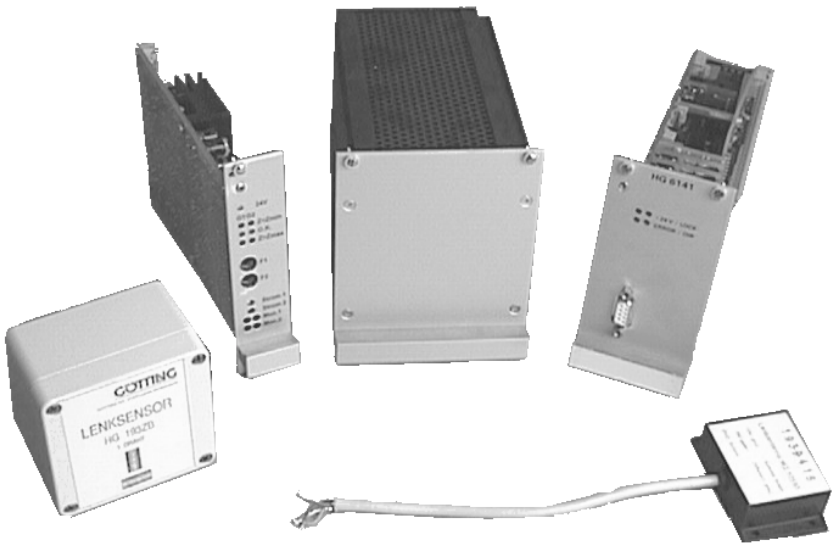


# Track Guidance System

# HG 895

| | |
|---|---|
| Revision B (English) | Developed by: W.M. |
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GÖTTING

# Contents

# 1 Track Guidance System

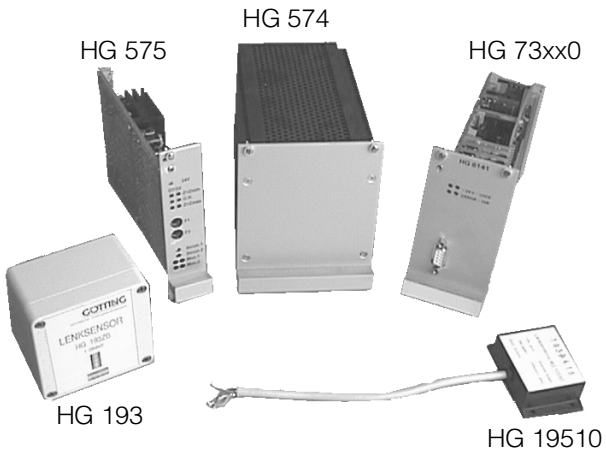
The system consists of several components, that can be arranged in various ways, depending on the different tasks and the different customer specifications. This system description gives a general overview of the set-up and operation of track guidance system HG 895. For more detailed information on each of the components, please refer to the additional descriptions that are available (chapter 3.7 on page 15 shows a list of descriptions that are available for the different components).

## 1.1 Brief Summary

The track guidance system enables guidance of a mobile vehicle along a current-carrying conductor.

## 1.2 System Components

**Drawing 1** Available system components




The system consists of four different components:

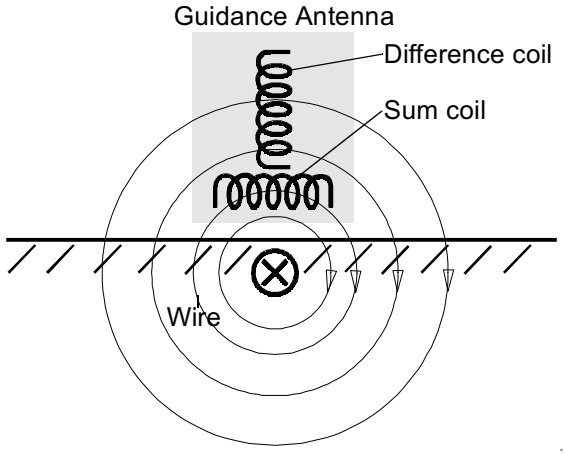
1. Generator HG 574 / HG 575
2. Control Antenna HG 193 / HG 19510
3. Interpreter HG 73xx0
4. Ground equipment (to be supplied by the customer)

## 1.3 System Tasks

1. Generation of an alternating magnetic field along the guide conductor
2. Detection of magnetic field components
3. Computation of lateral offset (x) to guide conductor
4. Output of control variable

