

## **User Manual**

# **VHF Direction Finder System RHOTHETA RT-1000 A**

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## **NOTE**

The manufacturer reserve the right to make modifications at any time and without previous information of the here described product.

Section 1

## **General Information**

General Description, Characteristics, Flexible System Configuration,  
Bearing Display and Bearing Quality Analysis, Antenna System,  
Antenna Mast, Technical Data

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Section 2

## **Controller RTC 1100.B**

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Section 3

## **Not Applicable**

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Section 4

## **Direction Finder Antenna RTA 1300.A**

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Section 5

## **Appendix**

Approval of the Direction Finder System and Manufacturer Declarations  
Inter-wiring of the Direction Finder  
Test Record

# **1 GENERAL INFORMATION**

## **List of Contents:**

<b>1 GENERAL INFORMATION .....</b>	<b>1.1</b>
<b>1.1 General Description .....</b>	<b>1.2</b>
1.1.1 Options .....	1.2
1.1.2 System Configuration .....	1.3
1.1.3 Subsystems .....	1.3
1.1.4 Block Diagram .....	1.4
<b>1.2 Technical Data .....</b>	<b>1.5</b>
1.2.1 Basic Data .....	1.5
1.2.2 Electrical Characteristic.....	1.6
1.2.2.1 System Characteristic.....	1.6
1.2.2.2 Power Supply.....	1.7
1.2.2.3 Interface .....	1.7
1.2.3 Mechanical characteristics.....	1.8
1.2.3.1 Antenna RTA 1300.A .....	1.8
1.2.3.2 Controller RTC 1100.B .....	1.9
1.2.4 Environmental Conditions.....	1.10
1.2.4.1 Antenna RTA 1300.A .....	1.10
1.2.4.2 Controller RTC 1000.B .....	1.10
<b>1.3 Safety.....</b>	<b>1.11</b>
1.3.1 Symbols.....	1.11
1.3.2 Basic Safety Note .....	1.12
<b>1.4 Disposal within the European Union .....</b>	<b>1.12</b>
<b>1.5 Disposal outside the European Union.....</b>	<b>1.12</b>

## 1.1 General Description

The direction finder system RT-1000 A is designed for ATC (air traffic control) and VTS (vessel traffic service) application. The system can be used in stationary and mobile applications.

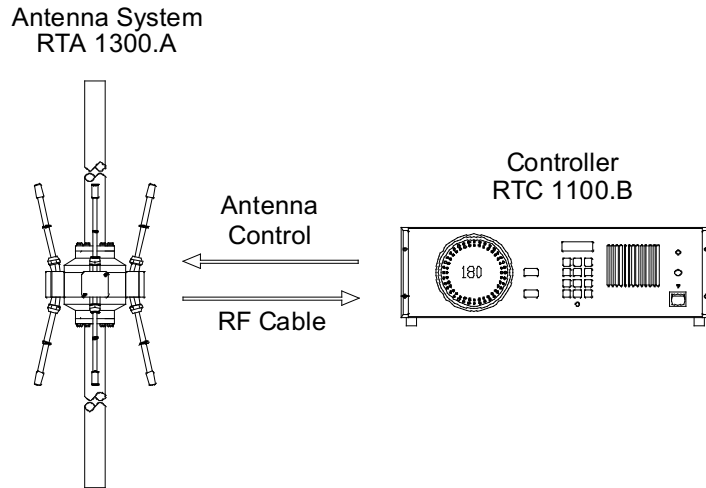
### 1.1.1 Options

Options		
Option Designation	Information	Part No.
Antenna Model RTM-1501	Accessories: System Test and Maintenance	RTM-1501 A
Service-Kit RT-1000	Accessories: System Test and Maintenance	RTM-1500 A
Antenna Mast RTA 1306.C	Accessories: Antenna mounting	RTA-1306 C
Obstacle Light	Accessories: Antenna mounting	RTA-1306.740 A RTA-1306.740 A-001
Line Protection	Accessories: Antenna mounting	RT-8731
Improved Bearing Accuracy 1° RMS <sup>1)</sup>	Antenna Calibration	RT-9021
VHF maritime band with VHF air band <sup>2)</sup>	Unlock: 156,000-174,000 MHz	-
VHF maritime band with Emergency Frequency 121,5 MHz <sup>3)</sup>	Unlock: 156,000-174,000 MHz + 121, 500MHz	-
Red Display	Modification: Indication of frequency and bearing in red colour.	RTU-1000 A RTU-1000 C
8,33 kHz Channel Spacing for air band	Unlock: Support of the 8,33 kHz Channel Spacing	-
AIS Suppression Notch	Accessories: VTS	RT-8730
RS232 to LAN Converter	Accessories: Network Connectivity	RT-8757

- 1) The "Improved Bearing Accuracy" option is achieved by calibration of the antennas.
- 2) Frequency Range Extension to maritime band 156,000 – 174,000 MHz
- 3) VHF maritime band 156,000 – 174,000 MHz incl. Emergency Frequency 121,500 MHz instead of VHF air band 118,000 – 174,000 MHz

### 1.1.2 System Configuration

#### System Configuration RT-1000 A



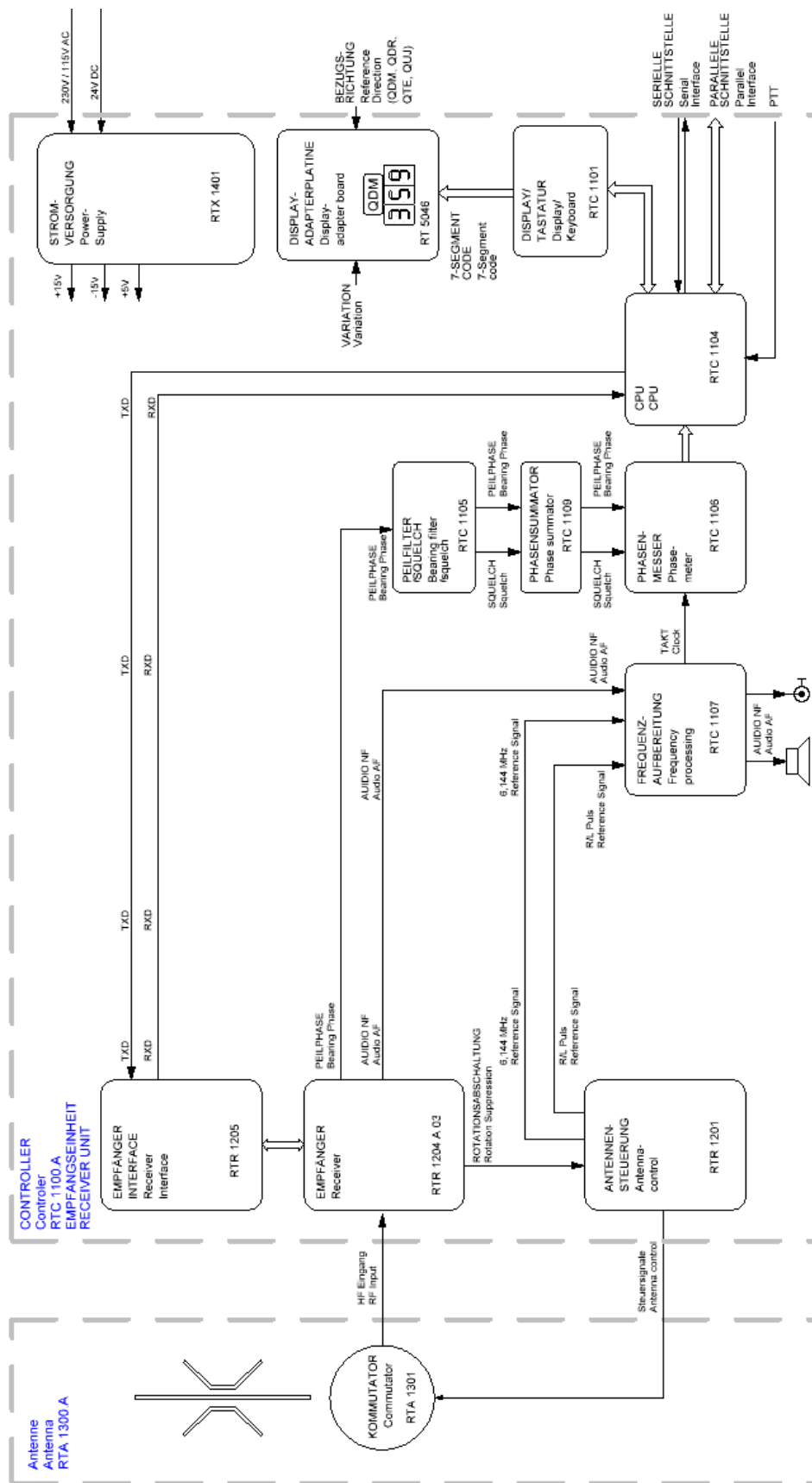
**Configuration:**

The system operates in „non remote mode“. Receiver, demodulator and antenna control module are integrated in the controller unit located at the antenna position. They are connected by means of a 6-wire control line and a coaxial RF wire.

### 1.1.3 Subsystems

Subsystems			
No	Designation	File Reference	Part No.
1	RT-1000 A Controller RTC 1100.B	12-9-2-0020-2-1	RTC-1100 B
2	RT-1000 Antenna RTA 1300.A	12-9-2-0019-2-1	RTA-1300 A

### 1.1.4 Block Diagram



## 1.2 Technical Data

### 1.2.1 Basic Data

Basic Data		
Parameter	Condition	Data
DF method	-	Doppler (3 kHz rotation frequency)
Response time <sup>1)</sup>	With sufficient signal strength	≤ 500 ms / typ. ≤ 250 ms
Minimum signal duration <sup>2)</sup>	-	typ. ≤ 300 ms
Internal system resolution	-	0,5°
Frequency range <sup>3)</sup>	Air band VHF	118,000 – 136,975 MHz
	Maritime band	156,000 – 174,000 MHz
Operating Channels	Air band VHF	760 (25 kHz) 2278 (8,33 kHz)
	Maritime band	Channel 01 - 88 (incl. duplex channels)
Channel Spacing	Air band VHF	25 kHz 8,33 kHz (Option)
	Maritime band	25 kHz
Bearable modulation types	-	A3E, F3E, A3X (ELT-modulation)
Number of bearing Channels	simultaneous bearing Channels	1
Polarization	-	vertical
Polarization Error	With field vector rotation up to 45°	±1°
Cone of confusion	Bearing Fluctuation ±5°	≤ 45° / typ. 35°
Height of installation site		Max. 3000 m a.s.l.
MTBF	Complete System	≥ 168.000 h

1) Time required determining and displaying a bearing value

2) Minimum required signal duration to determine a bearing value

3) Frequency range depend on the software configuration (Unlock Options)



## 1.2.2 Electrical Characteristic

### 1.2.2.1 System Characteristic

System Properties			
Parameter	Condition	Limit	Typical
Bearing sensitivity	118,000 – 136,975 MHz, ±2° bearing fluctuation	≤ 5 μV/m	≤ 2,5 μV/m
	156,000 – 174,000 MHz, ±2° bearing fluctuation	≤ 5 μV/m	≤ 2,5 μV/m
Bearing accuracy <sup>1)</sup>	118,000 – 136,975 MHz	2° RMS 1° RMS (Opt.) <sup>2)</sup>	2° RMS 1° RMS (Opt.) <sup>2)</sup>
	156,000 – 174,000 MHz	2° RMS 1° RMS (Opt.) <sup>2)</sup>	2° RMS 1° RMS (Opt.) <sup>2)</sup>

1) Measured in undisturbed wave field, with unmodulated signal, with sufficient signal strength

2) Option with improved Bearing Accuracy 1° RMS

**1.2.2.2 Power Supply**

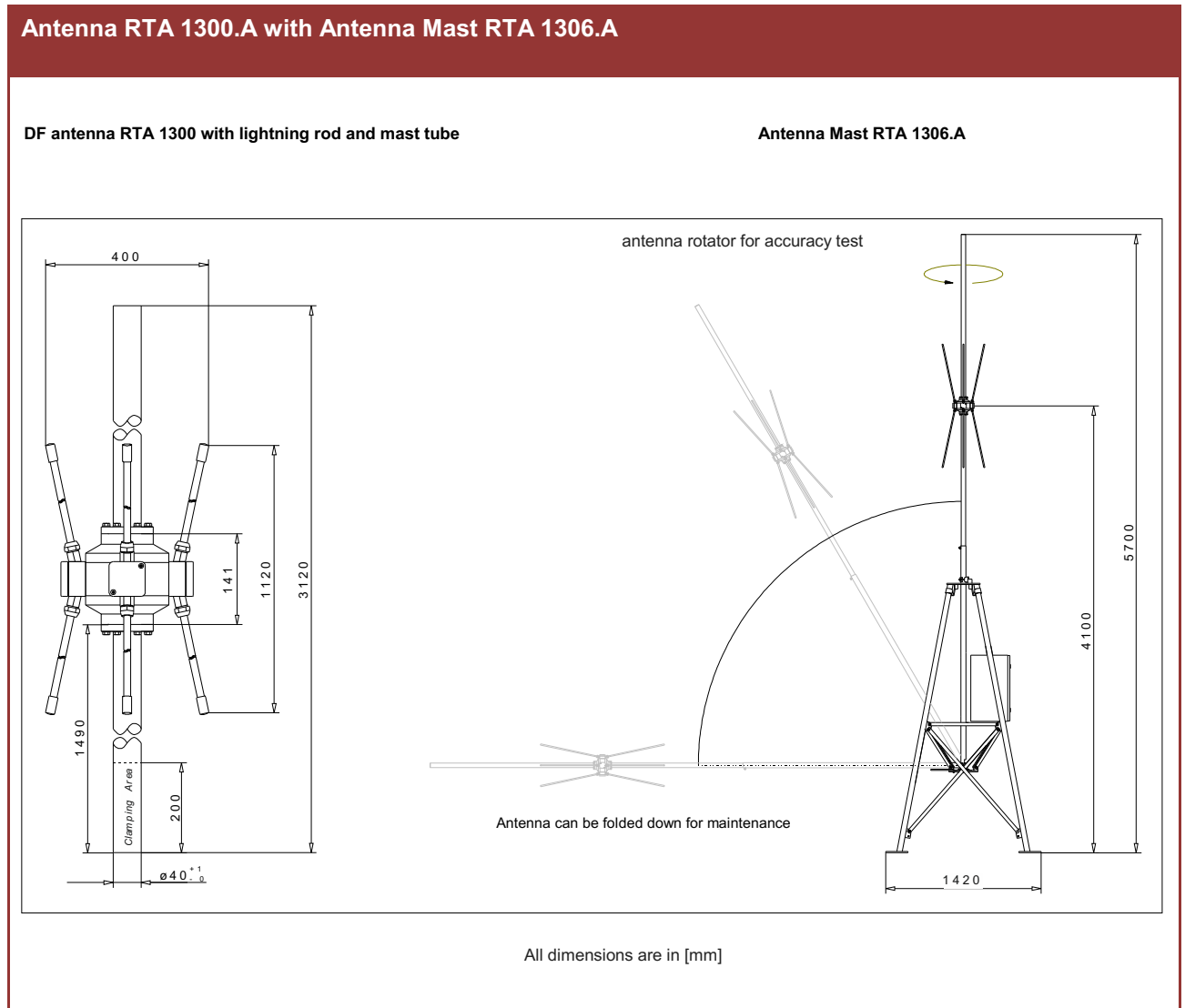
<b>Technical Data</b>		
<b>Parameter</b>	<b>Condition</b>	<b>Data</b>
Power supply	AC	115 / 230 V $\pm$ 15 %; 47...63 Hz
	DC	24 V -10 % / +20 %
Power consumption	Controller	20 VA

**1.2.2.3 Interface**

<b>Interfaces and Protocols</b>				
<b>Designation</b>	<b>Connector</b>	<b>Transmission Type</b>	<b>Protocol</b>	<b>Max. Data Rate</b>
Serial Interface	1x D-Sub 9-pol Female	RS-232	ASCII-8-bit	1200 baud

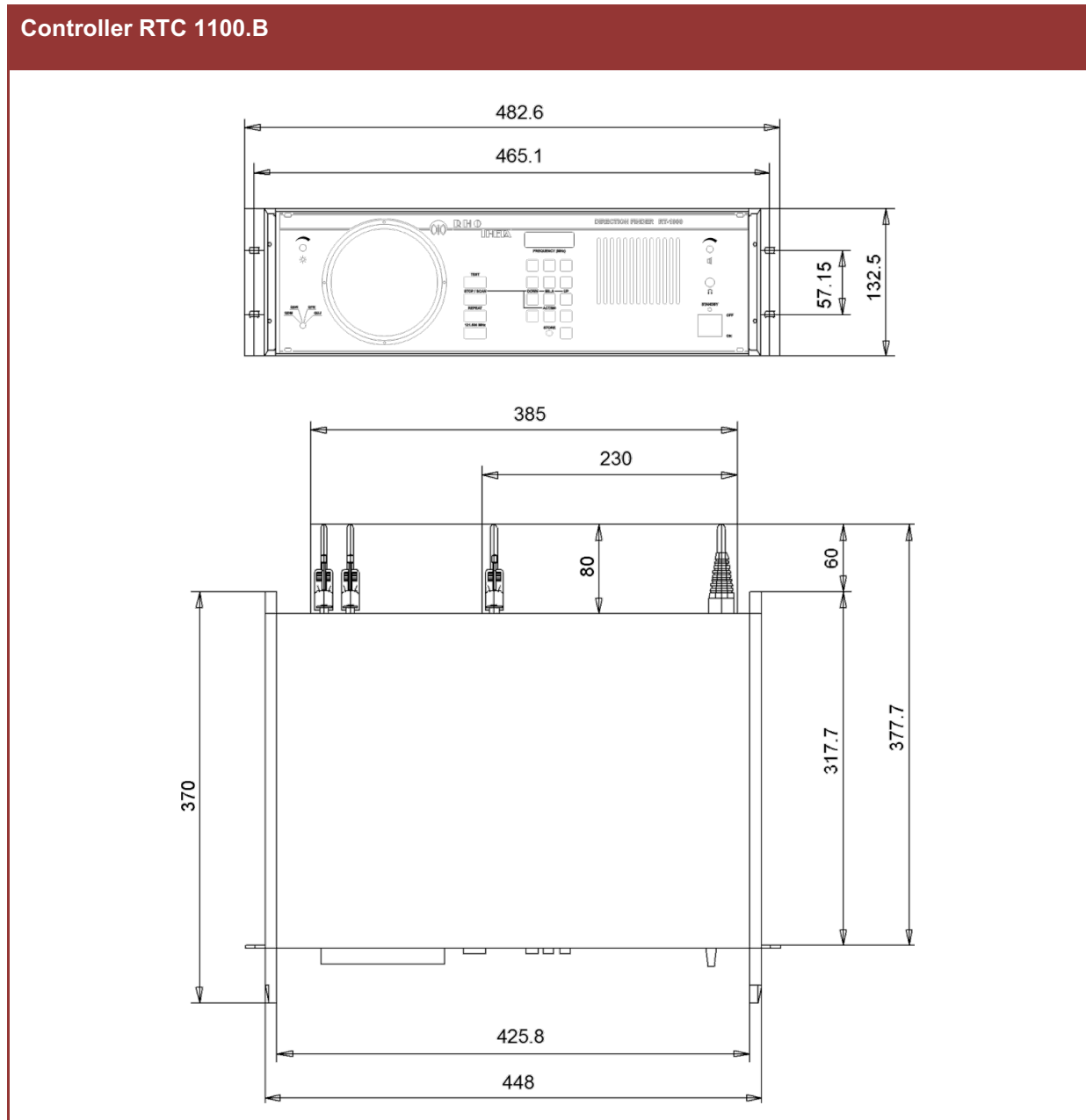
### 1.2.3 Mechanical characteristics

#### 1.2.3.1 Antenna RTA 1300.A



Mechanical Characteristis			
Subsystem	Width	Height	Weight
RT-1000 Antenna RTA 1300.A	400 mm	3120 mm	10,2 kg
RT-1000 Antenna RTA 1300.A + Antenna Mast RTA 1306.C	1420 mm	5700 mm	120 kg

1.2.3.2 Controller RTC 1100.B



Mechanical Characteristic				
Subsystem	Length	Width	Height	Weight
RT-1000 Controller RTC 1100.B	482,6 mm	377,7 mm	132,5 mm	9,3 kg <sup>1</sup>

<sup>1</sup> The weight is valid for the Controller without remote operation mode

## 1.2.4 Environmental Conditions

### 1.2.4.1 Antenna RTA 1300.A

Environmental Conditions	
Parameter	Data
Wind load <i>(with constant wind speed)</i>	150 km/h / 135 N 180 km/h / 195 N
allowed wind speed	≤ 240 km/h
Operating temperature range	-40°C...+80°C
Storage temperature range	-40°C...+80°C
Ingress protection	IP 65

### 1.2.4.2 Controller RTC 1000.B

Environmental Conditions	
Parameter	Data
Operating temperature range	-20°C...+55°C
Storage temperature range	-40°C...+60°C
Humidity	95% at 35°C 60% at > 35°C

## 1.3 Safety

RHOTHETA Elektronik GmbH is constantly striving to keep the safety standard of its products up to date. We try to offer our customers the highest possible degree of safety.

RHOTHETA products are designed and tested in accordance with the current applicable safety regulations. The compliance with these standards is continuously monitored by our quality assurance system. This product is built in according to the EU certificate of conformity, and has left the factory in perfect technical condition.

To maintain this safety condition and to ensure safe operation, the user must observe all instructions and warnings which are provided. For all questions regarding these safety instructions RHOTHETA Elektronik GmbH will be at your disposal at any time.

Observing the safety instructions will help to prevent personal injury or damage from hazards of all kinds. This requires that the following safety instructions have to be read and understood before using the product and they have to be observed while using the product. All further safety instructions, such as personal safety instructions, which appear in the relevant parts of the product documentation, must also be strictly observed.

Moreover, it is in the responsibility of the user to use the product in a proper way. It is not allowed to use the DF system RT-1000 A in a way, which can cause damage to a person or a thing.

The use of this product in an other than its designated purpose or in disregard of the manufacturer's instructions is the responsibility of the user. The manufacturer assumes no responsibility for the misuse of the product.

**The manufacturer is not liable beyond the scope of legal rules!**

This manual is part of the product RT-1000 A and is to keep during the lifetime and pass on to the product.

### 1.3.1 Symbols

#### NOTE

With "Note", tips or supplementary notes are marked which must be observed and make work easier.

#### **ATTENTION**

**means that failure to observe the instructions can result in property damage or loss of data.**

#### **WARNING**

**means that failure to observe the instructions may be a danger to health or life.**

### 1.3.2 Basic Safety Note

#### **ATTENTION**

**Read and observe the following instructions, warnings and safety instructions of the manufacturer!**

- At all activities, local or national safety and accident prevention regulations must be observed.
- Only use manufacturer prescribed components and / or use only material recommended by the manufacturer and do not modify them.
- Only connect approved accessories or ancillary equipment.
- The product may only be opened by authorized service personnel.
- The product voids its type approval on operating with unauthorized modifications on the device or unintended use.

## 1.4 Disposal within the European Union

### Product Recycling



■ Product labelling in accordance with EN 50419

At the end of product life, this product may not be disposed together with normal household waste. Even disposal via the municipal waste disposal collection for electrical and electronic equipment is not permitted.

The correct disposal of this product helps to protect the environment and prevent any potential damage to the environment and human health, which can occur due to improper handling of the product.

- Therefore, supply the device to an electronics recycling after the final taken out of service.

Otherwise

- RHOTHETA Elektronik GmbH takes back all products that are subject to the requirements of the WEEE Directive (2012/19/EU) of the European Union to supply these products to professional disposal.

## 1.5 Disposal outside the European Union

For proper disposal of used electronic equipment in accordance with the respective national regulations in countries outside the European Union please check it with your dealer or the local authorities.

