January 2013
Version 1.04

Scintec Flat Array Sodars

Hardware Manual

SFAS, MFAS, XFAS

including RASS RAE1
and windRASS

Scintec AG
Wilhelm-Maybach-Str. 14
72108 Rottenburg
Germany

Tel [+49]-7472-98643-0
Fax [+49]-7472-9808714
E-Mail info@scintec.com
www.scintec.com

Contents

1 INTRODUCTION TO SCINTEC FLAT ARRAY SODARS 6

1.1 GENERAL FEATURES AT A GLANCE 6
1.2 BASIC OPERATION PRINCIPLES 7
1.3 MULTI-FREQUENCY OPERATION 7
1.4 MULTI-BEAM OPERATION 8
1.5 SHADING MODE 8
1.6 VARIABLE PULSE LENGTHS 8
1.7 SELF-TEST 8
1.8 QUICK REFERENCE GUIDE 9

2 HARDWARE PREPARATIONS 10

2.1 SITING ASPECTS 10
2.1.1 ENVIRONMENTAL NOISE 10
2.1.2 SOUND EMITTED BY SODAR 10
2.1.3 FIXED ECHOES 10
2.2 INSTALLING THE INSTRUMENT 11
2.2.1 PACKING LIST 11
2.2.2 SETTING UP THE HARDWARE 11
2.2.3 APPLYING THE OPTIONAL BATTERY POWER SUPPLY CABLE 12
2.2.4 NOTE ON ELECTRICAL INSTALLATION OF SODAR XFAS 13

3 RASS EXTENSION 14

3.1 OPERATION PRINCIPLE OF THE RASS EXTENSION 14
3.2 INSTALLATION OF THE RASS EXTENSION 14
3.2.1 PACKING LIST 14
3.2.2 ASSEMBLY OF THE RASS ANTENNAS 15
3.2.3 SETTING UP THE HARDWARE 17
3.3 PRECAUTIONS FOR USE OF RASS RF COMPONENTS 18
3.3.1 AVOID OVER-TORQUING CONNECTORS 18
3.3.2 KEEP CONNECTORS CLEAN 18
3.4 DIMENSIONS OF SODAR/RASS CONFIGURATIONS 19

4 WINDRASS EXTENSION 26

4.1 OPERATION PRINCIPLE OF THE windRASS EXTENSION 26
4.2 INSTALLATION OF THE windRASS EXTENSION 26
4.2.1 PACKING LIST 26
4.2.2 ASSEMBLY OF THE windRASS ANTENNAS 27
4.2.3 SETTING UP THE HARDWARE 29
4.3 PRECAUTIONS FOR USE OF windRASS RF COMPONENTS 32
4.3.1 AVOID OVER-TORQUING CONNECTORS 32
4.3.2 KEEP CONNECTORS CLEAN 32

APPENDIX A THEORY 33

A.1 VELOCITY OF SOUND 33
A.2 SIGNAL SCATTERING 33
A.3 PULSE LENGTH VERSUS VERTICAL RESOLUTION 34
A.3.1 Pulse length 34
A.3.2 Frequency resolution 34
A.4 DOPPLER COMPOSITE 35
A.5 WIND CALCULATION 35
A.5.1 Doppler shift 35
A.5.2 3D-wind profiles 35

A.5.3 Standard deviations of u, v and w 36
A.6 NON-PROFILE DATA 37
A.6.1 Mixing height 37
A.6.2 PG-stability class 37
A.6.3 Kinematic Heat flux 37
A.6.4 Mean potential temperature 38
A.6.5 Monin-Obukov length 38
A.6.6 Friction velocity 39
A.7 RASS THEORY 39
A.8 REFERENCES 41

APPENDIX B DESCRIPTION OF THE INSTRUMENT 42

B.1 ACOUSTIC ANTENNA 42
B.1.1 GENERAL DESCRIPTION 42
B.1.2 ANTENNA DIMENSIONS AND TRANSDUCER NUMBERING 43
B.1.2.1 SFAS 43
B.1.2.2 MFAS 43
B.1.2.3 XFAS 44
B.1.3 CONNECTORS AT ACOUSTIC ANTENNAS 44
B.1.3.1 CONNECTORS TO SIGNAL PROCESSING UNIT 44
B.1.3.2 CONNECTOR TO SODAR POWER SUPPLY 46
B.1.3.3 CONNECTOR TO HEATING POWER SUPPLY SFAS/MFAS (OPTIONAL) 46
B.1.3.4 FEMALE CONNECTOR TO HEATING POWER SUPPLY XFAS (OPTIONAL) 46
B.1.3.5 MALE CONNECTOR TO HEATING POWER SUPPLY XFAS (OPTIONAL) 47
B.2 SIGNAL PROCESSING UNIT 47
B.3 RS232 CONNECTION CABLE 48
B.4 SODAR POWER SUPPLY 49
B.4.1 SFAS / MFAS 49
B.4.2 XFAS 49
B.5 HEATING POWER SUPPLY (OPTIONAL) 50
B.5.1 SFAS / MFAS 50
B.5.2 XFAS 51
B.6 ENCLOSURE (OPTIONAL) 52
B.6.1 ANTENNA ENCLOSURES 52
B.6.1.1 DIMENSIONS OF ANTENNA ENCLOSURES 52
B.6.1.2 ASSEMBLY OF ANTENNA ENCLOSURES 53
B.6.2 FREESTANDING ENCLOSURES 54
B.6.2.1 DIMENSIONS OF FREESTANDING ENCLOSURES 54
B.6.2.2 ASSEMBLY OF FREESTANDING ENCLOSURES 55
B.6.3 ATTACHING FOAM SHEET HOLDERS 56
B.7 RASS AND windRASS COMPONENTS 58

APPENDIX C SPECIFICATIONS 59

C.1 SFAS 59
C.2 MFAS 60
C.3 XFAS 61
C.4 RASS AND windRASS EXTENSIONS 62

APPENDIX D DECLARATION OF CONFORMITY 64

Important User Information

Note on Hardware Manual:

This manual is intended for customers who have purchased a Scintec Flat Array Sodar with or without the RASS or windRASS Extension. A careful reading of this manual is important in the proper use and safe operation of the Scintec Flat Array Sodar.

Safety Considerations:

During operation, Scintec Flat Array Sodars emit strong sound pulses in the audible frequency range which may be harmful to the human ear in the vicinity of the acoustic antenna. Therefore:

- Never approach the acoustic antenna without sufficient ear protection.
- Even with ear protection, never let your head be within ±45° zenith angle (i.e. the main emission direction) above the acoustic antenna and a distance less than 10 m.
- Wear sufficient ear protection if within the ±45° zenith angle (i.e. the main emission direction) above the acoustic antenna and a distance of 10 to 100 m.
- Without sufficient ear protection, always observe a minimum safety distance of 10 m.
- Never operate the sodar in closed rooms with the exception of special facilities and with everyone wearing sufficient ear protection.

Warranty and Liability:

Scintec guarantees that the product has been thoroughly tested. The warranty included in the conditions of delivery is valid only if the Flat Array Sodar System, and where applicable the RASS Extension or windRASS Extension, has been installed and used according to the instructions supplied by Scintec.

Scintec shall in no event be liable for incidental or consequential damages resulting from the incorrect and faulty use of the product. Note that user modifications of the product might affect the validity of the CE declaration.

Scintec reserves the right to make modifications to the design and technical specifications of its products without prior notice.

1 INTRODUCTION TO SCINTEC FLAT ARRAY SODARS

1.1 GENERAL FEATURES AT A GLANCE

Scintec Flat Array Sodars* are advanced and very powerful acoustic instruments for remote measurements of profiles of the three-dimensional wind speed and direction and turbulence characteristics in the lower atmosphere. There are three different models available: The XFAS is optimized for long ranges while the MFAS compromises high spatial resolution and easy portability. The SFAS is the smallest Sodar commercially available today with a high resolution of 5 m.

With their superior performance, flexibility and ease-of-operation, Scintec Flat Array Sodars not only meet the needs of routine boundary layer monitoring, but they are particularly powerful tools for a variety of research applications. Some design features of the Scintec Flat Array Sodars are:

- Acoustic antenna in flat array design with unmatched high efficiency
- 64 piezo-electric transducers (SFAS, MFAS) or 52 electromagnetic pressure chamber transducers (XFAS) for acoustic emission and reception
- Digitally-controlled phased array
- Operation with up to 10 frequencies within one pulse sequence cycle
- Beams can be emitted in up to nine directions
- Antenna can be operated in shaded or non-shaded mode for optimum side lobe suppression
- Variable pulse lengths within a single emitted sequence
- Simultaneous emission of up to 10 frequencies
- Simultaneous reception of all frequencies
- Simultaneous reception of opposite beams
- Fast Fourier Transform performed in real time
- Thickness of resolved layers down to 5m (SFAS), 10 m (MFAS) or 20 m (XFAS)
- Up to 100 (SFAS / MFAS) or 256 (XFAS) vertical layers
- Operation parameters set via auto-configuration or individually configurable by the user:
  - Number of frequencies, values of frequencies
  - Lengths of all pulses within emitted sequence
  - Number and order of used beam directions
- Real time tabulated and graphical output including
  - Horizontal wind speed and direction
  - Vertical wind speed and direction
  - Standard deviation of all wind velocity components
  - Reflectivity, temperature structure parameter C_T^2
  - Pasquill-Gifford stability classes
- All raw spectra accessible for research applications
- Automatic fixed echo detection and correction
- Low power consumption allowing battery operation (SFAS / MFAS)
- Easy interfacing with terminal PC via serial port (RS232 or RS485)
- Optional remote control via LAN, Radio or GSM Modem
- Extensive self-test capability
- Small size and light weight (SFAS / MFAS)
- Epoxy-coated aluminium body for durability even in harsh environmental conditions

* Patented, SODAR = Sound Detection and Ranging

1.2 BASIC OPERATION PRINCIPLES

Scintec Flat Array Sodars are advanced and powerful acoustic instruments for remote measurements of three-dimensional profiles of the wind speed and direction as well as turbulence characteristics in the lower atmosphere.

In operation, the antenna emits short sound pulses, which are backscattered at temperature inhomogeneities in the air. The antenna then receives the echoed sound pulses, and the amplitude and frequency of the backscattered waves are evaluated. The Scintec Flat Array Sodars are acoustic instruments of the monostatic type, i.e. the same antenna is used for emission and reception of sound.

The Scintec Flat Array Sodars generate different beam angles during emission and reception by phase delayed driving and sensing, respectively, of the rows or columns of an array of acoustic transducers. The phase delays in the emission and reception modes are produced digitally, resulting in long-term stability of the phase-shift and related performance. General advantages of phased array systems over three component horn antenna systems are smaller antenna size and more flexible use.

The height resolution is gathered by range gating, i.e. by considering the time the pulse needs to propagate from the antenna to the measured layer and back to the antenna. From the amplitude of the backscattered wave, detailed information about the turbulence structure in the atmospheric boundary layer can be obtained. By evaluating the spectrum of the backscattered wave, the wind speed is determined. This is possible because of the Doppler frequency shift resulting from the movement of the scattering temperature inhomogeneities with the mean wind. When at least three beams are emitted at different angles, a vertical profile of the three dimensional wind vector can be derived.

With the Scintec Flat Array Sodars, the spectra are determined by applying a Fast Fourier Transform to the acoustic signals received from the different directions.

The optional RASS[*] extension enables the system to determine temperature profiles by combining acoustic sound emission with radio wave measurements.

The optional windRASS extension enhances the RASS extension by adding the ability to perform not only temperature measurements but also wind measurements with the combined radio-acoustic measurement technique.

1.3 MULTI-FREQUENCY OPERATION

Scintec Flat Array Sodars can be operated in single-frequency or multi-frequency mode. In the single-frequency mode, a single pulse with a well defined frequency is emitted and its backscattered signal is recorded and evaluated. This procedure is repeated in several directions.

In the multi-frequency mode, sequences composed of pulses of different frequencies are emitted and the backscattered waves of all frequencies are received simultaneously. Up to 10 out of 64 equally spaced frequencies in the ranges of 2540 to 4850 Hz (SFAS), 1650 to 2750 Hz (MFAS) or 830 to 1370 Hz (XFAS) can be selected. Multi-frequency operation significantly increases the signal-to-noise ratio, since more acoustic power can be emitted into the atmosphere without increasing the pulse length per frequency, i.e., without reducing the vertical resolution. As before, this procedure is repeated in several directions.

[*] RASS = Radio Acoustic Sounding System

1.4 MULTI-BEAM OPERATION

Scintec Flat Array Sodars can emit sonic beams in 9 different directions:

	Beam Directions SFAS		Beam Directions MFAS/XFAS	
Identifier	**Main Beam**	**Mirrored Beam**	**Main Beam**	**Mirrored Beam**
Vertical	0°	N/A	0°	N/A
North	24° North	19° South	29° North	22° South
East	24° East	19° West	29° East	22° West
South	24° South	19° North	29° South	22° North
West	24° West	19° East	29° West	22° East

Complementary pulse pairs with opposite directions (24°-19° or 29°-22°) can be emitted even within a single pulse sequence. The waves backscattered from these two directions are received simultaneously. This results in another significant increase of the signal-to-noise ratio without sacrificing vertical resolution.

Due to the unique phase delay generation technique of Scintec Flat Array Sodars, the emission angles are independent of frequency.

1.5 SHADING MODE

The acoustic antenna can be operated in two modes: non-shaded and shaded mode. In non-shaded mode, the directivity of the main lobe (emission in the main direction) of the antenna is highest. In shaded mode the side lobes (emission in other than the main direction) are smallest, but in exchange, the main lobe widens slightly. For most sites the shaded mode will provide better results since it makes the measurement less sensitive to environmental noise and unwanted fixed-echo distortions. By default shading is enabled, but you can change the mode using a simple software switch.

1.6 VARIABLE PULSE LENGTHS

Within a single emitted sequence, pulses of different frequencies or direction can have different lengths. The shortest possible pulse length corresponds to a layer thickness of 5 m (SFAS), 10 m (MFAS) or 20 m (XFAS) during data evaluation. Longer pulses are a multiple of this base length.

When multiple pulses are emitted in one sequence, the first pulses of the sequence are used to sense at higher altitudes. With the Scintec Flat Array Sodars, the lengths of the pulses within a single sequence can vary. In particular, it is often advantageous to have a long first pulse in a sequence for a better signal-to-noise ratio at high altitudes. This increases the achievable range without sacrificing vertical resolution at lower altitudes.

Scintec Flat Array Sodars give the user full flexibility in defining the composition of the pulse sequence. The correct height referencing is automatically ensured by the evaluation software.

1.7 SELF-TEST

Scintec Flat Array Sodars can perform an extensive, fully automated self-test. For a detailed description of the self-test mode, please refer to the Software Manual.

1.8 QUICK REFERENCE GUIDE

Scintec Flat Array Sodars can be set up and prepared for operation quickly and easily. This section summarizes the steps required prior to performing a measurement:

1. Install the acoustic antenna. Connect the acoustic antenna with the Signal Processing Unit, connect the acoustic antenna with the power supply unit, and connect the terminal PC with the Signal Processing Unit.

2. Install the Sodar Operation Software on your terminal PC (see Software Manual). You first have to create a Workspace (see Software Manual) specifying some basic parameters, such as your Sodar device type, its serial number and the serial port of the terminal PC to which the Signal Processing Unit is connected to.
3. Before starting a measurement, you may perform a system self-test (see Software Manual).

4. Create the measurement settings using the submenu "Primary Settings >> Primary Settings Creator" (see Software Manual). For getting started, you may use default values, which are already displayed once the "Primary Settings Creator" window is opened. You may also define your configuration manually by changing the default values and pressing the “create” button.

5. Start the Device Server by choosing the option “Start Device Server” in the “Device” menu (see Software Manual).

6. Start the measurement by choosing the option “Start Measurement” in the “Device” menu (see Software Manual).

7. While measuring, select data view options in real time (see Software Manual).

2 HARDWARE PREPARATIONS

2.1 SITING ASPECTS

When setting up a sodar, the following siting aspects should be considered:

2.1.1 ENVIRONMENTAL NOISE

Since the sodar evaluates acoustic backscatter signals of very small amplitude, it is important to operate the instrument in a quiet environment. In particular, this refers to noise in the range of the frequencies sensed, i.e. the selected operation frequencies. Typical noise sources are: machines and engines (such as air conditioning units), traffic, airplanes, wind at obstacles (whispering trees), and birds or other wildlife.

Antenna enclosures reduce the susceptibility to noise sources close to the ground. Therefore noisy environments will require a large acoustic enclosure.

2.1.2 SOUND EMITTED BY SODAR

A sodar emits strong audible sound pulses which might disturb persons in the vicinity of the antenna during operation or nearby residents. This should be kept in mind when selecting a site near buildings or public areas. The potentially disturbing noise generated by the sodar mainly stems from the antenna sidelobes. This noise can be significantly reduced by using an antenna enclosure or even more by using a freestanding enclosure. Also, an installation of the sodar on platforms several meters above the ground can reduce the emitted noise. In the shaded mode, due to sidelobe suppression, the antenna generally emits less noise than in the non-shaded mode.

2.1.3 FIXED ECHOES

Higher obstacles like buildings, trees or hills within the sensing range of the sodar may reflect sound pulses and disturb the measurements. This effect is called "fixed echo", "ground clutter" or "passive noise". It is the most common source of problems with sodar measurements in general.

Even though Scintec Flat Array Sodars have implemented fixed echo identifications and corrections, fixed echoes nevertheless may result in limitations of the measurement capability or accuracy. With fixed echoes, typically a reduction of the measured wind velocities is observed due to the (usually) zero velocity of the reflecting surfaces at the respective height or distance. In addition, increased backscatter values typically result.

The first choice to eliminate fixed echoes is the use of a large acoustic enclosure. In many cases, increasing the installation height of the antenna can also help. Generally, the antenna should be operated in shaded mode when there are fixed echoes. Rotating the antenna, using other emission angles or changing the operation frequencies are also standard procedures to reduce the fixed echo amplitudes. This, however, requires a careful investigation of sodar returns with different antenna orientations and operation parameters.

2.2 INSTALLING THE INSTRUMENT

2.2.1 PACKING LIST

When receiving a new Scintec Flat Array Sodar, you will find the following items:

System Components	Quantity
Acoustic antenna	1
Sodar Power Supply (optional)	1
Signal Processing Unit SPU	1
Antenna heating power supply (optional)	1
Connection Cables	**Quantity**
Power cable for external power supply (optional)	1
Signal cables from antenna to Signal Processing Unit SPU	2
Serial data cable from Signal Processing Unit to terminal PC	1
Adapter(s) for remote data communication and respective power supplies (optional)	N/A
Enclosure (optional)	**Quantity**
4, 8 or 16 metal sheets, depending on type of enclosure	N/A
Accessories for enclosure	N/A
Manuals/Software	**Quantity**
Hardware Manual for the Sodar	1
Software Manual for the operation software	1
Operation Software on CD-ROM	1

2.2.2 SETTING UP THE HARDWARE

First install the Sodar antenna: It must be placed on a stable and even ground or platform. An exact horizontal levelling is required (~ ±0.5°) for correct measurements of the wind velocity components. If possible (see under Section 2.1.3, "Fixed echoes"), the side of the antenna with the "North" label should exactly face to the geographic north direction in order to comply with the direction convention used by the software. Otherwise, you have to enter the actual direction of the antenna north side in the APRun software (see APRun Software Manual). Note that there is a difference between magnetic north and geographic north direction.

