerative resistor is connected externally to the unit. (Combined use with the built-in resistor is not possible.)
When the power supply regeneration method is used, consider using the MDS-D2-V1/V2, MDS-D2-SP/SP2 Series, MDS-DM2-SPV Series.

POINT

Make sure to mount the optional regenerative resistor outside the MDS-DJ-SP/SP2 Series (spindle) unit. A built-in regenerative resistor is not mounted.

7.3.2 Calculation of the Regenerative Energy

Calculate the regenerative energy for stopping from each axis' rapid traverse rate (maximum rotation speed for spindle), and select a regenerative resistor having a capacity that satisfies the positioning frequency determined from the machine specifications.

(1) For horizontal servo axis and spindle

The regenerative energy ER consumed by the regenerative resistor can be calculated from expression (7- 13). If the ER value is negative, all of the regenerative energy is absorbed by the capacitor in the drive unit (capacitor regeneration), and the energy consumed by the regenerative resistor is zero (ER= 0).

$$E_R = 5.48 \times 10^{-7} \cdot \eta \cdot (J_L + J_M) \cdot N^2 - Ec \quad (J) \quad \cdots (7\text{-}13)$$

η	:Motor reverse efficiency	
J_L	:Motor inertia	($\times 10^{-4}$ kg•m^2)
J_M	:Load inertia	($\times 10^{-4}$ kg•m^2)
N	:Motor speed	(r/min)
Ec	:Unit charging energy	(J)

(Example) When a load with the same inertia as the motor is connected to the HF54, determine the regenerative energy to stop from the rated rotation speed. Note that the drive unit is MDS-DJ-V1-30 in this case.
According to expression (7-13), the regenerative energy ER is:

$E_R = 5.48 \times 10^{-7} \times 0.85 \times (6.1 + 6.1) \times 3000^2 - 18 = 33.1$ (J)

Drive unit charging energy

Drive unit	Charging energy Ec (J)	Drive unit	Charging energy Ec (J)
MDS-DJ-V1-10	9	**MDS-DJ-SP-20**	18
MDS-DJ-V1-15	11	**MDS-DJ-SP-40**	36
MDS-DJ-V1-30	18	**MDS-DJ-SP-80**	40
MDS-DJ-V1-40	36	**MDS-DJ-SP-100**	45
MDS-DJ-V1-80	36	**MDS-DJ-SP-120**	45
MDS-DJ-V1-100	40	**MDS-DJ-SP-160**	70
MDS-DJ-V2-3030	44	**MDS-DJ-SP2-2020**	44

Motor reverse efficiency

Motor	Motor reverse efficiency η	Motor	Motor reverse efficiency η
HF75,105	0.85	**All spindle motors**	0.90
HF54, 104, 154, 224, 123, 223, 142	0.85		
HF204, 354, 303, 302	0.85		
HF-KP13	0.55		
HF-KP23	0.70		
HF-KP43	0.85		
HF-KP73	0.85		

POINT

The charging energy values apply when the unit input power voltage is 220V. If the input voltage is higher, the charging energy decreases, and the regenerative energy increases.

(2) For servo unbalance axis

The regenerative energy differs in the upward stop and downward stop for an unbalance axis. A constant regeneration state results during downward movement if the unbalance torque is the same as or larger than the friction torque.

Regenerative energy		
Upward stop	A regenerative state only occurs when deceleration torque (downward torque) is generated. $E_{RU} = 5.24 \times 10^{-5} \cdot \eta \cdot T_{du} \cdot N \cdot t_d - Ec$ (J)	••• (7-14)
	η :Motor reverse efficiency T_{du} :Upward stop deceleration torque N :Motor speed t_d :Deceleration time (time constant) Ec :Unit charging energy	(N•m) (r/min) (ms) (J)
Downward stop	A regenerative state occurs even during constant rate feed when the upward torque Ts during dropping is generated. Calculate so that Ts = 0 when Ts is downward. $E_{RD} = \frac{2\pi \cdot \eta \cdot Ts \cdot L}{\Delta S} + 5.24 \times 10^{-5} \cdot \eta \cdot T_{dd} \cdot N \cdot t_d - Ec$ (J)	••• (7-15)
	η :Motor reverse efficiency Ts :Upward torque during dropping L :Constant speed travel ΔS :Travel per motor rotation T_{dd} :Downward stop deceleration torque N :Motor speed t_d :Deceleration time (time constant) Ec :Unit charging energy (J)	(N•m) (mm) (mm) (N•m) (r/min) (ms) (J)
The regenerative energy per cycle (E_R) is obtained using expression (7-16) using one reciprocation as one cycle. $E_R = E_{RU} + E_{RD}$ (J)		••• (7-16)

(Example)

Using a machine tool vertical axis driven by an HF154 motor, reciprocation is carried out with F30000 at an acceleration/deceleration time constant of 100ms for a distance of 200mm. Obtain the regenerative energy per reciprocation operation in this case.

Where:

Servo drive unit	: MDS-DJ-V1-80
Travel per motor rotation	: 10 mm
Upward stop deceleration torque	: 20 N•m
Downward stop deceleration torque	: 30 N•m
Upward torque during downward movement	: 3 N•m

Using expression (7-14), the upward stop regenerative energy E_{RU} is as follows:

$$E_{RU} = 5.24 \times 10^{-5} \times 0.85 \times 20 \times 3000 \times 100 - 40 = 227.2 \text{ (J)}$$

The acceleration/deceleration distance required to accelerate at the 100ms acceleration/deceleration time constant to 30000mm/min. is as follows:

$$\frac{30000 \times 100}{2 \times 60 \times 1000} = 25 \text{ (mm)}$$

Therefore, the constant speed travel is 150mm.

The downward stop regenerative energy E_{RD} is obtained using the following expression (7-15).

$$E_{RD} = \frac{2\pi \times 0.85 \times 3 \times 150}{10} + 5.24 \times 10^{-5} \times 0.85 \times 30 \times 3000 \times 100 - 40 = 601.2 \text{ (J)}$$

Thus, the regenerative energy per reciprocation operation E_R is as follows:

$$E_R = 227.2 + 601.2 = 828.4 \text{ (J)}$$

7.3.3 Calculation of the Positioning Frequency

Select the regenerative resistor so that the positioning frequency (deceleration stopping frequency for spindle) DP (times/minute) calculated from the regenerative resistor capacity PR (W) and regenerative energy ER (J) consumed by the regenerative resistor is within the range shown in expression (7-17). For the unbalance axis, calculate using the regenerative energy ER per reciprocation operation, and judge the numbers of operation cycles for rising and lowering as DP.

$$DP < 48 \cdot \frac{P_R}{E_R} \quad \text{(times/minute)} \quad \cdots(7\text{-}17)$$

List of servo regenerative resistor correspondence

Corresponding servo drive unit	Standard built-in regenerative resistor		External option regenerative resistor						
			MR-RB032	MR-RB12	MR-RB32	MR-RB30	MR-RB50	MR-RB31	MR-RB51
				GZG200W39 OHMK	GZG200W120 OHMK ×3 units	GZG200W39 OHMK ×3 units	GZG300W39 OHMK ×3 units	GZG200W20 OHMK ×3 unit	GZG300W20 OHMK ×3 unit
	Parameter setting value		1200h	1300h	1400h	1500h	1600h	1700h	1800h
	Regenerative capacity		30W	100W	300W	300W	500W	300W	500W
		Resistance value	40Ω	40Ω	40Ω	13Ω	13Ω	6.7Ω	6.7Ω
MDS-DJ-V1-10	10W	100Ω	○	○					
MDS-DJ-V1-15	10W	100Ω	○	○					
MDS-DJ-V1-30	20W	40Ω	○	○	○				
MDS-DJ-V1-40	100W	13Ω				○	○		
MDS-DJ-V1-80	100W	9Ω				○	○	○	○
MDS-DJ-V1-100	100W	9Ω				○	○	○	○
MDS-DJ-V2-3030	100W	9Ω				○	○		

Corresponding servo drive unit	Standard built-in regenerative resistor		External option regenerative resistor					
			FCUA-RB22	FCUA-RB37	FCUA-RB55	R-UNIT2	FCUA-RB55 2 units connected in parallel	FCUA-RB75/2 2 units connected in parallel
	Parameter setting value		2400h	2500h	2600h	2900h	2E00h	2D00h
	Regenerative capacity		155W	185W	340W	700W	680W	680W
		Resistance value	40Ω	25Ω	20Ω	15Ω	10Ω	15Ω
MDS-DJ-V1-10	10W	100Ω						
MDS-DJ-V1-15	10W	100Ω						
MDS-DJ-V1-30	20W	40Ω	○					
MDS-DJ-V1-40	100W	13Ω		○	○	○		○
MDS-DJ-V1-80	100W	9Ω			○	○	○	○
MDS-DJ-V1-100	100W	9Ω				○	○	○
MDS-DJ-V2-3030	100W	9Ω		○	○			

List of spindle regenerative resistor correspondence

Corresponding spindle drive unit		External option regenerative resistor			
		MR-RB12	MR-RB32	MR-RB30	MR-RB50
		GZG200W39OHMK	GZG200W120 OHMK×3 units	GZG200W39 OHMK×3 units	GZG300W39 OHMK×3 units
	Parameter setting value	1300h	1400h	1500h	1600h
	Regenerative capacity	100W	300W	300W	500W
	Resistance value	40Ω	40Ω	13Ω	13Ω
MDS-DJ-SP-20	---	○	○		
MDS-DJ-SP-40	---			○	○
MDS-DJ-SP-80	---			○	○
MDS-DJ-SP-100	---			○	○
MDS-DJ-SP-120	---				○
MDS-DJ-SP-160	---				
MDS-DJ-SP2-2020	---			○	○

Corresponding spindle drive unit		External option regenerative resistor			
		FCUA-RB22	FCUA-RB37	FCUA-RB55	FCUA-RB75/2 (1 unit)
	Parameter setting value	2400h	2500h	2600h	2700h
	Regenerative capacity	155W	185W	340W	340W
	Resistance value	40Ω	25Ω	20Ω	30Ω
MDS-DJ-SP-20	---	○	○		
MDS-DJ-SP-40	---	○	○	○	○
MDS-DJ-SP-80	---		○	○	○
MDS-DJ-SP-100	---			○	
MDS-DJ-SP-120	---				
MDS-DJ-SP-160	---				
MDS-DJ-SP2-2020	---	○	○	○	

Corresponding spindle drive unit		External option regenerative resistor						
		R-UNIT1	R-UNIT2	R-UNIT3	R-UNIT4	R-UNIT5	FCUA-RB55 2 units connected in parallel	FCUA-RB75/2 2 units connected in parallel
	Parameter setting value	2800h	2900h	2A00h	2B00h	2C00h	2E00h	2D00h
	Regenerative capacity	700W	700W	2100W	2100W	3100W	680W	680W
	Resistance value	30Ω	15Ω	15Ω	10Ω	10Ω	10Ω	15Ω
MDS-DJ-SP-20	---							
MDS-DJ-SP-40	---	○	○	○				○
MDS-DJ-SP-80	---	○	○	○	○	○	○	○
MDS-DJ-SP-100	---		○	○	○	○	○	○
MDS-DJ-SP-120	---		○	○	○	○	○	○
MDS-DJ-SP-160	---				○	○		
MDS-DJ-SP2-2020	---							

⚠ CAUTION

MDS-DJ-SP/SP2 (spindle) unit is not equipped with a built-in regenerative resistor.

Thus, always mount the optional regenerative resistor outside the unit.

7.4 Required Capacity of Power Supply

For the power supply capacity, calculate the required spindle rated output and servo motor rated output each, and select the power supply capacity satisfying them.

(1) Spindle rated output required for power supply

The spindle rated output required for power supply is calculated according to the following procedure.

(a) Spindle motor rated output

The spindle motor rated output is calculated from the following expression.

Spindle motor rated output =

MAX (continuous rated output, short-time rated output × short-time rated output coefficient α, %ED rated output × %ED rated output coefficient β)

(Note 1) For the spindle motor rated output, use the maximum value of "continuous rated output", "short-time rated output × short-time rated output coefficient α", and "%ED rated output × %ED rated output coefficient β".

(Note 2) Select the maximum value for the spindle motor with multiple %ED rated output characteristics.

For the spindle short-time rated output coefficient α, use the value in the "Table 1.1", and for the %ED rated output coefficient β, use the value in the "Table 1.2".

