



# Steering units by SKF

By-wire technology for improved vehicle efficiency and performance



# Steer-by-wire for modern off-highway vehicles

By-wire technology offers several advantages in the operation and control of industrial and off-highway vehicles. When mechanical or hydraulic systems are replaced with by-wire technologies, for example, programmable steering functions and ergonomic improvements are possible. By-wire technology can also improve vehicle efficiency and enhance performance. Vehicles with better performance that consume less energy can significantly reduce cost of ownership for the end user.

SKF was one of the first companies to develop electronic steering input devices for industrial and off-highway vehicles.

Requirements put on steering input devices for industrial and off-highway vehicles represent a wide scenario.

Therefore, SKF offers two different families of steering units. With a range of functional capabilities appropriate to a variety of practical steering applications with different driver steering feedback options. Both are safe and reliable, virtually "maintenance-free" cost-effective compact solutions.



## Steering units by SKF

### A compact and robust design

SKF steering units are designed to operate in harsh environments. The housing, fully protects the inner mechatronic components from dusty, humid and corrosive environments, making it easy to install the unit in virtually any position. The shaft for connecting the steering wheel is made of stainless steel.

### A long-service life solution

SKF steering units can replace conventional steering columns and they don't require relubrication or adjustments during their expected service life.

### Reliable control signals

Non-contact position sensors are used to track the movement of the steering wheel. These magnetic sensors are protected from external influences, and are designed to provide maximum service life. As steering requires a safety sensitive design, redundancy of the output signals is necessary. SKF steering units are made to support this safety architecture of steer-by-wire systems.

### A cost-effective solution

SKF steering units can simplify current designs. When considered over the entire product lifetime, these units are a very cost-effective solution.

### Possible applications

- Forklifts
- Harvesters
- Tractors
- Construction and mining equipment
- Industrial electric vehicles
- Mowers and utility vehicles

### Features

- Compact input device for steering wheel position, steering speed and direction
- Redundant steering signal output
- Steering feel constant or variable
- Non-contact sensors

### Benefits

- Enables more ergonomic cabin design, improved operator comfort and increased productivity
- Reduction in components enhances system reliability
- Redundant signals and robust design provide an extra margin of safety
- Integrated and virtually maintenance-free technology reduces lifetime cost



## SKF Steering Encoder Unit – with constant friction torque

The SKF Steering Encoder Unit is based on well-proven SKF technologies. The unit has been designed from the inside out, starting with bearing encoder technology, to precisely monitor steering direction and speed. From there, a constant friction torque device, a technical interface for mounting, and a shaft to connect the steering wheel are added to create a complete unit. The friction torque device provides the adequate feel in the steering wheel to the operator. The SKF Steering Encoder Unit contains two sets of sensors to provide signal redundancy. Each unit is supplied ready to mount. Connection to a steer-by-wire system is achieved by plugs.

The solution can be customized to meet the needs of a particular application with different:

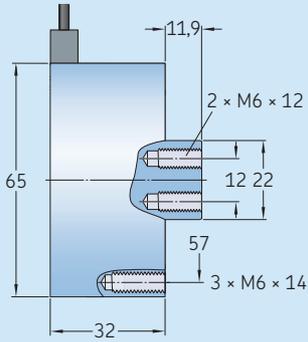
- torque values (0,1/0,6 Nm)
- cable lengths (250 to 820 mm)
- connectors
- shaft interfaces ( $\varnothing$ , length and threads)
- resolutions (64 or 256 pulses per turn, absolute)

### Sensor technology and electrical data

The units provide two independent sets of square wave signals via open collector circuits. They require a regulated voltage supply, which can range from 5 to 24 V DC. Pull-up resistors should be placed between the voltage supply and the conductors for the output signals to limit the output current to 20 mA.



