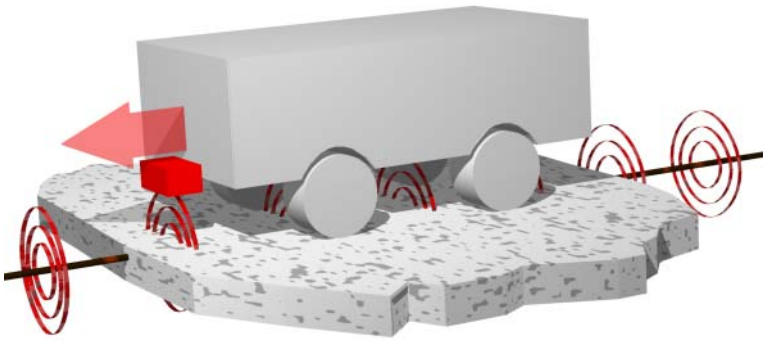

Track Guidance System

for Inductive Guidance of Outdoor Vehicles

HG G-21934

Revision 04 (English)	Developed by: W.M.
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1 Introduction

The herein described system is especially suited for vehicles working in an outdoor environment. The electronic unit within the antenna casing is fully submerged in a sealing compound. All important adjustments are carried out via sealed potentiometers.

1.1 System Components

The track guidance system consists of mainly three different components:

- Track guidance antenna(s) HG 19534
- Ground unit with guide wire, loop adapter HG 94210 and possibly an end resistance HG 97110
- Track guidance generator(s) HG 57400

1.2 Functional Description

A rotationally symmetric, alternating magnetic field is produced when the guide wire is connected over the loop adapter to the generator. The steering antenna receives over separate channels the vertical and horizontal components of this field. Both components are then filtered, strengthened and rectified, so that U_{sum} and U_{dif} are available at the output pins.

Furthermore there is a switchable output, which validates the output voltage. The reception range is given by the measured sum voltage and is like this voltage; interdependent upon the height and current used. It is possible to select one of eight possible receiving frequencies by use of the three frequency select inputs.

In order to compensate for height **or** current fluctuations, a correction calculation has to be carried out with an external computer, because the given voltages are interdependent on height and current.

In order to register the vehicles angle in relation to the guide wire, a second antenna should be connected to the vehicle. The correction calculation and calculation of the vehicles angle is not part of this system.

2 Components and Operation

2.1 Components in the Ground

The accuracy of the system is effected by

- large metallic objects on the ground
- metallic reinforcements within a close area of the guide wire.

Inductive loops have a large influence on the system's accuracy, (such as those caused by steel mating). Individual metal bars have lesser effect upon the system.

Environmental conditions have no effect upon the system e.g.

- snow, ice, water
- oil, tar, sand, soil, dirt and such

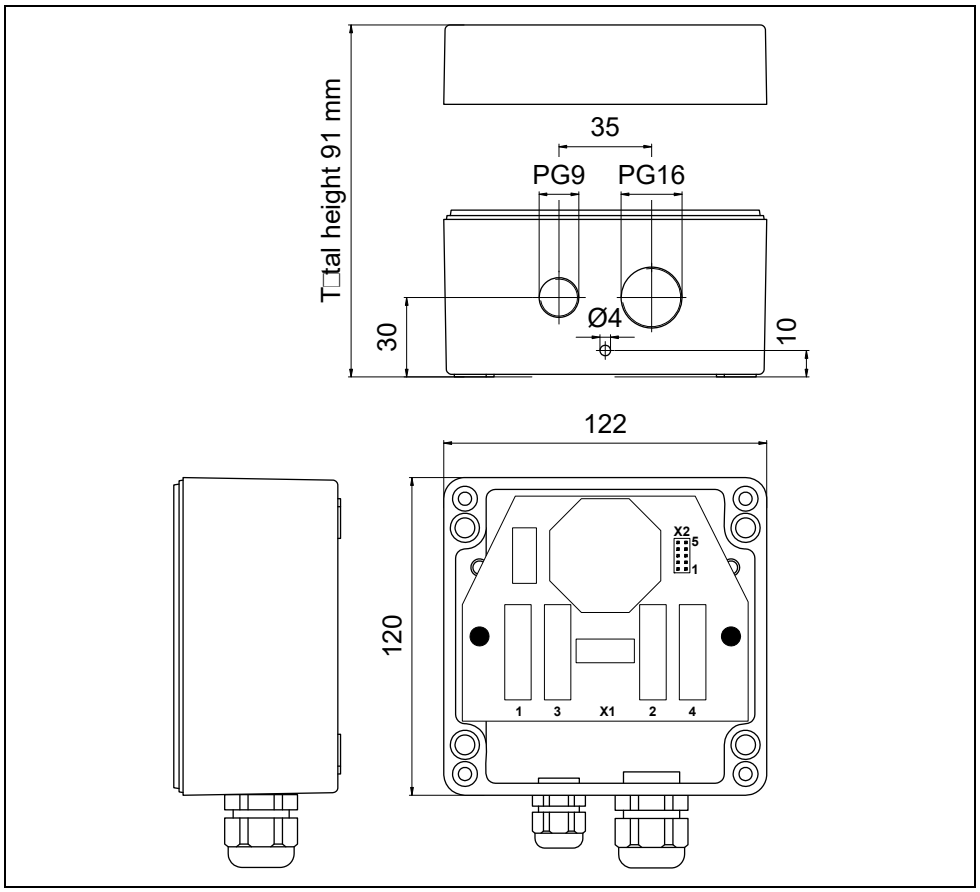
There are however restrictions to the permissible length of the guide wire and their surroundings, which will be described in more detail later.