Table1.1 List of short-time rated output time and short-time rated output coefficient

Short-time rated output time	Short-time rated output coefficient α	Short-time rated output time	Short-time rated output coefficient α
1 minute	0.2	**5 minutes**	0.7
2 minutes	0.4	**6 to 7 minutes**	0.8
3 minutes	0.5	**8 to 9 minutes**	0.9
4 minutes	0.6	**10 minutes or more**	1.0

(Note 1) Select the set time for the short-time rated output of your spindle motor from the list.
E.g.) When the set time for the short-time rated output is "1/12h", it means "5 minutes".

(Note 2) For the motor with coil changeover specification, select the set time for the short-time rated output of the high-speed coil.

Table 1.2 List of %ED rated output time and %ED rated output coefficient

%ED rated output time	%ED rated output coefficient β
More than or equal to 10% but less than 20%	0.7
More than or equal to 20% but less than 30%	0.9
More than or equal to 30%	1.0

(b) Spindle rated output required for power supply

Spindle rated output required for power supply =

Spindle motor rated output × motor output coefficient γ of combined spindle drive unit

For the spindle motor rated output of the above expression, use the value calculated in (a).

For the motor output coefficient of the combined spindle drive unit, use the value corresponding to the used spindle drive unit in the table 2.

Table 2 List of motor output coefficient of the combined spindle drive unit

Spindle motor rated output	Combined spindle drive unit MDS-DJ-SP					
	20	**40**	**80**	**100**	**120**	**160**
to 0.75kW	1.00	1.2	1.3	-	-	-
to 1.5kW	-	1.0	1.15	1.25	1.3	-
to 2.2kW	-	1.0	1.05	1.15	1.25	1.3
to 3.7kW	-	-	1.0	1.0	1.1	1.2
to 5.5kW	-	-	-	1.0	1.0	1.1
to 7.5kW	-	-	-	-	1.0	1.0
to 11.0kW	-	-	-	-	-	1.0

(2) Servo motor rated output required for power supply

For the servo motor rated output required for power supply, use the value corresponding to the servo motor in table 3.

Table 3. Data for servo motor output selection

Moter HF	75	105	54	104	154	224	204	354
Rated output [kW]	0.75	1.0	0.5	1.0	1.5	2.2	2.0	3.5

Moter HF	123	223	303	142	302
Rated output [kW]	1.2	2.2	3.0	1.4	3.0

Moter HF-KP	13	23	43	73
Rated output [kW]	0.1	0.2	0.4	0.75

(3) Calculation of rated output required for power supply

(a) For the spindle motor

Rated capacity required for power supply = Σ(spindle motor rated output required for power supply)

(b) When there is only one servo motor axis

Rated capacity required for power supply = (servo motor rated output required for power supply)

(c) When there are two servo motor axes

Rated capacity required for power supply = 0.7 Σ (servo motor rated output required for power supply)

Substitute the output calculated from the item (1) and (2) to the expression (a), (b), and (c), and calculate the rated capacity required for the power supply.

(4) Calculation of required power supply

Power supply capacity (kVA) =

Σ{(Required rated capacity calculated in the item (3)(kW) / Rated output of the drive unit (kW)) × Power supply facility capacity (kVA)}

The rated output and power supply capacity base value corresponding to the capacity of the drive unit is as the following table.

< MDS-DJ-V (Servo) >

Unit / MDS-DJ-	V1-10	V1-15	V1-30	V1-40	V1-80	V1-100	V2-3030
Rated output [kW]	0.3	0.4	0.7	1.0	2.0	3.5	0.75(L/M)
Power supply capacity base value [kVA]	0.5	1.0	1.3	1.7	3.5	5.5	2.6

< MDS-DJ-SP (Spindle) >

Unit / MDS-DJ-	SP-20	SP-40	SP-80	SP-100	SP-120	SP-160	SP2-2020
Rated output [kW]	0.75	2.2	3.7	5.5	7.5	11.0	0.75(L/M)
Power supply capacity base value [kVA]	2.0	4.0	7.0	9.0	12.0	17.0	4.0

Appendix 1

Cable and Connector Specifications

Appendix 1.1 Selection of Cable

Appendix 1.1.1 Cable Wire and Assembly

(1) Cable wire

The specifications of the wire used for each cable, and the machining methods are shown in this section. Mitsubishi uses the cables shown in the tables below. When manufacturing the encoder cable and battery connection cable, use the wires shown below or equivalent products.

(a) Heat resistant specifications cable

Wire type (other manufacturer's product)	Finish outer diameter	Sheath material	No. of pairs	Wire characteristics					
				Configuration	Conductive resistor	Withstand voltage	Insulation resistance	Heat resistance temperature	Flexibility
BD20288 Compound 6-pair shielded cable Specification No. Bangishi-17145 (Note 1)	8.7mm	Heat resistant PVC	2 ($0.5mm^2$)	100 strands/ 0.08mm	40.7Ω/km or less	500VAC/ 1min	1000 MΩ/km or more	105°C	$70×10^4$ times or more at R200
			4 ($0.2mm^2$)	40 strands/ 0.08mm	103Ω/km or less				

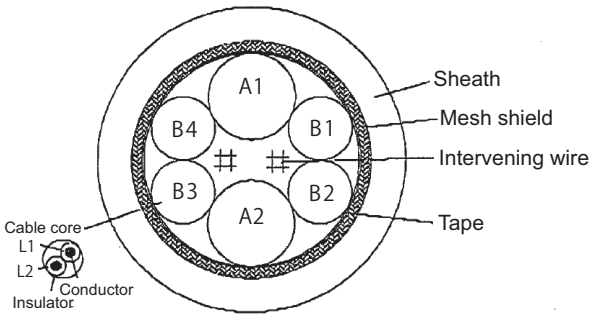
(b) General-purpose heat resistant specifications cable

Wire type (other manufacturer's product)	Finish outer diameter	Sheath material	No. of pairs	Wire characteristics					
				Configuration	Conductive resistor	Withstand voltage	Insulation resistance	Heat resistance temperature	Flexibility
BD20032 Compound 6-pair shielded cable Specification No. Bangishi-16903 Revision No. 3 (Note 2))	8.7mm	PVC	2 ($0.5mm^2$)	100 strands/ 0.08mm	40.7Ω/km or less	500VAC/ 1min	1000 MΩ/km or more	60°C	$100×10^4$ times or more at R200
			4 ($0.2mm^2$)	40 strands/ 0.08mm	103Ω/km or less				

(Note 1) BANDO Electric Wire (http://www.bew.co.jp/)

(Note 2) The Mitsubishi standard cable is the (a) Heat resistant specifications cable. When the working environment temperature is low and so higher flexibility is required, use the (b) General-purpose heat resistant specifications cable. For MDS-C1/CH series, (b) or equivalent is used as the standard cable.

Compound 6-pair cable structure drawing



Core identification

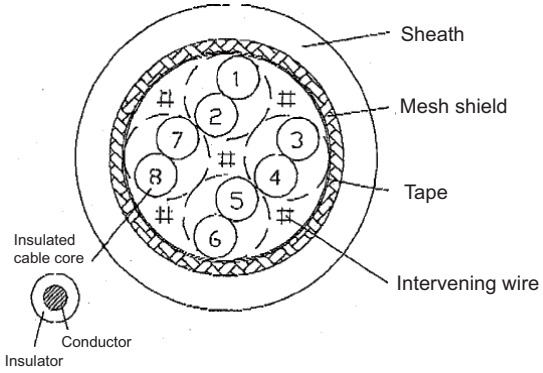
Pair No.	Insulator color	
	L1	L2
A1 ($0.5mm^2$)	Red	White
A2 ($0.5mm^2$)	Black	White
B1 ($0.2mm^2$)	Brown	Orange
B2 ($0.2mm^2$)	Blue	Green
B3 ($0.2mm^2$)	Purple	White
B4 ($0.2mm^2$)	Yellow	White

(c) HF-KP motor encoder cable

Wire type (other manufacturer's product)	Finish outer diameter	Sheath material	No. of pairs	Wire characteristics					
				Configuration	Conductive resistor	Withstand voltage	Insulation resistance	Heat resistance temperature	Flexibility
ETFE・SVP 60/ 0.08mm 4-pair shielded cable Specification No.Bangishi-17669(Note 1))	7.1mm	PVC	4 ($0.5mm^2$)	60 strands/ 0.08mm	73.0Ω/km or less	500VAC/ 1min	1500 MΩ/km or more	105°C	R200 ($70×10^4$ times or more)

(Note 1) BANDO Electric Wire (http://www.bew.co.jp/)

4-pair shielded cable structure drawing

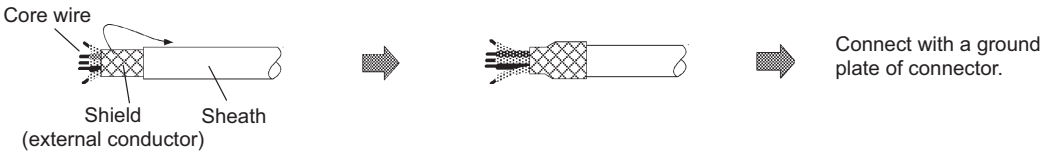


Core identification

No.	Color
1	Black
2	White
3	Red
4	Green
5	Yellow
6	Brown
7	Blue
8	Gray

(2) Cable assembly

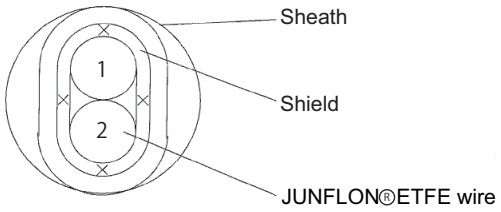
Assemble the cable with the cable shield wire securely connected to the ground plate of the connector.



(3) Battery connection cable

Wire type (other manufacturer's product)	Finish outer diameter	Sheath material	No. of pairs	Wire characteristics					
				Configura-tion	Conductive resistor	Withstand voltage	Insulation resistance	Heat resistance temperature	Flexibility
J14B101224-00 Two core shield cable	3.3mm	PVC	1 ($0.2mm^2$)	7strands / 0.2mm	91.2Ω/km or less	AC500V/ 1min	1000MΩ/ km or less	80°C	R33mm

(Note 1) Junkosha Inc. http://www.junkosha.co.jp/english/index.html
Dealer: TOA ELECTRIC INDUSTRIAL CO.,LTD. http://www.toadenki.co.jp/index_e.html



Two core shield cable structure drawing

Core identification

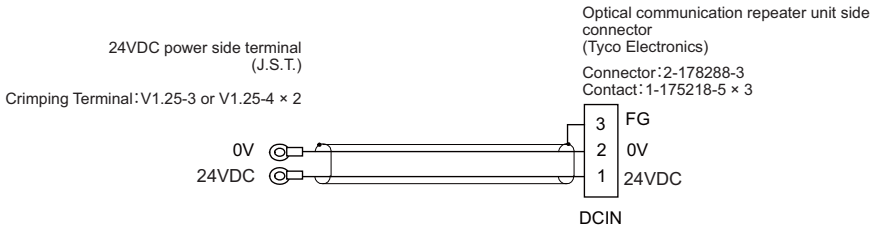
No.	Insulator color
1	Red
2	Black

Appendix 1.2 Cable Connection Diagram

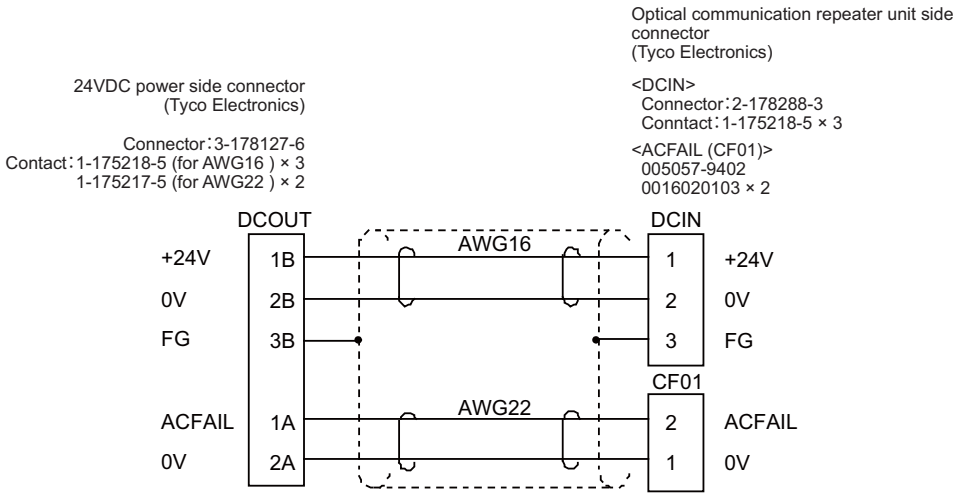
> **⚠ CAUTION**
>
> 1. Take care not to mistake the connection when manufacturing the encoder cable. Failure to observe this could lead to faults, runaway or fire.
> 2. When manufacturing the cable, do not connect anything to pins which have no description.