If you use a freestanding acoustic enclosure, the acoustic antenna must be carefully centered within the enclosure. Then install the Processing Unit and power supply. In hot climates it is required that the Processing Unit and power supply be shielded from direct sun radiation to avoid overheating. In humid climates, it may be necessary that both units are installed indoors or within an appropriate enclosure to avoid temperature and humidity changes causing condensation within the units. Connect the Processing Unit with the acoustic antenna using the supplied cables.

Provide a terminal PC and connect a RS232 serial port of the PC with the respective port of the Processing Unit. If an optional RS422 or RS485 connection is used, connect the corresponding adapter to the data cable and plug the adapter to preferably the first or second serial port of the terminal PC. Then connect the corresponding power supply of the adapter.

Finally connect the power supply unit to the acoustic antenna. Alternatively, for SFAS and MFAS systems, it is possible to use an optional battery power supply cable to connect the acoustic antenna to appropriate batteries (see Section 2.2.3).

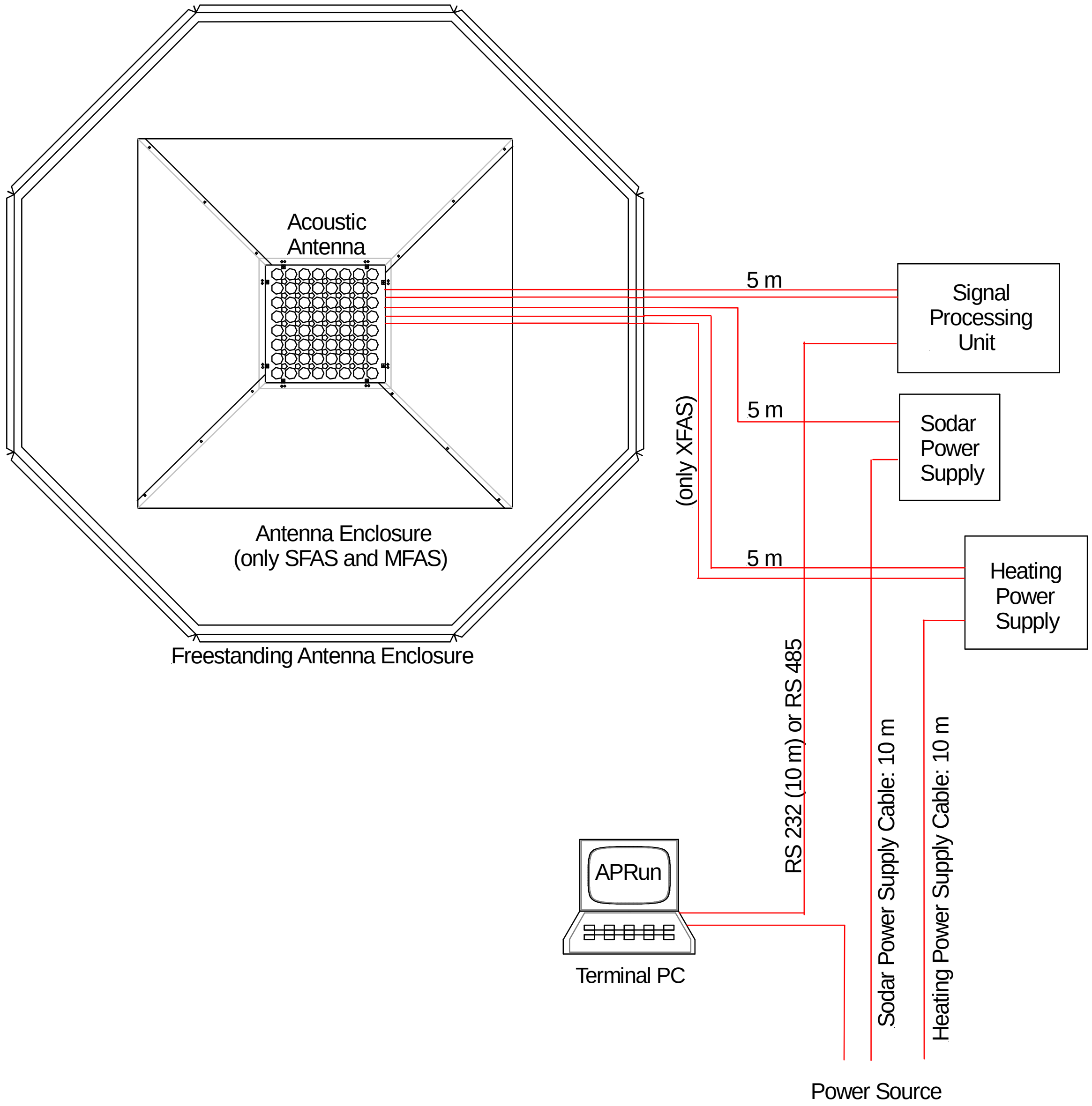
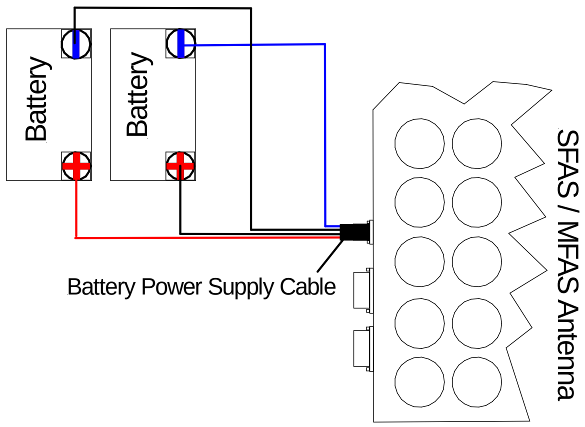


Figure 2.1: Wiring scheme for Scintec Flat Array Sodars

After the Processing Unit has been powered on, it will take approximately 1 minute to boot up before being ready for communication with the terminal PC. The system is installed now and ready for operation with the Sodar Operation Software APRun.

2.2.3 APPLYING THE OPTIONAL BATTERY POWER SUPPLY CABLE

Both SFAS and MFAS systems can be operated using batteries as power sources. To do so, an optional battery power source cable is available on request. The battery power source cable consists of four individual wires. The following sketch shows the wiring in a schematic fashion. Furthermore, a color connection scheme for the battery power supply cable is given. Ensure that the specifications of the batteries comply with the voltage and average as well as peak current specifications of the SFAS /MFAS system (see Sections C.1 and C.2).



Color Connection scheme for Battery Power Supply Cable	
Function	
Supply in +12 VDC	**RED**
Supply GND 0 VDC	**BLACK**
Supply GND 0 VDC	**BLACK**
Supply in -12 VDC	**BLUE**

Before applying the battery power supply cable, first get familiar with the diagram and connection scheme given above. Furthermore, read the following notes carefully:

Important Notes on Battery Power Supply Cable:

- **The battery power supply cable should be connected to appropriate batteries only, not to other power sources.**
- **Do not recharge the batteries by using an AC-charger while the Sodar system is connected to the batteries.**
- **Always connect ground (GND) first to the batteries, then the cables for the positive and negative voltage branches.**
- **Always disconnect ground (GND) last from the batteries.**
- **Ensure that proper polarization is applied.**

2.2.4 NOTE ON ELECTRICAL INSTALLATION OF SODAR XFAS

When installing the XFAS, verify that a proper PE (Protective Earth) at the AC line adapter is provided. If this is not the case, the system may pick up electromagnetic noise, including 50/60 Hz AC line frequencies, which will deteriorate performance.

3 RASS Extension

3.1 OPERATION PRINCIPLE OF THE RASS EXTENSION

The Radio Acoustic Sounding System (RASS) extension to Scintec's Sodar instruments determines virtual temperature profiles in the atmospheric boundary layer with high spatial and temporal resolution. The RASS extension is an option that may be added to any of the Scintec Flat Array Sodars. Its measurement principle rests on the detection of electromagnetic waves scattered at the known density pattern of an acoustic wave. The Sodar is used to generate a vertically propagating acoustic wave, whereas the RASS transmitter generates a continuous electromagnetic wave which is detected by the receiver component in the RASS Transceiver. For further signal processing, the capabilities of the Sodar system are employed. The theoretical background is described in Appendix A. The setup and operation mode classify the Scintec Sodar- RASS as a so-called bi-static, acoustical pulse modulated system. This means that the acoustic signal is a frequency-modulated pulse and that the electromagnetic signal is transmitted continuously during RASS operation. The properties of the pulse modulation are configurable in the Sodar Operation Software APRun (for details, see the Software Manual).

3.2 INSTALLATION OF THE RASS EXTENSION

3.2.1 PACKING LIST

The Scintec RASS extension comprises the following items:

RASS Components	Quantity
RASS Transceiver	1
RASS Transceiver Power Supply	1
RF coaxial cable, approx. 9m	2
LF signal cable, approx. 5m	1
RASS Enclosure	**Quantity**
Aluminum sheets	16
Accessories for enclosure	N/A
Two RASS Antenna Support Frames	**Quantity**
Aluminum Profile Type 1 (Corner) (length: 500mm, plastic covered adjustable foot, 2 drill holes at one end)	8
Aluminum Profile Type 2 (Lateral) (length: 670mm, threads on the small front and back faces of the profile)	12
Aluminum Profile Type 3 (Antenna Support) (length: 670mm, drill hole at 335mm, has 2 lateral cylindrical cavities at each end)	4
Allen Screw (to connect profile type 1 to profile type 2)	24
Special Purpose Connector (to connect profile type 3 to profile type 1)	16
Special Purpose Allen Screw (to connect the angle mounting part to the profile type 1)	8
Adjustable Foot (for profile type 1)	8

Allen Key	1
Angle Mounting Part (to fix the antenna support frame to the ground)	4
Tent pegs	4
Two RASS Antennas	**Quantity**
Parabolic Antenna Dish	2
Antenna Feed Horn (cylindrical exterior, black, N-connector)	2
Feed Horn Support Tube (to mount the feed horns onto the dishes)	6
Pan Head Screw (each with 1 nut and 2 flat washers)	6
Butterfly Nut M6 (with flat washers for the bolt end of the feed horn support tube)	6
U-Profile Mounting Support (each with 2 butterfly nuts and washers)	4
Aluminum Plate (to mount the dishes onto the support frames)	4

3.2.2 ASSEMBLY OF THE RASS ANTENNAS

A) ANTENNA ASSEMBLY

Each parabolic reflector comes with three tubes that end in a M6 bolt on one side and an eyelet on the other side. Connect the eyelets of these tubes to the according three eyelets at the edge of each antenna dish using the provided screws and washers. Then bolt each feed horn to the three tubes on one of the reflectors, using provided washers and M6 butterfly nuts. Please note the orientation of the feed horns and make sure that the antennas are set up such that the feed horns are oriented in parallel.

B) ANTENNA SUPPORT FRAME ASSEMBLY

Prepare two of the type 2 profiles by pushing two of the half-cylinder-shaped groove stones of the special purpose connector into one of the lateral grooves of each profile. The three different profile types are illustrated in Fig. 3.1. Now fix the type 3 profile to the prepared profiles inserting the special purpose connectors into the cylindrical cavities of the type 3 profile. You should obtain a symmetric H-shaped structure. Follow the same steps to obtain a second H-shaped structure.

Figure 3.1: Antenna Support Frame

Similarly, connect two of the type 1 profiles with one type 2 profile using the provided Allen screws and fixing elements. For each connection between two profiles, assemble an Allen screw and a fixing element (see Fig. 3.3). Turn the screw a few times into the provided matching threads at the end faces of the aluminum profiles. Then slide the opposite profile over the fixing element(s). For each connection, there is a drill hole in the profiles which allows you to reach the screws with the Allen key. You may find it helpful to fasten the screws tightly only at the end of the assembly process to allow for some flexibility during setup.

Figure 3.2: Connecting profiles 2 and 3

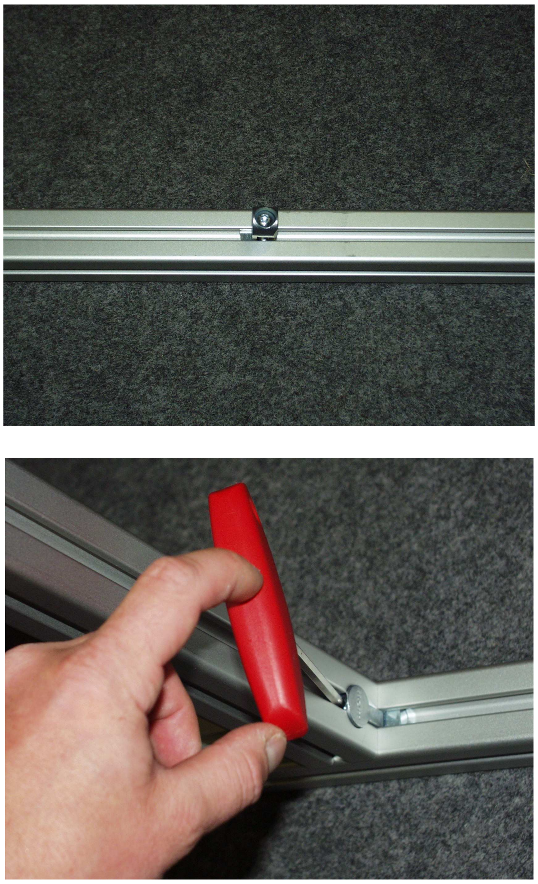


Figure 3.3: Connecting profiles 1 and 2

Repeat to obtain two structures (H-shaped with elongated upper part) which attach to the opposite sides of the H-shaped structure obtained in the first step to form a table-like aluminum skeleton. Finally, complete a square at the top of this table using the remaining two type 2 profiles.

To attach the antennae to the supports, put the parabolic antennae onto the center parts of the upper middle type 3 profiles of each support frame, respectively. Use the U-profile mounting elements, the aluminum plates and the butterfly screws to attach the antenna firmly to the support frames (see Fig. 3.4 for reference).

Figure 3.4: Close-up of mounting support

Figure 3.5: Assembled Antenna

3.2.3 SETTING UP THE HARDWARE

The basic components of a RASS extension are the two parabolic grid antennas with the support frames, the transceiver and the transceiver power supply unit. The two 9 m RF coaxial cables are used to connect the RASS transceiver to the feed horns of the receiving and transmitting antenna, respectively. Putting the transmitter close to the antenna minimizes losses in the connecting cables. RASS transceiver and transceiver power supply are intended to be operated close to the Sodar's signal Processing Unit.

A) POSITIONING
The centers of the RASS antennas and the center of the sodar antenna must form a straight line. The RASS receiver and transmitter antennas are situated at the end of this line with the sodar exactly in the center. We recommend a distance of 8 m between the two antennas (see also Figures 3.7 – 3.11). Please determine after setup the distance between the RASS antennas. This distance is a parameter that is needed by the Sodar operation software for temperature profile calculations.

B) RASS ASSEMBLY
Align the radar antennas so that both black arrows on the feed horn point in the same direction and are parallel. Then adjust the height of the feet of the mounting support by screwing up or down to obtain horizontal leveling of both antennas. Connect the transceiver (labeled RF OUT) to the feed horn of the transmitting antenna using one of the 9 m RF coaxial cables (see Fig. 3.6). Similarly, connect the transceiver (labeled RF IN) to the feed horn of the receiving antenna using the second 9 m RF coaxial cable. Use the 5 m LF signal cable to connect the RASS transceiver (labeled To SPU) to the SPU (labeled To RASS transceiver).

Put the enclosure around the RASS transmitter antenna so that the antenna is centered inside the enclosure. For assembly of the enclosure, please refer to the instructions applicable to the XFAS enclosure (Section B.6) which is mechanically identical.

Finally, the power cable from the RASS transceiver power supply must be plugged into a main voltage socket (190~260V, or 110V). Green lights at the RASS transceiver and the transceiver power supply indicate the presence of operating voltage. The yellow LED on the transceiver indicates an ongoing RASS measurement, which is accompanied by the emission of electromagnetic radiation at the transmitter antenna. **For safety, do not stay inside the RASS transmitter enclosure during RASS operation.**

3.3 PRECAUTIONS FOR USE OF RASS RF COMPONENTS

3.3.1 AVOID OVER-TORQUING CONNECTORS

Over-torquing connectors is destructive as it may damage the connector center pin. Finger tight is usually sufficient for mating the connectors. Never use pliers to tighten connectors.

3.3.2 KEEP CONNECTORS CLEAN

The precise connection geometry can be easily disturbed by dirt or other contamination adhering to connector interfaces. When the RASS extension is not in use, keep the connectors covered. To clean the connector interfaces, use a clean cotton swab, dry or soaked with denatured alcohol. The following are some tips on cleaning connectors:

- Use only denatured alcohol as cleaning solvent.
- Do not use excessive amounts of alcohol.
- Never put lateral pressure on the center pin of the connector.
- Verify that no cotton or other foreign material remains in the connector after cleaning.
- If available, use compressed air to remove foreign particles and to dry the connector.

3.4 DIMENSIONS OF SODAR/RASS CONFIGURATIONS

The overall dimensions of the RASS extension combined with the Flat Array Sodars SFAS, MFAS and XFAS are shown in Fig. 3.7 – 3.11. For the SFAS and MFAS models, standard and large acoustic antennas are available, respectively, whereas only a large enclosure is available for the XFAS model. The distance between the RASS receiver and transmitter antennas is 8 m, as recommended in section 3.2.3. The center of the Sodar antenna is in the middle of a straight line connecting the two RASS antennas. The blue circles illustrate radii (counted from the center of the corresponding enclosure) at which tent pegs have to be positioned to fix the guy lines to the ground. If permanent installation on solid ground of the Sodar/RASS system is anticipated, it is important to note that the prepared base is broader than the distance between two diametrically opposed guy lines, i.e., 9100 mm.

