Servo Motors

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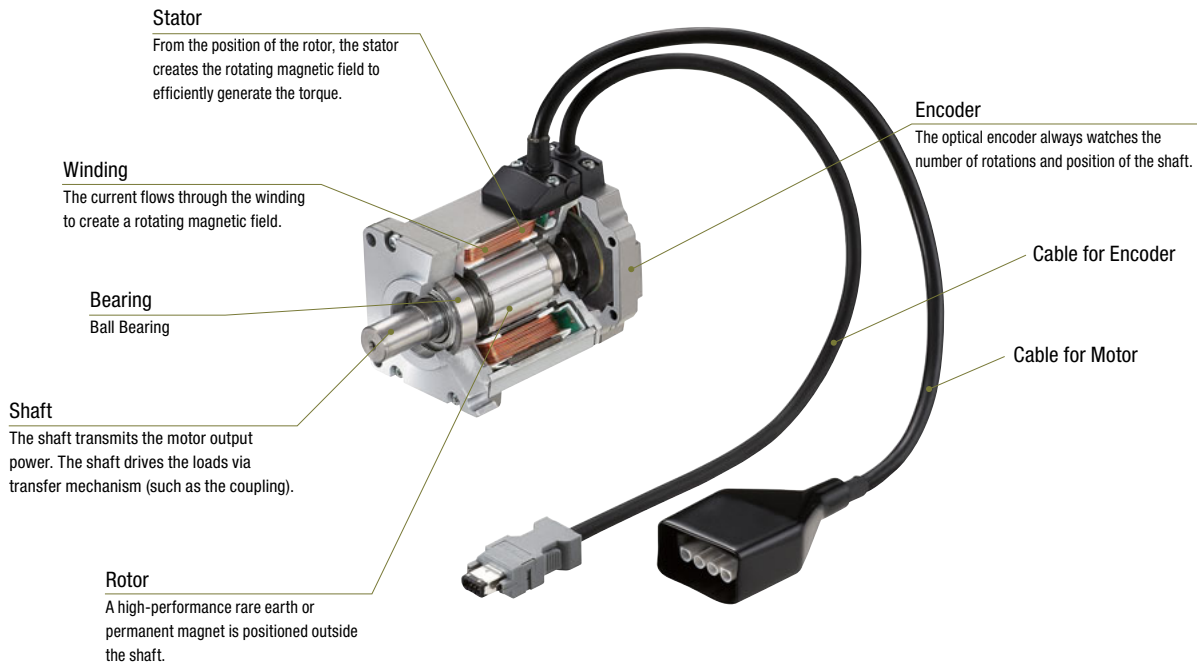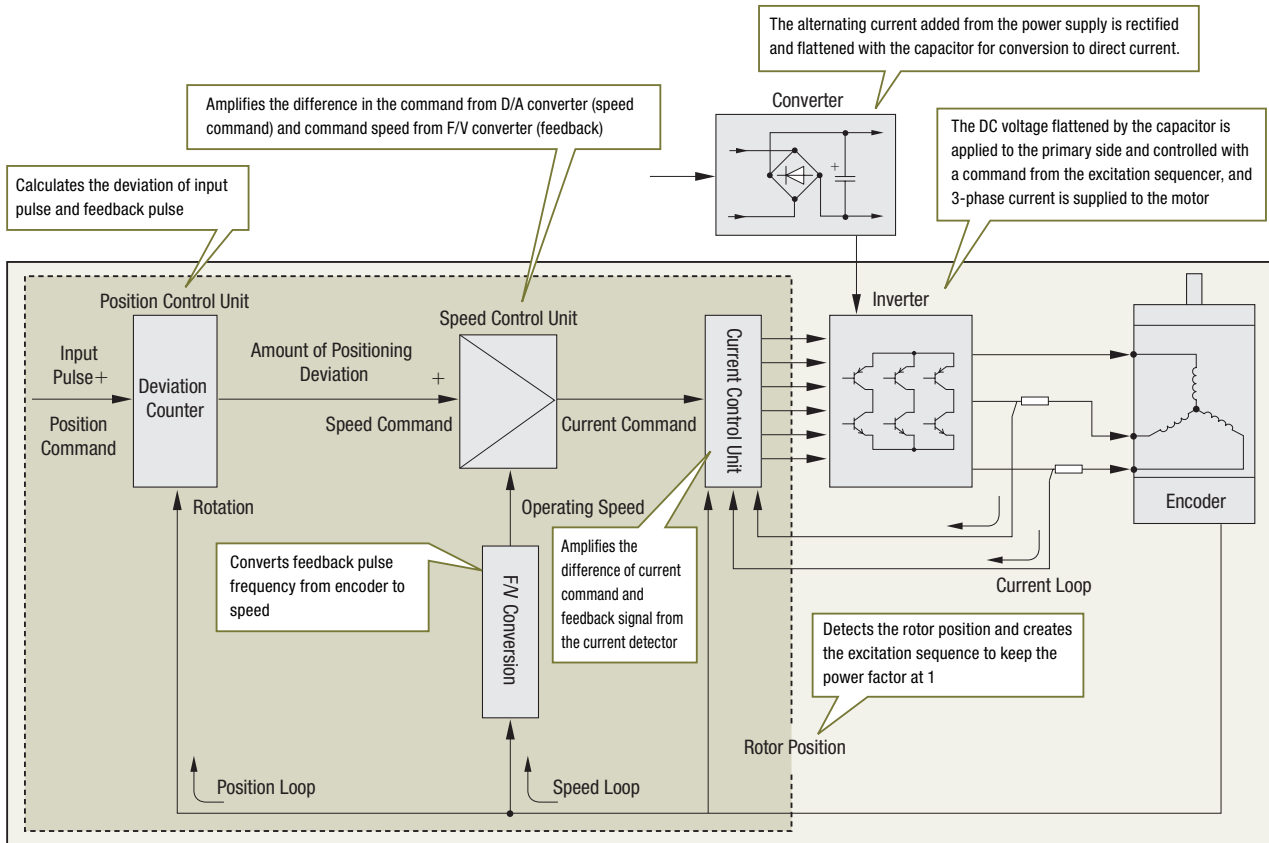## ■ Structure of Servo Motors