## 2 CONTROLLER RTC 1100.B

### List of Contents:

<b>2</b>	<b>CONTROLLER RTC 1100.B .....</b>	<b>2.1</b>
<b>2.1</b>	<b>Key to Front and Rear Views .....</b>	<b>2.5</b>
<b>2.2</b>	<b>Preparation for Use .....</b>	<b>2.9</b>
2.2.1	Grounding .....	2.9
2.2.2	Mains Voltage .....	2.9
2.2.3	Mains Fuse .....	2.10
2.2.4	DC Voltage Connection.....	2.10
2.2.5	Power Supply.....	2.11
2.2.6	Connection of the Antenna Unit.....	2.11
2.2.7	Rack Mounting.....	2.12
2.2.8	Switching on / Reaction from Unit.....	2.12
2.2.9	Phase Adjustment .....	2.12
2.2.9.1	Adjustment Using RTM 1501 Dummy Antenna (Option) .....	2.13
2.2.9.2	Adjustment Using a Transmitter.....	2.13
2.2.10	North Adjustment .....	2.14
2.2.11	Adjustment of the Squelch threshold.....	2.14
2.2.12	Variation Adjustment .....	2.15
2.2.13	Disable Selection of Reference Direction .....	2.16
2.2.14	Ground Transmitter Suppression.....	2.17
<b>2.3</b>	<b>Display and Operating Functions.....</b>	<b>2.18</b>
2.3.1	Bearing Display and Bearing Quality Analysis.....	2.18
2.3.2	Test Function .....	2.18
2.3.3	“REPEAT” Repetition of Bearing Indication.....	2.19
2.3.4	Frequency Selection .....	2.20
2.3.4.1	Direct Frequency Selection in the 25 kHz channel spacing.....	2.20
2.3.4.2	Direct Frequency Selection in the 8.33 / 25 kHz channel spacing.....	2.21
2.3.4.3	Recalling a Frequency Memory .....	2.24
2.3.4.4	Programming the Frequency Memory .....	2.24
2.3.5	Direct Selection of Channel Number in Maritime Radio Communication.....	2.25
2.3.6	Scanning .....	2.26
2.3.6.1	Selection of Scan Mode.....	2.26



2.3.6.2	Stopping Scanning.....	2.27
2.3.7	Direct Recall of the Distress Frequency 121.500 MHz .....	2.27
2.3.8	North Adjustment .....	2.27
2.3.9	Selection of the reference directions QDM, QDR, QUJ und QTE .....	2.28
2.3.10	Checking the Variation adjustment .....	2.30
2.3.11	Frequency Deviation .....	2.30
2.3.12	Error Indication.....	2.30
2.3.13	Dimmer (1) "DIM".....	2.31
2.3.14	Volume Control (9) .....	2.31
2.3.15	Headphones Connection (10).....	2.31
2.3.16	"STANDBY" Indicator (11) .....	2.31
2.3.17	ON / OFF Switch (12).....	2.31
2.3.18	"Line" Mains Switch (19) .....	2.32
2.3.19	Power Supply "OK" Indicator (21) .....	2.32
2.3.20	"Data-Port" Data Interface (22).....	2.32
2.3.21	"Sync" Synchronisation Indicators (23, 24).....	2.34
2.3.22	"DF Signal 2" Test Plug (26).....	2.34
2.3.23	"R/L" Test Connector (25) .....	2.34
2.3.24	"Serial Port" Serial Interface (30) .....	2.35
2.3.24.1	Data Output.....	2.36
2.3.24.2	Data Input.....	2.38
2.3.24.3	Technical Data .....	2.41
2.3.24.4	"Ser. Port" Plug Wiring (30).....	2.41
2.3.24.5	Connection to a Data Terminal or Data Transmission Device.....	2.42
2.3.24.6	Compatibility mode .....	2.43
2.3.25	"Parallel Port" Parallel Interface (31) .....	2.43
2.3.25.1	Time Sequence .....	2.44
2.3.26	R/L Off Button (42) .....	2.44
2.3.27	"IF" Intermediate Frequency Jack (43).....	2.44
2.3.28	Receiver Status Indication (44, 45, 46, 47, 48) .....	2.44
2.3.29	Manual Squelch Adjustment Potentiometer (49).....	2.45
2.3.30	Antenna Control Jack (50) .....	2.45
2.4	Installation Dimensions .....	2.46




**List of Figures:**


**Figure 2-1 Front view ..... 2.7**  
**Figure 2-2 Rear view ..... 2.8**  
**Figure 2-3 Mains voltage selector ..... 2.9**  
**Figure 2-4 Mains power connection, mains fuse holder ..... 2.10**  
**Figure 2-5 Variations Adjustment ..... 2.15**  
**Figure 2-6 Disabling Selection of Reference Direction ..... 2.16**  
**Figure 2-7 Wiring diagram for ground transmitter suppression ..... 2.17**  
**Figure 2-8 Wiring diagram for ground transmitter suppression with non-floating contact ..... 2.17**  
**Figure 2- 9 D-sub-jack 9-way ..... 2.17**  
**Figure 2-10 Bearing Display ..... 2.18**



## 2.1 Key to Front and Rear Views

All the position numbers refer to operating elements shown in the front and rear views (Figure 2-1 and Figure 2-2).

No.	Designation	Function	see Section
1	DIM / ☼	Dimmer	2.3.13
2		Digital bearing display	2.3.1
3	N/E/S/W	Bearing direction (Ref.: QDR)	2.3.1
4	N/E/S/W	Live bearing direction (Ref.: QDR)	2.3.1
5	<>	Frequency deviation	2.3.11
6		Error indication	2.3.12
7	TEST	Test function	2.3.2
8	FREQUENCY (MHz)	Display of frequency, north adjustment and error code	2.3.4 2.3.5 2.3.8
9		Volume control	2.3.14
10		Headphones connection	2.3.15
11	STANDBY	Control lamp for STANDBY mode	2.2.8 2.3.16
12	OFF / ON	ON/OFF switch	2.3.17
13		Keypad for entering frequency / channel / scan	2.3.4
14	REPEAT	Repetition of bearing indication	2.3.3
15	121.500 MHz	Call-up of distress frequency 121.500 MHz	2.3.7
16	STOP/SCAN	Termination or selection of scan mode	2.3.6
17		Reference direction Indicator	2.3.1 2.3.9
18	QDM; QDR; QUJ; QTE	selection switch for reference direction	2.3.9
19	Line	Mains switch	2.3.18
20	F1	24-V DC fuse	2.2.4
21	OK	Power supply control lamp	2.3.19
22	Data-Port	Data interface	2.3.20

No.	Designation	Function	see Section
23	Sync	Control indication: synchronisation NOK	2.3.21
24	Sync	Control indication: synchronisation. OK	2.3.21
25	R/L	Test plug R/L signal	2.3.23
26	DF-Signal 2	DF signal (filtered)	2.3.22
27	PTT	Connection jack for ground transmitter suppression	2.2.14
28	North-Adj. +	Positive variation of north adjustment value	2.2.10
29	North-Adj. -	Negative variation of north adjustment value	2.2.10
30	Ser. Port	Serial port	2.3.24
31	Par. Port	Parallel port	2.3.25
32	fine	Rotary switch 1 for fine phase adjustment	2.2.9
33	coarse	Rotary switch 2 for coarse phase adjustment	2.2.9
34	Phase-Adj	Control lamp for phase adjustment	2.2.9
35		Earth connection (M6)	2.2.1
36	Power Select	Mains voltage selector (115/230 V)	2.2.2
37	24V DC +	+24-V battery connection	2.2.4
38	24V DC -	0-V battery connection	2.2.4
39	F2, F3	Mains fuse holder	2.2.3
40		Mains connection	2.2.2
41	RF-Ant	RF Input from Antenna	2.2.6
42	R/L off	Test button (R/L off)	2.3.26
43	IF	Receiver test jack	2.3.27
44	Power	Control lamp receiver supply voltage	2.3.28
45	Sql	Control lamp for receiver squelch	2.3.28
46	F-	Control lamp, frequency deviation negative	2.3.28
47	F+	Control lamp, frequency deviation positive	2.3.28
48	No Sync	Control lamp for error in receiver	2.3.28
49	Sql	Slot for manual squelch adjustment	2.3.29
50	Antenna	Control Output to Antenna	2.2.6
	Control		2.3.30

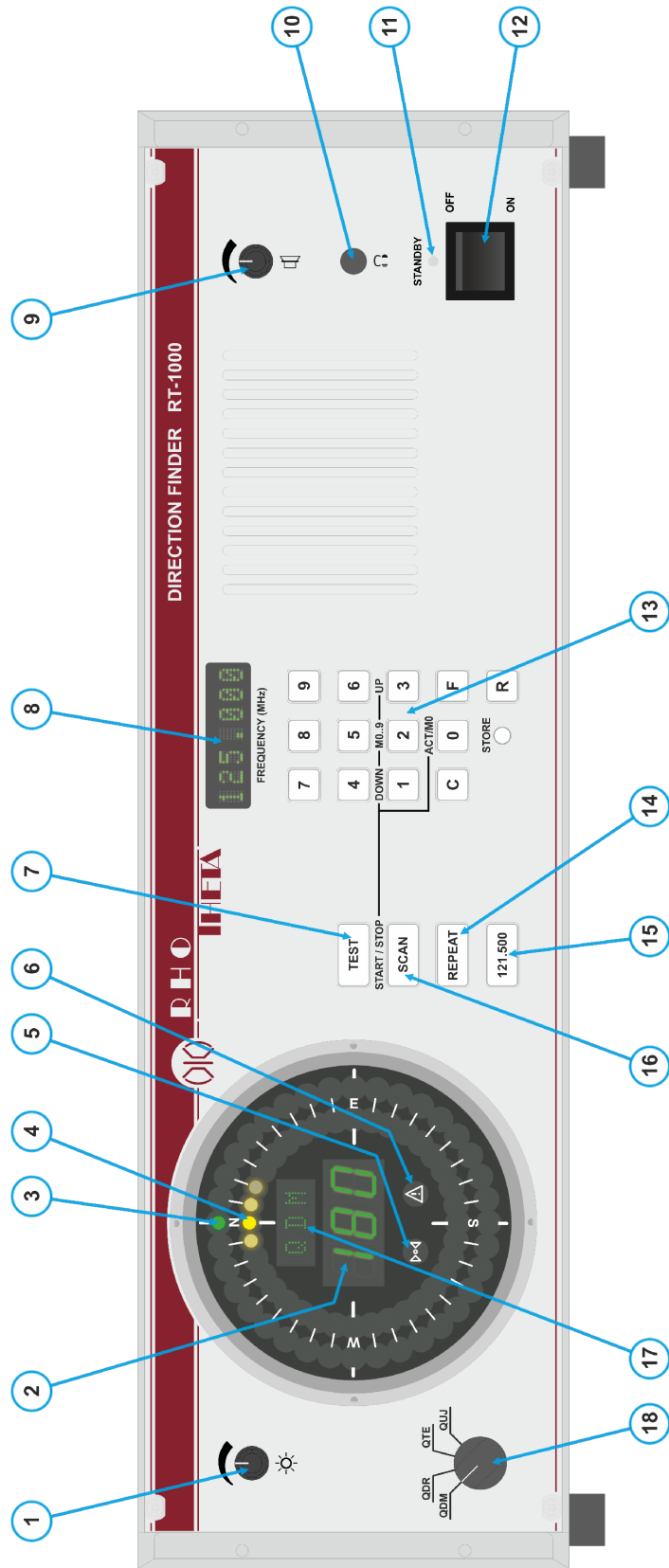


Figure 2-1 Front view

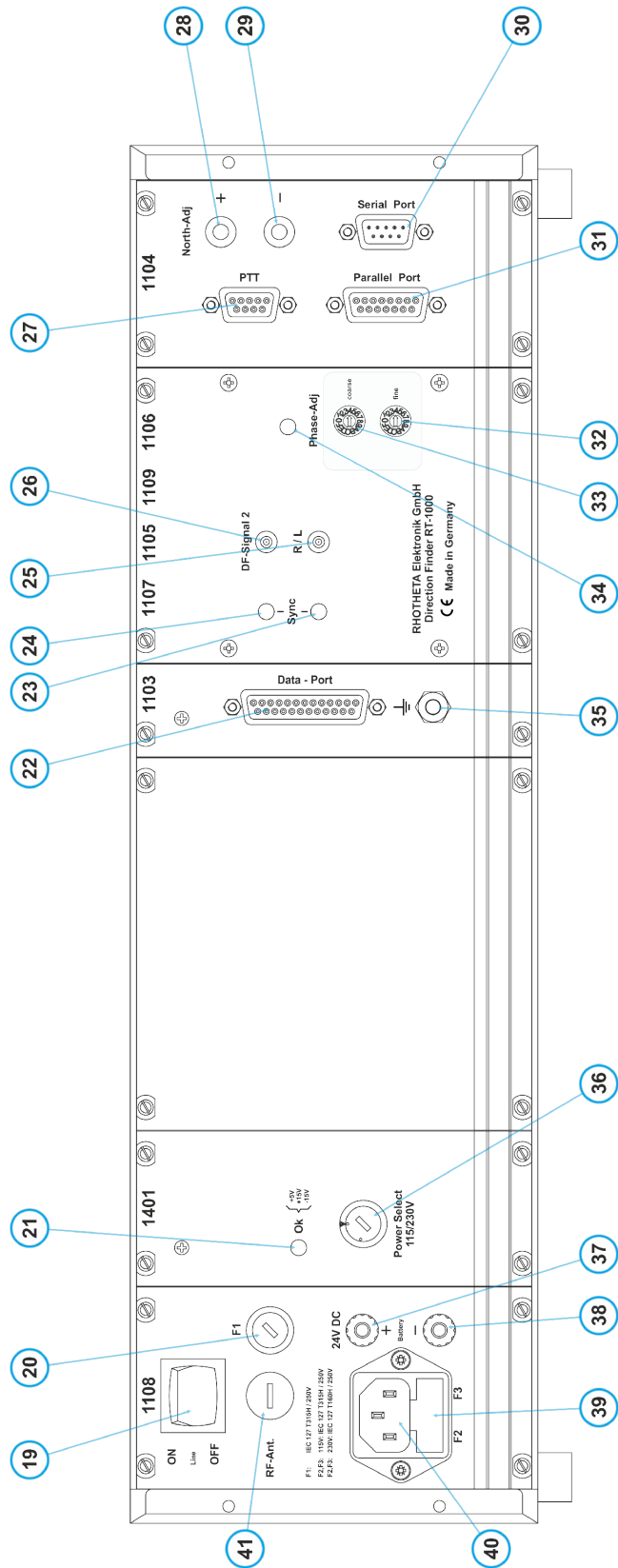


Figure 2-2 Rear view

## 2.2 Preparation for Use

### 2.2.1 Grounding

The RTC 1100 Controller housing is earthed by means of the grounding contact in the mains plug. At the rear of the housing there is a M6 grounding screw (35 Fig. 2-2). This should be used to make a low-impedance and low-inductivity connection between the unit and earth potential (system earth). Connect the controller to earth using the same connection as for the other equipment at your work-place, in order to avoid dangerous voltage peaks between the different units in case of a lightning strike. If using the direction finder as a portable unit, it must be earthed using an appropriate grounding rod, surface earth or grounding plate. If possible, connect the unit to the metal operating environment (vehicle or shelter).

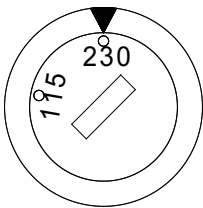
### **WARNING**

**Observe all local safety regulations**

### 2.2.2 Mains Voltage

The RTC 1100 Controller can be operated using mains voltage of 115 V or 230 V  $\pm 15\%$ . The unit is factory-set to 230 V mains voltage.

Before using the unit, check that the correct operating voltage range is set. Use a screw-driver to move the mains voltage selector (36, Fig. 2-2) on the front panel of the RTX 1401 Power Pack module.

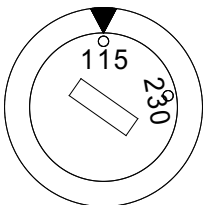


Selector position for 230 Volt range :

Permissible operating voltages:

$$V_{\min} = 195.5 V_{\text{rms}}$$

$$V_{\max} = 264.5 V_{\text{rms}}$$



Selector position for 115 Volt range:

Permissible operating voltages:

$$V_{\min} = 97.75 V_{\text{rms}}$$

$$V_{\max} = 132.25 V_{\text{rms}}$$

**Figure 2-3 Mains voltage selector**

After setting the mains voltage, make sure that the appropriate mains fuses F2 and F3 are in the mains fuse holder (39, Fig. 2-2).



**ATTENTION**

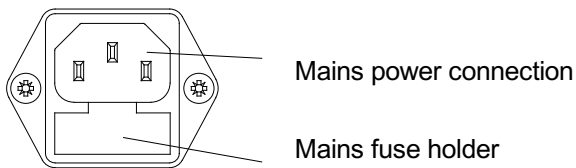
**If the mains voltage selector is not set correctly, the unit may be damaged beyond repair.**

**2.2.3 Mains Fuse**

The mains fuses are contained in the mains power connection (40, Fig. 2-2). There is a separate fuse for phase and the neutral wire. The fuse holder (39, Fig. 2-2) can be easily unlatched by inserting a screwdriver into the slot in the upper part of the fuse holder. Insert fuses F2 and F3 into the fuse holder according to the selected mains voltage :

115 V : IEC 127 T 315 mA H / 250 V

230 V : IEC 127 T 160 mA H / 250 V



**Figure 2-4 Mains power connection, mains fuse holder**

**WARNING**

**Before opening the fuse holder, make sure that the unit is disconnected from the mains supply.**

**2.2.4 DC Voltage Connection**

The RTC 1100 Controller is fitted with a DC supply connection. This allows the unit to be operated using batteries or a 24-V DC mains connection. Connection is through the red pole terminal (37, Fig. 2-2) to the positive pole and blue pole terminal (38, Fig. 2-2) to the negative pole of the power supply. The pole terminal (38, Fig. 2-2) connection is connected to the housing earth inside the unit.

Fuse F1 inserted in the fuse holder (20, Fig 2-2) protects the unit during DC operation.

Use a IEC 127 T 1.0 A H / 250 V fuse. The supply voltage range for DC voltage is 24 V DC, with a permitted tolerance range of -10 / +20 %.

### **ATTENTION**

**Voltages greater than 30 V may lead to the unit being damaged beyond repair.**

#### **2.2.5 Power Supply**

The unit can be alternatively used with mains power or 24-VDC supply.

When connecting the unit to a power supply, ensure that the mains ON/OFF switch (19, Fig. 2-2) at the rear of the unit and the ON/OFF switch (12, Fig. 2-1) at the front are both switched off.

In order to operate the unit off the mains, plug the mains cable into the mains power connection (40, Fig. 2-2) to connect the unit to the mains supply. In order to operate the unit using DC, connect the unit to the DC supply via pole terminals (37, Fig. 2-2) and (38, Fig. 2-2).

### **WARNING:**

**Only connect the unit to the mains using a grounding-type receptacle.**

If the unit is connected to both power supply types and the mains ON/OFF switch (19, Fig. 2-2) is switched on, the unit is normally operated off the mains. If mains supply is interrupted, the unit switches over to DC supply internally. This allows an automatic change-over to a DC emergency power source. If mains supply is switched off at the mains ON/OFF switch (19, Fig. 2-2), the DC supply only is effective.

#### **2.2.6 Connection of the Antenna Unit**

The RTC 1100.B Controller is connected to the RTA 1300.A Antenna Unit by means of a six-wire communications cable and a RF coaxial cable. On the RTC 1100.B Controller, use the 9-pole D-SUB jack, "Antenna Control Port" (50, Fig. 2-2) and the BNC jack "RF-Ant". See sections 4.4 and 5.3 for plug allocations.

## 2.2.7 Rack Mounting

Use the adapters (supplied) to mount the RTC 1100.B Controller in 19" racks.

### NOTE

If mounting in a rack, ensure that the permissible ambient temperature of 55°C is not exceeded. This is especially important if mounting together with other units which give off heat.

## 2.2.8 Switching on / Reaction from Unit

Ensure that the mains ON/OFF switch (19, Fig. 2-2) and the ON/OFF switch (12, Fig. 2-1) are both switched off. If the unit shall operate on AC power supply, connect the unit to the mains supply and move the mains ON/OFF switch (19, Fig. 2-2) at the rear of the unit to "ON". The unit is now in standby mode. The yellow control lamp "STANDBY" (11, Fig. 2-1) lights up. The unit is ready to operate when the ON/OFF switch (12) at the front of the unit is moved to "ON".

If the unit shall operate at the DC source, connect the unit to the DC supply. The unit is ready to operate when the ON/OFF switch (12, Fig. 2-2) is moved to "ON".

In both cases, the frequency display (8, Fig. 2-1) lights up to show that the unit is ready to operate.

After switching on, the frequency display (8, Fig. 2-1) shows the actual software version (approximately 1 second), followed by the serial no of the unit for approximately 2 seconds. Then it shows the actual frequency.

The digital bearing display (2, Fig. 2-1) shows the number  $\beta$  on all digits. The individual lamps of the bearing direction indicators (3; 4, Fig. 2-1) light up one after the other. The frequency deviation (5, Fig. 2-1) and error indication (6, Fig. 2-1) lamps light up. The reference direction indicator (17, Fig. 2-1) shows "VAR" (Variation). After the switch on routine is finished, the digital bearing display shows the selected variation value for about 3 seconds (see chapter 2.2.12).

After finishing this test sequence, the frequency display (8, Fig. 2-1) shows the bearing frequency which was chosen before switching off the device.

## 2.2.9 Phase Adjustment

A special feature of the RT-1000 Direction Finder is its phase compensation by left / right rotation of the antenna. This allows complete compensation of direction finding errors caused by signal phase variations in the reception channel. However, it is only possible to compensate for a limited phase value. For this reason, make a pre-adjustment to the centre of the variation range.

The adjustment can be made either using the RTM 1501 Dummy Antenna (Option) or aligning of the labelled antenna radiator (North dipole) onto a transmitter.

**NOTE**

For the phase adjustment, it is important that the selection switch for reference direction (18, Fig. 2-1) is in position **QDM** and the North adjustment is 0°.

**NOTE**

The RT-1000 does not include a test transmitter for this purpose, so an external signal source or transmitter must be used.

**2.2.9.1 Adjustment Using RTM 1501 Dummy Antenna (Option)**

- Connect the dummy antenna instead of the RTA 1300.A Direction Finder Antenna (see description of RTM 1501 Dummy Antenna).
- Feed in a VHF signal in the ATC band range with a signal level of approx. 100 mV at the dummy antenna RF input and adjust the receiver to the appropriate frequency. Move the antenna signal switch on the dummy antenna to the 180° position.
- The selection switch for reference direction selection (18, Fig. 2-1) must be set to QDM.

**NOTE**

Since the direction finder was pre-set in the factory, the bearing display must show QDM 180° and QDR 0° on condition that the north adjustment is set to 0° (see 2.2.10). QDM 0° and QDR 180° may also be displayed if the phase is completely misaligned.

- Phase adjustment can be set using the two rotary switches, "fine" (32, Fig. 2-2) and (33, Fig 2-2) "coarse". The total of 256 steps (8 bit) on the coarse switch are divided into 16 steps, and these coarse steps are sub-divided into a further 16 steps on the fine switch. Use these rotary switches (32, Fig 2-2) and (33, Fig 2-2) to find the middle of the range where the green control lamp (34, Fig 2-2) lights up. The QDM display should then show 180° (QDM). Up to ±2° deviation from this value are possible due to dummy antenna tolerances.

**2.2.9.2 Adjustment Using a Transmitter**

Position a test transmitter (e.g. walkie-talkie) approximately 100 m away, exactly to the north of the direction finder antenna (dipole north with label pointing towards the transmitter). The bearing display should show QDM 180° and QDR 0°. The north adjustment on the controller must be set to 0° (see 2.2.10). Phase adjustment is done as described in 2.2.9.1.

**NOTE**

The transmitter has to be exactly in the north of the Antenna. The digital bearing display (2, Fig 2-1) has to show 180° (or 000°). A deviation of more than ±2° will make it impossible to execute the phase adjustment.

### 2.2.10 North Adjustment

The bearing display (QDM/QDR) is relative to magnetic north, under the condition that the antenna is mechanically adjusted towards magnetic north (see section 4, Antenna).

Perform exact adjustment using the north adjustment of the controller. The correction value for north adjustment appears on the frequency display (8, Fig. 2-1) when buttons TEST (7, Fig 2-2) and REPEAT (14, Fig 2-2) are pressed simultaneously.

Example :        Display indicates correction value +3.5° :

N +03.5

Correction can be made in 0.5° steps in a ±90° range. Press the following buttons simultaneously to perform the adjustment:

TEST (7, Fig 2-1) and REPEAT (14, Fig 2-1) and NORTH-ADJ.+ (28, Fig. 2-2) to increase or  
TEST (7, Fig 2-1) and REPEAT (14, Fig 2-1) and NORTH-ADJ.- (29, Fig. 2-2) to decrease the value.

### 2.2.11 Adjustment of the Squelch threshold

Keep the key "TEST" (7, Fig. 2-1) pressed for about 2.5 seconds. In the frequency display (8, Fig 2-1), the squelch threshold value is shown followed by the current receiving signal level. Both values are not calibrated, they are displayed as a percentage value in relation to the maximum signal level.

Example Frequency display:

50 <24>; means: Squelch level = 50%; receiving signal level = 24%; squelch is active: no bearing, no audio.

#### NOTE

The squelch threshold works with an hysteresis. So it may happen that there is a difference between the value of the squelch level and the signal level. The indicated value has to be interpreted as a guiding value.

While pressing the key "TEST" (7, Fig 2-1), it is possible to change the squelch level by pressing the keys "+" (28, Fig. 2-2) or "-" (29, Fig. 2-2). Key "+" is increasing the squelch level, the key "-" is decreasing it. The keys are placed on the backside of the controller. If the controller integrated in a rack, it has to be removed before adjustment. The factory pre-set is 50%. It should be the right adjustment for most cases.

#### NOTE

The reaction time of the indication is slow due to characteristics of the system. Please wait, after each single pressing of the key "+" or "-", for the reaction in the display.

