

Minebea

MinebeaMitsumi Inc.

Automotive Application

VR RESOLVERS



CONTENTS

Precautions & Instructions for Use	2
Selecting the resolver	3
VR resolver standard series	4
10VRX Type / 15VRX Type / 21VRX Type	5
40VRX Type / 52VRX Type / 63VRX Type	6
Options / applications	7
Glossary	8
Mounting method	9
Effect of mounting accuracy (robustness)	10
Technical information	11
R/D converter.....	13
Q & A	14

Automotive Application VR RESOLVERS

VR resolvers, angle sensors based on a variable reluctance method, have a promising future mainly for use in controlling motors in automobile-related applications. VR resolvers are expected to find a wide range of applications in the future, such as in electric powered steering, hybrid cars, electric cars, integrated starter generators, brake by wires, steering by wires, and valve controls. The signal from a VR resolver can be converted digitally using the same R/D converter as those intended for the brushless resolver.



15VRX



34VRX



Precautions & Instructions for Use

For safe use of the product

To use the product correctly and safely, read these precautions very carefully before use.



WARNINGS

- Do not use the product in an environment with volatile or flammable gas, or in wet locations. Doing so may result in fire, injury, or electric shock.
- Do not pull or pinch the lead wire when electricity is being supplied. Doing so may result in electric shock. In addition, do not touch the live portion (e.g., connection terminal) when electricity is being supplied. Doing so may result in electric shock.
- Have a professional who has technical knowledge perform the mounting work, wiring work, inspection work, and the like. If there is a fault (e.g., wrong wiring), the product may malfunction, resulting in breakdown or burnout.
- Perform work after the power is turned OFF and safety is confirmed. Stop the operation of the equipment immediately if there is any abnormality. Failure to do so may result in electric shock, injury, or fire, etc.



CAUTIONS

- Design your device in such a way that the device equipped with this product will stop this product safely should any abnormality occur in this product.
- Do not touch the rotating portion (e.g., shaft) with your fingers when the portion is rotating, since you may get injured.
- Do not take hold of the lead wire portion. Doing so may result in failure such as breaking of wire, or may result in injury due to the product falling.
- The products listed are not manufactured for use in components related to nuclear control. Do not use the product in areas related to nuclear control.
- Be sure to observe the specifications range and usage environment described in this catalog when using the product.
- When mounting and fixing the product, do so securely while taking account of product mass, vibration during operation, vibration from the surroundings, and the like.
Resonance may result in abnormal vibration or noise, or cause a decline in performance, characteristics, function, or the like.
- Do not use a product that was hit by something or was dropped. Doing so may result in failure to satisfy the performance due to deformation or due to effects on magnetic characteristics.
- Due to design modifications, the design and standard are subject to change without prior notice.