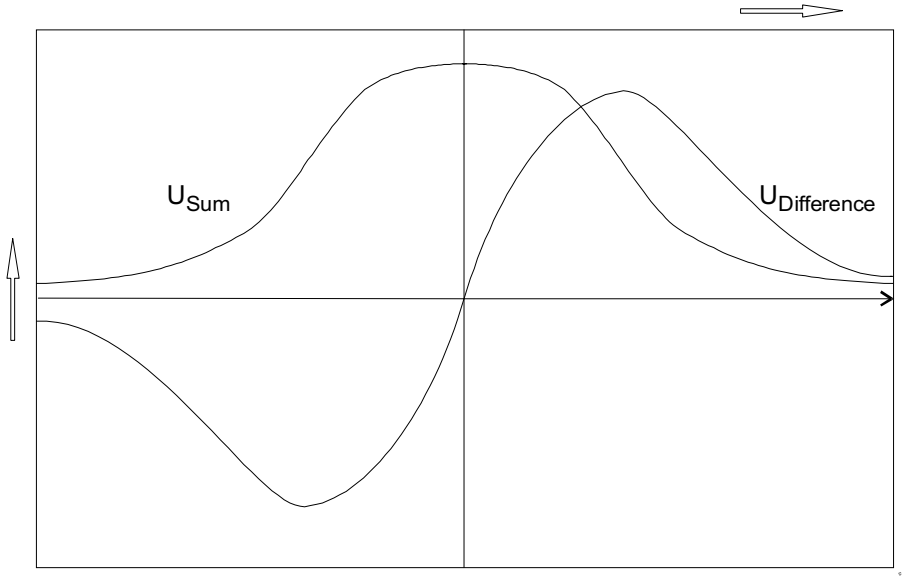
## 1.4 Description

The generator feeds current into the guide conductor in the ground. This produces an alternating magnetic field along the guide conductor.




**Drawing 2** Magnetic field of the guide conductor

The control antenna then detects the field line components in both horizontal and vertical directions.




**Drawing 3** Induced Voltage in sum and difference antenna

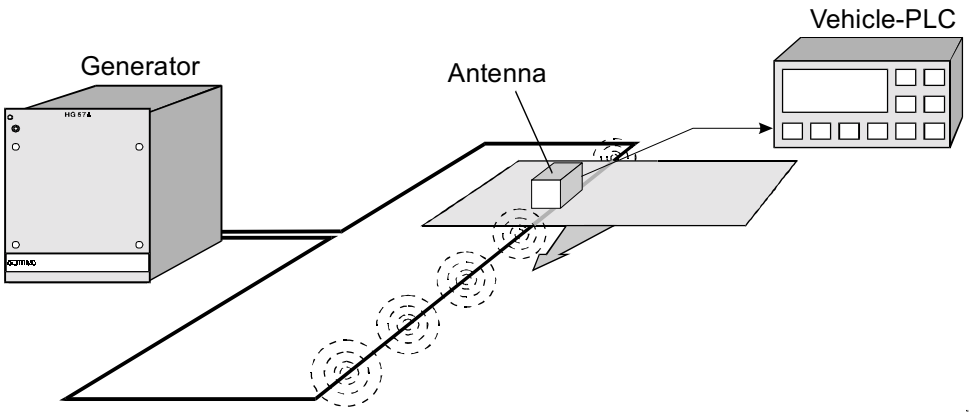
The characteristic potential gradient from the horizontal component of the lines of flux (sum voltage) crosswise to the wire is a distribution curve (bell curve). The potential gradient of the vertical component of the lines of flux (difference voltage) show to the right and left of the wire, at defined positions, positive and negative maxima, while showing 'zero' directly above the wire.

The potential output gradients of antenna HG 193 correspond to those shown in Drawing 3. In addition, there is a 'switch output' that is activated when crossing an (adjustable) sum threshold.

The interpreter HG 73xx0 amplifies both voltages and rectifies them synchronously. The processor then measures them. A special algorithm enables the µP to determine the lateral distance from guide conductor without reference to guiding current. A regulator with PID behaviour is implemented in the µP. Furthermore, there is the option of connecting another control antenna to the interpreter enabling backward movement of the vehicle. The calculated position value (or variable) can be output over the analog interface.

