Micro Rain Radar
MRR PRO

Manual

METEK
Meteorologische Messtechnik GmbH

Date: 10.04.2019

Content

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1 Safety Guidelines

It is the obligation of the operator of a METEK MRR system to assure that any transportation, set up, operation or dismantling of the MRR system or any other attached technical components at a measuring site is performed exclusively by trained and skilled personnel and according to the system documentation which consists of:

- This manual
- To be regarded but not explicitly listed here are the manuals and datasheets of vendor parts (e.g. PC).

It is recommended to train the operational personnel at least every 12 months on all work or actions associated with the transportation, set up, operation or other work at the site or of the METEK MRR system or on any other technical component!

Safety risks:

- METEK MRR systems are delivered with a power supply at 230 VAC which provides both, high voltages and high currents, which can be hazardous for staff personnel or for other persons within the vicinity and may cause severe or even fatal injuries!
- The external 230 VAC power outlet connected to the MRR system needs a ground fault circuit interrupter 30 mA (RCD); fuse 16A.
- The MRR must not be set into operation unless all set up work and safety installations are done properly! This includes the provision of a earthing peg for grounding of the system.

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- For any work at the MRR site which might include installation, operation, repair, maintenance or dismantling the personnel must be aware of further risks which might occur. Some of these risks will become more dangerous in case of poor daylight conditions or at night time. Therefore, any work case under poor daylight conditions or at night time should be avoided or performed with extra care. Such risks are:

  - Slippery surfaces can cause falling of persons when working around the system or at the system surfaces of the supporting stand.
  - Persons can step on cables or trip by cables or guy lines. If reasonable some flags can be used to mark the cables and guy lines to make them more easy to detect. If possible cables should be hanged up to avoid tripping by them.
  - The grounding nail should be placed beneath antennas so it is impossible to trip.

- Also related to a safe use of the MRR is the avoidance of misuse of the system or of system components.
- Do not open the outdoor boxes of antenna electronic or power supply unless in dry weather periods without liquid or solid precipitation.
- When opening the outdoor boxes of antenna electronic or power supply, dry or wipe off any rain drops, hail stones or snow on top to avoid that these particles will fall inside the opened box.

For an assessment radiation exposure, see chapter 12.

Disclaimer:

METEK GmbH does not take any obligation for any damages of persons, of animals, of materials or any other items which might result from the transportation, set up, operation or dismantling of the MRR system or any other attached technical components or items which are delivered by METEK with the MRR system if the MRR system has not been operated properly according to all above listed instructions or has not been operated within the specified operating conditions! Moreover, METEK limits its obligation for proven damages of persons, of animals, of materials or any other items which might result from the transportation, set up, operation or dismantling of the MRR system or any other attached technical components or items which are delivered by METEK with the MRR system to a maximum amount which equals the price of the purchased items as far as no other laws or directives are applicable.

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2 Sicherheitsrichtlinien

Es liegt in der Verantwortung des Betreibers des METEK MRR Systems sicherzustellen, dass jeder Transport, Aufbau, Betrieb oder Abbau des MRR Systems nur durch geschultes und qualifiziertes Personal und entsprechend der Gerätedokumentation erfolgt. Die Dokumentation besteht aus folgenden Dokumenten:

- diesem Handbuch
- außerdem müssen Handbücher und Datenblätter von Zubehörteilen betrachtet werden (z.B. Dell PC), auch wenn sie hier nicht explizit genannt sind.

Wir empfehlen, das Bedienpersonal mindestens alle 12 Monate erneut mit den Sicherheitsrichtlinien für den Transport, Aufbau, Betrieb oder Abbau des MRR Systems vertraut zu machen.

Sicherheitsrisiken:

- METEK MRR Systeme werden für den Anschluss an 230 VAC Netzspannung geliefert. Dieser 230 VAC Anschluss stellt hohe Spannungen und Ströme bereit und kann schwere und auch tödliche Verletzungen verursachen.
- Der 230 VAC Anschluss für das MRR System ist mit einem Fehlerstromschutzschalter mit einem Nennfehlerstrom von 30 mA auszurüsten.
- Das MRR System darf erst dann in Betrieb gesetzt werden, wenn alle Sicherheitsrichtlinien beachtet wurden. Dies beinhaltet auch die ordnungsgemäße Installation des Erdungsankers zur Erdung des Systems.
- Bei allen Arbeiten am Messplatz wie Installation, Betrieb, Reparatur, Wartung oder Abbau muss dem Personal bewusst sein, dass überall weitere Gefahren lauern. Einige dieser Gefahren können durch schlechte Lichtverhältnisse bei fehlendem Tageslicht oder zur Nachtzeit versursacht werden. Daher sollten Arbeiten bei diesen Verhältnissen nicht oder nur mit besonderer Vorsicht durchgeführt werden.

Einige dieser Gefahren sind:

– In der Umgebung des MRR Systems kann es zu SRS-Unfällen (Stolper-, Rutsch- oder Sturzunfällen) kommen.
Ursache hierfür können u.a. sein:
  o schlechte Lichtverhältnisse
  o Stolpern über Kabel, Abspannseile. Es kann daher sinnvoll sein, die Kabel und Abspannseile durch Flaggen entsprechend zu markieren. Kabel sollten nicht am Boden verlegt werden, sondern mit geeigneten Pfählen hochgelegt werden.
  o Stolpern und Stürzen über Erdungsanker, der Anker sollte daher so platziert werden, dass die Stolpergefahr minimiert wird.

- Für die Sicherheit ist der bestimmungsgemäße Betrieb des MRR Systems wichtig, daher gilt:
  o Öffnen Sie die Gehäuse im Außenbereich nur bei trockener Witterung ohne feuchten oder festen Niederschlag. Entfernen Sie vor dem Öffnen Wassertropfen, Hagel oder Schnee vom Gehäuse, damit kein Wasser in das Gehäuse tropft.

Haftungsausschluss:

METEK GmbH übernimmt keine Haftung für Schäden an Personen, Tieren, Material oder anderen Dingen, die durch den Transport, Aufbau, Betrieb oder Abbau des MRR Systems oder anderen technischen Komponenten, die von METEK mit dem MRR geliefert wurden, entstehen, wenn das MRR System nicht bestimmungsgemäß nach den obigen Anweisungen innerhalb der technischen Spezifikationen betrieben wurde.

Weiterhin beschränkt METEK die Haftung für nachgewiesene Schäden an Personen, Tieren, Material oder anderen Dingen die durch den Transport, Aufbau, Betrieb oder Abbau des MRR Systems oder anderen technischen Komponenten die von METEK mit dem MRR geliefert wurden, auf einen Höchstbetrag, der dem Kaufpreis dieser Waren entspricht, sofern diesem Vorgehen keine gesetzlichen Regelungen entgegenstehen.

3 List of Parts

The Micro Rain Radar MRR Pro consists of the following main components

- Antenna
    - Offset-Parabolic-Dish
    - Option: Antenna Heating 115 VAC or 230 VAC
    - Radar-Support Shaft
        - Transceiver
        - Round Level
        - RCPD
- Stanchion
- Power Supply
- Tripod (option)

The package further contains

- USB Stick containing manuals and installer software for MRR Pro GUI
- LAN-Cable (1m)
- LAN-Cable (25m)
- Control Cable (1m)
- Heating Power Cable (1m)
- Power Cable (25m)

The following tools are needed for set up (not included in delivery):

- Screw wrench (13,15,22 mm)
- Hex wrench (5 mm)

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1 Transceiver

2 Round Level

3 Antenna Dish

4 RCPD
   (**R**adar **C**ontrol
   and **P**rocessing
   Device)

5 Stanchion

6 Power Supply

7 Tripod (Option) with
   Guy Chains and
   Pegs (8) and
   Levelling Feet (9)

Figure 1: Overview
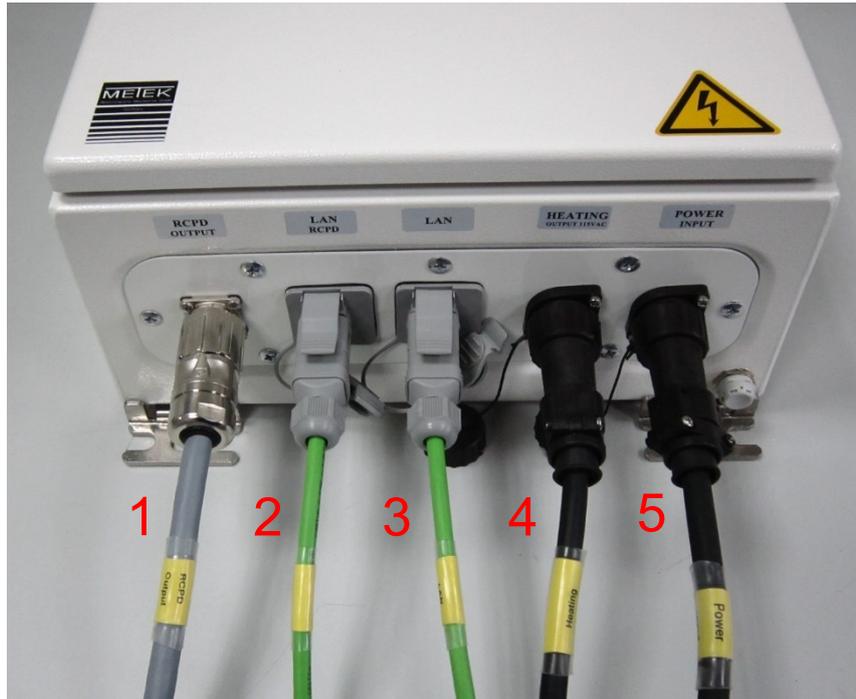
Figure 2: Cable connections to Power Supply