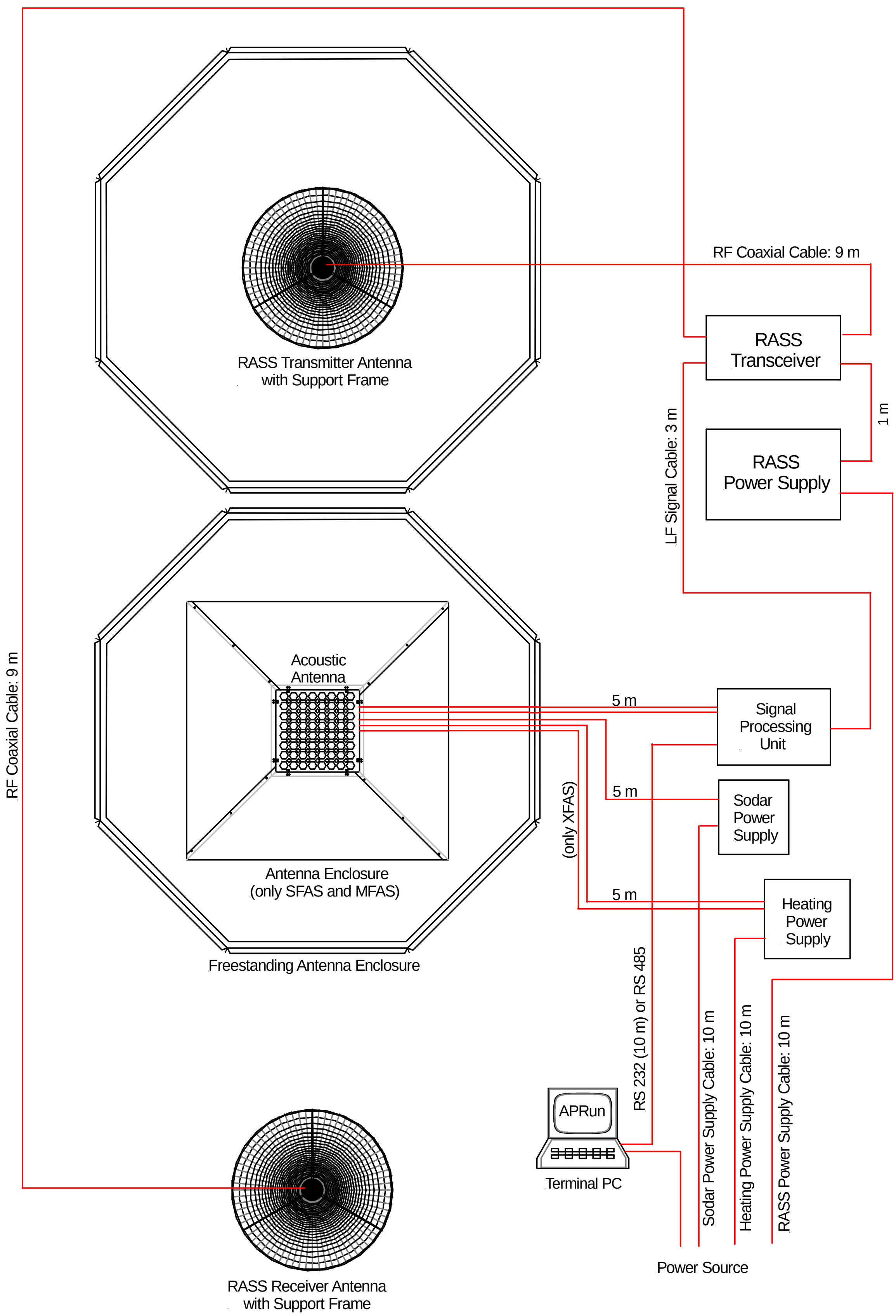


Figure 3.6: Wiring diagram for a Scintec Flat Array Sodar with RASS extension

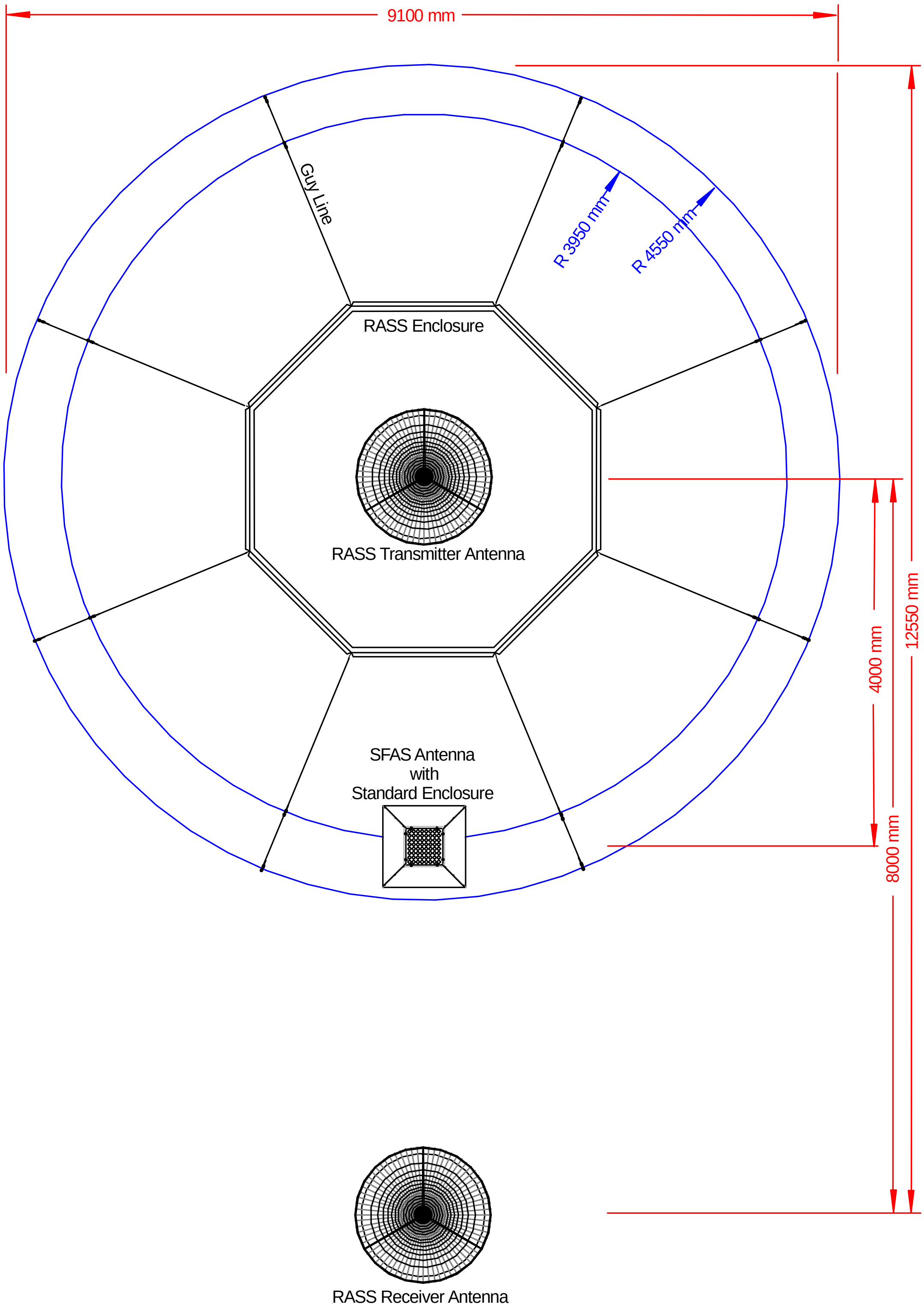


Figure 3.7: Overall dimensions of Sodar/RASS system: SFAS with standard enclosure.

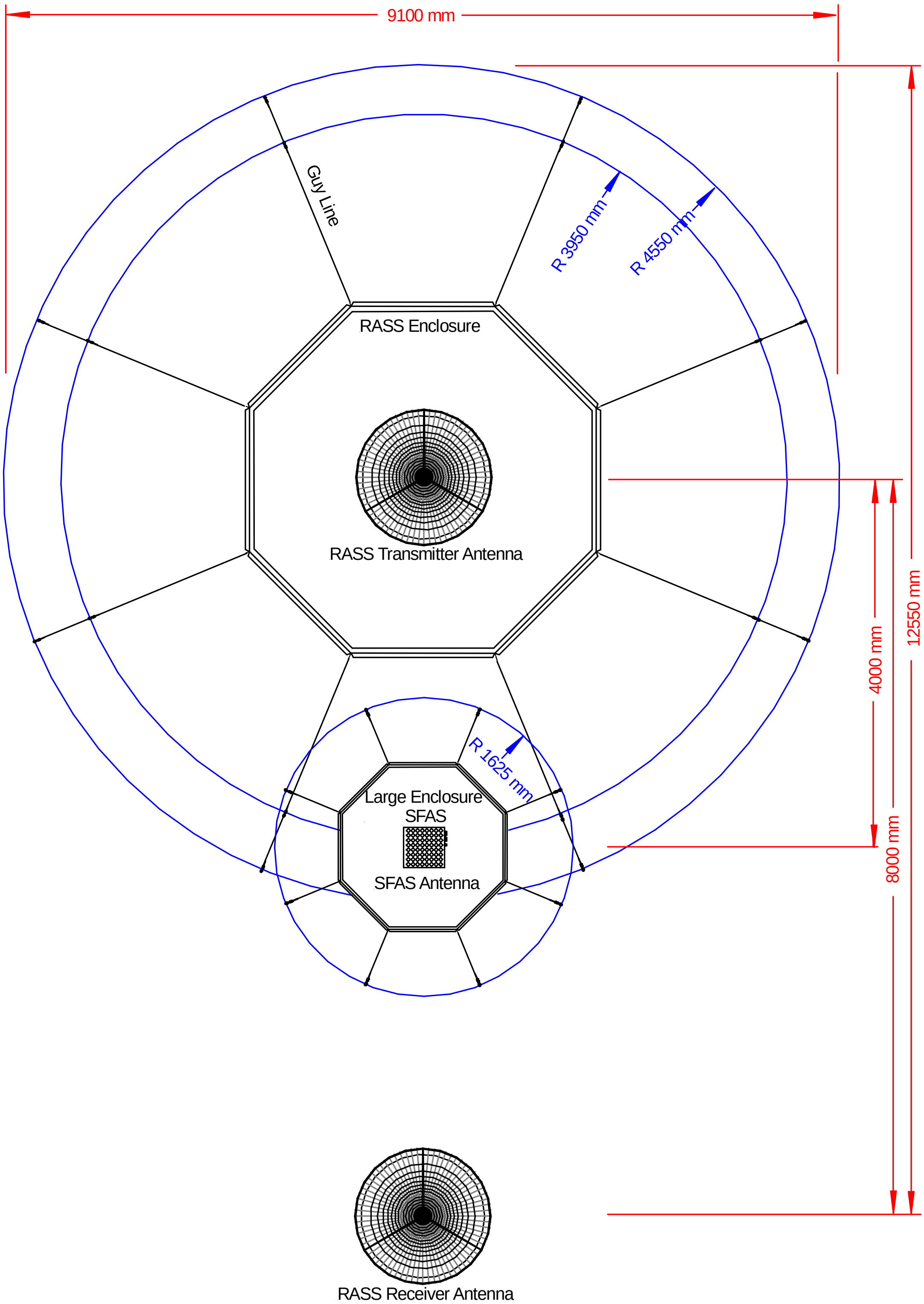


Figure 3.8: Overall dimensions of Sodar/RASS system: SFAS with large enclosure.

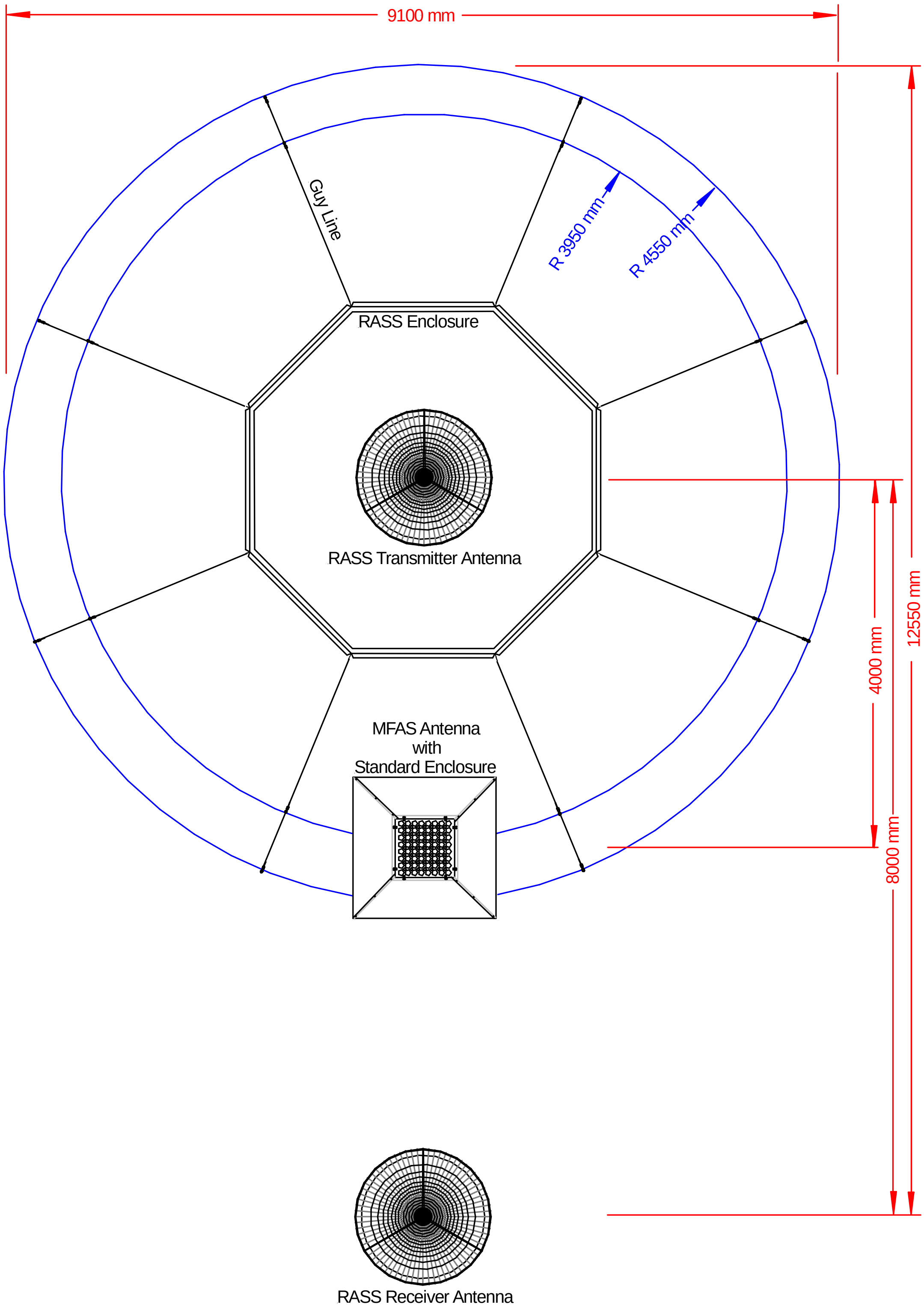


Figure 3.9: Overall dimensions of Sodar/RASS system: MFAS with standard enclosure.

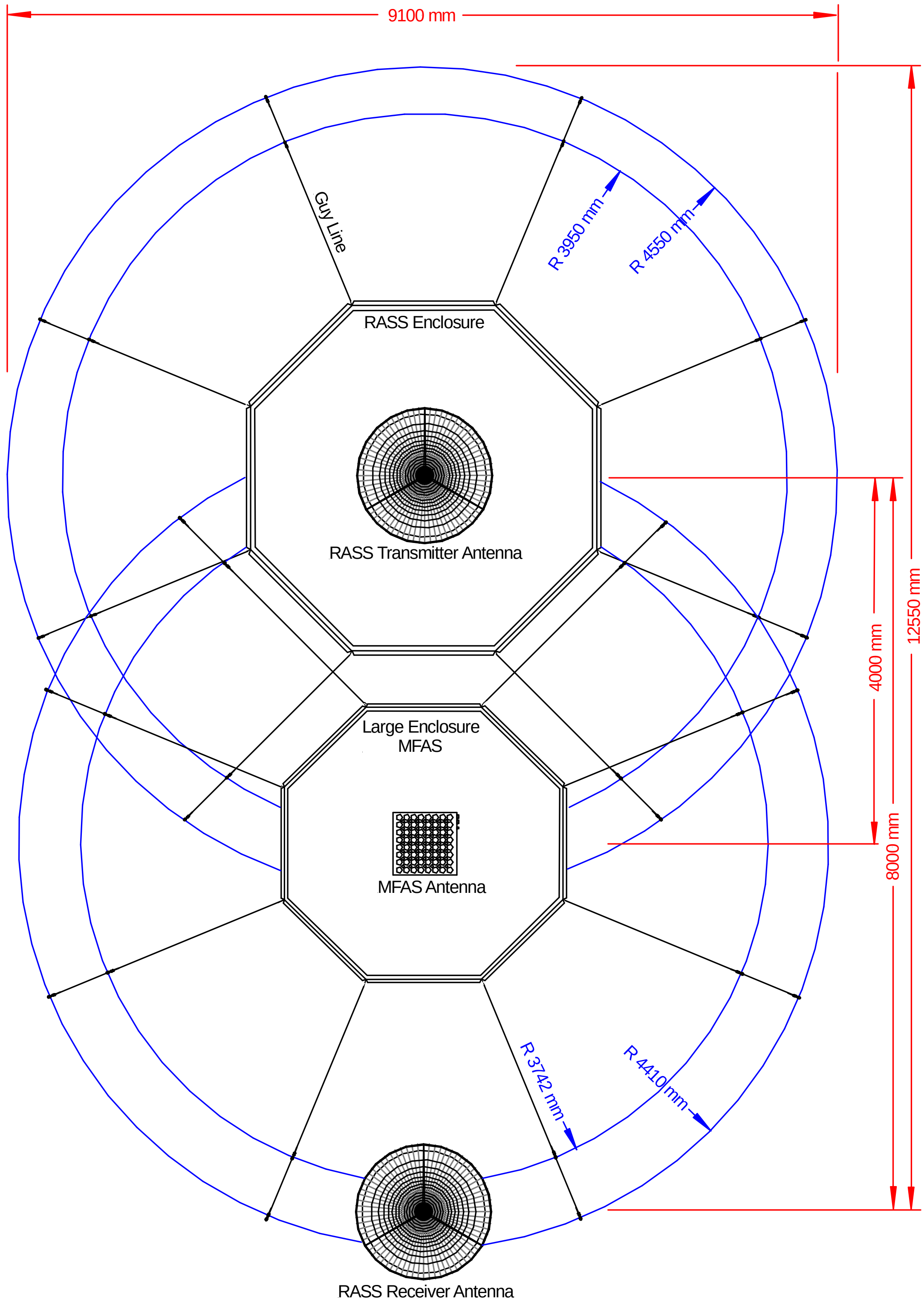


Figure 3.10: Overall dimensions of Sodar/RASS system: MFAS with large enclosure.

