Built-on optoelectronic rotary encoders

Introduction

Overview

SIMODRIVE sensors are built-on optoelectronic rotary encoders for the recording of paths, angles of rotation, or speeds of machines. They can be used in conjunction with numerical controllers, programmable logic controllers, drives and position displays, e.g. for:

- SINAMICS drive systems
- SIMOTION Motion Control systems
- SINUMERIK CNCs
- SIMATIC programmable logic controllers
- SIMODRIVE and SIMOVERT MASTERDRIVES drive systems

Application

A distinction is made between incremental and absolute measuring procedures:

- In the case of incremental encoders, the machine must travel to a reference point after each power-off state, as the position is not usually stored in the controller, and movements of the machine while the power is off are not recorded.
- Absolute encoders, on the other hand, also record these movements while the power is off and return the actual position with power On. Travel to a reference point is not necessary.

Design

All encoders are available in Synchro flange and supported flange joint versions. Encoders with a Synchro flange can be attached to the machine with 3 clamp straps or mounted with axial screws. The encoder is driven by means of a plug-in coupling or a spring disk coupling. Alternatively, pulleys can also be used.

The encoder supply voltage is 5 V DC or alternatively 10 V to 30 V DC. The 10 V to 30 V DC version supports longer cable lengths. Most control systems apply the supply voltage directly on the measuring circuit connector. With SINAMICS, the power supply for the measuring systems is provided via the Sensor Modules.

For rotary encoders with cables, the cable length including the connector is 1 m (3.28 ft).
The following bending radii for the cables at the encoder must be complied with:

- One-time bending: ≥ 20 mm (0.79 in)
- Continuous bending: ≥ 75 mm (2.95 in)

Incremental encoders

Function

Incremental encoders deliver a defined number of electrical pulses per rotation, which represent the measurement of the traveled distance or angle.

Incremental encoders operate on the principle of optoelectronic scanning of dividing disks with the transmitted light principle. The light source is a light emitting diode (LED). The light-dark modulation generated as the encoder shaft rotates is picked up by photoelectronic elements. With an appropriate arrangement of the line pattern on the dividing disk connected to the shaft and the fixed aperture, the photoelectronic elements provide two trace signals A and B at 90° to one another, as well as a reference signal R. The encoder electronics amplify these signals and convert them into different output levels.

The following output levels are available:

- RS 422 difference signals (TTL)
  In the case of RS 422 encoders (TTL), the resolution can be improved by a factor of four by means of edge evaluation.
- sin/cos 1 V_{pp} analog signals
  Even better resolution can be achieved for encoders with sinusoidal signals by interpolating them in the higher-level controller.
- HTL (High Voltage Transistor Logic)
  Encoders with HTL interfaces are designed for applications with digital inputs with 24 V levels.

