This document contains the specification of the ground station for the C, UHF and VHF - bands Satellite Radio system.

Contents

List of acronyms

CBSR C-band Satellite Radio

1. Antenna System

An important component of the CBSR ground station is the antenna system. It consist of the 3m parabolic antenna for C-band as well as Yagi antennas for VHF/UHF bands, installed on a masts located on the top of the 8-floor building of the Electrical Engineering Faculty. The antennas are able to track the satellite, which moves in the sky and visits the location several times per day for a short period of 10-15 minutes.

1.1. C-band Subsystem

1.1.1. Parabolic antenna

The parabolic antenna used in CBSR ground station is a 3m prime focus mesh dish, produced by RF HAMDESIGN B.V. and delivered as a "DO IT YOUR SELF KIT" [1]. The support is made of aluminum and the mesh is made of galvanized steel (Fig. 1.1) The useable frequency of the dish with the 2.8mm mesh is 1 - 11GHz and $F/D=0.4$. The gain at 5.8GHz is 43dB and the -3dB angle is 1.3 deg.

Fig 1.1 3m prime focus mesh dish

1.1.2. Septum feed

The parabolic antenna uses a feed to convert the electromagnetic waves energy to the electric current fed to the receiver. Since CBSR system uses circular polarization (LHCP/RHCP) to avoid antenna polarization misalignment loss, a septum type feed is used. The feed has been designed and built by Bert Modderman (call sign PE1RKI) [2], see Fig. 1.2. It has been tuned to 5840MHz center frequency and has a return loss ~25dB and LHCP/RHCP isolation ~35dB. It can be mounted to the dish using a slightly modified CLX06 bracket from RH HAMDESIGN (Fig. 1.3).

Fig 1.2 6cm septum feed

Fig. 1.3 Feed bracket with the feed installed

1.1.3. AZ&EL Rotator

For tracking the satellite an azimuth and elevation rotator is used. High precision BIG-RAS/HR rotator is a two engine rotator which has installed two position sensors counting 0.1 degree on impulse (Fig. 1.4). It is produced by a Polish company SPID Elektronik and delivered together with a MD-01 Rotator Controller and PS-01 Dual Voltage Power Supply [3]. The rotation range for AZ/EL is 360/180 deg. with a 0.1 deg. resolution. The BIG-RAS/HR rotator is able to carry big dishes with diameter up to 6m.

The dish is coupled with the rotator using a heavy-duty mounting bracket with counter-weight arms UA-01 from SPID Elektronik (Fig. 1.4). It requires cheap and easy to buy exercise weights to be used as the counter-weights.

Fig. 1.4 SPID BIG-RAS/HR Rotator with mounting bracket

1.1.4. Antenna Pre-amplifier

The antenna pre-amplifier consists of a band-pass receiving filter and an LNA. The filter is a Mini-Circuits ZVBP-5800-S+ narrow-band, low insertion loss cavity filter [4]. The pass band is 5725-5875MHz with the insertion loss of 0.8dB only (Fig. 1.5).

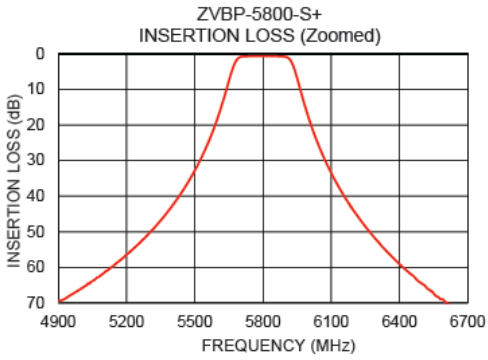

Fig. 1.5 Typical performance of ZVBP-5800-S+ filter

The LNA is a C-band super low noise amplifier KU LNA 500590 A produced by Kuhne electronic GmbH [5]. The typical gain is 28dB and the noise figure is as low as 1.5dB. The amplifier uses a remote power supply via RF output and a T-bias, located at the receiver site.

The pre-amplifier is protected by a water-proof housing, located close to the feed (Fig. 1.6). The amplified signal is fed to the main receiver site using a 20m feeder made with the LDF4-50A, 1/2" corrugated coaxial cable.

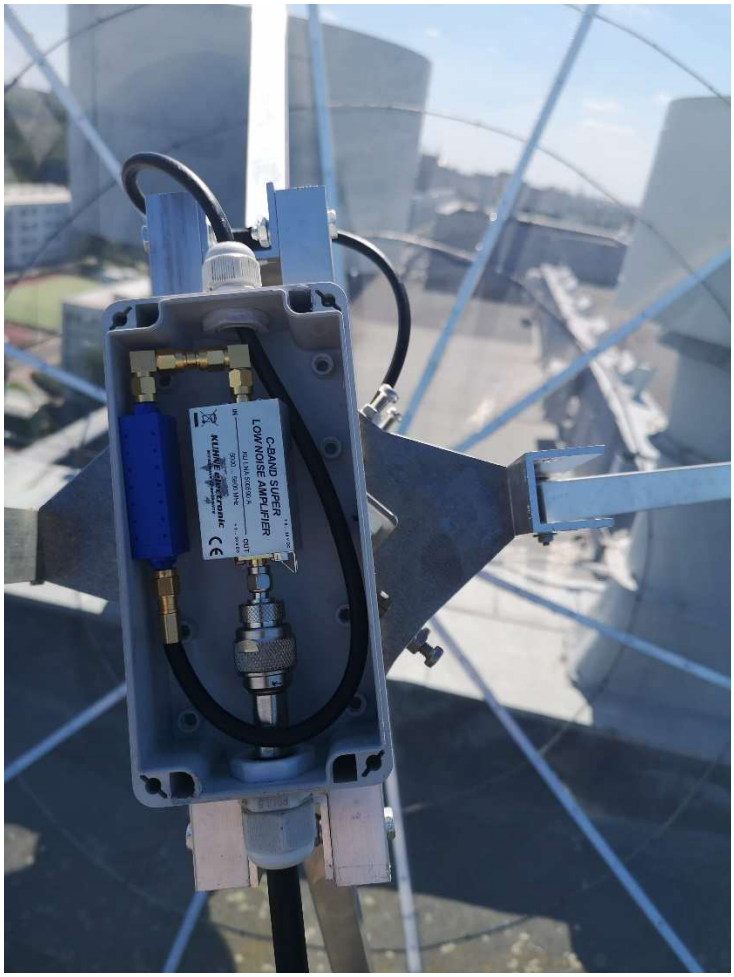

Fig. 1.6 Antenna pre-amplifier in a water-proof housing

1.2. VHF/UHF-band Subsystem

The VHF/UHF-band subsystem is not a part of CBSR system, however, many Cubesats implements this form of communication links for telemetry and control. Since CBSR operates on the downlink only, another communication link is necessary for controlling the system. Therefore, CBSR system closely cooperates with other communication subsystems to transmit commands on the uplink.

