

Evolving Servo System with High Speed,  
High Precision and Energy Efficiency

# FANUC

## $\alpha$ i-D series SERVO



# Evolving Servo System with High Speed, High Precision and Energy Efficiency

## FANUC $\alpha$ i-D series SERVO

Mach  
perform

- Servo motor : Increased smoothness
- Spindle motor : More power and torque
- Control : Higher precision and quality

### CNC



FANUC Series 500*i*-A



Oi-F Plus, 30*i*-B Plus,  
Power Motion *i*-A Plus

### FANUC SERVO AM

FSSB (FANUC Serial Servo Bus)



### FANUC SERVO MOTOR $\alpha$ i-D series



LINEAR MOTOR DD MOTOR



- Improved durability against cutting fluid
- Trouble prediction
- Quick maintenance

Maximizing  
uptime

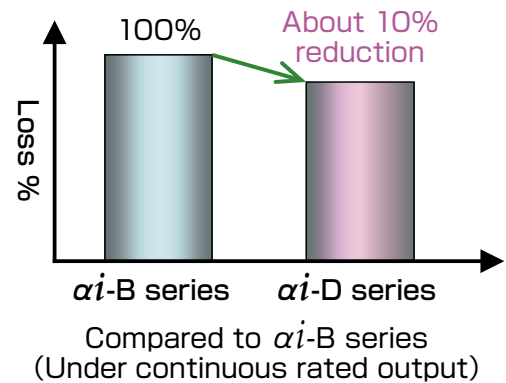
Performance

## Energy conservation

- Highly efficient motors
- Highly efficient current control
- Power regeneration as standard
- Amplifiers with low-loss power devices
- Low-loss AC reactor



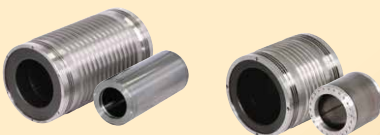
### AMPLIFIER $\alpha$ i-D series



### FANUC SPINDLE MOTOR $\alpha$ i-D series



### BUILT-IN SPINDLE MOTOR



- Downsized and reduced wiring
- Easy setting and tuning
- Convenient sizing

Ease of use

# Servo motor

## Applicable to feed axes of various machines

- A wide line-up range for feed axes of various machines
  - **$\alpha$ iS-D series** . . . Achieve high-speed and high-acceleration
  - **$\alpha$ iF-D series** . . . Achieve exceptional smoothness
- Newly added 200 sq. flange size model increases the servo motor choices available for large machines.
- Productivity is improved by raising maximum speed of live tool motors (40, 60, 90 sq.) to 8000min<sup>-1</sup>.

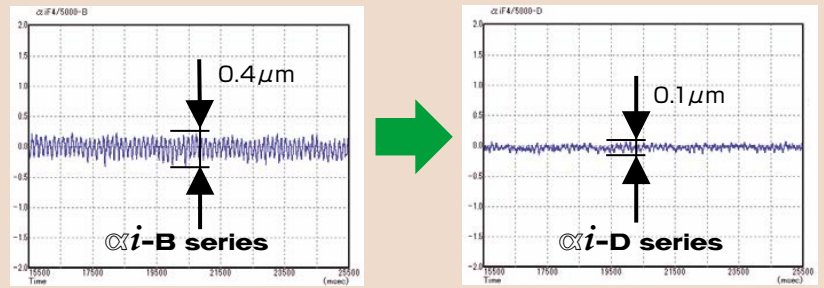


## Achievement of high-speed, high-accuracy, and high-quality machining

### High-accuracy, high-quality machining

- $\alpha$ i-D servo motors have been improved to achieve higher accuracy, lower cogging torque, and faster communication speed with the Pulsecoder. Higher response and machining quality are achieved with the combination of  $\alpha$ i-D servo amplifiers and servo HRV control.

Ex.)  $\alpha$ iF4 (130 sq.) feed accuracy

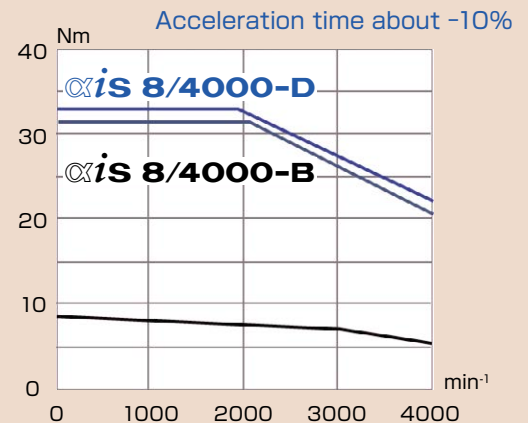


[Conditions] Feed rate 6min<sup>-1</sup>, Lead 10mm/rev conversion

### High-speed machining (Reduction of cycle time)

- Enhanced maximum torque characteristics contribute to quicker acceleration and shorter cycle time.
- Increased maximum speed contributes to positioning operations at high feed rates and shortens cycle time.