2.2 The Installation Components

2.2.1 Loop Adaptor HG 94210

The loop adaptor is contained within an aluminium casing, size 120 x 122 x 91 mm. It is fitted with two PG plugs, one for the RG 213 coax cable from the generator and the other for both ends of the loop conductor 2,5 mm². The casing should be earthed as the voltage over-load is connected to it.

The Coax Cable RG 213 should not be longer than 30 m and the loop conductor to the guide wire should not be longer than 10 m in length.



Connection	Function
1	Loop
2	Coax RG213 core (from Generator)
3	Coax RG213 shield (from Generator)
4	Loop
Casing	Ground

Table 1 Connection Plan for the Loop Adaptor

2.2.2 Track Guidance Generator HG 57400

2.2.2.1 Frequency Setting

Position of the HEX switch	Frequency/Hz	Position of the HEX switch	Frequency/Hz
0	5050	8	7000
1	5100	9	7500
2	5150	A	7800
3	5200	B	8000
4	5700	C	8500
5	6000	D	9000
6	6300	E	9500
7	6500	F	10000

Table 2 Frequency Setting

2.2.2.2 Loop Current and Impedance

Long loop: Impedance 0 to 75 Ω
Short loop: Impedance 0 to 15 Ω

For short loops the loop current can be up to 600 mA_{eff}. By long loops the maximum currant is 300 mA_{eff}. In this case the definition long or short loop is not based on the actual length of the loop but on the chosen connections.

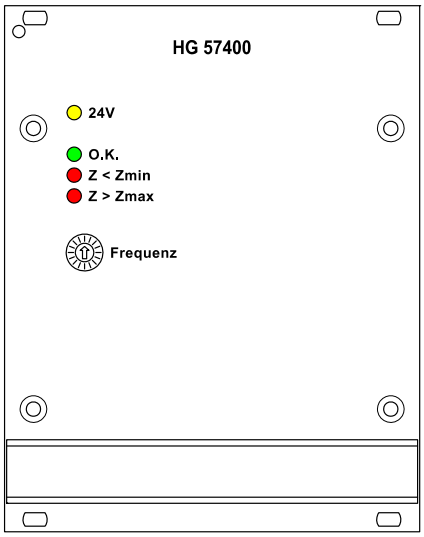
In general when a loop is connected to the outputs loop end long and loop start, with a loop current of 300 $mA_{eff,}$ the actual loop can be as long as is wished up to a maximum impedance of 75 Ω.

By higher currents more than 300 mA_{eff} the outputs „loop short“ and „loop start“ have to be used. The maximum impedance here is 15 Ω for a 600 mA_{eff} loop current.

A load impedance greater than 75 Ω can be compensated by connecting a condensator to the circuit board. In order to do so the loop has to be connected to the output „loop end long compensated“. The capacity of the condensator has to be worked out individually from case to case.

2.2.2.3 Front Plate Elements

Figure 1 Front plate HG 57400



24V	shows that power supply is on
O.K.	correct load impedance
Z<Zmin	short- circuit or load impedance too low
Z>Zmax	cable break or load impedance too high
Frequenz	Frequency setting (see Table 2 on page 7)

2.2.2.4 Short-circuit or Cable Break

A low load impedance is indicated by the red LED „Z<Zmin“. Transitional resistances amongst other things add to the load impedance of a system; therefore it is not guaranteed that a short-circuit would be indicated. High load impedances are detected as an interruption within the loop and are indicated by the red LED „Z>Z max“. In the normal load range the green LED „O.K“. is lit. The detection range is dependant upon the chosen outputs and current rate.

Load impedance range when connected to loop end:

LED	Short (I = 600 mA)	Long (I = 300 mA)
LED Z<Zmin	—	0 to 3 Ω
LED O.K.	1 to 15 Ω	3 to 75 Ω
LED Z>Zmax	> 15 Ω	> 75 Ω

Table 3 Load Impedance Ranges of the Generator

For the correct detection of cable break or short-circuit the actual required current and size of impedance should be known, so that the generator can be set to these requirements.

2.2.2.5 Connection Plan for the Generator

Connection Plan (according to DIN 41612, Form C, 64 pins, ac-equipped)			
1ac	+24 V	25ac	Loop Start
2ac		26ac	
15ac	Loop End Long	31ac	Ground
16ac		32ac	
20ac	Loop End Short		
21ac			

Table 4 Connection plan generator

2.3 Components on the Vehicle (Antenna HG 19534)

The antenna and the electronics are built into a casing, size 120 x 122 x 91 mm. The reading side is the case's top (lid). The 12+1 pin M3 plug connector points in direction of travel.

