METEK

Meteorologische Messtechnik GmbH

Ka Band Cloud Radar
MIRA3x

Radar Server
and
Clients

CONTENTS

1.1 Introduction

The radar hardware (denoted as transmitter-receiver block, TRB) consists of several modules which are controlled by separate embedded controllers. Each controller has several analog and digital inputs and outputs for measuring signals from different circuits and sensors, and for controlling the hardware. The controllers can handle many processes autonomously and they protect the hardware without relying on the software running on the PC. The radar PC can control the modules and read information about their state through the "main" controller which routes the information between the controllers and the PC. The DSP reads the data from the digital receiver over a fast data link, performs the FFT-processing, the spectral averaging, and the estimation of the spectral moments, and it also outputs a signal for synchronizing the transmitting pulses and the receiver (the synchronizing signal is only accessible at the 30kW radar). The DSP board is also part of the radar hardware. It communicates to the PC through over a fast data link (Gigabit-LAN). Also, the communication between the PC and the radar controllers is done over this fast data link. By using DMA (direct memory access) raw data can be transferred from the DSP to the PC at high data rates without causing much CPU load.

The program "radarserver" which runs as demon on the radar performs the following tasks:

- Controlling the TRB via Gigabit-LAN interface.

- Controlling the DSP to start data processing with the parameters chosen by the radar user.

- Reading the processed radar data from the DSP and writing it to the hard disk (pds data).

- Reading the BITE data (Built-In Test Equipment) from the TRB and the DSP and saving to the hard disk (log-data).

- Providing a network service to which control client can be connected to control the radarserver and through it the TRB and the DSP.

- Providing a network service to which data clients can be connected to view the radar data.

Control and visualization is provided by separate network client programs. GUI clients are provided for windows and for Linux platforms. Additionally, a text based client for controlling the radar and reading the meteorological data are provided.

The main software modules are listed in the following table:

Table 0-1: Software modules

№	Name	Description	Hardware
1	radarserver	Radar Network Server (Linux OS, 2.6.xx kernel)	Radar Host Computer
3	cclient	Text mode Control Client software (Linux)	Remote computer or Radar Host Computer

4	dclient	Text mode Data Client software (Linux)	Remote computer or Radar Host Computer
5	WinCC.exe, lincc	Graphic Control Client software (Linux, Windows'98/NT/2k/XP,7,10)	Remote computer or Radar Host Computer
6	WinDC.exe, lindc	Graphic Data Client software (Linux, Windows'98/NT/2k/XP,7,10)	Remote computer or Radar Host Computer

The control clients (*WinCC.exe*, *lincc*, *cclient*) provide an interface for controlling the radar and for monitoring the BITE parameter. It interacts with the server software by specially designed protocol. The GUI control clients (WinCC.exe and lincc) translate the commands given by mouse clicks and by filling out forms to server commands. The text based control client only connects to the radarserver and transfers the commands given on stdin.

The data clients (*WinDC.exe*, *lindc*, *dclient*) perform remote receiving of the meteorological data via network and displaying data on-the-fly (in real time). A very efficient protocol is used for the client-server data exchanging.

1.2 Software and the hardware interaction

The general structure of the interrelation of the Transmitter-Receiver block (TRB), the data acquisition and signal processing units, and radar network server are shown in Figure 1
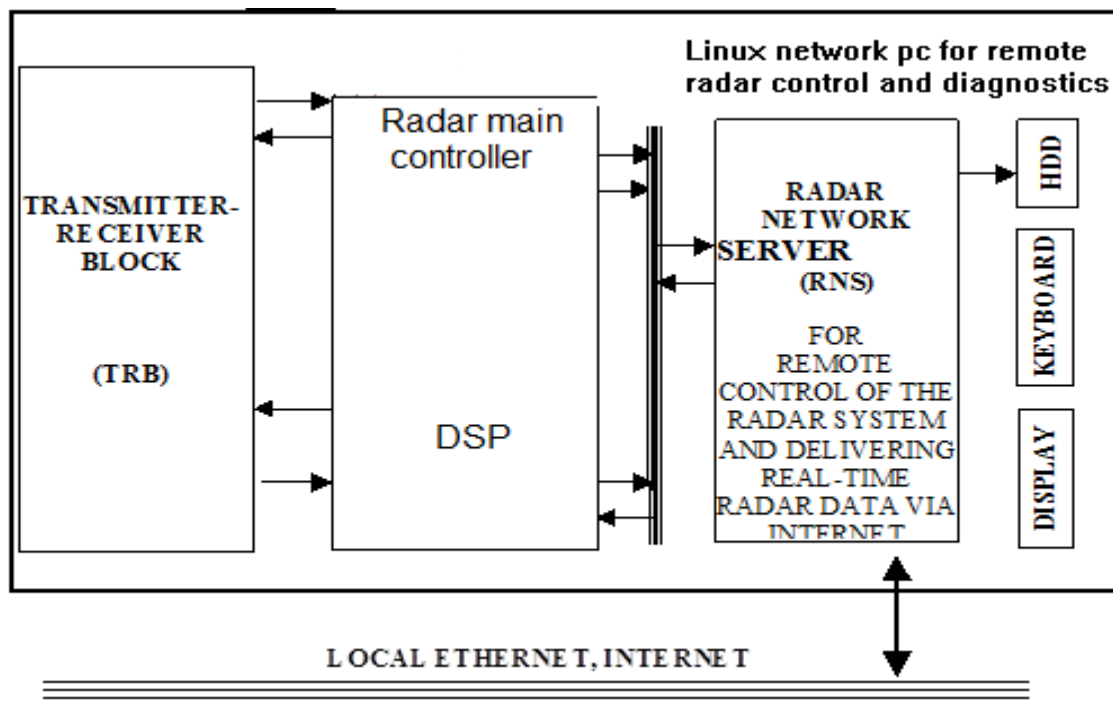

Figure 1: Block scheme of the interrelation of the transmitter-receiver block, data acquisition/processing units, and radar network server.

The IF signals with central frequency of 280MHz and bandwidth of ±25MHz coming from from both Co- and Cross- receiver channels are digitized by and preprocessed by the "digital receiver" which is located inside the receiver. The signals from the co- and cross-channel are digitized by two 16 bit, 125 MHz ADCs and preprocessed by a Xilinx FPGA. After

reading the co- and cross-channel signals from the ADCs the FPGA corrects the phase of the returned signals by the phase of the transmitted pulse, performs phase correction of the received signals by correlating the return signal to the foot print of the transmitted pulse, and digital to produce the raw radar data, i.e. I and Q signals. Data stream of the raw radar data is processed in the DSP 320C6416 by FFT based algorithms for spectrum moments estimations.

Spectra (or I,Q data) from all height gates are transferred to the PC memory via Gigabit LAN and it gives the possibility to save raw data to hard disk. The processed radar data (spectral moments, which are intensity, velocity, and velocity RMS deviation) are passed to the main processor for the final processing, which include creating real time oscillograms, images, and storing data to a file on a local hard disk along with the raw data. The TRB is connected to the host computer also via the Gigabit LAN interface. The control commands from the host computer are transferred to the TRB via this interface. The host computer uses also this connection for permanent keeping trace of the TRB status, including values of about 200 control parameters of the TRB.

Minimal requirements to the radar host computer hardware: PC on the base of CPU compatible with Pentium with clock frequency not lower then 3GHz, 8Gbyte RAM, 300GB hard disk (or RAID-0 system) which is capable to save data on rate not lower then 50Mbyte/sec, color monitor (optional) - 17'' with resolution not lower than 1024x768. Operation system: Linux with patched 2.6.x kernel (big phys area patch).

