ISIS Ground Station
Datasheet V2.2

VHF, UHF and S-band ground station for LEO satellite missions.

**ISIS Ground Station
Datasheet**

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List of Acronyms/Abbreviations

1/2/3U	1-Unit, 2-Unit, 3-Unit; commonly referring to the singles and multiples of the commercially available CubeSat sizes
ADC	Analogue to Digital Converter
AFSK	Audio Frequency-Shift Keying
AOS	Acquisition of Signal
Az	azimuth
BPSK	Binary Phase Shift Keying
Bps	bits per second
BNC	Bayonet Neill-Concelman
CPU	Central Processing Unit
CW	Continuous Wave
DAC	Digital to Analogue Converter
dBic	decibel-isotropic circular
DDC	Data Distributed Centre
DGS	Distributed Ground Station
DSP	Digital Signal Processing
EI	Elevation
FCS	Frame Check Sequence
FFT	Fast Fourier Transform
GUI	Graphical User Interface
G/T	Gain over Temperature
ISIS	Innovative Solutions In Space BV.
LEO	Low Earth Orbit
LHCP	Left hand circular polarization
LOS	Loss Of Signal
LPB	Lightning Protection Box
LNA	Low Noise Amplifier
IP	Internet Protocol
KISS	Keep It Simple and Stupid
MGSE	Mechanical Ground Support Equipment
MHz	Mega Hertz
N/A	Not Applicable
NDA	Non-Discloser Agreement
OS	Operating System
PC	Personal Computer
PTT	Push To Talk
RF	Radio Frequency
RHCP	Right Hand circular polarization
SDR	Software Defined Radio
TBC	To Be Confirmed
TBD	To Be Determined
TBW	To Be Written

TCP/IP	Transmission Control Protocol/Internet Protocol
TLE	Two-Line Element set
TNC	Terminal Node Controller
TT&C	Telemetry, Tracking & Command
TXS	Transmitter S-band: ISIS product
UDP	User Datagram Protocol
UM	User Manual
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
UTC	Universal Time, Coordinated
UHF	Ultra High frequency (400-470MHz within this context)
VDC	Voltage DC
VHF	Very High frequency (130-170MHz within this context)
VSWR	Voltage Standing Wave Ratio

System Features:

- Remote operations
- Steerable antennas
- Lightning protection
- Pre-assembled and tested
- Heavy duty all-weather azimuth & elevation rotators
- Software defined radio transceiver
  - VHF and UHF downlink capability
  - VHF and UHF uplink capability
  - Dual Band full duplex
  - Supports BPSK downlinks up to 9600 bps on UHF and VHF (APSK, FSK and GMSK also possible)
  - By default supports AFSK, uplinks up to 1200 bps on UHF and VHF (Other modulation schemes and higher data-rates are also possible)
  - Graphical User Interface software for Debian/GNU LINUX
  - VHF and UHF power amplifiers
  - Over temperature protection
  - VSWR protection
  - Built-in antenna polarization switch drive
  - Built-in LNA sequencer
  - USB2.0 connection to a PC

Specifications

- Yagi antennas:
  - VHF: 12.3 dBic gain, switchable RHCP-LHCP
  - UHF: 15.5 dBic gain, switchable RHCP-LHCP
- Software defined radio transceiver
  - VHF frequency range 143 – 148 MHz
  - UHF frequency range 432 – 440 MHz
  - VHF RF output power: 100Watts CW
  - UHF RF output power: 120Watts CW
  - Harmonic suppression: < -50dBc, typical -60dBc
- VHF System noise figure: 1.6 dB
- UHF System noise figure: 2 dB
- N-Type RF connectors
- BNC type for polarization switching output, 0 / +12V DC, 1A max fused
- DC bias for LNA's. 12V via coaxial cable, fused 1A
- Packet and control Interface using TCP/IP sockets
- Support for AX.25 amateur radio protocol

Optional capabilities

- VHF alternative range: 10 MHz within the 130 – 170 MHz range.
- UHF alternative range: 10 MHz within the 400 – 470 MHz range.
- Other protocols upon request
- S-band downlink capability
  - Frequency range 2200 - 2500 MHz
  - Data rate up to 115.2 kbps
  - 31.35 dBi (S-Band)
  - 2m dish (3m available in S-band only ground station configuration)
  - Compatible with ISIS TXS S-band transmitter
  - G/T[1]: ~ 4.9 dB (2m Dish) and ~8.6 dB (3m Dish)
- Site Survey and Onsite installation
- Onsite servicing and maintenance
- Onsite training of personnel and students
- Multiple Ground Stations Network

Applications

- CubeSat TT&C
- Microsat TT&C
- Education

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[1] Reference noise level: -128dBm.

1 Introduction

1.1 Scope of this Document

The ISIS Ground Station Datasheet provides an overview of the specifications, features and the different hardware and software elements of the complete ISIS Ground Station kit.

The complete information required to use and handle the ISIS Ground Station is included in the ISIS Ground Station User Manual. Please refer to that document for further information on how to operate the ISIS Ground Station.
This document is only available upon detailed request, after signature of a NDA or procurement of a Ground station. ISIS reserves its right to not disclose this document prior to delivery of the product.

1.2 General Description

The ISIS Small Ground Station is designed specifically for the reception on ground of a satellite downlink and for commands uplink. The Ground Station is capable of performing autonomous tracking of multiple satellites on priority basis. The components in the ground station including the transceiver, rotor control and CPU comes in a single 19" rack which makes the system very compact. The transceiver makes use of SDR, giving the added flexibility to swiftly reconfigure modulation/coding/data-rate on the run. Most of the commonly used modulation schemes and coding methods are already implemented, any customization requests are also handled.

This device is compliant with the whole ISIS satellite transmitter / transceiver family of products.

1.3 Radio Spectrum Licensing

The ground station is capable of transmitting up to 100 Watts (CW) in VHF (130 … 170 MHz) or 120 Watts (CW) in UHF (400 … 470 MHz). Please make sure that all applicable laws in your country are met, and that you obtain the proper license(s) if needed. Also depending on your country, listening to certain stations may be restricted. The customer is responsible for acquiring all necessary licenses and the license fees are on your expense.