No.	Function	Source	Destination	Cable Type
1	Supply RCPD	Power Supply	RCPD	grey, L=1 m
2	LAN	Power Supply	RCPD	green, L=1 m
3	LAN	Power Supply	LAN External	green, L=25 m
4	Antenna Heating	Power Supply	Antenna Heating	black, L=1 m
5	Power Cable	Power-Socket	Power Supply	black, L=25 m

Table 1: Description of cables

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4 Installation of Hardware Components and Cabling

1. The Tripod is assembled, set up and secured with the guy chains and pegs.
2. The Stanchion of the Offset Parabolic Dish is mounted on the Tripod and secured with screws.
3. The Radar Support Shaft with Round Level and RCPD is mounted into the bearing at the Offset Parabolic Dish and secured with screws.
4. The Power Supply is fixed with screws to the mounting plate at the Stanchion.
5. All cables (Table 1, Figure 2) are plugged in.
   Caution: Connect all cables before you plug in the Power Cable.
6. Align the radar for vertical pointing direction using the levelling feet of the Tripod. Check the alignment with the round level.

5 Establishing connection to the MRR Pro

A LAN interface is used for communication between MRR Pro and a PC. Make sure that the MRR Pro and the PC are in the same IP domain. The default configuration of the MRR Pro LAN interface is "DHCP / Link Local".

Depending on the chosen connection mode some settings are required which are described below.

5.1 Settings IPv4 DHCP

If the MRR Pro shall be integrated into a LAN with DHCP server, it acquires an IP address. The PC, which is planned to connect to the MRR Pro, must be member of the same LAN. No further settings are required.

5.2 Settings IPv4 Link Local

The address range for Link Local connections is 169.254.0.0 to 169.254.0.16. The PC to be connected to the MRR Pro must be configured with a fixed address within this range.
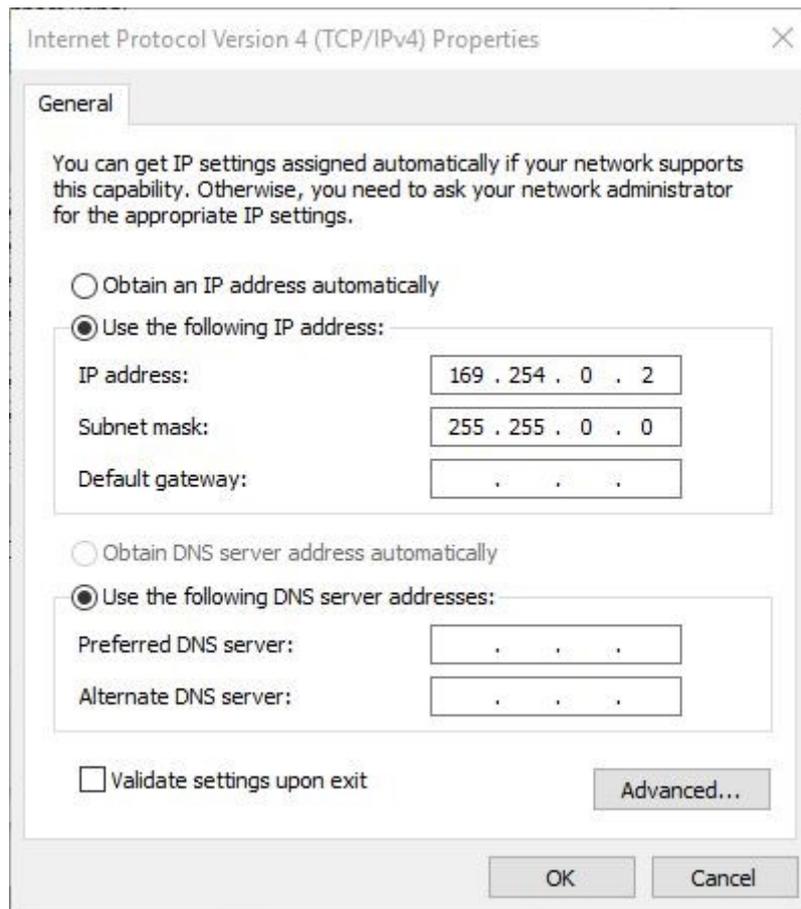
Figure 3: Example for Link Local network settings of the client PC

5.3 User Interface

The MRR Pro offers two possibilities for a user to connect.

1. Only for WINDOWS operation systems: The program **MRR Pro GUI** allows the identification of the MRR Pro residing in the local network, configuration of the MRR Pro and visualization of real time data.
2. Independent of operation systems: The MRR Pro includes a web server which allows access to the MRR Pro via web browsers.

5.3.1 MRR Pro GUI

The program **MRR Pro GUI** installation tool comes with delivered USB stick. Installation is possible on PCs with WINDOWS version Windows XP Service Pack 3 or newer.

On start-up of the program MRR Pro devices are identified in the local network using a UDP broadcast. All identified devices are indicated in the panel *Controller Address* with the current IP address and device ID. The search can be repeated by clicking the *Find Devices* panel. Connection to a selected device is established by clicking into the *Connect* panel. Current data are displayed in the tab *Data Display*. Control- and monitoring options are available in two tabs.

In case that the connection cannot be established please check your firewall settings, see chapter 5.3.2 :
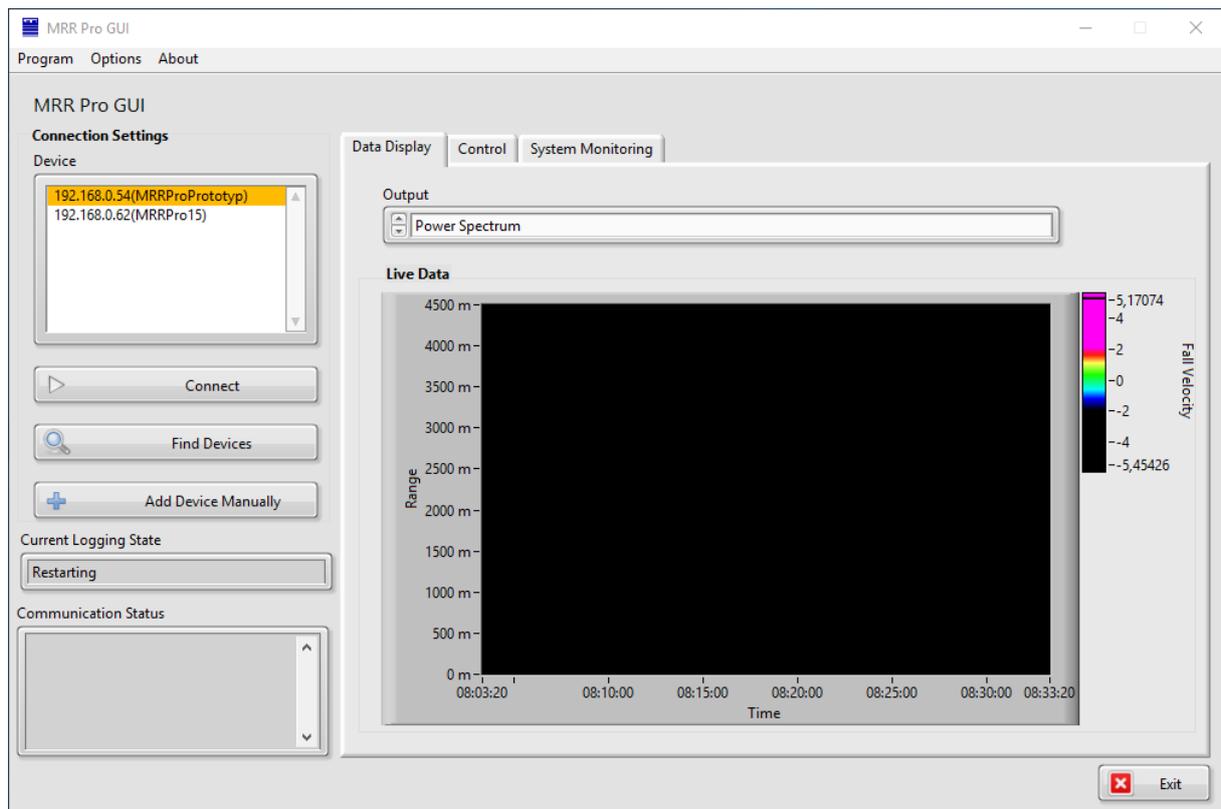
Figure 4: MRR Pro GUI Start Menu

5.3.2 Firewall settings

For a seamless operation of the MRR Pro GUI it is necessary that some firewall settings of the Windows system are modified. Normally this is done during installation of the MRR PRO GUI, but sometimes these settings are not accepted, then the MRR Pro GUI cannot connect to the MRR PRO system.