1.3 Radar Network Server

1.3.1 General structure of the radar network server

In this section, a description of the Linux network radar server (RNS) is provided. A general structure of the interrelation of the transmitter-receiver block (TRB), data acquisition, and signal processing units with the RNS is shown in Figure 1. Interaction of the server with the external world can be performed both locally and remotely. Using of the keyboard, mouse and displaying monitor are optional for the Radar Host Computer. All control server commands, requests, and server answers can be performed through a network, so it is necessary to have a possibility of the TCP/IP connections. Thus, the host computer must be connected to a network via a local Ethernet or a modem connection by using the PPP protocol. In the case, when the PC is not connected to a network, the *localhost* network interface can be used for radar control. In this case, the Linux *Control* and *Data* clients can be used only.

The RNS is supplied as a part of the radar network software package. The RNS with the corresponding client parts (see **Sections 1.2, 1.3**) is software, which is developed for providing the final processing of the radar data and delivering real-time radar *log* and *meteorological* data to numerous clients via the Internet. This software with the corresponding client parts can be used also for remote control, adjustment, calibration, and diagnostics of the radar. Two types of the radar network clients can be serviced by the RNS: *Control client* and *Data client*. Only one of numerous *Control clients* at the same time has the possibility to control the radar operation, i.e., to modify any parameter of the radar operation. The server gives permission for the control only for a single *Control client* at the same time. The rest of *Control clients* can only view the radar state, all processing parameters and settings, view log-data of all critical parameters of radar hardware, i.e. to operate in the passive mode. The *Data clients* have the possibility of data viewing and storing. A number of D*ata clients* can be connected to the radar simultaneously.

The RNS provides also simultaneous storing the raw data (spectra or I, Q data) and spectral moments to the *.pds file on the local hard disk. The detailed structure of the RNS is described in the next section.

1.3.2   Starting RNS

The RNS starts as a daemon during operating system start up. The record for starting *radarserver* can be inserted to the file `/etc/rc.d/boot.local`. All control server commands, requests and server answers are transferred from/to network clients. The detailed structure of the RNS is shown in Figure 2, where the destination of all parts of the radar server is shortly outlined.

To start the RNS manually, one can type the command from the shell which will launch the executable file **radarserver** from the corresponding directory with the listening port number as a single command line parameter. The script contains something like:

```
/…path…/radarserver 28386
```

In general, the choice of the radar service port number is somewhat arbitrary. It is sufficient to go out from the region of the system service port numbers (from 0 to 1024, telnet, ftp, etc.). But it should be noted that all client parts of the network software package use the number 28386 by defaults (see Sections 1.2, 1.3).
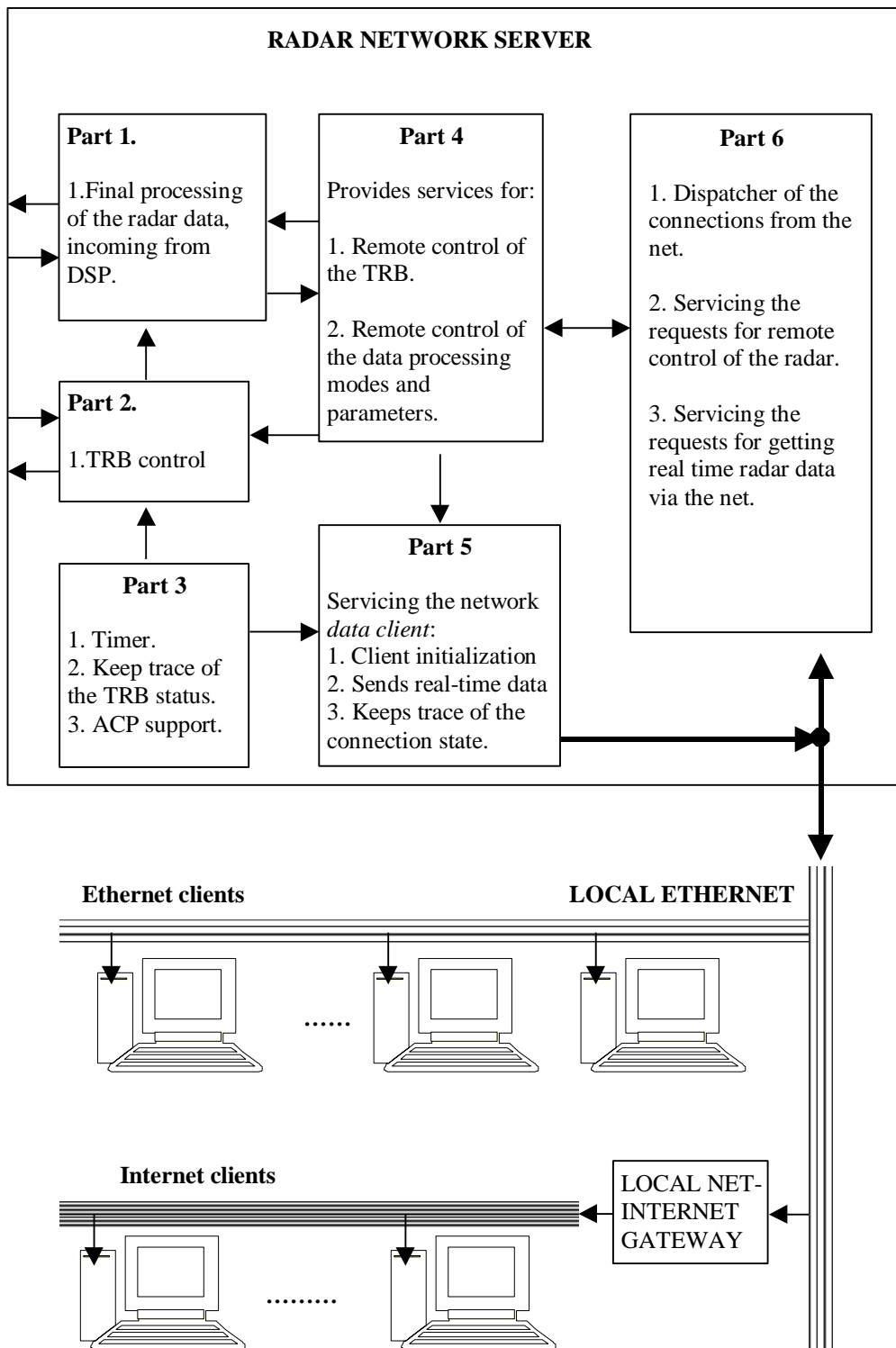
RADAR NETWORK SERVER

Part 1.

1.Final processing of the radar data, incoming from DSP.

Part 2.

1.TRB control

Part 3

1. Timer.
2. Keep trace of the TRB status.
3. ACP support.

Part 4

Provides services for:

1. Remote control of the TRB.

2. Remote control of the data processing modes and parameters.

Part 5

Servicing the network *data client*:
1. Client initialization
2. Sends real-time data
3. Keeps trace of the connection state.

Part 6

1. Dispatcher of the connections from the net.

2. Servicing the requests for remote control of the radar.

3. Servicing the requests for getting real time radar data via the net.

Ethernet clients   **LOCAL ETHERNET**

......

Internet clients

....