1.2.1. Yagi antennas

Two separate high-gain Yagi antennas are used to establish bi-directional communication with the Cubesat in VHF/UHF bands.

The uplink operates in 145MHz band and uses WX-220 antenna from WiMo Antennen und Elektronik GmbH [6]. This is 2x10 element crossed Yagi (circular polarization) with 4.6m length, 12dBi gain and 1200W PEP (Fig. 1.7).

The downlink operates in 432 MHz band and uses WX-7036 antenna from WiMo Antennen und Elektronik GmbH [6]. This is 2x18 element crossed Yagi (circular polarization) with 3.4m length, 14dBi gain and 800W PEP (Fig. 1.7).

Fig. 1.7 Yagi antennas

1.2.2. AZ&EL Rotator

Both Yagi antennas are mounted on a crossbar (Fig. 1.8) attached to the high precision BIG-RAS/HR azimuth and elevation rotator (see 1.1.3).

Fig. 1.8 Yagi antenna rotator

1.2.3. Antenna Pre-amplifier

The UHF antenna uses the off-the-shelf SP-70 mast pre-amplifier from SSB-Electronic [7] (Fig. 1.9). It is designed to operate in 430 – 440MH frequency range with a variable 12 – 22dB gain and typical noise figure 0.7dB. The amplifier uses a remote power supply via RF output and a T-bias, located at the receiver site.

The VHF antenna uses the off-the-shelf SP-200 mast pre-amplifier from SSB-Electronic GmbH [7] (Fig.1.9). It is designed to operate in 144-146MH frequency range with a variable 10 – 20dB gain and typical noise figure 0.5dB. The amplifier uses a remote power supply via RF output and a T-bias, located at the receiver site.

The amplified signal is fed to the main receiver site using a 20m feeder made with the LDF5-50A, 7/8” corrugated coaxial cable. The same type of feeder is used for both VHF and UHF antennas.

Fig. 1.9 SP-70/SP-200 mast pre-amplifiers

1.3. Antenna support

The antenna system is located on the roof of the Electrical Engineering Faculty building (16° 57' 03" E, 52° 24' 07" N), roughly 35m above the ground. Two 3m high masts have been mounted, one for the C-band antenna subsystem and the other for VHF/UHF-band antenna subsystem (Fig. 1.10, Fig. 1.11).

The selected location guarantees that there are no obstacles blocking the line-of-sight communication between the satellite and the ground station antenna, even for very low elevation angles and 360 deg. azimuth.

Fig. 1.10 Antenna masts

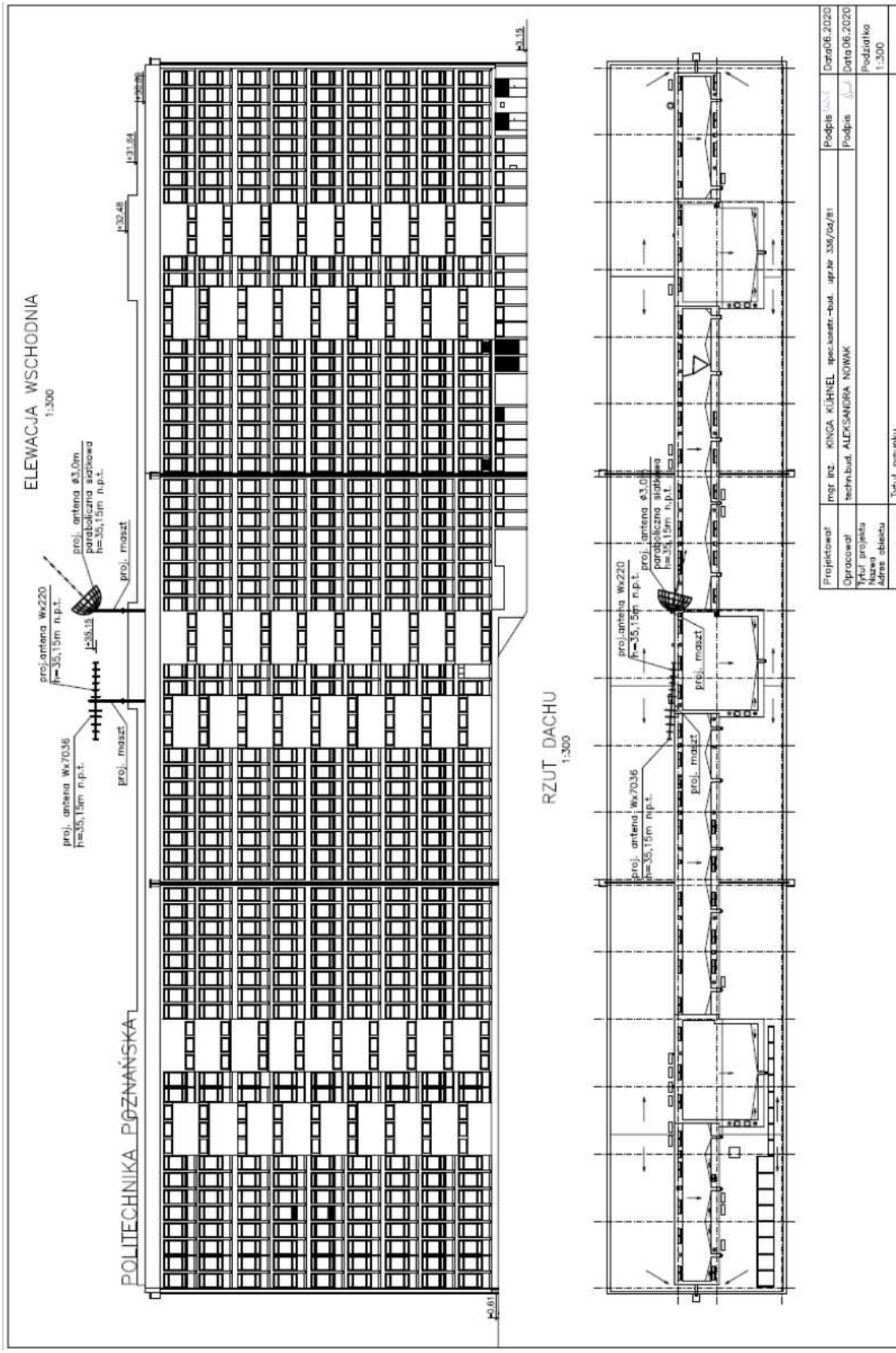

Fig. 1.11 Antenna system location

1.4. Other equipment

Since the antenna system is managed from the Control Centre, there is some additional hardware installed close to the masts to support the remote control.