1.4 Overall specifications

Table 1 – Ground Station Specifications

Parameter	Typical Value	Comments
Instrumentation Rack		
Supply voltage	110 V AC (50 – 60 Hz) 220 V AC (50 – 60 Hz)	
Supply current	Max 7.0 A (210 V) Max 3.5 A (220 V)	
Temperature range	20 ^{o}C to 35 ^{o}C (Optimal operation @ 25 ^{o}C)	
Relative humidity	0 – 90 % Non-condensing	
Weight	94 kg (VHF + UHF) 98 kg (including S-band)	S-band optional
TX Frequency range	143 – 148 MHz (VHF) 433 – 440 MHz (UHF)	
Maximum output power	50 dBm (VHF) 50 dBm (UHF)	
Uplink modulation	AFSK, FSK, BPSK	Other modulation types on request.
Uplink data rate	Default: 1200 bps. Configurable: 2400, 4800, 9600 bps	
Uplink protocol	AX.25	
RX Frequency Range	143 – 148 MHz (VHF) 433 – 440 MHz (UHF) 2.2 – 2.5 GHz (S-band)	S-band optional
Overall Noise Figure (cable length 10 m)	1.6 dB (VHF) 2 dB (UHF)	S-band optional
Maximum Input Signal	-20 dBm	
Downlink modulation	Raised-Cosine BPSK, AFSK, FSK, GMSK.	
Downlink data rate	1.2 – 9.6 kbps (VHF and UHF) 14.4 – 115.2 kbps (S-band)	S-band optional
Downlink protocol	AX.25	
Antenna System		
Weight	140 kg (VHF + UHF) 165 kg (including S-band)	S-band optional
Width	5.07 m (VHF + UHF) 5.97 m (including S-band)	S-band optional
Height	2.3 m (From cross-boom to ground) 3.3 m (From ground to top of the dish)	S-band optional
Temperature range	-40 to 70°C	
Gain	13.2 dBi (VHF) 16.3 dBi (UHF) 31.35 dBi (S-band)	S-band optional
Beam-width	52° (VHF) 30° (UHF) 5.1° (S-Band)	S-band optional
Antenna size	14 elements / 3.2 m (VHF) 30 elements / 3.0 m (UHF) 2 m diameter (S-band with UHF / VHF) 3 m diameter (S-band only version)	S-band optional

2 System overview

The ISIS Ground Station is designed to communicate with satellites in LEO using VHF and UHF frequency bands (S-band reception is optional). Figure 1 below shows the main components that make the complete product. They can be divided into two main groups according to the location: an outdoor part, comprising antenna and rotators and an indoor part housing most of the electronic systems. The antennas are shown in Figure 2, where the circularly polarized VHF and UHF Yagi-uda antennas along with the 2m S-band dish are assembled on a roof top.

The antenna system is composed of an antenna mast designed to support the rotators and the antennas also in adverse weather conditions. The rotators are connected to a cross-boom that supports the VHF and UHF antennas on the sides and an optional 2m S-band dish antenna can be accommodated in the central section. (2m dish for a combined UHF/VHF/S ground station, 3m for an S-band standalone version)

The antenna system is connected with several cables to the instrumentation rack, housing the transceivers, the rotator controller and a computer. UPS is not a part of the ground station but it is advised to the customers to use a UPS to ensure the ground station is capable of completing a satellite pass without grid power (for at-least 15 minutes)
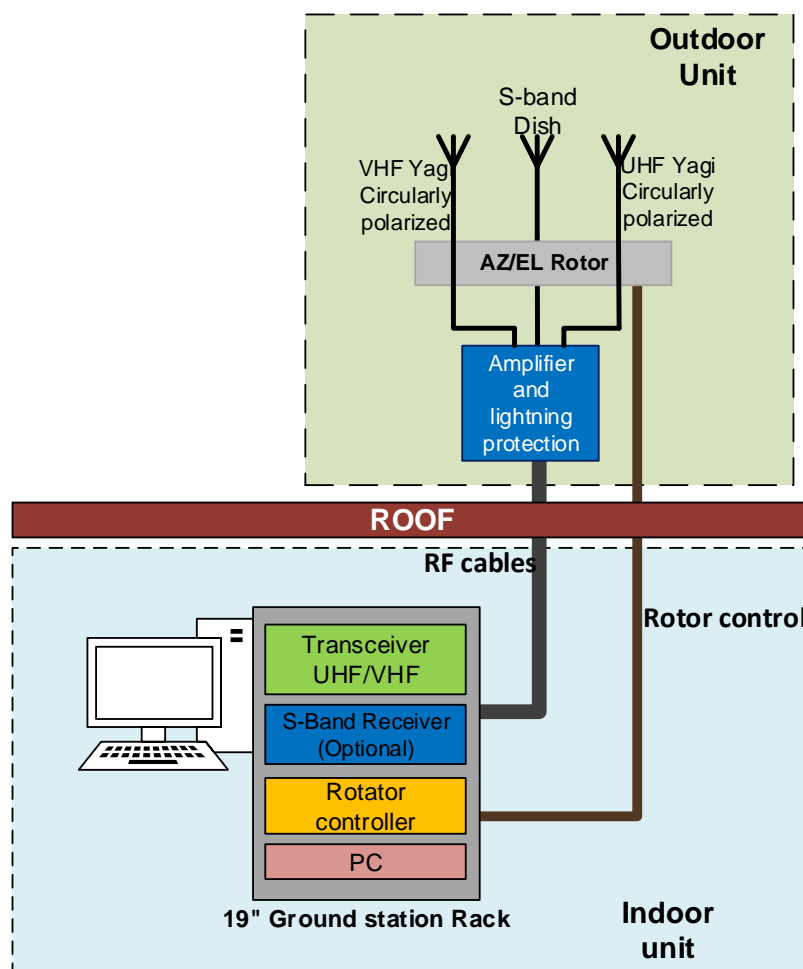

Figure 1: ISIS GS block diagram

3 Antenna system and outdoor equipment:

The outdoor unit comprises of circularly polarized VHF and UHF Yagi-uda antennas, circularly polarized S-band dish, AZ/EL rotors, amplifiers and lightning protection box. The VHF and UHF antenna come with a polarization switches that can be controlled on the front panel of the transceiver to switch between RHCP and LHCP. The gain of VHF and UHF antennas are 12.3 dBic and 15.5 dBic respectively. In-order to improve the overall system G/T, the received signals is amplified very close to the antennas and low-loss cables are used between the antennas and the pre-amplifiers. The 2m S-band dish fits at the centre of the antenna mast providing a good balance to the structure. The S-band dish is provided with counter weight for smooth movement through the pass. The structure is capable of handling wind speeds up to 120 kmph.

