Quadrature interface

Summary

Description of the quadrature interface of incremental encoders

Applies to

All incremental encoders from FAULHABER

Output signals

Two signals that have been phase-shifted electrically by 90° – also known as square wave signals – are available at the output (Figure 1) of FAULHABER incremental encoders. Encoders with three channels also provide one index pulse per motor revolution as a reference (Figure 2), in addition to the two channels A and B. This allows homing, for example, to be carried out after switching on. If homing is not performed via the zero pulse or a mechanical limit switch, the absolute position of the motor is not known. As a result, only relative positioning can be carried out in addition to speed control. The pulse width is usually equal to an edge separation between A and B (corresponds to 90°e).

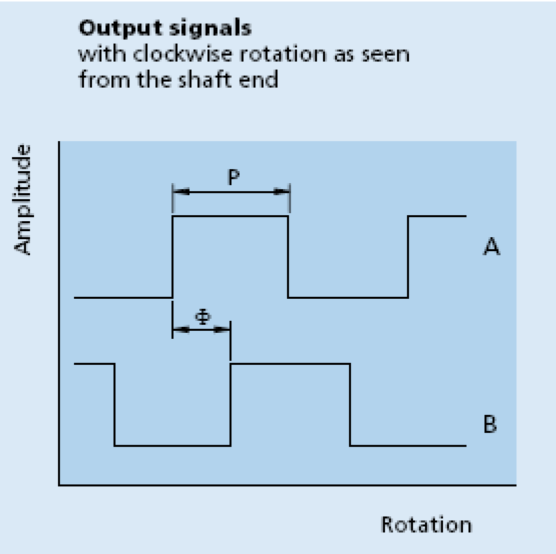

Figure 1: Output signals with IE2

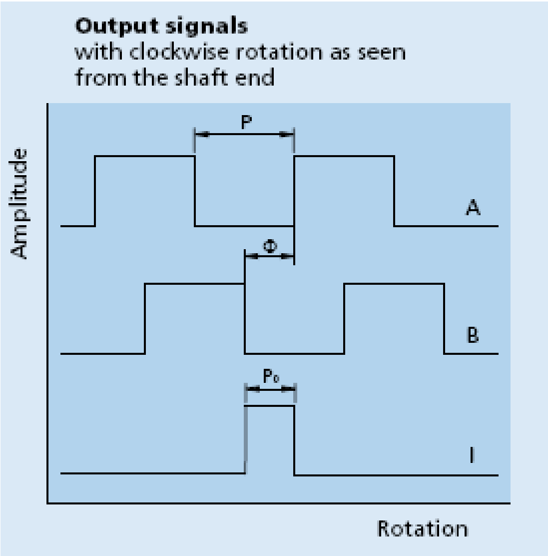

Figure 2: Output signals with IE3

Encoders with a line driver interface are additionally equipped with differential signal outputs (Figure 3). The symmetrical or differential transmission of the encoder signals offers robust resistance to common-mode interference, which can be caused for example by parallel motor lines with PWM. This enables common-mode interference to be suppressed, facilitating longer supply lines.

On the connection side, these differential signals must be combined again with a receiver module. Suitable receiver modules are available as a connection adapter or may already be integrated in the motor control. The actual line length that can be achieved depends on ambient conditions as well as on the type of evaluation. Ideally, the differential signals are transmitted via twisted-pair wires so that the interference injected at the end of the line can be decoded with as few errors as possible using differential evaluation. In the case of longer lines, buffering the encoder voltage supply on the encoder side at the end of the line may need to be considered in order to ensure stable voltage supply. Line termination with wave impedance (100 Ohm) may also be advisable in the case of longer lines. This must be tested for the particular application.

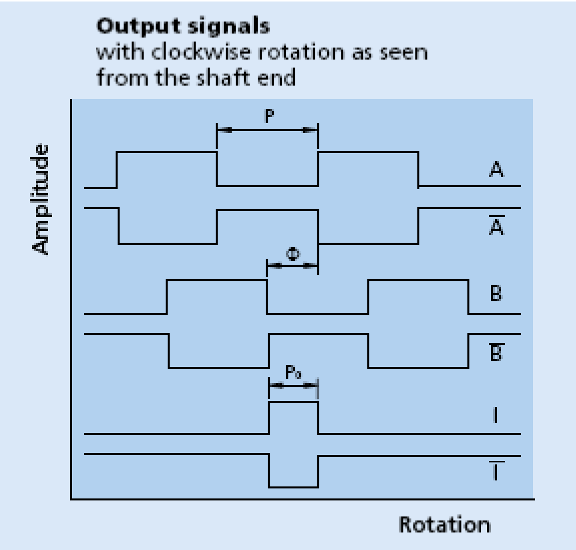

Figure 3: Output signals with IE3L

Number of pulses and resolution

In FAULHABER data sheets, the number of pulses per motor revolution is indicated as standard. The resolution for four-edge evaluation is thus four times higher. In four-edge evaluation, the rising and the falling edge is recorded for both channels. The resolution should not be confused with the absolute accuracy of the sensor. This is not indicated in the data sheets of FAULHABER encoders, and is generally not the same as the resolution! In the case of special requirements, it is advisable to select the correct combination for the customer's application in consultation with support or development staff.