The servo motor can perform high resolution and high response positioning operation by detecting the rotor position and speed with the rotation detector (encoder) on the back shaft side of the motor.

Stator
From the position of the rotor, the stator creates the rotating magnetic field to efficiently generate the torque.

Winding
The current flows through the winding to create a rotating magnetic field.

Bearing
Ball Bearing

Shaft
The shaft transmits the motor output power. The shaft drives the loads via transfer mechanism (such as the coupling).

Rotor
A high-performance rare earth or permanent magnet is positioned outside the shaft.

Encoder
The optical encoder always watches the number of rotations and position of the shaft.

Cable for Encoder

Cable for Motor

The encoder is a sensor for detecting the speed and position of the motor.
Light from the light-emitting diode (LED) passes through a position detection pattern on the slit disk and is read by the light-receiving component. Dozens of phototransistors are integrated in the light receiving component. Every pattern for absolute positioning detection varies depending on the encoder rotation angle. The CPU is installed in the encoder to analyze the pattern for absolute positioning detection. The current position data is transmitted to the servo driver via serial transmission.

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■Control Block Diagram of Servo Motors

A pulse signal that is externally applied (when it is the pulse input type) and the rotation detected by the servo motor encoder are counted, and the difference (deviation) is output to the speed control unit. This counter is referred to as the deviation counter.
During motor rotation, an accumulated pulse (positioning deviation) is generated in the deviation counter and is controlled so as to go to zero.
The function for holding the current position (position holding by servo control) is achieved with a position loop (deviation counter).

The alternating current added from the power supply is rectified and flattened with the capacitor for conversion to direct current.

Amplifies the difference in the command from D/A converter (speed command) and command speed from F/V converter (feedback)

The DC voltage flattened by the capacitor is applied to the primary side and controlled with a command from the excitation sequencer, and 3-phase current is supplied to the motor

Calculates the deviation of input pulse and feedback pulse

Converter

Inverter

Position Control Unit

Speed Control Unit

Current Control Unit

Input Pulse+
Position Command

Deviation Counter

Amount of Positioning Deviation

Speed Command

Current Command

Rotation

Operating Speed

Converts feedback pulse frequency from encoder to speed

Amplifies the difference of current command and feedback signal from the current detector

F/V Conversion

Current Loop

Detects the rotor position and creates the excitation sequence to keep the power factor at 1

Rotor Position

Encoder

Position Loop

Speed Loop

The servo motor consists of three components: a motor, an encoder and a driver. The driver compares the positioning command and position/speed information from the encoder and controls the drive current. The servo motor always detects the motor status with the positioning/speed information from the encoder.
Even if the motor stops, the servo motor outputs the alarm signal to the controller so that you can detect the abnormalities. The servo motor must adjust the control type parameters according to the rigidity of mechanism and load conditions, however, the real-time automatic tuning has made the adjustment easy in recent years.

■Glossary

●Encoder

The encoder is a sensor that notifies the driver of the motor speed and position.

The encoders (position detector) used for the servo motor are structurally classified as "incremental encoders" and "absolute encoders."

Oriental Motor uses a 20-bit absolute encoder for our servo motors **NX** series for low vibration at low speed range.

