Development of the AZX Series Servo Motors Equipped with ABZO Sensor

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To shorten takt time, especially for an axis moving a large load in a long stroke, motors need to have higher torque in the high-speed range. Unifying motor control is also necessary to reduce wiring through compatibility with various industrial networks and to reduce equipment startup time.

The **AZX** Series is developed on "the concept of achieving higher output power" with the **AZ** Series. Higher torque in the high-speed range is achieved by changing a hybrid stepper motor of the **AZ** Series to an SPM[*1] motor. In addition, the **AZX** Series has the same level of operability as the **AZ** Series by inheriting its extensive functions, including the "ABZO Sensor" and the simple sequence function.

This article explains the features of the **AZX** Series, as well as the heat separation design and heat dissipation structure change made to the motor and driver to handle increased heat generation due to higher output power.

1. Introduction

Oriental Motor has been expanding its product lineup of the **AZ** Series, equipped with the "ABZO Sensor" (mechanical absolute encoder), by adding multi-axis drivers and mini Driver as well as functions to support various industrial networks.

Generally, to shorten equipment takt time, higher torque motors are in need in the high-speed range for an axis of a large load in a long-stroke application. However, as the **AZ** Series adopts a hybrid stepper motor, the torque decreases in the high-speed range, which prevents its application to such needs.

Therefore, we have developed the **AZX** Series on "the concept of achieving higher output power" than the **AZ** Series.

The **AZX** Series achieves higher torque in the high-speed range by adopting a different motor from the **AZ** Series. This new series has the same operability as the **AZ** Series, adopting its ABZO sensor, and extensive operation functions.

Figure 1. **AZX** Series

2. Features of the AZX Series

2.1. Higher Output Power with the AZ Series

The **AZ** Series uses a hybrid stepper motor, which provides high positioning accuracy. While the **AZ** Series can operate at high torque in the low-speed range, the torque is reduced in the high-speed range. The **AZX** Series adopts the SPM motor, which is combined with the ABZO Sensor as a servo motor. This achieves higher torque in the high-speed range, as well as higher output, compared to the **AZ** Series. Figure 2 shows a comparison of torque characteristics between **AZM911AC** (**AZ** Series model with the highest output power) and **AZXM960AC** (**AZX** Series model), both with a frame size of 85 mm. Figure 3 shows a comparison of dimensions (**AZM911AC** and **AZXM960AC**).

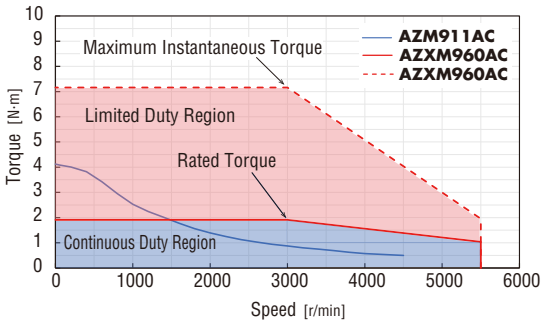


Figure 2. Comparison of Torque Characteristics (**AZM911AC** and **AZXM960AC**)

(*1) SPM: Abbreviation for Surface Permanent Magnet, meaning a synchronous motor with a permanent magnet attached to the surface of the rotor.

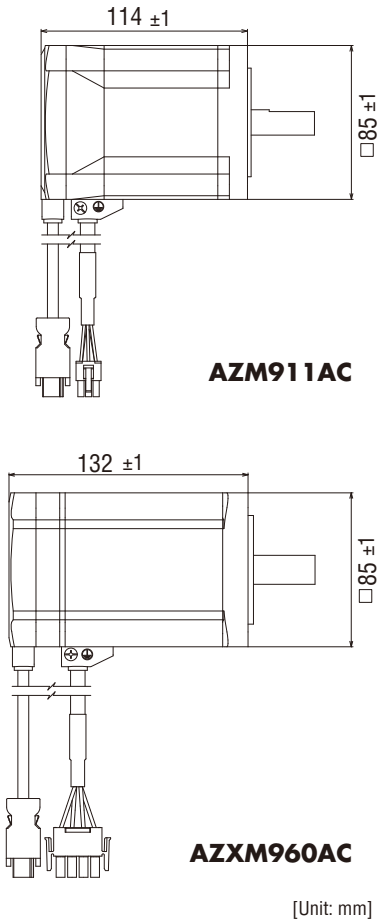
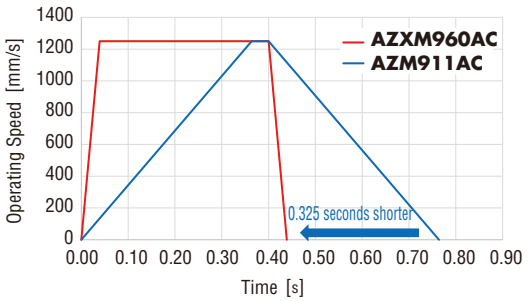


Figure 3. Comparison of Dimensions (**AZM911AC** and **AZXM960AC**)

The **AZX** Series can generate a maximum instantaneous torque, which is three times the rated torque, up to 3000 r/min, enabling acceleration up to the high-speed range in short time. This makes shorter positioning time possible compared to the **AZ** Series for long-stroke positioning operations . Figure 4 shows a comparison of positioning time between **AZM911AC** and **AZXM960AC**.