LOCAL NET-INTERNET GATEWAY

Figure 2: Detailed structure of the radar network server

1.4   Control Clients

There are three kinds of the *Control Client* software for controlling the radar operation. The first is the Win32 *Control Client* software (WinCC.exe), which provides both low-level control and visualized high-level server control in the graphic mode. The second is the Linux *Control Client* software (LinCC), which also provides both low-level control and

visualized high-level server control in the graphic mode. The third possibility is to use the Linux text mode *Control Client* program *cclient* which is described in Section 1.4.1. The high-level server control is more convenient and safe, and it is strongly recommended for usual users. That software has friendly graphic interface which is intuitively understandable. This software is shortly described in Section 1.4.2.

A brief description for each parameter, which is present in the control client is given in the document "ServerCommands+Formats.pdf.

There are two different ways to control the radar with the different Control Clients. The *Control Clients* are described more in detail further below.

1.) To run the *Control Client* software on a local computer and connect to the radarserver running on the radar PC deployed at a remote place, a ssh client like *Putty* is necessary. Here, the configuration of *Putty* is described:

-in field *Host Name* the user (for connections to the radar PC always user data must be chosen) and the IP address of the radar PC must be written. The port number is always the ssh standard port 22.
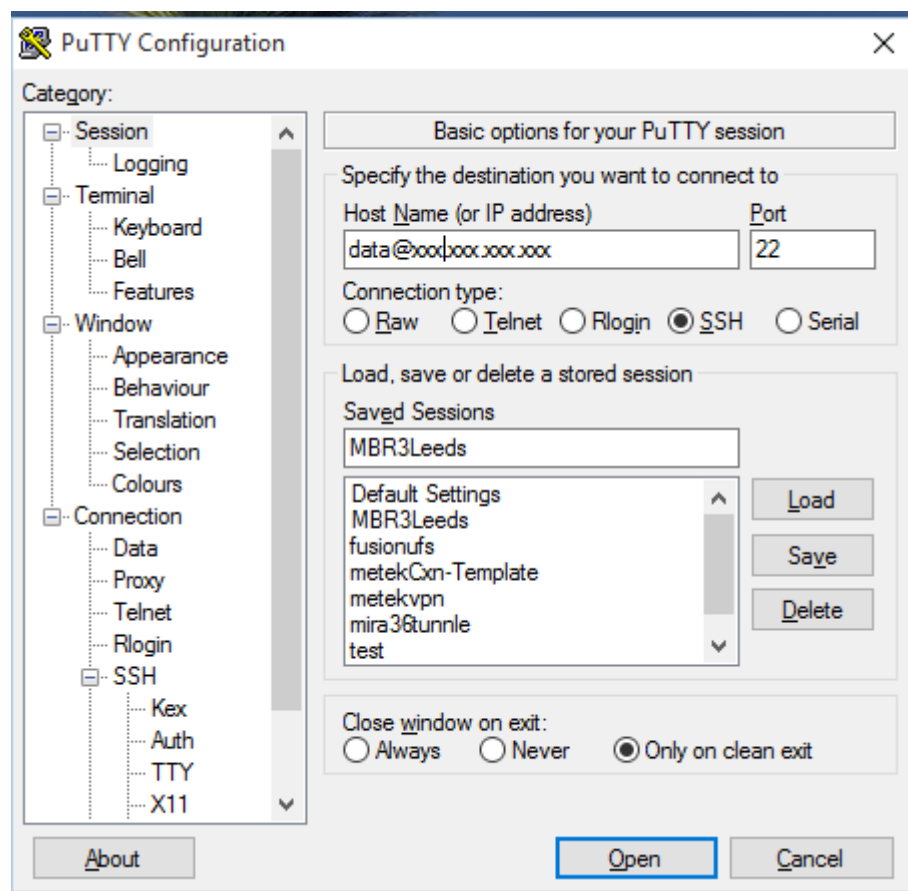

Figure 3: Parameter tree section *Session* of putty configuration

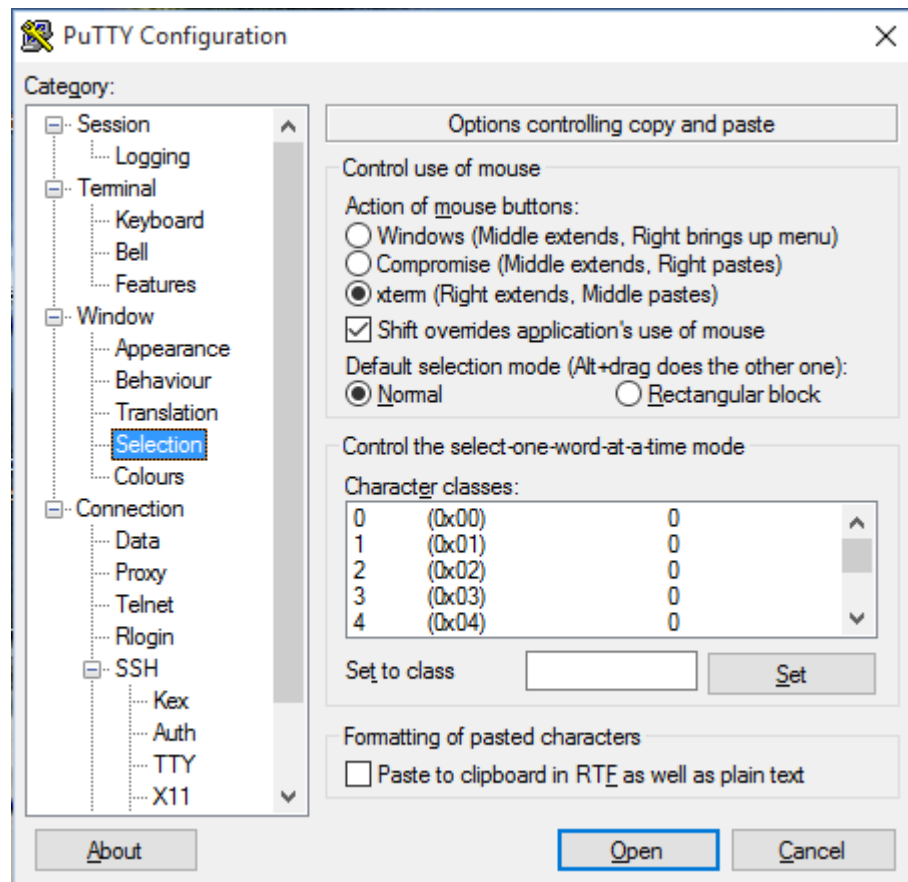-Down in the parameter tree section Window -> Selection *xterm* must be chosen.