Ex.)  $\alpha$ iS8 (130 sq.) torque characteristic



## Battery replacement unnecessary

### Battery-less Pulsecoder

- Battery-less Pulsecoder can be selected for all servo motors.
- Battery change in all axes including peripheral axes is not required.



Battery-less Pulsecoder

# Spindle motor

## Applicable to various machining

- A wide variety and range of line-up meets various machining needs of machine tools.

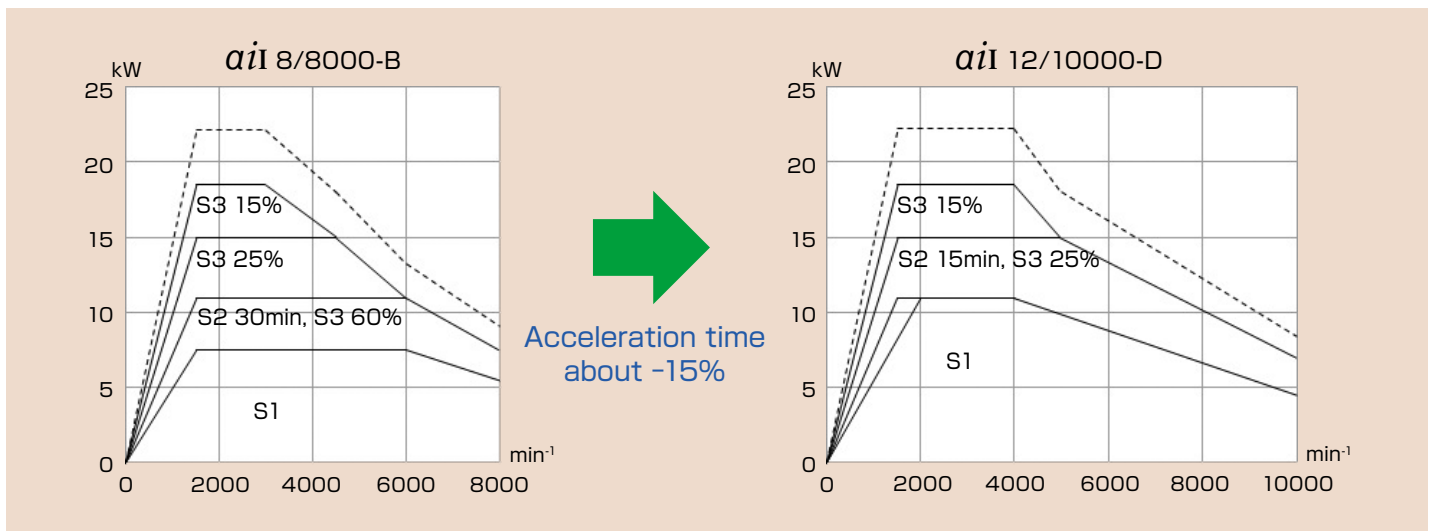
- **$\alpha$ i-D series** . . . Achieve excellent machining performance with high-speed and high-power
- **$\alpha$ iP-D series** . . . Realize high-torque with smaller amplifier
- **$\alpha$ iIT-D series** . . . Enable center-through coolant by hollow shaft
- **$\alpha$ iL-D series** . . . Attain low temperature rise and high-torque with liquid-cooling
- **$\alpha$ iS-D series** . . . Create high-power and high-acceleration by using neodymium magnets

- Models for lathe, suitable for belt drive with higher allowable radial load, are also available.