Table 1



SKF Steering Encoder Unit

| Designation | Rotational speed max<br>r/min | Electronic specifications |                   |              |               |
|-------------|-------------------------------|---------------------------|-------------------|--------------|---------------|
|             |                               | Pulses/rev                | Period accuracy % | Duty cycle % | Phase shift ° |
| AHE-5401 D  | 300                           | 64                        | ±8                | 50±10        | 90±30         |
| AHE-5701 C  | 300                           | 256                       | ±20               | 50±10        | 90±30         |

Fig. 1

SKF Steering Encoder Unit  
(main dimensions, mm)

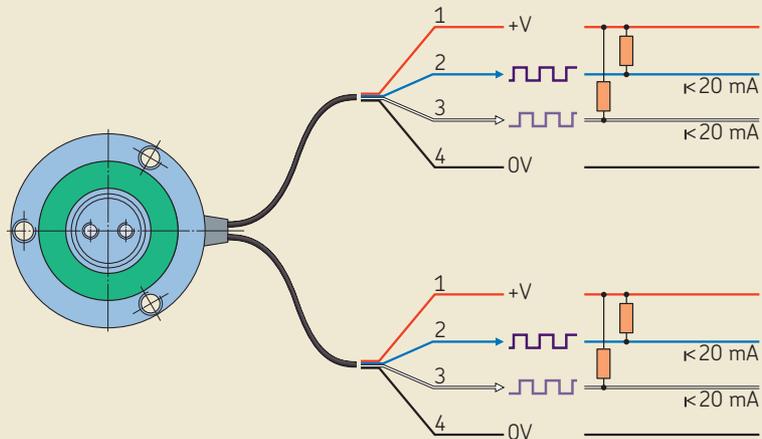


Table 2

Technical data

|                        |                                   |
|------------------------|-----------------------------------|
| Weight                 | 0,55 kg                           |
| Operating temperature  | -40 to +85 °C<br>(-40 to +185 °F) |
| Maximum rotation speed | 300 rpm                           |

Table 3

Sensor data

|                      | Incremental sensor with standard resolution (AHE-5401 D) | Incremental sensor with high resolution (AHE-5701 C)     |
|----------------------|--|--|
| Sensor type          | Non-contact, redundant Hall elements                     |  |
| Power supply         | 5 to 24 V DC   |  |
| Resolution           | 64 impulses per revolution, i.e. 256 electrical events   | 256 impulses per revolution, i.e. 1024 electrical events |
| Signal output        | Square wave A and B in quadrature, incremental           |  |
| Electrical interface | Open-collector   | Push-pull  |

## SKF Electronic Steering Input Unit – with variable steering feel

The SKF Electronic Steering Input Unit is an advanced steering unit family conceived by SKF.

Its main features are:

- a stub shaft to mount the steering wheel
- two independent contact-less rotary absolute position sensors
- redundant Electronic Control Unit, providing two independent CAN interfaces
- an integrated friction device
- a corrosion resistant housing
- sealed SKF Explorer bearings

The SKF Electronic Steering Input Unit detects the position of the steering wheel and provides programmable steering feel and end stops.

### Individual “steering feel”

The integrated friction device provides the driver with realistic feedback by changing the torque resistance to the steering wheel. Feedback can be remotely controlled by the steering system via the CAN-bus. In alternative, the steering feedback can be controlled directly by the logics embedded in the unit, allowing advanced feedback functions adapted to different driving conditions: for example, the steering wheel “resistance” can be controlled proportionally to the steering wheel turning speed.

The friction device is also used to simulate end-stops that keep the steering wheel from turning when the actual end-stop position of the steered wheels is reached. By a special patented solution, the brake is released as soon as the steering wheel is moved in

the opposite direction. The steering unit end-stop positions are programmable, unlike mechanical or hydraulic steering systems where the end-stops are fixed.

### Standard interfaces with redundancy

Two non-contact absolute position sensors are integrated into the steering unit and the redundant Electronic Control Unit provides a robust interface to the steering system.