8

Figure 4: Parameter tree section *Selection* of putty configuration

-In parameter tree section Connection -> SSH -> X11 *X11 forwarding* must be selected
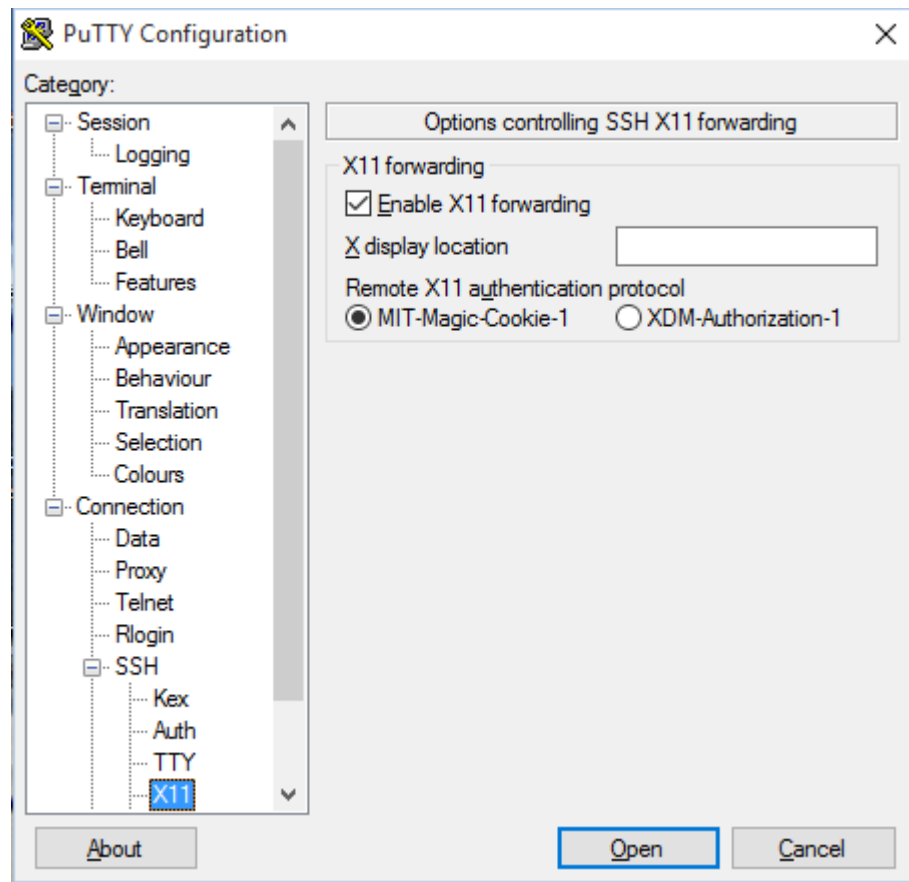
Figure 5: Parameter tree section *X11* of putty configuration

-In the parameter tree section Connection -> SSH -> Tunnels, a port forwarding for the Control Client must be configured. Therefor the following parameters must be specified:

Source Port: 28386

Destination: 127.0.0.1:28386

Then the *Add* button must be pressed. In the white field between the *Remove* and *Add* buttons a notification like the one in Figure 3 should be shown.

These settings can be stored by writing a name in the *Saved Sessions* field in the first parameter tree section *Session* and pressing the *Save* button.
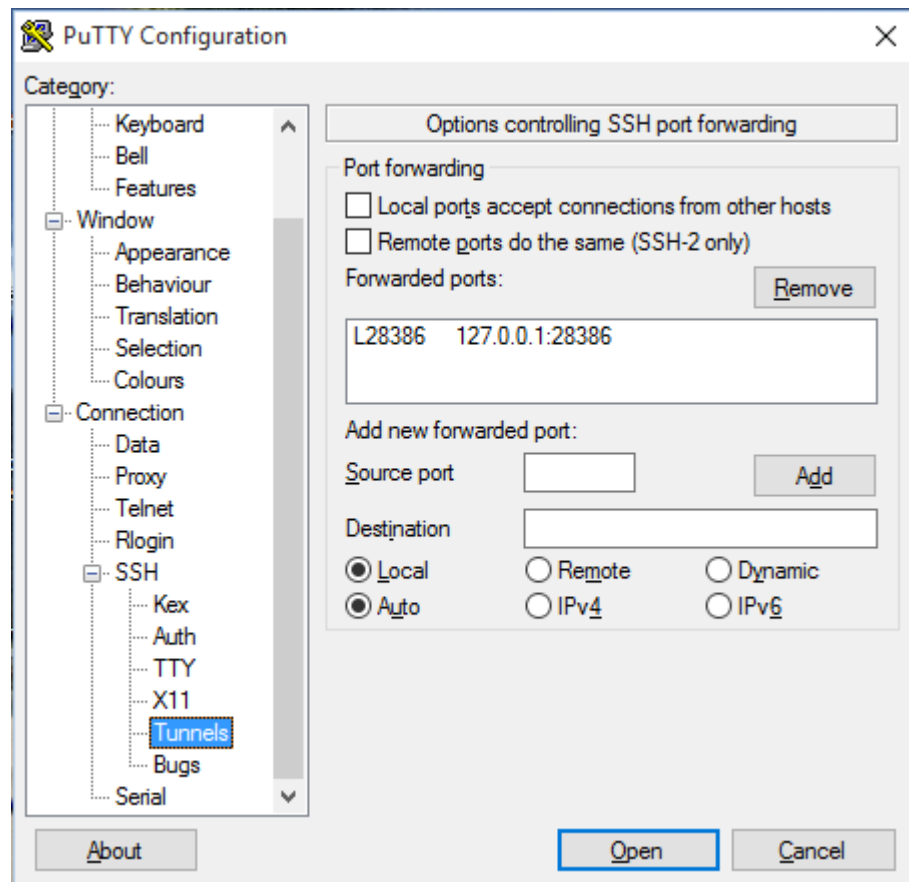
Figure 6: Parameter tree section *Tunnels* of putty configuration

By pressing the *Open* button the connection to the radar PC will be established. Then, the *Control Client* can be started on the local computer and connected to the radarserver as described further down.

2.) To run the Control Client on the remote radar PC a VNC connection must be established. As standard port for VNC connections port 5904 is configured on the radar PC. The vnc_server on the radar PC can be started by

data@radarPC>start_vnc

Then, a ssh tunnel must be built from the local computer to the radar PC by

user@localPC>ssh data@IP_of_radar_PC -L 5904:localhost:5904

Then the VNC connection can be established (here, the program vncviewer is used) by:

user@localPC>vncviewer localhost:0

where the number behind localhost is the display number of the VNC-server on the radar PC to which the connection shall be established. Then the Control Client can be opened on the radar PC.

1.4.1 Text mode control client (Linux)

This software is installed on the host computer with the radarserver software but it can be used on any remote network computer with Linux OS. The main goal of this control client is to give possibility to write a script file started by cron and control the radar in automatic

11

mode. So, one can use the **telnet** or **ssh** service to connect to the host computer with the radar server and launch the *Control Client* by using the command

```
/…path…/cclient 28386
```

The *Control Client* will work through the OS internal loopback interface. If the *cclient* is operating from any remote computer with the Linux, that two command line parameters must be provided in command line. These parameters are the port number and name or IP address of the Radar Host Computer. The domain name can be given in dot-number notations, for example:

```
/…path…/cclient 28386 name.domain.de

/…path…/cclient 28386 141.4.2.71
```

After *Control Client* launching and the successful authentication, the command prompt will appear:

```
Ready >
```

Now the user can send the low-level server commands. All server commands are described in the Annex 7.1. It should be noted that in contrast to the Windows/Linux graphic *Control Client* programs, the program *cclient* uses only low-level server commands, that is why it should be used carefully and by qualified personnel only.

1.4.2   Graphic Control Clients (WinCC.exe, LinCC)

The program **WinCC.exe** is developed for providing remote control of the radar via the Internet. This software tool is designed as a Win32 application, and it has a convenient graphic user interface. **WinCC.exe** is supplied as a part of the network radar software package, which is constructed on the base of the client-server architecture (see Section 1.3). This program tool is one of the client parts of the package. This client is connected to the radar server by the TCP/IP protocol to control remotely the radar via the Internet.