1.4.1. Weather station

A Davis Vantage Pro2 Weather Station (Fig. 1.12) is used to monitor the current weather conditions which may impact satellite signal reception. The station monitors the following parameters: air temperature and humidity, barometric pressure, dew point, rainfall, wind speed and direction [8]. It is connected by wires to the interface located at the receiver site. The weather station has a static IP address, but all the data is sent to a remote server managed by Davis Instruments. Data collected by the weather station can be accessed on the website www.weatherlink.com, username and a default password is required to successfully login.

Fig.1.12 Davis Vantage Pro2 Weather Station

1.4.2. IP Camera

The HIK Vision HWP-N4215IH-DE IP camera (Fig. 1.13) is used to verify the operation of the antenna system. It is a 2.0 MP, 15× optical zoom, infrared speed dome camera with wide dynamic range, supporting H.265+/H.265 video compression modes [9]. It is connected by wires to the Ethernet switch located at the receiver site and can be accessed via internet browser. Username and default password should be entered to have access to the video feed. Presets were set up for quicker transition between satellite dish, Yagi antennas and weather station.

Fig.1.13 HIK Vision HWP-N4215IH-DE IP camera

1.4.3. LED lamps

The antenna system can be illuminated to allow visual observation during the night by two 7000lm LED lamps, which can be remotely switched on-off from the Control Centre. LED floodlights are connected to the IP Power Socket to the fifth socket from the left.

2. Transceiver Station

The transceiver station is located in the attic of the Electrical Engineering Faculty building, as close to the antenna system as possible to minimize cable losses.

All the components of the transceiver station are enclosed in a single 19” 27U floor-standing rack cabinet (Figs. 2.1-2.2).

Fig. 2.1 Transceiver station – front

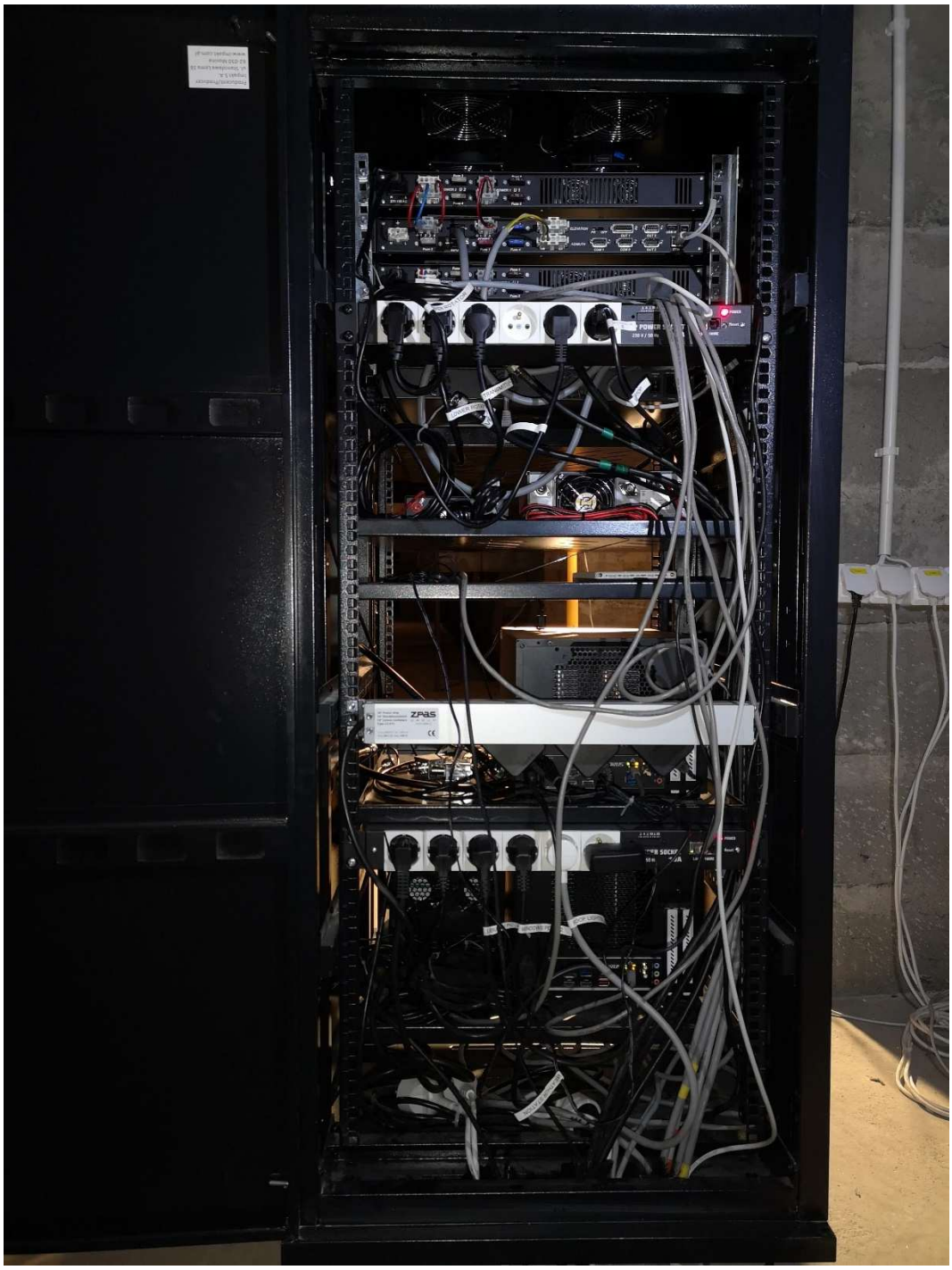

Fig. 2.2 Transceiver station – back

2.1. Rotator Controller

The MD-01 Rotator Controller controls the antenna rotator. It has a build in backlight display which shows Azimuth & Elevation in real time at 0.1 degree resolution (Fig. 2.2). This means the rotator can also be used as a stand-alone configuration and the Azimuth & Elevation engine can be moved using the arrow buttons on the front panel. The menu can also be entered on the front panel and changes can be made to all available functions. The controller can handle 2 rotor systems, this means it can also drive two azimuth or two elevation rotators or one Az/El rotator at the same time. Build in the controller is also a track interface which can be connected through USB or Ethernet interfaces.