Appendix 1.2.1 Optical Communication Repeater Unit Cable

< F070 cable connection diagram >

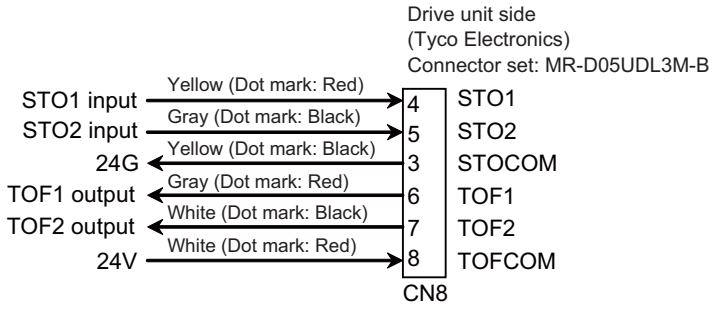


< F110 cable connection diagram >



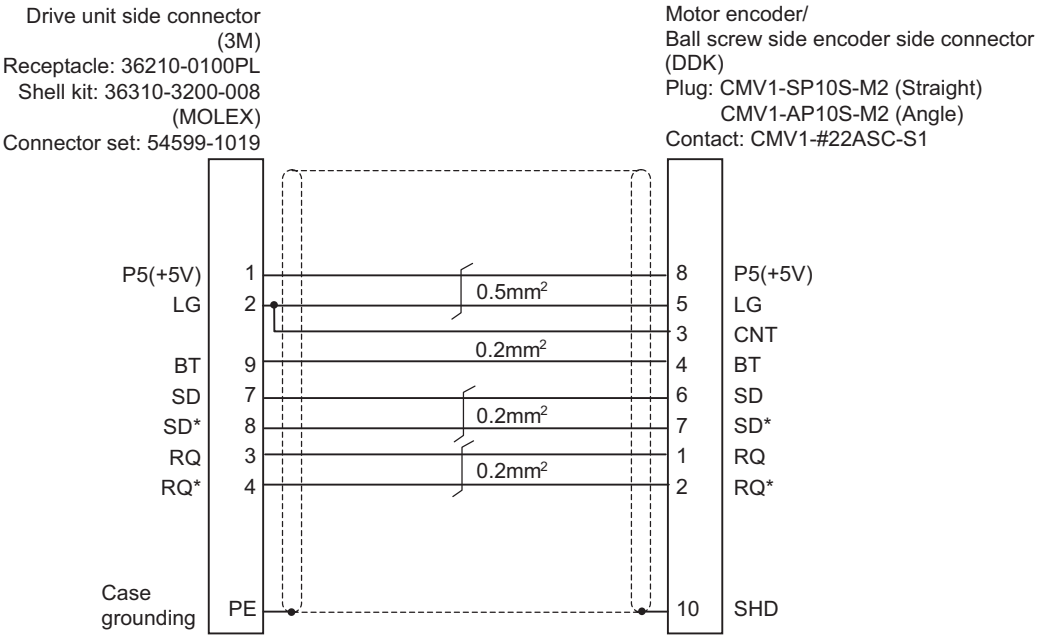
Appendix 1.2.2 STO Cable

< CN8 STO input connector connection diagram >

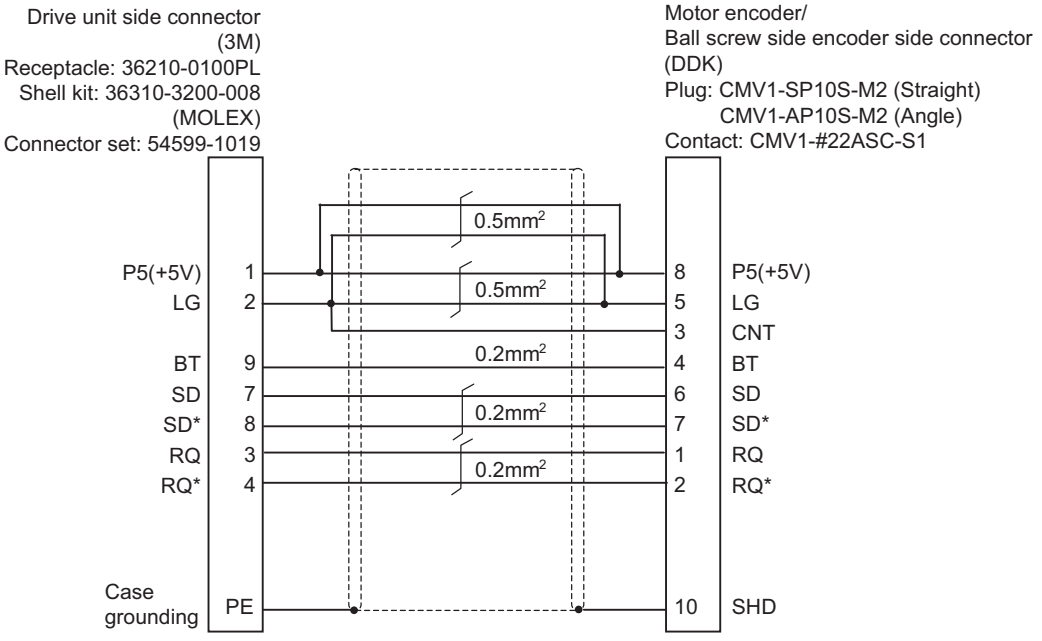


Appendix 1.2.3 Servo / Tool Spindle Encoder Cable

< CNV2E-8P, CNV2E-9P cable connection diagram >

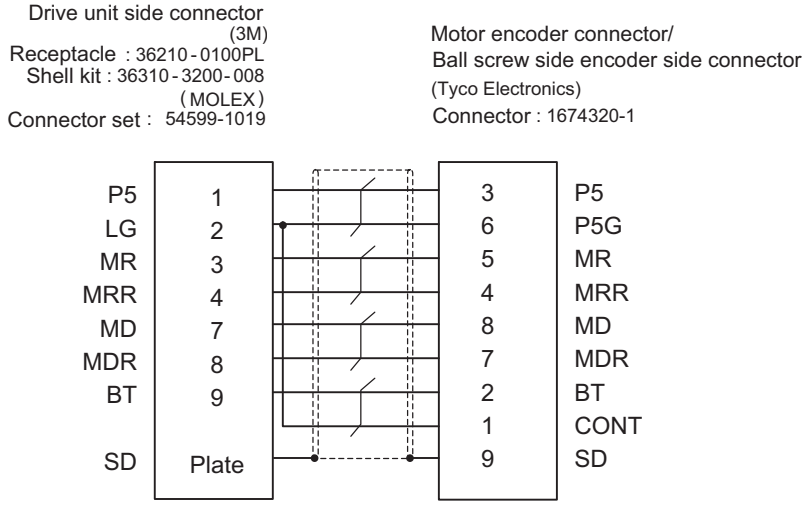


< For 15m or less >

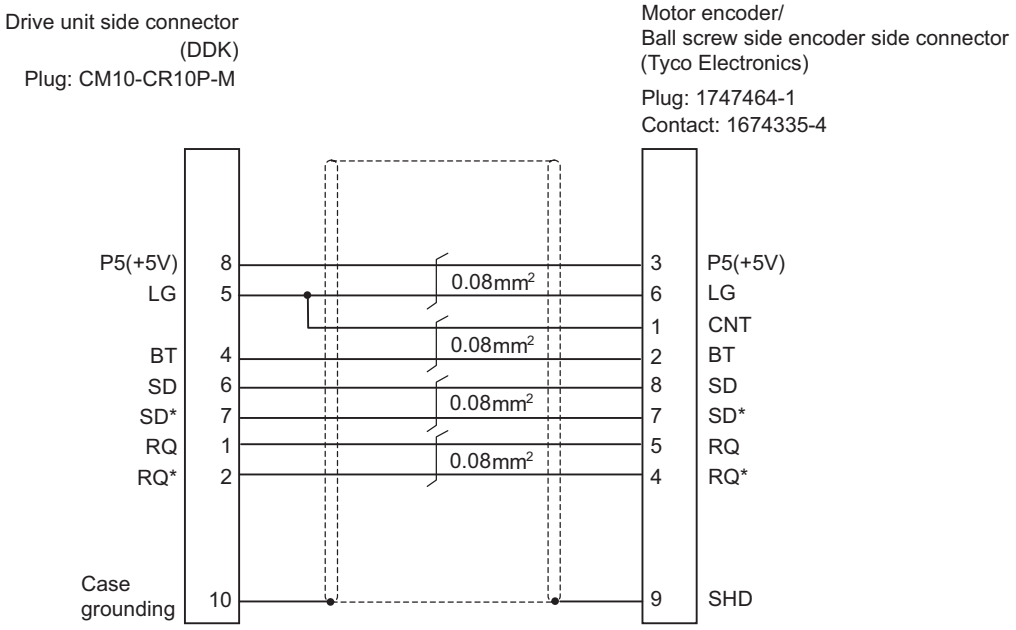


< For 15m to 30m >

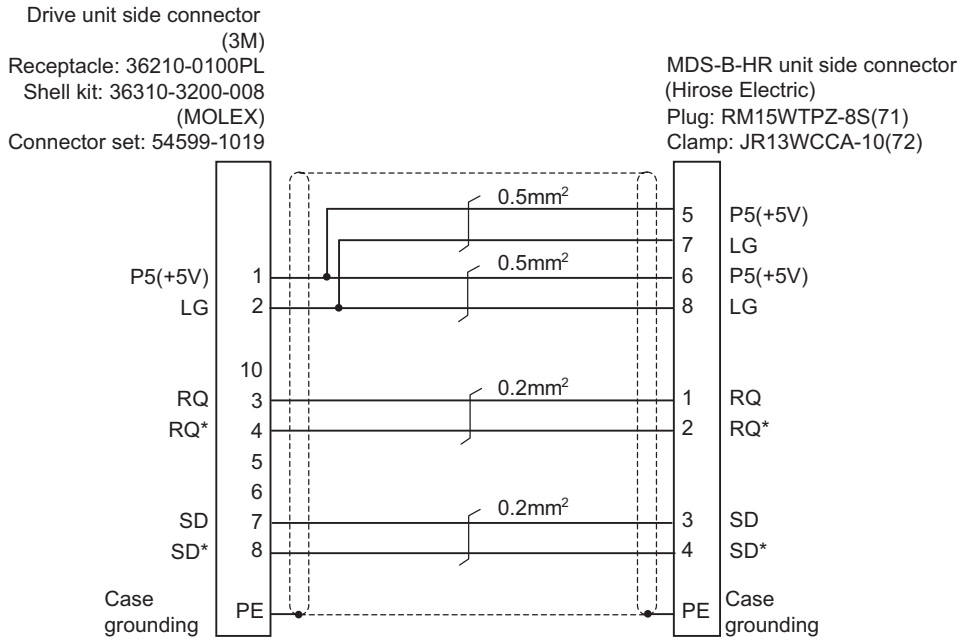
< CNV2E-K1P, CNV2E-K2P cable connection diagram (Direct connection type) >