Selecting the resolver

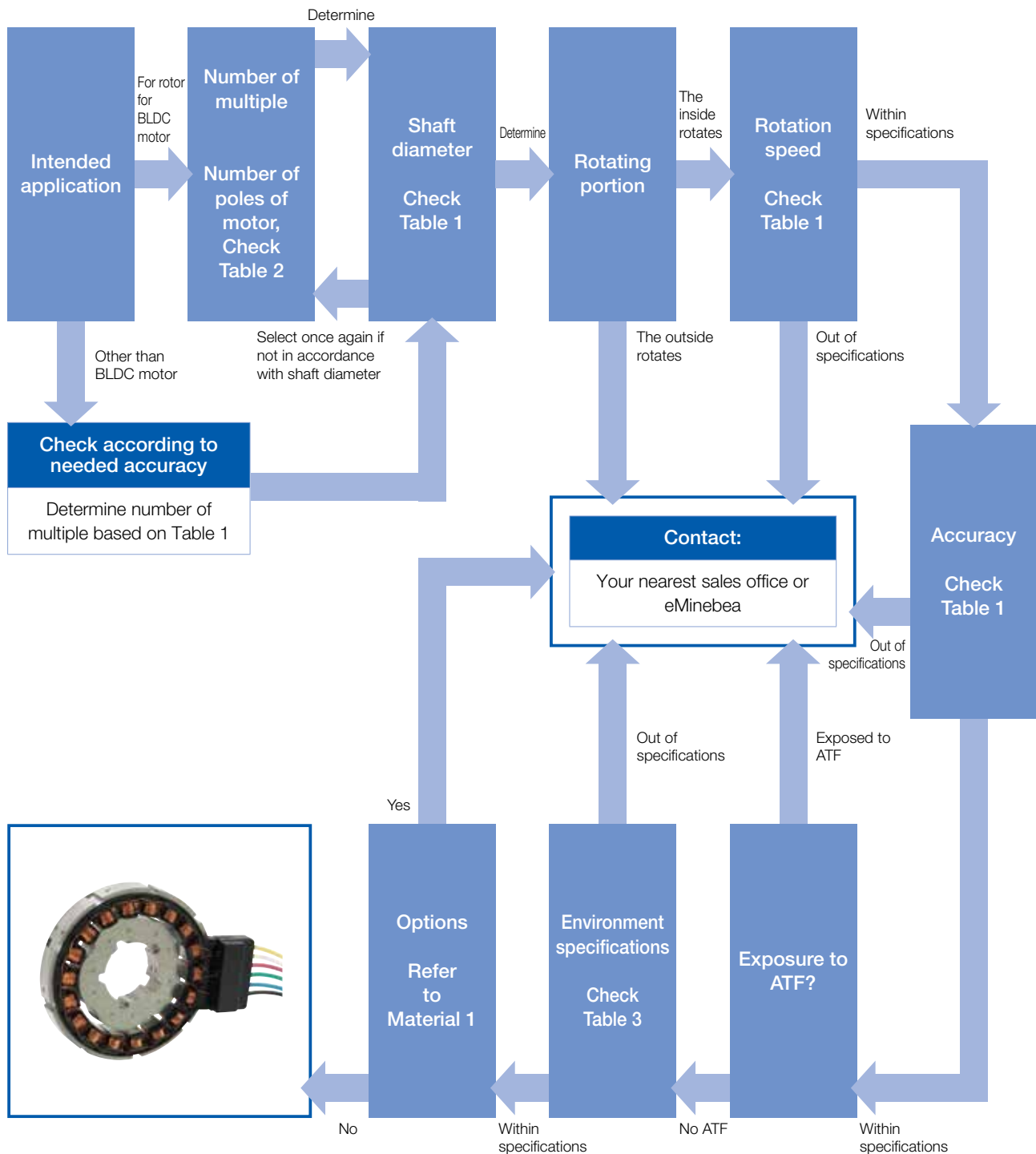


Table 1 : List of characteristics	Page 4
Table 2 : Number of pole pairs of BLDC motor and number of multiple of resolver	Page 12
Table 3 : Environmental durability	Page 12
Material 1: Special shapes of connectors, etc. (option)	Page 7

VR resolver standard series

VR resolver standard series

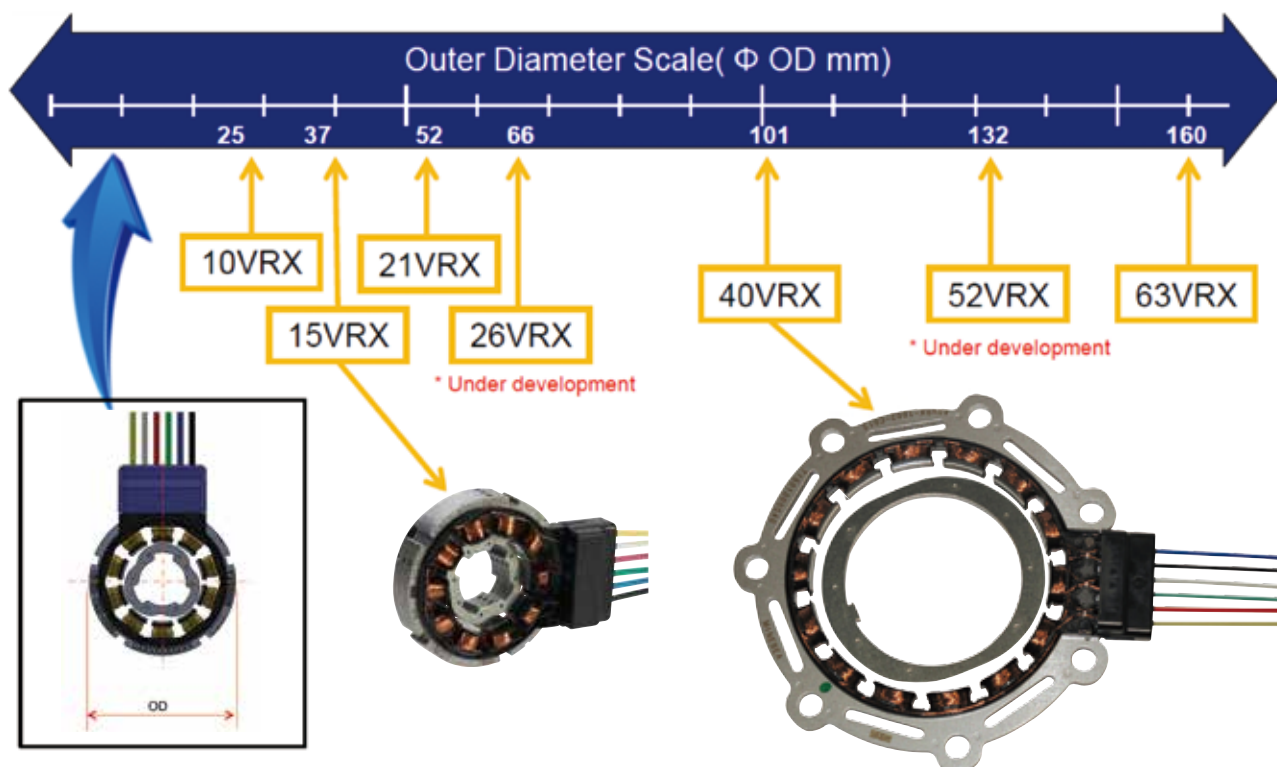
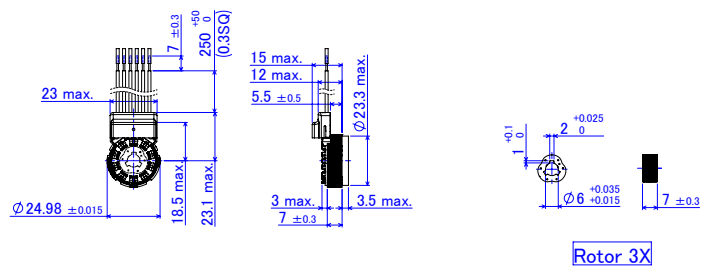