[Operating Conditions]

Load Inertia	:	7.86×10^{-4} kg·m²
Travel Amountt	:	500 mm (Number of Motor Revolutions: 20)
Maximum Operating Speed	:	1250 mm/s (Motor Speed: 3000 r/min)
Ball Screw Lead	:	25 mm

Figure 4. Comparison of Positioning Time (**AZM911AC** and **AZXM960AC**)

2.2. Unified Operability with the **AZ** Series

The **AZX** Series unifies operability by inheriting many of the same functions as the **AZ** Series while achieving higher output power. This section introduces some examples.

2.2.1. Operation Functions

Equipped with the ABZO Sensor, the **AZX** Series is an absolute system that does not require a battery, which reduces the need for external sensors. Additionally, upon recovery from a power outage, operation can be resumed without returning to a home position. The simple sequence function as shown in Figure 5 and the hierarchized I/O function consisting of internal I/O and interface I/O enable both faster processing by simplifying control procedure with the host controller and load reduction on the host controller(1).

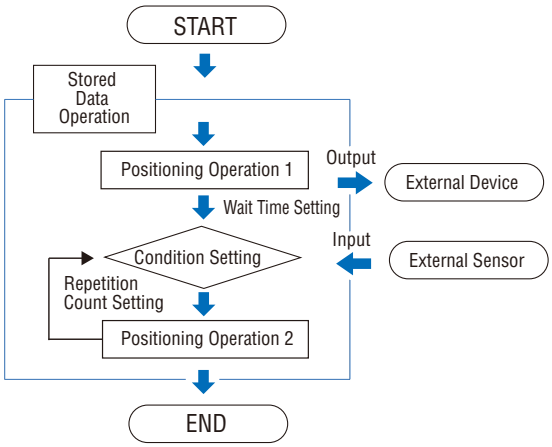


Figure 5. Simple Sequence Function

2.2.2. Network Compatible

The **AZX** Series lineup includes an EtherNet/IP™*2 type. Since EtherNet/IP™ is equipped as standard in most PLCs, it can be easily added by connecting a single Ethernet cable to each driver. Furthermore, as shown in Figure 6, the standardized interface and parameter IDs unified with the **AZ** Series via EtherNet/IP™ control helps reduce equipment startup time when both series are used within the same equipment.

The **AZX** Series lineup also includes an EtherCAT®*3 type and a PROFINET*4 type in addition to the EtherNet/IP™ type.

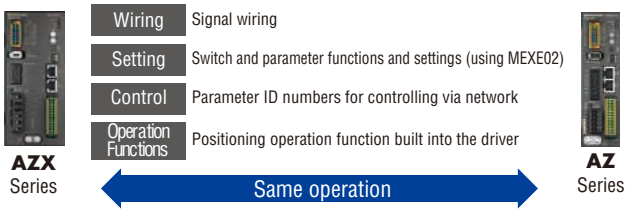


Figure 6. Same Operability as the **AZ** Series (EtherNet/IP™)

(*2) EtherNet/IP™ is a trademark of ODVA (Open DeviceNet Vendor Association).
(*3) EtherCAT® is a registered trademark and patented technology licensed by Beckhoff Automation GmbH (Germany).
(*4) PROFINET is a trademark or a registered trademark of PROFIBUS Nutzerorganisation e.V. (PNO).

2.2.3. Combining with a Rotary Table Mechanism

Like the **AZ** Series, the **AZX** Series is equipped with a convenient wrap function for rotary tables. Based on the set wrap range, the wrap function resets the number of degrees to 0 when the table rotates 360 degrees. This enables the management of position within a rotation and the wrap proximity positioning (positioning to a proximate rotational direction in a position within a rotation) even during continuous rotation in the same direction.

Oriental Motor also has a lineup of the **DGII** Series hollow rotary actuators for combined use with the **AZX** Series.

2.3. Gain Tuning

Using a servomotor requires load inertia setup, responsiveness adjustment, and resonance suppression setup.