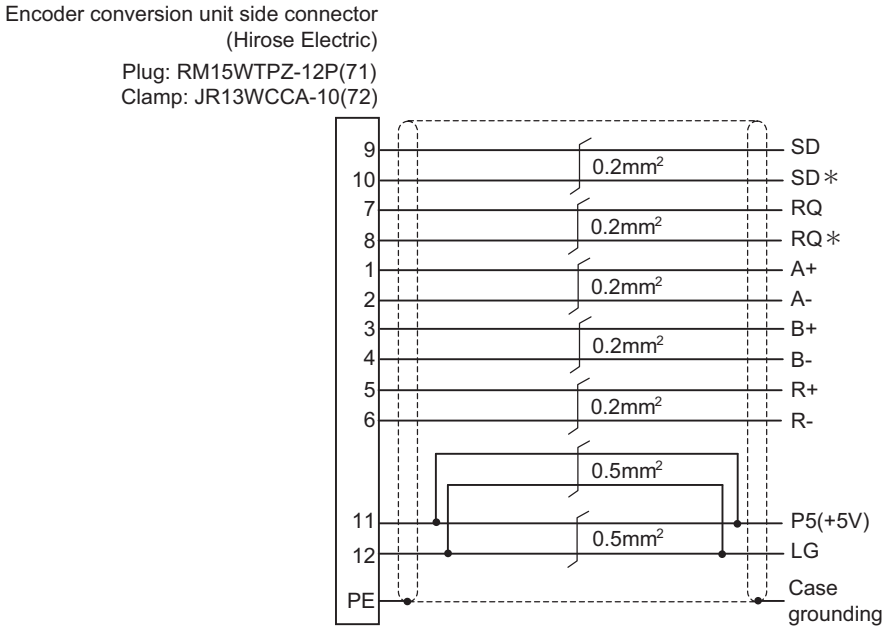
< CNV22J-K1P, CNV22J-K2P cable connection diagram (Relay type) >



< CNV2E-HP cable connection diagram >

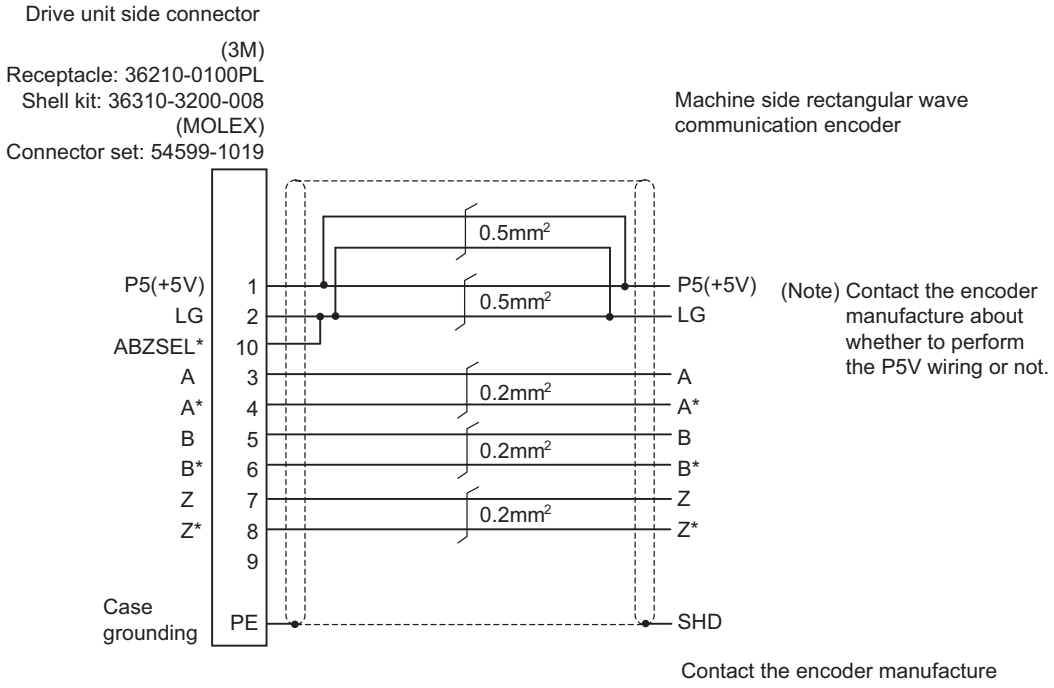


< Cable connection diagram between scale I/F unit and scale (CNLH3 cable, etc.) >



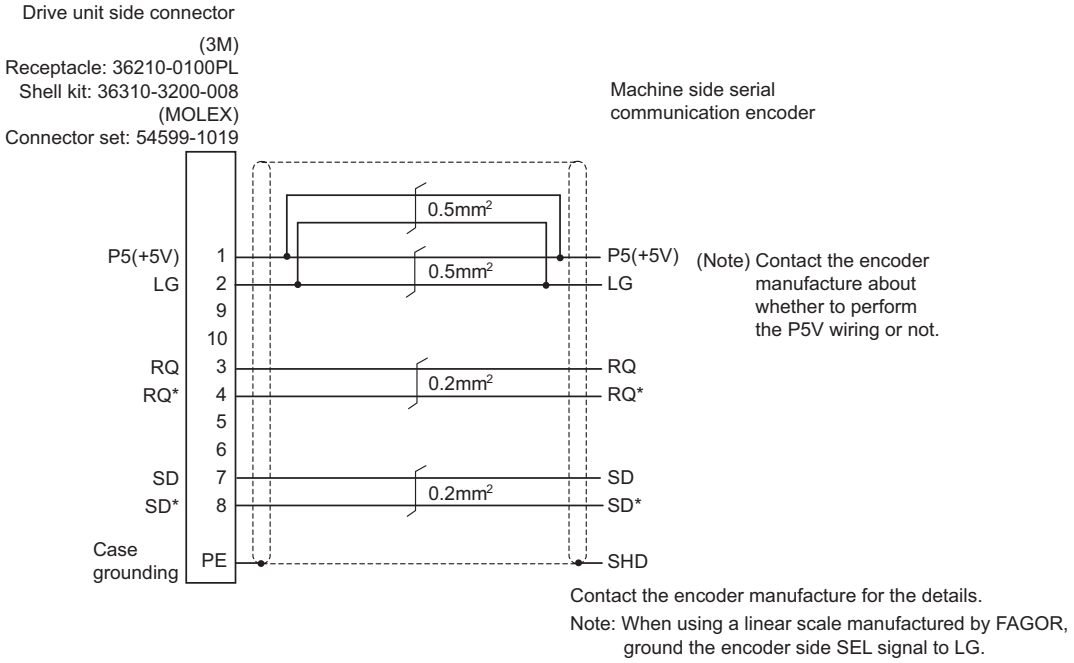
(Note) This cable must be prepared by the user.

< Rectangular wave communication encoder (linear scale, etc.) cable connection diagram >



(Note)This cable must be prepared by the user.

< Serial communication encoder (linear scale, etc.) cable connection diagram >



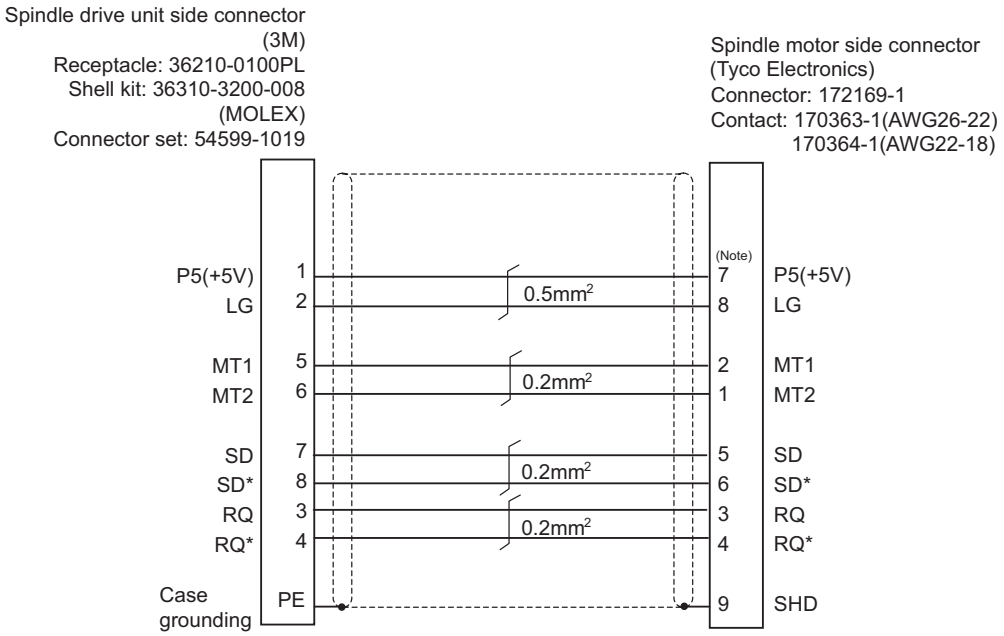
(Note)This cable must be prepared by the user.

POINT

For compatible encoder, refer to the section "Servo Option" in Specifications Manual.

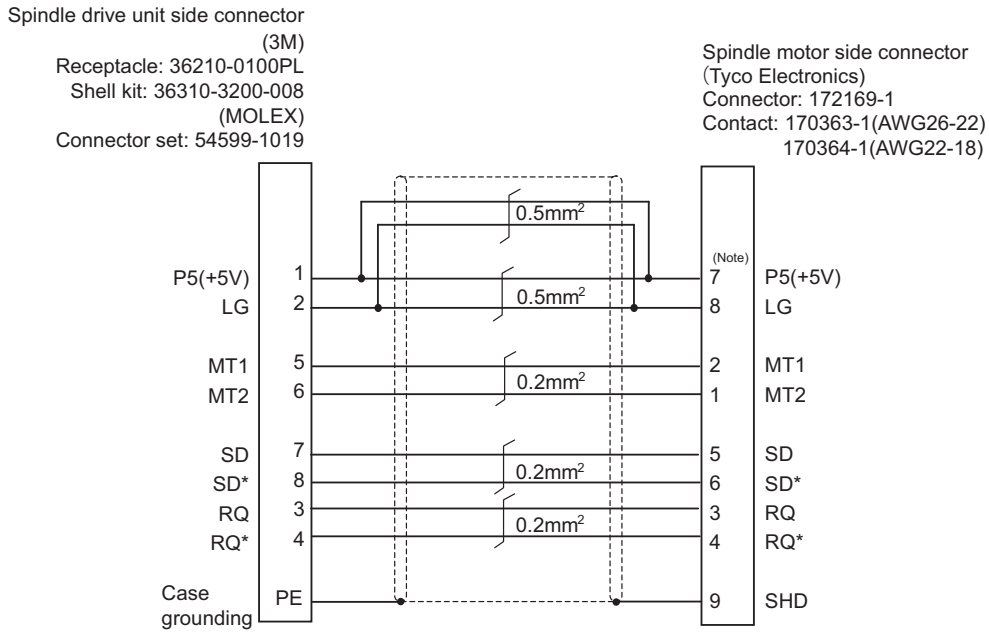
Appendix 1.2.4 Spindle Encoder Cable

< CNP2E-1 cable connection diagram >



(Note) For the pin "7" or "8", use the contact "170364-1".
For the other pins, use the contact "170363-1".