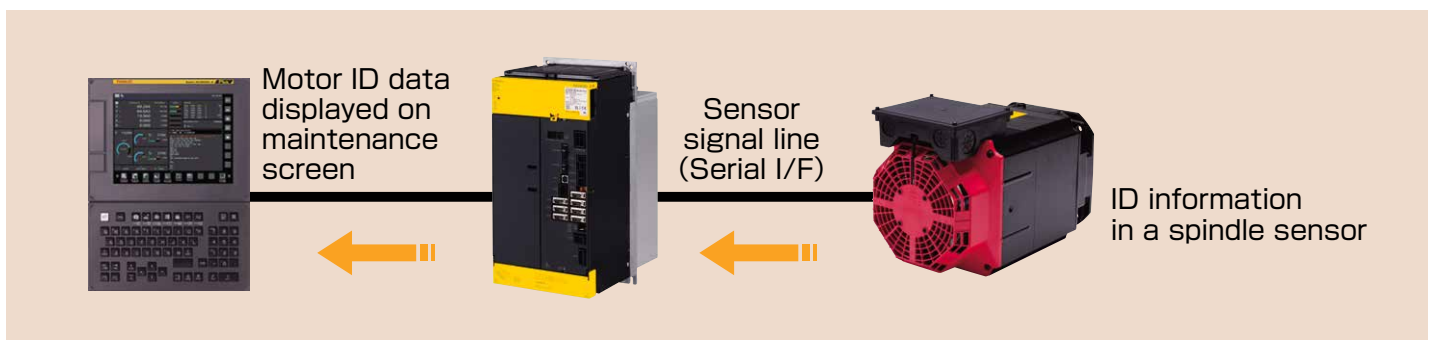
## Higher machining performance

- Enhanced maximum output characteristics contribute to quicker acceleration up to high-speed range and shorter cycle time.
- Superior continuous output characteristics contribute to high-efficiency machining.
- Increased maximum speed contributes to wider application range of machining.
- Vibration class of V3 as standard contributes to high-accuracy machining.



## Visualization of spindle motor information

- Information such as Motor ID is available on CNC screen and contributes to improvement of motor traceability.





# Servo Amplifier

## Flexible combination for various machine configurations

### Separated-type amplifiers

- The best suited arrangement according to various machine layouts is possible with the combination of servo amplifiers, spindle amplifiers and common power supplies.

- ⊗ **aiSV-D series** : "Servo amplifier", which drives servo motors
- ⊗ **aiSP-D series** : "Spindle amplifier", which drives spindle motors
- ⊗ **aiSVP-D series** : Multi-axis amplifier which has servo axes and spindle axes
- ⊗ **aiPS-D series** : "Common power supply", which supplies main power for driving motors



### Integrated-type amplifiers

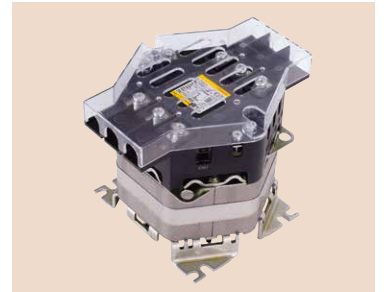
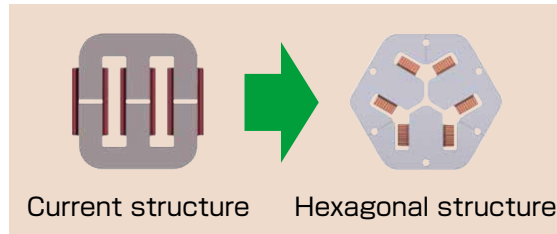
- The integrated-type amplifiers achieve downsizing and simple wiring by integrating servo axes, spindle axis and power supply.
- Additional separated-type amplifiers can be installed with ⊗ **aiPSVSP-D** easily by connecting directly with DC-link short bars.

- ⊗ **aiPSVSP-D series** : Common power supply, Servo amplifier and Spindle amplifier integrated amplifier
- ⊗ **aiPSV-D series** : Common power supply and Servo amplifier integrated amplifier



### AC Reactor

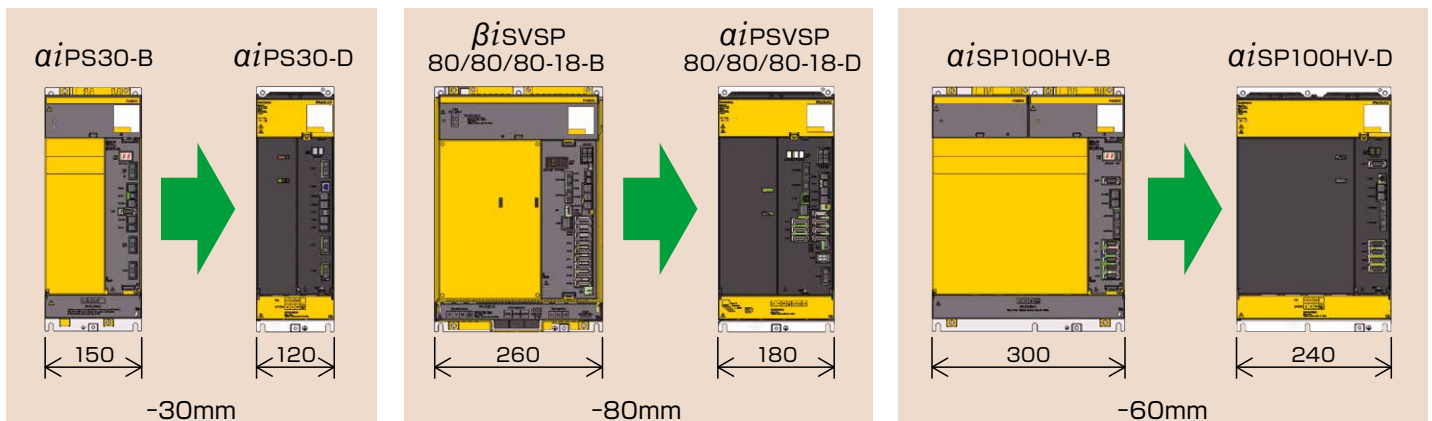
- The design has been renewed by adopting a unique new hexagonal structure, which reduces losses and contributes to energy conservation.
- The thermostat provides overheat protection for the AC reactor.



