Servo System Technology That Changes The Conventional Trend

Batteryless Absolute Sensor "RA062"

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1. Introduction

To control a servo motor, the sensor which detects the axis position of the motor and to sends this information to the servo amplifier is critical. The performance of the servo system is determined largely by the performance of this sensor. The resolution, positional accuracy, and response, etc. of the sensor are of great importance. Moreover, the sensor is the most fragile part in the servo system and the longevity of the sensor connects directly with the longevity of the servo system. Because it is attached directly to the motor the sensor is put in a very severe environment with respect to vibration and temperature.

The sensor is divided into an optical sensor and a magnetic sensor by the detection principle. And further, it is divided into an incremental sensor and an absolute sensor according to the output form of the location information. The optical sensor is highly accurate in general and it is used when smooth rotation is necessary and accurate positioning by a direct drive is needed. On the other hand, while the accuracy of a magnetic sensor is below that of an optical sensor, it has a simple and solid structure, and is used for the servo motor that is put under a severe condition such as large vibrations, etc. As a signal form, the incremental output requires an outside starting point sensor in another system. And in the application that controls the position, it needs the starting point resume operation. On the other hand, for the absolute output, the sensor can arbitrarily provide the starting point from the absolute location information and the starting point resume operation is unnecessary. However, to maintain the absolute location information including the rotation frequency, it requires an external battery and regular maintenance work becomes necessary. In the application that positions by decelerators such as robots and injection molding machines, an absolute output is often used.

This section introduces the SANMOTION SENSOR "RA062" (hereafter, it is called "RA062"). It is an absolute output sensor of the resolver type. The battery that conventional absolute sensors require is no longer needed. Moreover, as for the resolution and accuracy, it has reached the level equal to the optical sensor level. Fig.1 shows the exterior of the "RA062". The diameter of the sensor is 62mm and the height is 37.6mm. Section 2 explains the features of "RA062". Section 3 explains the principle of the multi rotation maintenance that is the best feature of "RA062." Section 4 shows the control block chart, and the internal processing composition. The conclusion is presented in Section 5.

Fig.1 RA062

2. Features of "RA062"

2.1 The Rotation Frequency Maintained Without Battery

The best feature of "RA062" is to maintain the absolute position that includes the rotation frequency without using a battery. General absolute sensors required an external battery to maintain the rotation frequency and also had to possess a large-scale electrolytic capacitor inside of the sensor. If one only needs to write the rotation frequency immediately before the power in a nonvolatile memory and back up, an external battery is not needed. However, only by this, the position will shift by the rotation frequency when the shaft of the motor is rotated while power is off. In the past, to prevent this problem, in the conventional general absolute sensor, when the power of the entire device was intercepted, the power was still supplied to the sensor by a battery, and the movement of the motor shaft was observed. However, because the batteries need to be replaced, regular maintenance is necessary. They also negatively affect the environment as a harmful waste. Furthermore, when the capacity of the battery decreases, occasionally the rotation frequency could not be maintained correctly.

The "RA062" has multiple cogwheels internally and it adopted the method to calculate the rotation frequency from mutual position of the cogwheel. The internal cogwheel is mechanically connected with the motor shaft, and no matter if the power is ON or OFF, it rotates in proportion to the rotation frequency of the motor shaft. When the power of the sensor is turned on, it reads the position of each cogwheel and calculates the rotation frequency from this position. As a result, a continuous power supply is not necessary, and the battery is no longer needed. The detection principle of the rotation frequency is explained in detail in Section 3.

2.2 Achieved Partitions 17bit And The Absolute Position Accuracy 10 min.

In the conventional resolver sensor of SANYO DENKI, the resolution was 12bit and the absolute positional accuracy was 30 minutes. In "RA062," the maximum partition numbers can set to 17bit (131072 division) and it takes 10 minutes or less of absolute positional accuracy. In the error factor of the resolver, there was an impedance difference of the coil, a shape difference of the rotor and a wick difference when the sensor was assembled. The error was corrected in analog in the conventional model by obtaining resistance between coils. In this method, the impedance difference of the coil can be corrected. However, the shape difference of the rotor and the wick difference of the assembly remained as the final error margin. On the other hand, "RA062" performs a digital correction by writing the proofreading data in the flash memory. In this method, not only the impedance difference of the coil, but also the shape difference of the rotor and wick difference at the assembly can be corrected. As a result, high accuracy equal to an optical sensor was achieved.