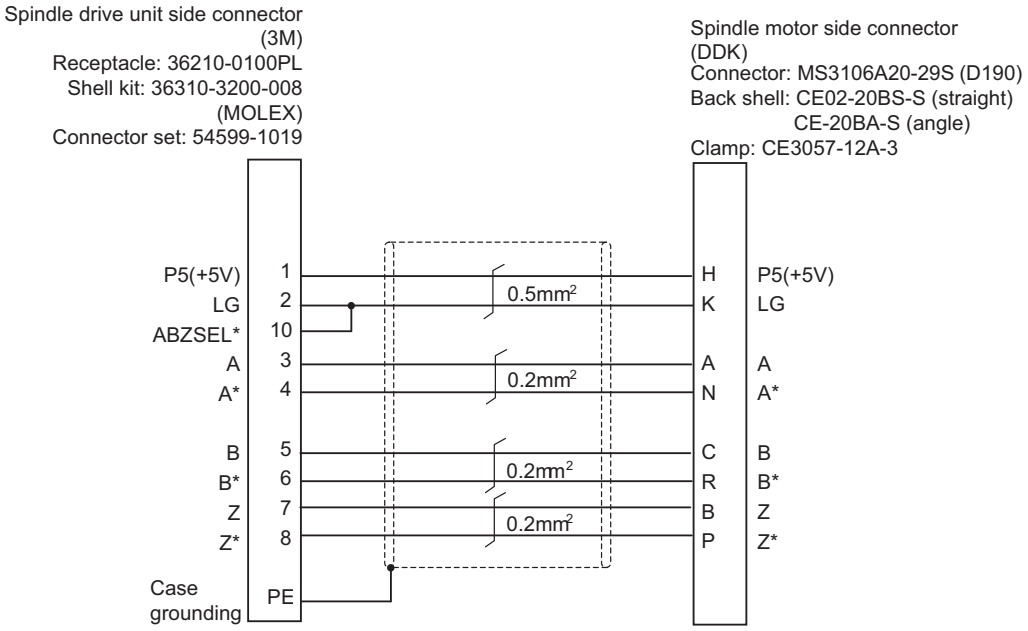
< For 15m or less >



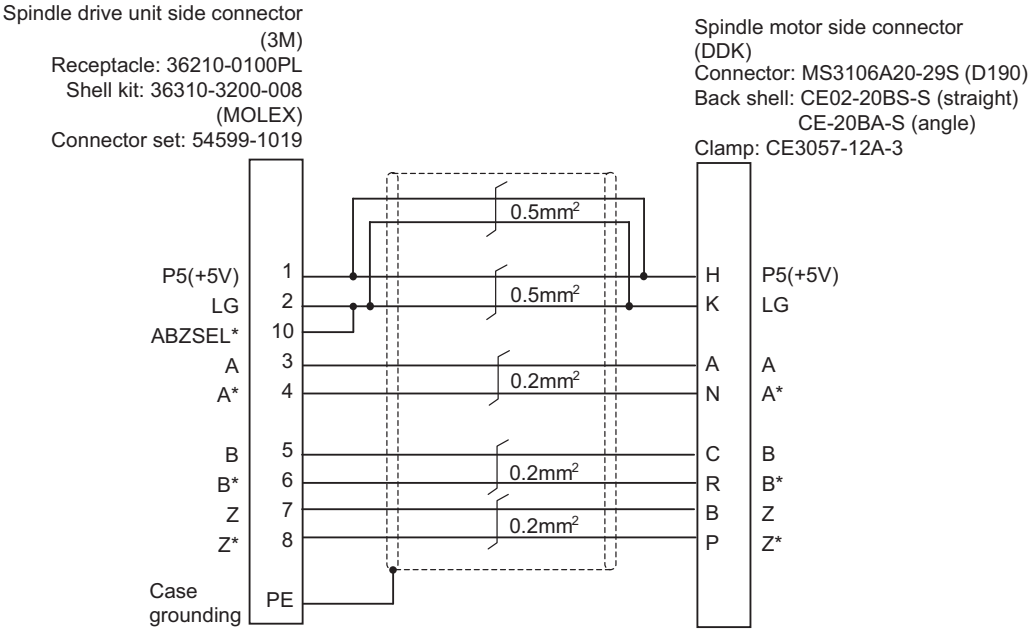
(Note) For the pin "7" or "8", use the contact "170364-1".
For the other pins, use the contact "170363-1".

< For 15m to 30m >

< CNP3EZ-2P, CNP3EZ-3P cable connection diagram >



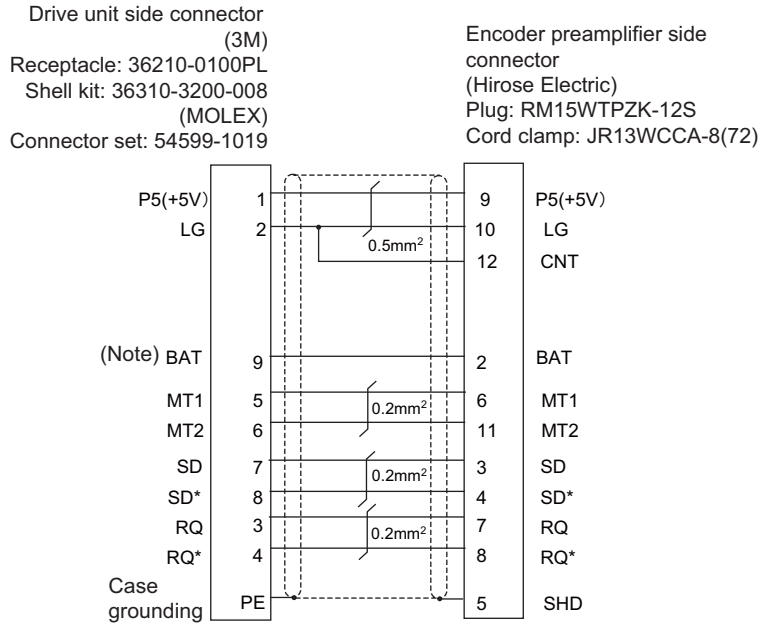
< For 15m or less >



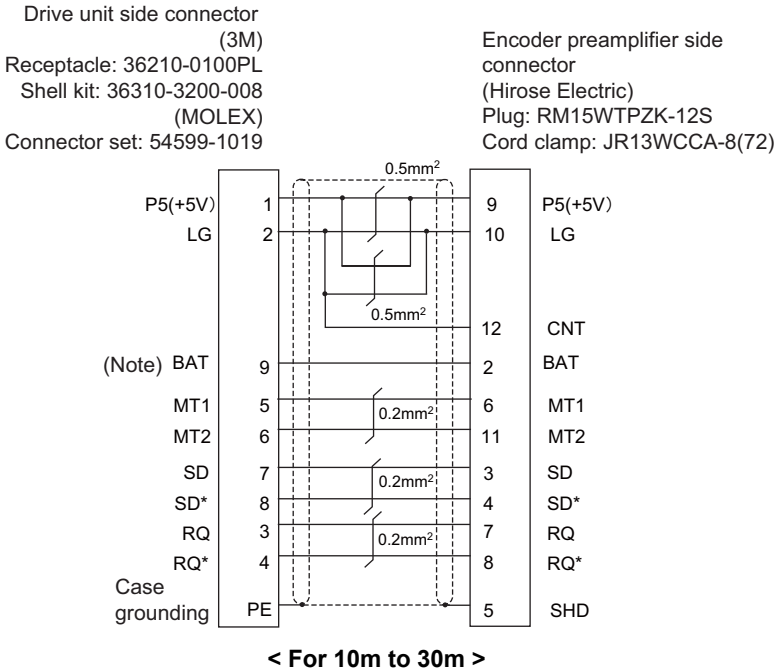
< For 15m to 30m >

Appendix 1.2.5 Twin-head Magnetic Encoder Cable

< Twin-head magnetic encoder (MBA Series) connection diagram >



< For 10m or less >



< For 10m to 30m >

(Note) The above wiring diagrams apply to both MBA405W and MBE405W.
The connection of BT can be omitted for MBE405W (incremental).

Appendix 1.3 Connector Outline Dimension Drawings

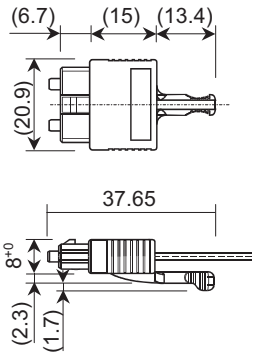
Appendix 1.3.1 Connector for Drive Unit

Optical communication cable connector

Optical communication connector

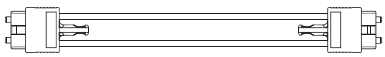
[Unit:mm]

For wiring between drive units (inside panel)
Manufacturer: Japan Aviation Electronics Industry
<Type>
Connector: PF-2D103



Cable appearance
<Type>
Connector: PF-2D103 (Japan Aviation Electronics Industry)
Optical fiber: ESKA Premium (MITSUBISHI RAYON)

(L≦0.1m)



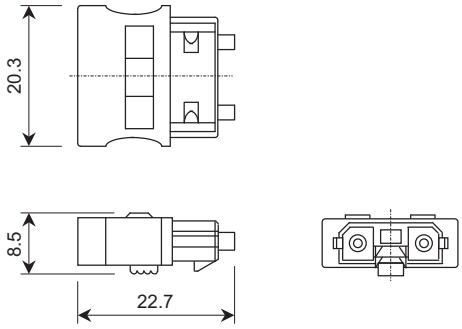
(L≧0.2m)

(Note 1) The POF fiber's light amount will drop depending on how the fibers are wound. So, try to avoid wiring the fibers.
(Note 2) Do not wire the optical fiber cable to moving sections.
(Note 3) Contact: Japan Aviation Electronics Industry, Limited http://www.jae.com/jaehome.htm

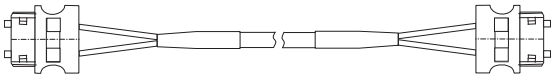
Optical communication connector

[Unit:mm]

For wiring between drive units (outside panel)
Manufacturer: Tyco Electronics
<Type>
Connector: 1123445-1



Cable appearance
<Type>
Connector: 1123445-1 (Tyco Electronics)
Optical fiber: ESKA Premium (MITSUBISHI RAYON)



(Note 1) The PCF fiber's light amount will drop depending on how the fibers are wound. So, try to avoid wiring the fibers.
(Note 2) Do not wire the optical fiber cable to moving sections.

For wiring between NC and drive unit

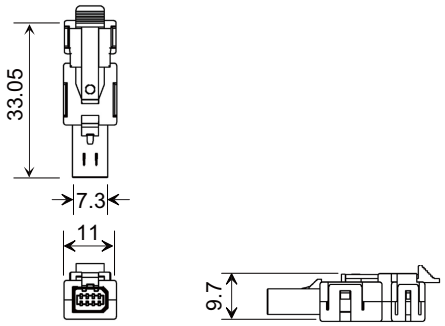
Refer to the instruction manual for CNC.

STO input connector

Drive unit connector for CN8 (STO input)

[Unit:mm]

Manufacturer: Tyco Electronics
<Type>
Connector set: 2069250-1



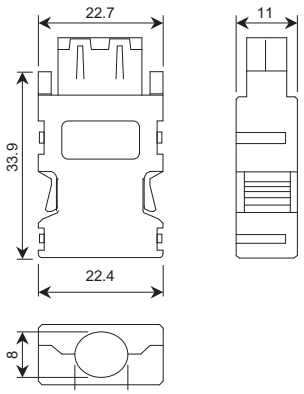
Connector for encoder cable

Spindle drive unit connector for CN2/CN3

[Unit:mm]

Manufacturer: 3M
< Type >
Receptacle: 36210-0100PL
Shell kit: 36310-3200-008

Compatible part (Note 1)
(MOLEX)
Connector set: 54599-1019
(J.S.T.)
Plug connector: XV-10P-03-L-R
Cable kit: XV-PCK10-R



(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

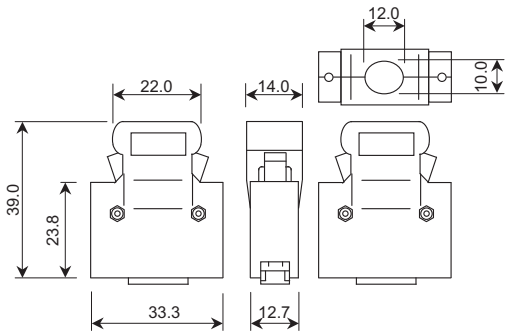
Connector for CN9

Connector for CN9 (For MDS-DJ-V1, MDS-DJ-SP)

[Unit:mm]

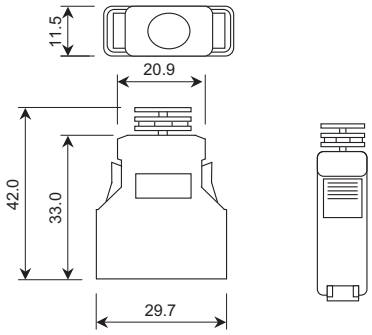
Manufacturer: 3M
< Type >
Connector :10120-3000VE
Shell kit :10320-52F0-008

Compatible part (Note 1)
(J.S.T.)
Connector: MS-P20-L
Shell kit: MS20-2B-28



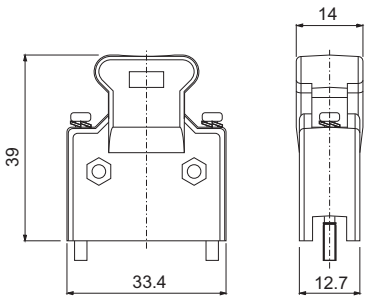
[Unit:mm]

Manufacturer: 3M
< Type >
Connector :10120-6000EL
Shell kit :10320-3210-000
This connector is integrated with the cable, and is not available as a connector set option.