The **AZX** Series can also operate with the automatic setting function even when the load inertia is unknown.

In addition, when using the **MEXE02** support software, the response can be changed in real time on the gain tuning screen as shown in Figure 7. These functions together help adjust responsiveness and set up resonance suppression.

If automatic setup is insufficient, resonances can be further suppressed by identifying the resonance frequency from the FFT monitor shown in Figure 8 and setting it manually.

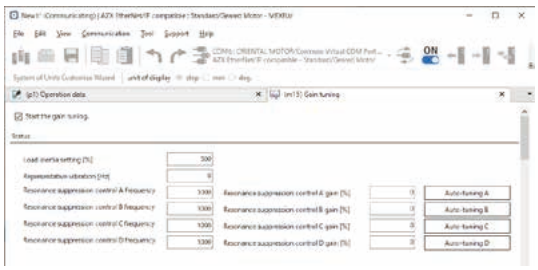


Figure 7. Gain Tuning Screen

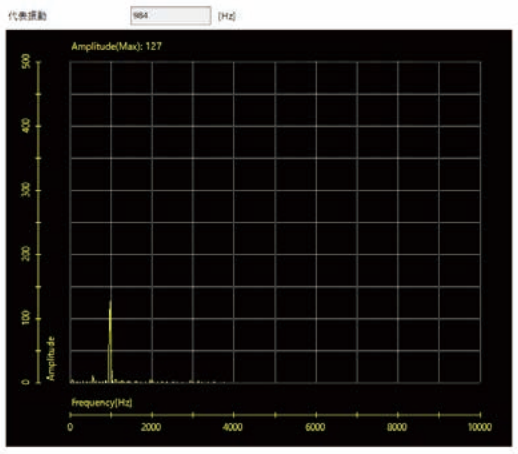


Figure 8. FFT Monitor Screen

3. Higher Output Power

3.1. Heat Dissipation Design of the ABZO Sensor

The hybrid stepper motor used in the **AZ** Series has a structure with a large number of small teeth, which enables a high degree of positioning accuracy. At the same time, the higher frequency of the power supplied to the motor upon rotation generates more heat caused by iron loss, particularly during high-speed rotation. With the upper temperature limit for electronic components used in the ABZO Sensor being 85 °C, the **AZ** Series was incapable of achieving higher speed and output. On the other hand, the **AZX** Series adopts the SPM motor, which reduces heat generation during high-speed operation, in addition to a design that efficiently dissipates the temperature of the ABZO sensor, both of which achieve continuous rating and higher output power at 3000 r/min.

The **AZX** motor integrates a heat dissipation sheet with higher thermal conductivity than air between the ABZO Sensor and the aluminum sensor cover, which efficiently conducts the heat the ABZO Sensor receives from the motor to the sensor cover, leading to excellent heat dissipation performance. The installation of the heat insulation plate between the sensor cover and the motor, which is the heat source, suppresses the temperature increase of the sensor cover and efficiently releases the heat from the ABZO Sensor. (See Figure 9.)

The thermal conductivity of each component is shown in Table 1.

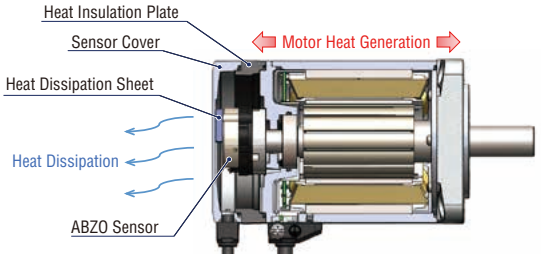


Figure 9. Heat Dissipation Design of the **AZX** Motor

Table 1. Comparison of Thermal Conductivity

	Air	Heat Insulation Plate (Resin)	Heat Dissipation Sheet	Sensor Cover (Aluminum Alloy)
Thermal Conductivity [W/(m·K)]	0.024	0.3	1.2	96

This design achieves an appropriate 10 °C drop in the temperature of the ABZO Sensor at rated operation and higher speed and higher output power of the motor. (See Figure 10.)

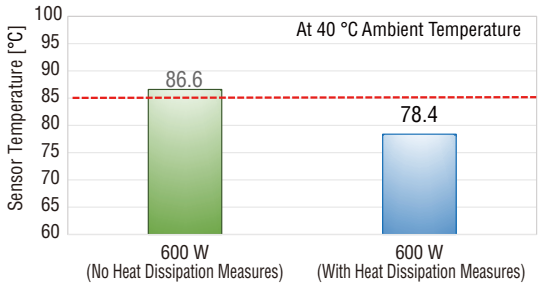


Figure 10. Comparison of the Effect of Sensor Heat Dissipation Design

3.2. Heat Dissipation Design of the Driver

Higher output power also increases heat generation in power devices, including the driver's inverter circuit. Having the same heat dissipation structure as the **AZ** driver will cause heat to transfer to the entire driver, leading to the control devices that are sensitive to heat being exposed to temperatures higher than their temperature rating.

