SICK AG WHITEPAPER

INFORMATION ON THE BEHAVIOR OF ENCODERS WITH INTEGRAL BEARINGS AND STATOR COUPLING WHEN SUBJECTED TO SHOCK AND VIBRATION

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CONTENT

Introduction

Encoders react to the conditions in their installation environment. Electrical, thermal or even mechanical conditions can influence the performance of these products. Due to their “flexible” connection to customer applications, encoders with integral bearings and stator coupling react in particular to static and dynamic mechanical influences of the environment (Fig. 1).
These reactions are determined by internal characteristics of the product, such as the dead weight, center of gravity and quality of the interface elements (shaft, stator coupling) as well as by external influences, such as inaccuracies in mounting, quality of the drive shaft or orientation of the cabling.
While the latter influences are partially determined by the customer, the internal characteristics of the product are given.

This white paper deals with the mechanical effects of shock and vibration and provides the user with information on the expected performance and, if applicable, the safety-related characteristic values of the system.

Mounting with stator coupling

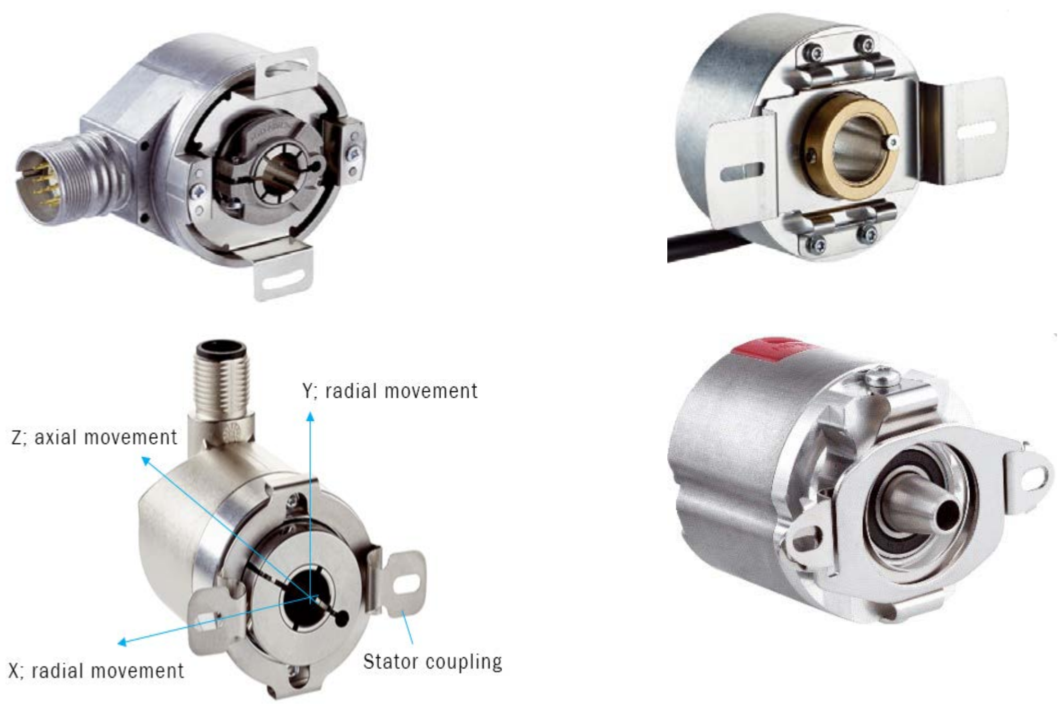

Fig. 1: Different encoders with stator coupling

Encoders with hollow shafts or motor feedback systems are usually attached to customer applications with a stator coupling. The stator coupling is used to compensate for radial and axial movements of the drive shaft and the permissible mounting tolerances. This compensation should not have negative impacts on the performance (e.g. measurement accuracy and service life) of the product.

The ideal stator coupling has high mechanical (torsional) stiffness while still offering high flexibility for absorbing dynamic and static tolerances without impairing measurement accuracy.

Stator couplings are typically made of sheet steel, elastomer or an elastomer-steel composite.

Vibration and shock

Depending on the application, encoders from SICK are exposed to different loads caused by vibration and shock. In order to standardize these loads and make the ruggedness of the products (from other manufacturers as well) comparable, they are developed and tested in accordance with the applicable standards. EN 60068-2-6 is used for testing resistance to vibration, and EN 60068-2-27 is used for testing resistance to shock. If loads occur in the applications that are not adequately described in the standards, it may be necessary to carry out individual tests on the application. This can be particularly useful when it comes to short and strong shocks (e.g. when a brake is applied).