Technical specifications

Product name	TTL (RS 422) incremental encoder	sin/cos 1 V_{pp} incremental encoder	HTL incremental encoder	TTL (RS 422) double-track incremental encoder
Operating voltage V_p on encoder	5 V DC ± 10% or 10 … 30 V DC	5 V DC ± 10%	10 ... 30 V DC	5 V DC ± 5%
Limit frequency, typical	–	≥ 180 kHz (-3 dB) ≥ 450 kHz (-6 dB)	–	–
Scanning frequency, max.	300 kHz	–	300 kHz	Track 1: 160 kHz Track 2: 1 MHz
No-load current consumption, max.	150 mA	150 mA	150 mA	150 mA per track
Signal level	TTL (RS 422)	sinusoidal 1 V_{pp}	V_H ≥ 21 V at I_H = 20 mA at 24 V V_L ≤ 2.8 V at I_L = 20 mA at 24 V	TTL (RS 422)
Outputs protected against short-circuit to 0 V	Yes	Yes	Yes	Yes
Switching time (10 … 90%) (1 m (3.28 ft) cable and recommended input circuit)	Rise/fall time t_+/t_- ≤ 50 ns	–	Rise/fall time t_+/t_- ≤ 200 ns	Rise/fall time t_+/t_- ≤ 100 ns
Phase angle, signal A to B	90°	90° ± 10°el.	90°	90°
Edge spacing, min. at				
• 1 MHz	–	–	–	Track 2: ≥ 0.125 µs
• 300 kHz	≥ 0.45 µs	–	≥ 0.45 µs	–
• 160 kHz	–	–	–	Track 1: ≥ 0.8 µs
Cable length to down-stream electronics[1], max.	100 m (328 ft)	150 m (492 ft)	300 m (984 ft)	Up to 500 kHz: 100 m (328 ft) Up to 1 MHz: 50 m (164 ft)
LED failure monitoring	High-resistance driver	–	High-resistance driver	–
Resolution, max.	5000 S/R	2500 S/R	2500 S/R	Track 1: 1024 S/R Track 2: 9000 S/R
Accuracy (in angular seconds)	± 18° mech. x 3600/ number of signals/revolution z	± 18° mech. x 3600/ number of signals/revolution z	± 18° mech. x 3600/ number of signals/revolution z	Track 1: ± 63 Track 2: ± 12
Speed, max.				
• Electrical	(18×10^6 rpm)/ number of signals/revolution	(27×10^6 rpm)/ number of signals/revolution (at -6 dB)	(18×10^6 rpm)/ number of signals/revolution	Track 1: 9000 rpm Track 2: 6500 rpm
• Mechanical	12000 rpm	12000 rpm	12000 rpm	12000 rpm
Friction torque (at 20 °C) (68 °F)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)
Starting torque (at 20 °C) (68 °F)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)	≤ 0.01 Nm (0.04 oz_f)
Shaft loading capacity				
• n > 6000 rpm				
- Axial	10 N (2.25 lb_f)	10 N (2.25 lb_f)	10 N (2.25 lb_f)	–
- Radial at shaft extension	20 N (4.50 lb_f)	20 N (4.50 lb_f)	20 N (4.50 lb_f)	–
• n ≤ 6000 rpm				
- Axial	40 N (8.99 lb_f)	40 N (8.99 lb_f)	40 N (8.99 lb_f)	10 N (2.25 lb_f)
- Radial at shaft extension	60 N (13.5 lb_f)	60 N (13.5 lb_f)	60 N (13.5 lb_f)	20 N (4.50 lb_f)
Angular acceleration, max.	10^5 rad/s^2	10^5 rad/s^2	10^5 rad/s^2	10^5 rad/s^2
Moment of inertia of rotor	1.45×10^{-6} kgm^2 (12.8×10^{-6} lb_f-in-s^2)	1.45×10^{-6} kgm^2 (12.8×10^{-6} lb_f-in-s^2)	1.45×10^{-6} kgm^2 (12.8×10^{-6} lb_f-in-s^2)	20×10^{-6} kgm^2 (177×10^{-6} lb_f-in-s^2)
Vibration (55 … 2000 Hz) to EN 60068-2-6	≤ 300 m/s^2 (984 ft/s^2)	≤ 300 m/s^2 (984 ft/s^2)	≤ 300 m/s^2 (984 ft/s^2)	≤ 100 m/s^2 (328 ft/s^2)
Shock to EN 60068-2-27				
• 2 ms	≤ 2000 m/s^2 (6562 ft/s^2)	≤ 2000 m/s^2 (6562 ft/s^2)	≤ 2000 m/s^2 (6562 ft/s^2)	–
• 6 ms	≤ 1000 m/s^2 (3281 ft/s^2)	≤ 1000 m/s^2 (3281 ft/s^2)	≤ 1000 m/s^2 (3281 ft/s^2)	≤ 1000 m/s^2 (3281 ft/s^2)

S/R = signals/revolution

1) With recommended cable and input circuitry of the downstream electronics, observe max. permissible cable length of module to be evaluated.