If the squelch level is reduced to the value 00% and the key “-” (29, Fig. 2-1) is pressed one more time, the display shows the character “PT” ( “PT” = Potentiometer) alternating with the squelch value, which is set by the manual squelch. This is the adjustment which is done by the potentiometer setting on the receiver module ( see chapter 3.3.2.10.5).

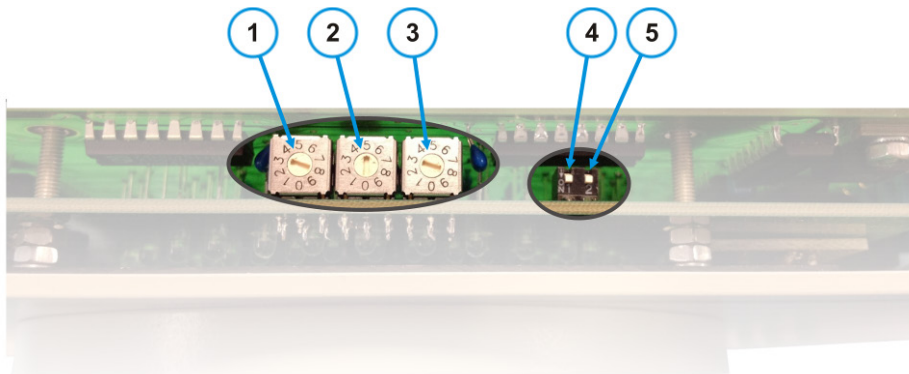
Pressing the key “+” (28, Fig. 2-2) or “-” (29, Fig 2-2) again will switch back the squelch setting into normal mode.

## 2.2.12 Variation Adjustment

To show directions with magnetic reference as well as directions with true north reference, it is necessary to set the local variation.

For this purpose, please act as follows:

1. Unscrew the front panel and pull it a little bit out of the housing.
2. Now you can see the rotary code switches ①;② and ③ as well as the switch ④ and ⑤.



**Figure 2-5 Variations Adjustment**

3. The variation will be adjusted by the rotary switch ①, ② and ③. Switch ① is equivalent to hundreds, switch ② is equivalent to tens and switch ③ is equivalent to ones.

4. The adjustment value has to be entered as follows:

East Variation has to be set directly (prefix „+“)

Example:

Variation: 3° E . → 000° + 003° = 003°

Adjustment: switch ① value 0

switch ② value 0

switch ③ value 3

West variation has to be set with negative prefix

Example: Variation 3° W → 360° - 003° = 357°

Adjustment: switch ① value 3

switch ② value 5

switch ③ value 7

### NOTE

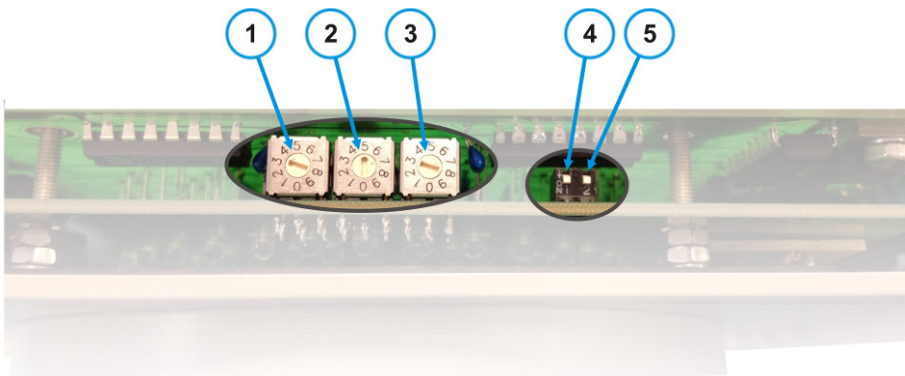
The variation can change over a longer period and has to be verified once a year.

### 2.2.13 Disable Selection of Reference Direction

There are applications where a change of reference direction from QDM to another direction is not allowed or makes no sense. For those cases, it is possible to disable the reference direction switch. If it is disabled, digital display (2, Fig. 2-1) always shows the QDM value.

For this purpose, please act as follows:

1. Unscrew the front panel and pull it a little bit out of the housing.
2. Now you can see the switches ④ and ⑤.



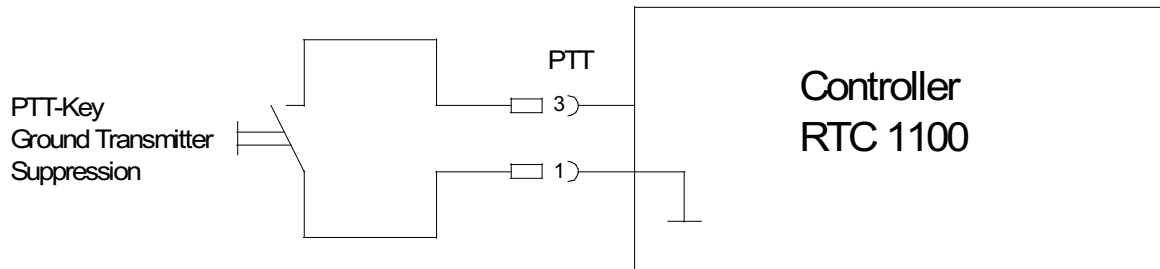
**Figure 2-6 Disabling Selection of Reference Direction**

3. Turn the switch ⑤ in position OFF (up away from the board) → the switch function is disabled.

The default setting of the switch ④ is “ON”. This means the antenna is mechanically oriented to magnetic north. In rare occasions, the antenna can be mechanically adjusted to the true north direction, so only in this case the switch ④ has to be set to position “OFF”.

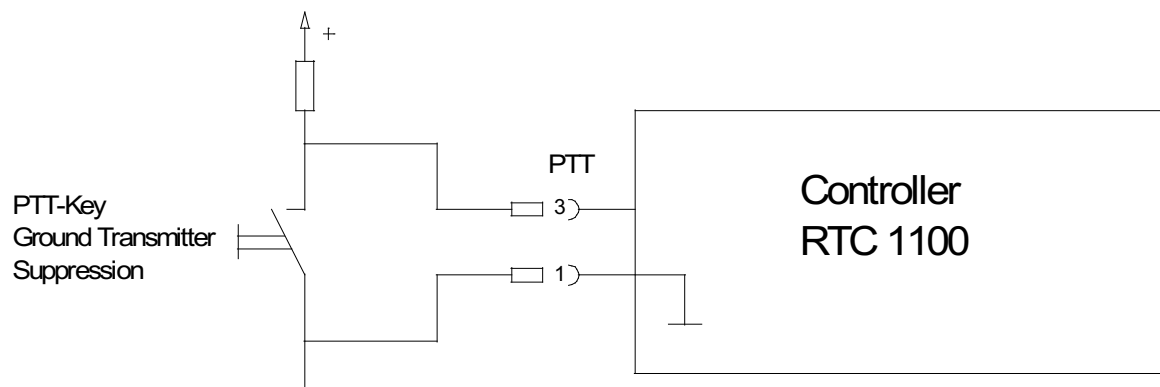
### 2.2.14 Ground Transmitter Suppression

If you do not want to measure the bearing to the ground transmitter, connect the PTT jack (27, Fig. 2-2) on the rear of the unit with a normally-open contact of the transmit button. See Figure 2-7 for wiring diagram.



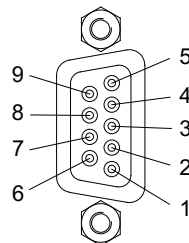
**Figure 2-7 Wiring diagram for ground transmitter suppression**

If the normally-open contact is not floating, arrange the wiring according to Figure 2-8.



**Figure 2-8 Wiring diagram for ground transmitter suppression with non-floating contact**

Ground transmitter suppression is operational when contacts 1 and 3 of the PTT jack (23, Fig. 2-7) are connected and thus contact 3 is connected to earth potential.



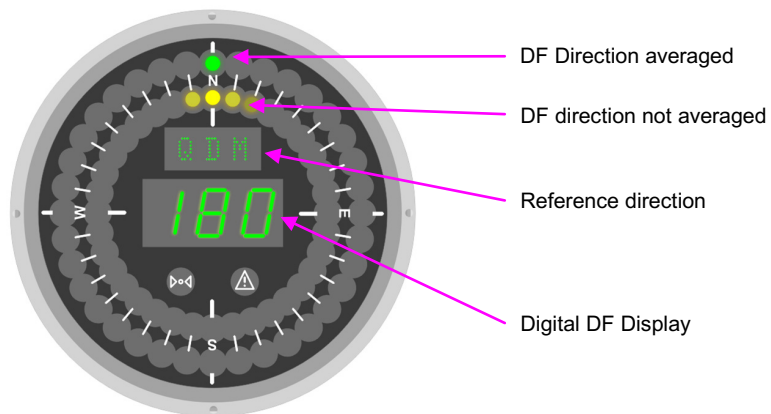
**Figure 2-9 D-sub-jack 9-way**



## 2.3 Display and Operating Functions

### 2.3.1 Bearing Display and Bearing Quality Analysis

The bearing is displayed on a luminous, 3-figure digital display (2, Fig. 2-1) which may be dimmed for use in darkened rooms (1, Fig. 2-1). The resolution is 1°. Additionally, there is a display (QDR) in 10° steps using light dots arranged around a compass scale (3, Fig. 2-1). The reference direction display (17, Fig. 2-1) indicates the selected reference direction (QDM, QDR, QTE or QUJ) for the digital bearing display.



**Figure 2-10 Bearing Display**

To obtain an optimally settled display, the bearing signal is averaged and then processed using a special algorithm.

In order to infer the quality of the displayed bearing, there is a second concentric circle of light dots (4, Fig. 2-1) in the display area which displays the actual, i.e. not averaged ("live") bearing direction in a 20-ms rhythm. This dual compass scale allows optimum bearing quality analysis because the non-averaged bearing is displayed in direct relation to the mean bearing.

#### **NOTE**

If the "live" bearing display (4, Fig. 2-1) (circle of yellow lamps) shows considerable variations or differences to the averaged mean bearing display (3, Fig. 2-1) (circle of green lamps), the operator can see that the direction finder is being affected by noise, shadowing, reflections or strong modulation. To analyse, it makes sense to work with the audio signal (speaker) in addition.

### 2.3.2 Test Function

After switching on the controller, the unit automatically performs a test routine (see 2.2.8). If the system is used continually over longer periods, we recommend activating the test function every day.

The test function is activated using the test button (7, Fig. 2-1).

Additionally, the calculation of the bearing is inhibited when the test function is activated. When releasing the test key (7), the bearing calculation is started again.

a) Functional check of the digital bearing display (2, Fig. 2-1):

To check the illumination of the segments of the digital bearing display the display shows "8888".

- b) Functional check of the two LED rings (3; 4, Fig 2-1) "Frequency offset", "error":  
The LEDs of the circular bearing display (3; 4, Fig. 2-1) are illuminated cyclically as long the key "TEST" is pressed.
- c) Functional check of LEDs (5; 6, Fig 2-1) "Frequency offset", "error":  
The indicator for frequency offset (5, Fig. 2-1) and the error indicator (6, Fig. 2-1) will be illuminated as long as the key "TEST" is pressed.
- d) The bearing reference indicator (17, Fig. 2-1) shows the selected reference direction (QDM, QDR, QTE or QUJ).
- e) Functional check of receiver squelch and audio (7, Fig. 2-1):  
For the first 2 seconds after pressing the "TEST" key, the squelch function is disabled and noise will be heard out of the speaker (if no radio signal is available). During this period of time, the frequency display (8, Fig. 2-1) shows : "AUDIO..".
- f) Functional check of receiver squelch threshold and the receive signal level:  
After further 2 seconds, the frequency display (8, Fig. 2-1) shows "**SQ<LEV>**" for squelch level threshold and Signal level for a short period. Then the actual squelch level and the signal level are displayed as long the TEST key is pressed.  
Example: 47<79%> means Squelch threshold = 47%; Signal level = 79%.

#### NOTE

The indicated level values are not calibrated. The squelch threshold has a hysteresis in its switching characteristics. So it is possible that there can be differences in shown values. The displayed values have to interpreted as guidance level .

g) "CLEAR" function

While the key "TEST" (7, Fig. 2-1) is pressed, the memory for averaged bearing values is deleted and the averaging function is not working. After releasing the key, averaging is restarted.

### 2.3.3 "REPEAT" Repetition of Bearing Indication

The repeat function, called up using the REPEAT button (14, Fig. 2-1), is used to display the last bearing calculated. In addition, when the REPEAT button is pressed, the current bearing is retained. In this function, the "live" bearing direction indication (4, Fig. 2-1) is not active.

### 2.3.4 Frequency Selection

Depending on the chosen options, the following frequency ranges are available:

VHF – air band 25 kHz frequency steps: 118.000 to 136.975 MHz

VHF – air band 25 / 8.33 kHz frequency steps: 118.000 to 136.975 MHz

VHF – marine band 25 kHz frequency steps: 156.000 to 174.000 MHz

Frequencies may be entered directly using the key pad (13, Fig. 2-1) or may be called up from the frequency memory. The unit provides 10 frequency memories which are retained if the unit is switched off. The display (8, Fig. 2-1) indicates the active frequency.

#### 2.3.4.1 Direct Frequency Selection in the 25 kHz channel spacing

Frequencies can be entered directly using buttons F (frequency) and 0 to 9 on the keypad for entering frequencies (13, Fig. 2-1).

Example: Entering a frequency of 118.975 MHz

Input	Frequency display (8, Fig. 2-1)
<b>F</b>	— — — . — — —
<b>1</b>	1 — — . — — —
<b>1</b>	1 1 — . — — —
<b>8</b>	1 1 8 . — — —
<b>9</b>	1 1 8 . 9 — —
<b>7</b>	1 1 8 . 9 7 5

#### NOTE

It is not necessary to input the last figure (kHz figure), because the controller generates this automatically. If the frequency is not entered correctly within 10 seconds., the controller switches back to the last frequency set. Is a value chosen which is outside the available value facet the input will be not accepted.

### 2.3.4.2 Direct Frequency Selection in the 8.33 / 25 kHz channel spacing

If the system is equipped with the option 8.33 kHz channel spacing, the frequency input has to be performed according to ICAO Annex 10 Volume V clause 4.1.2.4 table 4.1. Please note that it is possible to work on both channel spacing, 8.33 and 25 kHz. This is necessary because both channel spacings are existing at the same time.

Typically, the 8.33 kHz spacing is in use at the upper airspace. In many countries, the 25 kHz spacing is still in use at the lower air space.

The frequency range which was reserved for one channel in the 25 kHz spacing is shared by three channels in the 8.33 kHz spacing. This means that the bandwidth is reduced to a  $\frac{1}{3}$  of the bandwidth of the 25 kHz spacing. Inside the receiver, the signal filtering is switched in accordance to the selected channel spacing.

#### NOTE:

The selection of channel spacing is carried out, in accordance with standards, off the syntax of the input frequency.

The scheme is illustrated by the following example:

Frequency Setting / -Display [MHz]	Channel Spacing	Bandwidth	Receiving Frequency [MHz]
118,000	25 kHz	wide	118,0000
118,005	8,33 kHz	narrow	118,0000
118,010	8,33 kHz	narrow	118,0083
118,015	8,33 kHz	narrow	118,0167
118,020	Not valid		
118,025	25 kHz	wide	118,0250
118,030	8,33 kHz	narrow	118,0250
118,035	8,33 kHz	narrow	118,0333
118,040	8,33 kHz	narrow	118,0417
118,045	Not valid		
118,050	25 kHz	wide	118,0500
118,055	8,33 kHz	narrow	118,0500
118,060	8,33 kHz	narrow	118,0583
118,065	8,33 kHz	narrow	118,0667
118,070	Not valid		
118,075	25 kHz	wide	118,0750
118,080	8,33 kHz	narrow	118,0750
118,085	8,33 kHz	narrow	118,0833
118,090	8,33 kHz	narrow	118,0917
118,095	Not valid		
118,100	25 kHz	wide	118,1000
118,105	8,33 kHz	narrow	118,1000
•	•	•	•
•	•	•	•

Frequency Setting / -Display [MHz]	Channel Spacing	Bandwidth	Receiving Frequency [MHz]
•	•	•	•
xxx,x00	25 kHz	wide	xxx,x000
xxx,x05	8,33 kHz	narrow	xxx,x000
xxx,x10	8,33 kHz	narrow	xxx,x833
xxx,x15	8,33 kHz	narrow	xxx,x167
xxx,x20	Not valid		
xxx,x25	25 kHz	wide	xxx,x250
xxx,x30	8,33 kHz	narrow	xxx,x250
xxx,x35	8,33 kHz	narrow	xxx,x333
xxx,x40	8,3 3kHz	narrow	xxx,x417
xxx,x45	Not valid		
xxx,x50	25 kHz	wide	xxx,x500
xxx,x55	8,33 kHz	narrow	xxx,x500
xxx,x60	8,33 kHz	narrow	xxx,x583
xxx,x65	8,33 kHz	narrow	xxx,x667
xxx,x70	Not valid		
xxx,x75	25 kHz	wide	xxx,x750
xxx,x80	8,33 kHz	narrow	xxx,x750
xxx,x85	8,33 kHz	narrow	xxx,x833
xxx,x90	8,33 kHz	narrow	xxx,x917
xxx,x95	Not valid		

Example: Entering the operating frequency 118,975 MHz in the 25 kHz spacing

Input frequency display (8, Fig. 2-1)

F	— — — . — — —
1	1 — — . — — —
1	1 1 _ . — — —
8	1 1 8 . _ _ _
9	1 1 8 . 9 _ _
7	1 1 8 . 9 7 5

Example: Entering the operating frequency 118,975 MHz in the 8.33 kHz spacing

Input frequency display (8, Fig. 2-1)

<b>F</b>	_ _ _ . _ _ _
<b>1</b>	1 _ _ . _ _ _
<b>1</b>	1 1 _ . _ _ _
<b>8</b>	1 1 8 . _ _ _
<b>9</b>	1 1 8 . 9 _ _
<b>8</b>	1 1 8 . 9 8 _
<b>0</b>	1 1 8 . 9 8 0

If the frequency is not entered correctly within 10 seconds, the controller switches back to the last frequency set.

If a digit is out of the valid range, the setting is not taken over and a beep is sounding.

Entering the last digit (kHz digit) is not required if the penultimate place already allows an unambiguous assignment of the channel. The last digit is generated automatically by the controller in this case.

#### NOTE

At least it doesn't matter which physical frequency setting in the receiver will be caused by a frequency input. The frequency input can be considered as a channel name that has to be chosen. The DF system will set all relevant parameters itself.

### ATTENTION

**If, in the 25 kHz spacing, the channel spacing of 8.33 kHz is chosen accidentally, in worst case, it may happen that a station will not be received because the frequency offset is too large.  
If the 25 kHz spacing is chosen accidentally instead of the 8.33 kHz spacing, it may happen that stations will be received which are above or below the selected frequency.**

### 2.3.4.3 Recalling a Frequency Memory

Frequencies may be recalled from frequency memories 0 to 9 using the R (Recall) button and buttons 0 to 9 on the key pad for entering frequencies (13, Fig. 2-1). First, press the R button, followed by number 0 to 9 as required.

Example: Call up frequency memory 0

Input	Frequency display (8, Fig. 2-1)
<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">R</div> <div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">0</div>	<p style="text-align: center;">R C L _</p> <p>e.g. 1 2 1 . 5 0 0</p>

If the frequency has not been recalled from the frequency memory within 10 seconds after pressing the R button, the controller switches back to the last frequency set.

### 2.3.4.4 Programming the Frequency Memory

The frequency currently set can be entered into the frequency memory positions 0 to 9. This is done by pressing the store button and buttons 0 to 9 in the key pad for entering frequencies (13, Fig. 2-1). Press the store button and the button for the desired memory number simultaneously.

Example: Program frequency memory 0

<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">STORE</div>	<div style="border: 1px solid black; display: inline-block; padding: 2px 5px;">0</div>
--	--

The last frequency set is automatically programmed into an additional frequency memory. Thus the frequency set is retained even after the unit is switched off.

#### NOTE

It is also possible to store channel numbers for maritime radio communications into the frequency memory. This may be useful for scanning of frequency memories 0 to 9 (see section 2.3.6).

### 2.3.5 Direct Selection of Channel Number in Maritime Radio Communication

Channel number ranges in duplex operation: 01 to 07, 18 to 28, 60 to 66 and 78 to 88  
 simplex operation: 08 to 17 and 67 to 77

For direct channel number selection (for maritime radio communication only), use the bottom "C" (Channel) and keys 0 to 9 of the keypad (13, Fig. 2-1).

The last digit of the channel display (8, Fig. 2-1) shows the selected mode in the upper and lower sidebands.

- S = (Sea) bearing of sea station (lower sideband)
- C = (Coast) bearing of a coast station (upper sideband)
- X = channel number in simplex operation (upper sideband = lower sideband)

Selection of the upper or lower sideband (coast or sea station) is made by pressing button "C" (13, Fig. 2-1) repeatedly when entering the channel number.

Example: Enter channel number 78 (bearing mode, reception of a sea station)

Input Channel display (8, Fig. 2-1)

**C** C H \_ \_ S

**7** C H 7 \_ S

**8** C H 7 8 S

Example: Input of the channel number 78 (reception of a coast station)

Input frequency / channel display (8, Fig. 2-1)

**C** C H \_ \_ S

**C** C H \_ \_ C

**7** C H 7 \_ C

**8** C H 7 8 C



Example: Input of channel number 16 (reception of a simplex channel)

Eingabe	Anzeige Kanal-Display (8, Fig. 2-1)
<b>C</b>	<b>C H _ _ S</b>
<b>1</b>	<b>C H 1 _ X</b>
<b>6</b>	<b>C H 1 6 X</b>

If the channel number is not entered correctly within 10 seconds, the controller switches back to the last frequency or channel set.

### 2.3.6 Scanning

In scan mode, the frequency is changed continually. While a signal is being received, the current frequency stays active. When reception stops, scanning resumes after approximately 2.5 seconds.

#### 2.3.6.1 Selection of Scan Mode

In order to start scanning, first press button "STOP/SCAN" (16, Fig. 2-1) followed by one of the four possible scan mode keys (key: 1= DOWN, 3= UP, 2 = M0..9, 0 = ACT/M0).

Scan modes:

- **DOWN**: The entire currently active frequency band (aeronautical or maritime radio communication) is scanned continuously in downward direction. The frequency increment is 25 kHz. Once the lowest frequency of the band has been reached, scanning restarts at the highest one.
- **UP**: the frequency band is scanned in upward direction (otherwise as in DOWN scanning).
- **M0..9**: The ten frequency memories (see section 2.3.4.3) are scanned continuously.
- **ACT/M0**: Two frequencies are scanned, namely the active frequency and the one in memory 0.

Example: Scanning frequency memories 0 to 9

**STOP/SCAN** **M 0..9**

Remarks:

- While scanning is in progress, the display (8, Fig. 2-1) briefly shows the message SCANNING every two seconds
- While scanning is in progress, the scan mode is only changed by pressing the relevant mode key. If, for example, you wish to change from UP to DOWN scanning, just press the "DOWN" key.

- If you wish to continue scanning although a signal is being received, press the relevant scan mode key and keep pressing until a new frequency is set.  
Example: In UP scanning, a signal is being received at 125.000 MHz and scanning stops. If you still wish to continue UP scanning, press key "UP" until 125.025 MHz appears and UP scanning continues automatically.
- You may also store channel numbers for maritime radio communication in frequency memories 0 to 9 for scanning.

### **2.3.6.2 Stopping Scanning**

To stop all active scanning processes immediately, press the "STOP/SCAN" button (16, Fig. 2-1) or any other function key.

### **2.3.7 Direct Recall of the Distress Frequency 121.500 MHz**

By pressing button 121.500 MHz (15, Fig. 2-1), this frequency is activated immediately (international distress frequency in civil aviation).

### **2.3.8 North Adjustment**

The correction value set for north adjustment is shown on the frequency display (8, Fig. 2-1) if the buttons "TEST" (7, Fig. 2-1) and "REPEAT" (14, Fig. 2-1) are pressed simultaneously. Corrections can be set in 0.5° steps in a range of  $\pm 90^\circ$ .