Modify manually the firewall settings by copying the following lines into a text file with the name "mrrfirewall.bat" and then execute the file as administrator.

```
if %PROCESSOR_ARCHITECTURE%==x86 (

  netsh adv firewall add rule name="NI PSP Service Locator" dir=in
program=c:\windows\System32\lkads.exe action=allow

) else (

  netsh adv firewall add rule name="NI PSP Service Locator" dir=in
program=c:\windows\SysWOW64\lkads.exe action=allow

)

netsh adv firewall add rule name="MRR Pro GUI" dir=in
program=%1\MRRPROGUI.exe action=allow
```

5.3.3 National Instruments Management

The login to the National Instruments management console is only possible with the Microsoft Internet Explorer with Silverlight extension.

http://(IP address of MRR Pro)

If the IP address of the device is unknown, the local DNS-name of the device can be used:

http://mrrpro(#).local

(#) must be replaced by the device number. Login via the IP address is preferable, because the response times tend to be shorter.

Since the user management is based on National Instruments proprietary software a *National Instruments Login* page appears.
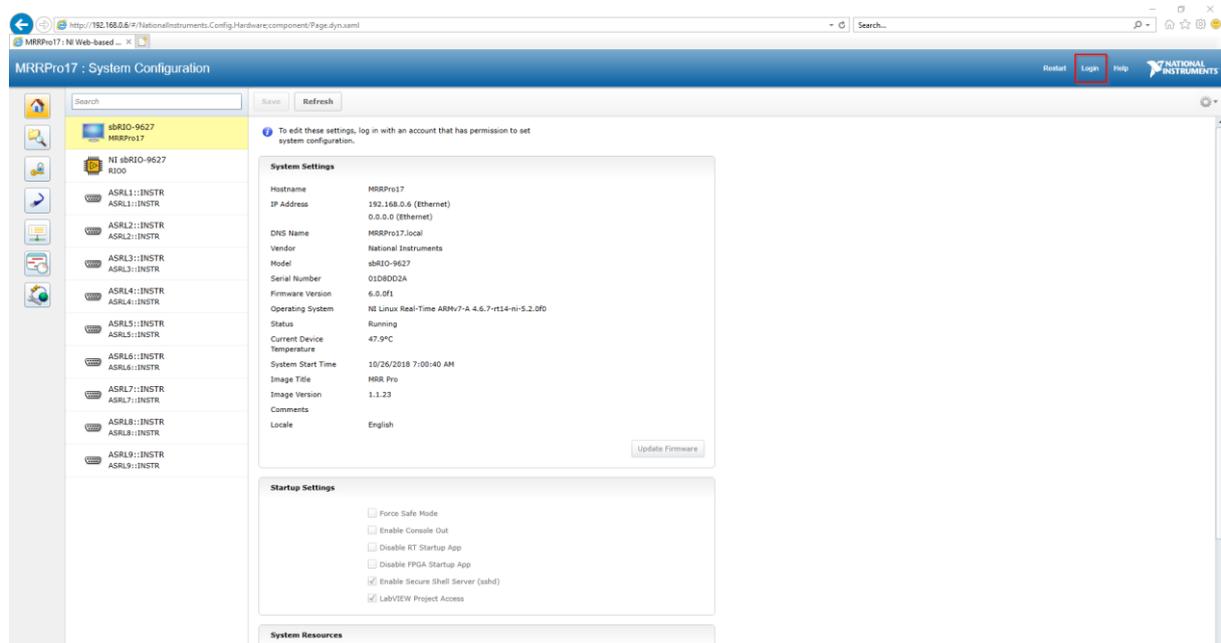
Figure 5: National Instruments Login

There is one user-account with the name "mrruser" available, the default password for this user is "metek". The password can be changed, see chapter 11.2 for details.

After successful login you are transferred to the start page of the web service.

5.3.4 Connection via Webbrowser

The web service for configuring the MRR Pro is to be found under

http://(IP address of MRR Pro):8001/Config/

If the IP address of the device is unknown, the local DNS-name of the device can be used:

http://mrrpro(#).local:8001/Config/

(#) must be replaced by the device number.

On the data display screen, right clicking on the scales opens the context menu that allows changing auto scaling. Changing the values on the scales allows detailed views of different data areas.
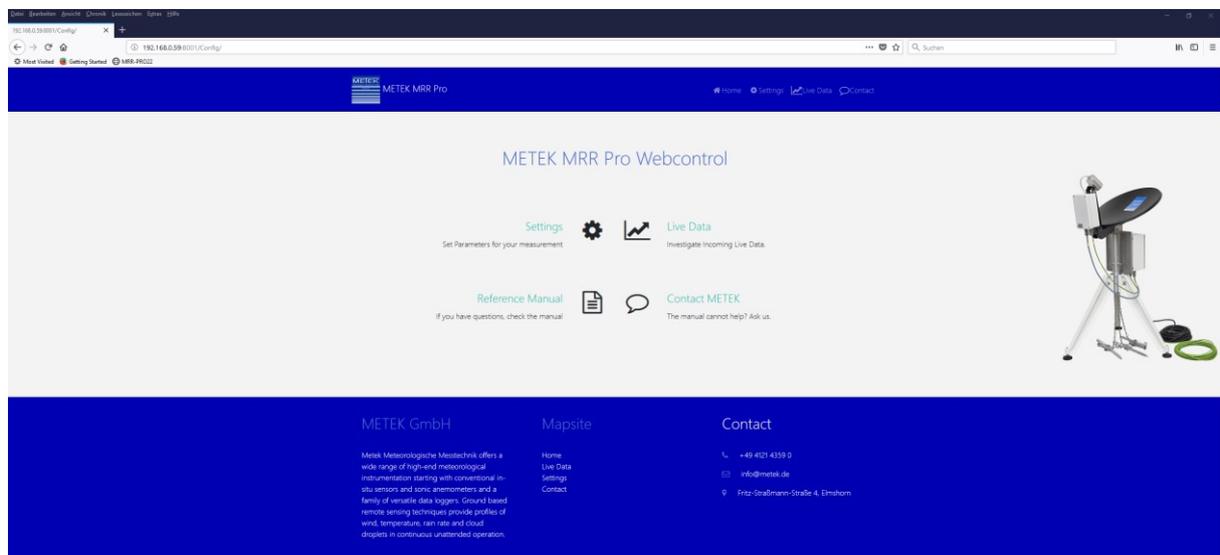
Figure 6: Start page of the MRR Pro web service

