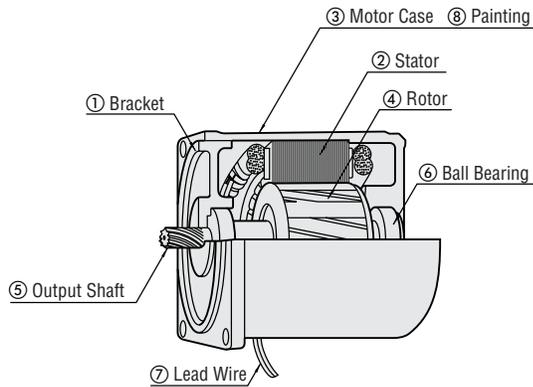


Standard AC Motors

Construction of AC Motors

The following figure shows the construction of a standard AC motor.

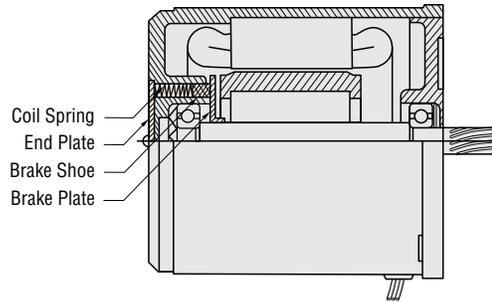
- ① Bracket: Die-cast aluminum bracket with a machined finish, press-fitted into the motor case.
- ② Stator: Comprised of a stator core made from laminated silicon/steel plates, a polyester-coated copper coil and insulation film.
- ③ Motor Case: Die-cast aluminum with a machined finish inside.
- ④ Rotor: Laminated silicon/steel plates with die-cast aluminum.
- ⑤ Output Shaft: Available in round shaft and pinion shaft types. The metal used in the shaft is S45C. Round shafts have a shaft flat (output power of 25 W or more), while pinion shafts undergo precision gear finishing.
- ⑥ Ball Bearing
- ⑦ Lead Wire: Lead wires with heat-resistant polyethylene coating.
- ⑧ Painting: Baked finish of acrylic resin or melamine resin.



Brake Mechanism of the Reversible Motor

A reversible motor has a simple, built-in brake mechanism (friction brake) at its rear. This mechanism is provided for the following purposes:

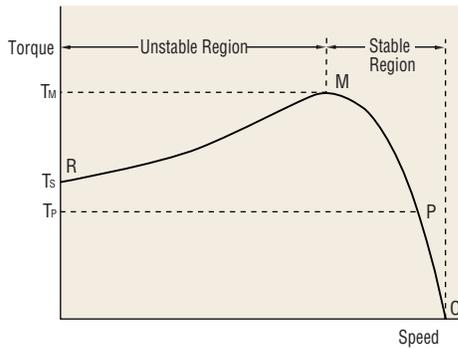
- a. To improve the instant reversing characteristics by adding a friction load
- b. To reduce overrun



The brake mechanism is constructed as shown in the figure above. The coil spring applies constant pressure to allow the brake shoe to slide toward the brake plate. This mechanism provides a certain degree of holding brake force, but the force is limited due to the mechanism's structure, as described above. The brake force produced by the brake mechanism of an Oriental Motor reversible motor is approximately 10% of the motor's output torque.

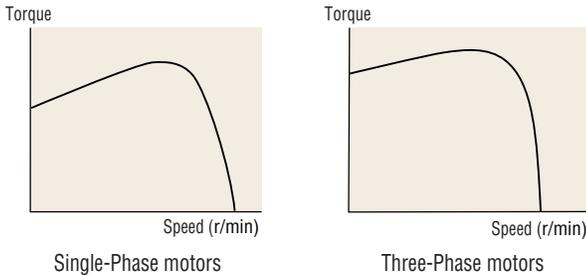
■ Induction Motor Speed – Torque Characteristics

The figure below shows the motor's characteristics of speed and torque.



Under conditions of no load, the motor rotates at a speed close to synchronous rotation (O). As the load increases, the motor's speed drops to a level (P) where a balance is achieved between load and motor torque (T_p).

If the load is further increased and reaches point M, the motor can generate no greater torque and stops at point R. In other words, the motor can be operated in a stable range between M and O, while the range between R and M is subject to instability.