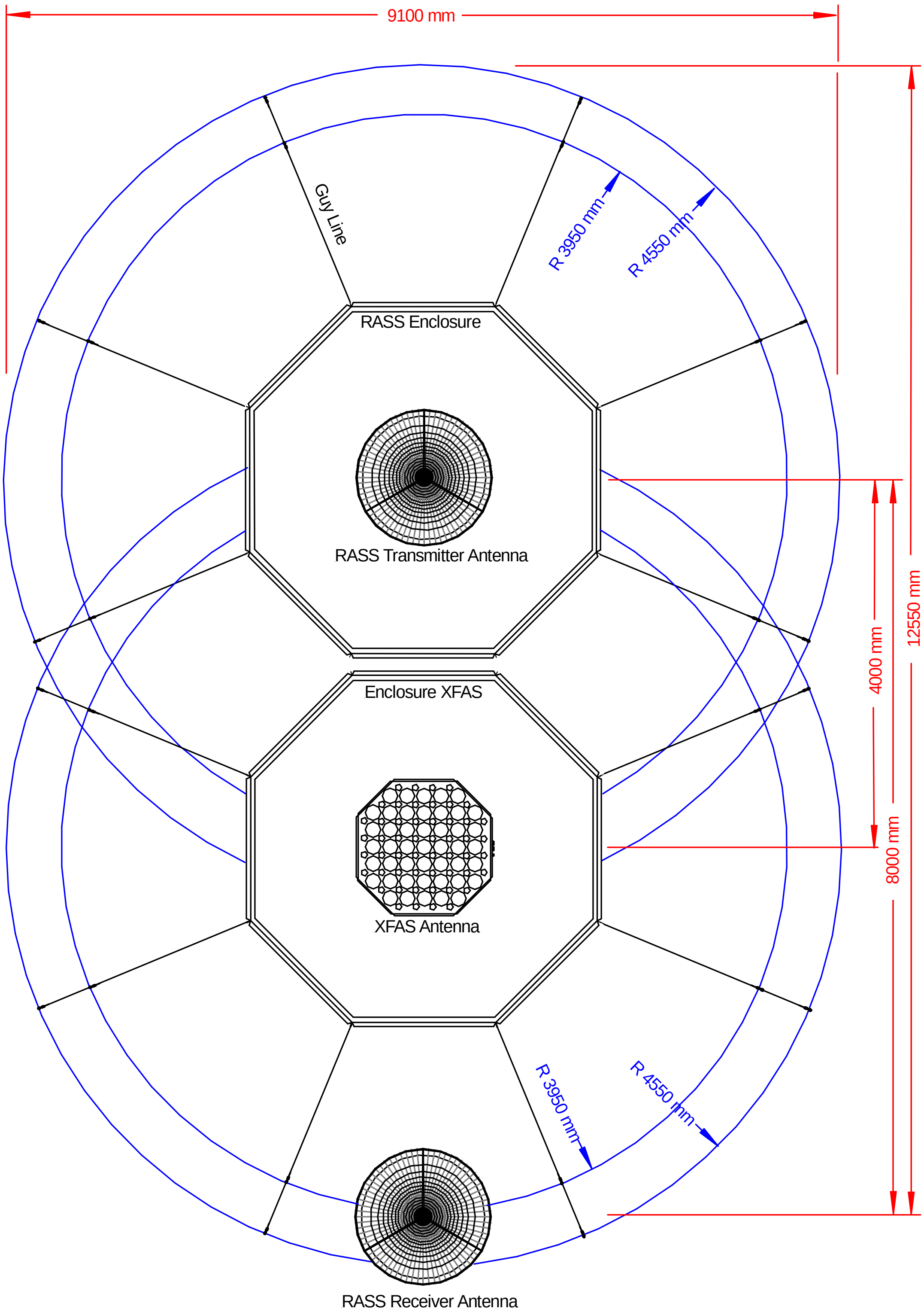


Figure 3.11: Overall dimensions of Sodar/RASS system: XFAS with enclosure.

4 windRASS EXTENSION

4.1 OPERATION PRINCIPLE OF THE windRASS EXTENSION

The windRASS extension is an enhanced type of RASS extension. It incorporates the additional capability to emit radio and acoustic waves not only vertically but also into horizontally tilted directions. This permits to measure not only profiles of air temperature like the RASS extension but also profiles of horizontal wind using Radio Acoustic Sounding techniques. Compared to plain Sodar measurements, Radio Acoustic Sounding employs some important advantages. It is insensitive to most site properties that limit plain Sodar operation:

- The windRASS is insensitive to environmental acoustic noise.
- The windRASS is insensitive to ground clutter distortions.
- The windRASS operates under harshest environmental conditions.
- The windRASS allows for shorter averaging periods.

4.2 INSTALLATION OF THE windRASS EXTENSION

4.2.1 PACKING LIST

The Scintec windRASS extension comprises the following items:

windRASS Components	**Quantity**
RASS Power Supply (with installed cables to the socket and the RASS Transceiver)	1
RASS Transceiver	1
windRASS Controller	1
RF coaxial cable, length 9m (to connect RASS antennas to windRASS Controller)	4
LF signal cable, length 1m (to connect windRASS Controller to RASS Transceiver)	1
LF signal cable, length 1m (to connect RASS Transceiver to Signal Processing Unit)	1
Four windRASS Antennas and Support Frames	**Quantity**
RASS Slot Antenna	8
RASS Support Frame	4
RASS Support Frame Leg	16
RF Power Splitter	4
Mounting brackets for RF Power Splitter	8
RF coaxial cable, length: approx. 1m (to connect two slot antennas to RF Power Splitter)	8
RF coaxial cable, length: approx. 1m (to connect windRASS Controller to RASS Transceiver)	2
Lens head screw (M3x6) for RF Power Splitter mounting brackets	16
Knurled head screw for antenna mounting	16
Angle mounting part (for fixing support frames to the ground)	8
Tent pegs	8

4.2.2 ASSEMBLY OF THE windRASS ANTENNAS

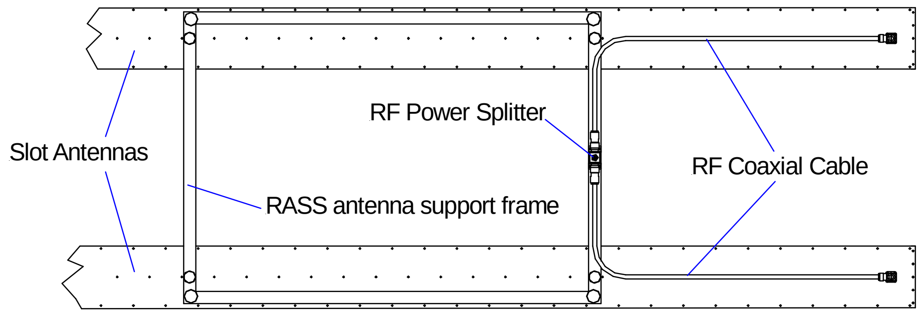
The windRASS Extension comes with four RASS antenna support frames. Each of these rectangular frames hosts two of the eight slot antennas. Fig. 4.1 gives an overview over the components and several mounting holes of a support frame. For assembling such a frame, proceed as follows:

- Turn the frame upside down and attach the support frame legs to the frame. Each leg is already equipped with a corresponding thread bolt and a foot.

- Attach the RF Power Splitter to the frame (Fig. 4.1). To do so, guide the two shorter ends of the RF Power Splitter through the two mounting brackets (close-up in the lower panel of Fig. 4.1), insert the corresponding screws through the flat washer and the spring ring, and screw the RF Power Splitter onto the frame.

- To attach the two antennas to the support frame, put the antennas onto the frame such that the two threads, which are already attached to the antennas, slide into the antenna mounting holes (Fig. 4.1). Ensure that the RF connectors of both antennas point towards the RF Power Splitter. Now, fix the antennas to the frame by using the knurled head screws.

- Connect two RF coaxial cables (length approx. 1m) to the short ends of the RF Power Splitter. The open ends of the RF coaxial cables have to be connected to the RF plugs located on the bottom side of the slot antennas (see illustration below).



- Repeat the steps given above to assemble all four RASS antenna support frames.

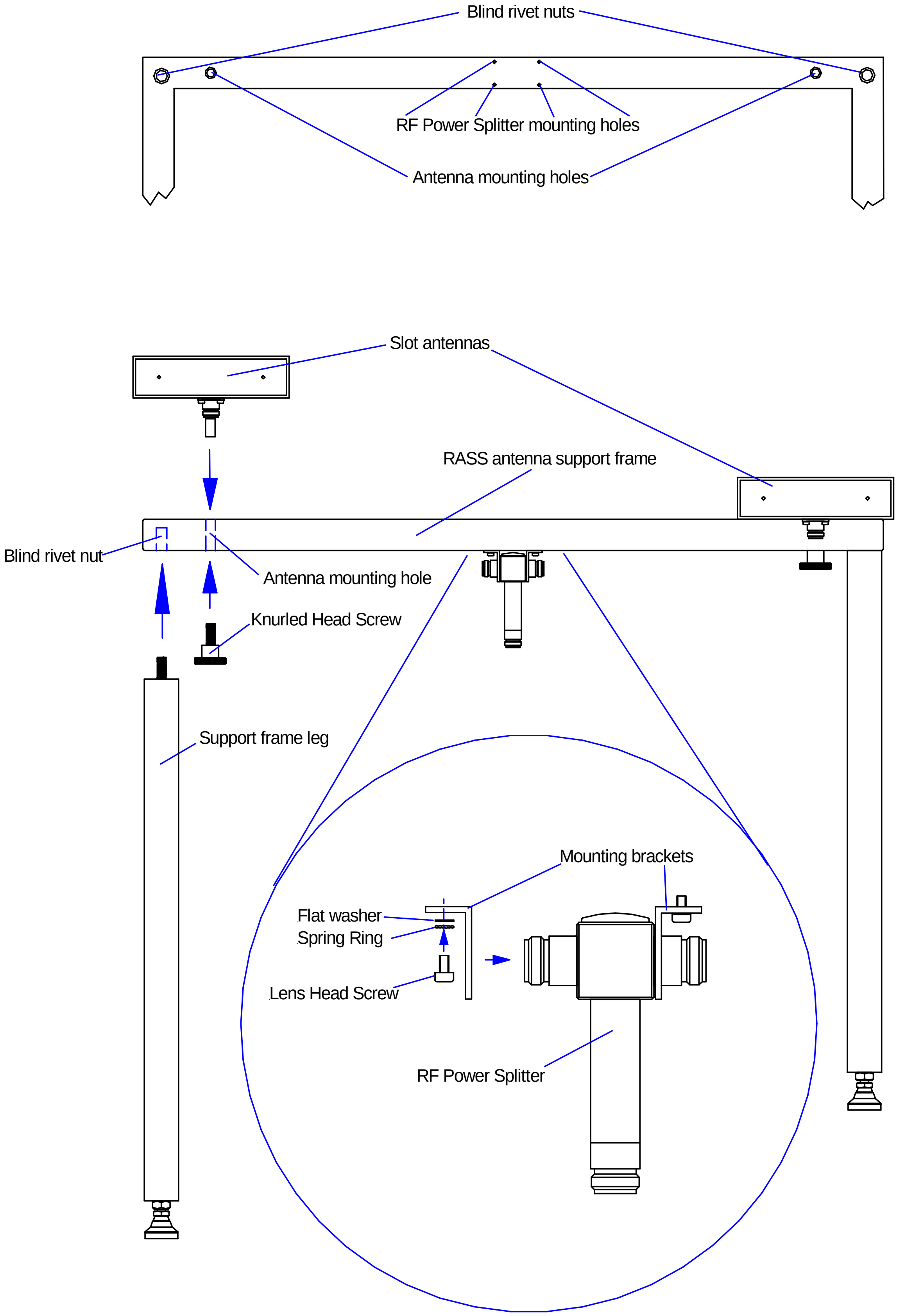


Figure 4.1: Assembling a RASS antenna with support frame

4.2.3 SETTING UP THE HARDWARE

After having assembled the four windRASS antennas, the entire system has to be set up. In order to do so, follow the notes given below. An overall configuration and wiring scheme is given in Fig. 4.2.

A) POSITIONING

For both the North-South and the East-West directions, the centers of the two corresponding windRASS antennas and the center of the sodar antenna must form a straight line. This is indicated by the two blue lines as shown in Fig. 4.2. They represent the East-West and the North-South Axis of the complete system, respectively. The windRASS receiver and transmitter antennas for one direction are situated at the end of this line with the sodar exactly in the center of the line. We recommend a distance of 8m between the centers of the two windRASS antennas for one direction. Note that this distance has to be identical for both the North-South as well as the East-West direction. Please determine after setup the distance between the windRASS antennas for each direction. This distance is one of the parameters that determine the lowest measurement height. Together with the geographical offset from North direction of the entire system, i.e., the sodar antenna as well as the four windRASS antennas, it must be known to use all capabilities of the Sodar operation software to determine precise temperature profiles.

B) windRASS ANTENNA ALIGNMENT

Align the windRASS antennas such that the two windRASS antennas for one direction are as parallel as possible to each other. Then adjust the height of the feet of the windRASS antenna support frame by screwing up or down to obtain the best horizontal levelling of the windRASS antennas.

C) WIRING OF windRASS EXTENSION

The windRASS Extension comes with a set of RF coaxial cables and several LF signal cables for establishing connectivity between individual components and to the components of the sodar system. We recommend the following steps for carrying out the wiring:

- **Establish connectivity between windRASS antennas and windRASS Controller**

  Connect the four RF coaxial cables with length 9m to the open ends of the RF Power Splitters of the four windRASS antennas. The laying of the cables should be conducted in such a manner that the open ends of the RF coaxial cables cross at one point, where the windRASS controller has to be placed. Now connect the open ends of the RF coaxial cables to the four RF connectors being located in the panel labeled “To Antennas” of the windRASS Controller. The left column of the connector array represents the windRASS antennas used for the RF transmission and reception in North-South direction (labeled “North/South”). The right column represents the two RASS antennas aligned along the East/West axis. As indicated by the LEDs given on the right-hand side of the array, the two upper connectors have to be connected to the RF receiving windRASS antennas, whereas the two lower connectors are used for the RF transmitting windRASS antennas. Make sure that the windRASS antennas aligned along one of the two axes are connected column-wise to the corresponding connectors of the array.

- **Establish connectivity between windRASS Controller and RASS Transceiver**

  Connect the windRASS Controller and the RASS Transceiver by using the two remaining RF coaxial cables with length 1m. Two RF connectors are located in the panel labeled “To RASS Transceiver” of the windRASS Controller: RF Receive and RF Transmit. Matching connectors can be found on the front-side of the RASS Transceiver. Furthermore, use the 1m LF signal cable and plug it in the RASS Transceiver connector labeled “To windRASS Controller”

– **Establish connectivity between RASS Transceiver and Signal processing Unit**

Use the 1m LF signal cable to connect the RASS Transceiver (labeled “To Signal Processing Unit”) to the SPU (labeled “To RASS Transceiver”).

Finally, the 1m cable of the RASS Power Supply has to be connected to the RASS Transceiver and the 10m power cable must be plugged into a main voltage socket (220~240V, or 110V optionally). Green lights at the RASS Power Supply and the RASS Transceiver indicate the presence of operating voltage. The yellow LED on the front-side of the RASS Transceiver indicates an ongoing RASS measurement, which is accompanied by the emission of electromagnetic radiation at the transmitter antennas.

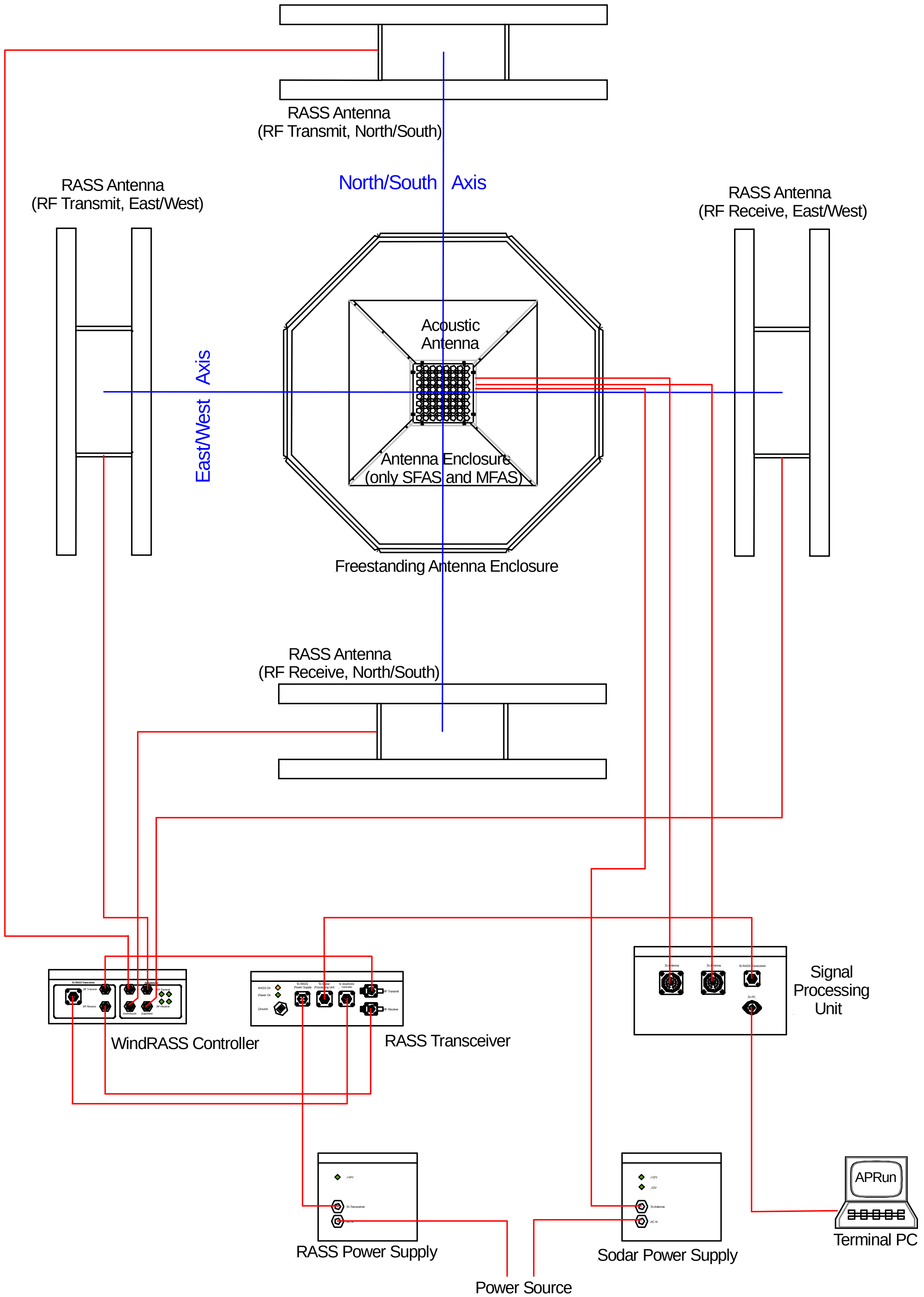


Figure 4.2: Wiring diagram for a Scintec Flat Array Sodar with windRASS extension

4.3 PRECAUTIONS FOR USE OF windRASS RF COMPONENTS

4.3.1 AVOID OVER-TORQUING CONNECTORS

Over-torquing connectors is destructive; it may damage the connector center pin. Finger tight is usually sufficient for mating the connectors. Never use pliers to tighten connectors.

4.3.2 KEEP CONNECTORS CLEAN

The precise connection geometry can be easily disturbed by dirt or other contamination adhering to connector interfaces. When the windRASS extension is not in use, keep the connectors covered. To clean the connector interfaces, use a clean cotton swab, dry or soaked with denatured alcohol. The following are some tips on cleaning connectors:

- Use only denatured alcohol as cleaning solvent.
- Do not use excessive amounts of alcohol.
- Never put lateral pressure on the center pin of the connector.
- Verify that no cotton or other foreign material remains in the connector after cleaning.
- If available, use compressed air to remove foreign particles and to dry the connector.

APPENDIX A THEORY

The Scintec Flat Array sodar is a remote sensing instrument. Remote sensing is often used to measure regions where it is hard to install *in-situ* instrumentation to measure directly.
The sodar provides remote measurements that are made of a volume of air some distance away from the antenna. These measurements are made by sending sound pulses in the vertical and several tilted directions. The signal is scattered back at turbulence in the atmosphere at all heights and received at the sodar antenna.
To calculate the final atmospheric properties (profiles of wind speed, wind direction, turbulence intensity, etc), some assumptions have to be made about, for example, how sound travels through the atmosphere.

In the following, basic theoretical relations of the sodar theory and the used algorithms are briefly explained.