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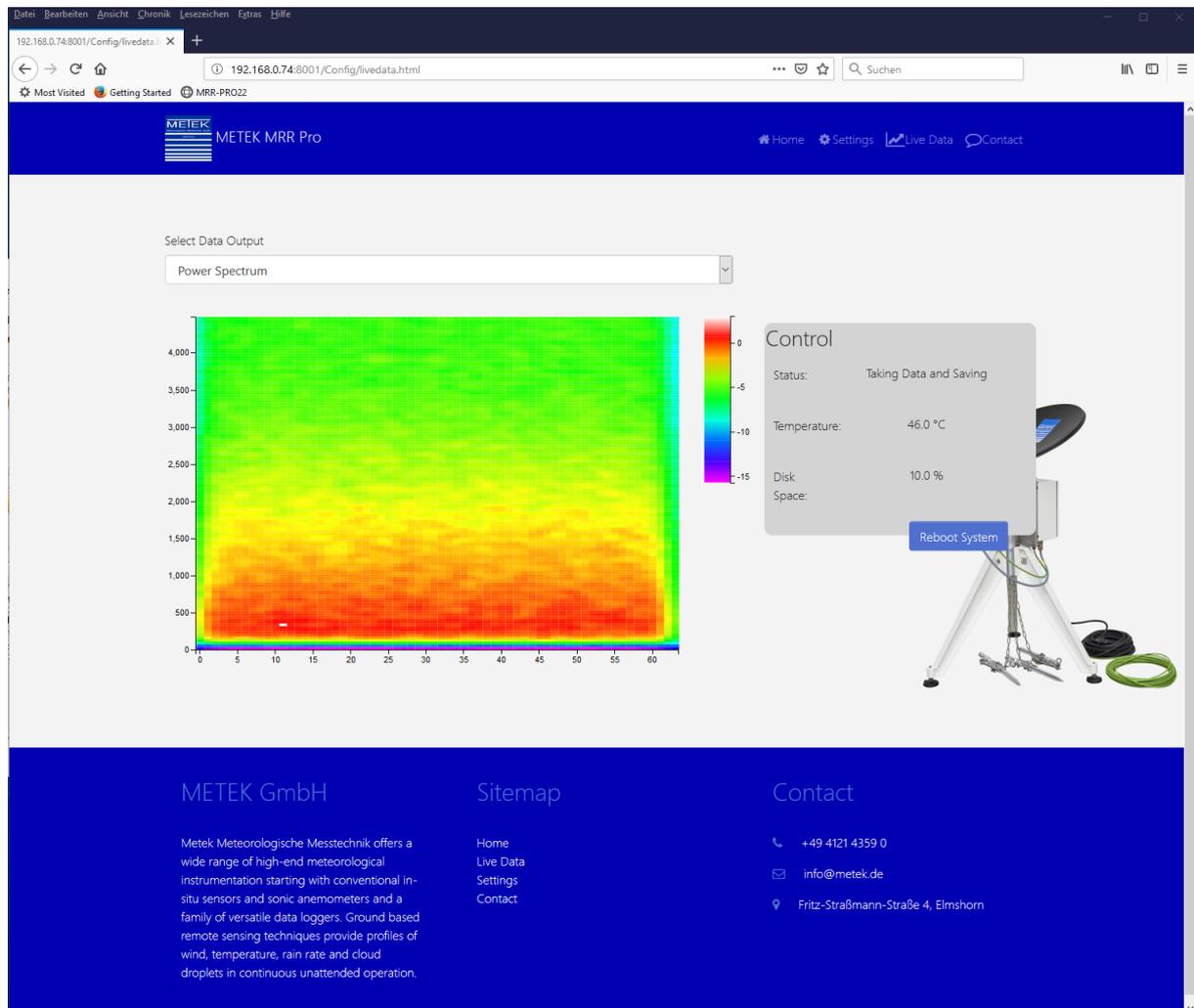
Figure 7: Live Data Display in web browser

6 Configuration of the MRR Pro

The MRR Pro GUI as well as the web browser allow configuration of system parameters of the following categories.

- Measurement
- Data Logging
- FTP Transfer
- Time Synchronisation
- Network Settings

6.1 Measurement

In MRR Pro GUI the parameter menu is accessed via the panel *Change Parameters*
in the tab *Control*. The web browser offers the necessary links in the task line.

Figure 8: „Measurement" Menu in Web Browser.

There are seven parameters in the category Measurement which can be configured:

1. *Number of Rangegates:*

   Controls the number of analyzed range gates. The velocity range is inverse
   proportional to this number. The following values are possible: 32, 64, 128 and
   256 (default 128).

2. Number of Lines in Spectra:

     Controls the velocity resolution. The velocity range remains constant. The following values are possible: 16, 32, 64, 128 and 256 (default 64).

3. *Averaging Time:*

   Averaging time of power spectra in s. Minimum is 1 s (default 10 s).

Note! The product of *Number of Lines in Spectra* and *Number of Rangegates* must not exceed 8192.

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4. Height Resolution:

     Range Resolution in m (default 35 m).

5. *Height Above Sea Level:*

   The height of the installation site above sea level is used to account for the air density in the relation between drop size and fall velocity (default: 0 m).

6. *Calibration Tuning:*

   Dimensionless constant. Factory setting is 1. If the current radar sensitivity is observed to be higher (lower) than the factory setting, the deviation can by compensated by a calibration constant lower or higher than 1.

6.2 Data Logging
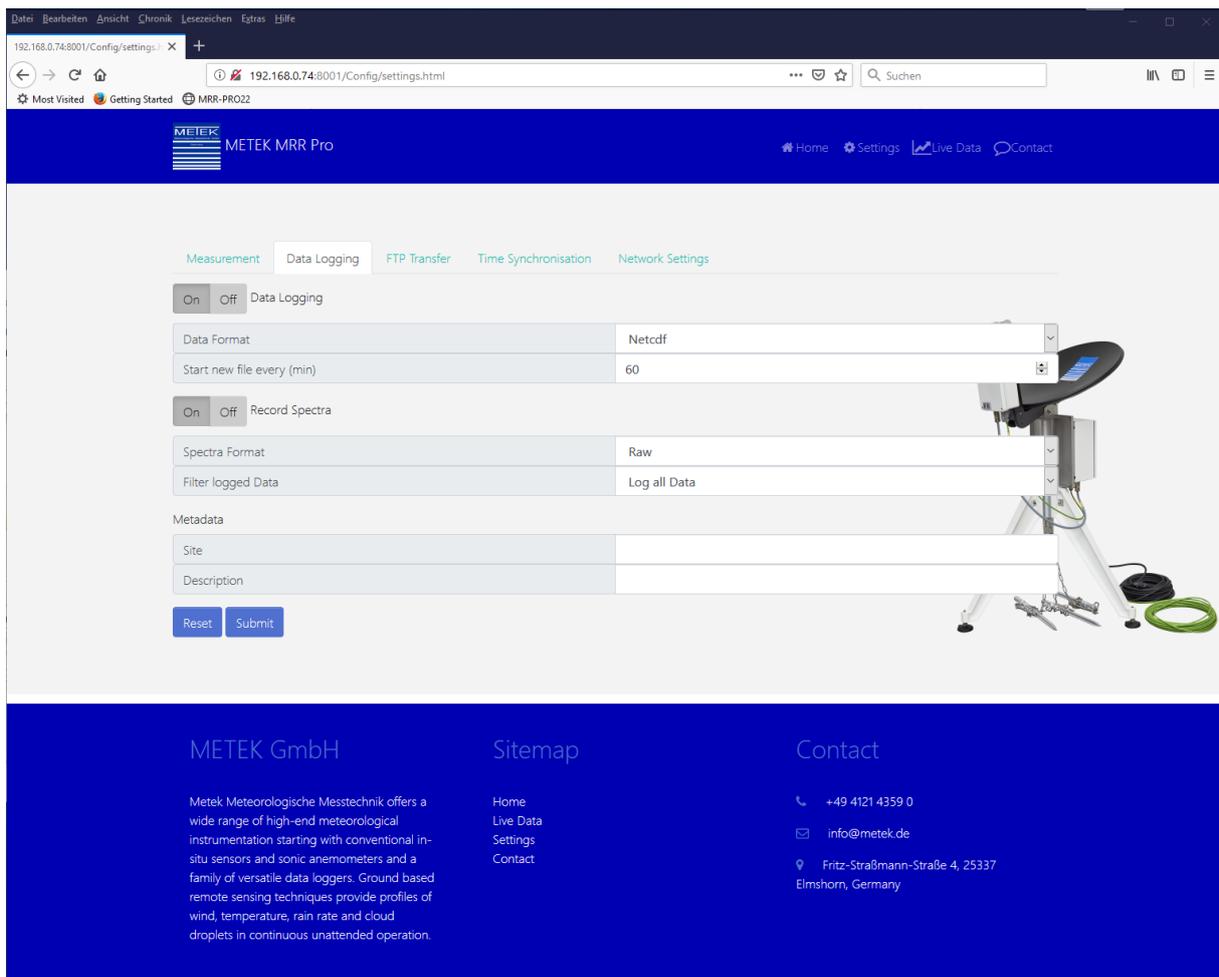
Figure 9: Menu „Data Logging" as it appears using the web browser.

There are six configurable parameters in the category Data Logging.

1.	Activate Data Recording:	Self describing
2.	Data Format:	NetCDF or ASCII data format can be selected

3.	New Data File Every:	Determines the time interval after which a new file is created. The first automatically created file of a day always starts at midnight UTC. (default 60 min)
4.	Log Spectra:	Enables logging of power and drop size spectra. All other products are logged unconditionally.
4	Select data filtering	"Log all Data" or "Data containing detected Echoes only" can be selected.
5.	Site:	Unformatted description of the measuring site. It is included in the netCDF data.
6.	Description:	Description of the measured variables. It is included in the netCDF data.