### 2.3.9 Selection of the reference directions QDM, QDR, QUJ und QTE

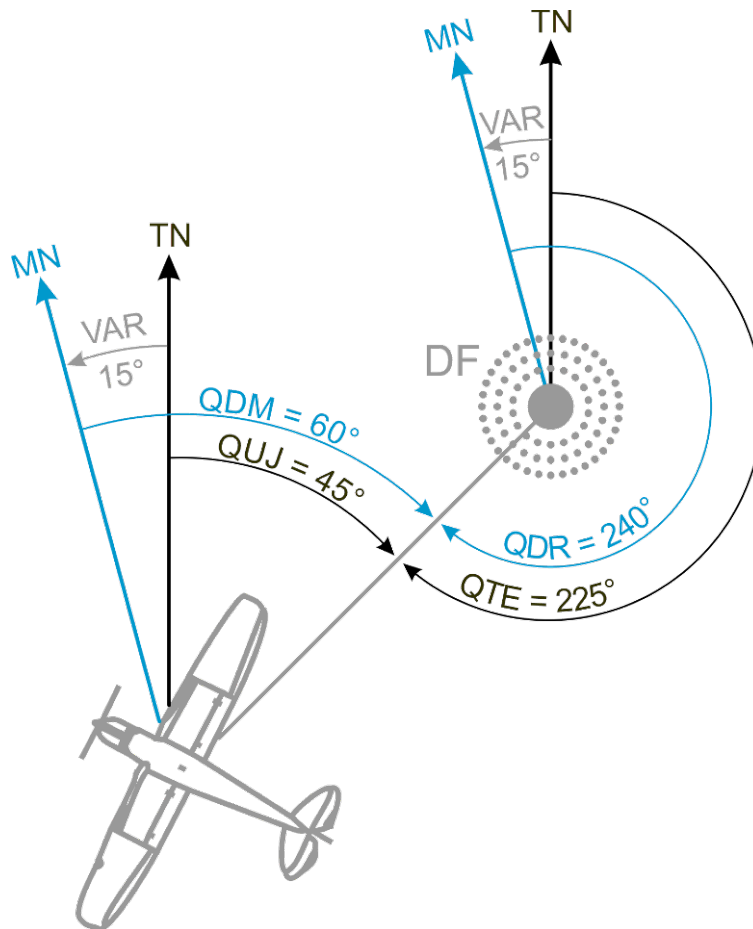
By use of the reference direction switch (18, Fig. 2-1), the reference directions QDM, QDR, QUJ and QTE can be displayed on the digital bearing display. The selected reference direction is shown at the reference display (17, Fig. 2-1) and at the legend of the switch position (18, Fig. 2-1).

Switch Position / Reference Direction Display	Meaning	Reference Direction	
QDM	Magnetic bearing (course) of aircraft / vessel to the DF station	Magnetic north	QDM = QDR $\pm$ 180° QDM = QUJ - VAR
QDR	Magnetic bearing from the DF to the aircraft / vessel	Magnetic north	QDR = QDM $\pm$ 180° QDR = QTE - VAR
QTE	True bearing from the DF to the aircraft / vessel	True north	QTE = QUJ $\pm$ 180° QTE = QDR + VAR
QUJ	True bearing (track) of aircraft / vessel to the DF station	True north	QUJ = QTE $\pm$ 180° QUJ = QDM + VAR
VAR <sup>1</sup>	Variation		

<sup>1</sup> The west variation has a negative sign "-" and the east variation has positive sign "+".

The interrelation will be shown in the following Figure:

The picture shows the variation of 15°W. Then the variation value is -15°



acronym	meaning
TN	True north
MN	Magnetic North

**ATTENTION**

**Only forward QDM bearings to an aircraft pilot. Other reference directions will cause a significant danger of confusion!**

### 2.3.10 Checking the Variation adjustment

After switching on the Controller Unit, the test routine will start. The reference display (17, Fig. 2-1) shows "VAR" for variation. At the end of the test routine, the adjusted value for the variation is shown on the digital bearing display (2, Fig. 2-1) for 3 seconds.

### 2.3.11 Frequency Deviation

The RTC 1100.A controller incorporates a measuring device to monitor the frequency deviation of the signal being received. If the frequency offset becomes excessive, bearing evaluation is interrupted. This condition is signalled by the LED (5, Fig. 2-1) in the display field.

### 2.3.12 Error Indication

The equipment has a wide range of self-test devices. If an error is discovered, a LED (6, Fig. 2-1) in the bearing display field lights up. Additionally, the error code is shown flashing in the frequency display (8, Fig. 2-1) at intervals of 1 second.

Display: **E R R 7**

Error code	Error type
1	Processor
2	EPROM
3	RAM
4	Power supply
5	EEPROM
6	Synchronisation
7	Phase measurement
8	Data transfer or power supply or receiver module
9	Receiver control

## ATTENTION

**If an error message appears, the system no longer functions.**

### 2.3.13 Dimmer (1) "DIM"

The dimmer (1, Fig. 2-1) is used to change the brightness of the QDM display (2, Fig. 2-1), circle of bearing display (3, Fig. 2-1), circle of "live" bearing display (4, Fig. 2-1), error display (6, Fig. 2-1) and frequency deviation display (5, Fig. 2-1). The dimmer has no effect on the frequency display (8, Fig. 2-1). When set to minimum, the circle of bearing display (4, Fig. 2-1) is almost completely darkened.

### 2.3.14 Volume Control (9)

The volume control (9, Fig. 2-1) is used to change the volume of the AF signal (speech signal), which can be monitored in the speaker or headphones. If set to minimum, the AF signal is no longer audible.

### 2.3.15 Headphones Connection (10)

Headphones can be connected to jack socket (10, Fig. 2-1) for monitoring the AF (speech) signal. The speaker in the controller is silenced when the jack plug is inserted.

Suitable jack plug : 6.35 mm

Terminal allocation :

Centre terminal : + (audio signal)

Outer connection : - (ground)

### 2.3.16 "STANDBY" Indicator (11)

With AC power supplied and power switch (12, Fig. 2-1) set to "ON" position, the controller is in STANDBY mode because voltage is present at the mains transformer. This state is indicated by the yellow "STANDBY" indicator (11, Fig. 2-1).

### 2.3.17 ON / OFF Switch (12)

This switch (12, Fig. 2-1) is used to switch the controller on and off. The switch activates or blocks the power supply voltage regulator. In the "OFF" position, it also cuts off the DC power supply. The transformer is not disconnected from mains supply.

### 2.3.18 "Line" Mains Switch (19)

Mains switch (19, Fig. 2-2) provides a double-pole disconnection of the power supply module from the mains. The DC power supply is not affected, which means that, with the switch in the "OFF"-position, the power supply module is switched to the DC power input.

Modes:

Mains Switch Setting (19, Fig. 2-2)	DC Power Supply	ON / OFF Switch Setting (12, Fig. 2-1)	Controller	"Standby" Indicator (11)
OFF	not connected	ON	OFF	OFF
OFF	not connected	OFF	OFF	OFF
OFF	connected	OFF	OFF	OFF
OFF	connected	ON	operates in DC mode	ON
ON	not connected	OFF	OFF	ON
ON	not connected	ON	operates in mains mode	ON
ON	connected	OFF	OFF	ON
ON	connected	ON	operates in mains mode	ON

### 2.3.19 Power Supply "OK" Indicator (21)

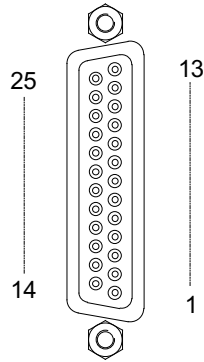
After switch-on, the green indicator (21, Fig. 2-2) lights up. This indicates that the power supply module is operating correctly.

### 2.3.20 "Data-Port" Data Interface (22)

The internal power supply voltages and the AF signal (audio signal, floating, via a separate amplifier) are applied to this connector.

In RT-1000 C Systems (Remote operation), the data port is used to connect the RTR 1200.A Receiver Unit to the RTC 1100.A controller.

Plug type: D sub miniature female multipoint connector, 25-way



D-sub-jack 25-way

Plug wiring:

Pin	Signal	Meaning
01	NF 2	AF audio signal (floating) (RT-1000 C only)
02	PHI-1	Bearing signal 1 (RT-1000 C only)
03	PHI-2	Bearing signal 2 (RT-1000 C only)
04	PHI-2	Bearing signal 2 (RT-1000 C only)
05	Data-1	Data communication line 1 (RT-1000 C only)
06	Data-1	Data communication line 1 (RT-1000 C only)
07	-15V	-15-Volt power supply
08	Data-2	Data communication line 2 (RT-1000 C only)
09	Data-2	Data communication line 2 (RT-1000 C only)
10	48kHz-1	Reference signal 1 (RT-1000 C only)
11	48kHz-1	Reference signal 1 (RT-1000 C only)
12	48kHz-2	Reference signal 2 (RT-1000 C only)
13	48kHz-2	Reference signal 2 (RT-1000 C only)
14	NF1	AF audio signal (floating) (RT-1000 C only)
15	TXD-5V	Serial 5-V interface
16	RXD-5V	Serial 5-V interface
17	RXD	RS-232 interface (receive)
18	TXD	RS-232 interface (transmit)
19	NF-X2	AF input
20	PTT-X2	Input for ground transmitter suppression
21	SQU	Squelch input
22	GND	Ground
23	GND	Ground
24	+15V	+15-V power supply
25	5V	+5-V power supply



### 2.3.21 "Sync" Synchronisation Indicators (23, 24)

The green indicator (24, Fig. 2-2) lights up if, in the controller, the electronics in the Frequency Processing module RTC 1107 is synchronised with the reference signal from the Antenna Control module RTR 1201.

The red indicator (23, Fig. 2-2) lights up if the above mentioned synchronisation is not achieved.

If this indicator is enlightened, it indicates the following possible malfunctions:

- RTR 1201 Antenna Control module defective
- RTC 1107 Frequency Processing module defective

### 2.3.22 "DF Signal 2" Test Plug (26)

The relevant signal for bearing value calculation is applied to the test connector (26, Fig. 2-2). The signal can be monitored using an oscilloscope. It indicates the quality of the bearing value (refer to section 4.4.3.1).

Plug type: SMB

### 2.3.23 "R/L" Test Connector (25)

The signal for switching the sense of antenna rotation from clockwise to counter-clockwise is applied to the test plug (25, Fig. 2-2). This signal is used for triggering the oscilloscope when monitoring the DF signal described in 2.3.22.

Plug type: SMB

### 2.3.24 "Serial Port" Serial Interface (30)

The serial interface (30, Fig. 2-2) enables the transfer of bearing data to an external control unit and also permits remote control by an external control unit.

The characters to be transferred are transmitted in ASCII code by the RTC 1100.B Controller. The data bit sequence, which is assigned in each case to the characters to be transmitted, is preceded by a start bit and followed by a stop bit. Both additional bits ensure that both, transmitter and receiver, are time-synchronized.

The data traffic on the serial interface is in asynchronous mode. For time-synchronisation of the data transmitter and data receiver, the data receiver is triggered by the rising edge of the start bit at the beginning of the bit sequence of a character.

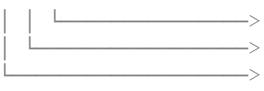
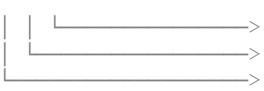
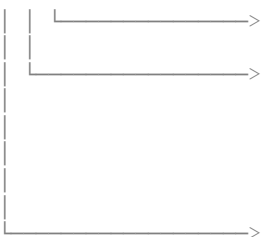
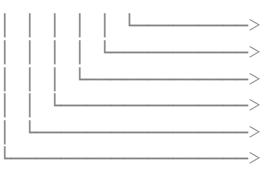
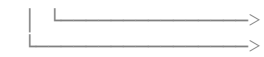
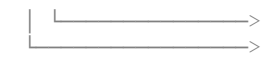

The transmission of a message begins with the header, consisting of an alphanumeric character. The actual message content forms a string of (ASCII) decimal numbers. The transmission of a message is ended by the final identifier "CR" (decimal code 13) and "LF" (decimal code 10).

The signal level on the data lines corresponds to the RS-232 standard, i.e. a HIGH is defined as a voltage between +3 V and +15 V and a LOW as a voltage between -3 V and -15 V. The data is transmitted in negative logic.

The bearings are output as QDR values and therefore differ by 180° from the values shown in the QDM display (2, Fig. 2-1).

### 2.3.24.1 Data Output

The data output is continuous, i.e. no control by means of a handshake signal or control characters is necessary.

Message	Header	Content
„Average“ bearing (QDR-value)	A	X X X [CR][LF]      0° ... 359° (QDR)  Units Tens Hundreds
„Live“ bearing, (QDR-value)	L	X X X [CR][LF]      0° ... 359° (QDR)  Units Tens Hundreds
Status	S	X X X [CR][LF]  Error No.:      0 = Ok / 1...9 = Error No. actual Scan Mode      0 = Off 1 = Scan Mode: <a href="#">DOWN</a> 2 = Scan Mode: <a href="#">MO..9</a> 3 = Scan Mode: <a href="#">UP</a> 4 = Scan Mode: <a href="#">ACT/MO</a> Status Info:    0 = Bearing signal off 1 = Bearing signal on 2 = RF TX deviation (no bearing) 3 = Test 4 = Ground transmitter suppression 5 = (Reserved for testing)
Frequency	F	X X X X X X [CR][LF]      118,000 ... 174,000 MHz <sup>1)</sup>  kHz units kHz tens kHz hundreds MHz units MHz tens MHz hundreds
Receive level	P	0 X X [CR][LF]      000 ... 099 %  Units tens
Squelch Level	Q	0 X X [CR][LF]      000 ... 090 %  Units Tens
Serial No.	N	X X X X X X [CR][LF]      DF System Info  Licenced options: 0...8 Serial No. 00000...65534
Power On Time	T	X X X X X X [CR][LF]      000000 ... 999999 [minutes] (= max. 694 days)

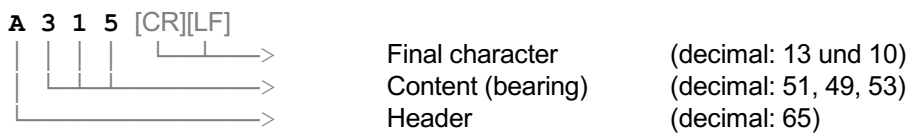
1) Frequency output in the range 118.000 .. 136.975 MHz in accordance with ICAO Annex 10 Vol. V Clause 4.1.2.4 Table 4-1.

See Chapter 2.3.24.2 / ICAO channel-frequency-table (air band)

**Timing und priority of cyclic data output**

Message		
„Average“ bearing	approx. every 0,25 sec	The first bearing value (after start of signal) will be transmitted immediately. Without signal, no average value will be transmitted.
„Live“ bearing	approx. every 0,1 sec	With low priority. (in all available transmission breaks). Without signal, no live bearing value will be transmitted.
Status	approx. every 0,5 sec	After start of signal, „S000[CR][LF]“ → „S1000[CR][LF]“ will be transmitted immediately.
Frequency	approx. every 2 sec	When frequency changes, the new frequency will be transmitted immediately (also at active Scan Mode)
Receive level	approx. every 0,5 sec	
Squelch Level	approx. every 2 sec	
Serial No.	approx. every 10 sec	
Power On Time	approx. every 60 sec	

The following example shows the output of the average QDR bearing 315° as a sequence of ASCII characters



**Example of 5 sec data output (with start of signal, respectively begin of bearing)**



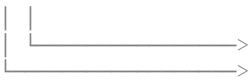

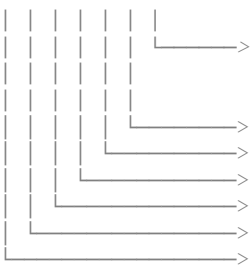
UTC Time (sec)	delta Time	Data Output (ASCII)	UTC Time (sec)	delta Time	Data Output (ASCII)	UTC Time (sec)	delta Time	Data Output (ASCII)
05:43:06.480	0.369	Q030\r\n	05:43:09.050	0.402	P017\r\n	05:43:10.856	0.050	L271\r\n
05:43:06.530	0.050	P017\r\n	05:43:09.158	0.107	S000\r\n	05:43:10.906	0.049	L271\r\n
05:43:06.620	0.089	S000\r\n	05:43:09.489	0.331	F121650\r\n	05:43:10.956	0.049	S100\r\n
05:43:06.782	0.162	N002545\r\n	05:43:09.555	0.066	P017\r\n	05:43:11.006	0.049	A271\r\n
05:43:07.018	0.235	P017\r\n	05:43:09.663	0.107	S000\r\n	05:43:11.056	0.050	L273\r\n
05:43:07.126	0.107	S000\r\n	05:43:10.063	0.399	P017\r\n	05:43:11.106	0.049	L262\r\n
05:43:07.444	0.318	F121650\r\n	05:43:10.171	0.107	S000\r\n	05:43:11.156	0.049	P045\r\n
05:43:07.525	0.081	P017\r\n	05:43:10.401	0.230	S100\r\n	05:43:11.206	0.049	L268\r\n
05:43:07.633	0.107	S000\r\n	05:43:10.451	0.049	A269\r\n	05:43:11.256	0.050	A270\r\n
05:43:08.033	0.399	P017\r\n	05:43:10.556	0.104	L265\r\n	05:43:11.306	0.049	L268\r\n
05:43:08.140	0.107	S000\r\n	05:43:10.606	0.049	P017\r\n	05:43:11.356	0.050	L276\r\n
05:43:08.259	0.119	T001334\r\n	05:43:10.756	0.050	Q030\r\n	05:43:11.406	0.049	L273\r\n
05:43:08.525	0.265	Q030\r\n	05:43:10.706	0.049	L272\r\n	05:43:11.456	0.050	L271\r\n
05:43:08.575	0.049	P017\r\n	05:43:10.756	0.050	A271\r\n	05:43:11.506	0.049	S100\r\n
05:43:08.648	0.072	S000\r\n	05:43:10.806	0.049	L276\r\n	05:43:11.556	0.050	A271\r\n

Remark:  
 Data logging with Wireshark via TCP/IP; Timestamp as additional info; final character is displayed here as „\r\n“ instead of [CR][LF]

**2.3.24.2 Data Input**

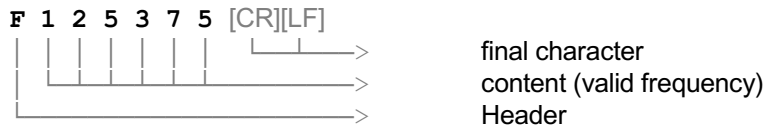
All received data are checked for correct syntax and plausibility referring to the actual unit setting. All received data are also checked for compliance with the limiting values. The data input is monitored over a time-out of 100 ms, i.e. all ASCII characters of a message must be transmitted to the bearing unit within this time.

If errors are found, the received commands are not carried out. A correct data input momentarily sets the direction finder to the required setting.

Message	Header	Content
Status	S	<p>X [CR][LF]</p>  <p>0 = Clear average memory                      1 = (not used)                      4 = Ground transmitter suppression active                      9 = Initiate System Reset</p> <p>3 = Clearance for EEPROM save functionality (1 sec active)</p> <p>2 = Scan Mode: <a href="#">M0..9</a> start / continue                      6 = Scan Mode: <a href="#">ACT/M0</a> start                      7 = Scan Mode: <a href="#">UP</a> start / continue                      8 = Scan Mode: <a href="#">DOWN</a> start / continue</p> <p>5 = Scan Mode: <a href="#">STOP</a> Stop (finish) active Scan Modes</p>
Frequency	F	<p>X X X X X X [CR][LF]</p>  <p>118,000 ... 174,000 MHz <sup>1)</sup></p> <p>kHz units                      kHz tens                      kHz hundreds                      MHz units                      MHz tens                      MHz hundreds</p>
Squelch Level	Q	<p>X X [CR][LF]</p>  <p>00 ... 90 % (Standard input for digital squelch)                      -1 (Receiver squelch potentiometer instead of digital squelch)</p> <p>units                      tens</p>
MEM Recall	R	<p>X [CR][LF]</p>  <p>0 ... 9</p> <p>Recall of one frequency memory from M0...9</p>
MEM Store	R	<p>X X X X X X X [CR][LF]</p>  <p>0 ... 9 (<a href="#">M0..9</a>)</p> <p>118,000 ... 174,000 MHz <sup>1)</sup> (valid frequency)</p> <p>kHz units                      kHz tens                      kHz hundreds                      MHz units                      MHz tens                      MHz hundreds</p>

1) Frequency input is possible only within the valid range. Frequency settings in the range 118.000 .. 136.975 MHz have to be in accordance with ICAO Annex 10 Vol. V Clause 4.1.2.4 Table 4-1. Other inputs will be ignored (also see ICAO channel frequency table next page).

The following example shows the data sequence for the frequency command (set new frequency 125,375 MHz)