Technical specifications (continued)

Product name	TTL (RS 422) incremental encoder	sin/cos 1 V_{pp} incremental encoder	HTL incremental encoder	TTL (RS 422) double-track incremental encoder
Ambient temperature				
Operation				
• Flange outlet or fixed cable				
- At V_p = 5 V ± 10%	-40 ... +100 °C (-40 ... +212 °F)	-40 ... +100 °C (-40 ... +212 °F)	-40 ... +100 °C (-40 ... +212 °F)	-10 ... +70 °C (+14 ... +158 °F)
- At V_p = 10 … 30 V	-40 ... +70 °C (-40 ... +158 °F)	–	–	–
• Flexible cable				
- At V_p = 5 V ± 10%	-10 ... +100 °C (+14 ... +212 °F)	-10 ... +100 °C (+14 ... +212 °F)	-10 ... +100 °C (+14 ... +212 °F)	-10 ... +70 °C (+14 ... +158 °F)
- At V_p = 10 … 30 V	-10 ... +70 °C (+14 ... +158 °F)	–	–	–
Degree of protection to EN 60529 (IEC 60529)				
• Without shaft input	IP67	IP67	IP67	IP67
• With shaft input	IP64	IP64	IP64	IP64
EMC	Tested in accordance with the guidelines for electromagnetic compatibility 89/336/EEC and the regulations of the EMC guidelines (applicable basic standards)			
Weight, approx.	0.25 kg (0.55 lb)	0.25 kg (0.55 lb)	0.25 kg (0.55 lb)	0.7 kg (1.54 lb)
CE mark	Yes	Yes	Yes	Yes

Selection and Ordering Data

Designation	Order No.
TTL (RS 422) incremental encoder	
Synchro flange and 5 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-2G■■■**
• Radial flange outlet	**6FX2001-2E■■■**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-2C■■■**
Synchro flange and 10 ... 30 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-2H■■■**
• Radial flange outlet	**6FX2001-2F■■■**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-2D■■■**
Supported flange joint and 5 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-2R■■■**
• Radial flange outlet	**6FX2001-2P■■■**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-2M■■■**
Supported flange joint and 10 ... 30 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-2S■■■**
• Radial flange outlet	**6FX2001-2Q■■■**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-2N■■■**
Resolution	
500 S/R	**A 5 0**
1000 S/R	**B 0 0**
1024 S/R	**B 0 2**
1250 S/R	**B 2 5**
1500 S/R	**B 5 0**
2000 S/R	**C 0 0**
2048 S/R	**C 0 4**
2500 S/R	**C 5 0**
3600 S/R	**D 6 0**
5000 S/R	**F 0 0**

S/R = signals/revolution

Designation	Order No.
sin/cos 1 V_{pp} incremental encoder	
Synchro flange and 5 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-3G■■■**
• Radial flange outlet	**6FX2001-3E■■■**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-3C■■■**
Resolution	
1000 S/R	**B 0 0**
1024 S/R	**B 0 2**
2500 S/R	**C 5 0**
HTL incremental encoder	
Synchro flange and 10 ... 30 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-4H■■0**
• Radial flange outlet	**6FX2001-4F■■0**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-4D■■0**
Supported flange joint and 10 ... 30 V DC supply voltage	
Connection:	
• Axial flange outlet	**6FX2001-4S■■0**
• Radial flange outlet	**6FX2001-4Q■■0**
• Cable 1 m (3.28 ft) with connector[1]	**6FX2001-4N■■0**
Resolution	
100 S/R	**A 1**
500 S/R	**A 5**
1000 S/R	**B 0**
2500 S/R	**C 5**
TTL (RS 422) double-track incremental encoder	
Synchro flange and 5 V DC supply voltage	
Connection:	
• Cable 1 m (3.28 ft) with axial connector 2 types of resolution: 9000/1024 S/R	**6FX2001-2UK00**

[1] Universal integrated cable outlet for axial and radial outlet direction.