AZ/EL Rotor: The rotor system can provide a pointing accuracy of 0.1^0. The rotators are powered by 27 VDC @3.2A through the rotor controller. The Azimuth rotor can turn from 0° (reference North) back to 360° , the time it takes for this complete rotation is about 180 sec (This is the default speed) and the Elevation rotor can point from 0° to 180° in about 100 sec (default speed). It is also possible to control the speed at 9 levels starting at the lowest possible speed corresponding to level 1 and maximum speed corresponding to level 9. The user manual provides more information about how the system needs to be calibrated during the time of installation. The rotors are connected with military grade connectors to provide reliable operation at harsh outdoor weather conditions.
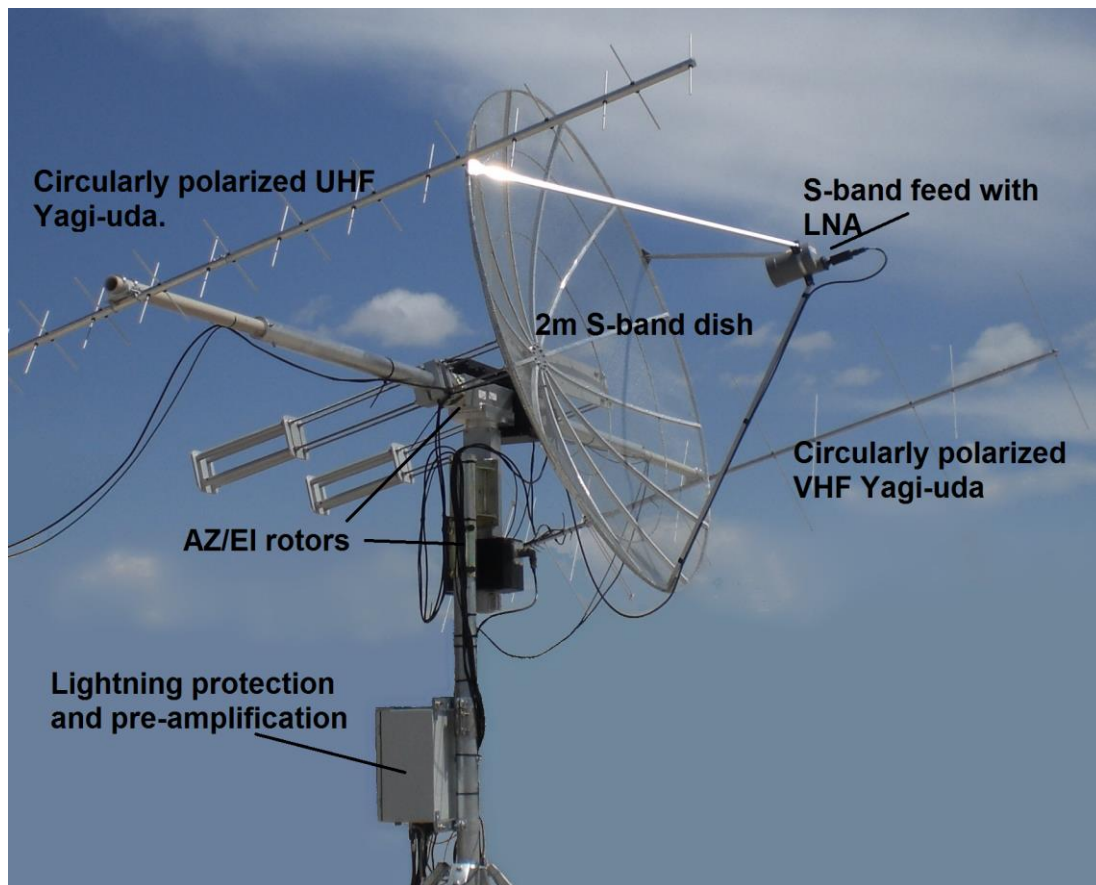

Figure 2: VHF and UHF antennas combined with the optional 2m S-band dish

Lightning protection box: The RF signal passes through a surge protection that can handle up to 10kA. In case of a lightning strike, the circuit breaks and protects the transceiver and other electronics in the instrumentation rack. The surge protection system provides very minimal insertion loss (~0.2 dB). The RF signal is then passed through a pre-Amplifier that is placed inside the lightning protection box. It is necessary to inspect the condition of these surge protectors often after a thunder storm and replace if required. These VHF and UHF amplifiers are powered from the transceiver through the coaxial cable, reducing the hassle to power them separately. The pre-amplifier/LNA for the optional S-band antenna is placed on the antenna feed and is again powered from the transceiver.

VHF/UHF antennas: The default VHF antenna operates from 143 MHz to 148 MHz with a gain of 12.34 dBic. The 3 dB beamwidth of the antenna is 52° circular with a maximum VSWR of 1.3:1 in the specified frequency range. The default UHF antenna operates from 432 to 440 MHz with a gain of 15.5 dBic and a 3 dB beamwidth of 30°circular. The maximum VSWR is 1.6:1 in the specified frequency range. The feed for both these directional antennas are folded dipole with a feed impedance of 50 Ohms. Both the antennas come with polarization switches that can be controlled by the software provided, an indication of the polarization is displayed on the front panel.

Cable assembly and routing: The cable cart comprises of 2 rotor controller cables (~20 meters long), 2 or 3 RF cables (~20 meters long) that connect the transceiver to the lightning protection box and 2 or 3 low loss RF cables (~5 meters) that connect from the lightning protection box to the antennas (3 cables if S-band upgrade is included). By default 20 meter long cables are provided, it is possible to provide additional length cables on request. The assembly manual provides clear instructions on how the cables need to be routed. It is very essential to follow this to prevent entangling of cables during the operations. All the connectors are covered with vulcanizing tapes to protect them from rain water entering into the connectors.

4 Instrumentation rack

The GSKit rack mainly comprises of the control units, transceiver and a computer that comes with a standard LCD display. Individual power cords from the instruments in the rack are routed to the back panel of the rack which can be connected to standard 240V/110V AC supply. The rack mainly comprises of the following components.

4.1 Computer

The computer in the rack runs various software used to control the rotors and transceivers. The software architecture of the Ground Station is elaborated in Section 5. The computer is interfaced to the AZ/EL Rotor controller using a RS-232 interface. The computer talks to the SDR transceiver using USB interface. The computer occupies 2U of the rack. The computer can be turned on using the power button on a side of the front panel and, in case of power failure, it will turn ON automatically (if it was ON before the power failure). More information about the software architecture of the ISIS ground station can be found in the next section.