6.3 FTP Transfer
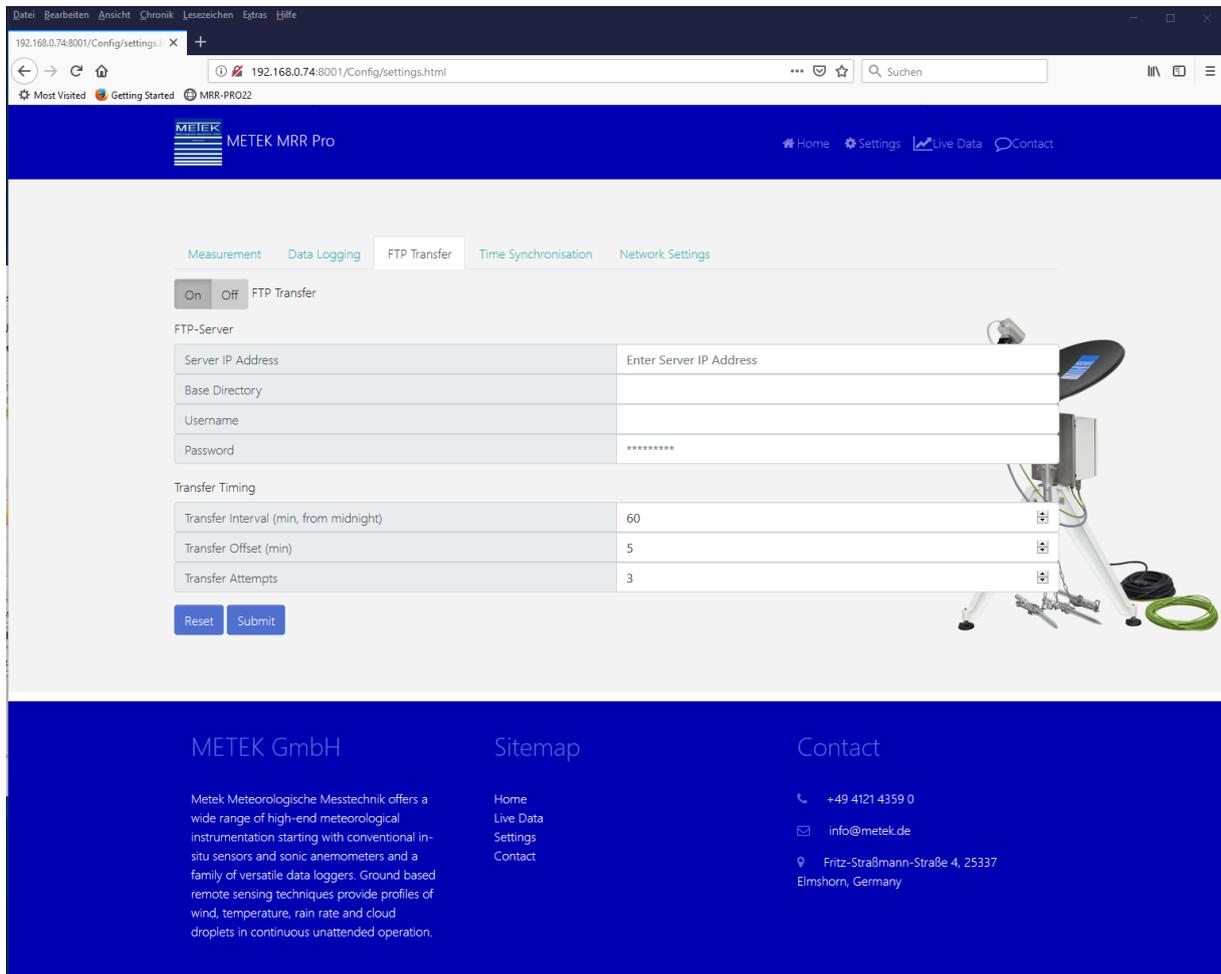
Figure 10: Menu "FTP Transfer" as it appears using the web browser.

Daily measuring data can be transferred to a FTP server. For this purpose the address and access data of the desired FTP server must be configured.

1.	Activate FTP Transfer:	Self describing

2.	Server	Address of the destination FTP server. An IP address (xxx.xxx.xxx.xxx) or a name can be used (e.g. ftp.metek.de).
3.	Directory:	This directory must exist on the server. The MRR Pro creates a copy of the internal file structure in this directory
4.	Username:	Name which is used by MRR Pro for log-in on the FTP server
5.	Password:	Assigned password
6	Transfer Interval (min, from midnight)	Time interval for FTP transfer (default 60 min)
7	Transfer Offset (min)	Time offset (default 5 min) Example: If Transfer interval is 60 min and Time Offset is 5 min, data transfer will be executed at 05 min after every full hour
8	Transfer Attempts	Number of attempts for FTP file transfer (default 3)

In MRR Pro GUI the menu includes the option to test the connection with the FTP server. During this procedure a test file is transferred to the server and is deleted afterwards.

6.4 Time Synchronization

Figure 11: Menu "Time Synchronization ", as it appears using the web browser.

The Time Synchronization is activated by selecting *Activate Time Synchronization*.

In the panel *Timeservers* up to 4 NTP time servers can be chosen. If it is left empty the NTP server "pool.ntp.org" is used.

6.5 Network Settings
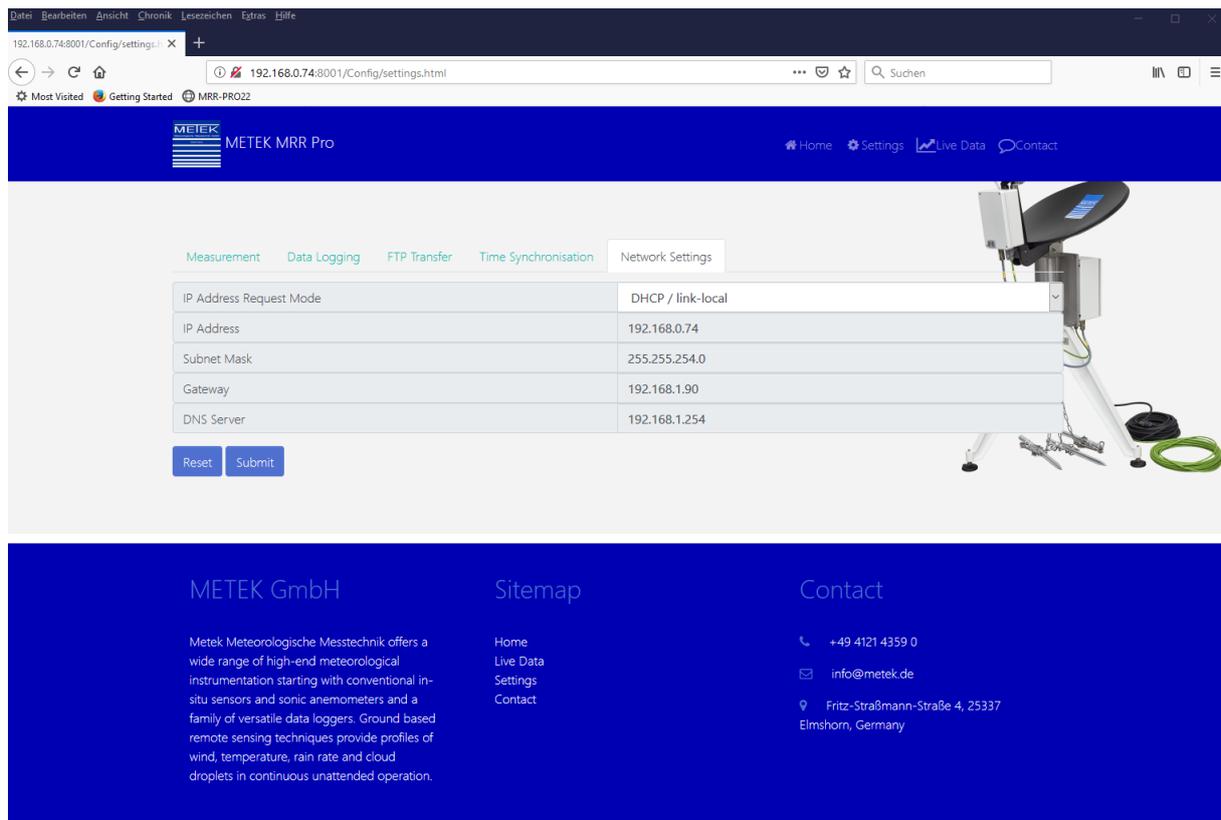
Figure 12: Menu "Network settings", as it appears using the web browser.

In the category Network Settings, the acquisition of the IP address is supported.

The MRR Pro can be operated either in the *DHCP or link local* mode. Thus, it acquires its network settings either from a DHCP server within the local network or, if such server does not exist, an address in the link local area is selected.

If one of the modes *DHCP or link local* is selected, the other panels are ignored. Any change of settings in this menu requires establishment of a new connection.

7 File Management

All data are stored locally in the MRR Pro directory */u/data*. Here monthly subdirectories are created. The data files are stored in the monthly subdirectories with the name convention

YYYYMM\MMDD_hhmmss.[ext]

YYYY is the year, MM the month, DD the day of the month, and hhmmss hour, minute and second of the day. The file extension is *nc* for netcdf files and *mrr* for ASCII files.

In addition, a logfile with the name YYYYMMDD.log is created, which contains internal parameters describing the system state of the MRR Pro.

If the free space of the internal memory is less than 10%, the oldest data are deleted. Several weeks of data are maintained for typical MRR Pro settings.