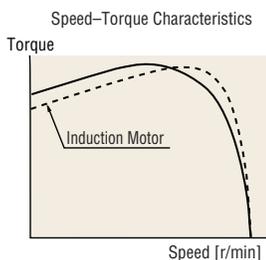


Induction motors are available in two types: single-phase (capacitor run) and three-phase induction motors. With the single-phase motor, the starting torque is generally smaller than the operating torque, while the three-phase motor features a relatively greater starting torque.

■ Reversible Motor Speed – Torque Characteristics

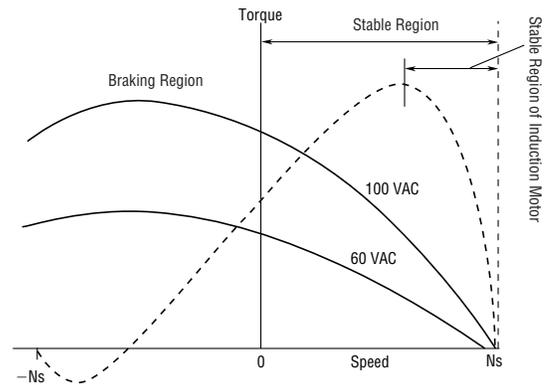
The reversible motor is a capacitor-run, single-phase induction motor that features the same characteristics as an induction motor, as described above.

However, the reversible motor features a higher starting torque than an induction motor in order to improve the instant reversing characteristics.



■ Torque Motor Speed – Torque Characteristics

The figure below shows the torque motor's characteristics of speed and torque. The speed and torque characteristics of torque motors differ from those of induction motors or reversible motors. As the graph shows, they have special torque characteristics (torque is highest at zero speed and decreases steadily with increasing speed), so they can provide stable operation through the entire speed range, from starting to no-load speed. The torque generated during reversal of the motor is a large positive torque in the same direction as the rotational magnetic field. When the motor is locked by the load and the motor is rotated opposite the desired direction, this torque acts as a force (braking force) to inhibit the motor from rotating backwards.



■ Service Life of an AC Motor

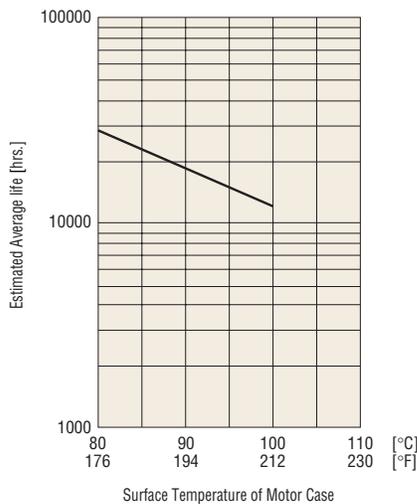
The service life of an AC motor is affected by a number of factors, but in most cases it is determined by the bearings. The useful life of a bearing is represented in terms of ① bearing mechanical life and ② grease life, as described below.

[Bearing Life]

- ① Mechanical life is affected by rolling fatigue
- ② Grease life is affected by grease deterioration due to heat

The AC motor's bearing life is estimated based on the grease life, since the bearing life is more affected by grease deterioration due to heat than the load applied to the bearing. Temperature is the primary determinant of grease life, meaning that grease life is significantly affected by temperature. Grease life will be extended at a lower temperature as long as it is within the ambient temperature range specified in the motor's general specifications. Oriental Motor uses bearings that offer an especially high resistance to temperature. The graph below shows the estimated average life characteristic based on actual data measured with regard to the motor case's surface temperature.

According to this graph, the estimated average life is approximately 20,000 hours at 188.6°F (87°C). And this graph indicate that the useful life doubles when the surface temperature of the motor case is lowered 32.4°F (18°C). For the useful life of a gearhead, see page F-45.



■ Capacitor

Oriental Motor's single-phase AC motors are permanent split capacitor types. Capacitor-run motors contain an auxiliary winding offset by 90 electrical degrees from the main winding. The capacitor is connected in series with the auxiliary winding, causing the current in the auxiliary winding to lag the current in the main phase.

The motor employs a UL-recognized, metallized electrode capacitor. This type of capacitor, which uses a metallized paper or plastic film as an element, is also known as a "self-healing (SH) capacitor," because of the self-healing property of the capacitor element. Although most of the previous capacitors used paper elements, the plastic film capacitor has become a mainstream model in recent years due to the growing demand for compact design.