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4.2 Rotator controller

It is used to control the azimuth and elevation rotor to follow the satellite during a pass. The rotor controller can be manually controlled using the knobs in the front panel or can be controlled by the computer through the RS232 interface. The computer runs a satellite tracking program that generates the Azimuth and Elevation angles of the satellite relative to the ground station when the satellite enters the communication window. The rotor is powered through the rotor control box. The rotor controller occupies 3U of the rack. A picture of the controller used is shown in the Figure 3 below:

Figure 3: Rotor controller

4.3 VHF UHF Transceiver:

The transceiver consists of the TX and RX modules, gain blocks, antenna polarization switches and protection against reflected power. The transceiver occupies 3U of the rack. Figure 4 shows the front panel of the transceiver:
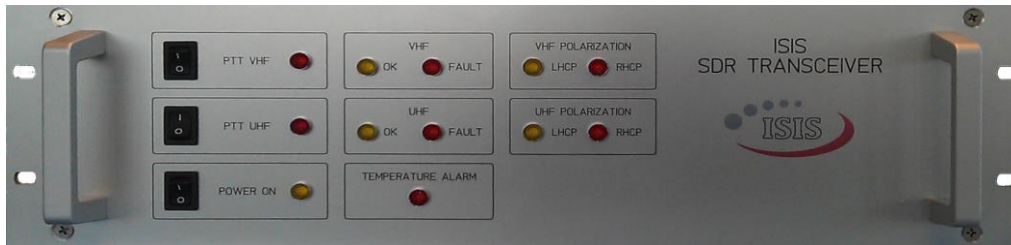

Figure 4: VHF&UHF transceiver.

The different functionality that can be controlled and monitored on the front panel of the transceiver are as follows:
- **PTT VHF** is used to enable / disable the VHF transmitter: if the switch is set to 0, the transmitter is disabled while when 1 is selected, the transmitter can be used. When the PTT
- LED is ON, the transmitter is active.

- **PTT UHF** is used to enable / disable the UHF transmitter: if the switch is set to 0, the transmitter is disabled while when 1 is selected, the transmitter can be used. When the PTT LED is ON, the transmitter is active.

- **Power ON** controls the power to the radio, if set to 0 the device is OFF.

- **VHF OK** signals that the VHF transmitter is in nominal state.

- **VHF FAULT** signals that the VHF transmitter is not properly connected to a 50 Ohm antenna. This LED signals that the protection circuit is reducing the transmitted power to avoid damaging the power amplifier. The protection circuit is designed to stand a 100% duty cycle.

- **UHF OK** signals that the UHF transmitter is in nominal state.

- **UHF FAULT** signals that the UHF transmitter is not properly connected to a 50 Ohm antenna. This LED signals that the protection circuit is reducing the transmitted power to avoid damaging the power amplifier. The protection circuit is designed to stand a 100% duty cycle.

- **Temperature Alarm** signals that the temperature on the power amplifiers is higher than 50°C. In case the temperature raises further the power amplifiers will be automatically disabled to prevent any damage.

- **VHF LHCP / RHCP Polarization** indicators signal which polarization is currently selected on the VHF antenna.

- **UHF LHCP / RHCP Polarization** indicators signal which polarization is currently selected on the UHF antenna.

4.4 S-band receiver (optional):

Comprises of the receive chain configured to receive between 2200 to 2500 MHz (Other frequencies on request). The S-band receiver is interfaced to the PC through USB3.0/USB2.0 interface. The overall noise figure of the S-band system is < 15dB. The downlink data-rate is configurable up to 115.2 kbps. The S-band receiver comes with a separate GUI to control the radio and display the received data. The S-band receiver occupies 1U of the rack. A picture of the S-band receiver is shown in the figure below

Figure 5: S-band receiver.

5 Software

The GSKit 19"rack comprises of a PC running Linux OS: the computer is used to perform control tasks such as satellite tracking, rotor control, Doppler correction, automatically update TLE (Two Line Elements) and radio control for digital data modulation / demodulation. A block diagram representation of the software architecture implemented is shown in figure below:
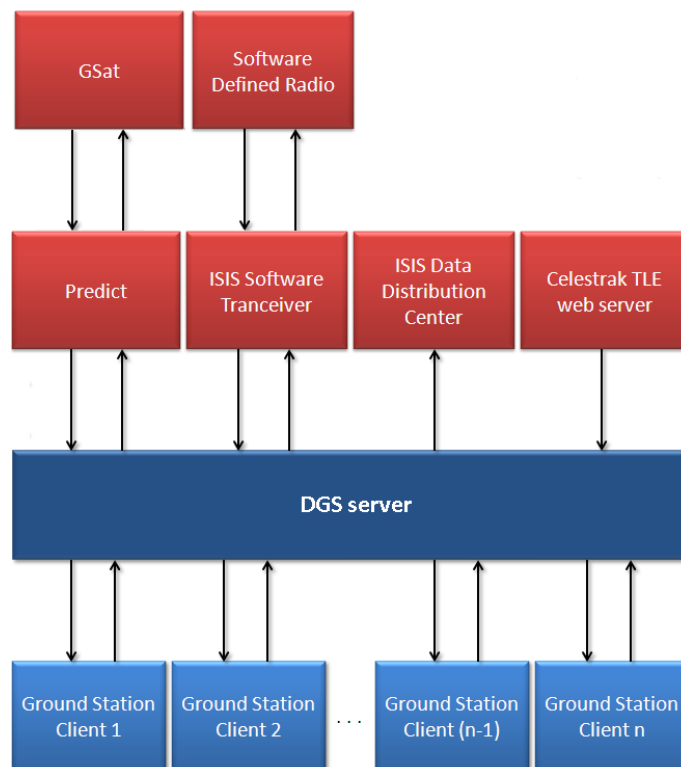
Figure 6: Software architecture of the complete system

The PC comes with the following software already installed:

5.1 DGS (Distributed Ground Station) server:

DGS is the core of the ground station software which runs in the background. Some of the tasks it performs include:

- Scheduling satellite passes based on priority.
- Command the ISIS software transceiver to tune the SDR to the corresponding downlink/uplink frequencies.
- Obtain the positions of the satellite with respect to the ground station position and provide the corresponding Doppler correction to the SDR.
- Command the rotor controller to point to the satellite of interest when the satellite is in the communication window.
- Automatically update the TLEs (Two line Elements) from Celestrack website periodically.
- Provide a clear configuration and monitoring interface with the ground station clients.