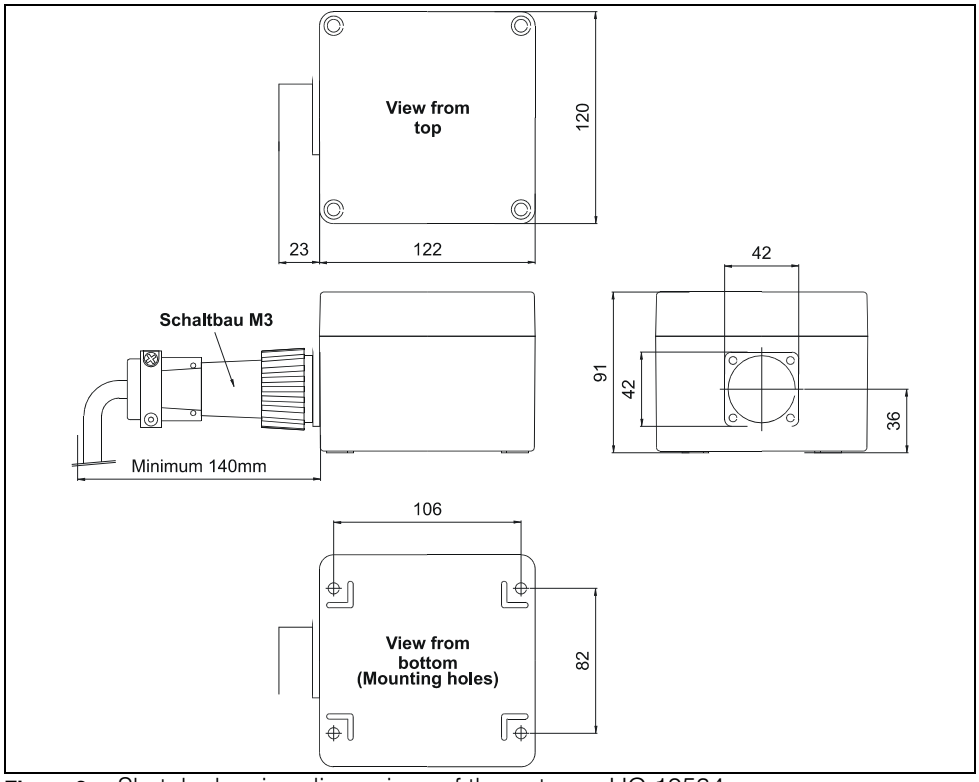


Figure 2 Sketch showing dimensions of the antenna HG 19534

2.3.1 Connection Plan of the 12+1 Pin Socket

The connection plan for the system used is:

Pin #	Function	Pin #	Function
1	+24 V	8	Do not connect.
2	GND	9	„Guide wire detected“
3	$F_{sel}1$ *)	10	$F_{sel}3$ *)
4	$F_{sel}2$ *)	11	U_{sum}
5	Do not connect.	12	U_{dif}
6	Do not connect.	PE	Shield
7	Do not connect.		
*) = as it is of advantage for large loops to use as low a frequency as possible, Fsel 1-3 should be left unconnected. They are internally connected over a 10 KOhm resistor to GND.			

Table 5 Connection Plan of the 1+1 Pin Socket

The current consumption is approx. 100 mA. The input F_{sel} 1 to 3 for selection of a loop frequency have to be connected according to the following table:

	5100 Hz	5700 Hz	6300 Hz	7000 Hz	7800 Hz	9000 Hz	10000 Hz	12000 Hz
$F_{sel}1$	O	+	O	+	O	+	O	+
$F_{sel}2$	O	O	+	+	O	O	+	+
$F_{sel}3$	O	O	O	O	+	+	+	+
- O = connect pin with GND or leave open - + = connect pin with +24 V								

Table 6 Frequency selection over the three Fsel inputs

Pin 9 is an electronic switchable contact to +24 V and has a limited current output of 20 mA. It is switched to +24 V when a guide wire with the correct current and frequency settings, is detected. It is possible to set the detection threshold via a potentiometer.

The capacity and offset of the DC voltages U_{sum} and U_{dif} are in the range ±10 V setable over potentiometers.

2.3.2 External signal processing (not included within the systems scope of delivery)

As it can be seen from Figure 6 on page 19 in the annex, the course, the difference voltage takes between its maxima is on the whole linear. The maxima occur in both directions exact at the point designated by the installation height, therefore with an installation height of 200 mm the maximums occur 200 mm left and right of the wire.

From this we see, that the rate of climb of the difference voltage course is dependant upon the installation height of the antenna, the size of the maxima are also proportional to the current rate used.

There are therefore the following unknown variables, ***right angular deviation*** (requires to be calculated), ***height above guide wire*** (varies according to vehicle load) and ***current rate within guide wire*** (can be measured and is, when using a suitable adaptor on the whole constant). For the solution of this there are 2 field equations for the horizontal and vertical components available.

Under consideration of the sum voltage, it is possible to calculate the right angular deviation irrespective of the height (= height compensated) or irrespective of the guide wire current (= current compensated).

However under certain conditions it may not be possible for a PLC to calculate the required equations, the following approximations can be carried out:

NOTE! These approximations only work with a constant current input and a height variation of max. 1.5.