● Capacitance

The use of a capacitor with a different capacitance may cause excessive motor vibration and heat generation or may result in torque drops and unstable operation. Be sure to use the capacitor supplied with the motor. The capacitor's capacitance is expressed in microfarads (μF).

● Rated Voltage

Using the capacitor at a voltage level exceeding the rated voltage may significantly reduce the capacitor's service life. Be sure to use the capacitor supplied with the motor. The rated voltage of the capacitor is expressed in volts (V). The capacitor's rated voltage is indicated on the surface of the capacitor case. Take proper precautions, since the capacitor's rated voltage is different from that of the motor.

● Rated Conduction Time

The rated conduction time is the minimum design life of the capacitor when operated at the rated load, voltage, temperature and frequency. The standard life expectancy is 25,000 hours. We recommend that the capacitor be replaced after the rated conduction time.

● Safety Feature of Capacitor

The UL-recognized capacitors, supplied with the motors, are equipped with a safety feature that allows for safe and complete removal of the capacitor from circuits to prevent smoke and/or fire in the event of a dielectric breakdown. Oriental Motor uses capacitors with UL-recognized safety features that have passed the UL810 requirement of the 10,000-A fault current test.

Temperature Rise in Standard Compact AC Motors

When a motor is operating, all energy loss from the motor is transformed into heat, causing the motor's temperature to rise.

- **Induction motors:** Induction motors, which are rated for continuous duty, reach the saturation point of temperature rise after two or three hours of operation, whereupon its temperature stabilizes.
- **Reversible motors:** Reversible motors (30 minute rating) reach their limit for temperature rise after 30 minutes of operation. The temperature will increase further if operation continues.

Measuring the Temperature Rise

The following is a description of the methods Oriental Motor uses for temperature measurement and for the determination of a motor's maximum allowable temperature rise.

Thermometer Method

The temperature at which the temperature rise during motor operation becomes saturated is measured using a thermometer or thermocouple attached to the center of the motor case. The temperature rise is defined as the difference between the ambient temperature and measured temperature.

Resistance-Change Method

In the resistance-change method, the winding temperature is measured according to the change in resistance value. A resistance meter and thermostat is used to measure the motor's winding resistance and ambient temperature before and after operation, from which the temperature rise in the motor windings is obtained.

Reversible Motor's Operation Time and Temperature Rise

The reversible motor is rated for 30 minutes. However, when operating the motor intermittently for a short period of time, the operation time may vary in accordance with the operating conditions. Intermittent operation of the reversible motor for a short period of time will result in a considerable flow of electric current when the motor is started or reversed, thus causing greater heat generation. However, the motor's temperature rise can be managed by keeping the motor at rest for a longer period of time, thereby enhancing its natural cooling capability.

Motor case temperature is the sum of the motor's temperature rise and the ambient temperature. In general, if the motor's case temperature is 194°F (90°C) or below, continuous motor operation under such operating conditions is possible, considering the insulation class of motor winding. The life of the bearing grease is extended according to the lower motor temperature.

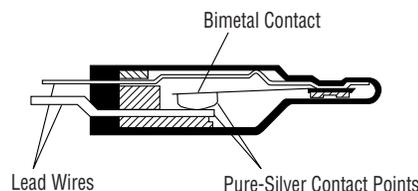
The motor temperature varies depending on load conditions, operating cycle, motor installation, ambient temperature and other factors. Use these factors as rough guidelines, since it is difficult to evaluate everything based solely on data regarding these factors.

Overheating Protection Devices

If a motor operating in run mode locks due to overload or the input current increases, the motor's temperature rises abruptly. If the motor is left in this state, the performance of the insulation within the motor may deteriorate, reducing its service life and, in extreme cases, scorching the winding and causing a fire. In order to protect the motor from such thermal abnormalities, UL, CSA, EN and IEC standard motors from Oriental Motor are equipped with the following overheating-protection devices.

Thermally Protected Motors

Motors with a frame size of 2.76 inch sq. (70 mm sq.), 3.15 inch sq. (80 mm sq.), 3.54 inch sq. (90 mm sq.) or 4.09 inch sq. (104 mm sq.) contain a built-in automatic-return type of thermal protector. The construction of a thermal protector is shown in the figure below.