[Unit:mm]

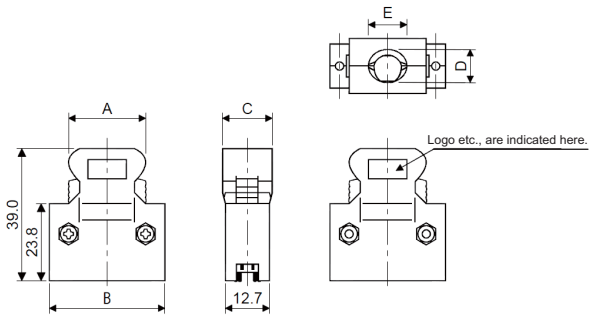
Manufacturer: J.S.T.
<Type>
Connector: MS-P20-L
Shell kit: MS20-2A-28



Connector for CN9 (For MDS-DJ-V2, MDS-DJ-SP2)

[Unit:mm]

Manufacturer: 3M
< Type >
Connector :10126-3000PE
Shell kit :10326-52F0-008



Dimensions				
A	B	C	D	E
25.8	37.2	14.0	10.0	12.0

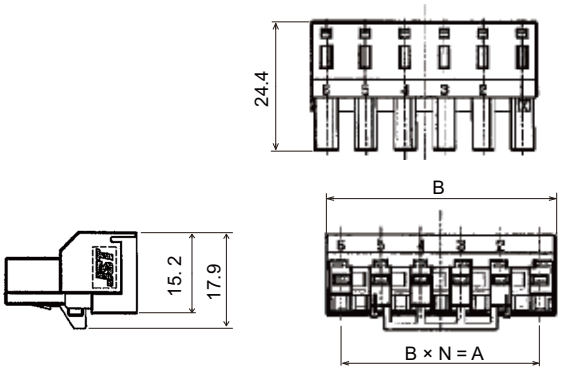
(Note 1) The names of compatible parts may be changed at the manufacturer's discretion. Contact each manufacturer for more information.

Drive unit side main circuit connector

Drive unit CNP1 connector (for power supply), CNP3 connector (for motor power) (For MDS-DJ-V1, MDS-DJ-SP)

[Unit:mm]

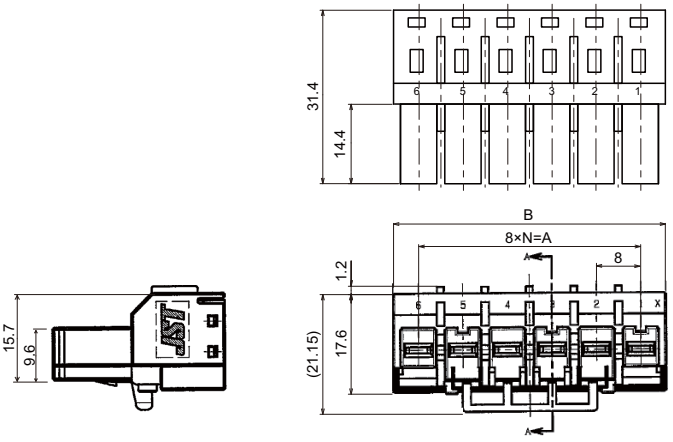
Manufacturer: J.S.T.
For MDS-DJ-V1-10/15/30
MDS-DJ-SP-20
Drive unit side main circuit connector
CNP1,CN3P



Type	A	B	N	No. of poles
06JFAT-SAXGDK-H7.5	37.5	43.3	5	6 (for CNP1)
03JFAT-SAXGDK-H7.5	15	20.8	2	3 (for CNP3)

[Unit:mm]

Manufacturer: J.S.T.
For MDS-DJ-V1-40/80/100
MDS-DJ-SP-40/80
Drive unit side main circuit connector
CNP1,CN3P

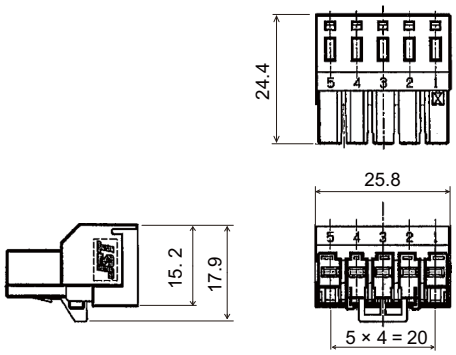


Type	A	B	N	No. of poles
06JFAT-SAXGFK-XL	40	49.1	5	6 (for CNP1)
03JFAT-SAXGFK-XL	16	25.1	2	3 (for CNP3)

Drive unit CNP2 connector (for control power) (For MDS-DJ-V1, MDS-DJ-SP)

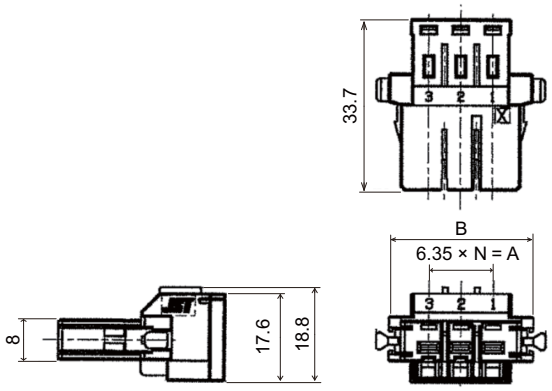
[Unit:mm]

Manufacturer: J.S.T.
< Type >
Connector:05JFAT-SAXGDK-H5.0



Drive unit CNP1 connector (for power supply) (For MDS-DJ-V2, MDS-DJ-SP2)

[Unit:mm]

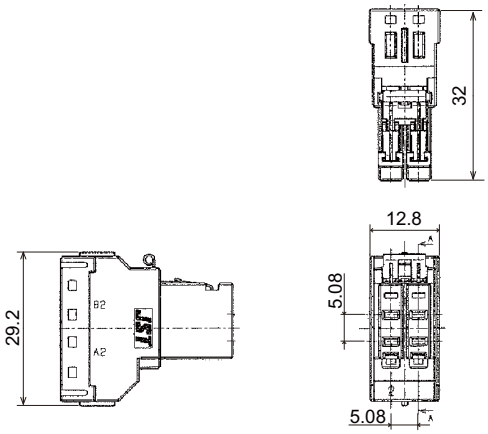


Manufacturer: J.S.T.
<Type>
Connector: 03JFAT-SAXGFK-43

Type	A	B	N	No. of poles
03JFAT-SAXGFK-43	33.5	12.7	2	3 (for CNP1)

Drive unit CNP3L,CNP3M connector (for motor power) (For MDS-DJ-V2, MDS-DJ-SP2)

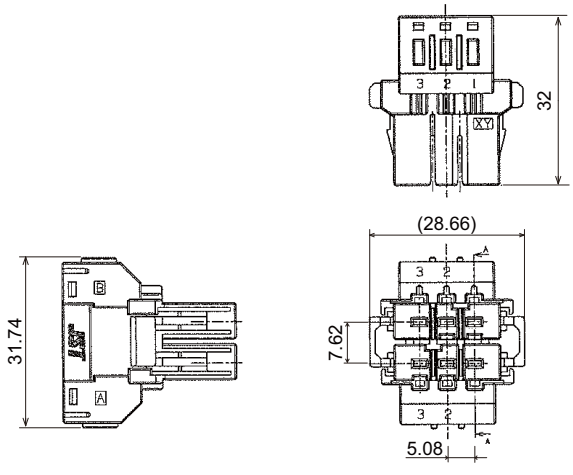
[Unit:mm]



Manufacturer: J.S.T.
<Type>
Connector: 04JFAT-SAGG-G-KK

Drive unit CNP2 connector (for control power) (For MDS-DJ-V2, MDS-DJ-SP2)

[Unit:mm]

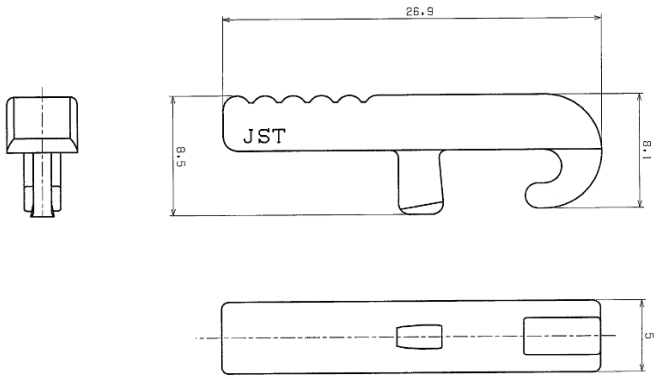


Manufacturer: J.S.T.
<Type>
Connector: 06JFAT-SAXYGG-F-KK

Connection lever for drive unit

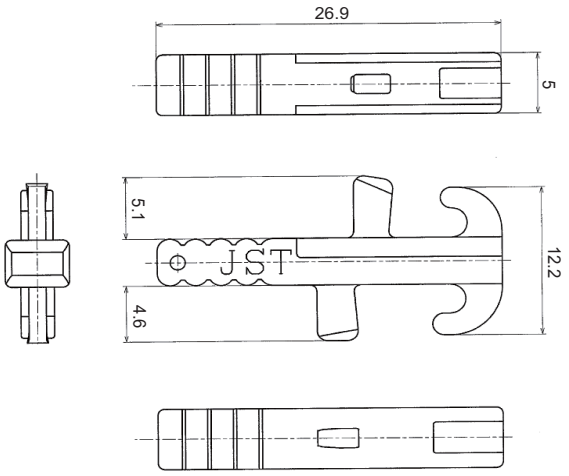
[Unit:mm]

Manufacturer: J.S.T.
< Type >
Connector:J-FAT-OT



[Unit:mm]

Manufacturer: J.S.T.
< Type >
Connector:J-FAT-OT-EXL



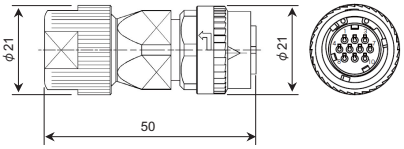
Appendix 1.3.2 Connector for Servo and Tool Spindle

Motor encoder connector

Motor side encoder connector / Ball screw side encoder for connector

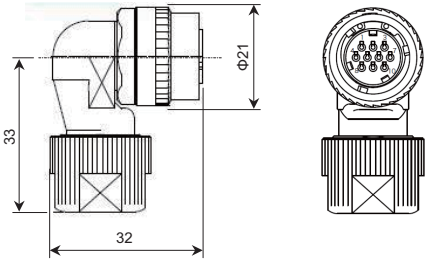
[Unit:mm]

Manufacturer: DDK
<Type>
Plug:CMV1-SP10S-M2



[Unit:mm]

Manufacturer: DDK
<Type>
Plug:CMV1-AP10S-M2

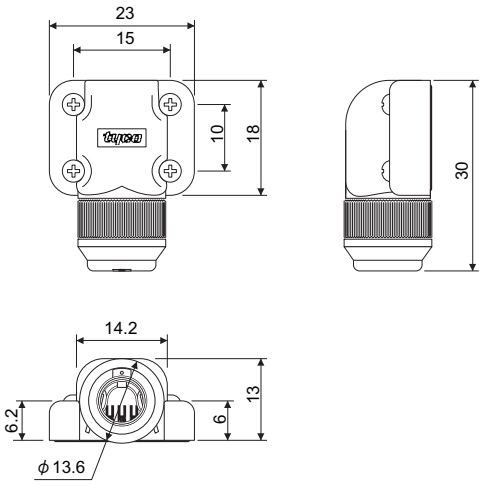


(Note) For the manufacturing method of CMV1 series connector, refer to the section "Cable and Connector Assembly" in Instruction Manual.
Contact: Fujikura Ltd. http://www.fujikura.co.jp/eng/

Motor side encoder connector

[Unit:mm]

Manufacturer: Tyco Electronics
<Type>
Assembly: 1674320-1

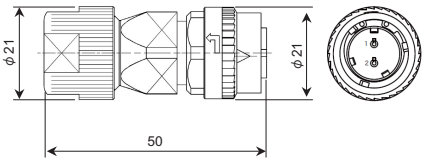


Brake connector

Brake connector

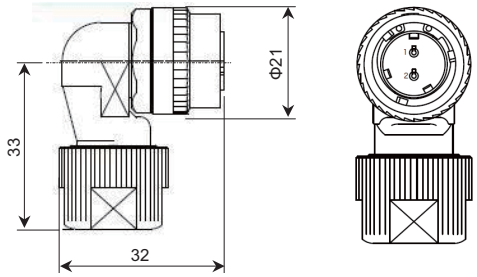
[Unit:mm]

Manufacturer: DDK
<Type>
Plug: CMV1-SP2S-S



[Unit:mm]

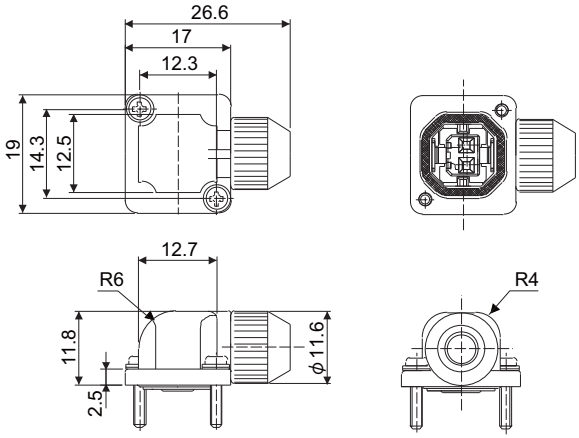
Manufacturer: DDK
<Type>
Plug: CMV1-AP2S-S



(Note) For the manufacturing method of CMV1 series connector, refer to the section "Cable and Connector Assembly" in Instruction Manual.