A.1 VELOCITY OF SOUND

The speakers create small pressure fluctuations that propagate away from the antenna. These sound waves travel through the atmosphere with the speed of sound, *c*.
The speed of sound in air is defined as the propagation velocity of the phases of acoustic waves relative to the air. Since there is no dispersion with acoustic waves, the speed of sound equals the propagation velocity of sound groups relative to the air. In the atmosphere, it equals the speed of sound in dry air with good approximation:

$$c = \sqrt{\frac{c_p}{c_v} R_g T_0} \tag{1}$$

where $c_p = 1004$ J kg^{-1} K^{-1} is the specific heat of dry air at constant pressure, $c_v = 717$ J kg^{-1} K^{-1} is the specific heat of dry air at constant volume, $R_g = 287.04$ J kg^{-1} K^{-1} is the gas constant of dry air and *T* is the temperature in Kelvin. Values for the speed of sound at different air temperatures are listed in the following table:

T [℃]	T [℉]	T [K]	c [m/s]
-20	-4	253.15	319.0
-10	14	263.15	325.2
0	32	273.15	331.3
10	50	283.15	337.4
20	68	293.15	343.3
30	86	303.15	349.1

A.2 SIGNAL SCATTERING

In the atmosphere, sound waves are scattered at turbulent temperature and wind inhomogeneities. A sodar system is called monostatic when transmitter and receiver positions are identical. This means that only direct backscatter, i.e. scattering at an angle of 180 degrees, is measured. Then wind fluctuations do not contribute to the scattering and the scattering cross section per unit volume η simply is

$$\eta = 0.0039 k^{1/3} \left(\frac{C_T^2}{T^2} \right) \quad \textbf{(2)}$$

where k is the acoustic wavenumber

$$k = 2\pi / \lambda \quad \textbf{(3)}$$

and C_T^2 is the temperature structure function constant.

Backscatter is effective only for turbulent eddy sizes fulfilling the Bragg condition, i.e. where the spatial wavenumber of the turbulent temperature fluctuations k equals $2k$. For the validity of (3) it is required that these eddy sizes are within the inertial subrange of turbulence. For sound waves with wavelengths of the order of 0.1 m, this is usually the case.

Besides turbulent temperature structures, sound may also be backscattered at quasi-static density discontinuities. In the atmosphere, such discontinuities are formed by strong temperature inversions. Finally, particles like rain drops, snow flakes, larger cloud droplets and birds can produce backscatter.

A.3 PULSE LENGTH VERSUS VERTICAL RESOLUTION

A.3.1 Pulse length

A sound pulse of duration t_p produces a wave group of length

$$L_p = c \cdot t_p \quad \textbf{(4)}$$

propagating through the atmosphere with speed c. After a time t_a from the end of the pulse emission, the spatial separation between the beginning and the end of the group remains

$$c(t_p + t_a) - ct_a = L_p \quad \textbf{(5)}$$

However, due to the additional time the sound needs to return to the receiver, the backscattered signal received at the emitter position after the time t_a originates from the range

$$c(t_p + t_a)/2 \quad \text{to} \quad ct_a/2 \quad \textbf{(6)}$$

The length of this group is

$$c(t_p + t_a)/2 - ct_a/2 = L_p/2 \quad \textbf{(7)}$$

In other words, it is only half as long as the actual pulse length L_p. This is called the "effective pulse length" L_e. This effective pulse length defines the achievable vertical resolution of a sodar. In other words, the achievable spatial resolution is half the length of the actual sound pulse.

A.3.2 Frequency resolution

If we consider an averaging period t_{avg}, this corresponds to a smallest resolvable vertical layer of

$$\Delta Z = t_{avg} \cdot c/2 \quad \textbf{(8)}$$

As can be shown by Fourier transform theory, the best frequency resolution achievable over a period t_{avg} is

$$\Delta f = 1/t_{av} \quad \textbf{(9)}$$

Thus, there is a principal relation between the vertical resolution of a sodar and the maximum possible frequency resolution:

$$\Delta Z \Delta f = \frac{c}{2} \quad \textbf{(10)}$$

Hence with a vertical resolution of 10 m, a frequency resolution of about 17 Hz is possible. With a frequency of 2400 Hz for example, this corresponds to a possible resolution of the vertical wind Δw of 1.2 m/s and, with $\theta = 29°$, a possible resolution of the horizontal win d ΔU of 2.5 m/s. Due to the smooth statistics of the fluctuations of the vertical and horizontal wind components however, interpolations between adjacent frequency points finally lead to much better resolutions for the mean wind. To some degree this is valid also for the standard deviations of the wind components.

A.4 DOPPLER COMPOSITE

The sodar receives a backscatter profile for every pulse sequence. In multi-frequency mode typically 10 frequencies are transmitted. For every beam direction this pulse sequence is repeated *n* times (*n* = pulse repetition sequence). The backscatter signals (time series) are transformed to frequency spectra using fast Fourier transformation (FFT) for every height gate, *z*. These *n* x *z* spectra are averaged in time and used to calculate one Doppler image for each direction and each frequency. As the Doppler-shift scales with the transmitted frequency, one image is determined per frequency. A Doppler image is a 2-D image that yields information on the Doppler-shift against height.
These Doppler images are then averaged over the averaging interval which results in one Doppler image per beam direction and frequency. In case of 5 directions and 10 frequencies, 50 Doppler images are calculated.
These 50 Doppler images are finally used to calculate the composite Doppler images for all three components for the selected averaging interval. These Doppler composites are used to calculate the 3-D wind vector.

A.5 WIND CALCULATION

A.5.1 Doppler shift

The frequency of the backscattered signal is shifted due to the wind velocity component in the direction of the emitted sound pulse u_r. The magnitude of the frequency shift is

$$\delta f = -2\frac{u_r}{c} f \tag{11}$$

$$\delta f_V = -2\frac{w}{c} f_V \tag{12}$$

Here, f is the frequency of the emitted sound pulse. For the vertical beam with frequency f_V and the vertical wind speed w, this means in particular that δf_V is proportional to w.

A.5.2 3D-wind profiles

If we consider a beam with frequency f_E that is tilted from the vertical by an angle θ_E into eastern direction and u is the horizontal wind component in the eastern direction, the frequency shift is

$$\delta f_E = -2\frac{u}{c} f_E \sin(\theta_E) - 2\frac{w}{c} f_E \cos(\theta_E) \tag{13}$$

From this we can derive the case where 3 beams are used: one of frequency f_E which is tilted from the vertical by an angle θ_E into eastern direction, one of frequency f_N which is tilted from the vertical by an angle θ_N into northern direction and a vertical beam with frequency f_v. If we assume the three-dimensional wind to be equal in each beam at the respective layers, the easterly wind speed *u*, the northerly wind speed *v* and the vertical wind speed *w* are calculated from the frequency shifts via

$$u = -\frac{\delta f_E}{2 f_E}\frac{c}{\sin(\theta_E)} + \frac{\delta f_V}{2 f_V}\frac{c}{\tan(\theta_E)} \tag{14}$$

$$v = -\frac{\delta f_N}{2 f_N}\frac{c}{\sin(\theta_N)} + \frac{\delta f_V}{2 f_V}\frac{c}{\tan(\theta_N)} \tag{15}$$

$$w = -\frac{\delta f_V}{2 f_V} c \tag{16}$$

Of course, f_E, f_N and f_v can be identical.

When 5 directions with the tilted angles θ_E, θ_N, θ_W, θ_S are used with the frequencies f_E, f_N, f_W, f_S respectively, and the frequency f_v for the vertical, and we assume again that the three-dimensional wind is equal in each beam at the respective layers, then we can average over the Doppler shift at opposite beams. If $\theta_E = -\theta_W$ and $\theta_N = -\theta_S$, then the contributions of the vertical wind vanish. We then simply find:

$$u = -\frac{1}{2}\left[\frac{\delta f_E}{2 f_E}\frac{c}{\sin(\theta_E)} + \frac{\delta f_W}{2 f_W}\frac{c}{\sin(\theta_W)}\right] \tag{17}$$

$$v = -\frac{1}{2}\left[\frac{\delta f_N}{2 f_N}\frac{c}{\sin(\theta_N)} + \frac{\delta f_S}{2 f_S}\frac{c}{\sin(\theta_S)}\right] \tag{18}$$

$$w = -\frac{\delta f_V}{2 f_V} c \tag{19}$$

A.5.3 Standard deviations of u, v and w

For every Doppler image (for every direction and every frequency) the wind components are determined. These wind components are used to calculate the standard deviations over a certain time period or number of data points *N*

$$\sigma_x^2 = \frac{1}{N-1}\sum\left(\frac{x-\bar{x}}{N}\right)^2 \tag{20}$$

where *x* is the wind components *u, v* or *w* and over bar indicates the mean value.

The standard deviation of the vertical wind σ_w is determined from the wind measured in the vertical direction. This means, that σ_w can be determined directly without any beam corrections. The standard deviation of the horizontal wind components (u, v) are determined from the wind measurements in the North, East, South, West, beam direction. As these beams are not directed horizontally, these standard deviations have to be corrected.

The standard deviations of *u* and *v* are determined under the assumption that there is no correlation between σ_w and σ_u or σ_v (e.g. Bradley, 2008),

$$\sigma_u = \left[\frac{\sigma_u{'}^2}{\sin(\phi)^2} - \frac{\sigma_w{'}^2}{\tan(\phi)^2} \right]^{1/2}, \quad \textbf{(21)}$$

Where σ_u‘ is the standard deviation in beam direction and ϕ the beam angle. The above equation is also valid for σ_v (exchange *u* with *v*).

A.6 NON-PROFILE DATA

A.6.1 Mixing height

The profiles of temperature and backscatter are used to estimate the mixing height, z_i.
The following variables are checked in the given priority order:

1. Find the lowest temperature-inversion height.
2. Find the lowest backscatter-inversion height (using the backscatter flags).
3. Or, if position 1 and 2 cannot be found, maximum backscatter and temperature range.

A.6.2 PG-stability class

The Pasquill-Gifford stability class is calculated according the $\sigma\phi$– method (EPA, 2000), which is based on the standard deviation of the elevation angle of the wind ($\sigma\phi$). The roughness length z_0 is set to 0.15 m (standard value) and can be changed in the ‘advanced modelling settings’ in the APRun software.

Table 1: $\sigma\phi$ boundaries valid for z = 10 m and z0 = 0.15 m

P-G stability class	$\sigma\phi$ [deg] lower boundary	Height exponent, P
A	11.5	0.02
B	10	0.04
C	7.8	0.01
D	5.0	-0.14
E	2.4	-0.31

These boundaries are valid for a measurement height of z = 10 m and a roughness length of z_0 = 0.15 m. The P-G stability class is estimated for any height and any roughness length with the following correction for $\sigma\phi$:

$$\sigma\phi_{corr} = \sigma\phi \cdot \left(\frac{z}{10} \right)^P \cdot \left(\frac{z_0}{0.15} \right)^{0.2} \quad . \quad \textbf{(22)}$$

A.6.3 Kinematic Heat flux

The kinematic heat flux is calculated only for convective conditions, which means, for PG-stability classes A, B or C.
The kinematic surface heat flux Q_0, according to Melas et al., 2000,

$$Q_0 = b^{-3/2} \cdot \left(\frac{g}{\theta}\right)^{-1} \cdot \langle w' \rangle^{3/2} \cdot z_i^{-1} \qquad . \qquad \textbf{(23)}$$

with θ as the mean potential temperature (see next paragraph) given as a fixed value (from the Hardware, Site and Environment settings) or calculated from the RASS temperature profile. And with the variance of the vertical wind w', the brackets <> indicate an average calculated over a height interval of $0.1z_i – 0.7z_i$.
The value b = 0.45 is a constant given by Melas et al,. 2000.

The surface heat flux H_0 in [W/m²] is then calculated,

$$H_0 = Q_0 \cdot \rho \cdot c_p \qquad . \qquad \textbf{(24)}$$

With the air density ρ = 1.21 [kg/m³] and the specific heat capacity at constant pressure c_p = 1005 [J/kg/K].

A.6.4 Mean potential temperature

The potential temperature θ is calculated from the temperature T using the pressure P,

$$P = \left(1 - \frac{z}{288.15} \cdot 0.0065\right)^{5.255} \cdot 1013.25 \qquad , \qquad \textbf{(25)}$$

where z is the height of the antenna above sea level z_{asl} + the height of the antenna above ground level z_{agl} (from the Hardware, Site and Environment settings),

$$z = z_{asl} + z_{agl} \qquad . \qquad \textbf{(26)}$$

The height above sea level is calculated by the given pressure (as set in the environment settings),

$$z_{asl} = \frac{288.15}{0.0065} \cdot \left[1 - \left(\frac{P}{1013.25}\right)^{\frac{1}{5.255}}\right] \qquad . \qquad \textbf{(27)}$$

Finally the potential temperature is,

$$\theta = (T + 273.15) \cdot \left(\frac{1000}{P}\right)^{\frac{R_d}{c_p}} \qquad , \qquad (28)$$

with the specific gas constant for dry air R_d = 287 [J/kg/K].

A.6.5 Monin-Obukov length

The Monin-Obukov length λ is calculated iterative for convective conditions (Melas et al., 2000) using the following equations:

$$\lambda = -\frac{u_*^{\ 3} \cdot \theta}{g \cdot \kappa \cdot Q_0} \qquad , \tag{29}$$

$$u_* (a) = \kappa \cdot \langle U \rangle \cdot \left[\ln\left(\frac{z_i}{z_0}\right) - 0.5 \cdot \ln\left(\frac{z_i}{|\lambda|}\right) - 2.3 \right]^{-1} \qquad , \tag{30}$$

$$u_* (b) = \left(-\lambda \cdot g \cdot \kappa \cdot Q_0 / \theta \right)^{1/3} \qquad , \tag{31}$$

with g = 9.81 m/s² the acceleration due to gravity, κ = 0.4 the von Karman constant and the mean horizontal wind <*U*>.
The solution is found for λ when [u_* (a) - u_* (b)] smallest.

A.6.6 Friction velocity

When the Monin-Obukov length λ is known, the friction velocity for convective conditions is calculated,

$$u_* = \left(-\lambda \cdot g \cdot \kappa \cdot Q_0 / \theta \right)^{1/3} \qquad . \tag{32}$$

A.7 RASS THEORY

The Radio Acoustic Sounding System (RASS) is used to measure temperature profiles. The RASS is used complementary to a sodar system (see Figure 1) and exists of a radio transmitter and receiver. The electromagnetic signal is reflected at the sodar acoustic signal which travels with the speed of sound. The propagation of the speed of sound depends on the temperature and humidity of the air.

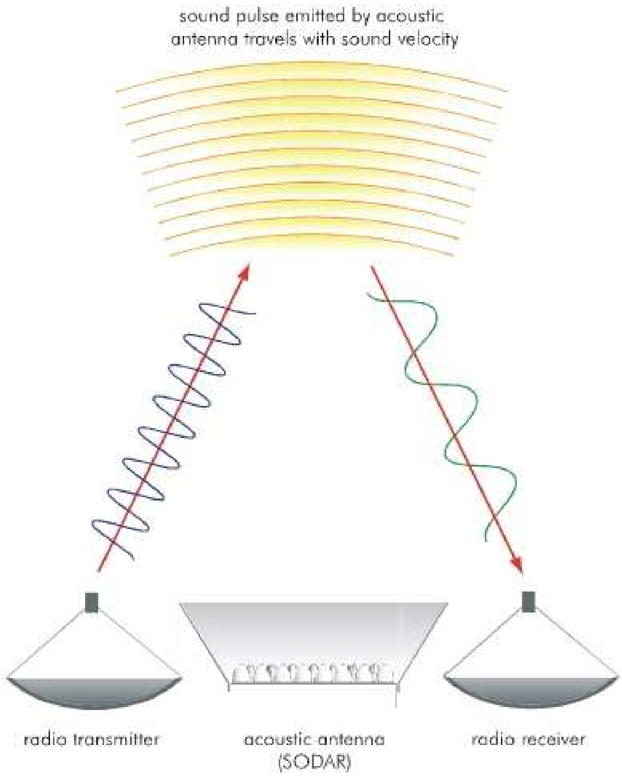


Figure 1: RASS working principle

RASS signals register at the receiver if the wavelength λ_a of the sound waves and the wave length λ of the electromagnetic waves fulfil a Bragg condition, i.e.,

$$\lambda = 2\lambda_a \tag{33}$$

Only in this case the reflections from matching region(s) of the emitted acoustic wave train add up coherently and are strong enough to be detectable. Since we scatter at moving density perturbations, the received electromagnetic waves are Doppler shifted in frequency by the amount Δf with respect to the emitted electromagnetic signal at f_0,

$$\Delta f = -2\frac{c_a + w}{c} f_0 \tag{34}$$

For known vertical wind velocity w, speed of the electromagnetic waves in air c, and emitted electromagnetic frequency f_0, we can deduce the sound velocity c_a from a measurement of this Doppler shift. The height information is obtained by use of Eq. (13), which, introduced into (14), yields

$$\Delta f = -f_a - 2\frac{w}{c} f_0 \tag{35}$$

where f_a is the acoustic frequency of that part of the wave train which fulfils the Brag condition (13) at the moment of reception of the electromagnetic signal. As we have control over the frequencies of the emitted acoustic signal, we can deduce the current position of the wave train element in question. We now have knowledge of the speed of sound as a function of vertical position above the Sodar/RASS. The temperature profile is derived by making use of the known square-root relationship between temperature T (in Kelvin), mixing ratio r (g/g) and speed of sound c_a (in m/s):

$$c_a = 20.067\sqrt{T(1+0.61r)} \tag{36}$$

The quantity under the square root is known as the virtual temperature

$$T_v = T(1 + 0.61r) \tag{37}$$

which is thus directly accessible by a RASS measurement. If the specific humidity q is known as a function of height or, assuming perfect mixing, by measurement on the ground, then the temperature T can be found as a function of height.

Please note that the acoustic frequencies leading to RASS signals depend on the temperature and on the frequency of the electromagnetic signal. APRun will attempt to automatically track the temperature with the acoustic frequencies chosen if the appropriate options are selected. If the electromagnetic frequency is 1290 MHz[*], then the acoustic frequencies are in the vicinity of 3 kHz.

If measurements for q are not available then it is possible to substitute the relative humidity h and the air pressure p, which determine q by

$$q = 0.622h \frac{e^*}{p - 0.378e^*} \tag{38}$$

where e^* is the saturation vapour pressure. Above liquid containing surfaces as wet soil or water surfaces, e^* takes the approximate value (in Pa) (Bolton, 1980)

$$e^* = 6.112 \exp\left(\frac{17.67(T - 273.15)}{T - 29.65}\right) \tag{39}$$

Finally it should be noted that the specific humidity is related to the mixing ratio r by

$$q = r \frac{1}{1 + r} \tag{40}$$

so that $q \approx r$ for small q.

A.8 REFERENCES

Bradley, S., 2008, Atmospheric acoustic remote sensing, CRC Press

Bolton, D, 1980, The Computation of Equivalent Potential Temperature, Monthly Weather Review, Volume 108, p 1046-1053

EPA, 2000, Meteorological Monitoring Guidance for Regulatory Modeling Applications, U.S. Environmental Protection Agency, EPA-454/R-99-005

Melas, D. et al., 2000, Estimation of Meteorological Parameters for Air Quality Management: Coupling of Sodar Data with Simple Numerical Models, Journal of Applied Meteorology, Volume 39, p. 509-515

[*] 1290 MHz is the standard frequency. The RASS hardware can be equipped for a customer-specific frequency.

APPENDIX B DESCRIPTION OF THE INSTRUMENT

In the following, descriptions and technical specifications of the instruments are given.