## 1.5 Possible System Configurations

### 1.5.1 Track Guiding Cars (robust outside Application, large distance between Conductor <-> Antenna)




**Drawing 4** Track Guiding a car

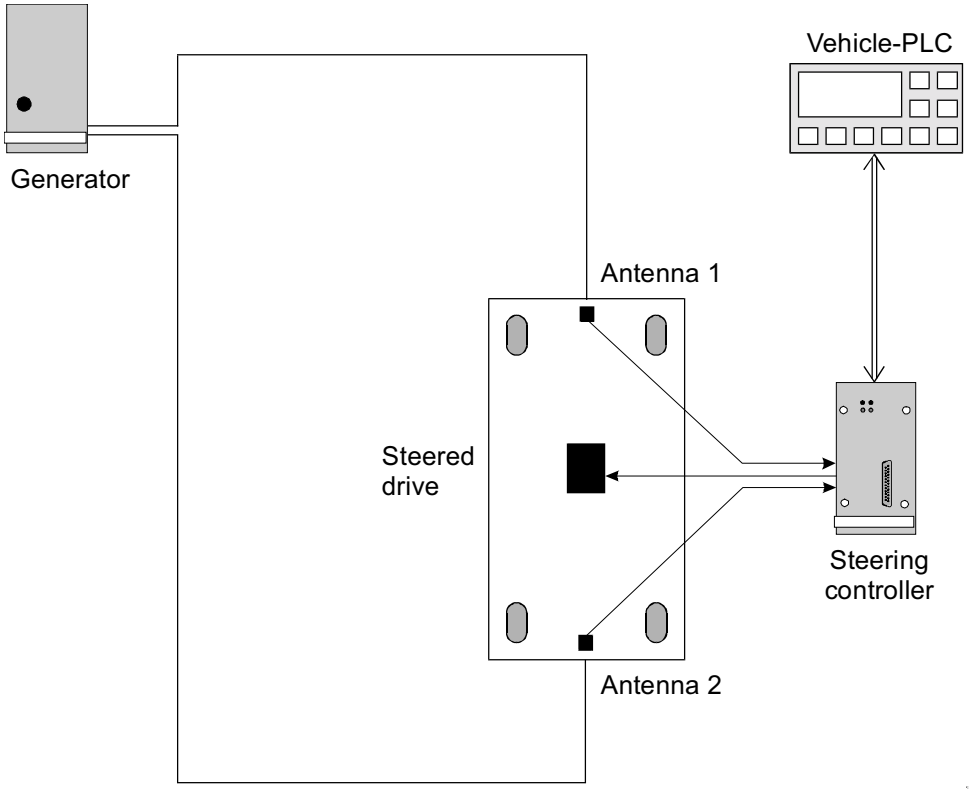
Due to its large output current, generator HG 574 in connection with antenna HG 193 is especially designed for robust systems with a relatively large mounting height of the antenna. Interpretation of the output voltage within the vehicle computer is not part of this system.

Reading height: 100 to 400 mm

The following systems include a steering controller, that relieve the vehicle computer or PLC of the short cycle times of control algorithms. The PLC is able to control the steering controller using only a few connecting wires.

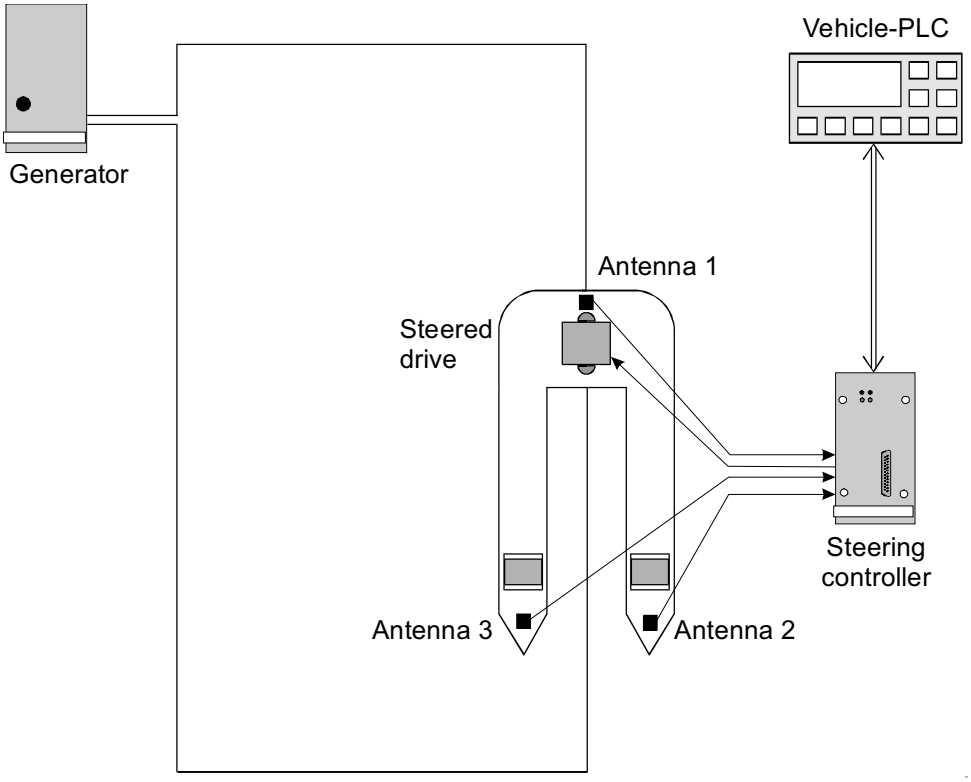
The output voltage for control of the steering motor is configurable in hub and offset within the range of ±9 V. The steering controller does not include a power driver.