The controller supports the following software:
✓ PST Rotor (Also /HR controllers MD-0X)
✓ MacDoppler (MacDoppler Ham Radio Satellite Tracking for Macintosh)
✓ N1MM Logger
✓ Ham Radio Deluxe
✓ Logic 7 Version => 7.0.45
✓ Orbiton Satallite Tracking
✓ Gpredict Satallite Tracking Linux and MAC
✓ SatPC32 Satallite Tracking - works on windows only
✓ DXLab (DX View)
✓ TRXmanager

Since two rotators are used, one for the C-band antenna and the other for VHF/UHF-band antennas, two MD-01 controllers (2 x 1U) are installed in the cabinet.

To control these rotators remotely they have to be set to allow remote connections via Internet, for that enter settings (S button), select Motor configuration (S button), find CONTROL AE settings and set it to ETH. Save settings and exit from the configuration menu.

Fig. 2.2 MD-01 Rotator Controller

2.2. Power Supply

The PS-01 Power Supply Module is a dual voltage PSU, designed to work with high resolution rotator system SPID BIG-RAS/HR (Fig. 2.3). It delivers 15V/10A and a 22V/22A.

Since two rotators are used, one for the C-band antenna and the other for VHF/UHF-band antennas, two PS-01 power supply modules (2 x 1U) are installed in the cabinet.

Fig. 2.3 PS-01 Dual Power Supply

2.3. PCs

There are two (optionally – three) personal computers installed in the cabinet. All the PCs have the same configuration:

✓ AMD Ryzen 5 3600 CPU
✓ 16GB RAM
✓ 1TB SSD
✓ 4TB HDD
✓ 500W PSU
✓ mini-ITX housing

One of the PC's is configured as the SDR receiver for the C-band Satellite Radio. It uses Ettus Research USRP B210 as the radio front-end. The other PC is configured as the SDR receiver for the UHF-band satellite communication system. It uses FunCube Dongle as the radio front-end. It is also connected via USB to the VHF transceiver (see below) and acts as the SDR transmitter for the VHF uplink.

2.4. VHF/UHF Transceiver

The uplink communication with the Cubesat is implemented using off-the-shelf ICOM IC-9700 radio amateur transceiver (Fig. 2.4). It is an all mode Tri-band transceiver, covering 2 m, 70 cm, and 23 cm. In addition to the traditional SSB, AM, FM, CW, and RTTY modes, the transceiver also incorporates D-STAR DV and DD modes. The power amplifier outputs stable power with high efficiency (144/430 MHz band: 100/75 watts).

The transceiver uses a PS-30SW5 14.4V/30A power supply and is operated remotely from the Control Centre via Ethernet.

Fig. 2.4 IC-9700 Transceiver

NOTE: This is a temporary solution – the transceiver should be replaced by the SDR transmitter with a VHF power amplifier to allow higher bit rates on the uplink.

2.5. Weather Station Interface

The Davis Instruments' Weather Envoy provides a way of getting weather data from the Vantage Pro2 weather station into the computer using the provided WeatherLink software. The Weather Envoy includes the data collection and logging functions of the Vantage Pro2 console.

The interface is located in the cabinet and connected to the Control Centre via Ethernet.

2.6. Network Attached Storage

The data collected from the Cubesat is stored on a Synology DS410 Network Attached Storage, located in the cabinet.

2.7. Ethernet Switch

As already mentioned, the receiving station and the antenna system is managed remotely from the Control Centre. It uses the Planet FGSW 2620VMP4 Ethernet switch located in the cabinet (1 x 1U) to connect all the devices to the PUT local area network. The following devices are connected to the switch:

✓ 2 rotator controllers
✓ 3 PCs
✓ weather station interface
✓ IP camera
✓ NAS
✓ 2 managed IP power sockets
✓ VHF/UHF transceiver

2.8 Managed IP Power Socket

All devices located in the cabinet (excluding the Ethernet switch) are connected to 230VAC via two IP power sockets 6G10A. The sockets are managed via Ethernet from the Control Centre. This makes remote restarting of all the devices possible in case of any failure. Both of the IP sockets have web interface, watchdog (automatic on/off switch in case of ping failure), SMTP notifications, SNMP and sensors to probe temperature and react on triggers.

Equipment connected to the Upper IP Power Socket, from left to right is the following:

- Power supply for rotators
- Power supply for rotators
- Transmitter
- <empty>
- Cooling fans
- Laptop for local configuration of servers

Equipment connected to the Lower IP Power Socket, from left to right is the following:

- Power supply for preamplifiers
- Network access storage
- Windows Server
- Ubuntu Server
- LED Floodlights
- Weather station

3. Control Centre

The ground station is managed from the control center located in room P019 in the building of Computing and Telecommunication Faculty.

The control station consists of two personal computers and four displays (Fig. 3.1). The computers are connected to PUT local area network and uses VLAN connection to communicate with the receiving station. The contents shown on the displays is configurable; typical configuration is the following:

✓ display 1 – Ham Radio Deluxe software used for tracking the satellite (other software may be used as well)
✓ display 2 – view from the IP camera, weather station information
✓ display 3 – communication software (telemetry readouts, commands sent, etc.)
✓ display 4 – VHF/UHF transceiver front panel