Structure of a Thermal Protector

The thermal protectors employ a bimetal contact with pure silver used in the contacts. Pure silver has the lowest electrical resistance of all materials and has thermal conductivity second only to copper.

Operating temperature of thermal protector

- Open...266°F±9°F (130°C±5°C) (the operating temperature varies depending on the model, e.g., **BH Series:** 302°F±9°F (150°C±5°C))
- Close...179.6°F±27°F (82°C±15°C) (the operating temperature varies depending on the model, e.g., **BH Series:** 204.8°F±27°F (96°C±15°C))

The motor winding temperature, where the thermal protector is working, is slightly higher than the operating temperature listed above.

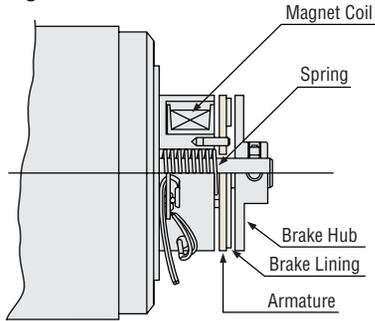
Impedance Protected Motors

Motors with frame sizes of 2.36 inch sq. (60 mm sq.) or less are equipped with impedance protection. Impedance-protected motors are designed with higher impedance in the motor windings so that even if the motor locks, the increase in current (input) is minimized and temperature will not rise above a certain level.

Construction of an Electromagnetic Brake

An electromagnetic brake motor is equipped with a power off activated type electromagnetic brake.

As shown in the figure below, when voltage is applied to the magnet coil, the armature is attracted to the electromagnet against the force of the spring, thereby releasing the brake and allowing the motor shaft to rotate freely. When no voltage is applied, the spring works to press the armature onto the brake hub and hold the motor's shaft in place, thereby actuating the brake.



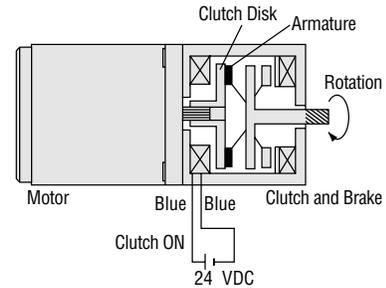
Structure and Operation of a Clutch-Brake Motor



The photograph above shows the structure of the clutch-brake motor. When 24 VDC is not applied to either the clutch coil or brake coil, the output shaft can be rotated by hand.

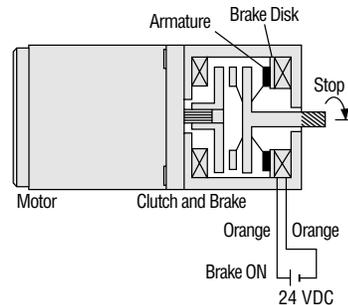
Run

When 24 VDC is applied to the clutch coil, the armature of the clutch coil is drawn against the clutch plate, transmitting motor rotation to the output shaft. The motor continues to rotate.

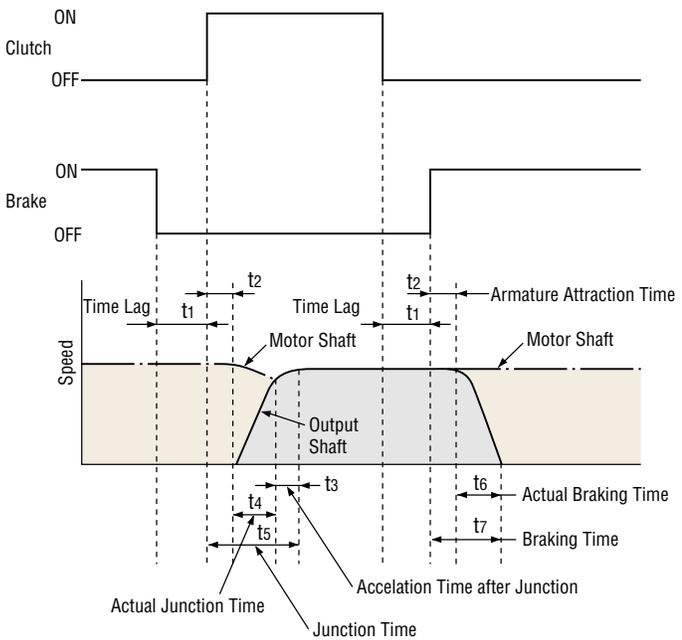


Stopping and Load Holding

By removing the 24 VDC from the clutch coil and, after a certain time lag, applying 24 VDC to the brake coil, the output shaft will come to a stop. During braking, the output shaft is released from the motor shaft, so the shaft may be stopped without being influenced by motor inertia. The motor continues to rotate.