### 1.5.2 Track Guiding an AGV in two Directions




**Drawing 5** Track Guiding an AGV in two Directions

### 1.5.3 Track Guiding a Forklift Truck in two Directions




**Drawing 6** Track Guiding a Forklift Truck in two Directions

The following types of steering controllers are available for the applications in sections 1.5.2 and 1.5.3.

| front cross coil/ rear cross coil | front cross coil only | front cross coil/ rear 2 sum coils (forklift truck) | Ground Equip-ment |
|---|---|---|---|
| 73130 | 73120 | 73110 | single-frequency |
| 73230 | 73220 | 73210 | multi-frequency |

**Table 1** Different versions of steering controllers

# 2 Ground Equipment

## 2.1 General

This chapter is not meant to describe the necessary mechanical and constructional conditions of the ground, but to explain the geometry and the electro-magnetic features of the ground equipment.

These descriptions are especially for the different applications of the of the steering (drive) controller family HG 73xx0 in single- and multi-frequency systems.

## 2.2 Various Antenna Configurations

The steering controllers discussed in this chapter offer two different antenna configurations: The so-called 'Raymond coils' for HG 73x10 in the rear system for mounting at the fork, and the 'cross coils' for the other controllers and directions. The following table gives a comparison of these coils' features:

| Cross Coil | | Raymond Coil | |
|---|---|---|---|
| 👍 | Measuring the field in one place | 👎 | Measuring the field in two different places |
| 👍 | Low sensitivity to reinforcement, since both coils are equally involved | 👎 | Bad characteristics with reinforcement and asymmetrical influences |
| 👍 | Measuring range theoretically indefinite and linear | 👎 | Measuring range limited to coil spacing |
| 👍 | Travelling with lateral offset to wire possible (offset movement) | 👎 | Offset movement not possible |
| 👍 | Exact travelling above the conductor due to clearly defined polarity change of the vertical lines of flux | 👎 | Determination of the difference of 2 strong signals, is in principle less accurate and more susceptible to electromagnetic interference |
| 👍 | Clearly defined reception range, clearly defined determination of sign | 👎 | Reception range solely inside the coils, outside the sign is ambiguous! |
| 👎 | Large error for right angle crossings and/or arresters for single-frequency equipment | 👍 | Insensitive to crossings and arresters. |
| 👎 | An area above the antenna approximately equivalent to the mounting height has to be free of metal parts | 👍 | Not sensitive to metal parts above the antenna |
| 👎 | Flat propagation of the field, i.e. large reading height above the conductor, causes bad characteristics | 👍 | Good characteristics with flat propagation of the field, i.e. large reading height above the conductor is possible |

**Table 2** Comparison of the two possible antenna configurations

## 2.3 Appropriate Mounting of the Antenna Systems

Correct mounting of the antennae can be done, after all consequences from the listings in above table have been considered.

### 2.3.1 Cross Coils Systems

Due to the laws of automatic control engineering, it is recommended the antennae are mounted in a steered position using a plastic holder in front of the driving wheel. In addition, this installation is favoured due to sensitivity to interference from above (the drive's PWM). In the past there have also been vehicles where the antenna was mounted on the vehicle's frame; however, in this case only large turning radii are allowed because otherwise the antenna could be turned up to 90$^{o}$ relative to the guide conductor, thus there would be no induced voltages.

For fixed mounting or mounting a short distance in front of the steering axis, as well as for manual steering, a steering potentiometer is necessary.