- When the sum voltage drops below 80 % of the maximum level, the difference voltage is multiplied by 1.2.
- When the sum voltage drops below 60 % of the maximum level, the difference voltage is multiplied by 1.6.
- When the sum voltage droops below 40 % of the maximum level, the difference voltage is multiplied by 2

Those levels are examples. They are shown in the annex as three graphs (Figure 7 on page 19 to Figure 9 on page 20). The antenna is calibrated as follows.

- Guide wire current = 300 mA; height above guide wire = 200 mm; switchable output set at approx. 3,3 V sum voltage.

2.3.3 Error Influence

- The described system shows an antenna and is unable to determine a difference between useful and interfering signals on the same frequency.
- Furthermore the influence on the system caused by the return side at the guide wire is to be taken into consideration. This side causes an offset factor within the magnetic field and should have a distance between outwardside and returnside of 100 x the reading height between antenna and guide wire.
- On a long loop (e. g. by 5 kHz > 500 m), which is not fitted with a wave resistance at its end, standing waves are formed. E. g. it appears that in a loop of length λ/4 (1/4 wave) that at the input point no current flows but at the end maximum current flows. A height compensated calculation would in this event not be possible. In order to avoid stand waves a wave resistance (adaptor resistance) is to be fitted to the guide wire at the furthest point from the generator, because the wave impedance is relative to the geometrical layout of the loop; the adaption will only work, if this layout is symmetrically built. This means that the return leg of the loop should always be laid with a constant spacing from the outward leg.

- More often in large installations there are also neighbouring loops in operation. As the generators are not phase rigidity interconnected, they make themselves noticed as suspensions within the field. To avoid this it is possible to set the frequencies with ±50 Hz steps. On the one side this stepped frequency is hardly restricted by the antenna filter, but on the other side, as the suspensions are formed as 100 Hz, they are suppressed in the filters.

3 Mounting

3.1 Mounting Instructions for Guide Wire

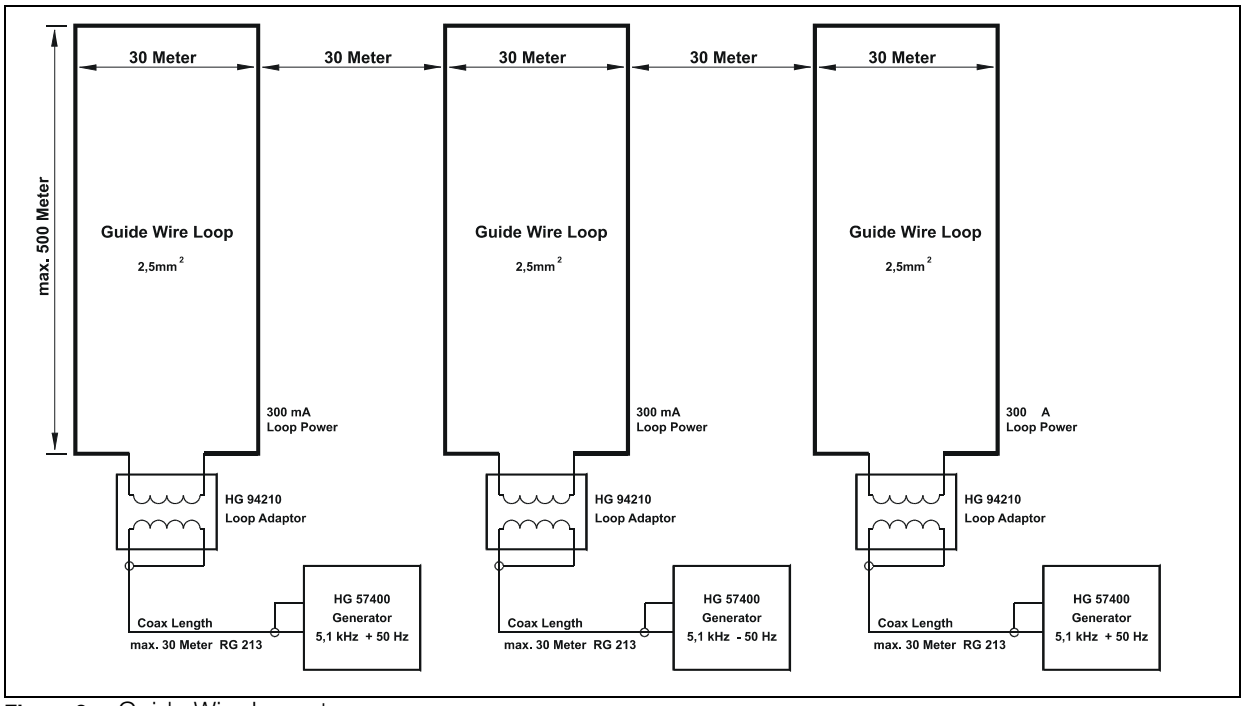


Figure 3 Guide Wire Layout

- By a layout as shown in the diagram no adaptor resister is required.
- The guide wire should be set in the ground at a depth of 30 to 40 mm.
- The iron free area around the guide wire should be

  - left and right of guide wire: approx. 400 mm
  - parallel to tracks or large metal objects and metal reinforcement within the track: ±800 mm
  - below the guide wire: ca. 100 mm

3.2 Mounting the loop adaptor HG 94210

The loop adaptor is fitted into an aluminium casing. The casing should be earthed as the voltage peak cable is earthed to this casing. The casing should be mounted with the PG plugs downward most and fitted to a mast. In order to mount the loop adapter the lid has to be removed. 4 x M 5 positions have been prepared for this.