Linux control Client (LinCC) is developed with QT3 graphic library. The GUI interfaces of the WinCC and LinCC programs are visually the same. There are two different versions of the WinCC and the LinCC programs. One version of WinCC and LinCC respectively is intended to connect to the new xcrl-server. Theses *Control Clients* are necessary to select and control the new features of the new xcrl-server. Therefore, they include some more selectable parameters then the second version of WinCC and LinCC which are described here. Please refer to the document "xcrl-server_new_features.pdf" for a detailed description of the additional functions of the xcrl-compatible *Control Clients*. The basic functions are the same for both versions of *Control Clients*. These basic functions are described in the following sections.

The *Control Client* starts up unconnected. The only active radio button is the *CONN* button which has to be pressed to open the connection dialog, see Figure 7.
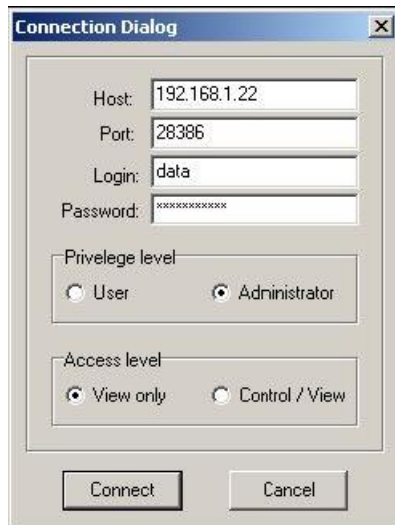
Figure 7: Connection dialog

The four fields of the connection dialog must be filled by the internet-address or IP-number, the port number, the user login name, and the password. In the two rows below the user can choose the desired privilege level and the access level. After pressing the **Connect** button the control client comes up in the so called High Level Control Mode with only the Main Control Display active (see Figure 8). If the connection with one of the higher levels is not possible the connection will automatically be established using the lower level and a warning message will appear. The initial values of the login form may be edited in the file WinCC.ini (or LinCC.ini) which is in the directory from which the client is started. After connecting the values in these fields (except the password) are saved to the that corresponding ini-file.

The program has three panels (corresponding to buttons names) "MAIN", "LOG", and "TREE". After successful connection to the server, only the "MAIN" panel is opened by default. It provides the high level (button "HIGH") and low-level (button "LOW") control of the radar. Pressing the "HEALTH" the panel for monitoring error states and controlling the miscellaneous sub-systems of the radar (antenna heating, compressor switching on/off) is opened.

With the "main panel mode buttons" **HIGH**, **LOW**, and **HEALTH** the mode of the main panel can be selected. The first main panel mode button selects the **HIGH** Level Control panel shown in Figure 8. It contains buttons for switching the power, the TR-block and the radiation on and off, and a drop-down menu to select predefined magnetron modes in the upper part. In the lower part, it contains fields for setting the most important DSP parameters. Below the fields four buttons indicate the status of the main auxiliary parts by red or green color. In the lowest field two buttons to apply new settings and to update the display of the actual setting can be found. In the same field the global state of the radar, the operational mode of the TR block and the on-time are displayed.
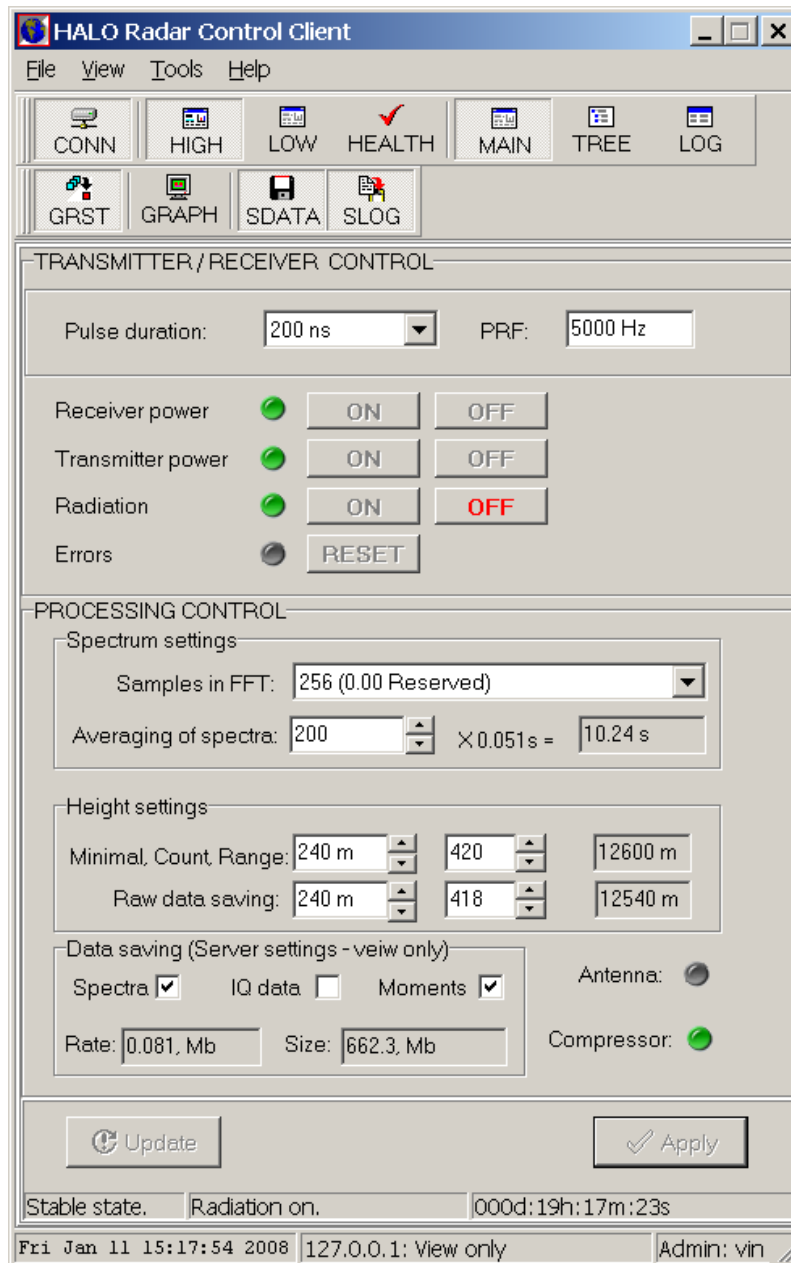
13