Table 1 : List of characteristics

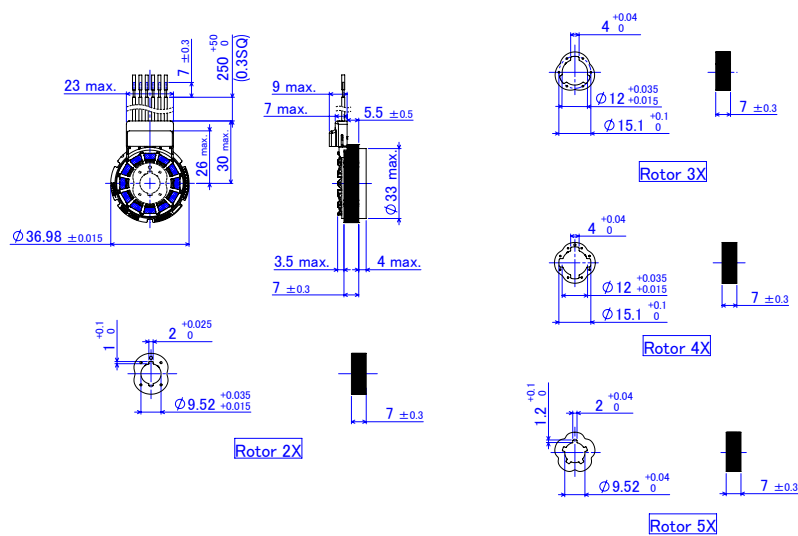
Size	10VRX	15VRX	21VRX	26VRX	40VRX	52VRX	63VRX
Number of multiple	2X-4X	2X-5X	2X-8X	2X-8X	2X-6X	2X-6X	2X-6X
Input voltage	AC 7Vrms						
Input frequency	10kHz						
Transformation ratio	0.286±10%						
Maximum rotation speed	30,000r/min				12,000r/min		
Temperature range	-40℃～+125℃						
Stator outer diameter	25mm	37mm	52mm	66mm	101mm	132mm	160mm
Rotor inner diameter	6mm	12mm	18mm	30mm	45mm	52mm	93mm
Stack thickness	7mm				4mm		
Number of multiple	2X	3X	4X	5X	6X	7X	8X
Angle error	±60′max	±40′max	±30′max	±24′max	±20′max	±18′max	±15′max