The output voltages of these antenna systems generally do not have to be readjusted since they are designed and preset for this application.

The current through the guide conductor has to be adjusted in such a way that a sampling rate of 300 to 600 samples in a central position above the conductor at nominal reading height can be achieved (also refer to description HG 73xx0, chapter Set up – Terminal program – status line).

### 2.3.2 System with 2 Raymond Coils

In this case the systems are mounted on the fork tines. It is necessary to prepare mounting holes in the forks as well as to mount the system tilted towards the conductor using a wedge. The antennae need to 'see' the conductor from any lifting height. The antennae should be mounted at a certain distance from the jack-up wheels in the corresponding direction of travel.

In this application the amplification of the sum signals needs to be increased; the difference channels are not evaluated (refer to description HG 19510). Again, at nominal height and at set current with the conductor at central position between the sensors, a sampling rate of 300 to 600 samples per channel has to be achieved.

## 2.4 Requirements on Ground Structure

- The permissible point load, area load, surface hardness and bending tensile strength must not be exceeded.
- A sufficient friction factor needs to be guaranteed over the complete operation period of the equipment.
- The guide conductors need to be mounted in such a way, that no cable breaks will occur (paying attention to dilation interstices, etc.). Cable breaks lead to the effect, that due to the electric field, a magnetic field is indicated to the steering controller, so no direction can be assigned. However, the range of this field is rather small. When the generator HG 575 is being used, diagnosis is simplified by a cable break indication.

- Piles of metal may interfere due to deflection the magnetic field. The following spacings are recommended:
  - Minimum spacing to steel building mats under conductor: 40 mm
  - Minimum spacing to steel sheets and girders under conductor: 60 mm
- Metal ducts and shaft covers have to be a minimum of approx. ±250 mm from the conductor of a cross coil antenna – applies also to a Raymond coil.
- Resistance to earth has to be in the range of $10^3$ OHMS < RE < $10^6$ OHMS (the upper limit is restricted by the VDI Standard 3645). The lower limit cannot be defined exactly; but as a rule, that the larger the ground conductivity, the larger the field attenuation and the less accurate the track guidance.

## 2.5 Single-Frequency Systems

Due to the sensitivity of the cross coil systems that are used in normal operation, in single-frequency systems, inevitable crossings and parting conductors have to be virtually ignored.

Since the steering controllers HG 73xx0 enable 'Unguided travel straight forward' over a limited, straight part of the track, crossings and arresters may only be located on such straight parts of the track, after the vehicle is already aligned for straight forward travel. An exception may be made for crossings in which it is possible to switch the currents of the crossing wires, so that the magnetic fields of the currents compensate each other; i.e. the beginning and the end of the loops have to be laid down accordingly and the generators have to operate in-phase.

Arresters and crossings can be marked by using the Transponder Identification System HG 393.

## 2.6 Multi-frequency Systems

- For these systems, the frequencies should not be any closer than the set default frequencies mentioned in the documentation (>10 %). The generators have to be able to generate the set frequencies with an accuracy of ±50 Hz. Frequencies that are typically interfering frequencies, e.g. for PWM controlled drives, may not be used as guide frequencies.
- Wires with the currently used frequency may not cross, just as in the case of the single-frequency system. Since currents with differring frequencies still cause a certain noise, it is recommended that crossings be avoided in sharp curves. This is because in sharp curves the vehicle always travels with a certain offset and therefore has less useful signal. Depending on the assigned parameters of the antenna, a steering motion may be provoked.
- In one groove, no more than three frequencies should be laid together; the currents of these three frequencies should have approximately the same amplitude.
- The sum of the currents combined in one groove may not exceed 200 mA.

- Alterations in the frequency may not be carried out just before, in, or just after a curve since the controller needs about 300 to 400 ms for change-over. During this period of time, the steering angle is being maintained and a certain distance is being travelled in unguided travel.

- For certain applications, the vehicle computer carries out an automatic search for the frequency when put on top of the wire. It will sequentially activate all frequencies at the controller until the current frequency has been detected and a reply received.
  In the case of an unfavourable system configuration, a frequency, which is not fed into the respective loop, will be detected due to mutual coupling of the various conductor loops. The vehicle computer selects this frequency, the vehicle follows the loop and leaves its actual course. **Therefore, special attention should be paid to decoupling of the loops by making sure that the mutually enclosed areas are small when designing the system layout.** In addition, variation of the lock-down threshold may also lead to an improvement.