Figure 8: High level control panel

The second main panel mode button "HEALTH" selects the system **HEALTH** panel which has two tabs: **PS/Rx/Tx** and **Miscellaneous** (see Figure 99).
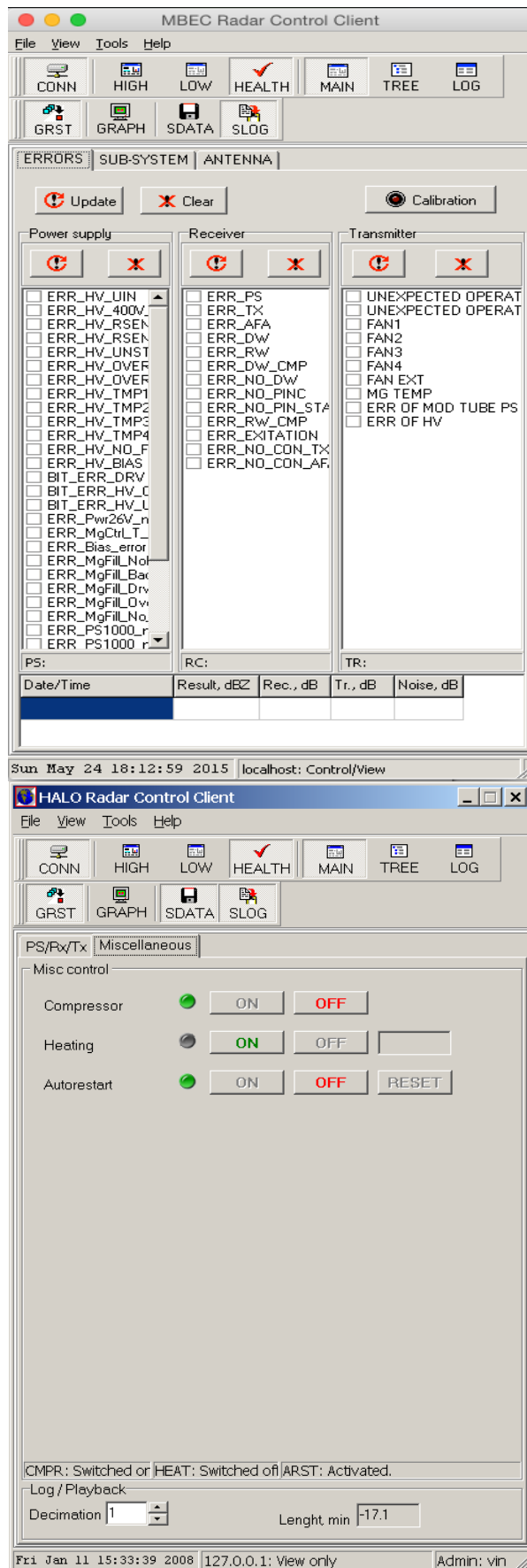
Figure 9: PS/Rx/Tx and Miscellaneous pages

The *PS/Rx/Tx* page shows error flags and status information of the power supply, the receiver and the transmitter. Above these displays buttons are available to update and clear the error flags either for all three sections (top) or for each of the section separately (directly above the displays). Note, that the errors shown here represent the accumulated errors that had occurred since pressing the clear button or switching on the radiation at the last time.

The *Miscellaneous* page of the **HEALTH** panel provides buttons for switching the pump (compressor) for the waveguide ventilation system (only installed in 30kW radars), radar auto-restart function (which is implemented in the main radar controller), and the antenna heat system (for antennas equipped with heat system). It also contains the decimation factor which determines the time resolution using the graphic display for log-parameters.

The third main panel mode button selects the **Low** Level Control for browsing and changing the radar parameters on the level of server commands. Low Level Control page is shown in Figure 10.
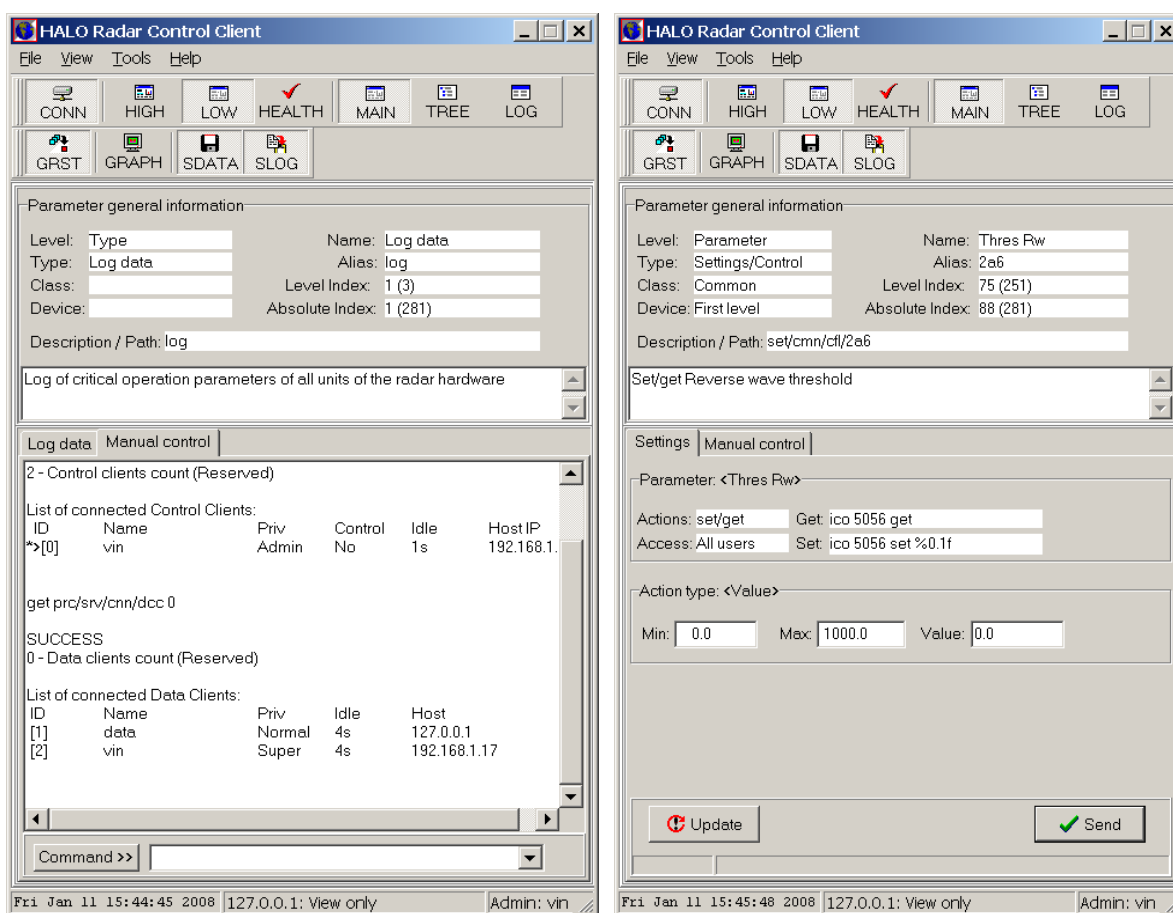

Figure 10: Low Level Control page

On left window, the "Manual control" page is opened. The low-level commands can be manually typed in the edit field "Command>>", and after pressing on button "Command>>" or pressing "Enter" the command will be sent to the server. On the "terminal" window above one can see the log of the information exchanging between client and server.

On the right window page, which allows to show and set the various radar TRB parameters, is opened. After setting a value in the field "Value" and pressing the button "Send", the corresponding value will be set to the TRB main controller by the radar server. The list of all