Outline dimensions

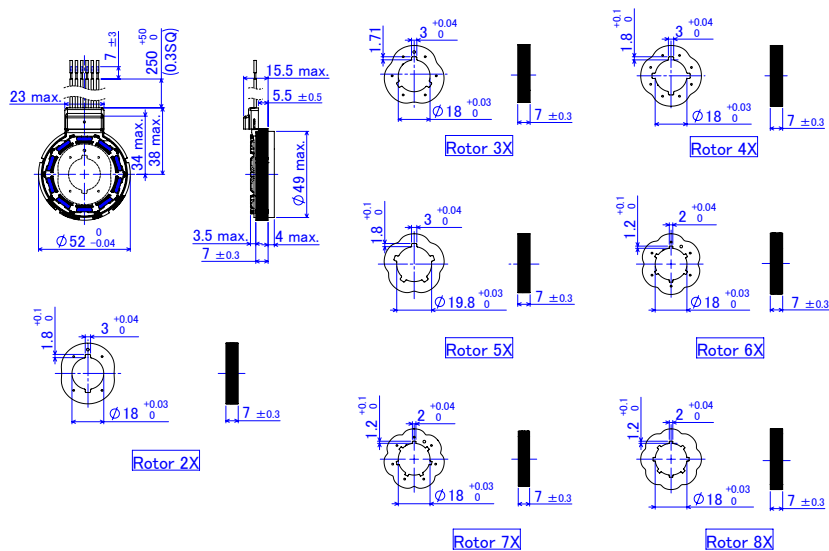
10VRX



15VRX

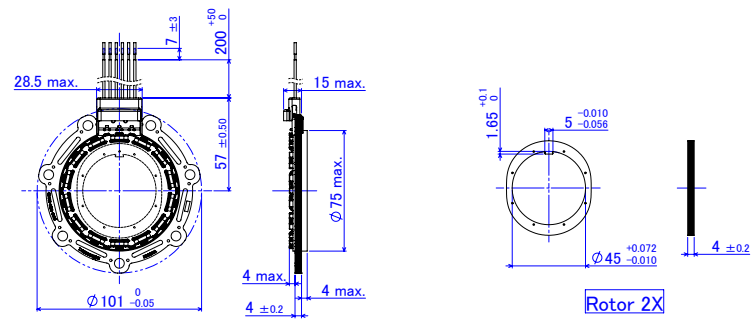


21VRX

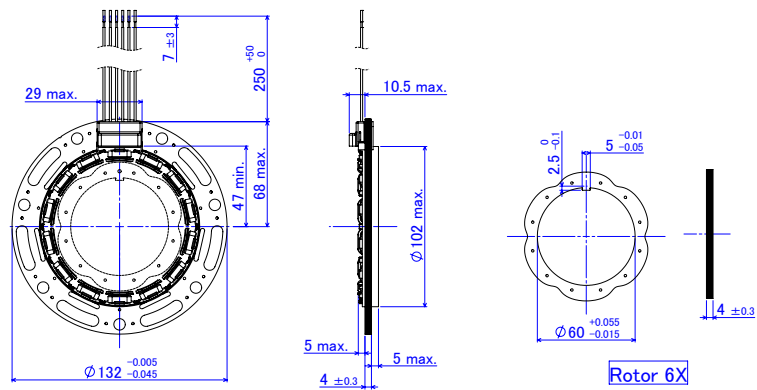


Outline dimensions

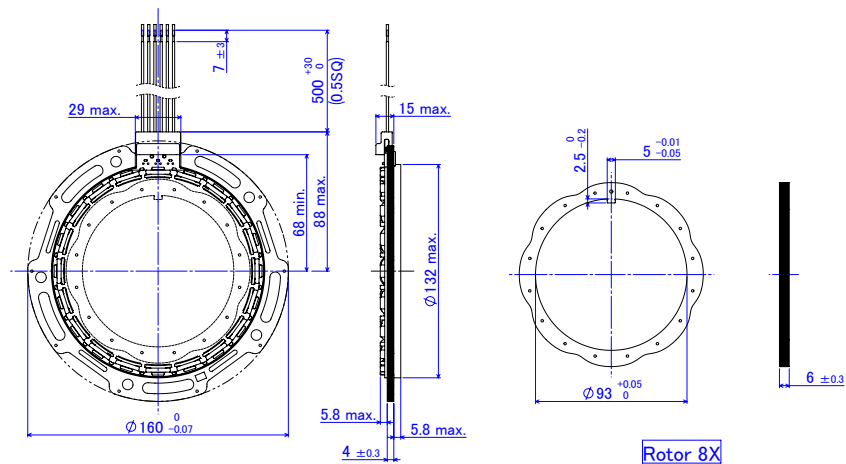
40VRX



52VRX



63VRX



Options/applications

MinebeaMitsumi can offer options such as those shown below at the customer's request.

<representative example>

Material 1 : Special shapes of connectors, etc. (option)



* Specifications for a specified customer

Coating of the rotor/stator stack



* Specifications for a specified customer

Lead wire assembly (connector)



* Specifications for a specified customer

Connector mounted type



* Specifications for a specified customer

Outer rotor

Applications

Resolver for ISG



Resolver for cooperative regenerative brakes



Resolver for main drive motor



Resolver for EPS



Glossary

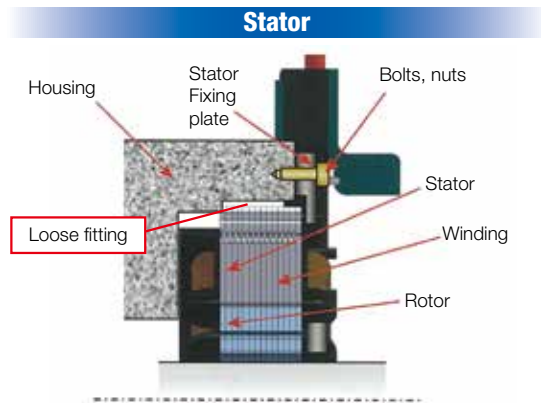
Term	Description
Resolver	Analog converter that converts the rotor's mechanical rotation angle into electric signals based on electromagnetic induction.
VR Resolver	Variable reluctance type resolver.
Primary winding	Input winding (input side).
Secondary winding	Output winding (output side).
Input Voltage	Voltage applied to the primary winding.
Output Voltage	Voltage induced in the secondary winding.
Number of multiple	Value that shows the number of electric signal cycles that will be output when the rotor makes one revolution. <div data-bbox="416 837 1211 1207" data-label="Figure"> <p>The graph displays four waveforms over a mechanical angle from 0° to 360°. The top waveform is the 'Input Voltage', a high-frequency sine wave. Below it are three 'Output Voltage' waveforms: 'Output Voltage (1X)' with one cycle, 'Output Voltage (2X)' with two cycles, and 'Output Voltage (nX)' with n cycles. The x-axis is labeled 'Mechanical angle' with markers at 0°, 360/n°, =Electrical angle 360°, 180°, and 360°. A break symbol is shown between 180° and 360°.</p> </div>
Transformation ratio	Ratio of maximum output voltage to input voltage. (Transformation ratio = maximum output voltage / input voltage)
Phase shift	Shift in time of output voltage to input voltage. <div data-bbox="416 1366 1211 1738" data-label="Figure"> <p>The graph shows two sine waves: 'Input Voltage' (thick line) and 'Output Voltage' (thin line). The x-axis is 'time [ms]' with markers at 0, 0.05, 0.10, 0.15, and 0.20. The y-axis is 'Voltage'. The 'Output Voltage' lags behind the 'Input Voltage'. A horizontal double-headed arrow between the peaks of the two waves is labeled 'Phase shift'. A horizontal double-headed arrow spanning one full cycle of the input voltage is labeled '1 cycle = 360°'.</p> </div>
Angle accuracy	Maximum error when the mechanical angle is 360°.
Input frequency	Frequency of the input voltage applied to the primary winding.
Input Impedance	Minimum impedance at the input side.
Output impedance	Maximum impedance at the output side.

Mounting method

Fixing method of small-diameter resolver

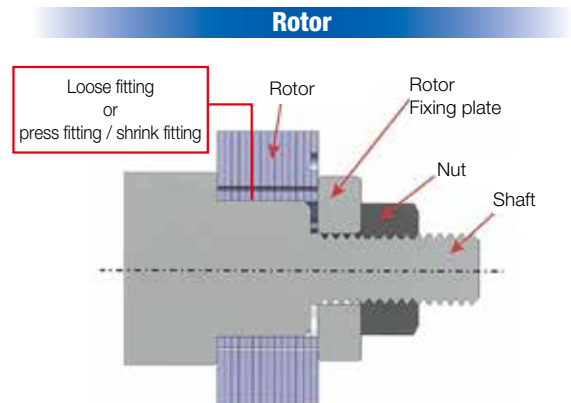
Stator mounting method (fixed plate)

- Mount to the housing in a loose fitting.
- Do not fix by press fitting.
- Fix the stator by fastening it with the fixing plate using bolts and nuts.