3.3 Mounting the Track Guidance Generator HG 57400

The track guidance generator is to be fitted into a suitable cabinet, so that the temperature range of 0 to 50 °C can be kept. If the generator is not turned off then a temperature of up to -20 °C is allowable.

The coax cable RG 213 to the loop adaptor is connected to the generator as follows:

- Shielding to loop start
- Core to loop end long (see also Table 4 on page 8).

3.4 Mounting the Track Guidance Antenna HG 19534

So that the system's function is not effected it is imperative that the area left and right of the antenna is of at least the same distance, as its height above the guide wire is kept free of iron obstacles. Within this area there should be no large electrically conductive obstacles.

It is also important to note that the proportions in this area should not change when the vehicle is driven, this means that the antenna should not pass by any large metallic objects when steering. The area in front and behind the antenna is not sensitive to metallic objects. In order to mount the antenna the casing lid has to be removed. 4 positions for M 5 screws have been prepared.

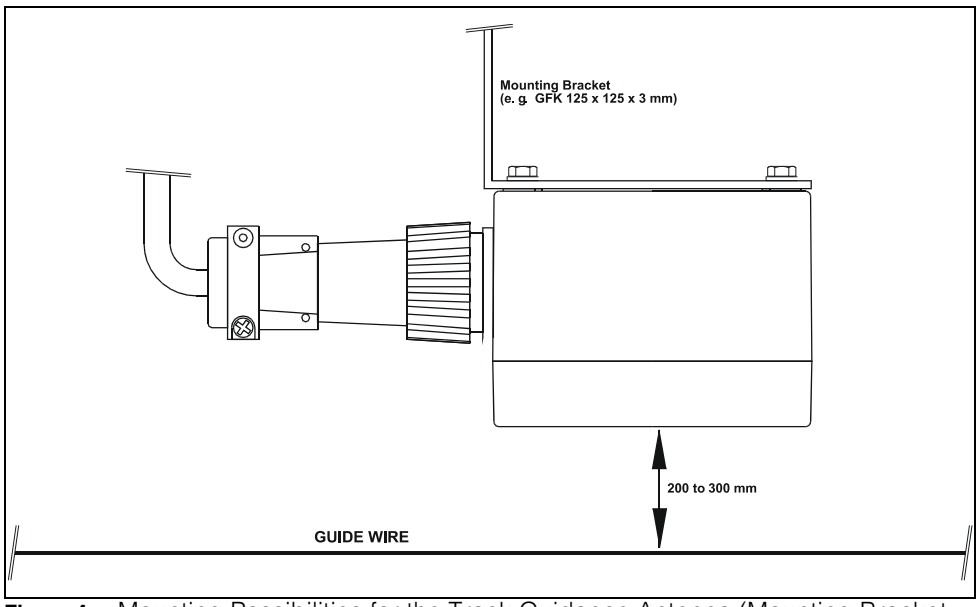


Figure 4 Mounting Possibilities for the Track Guidance Antenna (Mounting Bracket not included in Delivery Package)

4 Set-Up

4.1 Setting the track Guidance Generator

Connect all necessary connections to the generators, check power supply before turning the generators on.

Set required frequency as shown in the plan at Figure 3 on page 13, so that neighbouring loops have a frequency difference of 100 Hz. The generator current is factory set at 300 mA and is maintained at this level as long as the loop length does not go over 300 m.

4.2 Calibrating the Track Guidance Antenna

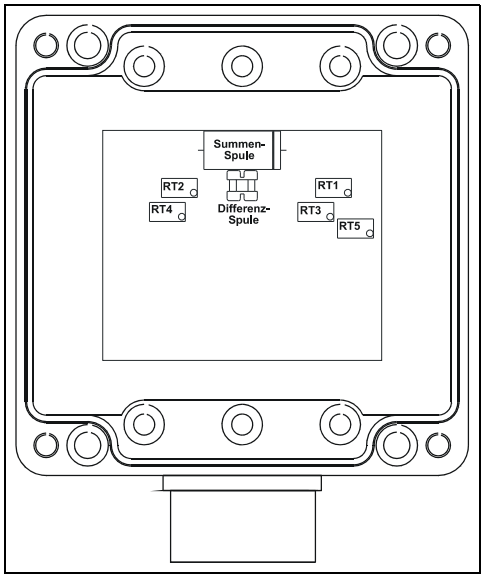


Figure 5 Positions of the Potentiometers

Connect all necessary connections to the antenna and check the power supply before switching the system on. Position a guide wire with the chosen frequency and current level under the antenna. The distance between antenna and guide wire should be set at the smallest distance which will occur when in use (e. g. height above cable = 200 mm). The difference voltage should be 0 V, when the antenna is exactly central over the guide wire and the sum voltage should be at its maximum (G 10 Volts). Adjust the sum voltage via poti RT 2 as necessary.