[Unit:mm]

Manufacturer: Japan Aviation Electronics Industry
<Type>
JN4FT02SJ1-R

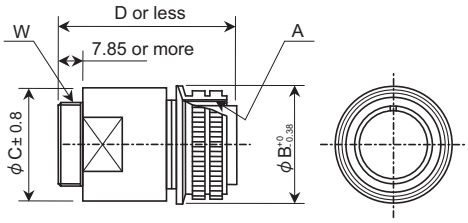


Motor power connector

Motor power connector

[Unit:mm]

Manufacturer: DDK

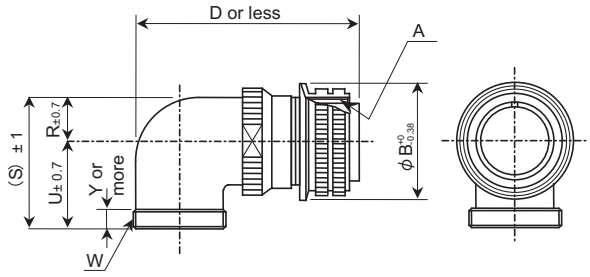


Plug:

Type	A	B +0 -0.38	C±0.8	D or less	W
CE05-6A18-10SD-C-BSS	$1^{1}/_{8}$-18UNEF-2B	34.13	32.1	57	1-20UNEF-2A
CE05-6A22-22SD-C-BSS	$1^{3}/_{8}$-18UNEF-2B	40.48	38.3	61	$1^{3}/_{16}$-18UNEF-2A

[Unit:mm]

Manufacturer: DDK

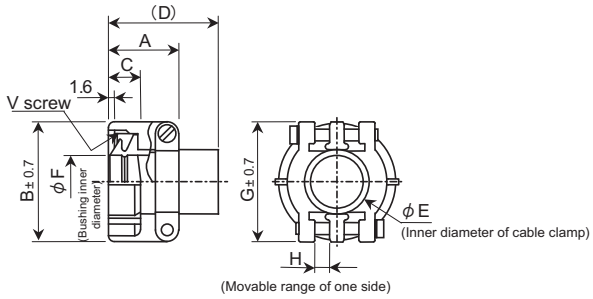


Plug:

Type	A	B +0 -0.38	D or less	W	R±0.7	U±0.7	(S)±1	Y or more
CE05-8A18-10SD-C-BAS	$1^{1}/_{8}$-18UNEF-2B	34.13	69.5	1-20UNEF-2A	13.2	30.2	43.4	7.5
CE05-8A22-22SD-C-BAS	$1^{3}/_{8}$-18UNEF-2B	40.48	75.5	$1^{3}/_{16}$-18UNEF-2A	16.3	33.3	49.6	7.5

[Unit:mm]

Manufacturer: DDK



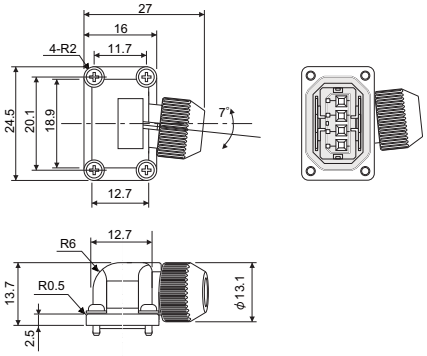
Clamp:

Type	Shell size	Total length A	Outer dia. B	Avail. screw length C	D	E	F	G	H	Fitting screw V	Bushing	Applicable cable
CE3057-10A-1(D240)	18	23.8	30.1	10.3	41.3	15.9	14.1	31.7	3.2	1-20UNEF-2B	CE3420-10-1	Φ10.5 to Φ14.1
CE3057-12A-1(D240)	20	23.8	35	10.3	41.3	19	16.0	37.3	4	$1^{3}/_{16}$-18UNEF-2B	CE3420-12-1	Φ12.5 to Φ16.0

Motor power connector

[Unit:mm]

Manufacturer: Japan Aviation Electronics Industry
<Type>
JN4FT04SJ1-R

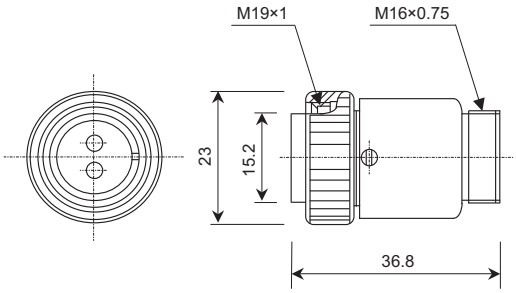


MDS-B-HR connector

MDS-B-HR connector

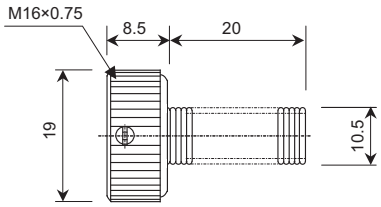
[Unit:mm]

Manufacturer: Hirose Electric
<Type>
Plug:
RM15WTPZ-8S(71) (for CON1,2)
RM15WTPZ-12P(71) (for CON3)
RM15WTPZ-10P(71) (for CON4)



[Unit:mm]

Manufacturer: Hirose Electric
<Type>
Clamp: JR13WCCA-10(72)



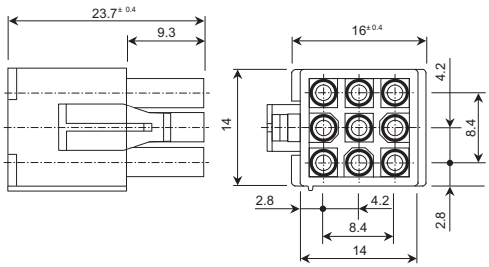
Appendix 1.3.3 Connector for Spindle

Motor encoder connector

Motor side PLG (TS5690) connector

[Unit:mm]

Manufacturer: Tyco Electronics
<Type>
Plug: 172169-1

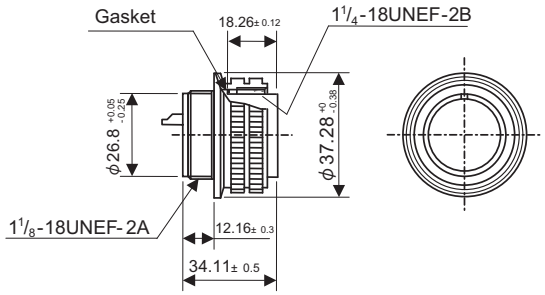


Spindle side encoder connector (for OSE-1024)

Spindle side encoder connector (for OSE-1024)

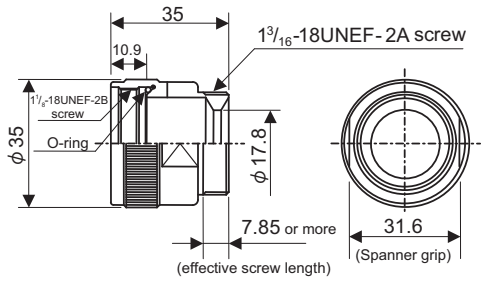
[Unit:mm]

Manufacturer: DDK
<Type>
Connector: MS3106A20-29S(D190)



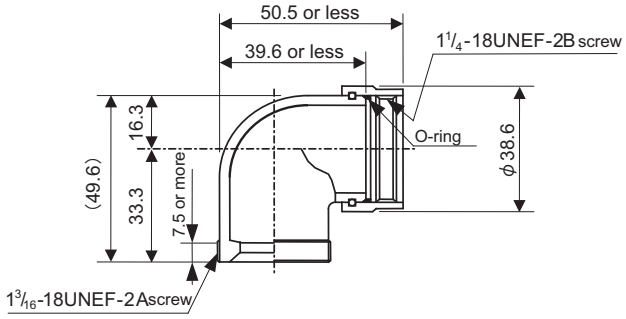
[Unit:mm]

Manufacturer: DDK
<Type>
Straight back shell: CE02-20BS-S



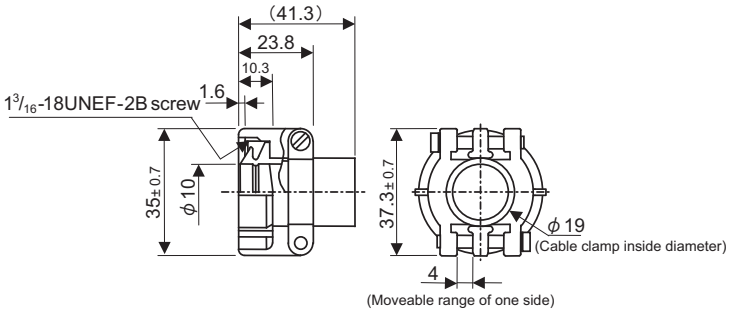
[Unit:mm]

Manufacturer: DDK
<Type>
Angle back shell: CE-20BA-S



[Unit:mm]

Manufacturer: DDK
<Type>
Cable clamp:CE3057-12A-3



Appendix 2

Restrictions for Lithium Batteries

Appendix 2.1 Restriction for Packing

When transporting lithium batteries with means such as by air transport, measures corresponding to the United Nations Dangerous Goods Regulations (hereafter called "UN Regulations") must be taken.
The UN Regulations classify the batteries as dangerous goods (Class 9) or not dangerous goods according to the lithium metal content. To ensure safety during transportation, lithium batteries (battery unit) directly exported from Mitsubishi are packaged in a dedicated container (UN package) for which safety has been confirmed.
When the customer is transporting these products with means subject to the UN Regulations, such as air transport, the shipper must follow the details explained in the section "Transportation Restrictions for Lithium Batteries: Handling by User".
The followings are restrictions for transportation. Each restriction is specified based on the recommendation of the United Nations.

Area	Transportation method	Restriction	Special clause
World	Air	ICAO, IATA	-
World	Marine	IMO	188
United States	All (air, marine, land)	DOT	49 CFR 173.185
Europe	land	RID, ADR	-

Appendix 2.1.1 Target Products

The following Mitsubishi NC products use lithium batteries. If the lithium metal content exceeds 1g for battery cell and 2g for battery, the battery is classified as dangerous good (Class9).
In order to avoid an accidental actuation during the transportation, all lithium battery products incorporated in a machinery or device must be fixed securely and must be shipped with wrapped over the outer package as to prevent damage or short-circuits.

(1) Materials falling under Class 9

Mitsubishi type (Type for arrangement)	Battery type	Lithium metal content	Number of incorporated batteries	Application (Data backup)	Battery class	Outline dimension drawing
CR23500SE-CJ5	CR23500SE-CJ5	1.52g	-	For NC SRAM (M500)	Battery cell	Refer to "Battery Option" in the specification manual for drive unit you are using for the outline dimension drawing for servo.

(2) Materials not falling under Class 9

Mitsubishi type (Type for arrangement)	Battery type	Lithium metal content	Number of incorporated batteries	Application (Data backup)	Battery class	Outline dimension drawing
CR2032 (for built-in battery)	CR2032	0.067g	-	For NC SRAM/	Battery cell	Refer to "Battery Option" in the specification manual for drive unit you are using for the outline dimension drawing for servo.
CR2450 (for built-in battery)	CR2450	0.173g	-	For NC SRAM		
ER6, ER6V series (for built-in battery)	ER6, ER6V	0.65g	-	For NC SRAM/ servo encoder		
A6BAT(MR-BAT)	ER17330V	0.48g	-	For servo encoder		
Q6BAT	Q6BAT	0.57g	-	For NC SRAM		
MDS-BAT6V1SET	2CR17335A	1.2g	2	For servo encoder	Battery	
MR-BAT6V1SET						

(Note) If the number of batteries exceeds 24 batteries for the battery cell or 12 batteries for the battery, the dedicated packing (for materials falling under Class 9) is required.