Rotor mounting method

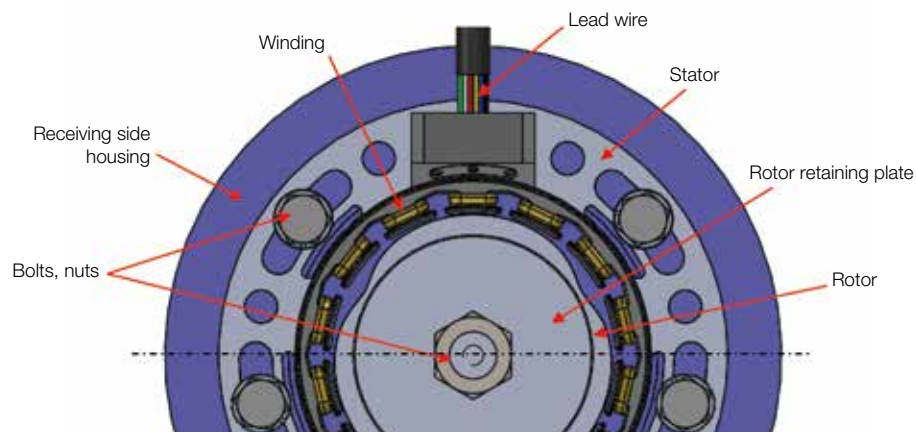
- Mount to the shaft either in a loose fitting or press fitting. If the rotor has been fit in a loose fitting, fix the rotor by fastening it with the fixing plate using bolts and nuts.
- Do not perform press fitting that will deform the rotor.



Fixing method of large-diameter resolver (Bigger than 40VRX)

Mounting method of stator and rotor

- Fix the stator in a loose fitting with the coaxiality of the rotor (Recommendation: 0.1mm or less). Mount the rotor either in a loose fitting or by press fitting.
- Fix the stator to the housing with bolts and nuts, etc. using fixing holes.
- If the rotor has been fit in a loose fitting, fix it by fastening the rotor with the fixing plate using bolts and nuts.
- Do not perform press fitting that will deform the rotor. Doing so may degrade the accuracy.



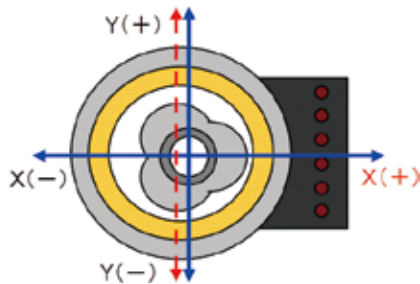
- Fix the rotor and the stator using the fixing plate with bolts and nuts.
- Use your hands or a press when mounting the rotor and stator so that the product does not tilt. Do not strike the product with a hammer, etc. Doing so may degrade the electrical characteristics.
- Be careful not to damage the winding while performing work. Damaging the winding may result in the wire breaking or an insulation failure.

Effect of mounting accuracy (robustness)

Mounting accuracy

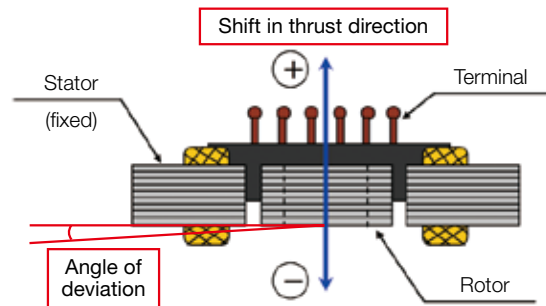
Coaxiality/runout

- Coaxiality tolerance between the rotor and stator shall be 0.05 mm (TIR) or less.
- Runout of the rotor shall be 0.05 mm (TIR) or less.



Shift in thrust direction / angle of deviation

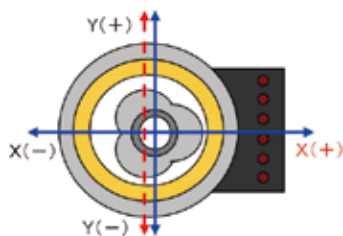
- Shift in thrust direction between the rotor and stator shall be within ± 0.1 mm.
- Angle of deviation shall be within ± 0.05 deg.



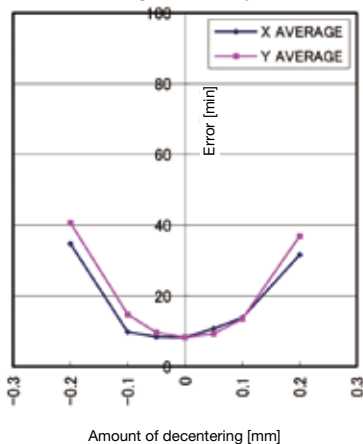
Robustness

When the rotor and the stator of the resolver are mounted, resolver accuracy, etc. will degrade if there is rotor decentering/stator decentering/shift in the thrust direction between the rotor and stator. Representative examples are given below to show their influence.