Position the guide wire then to the side of the antenna, with the distance from the wire symmetrical to the height above the wire (e. g. height = 200 m side setting = 200 mm to left or right of wire). The difference voltage should then be adjusted to the required amount via poti RTI (e. g. sum max = 10 V, diff. Voltage = ±10 V).

Position the guide wire now at the point in which the signal „guide wire readable“ is distinguished. Adjust as required the threshold via poti RT 5. Note that this position is proportioned to the antenna height.

5 Fault Finding

In the following table you will find a list of possible faults. To every fault is a system description and in the third column a description of how to locate and/ or remove the fault.

Should you be unable to remove a fault, use the table to locate the problem as best as possible before contacting us for advice.

Fault	Possible Causes	Diagnosis/Remedy
No system function although guide wire within field of view	1. Power supply voltage to low 2. Guide wire broken 3. Wrong generator frequency	1. check power supply at necessary contacts 2. measure generator current 3. check frequency setting on generator hex switch
Output levels not reproducible Inadequate accuracy level	1. Interference to the frequency range 5 kHz 2. Two neighbouring loops Working on the same frequency	1. choose a new location, away from possible causes of interference for the antenna 2. to avoid interference from other loops set neighbouring loops at 100 Hz difference
Crane drives with an offset	1. Return leg of loop too close (< 30 m) 2. Onesided collection of large metal objects either on or in the ground or near the antenna	1. guide wire layout as shown in Figure 3 on page 13 2. by an even offset eventually adjust the difference voltage via poti RT 3

Table 7 Fault Finding

6 Technical Data

6.1 Loop adaptor HG G-94210

Loop Adaptor	
Casing	ROSE 01.12 12 09 Alu
Temp. range	-20 to +50 °C, max. 95 % moderate humidity
Mech. stress load	5 g 11 ms / 2 g 10 to 55 Hz
International protection code	IP55
Connections	4 connector blocks (see Table 1 on page 6)

Table 8 Technical Data Loop Adaptor

6.2 Generator HG G-57400

Track Guidance Generator	
Dimensions	Euro cassette 20TE, 3HE
Plug	DIN41612, Type C, 64 pin, ac-equipped (see also Table 4 on page 8)
Power supply	24 V ±5 %
Power consumption	less than 0,7 A
Load impedence	0 to 75 Ω by 300 mA loop long, 0 to 15 Ω by 600 mA loop short
Power output	max. 300 mA loop long, max. 600 mA loop short
Surrounding temp.	0 to 50 °C
Output frequency	As selected on the HEX switch on the front plate (see also Table 2 on page 7). Upon request as required in the range 4 kHz to 12 kHz, with1 Hz seperation
Frequency accuracy	better than 0,02 % quarz stability

Table 9 Technical Data Track Guidance Generator

6.3 Antenna HG G-19534

Track Guidance Antenna	
Casing	ROSE 02.121209 Polyester + GFK
Power supply	24 V ±10 %, approx. 100 mA
Temp. range	-20 to +50 °C, max. 95 % moderate humidity
Mech. stress load	5 g 11 ms / 2 g 10 to 55 Hz
International protection class	IP65
Connection	13 pin Schaltbau M3 screw socket with gold plated contacts
Nominal reading height	300 mm (distance guide wire –> underside reading antenna)
Data inputs Fsel	24 V, R_i = 10 KΩ
Detect output	24 V, 20 mA power restricted
Analog outputs Usum and Udiff	-10 to +10 V / Ia < 1 mA

