Development of the High Precision and High Reliability Batteryless Absolute Encoder "HA062"

Yoshihiro Shoji Tooru Miyajima Tomohito Yamazaki Toshiaki Ayuzawa

Kazuhiro Makiuchi Shouji Itou

1. Introduction

Machine tools, industrial robots, injection molding machines, and other such equipment that support the world's manufacturing must have high precision positioning and driving to create precision parts. Therefore, there is a demand for higher precision from the encoders that serve as position detection equipment for servo motors on mechanical equipment.

Currently, the primary type of detection is the battery backup method on multi-turn data detection on absolute encoders that are equipped in servo motors. However, batteries must be changed regularly, so there were demands for an encoder that does not require maintenance.

Furthermore, as the approach of "functional safety" is expanding primarily throughout Europe, it is becoming essential for mechanical devices that will be developed in the future to have higher safety.

With this in mind, we developed the high precision and high reliability batteryless absolute encoder "HA062" .

This document shows the main specifications and features of the "HA062" and introduces the methods used to achieve them.

2. Specifications

Sanyo Denki has a lineup of the high precision encoder "PA062" in addition to the standard absolute encoder "PA035" . These encoders use optical detection for single-turn detection and the battery backup method for multi-turn detection. The battery backup method supplies power from the battery even when the power supply for the device is cut off in order to detect the shaft rotations for the motor. With this method, the device will not accidentally restart even if the shaft rotates for any reason after the device has been turned off. However, the battery must be regularly changed with this method, which makes maintenance necessary.

Sanyo Denki has already realized a maintenance-free model with a lineup that includes the batteryless encoder "RA035" [(1)] that can detect multi-turn through a resolver and combination of gears. "RA035" is a resolver encoder, and it features superior environment resistance characteristics. On the other hand, it had problems because high accuracy was more difficult compared to the optical encoder.

The recently developed "HA062" has the strengths from both the high precision "PA062" and the batteryless "RA035" encoders. Fig. 1 shows the appearance of "HA062" . Table 1 shows a comparison of specifications between the new model and the conventional model.

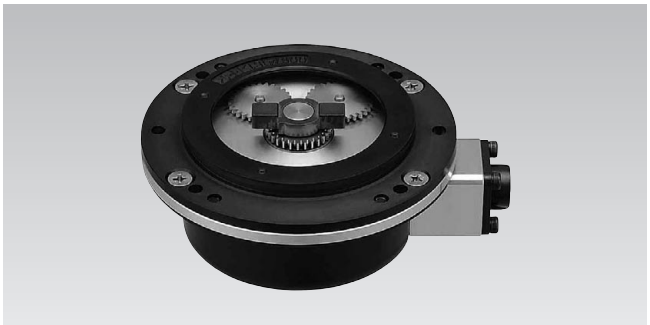


Fig. 1: Appearance of "HA062"

Table 1: Comparison of specifications between the conventional model and the new model

Item	Conventional model			New model
	PA035	PA062	RA035	HA062
Single-turn detection method	Optical		Resolver	Magnetic + optical
Absolute position accuracy	600 s or less	50 s or less	600 s or less	50 s or less*
Resolution	17 bit (20 bit)	20 bit	17 bit	17 bit, 20 bit
Multi-turn detection method	Magnetic	Optical	Resolver	Magnetic
Multi-turn backup method	Battery		Mechanical gear (batteryless)	
Multi-turn count	16 bit	1800	14 bit, 16 bit	14 bit, 16 bit
Communication method	NRZ start stop synchronization (Sanyo format)			
Communication speed	2.5 Mbps or 4 Mbps			
Communication cables	3 pair 6 cables		2 pair 4 cables	
Consumption current	180 mA	500 mA	80 mA	200 mA

*For high precision specifications

3. Features

3.1 Equipped with batteryless technology developed for the RA series

"HA062" is equipped with batteryless technology developed for the RA series. Fig. 2 shows the cross-section of "HA062" . The interior of the "HA062" engages gears with different numbers of teeth on three rotational axes.

The gears are structured so that the two sub rotational axes have a different number of rotations from the main rotational axis. Each rotational axis has a bi-polar permanent magnet installed. The angle of each permanent magnet is detected by the magnetic encoder, and by reading the relative positions of the gears, the device can calculate the absolute position for multiple rotations.

This method uses the mechanical relative positions to calculate multi-turn data. This method does not consume the power used to maintain the multi-turn data like with the battery backup method. As a result, the device can be batteryless. Batteries are parts that must be changed regularly, so by removing the battery, the device can be made maintenance-free. For customers, this enables a reduction of loss due to maintenance costs or stopped devices.