If there is high variance within a product family (e.g. due to the connection type), the characteristic values are differentiated in the data sheets or in the operating instructions:

	Solid shaft, servo flange	Solid shaft, face mount flange	Blind hollow shaft	Through hollow shaft
Resistance to vibration (per variant)				
Male connector, M23, 12-pin	30 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)		10 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)	
Male connector, M12, 12-pin	30 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)		10 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)	
Cable, 12-wire	30 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)		10 g, 10 Hz ... 1,000 Hz (EN 60068-2-6)	

As with most mechanical arrangements, resonances can occur in encoders during excitation by shock or vibration. Depending on the direction of excitation (X/Y/Z), they can also occur at different frequencies.

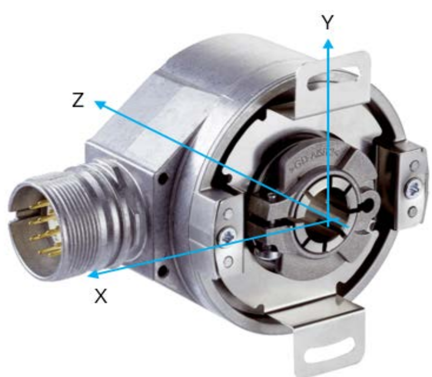

Fig. 3: Excitation directions using the example of an AFM60 encoder

The resonant frequencies in these axes typically lie in the range from 700 Hz to 1,200 Hz. Possible resonance points are shown qualitatively in the following spectrum (Fig. 4). Continuous operation of the component at such a resonance could limit the function of the product or cause permanent damage. We therefore advice extensive tests of the entire system. To increase repeatability, modern data sheets specify the vibration measuring point on the product.

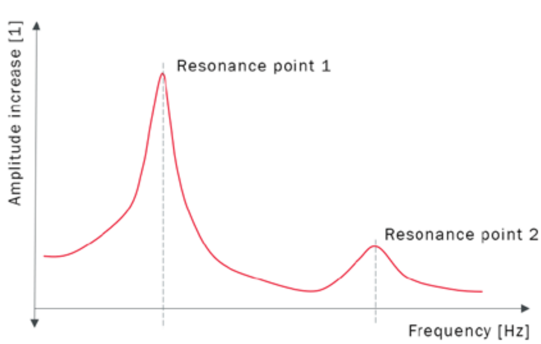

Fig. 4: Exemplary spectrum with resonance points

Torsion

If the center of gravity of the encoder including its attachments, such as the cabling, is not precisely on the Z-axis, torsion will also occur when the encoder is excited in axis direction Y (Fig. 5).

As the relation between encoder housing and shaft diameter determines the measured value, this torsion can influence the measured value or violate the error limit.

An oscillating system with the resonant frequency is also created:

$$fr = \frac{1}{2\pi} * \sqrt{C}/I$$

where ***C*** is the spring constant of the stator coupling and ***I*** is the moment of inertia of the encoder including attachments.

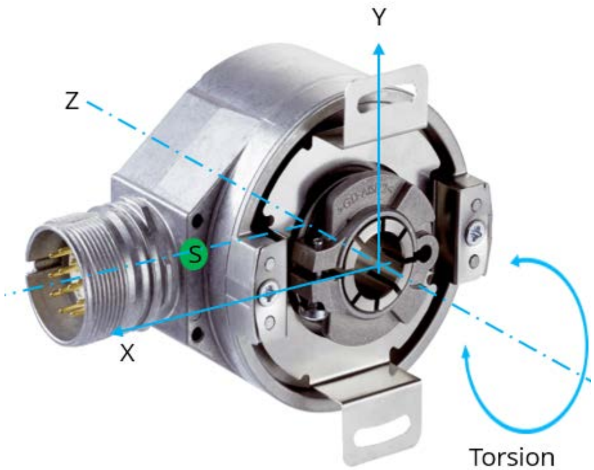

Fig. 5: Torsion axis and center of gravity using the example of an encoder with M23 connection

For encoders with fixed cable connections or axial connection types, such torsional resonance frequencies are typically between 400 Hz and 900 Hz. They can, however, also be considerably lower than these values for an encoder with radial M23 connection and a non-fixed cable guide.
If center of mass S is far away from the encoder center axis, impact loads can also cause permanent damage to the stator coupling. This can be prevented by the following:

- Suitable selection of the connection type
- Correct alignment of the male connector (Fig. 7)
- Support/Fixation of the connected cable in the area of the male connector

The following is an example of the time curve of a shock response, meaning the torsional oscillation of an encoder with flexible cabling. The level of the amplitude corresponds to the resulting measurement error (Fig. 6).