Table 10 Technical Data Track Guidance Antenna

7 Appendix

A Course taken by Sum and Difference Voltage of a crossed coil

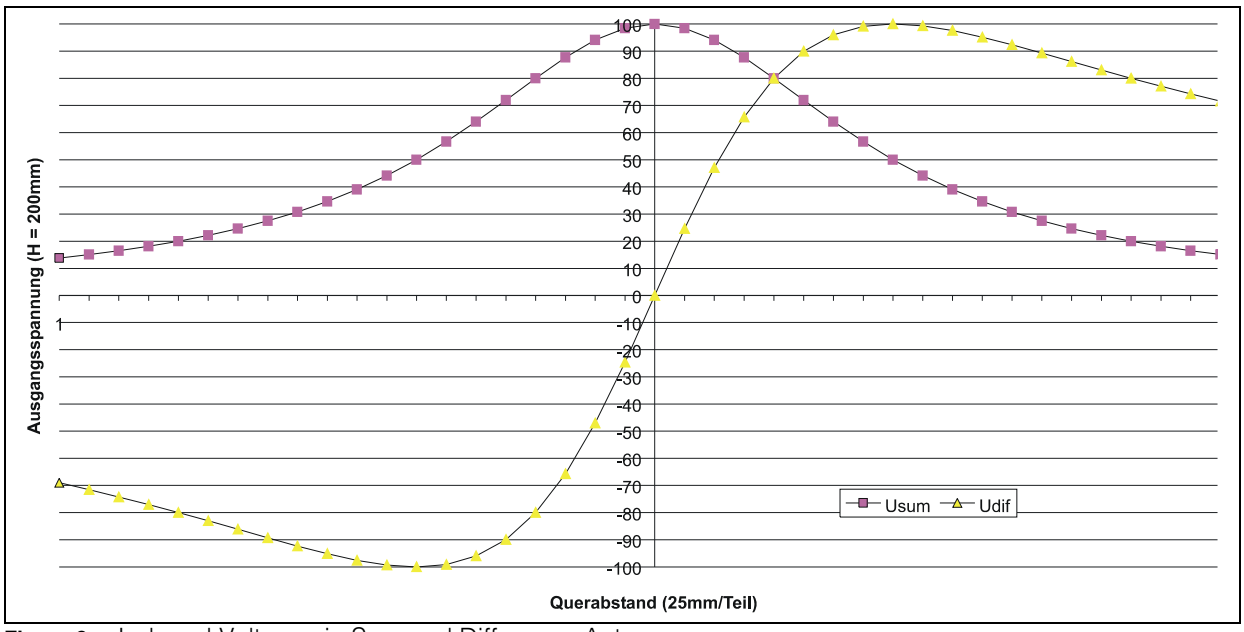


Figure 6 Induced Voltages in Sum and Difference Antenna

B Course taken by Sum and Difference Voltage of a Compensated Crossed Coil

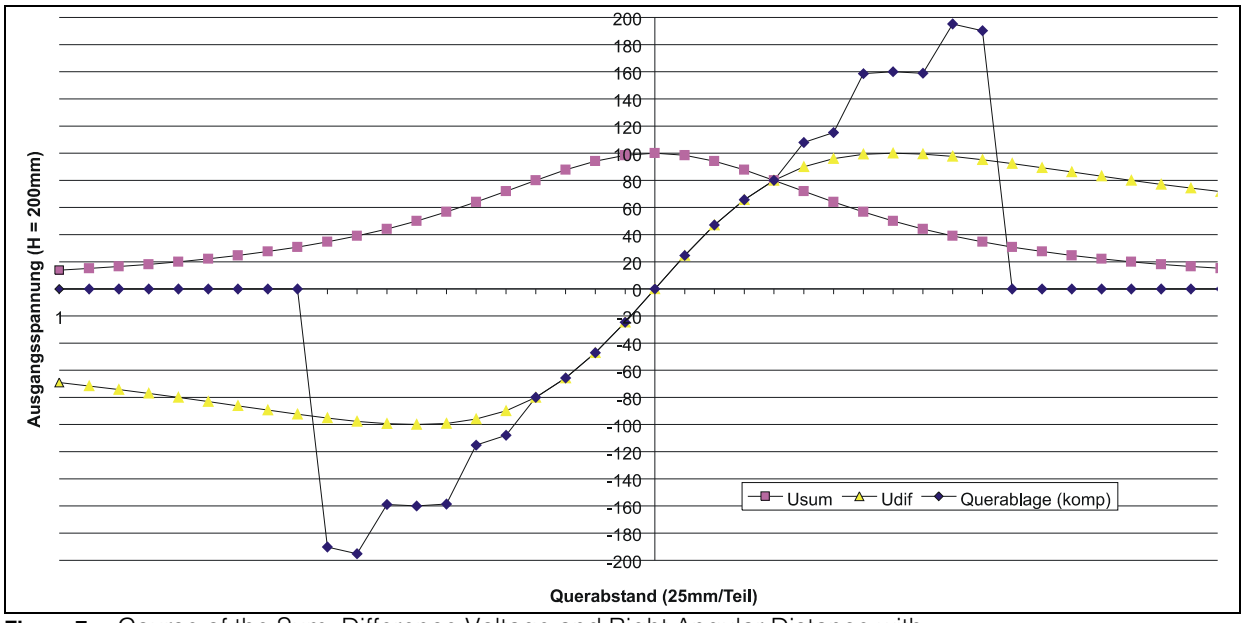


Figure 7 Course of the Sum, Difference Voltage and Right Angular Distance with Height Compensation (H = 200 mm)