## Downsizing of a control cabinet

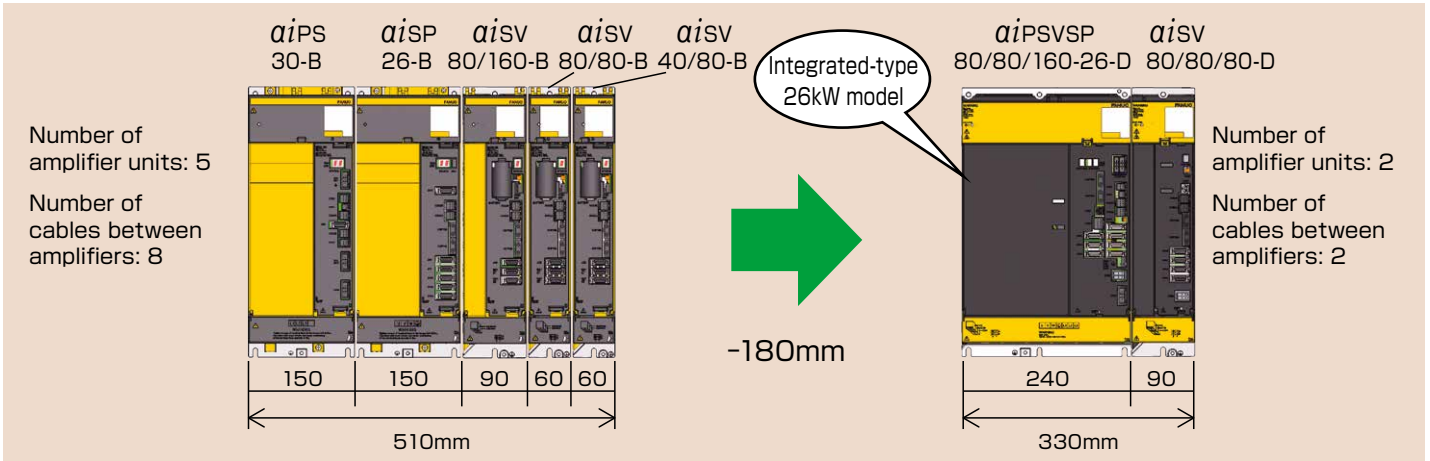
### Smaller amplifiers

- The width of amplifiers are reduced by up to 30% compared with previous models.



## Expanded line-up of multiple-axis amplifiers

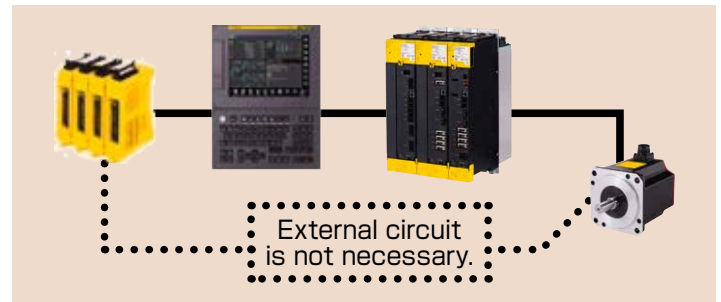
- The use of suitable multiple-axis amplifiers realizes downsizing of a control cabinet, and simplified wiring with a reduced number of amplifier units.