The figure below shows the relationship between the action of the motor shaft and output shaft and the state of excitation of the clutch and brake coils.



● **Operation**

When operation is shifted from holding the load to moving the load, there is a lag of 20 msec. between the time the brake is released and the time voltage is applied to the clutch. This is to prevent the clutch and brake from engaging at the same time, denoted as t_1 .

The time required for the clutch/brake output shaft to reach a constant speed after voltage is applied to the clutch is called the junction time (t_5) and is calculated by adding the following elements:

① **Armature Attraction Time t_2**

The time required from application of voltage to the clutch coil until contact of the armature with the clutch plate.

② **Actual Junction Time t_4**

The time required after the armature comes in contact with the clutch for the clutch/brake output shaft, accelerated by dynamic friction torque, to engage completely with the motor shaft.

③ **Acceleration Time After Junction t_3**

The time needed to accelerate back to the required speed if a load is suddenly applied to the motor during the actual junction time, causing a temporary drop in speed.

● **Braking**

When operation is shifted from rotation to stopping or holding a load, a time lag of about 20 msec. is necessary after the clutch is disengaged before voltage is applied to the brake coil denoted as t_1 .

The time required after applying voltage to the brake for the clutch/brake output shaft to actually stop is called the braking time (t_7), and is obtained by adding the following elements:

① **Armature Attraction Time t_2**

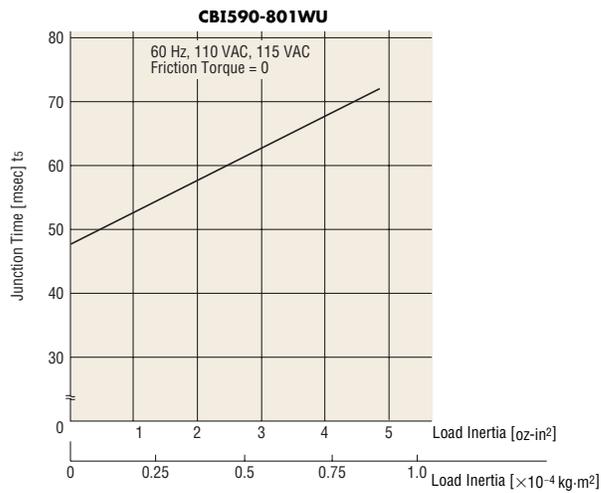
The time from the application of voltage to the clutch coil until contact of the armature with the brake plate.

② **Actual Braking Time t_6**

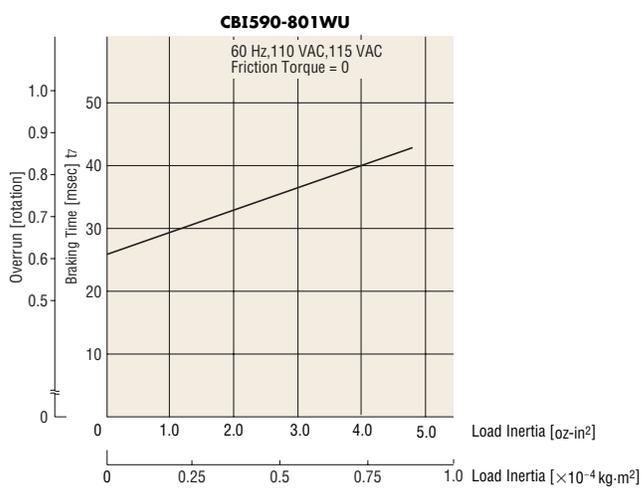
The time required from the moment the armature comes in contact with the brake plate until the moment the output shaft comes to a complete stop.

The following graphs indicate examples of junction and braking characteristics.