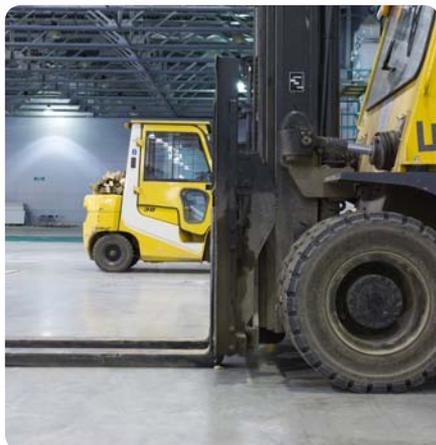


Table 4

**Operating parameters**

|                                    |          |
|------------------------------------|----------|
| Supply voltage                     |          |
| Nom.                               | 12/24 V  |
| Min.                               | 10 V     |
| Max.                               | 36 V     |
| Supply current                     |          |
| Nom.                               | 80 mA    |
| Max.                               | 120 mA   |
| Supply current brake (max. torque) |          |
| Nom.                               | 980 mA   |
| Max.                               | 1 100 mA |

**Signal parameter**

|                      |                            |
|----------------------|----------------------------|
| Sensor accuracy      |                            |
| Nom.                 | ±2 degree                  |
| Sensor resolution    |                            |
| Nom.                 | 12 / 14 bit (configurable) |
| Sensor repeatability |                            |
| Nom.                 | ±0,2 degree                |

**Can interface**

|                 |   |
|-----------------|---|
| CAN-Bus version | 2.0B                                    |
| CAN-Bus speed   | 250 kbps (different speed configurable) |
| CAN transceiver | High speed standard                     |

Table 5

**Mechanical specifications**

|                           |           |
|---------------------------|-----------|
| Weight                    | 1,8 kg    |
| Resistive feedback torque | 0,3–12 Nm |
| Max static axial force    | 1 500 N   |
| Max tilting moment        | 100 Nm    |
| Max steering speed        | 180 r/min |

Table 6

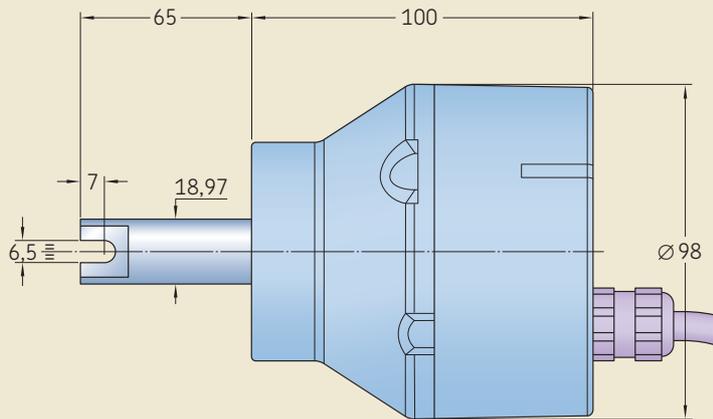
**Environmental specification**

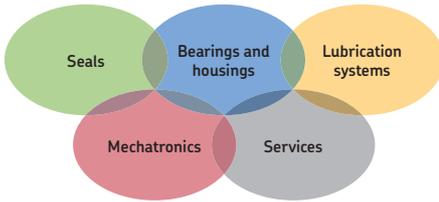
|                                 |               |
|---------------------------------|---------------|
| Ambient operating temperature   |               |
| Nom.                            | 25 °C         |
| Range                           | -40 to +85 °C |
| Storage temperature             |               |
| Nom.                            | 25 °C         |
| Range                           | -40 to +85 °C |
| Humidity                        |               |
| Nom.                            | -             |
| Range                           | 0 to 95 %     |
| Protection level                | IP 67         |
| Salt spray corrosion resistance |               |
| Nom.                            | 300 h         |
| Random vibration (rms)          |               |
| Nom.                            | 7,5 g         |



Fig. 2

**ADD-6203 electronic steering input unit**  
(main dimensions, mm)





### The Power of Knowledge Engineering

Combining products, people, and application-specific knowledge, SKF delivers innovative solutions to equipment manufacturers and production facilities in every major industry worldwide. Having expertise in multiple competence areas supports SKF Life Cycle Management, a proven approach to improving equipment reliability, optimizing operational and energy efficiency and reducing total cost of ownership.

These competence areas include bearings and units, seals, lubrication systems, mechatronics, and a wide range of services, from 3-D computer modelling to cloud-based condition monitoring and asset management services.

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