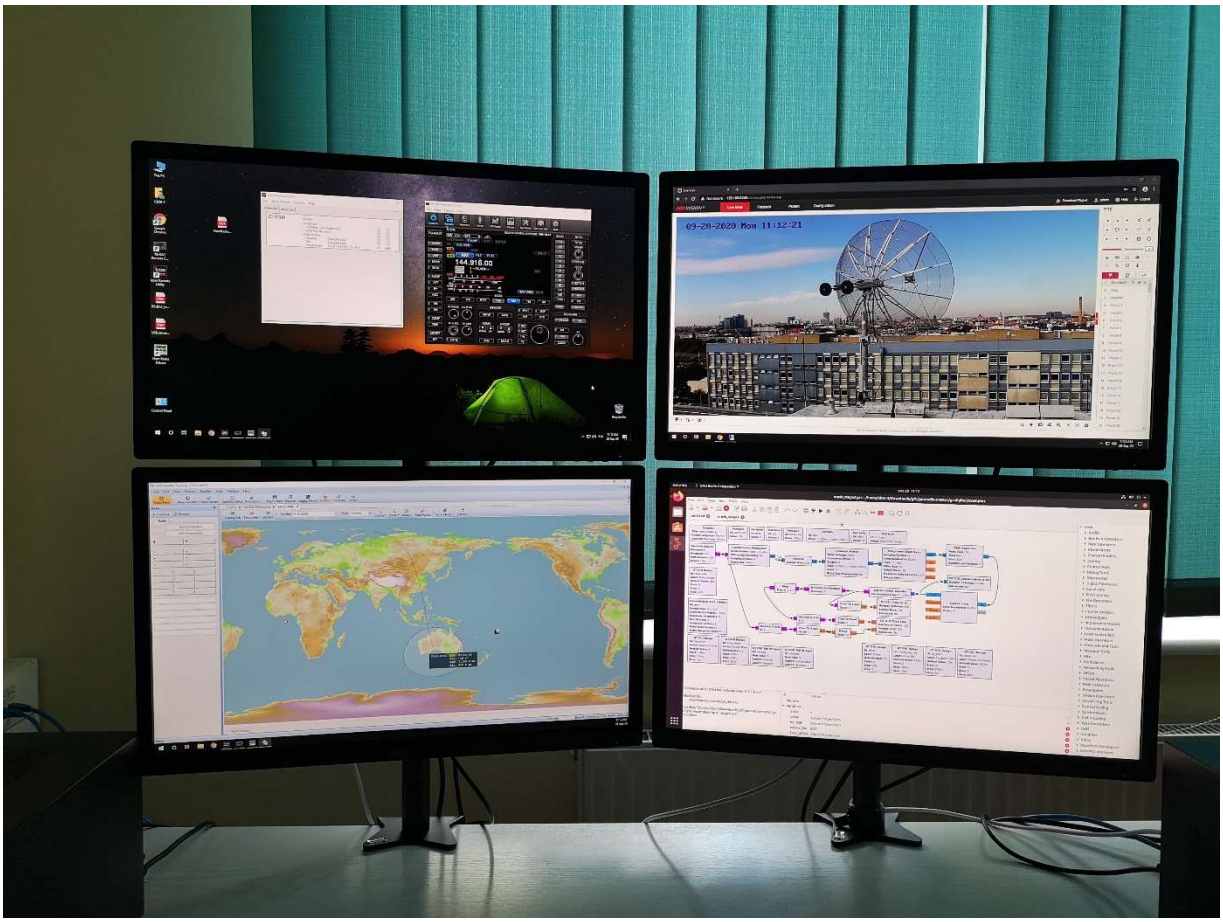

Fig. 3.1 Control station displays

All communication using amateur bands is done using call-sign SP3PET, belonging to the Amateur Radio Club associated to Poznan University of Technology.

Computers are configured to turn on as soon as power is returned. This is done to mitigate the downtime of the servers if power is suddenly lost. To further reduce downtime Wake on LAN (WoL) is configured and sleep mode is turned off. Computers are also connected to the IP Power Socket, which can monitor and control power to computers automatically as well as manually via remote control.

The two PCs works as servers (with no display/keyboard/mouse attached) and they are managed remotely from the Control Centre, using remote desktop protocol. However, local control is possible as well via a terminal (a laptop) located in the cabinet.

Each computer can be accessed using remote desktop protocol. For various devices which do not need static IP address DHCP service is available.

To extend the ability for remote connection to PCs a VPN PPTP connection can be configured. To do it on Windows 10, the following steps have to be done:

1. Click “Add a VPN connection” in “VPN” of the “Network and Internet” settings.
2. Choose “Windows (built-in)” as VPN provider, type user-friendly name in “Connection Name”, save.
3. In “Change adapter options” right-click newly created adapter and select “Properties”.
4. In Security tab choose PPTP as Type of VPN and choose to Require encryption as Data encryption.
5. In Networking tab select TCP/IPv4, choose Properties and click “Advanced” button, unmark “Use default gateway on remote network” and ensure “Disable class based route” addition is unmarked (unmark it otherwise), save all changes.

When VPN connection is established, the PCs can be accessed via DNS name, which will be resolved to computer’s IP.

4. Structure of IP network

IP addresses are assigned by DHCP on the router for devices with dynamic IP addresses. The following devices have a static IP address or IP address is reserved via MAC address of the device:

Name of the device
Switch
Windows 11 control center
Windows 11 remote server (native)
Windows 11 control center
Ubuntu remote server
ICOM IC-9700 transceiver
Synology DS410 NAS
Windows 11 remote server (virtual OS)
Weather station
IP camera
IP Power Socket (upper)
IP Power Socket (lower)
Electronic driver for rotors (dish antenna)
Electronic driver for rotors (Yagi antenna)
Router

To remotely access devices or login to the websites username and password is required.

Appendix A

An additional information is provided below about configuration of **HAM Radio Deluxe (HRD)**

Initial configuration

Upon the start of the HAM Radio Deluxe a window will open with defined presets and a possibility to create a new definition, to connect to IC-9700 following options were chosen:

- Company: ICOM
- Radio: IC-9700
- COM port: COM3
- Speed: 19200
- CI-V: A2

Every other option was left as default.

The locator of the station has to be set to have a correct location of the station on the map, to do so following steps have been performed:

- Open HAM Radio Deluxe
- Open Logbook program from HAM Radio Deluxe
- Go to Tools -> Configure -> My Station
- Set the locator to JO82LJ, which corresponds to the actual location square of the station

Since both rotators are accessible via Ethernet and HAM Radio Deluxe is able to connect to rotators only via COM ports, we need an additional program which will perform the conversion, currently it is Virtual Serial Ports Emulator (VSPE)

To configure virtual COM port in VSPE (in case of non configured VSPE client presets on the desktop -> normally skip this part):

- Device -> Create -> Connector, any non-existent COM number can be chosen, like COM15
- Device -> Create -> TCP Client
- Source serial port: COM15 or the one which was created via first step
- Emulation -> Start

After both Status messages are OK, HAM Radio Deluxe can be configured to connect to virtual COM port.