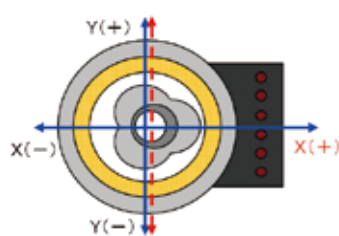
Stator decentering



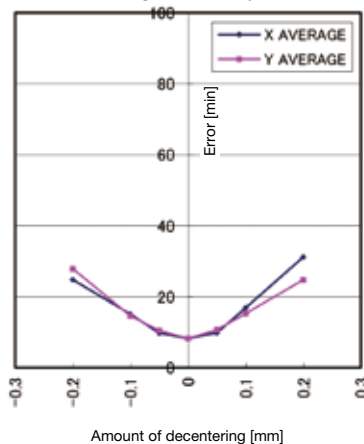
Stator decentering characteristics on angle accuracy



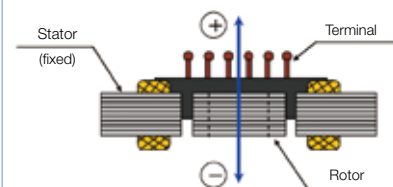
Rotor decentering



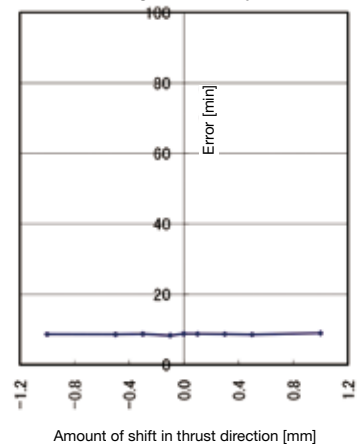
Rotor decentering characteristics on angle accuracy



Shift in thrust direction



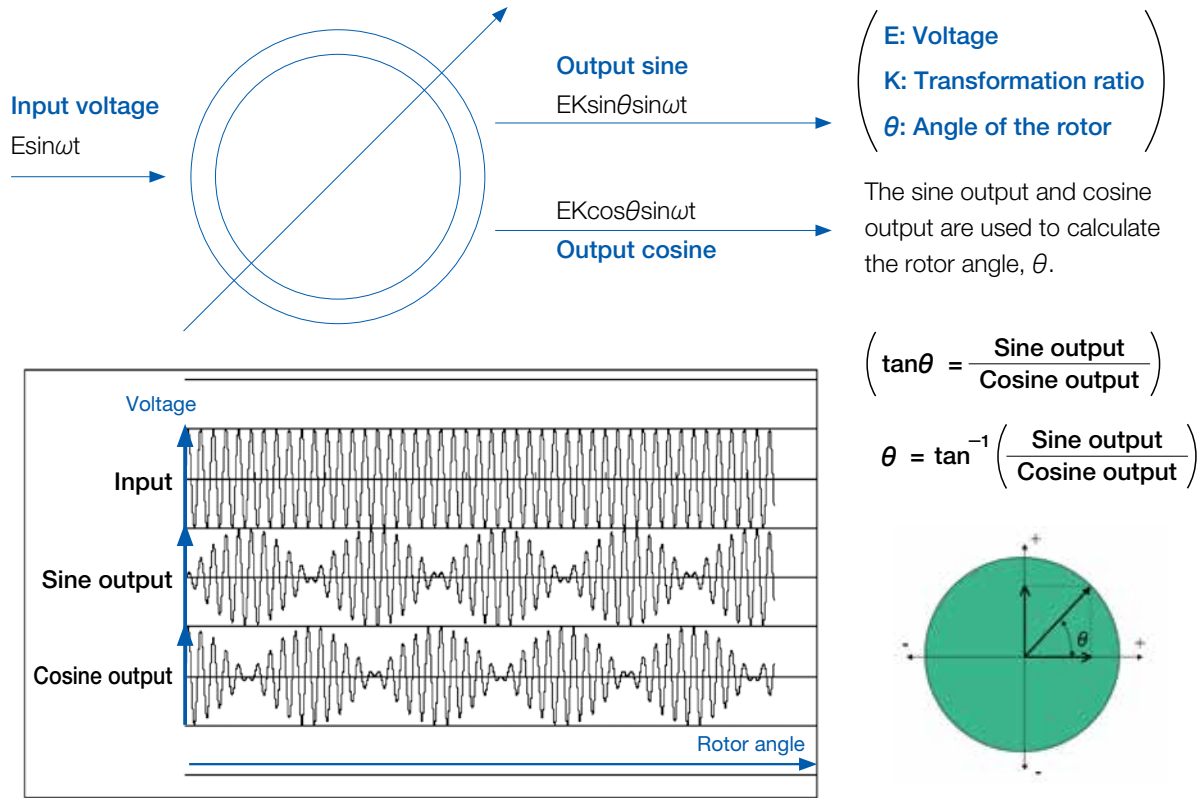
Thrust-direction shift characteristics on angle accuracy