Appendix 2.1.2 Handling by User

The shipper must confirm the latest IATA Dangerous Goods Regulations, IMDG Codes and laws and orders of the corresponding export country.
These should be checked by the company commissioned for the actual transportation.

IATA: International Air Transport Association
http://www.iata.org/
IMDG Code: A uniform international code for the transport of dangerous goods by seas determined by IMO (International Maritime Organization).
http://www.imo.org/

Appendix 2.1.3 Reference

Refer to the following materials for details on the regulations and responses.
Guidelines regarding transportation of lithium batteries and lithium ion batteries
Battery Association of Japan
http://www.baj.or.jp/e/

Appendix 2.2 Products Information Data Sheet (ER Battery)

MSDS system does not cover the product used in enclosed state. The ER battery described in this section applies to that product.
This description is applied to the normal use, and is provided as reference but not as guarantee.
This description is based on the lithium battery's (ER battery) hazardous goods data sheet (Products Information Data Sheet) which MITSUBISHI has researched, and will be applied only to the ER batteries described in "Transportation Restrictions for Lithium Batteries: Restriction for Packing".

(1) Outline of hazard

Principal hazard and effect	Not found.
Specific hazard	As the chemical substance is stored in a sealed metal container, the battery itself is not hazardous. But when the internal lithium metal attaches to human skin, it causes a chemical skin burn. As a reaction of lithium with water, it may ignite or forms flammable hydrogen gas.
Environmental effect	Not found.
Possible state of emergency	Damages or short-circuits may occur due to external mechanical or electrical pressures.

(2) First-aid measure

Inhalation	If a person inhales the vapor of the substance due to the battery damage, move the person immediately to fresh air. If the person feels sick, consult a doctor immediately.
Skin contact	If the content of the battery attaches to human skin, wash off immediately with water and soap. If skin irritation persists, consult a doctor.
Eye contact	In case of contact with eyes due to the battery damage, rinse immediately with a plenty of water for at least 15 minutes and then consult a doctor.
Ingestion	If swallowed, consult a doctor immediately.

(3) Fire-fighting measure

Appropriate fire-extinguisher	Dry sand, dry chemical, graphite powder or carbon dioxide gas
Special fire-fighting measure	Keep the battery away from the fireplace to prevent fire spreading.
Protectors against fire	Fire-protection gloves, eye/face protector (face mask), body/skin protective cloth

(4) Measure for leakage

Environmental precaution	Dispose of them immediately because strong odors are produced when left for a long time.
How to remove	Get them absorbed into dry sand and then collect the sand in an empty container.

(5) Handling and storage

Handling	**Cautions for safety handling**	Do not peel the external tube or damage it. Do not dispose of the battery in fire or expose it to heat. Do not immerse the battery in water or get it wet. Do not throw the battery. Do not disassemble, modify or transform the battery. Do not short-circuit the battery.
Storage	**Appropriate storage condition**	Avoid direct sunlight, high temperature and high humidity. (Recommended temp. range: +5 to +35°C, humidity: 70%RH or less)
	Material to avoid	Flammable or conductive material (Metal: may cause a short-circuit)

(6) Physical/chemical properties

Appearance	**Physical form**	Solid
	Shape	Cylinder type
	Smell	Odorless
	pH	Not applicable (insoluble)
	Boiling point/Boiling range, Melting point, Decomposition temperature, Flash point	No information

(7) Stability and reactivity

Stability	Stable under normal handling condition.
Condition to avoid	Do not mix multiple batteries with their terminals uninsulated. This may cause a short-circuit, resulting in heating, bursting or ignition.
Hazardous decomposition products	Irritative or toxic gas is emitted in the case of fire.

(8) Toxicological information

As the chemical substance is stored in a sealed metal container, the battery has no harmfulness. Just for reference, the table below describes the main substance of the battery.

< Lithium metal >

Acute toxicity	No information
Local effect	Corrosive action in case of skin contact

< Thionyl chloride >

Acute toxicity	Lc_{50}: 500ppm (inhaled administration to rat)
Local effect	The lungs can be damaged by chronic cough, dyspnea and asthma.

< Aluminum chloride >

Acute toxicity	L_{D50}: 3700ppm (oral administration to rat)
Local effect	Not found.

< Lithium chloride >

Acute toxicity	L_{D50}: 526ppm (oral administration to rat)
Local effect	The central nerves and kidney can be influenced.

< Carbon black >

Acute toxicity	L_{D50}: 2,000mg/kg > (rat)
Carcinogenicity	LARC group 2 (suspected of being carcinogenic)

(9) Ecological information

Mobility, Persistence/ Decomposability, Bio-accumulation potential, Ecological toxicity	Not found.

(10) Caution for disposal

Dispose of the battery following local laws or regulations.

Pack the battery properly to prevent a short-circuit and avoid contact with water.

Appendix 2.3 Forbiddance of Transporting Lithium Battery by Passenger Aircraft Provided in the Code of Federal Regulation

This regulation became effective from Dec.29, 2004. This law is a domestic law of the United States, however it also applies to the domestic flight and international flight departing from or arriving in the United States. Therefore, when transporting lithium batteries to the United State, or within the United State, the shipper must take measures required to transport lithium batteries. Refer to the Federal Register and the code of Federal Regulation for details.
When transporting primary lithium battery by cargo aircraft, indicate that transportation by passenger aircraft is forbidden on the exterior box.
"Lithium Metal batteries forbidden for transport aboard Passenger aircraft"

Appendix 2.4 California Code of Regulation "Best Management Practices for Perchlorate Materials"

When any products that contain primary lithium batteries with perchlorate are shipped to or transported through the State of California, they are subject to the above regulation.The following information must be indicated on the package, etc. of the products that contain primary lithium batteries (with a perchlorate content of 6 ppb or higher).
"Perchlorate Meterial-special handling may apply. See http://www.dtsc.ca.gov/hazardouswaste/perchlorate"

Appendix 2.5 Restriction Related to EU Battery Directive

EU Battery Directive (2006/66/EC) has been enforced since September 26th in 2008. Hereby, battery and machinery incorporating battery marketed in European Union countries must be in compliance with the EU Battery Directive. Lithium battery provided by MITSUBISHI are subjected to this restriction.

Appendix 2.5.1 Important Notes

Follow the instruction bellow as shipping products incorporating MITSUBISHI device.

(1) When shipping products incorporating MITSUBISHI device any time later than September 26th, 2008, the symbol mark shown as Figure 1 in section "Information for End-user" is required to be attached on the machinery or on the package. Also, the explanation of the symbol must be added.

(2) Machinery with battery and maintenance battery produced before the EU Battery Directive are also subjected to the restriction. When shipping those products to EU countries later than September 26th, 2008, follow the instruction explained in (1).

Appendix 2.5.2 Information for End-user

Figure 1

Note: This symbol mark is for EU countries only.

This symbol mark is according to the directive 2006/66/EC Article 20 Information for end-users and Annex II.

Your MITSUBISHI ELECTRIC product is designed and manufactured with high quality materials and components which can be recycled and/or reused. This symbol means that batteries and accumulators, at their end-of-life, should be disposed of separately from your household waste.

If a chemical symbol is printed beneath the symbol shown above, this chemical symbol means that the battery or accumulator contains a heavy metal at a certain concentration. This will be indicated as follows:Hg: mercury (0,0005%), Cd: cadmium (0,002%), Pb: lead (0,004%)

In the European Union there are separate collection systems for used batteries and accumulators. Please, dispose of batteries and accumulators correctly at your local community waste collection/recycling centre.

Please, help us to conserve the environment we live in!

Revision History

Date of revision	Manual No.	Revision details
Oct. 2013	IB(NA)1501130-A	First edition created.
Aug. 2014	IB(NA)1501130-B	- The words "detector" were replaced by "encoder". - "System Configuration" was revised. - "Explanation of Type" was revised. - "Torque Characteristics" was revised. - "Specifications" and "Output Characteristics" in "Spindle Motor" were revised. - "Specifications" and "Output Characteristics" in "Tool Spindle Motor" were revised. - "Servo Drive Unit" and "Spindle Drive Unit" were revised. - Function Specifications List was revised. - "Proximity Switch Orientation Control" was revised. - "Retraction Function at Power Failure" was added. - "Monitor Output Function" was revised. - "Motor Temperature Display Function" was revised. - "Environmental Conditions" in "Servo Motor" was revised. - "Shaft Characteristics" in "Spindle Motor" and "Tool Spindle Motor" were revised. - "Environmental Conditions" in "Drive Unit" was revised. - "Servo Options" was revised. - Absolute position encoder in "Machine Side Encoder" was revised. - "Spindle Options" was revised. - "Spindle Side Accuracy Serial Output Encoder (ERM280, MPCI Series)(Other Manufacturer's Product)" was revised. - "Optical Communication Repeater Unit (FCU7-EX022)" was revised. - "List of Cables and Connectors" was revised. - Tolerable current list was added to "Example of Wires by Unit". - "Selection of Servo Motor Capacity" was revised. - "Selection of the Spindle Motor" was revised. - "Required Capacity of Power Supply" was added. - "Cable and Connector Specifications" was revised. - "Compliance to EC Directives" was deleted. - "EMC Installation Guidelines" was deleted. - "Global Service Network" was revised. - Miswrite is corrected.
Apr. 2017	IB(NA)1501130-C	- "Introduction" was revised. - "Explanation of Type" was revised. - Specifications lists of servo motor and tool spindle motor were revised. - "Servo Drive Unit" and "Spindle Drive Unit" were revised. - "Function Specifications List" was revised. - "Speed Command Synchronous Control" and "Monitor Output Function" were revised. - "Shaft Characteristics", "Oil / Water Standards" and "Installation of Servo Motor" in "Servo Motor" were revised. - "Servo Options" was revised. - Manufacturer names and the contact information were updated. - "Battery Option", "Ball Screw Side Encoder (OSA105ET2A)" and "Machine Side Encoder" were revised.

Date of revision	Manual No.	Revision details
Apr. 2017	IB(NA)1501130-C	- Example of wiring was added in "Serial Output Interface Unit for ABZ Analog Encoder MDS-B-HR". - "Regenerative Option" was revised. - "List of Cables and Connectors" was revised. - "Example of Wires by Unit" and "Selection of Contactor" were revised. - "Noise Filter" was revised. - "Selection of the Servo Motor" was revised. - "Calculation of the Positioning Frequency" was revised. - "Cable and Connector Specifications" was revised. - "Restrictions for Lithium Batteries" was revised. - "EC Declaration of Conformity" was revised. - "Instruction Manual for Compliance with UL/c-UL Standard" was revised. - "Global Service Network" was revised. - Miswrite is corrected.
Sep. 2020	IB(NA)1501130-D	- "Introduction" was revised. - "Precautions for Safety" was revised. - "System Configuration" was revised. - "Torque Characteristics" was revised. - "Servo Drive Unit", "Spindle Drive Unit", and "Explanation of Each Part" were revised. - "Restrictions for Lithium Batteries" was revised. - "Global Service Network" was revised. - Miswrite is corrected.
Sep. 2022	IB(NA)1501130-E	- "Precautions for Safety" was revised. - "1 Introduction" was revised. - "2 Specifications" was revised. - "3 Function Specifications" was revised. - "4 Characteristics" was revised. - "5 Dedicated Options" was revised. - "6.2 Selection of Circuit Protector and Contactor" was revised. - "6.3 Selection of Earth Leakage Breaker" was revised. - "6.4 Branch-circuit Protection (for Control Power Supply)" was revised. - "6.8 Selection of Link Connection" was revised. - "7.1 Selection of the Servo Motor" was revised. - "Appendix 1.1 Selection of Cable" was revised. - "Appendix 3 EC Declaration of Conformity" was deleted. - "Appendix 4 Instruction Manual for Compliance with UL/c-UL Standard" was deleted. - "Global Service Network" was revised. - Miswrite is corrected.

Global Service Network

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Nashville, TN Service Satellite
Baltimore, MD Service Satellite
Pittsburg, PA Service Satellite
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Notice

Every effort has been made to keep up with software and hardware revisions in the contents described in this manual. However, please understand that in some unavoidable cases simultaneous revision is not possible.
Please contact your Mitsubishi Electric dealer with any questions or comments regarding the use of this product.

Duplication Prohibited

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MODEL	MDS-DJ Series
MODEL CODE	100-352
Manual No.	IB-1501130

IB(NA)1501130(ENG)-E(2209)MEE
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