Example: IE2-1024:

- The number of pulses N is equal to 1024 pulses per revolution with 0.35 degrees per pulse.
- In four-edge evaluation, a resolution of 4096 steps per revolution is achieved with 0.088° per step.
- The accuracy is not specified, however, in this case it is typically equal to ±0.4°.

Four-edge evaluation

Four-edge evaluation is often used to facilitate evaluation of quadrature signals that is not subject to errors or interferences. The direction of rotation of the motor can be detected based on the edge sequence. The edges then operate a position counter in the corresponding direction, which records the relative position since counting was initiated. The encoder data sheet specifies the leading channel in the case of clockwise rotation. Generally, channel A is the leading channel in the case of clockwise rotation, while channel B is the leading channel in the case of anticlockwise rotation (Figure 4). Four-edge evaluation is preferable to a simple pulse count or measurement of edge separation. Benefits include safeguarding against errors during counting, even in the case of noise pulses, as well as less sensitivity to fluctuations in pulse duration in speed control.

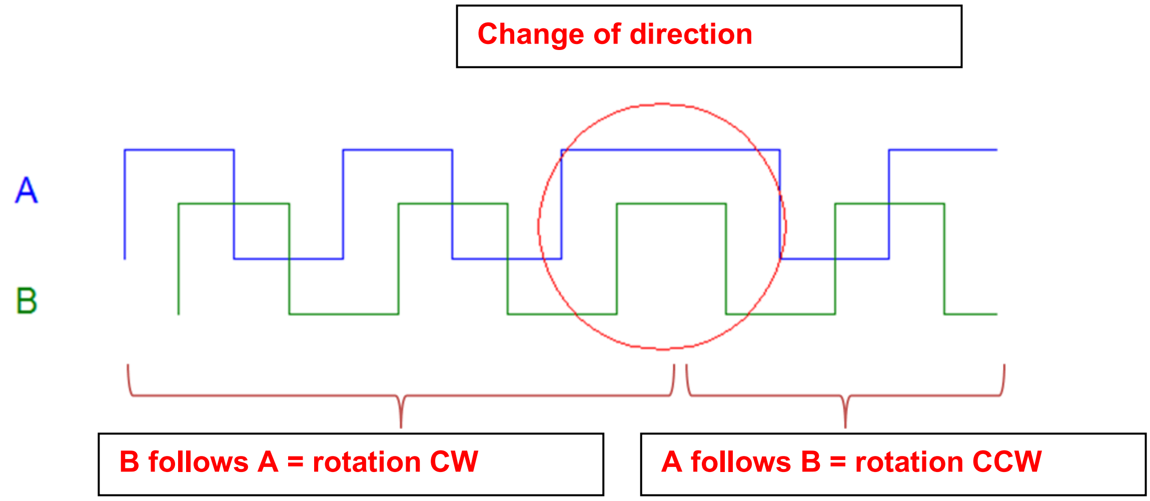

Figure 4: Detection of the direction of rotation

Hysteresis

Encoders with an incremental interface generally feature hysteresis. At very low speeds or at stoppage in positions close to a switching edge, hysteresis suppresses the occurrence of pulses. This prevents oscillations, for example as a result of mechanical clearance. Hysteresis specifies the angle that must at least be exceeded in the case of a change in the direction of rotation, until the next edge is generated. If hysteresis is excessive, this can prove detrimental, particularly in applications related to position control, as it must be viewed as "dead time" or slip. In some encoders (e.g. IE3, IEM3, IEH2), hysteresis is thus programmable and can be adapted if required via special programming / an option number.

Maximum frequency and edge separation

The maximum possible speed range of the sensor can be calculated using the parameter "Frequency range, up to". The maximum motor speed that is possible in this case is calculated using formula no. 1.

$$n(rpm) = f(Hz) * 60/N$$

Formula 1: Maximum speed

The control connected to the encoder must be able to process the maximum possible encoder frequency! Even at lower speeds, short pulses may occur (taking into consideration the minimum edge separation, see formula no. 2), which are otherwise not detected by the control. The minimum edge separation is currently not yet indicated in the data sheets of FAULHABER encoders.

$$Minimum\ edge\ separation(s) = 1/(4 * f(Hz))$$

Formula 2: Minimum edge separation

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