8 Data Access

There are several ways to download data from the internal memory.

1. WebDAV
2. Webbrowser
3. MRR Pro GUI
4. Livedata via LAN

> **Note!** If netCDF data recording is selected, the currently created file must not be accessed.
>
> In case of non-incrementally written file formats as netcdf parallel access may corrupt the copied as well as the original file.

8.1 WebDAV

A WebDAV server is installed on MRR Pro. WebDAV is a successor of the well-known FTP and is supported by all popular operation systems.

The simplest way to use WebDAV is to configure as a network drive. Using the menu *Connect Network Drive* of the respective operation system the folder

http://(IP-Address of the MRR Pro)/files/

must be connected. For access the user accounts described in section 5.3.3 can be used.

Note:

On Microsoft Windows systems the default download limit is set to 50000000 bytes. (47MB). To increase this value please modify the following registry entry:

1.Click Start, type regedit in the Start Search box, and then press ENTER.

2.Locate and then click the following registry subkey:

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\WebClient\Parameters

3.locate the DWORD FileSizeLimitInBytes

4.On the Edit menu, click Modify.

5.In the Value data box increase the Value from 50000000 to the max. value of 4294967295 (byte)

6.Exit Registry Editor.

7.Restart the Web Client Service

8.2 Webbrowser

The National Instruments configuration tool is accessed either using the MRR Pro IP address or using the local DNS name mrrpro(#).
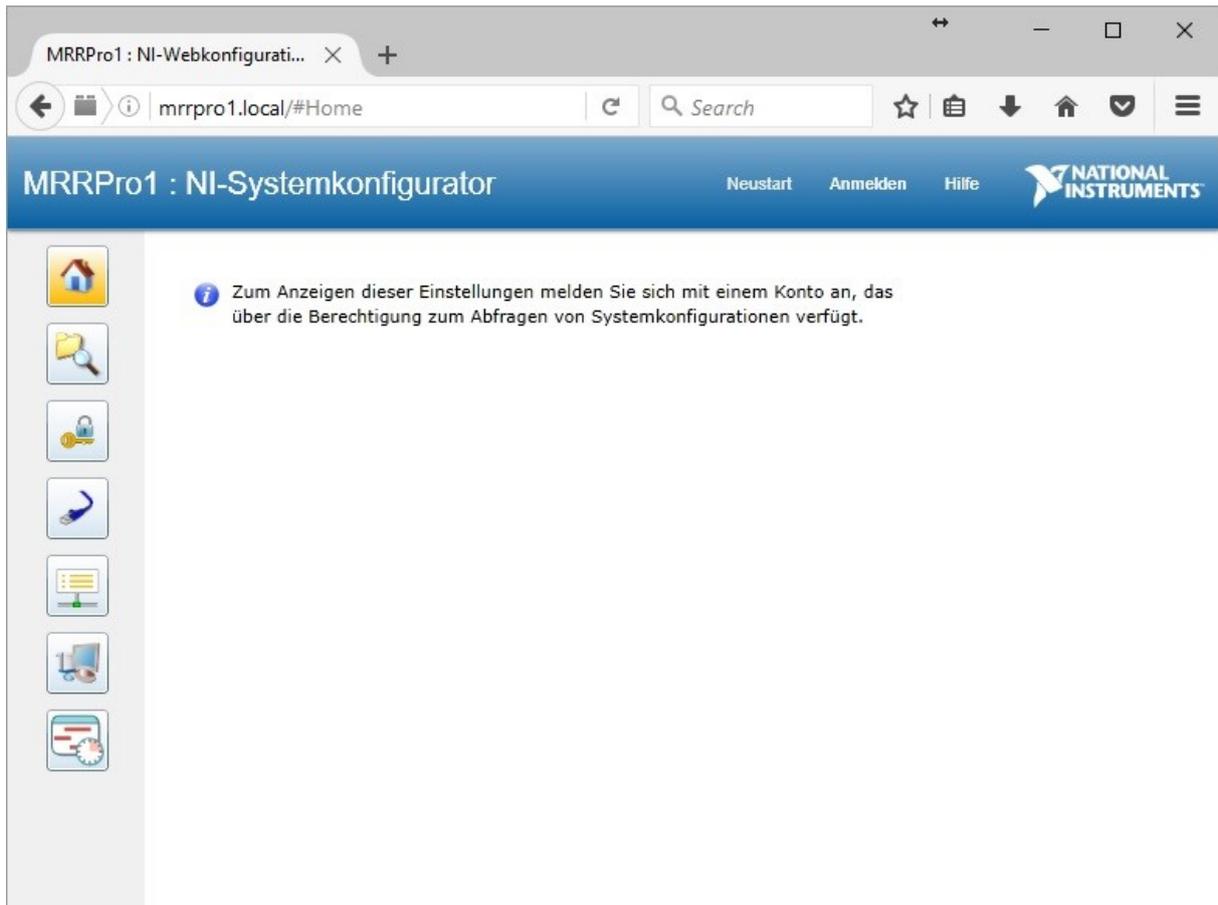
Figure 13: Start page National Instruments configuration tool.

By selecting the *Log in* panel the log in window is reached. Here are used the same access data as described in chapter 8.

Selecting the panel *Network File Manager* leads to the network file manager window. Here files can be copied between PC and device in both directions.
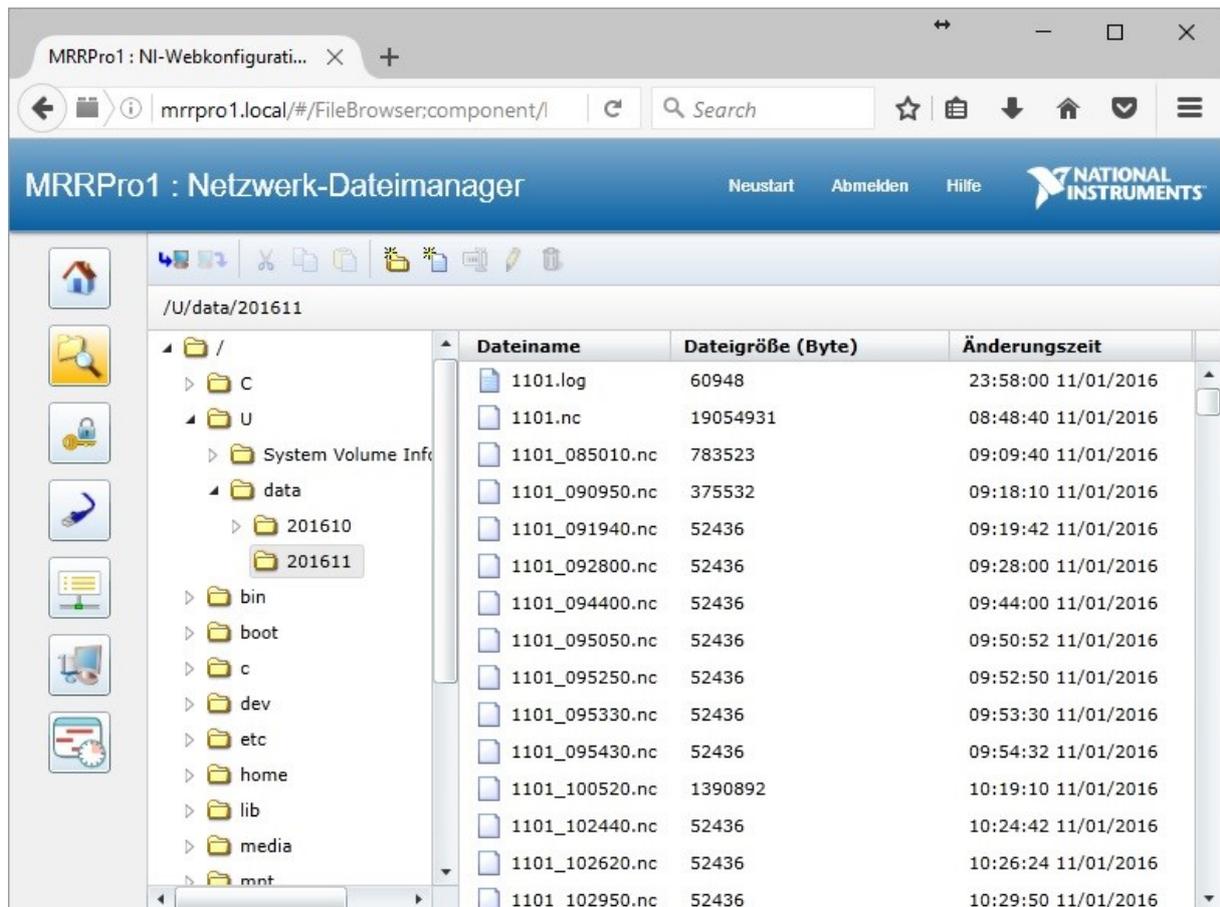
Figure 14: Network file manager window.