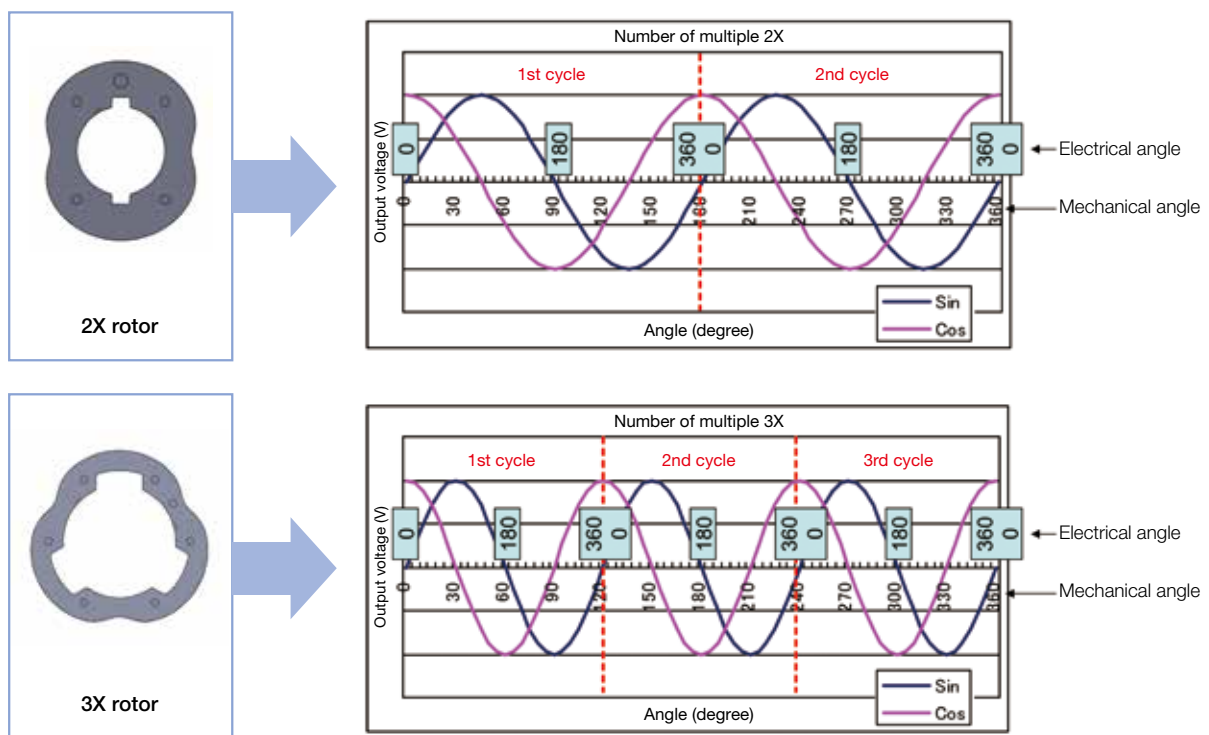
*1 The above are representative values and not guaranteed values. Characteristics will change depending on the model and number of multiple.
(The above are representative values of 3X.)

Technical information

Principle of angle detection of the resolver



Rotor shape and number of multiple

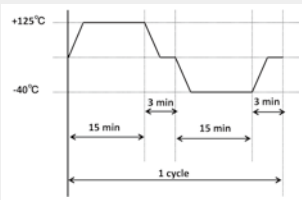


Technical information

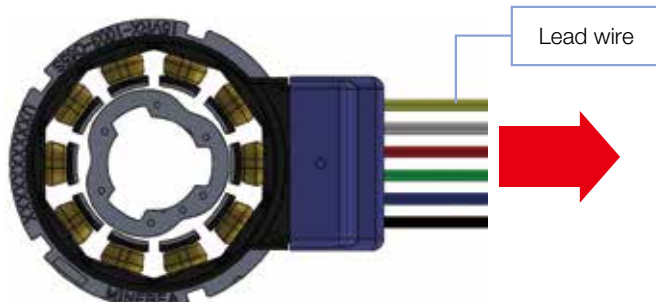
Table 2 : Number of pole pairs of BLDC motor and number of multiple of resolver

Number of pole pairs of motor		Number of multiple of resolver	
Number of magnetic poles	(Number of pole pairs)		
6	(3)	3X	–
8	(4)	4X	2X
12	(6)	6X	3X
14	(7)	7X	–
16	(8)	8X	4X

Table 3 : Environmental durability

Evaluation test results			
No.	Item	Test conditions	Checked items
1	High-temperature storage test	125°C 1000h	Electrical characteristics Appearance (Resin portion, rust, varnish, welded portion)
2	Low-temperature storage test	-40°C 144h	Electrical characteristics Appearance (Resin portion, rust, varnish, welded portion)
3	High-temperature and high-humidity storage test	85°C, 90~95%RH 1000h	Electrical characteristics Appearance (Resin portion, rust, varnish, welded portion, terminal)
4	Thermal cycle test	-40-125°C 1000 cycle 	Electrical characteristics Appearance (Resin portion, rust, varnish, welded portion, terminal)
5	Sweep vibration test	Acceleration: 98.1 m/s ² Frequency: 10~500 Hz / 15 min Apply vibration in each of X, Y and Z directions for 30 hours.	Electrical characteristics Appearance (Wire binding portion, welded portion, loose portion, stack, resin portion)
6	Impact test	Peak acceleration A: 981 m/s ² Continuous time T: 6 ms 3 times for each direction of X, Y and Z axes.	Electrical characteristics Appearance (Wire binding portion, welded portion, loose portion, stack, resin portion)

Lead wire tensile strength



Tensile strength of each lead wire:
30 N in the direction of the arrow.

Be careful not to apply force
exceeding this value.

R/D converter

Type of R/D converters

	RDC single unit	RDC + excitation circuit	RDC + excitation circuit + functional safety	Microcomputer + RDC	Excitation circuit + functional safety
Summary	This is the basic RDC that was initially developed. AD2S1205 / AD AD2S1210 / AD ADW71205/ AD	A simple excitation circuit was mounted in order to reduce the number of circuit components.	This RDC is certified with regards to the functional safety standards for road vehicles that will be required in the future, and is equipped with corresponding diagnosis circuits, and also has strong power for the excitation circuit. (PGA411/ TI)	If the rotation speed is low (e.g., for use in EPS motors), the microcomputer can calculate the resolver angle. However, when the rotation speed is tens of thousands of rpm (e.g., for use in main drive motors), calculation is difficult. So, a separate RDC was needed.	This is the IC that had the RDC circuit shown on the left removed from PGA411. This IC is certified with regards to functional safety. (PGA412/ TI (under development))
Advantages and disadvantages	<Advantages> This RDC has proven track records. Only AD2S1210 has the high accuracy of 16 bits. It is assumed that there are no other 16-bit products.	<Advantages> The number of circuit components can be reduced.	<Advantages> Equipped with functions to be reliably used in road vehicles.	<Advantages> Since a separate RDC IC is unnecessary, ECU size can be made compact.	<Advantages> If the IC for the RDC single unit or microcomputer + RDC will be used, a complex excitation circuit must be designed if functional safety is required. However, such design will be easy if this IC is used.
	<Disadvantages> An external excitation circuit will be required. Does not satisfy the requirements for functional safety for road vehicles.	<Disadvantages> Power of the excitation circuit is weak, and some may be susceptible to noise. Does not satisfy the requirements for functional safety for road vehicles.	<Disadvantages> Cost will be higher, since the circuit inside the IC as well as the manufacturing process will be complex.	<Disadvantages> A separate excitation circuit will be required.	<Disadvantages> The microcomputer is not integrated in the package.