More information on how to configure the DGS server can be found in the user manual.

5.2 DGS GUI

DGS GUI is the graphical user interface to access the DGS server and control it. The GUI provides various tabs to configure the server, an example of this is shown in the figure below where the tracking scheduler is configured:
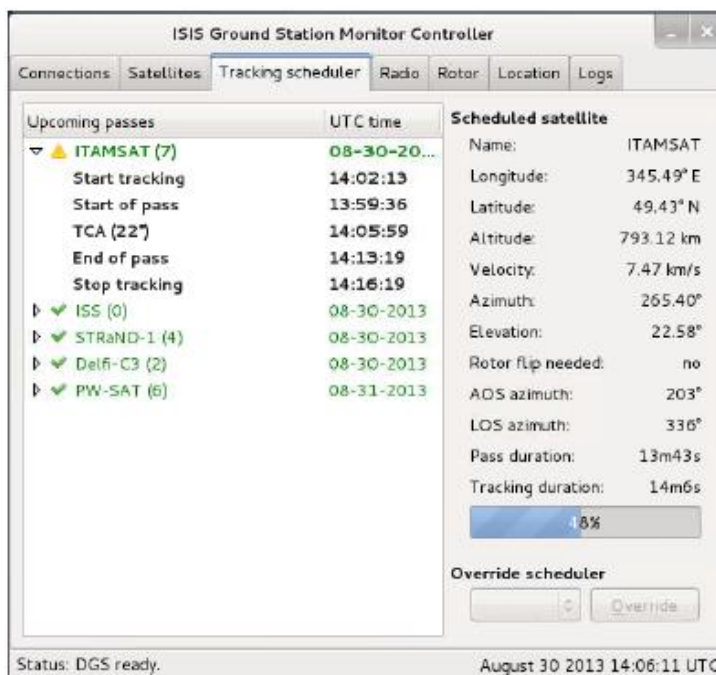
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Figure 7: The tracking scheduler tab that shows the upcoming passes that are scheduled.

5.3 UHV/VHF Transceiver

The ground station employs a SDR for digital data transmission and reception: baseband signals generated by the DAC are up-converted to RF in the transmitter chain while RF signals are down-converted and sampled using an ADC in the receiver chain. The figure below shows the user interface to control the transceiver:

1) Signal source selection: This slide-down option box can be used to select the desired input source. When a new source is selected, the demodulator is restarted. The signal level indicator displays the input signal strength: if the indicator bar is red, the input signal strength is too weak or too strong for optimal operations, while a green bar indicates good input signal strength.
2) Fine tune: This control shows the actual reception frequency (relative to the radio center frequency). The frequency information is computed by the demodulation loop and when the receiver locks on an input signal, a lock indicator is displayed.
3) Options panel: The ASCII output control is used to display packets in the Terminal window (7) as ASCII characters instead of hexadecimal data, the pause terminal check-box allows to disable the FCS check in AX.25 frames. The Log check-box instead enables packets logging.
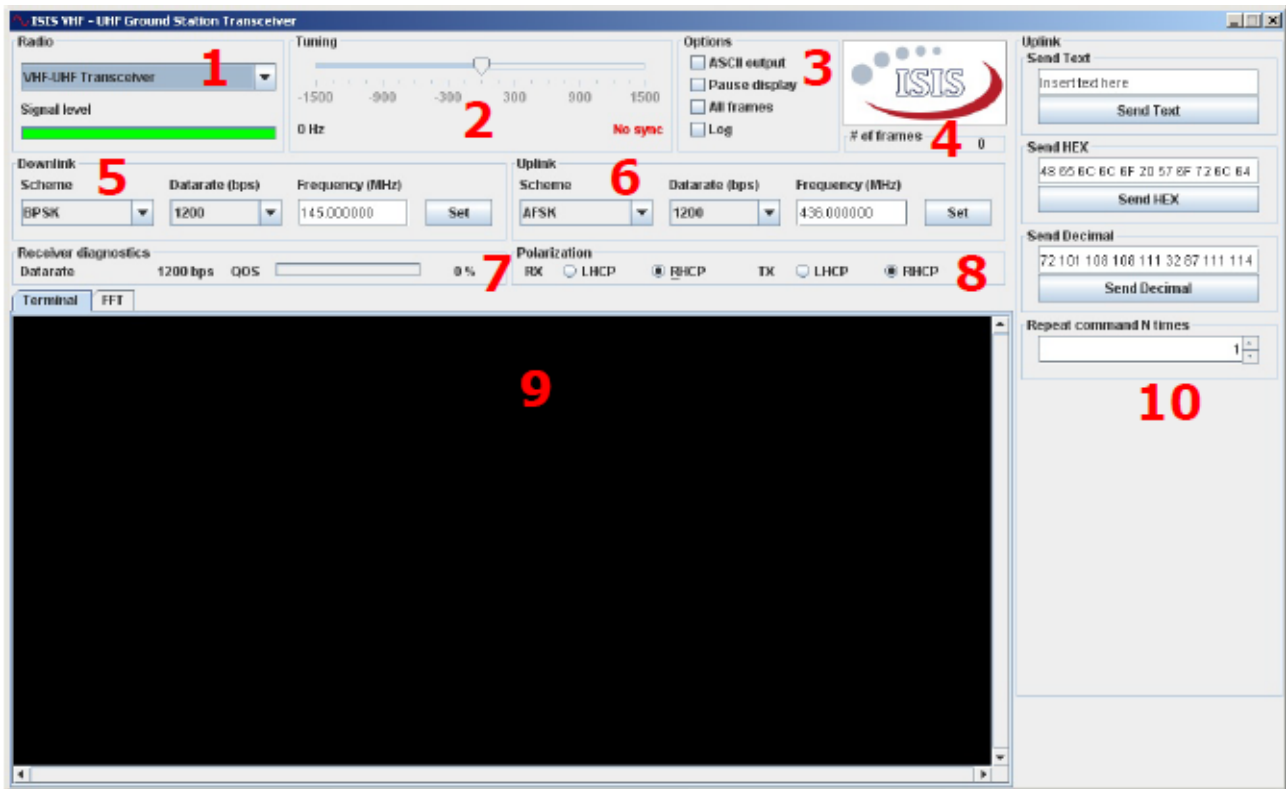
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Figure 8: ISIS Transceiver interface.