B.1 ACOUSTIC ANTENNA

B.1.1 GENERAL DESCRIPTION

Scintec Flat Array Sodars operate with an active acoustic antenna. This means that the antenna does not only house the transducers and switches, but also contains audio power drivers for emission and audio preamplifiers for reception mode. As emission elements, highly efficient transducers are used. The same elements reconvert the received sound waves into electric signals.

Most of the analog signal processing is performed in the Signal Processing Unit. By the acoustic antenna of the SFAS, the MFAS, and the XFAS, the following analog and digital information is received from or transmitted to the Signal Processing Unit:

- audio signals for emission, rows
- audio signals for emission, columns
- received audio signals, rows
- received audio signals, columns
- operation mode (emission / reception)
- power amplifier stand-by (supply on / off)
- self-test row / column selection

The acoustic antenna is powered by an external power supply (AC converter or battery) of ±12 VDC (SFAS / MFAS) or ±18 VDC (XFAS).

The orientation of the acoustic antenna is defined such that it is horizontally leveled and the "North" sign is pointing in the north direction. The connectors for power supply and signal cables are mounted on the eastward pointing side.
Under normal precipitation conditions, the acoustic antenna can be operated without additional weather protection.
In order to reduce emitted stray noise and to lower the instrument's susceptibility to active and passive environmental noise (including fixed echoes), an acoustic enclosure can be mounted on the acoustic antenna (Antenna enclosure) or can be set up around it (Freestanding enclosure).

B.1.2 ANTENNA DIMENSIONS AND TRANSDUCER NUMBERING

B.1.2.1 SFAS

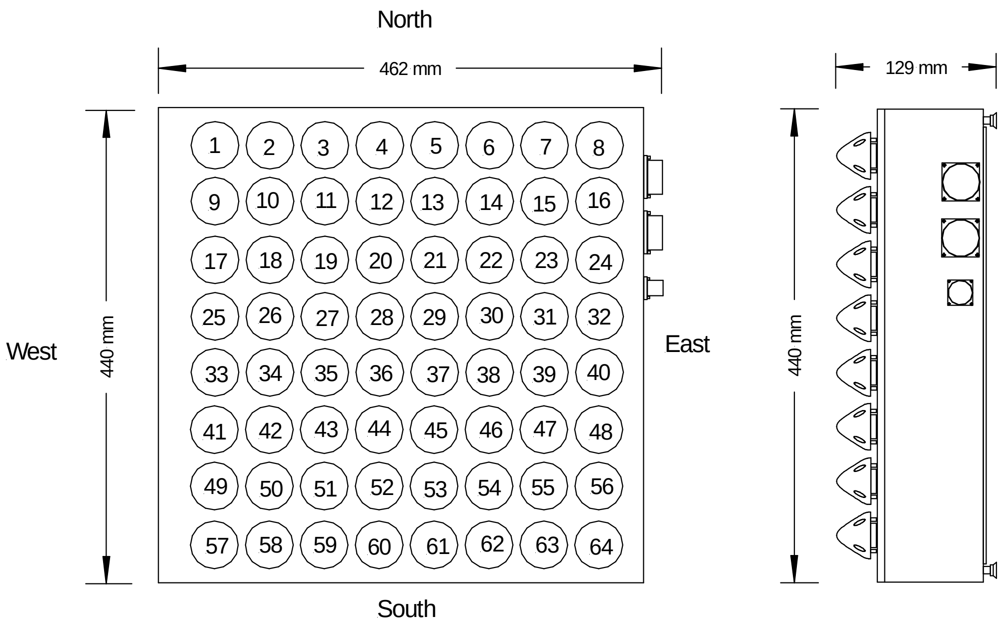


Figure B.1: Dimensions and transducer numbering of the Scintec SFAS antenna

B.1.2.2 MFAS

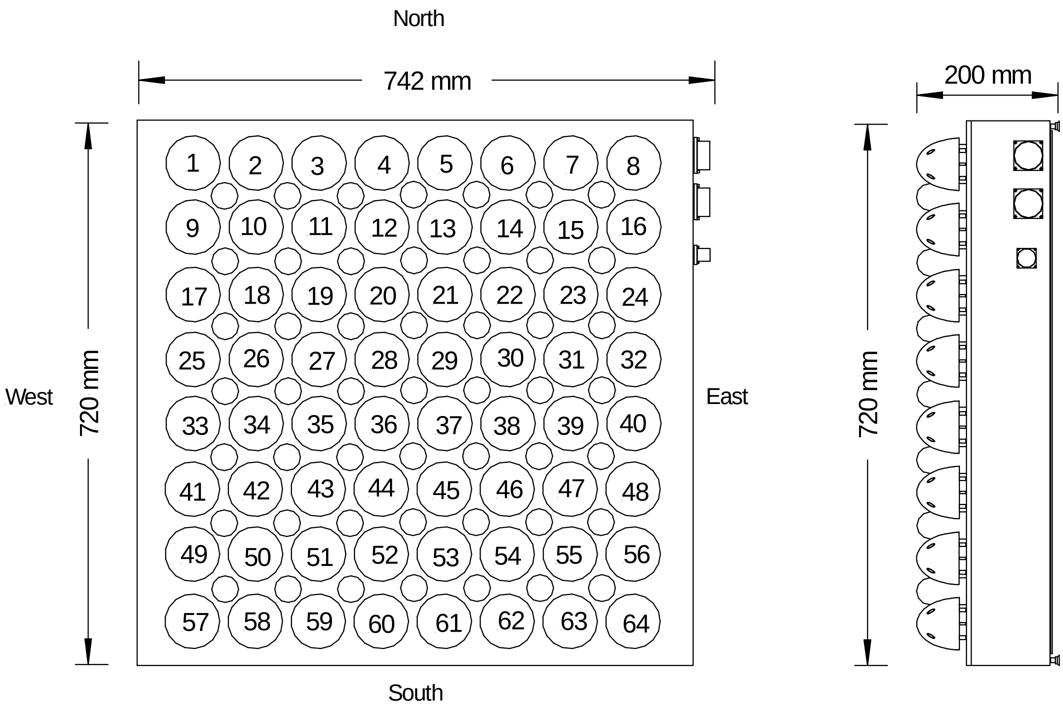


Figure B.2: Dimensions and transducer numbering of the Scintec MFAS antenna

B.1.2.3 XFAS

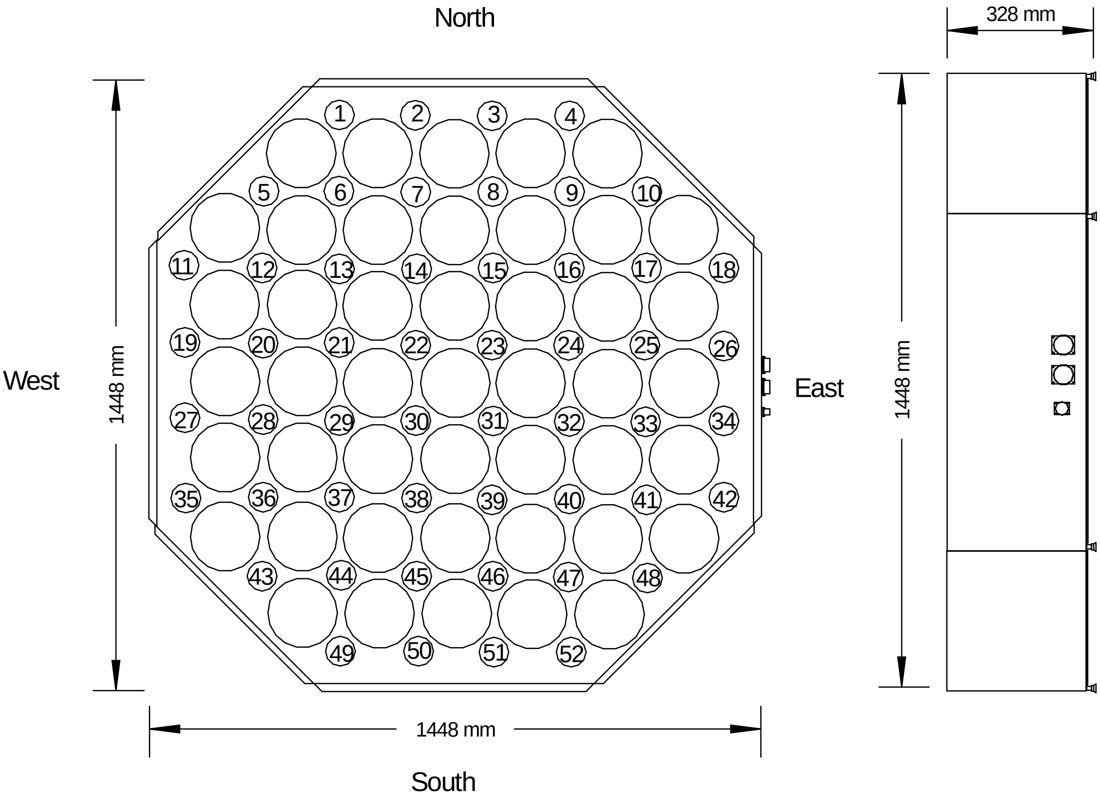


Figure B.3: Dimensions and transducer numbering of the Scintec XFAS antenna

B.1.3 CONNECTORS AT ACOUSTIC ANTENNAS

B.1.3.1 CONNECTORS TO SIGNAL PROCESSING UNIT

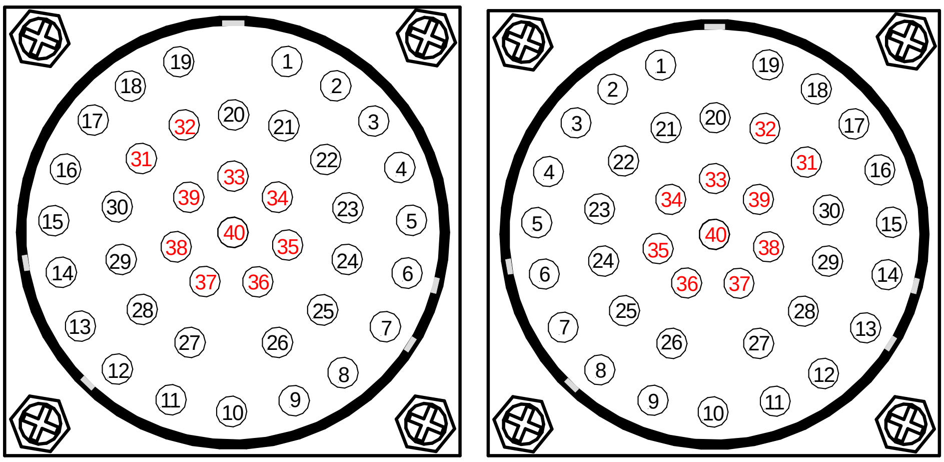


Figure B.4: Connectors at the acoustic antenna. Left: Male, Right: Female

SIGNAL CABLE PIN SCHEMES			
MALE		FEMALE	
Pin #	Function	Pin #	Function
1	TX row 1	1	RX row 1
2	TX col 1	2	RX col 1
3	TX row 2	3	RX row 2
4	TX col 2	4	RX col 2
5	TX row 3	5	RX row 3
6	TX col 3	6	RX col 3
7	TX row 4	7	RX row 4
8	TX col 4	8	RX col 4
9	TX row 5	9	RX row 5
10	TX col 5	10	RX col 5
11	TX row 6	11	RX row 6
12	TX col 6	12	RX col 6
13	TX row 7	13	RX row 7
14	TX col 7	14	RX col 7
15	TX row 8	15	RX row 8
16	TX col 8	16	RX col 8
17	SFAS/MFAS: +12V XFAS: +18V	17	Switch TX/RX row 1
18	SFAS/MFAS: +12V XFAS: +18V	18	Switch TX/RX row 2
19	SFAS/MFAS: +12V XFAS: +18V	19	Switch TX/RX row 3
20	GND	20	Switch TX/RX row 4
21	GND	21	Switch TX/RX row 5
22	GND	22	Switch TX/RX row 6
23	SFAS/MFAS: -12V XFAS: -18V	23	Switch TX/RX row 7
24	SFAS/MFAS: -12V XFAS: -18V	24	Switch TX/RX row 8
25	SFAS/MFAS: -12V XFAS: -18V	25	SFAS/MFAS: GND XFAS: signal GND
26	+12V TX	26	Shading
27	+12V TX	27	SFAS/MFAS: GND XFAS: signal GND
28	GND	28	SFAS/MFAS: GND XFAS: signal GND
29	SFAS/MFAS: +12V XFAS: +18V	29	SFAS/MFAS: GND XFAS: signal GND
30	SFAS/MFAS: -12V XFAS: -18V	30	SFAS/MFAS: GND XFAS: signal GND
31 .. 40	Not connected	31 .. 40	Not connected

B.1.3.2 CONNECTOR TO SODAR POWER SUPPLY

Pin connection scheme for SFAS/MFAS	
Function	**Pin**
Supply +12 VDC	1
Supply 0 VDC (Gnd)	2
Supply -12 VDC	3
Not connected	4

Pin connection scheme for XFAS	
Function	**Pin**
Supply +18 VDC	1
Supply 0 VDC (Gnd)	2
Supply -18 VDC	3
Not connected	4

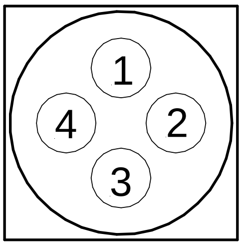


Figure B.5: Male connector to Sodar power supply

B.1.3.3 CONNECTOR TO HEATING POWER SUPPLY SFAS/MFAS (OPTIONAL)

PIN CONNECTION SCHEME	
Function	**Pin**
Heating Supply ~24 VAC	1
Heating Supply ~24 VAC	2
Not connected	3
Not connected	4

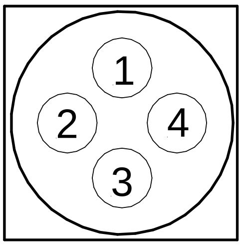


Figure B.6: Female connector to heating power supply

B.1.3.4 FEMALE CONNECTOR TO HEATING POWER SUPPLY XFAS (OPTIONAL)

PIN CONNECTION SCHEME	
Function	**Pin**
Heating 1 Supply +18 VDC	1
Heating 1 Supply 0 VDC	2
Heating 2 Supply +18 VDC	3
Heating 2 Supply 0 VDC	4

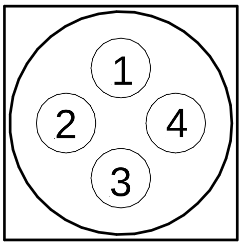


Figure B.7: Female connector to heating power supply XFAS

B.1.3.5 MALE CONNECTOR TO HEATING POWER SUPPLY XFAS (OPTIONAL)

PIN CONNECTION SCHEME	
Function	**Pin**
Heating Switch +12 VDC	1
Heating Switch 0 VDC	2
Not connected	3
Not connected	G

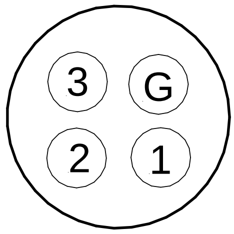


Figure B.8: Male connector to heating power supply XFAS

B.2 SIGNAL PROCESSING UNIT

The Signal Processing Unit operates as a slave processor following the instructions from the terminal PC. The Signal Processing Unit performs the following functions:

- Generation of the acoustic emission signals for all 8 rows or columns
- Control of the gain settings of the acoustic antenna
- Control of the direction modes (vertical, East-West, North-South) of the acoustic antenna
- Control of the operation mode (emission / reception) of the acoustic antenna
- Power management of the acoustic antenna
- Analog processing of the received signals
- Analog-to-digital conversion of the return signals from the acoustic antenna
- Combining the return signals of the rows and columns of the acoustic antenna with appropriate phase shifts
- Calculation of the Fourier transforms
- Temporal averaging of spectra
- Serial transmission of spectra to terminal PC

The Signal Processing Unit is connected to the acoustic antenna. All transducers are directly controlled by the Signal Processing Unit. For this purpose the two signal cables are needed. The Signal Processing Unit is supplied with electrical power from the acoustic antenna. The Signal Processing Unit communicates with the terminal PC via an RS232 line. Adapters (RS422 / RS485) can be used to bridge larger distances.

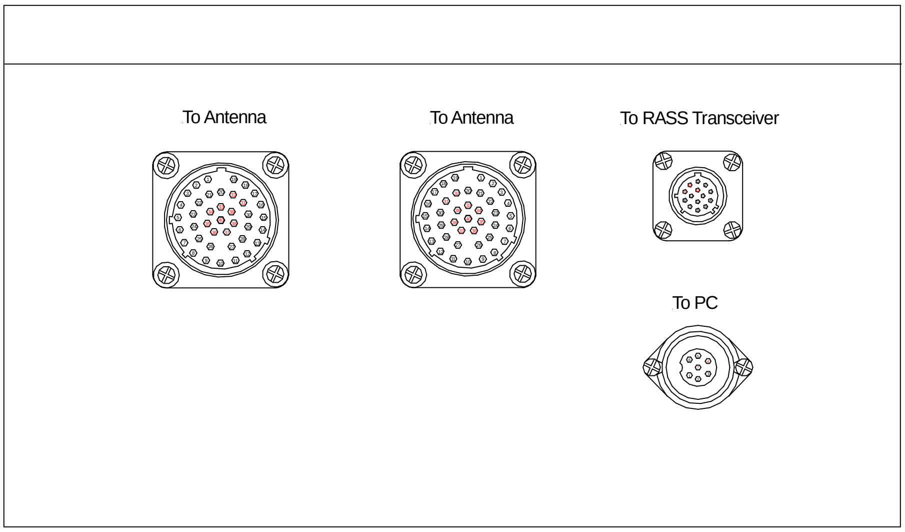


Figure B.9: Signal Processing Unit (front view)

B.3 RS232 CONNECTION CABLE

The RS232 cable used for the serial communication between the Processing Unit and the terminal PC is configured as follows:

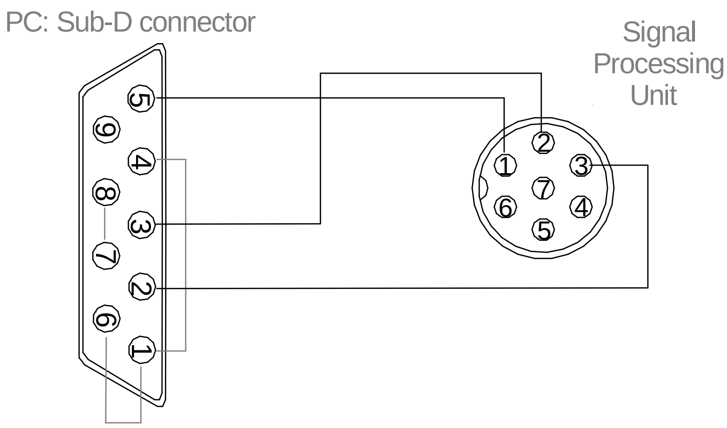


Figure B.10: Connection cable between Signal Processing Unit and PC: wiring diagram

B.4 SODAR POWER SUPPLY

B.4.1 SFAS / MFAS

The power supply is an AC adapter to provide the required ±12 VDC output power for the acoustic antenna and Processing Unit. Two LEDs signalize the correct DC voltages. The following AC line voltage versions are available:

115 VAC, 50/60 Hz
230 VAC, 50/60 Hz

Connection schemes see Section B.1.3

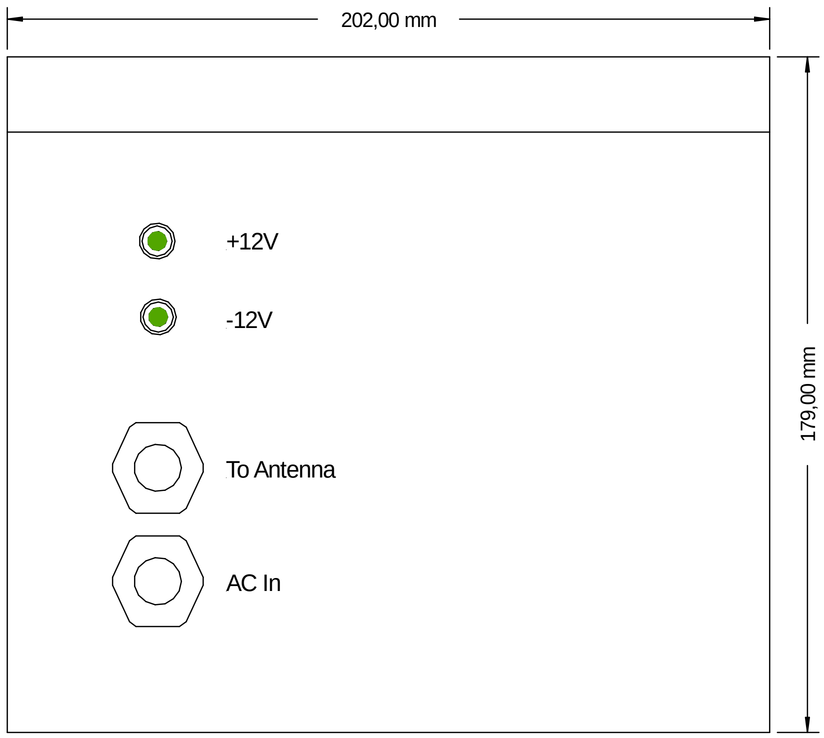


Figure B.11: SFAS / MFAS power supply

B.4.2 XFAS

The power supply is an AC adapter to provide the required ±18 VDC output power for the acoustic antenna and Processing Unit. Two LEDs signalize the correct DC voltages. The following AC line voltage versions are available:

115 VAC, 50/60 Hz
230 VAC, 50/60 Hz

Connection schemes see Section B.1.3

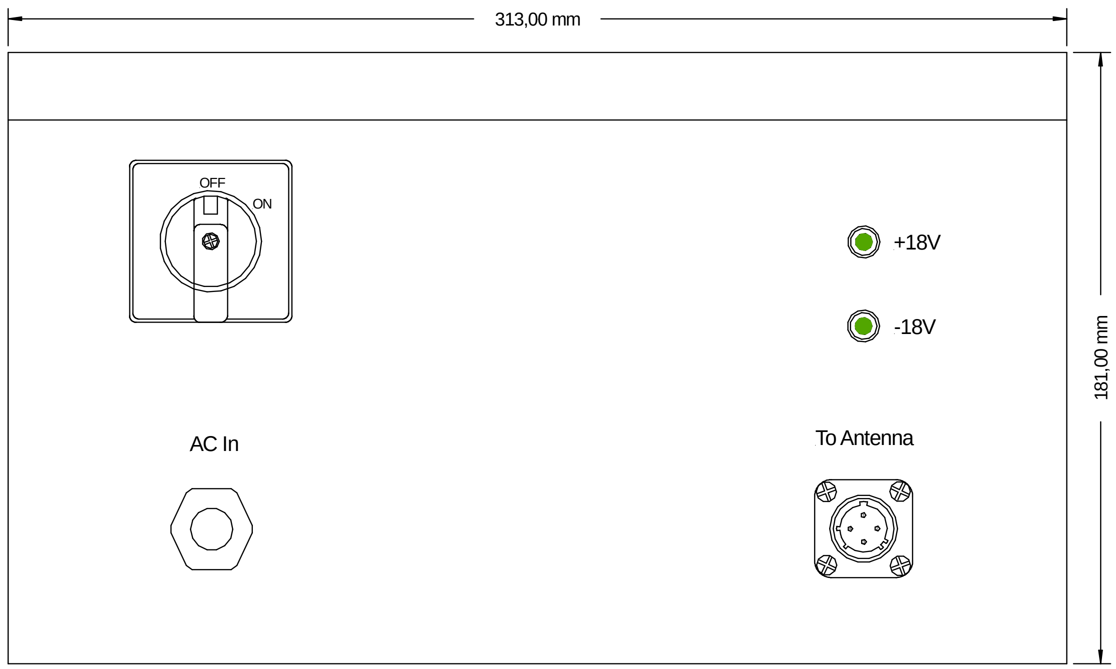


Figure B.12: XFAS power supply

B.5 HEATING POWER SUPPLY (OPTIONAL)

B.5.1 SFAS / MFAS

The power supply is an AC adapter to provide the required 24 VAC output power for the SFAS or MFAS acoustic antenna heating. The Main LED signalizes the correct AC voltage. The Heating LED is on while heating is active. If the Switch is in the 'Auto' position the heating is automatically controlled depending on the ambient temperature: The heating is started once temperature drops below approx. +10℃. The heating is stopped once te mperature gets higher than approx +20℃. Note, that the thermostat that measures ambient temperature is located inside the Heating Power Supply. Therefore heating conditions will not be detected automatically if the Power Supply is installed in a closed cabinet or shelter. In this case the heating should be manually set to permanent operation during the winter season. The following AC line voltage versions are available:

115 VAC, 50/60 Hz
230 VAC, 50/60 Hz

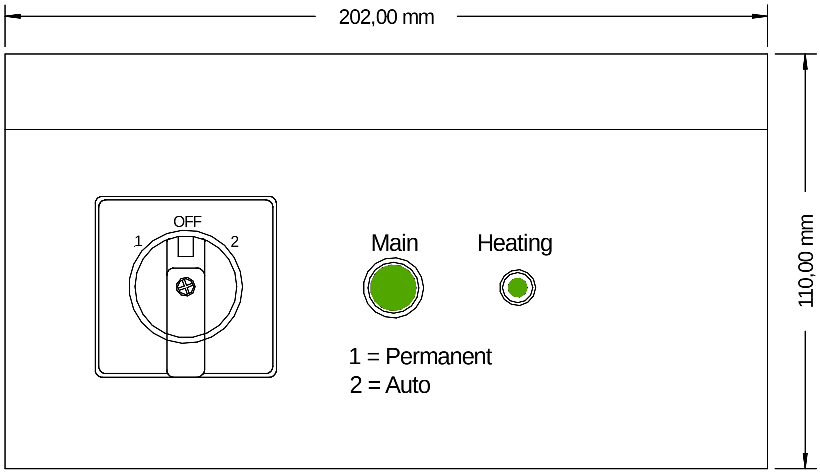


Figure B.13a: Optional SFAS/MFAS heating power supply (front view)

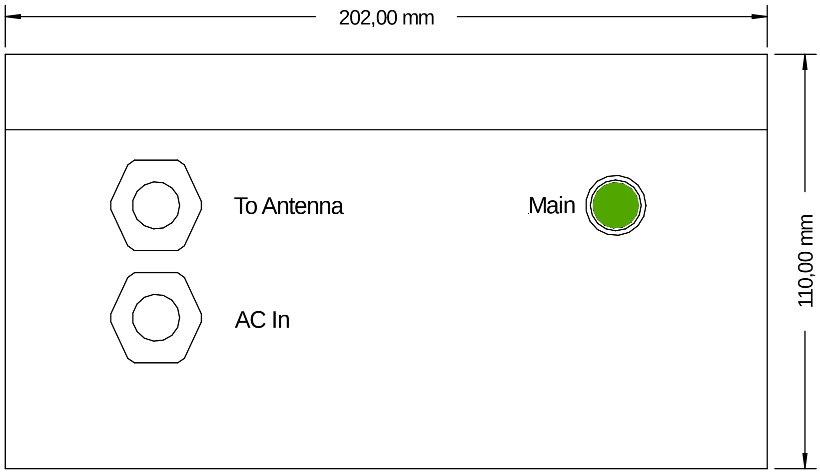


Figure B.13b: Optional SFAS/MFAS heating power supply (rear view)

B.5.2 XFAS

The power supply is an AC adapter to provide the required +18 VDC output power for the XFAS acoustic antenna heating. The heating supply is separated into two independent supply branches that both have individual LED indicators which are on while heating is active. If the Switch is in the 'Auto' position the heating is automatically controlled depending on the ambient temperature: The heating is started once temperature drops below approx. +4℃. The heating is stopped once temperature gets higher than approx +12℃. The ther mostat that measures ambient temperature is located inside the XFAS acoustic antenna. The following AC line voltage versions are available:

115 VAC, 50/60 Hz
230 VAC, 50/60 Hz

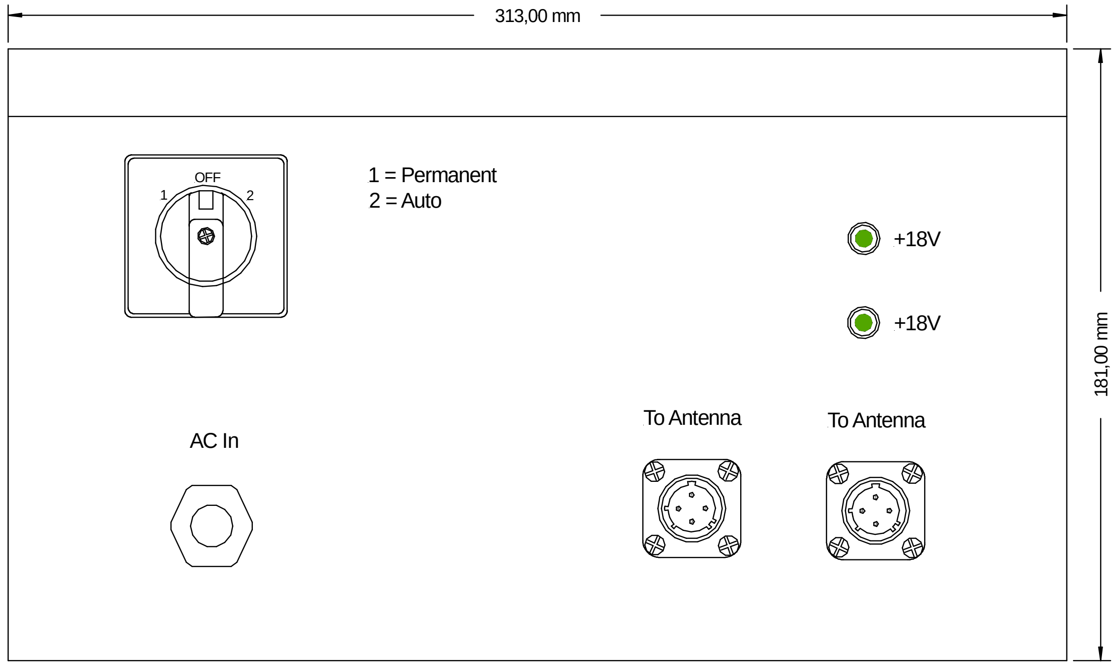


Figure B.14: Optional XFAS heating power supply (front view)

B.6 ENCLOSURE (OPTIONAL)

B.6.1 ANTENNA ENCLOSURES

B.6.1.1 DIMENSIONS OF ANTENNA ENCLOSURES

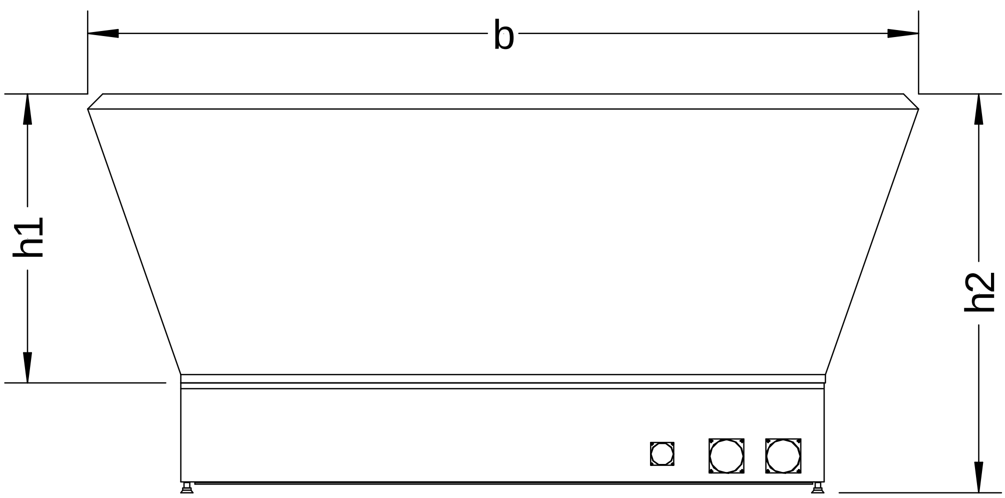


Figure B.15: Sodar with mounted standard enclosure

Outer Dimensions of acoustic antennas with standard enclosure		
Dimensions in mm	**SFAS Standard Enclosure**	**MFAS Standard Enclosure**
b	900	1550
h1	410	695
h2	580	825

B.6.1.2 ASSEMBLY OF ANTENNA ENCLOSURES

The standard enclosures are delivered as four metal sheets. They are coated with sound absorbing foam on one side. First connect the non-parallel sides of two sheets in a way that the short parallel sides meet in a right angle and on both sheets the foam is on the inside of this angle. The connection is fixed by four (SFAS) or three (MFAS) bolts and nuts. Then add the third and fourth sheet in the same manner and screw together the remaining edges. With the SFAS just put the enclosure onto the 12 brackets mounted at the sides of the acoustic antenna and fix it with the screws provided with the enclosure. After assembling an MFAS enclosure, you mount the eight brackets at the sides of the acoustic antenna, then place the antenna on the brackets, adjust its position and attach it to the brackets. The assembly of the MFAS enclosure is illustrated in Fig. B.16.

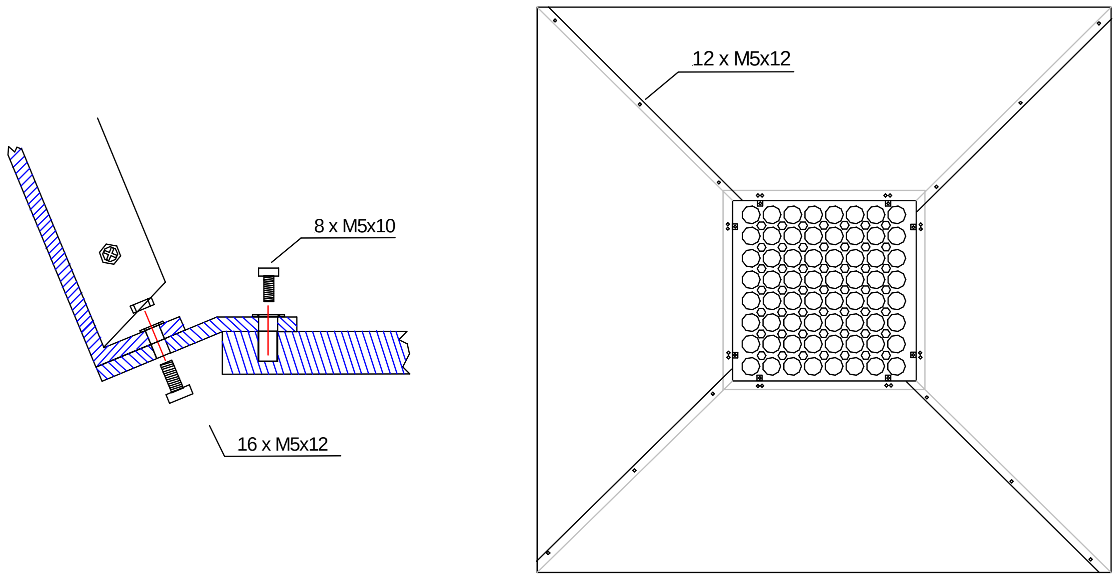


Figure B.16: Mounting an antenna standard enclosure (Example: MFAS)

B.6.2 FREESTANDING ENCLOSURES

B.6.2.1 DIMENSIONS OF FREESTANDING ENCLOSURES

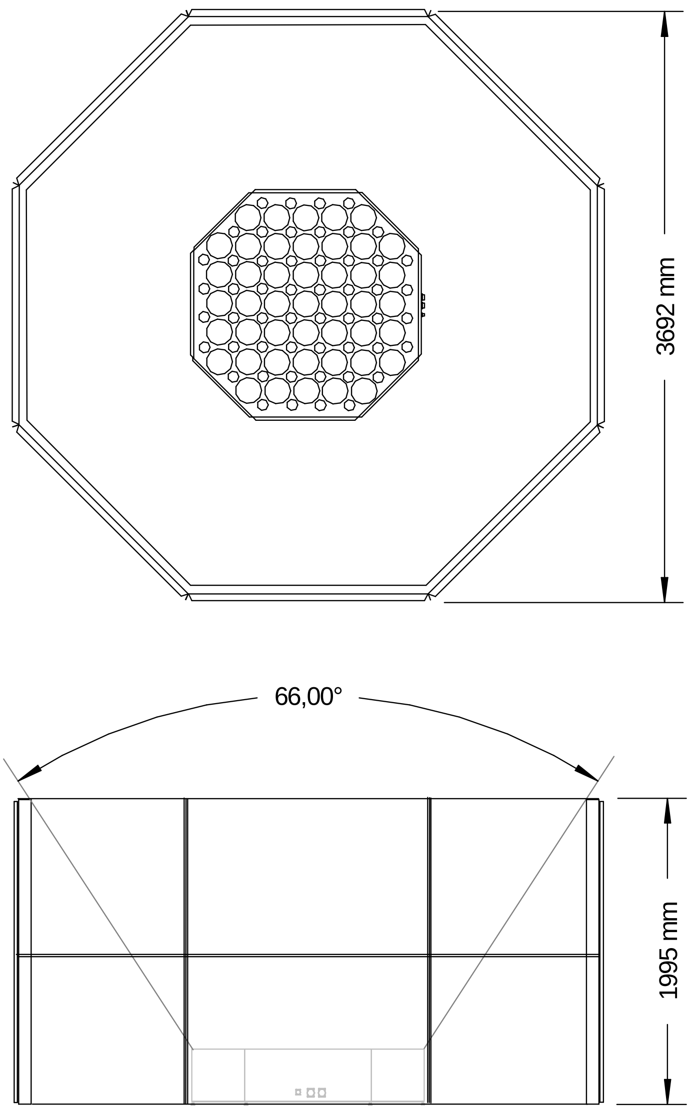


Figure B.17: Outer dimensions of a freestanding enclosure (Example: XFAS)

OUTER DIMENSIONS OF FREESTANDING ENCLOSURES			
Dimensions	**SFAS large enclosure**	**MFAS large enclosure**	**XFAS large enclosure**
Number of panels	8	16	16
Overall height	1200 mm	1720 mm	1995 mm
Full width	1799 mm	3000 mm	3692 mm
Width of each side	745 mm	1250 mm	1529 mm

B.6.2.2 ASSEMBLY OF FREESTANDING ENCLOSURES

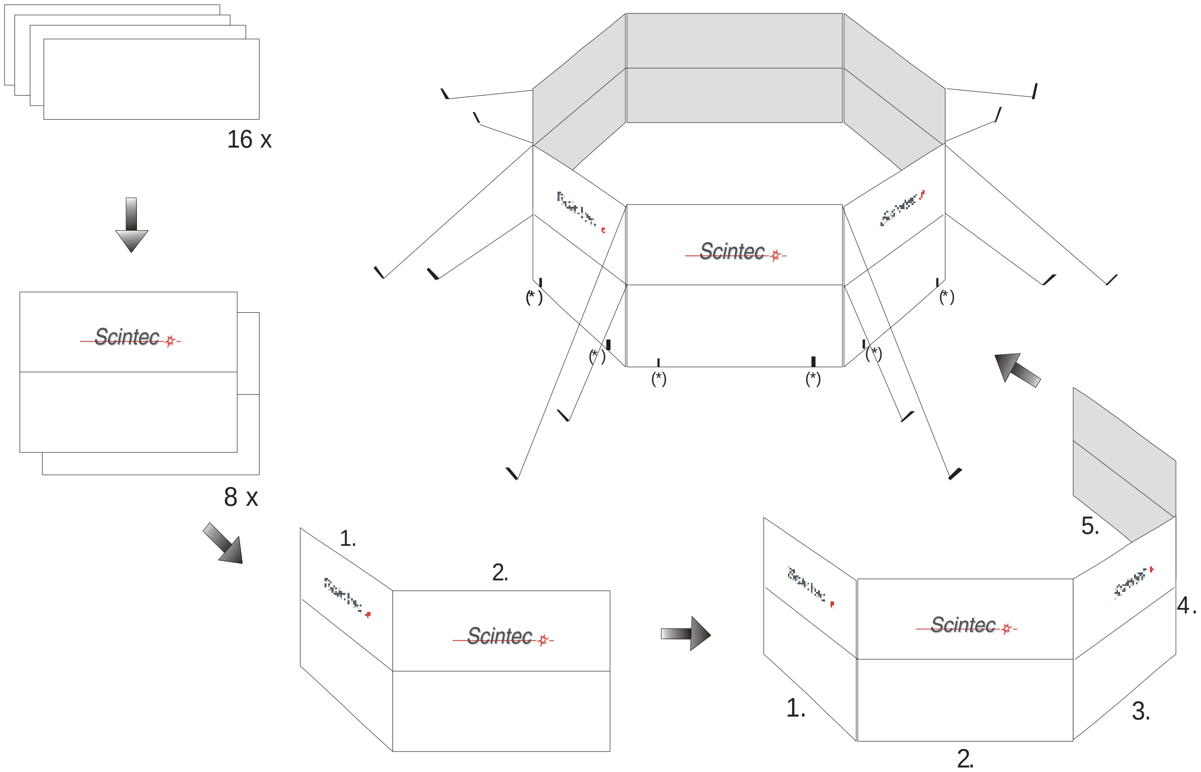


Figure B.18: Mounting a freestanding enclosure

The freestanding enclosures are shipped as 16 (XFAS and MFAS enclosure) or eight (SFAS enclosure) metal panels that are coated by sound absorbing foam on one side. It is recommended to assemble the enclosure with at least three people.