ADW71205

Features

Monolithic resolver/digital converter (RDC) equipped with all functions
 Parallel and serial 12-bit data port
 Function to detect system fault
 Accuracy: ± 11 arc minute
 Input signal range: $3.15 \text{ Vp-p} \pm 27\%$
 Output of absolute position and speed
 Maximum tracking rate: 1,250 rps, 12-bit resolution
 Incremental encoder emulation (1,024 pulses per 1 rotation)
 Equipped with a programmable sine-wave oscillator
 Single power source operation: $5.00 \text{ V} \pm 5\%$
 Operating temperature range: -40°C to $+125^\circ\text{C}$
 44-pin LQFP
 ESD protection: 4 kV

Applications

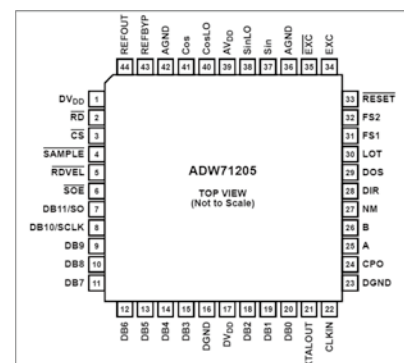
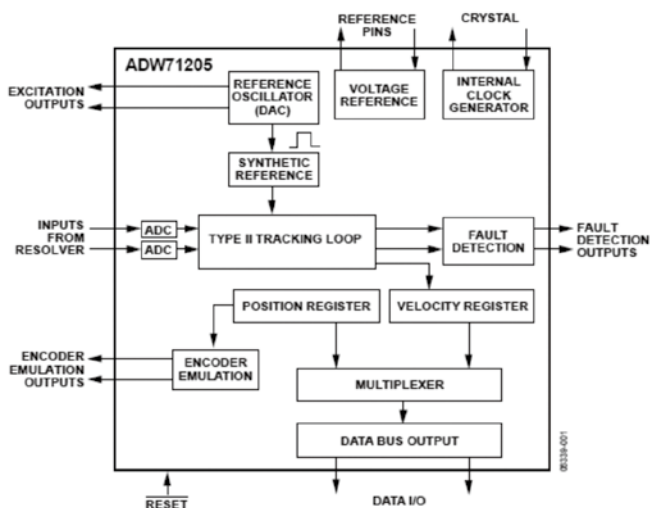
Motion sensing and control of automobiles
 Hybrid electric vehicles
 Electric powered steering
 Integrated starter generators/alternators
 Control of industrial motors
 Process control

Product highlights

1. Ratiometric tracking conversion: Type II tracking loop will output the position data continuously without delays in conversion. In addition, the reference signal and the input signal have durability against noise and harmonic distortion.
2. System fault detection: The fault detection circuit can detect the loss of resolver signal, out-of-range state of the input signal, mismatch of the input signal, and loss of position tracking.
3. Input signal range: The sine input and cosine input can correspond to the differential input voltage of $3.15 \text{ Vp-p} \pm 27\%$.
4. Programmable excitation frequency: The frequency selection pin (FS1 pin and FS2 pin) is used to easily set the excitation frequency between 10 kHz, 12 kHz, 15 kHz, and 20 kHz.
5. Triple-format position data: Access to the 12-bit, absolute angle position data is done through the 12-bit parallel port or the 3-line serial interface. The incremental encoder emulation supplies valid position outputs in the standard A-quad, B-format.
6. Digital speed output: Access to the 12-bit signed, digital speed output is done through the 12-bit parallel port or the 3-line serial interface.



FUNCTIONAL BLOCK DIAGRAM



Q&A

Question	Answer
The signal is not output.	Check the wiring.
	Check the rotor, and check whether the rotation stopper is working.
	Check whether the prescribed excitation signal is applied to the resolver.
	Check whether the resolver output signal is output within the receiving performance range of RDC.
	If RDC is connected, check whether the power is ON.
	Check the continuity of the resolver itself after disconnecting it with RDC.
The signal is disturbed.	Check the model, and check whether the stator and rotor have the performance for the same number of multiple.
	If noise is affecting the signal, take corrective measures such as re-locating the resolver away from the source of noise.
	Check whether the resolver output signal is output within the receiving performance range of RDC.
	Check the mounting method, and check whether the recommended mounting accuracy has been secured.
Advancement of the angle is in reverse.	Check the wiring. Check whether the wiring to Sin and Cos are in reverse.
Rust has formed.	Rust will form, since no rust-prevention measure has been taken. We have conducted rust tests and confirmed that rust, to a certain extent, will have little influence on performance. However, performance may be affected if rust forms significantly, so check the performance in the actual device.
Rotor inner diameter dimensions	Plug gauges are used in our delivery inspection. Results may change depending on the measuring method. Please measure with the same measuring method.
Cannot identify the corresponding relationships between terminal / lead wire and signal.	Check the specifications.

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Passion to Create Value through Difference

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