Junction Characteristics (Reference value)



Braking Characteristics (Reference value)



■ Glossary

● Ratings

◆ Ratings

Motor rating limitations pertaining to temperature rise are divided into two categories: continuous and short-term ratings. These establish working limitations on output, as well as on voltage, frequency and speed (r/min), and are known as rated output, rated voltage, rated frequency and rated speed (r/min).

◆ Continuous and Limited Duty Ratings

The period during which output can continue without abnormality is called a rating period. When continuous operation at rated output is possible, it is known as a continuous rating. When operation at rated output is possible only for a limited period, it is known as the short-term rating.

● Output Power

◆ Output Power

The amount of work that can be performed in a given period of time is determined by the motor's speed and torque. Each motor is marked with a rated output value. Output power is expressed in watts and in horsepower.

$$\text{Output Power [watts]} = 1.047 \times 10^{-1} \times T \times N$$

$$1 \text{ HP} = 746 \text{ watts}$$

where: 1.047×10^{-1} : Constant

T [N·m] : Torque

N [r/min] : Speed

◆ Rated Output Power

When optimal characteristics are achieved at the rated voltage and frequency in continuous operation, the motor is said to be operating at its rated output. The speed and torque that produce the rated output are called the rated speed and rated torque. Generally, the term "output" refers to rated output.

● Torque

◆ Starting Torque

This term refers to the torque generated the instant the motor starts. If the motor is subjected to a load greater than this torque, it will not operate. ①

◆ Stall Torque

This is the maximum torque under which the motor will operate at a given voltage and frequency. If a load greater than this torque is applied to the motor, it will stall. ②

◆ Rated Torque

This is the torque created when the motor is continuously producing rated output at the rated voltage and frequency. It is the torque at rated speed. ③

◆ Static Frictional Torque

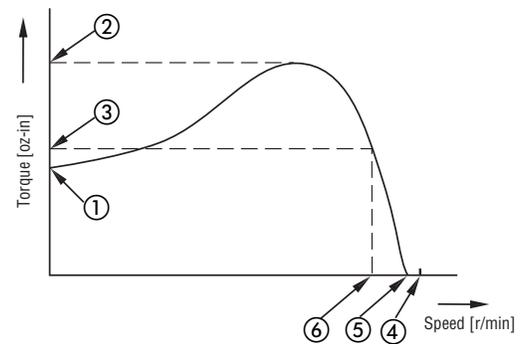
Static frictional torque is the torque output required to hold a load when the motor is stopped by an electromagnetic brake or similar device.

◆ Permissible Torque

The permissible torque is the maximum torque that can be used when the motor is running. It is limited by the motor's rated torque, temperature rise and the strength of the gearhead used with the motor.

Speed–Torque Characteristics

- ①: Starting torque
- ②: Stall torque
- ③: Rated torque
- ④: Synchronous speed
- ⑤: No-load speed
- ⑥: Rated speed



● Speed

◆ Synchronous Speed

This is an intrinsic factor determined by line frequency and the number of poles. It is calculated according to the following formula, and is normally indicated in r/min.

$$N_s = \frac{120f}{P} \text{ [r/min]}$$

N_s : Synchronous speed [r/min]

f : Frequency [Hz]

P : Number of poles

120: Constant

For example, for a four-pole motor with a line frequency of 60Hz, the synchronous speed will be:

$$N_s = \frac{120 \times 60}{4} = 1800 \text{ [r/min]}$$

See ④ in the figure above

◆ No-Load Speed

The speed of induction or reversible motors under no-load conditions is lower than synchronous speed by 2 to 20 percent. See ⑤ in the figure above.

◆ **Rated Speed**

This is the appropriate speed of the motor at rated output. From the standpoint of utility, it is the most desirable speed. See ⑥ in the figure on the previous page.

◆ **Slip**

The following formula is one method of expressing speed:

$$S = \frac{Ns - N}{Ns} \quad \text{or} \quad N = Ns(1 - S)$$

Ns: Synchronous speed [r/min]

N: Speed under a given load [r/min]

In the case of a four-pole, 60 Hz induction motor operated with a slip of $S = 0.1$, the speed under a given load will be:

$$N = \frac{120 \times 60}{4} (1 - 0.1) = 1800 (1 - 0.1) = 1620 \text{ [r/min]}$$

● **Overrun**

◆ **Overrun**

This is the number of excess rotations the motor makes from the instant the power is cut off to the time that it actually stops. It is normally indicated either by an angle or by revolutions.