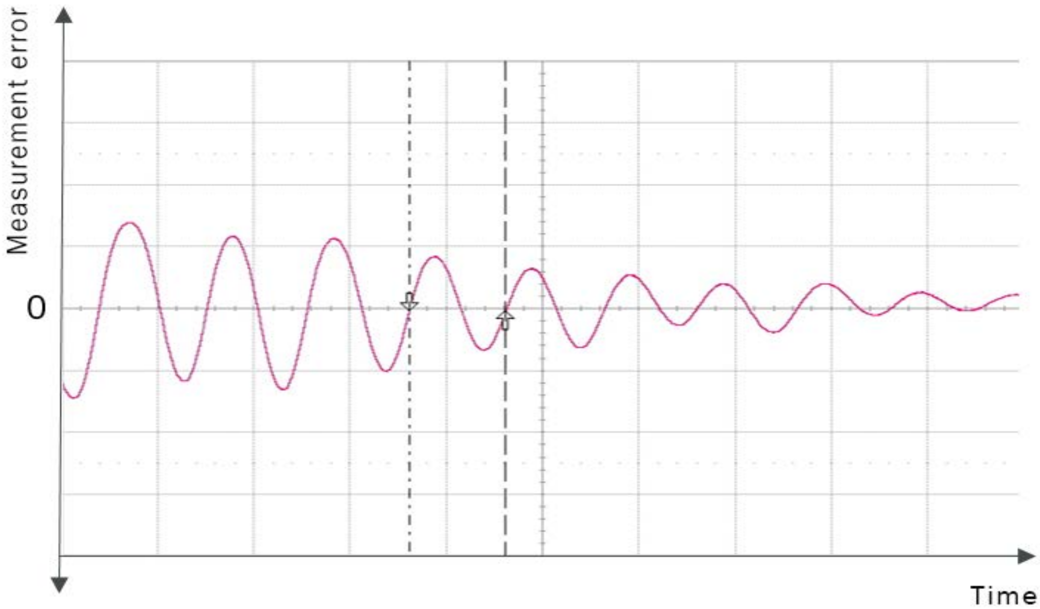

Fig. 6: Exemplary temporal course of a torsional oscillation

Other influences

In addition to the dynamic influences described above, static forces can also affect the measurement result. The influencing variables and how to avoid them are as follows:

- Dead weight of the cable -> positioning of the free cable in the direction of the expected shock or vibration (Fig. 7)
- Tensile forces of the cable -> minimization of the free length of cable by fixing the cable

Dead weight of the male connector plug -> positioning of the male connector plug in shock direction or use of a product with cable connection (Fig. 8)

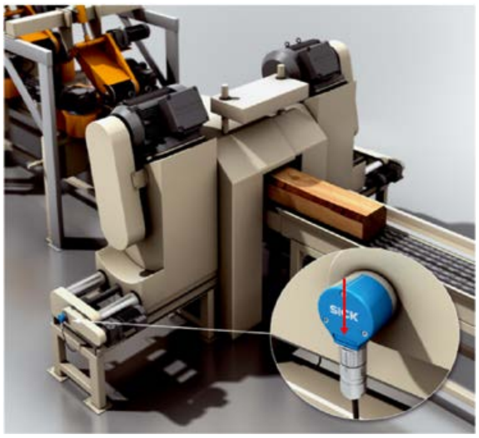

Fig. 7: Advantageous arrangement of the connection. Cable runs or shocks in the direction of the arrow do not cause the encoder to rotate

Fig. 8: Encoder with cable connection

Summary

An encoder or motor feedback system cannot be considered an isolated product, but one that forms a system together with the customer application that reacts to static and dynamic influences.

If, in a customer application, mechanical loads occur that deviate from the normative specifications, their influence on the performance of the encoder should be evaluated separately by tests of the overall system.

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