Configuring Rotators

For testing purposes, the satellite which will be tracked is ISS, in order to select it:

From HAM Radio Deluxe open Satellite Tracking

- Click New Satellite -> ISS (The information about ISS and its current location will be displayed on the map)

- To see information about the location of the satellite on the radar, an overlay can be enabled by going to Satellite -> Radar Plot
- Click Rotator -> Enable and Rotator -> Start
- Click Tuning Dial and Enable RX

From HRD Satellite Tracking go to Rotator or from HRD Rig Control go to Rotor Display:

- Select HRD SatTrack
- Click DDE: Connect
- Rotator: AlfaSpid RAS Az/El
- Protocol: AlfaSpid
- Port: COM2
- Speed: 19200
- Refresh rate: 2 sec
- Stop position: Controller Managed
- Click Connect
- DDE update every: 1 sec
- Step size: 1 degree
- When ready, click DDE: Track

An additional information is provided below about configuration of **SDR Radio Console v3**

Initial configuration:

- Connect FUNCube dongle first
- When starting SDR Console for the first time a window will show up that no definitions are found, click Definitions...
- Search -> FUNcube and add the device
- Select Soundcard and click start

Locally it works, but to have remote access we need to **set up a server:**

- Tools -> Server Manager
- Accounts -> Add, provide username and the default password, some appropriate comment, do not limit maximum connection time or have interval between connections
- Radios -> Definitions, add FUNcube radio as it was done previously
- Firewall -> Add, for additional security whitelist connections
- Network -> Windows Firewall -> Add port
- Welcome Text can be edited
- Service -> Install and Start if needed, be sure to check that Start service when Windows starts is selected

Server side done, now to **configure remote host:**

- Install SDR Console v3 on remote host

- Start SDR Console v3 -> Select Radio -> Radio Definitions -> Search -> V3 Server
- Search -> Select FUNcube -> OK
- Add 1 device to the list -> Save
- Select Radio -> Select FUNcube -> Connect
- Soundcard: Line (FUNcube Dongle V2.0)
- Bandwidth: any, can be changed later

Appendix B

Setup of ICOM transceiver for remote connection through Ethernet port (with local LAN network):

- 2nd DNS Server: (undefined)
- Network Control: ON
- Power Off Setting: Standby/Shutdown
- Internet Access Line: FTTH
- Network User 1 Administrator: YES
- Network User 2 Administrator: YES
- Network Radio Name: IC-9700

Setup of Remote Utility software for remote connection through Ethernet port (with local LAN network) on CBSR-2 computer:

- Virtual COM Port Number: COM 12
- Speaker: Realtek HD Audio 2nd Output (in case of use local computer soundcard) or Remote Audio (in case of use sound redirection to remote/access computer)
- Mic: Default Device

Setup of Remote Controller software for remote connection through Ethernet port (with local LAN network) on CBSR-2 computer:

- Connection: LAN
- COM Port: 12
- MOD Select: LAN

Appendix C

Configuration of the SPID MD-01 DDE program to connect to the SPID MD-01 positioner:

Motor tab:

- Template: -> 1:AZ, 2:EL
- Control AE (top row): -> USB
- Protocol AE (top row): -> SPID ROT2
- Control AE (lower row): -> NONE
- Protocol AE (lower row): -> NONE

ATTENTION!!!

Never select the option: Control AE -> ETH, because it may disconnect the positioner controller and the necessity to manually configure the settings using the front panel of the device. Although the entire controller is physically connected to the LAN via the Ethernet port, it uses an internal expansion card (network) that communicates with the controller using USB interface emulation - hence it is necessary to configure the SPID MD-01 DDE program to use the standard USB communication, despite the lack of physical use of the controller's USB port

Ports -> COM 0 tab:

- State: -> OFF
- Baud: -> 115 200
- Data bits: -> 8
- Stop bits: -> 1
- Parity: -> NONE

Ports -> COM 1 tab:

- State: -> OFF
- Baud: -> 115 200
- Data bits: -> 8
- Stop bits: -> 1
- Parity: -> NONE

Ports -> USB COM tab:

- State: -> ON
- Baud: -> 460 800

ATTENTION!

It is necessary to enable communication via the emulated USB port, even when using a physical Ethernet connection!

In case of mistakenly changing the connection parameters, read the values from the page. The KRISTECH network card integrated in the SPID MD-01 controller uses Port 0 to emulate a USB connection with connection speed parameters of 460 800 - it is possible to change the card's transmission speed, but then it is necessary to adjust the transmission speed in the SPID MD-01 DDE program.

Ports -> ETHERNET tab:

- State: -> OFF

TIP!

Azimuth and elevation values displayed by the controller in the range <0 degrees; 359 degrees > means the basic range of antenna movement - full rotation. Values between <0 degrees; +180 degrees> means that the antenna makes a second turn - after the basic 360 degree turn, it makes another half turn of an additional 180 degrees, so the total rotation of the antenna is 540 degrees. Values <-180 degrees; 0 degrees > means that the antenna can make half a full turn in the opposite direction from the initial position (so 0 degrees)

Configuration of the SPID MD-01 DDE program in order to load data (settings) to the memory of the SPID MD-01 positioner controller:

Motor tab:

- Template: -> 1:AZ, 2:EL
- Control AE (top row): -> USB
- Protocol AE (top row): -> SPID ROT2
- Control AE (lower row): -> NONE
- Protocol AE (lower row): -> NONE

ATTENTION!!!

Never select the option: Control AE -> ETH, because it may disconnect the positioner controller and the necessity to manually configure the settings using the front panel of the device. Although the entire controller is physically connected to the LAN via the Ethernet port, it uses an internal expansion card (network) that communicates with the controller using USB interface emulation - hence it is necessary to configure the SPID MD-01 DDE program to use the standard USB communication, despite the lack of physical use of the controller's USB port

Ports -> COM 0 tab:

- State: -> OFF
- Baud: -> 115 200
- Data bits: -> 8
- Stop bits: -> 1
- Parity: -> NONE

Ports -> COM 1 tab:

- State: -> OFF
- Baud: -> 115 200
- Data bits: -> 8
- Stop bits: -> 1
- Parity: -> NONE

Ports -> USB COM tab:

- State: -> OFF
- Baud: -> 460 800

Ports -> ETHERNET tab:

- State: -> ON

ATTENTION!

The "State" value must be set to ON, because the controller communicates with the management software and the PC via the Ethernet port!

ATTENTION!

When setting the parameters of the maximum angles of the antenna "Min angle" and "Max angle" using the SPID MD-01 DDE program and other parameters of the controller, remember that before starting the procedure of loading data to the controller's memory (using the "Upload" function) in the program SPID MD-01 DDE specify all the above values in accordance with this section of the manual (used ports and data transmission protocols).

TIP!

Azimuth and elevation values displayed by the controller in the range <0 degrees; 359 degrees > means the basic range of antenna movement - full rotation. Values between <0 degrees; +180 degrees> means that the antenna makes a second turn - after the basic 360 degree turn, it makes another half turn of an additional 180 degrees, so the total rotation of the antenna is 540 degrees. Values <-180 degrees; 0 degrees > means that the antenna can make half a full turn in the opposite direction from the initial position (so 0 degrees)

In order for the configuration changes made in the SPID MD-01 DDE program to be saved in the controller (positioner), it is necessary to use the "Upload" button

Configuration of settings on the front panel of the SPID MD-01 positioner:

MOTOR CONFIGURATION tab:

- TEMPLATE: -> 1:AZ, 2:EL
- CONTROL AE: -> ETH
- PROT. AE: -> SPID ROT2

ATTENTION!!!