## Reduction of devices in a control cabinet

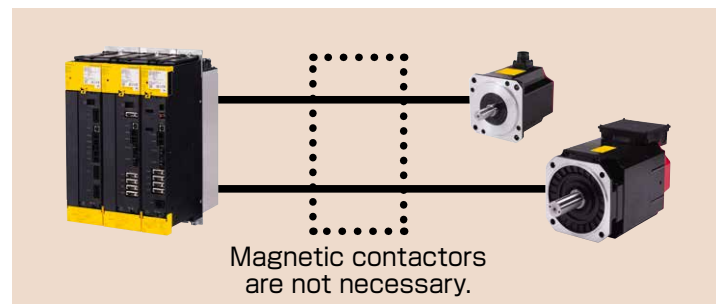
### Brake control circuit in amplifiers

- The circuit to control holding brakes of servo motors is built into servo amplifiers.
- It is not necessary to prepare brake control circuits separately and also wiring for control signals via I/O units.
- This feature contributes to downsizing, simple wiring and cost-saving of a control cabinet.



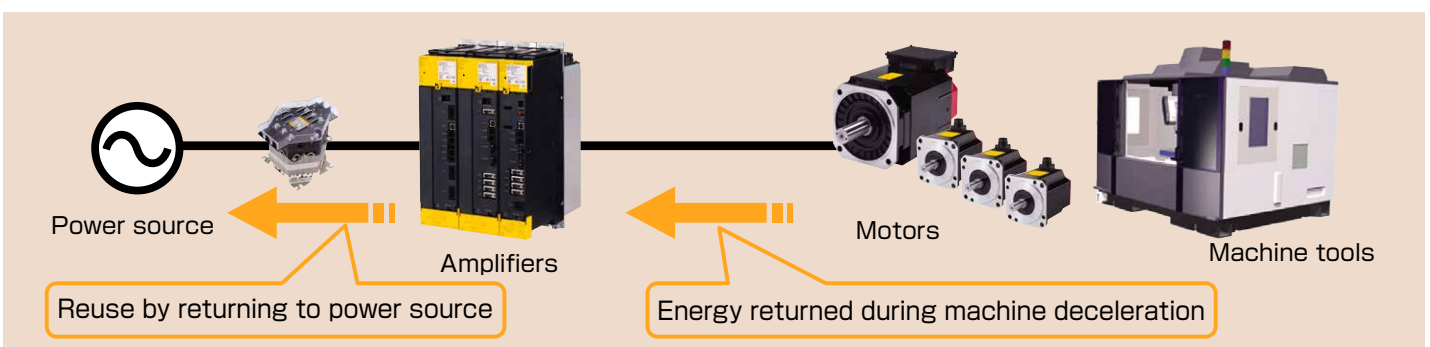
### Safe Torque Off (STO) function

- Motor power can be cut off safely by the duplicated cut-off circuit in amplifiers, conforming IEC 61800-5-2.
- It is not necessary to prepare magnetic contactors to cut off motor power.
- This feature contributes to downsizing, simple wiring and cost-saving of a control cabinet.



## Saving energy with power regeneration method

- Amplifiers (excepting for  $\alpha$ iPSV-D) save energy by returning regenerative energy during deceleration to power source without heat dissipation loss, which is also applied in conventional models.

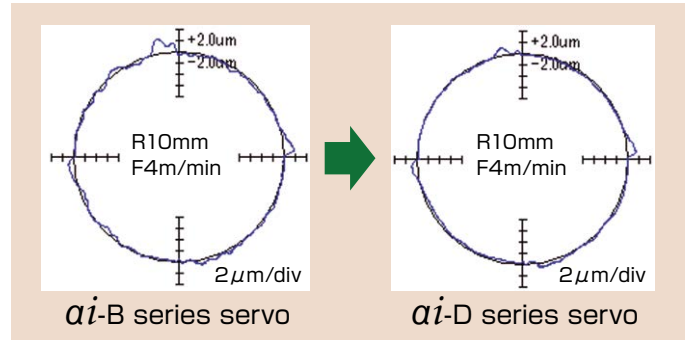


# Servo Control

## Servo control to achieve high-speed and high-accuracy

### SERVO HRV<sup>+</sup> Control (High Response Vector)

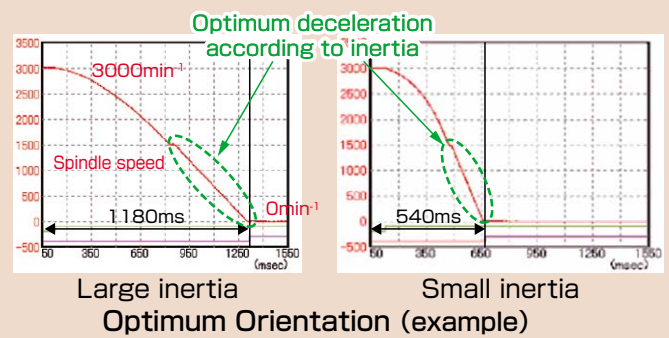
- In *ai*-D series SERVO, rotational smoothness of SERVO MOTOR, current resolution of SERVO AMPLIFIER, and communication speed of PULSECODER are improved. High-speed and high-accuracy machining at nanometer level can be achieved thanks to higher servo gain by both the latest SERVO HRV<sup>+</sup> control and hardware enhancement. The automatic-following HRV filter can suppress mechanical resonance even when its frequency changes.
- Higher cycle of position and velocity control can be used in FS500*i*-A. It will improve the smoothness of axis movement.