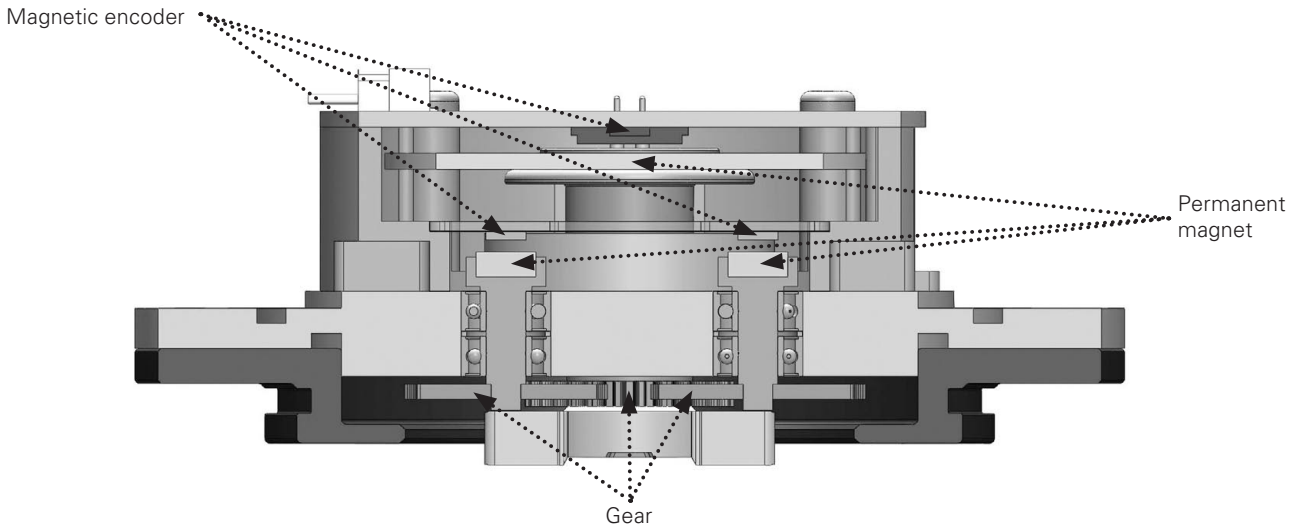


Fig. 2: Cross-section #1 of "HA062"

3.2 High precision

While the batteryless encoder "RA035" uses a resolver for single-turn detection, "HA062" uses an optical encoder. The resolver detects and electrically multiplies the rotational angle for the machined resolver rotor. The optical method detects and electrically multiplies the angle of a rotary disc that is engraved with over 100 times more division than the resolver rotor using photolithography technology. Therefore, the optical encoder enables fundamentally higher precision compared to the resolver. Furthermore, "HA062" includes a function that measures and corrects the errors from rotary disc eccentricity and distortions in the analog waveform for each slot when assembling the encoders. With this function, high precision is realized in less than 50 seconds.

3.3 Oldham coupling structure for easy exchange

"HA062" uses Oldham coupling in the connection to the servo motor. The Oldham coupling method does not require special adjustments when installing to the motor. Therefore, it can be installed easily. As a result, the customer can perform maintenance by exchanging the encoder for repair or similar processes without assistance.

3.4 Separate structure for gears and optical system

The optical detection mentioned in the previous section uses rotary discs carved with detailed patterns. Therefore, foreign matter such as dirt, dust, or oils can cause malfunctions. However, gears must use grease as lubrication. In order to solve these two conflicting demands, "HA062" has a structure that separates the space for the optical system and electrical circuit and the space for gears and the Oldham coupling. Fig. 3 shows the cross-section image. With this structure, there is no concern that the grease for the gears and Oldham coupling will be scattered on the rotary discs and cause false detection.

3.5 Part integration through IC

The light receiving element for the optical system in "HA062" introduces the PDIC technology that was used for the previously developed incremental encoder "PP031T" [2]. PDIC is one package that includes the light receiving element, amplifier, and comparator. In the conventional light receiving element, a slight current ran through the board pattern, but since an amplified voltage signal is output from the PDIC, this provides an advantage where the signal is strong against external noise. In addition, using a PDIC enables a drastic number of parts to be eliminated, which reduces production cost and contributes to achieving smaller part size and low current consumption.

Furthermore, the magnetic encoder that detects the angle of the permanent magnet uses a single package that combines multiple hole-elements and a calculation circuit. This reduces the effects on detection accuracy due to element variation and the effects from external noise.

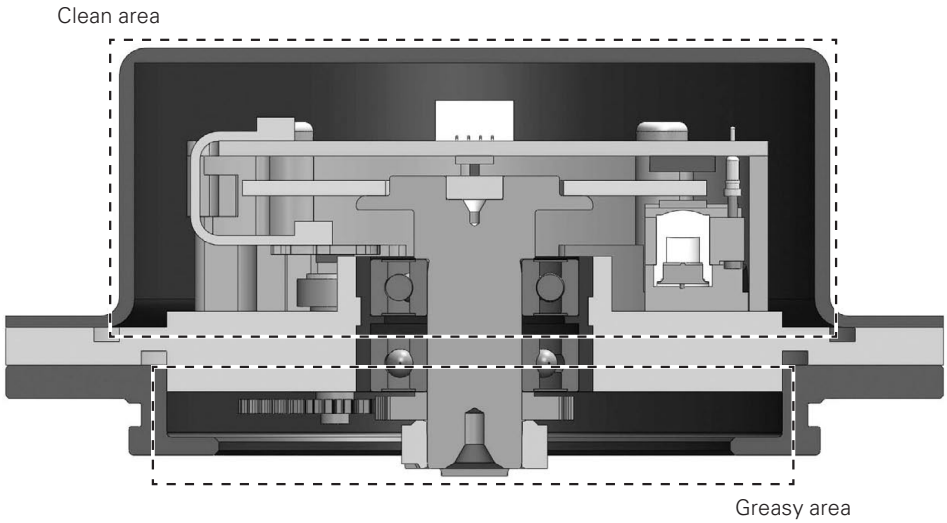


Fig. 3: Cross-section #2 of "HA062"