In order for the controller to be able to communicate via the Ethernet module, it is necessary to select the CONTROL AE: -> ETH option, otherwise it will not be possible to establish communication with the controller via the Ethernet port (although in the controlled program SPID MD-01 DDE the option of control via USB port).

SET COM 0 tab:

- STATE: -> OFF
- BAUD: -> 115 200
- DATA BITS: -> 8
- STOP BITS: -> 1
- PARITY: -> NONE

SET COM 1 tab:

- STATE: -> OFF
- BAUD: -> 115 200
- DATA BITS: -> 8
- STOP BITS: -> 1
- PARITY: -> NONE

SET USB COM tab:

- STATE: -> OFF
- BAUD: -> 460 800

ATTENTION!

It is necessary to set the STATE function: -> OFF, because the physical connection with the positioner is via the Ethernet port, while the physical USB port is not in use (although its emulation is necessary in the SPID MD-01 DDE control program). BAUD speed: -> 460 800 must be consistent with the settings of the KRISTECH network card implemented in the positioner and with the settings of the USB port speed in the SPID MD-01 DDE control program.

SET ETHERNET tab:

- STATE: -> ON

ATTENTION!

The "STATE" value must be set to "ON" to enable communication via the Ethernet port and thus enable remote control of the positioner via LAN.

TIP!

Azimuth and elevation values displayed by the controller in the range <0 degrees; 359 degrees > means the basic range of antenna movement - full rotation. Values between <0 degrees; +180 degrees> means that the antenna makes a second turn - after the basic 360 degree turn, it makes another half turn of an additional 180 degrees, so the total rotation of the antenna is 540 degrees. Values <-180 degrees; 0 degrees > means that the antenna can make half a full turn in the opposite direction from the initial position (so 0 degrees)

Appendix D

Configuration of the HRD Rotator program to work with the SPID MD-01 positioner controller:

- Rotator: AlfaSpid RAS Az/El
- Protocol: AlfaSpid
- Port: COM2
- Speed: 19200
- Refresh rate: 2 sec
- Stop position: Controller Managed

Appendix E

Instructions for starting the Yagi antenna rotor (UHF/VHF band) in the automatic satellite tracking mode using the SDR Console software:

- Run the VSPE program using the file "HRD rotator both config.vspe" placed on the desktop
- Emulation of COM and TCP ports should be initialized automatically (in the absence of initialization, press the "Start emulation" button)
- Wait until all TCP and COM ports are "OK"
- Then minimize the VSPE window, but do not close it with the "X" button
- Launch SDR Console
- In the "Select radio" dialog box, select "Line (FUNcube Dongle V2.0)" in the "Soundcard" field and press the "Start" button. The Fun Cube Dongle radio receiver will then be initialized and thus start receiving the signal on the set frequency
- ATTENTION!
- Starting the receiver is necessary to unlock the ability to automatically track and control the antennas!
- In the "View" tab, launch the dedicated satellite module "Satellites"
- In order to select a specific satellite, go to the "Satellite List" tab, and then select a specific satellite from the list
- ATTENTION!
- The receiver's carrier frequency, modulation mode and bandpass filter width will be set automatically depending on the selected satellite
- ATTENTION!
- If the satellite you are looking for is not visible in the satellite selection tab, enter the "Select" option and then select the specific satellite. Satellites with an eye icon are visible at a specific point in time, allowing you to start tracking immediately. Double-clicking on a specific satellite from the list causes its selection and automatic tuning of all receiver parameters
- Run HRD Rotator.
- In the satellite module of the SDR Console, select the "Enable Tracking" option, thanks to which the data will be sent to the HRD Rotator using the DDE client. Active data transmission from the SDR Console program will be visible on the bottom bar of the screen map, where the parameters "AZ" - azimuth and "EL" - elevation will be updated
- In the HRD Rotator, make sure that the "Orbitron" communication protocol (DDE client) is selected, and then activate the "DDE Connect" button. Then the button icon will be highlighted, which will indicate data transmission between the SDR Console and HRD Rotator software
- Next, activate the Connect button - the correct connection with the positioner will be confirmed by replacing the button with the "Disconnect" button
- In order to start tracking the satellite, activate the "DDE Track" button - the tracking procedure will be started and the antenna system will follow the trajectory of the selected satellite.

ATTENTION!

After the communication session ends and satellite tracking is complete, the antennas will return to their home position (0 degrees azimuth and 0 degrees elevation). In order for the antennas to return to their initial position, the "Enable Tracking" function in the SDR Console must be turned off

ATTENTION!

Satellite tracking is possible only when the elevation value is greater than 0 degrees! If you select a satellite whose elevation value at a specific moment is less than or equal to 0, the antenna will set itself in the position from which the satellite will be visible during the next flight. Selecting another satellite from the list during active tracking ("Enanle Tracking" option active) will result in pointing the antenna to the beginning of the trajectory of another satellite or its active tracking (if it is visible)

ATTENTION!

The SDR Console program, while actively tracking the satellite, also performs the Doppler effect compensation by retuning the receiver for the frequency deviation resulting from the calculated satellite movement trajectory!

ATTENTION!

TLE files used to predict the position of the satellite and determine the tracking path are updated from online databases automatically and in the background

ATTENTION!

Never run "spidMD01dde" when port emulation in VSPE is active!!!

Appendix F

Instructions for starting the Yagi antenna rotor (UHF/VHF band) in the automatic satellite tracking mode using the HRD Satellite Tracking program:

- Run the VSPE program using the file "HRD rotator both config.vspe" placed on the desktop

- Emulation of COM and TCP ports should be initialized automatically (in the absence of initialization, press the "Start emulation" button)
- Wait until all TCP and COM ports are "OK"
- Then minimize the VSPE window, but do not close it with the "X" button
- Launch the HRD Satellite Tracking program
- In the "Satellite" tab, select the satellite that is currently visible (visibility time will be marked with the abbreviation LOS).
- Then check the "RX" box - it is necessary to transfer tracking data to the HRD Rotator module, and thus the correct operation of the tracking mechanism.
- After checking the "RX" box, select "Enable" from the drop-down menu attached to the "Rotator" button.
- HRD Rotator should start automatically.
- In the HRD Rotator, activate the "DDE Connect" button. Then the button icon will light up, which will indicate data transmission between HRD Satellite Tracking and HRD Rotator
- Next, activate the Connect button - the correct connection with the positioner will be confirmed by replacing the button with the "Disconnect" button
- In order to start tracking the satellite, activate the "DDE Track" button - the tracking procedure will be started and the antenna system will follow the trajectory of the selected satellite.