8.3 MRR Pro GUI

The MRR Pro GUI contains the tab *Control* that provides an overview of current files in the local memory. By selecting of files or folders and by clicking the panel *Download Data Files,* all selected data are transferred to the host computer.

The destination folder can be configured, see "Options" -> "Configure"
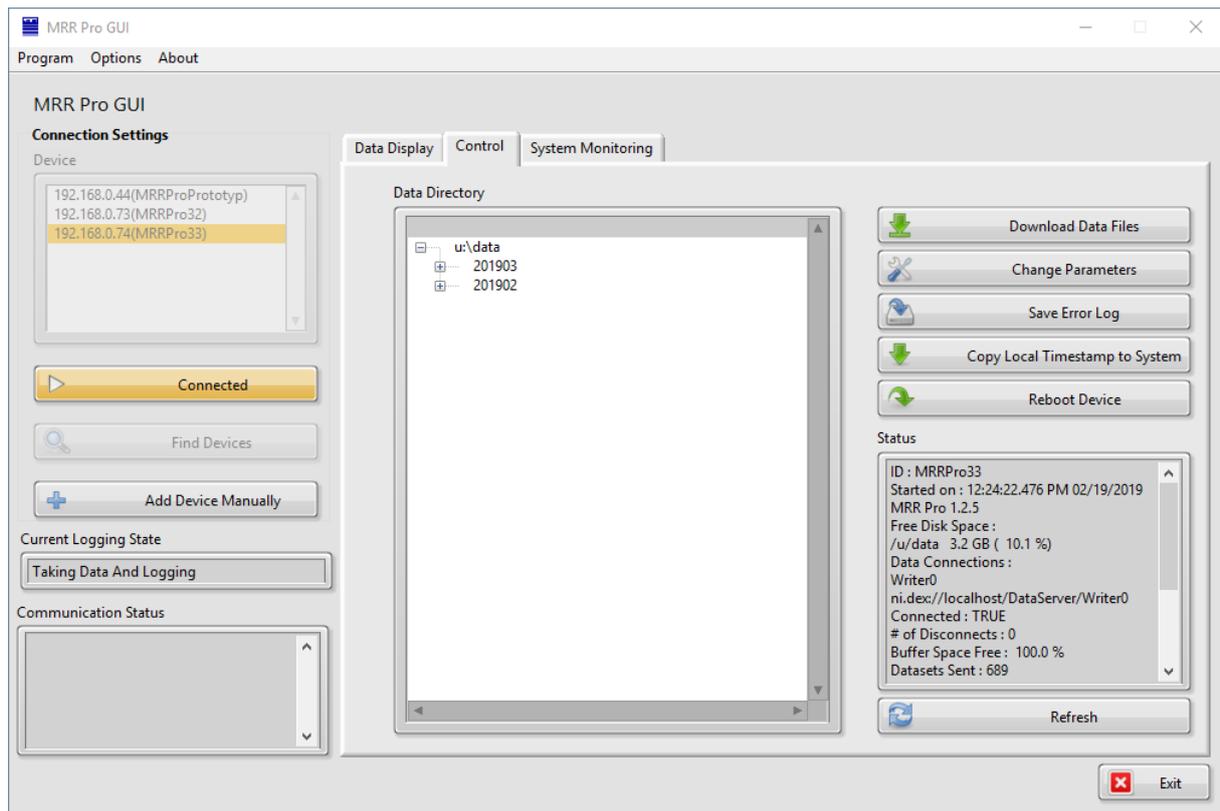
Figure 15: MRR Pro GUI, Tab *Control*

8.4 Live data via LAN

The live data connection via LAN provides the fastest access to current measuring data.

The MRR Pro waits for incoming LAN connections on Port 50002. In case of successful connection currently recorded data sets are written to this network port line by line in ASCII format. This is continued as long as the connection is established. In case of interruption of the connection the MRR Pro waits for the next connection establishment.

9 Structure of the measuring data

The MRR Pro provides one data set for each averaging interval. Averaging intervals are counted beginning from the full hour. The time zone used for the time stamps is UTC. The data sets contain the following variables

Short Name	Description	Unit
F	Spectrum	dBη
N	Drop Size Distribution Density	m^{-3} mm^{-1}
Z	Radar Reflectivity Factor	dBZ
Za	Attenuated Radar Reflectivity Factor	dBZ
Ze	Equivalent Radar Reflectivity Factor	dBZ
Zea	Attenuated equivalent Radar Reflectivity Factor	dBZ
RR	Rain Rate	mm/h
LWC	Liquid Water Content	g/m^3
W	Fall Velocity	m/s
WIDTH	Width of the Doppler Spectrum	m/s
PIA	Path Integrated Attenuation	
SNR	Signal to Noise Ratio	dB

9.1   Netcdf

netcdf files are created with the suffix .nc and follow the convention CF/radial Version 1.3. A description of the convention can be found on the delivered USB stick. For more information on the data format, visit www.unidata.ucar.edu/netcdf .

Each file contains attributes

Attribute	Value
Title	METEK MRR Data
Institution	
References	
Source	
History	
Comment	
Instrument_name	METEK MRR Pro, ID: , Software:
Site_name	
Field_names	Za,Z,Zea,Za,RR,LWC,PIA,VEL,WIDTH,SNR,spectrum_reflectivity,N

These attributes can be edited by the user. Site and Comment can be set online using the Parameters on the Data Acquisition tabs.

The field_names attribute contains the names of the variables containing the measurement data described above. There are several other variables that contain time and range information described in the convention.

9.2 ASCII

ASCII files are created with the suffix .mrr. The entries are separated by semicolons. The first line of each data set begins with the identifier *MRR* and a time stamp with the format YYYYMMDDhhmmss. YYYY is the year, MM the month, DD the day of the

month, and hhmmss hour, minute and second of the day. The rest of the line contains various parameters of the measurement. The subsequent lines contain the output variables. Each line begins with an identifier consisting of a short name of the output variable and in case of spectra of a three-digit line number.

10   Password change for user accounts

The password for a user account is changed using the National Instruments configurator which can be accessed through a Web Browser. Enter either the IP address of the MRR Pro or the local DNS name mrrpro(#) ("(#)" must be replaced by the number of the device.). This leads to the start page of the National Instruments configuration tool as shown in Figure 12. By clicking the panel *Log in* you can log in. On the left side is the panel "Safety Configuration". In the corresponding menu you can open a dialog for password change by clicking the panel *Change password*. After confirmation of the change you are transferred back to the start page of the NI System Configurator, where you can log in with the new password.
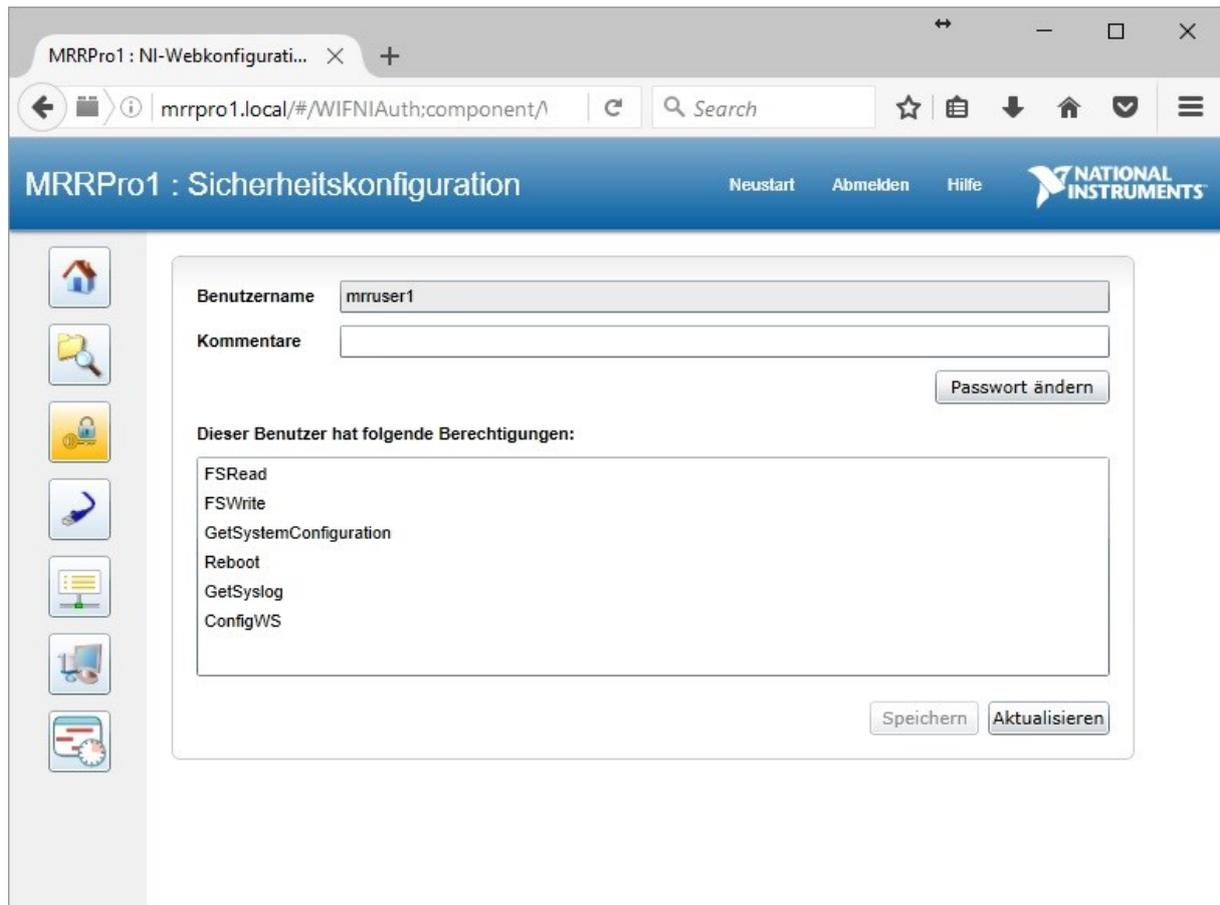
Figure 16: NI System Configurator, Safety Configuration.