## Spindle control to achieve high-response and high-efficiency

### SPINDLE HRV Control (High Response Vector)

- High-speed current control achieves the high-gain control and the low heat generation of motors at high-speed rotation which leads to energy conservation.
- Optimum Orientation function enables the optimum deceleration according to the inertia of workpieces or tools, and cycle time can be reduced.
- Nano Interpolation in position control enables Nano CNC system for spindle axis as well as feed axis.



## Smart Servo Control

### Optimizing control in real time

Smart Servo Control is a group of functions to optimize control in real time according to the change of machine conditions such as load, temperature and position. High-speed, high-accuracy and high-quality machining can be achieved by using these functions.

#### Smart Spindle-load Control

#### Smart Rigid Tapping

#### Smart Thermal Control

#### Smart Spindle Acc/Dec

#### Smart Feed-axis Acc/Dec

#### Smart Load Meter

#### Smart Overlap

#### Smart Backlash Compensation

#### Smart Machining Point Control




## Servo Learning Control / Servo Learning Oscillation


- Servo Learning Control enables high-speed, high-accuracy machining of workpieces that require repeatable cutting commands, such as aspheric workpieces, gears, and so on.
- Servo Learning Oscillation accurately follows high frequency oscillation commands, thereby ensuring reliable chip shredding during turning and drilling.

### Example of the application of Servo Learning Control

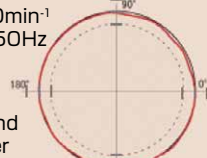
Aspheric lens



Piston  
(Non-cylindrical)



Example of piston machining



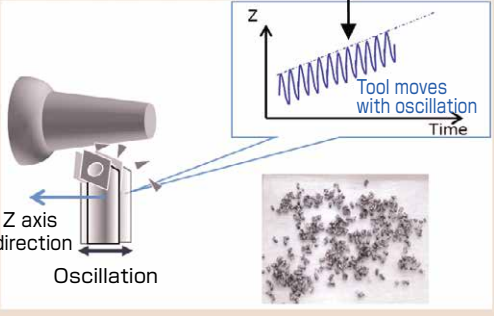
Spindle: 4500min<sup>-1</sup>  
Swing axis: 150Hz

Ellipse long and short diameter difference: 0.4mm

Error 2μm or less

Combinations with a DD or liner motor are particularly effective for achieving high-accuracy machining.

### Servo Learning Oscillation



Normal path

Z axis direction

Oscillation

Tool moves with oscillation

Shredded chips

## Servo Tuning Tool FANUC SERVO GUIDE Plus

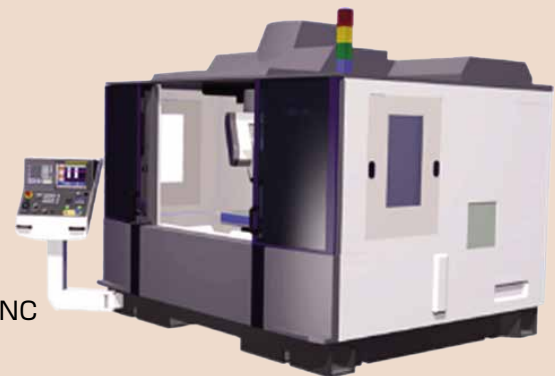
### Integrated tuning tool for Servo and Spindle

SERVO GUIDE Plus helps to improve machining performance through the various waveform analysis and the optimization of servo/spindle parameters according to machine characteristics.