4) Received frames: Displays the number of received frames. The counter can be reset by right clicking on the counter and selecting clear.

5) RX channel setting: The modulation select box allows choosing the desired downlink modulation scheme and the datarate. When a new modulation scheme or datarate is selected the demodulation is restarted. The downlink center frequency in MHz can be set in the text box provided.

6) TX channel settings: The uplink modulation, datarate and frequency (in MHz) can be set here. When any of these settings are changed, the modulator is reset.

7) Link diagnostics: This tab displays the measured datarate on the downlink channel and the estimated signal quality.

8) Polarization control: This tab is used to control the antenna polarization. The user can select polarization by clicking on the desired value or use the keyboard shortcut "Alt+R" for toggling the receiver polarization and "Alt+T" to toggle the transmitter polarization.

9) Display tab: This tab is a multi-functional panel used to display a wide range of information regarding the received packets and spectrum.

10) Uplink panel: This panel is used to send commands to the satellite. When a new command has been sent, it will also be displayed in the Terminal panel.

The following diagram shows the FFT panel and ASCII output of the transceiver software:
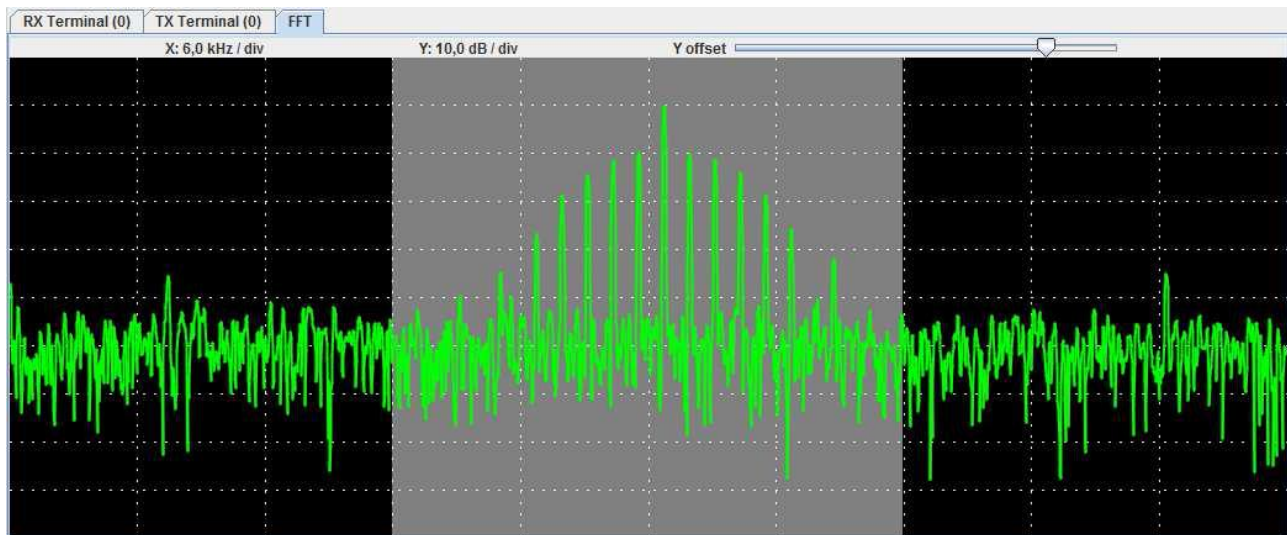

Figure 9: Spectrum of the received signal on the FFT tab.

Figure 10: Terminal display of the received data.

A more detailed insight into how to configure the transceiver can be found in the user manual.

5.4 ISIS Data Distribution Center (DDC)

The DDC is an optional functionality that can be used to safely store and archive received satellite packages. It is a two way connection from the DGS server to the DDC. The connection with the DDC can be enabled or disabled using the ground station configuration client.

5.5 Software Architecture

The core of the ground station software system is the DGS server. This is the program that interfaces with the required and optional external programs and the rotor controller. The main task of the DGS is to schedule satellite passes based on priority settings, command the ISIS software

transceiver to tune the software defined radio, command the rotor controller to let the rotor move to a specific position, automatically update Two-Line Element (TLE) sets and provide a clear configuration and monitoring interface with the ground station client. The DGS server can accept multiple ground station client connections.

Configuration and monitoring of the ground station has to be done through the ground station client application. Configuration of the ground station consists of configuring the host names and ports of the services with which the DGS server interfaces, adding new satellites, modifying and removing existing satellites, modifying the ground station location settings and configuring the rotor interface and characteristics. The monitoring options include monitoring of the current settings of the software defined radio including Doppler frequency correction information, monitoring of the connection status between the DGS server and the other external services and monitoring of the rotor controller.

The program Predict takes as input the location of the ground station and a set of satellite TLEs. Using the ground station location and the satellite TLEs, Predict will calculate current positions of the satellites in terms of azimuth and elevation with respect to the configured ground station location. The DGS will connect to Predict over an UDP socket to request the information that is needed in order to schedule satellite passes and control the rotor. Configuration of Predict (setting the set of satellite TLEs and configuring the ground station location) is done through local configuration files. This is the reason why Predict must run on the same computer as the DGS server.

In order to control the software defined radio, the ISIS Software Transceiver is needed. To control the software defined radio, the DGS server needs to connect to the ISIS Software Transceiver over a TCP socket. The ISIS Software Transceiver can then be commanded by the DGS server to set the frequency, modulation and data rate for the downlink and uplink. The ISIS Software Transceiver will further handle the frequency tuning of the software defined radio.

6 Data interface

Received data packets can be transferred to other applications by using a dedicated TCP/IP socket interface.

6.1 KISS Interface

The full AX-25 received packet (beginning with call-signs and ending with the Info field, excluding the FCS) is transmitted on the socket enclosed in a KISS frame, to simplify the use of existing software for data decoding.
The socket connection is bi-directional, so user defined packets can be sent to the satellite through this application, too. As in the case of downlink, AX-25 frames (beginning with call-signs and ending with the Info field, thus excluding the FCS) should be enclosed in KISS frames, as for the receive case.