2.3 Excellent Environment Resistance

Because "RA062" is a resolver sensor, and the detection part is composed only of accumulated magnetic steel plates and coil winding, it possesses solid and high reliability. In recent years, the demand of the environment resistant characteristics of the sensor has become severe. For example, when thinking about using the sensor in the environment in which grease mist disperses or strongly vibrates, the optical detection sensor has limitations to its application, but the resolver sensor does not have any limitation. Moreover, though in an optical sensor, it has the longevity parts such as the light emitting diode, "RA062" does not use electronic parts that correspond to the longevity. It can be said to be long-lived.

2.4 Wire Saving And High-Speed Serial Communications Method

Because the "RA062" has no battery, it leads to the wire saving and a couple of wires used conventionally for a battery became unnecessary. The communications method corresponds to serial communications of the Manchester encoded synchronous transmission method (2 Mbps or less) and the start stop synchronous transmission method (4 Mbps or less). And the former needs four pairs of wires and the latter needs only two pairs of wires. Two pairs of wires are the smallest number for positional detection among all the sensors in the world. It is easy to handle and it can also greatly contribute to cost reduction in the assembly at a customer site.

3. Detection Principle Of The Rotation Frequency

One four poles resolver (RS0) for positional detection in one rotation is placed inside of the "RA062." And three one pole resolvers (RS1,2,3) for the rotation frequency calculation are compactly arranged. The cogwheel with different number of cogs is installed in the center of each resolver. Fig.2 shows the composition outline of the resolvers and the cogwheels. The RS0 is connected directly with the motor shaft, and it has cogwheels with cogs Z_{01} and cogwheels with cogs Z_{02} concentrically. The RS1 has the cogwheel with cogs Z_1 concentrically, and is connected with the cogwheel with cogs Z_{01} which is connected directly with the above-mentioned RS0. The RS2 has cogwheels with cogs Z_2, and is connected with the cogwheels with cogs Z_{02} which is connected directly with the above-mentioned RS0. The RS3 has cogwheels with cogs Z_3 and is connected with the cogwheels with cogs Z_{02} that is connected directly with the RS0 as well as RS2. The combination of cogs can be changed and rotation frequency can be calculated from the position of each cogwheel. The cogs combination is applied in the patent (the application number: 2000-301511), and it explains the detail. Here, it explains the principle of the rotation frequency calculation with using the number of cogs shown in Table 1 as an example.

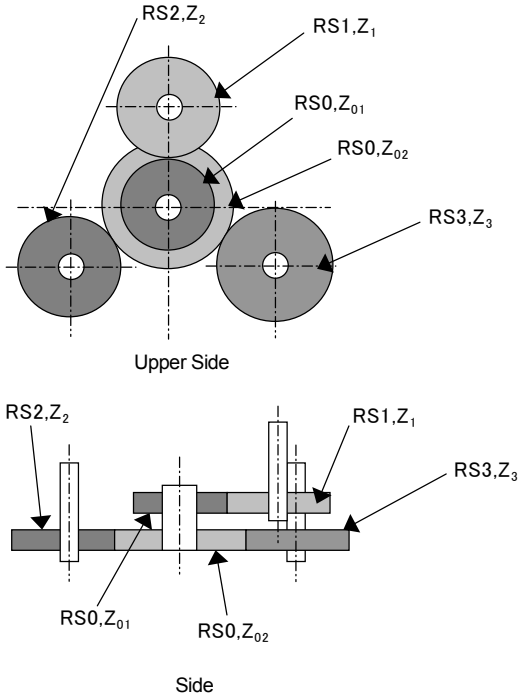


Fig. 2 Composition of Cogwheel in the RA062

Table 1 Example of Number of Cogs

Z_{01}	25Cogs
Z_{02}	28Cogs
Z_1	26Cogs
Z_2	27Cogs
Z_3	29Cogs
Distinguishable Rotational Speed	Z1 × Z2 × Z3=20358 Rotation