server parameters, TRB parameters, and logged parameters is contained in the "TREE" page, see Figure 1111 (on the left side).
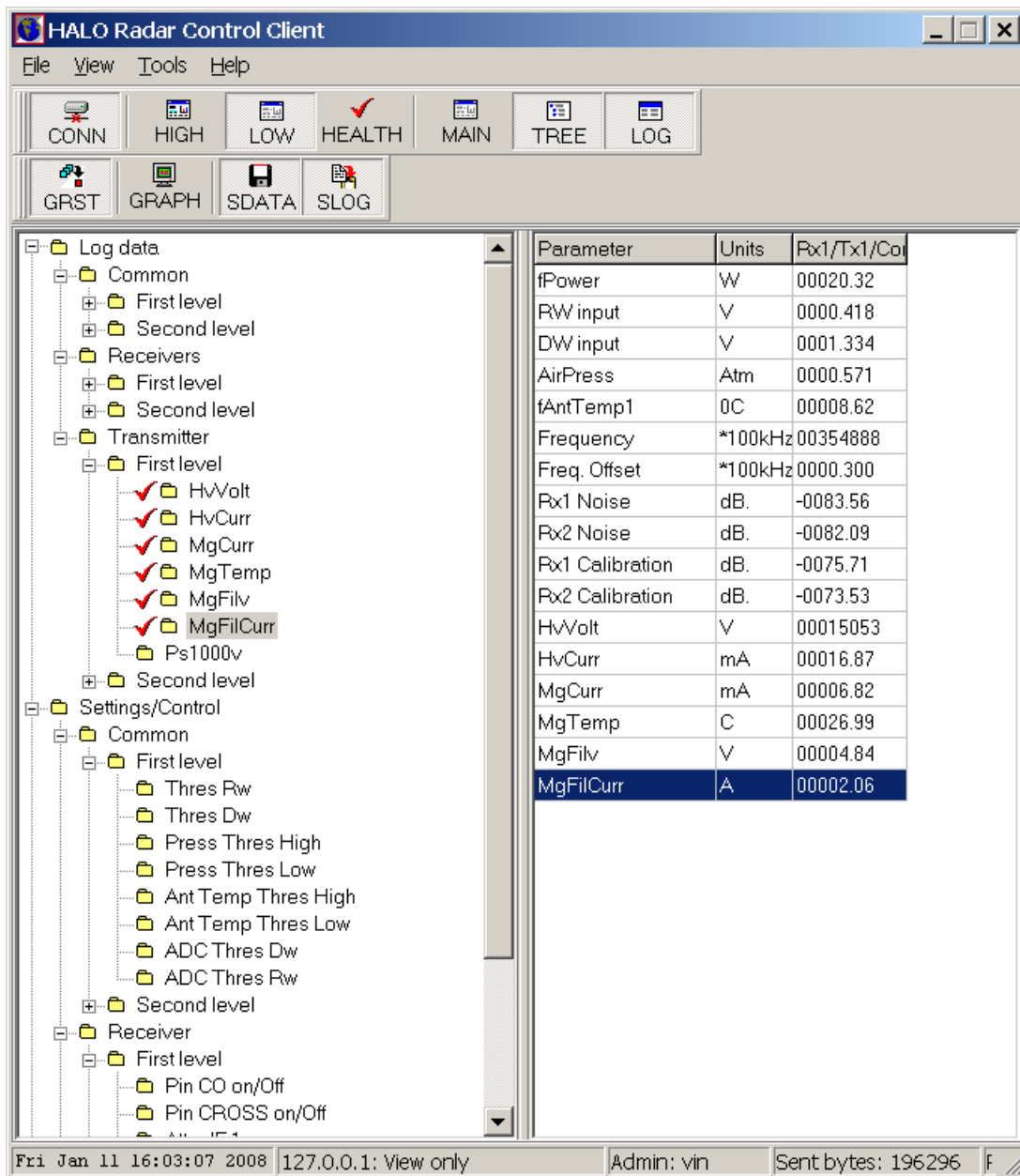

Figure 11: "TREE" and "LOG" pages

On the page "LOG" (see right side of the Figure 1111) the logged parameters can be viewed. The list of the viewed (via network) parameters is defined by the selecting needed parameter on the "TREE" page ("Log" branch in the parameter tree) and double clicking on it. So, the viewed parameter list is defined by each *Control Client* separately, in such way the various clients can view various lists of the parameters.

1.5 Data Clients

Three types of *Data Clients* programs are supplied in the network software package. The first possibility is the Win32 client program (WinDC.exe), which provides viewing real time cloud radar data in the convenient graphics mode. This software is described in the Section 1.7.2. The second possibility is to use the graphic Linux *Data Client* program (LinDC),

which also provides viewing real time cloud radar data in graphics mode. Its GUI interface is almost the same as for WinDC.exe, so, the Section 1.7.2 also can be referred as the description of LinDC. There is also Linux text mode *Data Client* (*dclient*), which is described in Section 1.7.1.

1.5.1 Text mode Data Client (Linux)

This client is installed on the host computer with the radar server software. But it can be compiled and installed on any remote computer with the Linux. In the first case, this program can be invoked by typing in the Linux command line

```
/…path…/dclient 28386
```

When the program is launched on the radar host computer, command line requires one parameter which is the connection port number. For the second case (remote computer), two command line parameters must be provided for starting the *Data Client*. These parameters are the port number and domain name or IP-address of the Radar Host Computer. The name and the address can be given in dot-number notations, for example:

```
/…path…/dclient 28386 name.domain.de
```
```
/…path…/dclient 28386 141.4.2.71
```

After the authentication token and selecting the needed measurements to be received, the connection to the server is established, and selected radar data (intensity, and/or velocity, and/or variance, and/or spectrum for one of the gates) for the first 10 height gates are displayed on the screen in the text mode. This program has no big practical meaning, but it can be very useful for quick testing and debugging of the *Data Client* connections to the server when one is developing a *Data Client* software.

There are two privilege levels for the *Data Clients*: 0 - super user, high level of data representation, 1 – common user, low level of data representation. These client privilege levels are listed in the decreasing order of the privileges. The server puts the *Data Clients* in certain order to form the chain of the connections. The connections with less privilege level are placed more far from the chain head. The radar server services the connections from the head to the tail of the chain. After servicing each connection, server checks the presence of the DSP request for processing new data for providing real time DSP service. In the case of numerous connections, server may have no time to service all connections. In this situation, the *Data Clients* with least privilege levels may be disconnected by the server.

1.5.2 Graphic Control Clients (WinDC.exe, LinDC)

The program WinDC.exe (or LinDC) is designed for viewing real time radar data via the Internet. WinDC.exe is supplied as a client part of the network radar software package, which is constructed on the base of the client-server architecture. The main goal of this program tool is providing the possibility to establish the TCP/IP connection with the radar server for getting radar data via the TCP/IP protocol. Then, the radar data can be stored on the client PC. WinDC.exe can be used in two modes: 1) for imaging current real time data, and, 2) for playback (forward and backward) of the radar data, which was earlier recorded by this program. These two modes of operation will be described below.

1.5.2.1 Getting real time radar data via the Internet

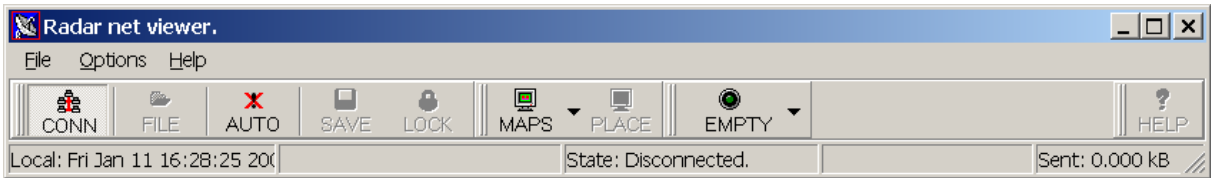After launching, the program WinDC.exe is in a disconnected state, and main control window appears, see Figure 1212.