If the enclosure consists of 16 pieces, first connect each of two of the panels by attaching the **longer** edges. Eight of the 16 panels are labeled "Scintec" and these form the upper half of the enclosure. Always connect one labeled panel to one blank panel. The foam-coated sides of both panels point to the interior of the enclosure to be assembled. The connection is accomplished with three (wing) nuts, washers and bolts. This procedure yields eight wall sections as tall as the full height of the enclosure.

With the eight wall sections properly secured proceed as follows: Place two wall sections parallel on the ground with the foam facing downward. The long sides of both wall sections should touch and the “Scintec” labels must be next to each other. Then lift both edges that are in contact together, so that the two wall sections form an angle of 45°. Otherwise the bearings at the sides of the wall sections would be bent when tightening the bolts. Then connect the two wall sections with the bolts. Next erect this first corner. Note that the labels "Scintec" should come on top. Please support the erected parts of the enclosure sufficiently as the unfinished enclosure is rather unstable.

Now add the other wall sections: erect the next wall section at an angle of 45° from the neighboring wall section and secure it with six bolts. Note that the label “Scintec” always has to be on top. Repeat, until the octagon is closed. Note that the acoustic antenna must be exactly centered inside the enclosure. Scintec also recommends that four of the wall sections be parallel to the sides of the acoustic antenna.

Finally, secure the eight corners of the enclosure twice using the tent pegs and guy lines that are shipped with the enclosure. The outcome should look as shown in Fig. B.18.

Note: For permanent installation or strong winds, it is necessary to solidly fix all eight lower sheets directly to the ground (See (*) in Fig. B.18).

Note: The tent pegs shipped with the enclosure are only for low wind speeds and temporary installation and will not provide sufficient stability in every kind of surface. For example, they cannot be used in sand or mud.

B.6.3 ATTACHING FOAM SHEET HOLDERS

Each ordered enclosure comes with an additional set of holders for the sound absorbing foam sheets. One holder unit consists of a screw, a black circular holder arm, a flat washer and a wing nut (Fig. B.19).

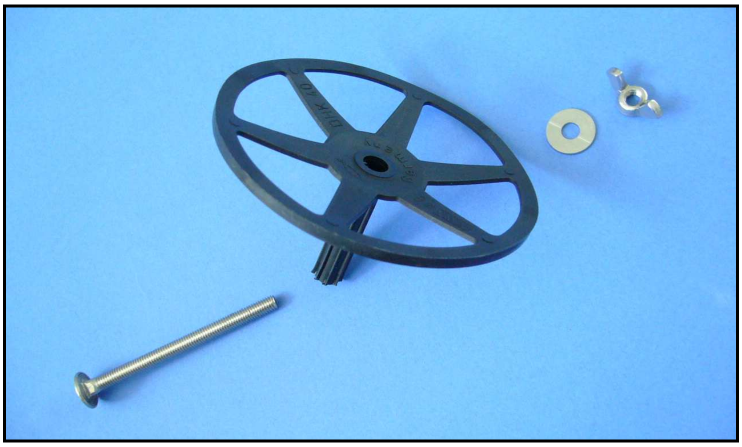


Figure B.19: Components of additional holder unit

In order to attach a holder to an antenna or a freestanding enclosure, proceed as follows:

1. Insert the screw into the prepared hole in the enclosure metal sheet (Fig. B.20)

Figure B.20

2. Put the black holder arm over the screw. The foam sheets are already equipped with corresponding holes.

3. Finally, use the washer and tighten the wing nut (Fig. B.21)

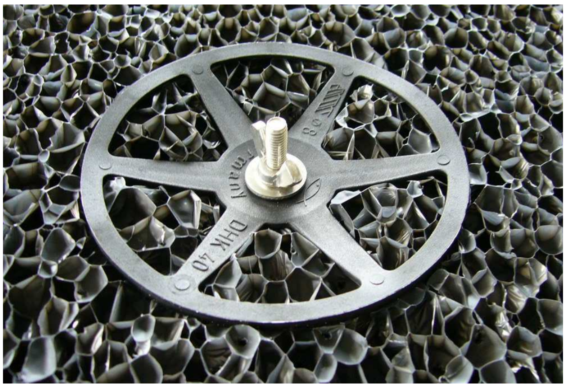


Figure B.21

B.7 RASS AND windRASS COMPONENTS

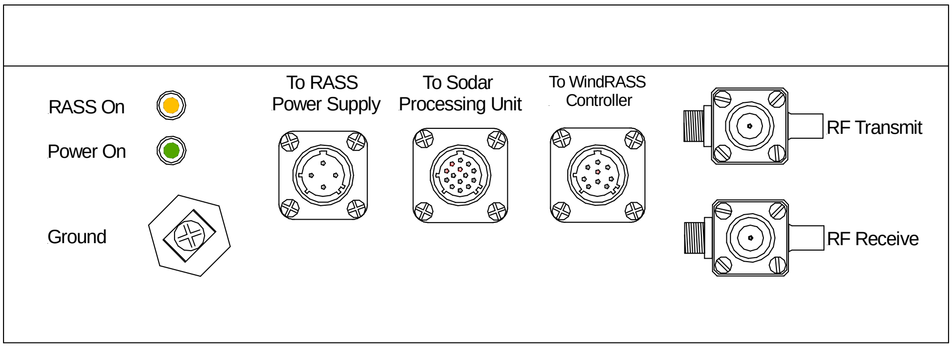


Figure B.22: RASS Transceiver

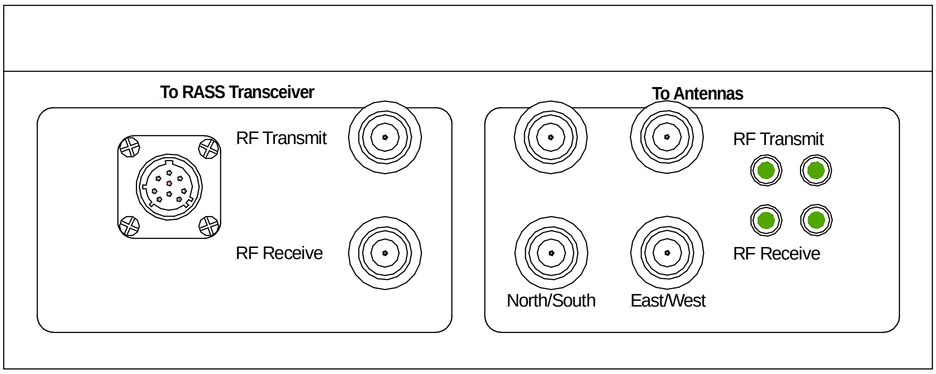


Figure B.23: windRASS Controller

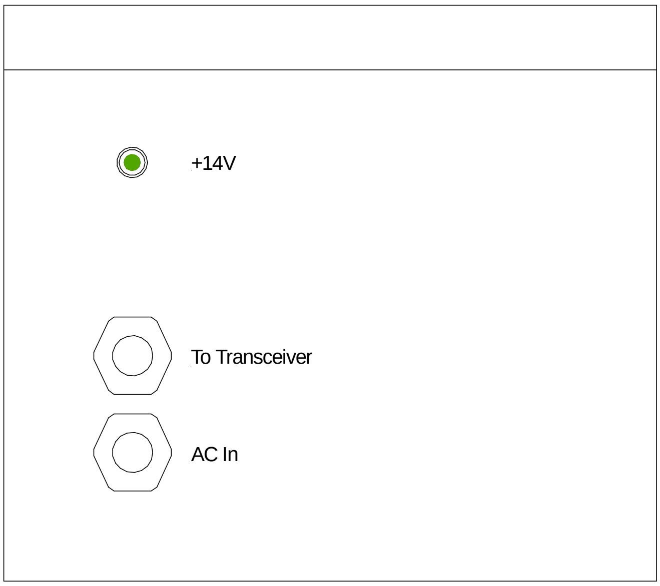


Figure B.24: RASS Power Supply

APPENDIX C SPECIFICATIONS

C.1 SFAS

SFAS System		
Description	**Specifications**	**Remarks**
No. of antenna elements	64	piezo-electric
Electric (acoustic) output power	20 W (5 W)	maximum, user selectable
Frequency range	2525 - 4850 Hz	auto-configuration or user-defined
Multi-frequency	yes	
Multi-beam operation	yes, up to 9 beams	
Beam angles	0°, ± 19°, ± 24°	independent of frequency
No. of range gates	100	maximum setting
Vertical resolution	5 m	finest setting
Minimum height	10 m	depending on settings, environment and atmosphere
Maximum height	500 m	
Averaging time	1 - 60 min	user-defined
Accuracy of horizontal wind speed	0.1 to 0.3 m/s	depending on mode, average over varying conditions
Accuracy of vertical wind speed	0.03 to 0.1 m/s	
Accuracy of wind direction	< 1.5°	at wind speeds > 2 m/s
Measurement range of horizontal wind speed	0 to 50 m/s	nominal
Measurement range of vertical wind speed	-10 to 10 m/s	
Operating temperature	-35 to +55°C (-30 to +130 °F)	
Power requirement DC operation	± 12 V, 1 to 2 A average	depending on settings
Power requirement AC line operation	100 to 240 VAC, 300 W	without antenna heating

SFAS Acoustic Antenna		
Description	**Specifications**	**Remarks**
Size	44 x 42 x 16 cm	Antenna without Enclosure
Weight	11.5 kg	

SFAS Signal Processing Unit		
Description	**Specifications**	**Remarks**
Size	60 x 31 x 18 cm	
Weight	17 kg	

SFAS Power Supply		
Description	**Specifications**	**Remarks**
Size	23 x 20 x 18 cm	
Weight	10 kg	

C.2 MFAS

MFAS System		
Description	**Specifications**	**Remarks**
No. of antenna elements	64	piezo-electric
Electric (acoustic) output power	50 W (7.5 W)	maximum, user selectable
Frequency range	1650 - 2750 Hz	auto-configuration or user-defined
Multi-frequency	yes	
Multi-beam operation	yes, up to 9 beams	
Beam angles	0°, ± 22°, ± 29°	independent of frequen cy
No. of range gates	100	maximum setting
Vertical resolution	10 m	finest setting
Minimum height	30 m	depending on settings, environment and atmosphere
Maximum height	1000 m	
Averaging time	1 - 60 min	user-defined
Accuracy of horizontal wind speed	0.1 to 0.3 m/s	depending on mode, average over varying conditions
Accuracy of vertical wind speed	0.03 to 0.1 m/s	
Accuracy of wind direction	< 1.5°	at wind speeds > 2 m/s
Measurement range of horizontal wind speed	0 to 50 m/s	nominal
Measurement range of vertical wind speed	-10 to 10 m/s	
Operating temperature	-35 to +55℃ (-30 to +130 ℉)	
Power requirement DC operation	± 12 V, 1 to 2 A average	depending on settings
Power requirement AC line operation	100 to 240 VAC, 300 W	without antenna heating

MFAS Acoustic Antenna		
Description	**Specifications**	**Remarks**
Size	74 x 72 x 20 cm	Antenna without Enclosure
Weight	32 kg	

MFAS Signal Processing Unit		
Description	**Specifications**	**Remarks**
Size	60 x 31 x 18 cm	
Weight	17 kg	

MFAS Power Supply		
Description	**Specifications**	**Remarks**
Size	23 x 20 x 18 cm	
Weight	10 kg	

C.3 XFAS

XFAS System		
Description	**Specifications**	**Remarks**
No. of antenna elements	52	
Electric (acoustic) output power	500 W (35 W)	maximum, user selectable
Frequency range	825 – 1375 Hz	auto-configuration or user-defined
Multi-frequency	yes	
Multi-beam operation	yes, up to 9 beams	
Beam angles	0°, ± 22°, ± 29°	independent of frequen cy
No. of range gates	256	maximum setting
Vertical resolution	20 m	finest setting
Minimum height	40 m	depending on settings, environment and atmosphere
Maximum height	> 2000 m	
Averaging time	1 - 180 min	user-defined
Accuracy of horizontal wind speed	0.1 to 0.3 m/s	depending on mode, average over varying conditions
Accuracy of vertical wind speed	0.03 to 0.1 m/s	
Accuracy of wind direction	< 1.5°	at wind speeds > 2 m/s
Measurement range of horizontal wind speed	0 to 50 m/s	nominal
Measurement range of vertical wind speed	-10 to 10 m/s	
Operating temperature	-35 to +55℃ (-30 to +130 ℉)	
Power requirement DC operation	± 18 V, 2 to 8 A average	depending on settings
Power requirement AC line operation	100 to 240 VAC, 1500 W	without antenna heating

XFAS Acoustic Antenna		
Description	**Specifications**	**Remarks**
Size	145 x 145 x 33 cm	Antenna without Enclosure
Weight	144 kg	

XFAS Signal Processing Unit		
Description	**Specifications**	**Remarks**
Size	60 x 31 x 18 cm	
Weight	17 kg	

XFAS Power Supply		
Description	**Specifications**	**Remarks**
Size	33 x 22 x 18 cm	
Weight	17 kg	

C.4 RASS AND windRASS EXTENSIONS

RASS Extension		
Description	**Specifications**	**Remarks**
Radio antenna	parabolic	
Radio frequency	1290 MHz	standard frequency – hardware can be equipped for a customer-specific frequency
Vertical resolution	5 / 10 / 20 m with SFAS / MFAS / XFAS	depending on Sodar model
Minimum range	40 m	depending on settings, environment and atmosphere
Maximum range	600 / 800 / 1000 m	
Averaging time	1 – 60 min	user-defined
Accuracy	0.2 ℃	virtual temperature
Measurement range	-50 ℃ to +60 ℃	
Operating temperature	-35 to +55℃ (-30 to +130 ℉)	
Power requirement DC operation	+14 VDC, 7A	depending on mode
Power requirement AC line operation	100 to 240 VAC, 500 W	

windRASS Extension		
Description	**Specifications**	**Remarks**
Radio antenna	dual-bar antenna	for easy disassembly for transport
Radio frequency	1290 MHz	standard frequency – hardware can be equipped for a customer-specific frequency
Vertical resolution	5 / 10 / 20 m with SFAS / MFAS / XFAS	depending on Sodar model
Minimum range	40 m	depending on settings, environment and atmosphere
Maximum range	600 / 800 / 1000 m	
Averaging time	1 – 60 min	user-defined
Accuracy of horizontal wind speed	0.3 to 0.5 m/s	depending on mode, average over varying conditions
Accuracy of temperature	0.2 ℃	virtual temperature
Measurement range	-50 ℃ to +60 ℃	
Operating temperature	-35 to +55℃ (-30 to +130 ℉)	
Power requirement DC operation	+14 VDC, 7A	depending on mode
Power requirement AC line operation	100 to 240 VAC, 500 W	

RASS Signal Characteristics		
Description	**Specifications**	**Remarks**
Radio frequency	1290 MHz	standard frequency – hardware can be equipped for a customer-specific frequency
RF Bandwidth (-3dB, 82% of the power)	0.8 MHz	
RF Second harmonic	< -40 dBc	

Occupied RF bandwidth (99% of the power)	1.2 MHz	
RF Receiver type	Direct down conversion	
RF Frequency stability	10 ppm	
Acoustic frequency in RASS mode	2570 – 3150 Hz	

RASS Transceiver		
Description	**Specifications**	**Remarks**
Size	60 x 31 x 11 cm	
Weight	16 kg	

RASS Power Supply		
Description	**Specifications**	**Remarks**
Size	23 x 20 x 18 cm	
Weight	10 kg	

APPENDIX D DECLARATION OF CONFORMITY

DECLARATION OF CONFORMITY
according to EN 45014

Name and address of manufacturer:

Scintec AG
Wilhelm-Maybach-Str. 14
72108 Rottenburg
Germany

We declare that the products

Acoustic Wind Profilers

Models
Sodar SFAS, Sodar MFAS, Sodar XFAS

and

Acoustic Wind Profiler Extensions

Models
RASS RAE1, windRASS [*]

comply with the Electromagnetic Compatibility Regulations (EMC) and as far as applicable with the Low Voltage Directive (LVD) of the European Community.

Conformity is guaranteed for delivered complete system and independently operable components. This declaration does not refer to systems resulting from an integration of external components such as data loggers, PCs, power supplies, cable, etc. by others than the manufacturer.

Applicable norms and standards:

EN 50081-1/2,
EN 50082-1/2,
EN 55022:1998 Class B,
EN 60555-2/3, A1:1991,
EN 55014,
IEC 801-1 (1988), IEC 801-2 (1991), IEC 801-3 (1984),
CCITT K20.

[*] For RASS RAE1 and windRASS additional country-specific regulations for radio frequency emissions may apply.