**ICAO channel-frequency-table (air band):**

Frequency [MHz]	Channel grid	Channel / Frequency Input FXXXXXXCRLF
118,0000	25 kHz	118000
118,0000	8,33 kHz	118005
118,0083	8,33 kHz	118010
118,0167	8,33 kHz	118015
118,0250	25 kHz	118025
118,0250	8,33 kHz	118030
118,0333	8,33 kHz	118035
118,0417	8,33 kHz	118040
118,0500	25 kHz	118050
118,0500	8,33 kHz	118055
118,0583	8,33 kHz	118060
118,0667	8,33 kHz	118065
118,0750	25 kHz	118075
118,0750	8,33 kHz	118080
118,0833	8,33 kHz	118085
118,0917	8,33 kHz	118090
118,1000	25 kHz	118100
118,1000	8,33 kHz	118105
118,1083	8,33 kHz	118110
~~~~~		
136,9583	8,33 kHz	136960
136,9667	8,33 kHz	136965
136,9750	25 kHz	136975

**Remark for frequency- and squelch input:**

If a newly tuned frequency or squelch value are retained permanently in the system, even after a RT-1000 device restart, it must be stored in the EEPROM device in addition. This is done by directly transmitting a previous "S3 [CR] [LF]" commands.

Warning: Since the allowable write cycles to EEPROMs are limited, this option should be used only when necessary.

**Remarks for Scan Mode:** see also chapter 2.3.6 Scanning

**Example of frequency change Data In/Output:**

Frequency-change to 133,400 MHz (with 8.33 kHz ICAO grid) using a data input message.

„Fxxxxxx[CR][LF]

Remark:  
After valid data input, the new changed frequency will be transmitted immediately ...

Data logging with Wireshark via TCP/IP;  
Timestamp as additional info;  
final character displayed as „\r\n“ instead of [CR][LF]

UTC Time (sec)	Data Output (ASCII)
08:11:41.662	P017\r\n
08:11:41.712	Q040\r\n
08:11:41.828	F118000\r\n
08:11:42.046	S000\r\n
08:11:42.170	P017\r\n
08:11:42.554	S000\r\n
08:11:42.679	P017\r\n
08:11:42.681	<b>F133405\r\n</b>
08:11:42.865	F133405\r\n
08:11:42.940	N002545\r\n
08:11:43.063	S000\r\n
08:11:43.184	P017\r\n
08:11:43.570	S000\r\n
08:11:43.692	P016\r\n
08:11:43.742	Q040\r\n
08:11:44.076	S000\r\n
08:11:44.199	P014\r\n
08:11:44.584	S000\r\n
08:11:44.708	P014\r\n
08:11:44.904	F133405\r\n
08:11:45.092	S000\r\n

**Example of storing one frequency to memory Data In/Output:**  
(is used as example, when configuring Scan Mode M0..9)

Frequency 156,800 MHz is stored to MEM3. and then recalled from the same memory for verifying:

- „S3[CR][LF]“  
(Clearance for EEprom)
- „Rxxxxxx[CR][LF]“  
(Store to M3)
- „Rx[CR][LF]“  
(Recall/Read from M3)

Remark:  
After valid data input, the new changed frequency will be transmitted immediately ...

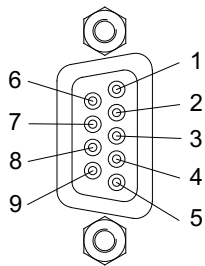
Data logging with Wireshark via TCP/IP;  
Timestamp as additional info;  
final character displayed as „\r\n“ instead of [CR][LF]

UTC Time (sec)	Data Output (ASCII)
08:54:11.917	S000\r\n
08:54:12.039	P016\r\n
08:54:12.280	F156100\r\n
08:54:12.423	S000\r\n
08:54:12.546	P016\r\n
08:54:12.673	<b>S3\r\nR1568003\r\n</b>
08:54:12.911	F156800\r\n
08:54:12.961	S000\r\n
08:54:13.077	P016\r\n
08:54:13.461	S000\r\n
08:54:13.463	<b>R3\r\n</b>
08:54:13.595	F156800\r\n
08:54:13.645	P016\r\n
08:54:13.720	N002545\r\n
08:54:13.770	Q040\r\n
08:54:13.968	S000\r\n
08:54:14.093	P016\r\n
08:54:14.478	S000\r\n
08:54:14.599	P016\r\n
08:54:14.984	S000\r\n
08:54:15.106	P016\r\n
08:54:15.491	S000\r\n
08:54:15.615	P017\r\n
08:54:15.690	F156800\r\n

**2.3.24.3 Technical Data**

Data format: ASCII-8-Bit (7 data bits + 1 parity bit)  
 (ASCII-II-character format)  
 Stop bit: 1  
 Parity: ODD  
 Baud rate: 1200  
 Mode: asynchronous  
 Level: RS-232  
 High: +3 V to +15 V  
 Low: -3 V to -15 V  
 Bearing output: QDR

**2.3.24.4 "Ser. Port" Plug Wiring (30)**

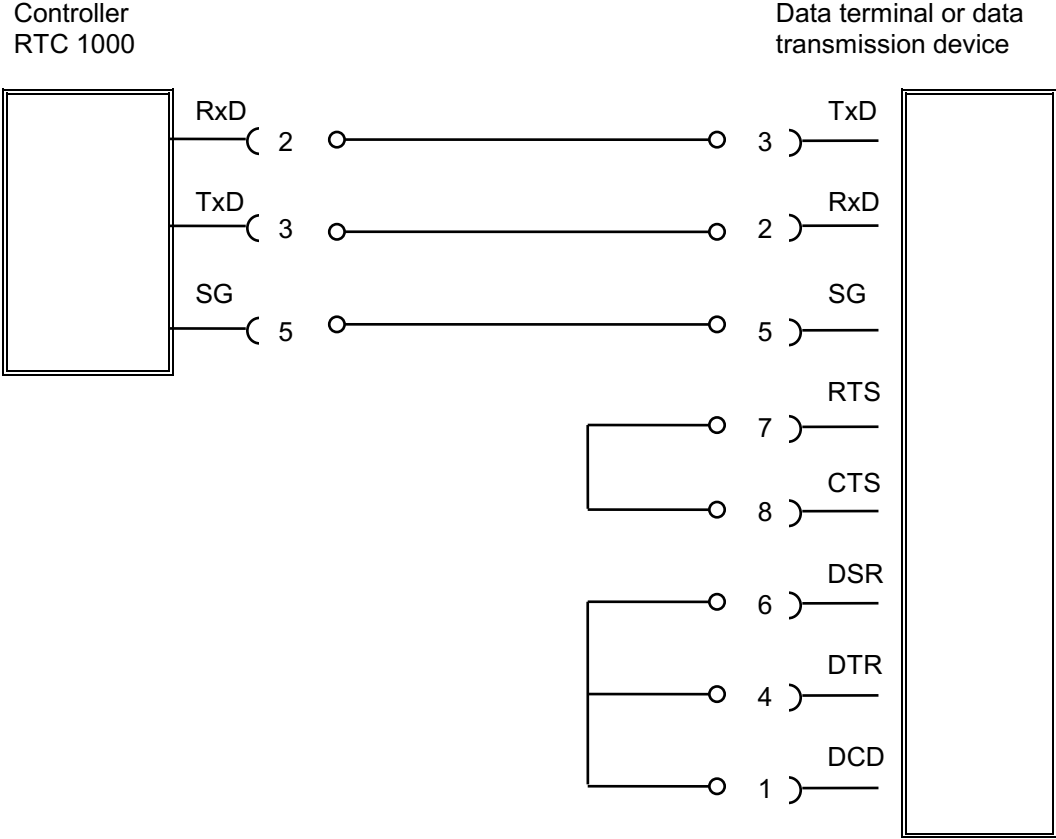


Multipoint connector, 9-way  
 Type: D sub miniature

PIN	Designation	Function	Input	Output
1	-	not wired		
2	RxD	Receive Data	X	
3	TxD	Transmit Data		X
4	-	not wired		
5	SG	Signal Ground		
6	-	not wired		
7	-	not wired		
8	-	not wired		
9	-	not wired		



2.3.24.5 Connection to a Data Terminal or Data Transmission Device

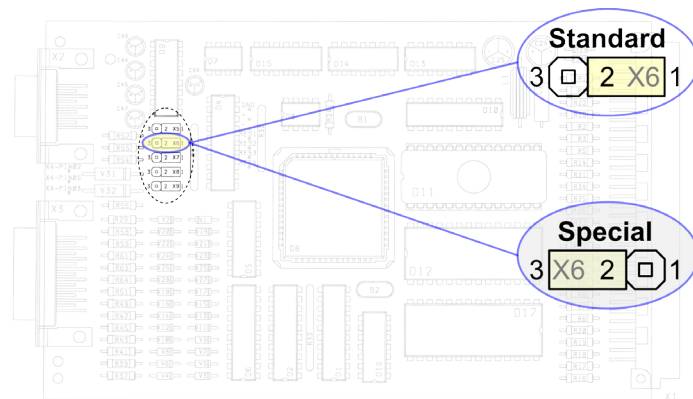


The pin numbering of the data terminal device connector applies for most PCs with 9-way D-Sub connectors. The terminal wiring has to be checked individually.

**2.3.24.6 Compatibility mode**

It is possible to select a compatibility mode for the serial interface. This can be useful if the interface is connected to already existing applications which cannot handle the new messages of the data output (RT-1000 system revisions of [Rev 4.00.00] or higher).

This setting has to be done on the module CPU (RTC 1104). For this purpose, the module has to be removed and the jumper X6 has to be set.



**Standard jumper setting:**

- All serial data outputs as described

**Special jumper setting:**

Serial data output as described but with the following exceptions:

- Each transmitted message will be finished with “CR” only (no “LF”)
- The messages for level “P..”, squelch level “Q..”, Serial No. “N...” and Power On Timer “T...” will be suppressed
- No Scan Mode Status output

**NOTE**

The compatibility mode corresponds to the serial output of CPU software [Rev ≤ 2.02].

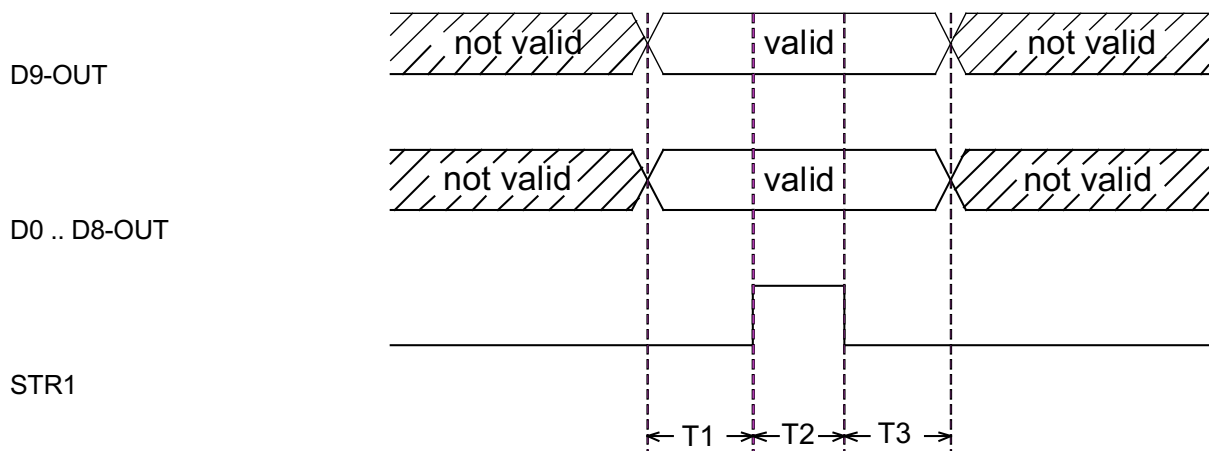
**2.3.25 "Parallel Port" Parallel Interface (31)**

The parallel interface (31, Fig. 2-2) is available for service purposes only. It will not be described here.

**NOTE**

Beginning with [Rev 4.00] of the CPU software, the output of the bearing result on the serial interface is not supported anymore.

### 2.3.25.1 Time Sequence



### 2.3.26 R/L Off Button (42)

The R/L Off button (42, Fig. 2-2) interrupts the right/left antenna rotation control. If this button is pressed and a received signal is present, the value 000° or 180°+ north adjustment (set on the controller) appears on the QDM display of the controller.

### 2.3.27 “IF” Intermediate Frequency Jack (43)

The intermediate frequency signal supplied by the receiver can be tapped at the IF SMB jack (43, Fig. 2-2).

Only for service use.

### 2.3.28 Receiver Status Indication (44, 45, 46, 47, 48)

After switching on, the green control lamp (44, Fig. 2-2) of the receiver RTR 1204 lights up. This shows that the power supply module is functioning correctly.

The yellow squelch control lamp (45, Fig. 2-2) lights up as soon as a signal of sufficient strength (signal strength is above the squelch threshold) is received. This shows that a bearing signal may be processed by the controller.

The red frequency offset control lamps (46, 47, Fig. 2-2) light up if a signal with a frequency deviation larger than allowed is received. This shows that a signal is being received which is not suitable for direction finding purposes.

#### NOTE

During the switch-on routine, the lamps are illuminated shortly

In case of a PLL lock error, the red lamp "No Sync" (48, Fig. 2-2) illuminates. It indicates a failure on the receiver RTR 1204.

#### NOTE

During the switch-on routine or while changing the operational frequency of the receiver the lamp is illuminated shortly.

### 2.3.29 Manual Squelch Adjustment Potentiometer (49)

Normally, the manual squelch adjustment is not in use.

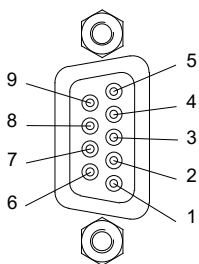
The activation is described in chapter 2.2.11.

Behind the hole (49, Fig. 2-2) there is a potentiometer which allows squelch adjustment. For this purpose, a small screw driver is necessary. Normally, the factory setting should not be changed.

If turning clockwise, the squelch threshold is reduced while turning counter-clockwise, the squelch threshold is increased.

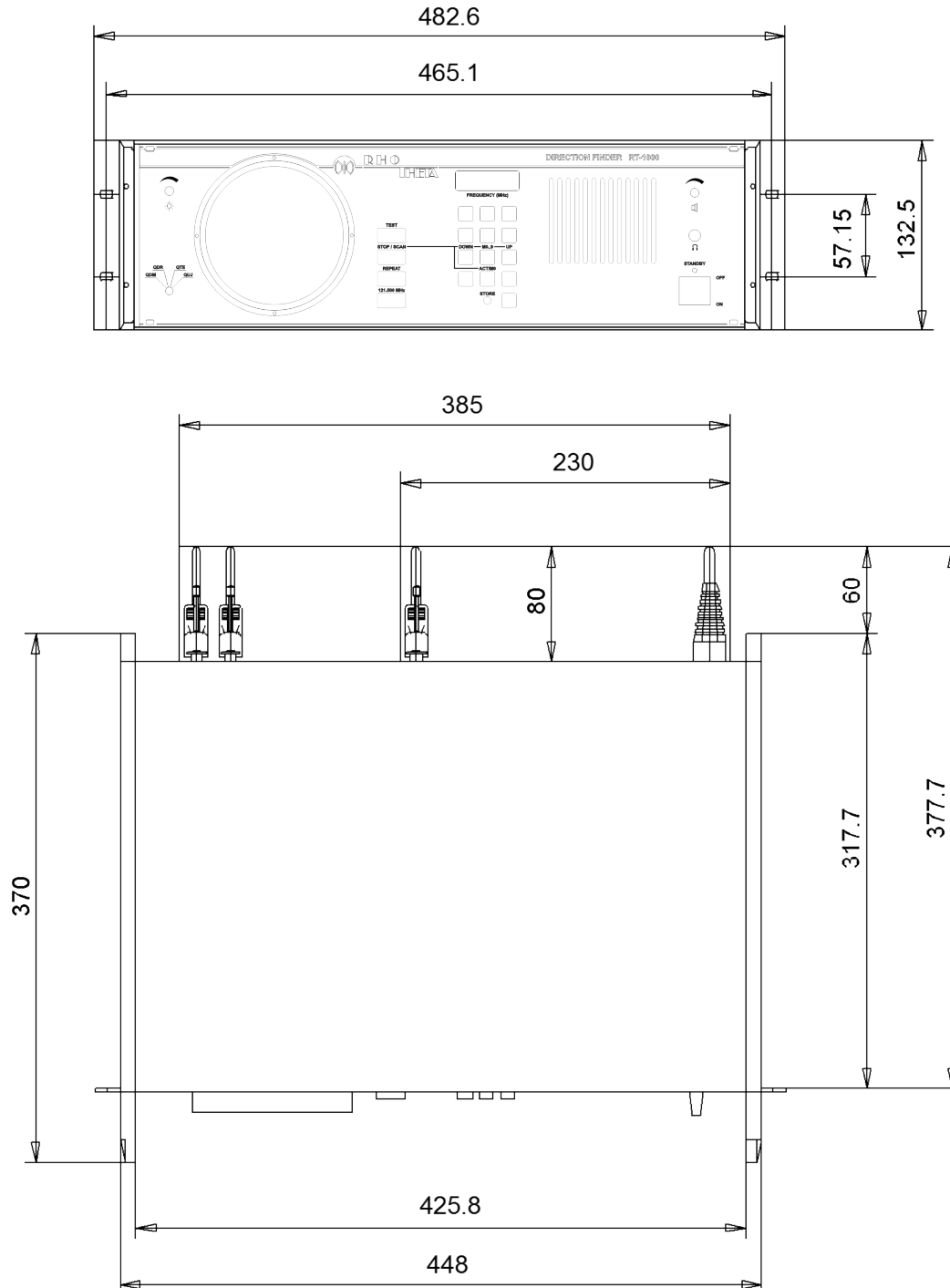
### 2.3.30 Antenna Control Jack (50)

The antenna control D-Sub jack (50, Fig. 2-2) is used to connect the RTA-1300.A Antenna or the RTM 1500 Dummy Antenna for testing purposes. Additionally, the R/L signal is available.

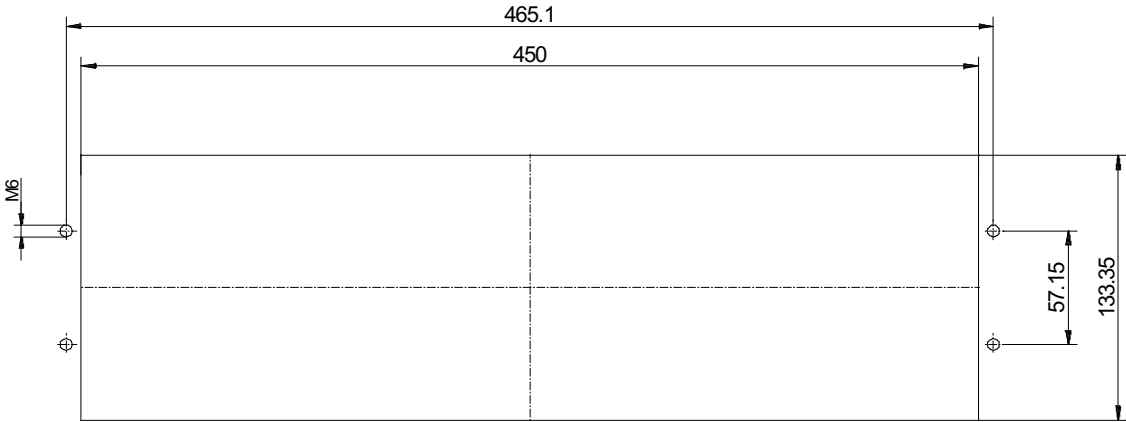


PIN	Signal	Function
1	OST-X2	Antenna control signal, east
2	WEST-X2	Antenna control signal, west
3	GND	Ground
4	GND	Ground
5	+15V-X2	+15-V supply
6	SUED-X2	Antenna control signal, south
7	NORD-X2	Antenna control signal, north
8	R/L	Right/left rotation change-over signal
9	+15V-X2	+15-V supply

## 2.4 Installation Dimensions



Mounting Cut-out



## **4 DIRECTION FINDER ANTENNA RTA-1300.A**

### **List of Content**

<b>4</b>	<b>DIRECTION FINDER ANTENNA RTA-1300.A .....</b>	<b>4.1</b>
<b>4.1</b>	<b>Installation.....</b>	<b>4.3</b>
4.1.1	General .....	4.3
4.1.2	Reflections and their influence of the bearing result .....	4.3
4.1.3	Influence of ground reflections to the DF accuracy .....	4.7
<b>4.2</b>	<b>Notes on Fig. 4-8 / 4-9, RTA 1300.A Direction Finder Antenna .....</b>	<b>4.12</b>
<b>4.3</b>	<b>Assembly Instructions .....</b>	<b>4.15</b>
<b>4.4</b>	<b>North Alignment of the Direction Finder Antenna and Determining the System Accuracy at the Installation Site.....</b>	<b>4.18</b>
4.4.1	North Alignment Using a Ground Transmitter (Pre-setting) .....	4.18
4.4.2	Flight Checking for Exact North Alignment and Determining the System Accuracy at the Installation Site .....	4.19
4.4.2.1	Determining the Position Using a Theodolite .....	4.20
4.4.2.2	Determining the Position Using a GPS Receiver .....	4.20
4.4.2.3	Simplified Method .....	4.21
4.4.3	Evaluation .....	4.21
4.4.3.1	Evaluation of Direction Finding Signal .....	4.21
4.4.3.2	Evaluation of QDR Live Display (Yellow Light Dot Circle).....	4.25
4.4.3.3	Evaluation of Measuring Results.....	4.26
4.4.4	Determining the North Correction .....	4.27
<b>4.5</b>	<b>Installation Dimensions .....</b>	<b>4.28</b>

**List of Figures**

Fig. 4-1	Free-space propagation of radio waves	4.4
Fig. 4-2	Field of lines of equal phase relations for two coherent waves	4.5
Fig. 4-3	Reflected path distance and direct path distance of the radio wave	4.6
Fig. 4-4	The phases between a direct wave W and reflected wave R	4.7
Fig. 4-5	Signal strength lobes plotted against angle of elevation	4.8
Fig. 4-6	Influence of ground reflection to the bearing result	4.10
Fig. 4-7	Surveying the direction finder using radial and circular flights	4.11
Fig. 4-8	RTA 1300.A Direction Finder Antenna	4.13
Fig. 4-9	RTA 1300.A Direction Finder Antenna (bottom view)	4.14
Fig. 4-10	Fitting O-ring	4.15
Fig. 4-11	Allocation of connections	4.15
Fig. 4-12	Assembly of radiators	4.16
Fig. 4-13	Setting up the ground transmitter	4.19
Fig. 4-14	DF signal 2 and R/L signal for undisturbed reception	4.22
Fig. 4-15	DF signal 2 and R/L signal with a modulated reception signal	4.23
Fig. 4-16	DF signal 2 and R/L signal with noisy reception signal	4.23



## **4.1 Installation**

### **4.1.1 General**

DF systems are used to locate aircraft, ships, vehicles or persons who have a radio transmitter. All prevalent DF systems determine the direction from which the signal reaches the DF antenna. If this direction is the same as the direction to the aircraft, to the vessel or to the vehicle, everything is fine. If, because of shadowing or reflections, the radio signal arrives to the DF antenna not in a direct way, the direction finder shows the direction to the reflector, where the signal (or the majority of the signal) comes from, and not the direction to the signal source.

This direction may have a big difference to the direction to the source of the signal, the aircraft, the vessel or the vehicle where the transmitter is located. The operator will regard this as a malfunction of the direction finder. In the physical way, this is not true. The problem is that the bearing we get from the direction finder is not the information the operator desires.

In practice, this means that we have to find an antenna location where the radio signals always arrive to the antenna in a direct way.

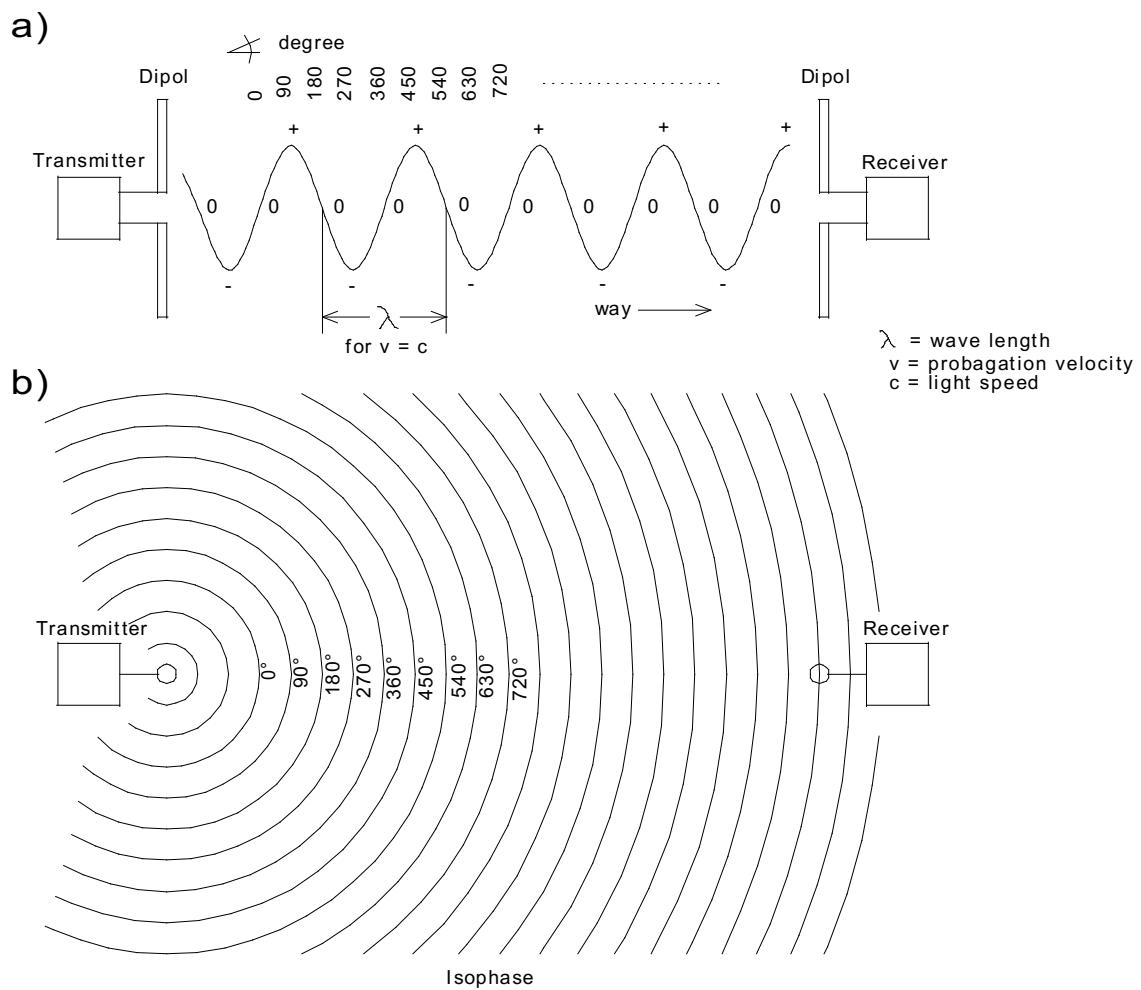
The achievable bearing accuracy largely depends on the physical conditions at the antenna location.

The remote concept of the RT-1000 C direction finder system separates the antenna and the high frequency components (Antenna RTA 1300.A, Receiver Unit RTR 1200.A) from the controller (Controller RTC 1100A) side performing the signal processing. So it is easy to place the antenna somewhere in the open field where the physical conditions are good, while the Controller is located at the tower side. The following information should help you to find a physically convenient antenna location.