● **Gearhead**

◆ **Gear Ratio**

The gear ratio is the ratio by which the gearhead reduces the motor speed [r/min]. The speed at the gearhead's output shaft is one over the gear ratio times the motor speed.

◆ **Maximum Permissible Torque**

This is the maximum load torque that can be applied to the gearhead. It is dependent upon such mechanical strength factors as the size and construction of the gears and bearings, and thus varies according to the gearhead type and ratio.

◆ **Service Factor**

This is a coefficient used to estimate the life of a gearhead. These values are determined in accordance with the results of service life tests under various loads and conditions of use.

◆ **Transmission Efficiency**

This is the efficiency of transmission when the torque is increased with the gearhead attached. It is expressed as a percentage (%) and is determined by the friction in the gears and bearings used in the gearhead and the resistance of the lubrication grease.

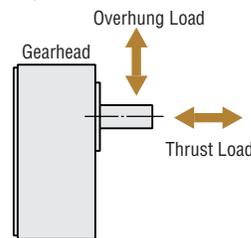
Transmission efficiency is usually 90% for one stage of reduction gears, and is 81% for two-stage gearheads. As the reduction ratio increases, the number of gear stages increases, with a consequent reduction in the gear efficiency to 73% and 66%, respectively, for each gear stage added.

◆ **Overhung Load**

This is a load on the gearhead's output shaft in the radial direction. The maximum overhung load on a gearhead shaft is called the permissible overhung load, and it varies with the gearhead type and distance from the shaft end. This is equivalent to tension under belt drive.

◆ **Thrust Load**

This is the load that is placed in the direction of the gearhead's output-axis shaft. The maximum thrust load on the gearhead is called the permissible thrust load, which differs by the type of gearhead.



● **Others**

◆ **CW, CCW**

This shows the direction of motor rotation. CW is clockwise as seen from the output shaft side, while CCW is counterclockwise.

■ Q&A

Q1. I may have to put the motor in an environment below 32°F (0°C) during transport. Will this create a problem?

A1. Extreme changes in temperature may lead to condensation within the motor. Should this occur, parts may rust, greatly shortening the service life. Take measures to prevent condensation.

Q2. Can the motors be shipped through tropical climates?

A2. No. When the humidity and temperature differences within the cargo space of ships and airplanes are severe, the insulation may deteriorate due to condensation. Successful countermeasures are to ship the motors packed in sealed containers or bags containing de-oxygenating material.

Q3. The motor gets extremely hot. Is this all right?

A3. The internal losses generated when the motor converts electrical energy to rotational movement becomes heat, making the motor hot. The motor temperature is expressed as the ambient temperature plus the temperature rise caused by losses within the motor. If internal losses within the motor is 90°F (50°C) and the ambient temperature is 85°F (29°C), the surface of the motor will be 175°F (79°C). This is not abnormal for a small motor.

Q4. Will large fluctuations in power supply voltage affect the motor?

A4. The torque produced by the motor is affected by changes in power supply voltage. The torque the motor produces is proportional to roughly twice the power supply voltage. For example, if the voltage of a motor rated at 115 VAC fluctuates between 103.5 VAC (90%) and 126.5 VAC (110%), the torque produced will vary between 80% and 120%. When using motors under large power voltage fluctuations, remember that the torque produced will vary, so select a motor that provides a sufficient margin.

Q5. Can a reversible motor be used as an induction motor if the brake shoes are removed?

A5. A reversible motor is not simply an induction motor with a simple braking mechanism added. The ratio of coils between the primary coil and the secondary coils in a reversible motor is different from that of an induction motor. Although a simple brake mechanism is added to the rear of the motor, the capacitance is also increased to increase starting torque. This means that if only the brake mechanism is removed, the reversible motor will not be usable at a continuous rating like an induction motor; it will simply lose its holding power and its reversing characteristics will be reduced.

Q6. What does it mean to say that a reversible motor is rated for 30 minutes?

A6. Reversible motors require a larger input power than induction motors to increase the starting torque and improve the instant reversing characteristics. This means that the losses are higher and the temperature rises more during continuous operation. If operated continuously, the motor will burn out. It is designed to provide maximum performance if operated for no more than 30 minutes continuously.