To retrieve the received packets it is necessary to connect a socket client on the receiver PC machine IP. A simple terminal application, like Realterm can be used on a Windows machine to check the received packets. This application is not necessary for correct data reception.
Applications designed to operate using a serial port can be used if their output is redirected to a

TCP socket. Linux applications can use socat for tunnelling while Windows users can use com0com and com0tcp (please see http://com0com.sourceforge.net/doc/UsingCom0com.pdf for further details).

Please see http://www.ka9q.net/papers/kiss.html for further details on the KISS TNC protocol.

6.2 Binary interface

The binary interface is used to transfer the received packets or the packets to send, together with further information regarding the packet (RSSI or reception timestamp). This is useful to acquire statistics about the received data to characterize the link.

Please refer to the Ground Station User Manual for further details.

7 Installation site requirements

The ISIS ground station kit consists of two assemblies, the ground station rack which is to be placed indoor at the ground station operating position, and the antenna assembly which is to be placed in an outdoor location with an unobstructed view of the sky. The following diagrams show the clearances needed to operate the antennas without any obstacles.
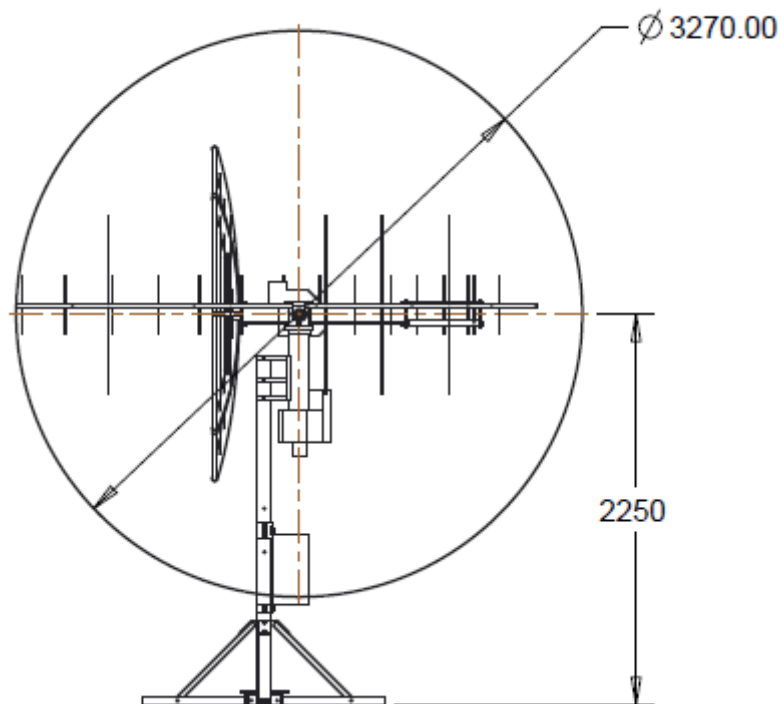

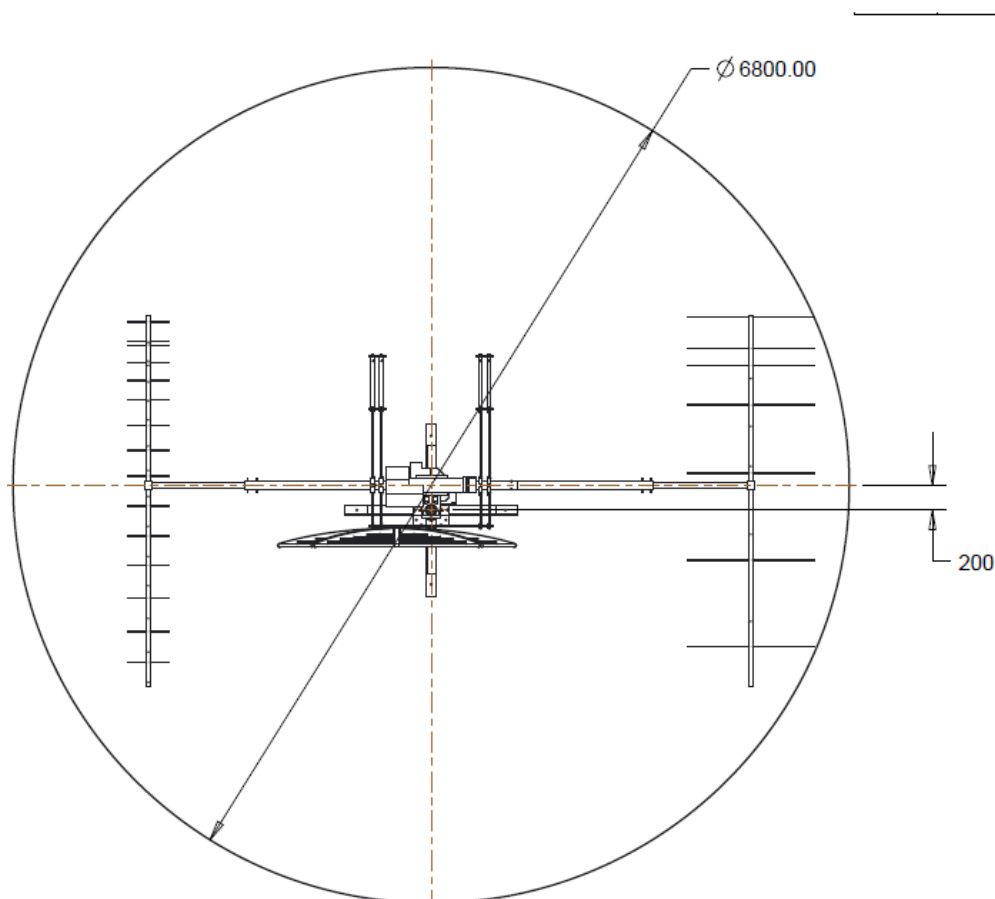**Figure 11: Side view representation of the outdoor unit.**