ATTENTION!

After the communication session ends and satellite tracking is completed, the antennas remain in the position where tracking was completed.

To park the antennas (Azimuth: 0 degrees, Elevation: 0 degrees):

- Turn off and completely close HRD Rotator and HRD Saellite Tracking
- Stop emulation of ports in VSPE by clicking on the "Stop emulation" button
- Run positioner management program "spidMD01dde"
- In the "spidMD01dde" program, go to the "Options" tab and make sure that the program has established a connection with the positioner controller. If the connection is established, the "Disconnect" button will be displayed. If the "Connect" button appears, activate it - then the current settings of the positioner and the position of the antennas will be downloaded to the program.
- In order to set the antennas to the initial value, enter "0" in the "M1" and "M2" fields, and then click the "Send" button.
- The antennas should return to their initial position, which will be visible in the control field (green), displaying the current position of the antennas in the elevation plane - the value "E2" and the azimuth "A1". Values are in degrees.

ATTENTION!

Never run "spidMD01dde" when port emulation in VSPE is active!!!

Appendix G

Manual of the power-on computers remotely by LAN (CBSR-1, CBSR-2, CBSR-3, CBSR-4) with use Windows command tool "wolcmd.exe"

- Open the command prompt

- Type command: wolcmd adress_MAC adress_IP subnet_mask port

  which "adress_MAC" = xxyyzzaabbcc

  "adress_IP" = ddd.eee.f.ggg

  "subnet_mask" = hhh.iii.jjj.kkk

  "port" = m

- Press Enter

ATTENTION!

This program sends power-on packet to boot up remote computer with use broadcast address, based on subnet mask and IP address

It's necessary to type MAC adres in followed format -> xxyyzzaabbcc (small letters)

For example:

C:\Users\CBSR-1>wolcmd xxyyzzaabbcc ddd.eee.f.ggg hhh.iii.jjj.kkk m

Appendix H

Manual of the power-on computers remotely by LAN (CBSR-1, CBSR-2, CBSR-3) with use Linux console tool "wakeonlan"

- Open the text terminal ("Terminal")
- Type command: wakeonlan adress_MAC

  which "adress_MAC" = xx:yy:zz:aa:bb:cc

- Press Enter

It's necessary to type MAC adres in followed format -> xx:yy:zz:aa:bb:cc

For example:

cbsr-4@CBSR-4:~$ wakeonlan xx:yy:zz:aa:bb:cc

Appendix I

Instructions for starting the UVSQ-SAT telemetry decoder

- Run the VSPE program using the file "HRD rotator both config.vspe" placed on the desktop

- Emulation of COM and TCP ports should be initialized automatically (in the absence of initialization, press the "Start emulation" button)
- Wait until all TCP and COM ports are "OK"
- Then minimize the VSPE window, but do not close it with the "X" button
- Launch SDR Console
- In the "Select radio" dialog box, select "Line (FUNcube Dongle V2.0)" in the "Soundcard" field and press the "Start" button. The Fun Cube Dongle radio receiver will then be initialized and thus start receiving the signal on the set frequency
- ATTENTION!
- Starting the receiver is necessary to unlock the ability to automatically track and control the antennas!
- In the "View" tab, launch the dedicated satellite module "Satellites"
- In order to select a specific satellite, go to the "Satellite List" tab, and then select the UVSQ-SAT satellite
- ATTENTION!
- The carrier frequency of the receiver and the modulation mode will be set automatically after selecting the satellite!
- In the main window of the SDR Console program ("Filter" receiving filter width control section), select a filter width of 20 kHz
- ATTENTION!
- If the satellite you are looking for is not visible in the satellite selection tab, enter the "Select" option and then select the specific satellite. Satellites with an eye icon are visible at a specific point in time, allowing you to start tracking immediately. Double-clicking on a specific satellite from the list causes its selection and automatic tuning of all receiver parameters
- Run HRD Rotator
- Run the Sound Modem program in the "BPSK (NRZI) - 9600 bps - only" version
- Make sure that the demodulated (audio) signal is transferred from SDR Console to Sound Modem - check the spectrogram plot in Sound Modem (it should have the same spectrum as the spectrogram in SDR Console)
- Run the UVSQ-SAT telemetry decoder contained in the "Telemetry decoder - UVSQ-SAT" folder. To do this, run the file "launchUVSQSat.bat"
- In the satellite module of the SDR Console program, select the "Enable Tracking" option, thanks to which the data will be sent to the HRD Rotator program using the DDE client. Active data transmission from the SDR Console program will be visible on the bottom bar of the screen map, where the parameters "AZ" - azimuth and "EL" - elevation will be updated
- In the HRD Rotator, make sure that the "Orbitron" communication protocol (DDE client) is selected, and then activate the "DDE Connect" button. Then the button icon will be highlighted, which will indicate data transmission between the SDR Console and HRD Rotator software
- Next, activate the Connect button - the correct connection with the positioner will be confirmed by replacing the button with the "Disconnect" button
- In order to start tracking the satellite, activate the "DDE Track" button - the tracking procedure will be started and the antenna system will follow the trajectory of the selected satellite.
- Press the Start button in the UVSQ-SAT telemetry decoder program. If you are successfully connected to Sound Modem, you should see "Connected to modem" at the bottom of the program window. The data decoding process should start successfully.

ATTENTION!

After the communication session ends and satellite tracking is complete, the antennas will return to their home position (0 degrees azimuth and 0 degrees elevation). In order for the antennas to return to their initial position, the "Enable Tracking" function in the SDR Console must be turned off

ATTENTION!

Satellite tracking is possible only when the elevation value is greater than 0 degrees! If you select a satellite whose elevation value at a particular moment is less than or equal to 0, the antenna will set itself in the position from which the satellite will be visible during the next flight. Selecting another satellite from the list during active tracking ("Enable Tracking" option active) will result in directing the antenna to the beginning of the trajectory of another satellite or its active tracking (if it is visible)

ATTENTION!

During active satellite tracking, the SDR Console program also performs Doppler effect compensation by retuning the receiver for the frequency deviation resulting from the calculated satellite movement trajectory!

ATTENTION!

TLE files used to predict the position of the satellite and determine the tracking path are updated automatically and in the background from online databases

ATTENTION!

Never run "spidMD01dde" when port emulation in VSPE is active!!!

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