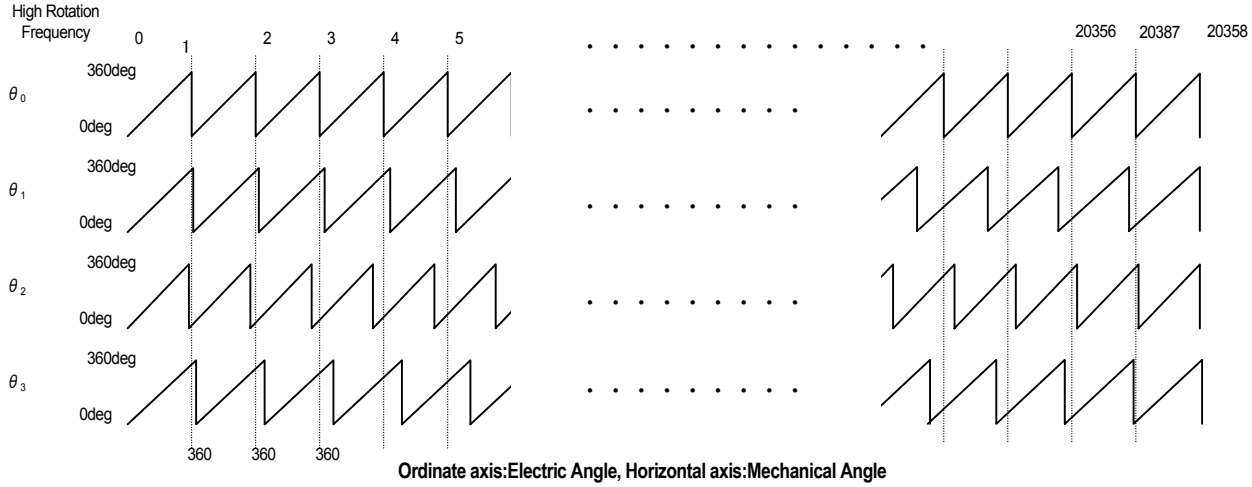
1. When the RS0 connected directly with the motor shaft rotates, each resolver rotates by a different rotation ratio through a cogwheel with different number of cogs.

2. By operating the angle that RS0 and RS1 output, continuous rotation frequency data such that 26 rotations makes one cycle (shown in Fig.3 (b)) can be obtained. To the same way, by the angle of RS0 and RS3, rotation frequency is found that 29 rotations makes one cycle. (θ_{01} is derived from RS0 and RS1, θ_{02} and θ_{03} are also similarly derived).

3. The interrelations of the three different cycles are independent relations up to 20358(26×27×29) rotations. The rotation frequency is calculated based on which relation being located.

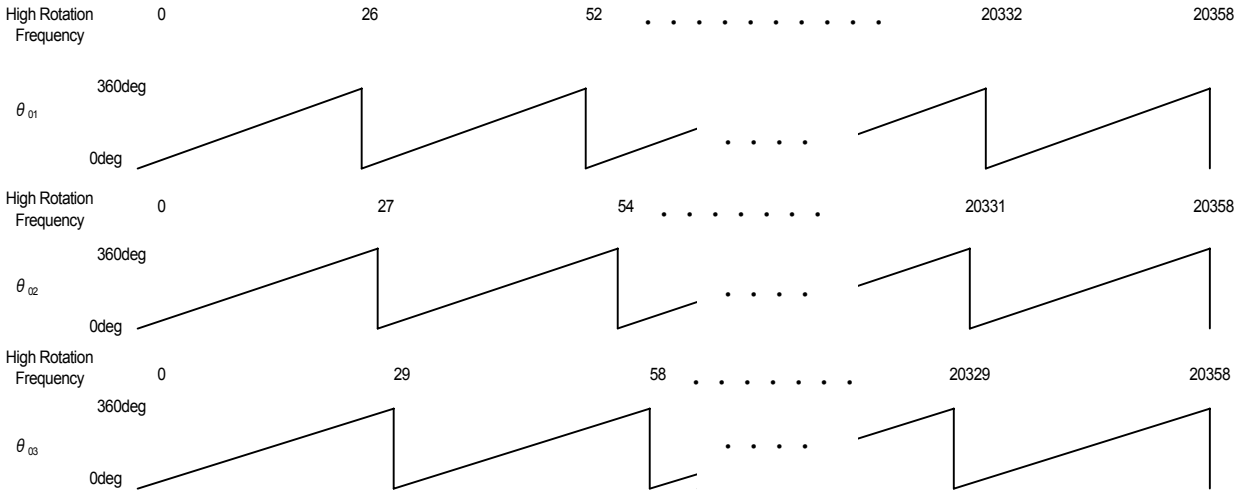
The rotation frequency that can be distinguished becomes the lowest common multiple of Z_1, Z_2, and Z_3. By choosing the number of cogs of Z_1, Z_2, and Z_3 to be a mutual relation of the source, a wide range of numbers can be efficiently obtained.