The information also applies to RT-1000 A direction finder systems, where receiver and controller unit are not separated. This might be useful if the RT-1000 A shall be remote controlled e.g. by a command and control software and may be installed close to an antenna site as recommended in this document. In all other cases, if bearing results of the RT-1000 A would not be sufficiently accurate due to the required unfavourable antenna position close to the controller, RT-1000 C should be chosen instead.

### **4.1.2 Reflections and their influence to the bearing result**

The antenna of a direction finder system can be considered as a sensor which analyses the incoming electromagnetic wave field to find out where it comes from. Similar to the waves on a quiet water surface, radio waves in the free (unobstructed) field spread out circular from around the transmitter, too.



**Fig. 4-1** Free-space propagation of radio waves

Figure 4-1 gives an extremely simplified representation of even radio wave propagation in free space. The sine wave in part a) corresponds to the instantaneous value of the electric field on the plane path to the receiver. Part b) is the vertical projection of part a). The circles represent the lines of equal phase relations for even waves.

If the distance between transmitter and receiver is adequate, these are practically straight lines when they reach the receiver location. Such an idealized situation is not to be found in areas covered with buildings, and especially not in mountainous regions. In such areas, the propagation path is obstructed by obstacles, mirror reflectors, diffuse reflectors with and without absorption characteristics, diffracting edges and resonators. Reflectors and conductive rods are acting as resonators if their size is approximately that of the wavelength to be received. Therefore, reflections increase as wavelengths become shorter, diffractions at edges however are reduced and so the effect of shadowing by obstacles is more important.

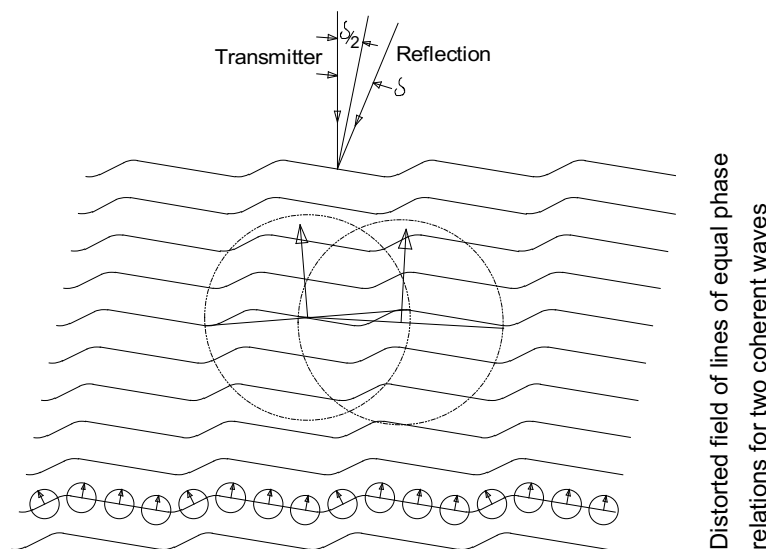
Accordingly, the propagation characteristics of radio waves of a wavelength of approximately  $\lambda < 10$  m increasingly resembles those of light.

At a wavelength of 1 m to 3 m, wave propagation requires a direct path and if this is not available, only reflected waves are received. In urban areas, these may come from several directions simultaneously. But there is more to it than that: The waves transmitted by the transmitter, usually of horizontal or vertical polarization, are also rotated to a certain degree due to diffuse reflectors and diffracting edges. If the wave arrives at the receiver, it may be oblique, elliptical, or even circular polarized. This fact becomes apparent by the curious antenna positions which often are necessary to obtain the best reception of radio or television waves.

These points should show that in the VHF / UHF range, direction finding of a stationary transmitter using a stationary direction finder in an area covered by buildings or even inside a building is practically impossible.

Conditions at airports are much more favourable. These instructions are intended to allow the best positioning of the direction finder antenna to be found.

Of course, airports are not free of reflectors, but these normally do not cause noticeable problems. All direction finders with field probes calculate the angle of signal incidence by finding out the path direction (vector) at which the largest phase modification per unit of distance is present.



**Fig. 4-2** Field of lines of equal phase relations for two coherent waves

In Figure 4-1 this vector is vertical

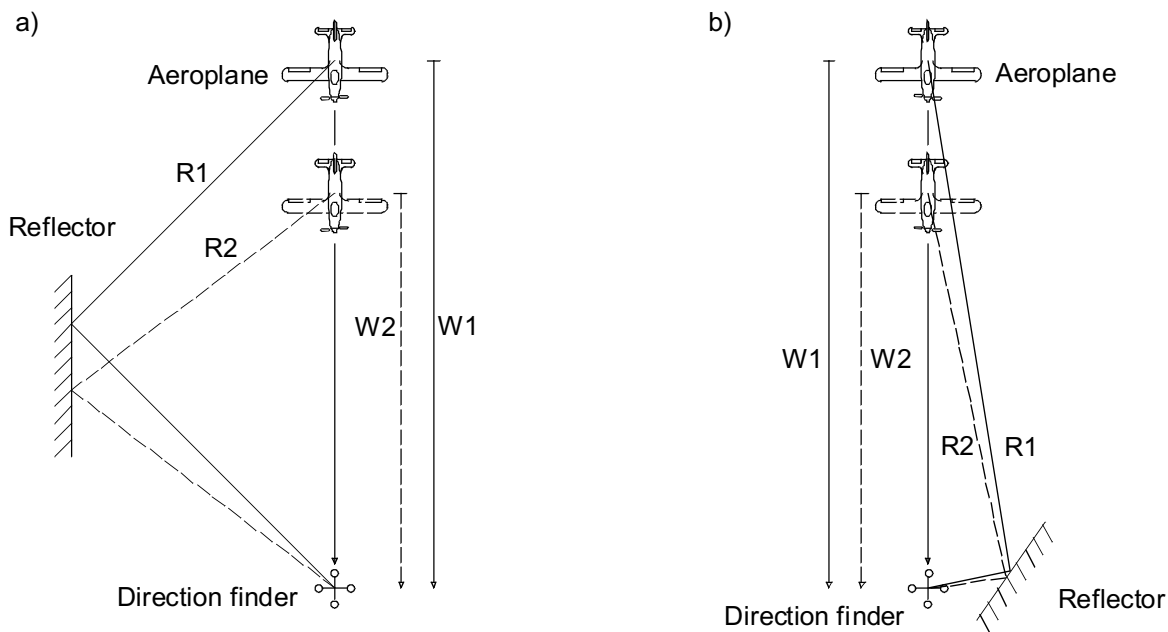
to the lines of equal phase relations. Figure 4-2 shows the distorted field of lines of equal phase relations for two coherent waves (reflection) from different directions with different field strengths.

Mainly 4 parameters are influencing the deviation of the bearing caused by reflections.

1. Position of the DF antenna
2. Position for the transmitter antenna
3. Position of the reflector
4. Wave length of the signal (signal frequency)

The advantage of wide-aperture direction finders is most noticeable in static conditions. Static conditions means that the position of the transmitter and direction finder as well as the transmitter frequency are constant in time. Should one of the four items named change (e.g. transmitter in aeroplane), the direction finder antenna and the field of lines of equal phase relations begin to move in relation of one among another. This movement accelerates proportionally to the relationship between the reflected path distance and the direct path distance of the radio wave (Figure 4-3).

As shown in Figure 4-2, in the case of wide-aperture direction finders, this movement causes slight azimuth oscillations. In contrary, this oscillation is larger in the case of compact direction finders - the series of small circles in Figure 4-2. If several values are averaged, however, both systems compute the same azimuth.



**Fig. 4-3** Reflected path distance and direct path distance of the radio wave

favourable:

unfavourable:

$$W1/W2 \gg R1/R2$$

$$W1/W2 \approx R1/R2$$

With moving transmitter:

Rapid phase shifting between  $W$  and  $R$  signal, therefore good bearing average possible

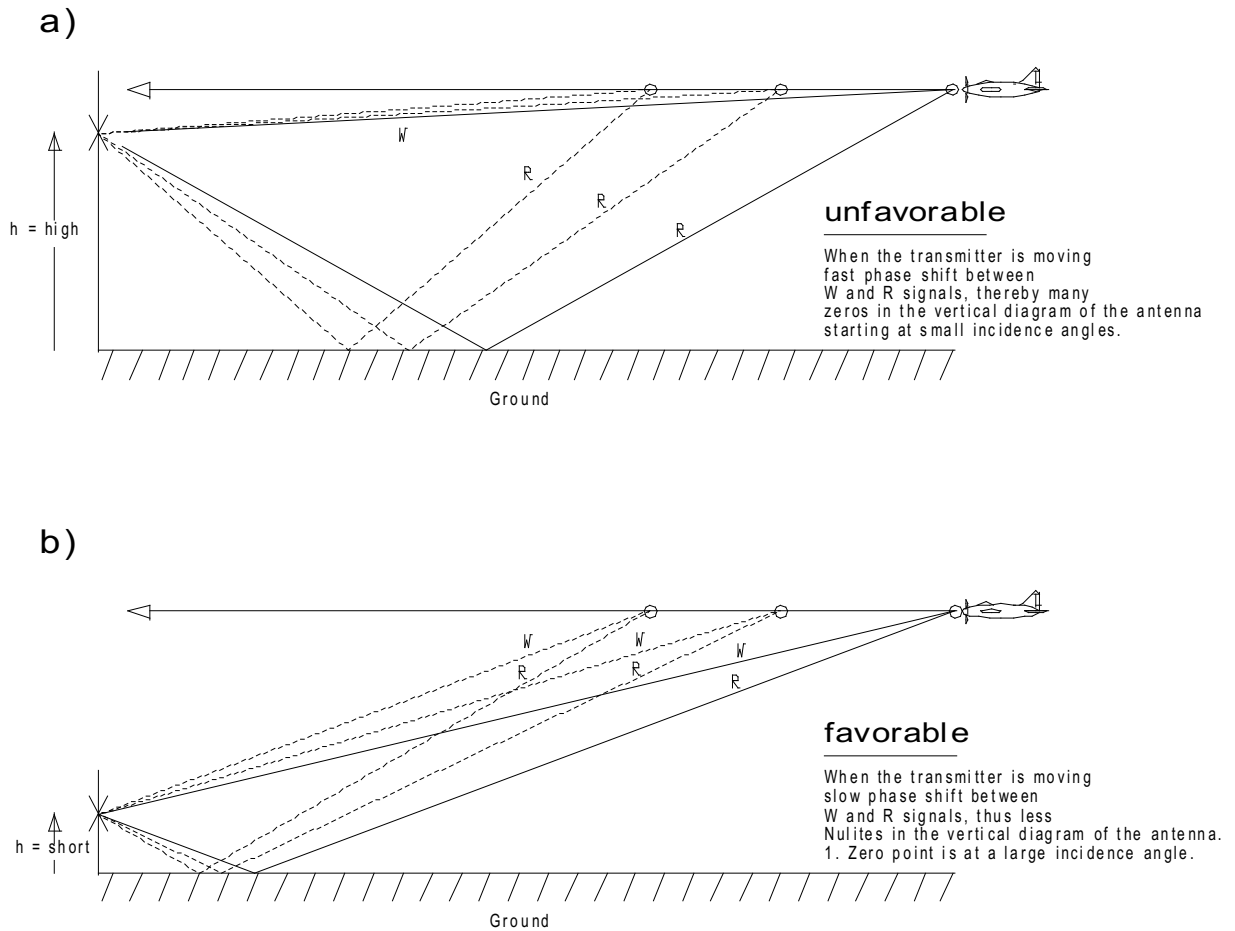
Only very slow phase shifting between  $W$  and  $R$  signal, so no averaging possible. The displayed bearing is oscillating slowly around the rated value.

**The following conclusions can be drawn:**

**Vertical reflector surfaces e.g. buildings, hangars, metal fences, metal masts, overhead lines as well as bushes and trees should not be within 100 m of the direction finder antenna if possible.**

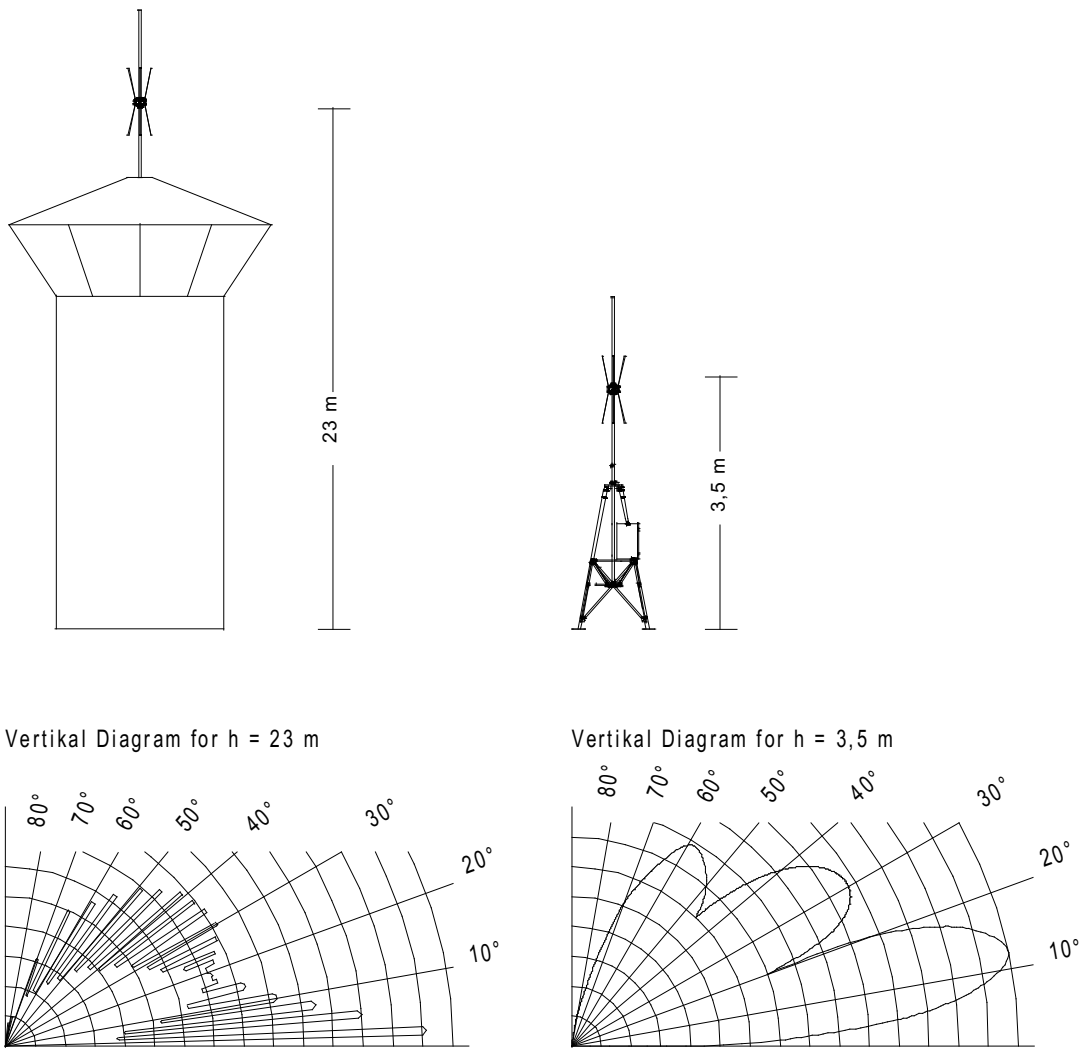
### 4.1.3 Influence of ground reflections to the DF accuracy

The signal transmitted by an aircraft transmitter will reach the DF antenna on the direct way. Additionally, a part of the signal will be reflected at the ground and will reach the antenna as well. Depending on the angle of incidence and the height at which the DF antenna is located above the ground, the direct signal and the reflected signal have to propagate over different distances.



**Fig. 4-4** The phases between a direct wave W and reflected wave R

As consequence, there are angles of the vertical angle of incidence of the signal where the signals are in phase and others where the signals arrives at the antenna in opposite phases. In the first case, the direct and the ground signal add each other, in the other case, the direct signal is cancelled or reduced by the ground-reflected signal. This is the reason why the vertical antenna diagram shows more zeros as higher as the antenna is being placed (see Fig. 4-5).



**Fig. 4-5** Signal strength lobes plotted against angle of elevation

The zeros of the vertical diagram can be determined using the following formula:

$$\tan \alpha = \frac{\lambda}{2h} n ; \lambda = \frac{c}{f} ; c = 299792458 \text{ m/s} ;$$

c= light velocity [m/s]

$\lambda$ = wave length of the signal [m]

h = height of the antenna head above the ground [m]

n = ordinal numeral of the zero point (1. 2. 3....)

f= signal frequency [Hz]

On its own, zeros in the vertical antenna diagram will not cause bearing failures. They only will cause a significant reduction of the signal field strength. The ground will absorb a part of the signal and not 100% will be reflected. In practice, the direct incoming signal and the ground reflected signal will not compensate each other, so that an attenuated signal is received.

In the area of the zeros of the antenna diagram, the direct signal from the aircraft will be attenuated by the ground reflection. All other signals, which reach the antenna through horizontal reflectors, will not be attenuated and now are strong in relation to the direct signal. The direction finder is not able to distinguish between direct and reflected signals. It shows the direction to the reflector from which, now, the strongest signal comes from. If an aircraft flies through the maxima and minima of the DF antenna while approaching the airport, significant bearing value fluctuations may occur. The cause is that the field strengths of the direct signal or of the reflected signal, will predominate alternating (see Fig 4-6).

If the antenna is mounted on the RHOTHETA antenna mast RT-1306, the antenna head is about 4 Meters above the ground. The 1. zero point will be in an elevation of approx.  $17^\circ$  above the horizon.

In the areas which are relevant for the air traffic controller (report points, traffic pattern, .. ), the aircrafts stays below of the first zero point.

The roof of the tower is, from a physical point of view, the worst antenna position to be found on an airfield. The very high antenna position with its unfavourable vertical antenna diagram, in combination with a lot of buildings around it, as well as other antenna systems and reflectors on the tower roof will influence the DF results in most applications to a not acceptable amount. The full performance of the DF system will be achieved only in very rarely cases on such an antenna position.

**The following conclusion may be drawn:**

**The best position for a direction finder antenna is on a flat surface at a distance from vertical reflectors, only 3.5 to 4 m above the ground.**

Summarized, we can state:

An antenna location in a free area, a few meters above the ground and in an ambit of some 100 meters free of reflecting obstacles, will give satisfying bearing results. An antenna position more than 10 meters above ground can be a problem and should be evaluated by a flight test before final installation.

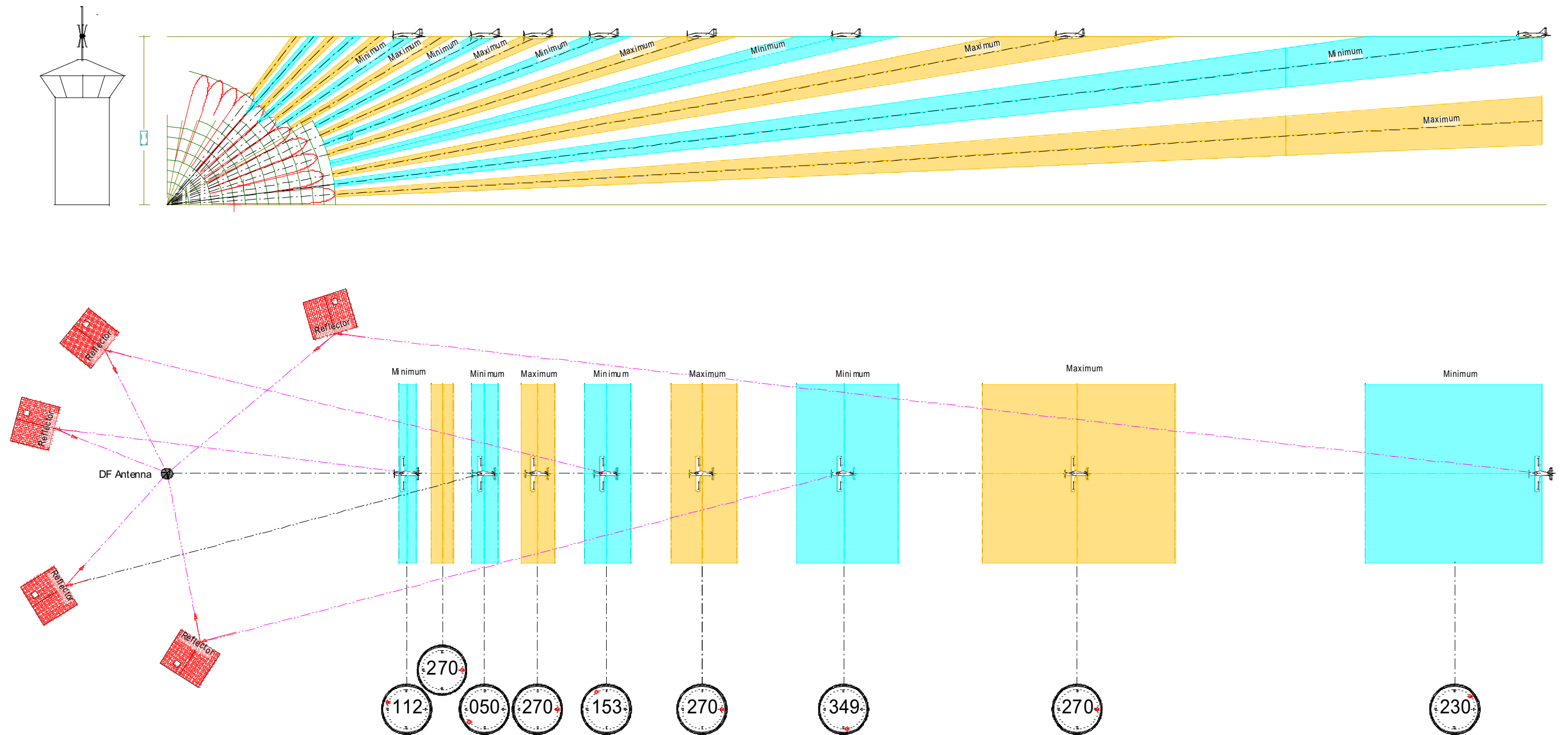
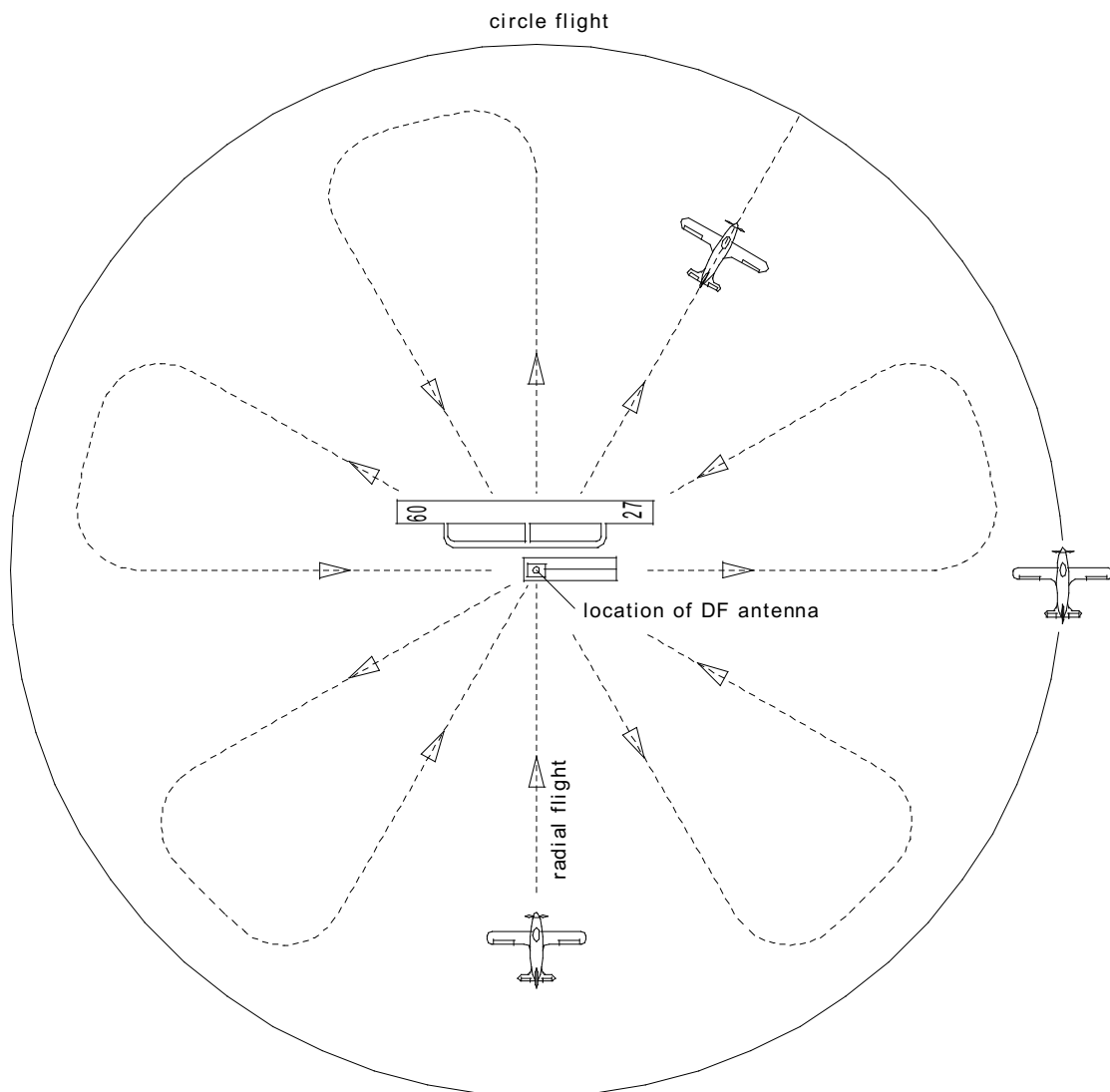


Fig. 4-6 Influence of ground reflection to the bearing result



In order to carry out evaluation and acceptance test, the direction finder is subjected to a "flight test" (Figure 4-7). By means of circular flights approx. 5 to 10 km away, the angular accuracy and influences due to vertical reflectors are calculated. These circular flights should be carried out in both directions in order to eliminate any possible "lag error" in the direction finder display. The aeroplane is tracked using a theodolite erected next to the direction finder antenna and angle values from this are compared with those from the direction finder display. It is also possible to do this with a GPS based procedure. There, the exact DF antenna position is stored as a way point in the GPS of the aircraft or vessel. During the test flight, the pilot transmits the GPS bearing to the DF side. Here, both bearings can be compared. RHOTHETA can support you with an automatic test recording system in this case.

During the radial flights, the aeroplane flies across the direction finder from various directions to find out detrimental ground reflections and the cone of silence, the area above the direction finder where no usable information can be obtained from the direction finder. These over-flight measurements are especially important for testing the usefulness of a direction finder antenna set-up on the tower.



**Fig. 4-7** Surveying the direction finder using radial and circular flights

## 4.2 Notes on Fig. 4-8 / 4-9, RTA 1300.A Direction Finder Antenna

No.	Designation	Function
1		Lightning conductor rod
2		Radiator cover
3		Radiator
4		Clamping nut
5		Radiator flange
6		Antenna head
7		North dipole label
8		Mast tube
9	X 21	Flat plug for control cable connection
10	X 13	Flat plug for control cable connection
11	X 17	Flat plug for control cable connection
12	X 15	Flat plug for control cable connection
13	X 19	Flat plug for control cable connection
14		Radiator housing
15		BNC jack for antenna cable
16		Cord grip
17	X 22	Flat plug for control cable connection
18		Radiator housing cover

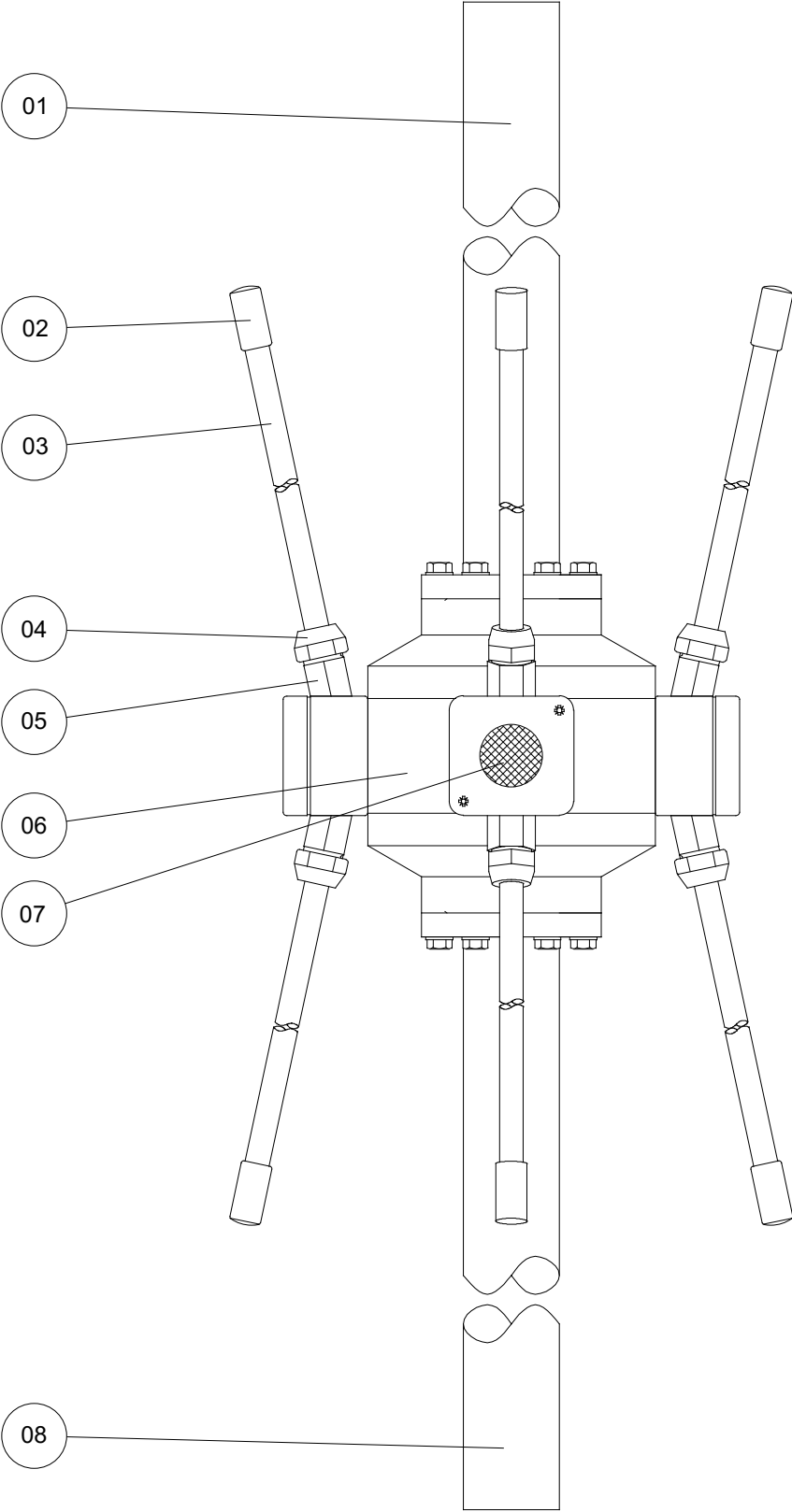


Fig. 4-8 RTA 1300.A Direction Finder Antenna

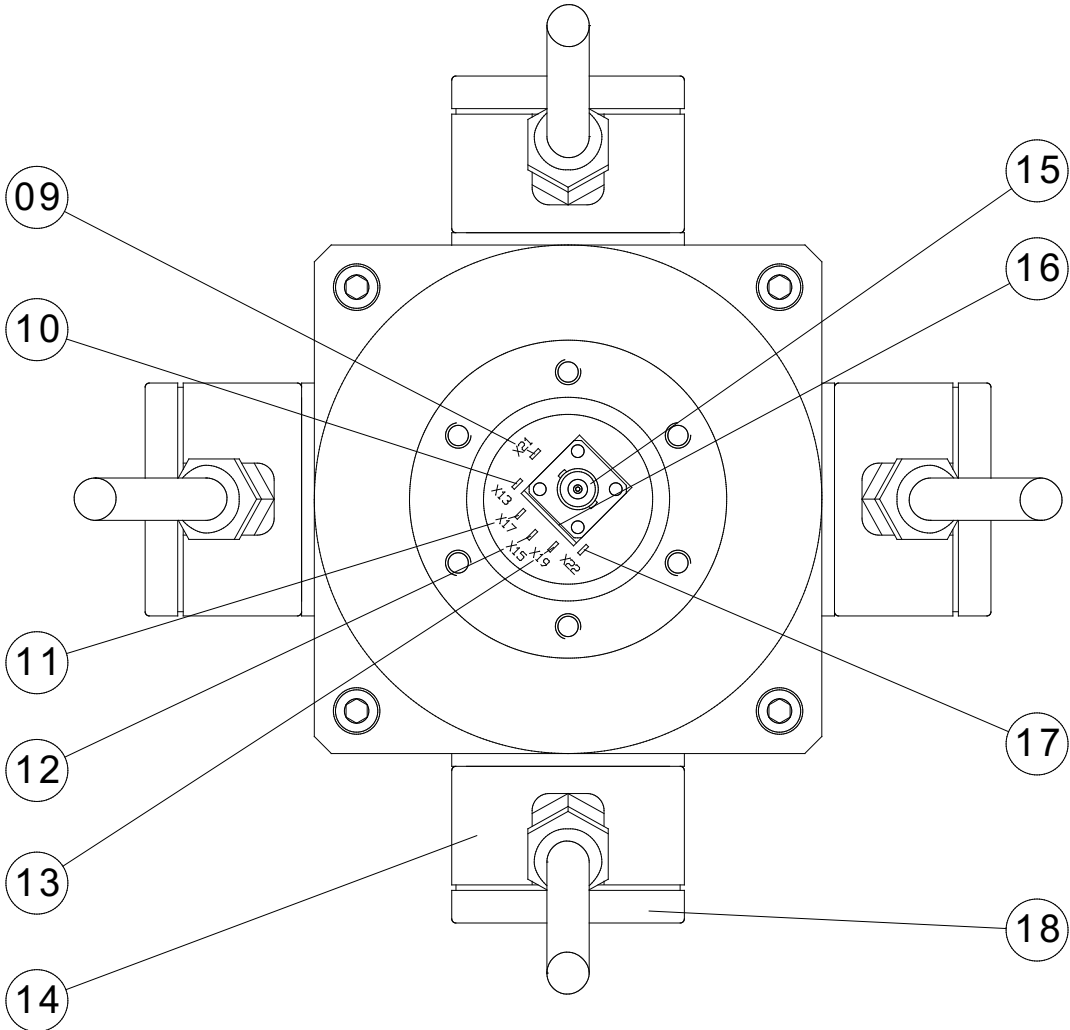
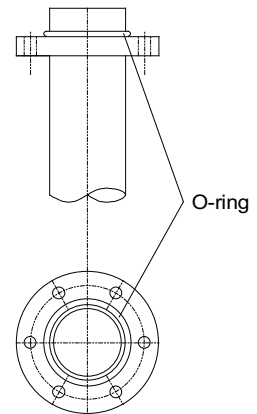


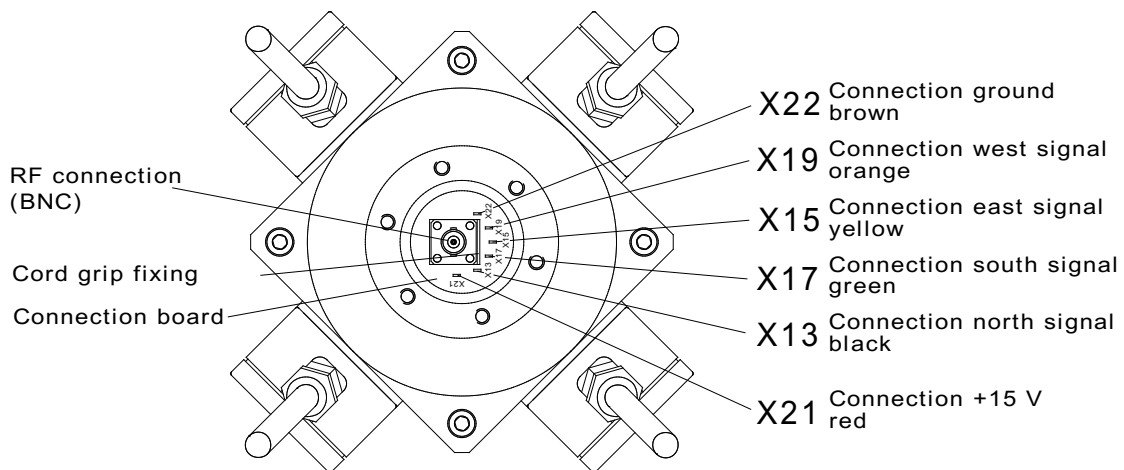
Fig. 4-9 RTA 1300.A Direction Finder Antenna (bottom view)

### 4.3 Assembly Instructions

1. Fit O-ring on mast tube.  
(see Figure 4-10).
2. Pull antenna cable through mast tube.
3. Connect RF cable.
4. Screw cord grip fixing to clamp RF cable.
5. Plug the control cable into the connection board:
  - Using pointed flat-nose pliers, grip the flat plug covers and push fully onto the flat plugs.
  - Push guard sockets back on again.