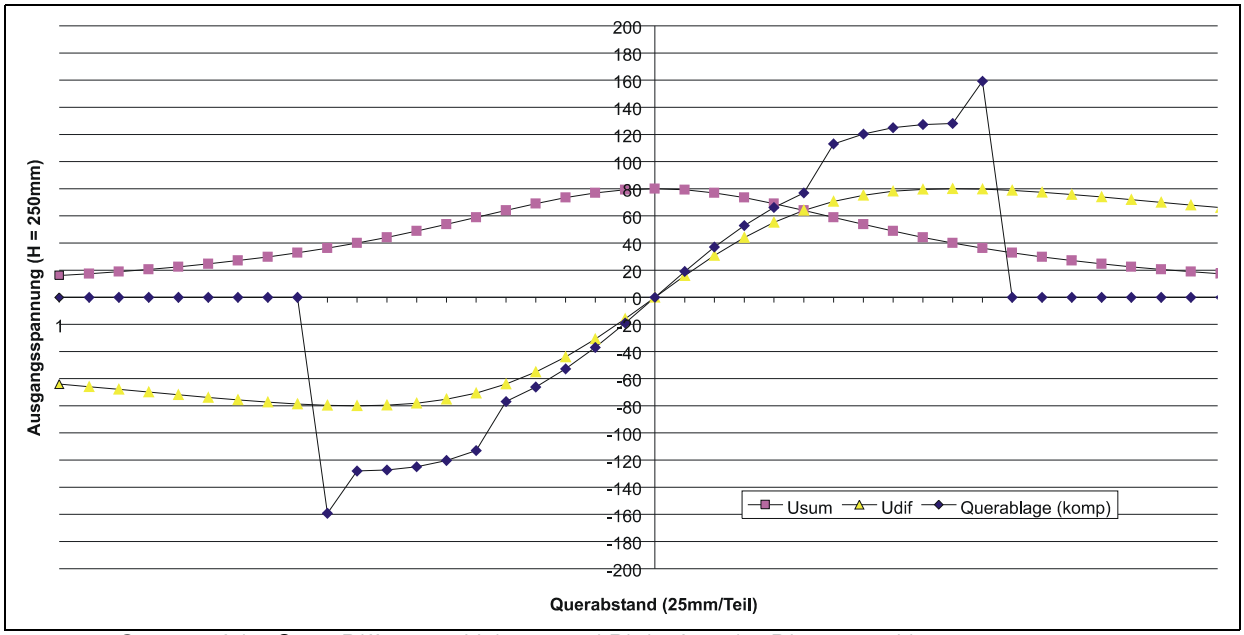


Figure 8 Course of the Sum, Difference Voltage and Right Angular Distance with Height Compensation (H = 250 mm)

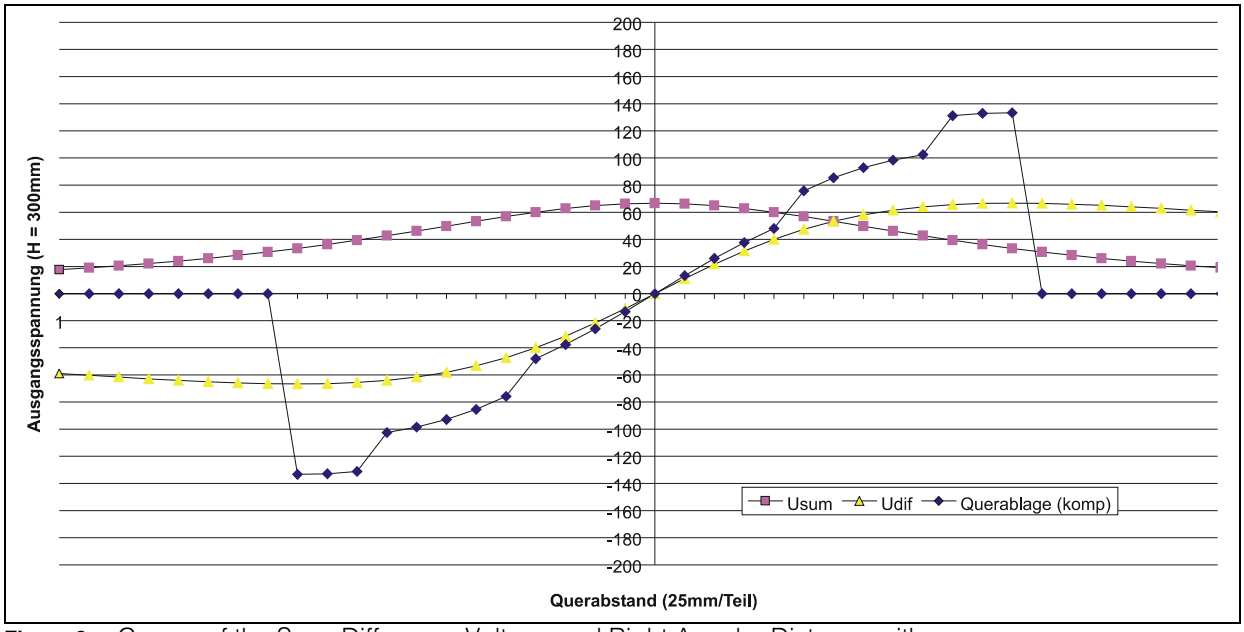


Figure 9 Course of the Sum, Difference Voltage and Right Angular Distance with Height Compensation (H = 300 mm)

8 Handbook Conventions

At the time this manual was printed, the following symbols and marks were used in all Götting KG documentations:

- For security advices, the following symbols stand for different degrees of danger and importance:

NOTE!

ATTENTION!

WARNING!

- Further information or advices are indicated as follows:

TIP!

- Program texts and variables are indicated through the use of the `Script Courier`.
- Whenever the pressing of letter keys is required for program entries, the required Letter Keys are indicated as such (for any programs of Götting KG small and capital letters are equally valid).
- Sections, drawings and tables are subsequential numbers throughout the complete document. In addition, each documents includes a list of contents showing the page numbers following the front. If a document exceeds 10 pages, it also has a drawings list and a list of tables on the last few pages. If required, in case a document is correspondingly long and complex, a index is added in the back.
- Each document shows a small table including meta information, such as deveopler, author, revision and date of issue, on the front page. The information regarding revision and date of issue are also included in the bottom line on each page of the document. This way it is possible to clear identify the source document for each bit of information.
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This instruction manual has been drawn up to the best of our knowledge. Installation, setup and operation of the device will be on the customer's own risk. Liability for consequential defects is excluded. We reserve the right for changes encouraging technical improvements. We also reserve the right to change the contents of this manual without having to give notice to any third party.

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10 List of Pictures

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