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Selecting Encoders DS01038/B

1. Introduction

This data sheet is intended as a guide to selecting the correct encoder system from the standard encoder options available for ThrustTube motor modules and also to assist in the selection of encoders for use with ThrustTube motor components. The contents of this data sheet should be considered as guidelines only rather than definitive statements for all systems and applications.

Standard options are Siko magnetic (Option MS) and Renishaw optical (Option OR) encoders. The Siko magnetic encoder system is supplied with a AS500 interpolator unit, with switch-selected resolutions and the Renishaw optical encoders supplied with fixed resolution. The Siko magnetic read head and interpolator unit are supplied as a matched pair and the cable length between the two cannot be altered.

Index pulses are produced at every 5mm of travel on Siko magnetic encoders and on Renishaw optical encoders a datum marker is fitted as a reference index point. The Renishaw optical read strip is an etched tape with self-adhesive backing and the Siko magnetic read strip consists of a magnetic strip with self-adhesive backing and a protective cover strip.

Both standard options are linear incremental encoders that output phase quadrature signals and give a value and tolerance for edge separation of 90 ° between A and B phases, which if measured in time can be used to calculate the velocity and direction at any point in time.

Other encoder systems successfully integrated with ThrustTube motor components are AMO (inductive) Heidenhain (closed optical), Elgo MIX1 and Sony (magnetic).

Normally it is the application that determines the initial criteria in selecting the best encoder system.

There are a number of points to consider when selecting the linear encoder for a particular application.

The main points to note are listed below.

- Operating environment
- Resolution
- Absolute accuracy
- Maximum speed
- Controller maximum encoder input frequency
- Output signal type

2. Operating environment

Selection of the right encoder for the right operating environment is paramount to ensure robustness of the complete system.

Magnetic encoder systems are more suitable for environments where dust and oil contamination are more likely, where as optical encoders are less environment tolerant but have greater absolute accuracy per metre than magnetic encoders.

Magnetic encoders should not be used in environments with ferrous swarf or areas with high magnetic fields in close proximity to the scale.

3. Resolution

The encoder resolution is the number of encoder edges per unit distance, commonly defined in microns, and is important for a number of factors. There is normally some trade off between accuracy, stiffness, overshoot, velocity control and stability when setting up a control system. In general an encoder should be chosen with as high a resolution as the system can handle as this gives the position controller the most information and hence optimises the controllability. Optical encoders normally have higher resolution and higher accuracy than magnetic types.

3.1. Positioning accuracy (repeatability)

The encoder resolution must be higher than the positioning repeatability required by the system. The system repeatability is normally given as the number of counts for the motor to settle within after a move has been made. Although it is possible to set up the position controller to give +/- 1 count positional repeatability, a more general figure +/-10 counts is much more realistic for the majority of applications. With higher loads and higher friction systems this figure may be much larger, say up to 100 counts. The higher the resolution the better the positional repeatability.

3.2. Servo stiffness:

The servo stiffness of the system is a statement of how able the position controller is able to maintain the set position when an external load is applied, and is normally defined in N/mm. Since the controller is error driven, a higher resolution encoder will produce a larger number of error counts and hence a larger output control voltage to a lower resolution system, assuming the same controller gains and positional displacement. Therefore, the reaction force to the disturbance is higher and generally quicker. Faster servo update frequency will also aid servo stiffness.

3.3. Velocity control

Control of the velocity can be improved by increasing the encoder resolution as this gives a higher resolution for the velocity calculation. This is most noticeable at lower speed where the number of encoder counts per servo update cycle and the discrete nature of the velocity calculation become important. Faster servo update frequency will also aid servo stiffness.

3.4. Large count values

The amplifier/controller specification should be checked to make sure that it can cope with large numbers when a high resolution encoder is used. This is especially important for commutation, maximum velocities, maximum acceleration/deceleration and maximum following error parameters. Saturation of controller variables and registers may need to be considered.