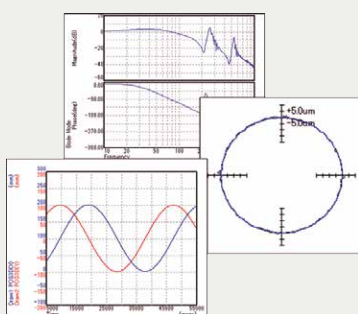
- All in one package for servo tuning including data measurement, parameter management and test program preparation
- Various views of waveform helps easy analysis of machine condition
- AI Servo Tuning is an auto-tuning algorithm with artificial intelligence. It can optimize parameters easily and in a short time.
- 3-D View Function (option) visualizes the tool path and path error and helps trouble shooting of 5-axis machining



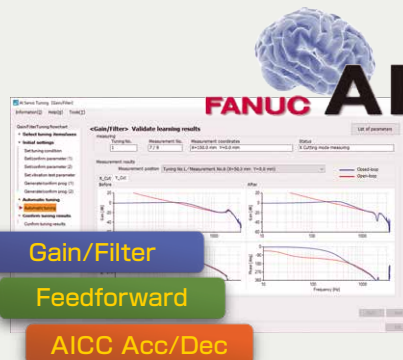
CNC



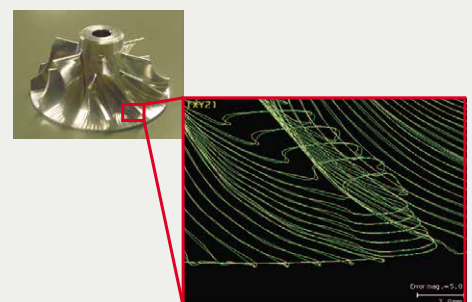
Machine tools



Various waveform view



AI Servo Tuning



Tool path by 3-D View Function

# Maximizing Uptime

## Reliable Improving of reliability for cutting fluid

### Servo motor IP67 as standard

Adopting new IP67 connector, sealing parts and an improved sealing structure has achieved higher cutting fluid resilience than former models.

*ai*-D series servo motors are IP67 as standard (200 sq. or less).

### Spindle motor

The risk of penetration of cutting fluid from shaft-through portion is reduced by improved seal structure of labyrinth for high-speed models. The environmental durability for high-speed models is enhanced.

### Molded Fan Motor

Molded fan motors have been adopted, in which the coils and printed circuit board are molded with resin.

Molded fan motor has high durability against coolant and prevents the failure of fan motor by itself.



## Predictable Trouble Prediction Function

Unexpected machine stop is prevented, and preventive maintenance becomes available, by detecting anomaly signs of the motor, amplifier, and fan motor.

### Leakage Detection Function

Leakage detection function measures the insulation resistance of the motor and detects insulation deterioration.

All *ai*-D servo amplifiers, including Integrated-type amplifiers have this leakage detection function.

### Capacitor Check Function

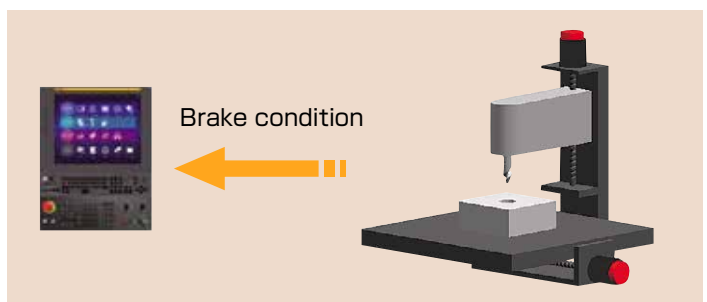
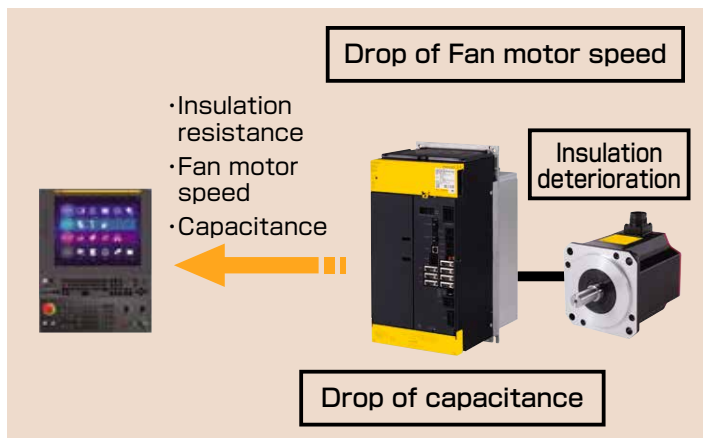
Capacitor check function measures the capacitance for main circuit in servo amplifier and detects drop of capacitance.

### Fan motor speed detection function

Fan motor speed detection function measures the speed of the fan motor in servo amplifier and detects drop of fan motor speed.

### Brake check function

The brake check function measures the brake condition and detects a failure of the brake.