As stated previously, in "RA062," when the power is turned on, the previously-mentioned rotation frequency is calculated. If it rotates by an external drive while power off, it can still obtain a correct rotation frequency when the power is turned on because the position of each cogwheel is mechanically maintained.



Ordinate axis:Electric Angle, Horizontal axis:Mechanical Angle

a Rotation Position Data from Each Resolver



Ordinate axis:Electric Angle, Horizontal axis:Mechanical Angle

b Rotation Position Data After Correction

Fig3. Rotation Frequency Detection Principle

4. Composition of the Processing Circuit

Fig.4 shows the processing circuit composition of the "RA062."

It is composed of the following: the analog ASIC (the resolver's excitation and detection), the digital ASIC (position operation), the flash memory (store error margin correction table), the EEPROM (store various parameters), the sending and receiving gate array (serial communications control), and the CPU (rotation frequency calculation and abnormal detection).

"RA062" has the correction table of the error in the flash memory, and achieves high accuracy (absolute position accuracy 10 minutes or less) by the digital correction. "RA062" has four resolvers internally and uses them by switching one by one. This processing was achieved through the analog ASIC developed only for "RA062." The high partition position output of "RA062" was realized by the digital ASIC that was newly developed, and maximum 17bit (division 131072) corresponds to 30000P/R or more of one rotation of optical sensors.

The abnormal resolver disconnection detection and the abnormal internal temperature detection, etc. are installed in the "RA062" as fail-safe functions. Moreover, in the telecommunications as shown above, it corresponds to the Manchester encode synchronous transmission method and the start stop synchronization method. And it is possible to connect them with a high-ranking amplifier by the wire saving.

5. Conclusion

"RA062" can greatly contribute to the reduction of the maintenance work because the battery becomes unnecessary. In addition, it is an environmentally friendly product and leads to a reduction of industrial waste. Also, it achieved the high partition by newly developed ASIC and high accuracy by the digital correction method. The resolver sensor has the performance that equals an optical sensor. Moreover, the resolver sensor can be utilized where the environment resistance characteristics are needed. The communications method is serial communication, and it connects with a high-ranking amplifier only by two pairs of cables, which are the smallest in the world. It is possible to contribute to the reduction of assembly cost and improvement of cable installation.

"RA062" has features that did not exist in the conventional resolver sensor and it can offer new value. We will continue to work on the development of new products that create new values and merit for our customers.

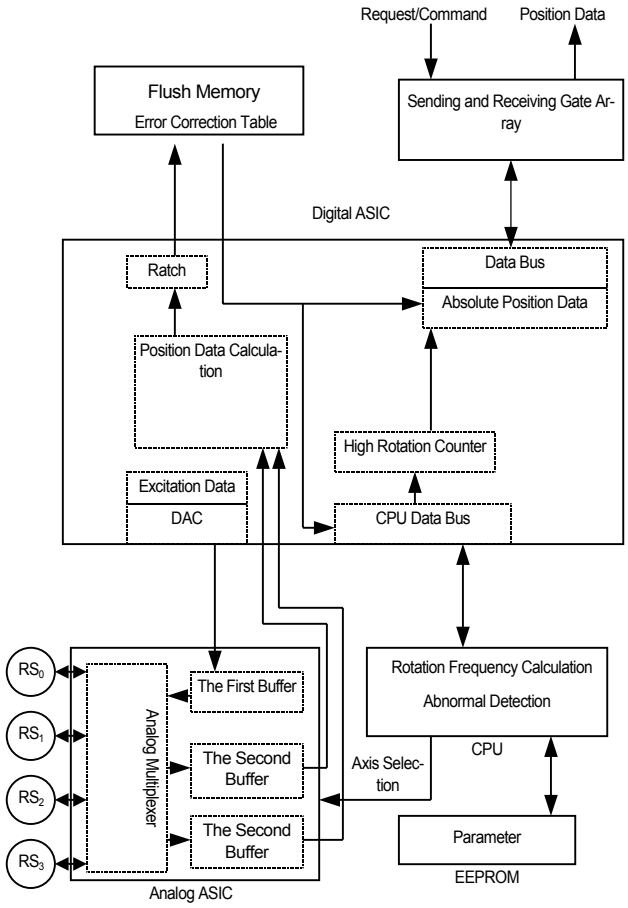


Fig.4 Block Chart of the Processing Circuit

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