The **AZX** driver has the power devices installed on the rear side and the control devices on the front side. The forced ventilation cooling by a built-in fan works on the heat sink where the power devices are installed. The heat transferred to the heat sink is then released to the top side from the bottom side, preventing the heat generated by power devices from conducting to the control devices. (See Figure 11.)

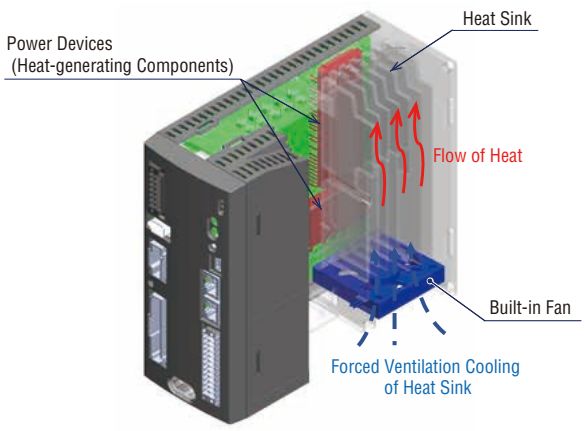


Figure 11. Heat Dissipation Structure of the **AZX** Driver

Figure 12 shows the temperature distribution with different output. The driver's power devices are implemented on the rear side, where the temperature rises as the output increases. On the other hand, the temperature at the front side where the control devices are implemented is mostly unaffected by the increased output power.

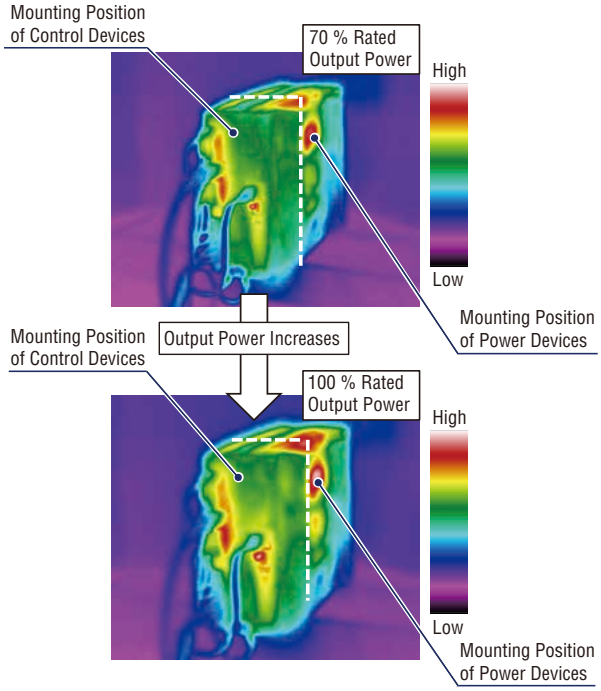


Figure 12. Changes in the Driver Temperature Distribution by Output Power

As shown above, the **AZX** Series has an improved heat dissipation structure that reduces the temperature effect on the heat-sensitive control devices and ensures the same maximum operating ambient temperature of 55 °C as the **AZ** Series even with increased output.

The maximum ambient temperature with closely installed drivers was 40 °C for the **AZ** Series, but the specifications have been improved to 45 °C for the **AZX** Series. (for three-phase 200 VAC input).

4. Summary

The **AZX** Series is developed on the concept of achieving higher output power than the **AZ** Series.

By changing the motor to an SPM motor—the same as servo motors and brushless motors—from a hybrid stepper motor, higher torque is produced in the high-speed range, enabling applications that are not covered by the conventional **AZ** Series.

The **AZX** Series is applicable to the same use environment as the **AZ** Series, thanks to the changes made to the motor and driver regarding the thermal separation design and heat dissipation structure in order to handle increased heat generation due to higher output.

The adoption of the ABZO Sensor and many other **AZ** Series features, such as the simple sequence function, contribute to provide the same usability as the **AZ** Series while reducing the time taken for equipment startup when using the **AZX** Series and the **AZ** Series in the same equipment.

Oriental Motor will continue to work toward providing products that are suitable for customers' equipment.

References

(1) Masaharu FURUTA, "Development of the **AZ** Series Closed Loop Stepping Motor and Driver Package with Battery-free Multi-turn Absolute Sensor, "ABZO"" RENGA, No.180 (2014)

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