## Fan motor stop detection function for Spindle motor

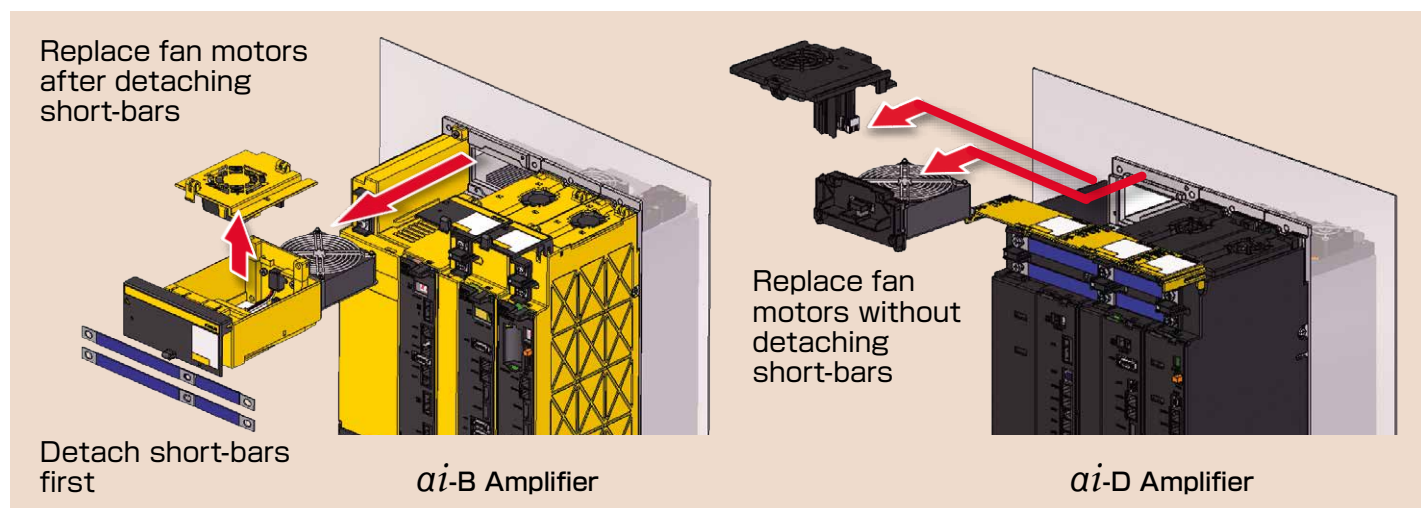
Detection of a stopped spindle motor fan is realized by the addition of thermostat to the fan motor. Preventive maintenance is possible before overheating of spindle motor since a fan motor "WARNING" will be displayed on the CNC.



## Easy to repair Quick Replacement of Fan motor

Fan motors can be replaced from the front of amplifiers without detaching amplifiers from a cabinet and disconnecting wiring.

Fan motor replacement time is greatly reduced.

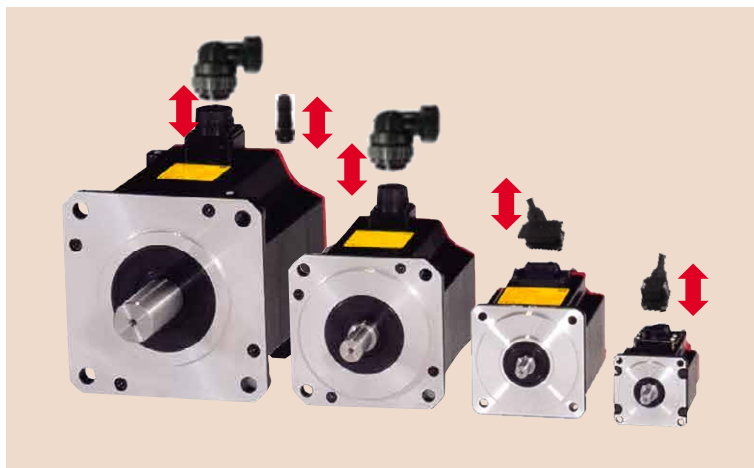


## Easy to repair One-touch connector

One-touch power connector usage is added for small servo motors.

Both of power and signal connector can be attached and detached with a single touch.

One-touch connectors contribute to reducing maintenance time.



# Service & Support

## Excellent Maintenance Services

FANUC service team delivers customer trust and confidence based on direction of service “Maximizing Uptime”, “Global Service” and “Lifetime maintenance”.

### *Service First*

Conforming to the spirit of “Service First”, FANUC provides lifetime maintenance to its products for as long as they are used by customers, through more than 260 service locations supporting more than 100 countries and regions throughout the world.

#### Maximizing Uptime



## FANUC ACADEMY

FANUC ACADEMY operates versatile training courses to develop skilled engineers effectively in several days.



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