11 SSH Access

The MRR Pro allows connecting per SSH (Port 22). This access can be used to

- copy data
- change the password
- set the system time
- reboot the system

The required access data are the same which are used for the web service.

Windows 10 Version 1803 or newer offers native SSH support, otherwise you have to use freeware tools like Putty (http://www.putty.org) and WinSCP (https://winscp.net).

11.1 Copy Data

Winscp offers a scripting language and it is possible to automate the transfer process of the MRR-PRO data files to the PC. Here you find an example script:

```
# Open scp connection, user=mrruser, password=metek
open scp://mrruser:metek@IP-Address of the MRR-PRO

# change local directory (PC)
lcd d:\Data\MRRPro\

# change remote directory (MRR-PRO)
cd /u/data

# Synchronize the local PC directory with remote directory
# include "*.log" and "*.nc" files
# exclude latest hidden data file ("|.*.nc")
# Criteria=filesize, needed to sync the changing *.log file
synchronize local d:\Data\MRRPro /u/data -criteria=size -
filemask="*.log; *.nc; |.*.nc"

# Close connection and exit WinSCP
close
exit
```

Save this script to a text file , e.g. "mrrcopy.script", then test the script with

winscp.com /script=mrrcopy.script

If the test is successful, you can automate this process with the windows task scheduler.

11.2 Change password

To change the password please login via ssh and the username "mrruser" and the default password "metek"

Then type

    passwd

11.3 Set system Time

In normal operation mode the system time is synchronized with ntp (network time protocol). In case that the time servers are not available and system time is wrong you can manually set the system time. The timezone of the MRR Pro is always UTC, that cannot be changed

To change the system time please login with ssh and the username "mrruser" and the default password "metek"

Then enter the correct UTC date and time information with the command

    sudo date -s YYYY.MM.DD-hh:mm[:ss]

The command date

    date

displays the current system time

11.4 Reboot the system

To reboot the system please login with ssh and the username "mrruser" and the default password "metek"

Then type

    sudo reboot

It takes approx. 2 minutes to reboot.

Date: 10.04.2019

12 Assessment of MRR concerning radiation exposure.

The **S**pecific **A**bsorption **R**ate $SAR_{whole\_body\_limit}$ is 80 mW/kg according to EN 50360, Recomm. ICNIRP, Recomm. European Counsel 1999/519/EG Appendix II Table 1.

Since $P < SAR_{whole\_body\_limit} \times 12,5$ the assessment of $SAR_{whole\_body\_limit}$ can be excluded according to EN 50392:2004 Appendix B Table B.1

The assessment of local SAR with a body phantom is applicable for distances between radiating surface and phantom of less than 40 cm. For the undisturbed MRR operation persons must maintain a distance oat least 1 m to the rim of the parabolic antenna. Therefore, SAR_{local} limits are also not applicable.

The MRR-beam axis is directed vertically.

In horizontal direction the EIRP is less than 1 mW for all azimuths.

In vertical direction the EIRP is 500 W.

The worst case is a person in the beam at less than 2 m distance from the antenna. A conservative approximation for the power density S in this region is achieved by assuming a plane wave, which is limited by the effective aperture A_{eff} of the parabolic antenna

$$S = \frac{P}{A_{eff}}$$

With $P = 50$ mW, $A_{eff} = 0.25 \ \text{m}^2$ one obtains $S = 0.2 \ \text{Wm}^{-2}$. This value is small compared to the limit exposure of $10 \ \text{Wm}^{-2}$ (Draft CNIRP Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (100 kHz TO 300 GHz), 11 July 2018).

The maximum field a person can be exposed in case of improper handling of the MRR occurs at the aperture of the antenna feed horn. The field is there $195 \ \text{Vm}^{-1}$ (corresponding to 10% of the power density of natural sun light). At a distance of $8 \ \text{cm}$ the field falls below the basic limit of $61 \ \text{Vm}^{-1}$ (see chapter 12.1).

12.1 Estimate of the field near the feed horn

The power density on the beam axis of a radiator with transmit power P and gain G at a distance x from the phase center is

$$S = \frac{P}{4\pi x^2} G_f$$

or with r_0 distance of the phase center and r distance of the measuring point from the aperture plane:

$$S = \frac{P}{4\pi(r + r_0)^2} G_f$$

The gain is related to the aperture A by

$$G_f \cong \frac{10A}{\lambda^2}$$

The position r_0 of the phase center relative to the aperture plane is estimated from the condition of consistence for the power density P/A in the aperture plane:

$$\frac{P}{A} = \frac{P}{4\pi r_0^2} \frac{10A}{\lambda^2}$$

$\rightarrow$

$$r_0 = \sqrt{\frac{10}{4\pi} \frac{A}{\lambda}}$$

With $A = 4.86$ cm^2 and $\lambda = 1.24$ cm one obtains $r_0 = 3.5$ cm.

In the figure below the field $E = \sqrt{PZ_0}$ (with Z_0 vacuum impedance) is displayed as function of r. E falls below the limit of 61 Vm^{-1} at $r = 7.6 \text{ cm}$.
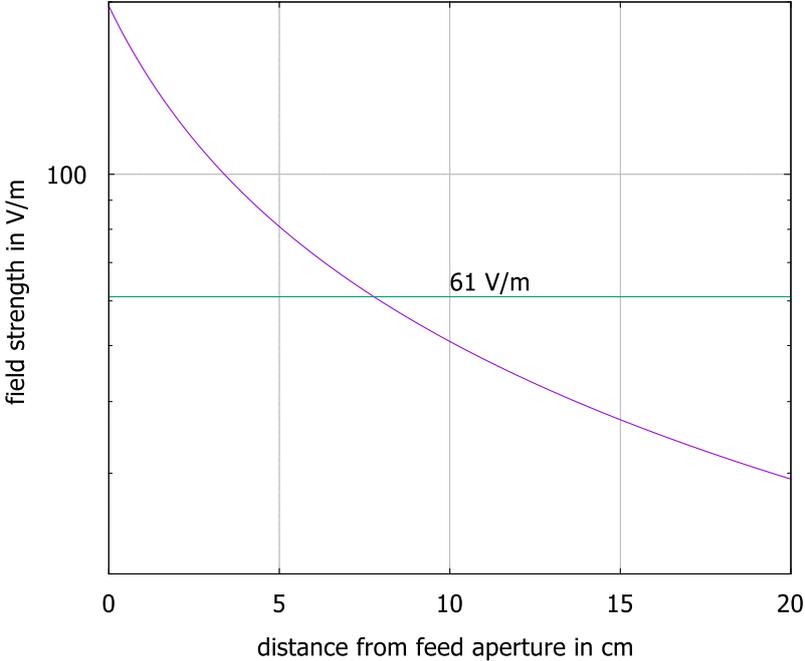
13 Technical Data

RCPD with Radar module

Operating Frequency:	24.230 GHz
Operating Mode:	FMCW
Modulation:	0.5 - 15 MHz
Output Power:	50 mW (+17 dBm) (antenna foot point)
OoB and Spurious Emission:	< -80 dBm/MHz (antenna foot point)
2nd Harmonic:	-37 dBm
ITU-Designation:	40M0F3N

Antenna

Type:	parabolic offset antenna
Diameter:	600 mm
3 dB Beamwidth:	approx. 1.5 °
Gain:	40.1 dBi

Antenna Heating (Option)

Power Supply:	115 **or** 230 VAC (50 .. 60 Hz)
Power :	approx. 500 W

Power Supply:

Input Voltage:	110 .. 240 VAC (50 .. 60 Hz)
Output Voltage	24 VDC; 5-8 VDC; ±15 VDC

Date: 10.04.2019