4. Absolute accuracy

Absolute positional accuracy is not an issue for the majority of applications. However in certain applications it is paramount. Thermal expansion of the encoder tape, straightness of the rail and backing plate will all contribute to the absolute accuracy of the measurement system. As long as the temperature of the sensor readhead is maintained within the operating ratings shown on the specification, the readhead will not affect the absolute accuracy. Magnetic encoders have less absolute accuracy than optical encoder systems. When deciding placement of read heads and encoder strips when using motor components the effect of the magnetic thrust rod must be considered on the magnetic encoder strip in order not to influence the performance of the encoder system. Absolute positional accuracy specifies the difference between a datum and a point if measured using a high precision measuring system such as a laser interferometer. It is normally expressed in microns per metre. For the majority of general purpose applications high precision accuracy is not an important issue. In applications where high precision accuracy is important, the coefficient of expansion of the encoder tape and the material that it is attached to should be taken into account. Optical encoders are normally used in these applications. The Renishaw encoder tape has a coefficient of expansion of 22μm/m/°C and the backing plate on standard ThrustTube modules a coefficient of expansion of 24.3μm/m/°C. A controlled environment will reduce the effects of thermal expansion.

5. Maximum speed

It is always important to check that the encoder is capable of operating at the required speed for the application. It is also prudent to allow for some headroom in case of velocity overshoot or changes to the performance requirement. Some encoders with an interpolator have some form of clocked output. Therefore, in order to run the system at maximum speed with clocked encoders, the maximum input frequency of the position controller/amplifier must be higher than, and preferably double the maximum frequency from the encoder or interpolator. Furthermore, the mark/space ratio (and distance between edges) at any point in time does not reflect the actual speed on encoders with clocked outputs.

6. Controller/Amplifier maximum encoder input frequency

The maximum encoder input frequency of the position controller/amplifier may limit the maximum speed at which the encoder can run. Above this speed the controller may miss encoder counts and see illegal states at the input. The maximum encoder input frequency is normally given in the controller specification. Always check whether the frequency given in controller specification is a pre- or post-quadrature counts value. The post-quadrature counts value is four times the pre-quadrature input frequency.

7. Output signal type

Encoders are generally available with different output types. The controller encoder input signal requirement should be checked. Renishaw optical encoders have RS422 outputs and Siko optical encoders have TTL outputs as standard. The encoder input of the position controller/amplifier should be checked for type compatibility. Most encoder manufacturers also have encoder options with outputs in the form of Sine / Cosine 1V peak-peak analogue signals as well as digital signals.

Some digital encoders operate in ‘burst mode’. Elgo MIX1 produces burst mode at under 150mm/s and then switches to true incremental mode. The Siko MSA/AE1 produces burst mode at over 100mm/s, in these cases the mark space ratio cannot be used as an indicator of speed across the complete speed range. Furthermore, these burst modes can affect velocity control and stability. Siko magnetic encoder systems have an error output signal that should always be integrated into the control system.

8. Encoder data

Renishaw RGH24 optical read head

Resolution (µm)	Maximum speed (m/s)	Maximum output frequency (Mhz)	Accuracy mm/m	Order code	Renishaw reference	Notes
5	10.00	10	0.003	OR4 50	D	REAL TIME OUTPUT
1	5.00	10	0.003	OR4 10	X	
0.5	3.00	10	0.003	OR4 5	Z	
0.2	1.25	10	0.003	OR4 2	W	CLOCKED OUTPUT
0.1	0.70	10	0.003	OR4 1	Y	

Note: Maximum speed on Renishaw optical encoders when finding the datum marker is limited to 250mm/s

Siko AS500 magnetic read head

Resolution (µm)	Maximum speed (m/s)	Maximum output frequency (Mhz)	Accuracy mm/m	Order code	Notes
50	25	10	10.0	-	REAL TIME OUTPUT STANDARD UNIT WITH SWITCH SELECTABLE RESOLUTION
25	25	10	10.0	-	
10	25	10	10.0	MS1 100	
5.0	25	10	10.0	MS1 50	

Renishaw optical and Siko magnetic read heads are available with 3 or 5 metre standard length cables.

Read head supply voltage is 5VDC nominal. Siko read head to interpolator unit cables must not be reduced or increased in length.