# 3 Technical Data

## 3.1 Complete System

| | HG 575, HG 19510, HG 73xx0 | HG 574, HG 193 |
|---|---|---|
| Reading Distance (Distance wire conductor - bottom side of the antenna) | 30 to 150 mm | 100 to 400 mm |
| Nominal reading height | 60 mm | 200 (preset) |
| Output RS 232 | configurable via PC using a terminal program | — |
| Resolution | 1 mm at nominal reading height | — |
| Output | analog voltage range ±9 V, generated by PWM (resolution 9 bits), offset and deviation adjustable | 1 to 11 V sum, difference, open collector sum voltage detector |
| Update rate | 5 ms | — |
| Repetition accuracy | ±1 mm | 1 % |
| Absolute accuracy | ±4 mm in the range of ±50 mm from the center of the wire<br>±8 mm in the range > ±50 mm | 5 % of final value |

**Table 3** Technical data of the Complete System

## 3.2 Generator HG 574

| HG 574 | |
|---|---|
| Casing | Euro card in Euro cassette slip-in case 101.6 mm,<br>circulation of the air must not be obstructed |
| Power supply | 24 V, depending on the set current, up to 1 A |
| Temperature range | $0^{o}$ C to $50^{o}$ C |
| Output signal | 10 kHz, 20 mA to 750 mA current-controlled<br>connections available for large and small loops |

**Table 4** Technical data Generator HG 574

## 3.3 Generator HG 575

| HG 575 | |
|---|---|
| Casing | Euro card in Euro cassette slip-in case 30.48 mm (circulation of air must not be obstructed) |
| Power supply | 24 V, depending on the set current up to 0.3 A |
| Temperature range | $0^{o}$ C to $50^{o}$ C |
| Output signal | 5 to 10 kHz, max. 200 mA current controlled connections available for large and small loops |

**Table 5** Technical data Generator HG 575

## 3.4 Steering Antenna HG 193

| HG 193 | |
|---|---|
| Structure | Cross coil system with selective amplifiers and rectifiers, f = 10 kHz |
| Power supply | 12 V, 20 mA |
| Temperature range | $0^{o}$ C to $40^{o}$ C |
| Casing | Polyester standard casing type T210, 80 x 82 x 55, IP65 |
| Mechanical stress limitations | 10 g shock, 2 g 10 to 55 Hz |
| Installation instructions | Minimum spacing to metal surfaces: 150 mm |

**Table 6** Technical data Steering Antenna HG 193

## 3.5 Steering Antenna HG 19510

| HG 19510 | |
|---|---|
| Structure | Cross coil system with amplifiers |
| Power supply | 10 V 0,05 A (through Interpreter HG 73xx0) |
| Temperature range | $-25^{o}$ C to $+85^{o}$ C |

**Table 7** Technical data Steering Antenna HG 19510 (part 1 of 2)

| HG 19510 | |
|---|---|
| Casing | ABS Module casing,<br>type 515, 68 x 42 x 23, IP54 |
| Mechanical stress limitations | 10 g shock, 2 g 10 to 55 Hz |
| Installation instructions | Minimum spacing to metal surfaces: 150 mm |

**Table 7** Technical data Steering Antenna HG 19510 (part 2 of 2)

## 3.6 Interpreter HG 73xx0

| HG 73xx0 | |
|---|---|
| Structure | Euro card, width 60.96 mm |
| Power supply | 24 V, 330 mA |
| Temperature range | $0^{o}$ C to $50^{o}$ C |
| Output control variable (standard version) | Analog voltage ±9 V, configurable deviation and offset |
| Front display | LED for operation, 3 LEDs for direction, error and guidance medium |
| Connection | 2 x 64 pin multipoint plug |

**Table 8** Technical data Interpreter HG 73xx0

## 3.7 Available Descriptions for the various Components

In case there is the need for more detailed information on one of the system components, the following list shows the available descriptions.

| Component | Data Sheet | | Full Description | |
|---|---|---|---|---|
| | German | English | German | English |
| HG 193 | ✓ | due shortly | — | — |
| HG 19510 | ✓ | due shortly | — | — |
| HG 574 | ✓ | due shortly | — | — |
| HG 575 | ✓ | ✓ | ✓ | — |
| HG 73xx0 | — | — | ✓ | ✓ |

- ✓ = available
- — = not available

**Table 9** List of available descriptions for each component

# 4 List of Pictures

# 5 List of Tables

# 6 Index