Figure 12: Main control window of the WinDC.exe

Pressing the button "CONN" the dialog window for the entering the connection information appears, see Figure 1313.
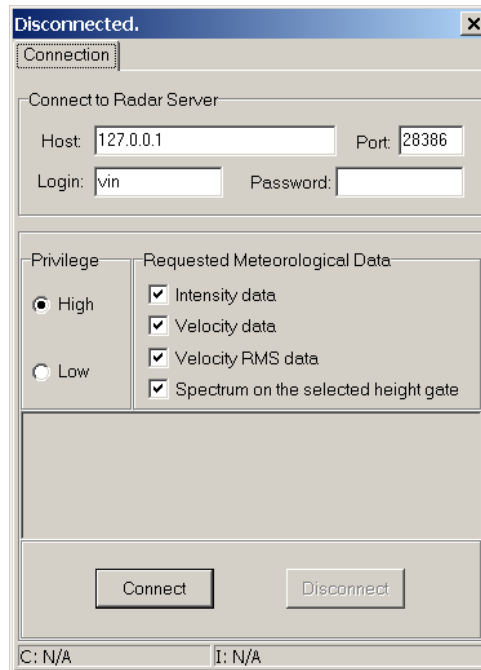

Figure 13: Connection dialog window

Before establishing a connection with the server, the fields *[Host], [Port], [Login], and [Password]* on the connection dialog window must be filled. Meaning of these fields is clear. One can assign the default contents of these fields (exclude password) in the configuration file WinDC.ini (or LinDC.ini in case of LinDC software).

The next step is choosing the *privilege* of the connection. *High* means the super user connection. In this mode, the client gets the finest coded data, but it results in increasing the network traffic. This connection is recommended for user, which want to save the radar data on a remote PC. *Low* means the common user connection. In this mode, the client gets coarser data, but it results in economic network traffic.

There are four check boxes on the connection page: *[Intensity]*, *[Velocity]*, *[Variance]*, and *[Spectrum]*. To request desired radar data from the server, the user has to mark the corresponding check boxes.

After the connection page was properly configured, one can initiate the connection with the server by clicking the button *[Connect]*. When the connection is established, the server sends the current configuration of the processing and connection parameters to the client. The server can perform some modifications in requested privilege level and requested types of radar data.

After connection is successfully established the program starts to receive the data from the radar server, and the windows corresponding to available types of radar data will be opened automatically as it is depicted on Figure 14.
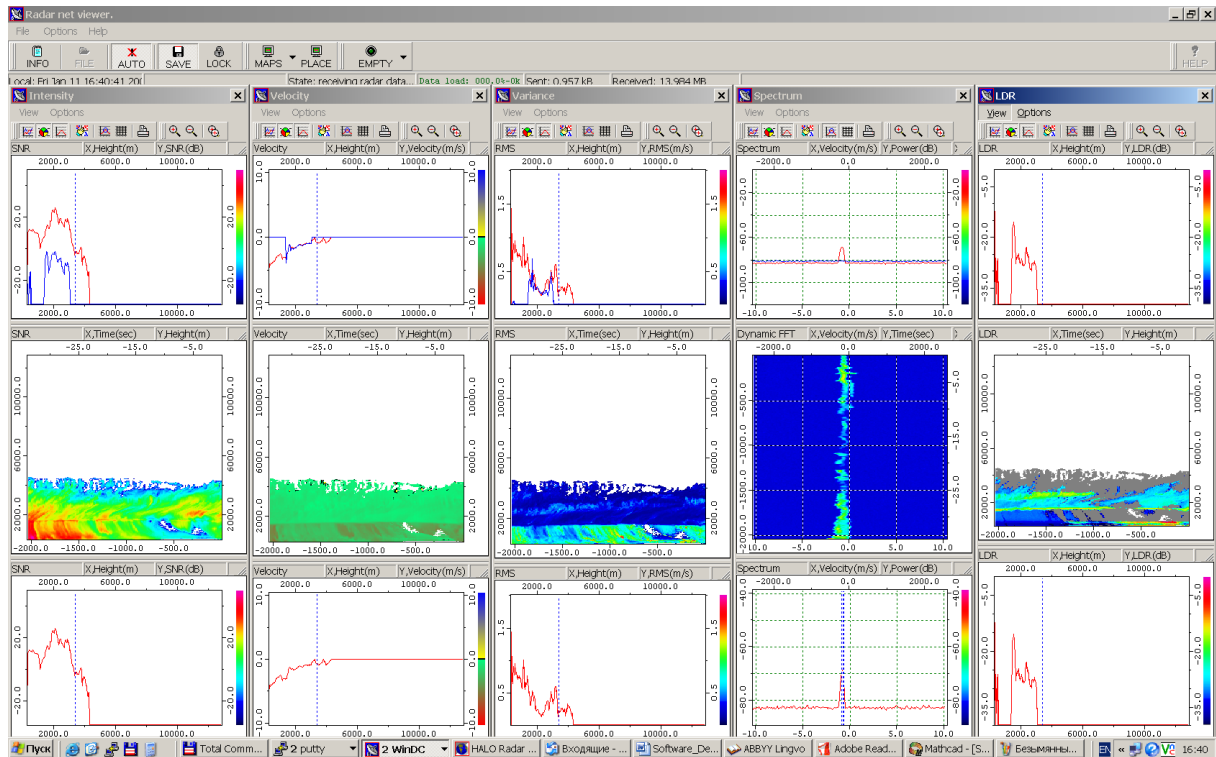

Figure 14: WinDC.exe (LinDC) in the connected state

During the radar data receiving a user can start storing the data in a file on a local PC by clicking the button *[Save]*. The button *[Close]* can be used to stop the data storing. However, it should be noted that during the radar data receiving the processing parameters can be changed on the server side. It may happen due to, for example, changing some parameters by the *control client*, which is connected to control the radar. In this case, the radar *data client* can asynchronously get the server request to reinitialize. The radar data storing to the current file will be automatically stopped and new file will be opened for the continuing data saving.

1.5.2.2 Playback of stored network radar data

When the WinDC.exe program is in a disconnected state, one can open any earlier stored radar data file (*.nrd) for playing back it. The button **[File]** on the main program window (see Figure 1212) allows to choose the desired *.nrd file.

After opening the file, the processing parameters and connection parameters are read from the file header, thus the program is automatically configured by the same parameters as they were during the data obtaining. The windows corresponding to the available types of the stored radar data will be opened automatically as it shown on Figure 1414. To perform forward and backward moving of radar images, one can use the "RUN" buttons on the main window which appear when the program goes to playback mode.
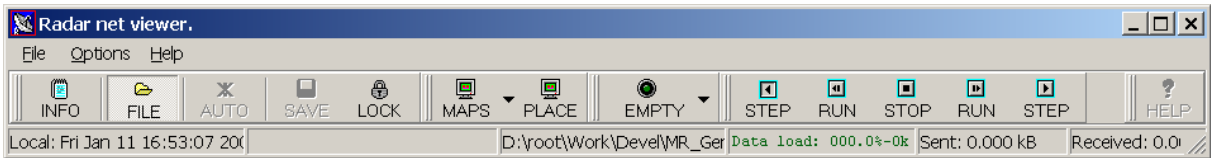
15: Main program window in the playback mode

1.6 PPI and RHI displays for scanning radars

1. Graphic windows to display data in scanning mode. For each profile (reflectivity, mean velocity, velocity RMS, and LDR) there are two SCAN windows: Plan Position Indicator (PPI) and Range Height Indication (RHI). The PPI window can operate in two modes: 1) to display slant range data during the azimuth scan; 2) to display radar data as projection on the ground during the azimuth scan with constant elevation angle.

2. Range-Time Maps windows and PPI windows keep trace dynamically on the elevation angle, if they are in the ground projection mode.

3. PPI and RHI windows can display data in dBZ units. Corresponding menu is in the list of context menu items.