**Fig. 4-10** Fitting O-ring



**Fig. 4-11** Allocation of connections

Allocation of connections:

Flat plug name	Control cable colour	Signal
X22 (GND)	brown	Ground
X13 (NORTH)	black	North dipole control current
X17 (SOUTH)	green	South dipole control current
X15 (EAST)	yellow	East dipole control current
X19 (WEST)	orange	West dipole control current
X21 (+15 V)	red	15-V supply voltage

6. Apply a thin coat of grease to the antenna head / mast tube contact faces.
7. Screw antenna head onto mast tube.
8. Fit O-ring to lightning conductor rod (see Fig. 4-10).
9. Apply thin coat of grease to antenna head / lightning conductor rod contact faces.
10. Screw lightning conductor rod onto antenna head.
11. Fix radiators (see Fig. 4-12):
  - Push clamping nut, clamping cone, washer and rubber seal onto radiator.
  - Push radiator fully into recess for radiator.
  - Carefully tighten clamping nuts.
12. Erect mast tube (if not already done).
13. Earth mast tube.
14. Align antenna
  - Point north dipole (marked by red point on radiator housing) northwards.

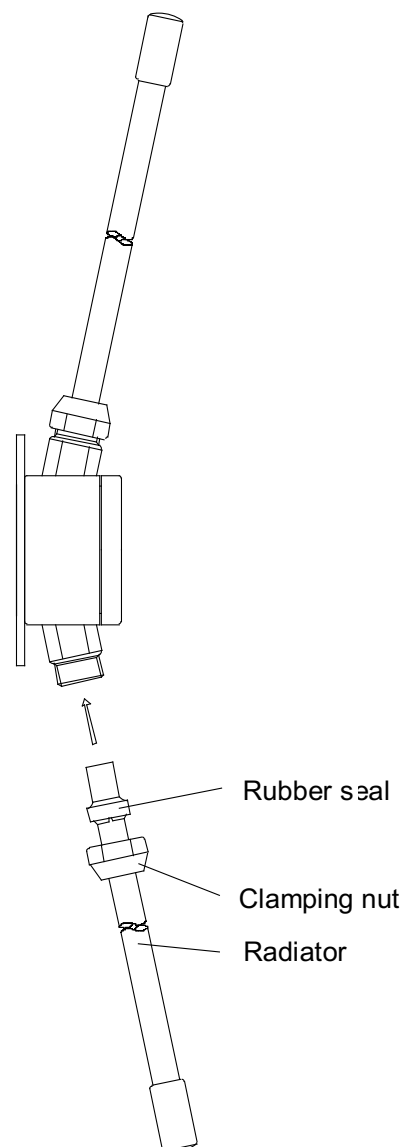


Fig. 4-12 Assembly of radiators

### WARNING

Observe all appropriate guidelines, especially VDE regulations, when conducting all building work, installation of electrical equipment and lightning protection measures.

**ATTENTION**

**LED-based obstacle lights should not be used.**

**LED-based obstacle lights may disturb the reception of the DF system due to the integrated power supply.**

**The use of the RHOTHETA obstacle light as defined in the options list will prevent such problems.**

## **4.4 North Alignment of the Direction Finder Antenna and Determining the System Accuracy at the Installation Site**

The north alignment is used to harmonize the angle determined by the direction finder with the actual (magnetic) north-related azimuth values.

### **4.4.1 North Alignment Using a Ground Transmitter (Pre-setting)**

Pre-setting, which requires further correction by the north adjustment on the controller in the  $\pm 90$  range (resolution  $0.5^\circ$ ) as described in section 2.2.10, is achieved by the mechanical alignment of the direction finder antenna.

Nevertheless, the setting of the antenna should be carried out as accurate as possible since this makes subsequent measurements easier.

#### **Procedure:**

- a) Mount the direction finder antenna on the antenna mast so that it is freely rotatable. Align the dipole marked with "N" to the north. If using the RTA 1306 Antenna Mast, loosen the clamping screws provided for this purpose.
- b) Switch on the direction finding system. Set the north adjustment to zero. Carry out a phase adjustment (refer to section 2.2.9).
- c) Set up a transmitter at an adequate distance (at least 100 m). From there, use a compass to determine the direction to the direction finder antenna.

### **WARNING**

**While measuring using the compass, ensure that, during the measurement, there are no objects (transmitters, cars, etc.) in the vicinity of the compass which could affect the magnetic field.**

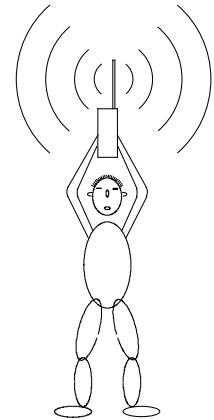


- d) Activate the transmitter and transmit a continuous signal.

**NOTE**

If transmitting with a monopole antenna (e.g. a hand held RT unit), due to undefinable radiation conditions, care must be taken to ensure that the antenna is as free as possible from disturbances and vertically installed.

For hand held radio units it is advisable to hold the unit above your head. In this case the antenna points vertically upwards (refer to Fig. 4-11).



**Fig. 4-13** Setting up the ground transmitter

- e) Rotate the direction finder antenna in the mast mounting until the controller, which is set to the transmitter frequency, indicates the QDM value determined by the compass (set the north adjustment to zero). The actual bearing value (QDR) is also shown at the display on the Receiver unit RTR 1200.A (RT-1000 C only). The display is located on the module RTR 1205. In this case, correcting the antenna setting by rotating clockwise (viewed from above, the single dipole moves in the north -- east -- south -- west direction) reduces the indicated QDM value, a counter-clockwise rotation causes an increase.

**NOTE**

The direction finder antenna should be rotated slowly with pauses because a considerable lag error occurs in the bearing determination in the direction finding unit. For the final adjustment, the person rotating the antenna must move away from the antenna after each correction in order to not disturbing the near field of the antenna and therefore influencing the direction finding.

**NOTE**

While carrying out the above measurements, there must be no objects (vehicles, parking aircraft, buildings...) in the vicinity of the transmitter or the direction finder which could disturb the wave propagation.

#### 4.4.2 Flight Checking for Exact North Alignment and Determining the System Accuracy at the Installation Site

For exact north alignment under operating conditions and for determining the system accuracy at the actual installation site, a flight check should be carried out.

To do this, a continuous-signal transmitter is installed in the aircraft, which then performs circular flights around the site of the direction finder.

**NOTE**

If the communication system of the aircraft is used as a transmitter, check beforehand whether it is suitable for continuous operation.

The radius of the circle and the flight speed shall be selected such that the "lag error" effect when determining the bearing is negligibly low. Therefore, it must be ensured that the angular velocity does not exceed 0.3°/s.

During all flight checking measurements, it must be ensured that an adequate reception field strength is present at the site of the direction finder antenna. Because of the quasi-optical wave propagation characteristic of VHF signals, there also must be a theoretical sight contact to the transmitter. If the transmitter is shadowed by hills, mountains, buildings or woods, the direction finder antenna cannot evaluate the direction of the directly transmitted signal, but instead assesses a signal which reaches the direction finder antenna via reflections. This normally leads to considerable bearing errors.

The instantaneous position of the aircraft can be determined by tracking with a theodolite or using a GPS receiver on the aircraft.

**4.4.2.1 Determining the Position Using a Theodolite**

- Set up the theodolite in the immediate vicinity of the direction finder antenna, aligned with magnetic north.
- The calibration aircraft then flies a circular flight path around the direction finder antenna and transmits a continuous signal.
- Track the aircraft using a theodolite.
- If the aircraft flies through a 10° mark, report this from the theodolite to the controller (e.g. by radio).
- Record the instantaneous bearing at the controller.

**4.4.2.2 Determining the Position Using a GPS Receiver**

- Store the site coordinates of the direction finder antenna in the GPS receiver.
- During the circular flight around the direction finder antenna, record the QDM values determined by the GPS receiver and transmit them by radio to the direction finder where they are then compared with the bearing.

#### 4.4.2.3 Simplified Method

If no theodolite or GPS receiver is available, a simplified measuring procedure must be used at the actual antenna installation site to precisely north align the system and determine its accuracy.

##### Route points:

With this method, the calibration aircraft overflies prominent landmarks (route points), the positions of which have been previously determined from conformal maps (scale approximately 1 : 200.000). Note that the angular values determined using the map are relative to geographical north and must therefore be corrected with the magnetic declination.

As the aircraft overflies the route point, this is transmitted by radio to the direction finder. At the direction finder site, the instantaneous bearing is recorded and compared with the desired value from the map. To achieve a constant bearing during the flight-over, the aircraft must fly radially relative to the direction finder antenna, i.e. it must either fly towards the direction finder antenna or away from it.

Due to the unavoidable errors when overflying, the route points chosen should be at least 10 km away from the direction finder antenna (at a distance of 10 km, a lateral offset of 175 m, with regard to the direction finder, when overflying the route point, produces an error of 1°).

##### NOTE

The PTT button should be pressed and held for at least 10 seconds before and after the flight-over, to enable the "before" and "after" history of the direction finding to be evaluated.

#### 4.4.3 Evaluation

The actual values measured by the direction finder (QDM bearings) are entered in a record for comparison with the desired values (theodolite bearings, GPS bearings, route points from the map).

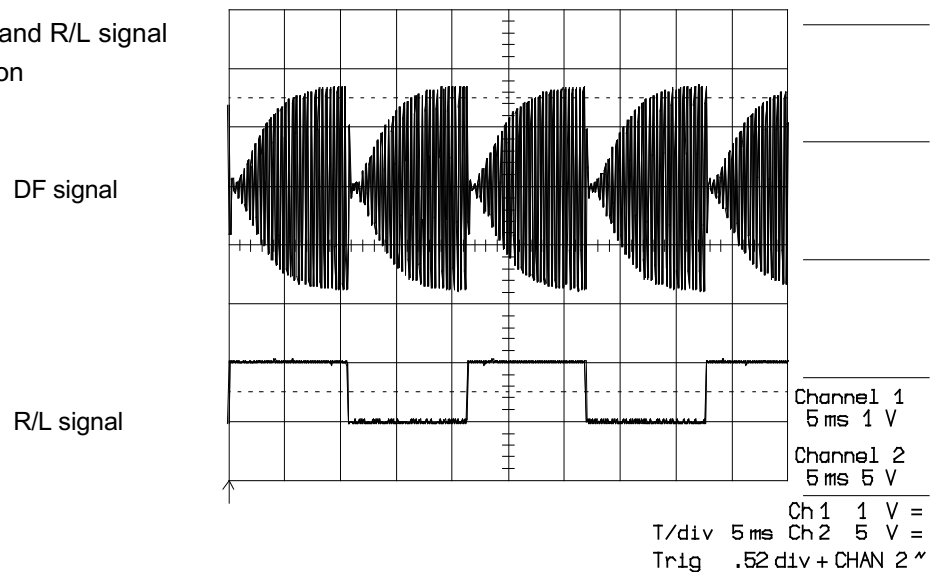
##### 4.4.3.1 Evaluation of Direction Finding Signal

To assess the suitability of the antenna site as accurate as possible and thereby to assess the functioning of the direction finder system, the direction finding signal (DF signal) relevant for determining the bearing should be observed on an oscilloscope during the measurements. The signal can be taken from the "DF signal 2" test output (26, Fig. 2-2) on the rear of the controller. The right / left rotation signal at the "R/L" test output (25, Fig. 2-2) is used to trigger the oscilloscope. The connecting cables for the test outputs are contained in the RTM 1500 Service Kit or can be ordered from your dealer.

a) Where there is correct reception without reflections the bearing signal appears as shown in Figure 4-14.

- Both blocks, clockwise and counter-clockwise rotation, have the same amplitudes. The envelope curve of the oscillation increases steadily (in accordance with an e-function) and has no "dips".
  - The blocks also experience no amplitude fluctuations over a long time period (5 seconds).
- If the bearing signal has the above shape, it can be assumed that the bearing indicated by the controller is correct.

Fig. 4-14 DF signal 2 and R/L signal for undisturbed reception

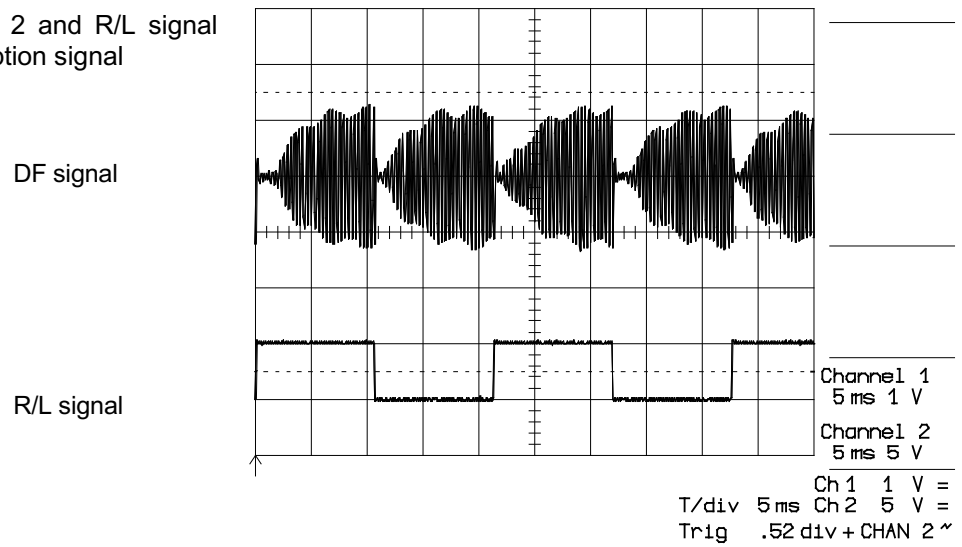


b) The amplitude of the bearing signal fluctuates within the individual blocks (refer to Fig 4-15). The fluctuation coincides with the rhythm of the audio signal.

Possible causes:

- the carrier is modulated (e.g. by speech)
- has no influence on the bearing accuracy

**Fig. 4-15** DF signal 2 and R/L signal with a modulated reception signal

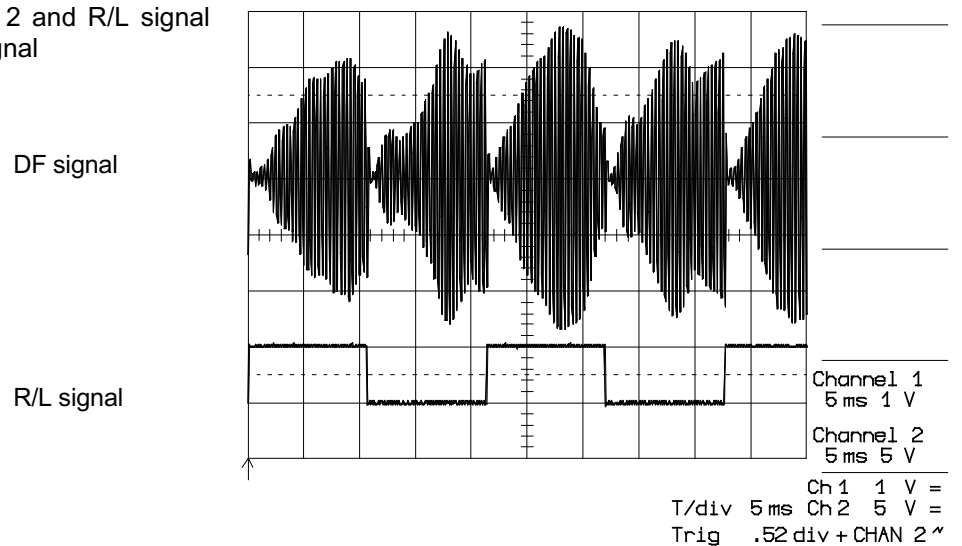


c) The direction finding signal is very noisy.

Possible causes:

- The field strength of the transmission signal is too low.
  - The transmitter is shadowed by hills, buildings, forests etc. There is no "theoretical" line of sight to the transmitter.
- The direction finding loose accuracy or is distorted by the masking.

**Fig. 4-16** DF signal 2 and R/L signal with noisy reception signal



- d)
- Amplitudes of clockwise rotation blocks or counter-clockwise rotation blocks "pump"
  - The amplitudes of the clockwise rotation blocks and counter-clockwise rotation blocks are different

Possible causes:

- Effect of reflection
  - Extreme flight manoeuvres of the calibration aircraft
  - Jamming transmitter on same channel
- e)
- Amplitude of R/L blocks is very large
  - Effect of reflection

It is not possible to list all the possible disturbances and influences of direction finding signals. As a rule it is assumed that if the direction finding signal is undisturbed the bearing shown by the controller is correct.

If the direction finding signal is observed during the complete circular flight, this provides a very good indication of the quality of the direction finding. This applies also for the azimuths at which no measuring points were recorded.

#### 4.4.3.2 Evaluation of QDR Live Display (Yellow Light Dot Circle)

The QDR live display (yellow light dot circle; 4, Fig. 2-1) serves as a further criterion of the quality of the direction finding (including during every day operation).

During a circular flight the yellow light dot circle should "wander" steadily around the compass-card corresponding to the direction of movement of the aircraft. Because it is not averaged, the yellow light dot circle display precedes that of the green dot. The display jumps backwards and forwards between a maximum of two light dots.