3.6 High reliability with a dual detection method of magnetic + optical

"HA062" compares the single rotation data from the magnetic encoder using multi-turn detection as mentioned previously and the single-turn data detected with the optical encoder. By comparing the single rotation data obtained from two types of encoders, if there is an error on one encoder, the error is output to the higher level equipment. This function can prevent malfunctions on the equipment due to inaccurate information. Furthermore, multi-turn data compares the multi-turn data calculated from the magnetic encoder signal and the multiple rotation data generated from calculations from the optical encoder data, so the reliability is improved. Fig. 4 shows a function block diagram of the "HA062" . In fact, the letter "H" at the beginning of the model name can also mean "Hybrid" , referring to the two detection methods.

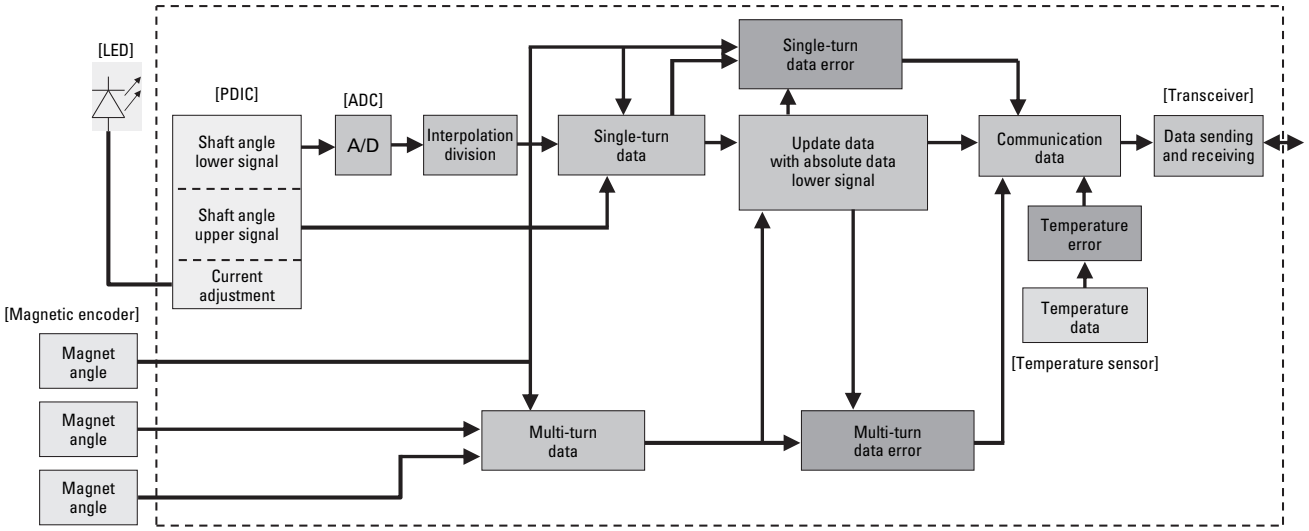


Fig. 4: "HA062" functional block diagram

4. Conclusion

This document introduced the specifications and features of the newly developed high precision and high reliability batteryless absolute encoder "HA062" .

The "HA062" is an encoder with two strengths: batteryless features of a conventional resolver encoder and high precision of an optical encoder. It also has two detection methods and enhanced reliability through improved structure and IC circuits.

By replacing the conventional encoder with the "HA062" , we believe that it can improve not only the maintainability and reliability, but also the safety of the customer's devices.

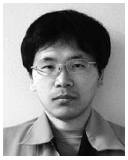
We will continue to further develop the technology for maintaining batteryless multiple rotations and develop products that can contribute new strengths to customers' devices.

Documentation

(1) Kazuhiro Makiuchi and Others: Development of the Small-size Batteryless Absolute Encoder "RA035"

(2) Yoshihiro Shoji and Others: Development of "PP031T" and "PP031H" Small-size Multiplier Incremental Encoders

Yoshihiro Shoji
Joined Sanyo Denki in 2006.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of encoders.



Tooru Miyajima
Joined Sanyo Denki in 1996.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of encoders.

Tomohito Yamazaki
Joined Sanyo Denki in 1998.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of encoders.

Toshiaki Ayuzawa
Joined Sanyo Denki in 2005.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of encoders.

Kazuhiro Makiuchi
Joined Sanyo Denki in 1998.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of servo motors and encoders.

Shouji Itou
Joined Sanyo Denki in 1980.
Servo Systems Division, 1st Design Dept.
Worked on the development and design of encoders.