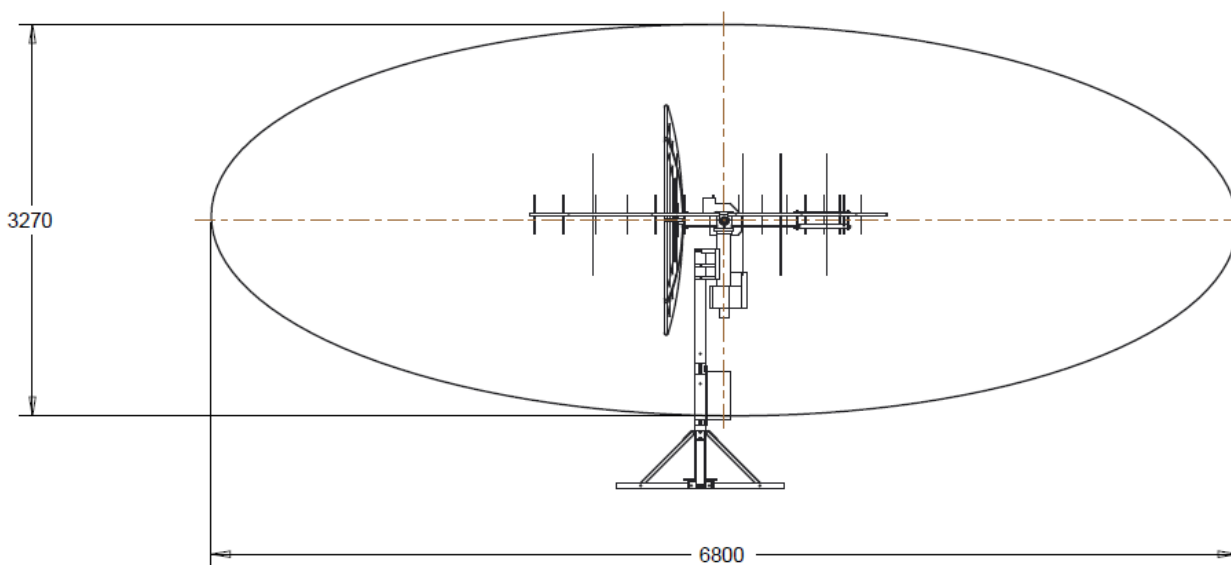**Figure 12: Top view representation of the outdoor unit.**

**Figure 13: Combined clearance profile.**

Following are the site requirements to perform the outdoor installation of the antenna system:

7.1 Requirements at the ground station operation room (indoor):

- Mains connection, single phase 220-240V or 110V 50-60Hz (phase, neutral, earth), fused 16A, Schuko connector. Alternatively, an extension cable with a IEC 60320-C13 plug can be used, replacing the provided extension cable.

- Ethernet network (according to TIA/EIA-568-B) connection to the Internet.

7.2 Requirements at antenna installation site (outdoor):

- A level mounting surface, prepared for installation of the antenna assembly mounting mast.

- No objects within a radius of 3.8 m measured from the antenna assembly mounting mast base center (4.2 meters in case of VHF / UHF and S-band).

- A lightning protection system, installed by a qualified company, which connects the antenna assembly mounting mast base to a lightning earth. Connection to the mounting mast base by means of a 12 mm ring lug.
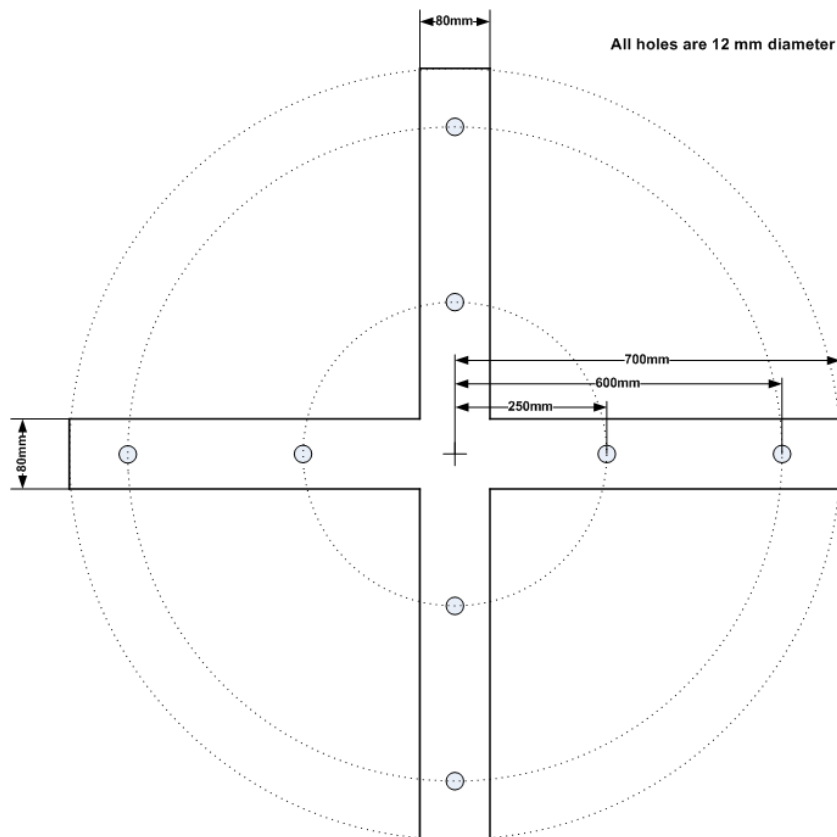
7.3 Requirement for cable routing between ground station operations room and antenna installation site:

- For routing cables between the ground station rack inside and antenna assembly outside, a minimum hole and / or conduit diameter of 100 mm is required. Cable conduits must have a minimum bending radius of 100 mm.

8 Static and Dynamic loads handled by the antenna support structure:

- The ISIS Ground station Kit, depending on the different options has a weight of:
  - 165 kg including the VHF-UHF and S-band (2 m dish) antenna systems
  - 140 kg including the VHF-UHF antenna systems

- In case of side wind, the support holding the mast should stand a strong momentum at its base (reference here is a wind with a speed of 120 km/h):
  - 4.2 kNm with the S-band dish (2 m)
  - 1.4 kNm without the S-band dish

9 Contents of shipment

- Instrumentation Rack consisting of:
  - PC
  - Rotator controller
  - VHF UHF transceiver
  - S-band receiver (Optional)

- Antenna subsystem consisting of

  - VHF Antenna parts
  - UHF Antenna parts
  - 2m S-Band dish antenna and feed (Optional) (3m available for S-band standalone GS)
  - S-band antenna brackets (Optional)
  - Mast assembly parts
  - Fasteners
  - Cross boom assembly parts
  - Coaxial cables
  - Azimuth rotator
  - Elevation rotator
  - Mounting mast
  - Lightning Protection Box

- Computer Screen
- US Keyboard
- Mouse
- Network cable
- European Power Cord (CEE7/7 to IEC 60320-C13)
- Software Package
- Manual documentation