#### NOTE

In case of the option "Red Display" being used, the QDR live display will be green while the average value will be displayed in red colour.

#### Malfunctions which can be detected by the yellow light dot circle:

- a) Rapid jumping backwards and forwards (spreading out) of the light dots around the averaged value.

Possible causes:

- Received power too low due to the long distance from the transmitter.
- The transmitter is shadowed.

- b) During circular flight, the light dots do not "wander" steadily around the compass-card, corresponding to the movement of the aircraft.

Possible causes:

- Influence of reflections
- Aircraft performs extreme flight manoeuvres
- Jamming transmitter on same channel

- c) Light dots jump (spontaneously) backwards and forwards in large areas of the compass-card.

Possible cause:

- Reflections

- d) Light dots jump backwards and forwards around the averaged value (green light dot) (spreading out).

Possible cause:

- Reception signal is modulated. The spreading out area depends on the type and strength of the modulation.

#### 4.4.3.3 Evaluation of Measuring Results

The deviations between the desired and actual values are entered in the test record compiled with the aid of the flight check. If in the case of a calibration aircraft the direction finding signal or the yellow light dot indication is evaluated, the observations made at the corresponding measured values are to be annotated. Bearing errors can be easily interpreted in this way. A test record of the following kind is obtained.

Example:

##### Test record

DESIRED	ACT	Deviation	Remarks
000°	000°	0°	
010°	011°	+1°	
020°	025°	+5°	Direction finding signal is noisy, indication fluctuates
030°	032°	+2°	
040°	041°	+1°	
050°	049°	-1°	
060°	060°	±0°	
070°	072°	+2°	
080°	083°	+3°	
090°	091°	+1°	
100°	099°	-1°	
110°	104°	-6°	Direction finding signal has amplitude fluctuations, display fluctuates by ±5°
120°	120°	±0°	
130°	131°	+1°	
140°	142°	+2°	
150°	150°	±0°	
160°	158°	-2°	
170°	170°	±0°	
180°	181°	+1°	
190°	189°	-1°	
200°	200°	±0°	
210°	217°	+7°	Direction finding signal "pumps", yellow light dot circle ±20°
220°	222°	+2°	
230°	231°	+1°	
240°	240°	±0°	
250°	251°	+1°	
260°	259°	-1°	
270°	270°	±0°	
280°	280°	±0°	
290°	290°	±0°	
300°	302°	+2°	
310°	311°	+1°	



320°	319°	-1°
330°	330°	±0°
340°	343°	+3°
350°	351°	-1°

In the example, larger deviations occur when measuring for the 20°, 110° and 210° desired values. As can be seen by the evaluation of the direction finding signal and the yellow light dot circle, they are due to shadowing of the transmitter and reflections. The measurements are no longer taken into account in further assessment. If interference of this kind occurs, the site of the antenna is to be changed.

In the example, the deviations are in the -2° to +3° range. In practice, the deviations can be greater due to measuring uncertainties or reflections at the antenna site. The details of the system accuracy given in the section 1 technical data "System Accuracy" apply to reflection-free reception conditions at the antenna site but in practice such conditions are never found. Whether an antenna site is suitable must therefore be assessed in the light of the requirements of everyday operation.

#### 4.4.4 Determining the North Correction

To determine the final north adjustment, the average value of the deviation is determined from the test record. To do this, the sum of all the different values (the signs must be taken into account) are added and divided by the number of measurements.

$$\text{average deviation} = \frac{\text{Sum of all deviations}}{\text{Number of measurements}}$$

Example:

$$+0.55^\circ = \frac{+18^\circ}{33}$$

In the example the direction finder has a bearing which is on average 0.55° too great. This can now be corrected with the aid of the north adjustment in steps of 0.5° (refer to section 2.2.10). The correction value to be set is obtained as follows:

$$\text{Correction value} = \text{average deviation} \times (-1)$$

Example:

$$0.55 = 0.55 \times (-1)$$

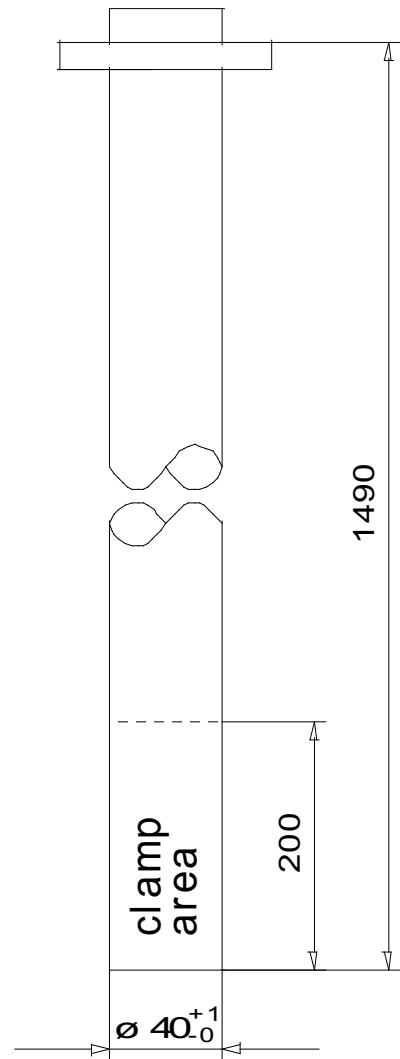
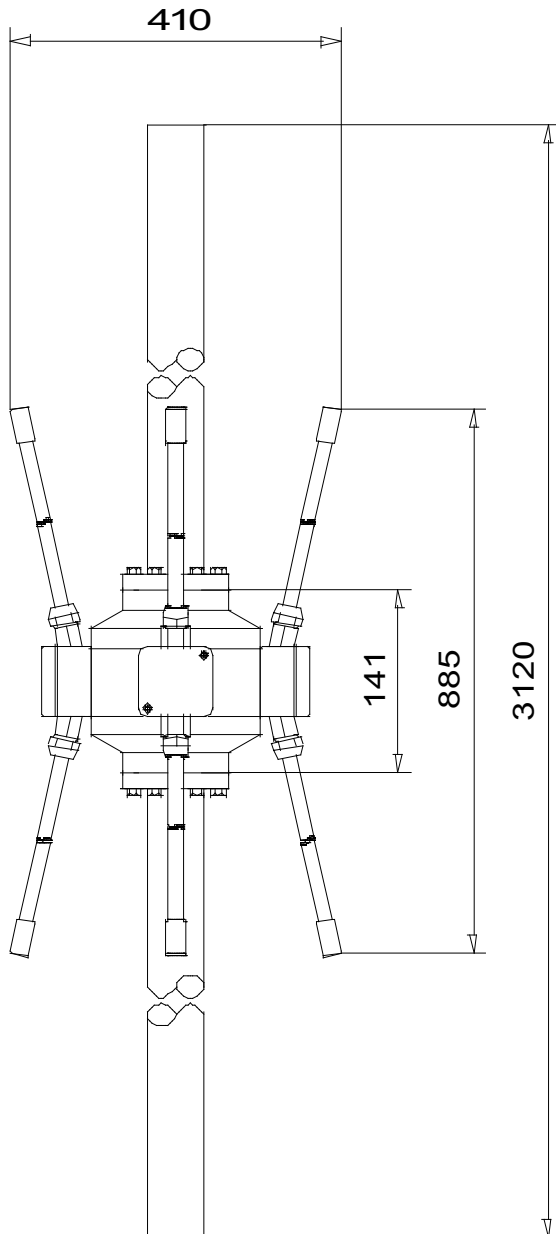
→ The value -0.5 is used as the correction value.

The direction finder system is now ready for operation but before the bearings can be transmitted to the aircraft approval by the relevant authorities in the respective country is necessary (refer also to section 5.2).

## 4.5 Installation Dimensions

RTA 1300.A Direction Finding Antenna  
with mast pole and lightning conductor rod

Mast pole



## 5 APPENDIX

### List of Contents:

<b>5 APPENDIX.....</b>	<b>5.1</b>
<b>5.1 EU Declaration of Conformity.....</b>	<b>5.2</b>
<b>5.2 Approval / Authorization of the direction finder RT-1000 A as a system in air traffic management.....</b>	<b>5.2</b>
5.2.1 Approval in the Federal Republic of Germany / EU .....	5.2
5.2.2 EC Declaration of Suitability for Use .....	5.3
5.2.3 RT-1000 A as a system in air traffic management - approval within the EU.....	5.4
<b>5.3 Interwiring of the Direction Finder RT-1000 A.....</b>	<b>5.5</b>
<b>5.4 Correlation channel number / frequency in the maritime radio band .....</b>	<b>5.6</b>
<b>5.5 Test Record / DF Final Test Report.....</b>	<b>5.8</b>

## 5.1 EU Declaration of Conformity

Hereby, RHOTHETA Elektronik GmbH declares that the product RT-1000 A is in compliance with the essential requirements to be put on the market, and with other relevant provisions:

- Directive 1999/5/EC on radio equipment and telecommunications terminal equipment, to be superseded by 2014/53/EU from June 13th, 2016 on; implemented in national German law by the "Gesetz über Funkanlagen und Telekommunikationsendeinrichtungen" (FTEG)
- Directive 2014/30/EU relating to electromagnetic compatibility
- Directive 2014/35/EU relating to electrical equipment designed for use within certain voltage limits
- Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment

A copy of the EU declaration of conformity is available at the following Internet address:

[http://www.rhotheta.com/products/rt\\_1000](http://www.rhotheta.com/products/rt_1000)

## 5.2 Approval / Authorization of the direction finder RT-1000 A as a system in air traffic management

After successful installation of all components and north alignment of the direction finder antenna as described in section 4.4, the system is ready for operation. But before bearings may be transmitted to an aircraft, approval from the appropriate authority must be obtained. This approval is regulated differently in every country.

### **NOTE**

Authorization or approval of the device itself and as a system within the air traffic management is regulated differently in every state.

### **NOTE**

Explanations in chapter 5.2.1 to chapter 5.2.3 refer to the state of rules in 2016. They are subject to change or alteration.

### 5.2.1 **Approval in the Federal Republic of Germany / EU**

The approval of the system RT-1000 A is carried out in Germany according to the FSMusterzuIV (air traffic control systems and equipment Pattern Approval Regulation).

### **NOTE**

This Regulation determines the requirements for type certification of equipment for air traffic control and lays down the procedure of the type certificate. In addition, it regulates the labeling and inspection of systems and equipment.

The German “Bundesaufsichtsamt für Flugsicherung“ (BAF) (= Federal Supervisory Authority for Air Navigation) performs as national regulatory authority for type certification according to “FSMusterzulV”.

The “Bundesaufsichtsamt für Flugsicherung” issues the type approval of an air-traffic control facility or equipment if the requirements as defined in §4 FSMusterzulV are fulfilled.

The approval number is labelled on the RT-1000 A.

**Approval label:**

The components of the direction finder RT-1000 A are provided with labels which contain the approval number of the “Bundesaufsichtsamt für Flugsicherung”.

These signs must not be removed nor covered.

They are attached to the following points in the system:

Controller:       backside of housing

Antenna Unit:    on the antenna housing next to the dipole housing of North dipole.

## 5.2.2 EC Declaration of Suitability for Use

In accordance with the interoperability Regulation (EC) No. 552/2004 RHOTHETA provides an EC declaration of suitability for use for the components of the DF-system RT-1000 A (Component for air traffic management).

The EC declaration of suitability for use is the formal statement of RHOTHETA Elektronik GmbH that the components, in this case, the DF Antenna RTA 1300.A and the controller RTC 1100.B, are suitable for use for the identified purpose as described in the declaration. The requirements of the interoperability Regulation and the relevant implementing rules are met.

The full text of the EC declarations of suitability for use is available at the following Internet address:  
[http://www.rhotheta.com/products/rt\\_1000](http://www.rhotheta.com/products/rt_1000)

### **5.2.3 RT-1000 A as a system in air traffic management - approval within the EU**

In the European Union, the RT-1000 A may be provided as a system for air traffic management at the service, only if it has been tested for compliance with the essential requirements and relevant implementing rules for interoperability and if it complies.

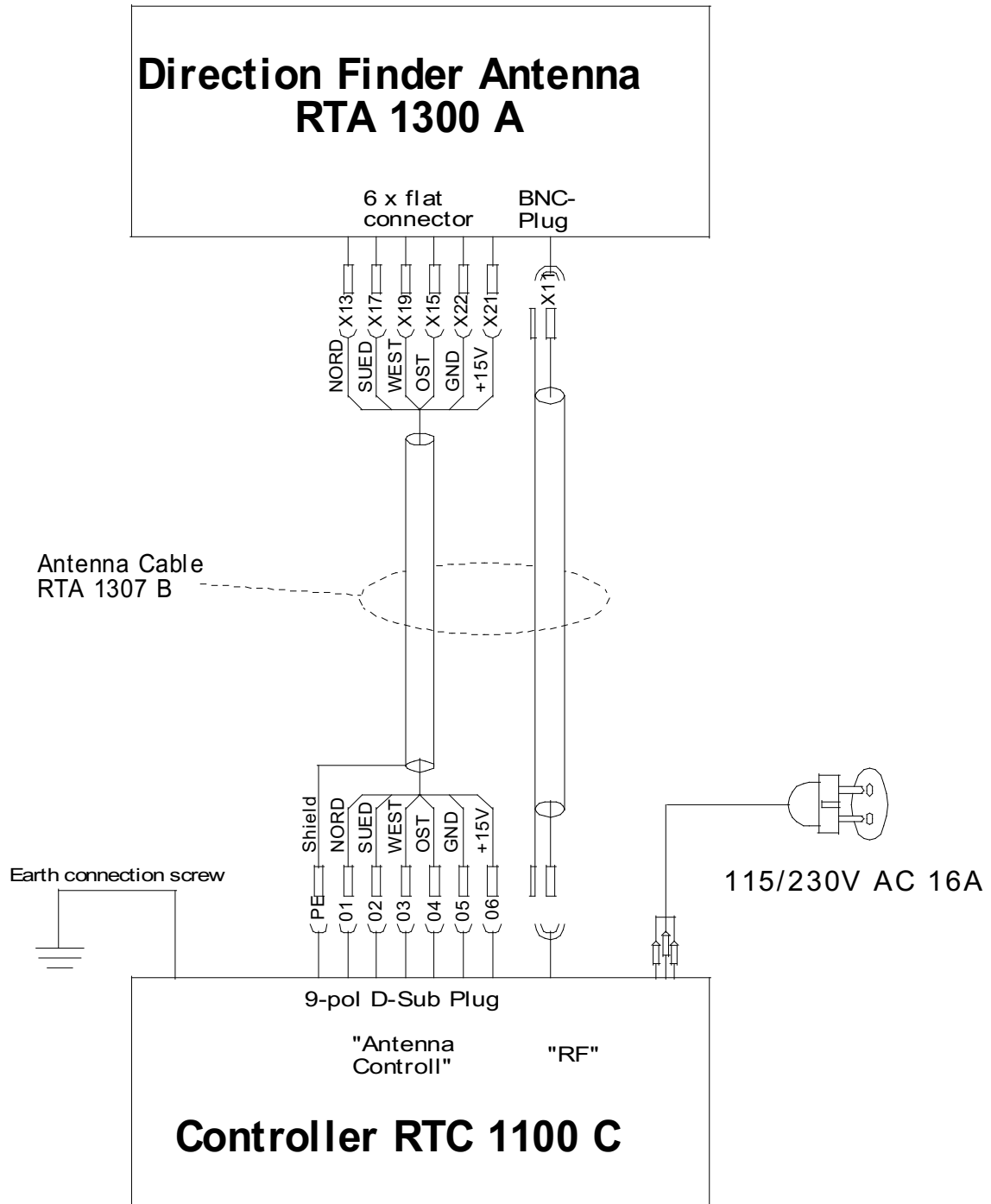
For this purpose, the air traffic control organizations will perform an EC-verification of the system according to the interoperability regulation (EC) No. 552/2004 and the relevant implementing rules for interoperability. The authority will confirm this in an EC declaration of verification of systems.

The EC declaration of verification of systems must be handed over to the national supervisory authority.

#### **NOTE**

National supervisory authority for Germany is the "Bundesaufsichtsamt für Flugsicherung" (BAF).

### 5.3 Interwiring of the Direction Finder RT-1000 A



## 5.4 Correlation channel number / frequency in the maritime radio band

Channel No.	Frequency (sea side station)	Frequency (coast station)
1	156,050 MHz	160,650 MHz
2	156,100 MHz	160,700 MHz
3	156,150 MHz	160,750 MHz
4	156,200 MHz	160,800 MHz
5	156,250 MHz	160,850 MHz
6	156,300 MHz	160,900 MHz
7	156,350 MHz	160,950 MHz
8	156,400 MHz	
9	156,450 MHz	
10	156,500 MHz	
11	156,550 MHz	
12	156,600 MHz	
13	156,650 MHz	
14	156,700 MHz	
15	156,750 MHz	
16	156,800 MHz	
17	156,850 MHz	
18	156,900 MHz	161,500 MHz
19	156,950 MHz	161,550 MHz
20	157,000 MHz	161,600 MHz
21	157,050 MHz	161,650 MHz
22	157,100 MHz	161,700 MHz
23	157,150 MHz	161,750 MHz
24	157,200 MHz	161,800 MHz
25	157,250 MHz	161,850 MHz
26	157,300 MHz	161,900 MHz
27	157,350 MHz	161,950 MHz
28	157,400 MHz	162,000 MHz
60	156,025 MHz	160,625 MHz
61	156,075 MHz	160,675 MHz
62	156,125 MHz	160,725 MHz
63	156,175 MHz	160,775 MHz
64	156,225 MHz	160,825 MHz
65	156,275 MHz	160,875 MHz
66	156,325 MHz	160,925 MHz
67	156,375 MHz	
68	156,425 MHz	
69	156,475 MHz	
70	156,525 MHz	

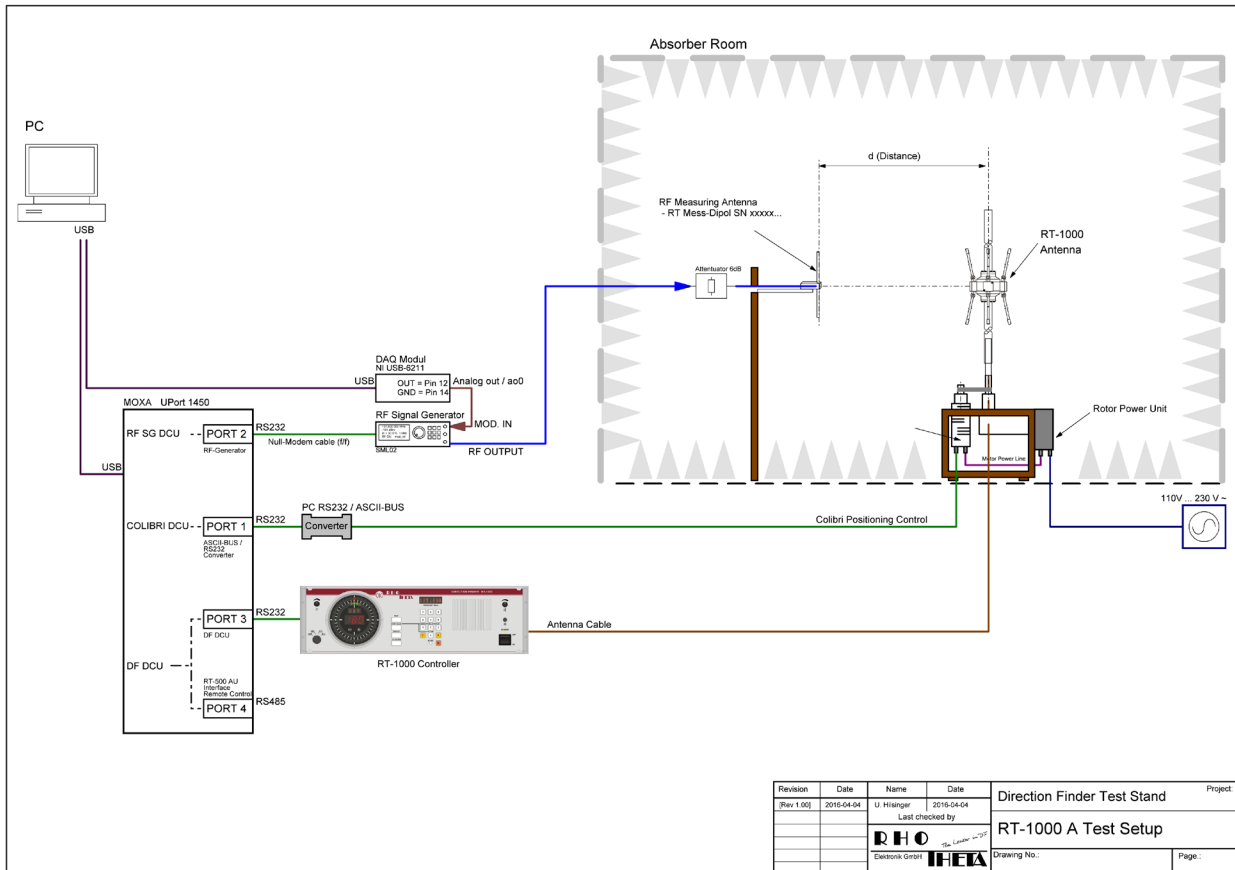


71	156,575 MHz	
72	156,625 MHz	
73	156,675 MHz	
74	156,725 MHz	
75	156,775 MHz	
76	156,825 MHz	
77	156,875 MHz	
78	156,925 MHz	161,525 MHz
79	156,975 MHz	161,575 MHz
80	157,025 MHz	161,625 MHz
81	157,075 MHz	161,675 MHz
82	157,125 MHz	161,725 MHz
83	157,175 MHz	161,775 MHz
84	157,225 MHz	161,825 MHz
85	157,275 MHz	161,875 MHz
86	157,325 MHz	161,925 MHz
87	157,375 MHz	161,975 MHz
88	157,425 MHz	162,025 MHz

## 5.5 Test Record / DF Final Test Report

Prior to delivery of the system RT-1000 A, each system is tested on bearing accuracy, bearing sensitivity, frequency offset handling, and on the flawless functionality on several operating frequencies.

For this purpose, RHOTHETA uses a fully automatized test stand. The result of each test is recorded in a test report "DF Final Test Report". To each direction finder system RT-1000 A, the test protocol is enclosed at delivery.



### Test Stand equipment as listed:

- PC with RHOTHETA LabVIEW application software running : "Drehstand.exe" [Rev ≥ 4.00]
- USB/Serial adapter MOXA UPort 1450 or other / internal adapter.
- Colibri Positioning Control
- RF signal generator (R&S SML)
- Modulation source DAQ module NI USB-6211
- RF measuring antenna with 6dB attenuator
- DUT (complete DF System RT-1000 A)