Q7. Can the speed of induction motors and reversible motors be changed?

A7. The speed of single-phase (AC) induction and reversible motors is determined by the power supply frequency. If your application requires changing speed, we recommend AC speed control motors, brushless DC motors.

Q8. Can a single-phase motor be driven using a three-phase power supply?

A8. A single-phase 230 VAC motor can be driven using a three-phase power supply. Use two of the three phases as the source of power supply. The same voltage can be obtained by combining two of the u, v, and w windings in one of the following patterns: U-V, U-W and V-W. When using a number of motors, be sure to connect them to the power supply so that a balanced supply of power is achieved from each phase.

Q9. Can instant reversal of a reversible motor be implemented using a SSR (solid state relay)?

A9. When instant forward/reverse operation is controlled with an SSR, the SSR characteristics can cause shorts in the circuit. Time must be allowed between switching from the SSR for clockwise rotation to the SSR for counterclockwise rotation.

Q10. The connection diagrams shows that a capacitor must be connected. Why is this necessary?

A10. Most of Oriental Motor standard compact AC motors fall within the broad group of single-phase induction motors are “capacitor-run motors”. To run an induction motor, a rotational magnetic field must be created. Capacitors perform the role of creating a power supply with the phase shift that is required for creating such a rotational magnetic field. Three-phase motors, by contrast, always supply power with different phases, so they do not require capacitors.

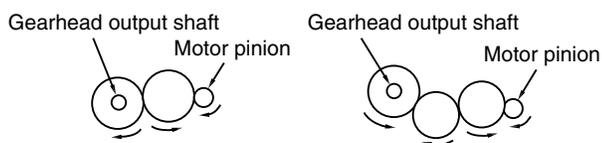
Q11. Can I use a capacitor other than the one that comes with the motor?

A11. The capacitor that comes with the motor has a capacitance that was selected to work optimally with the motor. When another capacitor is used, it should be a motor capacitor with the same capacitance and rated voltage as the capacitor that comes with the motor. Electrolytic capacitors may not be used.

Q12. Why do some gearheads output in the same direction as the motor while others output in the opposite direction?

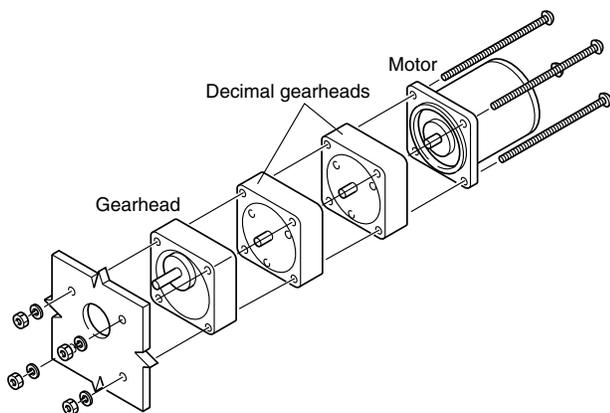
A12. Gearheads reduce the motor speed by 3:1 to 180:1. They do not, however, reduce the speed with a single gear stage, but with several. The number of gear stages depends on the gear ratio, so the direction of output shaft rotation differs.

● Rotating in motor axis direction ● Rotating opposite of motor axis direction



Q13. Can gearheads be used to reduce the motor speed to 1/18,000?

A13. Yes. A gearhead with a gear ratio of 180:1 must be connected to two decimal gearheads with a gear ratio of 10:1. The permissible torque is the same as if the 180:1 gearhead were used alone. Longer mounting screws must be used.



Q14. Do gearheads require oiling?

A14. Oriental Motor lubricates the surface of gears in gearheads with grease. Oiling is not required.

Q15. We wired the induction motor according to the wiring diagram, but it does not move. When we turned the shaft by hand, it started to move in the direction we turned it. What could be the cause of this?

A15. In order to turn a single-phase induction motor, it is necessary to use a capacitor to create two power supplies with different phases to obtain the rotating magnetic field. The problem described occurs, if the capacitor is not properly connected. Check for a cut line or contact defect near the capacitor section. The way to check is to measure the voltage across the capacitor terminals and check whether or not it is at least 1.5 times the power supply voltage. If not, the capacitor may not be working properly.