◇Absolute Encoder

Sensor Output	Angle
011	45°
001	90°
000	135°
100	180°
010	225°
101	270°
110	315°
111	360°
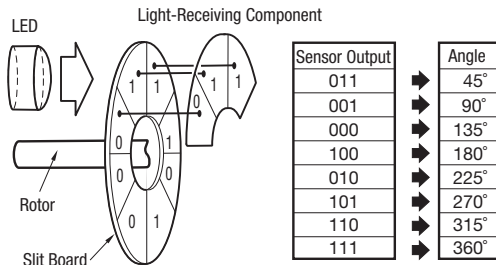
The encoder, which can detect the absolute position within a single rotation of servo motor, outputs the absolute position of rotation angle.

Normally, it transmits the multiple rotation information to the servo amplifier when the power is turned on. After that, the multiple rotation information is output to the current position control.

◇Incremental Encoder
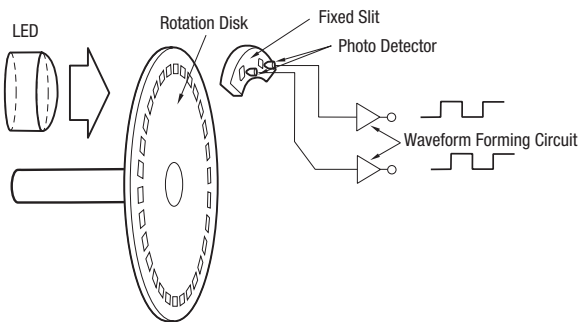
The encoder, which can detect the rotation amount, speed and direction of the servo motor, outputs the pulses depending on the alteration of rotation angle. Normally, it outputs the detected waveform without modification, so that the current position is lost during power blackouts.

●Resolution

This shows the angle that the motor rotates for 1 pulse.

The motor positioning accuracy is determined by the resolution. For example, resolution = 1000 p/rev means that a single rotation (360°) can be divided into 1000.

0.36°
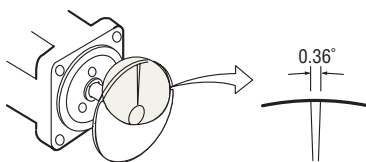
●Speed Control, Position Control

The speed and positioning control commands of **NX** Series are performed by inputting the pulse signal the same as with stepping motors. The relationship of pulse, speed and position is as follows:

- The rotation angle (position) is proportional to the pulse number.
- The rotation speed is proportional to the pulse frequency.

Additionally, torque control and tension control are possible for **NX** Series.

●Maximum Input Pulse Frequency

This is the maximum pulse frequency (speed) that can be input to the driver. The maximum motor speed is limited by the driver, so if the exceeded frequency is input to the driver, the motor can no longer follow and the alarm is output.

●Photocoupler "ON" "OFF"

Input (output) "ON" indicates that the current is sent into the photocoupler (transistor) inside the driver. Input (output) "OFF" indicates that the current is not sent into the photocoupler (transistor) inside the driver.
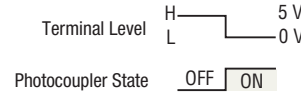
●Pulse Speed

For the pulse input type, the motor speed is proportional to the input pulse speed (pulse frequency).

$$\text{Pulse speed } f\,[\text{Hz}] = \frac{\text{Number of pulses for 1 rotation of the motor}}{60} \times \text{Speed [r/min]}$$

●Deviation Counter

The deviation counter counts the deviation of the input pulse and feedback pulse inside the driver. When the pulse is input to the driver, the pulses are added by the counter (integrated pulse). When the motor rotates, the feedback signal subtracts the integrated pulse in the counter and perform the positioning control so that the integrated pulse becomes 0.

●Hunting

During a standstill, the servo motor output shaft may vibrate slightly. This is called hunting.

●Settling Time

A delay occurs to the positioning command of pulse input and the actual motor operation. The settling time is the time difference that occurs at a motor standstill.
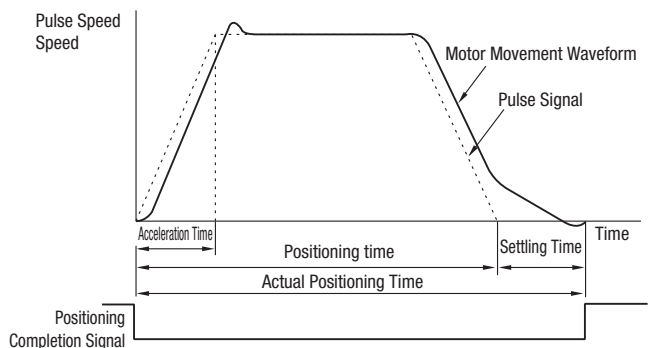
●Gain Adjustment

This is the adjustment for optimal control according to the load.

●Integrated Pulse

This is the difference between the command pulse input to servo motor and the feedback pulse output according to the motor rotation amount from built-in encoder.

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